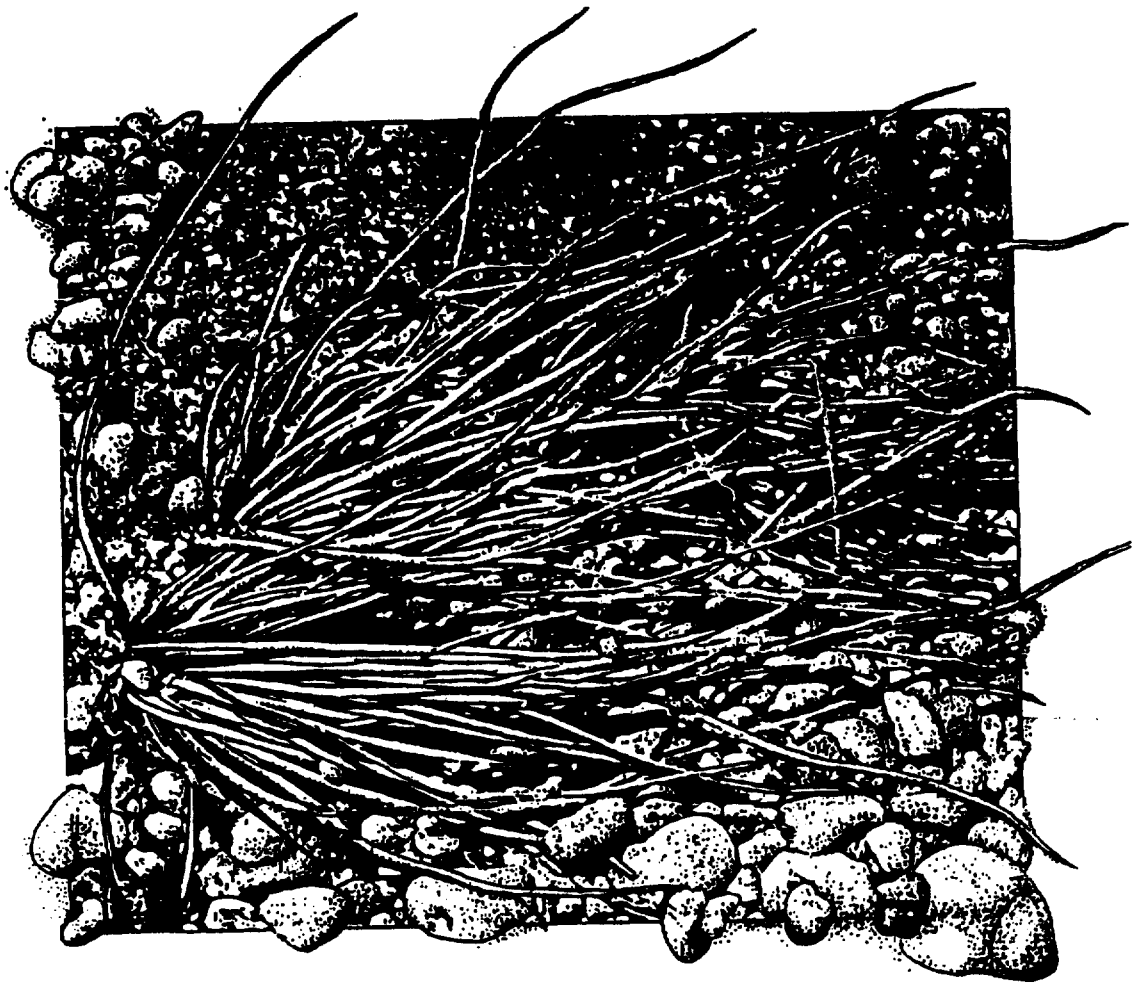


Recovery Plan  
For The  
Louisiana Quillwort  
(*Isoetes louisianensis*) Thieret



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

**LOUISIANA QUILLWORT**

*Isoetes louisianensis* Thieret

**RECOVERY PLAN**

Prepared by

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for

U.S. Fish and Wildlife Service  
Jackson, Mississippi

and

U.S. Fish and Wildlife Service  
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Approved: \_\_\_\_\_

*Noreen K. Clough*  
Noreen K. Clough, Regional Director,  
Southeast Region, U.S. Fish and Wildlife Service

Date: \_\_\_\_\_

*September 30, 1996*

Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect the species. Plans are prepared by the U.S. Fish and Wildlife Service, sometimes with the assistance of recovery teams, contractors, State agencies, and others. Objectives will only be attained and funds expended contingent upon appropriations, priorities, and other budgetary constraints. Recovery plans do not necessarily represent the views nor the official positions or approvals of any individuals or agencies, other than the U.S. Fish and Wildlife Service, involved in the plan formulation. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

By approving this document, the Regional Director certifies that the information used in its development represents the best scientific and commercial data available at the time it was written. Copies of all documents reviewed in development of the plan are available in the administrative record, located at the Jackson, Mississippi, Field Office.

**Acknowledgment:**

The cover illustration was originally done by Julia Larke of the Louisiana Natural Heritage Program. It was enhanced by Ms. Larke and Terri Jacobson of the U.S. Fish and Wildlife Service.

**Literature citations should read as follows:**

U.S. Fish and Wildlife Service. 1996. Recovery Plan for Louisiana quillwort (*Isoetes louisianensis* Thieret). Atlanta, Georgia. 26 pp.

**Additional copies may be purchased from:**

Fish and Wildlife Reference Service  
5430 Grosvenor Lane, Suite 110  
Bethesda, Maryland 20814

Telephone: 301-492-6403 or  
1-800-582-3421

Fees for recovery plans vary, depending upon the number of pages.

## EXECUTIVE SUMMARY

**Current Status:** *Isoetes louisianensis* is listed as endangered without critical habitat. It is currently known to occur in St. Tammany and Washington Parishes in southeastern Louisiana and in Jackson and Perry Counties in southern Mississippi. In Louisiana, all known sites are on private land; in Mississippi, all known sites occur on National Forest land.

**Habitat Requirements and Limiting Factors:** Louisiana quillwort occurs in the East Gulf Coastal Plain physiographic province in Pleistocene Prairie Terraces and Pleistocene High Terraces in southeastern Louisiana and in Pleistocene High Terraces in southern Mississippi. It appears to be restricted to sandy soils and gravel bars in or near shallow blackwater streams and overflow channels in riparian woodland/bayhead forests of pine flatwoods and upland longleaf pine. *Isoetes louisianensis* is extremely vulnerable because of its small population size and habitat loss from actions which affect the hydrology or stability of the streams it inhabits.

**Recovery Objective:** Delisting.

**Recovery Criteria:** This species will be considered for delisting when 10 reproductively viable and geographically distinct populations from different drainage systems are protected from foreseeable threats. A reproductively viable population is one which is reproducing and stable or increasing in size as shown by monitoring for at least a 10-year period.

**Actions Needed:**

1. Protect known populations by protecting their habitat.
2. Conduct life history research.
3. Monitor population trends and developing threats.
4. Search for additional populations in southeastern Louisiana, southern Mississippi, and south Alabama.
5. Preserve genetic stock.
6. Inform the public about the conservation needs of the species.

**Estimated Cost of Recovery:** It is not possible to estimate costs beyond the first few years. Cost estimates of recovery tasks over the next 3 years total \$74,000.

**Date of Recovery:** Since the species' recovery depends upon the outcome of several recovery tasks, it is not possible to determine a date at this time.

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## I. INTRODUCTION

### A. Background

*Isoetes louisianensis* Thieret, Louisiana quillwort, is a member of the Isoetaceae, a family of primitive seedless plants related to ferns. The family consists of a single genus, *Isoetes*, with approximately 150 species occurring nearly worldwide in aquatic and moist terrestrial habitats. Twenty-five species occur in North America (Brunton et al. 1994, Taylor et al. 1993) and one of the rarest is *I. louisianensis*. Within the East Gulf Coastal Plain physiographic province this species occurs in the Pleistocene Prairie Terraces and High Terraces in southeastern Louisiana and in the Pleistocene High Terraces in southern Mississippi. Louisiana quillwort is apparently restricted to sandy soils and gravel bars in or near shallow blackwater creeks and overflow channels in narrow riparian woodland/bayhead forest communities in pine flatwoods and upland longleaf pine.

In southeastern Louisiana, it is currently known from eight sites in St. Tammany and Washington Parishes; in southern Mississippi, it is known from a single site in Jackson County, and from three sites in Perry County. Louisiana quillwort is extremely vulnerable because of its small population size and restricted range. On October 28, 1992, the U.S. Fish and Wildlife Service (1992) officially listed *Isoetes louisianensis* Thieret (Louisiana quillwort) as an endangered species under the Endangered Species Act of 1973, as amended.

### B. Taxonomy and Description

*Isoetes louisianensis* Thieret was discovered by Garrie Landry in April 1972 at Thigpen Creek in Washington Parish, Louisiana, and later described (Landry and Thieret 1973). Type specimens are held at the Gray Herbarium (GH) and the University of Michigan (MICH). *Isoetes louisianensis* is a small, semi-aquatic, facultative evergreen plant with spirally-arranged leaves (sporophylls) arising from a globose, two-lobed corm. The pliant, hollow leaves are transversely septate and measure 2 to 3 millimeters (mm) (0.12 inch) wide, and up to 40 centimeters (cm) (16.0 inches) long. Spore-containing structures (sporangia) are embedded in the pale, broadened bases of the leaves. Kral (1983) has suggested that aquatic quillwort leaves may vary in length depending upon water depth.

Key morphological features that differentiate *Isoetes* taxa are megaspore ornamentation, texture, and size, and length of the velum (a membranous flap of tissue covering the sporangium) (Hickey 1986, Taylor et al. 1993). Megaspores are white and reticulate-cristate in texture with relatively thick proximal ridges; they measure 500 to 625 micrometers ( $\mu\text{m}$ ) (approximately 0.02 inch) in diameter. Surface texture of the girdle (a narrow band along the distal side of the equatorial ridge encircling the megaspore) is obscure and not distinguishable from the overall texture of the spore. Microspores are light brown in mass and densely spinulose; they measure 25 to 35  $\mu\text{m}$  (approximately 0.001 inch) in diameter. The velum in *I. louisianensis* covers less than one-half of the adaxial wall of the sporangium and the sporangial wall is brown-streaked. Biosystematic studies by Neil Luebke and Carl Taylor at the Milwaukee Public Museum indicate that this species is a tetraploid ( $2n=44$ ) (Taylor et al. 1993).

Sporogenesis appears to be weather dependent and occurs from late spring through fall as evidenced by collections and field observations of *Isoetes louisianensis* (Larke #3193, #3456 LSU, USL; Leonard, Mississippi Natural Heritage Program, pers. comm. 1996; Sorrie, Sand Pines, North Carolina, pers. comm. 1996). Apparently, if conditions are warm and wet enough, sporangia develop and spores mature. From observations, megasporophylls appear to be located on the outer edges of the spirally arranged leaves and it seems that megasporangia mature and disperse spores just prior to microsporangia. It is possible that leaf development follows a continual pattern of megasporophylls alternating with microsporophylls, and specimens might be found that show mature microsporangia on the outer leaves and mature megasporangia in the inner leaves. An earlier suggestion that an alternating cycle of sporogenesis occurs, with microspores maturing in the fall and megaspores in the late winter or early spring (Landry and Thieret 1973) may have come from observations of specimens that were collected after megasporophylls had matured and dropped off the plant.

Landry and Thieret (1973) described *Isoetes louisianensis* as closely resembling the diploid species *I. engelmannii* A. Braun var. *caroliniana* A. A. Eaton (= *I. caroliniana* (A.A. Eaton) Luebke). However, they noted that the brown-spotted sporangial walls of *I. louisianensis* easily separated the two species. Boom (1980, 1982) considered *Isoetes louisianensis* a hybrid of *Isoetes engelmannii* A. Braun x *I. melanopoda* Gay & Durieu.

Luebke and Taylor (1986) questioned the hybrid specific status for *Isoetes louisianensis* proposed by Boom and submitted that it was a legitimate species. *Isoetes* hybrids typically are sterile because spores are often malformed and variable in size, shape and texture; their studies revealed that *I. louisianensis* spores readily germinated in culture and were uniform in size and texture. Boom concurred with Luebke and Taylor's determination (U.S. Fish and Wildlife Service 1992).

Taylor et al. (1993) recognized *Isoetes louisianensis* as a full species in their treatment of the genus *Isoetes* for the *Flora of North America*. *Isoetes louisianensis* is an allotetraploid ( $2n=44$ ) of probable hybrid origin and the reticulate texture of the megaspore suggests *I. engelmannii* as a possible parent. Both *I. engelmannii* and *I. melanopoda* occur northward in the Mississippi River watershed and opportunities for contact via waterfowl exist because of the proximity of the Mississippi River flyway (Boom 1980, 1982). Further DNA and enzyme electrophoretic studies are needed to determine parentage.

The recently described *Isoetes hyemalis* (Brunton et al. 1994) is the only other tetraploid taxon in southeastern United States; it occurs in shallow creeks and sloughs primarily in the Coastal Plain in Virginia, North Carolina, South Carolina, Georgia, and Alabama. It also shares many features with possible diploid progenitors *I. engelmannii* and *I. caroliniana*. *Isoetes hyemalis* is very similar to *I. louisianensis* but it has a clear velum (not brown-streaked), and its megaspores are less reticulate and have a distinctly spiny equatorial band.

### C. Distribution

Louisiana quillwort is currently known from two parishes in southeastern Louisiana and two counties in southern Mississippi in the Gulf Coastal Plain physiographic province (Figure 1). A report of this species from Worth County, Georgia was in error (U.S. Fish and Wildlife Service 1992). In this recovery plan, a population is characterized as one that is reproductively viable and geographically distinct. Populations occurring in different drainage systems, where gene flow appears to be limited, are considered geographically distinct. Because it is difficult to identify gene flow patterns in aquatic species, it may be more



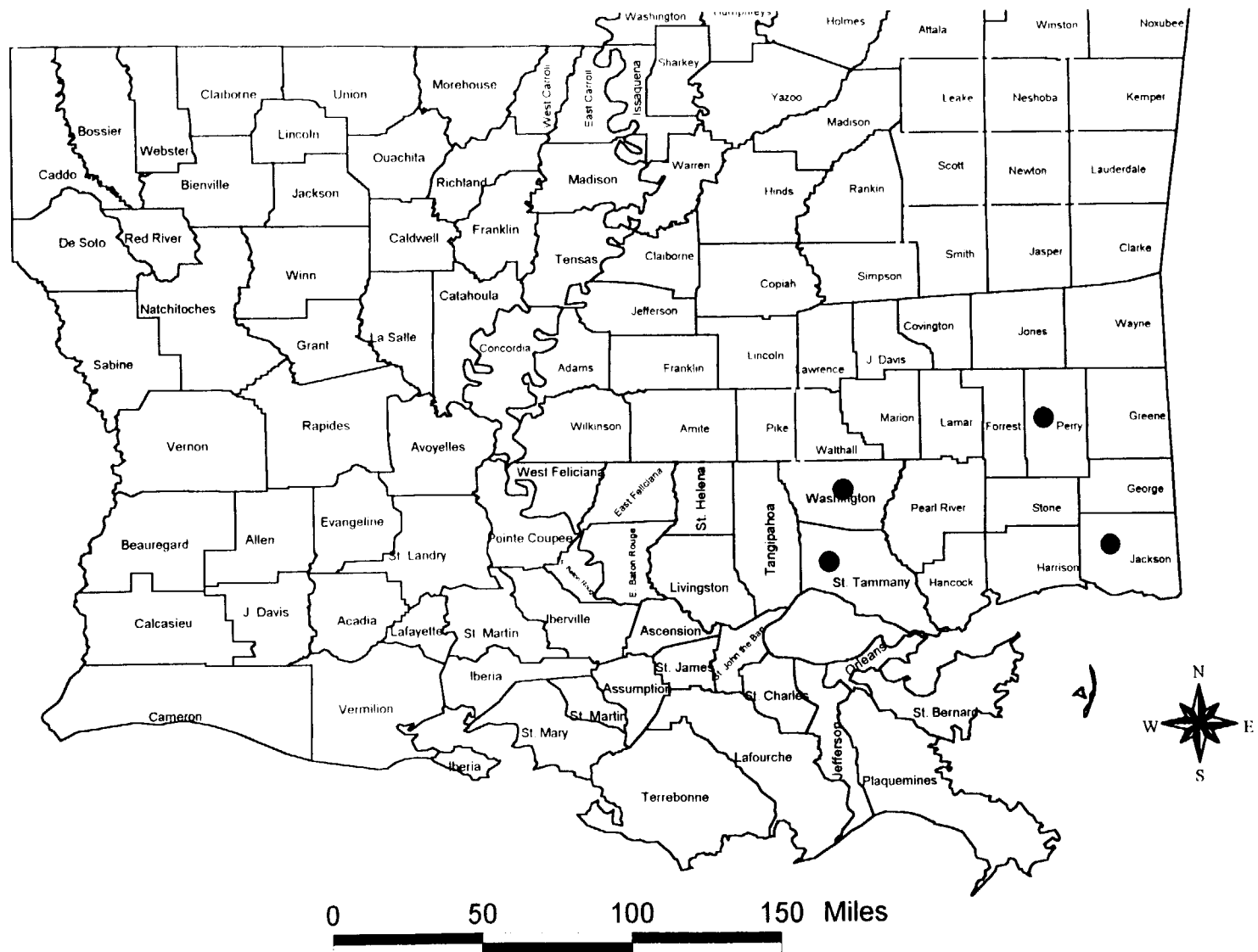


Figure 1. Current distribution of Louisiana quillwort

precise to use the term subpopulation when referring to populations in drainages of major watersheds. For Louisiana quillwort, population size in the spatial sense is linear, because plants follow the stream course, and spacing of individuals and subpopulations within the population tends to occur in patches or colonies. Ecological constraints, such as stream dynamics, moisture availability, and soil conditions limit population size and range for Louisiana quillwort.

Populations are located at the following sites in Louisiana:

Washington Parish:

The Bogue Chitto River watershed:

(1) Louisiana quillwort occurs in upper Mill Creek and the lower portions of Thigpen and Clearwater Creeks. Plants from the three sites constitute a single population. Over 2,600 plants are located along a 1.25 kilometer (km) (0.75 mile) section of Thigpen Creek; 335 plants occur in a 1.0 km (0.6 mile) section of Mill Creek; and, 20 plants occur along a 0.5 km (0.3 mile) section of Clearwater Creek. 2) Four plants occur at a site on Miller Creek.

St. Tammany Parish:

Tchefuncta River watershed:

The Bogue Falaya River drainage: (1) Over 1,500 plants are located along a 1.0 km (0.6 mile) section of a tributary to the Bogue Falaya. (2) Approximately 50 plants occur near the headwaters of a small drainage of LaTice Branch Creek.

The Little Bogue Falaya River drainage: Over 350 plants are located at the Little Bogue Falaya River southeast of Barkers Corner.

The Abita River drainage: (1) Approximately 400 plants occur along a 0.5 km (0.3 mile) section of Abita Creek, and 18 plants occur at a site on Coon Creek, a small tributary of Abita Creek. These two sites are considered a single population. (2) Two plants are located at Ten-Mile Creek.

Bayou Chinchuba drainage: Bayou Chinchuba drains directly into Lake Pontchartrain. This population of over 350 plants is atypical because it occurs in a seasonally-flooded small depression in wet-loblolly pine flatwoods instead of near a streamside. (Tad Zebryk in litt. 1995 ).

In 1996, Louisiana quillwort was discovered in Mississippi by Bruce Sorrie in Jackson County and Steve Leonard in Perry County. Populations occur at the following sites:

Jackson County:

DeSoto National Forest, Red Creek Wildlife Management Area, Tchoutacabouffa River watershed:

Approximately 50 plants occur in overflow channels near the streamhead of a branch of Bayou Billie.

Perry County:

DeSoto National Forest, Camp Shelby National Guard Training Site, Pascagoula River watershed:

(1) Approximately 2,500 plants are located in five colonies along a 1.6 km (ca 1.0 mile) stretch near the headwaters of Pearces Creek. (2) 1,500 plants occur in scour channels aggregated mainly along a 0.3 km (0.2 mile) section of a small tributary to Joes Creek. (3) 20 plants occur near an intermittent stream draining into Whiskey Creek.

D. Habitat

The following discussion focuses primarily on descriptions of quillwort habitat in Louisiana. Mississippi populations were recently discovered and are not fully described in this document. Observations on the habitat of Mississippi sites were contributed by Steve Leonard, Natural Heritage Inventory Botanist, Camp Shelby National Guard Training Site, DeSoto National Forest (*in litt.* 1996).

In southeast Louisiana, geomorphology, soils, hydrology, and vegetation combine to form an environment that supports one of the rarest quillworts in North America. The habitat has been well described by McInnis (1991a) and Hartfield (1991). Louisiana quillwort is apparently restricted to areas in or near shallow, blackwater streams in riparian woodland and bayhead forests of pine flatwoods and upland pine forests. These creeks originate in the dissected hills of the Pleistocene High Terraces and flow out into extensive flatwoods and bayhead forests of the Prairie Terrace formation. In these areas, *Isoetes louisianensis* grows singly, or in large patches of several hundred plants.

Plants grow in stable sand and gravel bars and moist overflow channels with silty sand substrate, and on low, sloping banks near and below water levels. They occur in a relatively firm substrate of fine sandy loam, and sometimes coarser sands and small to medium-sized gravel. One site at a seasonally flooded small depression is atypical because it is not a streamside habitat. This population may maintain itself because of an abandoned artesian well nearby, or because it is fed by subsurface seepage from the larger wetland surrounding the site. The surrounding flatwoods show evidence of flooding and immature *Isoetes* plants could easily have washed into the safe site of the moist depression (Zebryk *in litt.* 1995).

Sandy blackwater streams in southeast Louisiana are typically a clear, tannin-colored brown. They are shallow and range from only a few centimeters deep in riffle areas to 0.75 meters (m) (2.5 ft) deep, with occasional deeper pools (McInnis 1991a). Stream widths vary from 0.6 to 4.6 m (2 to 15 ft), narrowing in shallow areas, widening in deeper areas, and occasionally splitting or braiding temporarily between mossy hummocks, exposed tree roots, or cypress knees. Debris from flooding has been observed as high as 2.2 m (approximately 7 ft) and more commonly about 1.0 m (over 3 ft). Floodplain widths vary, from under 10 m to over 150 m (30 to over 500 ft).

Plants are regularly inundated following rains and may remain submerged for extended periods during flooding. Corms rooted in sandy soil are often overlain with coarser gravel, in some cases to nearly 4 cm (1.5 inches) in depth. Two *Isoetes* species (*I. georgiana* and *I. hyemalis*), that grow in similar habitat in southeastern United States, often are anchored in soils by a subterranean or surficial network of tree rootlets which allow the plants to withstand intense scouring by flood waters (Brunton *in litt.* 1995). Similar anchoring has been observed in *I. louisianensis* populations in Louisiana.

Quillwort populations in Louisiana appear to be facultatively evergreen. During summer dry periods, plants within the same population were observed to remain evergreen if growing in water, and to wither and die back if growing in areas such as overflow channels that became dry if located at a distance from the main channel. In Mississippi, all of the known Louisiana quillwort populations occur at sites that dry out during the summer (Leonard *in litt.* 1995). Brunton (*in litt.* 1995) notes that *I. georgiana* and *I. hyemalis* are found at sites that dry out completely by early summer and stay dry until early winter.

Soils from five of the six quillwort sites in St. Tammany Parish are mapped as Myatt fine sandy loam, frequently flooded (Natural Resources Conservation Service 1990). Myatt soils are found on broad flats or stream terraces in depressional areas or narrow drainageways; soil is level with a slope of less than 1 percent and is poorly drained with very slow water run-off. Brief flooding is said to occur mainly in the winter and spring, although flooding can occur anytime during the year. The site near Bayou Chinchuba is mapped as Abita silt loam, a soil type located in slightly raised positions on stream terraces. The adjacent stream is mapped as Myatt sandy loam. Although the soil survey for Washington Parish has not yet been published, the general soil map shows the quillwort sites occurring in the Myatt-Stough-Cahaba association (Natural Resources Conservation Service 1971).

Soils at the Perry County, Mississippi quillwort sites are mapped as Bibb silt loam and Trebloc silt loam in the Perry County Interim Soil Survey (Natural Resources Conservation Service, undated) (Leonard pers. comm. 1996). The soil type at the Jackson County site is not known at this time.

Vegetation along blackwater creeks is a riparian woodland/bayhead forest community with filtered light from a mostly closed canopy. The canopy is composed of *Nyssa biflora* (swamp blackgum), *Magnolia virginiana* (sweetbay magnolia), *Taxodium distichum* (bald cypress), *Acer rubrum* (red maple), *Quercus laurifolia* (laurel oak), and *Pinus taeda* (loblolly) and occasionally, *Pinus glabra* (spruce pine). Understory species include *Cyrilla racemiflora* (black titi), *Leucothoe axillaris* (fetterbush), *Itea virginica* (virginia willow), *Viburnum dentatum* (arrowwood), *Rhododendron viscosum* (summer azalea), *Vaccinium elliotii* (Elliott's blueberry), *Ligustrum sinense* (chinese privet), and various species of *Ilex* (holly). In areas where the floodplain widens, bayhead forests may be present with a similar species composition as the riparian zones (McInnis 1991a). Louisiana quillwort has been found growing in association with aquatics *Oronticum aquaticum* (golden club), *Potamogeton pusillus* (pondweed), and *Sparganium americanum* (bur-weed), and other species such as *Viola primulifolia* (violet), *Micranthemum umbrosum*, *Scirpus divaricatus* (bulrush), *Justicia lanceolata* (water-willow), *Hypoxis leptocarpa* (stargrass), *Woodwardia areolata* (netted chainfern), *Lycopus virginicus* (bugleweed), *Pallavicinia lyellii* (a liverwort), and *Mnium affine* (a moss).

## E. Reproductive Biology

Species of *Isoetes* appear to have evolved either by ecological isolation and genetic divergence, or by interspecific hybridization and chromosome doubling as divergent species migrated into the same aquatic habitats (Taylor et al. 1993). Early researchers, such as, Pfeiffer (1922) and Reed (1965), and later Boom (1980, 1982), characterized the genus and recognized that a proliferation of interspecific hybrids existed. A polyploid series has been identified in aquatic *Isoetes*, implying that some species in the series may have evolved abruptly through hybridization and allopolyploidy (Taylor et al. 1985). Of the 25 described species of quillwort in North America, 10 are polyploid submerged or emergent aquatics (Brunton et al. 1994, Taylor et al. 1993). Evidence for such hybridization has been obtained from distribution patterns, spore morphology, chromosome numbers, *in vitro* hybridizations, and enzyme electrophoresis (Hickey et al. 1989, Taylor et al. 1985).

When Louisiana quillwort was first discovered, Thieret (1980) collected live plants with surrounding soil and cultivated them in a greenhouse at the University of Southwestern Louisiana. Plants were still thriving after 6 months. Thieret noted that "numerous young quillwort plants appeared in the soil of the pots. Many of these, while still only about 1 cm long and still attached to the megaspore, floated to the surface of the water." He postulated that this phenomenon could be evidence, in natural conditions, for downstream dispersal of young plants. Brunton (*in litt.* 1995) observed this condition in young plants of *Isoetes hyemalis* in Alabama and agrees with Thieret's premise.

Taylor and Luebke (1986) experimented with spore germination and growing sporelings of aquatic species of *Isoetes*. They speculate (pers. comm. 1996) that the spiny surface ornamentation of microspores (and to a lesser degree, megaspores) may lend itself to trapping, as spores become caught in the bases of the parent or nearby plants, or become embedded in soil nearby. In this manner, spores maintain close proximity to the colony despite sometimes swift water currents. Taylor and Luebke also suggest that an optimal grain size of the sandy loam substrate may favor capture of spores in the soil near the bases of sporophyte plants. After fertilization of the gametophyte, young

sporophytes can emerge close to the parent sporophyte in a manner observed by Thieret (1980) and Taylor and Luebke (1986) and take root nearby or be dispersed downstream. This process may explain the often dense growth patterns in quillwort populations.

#### F. Reasons for Listing and Threats

*Isoetes louisianensis* is one of the rarest quillworts in the United States and is extremely vulnerable because of its small population size and restricted range. The current state of knowledge would suggest that suitable small-stream habitat is rare in Louisiana and Mississippi. However, the recent discovery of this species in Mississippi may indicate greater occurrence in the southern third of the state. It is not inconceivable that Louisiana quillwort will be found in southern Alabama as botanists search for stream habitat similar to that of Mississippi (Leonard *in litt.* 1996).

Habitat loss through land use practices that significantly transform riparian forest communities and alter stream quality and dynamics, poses the most serious threat to populations of Louisiana quillwort. This species is adapted to a dynamic stream environment and is negatively affected by adverse anthropogenic changes. Anthropogenic constraints change natural drainage patterns and stream dynamics, potentially damaging quillwort habitat and possibly inhibiting formation of new habitat. Dredging, ditching, channelization, road construction, and off-road vehicles (ORV) can alter natural processes and result in habitat loss. In addition, the effects of timber removal, mining, feral hogs, beaver dams, and plant collection are discussed in this section.

Timber removal increases surface runoff and contributes to stream erosion and sediment siltation. Removal of canopy alters light and temperature regimes on the forest floor; soils become drier and weedy vegetation tends to invade. Logging adjacent to creeks creates debris and detritus which can obstruct water flow and change stream dynamics. While streamside management zones (SMZs) are theoretically protective buffers to the streams themselves, observations of logging practices in Mississippi show that logging sometimes occurs to the stream edge, that slash is frequently left in the drainage, and that quillwort habitat is crossed by skidders and trucks during timber harvest. These

generally rough logging trails and roads are then used by hunters and others until saplings regenerate and block vehicular access (Leonard in litt. 1996).

Sand and gravel mining poses a significant threat, as evidenced by portions of Clearwater Creek in Washington Parish, Louisiana, that have been completely cleared, channelized, and re-routed. Degradation of water quality from siltation, prolific algal growth, and sediment pollution from overflow of adjacent gravel pits was observed at the creek site (McInnis 1991a). Mining operations in or adjacent to creeks and rivers can have a detrimental effect upon aquatic resources. A recent study by Brown and Curole (1995) discussed impacts of gravel mining in Louisiana on mussel assemblages. In their study, it was noted that most damage occurred upstream from mining activity resulting in channel degradation, bank erosion, and the formation of broader, shallow braided streams.

Feral hogs pose a potential threat to quillwort habitat in DeSoto National Forest in Mississippi. Rooting has been observed at one of the Camp Shelby sites. Wildlife managers on the national forest are aware of this problem and they are considering appropriate measures for controlling the hogs (Leonard pers. comm. 1996).

Beaver dams occur in drainages supporting quillwort habitat in Louisiana and in Mississippi. Beaver activity could easily inundate a population by impounding a stream and downstream plants could also be affected by changes in water flow.

Plant collectors could present a danger to quillwort populations if they are over zealous in their collecting of a species with such a small population size and extent. University students, environmental managers, members of botanical clubs, and others interested in making a field trip to observe this species need to remain aware of the rarity of Louisiana quillwort and treat its environment in an ecologically sound manner.

McInnis (1991a) and Larke (1996) searched, without success, numerous small-stream, riparian woodlands that appeared to have similar physiognomy and vegetation to known quillwort sites. The following conditions were observed at sites in Louisiana not supporting quillwort: (1) silty substrate with little coarse sand



or gravel; (2) instable substrate; (3) steep banks; (4) absence of sand and gravel bars; (5) differing stream dynamics with either too much energy preventing establishment of vegetation on gravel bars, or with too little energy resulting in swampy conditions; (6) excessive dryness during periods of low precipitation; and, (7) alteration due to activities such as channelization and ORV use.

Observations in Mississippi reveal that quillworts at drier sites are subject to desiccation and often cannot be seen during late June, July, and August. Therefore, it may not be possible to conclude that a particular stream does not have quillworts if one is searching during the hotter and drier summer months (Leonard *in litt.* 1996). It is also necessary to consider broader climate trends when surveying for quillwort (e.g., searches for quillwort during wet years might prove more successful than searches in drought years). More field observations are needed to fully understand the optimum environmental conditions for Louisiana quillwort populations.

Because development pressure within the known range is severe, populations may be unknowingly extirpated. Although the known range of Louisiana quillwort has recently broadened from two parishes in southeastern Louisiana to include two counties in southern Mississippi, any negative environmental impacts to quillwort habitat are important because of the small global range of this species. Research (Gilpin and Soule 1986) has shown that the possibility of local extinction is greater for species in variable dynamic environments and that more individuals are needed to maintain a minimum viable population (McInnis 1991a).

#### G. Conservation Measures

In 1992, Cavenham Timber Company established a portion of Thigpen Creek supporting quillwort as a protected Nature Area. The area is well-marked by signs indicating no trespassing and no wheeled or track vehicles. Timbering in the area is prohibited. Weyerhaeuser Timber Company purchased Cavenham Timber land in southeast Louisiana in 1996, and they are maintaining the protected Nature Area.

The Natural Areas Registry Program, a joint endeavor between The Nature Conservancy (TNC) and the Louisiana Department of Wildlife and Fisheries (LDWF), proposed the Thigpen Creek Natural Area in the early 1990's. A registry is a non-legal binding agreement to promote habitat conservation in significant natural areas. The landowner agrees to follow TNC/LDWF management recommendations designed to promote conservation of the biological diversity at the site. On Thigpen Creek, one of the private landowners with quillwort on their property has registered their land. Five others have registered as part of a buffer zone adjacent to the proposed Natural Area. Additional landowners in the area may reconsider their original decision not to register now that the local timber company has led the way in choosing to protect their quillwort colonies. Preliminary contacts have been made to landowners of quillwort sites in St. Tammany Parish to elicit their help in protection of this species.

All of the known Louisiana quillwort populations in Mississippi occur on DeSoto National Forest land. Three of them occur on lands leased from the U.S. Forest Service by the Mississippi Military Department for Camp Shelby, U.S. Army Reserve and National Guard Training Site in Perry County. The fourth population occurs at the Red Creek Management Area in Jackson County. Federal agencies are required to ensure that actions they authorize, fund, or carry out do not jeopardize the continued survival of the species. Military operations in wetlands are limited, and tracked vehicle use is restricted to designated wetland crossings. All new construction plans for projects that might impact wetlands and thus quillwort habitat include field inspection and habitat assessment. Attention is also given to upland construction where runoff and sedimentation might adversely impact known colonies (Leonard *in litt.* 1996).

Surveys for new populations have been conducted in Louisiana by the Louisiana Natural Heritage Program. Other surveys are ongoing or planned for Mississippi and Alabama. Additional research and field studies currently being conducted with *Isoetes* species, and specifically biosystematic research with *Isoetes louisianensis* by Taylor and Luebke at the Milwaukee Public Museum, are rapidly increasing our understanding of the life history and ecology of these obscure plants. An ecological study of Louisiana quillwort habitat at Camp Shelby, Mississippi has

recently been initiated by University of Southern Mississippi biologists (Leonard *in litt.* 1996). Results of these studies will allow biologists and land managers to make more informed decisions in conserving and protecting Louisiana quillwort populations and their habitat.

A sixth grade class in Sanford, Connecticut, undertook a class project of developing a plan to recover the Louisiana quillwort after learning of the species' status from the Fish and Wildlife Service's public notification process on draft recovery plans. The students wrote articles, made speeches and posters, and heightened the public's awareness of the Louisiana quillwort's plight. They also developed their own list of actions to be implemented to improve the status of the species, many of which corresponded with those in the Fish and Wildlife Service's recovery plan. Similar activities should be encouraged as educational experiences for students. These efforts help to inform the public on the recovery process and conservation needs of endangered species.

## II. RECOVERY

### A. Recovery Objective

The objective of this plan is the conservation of Louisiana quillwort habitat to ensure that populations are self-sustaining components of their ecosystem. Delisting is a primary goal of this plan. Louisiana quillwort will be considered for delisting when 10 viable and geographically distinct populations from distinctly separate drainages are protected. A viable population is one which is reproducing and stable or increasing in size as shown by monitoring for at least a 10-year period.

Recovery criteria may be revised based upon the availability of new information, including information gathered from identified recovery tasks.

### B. Narrative Outline

1. Protect existing populations and their habitat from further impacts. Based upon survey work to date, populations have been located in 12 drainages, eight in Louisiana and four in Mississippi. Over half of the known sites occur in St. Tammany Parish, Louisiana in areas undergoing intensive development. In Mississippi, currently known sites occur on national forest land. Continued survival of this species depends upon protection of the hydrology, soils, and plant communities in drainages where Louisiana quillwort is known to occur.

1.1 Ensure protection of populations on Federal land. The Endangered Species Act (ESA) provides for the protection of endangered plants on Federal lands through Section 7 and Section 9. Federal agencies must ensure that activities they implement, fund, or permit are not likely to jeopardize the continued existence of a listed species. Federal agencies are also instructed to implement programs for the conservation of listed species. Section 9 prohibits the malicious damage or destruction of endangered plants on Federal lands and prohibits their removal,

without a permit. The Fish and Wildlife Service will work with the Forest Service to ensure the protections of populations on their lands.

1.2 Protect populations on private land. All populations in Louisiana occur on private land. Survival of the species in Louisiana depends upon achieving protection for known sites.

1.2.1 Pursue land acquisition. Land acquisition for Natural Area reserves by organizations such as The Nature Conservancy, the Louisiana Department of Wildlife and Fisheries, or local area land trusts provide a high level of protection. The newly proposed Little Bogue Falaya Natural Area is a relatively small tract along a stretch of the creek containing Louisiana quillwort. It is currently being considered by The Nature Conservancy as a possible preserve site. However, current trends in preserve acquisition are to acquire large tracts of land with many rare species, and small area preserves such as the Little Bogue Falaya, with a single rare species, do not have as high priority for purchase.

1.2.2 Utilize conservation agreements and easements where appropriate. In Washington Parish, the Weyerhaeuser Timber Company Nature Area at Thigpen Creek provides protection for a section of creek supporting Louisiana quillwort. Conservation agreements and easements such as those of the Natural Areas Registry Program at Thigpen Creek Natural Area in Washington Parish also provide species protection. Preliminary contacts have been made by letter to landowners at quillwort sites in St. Tammany Parish.

1.2.3 Utilize indirect protection through Louisiana Natural and Scenic Rivers Act where applicable. State agencies provide indirect protection through their permitting processes. The Louisiana Natural and Scenic Rivers Act

established the Louisiana Department of Wildlife and Fisheries Scenic River System in the 1970's. Four rivers within the range of Louisiana quillwort are protected as part of the Scenic Rivers program: Pushepatapa Creek in Washington Parish; Bogue Chitto River in Washington and St. Tammany Parishes; the Bogue Falaya in St. Tammany Parish; and the Tchefuncta River and its tributaries in Washington, Tangipahoa, and St. Tammany Parishes. Tributaries of these scenic rivers are afforded protection if it is shown that activities on the tributary will negatively impact the river downstream. Indirect protection of quillwort habitat occurs because the following activities are prohibited on Scenic Rivers: channelization, channel re-alignment, clearing and snagging, impoundments of any type and commercial clear-cutting of timber within 50 to 100 m (165 to 330 ft.) of the low watermark. Activities that need permits are: bridge, pipeline, and powerline crossings; waste water discharges; and land development adjacent to the stream.

- 1.3 Enforce State laws protecting environmental quality. The Louisiana Department of Environmental Quality (DEQ) is responsible for permitting discharge into the State's streams and rivers. Sand and gravel mining operations near Louisiana quillwort habitat affect the hydrology, water quality, and substrate stability (Hartfield 1991). DEQ personnel can provide protection for the habitat by establishing rigorous permit requirements.
- 1.4 Enforce Federal law protecting Louisiana quillwort on private land. Habitat protection opportunities, through the ESA, are limited for listed plants on private lands. Federal agencies are required to ensure that any action they carry-out, fund, or authorize does not jeopardize the continued survival of a listed species. Compliance with Section 404 of the Clean Water Act and Section 7 of the Endangered Species Act, U.S. Army Corps of Engineers and Natural

Resources Conservation Service wetland determinations can provide indirect protection of endangered or threatened species. Federal permit requirements for receiving federal funds to develop private property, or develop wetland sites, offers some protection for quillwort habitat.

- 1.5 Establish management guidelines for the protection of Louisiana quillwort and its habitat. Water quality and natural hydrologic regimes of stream systems providing habitat for Louisiana quillwort must be safeguarded in order to maintain viable populations. The following timber company management guidelines for minimizing streamside habitat loss, as developed by McInnis (1991b), may serve as a basis for the development of management plans for this species:

Streamside zone protection - A streamside buffer of 50 m (165 ft) in which timber harvest is restricted is suggested. However Brunton (*in litt.* 1995) recommends a larger buffer of 2 to 3 tree lengths (approximately 100 m or 330 ft) to achieve protection from edge effects. Protection of a riparian zone will ensure that habitat conditions are not altered, such as changes in ambient light, increase in sediment load from run-off, or alteration of stream flow from debris deposition.

Timber management in areas other than streamside zones - To minimize erosion and maintain stream quality and watershed values, timber harvesting should involve selective cutting. Harvesting should be conducted during dry periods to prevent soil compaction and rutting, especially in wetland areas dominated by sweetbay, swamp blackgum, and bald cypress. Mechanical site preparation methods such as drum-chopping or disking should not be used. Timber removal should be conducted in a manner that favors maintenance of indigenous ground cover and minimizes soil disruption. Prescribed burning is considered compatible with management of an area for quillwort, especially in surrounding uplands. Herbicide application should be prohibited.

Sand and gravel mining - Surface mining for sand and gravel should be prohibited near known quillwort habitat and should be carefully monitored in watersheds. Mining in the area of Clearwater Creek has significantly degraded stream quality through sediment deposition. Dams around gravel pits erode and frequently break through during periods of heavy rainfall. Such an event would critically degrade the microhabitat of Louisiana quillwort and could pose a significant threat to a population.

Beaver dams - Beaver activity has been noted near sites near Thigpen Creek in Louisiana and near Pearces Creek in Mississippi. It should be closely monitored in both Louisiana (and Mississippi) to prevent permanent inundation of quillwort habitat.

Additional guidelines need to be designed to protect habitat from off-road vehicle use, flood control measures, road construction, and feral hogs.

2. Conduct biosystematic research on the species. Fertile live specimens of *Isoetes louisianensis* have been cultivated for biosystematic research by Taylor and Luebke. Specimens were collected from widely separated sites: 1) the northernmost site in the Bogue Chitto River drainage in Washington Parish; 2) from mid-range in the Abita River and Little Bogue Falaya River drainages in central St. Tammany Parish; and, 3) from the southernmost site near Bayou Chinchuba in south St. Tammany Parish. Taylor and Luebke plan to report results upon completion of their studies.
3. Monitor populations to learn more about the habitat, life history, and to determine positive and negative trends. All known sites should be checked at least yearly over a period of not less than 10 years. Population numbers and vitality should be recorded, as well as observations on specific habitat characteristics. Negative environmental impacts such as bank erosion, sand sedimentation, trash dumping, or increased competition from removal of canopy trees should also be noted. Monitoring of the population's status and habitat will aid in determining optimal habitat conditions.



4. Search for additional populations. Further systematic survey is needed. Many potential sites on private property in Louisiana have not been surveyed. It is highly probable that additional populations exist in the region near the known occurrences of this species. Surveys in Louisiana should also focus on Prairie Terraces west of the Mississippi in southwest Louisiana flatwoods in Allen, Beauregard, Calcasieu, and Jefferson Davis Parishes.

Potential quillwort habitat exists in the Pleistocene Prairie Terraces that extend from near Picayune, Mississippi in a narrow band along the Gulf Coast to Alabama. Although Rosso (1987) looked for *Isoetes louisianensis* without success in Forrest, Lamar, Lauderdale, Marion, Pearl River, Stone and Walthall counties, the recent discoveries of Louisiana quillwort in the Pleistocene High Terraces in Perry County and Jackson County have broadened the potential search range. Further surveys in Mississippi and Alabama are recommended.

5. Preserve genetic material. The collection, storage, and maintenance of genetically representative material from the wild is necessary to guard against destruction of populations. This material could also be used for education, research, and reestablishment, if needed. The Center for Plant Conservation can provide guidance in implementing this task.
6. Inform the public on conservation needs of Louisiana quillwort. Public education increases awareness of the rarity of this species and the importance of maintaining its habitat. As more is learned about the habitat and life history of Louisiana quillwort, Federal and State permitting agencies will be better able to protect quillwort habitat. Informing Corps of Engineers and Natural Resources Conservation Service wetland biologists, as well as those with State agencies and with private consulting firms, is needed to improve species recognition and understanding of quillwort habitat requirements. Any streamside *Isoetes* in southeastern Louisiana or southern Mississippi should be assumed rare. Management guidelines

developed under Task 1.5 will provide valuable assistance to landowners and others in the protection of this species' habitat.

Programs such as the Forest Stewardship Program, a national program coordinated in Louisiana by the Louisiana Department of Agriculture and Forestry, Office of Forestry, in cooperation with a number of State and Federal agencies, including the Louisiana Department of Wildlife and Fisheries Forestry Section, provide forest management plans to private landowners throughout the State. School programs, nature center programs, and public television can provide ways for the public to become aware of the rarity of Louisiana quillwort and importance of safeguarding its aquatic habitat. Such efforts will benefit other endangered species and the protection of natural environments.

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### 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 1 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 meet the recovery objective.

#### Keys to acronyms used in Implementation Schedule:

ALNHP - Alabama Natural Heritage Program  
COE - U.S. Army Corps of Engineers  
CPC - Center for Plant Conservation  
DEQ - Department of Environmental Quality  
HC - Habitat Conservation, U.S. Fish and Wildlife Service  
LANHP - Louisiana Natural Heritage Program, Louisiana Department of Wildlife and Fisheries  
LDAF - Louisiana Department of Agriculture and Forestry  
LDWF - Louisiana Department of Wildlife & Fisheries  
MSNHP - Mississippi Natural Heritage Program, Mississippi Department of Wildlife, Fisheries, & Parks  
NRCS - U.S. Department of Agriculture, Natural Resources Conservation Service  
TE - Endangered Species Division, U.S. Fish and Wildlife Service  
TNC - The Nature Conservancy  
USFS - U.S. Forest Service  
USFWS - U.S. Fish and Wildlife Service

IMPLEMENTATION SCHEDULE

PRIORITY NUMBER	TASK NUMBER	TASK DESCRIPTION	TASK DURATION	RESPONSIBLE PARTY			COST ESTIMATES (\$K)			COMMENTS/NOTES
				USFWS		Other	FY 1	FY 2	FY 3	
				Region	Division					
1	1.1	Protect populations on Federal lands.	Ongoing	4	TE	USFS				
1	1.2-1.2.3	Protect populations on private lands.	Ongoing	4	TE	TNC/LDWF LANHP	3.0	3.0	3.0	Estimates do not include cost of land acquisition.
1	1.3	Enforce State laws protecting environmental quality.	Ongoing	4	TE	DEQ, LDWF, LANHP	---	---	---	
1	1.4	Enforce Federal law protecting Louisiana quillwort on private land.	Ongoing	4	TE, HC	NRCS, COE	---	---	---	
1	1.5	Develop management guidelines.	1 year	4	TE	LANHP, USFS, TNC/LDWF	3.5	---	---	
2	2	Conduct biosystematic research on the species.	2 years	4	TE	LANHP & Others	10.0	8.0	---	
2	3	Monitor populations to learn more about the life history; monitor trends.	Ongoing	4	TE	LANHP, USFS	5.0	5.0	5.0	
2	4	Search for additional populations.	2 years	4	TE	ALNHP, LANHP, MSNHP, COE, USFS, NRCS	6.0	6.0	---	
3	5	Preserve genetic stock.	Ongoing	4	TE	CPC, Others	3.0	3.0	3.0	
3	6	Public information efforts.	Ongoing	4	TE	LANHP, USFS, LDWF, TNC, LDAF	2.5	2.5	2.5	

IV. APPENDIX

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The following agencies, organizations, and individuals were mailed copies of this recovery plan. This does not imply that they provided comments or endorsed the contents of this plan.

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