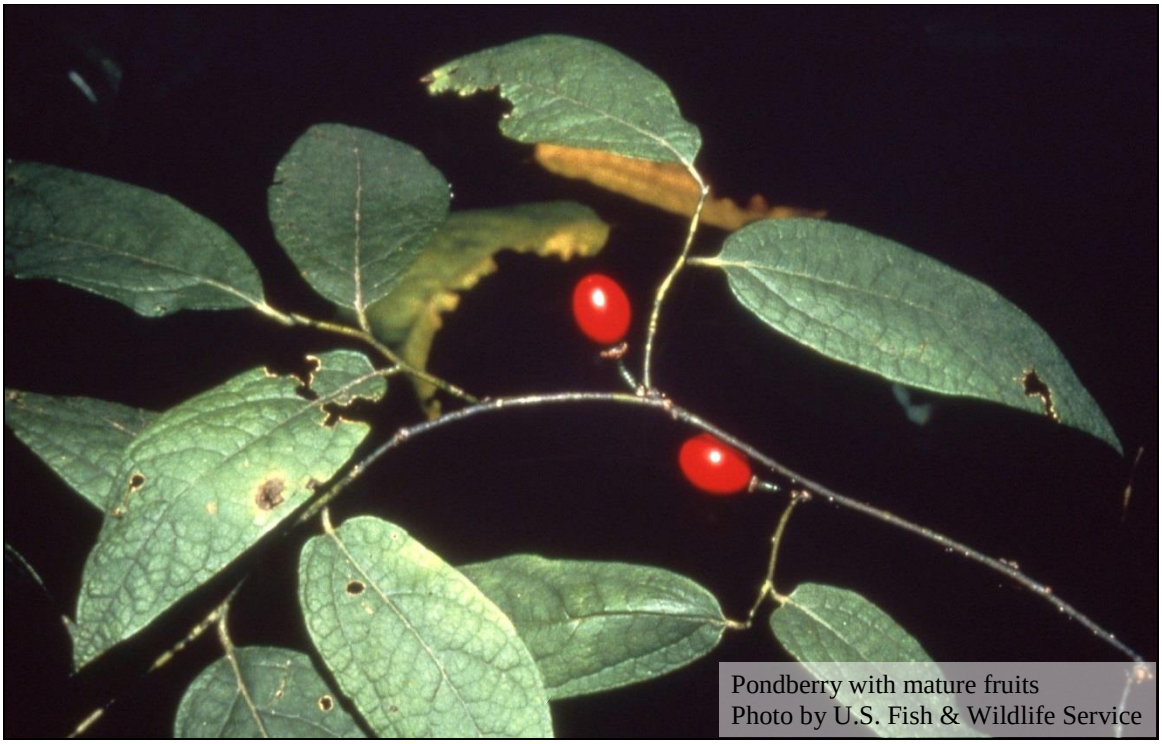
Pondberry
(*Lindera melissifolia*)

5-Year Review:
Summary and Evaluation



Pondberry with mature fruits
Photo by U.S. Fish & Wildlife Service

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

5-YEAR REVIEW
Pondberry (*Lindera melissifolia*)

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 contemporary distributions, life histories, genetics, habitats, disturbances, 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 solicited, including data housed at State natural heritage programs, 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; the U.S. Fish and Wildlife Service's (hereafter referred to as "the Service" or "Service") Biological Opinion on the U.S. Army Corps of Engineer's proposed Yazoo Backwater Reformulation Project; peer reviewed scientific publications; unpublished field observations by the Service, U.S. Forest Service, state and other experienced biologists; unpublished studies and survey reports; and notes and communications from other qualified individuals.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 affected Service offices and three peer reviewers for review. Comments were evaluated and incorporated into this final document as appropriate (see Appendix A). We did not receive any public comments during the 60-day open comment period.

B. Reviewers

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C. Background:

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

2. **Species status:** Stable to declining. Populations in Alabama, Missouri, and North Carolina are likely stable. Most populations in South Carolina are located on State- or Federally-owned lands and, while some populations are declining, recent searches have located additional populations on State and Federal lands. Recent surveys in Georgia have been unable to locate 3 known populations and their current status is unknown. Continued searches in Arkansas have identified 1 new population and increased the known area occupied by pondberry in another population; however, clearing and logging activities have extirpated 5 populations and reduced the size of 4 others. In Mississippi, there is no monitoring data for recent years, but previous monitoring data indicate an overall decline, while conditions at many sites are unchanged. Further monitoring is needed at sites range-wide.

3. **Recovery achieved:** 1 (1-25% recovery objectives achieved). Partial recovery objectives have been achieved through: searches for and discoveries of new populations and colonies; State and non-profit acquisition, protection, and management of land containing pondberry; management of pondberry on public lands; and conducting genetic, physiological, and ecological research on pondberry. Thirteen populations and partial populations receive some form of protection on State- or privately-owned land, while an additional 22 populations on Federally-owned lands receive protections under sections 7 and 9 of the Endangered Species Act. While these populations receive some level of protection, inconsistent monitoring hampers assessment of population trends, such as whether or not populations are self-sustaining. Furthermore, many populations have not been monitored recently or are monitored infrequently. Many populations, particularly those found in geographically isolated wetlands, are threatened by habitat destruction and altered hydrologic regimes. Small populations, fragmentation, and strongly biased sex ratios may increase the likelihood of developing inbreeding depression and reduce the ability of many populations to adapt to changing environments. Finally, the exotic and highly lethal, laurel wilt disease is an emerging threat to this species.

4. **Listing history**
   Original Listing
   FR notice: 51 FR 27495
   Date listed: July 31, 1986
   Entity listed: Species
   Classification: Endangered

5. **Associated rulemakings:** None.

6. **Review History:**

   Recovery Plan: 1993
   Recovery Data Call: annually from 2000-2012
   Five-year review: The Service conducted a 5-year review for pondberry in November 6, 1991 (56 FR 56882).

In this 1991 review, the Service simultaneously evaluated numerous species with no species-specific, in-depth assessment of the five factors or threats as they pertained to the individual species. The notice stated that the Service was seeking any new or additional information reflecting the necessity of a change in the status of the species under review. The notice indicated that if significant data were available warranting a change in a species' classification, the Service would propose a rule to modify the species' status. No change in the plant's listing classification was found to be appropriate.

7. **Species' Recovery Priority Number at start of review (48 FR 43098):** 8C
   Degree of Threat: Moderate
   Recovery Potential: High
   Taxonomy: Species
   Development and modification of wetlands and floodplain forests subject to Clean Water Act protections may incur conflict.

8. **Recovery Plan**
   Name of Plan: Recovery plan for pondberry (*Lindera melissifolia*)
   Date Issued: September 23, 1993

II. REVIEW ANALYSIS

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

The Endangered Species Act (ESA) defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate wildlife. This definition limits listing DPSs 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. However, these criteria could be made more quantifiable as more information has become available about the species.

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 numbers of protected populations for downlisting and delisting are not provided in the recovery plan. More information relevant to the biology and ecology of pondberry—including, genetics, physiology, and reproductive ecology—is now available than when the recovery plan was written. Despite this progress, more studies are needed to determine the minimum number of protected populations required to maintain genetic diversity and continued survival of pondberry. This

work is especially important given the emerging threat of the lethal laurel wilt disease in the southeastern United States.

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria? No. While the recovery criteria do generally take into account any threats to pondberry associated with the five listing factors by assuring that the populations be self-sustaining and protected, they do not specifically address threats posed by disease. Of particular concern is the emerging threat to pondberry populations posed by laurel wilt disease.

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 Objective is to delist pondberry. Recovery criterion for downlisting pondberry to threatened is the protection of 15 self-sustaining populations. The criterion for delisting is the permanent protection of 25 self-sustaining populations. Furthermore, determining what constitutes a self-sustaining population and what geographical distribution of populations is required to ensure the long-term survival of the species were listed recovery tasks. These criteria have not been met.

Since listing, new colonies and populations have been discovered in Alabama, Arkansas, Georgia, Mississippi, Missouri, North Carolina, and South Carolina. However, while new colonies/populations have been discovered in each of these states, with the exception of Alabama, populations have also been extirpated from these states during this time.

Selected pondberry populations have some form of protection in six of the seven states where extant populations occur. Although 13 extant populations partial populations are protected from habitat destruction on State-owned or privately owned property, inconsistent monitoring of pondberry populations on these sites limits assessment of their current trends and long-term sustainability. An additional state-owned population in Arkansas has likely become extirpated. Federally owned and managed lands are home to 22 pondberry populations, one of which extends onto State-owned land in Arkansas. Populations on these Federal lands receive protections primarily under sections 7 and 9 of the Endangered Species Act.

The recently discovered laurel wilt disease is highly lethal to infected pondberry plants and poses an emerging threat to pondberry. This rapidly spreading disease is known to affect at least one pondberry population (in Effingham County, Georgia) and has potential to spread to otherwise protected populations.

Finally, defining what constitutes a self-sustaining pondberry population was listed as a recovery task in the recovery plan. This definition has yet to be determined; however, ongoing ecological and genetic research will provide greater insight into the requirements of pondberry populations that can be considered self-sustaining.

Similarly, the geographic distribution of populations required to ensure long-term survival of pondberry has yet to be determined.

C. Updated Information and Current Species Status

1. Biology and Habitat

Information on the biology and habitat of pondberry is reviewed in the pondberry recovery plan (Service 1993) and in the Service's (2007) Biological Opinion of the proposed Yazoo Backwater Area Reformulation project. With the exception of populations discovered or extirpated since its completion, the Service's (2007) Biological Opinion provides the most current evaluation of population sizes/estimates for pondberry. Relevant information from these sources has been included in this review.

a. New information on the species' biology and life history:

A detailed review of pondberry's life history and reproductive ecology is provided in the Service's (2007) Biological Opinion.

Reproduction and Recruitment

Pondberry is a dioecious species, having both male and female plants, and is capable of producing abundant fruits, although fruit production may be erratic (e.g., Wright 1989, 1990; Devall *et al*. 2001, 2004b; Gustafson 2011). The species also has the ability to form short-term persistent soil seed banks (i.e., 1-2 years) (Connor *et al*. 2006, 2012; Hawkins *et al*. 2011) and some seeds may remain viable in the soil seed bank for longer periods (e.g., Smith 2003). However, seedlings have rarely been observed in pondberry colonies and populations (e.g., Tucker 1984; Wright 1989; Devall *et al*. 2001; Aleric and Kirkman 2005b; Connor *et al*. 2006). Skewed sex ratios at some sites may limit pollination success, thus resulting in poor fruit production (e.g., Wright 1989, 1994; Gustafson 2011) and subsequent seedling recruitment. Late frosts may also kill flowers (e.g., Tucker 1984) resulting in reduced fruit production and subsequent seedling recruitment. Depredation of seeds or seedlings may partially explain the paucity of observed seedlings. Indeed, Aleric and Kirkman (2005b) found that unprotected seeds on the soil surface with intact pulp were removed at high rates, presumably eaten by birds and mammals, whereas Connor *et al.* (2012) suggested that herbivores may eat pondberry seedlings. To date, five animals have been identified as potential pondberry seed or seedling predators and include the northern cardinal (*Cardinalis cardinalis*), brown thrasher (*Toxostoma rufum*), swamp rabbit (*Sylvilagus aquaticus*), nine-banded armadillo (*Dasypus novemcintus*), and gray squirrel (*Sciurus carolinensis*) (Abilio *et al*. 2008; Leininger *et al*. 2009). Other seeds may succumb to fungal infections, such as the ubiquitous black mold, *Colletotrichum gloeosporioides* (Devall *et al*. 2001; Unks

2011). Alternatively, Aleric and Kirkman (2005b) suggested that seedlings may have been overlooked because they lack distinctive identification characteristics.

Dispersal mechanisms of pondberry remain poorly understood. Pondberry's bright red fruits suggest that animals may play an important role in the dispersal of the species (Service 1993, 2007; Smith *et al*. 2004). While numerous animals have been associated with pondberry plants (e.g., Smith *et al*. 2004; Abilio *et al*. 2008; Leininger *et al*. 2009), only the hermit thrush (*Catharus guttatus*) has been confirmed as a dispersal agent of pondberry. The effectiveness of hermit thrushes as seed dispersal agents is limited by their small home range and, thus, they are considered to be short-range (about 160 feet [55 meters]) seed dispersers of pondberry (Smith *et al*. 2004). Other, larger animals, such as black bears (*Ursus americanus*) have been proposed as potential long-range dispersal agents (Devall *et al*. 2004b; Smith *et al*. 2004). Water has also been proposed as a potential dispersal agent of this species (e.g., Devall *et al*. 2001; Smith *et al*. 2004), but Hawkins *et al*. (2011) observed neither fruits nor seeds floating during flooding experiments and noted that water movement in pondberry habitats is limited. Taylor (2008), noted similar observations for fresh fruit and seeds, but also found that dried seeds could float.

Pondberry is a strongly clonal plant, with population recruitment dominated by vegetative, asexual production of new shoots. Most of the shrubs in any pondberry population are clones or genets of a much smaller number of genetically unique individuals (Godt and Hamrick 1996; Echt *et al*. 2011; Gustafson 2012, *in litt.*). Therefore, the persistence of existing pondberry populations is mostly affected by the vegetative production and survival of stems and shoots (Service 2007).

Light Availability

Pondberry is often found naturally occurring under hardwood stands with relatively closed canopies that create a low-light environment, but are not exclusively found under low-light conditions (Wright 1989, 1990; Aleric and Kirkman 2005a; Taylor 2008; Carter 2010; Unks 2011; Beckley 2012a). While pondberry exhibits the capacity to acclimate to a variety of light conditions, studies in both natural and experimental settings suggest that plant survival and growth may be highest at low to moderate light levels (Aleric and Kirkman 2005a; Lockhart *et al*. 2012, 2013). Pondberry's response to varying light regimes, however, is complex and may be related to other limiting factors, such as hydrological regimes and interspecific competition. For example, high light levels may increase moisture stress of plants (Wright 1990; Taylor 2008; Lockhart *et al*. 2012, 2013). High light levels may also promote growth of competing vegetation (Wright 1990), but regular flooding may limit the growth of potential competitors (Wright 1989; Glitzenstein and Streng 2004; Farrington 2011; Lockhart *et al*. 2013). On the other hand, too much shade may reduce survival (Lockhart *et al*. 2013) and seedling establishment (Unks 2011). Additionally, there is some evidence that light responses may differ by sexes. Lockhart *et al*. (2013) found

that females produced more ramets (clonal stems) with increasing light availability (from 5% to 37% and 70% of ambient light) at an experimental facility in Mississippi. Female plants also had slightly higher survival rates than males at 37% and 70% light availability as compared to those grown at 5% ambient light. These results indicate that female pondberry plants may require higher light levels than males; however, field studies by Taylor (2008) and Unks (2011) found no significant differences between male and female pondberry distributions with respect to available light in the natural environment. Clearly, observations from experimental studies under carefully manipulated conditions, such as those by Lockhart *et al*. (2012, 2013), need to be explored further in natural settings where natural hydrologic regimes and interspecific competition may influence pondberry's responses to particular light regimes. Overall, these studies in natural and experimental settings suggest the need to assess and test alternative forest management strategies to maintain and promote the health and vigor of pondberry populations across the range of habitats occupied by this species.

Flooding

Pondberry is a wetland plant found in habitats that experience regular flooding, whether by overbank flooding—such as many of the populations within bottomland hardwood forests of Mississippi—or seasonally flooded geographically isolated wetlands—such as those in the Atlantic and Gulf Coastal Plains of Georgia and the Carolinas (Service 1993, 2007; Beckley 2012a). Pondberry plants are clearly adapted to survive and thrive in wetlands (summarized in Service 2007). The species has been shown to be tolerant of prolonged flooding (i.e., at least up to 90 days) (Lockhart *et al*. 2013) and the species has been observed flowering in late spring, when pondberry habitats are typically still flooded (Hawkins *et al*. 2010). Seeds are tolerant of prolonged flooding and may not be able to form a seed bank without seasonal floods (Hawkins *et al*. 2011). The seeds do not germinate while submerged, but readily germinate once they are no longer submerged (Wright 1989; Hawkins *et al*. 2011).

Recent studies indicate that the effects of flooding on this species are complex and may differ by developmental stage. For example, Hawkins *et al*. (2009a) found reduced growth of juvenile (pre-reproductive) individuals with extended flooding in laboratory studies.

Regular flooding likely promotes pondberry by reducing competition from less-flood tolerant plant species. In the absence of such regular flood regimes, pondberry may be outcompeted by other vegetation (Wright 1989; Glitzenstein and Streng 2004; Farrington 2011; Lockhart *et al*. 2013).

Fire

Many pondberry populations in the Atlantic and Gulf Coastal Plains occur in geographically isolated wetlands that experience periodic fires (Wright 1989; Service 1993, 2007; Aleric and Kirkman 2005a; Beckley 2012a). Within these communities, fire frequency influences canopy cover (Aleric and Kirkman 2005a) and may reduce competition from other plant species (Glitzenstein and Streng 2004; Unks 2011). Pondberry is able to survive fires by regenerating from belowground rhizomes (Tucker 1984; Wright 1989; Unks 2011). Land managers and conservationists have suggested using frequent burning as a way to manage and maintain habitat for pondberry in Atlantic and Gulf Coastal Plain populations and, indeed, is being used to manage various populations (Glitzenstein *et al.* 2003; Glitzenstein and Streng 2004; Unks 2011; Pittman 2012, *in litt.*). However, Beckley's (2012a) study of pondberry populations in the Carolinas, found that the largest pondberry populations were those that experienced infrequent fires. Furthermore, pondberry was most frequently encountered in areas with 51-70 year fire return intervals. Periodic fires may be required to adequately control competing vegetation (Glitzenstein and Strong 2004; Unks 2011); however, Unks (2011) cautions that high intensity fires may reduce pondberry. Clearly, the relationship between pondberry and fire is complex and further study is warranted. Given the potential benefits and risk that fires pose to pondberry populations, use of fire as a management tool must be carefully examined prior to initiation of a prescribed fire program.

b. Abundance, population trends, demographic features, or demographic trends:

Populations

When pondberry was listed in 1986, the species was known from 17 extant locations in Arkansas (9), Georgia (1), Mississippi (1), Missouri (1), North Carolina (1), and South Carolina (4). It was considered to be extirpated in Alabama, Florida, and Louisiana where it had been historically collected. By the time the recovery plan was completed in 1993, continued surveys revealed additional pondberry occurrences, increasing the number of known naturally occurring populations to 36: Arkansas (10), Georgia (5), Mississippi (13), Missouri (1; considered to be part of a population occurring on both sides of the Arkansas–Missouri state line), North Carolina (3), and South Carolina (5). The species was still considered to be extirpated in Alabama, Florida, and Louisiana.

Additional pondberry surveys since listing and completion of the recovery plan have found new sites and populations. Most of these changes since listing represent an increase in the number of sites in the vicinity of previously known sites; however, surveys and chance discoveries in Alabama, Arkansas, Georgia, and South Carolina have identified pondberry in areas that were previously unknown to have pondberry. The then-available data for these new discoveries as well as the previously known occurrences were analyzed and described in a 2007 Service Biological Opinion. In this Biological Opinion, the Service recognized the need for a biologically and ecologically meaningful definition of what constituted

a pondberry population. Indeed, both the listing document (51 FR 27495) and the recovery plan (Service 1993) apparently equated locations of individual pondberry colonies or clusters of plants/colonies with the term "population." Subsequently, Service (2007) adopted an interim definition proposed by Devall *et al*. (2002) based on long-distance flight distances of ground dwelling bees that pollinate pondberry. Under the interim definition, pondberry colonies are considered to be separate populations if they are separated by at least one mile. Using this definition, the Service estimated that there were actually 12 known populations at the time of listing, reducing Arkansas' populations from 9 to 5. In the Service's 2007 Biological Opinion, the use of this definition equated to 54 potential natural populations from Alabama (2), Arkansas (19), Georgia (7), Mississippi (16), Missouri (1), North Carolina (2), and South Carolina (7). No such treatment was performed on the populations recognized in the recovery plan. Detailed information on these populations, including estimates of population sizes, locations, management, and habitats are provided in the Service's (2007) Biological Opinion.

Because of the clonal nature of pondberry, individual populations can be thought of in terms of both genetically distinct individuals (genets) and clones (ramets). Genets are often composed of numerous ramets (clonal stems). As such, population sizes in terms of stem counts overestimate the actual population in terms of genets (Tepedino 2012). For example, Echt *et al*. (2011) sampled 1876 stems across 14 pondberry sites range-wide and found only 450 unique genets. Challenges with using stem/ramet counts to assess populations, as well as visual estimates of number of genets are illustrated below under the description of Georgia's pondberry populations.

The interim population definition adopted by the Service (2007), described above, was used to evaluate the status of pondberry for this review. Currently, there are 61 extant natural pondberry populations in Alabama (1), Arkansas/Missouri (17), Georgia (13), Mississippi (16), North Carolina (2), and South Carolina (12) (Tables 1 and 2, Figure 1).

Specific information on several extant pondberry populations was not available for review and inclusion in the Service's 2007 Biological Opinion. Available information on these populations has been reviewed and included below, as have data on new discoveries since completion of the 2007 Biological Opinion.

State Population Summaries

Alabama

Pondberry was rediscovered in Alabama along pond margins at two sites in Covington County in 2004 (Schotz 2005). One site has approximately 350 stems, while the other has several thousand stems (Schotz 2005; Service 2007; Alabama Natural Heritage Program 2012). Together, these sites represent one population. Both ponds/sites are owned by a timber company, and at least one

site is threatened by intensive pine plantation management (Service 2007). Neither of these sites is currently protected. Subsequent surveys of 41 sites with potential pondberry habitat in Barbour, Clarke, Coosa, Covington, Dallas, Escambia, Henry, Houston, Russell, and Wilcox Counties did not result in additional pondberry colonies (Schotz 2010).

Arkansas

Currently, Arkansas has approximately 17 populations in eight counties. These counties include Clay (3), Craighead and Poinsett (1; extending across the county boundary), Crittenden (1), Jackson (9), Lawrence (2), and Woodruff (1). Three of these populations are protected or partially protected on State-owned lands.

Most (15) of the state's extant pondberry populations are associated with sand ponds. Sand pond populations are found in Clay (3), Jackson, (9), Lawrence (2), and Woodruff (1) Counties. Of these sand pond populations, only 2 are protected, both of which are owned and managed by the Arkansas Natural Heritage Commission and are designated as state Natural Areas. Swifton Sand Ponds Natural Area is a 60 acre preserve established in 2008 in Jackson County and protects a portion of the state's largest sand pond population along Highway 67 (Arkansas Natural Heritage Commission 2012b; Service 2007). The second largest sand pond population (Service 2007), Clay County's Stateline Sand Ponds Natural Area (140 acres) has been protected since 1994 (Arkansas Natural Heritage Commission 2012b). Furthermore, this population was likely historically part of a larger population extending across the state's border with Missouri (Service 2007). A 2009 ice storm damaged pondberry plants within the Stateline Sand Ponds Natural Area (Baker 2012, *in litt.*), but the extent of the damage and population impact is unknown. All other populations are privately owned and are threatened by clearing and conversion to agriculture. Fragmentation and conversion of the surrounding lands also has the potential to disrupt local hydrological regimes and limit seed dispersal. Furthermore, these sand ponds no longer receive protections under section 404 of the Clean Water Act (Service 2007). Clearing and logging activities have extirpated eight sand pond sites in Clay County, resulting in loss of 2 populations and portions of 2 other populations (one of which has been split into two smaller populations). Similarly, these activities have extirpated 7 occurrences in Jackson County, resulting in the loss of 3 populations and portions of 4 others (including one population that extended into Lawrence County) (Service 2007; Arkansas Natural Heritage Commission 2012a). Limited plant/colony count information is available for these sand ponds. Using available data from the Arkansas Natural Heritage Commission and elsewhere, Service (2007) estimated that sand ponds together support nearly 6,800 stems/plants.

The largest pondberry population in Arkansas—and possibly the largest range-wide population (Vanderpool *et al*. 2004)—is located within

bottomland hardwood forests associated with the St. Francis River in Craighead and Poinsett Counties. This area is part of the St. Francis Sunken Lands Wildlife Management Area, which consists of mixed ownership (state, private, and U.S. Army Corps of Engineers), and is regularly flooded by the U.S. Army Corps of Engineers as part of its operations of the St. Francis River floodway (Service 2007; Witsell and Baker 2011; Arkansas Natural Heritage Commission 2012a). Pondberry is found on over 1,500 acres of St. Francis Sunken Lands' Hatchie Coon Island (Baker and Witsell 2012). Exact counts of this population are not available, but Service (2007) estimated the population to be more than 20,000 plants/stems. Additional searches since the 2007 BO within the St. Francis Sunken Lands have discovered new colonies of pondberry, thereby expanding the size and extent of this population (Witsell and Baker 2011; Baker and Witsell 2012). A portion of this population is protected on the 80 acre state-owned St. Francis Sunken Lands Natural Area that was established in 2009. Baker and Witsell (2012) describe this Natural Area as having "[t]housands of stems in hundreds of colonies" (pp. 13).

Arkansas Natural Heritage Commission staff discovered a small pondberry population consisting of several clones during September 2012 in Crittenden County on Wapanocca National Wildlife Refuge (Peterson 2012a, pers. com.), which is owned and managed by the Service. Follow-up surveys in November 2012 located two additional clones near the original colonies (Peterson 2012b, *in litt.*). Future surveys of this site and other potential habitats on the Refuge are planned.

One small (10-25 plants) population of questionable status occurs in a lowland sand prairie in Ashley County within the Coffee Prairie Natural Area, which is a 56 acre preserve that has been State-owned and protected since 1991. This site is co-managed by both the Arkansas Natural Heritage Commission and Arkansas Game and Fish Commission (Service 2007; Arkansas Natural Heritage Commission 2012b). Plants were not relocated during surveys in 2010 and 2011 (Witsell and Baker 2011; Baker and Witsell 2012) and this population is considered extirpated.

Searches of potential habitat in Felsenthal National Wildlife Refuge, Beryl Anthony Lower Ouachita Wildlife Management Area, Felsenthal West Preserve, and private properties in Ashley and Union Counties did not locate any new pondberry populations (Witsell and Baker 2011; Baker and Witsell 2012).

Florida

As noted in pondberry's recovery plan (Service 1993), the species has not been found in Florida since the original collections by A.J. Chapman in the mid-1880s. Additional searches for pondberry since the recovery plan was written have been unsuccessful (e.g., Surdick and Jenkins 2010).

Georgia

Information from Carter (2010) and Patrick (2012, *in litt.*) indicate that Georgia supports approximately 13 extant pondberry populations in seven counties: Baker (2), Calhoun (3), Effingham (1), Miller (2), Taylor (1), Wheeler (2), and Worth (2). Combined, these populations represent at least 7,200 ramets/stems (Carter 2010; Wiggers 2012, unpub. data). In addition, based on visual observations, Carter (2010) estimated there to be only 87 genets among these populations. This latter estimate is likely an underestimate, given that Echt *et al*. (2011) identified 26 genets from 60 stems sampled from the Taylor County population, which is about 0.43 genets per stem counted. However, for other populations sampled in Alabama and the Carolinas by Echt *et al.* (2011), this ratio of genets to stems ranges from 0.04 (in Covington County, Alabama) to 0.31 (in Cumberland County, North Carolina). Together, this information indicates that Carter's (2010) estimate of genets is likely an underestimate for the state, but the magnitude of this underestimate remains uncertain. Clearly, more work remains to be done to better establish a relationship between stem/ramet counts and genets throughout pondberry's range in order to more thoroughly and accurately address population statuses and trends.

Effingham County's population consists of three ponds that are within one mile of each other, while the remaining 12 populations are associated with one pond each. In addition, one population associated with a sinkhole in Wheeler County has been destroyed (Patrick 2012, *in litt.*), likely by hog and cattle disturbance (Service 2007), while recent searches by Carter (2010) have failed to relocate two populations in Calhoun and Worth Counties and a portion of another population in Effingham County.

All of Georgia's pondberry populations are associated with geographically isolated wetlands that have been variously described as depressions, ponds, cypress domes, sinkholes, sandhill ponds, and bogs (Service 2007). Small population sizes, conversion, adjacent upland management activities, and fire exclusion threaten many of these populations (Service 2007; Carter 2010).

Four populations receive some level of protection in Georgia (Service 2007; Carter 2010; Moffett 2012b, *in litt.*). One population of approximately 1,000 stems is found on the Joseph W. Jones Ecological Research Center in Baker County. The Service's 2007 Biological Opinion stated that the Nature Conservancy protects a small population in Wheeler County (estimated at 200 stems/plants), but follow-up communication with staff of the Nature Conservancy have noted that this is in error and the property remains unprotected (Hodges 2013, pers. comm.). The remaining three populations are found on properties owned and managed by the Georgia Department of Natural Resources and include two populations on Mayhaw Wilderness Management Area in Miller County and one population on Fall Line Sandhills Natural Area in Taylor County.

Louisiana

Pondberry is historically known from Louisiana. Recent searches have failed to locate pondberry populations within the State (e.g., Gulf Coast Biological Surveys, Inc. 2003).

Mississippi

Sixteen extant pondberry populations, estimated to total at least 44,000 stems/plants (Service 2007), occur in Mississippi, all of which are associated with bottomland hardwood forests within the Mississippi Alluvial Plain. Extensive searches by U.S. Forest Service personnel and affiliates have located a number of colonies of pondberry within the Delta National Forest in Sharkey County. Together, these Delta National Forest plants/colonies account for 13 of the state's pondberry populations and Service (2007) estimated at least 35,000 stems/plants. The U.S. Forest Service avoids adverse ground disturbing activities to these plants/colonies during forest management (Banker and Goetz 1989; Bowker 1989, *in litt*.). However, despite these management activities, some pondberry colonies have become extirpated on the Forest, while others have experienced recent declines, potentially related to stem dieback, hydrology, interspecific plant competition, and natural canopy disturbances (Gulf South Research Corporation 2005; Service 2007). Devall (2013, *in litt.*) suggests that some apparent declines may be related to clonal stems (ramets) dying back within monitoring plots, while new clones grow outside the plots. In this way, the colonies effectively "move" out of the monitoring plots. Additional monitoring is needed to more adequately quantify and understand pondberry's long-term colony and population dynamics.

Bolivar County is home to two pondberry populations. Both populations are located on privately owned property surrounded by agricultural fields. The largest of these populations consists of an estimated 20,000 stems/plants, but has apparently experienced declines in recent years (Service 2007). Approximately 25% of this population is protected by a conservation easement. Despite such protection, this population appears to have declined in recent years, the reasons of which are not clear, but may be related to natural stem dieback or adjacent agricultural practices (e.g., growing season flooding, pesticides). The smaller Bolivar County population is approximately 500 stems/plants and may be threatened by excessive flooding during the growing season from adjacent rice production. Alternatively, agriculturally related flooding of these two populations also has the potential to maintain favorable hydrological conditions (Service 2007).

Sunflower County has a small, privately owned population consisting of approximately 1,500 stems/plants at two sites. Pondberry colonies are located near agricultural lands in small wooded patches along a drainage ditch. Similar to the Bolivar County populations, this population is vulnerable to

adjacent agricultural practices, including excessive growing season flooding of rice fields and pesticide application (Service 2007).

One putative population of pondberry was discovered by a private contractor on privately owned property in Tallahatchie County during 1993 (Huffstatler 1993, *in litt*.; Service 1997). This population consisted of six inconspicuous plants in an apparently infrequently flooded forested area and was associated with the more common *Lindera benzoin* (spicebush) (Service 1997). U.S. Fish and Wildlife Service's Will McDearman (2013, pers. comm.), who has visited this population and prepared the Service's 2007 Yazoo Backwater Reformulation Project Biological Opinion (see Service 2007), contends that these plants were actually atypical *L. benzoin* that were misidentified as *L. melissifolia*. Accordingly, this site was not considered in the final Biological Opinion of the Yazoo Backwater Reformulation Project by the Service (2007). Review of recent aerial imagery from the National Agriculture Imagery Program (Natural Resources Conservation Service 2012) of this site indicates that the forest has been cleared and converted to row crop agriculture.

No pondberry populations were discovered during 2006 and 2007 surveys of potential habitat in Panther Swamp National Wildlife Refuge in Yazoo County (Leonard 2010).

Missouri

Missouri has one population along the Arkansas–Missouri state border in Ripley County. Part of these plants/colonies in Missouri occur on Sand Ponds Natural Area, which is owned and managed by the Missouri Department of Conservation (Service 2007; Farrington 2012a, *in litt.*), while The Nature Conservancy owns adjacent land with additional plants/colonies (Farrington 2012a, *in litt.*). These plants/colonies and the nearby Stateline Sands Ponds Natural Area pondberry plants/colonies in Clay County, Arkansas, are considered to be part of the same population (Service 2007). These plants/colonies are located on at least 5 sand ponds/sites and collectively represent at least 5,000 plants (Service 2007; Missouri Natural Heritage Program 2012). A 2009 ice storm damaged Sand Ponds Conservation Area, opening the overstory canopy and apparently increasing growth of competing vegetation, such as vines of *Smilax* spp. (Farrington 2011, *in litt.*, 2012a, *in litt.*, 2012b). Such increases in competition were apparently limited to drier sites as Farrington (2011) noted pondberry plants thriving at another site with similar overstory canopy damage and standing water. Farrington (2011) suggested that seasonal flooding may reduce competing vegetation.

North Carolina

North Carolina has two extant pondberry populations in Cumberland and Sampson Counties, both of which are protected by the State. Sampson

County's population at Pondberry Bay Plant Conservation Preserve is owned and managed by the state of North Carolina's Plant Conservation Program. No recent complete population counts or estimates are currently available for this population, although there were approximately 1,200 plants in 1991 (North Carolina Natural Heritage Program 2012). Krings (2010) suggested that a drainage ditch near this pondberry population may be diverting water away from its associated wetland.

Big Pond Bay Plant Conservation Preserve in Cumberland County is also owned and managed by North Carolina's Plant Conservation Program. A portion of this population extends onto adjacent privately owned property. No recent complete population counts or estimates are currently available for this population, although there were approximately 4,000 to 5,000 plants in 1992 (Service 2007; North Carolina Natural Heritage Program 2012).

A population on Marine Corps Base Camp Lejeune, Onslow County, has not been relocated despite repeated searches since its discovery in 2003. The current size and status of this population is unknown. Repeated searches have failed to relocate a small (50-60 plants in 1983) pondberry population on privately-owned land in Bladen County. This site has become overgrown with competing vegetation and may also have been adversely affected by drainage ditches for increased timber production. This population is considered to be extirpated (Service 2007; North Carolina Natural Heritage Program 2012).

South Carolina

Currently, 12 natural pondberry populations are known to occur in 5 of the State's counties. Aiken County is home to 1 pondberry population on the U.S. Department of Energy's Savannah River Site. Beaufort County's 2 populations are located on the U.S. Marine Corps Air Base (1) and on privately owned land (1). Berkley County has 5 pondberry populations, all of which are on the Francis Marion National Forest. Dorchester County has 1 population on privately owned land. Marion County has and 3 populations, all of which are on the Woodbury Heritage Preserve. Stem counts and estimates indicate that South Carolina's statewide population is at least 72,000 plants/stems (Service 2007; South Carolina Heritage Trust 2011, 2012; Beckley 2012b, *in litt*.; Caldwell 2012, *in litt.*).

Marion County's three pondberry populations were recently discovered in 2009-2012 on the Woodbury Heritage Preserve and are associated with depressional ponds and the swamp forests. The Preserve is part of the greater Woodbury Wilderness Management Area and is owned and managed by South Carolina's Department of Natural Resources (South Carolina Heritage Trust 2011, 2012; Beckley 2012b, *in litt.*). Pondberry receives conservation considerations under sections 7 and 9 of the Endangered Species Act and resource management plans in Francis Marion National Forest, the Marine

Corps Air Station, and the Savannah River Site (U.S. Department of Energy 2005; Service 2007).

Encroachment of competing species, fire suppression, and inadequate fire regimes are persistent threats to pondberry populations in South Carolina (Glitzenstein and Streng 2004; Service 2007; Beckley 2012a, *in litt.*, 2012b, *in litt.*; Pittman 2012, *in litt.*). Hog disturbance may also threaten some populations in the State (Gustafson 2011; Pittman 2012, *in litt*.). Laurel wilt disease is also an emerging threat to these populations (Beckley 2012a, *in litt.*, 2012b, *in litt.*). Two large pondberry populations on the Francis Marion National Forest have experienced substantial declines in recent years that may be related to encroachment of competing vegetation due to fire exclusion (Glitzenstein and Streng 2004; Service 2007; U.S. Forest Service 2010; Mackie 2011, *in litt.*). One of these sites, the Honey Hill population may be negatively affected by altered hydrological regimes (Beckley 2012b, *in litt.*; Mackie 2012, *in litt.*).

Tennessee

Unsuccessful searches for pondberry were conducted in western Tennessee in 2007 by Tennessee Division of Natural Areas staff (Crabtree 2008). Crabtree (2012, *in litt*.) notes that additional searches in western Tennessee are warranted.

Demography

There are no detailed studies characterizing pondberry demography by size-stage or age dynamics, including survival rates, population rates of growth, and the factors affecting dynamics and rates in different environments. Colonies/populations often exhibit male biased sex ratios (e.g., Wright 1989; Devall *et al*. 2001; Vanderpool *et al*. 2004; Carter 2010; Echt *et al*. 2011; Gustafson 2011, 2012, *in litt.*; Unks 2011; Devall 2012) and many are unisexual (e.g., Wright 1989, 1994; Gustafson 2012, *in litt.*; Devall 2012). Net changes by general monitoring and observations of various colonies and sites indicate pondberry is not normally subject to large annual fluctuations in colony or population size in the absence of land use changes.

Pondberry experiences periodic episodes of stem dieback, whether by natural senescence or by fungal pathogens, so that an individual shrub rarely appears to live or persist for more than 10 years (e.g., Godt and Hamrick 1996; Devall *et al*. 2001). However, pondberry apparently is long-lived as genetic individuals (genets) in stable environments because of clonal growth following dieback from stolons and the production of new stems/shoots from adventitious meristems at or near the base of a surviving stem segment on the ground. An individual shrub may die, but the genet continues to exist by virtue of vegetative reproduction (Service 2007).

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

Genetic diversity in pondberry, assessed by allozymes, is low within and between pondberry populations, relative to that observed in other flowering woody plant species (Godt and Hamrick 1996). This is in part due to the restricted range and rarity of the species. It also reflects infrequent sexual reproduction resulting in successful production of fruits, seeds, and, ultimately, seedlings. Populations sampled by Godt and Hamrick (1996) represented from one to 18 genetically different clones (genets). Echt *et al*. (2011) detected much greater levels of genetic diversity using DNA microsatellites. Nevertheless, Echt *et al*. (2011) also found that colonies or clumps of plants mostly represented a single individual. This observation suggests that stem counts alone are inadequate estimates of population size for pondberry. In addition, neither study found evidence for inbreeding depression in the pondberry colonies sampled.

Of the 15 pondberry sites sampled, Godt and Hamrick (1996) identified two pondberry sites within the Delta National Forest of Mississippi as having the greatest genetic diversity, whereas sites in Baker County, Georgia and another in the Francis Marion National Forest in South Carolina had the lowest genetic diversity. Other sites in the Francis Marion National Forest, however, had moderate to high levels of diversity.

Echt *et al*. (2011) sampled 14 sites across pondberry's range and found that local populations could be grouped into larger eastern (Alabama, Georgia, North Carolina, and South Carolina) and western (Arkansas and Mississippi) populations. Missouri's inclusion in the western population is implied by its close proximity to sampling sites in Arkansas' Stateline Sand Ponds Natural Area. Diversity was highest in the Delta National Forest (Mississippi) and Francis Marion National Forest (South Carolina), while it was lowest in Stateline Sand Ponds Natural Area (Arkansas) and Taylor County, Georgia. Generally, there are greater genetic differences among eastern populations than among western populations.

Echt (2012) suggested that the observed patterns of differentiation between pondberry populations coupled with published paleoclimatic and phylogeographic models of forest types suggest that pondberry could have survived the last ice age in the northern Gulf and north Florida region. As the glaciers receded, pondberry likely migrated northeast along the Atlantic Coastal Plain, north into the Southeastern Plains and west along the Gulf Coastal Plain with continued migration north along the Mississippi Alluvial Valley (Echt *et al*. 2011). The northernmost pondberry population, in the Stateline Sand Ponds Natural Area, currently has the lowest genetic diversity and highest fixation index (which indicates the degree of genetic differentiation between populations), which is consistent with it being a leading edge population of a colonization front (Echt *et al*. 2011).

d. Taxonomic classification or changes in nomenclature:

The taxonomy of *Lindera melissifolia* was reviewed by the Service for both the listing document (51 FR 27495) and recovery plan (Service 1993), and is currently recognized as an accepted taxon by the Integrated Taxonomic Information System (2012) and Flora of North America (van der Werff 1997).

e. Spatial distribution, trends in spatial distribution, or historic range:

As described above, extant pondberry populations were known from Arkansas, Georgia, Mississippi, Missouri, North Carolina, and South Carolina when the species was listed. Historic records indicated that pondberry also occurred in Alabama, Florida, and Louisiana, although the species had not been found in recent years. Since listing, deliberate searches and fortuitous discoveries have identified new colonies and populations of pondberry in Arkansas, Georgia, Mississippi, Missouri, North Carolina, and South Carolina. In addition, the species was rediscovered in Alabama, although not in the same county as was historically known (i.e., Covington County rather than Wilcox County; Schotz 2005, 2010). However, searches have not relocated pondberry in either Florida (e.g., Surdick and Jenkins 2010) or Louisiana (e.g., Gulf Coast Biological Surveys, Inc. 2003).

f. Habitat or ecosystem conditions:

Pondberry is found within seasonally flooded wetlands that broadly include riverine bottomland hardwood forests and geographically isolated wetlands in the Atlantic and Gulf Coastal Plains and Mississippi Alluvial Valley of the southeastern United States. Four primary types of geographically isolated wetlands are known to support pondberry populations and include Carolina bays, limestone or limesink ponds, sand ponds, and lowland sand prairie depressions. Hydrology at these geographically isolated wetlands is typically maintained by precipitation, although some may be fed in part by groundwater. In contrast, hydrology at bottomland hardwood sites is maintained by overbank flooding, local rainfall, storage in depressions or at sites with soils that impede drainage independent of overbank flooding, or a combination of the previous two factors. Extant pondberry sites in Carolina bays occur in North Carolina and South Carolina; sites in limesink and related depressions are in South Carolina, Georgia, and Alabama; sand ponds are in northern Arkansas; sand prairie depressions are in southern Arkansas; and bottomland hardwoods occur in Arkansas and Mississippi (Service 2007). Detailed descriptions of these wetland types, along with descriptions of their geological origins and characteristic species, are found in the Service's (2007) Biological Opinion.

Canopy and subcanopy composition of bottomland forests associated with pondberry populations in Mississippi, Arkansas, and Missouri were studied by Hawkins *et al*. (2009b). Pondberry distribution was not associated with mean tree density or diameter at breast height. Similarly, no single indicator tree species could be identified, but, the authors did note that pondberry tended to be more associated with flood tolerant tree species than flood intolerant species.

Vascular plants associated with pondberry colonies in bottomland hardwood forests of Mississippi were studied by Hawkins *et al*. (2010). The authors found 69 species growing within 1 meter (≈39 inches) of pondberry colonies at their study sites in Bolivar and Sharkey Counties. Of these species, nine were identified as having weedy characteristics while eight species of vines (five *Smilax* spp. and three *Vitis* spp.) were identified that could strongly compete with pondberry for light. Additionally, Unks (2011) identified approximately 25 plants co-occurring with pondberry in a North Carolina bay.

Beckley (2012a, *in litt.*, 2012b, *in litt.*) characterized pondberry habitats within the Southeastern Coastal Plain (which encompasses portions of the Gulf and Atlantic Coastal Plains). This information was used to create a predictive habitat suitability model for pondberry that led to the discovery of new pondberry sites in the Francis Marion National Forest and Woodbury Wilderness Management Area in South Carolina.

g. Other:

Propagation and Population Establishment

A variety of techniques have been studied to propagate and transplant pondberry, including: stem cuttings (e.g., Aleric 2005), transplanting naturally rooted stems (e.g., Devall *et al*. 2001, 2004a), transplanting seedlings (e.g., Wright 1989, 1994; Smith 2003), direct planting of seeds (e.g., Wright 1989; Smith 2003), and cloning from cell cultures (e.g., Hawkins *et al*. 2007). However, attempts to transplant pondberry and establish new populations have met with limited success in Arkansas, Georgia, Mississippi, Missouri, and North Carolina.

In Arkansas, pondberry seeds sown into an upland forest exhibited only 5% germination after two years (Wright 1989), likely because the habitat was not suitable for this species. In another experiment, Wright (1989) germinated pondberry seeds in a greenhouse and transplanted the seedlings to a pond in Arkansas with a naturally occurring pondberry population. After one growing season, most seedlings planted in wetter locations had survived (Wright 1989), but less than 5% of all seedlings had survived by the end of the third growing season (Wright 1994).

As noted in the recovery plan (Service 1993), pondberry plants were transplanted from a threatened site in Wheeler County, Georgia to Ocmulgee State Park, also in Wheeler County. However, these transplants did not survive (Patrick 2012, *in litt.*). Patrick (2012, *in litt.*) and Moffett (2012b, *in litt.*) noted that plants have been transplanted to Ohoopee Dunes Natural Area in Emanuel County, Georgia. Other sites in Georgia are currently being assessed for their suitability to establish pondberry colonies (Moffett 2012b, *in litt.*). Transplanting rooted cuttings from North Carolina to four ponds in Baker County, Georgia resulted in 25% survival after nearly one year, possibly due to lengthy submergence during the wet season (Aleric 2005).

In Mississippi, experimental outplantings of naturally rooted pondberry stems were established at Leroy Percy State Park and Yazoo National Wildlife Refuge in Washington County as well as Hillside and Morgan Brake National Wildlife Refuges in Holmes County (Devall *et al*. 2004a). Survival one year after transplanting ranged from 35% to 84%. The current status of these transplants is unknown. In addition, plants cloned from populations in Sharkey and Bolivar Counties, Mississippi using micropropagation techniques (cf. Hawkins *et al*. 2007) were successfully transplanted to a research facility in Sharkey County (cf. Lockhart *et al*. 2006). This site is essentially a garden plot and well-maintained. It is unknown how these clones would perform in the wild.

The Missouri Department of Conservation attempted to establish experimental colonies in the Sand Ponds Conservation Area in 1993, but have had limited success (Smith 2003; Farrington 2011, 2012b). Another attempt at establishing a population was made in neighboring Butler County on Corkwood Conservation Area, but was unsuccessful (Service 2007; Farrington 2011, 2012a, *in litt.*).

In North Carolina, a small colony of 30 individuals was established along the margin of a Carolina bay wetland in Sampson County during 1995, only three of which had survived until 2006 (North Carolina Natural Heritage Program 2012). No recent information is available regarding the current status of this site.

Pondberry was transplanted to two sites in Berkley County, South Carolina on the Francis Marion National Forest in 1992. Both sites had surviving plants during recent monitoring efforts (Glitzenstein 2007; U.S. Forest Service 2010).

Safeguarding Efforts

Cuttings from Alabama's Covington County population have been collected and are being maintained at the Atlanta Botanical Garden in Atlanta, Georgia and Auburn University's Davis Arboretum in Auburn, Alabama (Alabama Plant Conservation Alliance 2012). Similar efforts are being undertaken in Georgia where the Georgia Plant Conservation Alliance has partnered with the Atlanta Botanical Garden and the State Botanical Garden in Athens, Georgia to safeguard pondberry (Moffett 2012a, *in litt*., 2012b, *in litt*.). Pondberry from seven populations are represented in these live plant holdings with more collections planned. These future seed collections will focus on populations that have been affected by laurel wilt disease (Moffett 2012b, *in litt*.). A collection of pondberry plants are also maintained at the Mercer Arboretum and Botanic Gardens in Humble, Texas as part of the Center for Plant Conservation's National Collection of Imperiled Plants (Center for Plant Conservation 2010). Factors affecting seed storage of pondberry have been studied by Connor *et al*. (2007).

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

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

Altered Hydrological Regimes

Altered hydrological regimes have likely contributed to the decline or extirpation of some pondberry colonies/populations. Large flood control projects within the Mississippi Alluvial Valley have likely contributed to the decline of pondberry populations within bottomland hardwood forests of this area, particularly within the Big Sunflower River and Yazoo River drainages of Mississippi (Service 2007). Smaller, more isolated hydrological alterations have also contributed to the decline and extirpation of some populations. For example, drainage ditches or a lowered water table may have contributed to the extirpation of the pondberry population in Bladen County, North Carolina (Service 2007). Similarly, declines at the Honey Hill population in the Francis Marion National forest may be influenced by altered hydrological regimes due to nearby development (Beckley 2012b, *in litt*.; Mackie 2012, *in litt*.). Furthermore, disruption of natural flooding regimes may promote the growth of vegetation that can outcompete pondberry (Glitzenstein and Streng 2004; Farrington 2011; Lockhart *et al*. 2013).

Runoff from agricultural fields during the growing season may stress plants, leading to colony/population decline or, more severely, extirpation, as may be the case for populations in Bolivar and Sunflower Counties, Mississippi and for a number of sand pond colonies in Arkansas. Alternatively, agricultural flooding may benefit some populations by increasing available water that has been reduced by local drainage ditching or larger flood control projects. One such site is a large population in Bolivar County, Mississippi, which had its natural hydrological regime altered by flood control projects and is now periodically exposed to runoff from neighboring rice fields that may keep this population artificially high compared with natural flood regimes. Additionally, flood control projects may help to maintain favorable habitat in the St. Francis Sunken Lands in Arkansas (Service 2007).

Destruction and Degradation of Habitat

Clearing, conversion, silvicultural activities, and agricultural activities remain persistent threats to pondberry colonies (Devall *et al*. 2001; Service 2007; NatureServe 2012). Clearing and conversion has recently destroyed populations in Arkansas (Arkansas Natural Heritage Program 2012a). Forestry (herbicide, excess sedimentation, logging, etc.) and agricultural practices (cattle grazing, ditching, growing season flooding, etc.) threaten or have recently destroyed pondberry sites in Alabama (Schotz 2005, 2010), Arkansas (Arkansas Natural Heritage Program 2012a), Georgia (Carter 2010), Mississippi (Service 2007), and North Carolina (Krings 2010; North Carolina Natural Heritage Program 2012). Habitat in South Carolina may also be degraded by encroachment of competing species due to incompatible fire regimes (Glitzenstein and Streng 2004; Service 2007; Beckley 2012b, *in litt*.; Pittman 2012, *in litt*.).

Fragmentation of Populations and Habitat

Many pondberry colonies and populations occur in isolation from one another and many suitable habitats are fragmented by agricultural fields or other converted lands (e.g., Service 1993, 2007; Devall *et al*. 2001; Beckley 2012a, 2012b, *in litt*.). Fragmentation of pondberry populations may increases the vulnerability of individual, small populations to succumb to a variety of deleterious biological and environmental factors, such as encroachment of invasive species and reduced sexual reproduction (Devall *et al*. 2001; Service 2007). No long-range animal seed disperser is known (Devall *et al*. 2004b; Smith *et al*. 2004) and no other potential long-range seed dispersal mechanism has been confirmed, although floodwaters may have played a role in the past (Devall *et al*. 2001). Furthermore, pondberry flowers are obligately insect-pollinated, requiring insects to transport pollen between male and female flowers for successful pollination and fruit production (Devall *et al*. 2001, Devall *et al*. 2004b). As distances between populations and suitable habitat increase, the likelihood of either pollinators or seed dispersers traversing these distances decreases, thus restricting gene flow between populations and limiting new colony establishment (Devall *et al*. 2001; Devall 2009; Echt *et al*. 2011).

Fire

Pondberry occurs in a variety of geographically isolated wetlands in the Atlantic and Gulf Coastal Plains (Service 1993, 2007; Beckley 2012a). Alterations to natural fire regimes may negatively impact some pondberry colonies by degrading habitats and killing plants. In the absence of fire, co-occurring vegetation has the potential to outcompete pondberry for resources, such as light (e.g., Glitzenstein and Streng 2004; Aleric and Kirkman 2005a). Alternatively, intense fires have the potential to kill pondberry plants (Unks 2011).

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

c. Disease or predation:

Laurel Wilt Disease

Laurel wilt disease has the potential to cause substantial mortality among members of the laurel family (Lauraceae)—which pondberry belongs to—in the southeastern United States. The disease, which is caused by the fungus *Raffaelea lauricola*, was first observed infecting redbay (*Persea borbonia*) in 2003 in South Carolina and Georgia, although its vector, the non-native redbay ambrosia beetle (*Xyleborus glabratus*), was first discovered in 2002 in Port Wentworth, Georgia (Fraedrich *et al*. 2008; Harrington *et al*. 2008; Mayfield *et al*. 2009). Since then, the disease has rapidly spread and has been confirmed in counties in Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina (Mayfield *et al*. 2009; U.S. Forest Service 2012). Of the counties where laurel wilt disease occurs,

six have extant natural pondberry populations (Effingham and Wheeler Counties, Georgia; Sampson County, North Carolina; and Beaufort, Berkley, Dorchester, and Marion Counties, South Carolina). One additional county, Georgia's Emanuel County, is home to a transplanted pondberry population.

Although laurel wilt-like symptoms have been found on pondberry plants in various counties in Georgia and South Carolina (e.g., Carter 2010; Fraedrich *et al*. 2011), laurel wilt disease has only been confirmed for pondberry plants in Effingham County, Georgia (Fraedrich *et al*. 2008; Fraedrich *et al*. 2011). While the effects of laurel wilt disease on pondberry populations are currently small, its potential impacts are great, as the disease is highly lethal to infected plants (Fraedrich *et al*. 2011). Pondberry plants typically have stem diameters smaller than those preferred by *X. glabratus*, thus potentially limiting laurel wilt disease's direct impact on pondberry (Fraedrich *et al*. 2011). However, as Fraedrich *et al*. (2008, 2011) note, even unsuccessful attacks of *X. glabratus* on small diameter stems may still infect plants with the laurel wilt pathogen, *R. lauricola*.

Laurel wilt disease has the potential to indirectly affect pondberry populations by disturbing (i.e., killing other Lauraceous species) this species' associated forested wetlands (Beckley 2012a). Indeed, Gramling (2010) noted that laurel wilt disease has been found infecting nine Lauraceous species, including pondberry. Furthermore, the potential for the disease to spread is significant as Lauraceous species are important components of 55 plant communities in the United States and Canada (Gramling 2010). The threat of laurel wilt disease may be minimized in pondberry populations where Lauraceous species, such as redbay are not prominent components of the plant community (Service 2007). However, in plant communities where Lauraceous species are prominent vegetational components, additional management measures may be required to limit the spread of laurel wilt disease to pondberry in these areas, such as removing redbay trees near pondberry colonies (Fraedrich *et al*. 2011, Beckley 2012a).

Stem Dieback

Pondberry periodically experiences stem dieback (Service 1993, 2007), which can be a natural feature of a mature or senescent plant (Godt and Hamrick 1996; Devall *et al*. 2001). Stem dieback at any plant age or size is also caused by the fungus *Botryosphaeria ribis* and exacerbated by the beetle *Xylosandrus compactus* (Wilson *et al*. 2004, 2005; Fraedrich *et al*. 2011). On larger plants with more branches, dieback can be partial, affecting one to several branches, and new growth continues from surviving branches. With more severe dieback, plants can form one or more new branches from the differentiation of adventitious meristems from the cambium on older surviving branch segments formed during previous years. With complete dieback, new branches sometimes form at the base of the plant, and in other instances the entire above ground plant dies. While the presence of dieback on any branch does not necessarily indicate that total dieback will occur, small plants appear to be more susceptible to complete dieback than

large ones (Service 2007). Female plants may be more susceptible to dieback than male plants (e.g., Taylor 2008).

Fruit, Seed, and Seedling Predation

Several animals have been identified as potential seed or seedling predators and include the northern cardinal (*Cardinalis cardinalis*), nine-banded armadillo (*Dasypus novemcintus*), and gray squirrel (*Sciurus carolinensis*), among others (Abilio *et al*. 2008; Leininger *et al*. 2009). Such depredation may reduce recruitment from sexual reproduction in pondberry populations, but the extent to which this may impact pondberry populations is unknown.

d. Inadequacy of existing regulatory mechanisms: Pondberry receives some protection in the states of Georgia, Missouri, and North Carolina; however, none of these laws provide protection against habitat destruction. Collection of pondberry plants on public lands without a permit is prohibited in Georgia under the Georgia Wildflower Preservation Act of 1973. No such provisions are afforded to plants found on privately owned lands in the State. Rule 3 CSR 10-4.111 of the Missouri Department of Conservation prohibits the exportation, transportation, or sale of pondberry and other state listed endangered species. North Carolina General Statute 106-202.12-202.19, also known as the Plant Protection and Conservation Act, authorizes the state to establish a list of protected plants and regulate the collection, sale, and transport of plants on this list. Pondberry is included on the state's list of protected plants. Pondberry does not receive any specific legal protections from state laws or regulations in Alabama, Arkansas, Mississippi, or South Carolina. As noted in the Service's (2007) Biological Opinion, pondberry populations occurring in geographically isolated wetlands no longer receive protections under section 404 of the Clean Water Act.

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

Small Population Sizes and Inbreeding Depression

Currently, no strong evidence for inbreeding depression has been found in pondberry populations (Godt and Hamrick 1996; Echt *et al*. 2011); however, small, isolated populations and those with sex ratios biased toward males increase the risk of inbreeding depression for some populations, particularly for those in pondberry's eastern range (Echt *et al*. 2011; Gustafson 2012, *in litt.*). Inbreeding depression or the low number of genetically different individuals (genets) in most or all eastern populations may reduce pondberry's ability to cope with environmental stochasticity, disease, and ultimately threaten the existence of these populations.

Climate Change

Climate change has the potential to affect distribution and abundance of plants by influencing seasonal weather patterns, frequency and timing of severe weather

events, and myriad plant physiological responses (Hawkins *et al*. 2008). The specific impacts of climate change to pondberry populations are poorly understood; however, a variety of impacts are possible. For example, climate change may threaten pondberry populations if the wetland habitats that the species relies on become drier (Devall 2009). Service (2007) noted that pondberry is susceptible to decline during drought cycles, especially in geographically isolated wetlands such as Carolina bays, limesinks, and related depressions in the Atlantic Coastal Plain, and the sand ponds of Arkansas and Missouri where the hydrology depends most directly on rainfall. In bottomland hardwood systems in Mississippi and Arkansas, the frequency and duration of overbank flooding at pondberry sites and populations also can vary depending on climatic conditions within local watersheds as well as regional climatic conditions in the Mississippi Valley (Service 2007). Additionally, climate change may exacerbate the spread of infectious diseases among plants, particularly if arthropod vectors become more widespread and abundant (Anderson *et al*. 2004, Garrett *et al*. 2006; Hawkins *et al*. 2008). Given the variety and complexity of climate change's potential effects (cf. Hawkins *et al*. 2008), more research is needed to assess its potential long-term impacts on pondberry populations and habitats.

Domestic Animal and Wildlife Disturbance

Trampling by domestic cattle (Service 1993; NatureServe 2012) and hog disturbance (Service 2007; Gustafson 2011; NatureServe 2012; Pittman 2012, *in litt.*) pose an apparently small risk to pondberry range-wide, but may pose a severe, highly localized threat to some colonies and populations (e.g., Service 1993).

D. Synthesis

Extensive searches throughout pondberry's historic range have resulted in discoveries of new colonies and populations, including the rediscovery of the species in Alabama. Currently, there are 61 extant, natural pondberry populations in Alabama, Arkansas, Georgia, Mississippi, Missouri, North Carolina, and South Carolina. However, while new colonies and populations have been discovered since the species was listed, others have become extirpated in Arkansas, Georgia, Mississippi, Missouri, North Carolina, and South Carolina. Still other pondberry populations are apparently declining in these states. Furthermore, repeated searches in recent years have failed to relocate one population in Arkansas, two populations and part of a third population in Georgia, and two populations in North Carolina. Furthermore, searches in Florida and Louisiana have not relocated pondberry in these states since their initial discoveries.

Thirteen populations and partial populations occur on State-owned or privately-owned lands and receive at least some protection from habitat destruction. An additional population on State-owned land in Arkansas was not relocated during recent searches. Another 22 populations occur on Federally-owned lands and receive conservation considerations via sections 7 and 9 of the Endangered Species Act. One population on Federally-owned land in North Carolina has not been found again since its discovery in

2003. The remaining populations occur on privately-owned land and are not known to be protected or managed.

Regardless of their ownership or current protection status, all populations are susceptible to the lethal laurel wilt disease, which has spread rapidly since its discovery in 2003 and is likely to continue spreading. Safeguarding efforts may provide some measure of protection from this disease, but these efforts are mixed and representative plant material from all populations and habitats has not been preserved.

Habitat destruction, fragmentation, altered hydrology, and encroaching vegetation remain persistent threats to pondberry colonies and populations. Geographically isolated wetlands that once sustained pondberry have been cleared for agriculture or timber operations. Similarly, agricultural and silvicultural activities adjacent to some pondberry sites have deleteriously affected these sites by altering hydrological regimes. Other sites have been extirpated by or are threatened by hogs or domestic cattle. Encroaching vegetation can reduce the suitability of some sites for pondberry.

Small populations—especially those with many fewer genets (genetically distinct individuals) than ramets (clonal stems)—fragmentation, and strongly biased sex ratios may increase the likelihood of developing inbreeding depression and reduce the ability of many populations to adapt to changing environments. This is particularly likely for small, isolated populations in the eastern portion of pondberry's range. Based on our threat evaluation, we believe this plant continues to meet the definition of an endangered species.

The lack of consistent monitoring of pondberry populations hampers our ability to evaluate recovery of this species. In particular, much of the monitoring data available equate "stems" and/or "clones" with "plants". In part, this can be attributed to the difficulties involved with monitoring clonal species, such as pondberry. Indeed, genetic studies indicate that individual genets may be composed of many ramets. As such, field identification of individual plants remains difficult or impossible in the field with current techniques. Another factor that makes current population estimates and monitoring data, is the lack of apparently consistent monitoring protocols with explicit definitions of the monitoring units to be quantified (e.g., stems, colonies). Furthermore, accurate assessments of population estimates and trends will require additional studies to determine ramet to genet ratios across pondberry's geographic range and habitats.

More work remains to be done to ensure the long-term survival of this species. Likewise, more information is required regarding effective population sizes of pondberry range-wide to better determine the long-term persistence of this species and restoration needs and potential of individual populations. Furthermore, defining what constitutes a self-sustaining pondberry population was listed as a recovery task in pondberry's recovery plan. Currently, an interim population definition based is being used. However, this interim definition has only been used to delimit populations and does not address the characteristics of "self-sustaining" pondberry populations. Ongoing ecological and genetic research will provide greater insight into the requirements of pondberry populations that can be considered "self-sustaining".

III. RESULTS

A. Recommended Classification:

__X__ No change is needed

B. New Recovery Priority Number: No change.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

- Further study and characterize potential threats posted by laurel wilt disease. Identify methods and management practices to limit this disease's potential to negatively impact pondberry and its associated habitats.
- Work with federal and state entities, non-governmental organizations, and private individuals to permanently protect and manage existing habitats and populations, including the development and implementation of management plans, as needed.
- Form recovery team to update the recovery plan, which will incorporate and address recent advances in our knowledge and understanding of pondberry genetics, physiology, ecology, threats, and management needs.
- Define what characterizes a "self-sustaining" pondberry population.
- Update existing and develop new monitoring and habitat management methods.
- Continue and expand conservation genetics work to include all populations and determine effective population sizes.
- Characterize genetic diversity and representation of current *ex situ* safeguarded collections. Expand *ex situ* preservation of genetic stock to represent all populations with increased emphasis placed on preserving and safeguarding individual genets within and across populations.
- Study the feasibility of and necessary methodology to augment genetically depauperate and sexually limited populations.
- Develop guidelines to efficiently establish plants and seedlings in natural habitats.
- Further study the effects of various types of disturbance (e.g., fire, prolonged flooding, overstory disturbance, etc.) on pondberry survivorship and reproduction.

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Table 1. Distribution of extant, naturally occurring pondberry populations.

Location (Pop. Count)	Counties (Pop. Count)
Alabama (1)	Covington (1)
Arkansas (17[1])	Clay (3[2]), Craighead (1[2]), Crittenden (1), Jackson (9), Lawrence (2), Poinsett (1[2]), Woodruff (1)
Georgia (13[1])	Baker (2), Calhoun (3), Effingham (1), Miller (2), Taylor (1), Wheeler (2), Worth (2)
Mississippi (16)	Bolivar (2), Sharkey (13), Sunflower (1)
Missouri (1)	Ripley (1[2])
North Carolina (2[1])	Cumberland (1), Sampson (1)
South Carolina (12)	Aiken (1), Beaufort (2), Berkley (5), Dorchester (1), Marion (3)
Total	**61**

Notes: [1]Recent surveys have failed to relocate some populations in these states (Ashley Co., AR; Calhoun, Effingham [partial population], and Worth Cos., GA; Bladen and Onslow, Cos., NC) and their current status is unknown, but may be extirpated. [2]Pondberry plants/colonies in Craighead and Poinsett Cos., AR are considered to be part of a single population, as are colonies on either side of the border between Clay Co., AR and Ripley Co., MO.

Table 2. Distribution of pondberry populations occurring on non-federally owned lands receiving some level of protection.

State	County	Site	Owner	Pop. Count
Arkansas[1]	Clay	Stateline Sand Ponds NA	State	1[2]
	Craighead/Poinsett	St. Francis Sunken Lands WMA & NA[3]	State	1
	Jackson	Swifton Sand Ponds NA	State	1
Georgia	Baker	Joseph W. Jones Ecological Research Center	Private	1
	Miller	Mayhaw WMA	State	2
	Taylor	Fall Line Sandhills NA	State	1
Mississippi	Bolivar	Conservation Easement	Private	1
Missouri	Ripley	Sand Ponds NA	State/Private	1[2]
North Carolina	Cumberland	Big Pond Bay PCP	State	1[5]
	Sampson	Pondberry Bay PCP	State	1
South Carolina	Marion	Woodbury Heritage Preserve	State	3
Total				**14**[2]

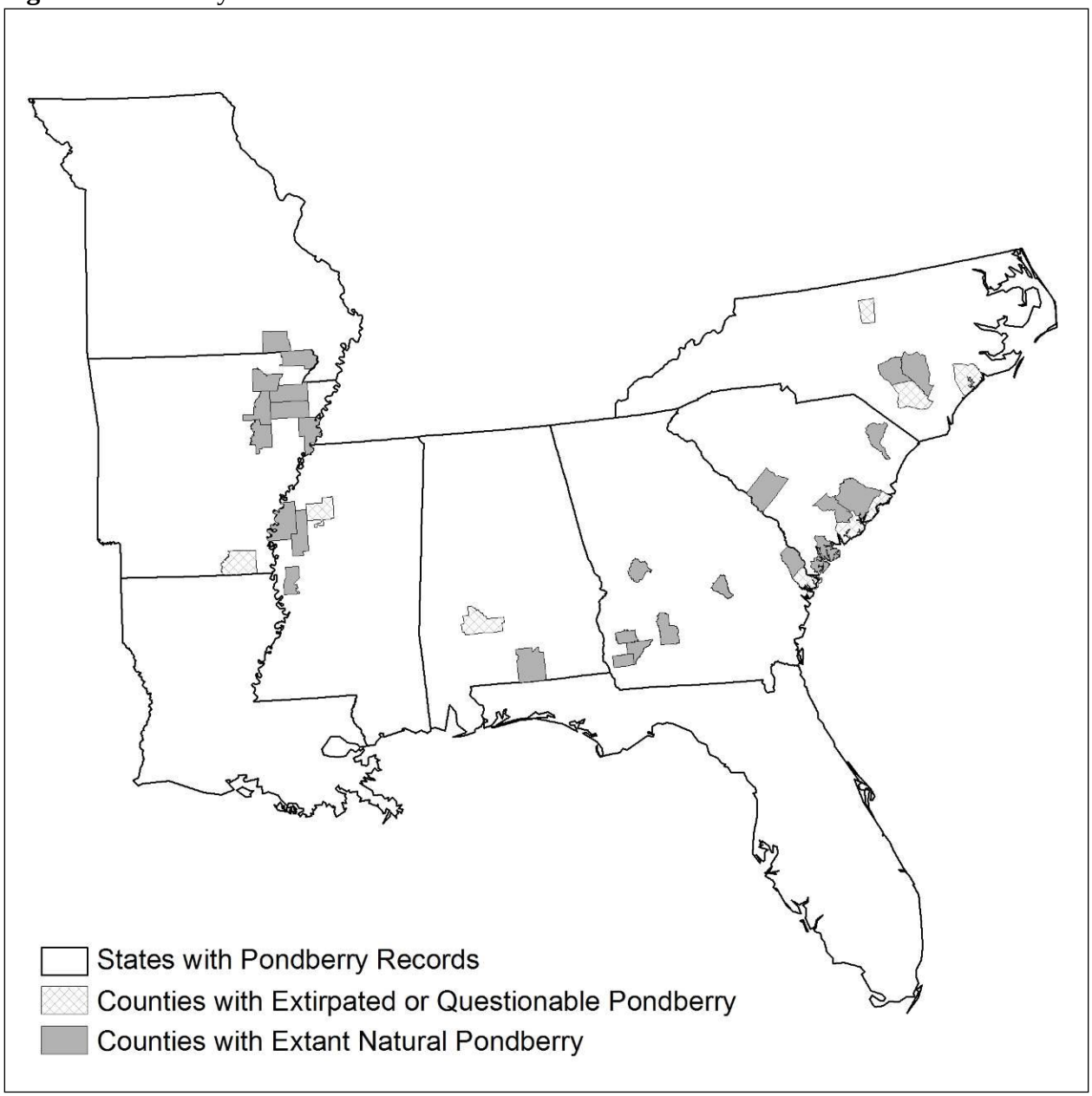
Notes: NA = Natural Area, NF = National Forest, NWR = National Wildlife Refuge, WMA = Wilderness Management Area, PCP = Plant Conservation Preserve. [1]Recent surveys have failed to relocate a population at Coffee Prairie NA in Ashley Co., AR, and this population is now considered to be extirpated. [2]Stateline Sand Ponds NA and Sand Ponds NA are considered to be part of one population extending across the AR–MO state line. [3]St. Francis Sunken Lands WMA is under mixed ownership (state, federal, and private) and extends across the county line between Craighead and Poinsett Cos., AR. St. Francis Sunken Lands NA is state owned property adjacent to the WMA in Poinsett Co.

Table 3. Distribution of pondberry populations occurring on federally owned and managed properties.

State	County	Site	Pop. Count
Arkansas	Craighead/Poinsett	St. Francis Sunken Lands	1[1]
	Crittenden	Wapanocca NWR	1
Mississippi	Sharkey	Delta NF	13
South Carolina	Aiken	Savannah River Site	1
	Beaufort	Marine Corps Air Station	1
	Berkley	Francis Marion NF	5
Total			**22**[2]

Notes: NF = National Forest, NWR = National Wildlife Refuge. [1]This is part of a single population extending onto state owned lands and is further described in Table 2, above. [2]One additional population on Marine Corps Base Camp Lejeune in Onslow Co., NC has not been seen since its initial discovery and its current status is unknown.

Figure 1. Pondberry distribution.



U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Pondberry (*Lindera melissifolia*)

Current Classification: Endangered.

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: Not applicable.

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

FIELD OFFICE APPROVAL:

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

Approve: _____ Date: 8/22/13

REGIONAL OFFICE APPROVAL:

for

Lead Regional Director, U.S. Fish and Wildlife Service, Region 4

Approve: _____ Date: 9-22-13

REGIONAL CONCURRENCE:

Cooperating Assistant Regional Director, U.S. Fish and Wildlife Service, Region 3

Concur: _____ Date: 3/5/14

Appendix A. Summary of peer review for the 5-year review of pondberry (*Lindera melissifolia*)

A. Peer Review Method: The Service conducted peer review. Four peer reviewers were selected by the Service for their knowledge of and expertise with pondberry. Individual responses were received from three of the peer reviewers.

Peer Reviewers: Dr. Margaret S. Devall, U.S. Department of Agriculture, Forest Service, Southern Research Station, Center for Bottomland Hardwood Research, Stoneville, MS; Dr. Craig Echt, U.S. Department of Agriculture, Forest Service, Southern Research Station, Saucier, MS; Mr. Tom Patrick, Georgia Department of Natural Resources, Nongame Conservation Section, Wildlife Resources Division, Social Circle, GA; Mr. Alfred Schotz, Alabama Natural Heritage Program, Auburn University, AL.

B. Peer Review Charge: See attached guidance.

C. Summary of Peer Review Comments:

Overall, peer reviewer comments by Dr. Margaret Devall, Dr. Craig Echt, and Mr. Alfred Schotz were supportive of the information and conclusions presented in this review. Mr. Tom Patrick did not provide comments. Drs. Craig Echt and Margaret Devall noted several grammatical and typographic errors, various sentences requiring revision for clarity, and citations that needed updates. Dr. Echt suggested revisions to sections addressing pondberry genetics. Drs. Echt and Devall suggested adding or revising recommended future actions. Dr. Echt also noted that *ex situ* safeguarding collections need to be representative of pondberry's genetic diversity and, in particular, ensuring adequate representation of unique genets within each population. Dr. Devall had several population-related questions/observations and suggested adding a table of pondberry populations occurring on Federally-owned lands.

D. Response to Peer Review: Comments and concerns received from peer reviewers were addressed and incorporated into this 5-year review as appropriate. Grammatical errors were corrected, various sentences were revised for clarity, and citations were updated throughout the document per reviewer comments. Dr. Echt's suggested revisions to sections addressing pondberry genetics were incorporated. Changes to the recommended future actions section were made following Drs. Echt's and Devall's suggestions. In particular, Dr. Echt's assertion about the need to protect unique genets from each population was emphasized as a recommended future action. Dr. Devall's comments/observations regarding specific pondberry populations were addressed in the updated 5-year review. In addition, a table listing the populations occurring on Federally-owned lands per Dr. Devall's suggestion was added.

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