

Beautiful pawpaw 5-Year Review

**Beautiful Pawpaw
(*Deeringothamnus pulchellus*)**

**5-Year Review:
Summary and Evaluation**



Photos by Michelle Smith, formerly with Florida Natural Areas Inventory

October 2021

**U.S. Fish and Wildlife Service
South Atlantic-Gulf Region
Florida Ecological Services Field Office
Vero Beach, Florida**

5-YEAR REVIEW
Beautiful Pawpaw (*Deeringothamnus pulchellus*)

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, and threats of this species. This review includes information from the previous 5-year review (U.S. Fish and Wildlife Service [Service] 2009) that is still applicable to the species, with updated or new information incorporated, as appropriate. We announced initiation of this review and requested information in a published *Federal Register* notice with a 60-day comment period in 2019 (84 FR 28850). We received one public comment during the open comment period. We evaluated and incorporated the comment as appropriate in this review. We used a variety of information resources, including monitoring reports, surveys, and other scientific and management information. Specific sources included: The final rule (51 FR 34415; Service 1986) listing this plant under the Endangered Species Act of 1973, as amended (ESA), the Recovery Plan (Service 1999), the last 5-year review (Service 2009), the recovery plan amendment (Service 2019), peer reviewed scientific publications, and unpublished field observations by Federal, State, and other experienced biologists. The Service contracted this review to a Florida Natural Areas Inventory (FNAI) botanist, and it was finalized by the lead recovery biologist for the beautiful pawpaw in the Florida Ecological Services Field Office (FESFO), Vero Beach. Literature and documents used for this 5-year review are on file at the FESFO. All recommendations resulting from this review are a result of thoroughly reviewing the best available information on the beautiful pawpaw. The Service did not seek additional peer review for this updated 5-year review.

B. Reviewers

Lead Region: South Atlantic-Gulf Region, Carrie Straight, (404) 679-7226

Lead Field Office: FESFO, Vero Beach, Heather Hitt, Heather_Hitt@fws.gov, (772) 469-4267

Cooperating Field Office(s): FESFO, Jacksonville, Todd Mecklenborg, (904) 731-3336

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 34415

Federal Register Notice date: September 26, 1986

Beautiful Pawpaw 5-Year Review

Effective listing date: October 27, 1986

Entity listed: Species

Classification: Endangered

3. **Associated rulemakings:** There are no associated rulemakings for this species.
4. **Review History:** Each year, the Service reviews and updates listed species information to benefit the required Recovery Report to Congress. Through 2013, we performed a yearly recovery data call. The last review conducted in 2010 showed this species as uncertain with no change recommended to the species' status due to the lack of population monitoring and ongoing threats.

Recovery Plan: 1999

Recovery Plan Amendment: 2019

Previous Five-Year Reviews: 1991 and 2009, both reviews recommended no change in status for the species.

5. **Species' Recovery Priority Number at start of review:** 2

Degree of Threat: High

Recovery Potential: High

Taxonomy: Species

6. **Recovery Plan**

Name of plan: South Florida Multi-Species Recovery Plan (MSRP) (Service 1999)

Date issued: May 18, 1999

Date of recovery plan amendment: September 24, 2019 (Service 2019)

Date of previous plan: April 5, 1988 (Recovery plan for three Florida pawpaws) (Service 1988)

II. REVIEW ANALYSIS

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

1. **Is the species under review listed as a DPS?** No. The 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?** Yes.

Beautiful Pawpaw 5-Year Review

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.
 - 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.
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 recovery criteria, as presented in the 2019 amendment to the 1999 recovery plan, are broken down into criteria ([1-3] in bold below). These criteria address listing factors A) the present or threatened destruction, modification, or curtailment of its habitat or range; C) disease or predation; D) inadequacy of existing regulatory mechanisms; and E) other natural or manmade factors affecting its survival. Factor B (overutilization) is not relevant to this species.

Beautiful pawpaw will be considered for delisting when:

[1] At least 30 populations exhibit a stable or increasing trend, evidenced by natural recruitment and multiple age classes. (Factors A, C, and E)

This criterion has not been met. Very little monitoring and demographic data are available for the beautiful pawpaw. Surveys have been conducted intermittently in the past, but trends are difficult to determine because surveys have generally only assessed a few populations at any one time and no one population has been assessed for more than 2 years in a row. Additionally, new populations have been discovered in multiple locations, the previous conditions of which are unknown relative to their current states. Based upon the most comprehensive data available, there are currently thought to be approximately 5,500 plants or more in 35 populations in Charlotte, Lee, and Orange Counties (Table 1; O'Neil and Proenza 2019; Allman 2021; FNAI 2021; Garner 2021). Note that this does not include seven populations listed as historical, possible failed translocation, extirpated, or possibly extirpated, three of which the most recent surveys did not reveal the presence of any plants on site, though they could still be present and simply dormant (Table 1). Based on limited repeated surveys and/or observational records, 9 of these populations appear to be stable or increasing, 6 appear to be declining, and the status of the remaining 20 populations is unknown. The number of plants ranges from just a few plants on some sites to 3,500 or more individuals within several populations on one managed area, Fred C. Babcock/Cecil M. Webb Wildlife Management Area (Babcock-Webb WMA).

Because the species is thought to be long-lived, annual reproductive success is not critical and recruitment rates are low (Service 1999). Other than follow-up monitoring during the first year after outplanting of three transplanted populations, no long-term estimates of survival have been obtained for the species (Service 1998; Preston et al. 2004). Closely monitored, repeated surveys revealed a high survival rate (87 percent)

Beautiful Pawpaw 5-Year Review

in the first year after transplantation at one location and modest first-year survival rates of 39 percent and 65 percent at other locations (Service 1998). Another translocation site has only been periodically revisited since the time of original outplanting with few plants remaining on site (O'Neil and Proenza 2019, 2021). However, many years of data are necessary to reveal the true success of plant translocations (Albrecht et al. 2011) and no follow-up data have been collected since this time. Additionally, no information has been reported on survival of individuals in natural populations on a yearly basis, and life history stage and population structure data have not been collected.

Because consistent annual surveys are needed to evaluate long-term population trends and additional studies need to be completed on survival at different life stages, reproductive rates, and overall population structure across the range of the species, there are not enough data available to demonstrate a stable or increasing trend for a minimum of 30 beautiful pawpaw populations. Without these surveys and the associated data, no population viability analyses can or have been completed at this time. Provided that there is unmanaged remnant habitat, it is thought that the species can remain dormant underground, reemerging when the habitat is opened through prescribed fire, mowing, or other management activities (Peterson 2019a). This phenomenon makes the status of populations difficult to determine without repeated surveys, especially after disturbance.

Beautiful pawpaw 5-Year Review

Table 1: Summary of the status of known beautiful pawpaw populations. Last observation date indicates when living plants at the site were last seen, although surveys may have been completed in a different year (see Population Estimates column). Population estimates and status are derived from Florida Natural Areas Inventory (FNAI) 2021 data unless otherwise indicated. Population numbers should be viewed as estimates and not precise numbers in almost all cases. Management actions listed may be for the management unit in which the beautiful pawpaw occurs and not concentrated at the exact beautiful pawpaw population location. EO = Element Occurrence, WMA = Wildlife Management Area

| Site Name | County | Ownership | EO Number | Last Observation Date | Population Estimates | Management Actions and Notes | Status |
|--|-----------|----------------------|-----------------|-----------------------|---|--|---|
| None | Orange | Private | 3 | 2019 | 132 in 2007 ~200 in 2019 | Powerline right-of-way with occasional mowing | Possibly Stable |
| None | Orange | Private | 20 | 1992 | 10 in 1992 0 in 2007 | None, residential area | Extirpated |
| None | Orange | Private | 21 | 2007 | 1 to 10 | None, scrubby flatwoods with heavy disturbance from lack of fire and an off-road vehicle trail | Unknown |
| None | Orange | Private | 22 | 2021 | 172 in 2019 fewer in 2021 | None, hardwoods encroaching and ornamental shrubs planted ¹ | Possibly Decreasing |
| None | Orange | Private | 49 ⁺ | 2009 | Unknown | None, some habitat still available | Unknown |
| Tosohatchee WMA* | Orange | State | 32 | 2019 | 21 planted in 2006 12 in 2007 3-5 in 2019 ² | Prescribed fire applied every 3-4 years, small occurrences of invasive plants along roads treated, area mowed in 2020 ³ | Possibly Decreasing |
| Babcock Ranch Preserve | Charlotte | State | 34 | 2006 | 22-100 in 2006 0 in 2007 and 2008 | Unknown, habitat still available | Possibly Extirpated |
| Charlotte Flatwoods Environmental Park | Charlotte | County | 9 | 1990 | Several in 1990 0 in 1992 and 1999 | Unknown, habitat still available | Possibly Extirpated |
| Charlotte Harbor Environmental Center* | Charlotte | Private Conservation | N/A | 1998 | 100 planted in 1997 ⁴ 66 in 1998 ⁴ 0 in 2021 ⁵ | No burning for last 20 years, some clearing around powerline and mowing for fireline prep in 2020, severely overgrown ⁵ | Possible Failed Translocation (Possibly Extirpated) |
| Babcock-Webb WMA (Main Tract) | Charlotte | State | 2 | 1928 | N/A | Unknown, some habitat still available | Historical (Possibly Extirpated) |
| Babcock-Webb WMA (Main Tract) | Charlotte | State | 11 | 2021 | 900 in 2006 ~25 in 2016-2018 Observed in 2021 | Burned every 1-3 years, invasive plant treatment every 2 years, chopping/mowing as needed ⁶ | Possibly Decreasing |
| Babcock-Webb WMA (Main Tract) | Charlotte | State | 25 | 2017 | 50-100 in 1996 30 in 1999 2 in 2017 | Burned twice in last ten years, herbicide invasives treatments as needed, chopping/mowing twice in last ten years ⁶ | Possibly Decreasing |
| Babcock-Webb WMA (Main Tract) | Charlotte | State | 26 | 2017 | 333 in 1999 540 in 2017 | Burned twice in last ten years, herbicide invasives treatments as needed, chopping/mowing once in last ten years ⁶ | Possibly Stable |

Beautiful Pawpaw 5-Year Review

| Site Name | County | Ownership | EO Number | Last Observation Date | Population Estimates | Management Actions and Notes | Status |
|-------------------------------|-----------|-----------|-----------|-----------------------|---|---|---------------------|
| Babcock-Webb WMA (Main Tract) | Charlotte | State | 27 | 2016 | 24 in 1999 37 in 2016 | Burned every 2-4 years, chopped 2020 ⁶ | Possibly Stable |
| Babcock-Webb WMA (Main Tract) | Charlotte | State | 28 | 2018 | 65 in 1999 12-21 in 2004 213 in 2016 135 in 2017 Observed in 2018 | Burned twice in last ten years, herbicide invasives treatments as needed ⁶ | Possibly Stable |
| Babcock-Webb WMA (Main Tract) | Charlotte | State | 38 | 2019 | 25-35 in 2017 8 in 2019 | Burned every 2-4 years, herbicide invasives treatments as needed, chopped 2019 ⁶ | Possibly Decreasing |
| Babcock-Webb WMA (Main Tract) | Charlotte | State | 40 | 2018 | 64 | Burned every 2-4 years, herbicide invasives treatments as needed, chopped 2019 ⁶ | Possibly Stable |
| Babcock-Webb WMA (Main Tract) | Charlotte | State | 41 | 2017 | 78 in 2005 2,638 in 2017 (larger area) | Burned every 2-3 years, herbicide invasives treatments as needed ⁶ | Unknown |
| Babcock-Webb WMA (Main Tract) | Charlotte | State | 43 | 2018 | 3 in 2004 4 in 2016 5 in 2018 | Burned every 2-5 years, herbicide invasives treatments as needed ⁶ | Possibly Stable |
| Babcock-Webb WMA (Main Tract) | Charlotte | State | 47+ | 2019 | 75-150 in 2017 155 in 2019 | Burned every 2 years, invasive plant treatments as needed, chopping/mowing as needed ⁶ | Possibly Stable |
| Babcock-Webb WMA (Main Tract) | Charlotte | State | 50+ | 2008 | Present but number unknown | Last burned 2014, herbicide invasives treatments as needed, chopped 2016 ⁶ | Unknown |
| Babcock-Webb WMA (Main Tract) | Charlotte | State | 51+ | 2018 | Present but number unknown | Burned August 2016, herbicide invasives treatments 2015 ⁶ | Unknown |
| Babcock-Webb WMA (Main Tract) | Charlotte | State | 52+ | 2008 | Present but number unknown | Burned January 2014, March 2015. Herbicide invasives treatments in 2014-2015, 2020 ⁶ | Unknown |
| Babcock-Webb WMA (Main Tract) | Charlotte | State | 53+ | 2019 | 1 | Burned August 2009, December 2012, herbicide invasives treatments in 2013, 2017-2018 ⁶ | Unknown |
| None | Charlotte | Private | 15 | 1992 | 50-200 | None, habitat still available | Unknown |
| None | Charlotte | Private | 23 | 1995 | 1 | None, habitat still available | Unknown |
| None | Charlotte | Private | 36 | 2007 | 151-1,100 in 2006 200-1,200 in 2007 | None, habitat still available | Unknown |
| None | Charlotte | Private | 44 | 2006 | 11-50 | None, some habitat still available | Unknown |

Beautiful Pawpaw 5-Year Review

| Site Name | County | Ownership | EO Number | Last Observation Date | Population Estimates | Management Actions and Notes | Status |
|---|-----------|----------------------|-----------------|-----------------------|---|---|---------------------|
| Yucca Pens Unit of Babcock-Webb WMA | Charlotte | State | 24 | 1995 | 5-6 | Burned August 2014, mowed 2019, herbicide invasives treatments as needed ⁶ | Unknown |
| Yucca Pens Unit of Babcock-Webb WMA | Charlotte | State | 48 ⁺ | 2017 | 93 | Herbicide invasives treatments 2019, 2020 ⁶ | Unknown |
| Yucca Pens Unit of Babcock-Webb WMA and Private Land | Charlotte | State/Private | 10 | 2017 | >2,500 in 1992 >500 in 2017 | None on private land, unknown for state land | Possibly Decreasing |
| Charlotte Harbor Preserve State Park and Private Land | Lee | State/Private | 31 | 2021 | ~1,000 in 2009 ⁵ ~100-1,000 in 2019 Observed in 2021 | None on private land (some areas developed). Roller chopping, prescribed fire, invasive plant herbicide treatments on state land ⁵ | Possibly Stable |
| None | Lee | Private | 55 ⁺ | 2021 | >2 | None | Unknown |
| None | Lee | Private | 6 | 2019 | 20-30 in 1992 2 in 2019 | Mowed along roadsides, mostly developed into residential area | Unknown |
| None | Lee | Private | 5 | 1992 | 150-200 | None, mostly residential area | Possibly Extirpated |
| None | Lee | Private | 4 | 1992 | 100 | None, mostly residential area | Possibly Extirpated |
| None* | Lee | Private | 17 | 2004 | 28 translocated on site in 1990 ⁷ 10-15 in 1992 409 in 2003 (248 translocated on site and 161 broke dormancy) ⁷ 376 in 2004 ⁷ | Unknown, habitat still available | Unknown |
| Buttonwood Preserve | Lee | County | 1 | 2021 | 2,000 in 1984 >1,000 in 1992 >20 in 2021 ⁸ | Fireline installation, invasive species removal, and hardwood reduction all planned and funded for 2021-2022 ⁸ | Unknown |
| None | Lee | Private | 18 | 1992 | ~500 | None, habitat still available | Unknown |
| Pine Island Preserve at Matlacha Pass | Lee | Private Conservation | 54 ⁺ | 2019 | 4 | Prescribed fire every 3-4 years and invasive plant treatments ⁹ | Unknown |
| Pine Islands Flatwoods Preserve | Lee | County | 19 | 2021 | 5 in 1992 1 in 2019 >40 in 2021 ⁸ | Invasive plant species control ⁸ | Possibly Increasing |
| St. James Creek Preserve* | Lee | Private Conservation | 46 | 2021 | 100 planted in 1996 ⁴ 40 in 1998 ⁴ 1 in 2006 ⁸ 4 in 2021 ⁸ | Invasive plant species control ⁸ | Unknown |

¹Norman 2021, ²O'Neil and Proenza 2019, ³O'Neil and Proenza 2021, ⁴Service 1998, ⁵Garner 2021, ⁶Pope 2021, ⁷Preston et al. 2004, ⁸Allman 2021, ⁹Amos 2019

Beautiful Pawpaw 5-Year Review

* Indicates a transplanted population.

+ Indicates a newly documented population/occurrence since the last review.

Beautiful pawpaw 5-Year Review

[2] Populations (meeting criterion 1) occur in pine flatwoods habitat distributed across the historical range of the species in order to maintain and enhance the species geographic patterns of genetic diversity. (Factor A)

Surveys have indicated that the beautiful pawpaw occurs throughout its historic range, but the populations are fragmented and occur primarily in two disjunct areas in Lee and Charlotte counties and in Orange County (FNAI 2021). Many acres of suitable habitat exist in these counties and those in between the disjunct areas that are unoccupied. Approximately sixteen populations are comprised of 50 or fewer pawpaws and the populations on private property that have not been assessed recently are likely of this size, if still extant (FNAI 2021). Small populations of plants tend to lack genetic diversity and may not be self-sustaining over time (Ellstrand and Elam 1993). They may also be more vulnerable to stochastic events. However, these small-sized populations are still very important to beautiful pawpaw recovery because they contribute to the overall genetic diversity that remains within the species and may represent appropriate sites for conservation translocations to help augment population viability in the future. Conservation efforts should focus on maintaining the genetic diversity of small populations and enhancing it wherever possible via management that encourages increased reproductive output and through carefully planned augmentations. Collections from a subsample of four populations from Charlotte (1), Lee (1), and Orange (2) counties have shown that a fairly high level of heterozygosity and genetic diversity exist within these populations (Edwards et. al 2020). However, additional work is needed to describe the geographic patterns of genetic diversity between populations and to quantify the total amount of diversity currently protected.

[3] Populations (meeting criterion 1) must be protected via a conservation mechanism and managed such that enough suitable habitat is present for the species to remain viable for the foreseeable future. (Factors A, C, D and E)

This criterion has been partially met. Only five publicly owned/protected sites were known at the time of the writing of the recovery plan, and two of these were transplanted populations (Service 1999). Currently, approximately 66 percent of the extant populations (23 out of 35) are either in public ownership or on privately protected lands at ten different managed areas, while about 34 percent (12 out of 35) are in privately owned unprotected sites (FNAI 2021). This increase in the amount and proportion of protected populations is due both to land acquisition and to the discovery of new populations on already protected lands. Since the time of the last status review (Service 2009), Lee County has acquired additional property for their Buttonwood Preserve with a population of beautiful pawpaw.

Even on public lands, resources for management actions may not always be available, and habitat needed to support pawpaws will degrade in the absence of regular management. Control of invasive plant species and prescribed fire are important management strategies for maintaining healthy pawpaw populations. The vegetation structure and diversity of pine flatwoods are typically maintained by fire, approximately every 3-5 years, especially during lightning season in the spring. On many privately owned properties, fire has historically been excluded, and habitat has not received regular maintenance. Because fragmented habitat where these plants

Beautiful Pawpaw 5-Year Review

occur is interspersed on a developed landscape, burning may also be unlikely due to proximity to the wildland urban interface. Where burning and/or targeted regular mowing occurs, plants are generally persisting (Garner 2021; Pope 2021).

Populations on private property are not adequately protected from further habitat loss, degradation, or destruction. One population in Orange County is considered extirpated, likely due to lack of habitat management or crushing of the plants by debris while several other populations on private property haven't been visited since the 90's (FNAI 2021). Additionally, plants newly discovered in a vacant lot on private property for sale in Lee County may be at imminent risk of development (Amos 2021a). Another population in Orange County has suffered from ornamental shrub plantings on the property that destroyed a number of plants (Norman 2021). With human population expansion predicted for the counties within its historic range over the next 50 years (Carr and Zwick 2016), the species remains vulnerable to development and even further fragmentation and fire exclusion.

C. Updated Information and Current Species Status

1. Biology and Habitat

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

Information on the habitat and life history of the beautiful pawpaw, a long-lived diminutive shrub of the custard apple family (Annonaceae), is summarized in the MSRP (Service 1999), the last 5-year review for this species (Service 2009), and the Service's Recovery Plan Amendment for Beautiful Pawpaw (Service 2019) with additional information provided below.

In-depth research on olfactory compounds emitted by beautiful pawpaw flowers has revealed much about the floral scent composition of this species. Since this species is protogynous (each flower maturing to the female stage first, then male), compounds could be analyzed at both sexual stages. The compounds emitted by both male and female flowers consist predominantly of sweet-smelling benzenoids, with the proportion of these compounds increasing from the female-to-male stages. Female flowers emit the also sweet-smelling monoterpene alcohol linalool compound. The presence of these pleasant floral odors is indicative of a broad pollinator-attracting strategy, although their use as a repellent against herbivorous insects cannot be ruled out (Goodrich and Raguso 2009).

Nevertheless, prior pollinator observations in the field have been scarce and have included a tumbling beetle (*Mordella atrata*) and two species of thrips (*Frankliniella bispinosa* and *Thrips hawaiiensis*) (Norman 2003). However, these observations were made during the day while beautiful pawpaw flowers may be especially attractive to night-flying noctuid moths (Goodrich and Raguso 2009; Jurgens 2009). Therefore, nighttime pollinator observations should be made to characterize insect visitation diversity and frequency more accurately. In the co-occurring species netted pawpaw (*Asimina reticulata*), the scarab beetle

Beautiful Pawpaw 5-Year Review

Trichiotinus rufobrunneus was found to be the most frequent insect visitor by far during observations of flowers made during morning, afternoon, and evening, though visitation rates were also low for this common pawpaw species (Barton and Menges 2018).

Disturbance to the plants, such as mowing or fire, generally results in stimulating increased flower production (Helkowski and Johnson 2000; Norman 2003). These forms of disturbance have also been found to lead to increased fruit production and retention in the related species netted pawpaw (Barton and Menges 2018), and it would not be unreasonable to expect similar results from beautiful pawpaw. Fruit set, which occurs very infrequently, is most likely possible after self-pollination of flowers (Norman 2003; Pang and Saunders 2014), and the low pollen to ovule ratio present in the *Deeringothamnus* genus is indicative of self-pollination potential (Norman 2007). However, fruit production could be reduced in comparison to outcrossing (Barton and Menges 2018) and seeds may have reduced viability (Norman 2003). The retention of self-compatibility in this and other species in the family may act as a safeguard when populations are small and isolated from one another and when pollinator visitation rates are low (Pang and Saunders 2014), all of which apply to beautiful pawpaw. Fruit typically takes 3-4 months to mature, and seeds can take up to a year after burial to germinate (Norman 2003; Norman 2007). The effects of infrequent pollinator visitation and fruit set, conditions required for seed germination and growth, and the disjunct distribution of existing populations all compound to make the reproductive capacity of this species quite limited.

Norman (2009) conducted limited experiments with seed collected from Orange County and reported good germination success but very low seedling survival. Conservation staff at Bok Tower Gardens have been able to germinate wild-collected seed at an 80-100 percent success rate (Peterson 2021). Norman suggested that the species may rely on a mycorrhizal fungi association to promote seedling survival (2009). Confirmation of this association would greatly increase the understanding of the needs of this species to persist. Notably, the congener Rugel's pawpaw (*Deeringothamnus rugelii*) was not found to be strongly associated with particular soil microbiome communities (Edwards et al. 2020).

b. Abundance, population trends, demography:

There are an estimated 35 extant populations for beautiful pawpaw documented within its current range in Charlotte, Lee, and Orange Counties while at least 7 are extirpated or likely extirpated (Table 1). However, it can be difficult to determine when a population should be considered extirpated since plants can remain dormant underground for several years and can reemerge once degraded habitats have been restored (Peterson 2019a). Populations were determined to be extirpated if the last survey found zero plants and the site was developed. Populations were determined to be possibly extirpated if the last survey found zero plants but there is still habitat in the area, even if it needs restoration, or the

Beautiful Pawpaw 5-Year Review

last survey that found plants was over 10 years ago and the area had been mostly developed.

Recent surveys have not been conducted at all known populations (4 populations have not been surveyed since the 1990s) and trend data are lacking, but data collected over the last 20 years indicates that the total number of plants may be in the order of approximately 5,500 individuals or more in the 35 extant populations (FNAI 2021). The last status review reported approximately 5,000 plants in 39 occurrences (Service 2009). Similarly, Johnson (1999) estimated the total population to be between 4,700 and 10,500 individuals, but only reported that the species occurred on 28 sites. This difference in the number of occurrences over time is the result of newly discovered occurrences, merging of occurrences, and differences in the definition of what constitutes an occurrence (also referred to as population for this review) according to NatureServe's guidance (2020). The number of populations and total plant numbers are probably much smaller than that which occurred in historic times, due to habitat fragmentation and degradation (Service 1999). It is possible that this species used to be especially more common on wetter sites with Oldsmar soils, but since these areas are even more prone to woody encroachment than drier sites, beautiful pawpaw has been lost from many of these areas (Hilsenbeck 1992). Since the last review (Service 2009), 18 of the previously known populations have been at least partially assessed and 9 new populations have been added (Table 1). The number of plants ranges from only one to two plants on some sites to thousands of individuals at Babcock-Webb WMA (FNAI 2021).

FNAI surveyed each year from 2016 to 2019 on the Babcock-Webb WMA resulting in a total count of approximately 3,800 plants within 18 populations, 6 of which were newly discovered. Approximately 2,600 of these plants were observed in one area less than 20 acres in size, showing how abundant plants can be when frequent burning is applied; this site had been burned 3 times in the preceding 6-year period. It should be noted that the FNAI surveys, while extensive, by no means captured all of the suitable habitat for this species on the property and so even more populations could exist on this managed area. Of the 12 previously recorded populations on the property revisited during these surveys, all still had beautiful pawpaw plants present, however in most cases differing survey efforts and search areas between years make direct comparisons over time difficult. At part of one population revisited within the Yucca Pens Unit, over 1,000 plants had been seen in 1992 while only 33 were seen in a thorough survey in 2017 (FNAI 2021). In part of another population, numbers have fluctuated from between 11-50 plants to hundreds of plants over a twelve-year period. Other populations have remained small over extended periods of time: one population with 24 plants counted in 1999 and 37 plants in 2016 and another population with 3 plants observed in 2004 and 5 plants observed in 2018 (Table 1). To some degree, fluctuations in numbers is not unexpected since the species can be difficult to detect in habitat that has not been recently burned or cleared and may be surviving completely underground in a vegetative state. Repeated surveys

Beautiful Pawpaw 5-Year Review

during the growing season after management actions have taken place are needed to determine the true population numbers and trends at managed sites.

No long-term estimates of survival for natural populations have been obtained for the species, but short-term survival was monitored in three transplanted populations. Experimental translocations of adult plants have taken place and been documented at four separate locations: one at St. James Creek Preserve in 1996, one at Charlotte Harbor Environmental Center in 1997, one at Tosahatchee WMA in 2006, and one on private land on Pine Island in the early 2000s (Service 1998; Preston et al. 2004; FNAI 2021). These populations were either monitored closely for the year following the experiment or at least revisited the following year, but none were followed carefully since this time. The Tosahatchee WMA population was revisited the year after the translocation and 12 of the original 21 plants (57 percent) remained (FNAI 2021). The mean initial survival rates were 39, 65, and 87 percent for St. James Creek Preserve, Charlotte Harbor Environmental Center, and Pine Island, respectively (Service 1998; Preston et al. 2004).

The especially high initial survival rate of the translocation on Pine Island may be due in part to repeated surveys during the growing season that allowed for observation of previously dormant plants (Preston et al. 2004). In general, initial survival rates appear to be higher in *Deeringothamnus* transplantations within existing populations compared introductions to new unoccupied sites (Preston et al. 2004; Norman 2007). Naturally occurring plants were previously present on the Pine Island translocation site while none were previously present at the Tosahatchee WMA site. It is unclear whether plants were previously present before translocation at St. James Creek Preserve or Charlotte Harbor Environmental Center. In 2021, only 4 plants were observed within the transplant area at St. James Creek Preserve though 100 were planted in 1996 (Allman 2021). It is possible these individuals may not all represent the exact individuals that were outplanted at the site; they could be naturally occurring plants or offspring of the original transplants. During a recent search in 2021, no plants were seen within the outplanted area at the Charlotte Harbor Environmental Center where 100 were planted in 1997 (Garner 2021); it is uncertain whether any plants from this project have survived long-term. Considering that at least part of the transplant project area is in an open powerline area that does not suffer from woody encroachment and no plants have been seen even there, this transplanting effort may have failed. At this time, the current status of the Pine Island private land transplants is not known. At Tosahatchee WMA, the most recent survey in 2019 found 3-5 individuals on site (FNAI 2021).

Translocation of beautiful pawpaw can be difficult, as plants have a long taproot that must not be allowed to dry out, so translocations should be carried out quickly (Norman 2007). While the reported moderate to high first year survival rates provide good preliminary evidence of the potential for translocation as a recovery technique for this species, many years of data on survival, reproduction,

Beautiful Pawpaw 5-Year Review

and habitat management activities may be necessary to reveal the true success of plant translocations (Albrecht et al. 2011). The apparent decreases in the Tosohatchee WMA and St. James Creek Preserve populations observed more recently help to demonstrate this fact while also calling attention to the question of whether specific management actions or different planting conditions could improve long-term survival rates. In the future, any additional translocation projects that occur should be closely monitored for several years following outplanting to more fully capture long-term survival rates. More frequent monitoring may be needed directly following management actions to assess beautiful pawpaw's responses. Additionally, details on flowering and fruiting rates should be reported to assess the viability of these transplanted populations. A Service-funded Coastal Program grant may allow for an additional introduction project to occur in the near future (Service 2021), in which case it should be monitored closely for several years to properly assess survival, recruitment, and mortality rates.

c. Genetics:

One currently ongoing study has begun to examine the genetic variation within a small proportion of the beautiful pawpaw populations. Although the primary focus of this study was the species' congener *Deeringothamnus rugelii* (Rugel's pawpaw), part of the research involved preliminary work to understand the genetic diversity and structure present within beautiful pawpaw populations and the level of hybridization with related species. Genetic analysis of leaf tissue collected from four populations showed fairly high levels of observed heterozygosity, indicating high genetic diversity (Edwards et al. 2020). Additionally, out of five beautiful pawpaw populations tested to detect the presence of hybrid individuals (i.e., *D. pulchellus* x *D. rugelii* and *D. pulchellus* x *Asimina pymaea* [dwarf pawpaw]), three out of five populations had one to two hybrid individuals present. Even greater numbers of *D. pulchellus* x *D. rugelii* hybrids were detected within known *D. rugelii* populations. Further sampling completed within the last year revealed that most hybrids present within populations were between *D. pulchellus* x *D. rugelii*, but that the former could also hybridize with *A. reticulata* (Edwards et al. 2021). The existence of the intrageneric hybrid type is especially interesting given that these two endangered species don't overlap in range according to known locations. *D. rugelii* is a Volusia County endemic whereas *D. pulchellus* is only known to occur in Orange, Lee, and Charlotte Counties. A *D. pulchellus* x *D. rugelii* hybrid was even detected in Lee County within a known *D. pulchellus* population from which the nearest known *D. rugelii* population is approximately 250 kilometers (km) (155 miles [mi]) away. These genetic results imply two likely scenarios: 1) pollinators are being carried long distances via storms and/or seed dispersers are traveling long distances to make interaction between populations of these two species possible (Edwards et al. 2020, 2021) and/or 2) additional, undiscovered populations of either or both species exist that would bring the two in closer proximity than previously thought. Both possibilities should be further investigated through pollinator/seed disperser characterization studies and through

Beautiful Pawpaw 5-Year Review

surveys of unsearched habitat. Additional work should also include the collection of voucher specimens of known hybrid individuals, in order to determine if these plants can be morphologically distinguished from their parents reliably. Currently, no voucher specimens of these hybrid plants exist.

Another important revelation from this genetic analysis with conservation implications for both species of *Deeringothamnus* is the discovery that the northern Orange County populations of *D. pulchellus* genetically cluster closer together with the southern Volusia County *D. rugellii* populations than with Charlotte/Lee County intraspecific populations. The implication is that these two species have recently evolutionarily diverged from one another and have not evolved reproductive mechanisms to isolate themselves; thus, it is their geographic separation that maintains them as separate species (Edwards et al. 2021). If climate change were to cause range shifts that brought populations of the two species closer together, the genetic integrity of both these endangered species could suffer (Edwards et al. 2021).

d. Taxonomic classification or changes in nomenclature:

The species was first named and described by John K. Small as the only species belonging to the genus *Deeringothamnus* and separated from the genus *Asimina* by its “dimorphous stems, the flat or depressed receptacle, and the narrow nearly uniform unsculptured petals” (Small 1924). Rehder and Dayton (1944) discussed placing the species in the genus *Asimina*. Because the use of the combination *Asimina pulchella* did not meet nomenclatural rules, they retained the *Deeringothamnus pulchellus* name. A subsequent treatment of taxonomy is consistent with that of Small (Kral 1960). However, Ward (2001) suggested that due to the presence of forms that appear to be intermediates between *D. pulchellus* and its congener *D. rugellii*, they should be treated as a single species and varieties should be used to distinguish the two forms. According to Ward’s (2001) assessment, beautiful pawpaw should be named *D. rugellii* var. *pulchellus*. The scientific community, however, has not fully embraced this taxonomic change (Norman 2003; Goodrich and Raguso 2009), and Ward also now considers them as two separate species (Norman 2008). Indeed, the floral scent composition of the two species differ markedly both from each other and from members of the genus *Asimina* (Goodrich and Raguso 2009). Detailed histological work has revealed differences between the two species that merit maintaining each as their own entity (Deroin and Norman 2016). Recent molecular work by Mercer et al. (2016) indicated that *Deeringothamnus* is nested within *Asimina*. Still, not all agree on the inclusion of *Deeringothamnus* in *Asimina* and further taxonomic revision is likely, possibly even leading to the resurrection of the genus *Pityothamnus* (Weakley 2020). Currently, the Integrated Taxonomic Information System (2021) does not indicate any formal changes to the name *D. pulchellus*.

Beautiful Pawpaw 5-Year Review

e. **Distribution and trends in spatial distribution:**

Historically, beautiful pawpaw occurred on poorly drained sands of slash pine (*Pinus elliottii*) and longleaf pine (*P. palustris*)-saw palmetto (*Serenoa repens*) flatwoods in Lee and Charlotte Counties in southwestern Florida and in Orange County east of Orlando (Kral 1960). However, much of the suitable habitat in the historical range has been degraded or converted for residential housing, commercial activities, and agriculture, and abundance and distribution of plants have decreased as a result (Service 1999). This species has not been documented in the region between these two population centers, however suitable habitat does exist here. Extensive survey efforts specifically for this species within this spatial gap have not been conducted.

The range extent of this species has not changed significantly since the time of the last review in that both newly observed populations and possibly extirpated ones occur within the species' core range. Of the 35 extant populations, 21 are in Charlotte County, 9 are in Lee County, and 5 are in Orange County (Table 1). Trends in spatial distribution do show increasing fragmentation of beautiful pawpaw habitat, as southwestern and central Florida have become developed and fire has been excluded. Land clearing associated with the development of the town of Cape Coral in Lee County probably resulted in substantial losses of habitat and plants (Service 1999). Demands for horticulture, tropical fruit production, grazing, and residential housing have destroyed habitat and plants throughout beautiful pawpaw's known range (Service 1999). Extant populations in Charlotte, Lee, and Orange Counties are isolated in a highly fragmented landscape. Most populations are located on Pine Island and on the mainland in the Charlotte Harbor and Caloosahatchee River area from Punta Gorda to Fort Myers (Service 1999). Approximately 180 km (112 mi) separates the populations in Charlotte and Lee Counties from those in Orange County (FNAI 2021).

f. **Habitat or ecosystem conditions:**

Beautiful pawpaw naturally occurs in mesic flatwoods with an open canopy of slash pine or longleaf pine. Major groundcover components typical of this community include wiregrass (*Aristida stricta*), dwarf live oak (*Quercus minima*), and saw palmetto along with a diverse herbaceous community. Species composition within flatwoods habitat seems to differ little between beautiful pawpaw occupied and unoccupied sites (Johnson 1999), but the vegetation structure of the habitat is important; beautiful pawpaw requires an open ground layer. Populations of this species are known from Oldsmar, Immokalee, Wabasso sand, Punta fine sand, Pomello fine sand, and Malabar fine sand soils (Johnson 1999; Norman 2007). Especially high densities of plants have been reported on Immokalee sand (Chicardi 1992; Garner 2021). Suitable but fragmented habitat remains in all three historic counties of occurrence, but the exact amount of habitat available and how it is distributed amongst those counties is not well known. Considering the area of mesic flatwoods occurring on the soil types outlined above within the known range of the species, approximately 48,800 suitable acres remain (FNAI 2021; Natural Resources Conservation Service

Beautiful Pawpaw 5-Year Review

2021). Yet beautiful pawpaw populations are only estimated to occupy an area of approximately 100 acres range wide (FNAI 2021).

Control of invasive plant species and prescribed fire are important management strategies for maintaining healthy pawpaw populations. Mesic flatwoods are typically maintained by frequent fire, especially during lightning season in the spring. On many privately owned properties, fire has historically been excluded and would be difficult to conduct due to proximity of development; therefore, the habitat has not received regular management to maintain an open structure. Although, a few private sites seem to undergo occasional mowing, at least along the perimeters, which benefits the species (Peterson 2019b; FNAI 2021). About two-thirds of beautiful pawpaw populations occur on protected lands, many of which are being managed appropriately. In Charlotte and Lee Counties, many protected populations receive frequent treatment for invasive plants and prescribed fire or mechanical hardwood/palmetto reduction approximately every 3 to 4 years and in these areas, plants are generally persisting (Table 1; Amos 2019; Allman 2020; Amos 2021b; Garner 2021). In one notable case at Charlotte Harbor Preserve State Park, roller chopping to reduce hardwood competition, prescribed burning every 3-4 years, and herbicide treatments of melaleuca (*Melaleuca quinquenervia*), Brazilian pepper (*Schinus terebinthifolia*), downy rose myrtle (*Rhodomyrtus tomentosa*), and old-world climbing fern (*Lygodium microphyllum*) have led to beautiful pawpaw being observed in areas not previously seen (Garner 2019; Garner 2021). While the roller chopping technique seems to benefit the species at least in the short-term at this location, long-term effects are unknown. Care should be taken that chopping is not applied too frequently or too severely as to create excessive ground disturbance and harm plants. Longer-term effects on plant populations should be noted through monitoring. Others have noted that chopping at wetter sites could be especially detrimental (Johnson 1999). At the time of this review, additional land management actions are planned for 2021-2022 in Lee County preserves through funding from the Service and the Florida Department of Agriculture and Consumer Services (FDACS) Florida Plant Conservation Program specifically targeting recovery of this species (Allman 2021). Projects at Buttonwood Preserve, St. James Preserve, and Pine Islands Flatwoods Preserve aim to improve beautiful pawpaw habitat by installing firelines for future burning, treating for invasive plants, and reducing hardwood and saw palmetto density through mowing or roller chopping (Allman 2021).

g. Other:

An important area of research for this species involves *ex situ* conservation methods. Unfortunately, beautiful pawpaw has recalcitrant seeds that are unable to be stored long-term in a seed bank (Peterson et al. 2008), which would otherwise make for a relatively easy means of genetic preservation. Instead, the Center for Conservation and Research of Endangered Wildlife at the Cincinnati Zoo and Botanical Garden has been able to use *in vitro* tissue culture methods to store several genotypes of this species (Pence 2006, 2012). Shoot tips were used

Beautiful Pawpaw 5-Year Review

to establish culture lines from 27 percent of the species' genotypes (Pence and Charls 2003). While some amount of genetic change in tissue culture and cryopreserved materials after approximately 10 years of storage has been detected, this does not seem to affect the growth or survival of these tissues (Philpott 2018). This further validates the use of these methods as an *ex situ* preservation strategy. Additionally, the technique of droplet vitrification cryopreservation has been investigated as a method for long-term storage of shoot tips and nodes. Results have shown a 9 percent survival rate of shoot tips after 18 weeks, much lower than that of its congener, Rugel's pawpaw, which exhibited a 40 percent survival rate (Karbowski and Pence 2018).

Living plants are also preserved *ex situ* at Bok Tower Gardens as a part of the National Collection for the Center for Plant Conservation. Twelve plants with provenance from Orange County are contained in the collection beds and four plants originating from tissue culture are maintained in the greenhouse (Clarke and Peterson 2021). In the Botanic Gardens Conservation International (BGCI) Database, four institutions are listed as having beautiful pawpaw in *ex situ* collection (including Bok Tower Gardens) (BGCI 2021).

2. Five-Factor Analysis (threats, conservation measures, 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.

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

Continued habitat loss, fragmentation, and changes in land use threaten the existence of beautiful pawpaw. Where plants occur on private sites, development has led to both direct destruction of habitat because of land clearing and habitat degradation from lack of management. For example, one of the private populations in Orange County has been extirpated due to overgrowth of the invasive Brazilian pepper and neighborhood trash dumping. Also, two private populations in Lee County have likely been extirpated due to residential development and a third population has only two plants as of 2019 and is mostly developed (FNAI 2021).

Populations remaining on private land are vulnerable to destruction and habitat loss. Currently, about 34 percent of the populations of beautiful pawpaw are on

Beautiful Pawpaw 5-Year Review

unmanaged lands (FNAI 2021). Threats from development and habitat degradation on private sites are expected to continue and increase. Within the range of beautiful pawpaw, the human population is predicted to grow from over 164,000 to over 237,000 in Charlotte County, from just over 653,000 to nearly 1,551,000 in Lee County, and from nearly 1,228,000 to more than 2,650,000 in Orange County between 2014 and 2070 (Carr and Zwick 2016).

When the MSRP was developed, only 5 of the 21 known populations at the time were protected (Service 1999). Two of these were transplanted populations on public lands, of which plant numbers have been severely reduced, likely due to lack of management (Woodmansee and Barry 2007; Allman 2021; Garner 2021). Currently, about 66 percent (23 out of 35) of the beautiful pawpaw populations are either in public ownership or on managed areas (FNAI 2021). Three of the populations accounting for this increase in public/protected ownership can be attributed to land acquisition, in two cases by Lee County and in one case by the Conservation Foundation of the Gulf Coast. Other populations were found within existing publicly owned lands since the time of listing. Even with protection from development, continuing land management will be necessary for plants to persist in these areas.

Fire suppression and lack of management has led to the overgrowth and degradation of beautiful pawpaw habitat. Because the sites are fragmented on a developed landscape, fire management may not always be feasible and encroachment by invasive plant species from neighboring properties is likely. Therefore, habitat loss, degradation, and fragmentation due to increasing development, lack of management, and encroachment of invasive plants will continue to threaten the beautiful pawpaw. Lack of management is even a concern on some protected sites. Vegetation restoration and management programs are costly, and the availability of resources is never assured. Luckily, in the case of Lee County preserves on Pine Island, funds were recently acquired to begin management actions that should benefit beautiful pawpaw, including the installation of firelines for future burning, mowing, and increased invasive plant treatments (Allman 2021).

On many privately owned sites, fire has historically been excluded, and habitat has not received regular maintenance. Where this species occurs on fragmented landscapes interspersed with development, burning may be unlikely due to proximity to neighbors. In areas that cannot be readily burned, mowing is sometimes used as a management strategy. In mowed habitat, the growth habit of this species is more prostrate with woody stems lying on the ground, while in fire-maintained habitat, it grows more erect with arching stems and flowering is enhanced (Service 1999; Norman 2003).

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

This was not identified as a potential threat in the original listing rule (Service

Beautiful Pawpaw 5-Year Review

1986), the recovery plan (Service 1988, 1999, 2019), or the previous 5-year review (Service 2009) and is not known to be a current threat.

c. **Disease or predation:**

No incidences of disease have been reported for the beautiful pawpaw. When listed, some insect damage was reported to occur to the leaves and flowers of the plants (Service 1986). Norman (2003) reported destruction to buds, leaves, flowers, and young fruits by the caterpillar stage of the leaf roller (*Chloristoneura parallela*). *Deeringothamnus* spp. are the larval host plant for the pyralid moth (*Omphalocera munroei*) and the zebra swallowtail butterfly (*Eurytides marcellus*) (Damman 1989, 1991). Based on studies with *Asimina* spp., it is likely that the pyralid moth could cause significant defoliation in beautiful pawpaw (Damman 1989, 1991). Damman (1989) showed a facilitative interaction between the pyralid moth defoliation, which elicits a refoliation response in the host, and the caterpillars of the specialist zebra swallowtail butterfly that can then feed on these younger leaves. However, the amount of damage by swallowtail butterfly caterpillars is unlikely to negatively impact plants and very little damage has been previously reported (Norman 2003).

Herbivores, such as whitetail deer (*Odocoileus virginianus*), may also consume leaves from pawpaw plants, but foraging on pawpaws is not considered to be extensive because deer primarily browse on higher vegetation rather than graze on low-growing plants (Service 1999). On the other hand, a small population of four plants on Pine Island Preserve at Matlacha Pass is regularly defoliated by gopher tortoises and possibly butterflies and shows no signs of reproduction; one plant has also been observed to suffer from burial by a gopher tortoise at this location (Amos 2019, 2021b). It is probable that eastern cottontail rabbits (*Sylvilagus floridanus*) opportunistically consume pawpaw fruits because forbs and small shrubs are seasonally important components of the diet of the species (Service 1999). Both eastern cottontail rabbits and gopher tortoises may aid in the dispersal of seeds (Service 1999). In the related and co-occurring species netted pawpaw, a raccoon has been observed to ingest fruit, seemingly without damaging the seeds (Barton and Menges 2018). In fact, this ingestion may provide beneficial scarification to seeds (Barton and Menges 2018).

d. **Inadequacy of existing regulatory mechanisms:**

Generally, managing agencies have limited regulatory tools. The ESA prohibits the removal of federally listed threatened and endangered plants or the malicious damage of such plants on areas under federal jurisdiction, or the destruction of endangered plants on non-federal areas in violation of state law or regulations or in the course of any violation of a state criminal trespass law. The ESA does not provide protection for plants on non-federal lands unless it is in violation of state law.

The beautiful pawpaw is also listed at the state-level by FDACS as State-endangered (5B-40.0055 Regulated Plant Index), which is not reliant on ESA

Beautiful Pawpaw 5-Year Review

protections. The State listing does not provide any direct habitat protection. Regulations associated with this listing require both written permission from the owner or legal representative and a permit issued by FDACS to collect or remove plants listed as endangered on the Florida Regulated Plant Index. Additionally, Title 62D-2.013 of the Florida Administrative Code prohibits the removal, destruction, or damage of plants from Florida Department of Environmental Protection, Division of Recreation and Park properties. This regulation provides protection for the populations that occur on state park lands but does rely on public adherence to the Code since monitoring is limited.

Lee County offers some protection for the beautiful pawpaw through Division 8 of their Land Development Code which requires a survey for listed species on all properties that will be developed and that may have “possible presence” of such species, except for “small” developments. If listed species are found, a management plan must be created and approved or off-site mitigation for adverse effects to these State and federally listed species must occur (Lee County 2020). Twelve of this species’ populations are located within Lee County and the county is actively managing for this species on its preserves (Allman 2021). In the Charlotte County Code of Ordinances Article XVII (2021), property with listed species may be designated as “Environmentally Sensitive Lands”, which provides some protections; however, participation by private landowners is voluntary.

Existing regulatory mechanisms do not adequately prevent the development of sites with listed species, as several private properties with pawpaws have been developed and others are at-risk (Amos 2021a). Because this plant occurs in habitat which is desirable for development along the southwestern coast and inland near Orlando, this species remains vulnerable to development pressures where it occurs on private property. Occasionally, plants have been “rescued” from sites slated for development (Preston 2004; Norman 2007). For example, the transplanted individuals at Tosahatchee WMA were rescued from a nearby site in Orange County, prior to development (FNAI 2021). However, the Service or conservation partners must first know of both the presence of the pawpaws on these sites and of the imminent land use change to be able to undertake such a conservation action, as well as have permission to perform the rescue. In conclusion, there are no existing regulatory measures that reduce the threat of loss/reduction of populations via removal/destruction of plants on private property. It has only limited protections if the species was not protected under the auspices of the ESA; therefore, existing regulatory mechanisms are inadequate to protect this species.

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

Trampling

A threat identified in the initial listing was damage by off-road vehicles (ORV) in at least a portion of the species’ range (Service 1986). Damage from ORV use at Babcock-Webb WMA has increased over the last 10 years (Florida Fish and Wildlife Conservation Commission 2020), and some beautiful pawpaw

Beautiful Pawpaw 5-Year Review

populations may be affected due to their proximity to roads and trails. It is presumed that this threat also continues at private populations where access is not restricted and on public lands that are easily accessed. Feral hogs (*Sus scrofa*) also pose a threat to beautiful pawpaw plants. They have been particularly noted for their impact at Charlotte Harbor Preserve State Park where their population has been increasing over the last ten years. At least ten plants were noted as being directly damaged from the hog rooting and they have not reemerged. Limited resources mean that control efforts, while persistent, have not been sufficient to eliminate this threat (Garner 2021).

Reproductive Capacity

As indicated in Section II.C.1.a. of this review, beautiful pawpaw appears to have very limited pollinator visitation rates (Norman 2003) which limits the opportunity for outcrossing. This in turn could lead to decreased fruit production and to decreased seed viability from any fruits produced as a result from selfing. Fruit production is in fact observed at very low rates in the wild (Chicardi 1992; Norman 2007).

Few, Small, Isolated Populations in a Limited Geographic Range

The known populations of beautiful pawpaw occur within two disjunct areas. The isolation between the two areas in combination with habitat loss has resulted in a highly fragmented landscape where the remaining pine flatwoods that provide habitat for beautiful pawpaw have become more and more isolated from each other, thereby making resiliency, redundancy, and representation more challenging to achieve.

Climate Change

There is currently no evidence of negative impacts to beautiful pawpaw from climate change factors, but this could change in the future. Florida is vulnerable to changes in rainfall and temperatures expected due to climate change. While the strong influence of ocean currents makes projecting regional climate in Florida difficult (Kirtman et al. 2017), estimates project that Florida's average annual temperatures will increase approximately 1.5 to 5.5 degrees Fahrenheit (°F) (0.8 to 3.1 degrees Celsius [°C]) by 2050 and from 2.0 to 11.5°F (1.1 to 6.4°C) by 2100 depending on the greenhouse gas emission rates and the region in Florida (Runkle et al. 2017). In addition, it is predicted that Florida will experience drier wet seasons (summer) and wetter dry seasons (winter) (Sun et al. 2015). Higher temperatures and changes in precipitation patterns could alter relative humidity levels and evapotranspiration rates, leading to the potential for more frequent and intense droughts and wildfire events. It is unclear how this anticipated future threat will fully affect species like beautiful pawpaw. It is possible that any future conservation translocations for this species would require an even higher level of attention and maintenance, specifically in the form of irrigation, in order to combat the effect of intense drought.

Beautiful Pawpaw 5-Year Review

In addition to changes in precipitation and temperatures patterns, there are also anticipated changes to the severity of tropical storms and hurricanes. Sweet et al. (2017) predicted a 20 percent increase in both rainfall rates and wind speeds near the center of storms due, in part, to higher sea surface temperatures. Beautiful pawpaw was not affected by Hurricane Charley, which crossed the southwest portion of the species' range in Lee and Charlotte Counties in 2004 (Woodmansee and Barry 2007). During this hurricane, storm surge did not impact the populations near the coast but could in cases where storm surge is greater. Stronger hurricane wind speeds could also cause treefall and limbfall to damage or kill plants or create a buildup of fuel that could cause higher intensity fires.

Sea-level rise (SLR) is another anticipated consequence of climate change in Florida. A recent acceleration in SLR suggests that by 2120, sea levels are more likely to rise at the medium to extreme-high SLR scenarios (1.3 to 3.6 meters [4.3 to 11.8 feet] than the low to intermediate-low scenarios (0.34 to 0.60 meters [1.1 to 2.0 feet]) (Sweet et al. 2017). Based on the extreme scenario of 3.6 meters (11.8 feet) of SLR by 2120, there could be some impacts to as many as six beautiful pawpaw populations in western Lee and Charlotte Counties that are close to the coast. While this potential SLR inundation is well into the future, the impacts to beautiful pawpaw could begin earlier. Prior to inundation, pine flatwoods are likely to undergo habitat transitions related to changes in the salinity of the water table and soils. Ross et al. (2009) suggested that interactions between SLR and pulse disturbances, such as storm surges, can cause vegetation to change sooner than projected based on sea level alone.

Currently, effects from climate change to the pine flatwood habitats are unknown and there is no evidence that beautiful pawpaw is negatively impacted by climate change factors. However, the predicted changes in temperature, precipitation, tropical storm activity, and SLR will likely impact beautiful pawpaw in the future. In addition, as sea level rises in coastal regions, development is likely to move inland, further increasing the threat of development in more inland areas, such as portions of Charlotte, Lee, and Orange Counties (Volk et al. 2017).

D. Synthesis:

Beautiful pawpaw is a long-lived shrub that occurs in open mesic flatwoods habitat within a disjunct range, occurring in Orange, Charlotte, and Lee Counties, Florida. The populations are fragmented and isolated within the range. Currently, there are an estimated 35 populations, though it is difficult to determine the status of each given the lack of monitoring. Consistent annual surveys are needed to evaluate long-term population trends and additional studies need to be completed on long-term survival, reproductive patterns, and population structure.

Despite newly identified populations, ongoing habitat management, and recovery efforts described above, the criteria for delisting have not been fully met because there are currently not at least 30 populations with a stable or increasing trend that are protected

Beautiful Pawpaw 5-Year Review

via a conservation mechanism and managed such that enough suitable habitat is present for the species to remain viable for the foreseeable future. Only 9 populations have exhibited generally stable to increasing population numbers in recent years. All other sites where beautiful pawpaw occurs either have decreasing population numbers or their status is unknown, largely on private property. About 34 percent of the extant populations are on private property and most of these sites are not being adequately managed to maintain habitat to support the species. The current status of most of these populations is unknown due to lack of access to private lands. Therefore, the estimate of the total number of populations could be an overestimate if these populations are no longer extant. Even those populations that are currently extant on private lands are at risk of development.

Where habitat remains intact, beautiful pawpaw depends upon active management to persist. Land management practices, especially prescribed fire used for the reduction of other woody species, are extremely important for maintaining the health of the pine flatwoods ecosystem in which this species occurs. The removal of invasive plant species is also important for maintaining habitat for the species, as is feral hog control. Where sites have received regular site maintenance, plants are generally persisting or even increasing in numbers, but other sites on private lands have suffered from habitat degradation. Existing regulatory mechanisms do not appear to be adequate on private lands. Because this plant occurs in habitat along the southwest coast of Florida and near Orlando, which is desirable for development, this species remains vulnerable where it occurs on private property. Habitat loss, fragmentation, and changes in land use continue, and conversion of habitat to urban use along the coast and near Orlando is projected to increase over the next 50 years. The species' limited distribution and its limited reproductive capacity also renders it vulnerable to stochastic natural events, such as hurricanes and drought. Due to the above ongoing threats and documented declining and unknown population status, this species continues to meet the definition of endangered under the ESA.

III. RESULTS

A. Recommended Classification:

X No change is needed

IV. RECOMMENDATIONS FOR FUTURE ACTIVITIES

A detailed discussion of recovery actions and criteria are presented in the Recovery Plan and amendment (Service 1999 and 2019, respectively). During this status review, new and/or targeted potential recovery activities were identified and are included below.

Recovery Activities

- Continue removal of hogs and invasive plants species around beautiful pawpaw populations. Depending upon site, management efforts may include licensed hunting or trapping of hogs and careful application of herbicides to invasive plants.

Beautiful Pawpaw 5-Year Review

- Continue applying prescribed fire and reintroduce fire to habitats where this species occurs. Use careful mowing with minimal ground disturbance where burning is not possible or in combination with burning as a mechanical treatment to open up habitat and make the vegetation structure more suitable for beautiful pawpaw growth.
- Restore habitat in potential areas where plants could occur but are not currently reported and provide follow-up surveys post-disturbance to determine if natural populations are present.
- Identify additional (re)introduction sites, donor sites, and if needed, rescue sites (private lands slated for development) and establish reintroduced populations; augmentations should also be implemented where small, non-viable populations occur.
- Focus conservation efforts on marginal and small populations to preserve the genetic diversity of the species.

Monitoring/Research Activities

- Continue to survey potential habitat all counties of occurrence and in corridor counties.
- Conduct surveys of previously documented populations on private lands with a focus on those that have not been visited in over 20 years, occur on larger tracts, and/or are adjacent to existing conservation lands.
- Conduct research on the response of beautiful pawpaw to fire and fire prescriptions necessary to benefit the species.
- Monitor burned and mowed sites more closely to assess which technique is most beneficial to pawpaw reproduction and survival.
- Determine long-term effects of using careful roller-chopping as a mechanical treatment on population viability
- Conduct demographic studies to determine the age class structure and long-term viability of populations, especially in areas with active recruitment, and determine critical life stages.
- Develop and carry out a monitoring protocol for reintroduced/augmented populations to better characterize long-term survival of individuals and population viability.
- Conduct further genetic research to determine the level of genetic diversity that remains and is protected and apply this knowledge to future introductions and augmentations. Also, conduct further research to determine the level of hybridization with *D. rugelii* (Rugel's pawpaw) and *A. pygmaea* (dwarf pawpaw) in populations not yet assessed and the level of hybridization with *A. reticulata*. Collect voucher specimens of known hybrids to document their morphological characters.
- Continue to identify and evaluate insect pollinators associated with the species with a focus on conducting pollinator surveys at night when likely but undocumented insect visitors may be active.
- Investigate potential seed dispersers and their effectiveness.
- Conduct additional seed germination trials and make efforts to develop additional outplanting techniques.
- Continue propagation efforts and make sure all populations are represented in the Center for Plant Conservation's National Collection of Endangered Plants.
- Support continued work and research into *ex situ* cryopreservation methods to preserve cell lines of this species.

Beautiful Pawpaw 5-Year Review

- Evaluate the effects of climate change on the species, including those that result from precipitation pattern changes and temperature rise.

Outreach Activities

- Promote partnerships to share information, conduct collaborative research on pine flatwoods habitat conservation, and provide land managers and the interested public with information about the ecosystem, threats, recovery actions, and associated rare biota.
- Actively engage and encourage private landowners to manage pine flatwoods for ecosystem health and listed species.
- Seek opportunities to include the media in conservation efforts to provide information about this species to the public.

V. REFERENCES

- Albrecht, M.A., E.O. Guerrant, K. Kennedy, and J. Maschinski. 2011. A long-term view of rare plant reintroduction. *Biological Conservation* 144: 2557-2558.
- Amos, L. 2019. Personal communication. Land Steward. Conservation Foundation of the Gulf Coast. E-mail to Bauer dated October 30, 2019.
- Amos, L. 2021a. Personal communication. Land Steward. Conservation Foundation of the Gulf Coast. E-mail to Rosner-Katz dated June 17, 2021.
- Amos, L. 2021b. Personal communication. Land Steward. Conservation Foundation of the Gulf Coast. E-mail to Rosner-Katz dated June 6-16, 2021.
- Barton, L.K. and E.S. Menges. 2018. Effects of fire and pollinator visitation on the reproductive success of *Asimina reticulata* (Annonaceae), the netted pawpaw. *Castanea* 83(2): 323-333.
- Botanic Gardens Conservation International (BGCI). 2021. PlantSearch online database. Botanic Gardens Conservation International. Richmond, U.K. Available at https://tools.bgci.org/plant_search.php.
- Carr, M.H. and P.D. Zwick. 2016. Florida 2070. Mapping Florida's Future – Alternative Patterns of Development in 2070. A research project prepared for Florida Department of Agriculture and Consumer Services and 1000 Friends of Florida. Prepared by the Geoplan Center at the University of Florida, Gainesville, Florida.
- Charlotte County. 2021. Code of Ordinances of Charlotte County, Florida. Codified through Ordinance No. 2021-016, adopted May 11, 2021. (Supp. No. 112)
- Chicardi, E.J. 1992. An Evaluation of *Deeringothamnus pulchellus*: Distribution and Habitat Preference. Submitted to the Florida Natural Areas Inventory.

Beautiful Pawpaw 5-Year Review

- Damman, H. 1989. Facilitative interactions between two lepidopteran herbivores of *Asimina*. *Oecologia* 78: 214-219.
- Damman, H. 1991. Oviposition Behaviour and Clutch Size in a Group-Feeding Pyralid Moth, *Omphalocera munroei*. *Journal of Animal Ecology* 60(1) 193-204
- Deroin, T. and É.M. Norman. 2016. Notes on the floral anatomy of *Deeringothamnus* Small (Annonaceae): cortical vascular systems in a chaotic pattern. *Modern Phytomorphology* 9: 3-12.
- Edwards, C.E, C.L. Peterson, E.M. Norman, V.C. Pence, and D.B. Young. 2020. Field surveys, land management, genetic and microbiome research, cryopreservation, and introductions of the endangered Rugel's pawpaw. Report submitted to Florida Department of Agriculture and Consumer Services. Tallahassee, Florida.
- Edwards, C.E, C.L. Peterson, E.M. Norman, V.C. Pence, and D.B. Young. 2021. Field surveys, land management, genetic and microbiome research, cryopreservation, and introductions of the endangered Rugel's pawpaw. Report submitted to Florida Department of Agriculture and Consumer Services. Tallahassee, Florida.
- Ellstrand, N.C. and D.R. Elam. 1993. Population genetic consequences of small population size: implications for plant conservation. *Annual Review of Ecology and Systematics* 24: 217-242.
- Florida Fish and Wildlife Conservation Commission. 2020. Babcock-Webb Off-Road Vehicle Use Flyer. Florida Fish and Wildlife Conservation Commission. Tallahassee, Florida.
- Florida Natural Areas Inventory (FNAI). 2021. Unpublished element occurrence point data.
- Garner, P. 2019. Personal communication. Environmental Specialist II. Charlotte Harbor Preserve State Park. E-mail to Bauer dated September 12-16, 2019.
- Garner, P. 2021. Personal communication. Environmental Specialist II. Charlotte Harbor Preserve State Park. E-mail to Rosner-Katz dated June 6-29, 2021.
- Goodrich, K.R. and R.A. Raguso. 2009. The oldfactory component of floral display in *Asimina* and *Deeringothamnus* (Annonaceae). *New Phytologist* 183: 457–469.
- Helkowski, J. and A.F. Johnson. 2000. A study of the effects of the 1998 Central Florida wildfires on populations of Rugel's pawpaw (*Deeringothamnus rugelii*): final summary report. Florida Natural Areas Inventory, Tallahassee, Florida.
- Hilsenbeck, R.A. 1992. Status survey for *Deeringothamnus pulchellus* (beautiful pawpaw) conducted by the Florida Natural Areas Inventory, Tallahassee, Florida.

Beautiful Pawpaw 5-Year Review

Integrated Taxonomic Information System. 2021. <http://www.itis.gov/>. Checked September 9, 2021.

Johnson, A.F. 1999. A survey for beautiful pawpaw (*Deeringothamnus pulchellus*) on Babcock-Webb Wildlife Management Area and Charlotte Harbor State Buffer Preserve, Charlotte and Lee Counties, Florida: an FNAI ecological inventory. Florida Natural Areas Inventory, Tallahassee, Florida.

Jurgens, A. 2009. The hidden language of flowering plants: floral odours as a key for understanding angiosperm evolution? *New Phytologist* 183(2): 240-243.

Karbowski, C.F. and V.C. Pence. 2018. Droplet vitrification- a favorable method of cryo-preservation for selected pawpaw species. *The Ohio Journal of Science* 118(1): A17-A17.

Kirtman, B.P., V. Misra, R.J. Burgman, J. Infanti, and J. Obeysekera. 2017. Florida Climate Variability and Prediction. In: *Florida's Climate: Changes, Variations, & Impacts*. <https://floridacclimateinstitute.org/docs/climatebook/Ch17-Kirtman.pdf>.

Kral, R. 1960. A revision of *Asimina* and *Deeringothamnus* (Annonaceae). *Brittonia* 12: 233-278.

Lee County. 2020. Land and Development Code Lee County, Florida. Codified through Ordinance No. 20-09, adopted September 15, 2020. (Supp. No. 20)

Mercer, E., B. Griffin, J. Steele, K.R. Goodrich, and C.M. Bush. 2016. Phylogenetic relationships of *Asimina* and *Deeringothamnus* (Annonaceae) based on morphology, floral scent chemistry, and Inter-Simple Sequence Repeat data 1. *The Journal of the Torrey Botanical Society* 143(1): 58-68.

Natural Resources Conservation Service. 2021. United States Department of Agriculture. Web Soil Survey. Available online at: <http://websoilsurvey.sc.egov.usda.gov/>.

Norman, E.M. 2003. Reproductive biology of *Deeringothamnus rugelii* and *D. pulchellus* (Annonaceae). *Taxon* 52: 547-555.

Norman, E.M. 2007. The “false” pawpaws: history, biology, and conservation of *Deeringothamnus*. *The Palmetto*. 24(4) 4-7.

Norman, E.M. 2008. Personal communication. Professor Emerita. Department of Biology, Stetson University. E-mail to Bradley dated August 22, 2008.

Norman, E.M. 2009. Personal communication. Professor Emerita. Department of Biology, Stetson University. E-mail to Knight dated April 3, 2009

Norman, E.M. 2021. Personal communication. Professor Emerita. Department of Biology, Stetson University. E-mail to Rosner-Katz dated June 3-18, 2021.

Beautiful Pawpaw 5-Year Review

- O'Neil, T. and L. Proenza. 2019. Personal communication. Biological Scientist II. Tosohatchee Wildlife Management Area. E-mail to Bauer dated October 7, 2019.
- O'Neil, T. and L. Proenza. 2021. Personal communication. Biological Scientist II. Tosohatchee Wildlife Management Area. E-mail to Rosner-Katz dated June 6-10, 2021.
- Pang, C.C. and R.M. Saunders. 2014. The evolution of alternative mechanisms that promote outcrossing in Annonaceae, a self-compatible family of early-divergent angiosperms. *Botanical Journal of the Linnean Society* 174(1): 93-109.
- Pence, V.C. and S.M. Charls. 2003. In vitro collecting and establishment of tissue culture lines of three endangered Florida pawpaws. *In Vitro Cellular & Developmental Biology Plant* 39, 19-A. [Abstract from Plant Contributed Paper Session]
- Pence, V.C. 2006. Propagating and preserving pawpaws (and other rare species) from Florida. *The Palmetto* 23(4): 8-11.
- Pence, V.C. 2012. From freezing to the field- in vitro methods assisting plant conservation *BGjournal* 9(1): 14-17.
- Peterson, C.L. 2019a. Personal communication. Conservation Program Manager. Bok Tower Garden. E-mail to Bauer dated September 25, 2019.
- Peterson, C.L. 2019b. Personal communication. Conservation Program Manager. Bok Tower Garden. E-mail to Bauer dated October 3, 2019.
- Peterson, C.L. 2021. Personal communication. Conservation Program Manager. Bok Tower Garden. E-mail to Rosner-Katz dated June 1-June 3 2021.
- Peterson, C.L., C. Campbell, L. Birch, K. Holten, and R. Rich. 2008. An integrated conservation program for the protection of Florida's rare and endangered flora- north and central Florida region. Final report to the Florida Plant Conservation Program of the Department of Agriculture for contract 011298. Gainesville, Florida.
- Preston, D., D. Workman, and W. Everham. 2004. *Deeringothamnus pulchellus* (beautiful pawpaw) relocation and first year monitoring project. Poster presentation at the 2004 Rare Plant Task Force Meeting. Miami, Florida.
- Pope, A. 2021. Personal Communication. Fred C. Babcock/Cecil M. Webb Wildlife Management Area. Email to Rosner-Katz dated June 15-16, 2021.
- Rehder, A. and W. Dayton. 1944. A new combination in *Asimina*. *J. Arnold Arboretum* 25: 84.
- Ross, M.S., J.J. O'Brien, R.G. Ford, K. Zhang, and A. Morkill. 2009. Disturbance and the rising tide: The challenge of biodiversity management on low-island ecosystems. *Frontiers in Ecology and the Environment* 7(9): 471-478.

Beautiful Pawpaw 5-Year Review

- Runkle, J., K. Kunkel, S. Champion, R. Frankson, B. Stewart, and W. Sweet. 2017. Florida State Climate Summary. NOAA Technical Report NESDIS 149-FL. 4 pp.
- Small, J.K. 1924. Plant novelties from Florida. *Bulletin of the Torrey Botanical Club* 51: 379-393.
- Sun, L., K.E. Kunkel, L.E. Stevens, A. Buddenberg, J.G. Dobson, and D.R. Easterling. 2015. Regional Surface Climate Conditions in CMIP3 and CMIP5 for the United States: Differences, Similarities, and Implications for the U.S. National Climate Assessment. NOAA Technical Report NESDIS 144. 111 pp. <http://dx.doi.org/10.7289/V5RB72KG>
- Sweet, W.V., R.E. Kopp, C.P. Weaver, J. Obeysekera, R.M. Horton, E.R. Thieler, and C. Zervas. 2017. Global and regional sea level rise scenarios for the United States. NOAA Technical Report NOS CO-OPS 083. 75 pp.
- U.S. Fish and Wildlife Service (Service). 1986. Endangered and threatened wildlife and plants; determination of endangered status for three Florida shrubs. *Federal Register* 51(187): 34415–34420.
- U.S. Fish and Wildlife Service (Service). 1988. Recovery Plan for Three Florida Pawpaws. U.S. Fish and Wildlife Service, Atlanta, Georgia. 20pp.
- U.S. Fish and Wildlife Service (Service). 1998. Unpublished data. U.S. Fish and Wildlife Service, Vero Beach, Florida.
- U.S. Fish and Wildlife Service (Service). 1999. South Florida multi-species recovery plan. U.S. Fish and Wildlife Service, Atlanta, GA. 2178 pp.
- U.S. Fish and Wildlife Service (Service). 2009. Beautiful pawpaw (*Deeringothamnus pulchellus*) 5-year Review: Summary and Evaluation. Atlanta, Georgia.
- U.S. Fish and Wildlife Service (Service). 2019. Recovery plan for beautiful pawpaw, Amendment 1. Atlanta, Georgia.
- U.S. Fish and Wildlife Service (Service). 2021. Beautiful Pawpaw and Rugel’s Pawpaw Field Surveys and Introductions. Northeast Coastal Program, FY21 Project Proposal.
- Volk, M.I., T.S. Hootor, B.B. Nettles, R. Hilsenbeck, F.E Putz, and J. Oetting. 2017. Florida land use and land cover change in the past 100 years. *Florida's Climate: Changes, Variations, and Impacts*.
- Ward, D.B. 2001. New combinations in the Florida flora. *Novon* 11: 360-365.
- Weakley, A.S. 2020. *Flora of the southeastern United States*. University of North Carolina Herbarium, North Carolina Botanical Garden.

Beautiful Pawpaw 5-Year Review

Woodmansee, S.W. and M.J. Barry. 2007. Post-hurricane field assessment of beautiful false pawpaw (*Deeringothamnus pulchellus* Small). Pages 5-31 in S.W. Woodmansee, M.J. Barry, K.A. Bradley, S.E. Green, and J.M. Mahoney. Post-hurricane field assessments of six federally endangered and candidate plant species. Final report to the U.S. Fish and Wildlife Service for contract #401815G156. Vero Beach, Florida.

Beautiful Pawpaw 5-Year Review

**U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Beautiful Pawpaw (*Deeringothamnus pulchellus*)**

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

Review Conducted By: Heather Hitt, Florida Ecological Services Field Office, Vero Beach

FIELD OFFICE APPROVAL:

**Division Manager, Classification and Recovery, Florida Ecological Services Field Office,
Fish and Wildlife Service**

Approve: LOURDES MENA Digitally signed by LOURDES MENA
Date: 2021.11.03 11:38:53 -04'00'

* In 2021, the Classification and Recovery Division Manager in the Florida Ecological Services Field Office was delegated authority to approve 5-year reviews that do not recommend a status change.