Pondberry
(*Lindera melissifolia*)

5-Year Review:
Summary and Evaluation

Pondberry with mature fruits (left) and pondberry with flowers (right)
Photo Credit: USFWS

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U.S. Fish and Wildlife Service
South Atlantic–Gulf and Mississippi Basin Regions
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 to this species. We announced initiation of this review and requested information in a published Federal Register (FR) notice on June 19, 2019 (84 FR 28850). We did not receive public comments during the comment period. To acquire the most current information available, various sources were solicited, including data housed at the state conservation agencies and heritage programs, and knowledgeable individuals associated with federal and state agencies, academia, and non-governmental conservation organizations. Specific sources included the 2014 5-year review; 1993 recovery plan; 1986 final rule listing this species under the Endangered Species Act; biological opinions written pursuant to section 7(a)(2) of the Act; peer reviewed scientific publications; unpublished field observations by federal, state, and other experienced biologists; unpublished studies and survey reports; and notes and communications from other qualified individuals.

B. Reviewers

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C. Background

1. Federal Register Notice citation announcing initiation of this review

June 20, 2019 (84 FR 28850)

2. Listing history

Original Listing
Federal Register Notice: 51 FR 27495
Date Listed: July 31, 1986
Entity Listed: Species
Classification: Endangered

3. Associated rulemakings

None.

4. Review history

Each year, the U.S. Fish and Wildlife Service (Service) reviews and updates listed species' information for inclusion in the required Recovery Report to Congress. Through 2013, we conducted a recovery data call that included status recommendations such as "Stable, Decreasing, or Increasing" for this species. We continue to show species status recommendations as part of our 5-year reviews. The most recent recovery data review for pondberry was performed in 2020.

Recovery Plan: 1993

5-year Reviews:

November 6, 1991 (56 FR 56882) – In this review, multiple species were simultaneously evaluated with no species-specific, in-depth assessment of the five factors or threats as they pertained to each species' recovery. The notices summarily listed these species and stated that no changes in the designation of these species were warranted at that time, including no changes to the status of pondberry.

March 5, 2014 – This review noted pondberry's status as stable to declining, with populations in parts of the species' range being stable, while others were in apparent decline or were of unknown status. Likewise, while some populations were discovered in the years prior to completion of this review, other populations were extirpated. Threats from habitat destruction, altered hydrologic conditions, small population sizes, population fragmentation, biased sex ratios, and laurel wilt disease influenced the long-term viability of populations.

5. Species' Recovery Priority Number at start of review: 8C

Degree of Threat: Moderate
Recovery Potential: High
Taxonomy: Species

The "C" reflects a potential degree of conflict with construction or other development projects or other forms of economic activity, which are identified as conversion and modification of wetlands subject to Clean Water Act protections.

6. Recovery Plan

Pondberry has a final, approved 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 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?

_X_ Yes
____ No

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?

____ Yes
_X_ No

Rationale for the numbers of protected populations required for downlisting and delisting are not provided in the recovery plan. More information relevant to the biology and ecology of the species—including, genetics, physiology, reproductive ecology, and habitat needs—is now available than when the recovery plan was written. Despite this progress, more studies are needed to determine the minimum number of self-sustaining (viable), protected populations required to maintain adequate genetic diversity and continued survival of pondberry into the foreseeable future. This work is especially important given the emerging threat and rapid spread 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 (and is there no new information to consider regarding existing or new threats)?

____ Yes
_X_ 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 achieved.

Recovery Criteria: "*Lindera melissifolia* will be reclassified from endangered to threatened status when there are 15 protected, self-sustaining populations distributed throughout the species' historic range. The species will be considered for delisting when there are 25 protected, self-sustaining populations distributed throughout the species' historic range. A population is defined to be one or more colonies that are in close enough proximity to regularly interbreed and separated from other populations by a sufficient distance to preclude interbreeding on a regular basis. What constitutes a self-sustaining population and the specific geographical distribution required will be determined as recovery tasks." (Service 1993, p. 14)

Neither the downlisting (reclassification) or delisting criteria have 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.

Although 46 natural pondberry populations are known entirely or in part from conservation lands in 6 of the 7 states where extant populations occur and receive at least some protections, there is inadequate evidence to suggest that these populations meet the requirement of being self-sustaining. Of these populations, 39 are known from state and federally owned/managed lands, of which 25 have been confirmed extant by recent observations, while 14 have no known recent observations (1 of which may now be historical) and 4 may have recently been extirpated. An additional population known from state lands is no longer extant in the wild and exists only in cultivation off site. Finally, seven populations occur on private properties owned and managed by non-governmental conservation organizations and/or protected by conservation easements established under various mechanisms and authorities. Of these, only two have been confirmed extant in recent years, while five have no available recent observations and their statuses are uncertain. Overall, populations on conservation lands may be protected from outright habitat destruction, but do not necessarily receive adequate habitat management. Furthermore, inadequate and inconsistent monitoring of pondberry on conservation lands throughout its range limits assessment of these populations' current trends and long-term viability (i.e., self-sustaining populations). Finally, occurrence of plants on conservation lands does not preclude extirpations and population declines, as evidenced by the potential extirpation of four populations on federal lands in Mississippi and substantial population declines on federal lands in Mississippi and South Carolina, and state lands in Georgia.

Current recovery criteria do not address threats posed to pondberry by laurel wilt disease, which is highly lethal to infected pondberry plants. This disease is already found in counties throughout much of the species' range and is rapidly spreading. It is known to affect at least one pondberry population (in Effingham County, Georgia) and has potential to spread to any protected or unprotected populations and habitats where pondberry occurs. More details of this disease are covered in section II.C.2.c. herein and in Service 2014a.

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, continued ecological and genetic research will provide greater insight into the requirements of pondberry populations that can be considered self-sustaining.

C. Updated Information and Current Species Status

1. Biology and habitat

The Service's 2014 5-year review (Service 2014a) and 2007 Biological Opinion (Service 2007) present the most comprehensive overviews of the species' biology and habitat. Limited new information not included in these documents is presented herein.

a. Summary of new information of species biology and life history:

Recent research has explored pondberry's responses to light and flooding, building on earlier research (summarized in Service 2014a). For example, extremely low light availability (5% light) can reduce pondberry's photosynthetic rate, as can extended flooding (90 days or more) (Lockhart *et al.* 2017). Lockhart *et al.* (2017) also noted that pondberry's photosynthetic function declined under flooded conditions, particularly for plants in higher light environments, but plants were able to rapidly recover photosynthetic function when flooded conditions were removed. The authors further suggested that this rapid recovery of photosynthetic function may offer some competitive advantage over other species that are unable to recover as quickly. Hawkins *et al.* (2019) further suggested that reductions in photosynthetic rates under extended flooding conditions, however, may result in reduced growth of pondberry plants. In addition, Lockhart *et al.* (2018) found that light availability influenced biomass accumulation more than flood regime with the greatest biomass gain occurring under intermediate light environments. Furthermore, light and flooding interacted to influence biomass accumulation in pondberry plants with plants acclimated to low light conditions demonstrating no response to variable flood regimes up to 90 days while plants grown under intermediate and high light environments experienced more reductions in biomass at 45 to 90 days of flooding. The effects of prolonged flooding longer than 90 days are poorly understood and require further study and assessment.

Hawkins *et al.* (2019) found differentiation in phenotypic plasticity among pondberry genotypes and suggested that such plasticity combined with clonal growth's preservation of genetic diversity increases pondberry's tolerance to environmental perturbations, such as flooding. Consequently, larger populations, with more genetic and phenotypic variation, are more likely to withstand anthropogenic or natural disturbances, while reductions in population sizes are expected to reduce pondberry's tolerance to such disturbances.

Hawkins *et al.* (2016) studied growth and competition of pondberry and a common competitor in some bottomland hardwood communities, redvine (*Brunnichia ovata*), under variable light and flood regimes. The authors noted that redvine's competitive ability may be reduced under low light conditions with

periodic flooding, but that the species may become a greater competitor with pondberry as light availability increases, particularly in the absence of flooding. Redvine's apparent competitive advantage over pondberry may be particularly pronounced in belowground interactions with young pondberry plants.

Earlier observations and speculations of actual and potential seed and seedling predators were confirmed and added to in a camera study by Martins *et al.* (2015). The authors identified various seed and seedling predators, including swamp rabbits (*Sylvilagus aquaticus*) and eastern wood rats (*Neotoma floridana*), and found that seeds had higher survival rates in plots with lower understory vegetation cover, suggesting that predation increases with increasing understory cover. Management activities that reduce competing understory vegetation competing may also benefit pondberry recruitment by increasing seed and seedling survival due to reduced predation pressure.

b. Abundance, population trends, demography:

Populations

Data for many pondberry element occurrences have not been updated in state Natural Heritage Program databases since completion of the 2014 5-year review. New populations have been discovered in Georgia, Mississippi, and South Carolina. In addition, the Service was unaware of one population discovered in South Carolina prior to the 2014 5-year review and omitted two known populations from Mississippi in the previous review, which have been included herein. Populations were determined using the 1-mile separation distance described in Service's 2007 biological opinion and 2014 5-year review (Service 2007, 2014a). We continue to use this definition of population throughout this document.

Based on the population definition presented in the 2014 5-year review, there are currently up to 73 natural populations potentially extant. However, only 35 of these populations have been confirmed extant by recent observations and the statuses of the remaining 38 are uncertain, of which 4 in Mississippi may have been extirpated while 1 population in North Carolina may be historical. In addition, one population in Arkansas no longer exists in the wild (i.e., extirpated in the wild) and is therefore not included in the total number of extant populations, but propagules from this population's only remaining plant are safeguarded *ex situ* (off-site). Two transplanted populations are also extant (one population each in Georgia and South Carolina) while the current status of a third such population (in North Carolina) is unknown. No new information is available for pondberry in Louisiana or Florida and, as such, pondberry's status in both states remains historical. Pondberry's current status and new information for states within the species' extant range are summarized below.

Alabama – Limited new information is available, but site visits during 2015–2018 found that Alabama's population remained extant and apparently healthy, with fruits observed during at least one visit (indicating sexual reproduction) (Thompson 2015, Gray and Thompson 2017, Yawn and Thompson 2018).

Arkansas – Of Arkansas's 24 known populations, 6 are extirpated, 1 exists only in cultivation (no longer extant in the wild), 5 (all on state- or federally owned or managed conservation lands) have been confirmed extant, and 12 (all on private lands, including 2 protected by conservation easements) are of uncertain status. Pondberry monitoring and surveys in Arkansas have been supported by section 6 funding from the Service and have largely focused on conservation lands in the state (e.g., Baker and Witsell 2015, Baker 2016, 2017, 2018). These surveys confirmed the continued existence of pondberry on state conservation lands, including St. Francis Sunken Lands Wildlife Management Area (WMA) and Natural Area (NA) in Craighead and Poinsett counties, Swifton Sand Ponds NA in Jackson County, and Stateline Sand Ponds NA in Clay County (this population is shared by adjacent conservation lands in Ripley County, Arkansas). Additional colonies were discovered in the St. Francis Sunken Lands WMA during 2017 surveys and two populations are now known from this area (Baker 2018), with one population being shared between the WMA and adjacent St. Francis Sunken Lands NA. However, the population on Stateline Sand Ponds NA is in apparent decline, while the population on Swifton Sand Ponds NA remains stable (Baker 2018). In Crittenden County, the population at Wapanocca National Wildlife Refuge (NWR) was last visited in 2020 and is apparently stable (Steven Rimer, Service, pers. comm., 2021). Of the 12 populations found on private lands that are of uncertain status, recent aerial imagery indicates that habitat remains intact, suggesting that these populations may yet persist. These populations are found in Clay (1 population), Lawrence (2), Jackson (8), and Woodruff (1) counties. The population in Ashley County is no longer extant in the wild, due to the last remaining plant being removed for *ex situ* safeguarding to conserve the population's unique genetic diversity (Baker 2016). As such, the remnants of this population only exist in cultivation.

Georgia – Twenty pondberry populations are known from Georgia, of which 4 are extirpated or historical and 16 may be extant. The four extirpated/historical populations are known from Chatham (1 population), Effingham (1), and Wheeler (2) counties. Of the 16 potentially extant populations, 1 was established using transplanted plant material (in Emanuel County), and only 6 of the 15 natural populations have been observed since completion of the 2014 5-year review. Of the 15 natural populations, 1 small pondberry population was discovered on private land in Jenkins County in 2015 (Mincy Moffett, GDNR, pers. comm., 2020). Likewise, recent discoveries have increased the known extent of two populations found on conservation lands. In Baker County, an additional colony was found near a previously known colony on the Jones Center (a private conservation research institution) in 2019 (M. Scott Wiggers, Service, pers. obs., 2019; Jennifer Ceska, University of Georgia and Georgia Plant Conservation Alliance, pers. comm., 2020), more than doubling the population's known size. Similarly, in Miller County, additional colonies were discovered near known colonies on Mayhaw Wildlife Management Area (WMA; Wiggers pers. obs., 2018). Recent land management activities on this WMA, including canopy thinning, have apparently benefited at least one of the site's three pondberry populations. Despite management efforts, recent observations indicate that the

Taylor County population on Fall Line Sandhills NA is in decline, with prolonged inundation thought to be the primary cause of the decline of one subpopulation (Ceska, pers. comm., 2020). All nine remaining populations with no recent observations are found on private lands (located in Baker [1 population], Calhoun [3], Effingham [1], Wheeler [2], and Worth [2] counties) and their statuses are uncertain; however, recent aerial imagery indicates that their habitat remains intact overall, suggesting that these populations may remain extant.

Mississippi – There are 20 pondberry populations known from Mississippi, representing an increase of 4 known populations compared with the previous 5-year review. This increase resulted from one population discovery and correction of three omissions from the previous 5-year review. Recent population statuses and/or population data are available for 11 of Mississippi's pondberry populations. These recent observations have confirmed that seven pondberry populations are extant in Mississippi and four may have recently been extirpated (follow-up surveys are required to confirm their statuses). The statuses of the state's remaining nine populations is uncertain, as recent observations are not available. Mississippi Natural Heritage Program (MNHP) data do not include numerous known occurrences of pondberry and are not considered to be current. In addition, MNHP data include one putative occurrence on the Delta National Forest (Delta NF) that does not correspond with other available pondberry location data and, as such, this putative occurrence is considered to be erroneous.

Four pondberry populations are now known from Bolivar County. A small population (approximately 220 stems) was discovered in 2014 within a forested depressional wetland on Dahomey NWR (Service 2014b). Observations in 2017 found nearly twice as many stems compared with 2014, while observations in 2020 found the colony to be healthy, although no stem counts are available for 2020 (Amber Floyd, Service, pers. comm., 2021). No recent data are available for the County's remaining three privately owned populations, including one protected by a conservation easement that is presumed extant. Available aerial imagery from 2016 and 2017 indicate that remnant bottomland hardwood stands remain at the county's other two populations, suggesting that these populations may be extant, but site visits are needed to confirm these populations' statuses.

All of Sharkey County's known pondberry populations are found on Delta NF. One population on Delta NF was erroneously omitted from the previous 5-year review and, as such 14 populations are known from the forest. Prolonged flooding within Delta NF, including areas with pondberry, has occurred in recent years (e.g., Stephanie Allison, U.S. Forest Service, pers. comm., 2019). Recent surveys of pondberry on Delta NF included portions of nine populations[1], five of which were confirmed extant, while four had no observed plants and may be extirpated (Fischer *et al.* 2020). Furthermore, these surveys indicated that long-term trends of declining populations on the Delta NF continue (these declines are described in more detail in Service 2007). The statuses of Delta NF's remaining 5 populations

[1] Attempts to visit pondberry colonies/sites in 10 populations were made in 2020, but erroneous coordinates for colonies/sites in 1 population resulted in only 9 populations being surveyed.

are unknown, as these sites have not been visited in at least 15 years, while follow-up surveys are needed to confirm the statuses of the 4 populations with no observed plants in 2020. However, visits to known pondberry locations on Delta NF in the summer of 2021 did not relocate plants at 132 of 194 sites visited[2], suggesting that the species' apparent decline on the forest may have hastened in recent months (Eli Polzer, Service, pers. comm., 2021). The cause(s) of this apparent rapid decline of pondberry on Delta NF are unknown.

Sunflower County has two known populations, including one population erroneously omitted from the previous 5-year review, both of which occur on private lands. One of Sunflower County's privately owned populations was recently observed to support 100+ stems in a small depressional wetland surrounded by agricultural fields (M.S. Wiggers, Service, T. Leininger, USFS, and T. Huggins, Delta Wildlife/Delta F.A.R.M., pers. obs., April 2018). No recent data are available for the County's other known population and its status is unknown, but remnant bottomland hardwood forest remains at the site (2017 aerial imagery), which suggests that the population may be extant, although site visits are necessary to confirm this population's status.

As described in the 2014 5-year review (Service 2014a), pondberry's occurrence in Tallahatchie County (on private property) is considered to be in error (arising from a misidentification) and, as such, this site is not considered to be part of pondberry's current or historic distribution within Mississippi.

Missouri – Missouri's one natural population remains extant in Ripley County and is shared with a population in Arkansas's adjacent Clay County. Observations in 2014 indicate that the state's sand ponds could support one of the largest, or possibly the largest, population of pondberry known. Together, these sand ponds may be home to over 70,000 stems (Susan Farrington, Missouri Department of Conservation [MDOC], pers. comm., 2019). Three monitoring plots were installed in 2014 at Sand Pond Conservation Area (CA), but formal monitoring has not yet been implemented at these sites; however, regular site visits by MDOC staff indicate that pondberry colonies are persisting and are generally healthy, but continued canopy closure and encroachment of invasive plants may negatively impact these colonies (Farrington, pers. comm., 2019). No new information is available for Ripley County's transplanted pondberry population.

North Carolina – Limited new information is available for pondberry in North Carolina. Pondberry is known from seven populations (including one transplanted population) in the state: Bladen (1 population), Cumberland (1), Onslow (2), Orange (1), Sampson (2). Populations in Bladen and Orange counties are considered historical or extirpated. Only two populations have been confirmed extant in the past 10 years, both on state-owned conservation lands (one population each in Cumberland and Sampson counties). Two populations are known from Marine Corps Base Camp Lejeune (Camp Lejeune) in Onslow

[2] These sites may represent entire populations or portions of populations, but adequate information to determine this was unavailable at the time this 5-year review was written.

County, only one of which the Service was aware of at the time of the 2014 5-year review. Of these, one population may be historical, as repeated searches have failed to relocate plants since the population's discovery in 2003, while the other population has not been observed since 2009 and its status is uncertain. The state's remaining population, in Cumberland County, is found on private lands and has not been observed since 2006 (North Carolina Natural Heritage Program data) and its current status is uncertain, although recent aerial imagery suggests that potential habitat remains at this site. Sampson County's second known population is a transplanted population and there is no current information available (North Carolina Natural Heritage Program data).

South Carolina – Seventeen populations are known from South Carolina, which include one transplanted population. Ten of these populations have recent observations available. The statuses of the state's remaining seven populations have no known recent observations available and are of uncertain status, although three such populations are found on state lands and are considered extant. Two populations are located in Barnwell County (erroneously attributed to Aiken County in the Service's 2014 5-year review) on the Savannah River Site, with one new population discovered in 2017 and an additional colony discovered in 2016 that expands the extent of the previously known population (South Carolina Heritage Trust Program data). Three populations are known from Beaufort County, including one on Marine Corps Air Station Beaufort (MCAS Beaufort) and two on nearby private lands. MCAS Beaufort, which is periodically monitored and has received some management to control encroaching loblolly pines (*Pinus taeda*), supports one of the largest known pondberry populations, with an estimated 31,000 stems (Gramling 2019). Of the county's two populations on private lands, one was included in the Service's 2014 5-year review, while the other, which was discovered in 2006 (Payne 2010), was unknown to the Service at that time. No recent observations are known for either of these privately owned populations and their precise locations are uncertain. As such, the statuses of these two populations are uncertain. Most of Berkley County's eight known populations occur on Francis Marion NF, which is home to six populations, five of which are natural, and one is a transplanted population. Surveys from 2015 to 2017 found that Francis Marion NF's 6 populations combined support over 31,000 pondberry stems, which represents an decline from over 61,000 stems in 2004 (Robin Mackie, U.S. Forest Service, pers. comm., 2019). Excessive use of prescribed fire is responsible for at least part of this decline, decreasing one population from 8,154 stems in 2004 to 38 stems in 2017 (Mackie, pers. comm., 2019). Berkley County's remaining known populations are found on private lands, one of which has not been observed in nearly three decades and may be historical (South Carolina Heritage Trust Program data), while the other private population was discovered in 2017 (April Punsalan, Service, pers. comm., 2017). One population is known from private land in Dorchester County, but a precise location is lacking and with no known recent observations of the population its status is uncertain. All three of Marion County's populations are known from Woodbury WMA and are presumed extant, although recent data are lacking (South Carolina Heritage Trust Program data).

Populations on Conservation Lands

Together, private, state, and federally owned conservation lands in Missouri and Arkansas are home to seven populations. One population, consisting of multiple subpopulations on conservation lands along either side of the Missouri–Arkansas state line, is found on a combination of state-owned/managed and non-governmental organization owned conservation lands (Sand Pond CA and The Nature Conservancy's Pondberry Preserve in Missouri; Stateline Sand Ponds NA in Arkansas). Observations from MDOC biologists in 2014 indicate that various sand ponds within these conservation lands may support some of the largest known populations, with 70,000 or more stems possible (Farrington, pers. comm., 2014); however, continued canopy closure and encroachment of invasive plants may have negatively impacted these sites (Farrington, pers. comm., 2019). Elsewhere in Arkansas, St. Francis Sunken Lands WMA and NA are home to two populations, while Swifton Sand Ponds NA and Wapanocca NWR are home to 1 protected population each. One population each, both of uncertain status, occur on private lands protected by conservation easements in Jackson and Woodruff counties. The population in Jackson County is protected by a Natural Resources Conservation Service (NRCS) Wetlands Reserve Program (WRP) conservation easement, while the population in Woodruff County is protected by a conservation easement held by the Arkansas Natural Heritage Commission. In southern Arkansas, Coffee Prairie NA once supported a small population, but the only remaining plant from this site was removed from the wild and placed into cultivation to prevent the loss of all individuals from the population and representative genetic material. This plant has been propagated via stem cuttings in a greenhouse, with plans to eventually return plants to Coffee Prairie NA (Baker 2016). Repeated searches have failed to locate additional plants at this site. Until plants are successfully reintroduced to Coffee Prairie NA, this population is considered to be extirpated in the wild.

In Mississippi, there are 17 populations known from conservation lands. Of these populations, 14 are known from Delta NF in Mississippi, but only 5 have been confirmed extant in recent years, which have experienced substantial population declines in the past 20 years (Service 2007, Fischer *et al.* 2020, Polzer, pers. comm., 2019). Dahomey NWR supports one small population while two populations occur on private lands protected by conservation easements (one held by the Service and one under the NRCS WRP). Recent observations are not available for either of the conservation easement populations and their statuses, population sizes, and trends are uncertain.

Eight pondberry populations in Georgia are known from conservation lands, including one established population and seven natural populations. The known extent of the Jones Center's (in Baker County) pondberry population has expanded following the recent (2019) discovery of a second colony in the same wetland as the previously known colony (Wiggers, pers. obs., 2019; Ceska, pers. comm., 2020). Habitat management activities (thinning and removal of off-site species) have promoted pondberry at Mayhaw WMA (in Miller County) (Wiggers, pers. obs., 2018), expanding the known extent of one of the three

known populations on the property. However, the population on Fall Line Sandhills NA (in Taylor County) is in decline (Ceska, pers. comm., 2020). Ohoopee Dunes NA is home to one small, transplanted population. One population on private lands was recently protected by a conservation easement held by a land trust in Wheeler County and another population on private lands in Calhoun County is protected under a NRCS WRP conservation easement, but no recent observations are available, and this population's status is uncertain.

Eleven natural and one transplanted pondberry populations occur on state or federally owned/managed lands in South Carolina. Two new colonies were discovered on the Savannah River Site in 2016 and 2017 in Barnwell County, South Carolina (South Carolina Heritage Trust Program data). These two colonies represent the expansion of the known extent of one population and discovery of one additional population on the Savannah River Site, bringing the site's total known pondberry populations to two. MCAS Beaufort, a military installation, supports one of the largest known populations and habitat management activities are improving conditions for pondberry at the site (Gramling 2019). Six populations occur on Francis Marion NF, including one transplanted population and five natural populations, one of which supports the second largest known pondberry population in the state; however, the forest's overall population size has declined by over 50% since 2004 (Mackie, pers. comm., 2019). Finally, Woodbury WMA is home to three known populations, but the WMA's populations have no recent observations available, and their statuses are uncertain, but presumed extant (South Carolina Heritage Trust data).

North Carolina is home to two confirmed extant populations on state-owned and managed conservation lands: Pondberry Bay Plant Conservation Preserve in Sampson County and Big Pond Bay Plant Conservation Preserve in Cumberland County. Two other populations are known from Marine Corps Base Camp Lejeune, in Onslow County (only 1 of which was known to the Service at the time of the 2014 5-year review), but one population has not been relocated since its discovery in 2003 and may be historical, while no observations are known for the installation's second population since 2009 (North Carolina Natural Heritage Program data).

c. Genetics:

No new information available.

d. Taxonomic classification or changes in nomenclature:

No changes to pondberry's taxonomic classification or nomenclature have been proposed since the 2014 5-year review and, as such, remain valid.

e. Distribution and trends in spatial distribution:

While pondberry is historically known from nine states (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Missouri, North Carolina, and South Carolina), extant pondberry is currently known from seven states (Florida and Louisiana are considered historical). As previously noted, Aiken County, South

Carolina, was erroneously included in the 2014 5-year review and should have been noted as Barnwell County. Additional colonies and populations have been found in South Carolina (including Barnwell County), but these discoveries are within pondberry's known range in the state. However, a new population was discovered in Jenkins County, Georgia, resulting in a modest expansion of the species' known range within the state. Overall, however, pondberry's known range remains unchanged since the 2014 5-year review.

Searches by Service and Arkansas Natural Heritage Commission staff during 2014 to rediscover pondberry in Aiken County, Arkansas, found only one plant at this population, which was later removed for *ex situ* (off-site) conservation. Follow-up surveys in 2015–2017 have not rediscovered additional plants at this site (Baker 2016, 2017, 2018). Surveys on neighboring conservation lands (e.g., Felsenthal NWR) and elsewhere in the county have likewise failed to find pondberry (Baker and Witsell 2015; Baker 2016, 2018). As such, the Ashley County population is considered extirpated in the wild, with the county's remaining pondberry existing only in cultivation.

Historical General Land Office (GLO) records suggest that pondberry may have been more widespread in Arkansas during the 1800s, as numerous references to "spice", "spice bush", "spicewood", "swamp spice", and "swamp spicewood" are found in these records (Baker 2016, 2017, 2018). While some of these may refer to pondberry's more common relative northern spicebush (*L. benzoin*), the frequent references to such plants in wet areas are suggestive of pondberry. However, recent surveys in Arkansas by Service and Arkansas Natural Heritage Program staff to locate new populations or relocate putative sites (from non-GLO sources, e.g., Pond Creek NWR) across the state have been unsuccessful. These surveys have occurred in Arkansas, Ashley, Drew, Hempstead, Jackson, Lee, Lonoke, Miller, Monroe, Phillips, Prairie, Sevier, and Union counties, and include two NWRs (Felsenthal and Pond Creek) and various state conservation lands (Baker and Witsell 2015; Baker 2016, 2017, 2018). Likewise, attempts to find additional pondberry occurrences on conservation lands with known populations have met with mixed success, resulting in expansions of the known extent of some local populations (Baker and Witsell 2015; Baker 2016, 2017, 2018).

f. Habitat or ecosystem conditions:

Descriptions of pondberry's habitat included in the Service's 2014 5-year review and 2007 biological opinion remain applicable and no new information is available. Recent habitat management activities throughout the species' range have had mixed effects on pondberry. Where canopies create excessive shading, limited removal of canopy trees has promoted pondberry growth; however, removal of too much canopy can create conditions with excessive light and promote growth of competing vegetation. Likewise, in fire-maintained landscapes, such as the Francis Marion NF in South Carolina, where prescribed fires are important and necessary tools to manage various habitats, excessive use of prescribed fire has proven deleterious to pondberry population. More details on habitat management needs and activities are provided in sections II.B.1.b.,

II.B.2.a., and II.B.2.e.

g. Other:

Propagation, Population Establishment, and Safeguarding

Auburn University conducted propagation studies and distributed propagated plants to various botanical gardens in Alabama for safeguarding (Thompson 2015, 2016a). These safeguarded plants remained in good health at least into 2017 (Thompson 2016b, Gray and Thompson 2017). An attempt to outplant four individuals in Covington County, Alabama, has had mixed results with two plants in poor health (Thompson 2016b). Attempts to supplement the populations at Arkansas's Swifton Sand Ponds NA by planting locally collected seeds on site have generally been unsuccessful due to poor seedling survival and/or poor germination (Baker, pers. comm., 2020). As noted previously, Aiken County, Arkansas's only known plant was removed from the wild and placed in *ex situ* cultivation to protect this county's remaining genetic material. This one plant has subsequently been propagated via stem cuttings at a private native plant garden (Baker 2016, 2018). In 2017, the Service, North Carolina Plant Conservation Program, and North Carolina Botanical Garden staff collected over 500 seeds from 29 maternal lines from North Carolina (Phil Wilson, North Carolina Department of Agriculture and Consumer Services, *in litt.* 2019). Over 400 seeds were sent to the National Laboratory for Genetic Resource Preservation in Ft. Collins, Colorado, for long-term cryogenic storage. North Carolina Botanical Garden grew 78 plants from the remaining seeds to maintain in cultivation. A small network of conservation organizations in Georgia maintains plants from multiple populations within the state in cultivation (Ceska, pers. comm., 2020). However, one of these Georgia safeguarding collections has been negatively impacted by the fungal pathogen, *Phytophthora cinnamomi*, which is a common fungus-like agricultural pathogen that can result in plant wilt, die-back, and mortality, and can be spread to natural communities (Hardham and Blackman 2018; Ceska, pers. comm., 2020). This pathogen may threaten the long-term sustainability of some *ex situ* safeguarding collections and outplantings established with plant material from such affected collections.

Other Activities

Best management practices (BMPs) have been developed for pondberry in Missouri (Missouri Department of Conservation 2015) and Alabama (Alabama Forestry Commission PB11082016 cited in Thompson 2016b). These BMPs may reduce negative impacts from development projects and forestry practices on pondberry in these states but can also be used to inform such activities in other states throughout the species' range.

The Service funded a species distribution model (completed in 2017) across much of pondberry's eastern range (i.e., from western Alabama through North Carolina, including northern Florida) and also included areas outside of the species' known range (e.g., Virginia; Chazal *et al.* 2017, Florida Natural Areas Inventory 2017) to inform a broader Conservation Blueprint initiative within this area (see

https://www.southatlanticlcc.org/blueprint/). The model identified a large amount of potentially suitable habitat within the modeled area, particularly within the Coastal Plain, but most of the putatively highly suitable habitat was concentrated around known populations. No potentially suitable habitat was identified outside of pondberry's currently known range and no attempt to verify this model's results in the field is known.

Service section 6 funds were used to support a project to address threats from laurel wilt disease (LWD) in North Carolina. This multi-level project was developed and implemented in the state from 2016 through 2018 by staff with the North Carolina Department of Agriculture and Consumer Services in cooperation with the state's Plant Conservation Program (Wilson *in litt.* 2019). Work included creation of an early detection scheme for LWD near pondberry populations. This scheme involved establishing and monitoring a network of traps for the vector (*Xyleborus glabratus*; redbay ambrosia beetle [RAB]) of the fungal pathogen (*Raffaelea lauricola*) that causes LWD as well as surveying and sampling lauraceous species for LWD within 5 miles of pondberry populations. No new occurrences of LWD were found and no RABs were caught during this project. A second part of this project was to reduce the cover of RAB host plants (i.e., other lauraceous species) at both state preserves with pondberry populations. To accomplish this, all red bay and sassafras trees over 1-inch diameter (the preferred diameter for RAB) were killed as part of this short-term project. Finally, phytotoxicity testing of a fungicide (Propiconazole) and surfactant (CNI 800 Plus) mixture was conducted in test plots. This mixture was tested via soil drenching within 1-ft^2 test plots within pondberry colonies. Most pondberry stems suffered no apparent ill effects from the fungicide/surfactant treatments, but dieback and resprouting of stems in one plot was noted during the 4-month study. It is unknown what caused this dieback during the study. Overall, these results suggest that fungicide application may be an effective and safe means to prevent or treat LWD in pondberry populations, but more research is needed to determine if the observed dieback was likely related to the fungicide treatment or some other cause. Likewise, the efficacy of other fungicide and surfactant mixes and application methods is needed to develop effective and safe LWD treatment options.

2. Five-factor analysis (threats, conservation measures, and regulatory mechanisms)

The purpose of a 5-year review is to recommend whether a listed taxon continues to warrant protection under the ESA and, if so, whether it should be reclassified (from threatened to endangered or from endangered to threatened). This task requires that the analysis of the threats to the species be performed while assuming that the species is not receiving the regulatory protections, funding, recognition, and other benefits of ESA listing. Summaries of ongoing applications of ESA protections may shed light on some future activities that constitute threats to the species; however, the analysis under Factor D (Inadequacy of Existing Regulatory Mechanisms) focuses on the adequacy of existing alternative (i.e., non-ESA) mechanisms to address the continuing and foreseeable threats.

Overall, the 5-factor analysis presented in the Service's 2014 5-year review remains applicable to pondberry. Limited new information is presented below.

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

There are limited available updates to the 2014 5-year review's summary of threats to pondberry; pondberry populations continue to be influenced by significant threats from habitat conversion, degradation, and altered hydrology, and these earlier summaries remain applicable.

Habitat management remains a persistent need within populations throughout the species' range, with excessive competing vegetation and/or canopies being noted (e.g., Alabama – Thompson 2016, Arkansas – Baker 2017, Mississippi – Fischer *et al.* 2020, Missouri – Farrington, pers. comm., 2019). While pondberry is considered a shade-tolerant species, excessive canopy closure has been suggested to reduce pondberry colony vigor in Missouri (Farrington, pers. comm., 2019). In addition, overstory thinning has apparently led to short-term increased growth of pondberry at two populations in Georgia and Arkansas (Wiggers, pers. obs., 2018; Brent Baker, Arkansas Natural Heritage Commission, pers. comm., 2020); however, longer-term impacts from expected increased growth of competing vegetation at these populations is uncertain, particularly if hydrologic regime is inadequate to limit such competing vegetation. In some populations, prescribed fire may also help control competing vegetation (e.g., Gramling 2019); however, too frequent fire can also prove deleterious to populations, as has occurred at one population on the Francis Marion NF in South Carolina (Mackie, pers. comm., 2019). As described in the 2014 5-year review, the interaction between increased light, hydrology, and competition is complex and in need of further study. Likewise, additional study is needed to explore potential management options and strategies to improve habitat conditions and control competing vegetation, such as those proposed by Lockhart (2016).

Recent, prolonged flooding within portions of the Mississippi Delta region may have contributed to long-term declines and potential extirpation of four populations of pondberry on the Delta National Forest along with excessive canopy closure (leading to low light availability) and competition from understory vegetation. However, lack of adequate monitoring data for pondberry on Delta National Forest (which is almost entirely lacking between 2006 and 2019) limit conclusions that can be drawn around factors contributing to pondberry's decline and potential extirpation in this area. As such, potential relationships between prolonged flooding and habitat management remain uncertain on the forest.

b. Overutilization for commercial, recreational, scientific, or educational purposes:

Not known to threaten this species.

c. Disease or predation:

Laurel wilt disease continues to spread rapidly throughout the southern United

States—occurring in every state within pondberry's current and historical range except Missouri and 22 of pondberry's known counties (9 in Georgia, 7 in South Carolina, 4 in North Carolina, and 1 each in Alabama and Arkansas; LWD distribution map available at *http://southernforesthealth.net/diseases/laurel-wilt/distribution-map*; distribution map dated March 10, 2021). As summarized in the 2014 5-year review, this disease continues to threaten pondberry via direct mortality and changes to the species' habitat (seed Service 2014a for more details on LWD's potential effects on habitat). Recent work has also revealed that infected stems can transmit the LWD fungus via root connections to other stems (Best and Fraedrich 2018), which increases the potential impact of an infection on a local colony because of pondberry's clonal nature. Currently, LWD's direct impact to pondberry populations is limited, with one population in Georgia having confirmed LWD infection, although LWD-like symptoms have been noted in several populations in Georgia and South Carolina (see Service 2014a for more details). New information on this population is not available since completion of the Service's 2014 5-year review. Limited research into developing safe and effective treatment/prevention options for LWD has been initiated in North Carolina with promising results (Wilson *in litt.* 2019).

Recently, the fungus-like pathogen, *Phytophthora cinnamomi*, has been found deleteriously affecting *ex situ* safeguarded pondberry plants at the State Botanical Garden of Georgia (Ceska, pers. comm., 2020). This is a widespread agricultural pathogen that can be spread to natural ecosystems (Hardham and Blackman 2018). Currently, effects of this pathogen are limited to this one *ex situ* conservation collection and it is not known to affect any natural populations *in situ*; however, because the pathogen can spread by transplanting infected plants, precautions are needed to avoid spreading the pathogen to natural populations via population augmentation efforts. The long-term sustainability of ex situ collections impacted by *P. cinnamomi* is uncertain.

There is no new information on periodic episodes of stem dieback noted in the 2014 review, although the phenomenon continues to be observed (e.g., Gramling 2019). Long-term impacts of stem dieback on population persistence and dynamics remains poorly understood and further investigation is necessary.

A camera study by Martins *et al.* (2015) identified various seed and seedling predators, including swamp rabbits (*Sylvilagus aquaticus*) and eastern wood rats (*Neotoma floridana*), among others. These observations added to and/or confirmed earlier observations and speculations of such predators. The study also found that seeds had higher survival rates in plots with lower understory vegetation cover, suggesting that predation increases with understory cover. Excessive seed and seedling predation can reduce pondberry recruitment.

d. Inadequacy of existing regulatory mechanisms:

Pondberry continues to receive some protections under state laws and regulations in Georgia (Georgia Wildflower Preservation Act of 1973), Missouri (Rule 3 CSR 10-4.111 of the Missouri Department of Conservation), and North Carolina (General Statute 106-202.12-202.19, also known as the Plant Protection and

Conservation Act). These state laws and regulations are limited to various aspects of collection, transport, and/or sale of covered plants in these states. Pondberry does not receive any specific legal protections from state laws or regulations in Alabama, Arkansas, Mississippi, or South Carolina.

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

The 2014 5-year review's summary of potential threats posed by small population sizes, biased sex ratios, climate change, and animal disturbance remain applicable.

Recent timber thinning operations at St. Francis Sunken Lands WMA, in Arkansas, damaged many pondberry plants. Damage included plants being driven over, crushed, and covered with slash (logging debris). First-year response of plants that were not excessively damaged or covered by slash during these operations suggested some apparent benefit from this disturbance by increasing growth; however, longer-term responses of the population, particularly from expected increased growth of competing vegetation remains uncertain. Likewise, responses of plants that were covered by slash or otherwise severely damage during these operations are uncertain (Baker, pers. comm., 2020).

D. Synthesis

Currently, pondberry continues to meet the definition of endangered under the ESA. Since completion of the last 5-year review, limited new information on the species' populations and trends is available, but indicate that the species may be stable to declining overall. Although substantial population declines and recent extirpations have occurred in some portions of the species' range (including on conservation lands previously known to support some of the largest concentrations of pondberry, such as the Delta National Forest in Mississippi and Francis Marion National Forest in South Carolina), small, new populations have been discovered elsewhere, while still other populations are apparently larger than previously known. However, limited availability of recent monitoring data for many populations increases the uncertainty associated with this assessment as the statuses of these populations are also uncertain. Increased monitoring is needed to adequately understand and assess the status, trends, and threats to pondberry, particularly for populations occurring on conservation lands.

Overall, recovery progress has been made for pondberry, with 46 populations occurring at least in part on public or conservation lands; however, 19 of these populations have not been observed in recent years and 5 of which may be extirpated or historical. Another population previously occurred on conservation lands but is currently only found growing in cultivation off site and is considered to be extirpated in the wild. Available monitoring data are inadequate to support determination of the self-sustaining statuses of the remaining populations found on conservation lands. Finally, existence of pondberry on conservation lands alone does not guarantee the continued persistence or long-term viability of these populations, as illustrated by the potential extirpation of four such populations and substantial declines in others.

Habitat management remains an important need of pondberry throughout its range, regardless of whether plants occur on conservation lands. Likewise, the lethal laurel wilt

disease continues to spread throughout the southeastern United States, posing an increasing threat to pondberry and its habitats. Small, isolated populations, biased sex ratios, and alterations to hydrologic regimes all pose persistent threats to pondberry.

Regardless of their ownership or conservation status, all populations are susceptible to the rapidly spreading and highly lethal laurel wilt disease. While the impacts of this disease on pondberry populations are currently limited, the disease's impacts on populations and habitats in coming years has the potential to increase. Safeguarding efforts may provide some measure of protection from this disease, but these efforts are currently limited. As the recent discovery of the fungus-like pathogen, *Phytophthora cinnamomi*, in one safeguarding collection highlights, such safeguarding collections are themselves susceptible to their own unique diseases.

Pondberry conservation efforts have been encouraged by, engaged in, and/or funded by the Service, U.S. Forest Service, U.S. Army Corps of Engineers, universities, state Plant Conservation Alliances, various state agencies and non-governmental organizations. Continued pursuit of these efforts and expansion of current and existing partnerships, will promote pondberry recovery.

III. RESULTS

A. Recommended Classification:

_____ Downlist to Threatened
_____ Uplist to Endangered
_____ Delist (Indicate reasons for delisting per 50 CFR 424.11):
  _____ Extinction
  _____ Recovery
_____ Original data for classification in error
__X__ No change is needed

B. New Recovery Priority Number: No change recommended.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

The following actions are recommended to support and promote recovery of pondberry. Use of a numbered list for these recommendations is for convenient reference and does not necessarily imply prioritization of any action over others.

1. 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.
2. Manage habitat—particularly on conservation lands—to promote pondberry population growth and persistence throughout the species' range, including removal of competing vegetation, control of invasive species (plants and animals, such as wild hogs), and experimental manipulations of overstory canopy to determine optimal light conditions.
3. Further study and characterize potential threats posed by laurel wilt disease. Identify methods and management practices to limit this disease's potential to negatively impact pondberry and its associated habitats.

4. Continue and expand conservation genetics work to include all populations and determine effective population sizes.
5. Define what characterizes a "self-sustaining" pondberry population.
6. 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.
7. Study the feasibility of and necessary methodology to augment genetically depauperate and sexually limited populations.
8. 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.

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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: 8C (no change)

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

FIELD OFFICE APPROVAL:

Field Supervisor Mississippi Ecological Services Field Office, Fish and Wildlife Service*

Approve JAMES AUSTIN Digitally signed by JAMES AUSTIN Date: 2021.10.27 14:33:17 -05'00' for Stephen M. Ricks Date 10/27/2021

*Since 2014, Field Supervisors in the Region have been delegated authority to approve 5-year reviews that do not recommend a status change.

OTHER REGIONAL OFFICE APPROVAL:

We emailed this 5-year review to the following regional and/or field offices for their concurrence prior to finalizing the document: Bloomington Regional Office and Missouri Field Office. We will retain any comments that we received, as well as verification of concurrence from other regions, in the administrative record for this 5-year review.