RECOVERY PLAN

Green Pitcher Plant

(*Sarracenia oreophila*)

U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

GREEN PITCHER PLANT

Sarracenia oreophila

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Acknowledgement

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EXECUTIVE SUMMARY

Current Status: *Sarracenia oreophila* is listed as an endangered species. There are 35 natural populations known to be extant, including 32 in northeast Alabama, 1 in northeast Georgia, and 2 in southwest North Carolina. An historical record exists for Tennessee. The majority of the populations occur on private lands and are small in number and the amount of area occupied.

Habitat Requirements and Limiting Factors: Habitat for *Sarracenia oreophila* varies somewhat with some populations located in moist upland areas and others along boggy, sandy stream edges. Soils of the sites are generally acidic and derived from sandstones or shales. Hydrological conditions (and periodic fire in upland sites) are important in the maintenance of suitable habitat for this species. Several populations have been lost and others have suffered declines in association with agricultural conversion, increased rural residential development, encroachment by woody plants due to hydrological alterations and fire suppression, and commercial and amateur collecting.

Recovery Objective: Delisting.

Recovery Criteria: This species will be considered for delisting when a minimum of 18 viable populations, representing the diversity of habitats and the geographic range of the species, are protected and managed as necessary to ensure their continued existence. Colonies should also include the wide spectrum of current genetic variation found in the species. Of the 18 populations, at least three colonies should be located within each of the following four geographic areas: Coosa Valley, Lookout Mountain, Sand Mountain (East), Sand Mountain (West), and Lake Chatuge. Viability of populations should be confirmed for at least a 20-year period through monitoring.

Actions Needed:

1. Survey for additional populations.
2. Protect, manage, and monitor populations.
3. Gather additional baseline and hydrological data.
4. Study pollination biology.
5. Conduct genetic analysis of populations.
6. Monitor transplant and reestablishment experiments.
7. Preserve genetic stock.
8. Continue public education efforts.

Total Estimated Cost of Recovery: The estimated cost for recovery tasks to be implemented in the next few years totals $214,000.

Date of Recovery: The permanent protection of populations is critical to this species' recovery. The date at which time this protection will be achieved can not be determined. Thus, a date of recovery can not be estimated at this time.

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I. INTRODUCTION

Background

On September 21, 1979, the Fish and Wildlife Service (1979) officially listed the green pitcher plant, *Sarracenia oreophila* (Kearney) Wherry, as an endangered species under the Endangered Species Act of 1973, as amended.

Sarracenia oreophila is restricted to areas of the Cumberland Plateau and the Ridge and Valley Provinces in northeast Alabama and the Blue Ridge of Georgia and North Carolina. This species previously occurred in Coastal Plain and Piedmont areas in Alabama and Georgia and also in the Cumberland Plateau of eastern Tennessee (Troup and McDaniel 1980). It is geographically isolated from all other species of the genus at the present time, though formerly it occurred with *S. rubra* subsp. *alabamensis* (Alabama canebrake pitcher plant) in central Alabama (Troup and McDaniel 1980). Although a few disjunct colonies do or formerly did occur elsewhere, the green pitcher plant's habitat during the recent past has been the Cumberland Plateau of northeast Alabama, particularly Sand Mountain and Lookout Mountain. Records, as well as inquiries with older residents (Troup pers. comm. 1985), suggest that this species was once fairly common in the area. However, because of changes in land usage since World War II, little remains of its former habitat. Past reduction in the range of *S. oreophila* and degradations to its populations and habitats have resulted from rural residential and agricultural development, encroachment of competing plants due to hydrological alterations and reductions in natural and prescribed fires, and commercial/amateur collecting of live plants. Other colonies have been lost along the river due to flooding and streambank changes in association with human disturbance of adjacent lands (Troup and McDaniel 1980).

Description and Systematic Relationships

Sarracenia oreophila is a carnivorous herb arising from moderately branched rhizomes 1 to 1.5 centimeters (cm) (0.4 to 0.6 inches) in diameter. The leaves are of two types. The pitcher leaves (hollow leaves), which appear in spring, are 20 to 75 cm (8 to 30 inches) long and 6 to 10 cm (2.4 to 4 inches) in circumference at the orifice and are gradually narrowed from the orifice to the base. In color, they are green to yellow-green with sunlit leaves sometimes maroon suffused, maroon veined externally, or rarely with a purple blotch at the orifice. Apically, a similarly colored hood arches over the orifice. The pitcher leaves wither by late summer, but are replaced by falcate phyllodia (flattened leaves) which persist until the next season. Flowers are borne singly on scapes 45 to 70 cm (18 to 28 inches) long. The petals are yellow. The fruit is a tuberculate capsule 1.5 to 1.8 cm (0.6 to 0.7 inches) wide (McDaniel 1971, Troup and McDaniel 1980).

Sarracenia oreophila was first named as a variety of *S. flava* by Kearney (1900) and was elevated to specific status by Wherry (1933). It is one of 8-13 taxa (Bell 1949, McDaniel 1971, Case and Case 1976, Schnell 1979) in the genus and one of four species of *Sarracenia* with yellow flowers. *Sarracenia oreophila* forms with *S. flava* and *S. alata*, a group of closely related, though clearly distinct and allopatric species. The distributions of these species and their morphological similarities suggest a common ancestry. *Sarracenia oreophila* may be distinguished from the two species mentioned above by the presence of numerous falcate phyllodia at the base of the plant as well as other more subtle differences (McDaniel 1971, Troup and McDaniel 1980).

Distribution and Population Size

Historically, the green pitcher plant grew in four States (Alabama, Georgia, North Carolina, and Tennessee) in five different provinces: Cumberland Plateau, Blue Ridge, Piedmont, Ridge and Valley, and Coastal Plain (Figure 1). Presently, *Sarracenia oreophila* is known to exist at 35 sites in only three geological provinces: Cumberland Plateau, Blue Ridge, and Ridge and Valley. Within these three provinces, the plant is known to be extant in northeast Alabama (Cherokee, DeKalb, Etowah, Jackson, Marshall Counties), northeast Georgia (Towns County), and southwest North Carolina (Clay County). Current populations are located within four local geological areas: Coosa Valley, Sand Mountain, Lookout Mountain, and Lake Chatuge.

Population sizes range from one to several thousand plants with estimates based on counts of discernable clumps of plants[1]. Fifty percent of the extant populations have 50 or fewer clumps and only five populations have 500 or more clumps. With the exception of three sites on State land (DeSoto State Park), populations are located on private lands including three which are owned by The Nature Conservancy.

Habitat and Ecology

Most of the extant populations of *Sarracenia oreophila* occur in the Coosa Valley and Plateau Regions of the Cumberland Plateau in northeastern Alabama (Harper 1943). Within this area, the natural vegetation is described by many authors as mixed mesophytic forest and oak-hickory forest (Braun 1951, Kuchler 1964). Because of clearing for agriculture, logging, and other human activities, little or none of this region's original vegetation remains. The region is now vegetated primarily by crops, pastures, and second-growth forests of varying composition. Thus, today, populations of *S. oreophila* occur in modified environments.

The habitats of extant populations of *Sarracenia oreophila* vary somewhat with populations found in moist upland areas and others along boggy, sandy streambanks. Soils of the green pitcher plant sites are generally acidic and derived from sandstones or shales (Troup and McDaniel 1980). Soils of the upland sites are sandy clays or loams while those of the streambank sites are almost pure sand (Troup and McDaniel 1980). The streambank sites are restricted to the Lookout Mountain area. Plant diversity is lower in the streambank sites, as compared to the upland sites (McDaniel 1986). The dominant plants of the streambank sites are alders, mountain laurel, red maple and, occasionally, rhododendron. Pitcher plants along the streambanks occur at sites about 2 feet above the average summer water level (Troup and McDaniel 1980). The upland sites have been generally categorized into two types: mixed oak flatwoods and seepage bogs (Troup and McDaniel 1980, U.S. Fish and Wildlife Service 1985). The flatwood sites are characterized as areas of flat relief with poor drainage and a high water table during the winter months. Canopy vegetation at these sites is a mixture of oaks and pines. Seepage bogs are moderately to steeply sloping areas which are moist throughout most of the year. Canopy vegetation is negligible and variable in these seepage bogs. The distinction between these two upland types is

[1]It is not possible to determine separate genetic individuals since this species is rhizomatous. Thus, the number of genetic individuals may be considerably lower than the estimated number of clumps.

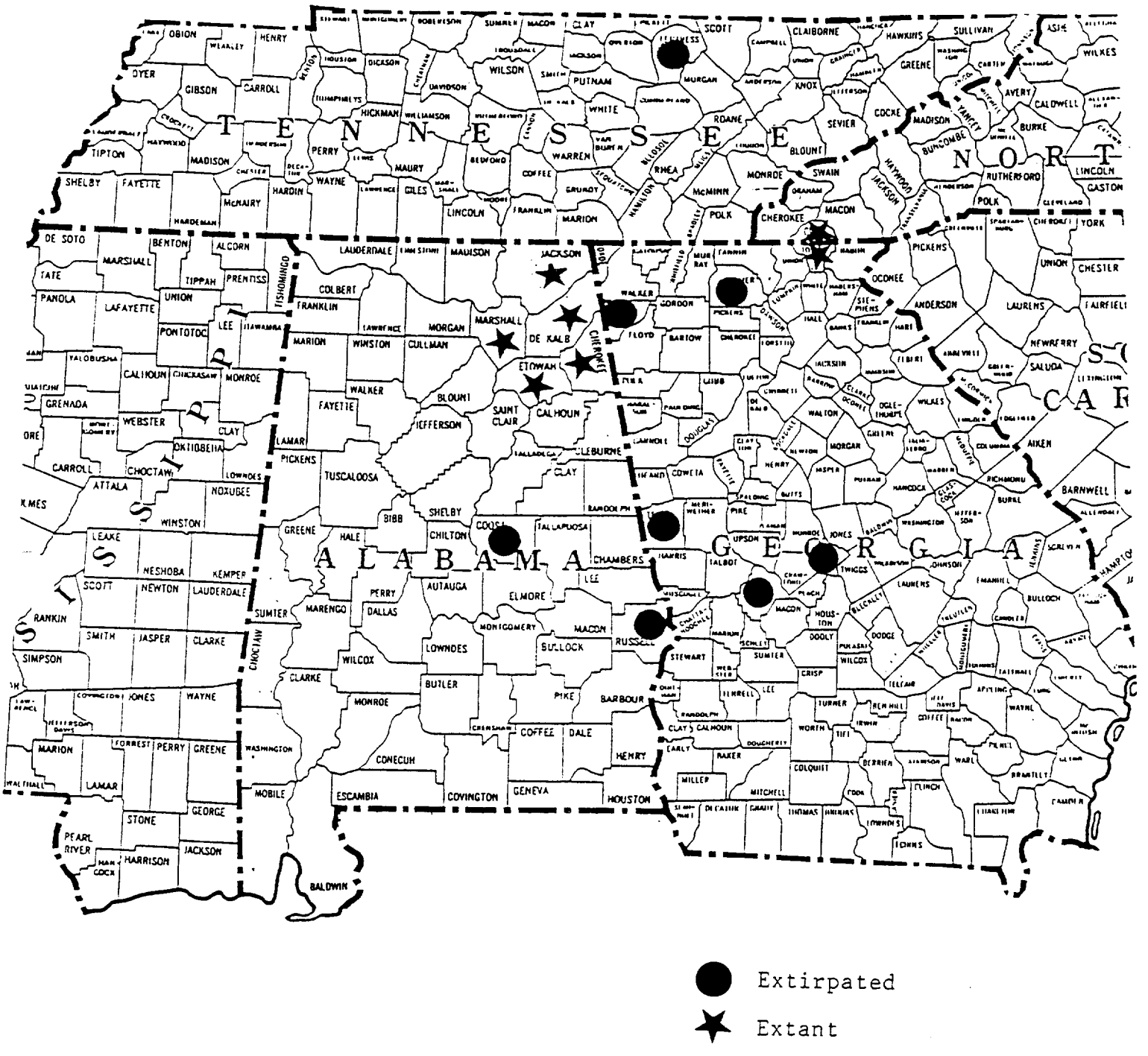

FIGURE 1: County Distribution of Green Pitcher Plant

not readily discernable at several sites, particularly some of the recently located Alabama populations. Further habitat studies will be needed to determine if the purported habitat differences in these upland sites are ecologically significant.

Sarracenia oreophila is phyto-geographically significant as a major constituent of disjunct communities. As noted by Kearney (1900), the green pitcher plant often occurs with plant species that are disjunct from their usual coastal plain distribution. In describing habitat in the Coosa Valley of Alabama, Harper (1943) remarked on the "considerable areas of longleaf flatwoods with sandy gravely soil, resembling some near the coast even to the extent of containing pitcher plants."

It is generally accepted that suitable pitcher plant habitat is maintained by a combination of edaphic features (saturated soils, acidic/poor nutrient soils) and periodic moderate fires which prevent encroachment of competing species (e.g. Barker and Williamson 1988, Eleuterius 1969, Folkerts 1977, 1982, McDaniel 1971, Troup and McDaniel 1980). Fire is a natural event in this species' habitat as much of the area of occurrence of *Sarracenia oreophila* has been subject to natural periodic fires. Historical accounts of areas within this region (Harper 1913, 1943, Mohr 1901) make frequent reference to the "open longleaf pinewoods," "level open woods," and "pine forests almost entirely bare of undergrowth" as well as to the "moderate" and "frequent" fires characteristic of these areas. Longleaf pine is an associate of the green pitcher plant at several sites. The significance of fire to, and adaptive features of, longleaf pine (Garren 1943, Harper 1943) and species in the genus *Sarracenia* are well-documented. Fire reduces competition, stimulates flowering, increases leaf production, rhizome thickness, and enhances seedling recruitment for *Sarracenia* species (Barker and Williamson 1988, Eleuterius 1969, McDaniel 1971, Folkerts 1977, 1982).

In the streambank environment, flooding appears to maintain, and perhaps create, suitable habitat by eliminating competing species (as does fire in the upland sites). Such habitats may be recolonized by green pitcher plants. However, the sporadic, violent floods of the mountain top rivers may also destroy some colonies. Human disturbances of surrounding habitat and resultant erosion, siltation, and disruption of natural stream flows have likely affected the sustainability of these streambank populations (Troup and McDaniel 1980).

Reproduction and Life History

The green pitcher plant reproduces both sexually and asexually; however, asexual reproduction (via rhizomes) is the principal mode of reproduction observed in the extant populations (Troup and McDaniel 1980, McDaniel 1991). Poor site conditions and lack of seedling recruitment areas may be a contributing factor to the lack of seedling recruitment. Rhizomes are long-lived (decades) so natural mortality is low (Folkerts 1992).

The pollinator for *S. oreophila* is the queen bumblebee (*Bombus*), with *B. pennsylvanicus* being the most commonly encountered species in the Alabama populations (Folkerts 1992). At a number of the Alabama populations, Folkerts (1992) noted that pollinators were not abundant and pollinator success was low (low seed counts). This was particularly true at wooded sites, where 20 or fewer flowers were present, as compared to the open sites which had more abundant flowering. Patch size is known to be the major limiting factor of pollinator success with bees (Rymal and Folkerts 1982). Since *Bombus* has a flight radius of no more than 1 mile, most of the green pitcher plant populations are effectively genetically isolated by distance (Folkerts 1992).

Changes in flowering and vegetative growth in the green pitcher plant appear to be primarily related to weather conditions, particularly rainfall (McDaniel 1991). Late freezes can also affect sexual reproduction by damaging flowers and fruits (McDaniel 1991). Frost damage (28° F), at the time the penduncle is bending, kills flowers by restricting nutrient/water flows (Folkerts 1992).

Life cycle events in *Sarracenia oreophila* are governed by temperature, as with other pitcher plant species (Folkerts 1992). Based on observations of the Alabama populations, Folkerts (1992) outlined the life cycle of the green pitcher plant as follows:

> Flowering primordia are formed in the fall and gradually enlarge throughout the winter. The rate of enlargement increases as the temperature rises in the spring. Growth of the peduncle, enlargement of the flower bud, and flowering occurs when temperatures become warmer in late April and May. Flowering typically occurs from April 20 to May 20 with those populations at higher elevations tending to be later in this period. Local microclimate conditions also tend to affect flowering times. Occasionally, a few plants will flower out of this season, usually in October. These flowers are occasionally pollinated but seldom produce many seeds.
>
> Fruit enlargement begins after pollination and typically reaches maximum size by late August. The fruits usually begin to dehisce, releasing seed, in mid to late September, continuing gradually until early spring. The fruit's capsule valves are sensitive to changes in relative humidity and tend to close during humid conditions.

Seedling recruitment appears to be low in the Alabama populations (McDaniel 1991, Folkerts 1992). Folkerts noted that many populations had no first year seedlings and others had only a few. At a number of sites, older seedlings were present; however, these were also in low numbers. Based on observations of the Alabama sites, the major limiting factor in sexual reproduction of the green pitcher plant appears to be availability of seedling microsites (Folkerts 1992). Seedlings require high soil moisture, open mineral soil, and high light intensity for growth during the first year. These conditions are not met at most sites due to past hydrological alterations (which has made the soils unnaturally dry) and the absence of fire which has allowed woody encroachment and shaded conditions (Folkerts 1992). Limited seedling establishment (10 or less seedlings) has also been reported for the Georgia and North Carolina sites (Benjamin in litt. 1993).

Associations with Insects

The carnivory exhibited by pitcher plants is their best-known association with insects. Insects serve as prey and provide a nutrient source for plants; however, the means by which pitcher plants benefit from consuming insects is still in question. There are a number of other ways in which insects interact with pitcher plants. Insects function as pollinators, as inhabitants of pitchers, and others feed on the plant tissue (Rymal and Folkerts 1982). Pitcher plant inhabitants feed on particulate matter in pitcher fluid and include species of *Diptera* (flies), *Hymenoptera* (wasps), and *Acarena* (mites) (Rymal and Folkerts 1982). At least five insect species feed on pitcher plant tissue and species of the genus *Exyra* (a moth) are host specific on *Sarracenia* (Rymal and Folkerts 1982, Folkerts 1992). *Exyra semicrocea* is the species which uses *Sarracenia oreophila* (Folkerts 1992).

In the past, there was concern that phytophagous insects were causing significant damage to the green pitcher plant populations (Troup and McDaniel 1980, U.S. Fish and Wildlife Service 1985). This concern prompted Folkert's (1992) study on flower/fruit predation in the green pitcher plant.

Folkerts (1992) identified 13 types of phytophagous arthropods which feed on the flowers and fruits of the green pitcher plant. However, the overall damage rate from these insects was found to be lower than that for many other perennial herbs in the U.S. and comparable to that of other large-fruited pitcher plants on the Gulf Coast (Folkerts 1992). Thus, it appears that the present levels of damage from phytophagous insects observed in *Sarracenia oreophila*, are not detrimental to the long-term survival of any of the populations (Folkerts 1992).

Threats

Habitat and *Sarracenia oreophila* populations have been lost for a number of reasons. The greatest threat comes from the clearing and degradation of land for residential, agricultural, silvicultural, and industrial purposes (Troup and McDaniel 1980). Some populations were probably inundated by the construction of Weiss Reservoir on the Coosa River (Folkerts 1977, Troup and McDaniel 1980), by Lake Chatuge Reservoir on the Georgia/North Carolina line (Dennis 1980), and by the construction of many small impoundments along the East and West Forks of the Little River in Alabama (Gunn, Alabama Natural Heritage Program, pers. comm. 1994). Populations along the Little River could be affected by future impoundments or increased pollution of this river. Future coal strip mining and road construction within the range could also impact populations, if measures are not taken to protect this species. Trampling and soil disturbance by cattle have destroyed one known population (Benjamin in litt. 1993) and damaged several others in areas which are intensively grazed (Allison 1993b). Populations in agricultural settings are also threatened with eutrophication (both from cattle and fertilizers) and broad scale use of herbicides.

As with all carnivorous plants, over-collecting by plant enthusiasts, botanists, and commercial dealers has resulted in the complete destruction or depletion of many of the sites (Troup and McDaniel 1980). Collecting continues to be a problem with this species, as reports of plants lost to collecting are received almost annually.

Periodic fires are needed to reduce the encroachment of competing vegetation. Populations have disappeared and others have declined due to fire suppression and subsequent succession (Troup and McDaniel 1980). Natural fires have been greatly reduced due to fire suppression (beginning in the 1920's) and fragmentation of land into smaller units by roads and clearing (Harper 1913, Folkerts 1977, McDaniel 1971, Frost et al. 1986). The practice of burning woods and fields in this region has also become less frequent (Troup and McDaniel 1980). Successional changes in vegetation are accelerated at those sites where the natural hydrology has been altered. Folkerts (1992) and McDaniel (1991) have both expressed concern over the lack of seedling establishment in the Alabama populations. The past practice of annual winter burning at the Alabama sites may be contributing to the lack of seedling establishment. Winter fires appear to be less effective at controlling woody encroachment (Frost et. al. 1986) and opening space for seed germination (Folkerts 1982).

Conservation Measures Taken

Since its designation as an endangered species and subsequent recovery plan preparation, there has been an active recovery program for the green pitcher plant. Searches for additional populations have been conducted and are continuing throughout this species' range (Troup and McDaniel 1980, Dennis 1980, Hillestad 1984, Govus 1987, Gunn pers. comm. 1992, Allison 1993b). Surveys have had limited success. Ten additional populations have been located since 1980; however, most of these were discovered through conversations with area landowners.

The Nature Conservancy has acquired three populations. Three other sites are protected from habitat destruction because they are located within a State park (DeSoto State Park). Voluntary Conservation Agreements between the Fish and Wildlife Service (Service) and private landowners have been obtained for 12 additional sites. These Conservation Agreements provide temporary protection to the sites and allow the Service to conduct management activities for the populations. The Service is pursuing Conservation Agreements for remaining populations as a temporary protective measure.

Studies of this species' habitat and biology have been initiated and some have been completed. Lists of associated species and baseline maps have been prepared for the Georgia and North Carolina sites and most of the Alabama sites (McDaniel 1986, Benjamin and Sutter 1991, Allison 1993a). In addition, monitoring programs are ongoing for populations in Alabama, Georgia, and North Carolina (McDaniel 1991, Allison 1993a, Benjamin and Sutter 1991, Benjamin 1992). McDaniel (1991) reports the Alabama sites to be "stable to marginally improved" but only six sites have consistent fruit production. Populations have spread vegetatively at some Alabama sites; however, this increase may be attributable to favorable weather conditions (McDaniel 1991). Monitoring programs for the North Carolina and Georgia sites were begun in 1990 and 1991; so, information is limited on population trends. However, an increase in the number of pitcher plant leaves was reported for the Eller Preserve in North Carolina during 1991 and 1992 (Benjamin 1992, in litt. 1993).

A study of flower/fruit predation in the green pitcher plant was recently completed by Folkerts (1992). Folkerts included a list of phytophagous insects which feed on the flowers and fruits; however, he determined the amount of damage observed in the populations to be nominal and of no threat to the survival of the species. His report also contained information on the life cycle, reproductive biology, and management needs of the green pitcher plant.

Transplant experiments and/or reestablishment efforts are ongoing in Alabama and Georgia (McDaniel 1990, 1992, Allison 1993a, Benjamin 1991, Moore 1991). In Alabama, a total of 22 plants have been transplanted to seven sites over the last 5 years (McDaniel 1992). To date, these transplants have not proven to be effective. Only two of the seven sites have plants remaining (three plants each) and only once has a plant flowered (McDaniel 1990, 1992). Introduction of greenhouse grown seedlings to suitable habitat in Georgia is ongoing. Of the four introductions that have been attempted in Georgia, two are still extant. The latest establishment attempts were on U.S. Forest Service land in Towns County. Approximately 300 plants, at each site, are surviving (Benjamin 1991). An attempt to establish a population in the Coosa Valley area of Cherokee County, Alabama is ongoing (Moore 1991). Of the four plots established, only one appears somewhat successful (approximately 50 percent survival).

Most of the recovery effort has focused on management of this species' habitat to reduce competition and increase light levels. Removal of trees through chemical treatments and burning have been implemented for most of the upland sites in Alabama since 1985. Pruning of woody vegetation on streambank colonies in Alabama has occurred to a limited extent in the past. The landowner of the Towns County, Georgia site has burned the site irregularly in the past, however, no burning has been done there in the last few years. The Nature Conservancy implemented a spring burn on the Eller Preserve in North Carolina in 1992 (Benjamin in litt. 1993). Restoration of natural hydrological regimes has recently become a focus of management activities for this species and will remain a priority in the future.

Other recovery activities include the preservation of genetic stock through long-term seed storage and maintenance of plants in cultivation. During 1984 through 1988, seeds were collected from all colonies in Alabama with sufficient seed production. These seeds are now in long-term storage at the USDA National Seed Technology Laboratory in Fort Collins, Colorado. The Atlanta Botanical Garden is propagating plants from seeds collected at the Georgia site for use in establishment efforts in that State.

A study was recently initiated by Godt and Hamrick (1993) of the University of Georgia to analyze the genetic structure of the green pitcher plant through allozyme analyses. Leaf samples were collected from 13 populations of the green pitcher plant (representing the geographic range and diversity of habitats) in June of 1993. Genetic analyses of this material is ongoing.

Education efforts are continuing. Numerous articles have been written regarding the green pitcher plant, its status, and recovery needs (i.e., McCabe and Jordan 1984, Smith 1985, Troup 1987). In 1986, a slide program entitled "Pitcher Plant and Its Habitat" was produced by Dr. Folkerts of Auburn University. This program, of which there are two versions, one for general audiences and the other for professional audiences, discusses the ecology and management needs of this extremely vulnerable habitat, while focusing on the green pitcher plant specifically.

Recovery Strategy

The emphasis of this species' recovery program should be on the location, protection, and management of natural populations throughout its range. The search for additional populations should continue through field surveys and discussions with area residents. Long-term protection of the sites with purchase of land by Federal/State governments or by private conservation groups should be the goal but protection through voluntary Conservation Agreements should be sought as an interim measure. The upland sites will have to be managed to maintain appropriate habitat. Unmanaged populations will likely be lost eventually due to successional changes. The goal of management will be to control woody plant competition, restore/maintain appropriate hydrological conditions, increase seed production, seedling establishment, and improve overall colony vigor. Quantitative studies will be needed to determine the optimum fire frequency and burning season for enhancement of this species' vigor and for maintenance of overall diversity in these habitats.

Site management plans should be developed (or revised) for all sites taking into account information obtained from management studies, past and ongoing management\monitoring programs, and other studies on the biology of this species. In addition to prescribed burns, these plans should specifically address modifications needed to restore proper moisture regimes (e.g., removal of drainage tiles, repairing fire plow ditches etc.). Since most of the populations occur on private lands, the cooperation of the landowners is/will be essential to the success of an effective management program.

Monitoring programs to track population trends and the response of this species to management activities should continue on as many sites as possible. However, these programs should be expanded and redesigned to monitor changes in associated vegetation (e.g., woody species, disturbance-adapted species such as *Rubus* etc.) or any animals (*Extrya* moth) which may serve as additional indicators as to the effectiveness of the management program for enhancement of the green pitcher plant and preservation of overall diversity in these habitats. Base maps and baseline data should be revised or obtained for all populations. Current monitoring programs should be critically evaluated and revised, if needed.

Studies relating to the population biology of the species, particularly pollination studies, germination requirements, and seedling ecology need to be investigated. Analyses of the genetic make-up of populations should continue to be a priority. Seed and plants should continue to be maintained in cultivation or long-term storage (seed) as a protective measure of genetic resources and as possible material for research or reestablishment.

II. RECOVERY

A. Recovery Objective. *Sarracenia oreophila* will be considered for delisting when a minimum of 18 viable populations, representing the diversity of habitats and the geographic range of the species, are protected and managed as necessary to ensure their continued existence. Colonies should also include the wide spectrum of current genetic variation found in the species, which will be investigated as a recovery task. Of the 18 populations, at least three colonies should be located within each of the following four geographic areas: Coosa Valley, Lookout Mountain, East Sand Mountain, West Sand Mountain, and Lake Chatuge.

A population will be considered protected when it is legally protected from any present or foreseeable threats and is actively managed. A population will be considered viable if it is successfully sexually reproducing and the population size is stable or increasing. A successfully sexually reproducing population is one which has consistent seed production followed by seedling establishment. Population viability should be confirmed through long-term monitoring (20- to 30-year period) before a final assessment of its eligibility for delisting is made.

Recovery criteria are preliminary and may be revised on the basis of new information.

B. Narrative Outline

1. Continue search for additional populations. Although there have been several intensive searches for this species, there still remains much suitable habitat to be investigated. Surveys are underway in upper and lower portions of the Coosa Valley and Lake Chatuge areas. Efforts should focus on surveying potential sites within the drainages of extant and historic sites, as identified through the literature, and through examinations of soil, topographic, and aerial maps. Discussions with local residents, in areas of potential habitat, have led to the discovery of additional populations and such should be continued.

2. Protect populations. Preservation of the green pitcher plant depends on freedom from both immediate and potential threats. The loss of populations through changes in land use remains a threat. An effort should be made to secure all known populations of this species because of the limited number of populations and its vulnerability due to mostly private ownership. Priority should be given to the larger populations; sites representing its total geographic range and diversity of habitats types; and sites with higher biodiversity. Information obtained from the genetic studies (Task 9.2) will also be useful in prioritizing protection efforts.

   2.1 Contact landowners and negotiate protection. Landowners of all known sites have been contacted and their cooperation in the protection of this species has been sought. For the most part, landowner cooperation has been excellent. Those sites on State-owned land (DeSoto State Park) and the Nature Conservancy properties are considered secure for the long term. The Service has voluntary Conservation Agreements with private landowners for 12 other sites but their future protection is contingent on a landowner's continuing cooperation. Permanent protection through acquisition by public agencies or private conservation groups or conservation easements should be pursued for those colonies determined to be essential to the recovery

of the species. Protection for any newly discovered colonies will always begin with communication with the landowner. Active management of the habitat is an integral part to ensuring the survival of populations so general site management needs should be discussed with landowners at this time (see Task 3).

2.2 Enforce protective legislation. Collecting has contributed to the endangered status of this species and remains an ever-present threat. Prevention of take is a complex problem. The Endangered Species Act's protection of endangered plants from interstate sale and exportation, and from taking in knowing violation of any State law or regulation (including State criminal trespass law) should be enforced.

3. Manage populations. Habitat management, as well as protection, is critical to ensuring the survival of populations. Management should focus on enhancing populations of the green pitcher plant by maintaining (or restoring) essential hydrological conditions and by removing competing vegetation primarily with controlled burns. In addition, management should strive to preserve overall habitat diversity. Regular and frequent monitoring of the green pitcher plant and associates will be needed to evaluate the effectiveness of the management program.

3.1 Gather baseline data. Baseline data have been gathered for most of the populations, but not for sites which were located in the last few years. General baseline studies/analyses will provide a reference for comparing the effectiveness of management efforts.

3.1.1 Determine population size. General information should be gathered and recorded such as: population size (approximate square meters), number of plants, and indications of vigor. Detailed maps showing the location and size of individual clumps within each population should be prepared (or revised) for all colony sites. Permanent markers should be established for comparative purposes once specific management actions are initiated.

3.1.2 Analyze seedling microhabitat and census seedlings. Seedlings appear to be rare in the green pitcher plant populations. A concerted effort should be made to locate/monitor seedlings and evaluate seedling microsite conditions in all populations. Correlations with site management history (fire frequency, fire season, etc.) should be noted. Information gathered under this task will assist in evaluating studies in task 3.2.1.

3.1.3 Conduct hydrogeological surveys. These surveys must be conducted for all upland sites in order to develop a plan to protect and/or restore natural hydrological conditions. Information gathered from these studies will also be useful in analyzing purported hydrological differences in the upland habitats. Additional qualitative analyses may be needed for those sites in agricultural areas to test for herbicide residues or eutrophication from fertilizers or from cattle pastured nearby.

3.2 Conduct experimental burns and monitor changes. Experimental studies are needed to determine the best season and frequency of fire for optimum management of the green pitcher plant in the upland sites. In the past, most of the burning of these sites in Alabama has been done during the winter months on a 1 to 3 year rotation. While there appears to be a slight increase in vegetative spread at these sites, woody competition continues to be a problem at many sites, flowering\fruiting is low at some sites, and seedling establishment is practically non-existent (McDaniel 1991, Folkerts 1992). Winter burning may have also aggravated damage by phytophagous insects by reducing populations of their natural enemies (most of which overwinter in stages or microsites vulnerable to winter fires) (Folkerts 1992). These problems indicate that the practice of winter burns needs to be reexamined.

Natural fires occurred most often in association with lightning during the summer (Frost et al. 1986, Folkerts 1982, 1992, Komareck 1965). Summer fires and winter fires differ and have varying effects on the vegetation (summer fires are hotter). The season fire occurs influences the floristic composition of habitats, differs in their effectiveness at controlling woody competition, and likely has varying effects on life cycle parameters (e.g. flowering, germination) (e.g. Folkerts 1982, 1992, Frost et al. 1986, Lemon 1949, 1967).

Control and burned plots should be established on representative sites. Various permutations of fire seasons and rotations should be implemented and compared. Information to be collected on the green pitcher plant may include such factors as vegetative growth, flowering\fruiting, and seedling establishment. Data should also be gathered on the response of associated vegetation (i.e., woody mortality and regrowth, and disturbance-adaptive species such as *Rubus* which may compete with the green pitcher plant).

3.2.1 Create experimental seedling establishment sites. Information gained from task 3.1.2. will contribute to our understanding of suitable seedling microsites for the green pitcher plant. However, experimental studies, aimed at creating suitable microsites for seedling establishment through burning or manual means, will provide additional data towards identifying optimum microsite conditions for seedling establishment. This information is critical to designing appropriate site management plans aimed at enhancing populations of this species.

3.3 Implement comparative study of *Exyra* populations. Management should be done as to preserve populations of all natural herbivores associated with this species (Folkerts 1992). Winter burning may have negatively affected populations of the host specific moth, *Exyra semicrocea*. A census of *Exyra* populations should be conducted for selected green pitcher plant sites. A comparative study of *Exyra* populations at sites with different burning regimes will aid in formulating appropriate burning schedules.

3.4 Develop site management plans. Revised management plans should be prepared for all colonies using information obtained from 3.1, 3.2, 3.3, and past management experiences. In addition to burning, competiting herbaceous and woody vegetation may be

removed by hand, chemical injection, mowing and/or bush hogging. The type of fire (backing fire, headfires etc.), placement of fire brake, burn season, and frequency of fire should be addressed in the site plans. An attempt should be made to establish permanent fire breaks to minimize disturbance to the sites and reduce labor. Care should be taken to design fire breaks which do not alter the natural hydrology. For those sites which have been hydrologically altered, a plan to restore hydrological integrity should be a component of the site management plans. Enclosures may be needed at sites which are being impacted from trampling by cattle or horses. Landowners should be kept informed of management needs at all stages. Implementation of the management plans is dependent upon the landowner's cooperation. Management plans should be reviewed annually and revised, as necessary.

3.5 Implement management actions as identified in the site management plans.

4. Study pollination biology. Studies by Folkerts (1992) indicated that pollinators were limited and pollinator success was low for the Alabama green pitcher plant populations. Further investigation is needed into the pollination biology of this species to identify factors which may be limiting to this species' sexual reproduction.

5. Monitor transplantation experiments. One of the stipulations of the court stay issued by United States District Judge U.W. Clemon in DeKalb County Commission vs Watt, Civil Action number 80-C-1242-M (D.N.D. AL 1981) was "that the recovery team will attempt to determine the botanical and economic feasibility of transfer of the species to other suitable habitat." Transplantation, as defined herein, involves the removal of plants from their natural habitat and placement at another site determined to have similar habitat conditions. Mature rhizomes can withstand unfavorable conditions and persist anywhere from a few years to decades. Thus, the fact that transplanted specimens live means little to the long-term survival of populations (Folkerts in litt. 1993). A successful transplant is one where the population is increasing in size and natural reproduction and seedling establishment are consistent. Seven transplants have been attempted in Alabama since 1985. Only two of these sites have plants remaining and neither of these populations have expanded (McDaniel 1990). All sites should continue to be monitored and habitat management should be implemented as needed.

6. Reestablish colonies and monitor. Established colonies should continue to be monitored to assess success. Habitat management to remove competition should be implemented as needed. The need for additional reestablishment sites should be assessed after intensive surveys have been conducted to search for natural populations and it has been determined that additional colonies are needed to reduce vulnerability of the species. Future reestablishment efforts should only be lands where long-term protection is assured. Site selection is critical to the success of reestablishment efforts. Poor site selection may have been a factor in past failures (Determann, Atlanta Botanical Garden, pers. comm. 1993).

Established colonies to date have been started with seedlings grown in-house from seed taken from natural populations nearby. An alterative reestablishment technique proposed by Folkerts (in litt.

1993) involves preparing suitable habitat with a prescribed burn, scattering seed from nearby populations, and evaluating seedling survivorship over time.

7. Preserve genetic stock. To guard against the possible loss of populations, germplasm should be preserved, through seed bank storage and by maintaining material in cultivation. This germplasm has, and may continue to be used for reestablishment efforts and research. These activities should be coordinated with the Center for Plant Conservation.

   7.1 Maintain seedbank. Seeds have been collected from all Alabama populations, with the exception of those discovered in the last few years, and are in storage at the USDA National Seed Technology Laboratory in Fort Collins, Colorado. Seeds should be collected from all remaining sites and shipped for long-term storage. Seeds should be recollected when testing indicates reduced viability.

   7.2 Maintain material in cultivation. Plants in cultivation also provide material for research, education, genetic preservation, and reestablishment. Plants, grown from seed, are currently maintained at the Atlanta Botanical Garden. These plants have been used in establishment efforts in Georgia and are available for additional establishment efforts in that State.

8. Continue to educate public on conservation of endangered plants. Public support is an important part of recovering any listed species. The green pitcher plant is an excellent "flagship" species to use in stressing the importance of conserving endangered plants and their habitats. Pitcher plants are exceptionally fascinating and typically generate considerable interest and support. In addition to its carnivory, this species has an intricate relationship with other species (particularly insects) and all have co-evolved under the influence of fire. The green pitcher plant illustrates the diversity and adaptability of nature and the importance of preserving a unique ecosystem.

   Landowners have been informed of the importance of protecting this species and are kept well-informed of recovery activities. The discovery of several new populations was a direct result of such communication with local landowners. Management is an intricate part of securing populations. An informational packet could be created for private landowners instructing them how to manage their land to enhance this species and keep overall biodiversity intact.

   As with many carnivorous plants, overcollecting has significantly contributed to this species' decline. The most effective way to combat taking will be prevention through education. Education efforts should continue to include informal communication with local landowners, written articles, and perhaps, the development of a brochure to be distributed at botanical gardens. An effort should be made to make the slides programs of Folkerts (1986) available for distribution to schools, clubs, and other groups.

9. Evaluate recovery progress and identify essential colonies. Recovery needs and criteria can be more clearly defined as more information is obtained on this species' biology and management needs. Monitoring will be essential in assessing progress towards recovery. The successful recovery of this species is dependent upon the protection and management of a number of essential colonies.

9.1 Continue (or initiate) monitoring programs and census populations. Monitoring programs have been developed to track population trends for populations in all States with populations. Censusing should continue and allow for measurement of general population growth and viability, flower/fruit production, and seedling establishment and growth. Growth measurements of selected individual plants should also be performed at selected colony sites. Current monitoring programs should be critically examined and redesigned, if needed. Monitoring plans should be designed and initiated for those sites currently not being monitored. The complexity of the monitoring program design is dependent upon population size and objectives. General observations, made annually, may be all that is needed for the smaller sites. Information obtained from Task 3.1 may serve as baseline information for monitoring programs.

9.2 Conduct genetic analyses of colonies. Analyses of the genetic variability in a species is important to assess the long-term survival of the species. Genetic analyses of populations will aid in identifying genetically essential colonies. Protected colonies should include a wide spectrum of the current genetic variability that is found in the species. Genetic analyses should be conducted for populations across this species' geographic range and include a sample of varying habitat types. Electrophoresis of representative populations is currently underway by staff of the University of Georgia.

9.3 Identify essential colonies. The analyses of genetic information, landowner's commitment to cooperation, and site conditions, are important elements in identifying colonies considered essential for recovery.

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PART III: IMPLEMENTATION SCHEDULE

The following Implementation Schedule outlines recovery actions and their estimated costs for the first 3 years of the recovery program. It is a guide for meeting the objective discussed in Part II of this plan. This Schedule indicates task priorities, task numbers, task descriptions, duration of tasks, the responsible agencies, and lastly, estimated costs.

Priorities in column one of the following Implementation Schedule are assigned as follows:

1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

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

Key to acronyms used in Implementation Schedule

USFWS - U.S. Fish and Wildlife Service
TE - Endangered Species Division, U.S. Fish and Wildlife Service
HC - Habitat Conservation, U.S. Fish and Wildlife Service
AL - Alabama Natural Heritage Program
TNC - The Nature Conservancy
TN - Ecological Services Division, Tennessee Department of Conservation
CPC - Center for Plant Conservation
DSP - DeSoto State Park
SLD - State Lands Division, Alabama Department of Conservation and Natural Resources
ABG - Atlanta Botanical Garden
LE - Law Enforcement, U.S. Fish and Wildlife Service
GA - Georgia Natural Heritage Inventory, Georgia Department of Natural Resources
NC - North Carolina Heritage Program
UGA - University of Georgia, Athens

IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION	RESPONSIBLE PARTY			COST ESTIMATES ($K)			COMMENTS/NOTES
				USFWS						
				Region	Division	Other	FY 1	FY 2	FY 3	
2	1	Continue surveys for additional populations.	ongoing	4	TE	AL,GA,NC TN	2.0	2.0	2.0	Surveys funded in AL and GA in the past.
1	2	Protect populations.	ongoing	4	TE,HC,LE	DSP,TNC	1.5	1.5	1.5	Costs estimated for Conservation Agreement renewals. More binding protection actions (conservation easements, acquisition, etc.) will significantly increase costs.
2	3.1.1	Determine population size.	2 years	4	TE	AL,GA,NC TNC	2.0	2.0	-	Partially completed, involves mostly revisions.
1	3.1.2	Locate seedlings/analyze microsites.	3 years	4	TE	AL,GA,NC TNC,contractor	3.0	3.0	3.0	
1	3.1.3	Hydrogeological surveys	1 year	4	TE	contractor	10.0			
1	3.2	Conduct experimental burns and monitor.	5 years	4	TE	AL,GA,NC SLD,TNC	5.0	5.0	5.0	
1	3.2.1	Create experimental seedling sites.	3 years	4	TE	AL,GA,NC TNC,contractor	3.5	3.5	3.5	
2	3.3	Initiate comparative study of ***Exyra*** populations.	2 years	4	TE	contractor	5.0	5.0		

IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION	RESPONSIBLE PARTY			COST ESTIMATES ($K)			COMMENTS/NOTES *
				USFWS						
				Region	Division	Other	FY 1	FY 2	FY 3	
1	3.4	Develop/revise site management plans.	2 years	4	TE	AL,GA, TNC	2.5	2.5		
1	3.5	Implement management actions.	ongoing	4	TE	AL,SLD, GA,TNC	30.0	30.0	30.0	
3	4	Study pollination biology.	2 years	4	TE	contrac-tor	5.0	5.0		
3	5	Monitor transplants.	ongoing	4	TE	contrac-tor	1.0	1.0	1.0	Ongoing project through NBS at Mississippi State University
3	6	Reestablish colonies/monitor.	ongoing	4	TE	UGA,GA, ABG	3.0	3.0	3.0	
3	7	Preserve genetic stock.	ongoing	4	TE	ABG,CPC	-	-	-	New material collected as needed
3	8	Public education efforts	ongoing	4	TE	AL,GA, TNC,DSP	1.0	1.0	1.0	
2	9.1	Monitor populations.	ongoing	4	TE	AL,GA,NC TNC	5.0	5.0	5.0	
2	9.2	Genetic analyses	2 years	4	TE	UGA	5.0	5.0		
2	9.3	Identify essential colonies.	1 year	4	TE	AL,GA,NC TNC	-	-	-	No costs involved

IV. APPENDIX

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