Louisiana quillwort
(*Isoetes louisianensis*)

5-Year Review:
Summary and Evaluation


Photo: M. Scott Wiggers, USFWS

U.S. Fish and Wildlife Service
Southeast Region
Mississippi Ecological Services Field Office
Jackson, Mississippi

5-YEAR REVIEW
Louisiana quillwort (*Isoetes louisianensis* Thieret)

I. GENERAL INFORMATION

A. Methodology used to complete the review: In conducting this 5-year review, we relied on the best available information pertaining to historical and current distributions, life histories, genetics, habitats, and potential threats of this species. We announced initiation of this review and requested information in a published *Federal Register* notice with a 60-day comment period (75 FR 18233). In an effort to acquire the most current information available, various sources were obtained or contacted, including data housed at the Alabama Natural Heritage Program, Louisiana Natural Heritage Program, Mississippi Natural Heritage Program, internet searches, and knowledgeable individuals associated with academia, and Federal, State, and non-governmental conservation organizations. Specific sources included the final rule listing this species under the Endangered Species Act; the Recovery Plan; peer reviewed scientific publications; unpublished field observations by the U.S. Fish and Wildlife Service, U.S. Forest Service, state and other experienced biologists; unpublished studies and survey reports; and notes and communications from other qualified individuals. The completed draft review was sent to cooperating Service Field Offices and three peer reviewers for review. Comments were incorporated into this final document as appropriate (see Appendix A).

B. Reviewers

Lead Region: Southeast Region, Kelly Bibb, (404) 679-7132

Lead Field Office: Mississippi Ecological Services Field Office, M. Scott Wiggers, (601) 364-6910

Cooperating Field Offices: Daphne Ecological Services Field Office, Shannon Holbrook, (251) 441-5837; Lafayette Ecological Services Field Office, Robert Smith, (337) 291-3138

C. Background:

1. **Federal Register Notice citation announcing initiation of this review:** April 9, 2010. 75 FR 18233.

2. **Species status:** Stable (2011 Recovery Data Call). The location of additional populations since this species' listing has greatly improved the species' status; however, overall the species' status is considered stable as compared to the previous year. There are two colonies in Alabama, nine in Louisiana; and over 50 in southern Mississippi. The Louisiana quillwort thrives in a dynamic stream environment and is adversely affected by changes in stream quality and dynamics. Numbers of plants were lower in several monitored plots in Mississippi but likely due to natural population fluctuations and not an indicator of an overall decline.

3. **Recovery achieved:** 1 (1 = 0-25% species' recovery objectives achieved)

4. **Listing history**
   Original Listing
   FR notice: 57 FR 48741
   Date listed: October 28, 1992
   Entity listed: species
   Classification: endangered

5. **Associated rulemakings:** None.

6. **Review History:**
   Recovery Plan: 1996
   Recovery Data Call: 2011, 2010, 2009, 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, and 2000

7. **Species' Recovery Priority Number at start of review (48 FR 43098):** 14

8. **Recovery Plan**
   Name of Plan: Recovery plan for the Louisiana quillwort (*Isoetes louisianensis* Thieret)
   Date Issued: September 30, 1996

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy

The Endangered Species Act (ESA or Act) defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing DPS to only vertebrate species of fish and wildlife. Because the species under review is a plant, the DPS policy is not applicable.

B. Recovery Criteria

1. **Does the species have a final, approved recovery plan containing objective, measurable criteria?** Yes.

2. **Adequacy of recovery criteria.**

   a. **Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?** No. Rationale for the recovery objective of 10 viable and geographically distinct populations is not provided. Limited information on genetics of Louisiana quillwort was available at the time the recovery plan was written. While somewhat more information is now available regarding population genetics of this species (discussed below), it is still

unknown what the likely minimum number of populations is required to maintain genetic diversity and continued survival of Louisiana quillwort.

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria? The recovery criteria do take into account any threats to this species in association with the five listing factors, since the assurance that populations are self-sustaining and secure from any foreseeable threats, is part of the criteria.

3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

The stated recovery goal of the plan is to delist Louisiana quillwort. Downlisting criteria were not identified in the recovery 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.

These criteria have not been met. Populations are known from 20 watersheds; however, the Louisiana quillwort is permanently protected along only a portion of one drainage: Abita Creek in St. Tammany Parish, Louisiana (Walz 2008, Faulkner *et al*. 2009, Leonard 2011). Populations in Mississippi on U.S. Forest Service lands receive some protection through Sections 7 and 9 of the Act. Long-term monitoring data exists for portions of some populations within Mississippi on the De Soto National Forest and the associated Camp Shelby Joint Forces Training Center (Lyman *in litt*. 2011b, Thriffiley *in litt*. 2011a). These data indicate that monitored populations are generally stable or increasing, but that populations may fluctuate widely from year to year (Lyman *in litt*. 2011b, Thriffiley *in litt*. 2011a). There are no long-term monitoring data available for any of the Alabama or Louisiana populations.

C. Updated Information and Current Species Status

1. Biology and Habitat

Information on the biology and habitat of Louisiana quillwort is summarized in the recovery plan for the Louisiana Quillwort (*Isoetes louisianensis*) Thieret (U.S. Fish and Wildlife Service 1996). Updated distribution and habitat information has been summarized by Leonard (2011). Relevant biology and habitat are summarized in this review.

a. Abundance, population trends (e.g., increasing, decreasing, stable), demographic features, or demographic trends:

Since Louisiana quillwort was listed in 1992, surveys have been ongoing in an effort to monitor known colonies and locate new occurrences (e.g., U.S. Fish and Wildlife Service 1996, Larke 1997, Leonard 1997, Leonard 1998, Rosso 1998,

Sorrie and Leonard 1999, Leonard and Faulkner 2001, Walz 2008, Lyman *in litt*. 2011b, Thriffiley *in litt*. 2011a). Louisiana quillwort has been found in a total of approximately 186 streams in southern Alabama (2), Louisiana (10), and Mississippi (174). Streams, as identified for this review, include named and unnamed streams, as well as permanent, intermittent, and ephemeral streams and drainages. Streams were identified using the best available location data for Louisiana quillwort colonies (U.S. Fish and Wildlife Service 1996, Lark 1997, Rosso 1998, Alabama Natural Heritage Program 2010, Lyman *et al*. 2010, Leonard 2011, Louisiana Natural Heritage Program 2011, and Mississippi Natural Heritage Program 2011) and topographic maps. Together, these streams are located in 43 subwatersheds and 20 watersheds (Table 1). Population definitions have been inconsistently applied to Louisiana quillwort in the literature. For consistency in this review, watersheds, as defined by current U.S. Geological Survey 10-digit hydrologic unit codes (HUCs), are equated with populations of Louisiana quillwort, thus the Service considers there to be 20 populations of this species.

Population monitoring of Louisiana quillwort has been inconsistent range wide. No populations are known to have been monitored in their entirety across a given watershed. Instead, subsets of these populations have been monitored at the stream or colony level. Furthermore, many colonies of Louisiana quillwort have not been monitored or have been monitored infrequently since their discovery. For those colonies where current monitoring has occurred and data are available, local populations of this species may fluctuate significantly from year to year (Lyman *in litt*. 2011b, Thriffiley *in litt*. 2011a). The natural amplitude of population fluctuations within suitable habitats is not known; however, Lyman (pers. comm. 2011a) suggests that these fluctuations may be due in part to differential survival between immature plants (sporelings) and mature plants during dry and wet years. Likewise, Leonard (2011) contends that estimation of population size is challenging, with estimates being affected by location, hydrology, and seasonality.

Lack of current data coupled with difficulties associated with accurately assessing population sizes hinders an accurate assessment of the range-wide Louisiana quillwort population (i.e., total individuals among all 20 watersheds). However, the likely minimum number of Louisiana quillworts range wide may be at least 30,000 (Alabama Natural Heritage Program 2010, Louisiana Natural Heritage Program 2011, Leonard 2011). In comparison, approximately 10,000 Louisiana quillworts were thought to exist at the time the recovery plan was written (U.S. Fish and Wildlife Service 1996). This apparent population increase of Louisiana quillworts is due to the discovery of additional colonies.

Summary of Populations Found in each State

Louisiana

Louisiana is home to two populations of Louisiana quillwort; these populations are in the Bogue Chitto and Bogue Falaya River watersheds (U.S. Fish and Wildlife Service 1996, Larke 1997, Leonard and Faulkner 2001, Leonard 2011, Louisiana Natural Heritage Program 2011). Within these watersheds, Louisiana quillwort colonies have been found along 10 streams. Streams in the Bogue Chitto watershed are Miller Creek, Clearwater Creek, Mill Creek, and Thigpen Creek, while streams in the Bogue Falaya River watershed are Abita Creek, Coon Fork, Tenmile Branch, Little Bogue Falaya, an unnamed tributary of Bogue Falaya River, and La Tice Branch. Leonard (2011) was unable to relocate the La Tice Branch colony in 2001 and speculates that this colony may have been destroyed by road construction.

Louisiana is also home to the only permanently protected colonies of Louisiana quillwort. These colonies are located on The Nature Conservancy's (TNC) Abita Creek Flatwoods Preserve (ACFP) (Leonard 2011). Other colonies outside of this preserve along Abita Creek remain unprotected.

Nine of the streams with Louisiana quillwort colonies have not been visited for at least 10 years (Leonard 2011) and recent population data (i.e., 2008) are only available for colonies located on or near TNC's ACFP (Walz 2008). Leonard (2011) considers TNC's ACFP populations to be healthy and stable at present. Overall, however, the state population of Louisiana quillwort may be declining due to increased development and logging activities (Leonard 2011, Smith *in litt*. 2011). Surveys are needed to assess the current status of Louisiana quillworts in Louisiana.

Mississippi

Louisiana quillwort was not known to occur in Mississippi at the time of listing (i.e., 1992). Louisiana quillwort was discovered by Bruce Sorrie along Bayou Billie in Jackson County and Steve Leonard in the Joes Creek drainage in Perry County in 1996 (Sorrie and Leonard 1999, Leonard 2011). Following these initial discoveries, additional searches identified numerous colonies in southern Mississippi. Today, Louisiana quillwort has been found in 174 streams from 35 subwatersheds in 17 watersheds across the state (U.S. Fish and Wildlife Service 1996, Rosso 1998, Lyman *et al*. 2010, Leonard 2011, Mississippi Natural Heritage Program 2011) (Table 1). Recent data are unavailable for many occurrences within these 17 populations; however, as previously noted, monitoring data from some colonies within DSNF and its associated CSJFTC indicate that local populations may fluctuate from year to year, but are generally stable or increasing (Lyman *in litt*. 2011b, Thriffiley *in litt*. 2011a).

Alabama

As with Mississippi, Louisiana quillwort was not known to occur in Alabama at the time of listing. Currently, two occurrences of Louisiana quillwort are known from south-central Alabama (Alabama Natural Heritage Program 2010, Barger *in litt*. 2011, Leonard 2011); both of these occurrences are within the Upper Murder Creek watershed (Table 1). One colony is located on an unnamed tributary of Murder Creek in Conecuh County while the other colony is located in the floodplain of the upper reaches of Murder Creek in Monroe County (Alabama Natural Heritage Program 2010, Leonard 2011). While these populations have no formal monitoring data, repeated visits by Leonard (2011) suggest that these colonies are robust and thriving.

Protected Populations

As noted above, TNC has protected some colonies along Abita Creek in St. Tammany Parish, Louisiana on their ACFP (Walz 2008). Furthermore, TNC has cooperated with the Service, Louisiana Natural Heritage Program, and Mercer Arboretum and Botanical Gardens (MABG) to establish an educational population at MABG in Humble, Texas. This *ex situ* population has also served as a source for population enhancement of the Abita Creek colonies on ACFP (Walz 2008, Faulkner *et al*. 2009, Tiller pers. comm. 2011).

By far the largest number of colonies in Mississippi—and, indeed, throughout the species' range—is located in the U.S. Forest Service's De Soto National Forest (Forrest, Greene, Harrison, Jackson, Jones, Perry, Stone, and Wayne Counties of the ten-county state distribution) (Leonard 2011). Because these colonies are located on federally owned lands, they receive some protection through Sections 7 and 9 of the Act; however, no permanent protections have been afforded these colonies. None of the colonies on private property in Mississippi are known to be protected.

Neither of the two known occurrences of Louisiana quillwort in Alabama, which both occur on private property, is protected (Barger *in litt*. 2011, Leonard 2011, Schotz *in litt*. 2011).

b. Genetics, genetic variation, or trends in genetic variation:

Evolutionary Origins

Louisiana quillwort is thought to be derived from a doubling of chromosomes from a cross of two diploid quillworts. Taylor *et al*. (1993) proposed that Isoetes louisianensis arose from a cross of the diploid ($2n = 22$) *I. engelmannii* and *I. melanopoda*; however, genetic work by Hoot *et al*. (1999) found little support for this proposed parentage. More recent genetic studies by Hoot *et al*. (2004) presented evidence that *I. louisianensis* shares a diploid parent (species "X") with *I. hyemalis*. The other diploid parent of *I. louisianensis*, they called species "W". While the whereabouts of species "W" is unknown, research by other

investigators indicates that species "X" (the *louisianensis-hyemalis* diploid parent) has been identified from a quillwort collection at Forty-Acre Rock, a large granitic expanse in Lancaster County, South Carolina, which is a short distance from the North Carolina State line (R. Matthews pers. comm. 2011 cited in Leonard 2011). The type locality for *I. hyemalis* is in nearby Harnett County, North Carolina (Brunton *et al*. 1994). In light of this new information, several hypotheses are possible: (a) that Louisiana quillwort has, or at some point in the past, had a broader range than the present Louisiana-Mississippi-Alabama distribution; (b) that the diploid parent's distribution once extended farther southwest than the Carolinas; (c) that parent or progeny or both have migrated by some unknown vector to disjunct locations (Leonard 2011). Genetic work also indicates other potential crosses and thus the origin of Louisiana quillwort may be polyphyletic, that is, the tetraploid ($2n = 44$) could have been formed between other diploid pairings (Hoot *et al*. 2004, Leonard 2011).

Genetic Diversity

In the late 1990s, Hoot *et al*. (1999) compared genetic diversity between *I. louisianensis* and its more common congeners, *I. melanopoda* and *I. echinospora*. Average genetic diversity of *I. louisianensis* was less (by about half) than both of the other quillwort species studied; however, these results were anticipated by the authors as locally endemic species are more likely to exhibit less genetic diversity than their more common relatives.

Hoot *et al*. (1999) also studied genetic diversity among *I. louisianensis* colonies in Louisiana and Mississippi. Overall, the authors found that genetic diversity differed significantly among populations. Attempts to correlate these observations with geographic location, population size, and spatial separation provided mixed results. Results indicated that geographic location of *I. louisianensis* colonies has little apparent effect on genetic diversity; the authors found sites with relatively low or high genetic diversity throughout the colonies sampled. Similarly, no apparent relationship exists between population size and genetic diversity within this species. Finally, analyses indicated that genetic diversity generally exhibited little correlation with geographic distance of Louisiana quillwort colonies sampled, except at the extremes (i.e., colonies nearest to each other were most genetically similar and Mississippi colonies were more genetically distinct from Louisiana colonies than colonies within either state). With respect to spatial separation, the authors suggested that their lack of definitive results could arise from transport of quillwort spores and corms (underground stem) by waterfowl.

Prior to listing, little was known about genetic diversity of Louisiana quillwort; however since its listing only one study into the genetic diversity, by Hoot et al. (1999), is known to have been performed. This study was limited to only 24 sites and 187 Louisiana quillwort individuals in Louisiana and Mississippi. Since this study was completed additional colonies of Louisiana quillwort have been discovered in Mississippi and Alabama, and genetic information on these new occurrences is unknown. Many questions remain regarding the genetic diversity

and its conservation implications for Louisiana quillwort. For example, the influence of spore and corm movement on *I. louisianensis* genetic diversity was not studied by Hoot *et al*. (1999) and remains unknown. Additionally, it is not known if the recovery plan's (U.S. Fish and Wildlife Service 1996) recovery objective of 10 viable and geographically distinct populations is sufficient to delist this species.

c. Taxonomic classification or changes in nomenclature:

The taxonomy of Louisiana quillwort has been reviewed by U.S. Fish and Wildlife Service (1996). Furthermore, The Integrated Taxonomic Information System (ITIS) was checked while conducting this review. ITIS states that *Isoetes louisianensis* is an accepted taxon (Integrated Taxonomic Information System 2011).

d. Spatial distribution, trends in spatial distribution, or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

At the time of listing and despite intensive searches, Louisiana quillwort was only known from two Louisiana parishes (St. Tammany and Washington). Within these parishes, a total of five streams were known to harbor Louisiana quillwort colonies, including the Little Bogue Falaya River in St. Tammany Parish and Clearwater Creek, Mill Creek, Thigpen Creek, and Miller Creek in Washington Parish. These streams are located within the Bogue Chitto and Bogue Falaya River watersheds (Table 1).

Additional searches following listing of Louisiana quillwort revealed colonies along nine additional streams in Louisiana and Mississippi—including additional streams within St. Tammany Parish, Louisiana as well as Jackson and Perry Counties, Mississippi—so that by the time the recovery plan was written for this species a total of 14 streams (10 in Louisiana and 4 in Mississippi) were known to support colonies of this species. Within St. Tammany Parish, Louisiana, new stream locations included colonies along Abita Creek as well as two of its tributaries (Coon Fork and Tenmile Branch) and an unnamed tributary of Bogue Falaya River in St. Tammany Parish. Another colony of Louisiana quillwort was thought to occur in a seasonally flooded depressional wetland associated with the Bayou Chinchuba drainage (U.S. Fish and Wildlife Service 1996, Larke 1997), but was later identified as blackfoot quillwort (*Isoetes melanopoda*) (Larke 1997, Leonard 2011). In Mississippi, Louisiana quillwort colonies were known from four streams: an unnamed headwater tributary of Bayou Billie in Jackson County as well as headwaters of Pearces Creek, an unnamed tributary of Joes Creek, and an unnamed tributary of Whiskey Creek in Perry County (U.S. Fish and Wildlife Service 1996).

Since approval of the recovery plan, intensive searches have revealed approximately 170 additional streams in Mississippi and Alabama. No new

streams have been discovered in Louisiana. These additional streams along with the previously known streams and their associated drainage systems (subwatersheds and watersheds) are listed in Table 1. However, Louisiana quillwort is difficult to identify accurately in the field (Larke 1997, Hoot *et al*. 1999, Leonard 2011) and, as the misidentification of the Bayou Chinchuba quillwort population (described in the preceding paragraph) illustrates, a note of caution must be applied when considering individual occurrences and the apparent distribution of this species.

Currently, there are 20 populations known for Louisiana quillwort as determined by the number of watersheds where the species has been found (Table 1). The species' range encompasses 14 counties across southern portions of three states (Figure 1). Colonies are known from St. Tammany and Washington Parishes, Louisiana. Most known colonies of Louisiana quillwort occur in Mississippi, occurring in Forrest, Greene, Hancock, Harrison, Jackson, Jones, Pearl River, Perry, Stone, and Wayne Counties. Finally, within Alabama, the species is known from Conecuh and Monroe Counties.

e. Habitat or ecosystem conditions:

Typical colonies in south-central Mississippi are located in shallowly entrenched, intermittent streams lined with swamp black gum (*Nyssa biflora*) and laurel-leaf oak (*Quercus laurifolia*) as well as a streamside, overhanging component of titi (*Cyrilla racemiflora*) and sparse herbaceous groundcover (Larke 1997, Leonard 2011). Leonard (2011) notes that tree roots often intersect these streams, thus disrupting flow during rain events. Deeper pools may be eroded within these streams where leaves and twig debris may settle and accumulate. These pools are able to persist into the hotter summer months but generally do not contain quillworts. However, quillworts may be found immediately upstream and downstream of these pools (Leonard 2011).

Toward the coast in both Louisiana and Mississippi, Louisiana quillwort habitat shifts to a perennial stream environment where bald cypress (*Taxodium distichum*) may be a prominent bottomland component and the stream itself may harbor macrophytes such as *Sparganium* spp. and *Orontium* spp. (Leonard 2011).

Leonard (2011) notes that thriving Louisiana quillwort colonies have also been found on well-drained floodplains with a high fine sand and clay, but suggests that such sites do not appear to be suitable for long-term survival, perhaps due to substrate instability.

Neither of the two Alabama colonies occurs in habitat that resembles any known Louisiana or Mississippi habitats. One colony is located in a spring-like seepage with sandy-muck soil and bald cypress (*Taxodium distichum*) overstory that drained into a permanently flowing creek. The other colony is located along the margins of a grassy meadow and small hardwood swamp (Leonard 2011).

A study of habitat characteristics and demographic trends was begun by The Nature Conservancy in early 2011 (Lyman pers. comm. 2011a).

2. Five-Factor Analysis

a. Present or threatened destruction, modification or curtailment of its habitat or range: Increased development in Washington and St. Tammany Parishes, Louisiana and coastal Mississippi counties continue to threaten Louisiana quillwort colonies in these areas (Leonard 2011, Smith *in litt*. 2011). Louisiana quillwort colonies in Louisiana and Mississippi are threatened by road construction and maintenance (such as widening and bridge replacement) (Leonard 2011, Smith *in litt*. 2011). One population along an unnamed tributary of La Tice Branch in St. Tammany Parish, Louisiana may have been destroyed by construction of North Meyers Road (Leonard 2011). Similarly, a bridge replacement project along Tucker Road necessitated moving the impacted Louisiana quillwort colony in Cypress Creek (Leonard 2011). Pipeline construction and maintenance may also threaten populations in these states (Leonard 2011). Habitat modification, such as overstory clearing, continues to threaten colonies in Louisiana and Mississippi (U.S. Fish and Wildlife Service 1996, Faulkner *et al*. 2009, Leonard 2011). The current threat of gravel mining to colonies in Louisiana is unknown. Off-road vehicle use and hay production threaten one colony in Alabama (Leonard 2011).

b. Overutilization for commercial, recreational, scientific, or educational purposes: Not known to threaten Louisiana quillwort. At the time of listing and writing of the recovery plan, collecting was considered to be a potential threat because the only known locations for Louisiana quillwort were restricted to only a small number of drainages. Discovery of additional populations has reduced this potential threat.

c. Disease or predation: Disease is not known to threaten Louisiana quillwort (Leonard 2011, Lyman *in litt*. 2011c). Rabbits (*Sylvilagus* spp.), white-tailed deer (*Odocoileus virginianus*), and waterfowl are believed to occasionally feed on sporophylls of Louisiana quillwort; however, the impacts of such feeding are apparently minimal (Hoot *et al*. 1999, Lyman *in litt*. 2011c, Tiller pers. comm. 2011) and likely do not threaten the long-term survival of this species.

d. Inadequacy of existing regulatory mechanisms: Louisiana quillwort does not receive specific protection from state laws or regulations in Alabama, Louisiana, or Mississippi (U.S. Fish and Wildlife Service 1996, Barger *in litt*. 2011, Reid pers. comm. 2011, Schotz *in litt*. 2011).

e. Other natural or manmade factors affecting its continued existence:

Wildlife Disturbance

Disturbance by rooting armadillos (*Dasypus novemcinctus*) has been noted on Camp Shelby Joint Forces Training Center (CSJFTC), which operates in part

under a special use permit on U.S. Forest Service lands within the De Soto National Forest, Mississippi. It is unclear whether armadillos are searching for and consuming Louisiana quillwort corms, but the impact of such foraging activities on Louisiana quillwort populations and habitat appears minimal (Lyman *in litt*. 2011c).

Significant soil disturbance by feral hogs (*Sus scrofa*) has been documented on CSJFTC and the associated Leaf River Wildlife Management Area, Mississippi (Leonard 2011, Lyman *in litt*. 2011c). Although it is unlikely that feral hogs are foraging for Louisiana quillwort corms (Leonard 2011), extensive soil disturbance by foraging hogs within stream channels and their associated floodplains pose a significant threat to existing populations of Louisiana quillwort as well as to suitable habitat (Leonard 2011, Lyman *in litt*. 2011c). Feral hog control efforts are increasing on De Soto National Forest (Thriffiley *in litt*. 2011b).

Beaver dams and their associated ponds may threaten some colonies of Louisiana quillwort in Louisiana and Mississippi (Leonard 2011, Lyman *in litt*. 2011b). Beaver dams downstream of two monitoring plots on CSJFTC caused water to become too deep and turbid to see or measure plants. As a result of these beaver ponds, monitoring was ceased and it is not known whether plants have survived (Leonard 2011, Lyman *in litt*. 2011b); however, it is conceivable that if water is too deep or turbid, that light levels may be inadequate to sustain these Louisiana quillwort populations. Alternatively, Leonard (2011) speculates that beaver ponds may leak, forming braided networks of small channels, thus providing new habitat for potential quillwort colonization.

Climate Change

Louisiana quillwort requires regular rainfall events of sufficient amount and duration to trigger scouring of stream channels and floodplains to maintain suitable habitat (U.S. Fish and Wildlife Service 1996, Leonard 2011). Wind-throw from hurricanes has the potential to reduce scouring by directly increasing litter accumulation and blocking stream flow, thus allowing greater accumulation of sediment in impacted stream systems (Leonard 2011). If climate change reduces rainfall rates or increases the frequency of hurricanes making landfall on Alabama, Louisiana, or Mississippi, Louisiana quillwort would likely be adversely affected. Climate projections for the Gulf Coast states are not very well defined, so the effects of climate change on Louisiana quillwort are not easy to predict.

D. Synthesis

Currently, there are 20 populations of Louisiana quillwort known from streams in 20 watersheds and 42 subwatersheds across southern portions of three states: Alabama, Louisiana, and Mississippi. Louisiana quillwort was thought to be limited to portions of only five streams in two Louisiana parishes at the time of listing in 1992. Intensive surveys have revealed colonies along five additional streams in these parishes.

Furthermore, these surveys have expanded the known range of Louisiana quillwort to two streams in two Alabama counties and approximately 174 in ten Mississippi counties. Permanent protection has been established for Louisiana quillwort colonies along only one of these streams: a portion of Abita Creek in St. Tammany Parish, Louisiana. Limited information is available on current population status of Louisiana colonies, but these colonies may generally be in decline due to increased development, one of which may have been destroyed by road construction. The two known Alabama occurrences appear to be thriving and more colonies may yet be discovered in the State. Finally, available information indicates that Mississippi populations on U.S. Forest Service land are likely stable overall, despite individual colony fluctuations.

Recovery efforts for this species have progressed, particularly in Mississippi where most colonies occur on U.S. Forest Service lands. The lack of recent population surveys (much of the available information is at least 10 years old) limits our knowledge of Louisiana quillwort's conservation status and many questions regarding population genetics, demographics, and microhabitat characteristics remain to be addressed. This species is sensitive to changes in hydrology and overstory conditions. Increased sedimentation from upstream habitat destruction and incompatible management, as well as windthrow from extreme weather events, such as hurricanes, continues to threaten Louisiana quillwort colonies. Feral hogs and beaver dams also pose potential threats to this species. At this time, Louisiana quillwort continues to meet the definition of an endangered species under the Act; however, additional population and monitoring data coupled with increased understanding of conservation genetics and habitat requirements of this species may allow for a revision of delisting criteria and creation of downlisting criteria. Furthermore, continued conservation efforts, including permanent protection of additional populations throughout its range, may improve the status of Louisiana quillwort to the point that delisting may be appropriate.

III. RESULTS

A. Recommended Classification:

__X__ No change is needed

B. New Recovery Priority Number: No change.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

- Perform population status assessment updates.
- Work with Federal and State entities, non-governmental organizations, and private individuals to permanently protect and manage existing habitats and populations.
- Implement aggressive feral hog (*Sus scrofa*) control programs.
- Search for additional populations on private lands, particularly around De Soto National Forest in Mississippi.
- Implement demographic and habitat studies to more fully understand underlying drivers of population fluctuations.

- Continue and expand conservation genetics work to include all watersheds with known occurrences.
- Preserve additional genetic stock.
- Update the recovery plan.

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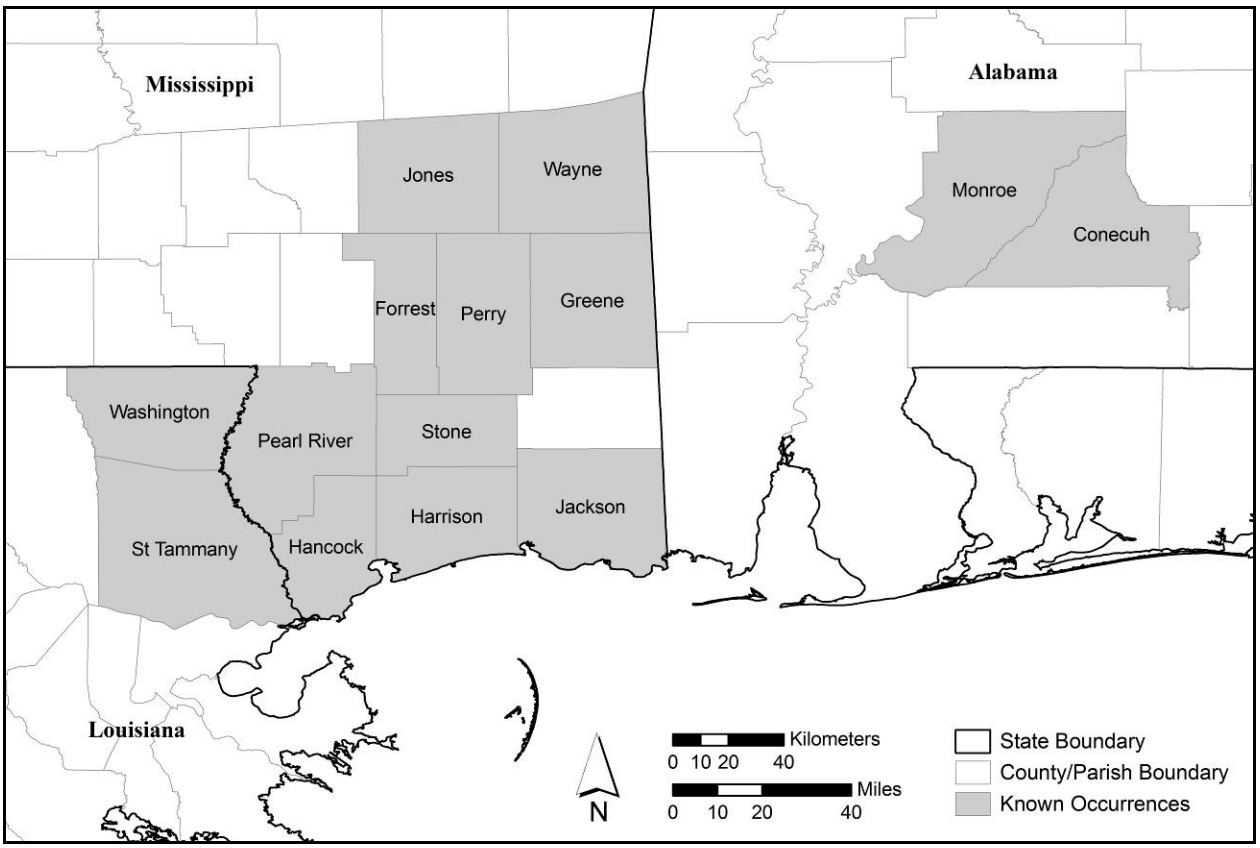
Figure 1. Current distribution of Louisiana quillwort.



Note: This map was created using data compiled from U.S. Fish and Wildlife Service 1996, Larke 1997, Rosso 1998, Alabama Natural Heritage Program 2010, Lyman *et al*. 2010, Leonard 2011, Louisiana Natural Heritage Program 2011, and Mississippi Natural Heritage Program 2011.

Table 1. Drainage systems with Louisiana quillwort occurrences.

State	Watershed	Subwatershed	Streams[1]
Alabama	Upper Murder Cr. (2, 2)[2]	Harpers Store (1)[3]	Murder Cr. trib. (1)[4]
		Spring Cr.-Murder Cr. (1)	Murder Cr.
Louisiana	Bogue Chitto (2, 4)	Berrys Cr.-Bogue Chitto (1)	Miller Cr.
		Thigpen Cr.-Mill Cr. (4)	Clearwater Cr. Mill Cr. Thigpen Cr.
	Bogue Falaya R. (3, 6)	Abita R. (3)	Abita Cr. Coon Fork Tenmile Br.
		Little Bogue Falaya R. (1)	Little Bogue Falaya
		Lower Bogue Falaya R. (2)	Bogue Falaya trib. (1) LaTice Br.
Mississippi	Atkinson Cr.-Leaf R. (1, 9)	Big Oktibee Cr.-Leaf R. (9)	Harverson Mill Cr. & trib. (8)
	Beaverdam Cr.-Black Cr. (5, 32)	Bowens Bay Cr.-Beaverdam Cr. (1)	Bowens Bay Cr. trib.
		Middle Cr.-Black Cr. (5)	Clear Cr. & trib. (2) Middle Cr. & trib. (1)
		Pearces Cr. (5)	Pearces Cr. & trib. (4)
		Poplar Cr.-Chaney Cr. (15)	Chaney Cr. trib. (1) Davis Cr. trib. (3) Long Br. trib. (1) Poplar Cr. & trib. (8) Walls Cr.
		Walls Cr. (7)	Walls Cr. & trib. (6)
	Big Cedar Cr.-Pascagoula R. (1, 36)	Whiskey Cr. (36)	Water Prong Cr. & trib. (5) Whiskey Cr. & trib. (17) Whiskey Flat & trib. (11)
	Bluff Cr.-Red Cr. (3, 5)	Clear Cr.-Bluff Cr. (1)	Bluff Cr. trib. (1)
		Cypress Cr.-Red Cr. (1)	Cypress Cr. trib. (1)
		Old Cr.-Red Cr. (3)	Long Br. & trib. (2)
	Buck Cr.-Bogue Homo (2, 6)	East Tiger Cr.-Tiger Cr. (4)	Little Tiger Cr. & trib. (1) Tiger Cr. trib. (2)
		Tiger Cr.-Bogue Homo (2)	West Tiger Cr. & trib. (1)
	Flint Cr.-Red Cr. (2, 3)	Hickory Cr.-Red Cr. (1)	Red Cr. trib. (1)
		Hurricane Cr.-Red Cr. (2)	Red Cr. trib. (2)
	Hickory Cr.-Big Black Cr. (3, 27)	Beaver Cr.-Hickory Cr. (17)	Hickory Cr. & trib. (7) Hickory Flat Br. & trib. (8)
		Joes Cr.-Cypress Cr. (9)	Joes Cr. & trib. (8)
		Long Br.-Black Cr. (1)	Black Cr. trib. (1)
	Hickory Cr.-Catahoula Cr. (1, 1)	Bayou Bacon (1)	Bayou Bacon

Table continued on next page.

Table 1. Continued from previous page.

State	Watershed	Subwatershed	Streams
Mississippi cont'd	Jourdan R.-Saint Louis Bay (1, 1)	White Cypress Cr.-Hickory Cr. (1)	White Cypress Cr.
	Little Biloxi R.-Biloxi R. (5, 15)	Fritz Cr.-Biloxi R. (1)	Fritz Cr.
		Horse Cr.-Biloxi R. (5)	Andrew Br. trib. (2) Crooked Cr. & trib. (2)
		Lower Little Biloxi R. (3)	Little Biloxi R. trib. (3)
		Palmer Cr.-Biloxi R. (1)	Loya Br.
		Saucier Cr. (5)	Beaver Dam Cr. trib. (1) McHenry Br. & trib. (1) Saucier Cr. trib. (1) Ship Br.
	Little Black Cr.-Black Cr. (2, 2)	Granny Cr.-Black Cr. (1)	Black Cr. trib. (1)
		Potato Cr.-Big Cr. (1)	Potato Cr.
	Little Bogue Homo-Bogue Homo (1, 3)	Camp Cr.-Bogue Homo (3)	Camp Cr. trib. (3)
	Little Thompson Cr.-Thompson Cr. (2, 5)	Hollis Cr.-Thompson Cr. (1)	Whetstone Br.
		West Little Thompson Cr.-Thompson Cr. (4)	West Little Thompson Cr. trib. (4)
	Mason Cr.-Big Cr. (1, 3)	Waterfork Br.-Mason Cr. (3)	Mason Cr. Waterfork Br. & trib. (1)
	Moungers Cr.-Bluff Cr. (1, 7)	Wolf Br.-Bluff Cr. (7)	Bluff Cr. & trib. (6)
	Piney Woods Cr.-Gaines Cr. (1, 4)	Piney Woods Cr. (4)	Gator Br. trib. (1) Hall Br. & trib. (1) Okey Br.
	Tuxachanie Cr.-Tchoutacabouffa R. (4, 15)	Bayou Billie-Tchoutacabouffa R. (4)	Bayou Billie & trib. (1) Tchoutacabouffa R. trib. (2)
		Bigfoot Cr.-Tuxachanie Cr. (4)	Boggy Br. Bridge Br. & trib. (2)
		Cypress Cr.-Tchoutacabouffa R. (1)	Cypress Cr.
		Hurricane Cr.-Railroad Cr. (6)	Butt Head Br. Hurricane Cr. & trib. (2) Little Railroad Cr. trib. (1) Railroad Cr.

[1]Streams as identified herein include named and unnamed streams, as well as permanent, intermittent, and ephemeral streams. Streams were identified using the best available location data for Louisiana quillwort and scale topographic maps. Stream counts reported herein are estimates only.
[2]Indicates number of subwatersheds (first number) and streams (second number) within each watershed with Louisiana quillwort colonies.
[3]Indicates number of streams within each subwatershed with Louisiana quillwort colonies.
[4]Indicates number of unnamed tributaries.
Note: This table was created using data compiled from U.S. Fish and Wildlife Service 1996, Larke 1997, Rosso 1998, Alabama Natural Heritage Program 2010, Lyman *et al*. 2010, Leonard 2011, Louisiana Natural Heritage Program 2011, and Mississippi Natural Heritage Program 2011.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Louisiana quillwort (*Isoetes louisianensis*)

Current Classification: Endangered.

Recommendation resulting from the 5-Year Review:

_____ **Downlist to Threatened**
_____ **Uplist to Endangered**
_____ **Delist**
__X__ **No change needed**

Review Conducted By: M. Scott Wiggers, Mississippi Ecological Services Field Office.

FIELD OFFICE APPROVAL:

for **Lead Field Supervisor, Fish and Wildlife Service**

Approve _____ Date 5-24-12

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

for Approve _____ Date 6/25/12

Appendix A. Summary of peer review for the 5-year review of Louisiana quillwort (*Isoetes louisianensis*)

A. Peer Review Method: Peer review was requested from three knowledgeable individuals. Responses were received from two of these peer reviewers.

B. Peer Review Charge: See attached guidance.

C. Summary of Peer Review Comments/Report: Peer reviewer responses were supportive of the information and conclusions presented in this review. It was brought to our attention that plants on privately owned land are protected from theft in the state of Mississippi.

D. Response to Peer Review: The Service was in agreement with all comments and concerns received from peer reviewers. Comments were incorporated into the 5-year review where appropriate.

Guidance for Peer Reviewers of Five-Year Status Reviews
U.S. Fish and Wildlife Service, Mississippi Ecological Services Field Office

As a peer reviewer, you are asked to adhere to the following guidance to ensure your review complies with U.S. Fish and Wildlife Service (Service) policy.

Peer reviewers should:

1. Review all materials provided by the Service.

2. Identify, review, and provide other relevant data apparently not used by the Service.

3. Not provide recommendations on the Endangered Species Act classification (e.g., endangered, threatened) of the species.

4. Provide written comments on:
   - Validity of any models, data, or analyses used or relied on in the review.
   - Adequacy of the data (e.g., are the data sufficient to support the biological conclusions reached). If data are inadequate, identify additional data or studies that are needed to adequately justify biological conclusions.
   - Oversights, omissions, and inconsistencies.
   - Reasonableness of judgments made from the scientific evidence.
   - Scientific uncertainties by ensuring that they are clearly identified and characterized, and that potential implications of uncertainties for the technical conclusions drawn are clear.
   - Strengths and limitation of the overall product.

5. Keep in mind the requirement that the Service must use the best available scientific data in determining the species' status. This does not mean the Service must have statistically significant data on population trends or data from all known populations.

All peer reviews and comments will be public documents and portions may be incorporated verbatim into the Service's final decision document with appropriate credit given to the author of the review.

Questions regarding this guidance or the peer review process should be referred to M. Scott Wiggers, Botanist, Mississippi Ecological Services Field Office, at (601) 364-6910, e-mail: marion_wiggers@fws.gov.