

Louisiana quillwort
(*Isoetes louisianensis*)

5-Year Review:
Summary and Evaluation[†]



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

[†]Please see Addendum 1 at the end of this, our original 5-year review document. The Addendum provides the limited new information we have gathered for our second 5-year review for this endangered plant that was initiated in the *Federal Register* (March 12, 2018, 83 FR 10737) and the analysis we have shared to explain the basis for continuing to recommend no change in status for this species.

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rule listing this species under the Endangered Species Act; the Recovery Plan; peer reviewed scientific publications; unpublished field observations by the U.S. Fish and Wildlife Service, U.S. Forest Service, state and other experienced biologists; unpublished studies and survey reports; and notes and communications from other qualified individuals.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, Thriffley *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, Thriffley *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, Thriffley *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, Thriffley *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, Thriffley *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 (*Cyrtilla 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 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 (Thriffley *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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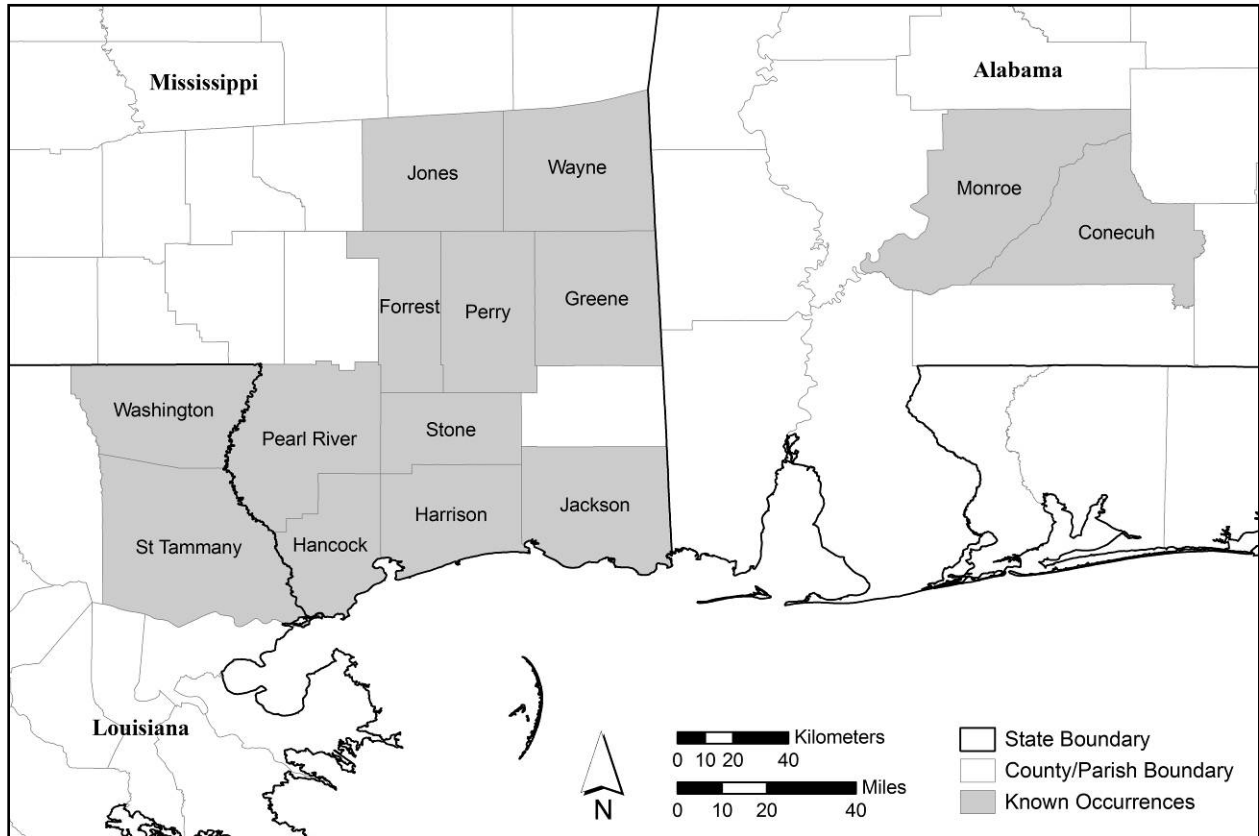
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Figure 1. Current distribution of Louisiana quillwort.



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	Streams¹
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)
Beaverdam Cr.-Black Cr. (5, 32)			Bowens Bay Cr.-Beaverdam Cr. (1)
		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)
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)
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) Horse Cr.-Biloxi R. (5)
		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)
			Boggy Br. Bridge Br. & trib. (2)
			Cypress Cr.-Tchoutacabouffa R. (1)
		Hurricane Cr.-Railroad Cr. (6)	Butt Head Br. Hurricane Cr. & trib. (2) Little Railroad Cr. trib. (1) Railroad Cr.

¹Streams 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.

²Indicates number of subwatersheds (first number) and streams (second number) within each watershed with Louisiana quillwort colonies.

³Indicates number of streams within each subwatershed with Louisiana quillwort colonies.

⁴Indicates 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
- No change needed

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

FIELD OFFICE APPROVAL:

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

Approve *Cary Wiggers* Date 5-24-12

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

fw Approve *Paul Wiggers* Date 6/20/12

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.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF LOUISIANA QUILLWORT
(Isoetes louisianensis)

Addendum 1. Summary of new information obtained since the 2012 5-year review.

The *Federal Register* notice announcing the initiation of this 5-year review was published on March 12, 2018 (83 FR 10737).

I. GENERAL INFORMATION

There are limited updates to this section since completion of the 2012 5-year review (U.S. Fish and Wildlife Service [Service] 2012). Updated information is presented below. In addition, as required, we conducted independent peer review of the new information (see Appendix A). We sought review from four knowledgeable experts on this species and its habitats. Peer review comments received have been incorporated into this addendum as appropriate.

B. Reviewers

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

Lead Field Office: Mississippi Field Office, M. Scott Wiggers, (228) 475-0765

Cooperating Field Offices: Alabama Ecological Services Field Office, Shannon Holbrook, (251) 441-5837; Louisiana Ecological Services Field Office, Robert Smith, (337) 291-3134

C. Background

2. **Species status:** Stable. There are 20 natural, extant populations of Louisiana quillwort, which is the same number of populations as noted in the 2012 5-year review. However, recent genetic work indicates that some of these populations may consist of one or more as of yet undescribed cryptic species and, as such, the total number of populations may be less than currently thought. This uncertainty has called into question the identities of some subpopulations. Sixteen populations occur either in part or entirely on conservation or public lands, with part of 1 population (which includes transplanted and naturally occurring plants) located on a preserve owned by The Nature Conservancy (TNC) in Louisiana and the remaining 15 occurring at least in part on lands owned by the U.S. Forest Service (USFS) or Department of Defense in Mississippi. Population monitoring is limited and inconsistent across the species' range, with many populations having no known monitoring in 10 or more years, which restricts our ability to assess Louisiana quillwort's overall population size and trends and increases uncertainties associated with this assessment.

II. REVIEW ANALYSIS

C. Updated Information and Current Species Status

1. Biology and Habitat

Information on abundance, population trends, distribution, biology, ecology, and habitat were summarized in the 2012 5-year review. New information is summarized below.

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

Data for many Louisiana quillwort element occurrences have not been updated in State Natural Heritage Program databases since completion of the 2012 5-year review (e.g., Mississippi Natural Heritage Program 2017, 2019; Louisiana Natural Heritage Program 2018; Alabama Natural Heritage Program 2019). Indeed, numerous occurrences have apparently not been monitored or data have not otherwise been updated in 10 or more years and the current status and trends of these occurrences are uncertain. The most robust monitoring of Louisiana quillwort occurs in Mississippi, specifically on the De Soto National Forest (DSNF) and associated Camp Shelby Joint Forces Training Center (CSJFTC), where population monitoring is conducted primarily by USFS and TNC staff, respectively. Overall, population monitoring remains inconsistent across the species' range (limiting assessment of its population trends) and substantial uncertainties remain, such as the natural amplitude of local population size fluctuations. However, recent surveys of TNC's Abita Creek Flatwoods Preserve in Louisiana indicate that the population on this property is likely stable (M. Scott Wiggers, U.S. Fish and Wildlife Service, pers. obs., April 24, 2019; William DeGravelles, TNC, pers. comm., 2019). Likewise, monitoring of various sites on CSJFTC indicates that these local populations are generally stable, with some colonies having been lost or in decline, while others are stable or increasing (Melinda Lyman, TNC, pers. comm., 2018b). Where available, recent data indicate that local populations of Louisiana quillwort can vary markedly in their sizes and densities, with Hall Branch on DSNF supporting an estimated 4,500 plants along a 100 meter (328 feet) length of stream (Mac Alford, University of Southern Mississippi, pers. comm., 2019), whereas only 290 plants were found along over 1.5 miles (1.6 kilometers) of Abita Creek (Wiggers, pers. obs., 2019; DeGravelles, pers. comm., 2019).

Protected Populations

Currently, 16 populations (i.e., watersheds [see section II.C.1.d, below, for population description]) or portions of populations are found on conservation or public lands and, as such, these populations receive enhanced protections and conservation considerations. Of these populations, 15 are found on USFS or Department of Defense lands in Mississippi (i.e., De Soto National Forest and Camp Shelby Joint Forces Training Center), while 1 is found on TNC lands in Louisiana. However, 8 of the 20 known populations (1 in Alabama, 2 in Louisiana, 5 in Mississippi) of Louisiana quillwort are also located entirely or partially on non-conservation lands, which includes 4 populations that occur in part on public or conservation lands.

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

Relevant genetics work in recent years has focused on phylogenetics and species delimitation within the *Isoetes* genus and a handful of *I. louisianensis* populations

throughout the species' range. As noted above, recent genetic and related taxonomic work (Walker 2017, Schafran *et al.* 2018) indicate that some records thought to be Louisiana quillwort may in fact consist of several currently undescribed cryptic quillwort species. The existence of such cryptic species may be a common phenomenon within the genus, as many polyploid species of quillworts (like Louisiana quillwort, which is a tetraploid species) are thought to consist of multiple cryptic species (Troia *et al.* 2016).

c. Taxonomic classification or changes in nomenclature:

The species is considered valid (Brunton 2015, Weakley 2015, Spaulding 2017, Integrated Taxonomic Information System 2019, NatureServe 2019); however, recent genetic work indicates that the taxon may consist of several cryptic species that have not previously been described (Schafran *et al.* 2018). Moreover, recent morphological work has identified additional diagnostic characters of *I. louisianensis* and other species within the genus that may assist with species delimitation, such as variation of scales and abscission caps (Bray *et al.* 2018).

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

Based on the provisional population definition presented in the 2012 5-year review (i.e., populations are equated with the standardized 10-digit HUC watersheds containing the plants), there are currently 20 extant, natural populations known in 3 states (Alabama, Louisiana, and Mississippi) (Figure 1, Table 1), which is the same number of populations as 2012. Populations have been found in 15 counties across these states (Figure 1, Table 2). Two populations of uncertain identity (one in Butler County, Alabama and one in Pearl River County, Mississippi) have been reported as Louisiana quillwort, but preliminary genetic analyses indicate that these putative populations are likely other quillwort species (Schafran *et al.* 2018; Daniel Brunton, pers. comm., 2019a, 2019b). Due to these uncertainties, these putative populations are not currently considered part of the total number of extant Louisiana quillwort populations. Likewise, the identity of plants in subpopulations of at least two Louisiana quillwort populations in Mississippi have also been called into question over similar concerns (Walker 2017, Schafran *et al.* 2018)—which includes plants along Okey Branch and Hall Branch (however, additional research revealed Hall Branch plants to be atypical Louisiana quillwort [Alford, pers. comm., 2019]) listed in Table 1 of the 2012 5-year review and another site not included in the previous review—but this does not currently affect the total number of presumed populations. While the range of Louisiana quillwort is apparently greater than was known when the species was listed, expansion of genetic studies using modern techniques (e.g., Schafran *et al.* 2018) may ultimately result in reduction of the species' range and number of populations if populations currently considered to be Louisiana quillwort are revealed to be other quillwort species. A range-wide investigation of the species that includes morphological, habitat, and genetic studies is needed to resolve current and potential future discrepancies between field identifications and genetic identity of Louisiana quillwort records.

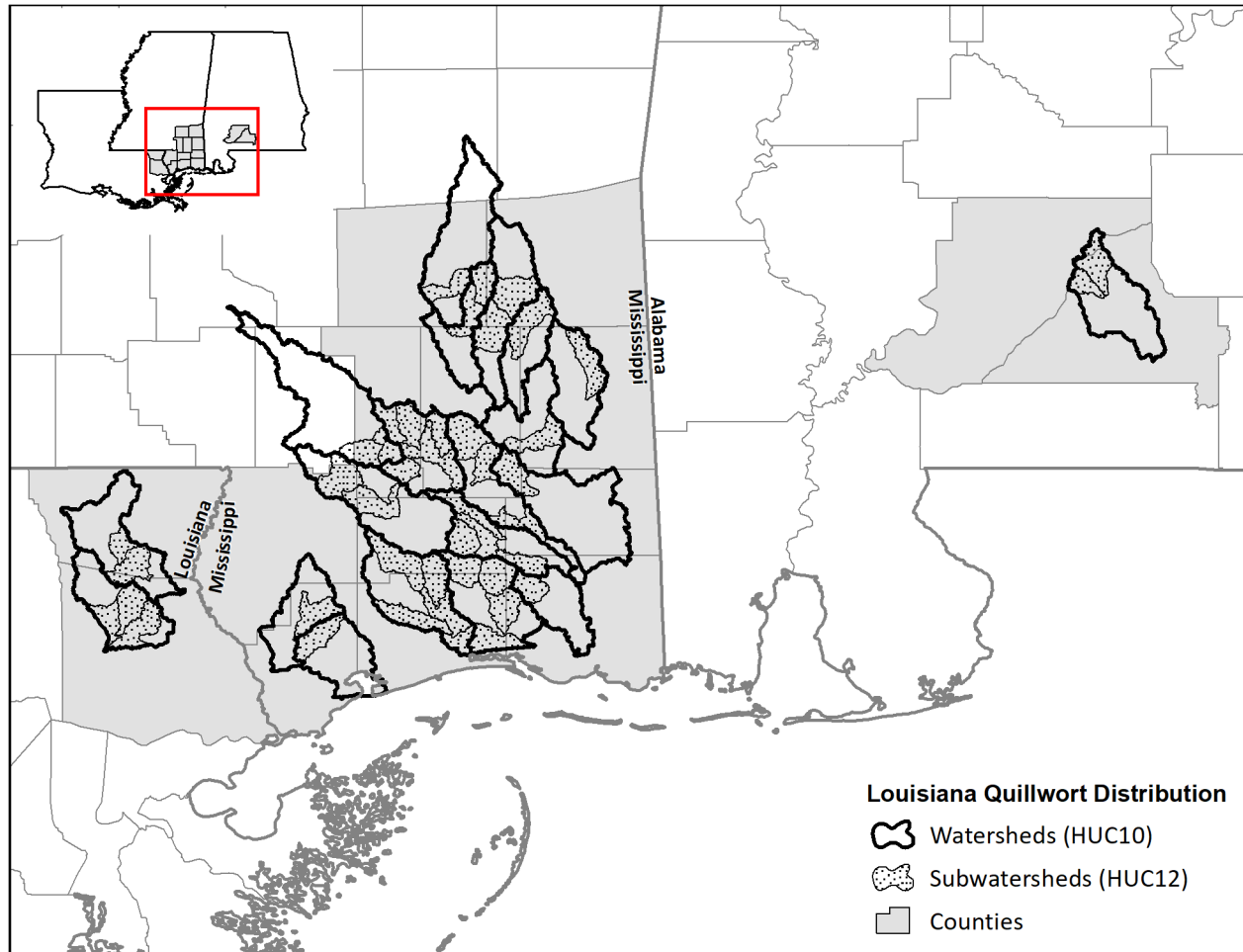


Figure 1. Current known distribution of Louisiana quillwort.

Some new records have been reported within Louisiana quillwort's known range since the 2012 5-year review. However, these records generally represent local expansions of previously known populations in Mississippi and Louisiana, resulting in additional subwatersheds, streams, or stream reaches included in the known distribution of Louisiana quillwort (Mississippi Natural Heritage Program 2017, 2019; Nelwyn McInnis, TNC, pers. comm. 2018; Lyman, pers. comm., 2019) (see Table 1).

e. Habitat or ecosystem conditions:

Recent research in the field confirms previous informal observations that Louisiana quillwort phenology is dependent on water availability. Walker (2017) found that plants senesced and became dormant within 2 to 3 weeks of streams drying up, but were capable of remaining green throughout the summer (when streams typically dry up and plants go dormant) if the streams remained wet.

Table 1. Watershed and subwatershed distributions of Louisiana quillwort.

State	Watershed	Subwatershed
Alabama	Upper Murder Cr.	Harpers Store Spring Cr. – Murder Cr.
Louisiana	Bogue Chitto	Berrys Cr. – Bogue Chitto
	Bogue Falaya R.	Thigpen Cr. – Mill Cr. Abita R. Little Bogue Falaya R. Lower Bogue Falaya R. Pearces Cr. Poplar Cr. – Chaney Cr.
Mississippi	Atkinson Cr. – Leaf R. Beaverdam Cr. – Black Cr.	Big Oktibee Cr. – Leaf R. Bowens Bay Cr. – Beaverdam Cr. Middle Cr. – Black Cr. Walls Cr.
	Big Cedar Cr. – Pascagoula R. Bluff Cr. – Red Cr.	Whiskey Cr. Clear Cr. – Bluff Cr. Cypress Cr. – Red Cr. <i>Little Red Cr.</i> ¹ Old Cr. – Red Cr.
	Buck Cr. – Bogue Homo	East Tiger Cr. – Tiger Cr.
	Flint Cr. – Red Cr.	Tiger Cr. – Bogue Homo
	Hickory Cr. – Big Black Cr.	Hickory Cr. – Red Cr. Hurricane Cr. – Red Cr. Beaver Cr. – Hickory Cr. Joes Cr. – Cypress Cr. Long Branch – Black Cr.
	Hickory Cr. – Catahoula Cr. Jourdan R. – Saint Louis Bay Little Biloxi R. – Biloxi R.	White Cypress Cr. – Hickory Cr. ² Bayou Bacon ² Fritz Cr. – Biloxi R. Horse Cr. – Biloxi R. Lower Little Biloxi R. Palmer Cr. – Biloxi R. Saucier Cr.
	Little Black Cr. – Black Cr.	Granny Cr. – Black Cr. Potato Cr. – Big Cr.
	Little Bogue Homo – Bogue Homo Little Thompson Cr. – Thompson Cr.	Camp Cr. – Bogue Homo Hollis Cr. – Thompson Cr. West Little Thompson Cr. – Thompson Cr.
	Mason Cr. – Big Cr. Moungers Cr. – Bluff Cr. Piney Woods Cr. – Gaines Cr. Tuxachanie Cr. – Tchoutacabouffa R.	Waterfork Branch – Mason Cr. Wolf Branch – Bluff Cr. Piney Woods Cr. Bayou Billie – Tchoutacabouffa R. Bigfoot Cr. – Tuxachanie Cr. Cypress Cr. – Tchoutacabouffa R. Hurricane Cr. – Railroad Cr.

¹Subwatersheds highlighted in italics are new occurrences that were not included in the 2012 5-year review. ²These subwatersheds were erroneously transposed between their associated watersheds in Table 1 of the 2012 5-year review.

Table 2. County and parish distribution of Louisiana quillwort.

State	County/Parish
Alabama	Conecuh Monroe
Louisiana	St. Tammany Washington
Mississippi	Forrest George Greene Hancock Harrison Jackson Jones Pearl River Perry Stone Wayne

2. Five Factor Analysis (threats, conservation measures, and regulatory mechanisms)

a. Present or threatened destruction, modification or curtailment of its habitat or range:

Continued development and habitat conversion within Louisiana quillwort's range will likely result in lost populations and range restriction (Leonard 2011; Robert Smith, U.S. Fish and Wildlife Service, pers. comm., 2011). Excessive sedimentation from inadequate sediment abatement in adjacent uplands or during bridge construction and/or replacement may smother Louisiana quillwort plants (Leonard 2011; Smith, pers. comm., 2011). Following appropriate sediment abatement and mitigation best management practices (BMPs) will prevent these problems. One Louisiana population is experiencing degradation of habitat quality due to failure of a culvert, which is apparently increasing sedimentation upstream from the structure (Wiggers, pers. obs., 2019). Similarly, overstory clearing and lack of adherence to appropriate streamside management zones (SMZs) can degrade Louisiana quillwort habitat (Service 1996, Leonard 2011). Likewise, adherence to appropriate SMZs and recommended buffer widths in the species' recovery plan (Service 1996) will alleviate such threats. Inclusion of and adherence to appropriate conservation measures in applicable land and resource management plans—such as has been done in the CSJFTC Integrated Natural Resources Management Plan (INRMP; Mississippi Army National Guard 2014) and Mississippi National Forests Land and Resources Management Plan (USFS 2014)—will minimize such threats on these lands and promote the species' recovery. While gravel mining was considered to threaten some Louisiana quillwort populations at the time the species was listed, the current threat of such activities is unknown. Off-road vehicle use and hay production were previously identified as a threat to one colony in Alabama (Leonard 2011), but current information on this threat is limited.

b. Overutilization for commercial, recreational, scientific, or educational purposes: Not known to threaten this species.

- c. Disease or predation:** Although the species may occasionally be eaten by marsh rabbits (*Sylvilagus* spp.), whitetail deer (*Odocoileus virginianus*), or waterfowl, these are not known to threaten Louisiana quillwort.
- d. Inadequacy of existing regulatory mechanisms:** Alabama, Louisiana, and Mississippi have no state laws affording specific protections to Louisiana quillwort or its habitat, although theft of plants from private lands is illegal in these states. The species is designated as a Plant of Conservation Concern in Alabama's *Wildlife Action Plan* (WAP) (Alabama Department of Conservation and Natural Resources 2016), a Species of Greatest Conservation Need in Louisiana's WAP (Holcomb *et al.* 2015), and a Plant Species of Concern in Mississippi's WAP (Mississippi Museum of Natural Science 2015). While these designations in state WAPs do not carry any legal protections, they do serve to highlight plants in need of conservation within these states and may help focus attention and resources on these species. Otherwise, the species is protected under provisions of sections 7 and 9 of the U.S. Endangered Species Act (ESA).

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

Unchecked wild hog (*Sus scrofa*) damage (Lyman, pers. comm., 2018a, 2018b, 2019) continues to affect some Louisiana quillwort populations in Mississippi; however, while wild hogs are recognized as a nuisance species throughout the southeastern United States that can cause extensive damage to natural resources and habitats (Animal and Plant Health Inspection Service 2015), the extent of their threat to Louisiana quillwort is poorly understood. Wild hog control efforts have been implemented in Mississippi, but are currently inadequate to limit wild hog damage in some Louisiana quillwort habitats (Lyman, pers. comm., 2018b). Likewise, beaver dams have inundated colonies of Louisiana quillwort in Mississippi and Alabama (Leonard 2011; Lyman, pers. comm., 2011, 2018b). Some of these colonies have apparently been destroyed, but, while such beaver activity may degrade or eliminate some Louisiana quillwort habitat upstream of the dams, they may enhance habitat downstream (Leonard 2011). Currently, however, while beaver activity may threaten local Louisiana quillwort populations, degrading their habitat, beavers are not considered a major threat to Louisiana quillwort range-wide. Given the localized impacts of beavers, beaver control may be required in some areas if their activities threaten entire populations of Louisiana quillwort, but they are otherwise considered to be a minor concern for the species.

Because Louisiana quillwort requires sufficient rainfall to promote favorable soil moisture and trigger periodic scouring of stream channels and floodplains (Service 1996, Leonard 2011), increased frequency, length, and/or intensity of droughts may reduce the availability of suitable habitats or lead to the elimination of populations. Likewise, increased accumulation of wind-throw from more frequent hurricanes may promote excessive sedimentation within stream systems (Leonard 2011), thereby degrading Louisiana quillwort habitat in these areas.

D. Synthesis

At this time, Louisiana quillwort continues to meet the definition of endangered under the ESA. Since completion of the last 5-year review, limited new available information on the species' populations and trends indicates that the species is likely stable overall. However, limited availability of recent monitoring data for many populations increases the uncertainty associated with this assessment. Increased monitoring is needed to adequately understand and assess the status, trends, and threats to Louisiana quillwort, particularly for populations occurring on conservation lands. Overall, recovery progress has been made with Louisiana quillwort, with 16 populations occurring at least in part on conservation or public lands (most of which are on USFS lands). Louisiana quillwort conservation efforts have been encouraged, engaged in, and/or funded by the U.S. Fish and Wildlife Service, Louisiana and Mississippi chapters of TNC, the USFS, state Natural Heritage Programs, universities, and Mississippi Army National Guard. Habitat destruction and degradation from development, particularly in Louisiana continue to threaten the species, while unchecked wild hog damage represents an increasing threat to the species range-wide. Prolonged inundation from beaver dams may have destroyed some Louisiana quillwort colonies in Mississippi, but the threat of beavers to the species long-term persistence is likely minor, as beaver activities may also enhance habitat downstream of dams. Finally, recent genetics work indicates that at least some populations considered to be Louisiana quillwort, may actually be other, as-yet undescribed species of quillwort, suggesting that there may be fewer populations of Louisiana quillwort than currently thought.

III. RESULTS

A. Recommended Classification: No change is needed.

IV. RECOMMENDATIONS FOR FUTURE ACTION

The previous 5-year review included a list of recommendations to improve recovery of the species. Accomplishments toward these recommended actions are summarized below.

- A. Monitoring is inconsistent range-wide with only some populations in Mississippi receiving regular monitoring.
- B. Work with Federal partners to protect and manage the species has continued primarily under the Service's section 7 consultation provisions (e.g., USFS 2014). Annual meetings between multiple Federal and State agencies, Mississippi Army National Guard personnel and staff, and TNC at Camp Shelby Joint Forces Training Center provide regular opportunities to discuss and address conservation of Louisiana quillwort and other species. The Service's Louisiana Ecological Services Field Office's Partners Program has provided funding to support land conservation on private lands that benefits at least one Louisiana quillwort population in Louisiana.
- C. Wild hog control efforts are underway, but would benefit from additional funding and focus on areas where Louisiana quillwort and wild hogs co-occur.
- D. Monitoring of and searches for Louisiana quillwort by TNC staff on Camp Shelby Joint Forces Training Center and by USFS staff on De Soto National Forest in Mississippi are ongoing. Likewise, periodic searches for the species occur throughout its range pursuant to section 7 consultation activities. However, limited efforts beyond section 7 related

activities have been made to focus searches on private lands within the species' range since 2012.

- E. The Nature Conservancy in Mississippi has engaged in some demographic and habitat studies of Louisiana quillwort on Camp Shelby Joint Forces Training Center, but the study is ongoing and results have not been formally analyzed or evaluated and, therefore, insights from this work are currently limited.
- F. While some genetics work has been conducted since the last 5-year review, this work has primarily focused on the phylogenetics and species discrimination.
- G. No additional genetic material has been placed into *ex situ* safeguarding collections. To date, the single known *ex situ* safeguarding collection only contains material from Louisiana.
- H. The recovery plan still needs to be updated.

In addition to the above accomplishments and remaining needs, the following activity is also recommended:

- I. A range-wide investigation of the species that includes morphological, habitat, and genetic studies is needed to resolve current and potential future discrepancies between field identifications and genetic identity of Louisiana quillwort records.

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FY 2019 APPROVAL*

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve 

Date 8/1/19

*In 2014, Southeast Region Field Supervisors were delegated authority to approve 5-year reviews that do not recommend a status change.

Field Supervisor signature on this document reflects:

1. We have no new information received, no new public comments, and the original five factor analysis remains an accurate reflection of the species' current status.
2. We have obtained a small amount of new information that we have summarized in Addendum 1, received no new public comments, and the original five factor analysis remains an accurate reflection of the species' current status.

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

A. Peer Review Method: Peer review was coordinated by the Service's Asheville Ecological Services Field Office, North Carolina. Four peer reviewers were selected by the Service for their knowledge of and expertise with Louisiana quillwort and its habitats. Individual responses were received from two of the four of the invited peer reviewers.

Invited Peer Reviewers: Dr. Mac Alford, Professor and Curator of the Herbarium, University of Southern Mississippi; Dr. Wayne Barger, Botanist, Alabama Department of Conservation and Natural Resources; Chris Doffitt, Botanist/Natural Areas Registry Coordinator, Louisiana Department of Wildlife and Fisheries; Melinda Lyman, Program Coordinator/Botanist, The Nature Conservancy – Camp Shelby Conservation Program

Responding Peer Reviewers: Dr. Mac Alford, Professor and Curator of the Herbarium, University of Southern Mississippi; Melinda Lyman, Program Coordinator/Botanist, The Nature Conservancy – Camp Shelby Conservation Program

B. Peer Review Charge: See attached text from the peer review invitation letter.

C. Summary of Peer Review Comments: Both responding peer reviewers agreed with the 5-year review's use of available information and conclusions. In addition, each peer reviewer provided specific comments and questions, which are summarized below.

1. Melinda Lyman noted confusion with how section II.C.2.a portrayed CSJFTC's INRMP's inclusion of and adherence to appropriate Louisiana quillwort conservation measures.
2. Melinda Lyman noted that TNC's long-term demographic studies of Louisiana quillwort mentioned in section IV, bullet E, are not yet complete, and, as such, have not been analyzed.
3. Dr. Mac Alford provided additional support for the 5-year review's assertions that additional cryptic species of quillworts are being revealed within Louisiana quillwort's range via a brief summary of pertinent literature regarding quillwort species found in Mississippi. This reviewer also noted that "lack of exploration and morphological similarity among the [quillwort] species has hampered knowledge of this group."
4. Dr. Alford provided additional information regarding the Hall Branch subpopulation noted in section II.C.1.d as being of suspect identity. Dr. Alford provided information confirming the identity of these plants as being atypical Louisiana quillwort, rather than another species of quillwort.
5. Dr. Alford provided additional observations supporting the conclusion that disease or predation are not currently threats to Louisiana quillwort.
6. Dr. Alford provided additional information on the estimated local population size of Louisiana quillwort at the Hall Branch site.
7. Dr. Alford summarized conclusions of Walker (2017) regarding the phenology of Louisiana quillwort being dependent on water availability.

D. Response to Peer Review: Responses to each peer reviewer's specific comments are summarized below.

1. The peer reviewer's confusion was due to an unclearly written sentence that was intended to highlight the cited INRMP (and USFS Land and Resources Management Plan) as documents that include appropriate conservation measures for Louisiana quillwort, rather than cite them as being inadequate. This sentence has been revised to clarify that these plans are documents that include appropriate conservation measures for Louisiana quillwort.
2. Revised bullet E to clarify that the demographic study has not been completed.
3. This comment supports the assertions of this 5-year review and no additional response is necessary.
4. Updated section II.C.1.d to note the current understanding of the identity of the Hall Branch Louisiana quillwort plants. Cited Dr. Alford.
5. No additional response necessary.
6. Updated section II.C.1.a to include Dr. Alford's population estimate. Cited Dr. Alford.
7. Added section II.C.1.e to include information on Louisiana quillwort's water-dependent phenology found in Walker (2017) summarized by Dr. Alford. Cited Walker 2017.

Peer Review Invitation Letter Text

On March 12, 2018, the U.S. Fish and Wildlife Service published a notice in the *Federal Register* (83 FR 10737) announcing a 5-year review of eight federally listed species, including Louisiana quillwort (*Isoetes louisianensis*). The purpose of 5-year reviews is to ensure that the classification of species as threatened or endangered is accurate and reflects the best available information.

Following current Service policy and guidelines on the process to conduct independent peer review, the Asheville Field Office is assisting the Mississippi Field Office to complete peer review of the science in the 5-year review for the Louisiana quillwort. You have provided data used to review the status of Louisiana quillwort and/or are knowledgeable about it. Therefore, in order to ensure that the best available information has been used to conduct this 5-year review, we now request your peer review of the attached draft document. The document we are asking you to review is an addendum to the 2012 5-year review. The 2012 5-year review is attached for your reference to aid in your review of the 2019 addendum. Specifically, we ask for comments on the 2019 draft addendum concerning:

- Have we assembled the best available scientific and commercial information?
- Is our analysis of this information correct and properly applied?
- Can you identify any additional new information on Louisiana quillwort that has not been considered in this review?

Please note that we are not seeking your opinion of the legal status of this species, but rather that the best available data and analyses were considered in reassessing its status.

As part of the peer review process, we must evaluate the potential for conflicts of interest with the subject species or the action. We therefore ask that you sign the enclosed Conflict of Interest Certificate and return it to this office with any notes, comments, or questions that you are willing to provide as your review.

We appreciate your interest in furthering the conservation of rare plants and animals by becoming directly involved in the review process of our Nation's threatened and endangered species. Your review and comments will become a part of the administrative record for this species, and you can be certain that your information, comments, and recommendations will receive serious consideration.

We hope that you view this peer review process as a worthwhile undertaking. Please give me a call (828-258-3939 x42238) or send me an e-mail (rebekah_reid@fws.gov) if you have any questions on this peer review. Please share your response by email or letter by July 31, 2019. Thank you in advance for your assistance.