Four-petal pawpaw
(Asimina tetramera)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Southeast Region
South Florida Ecological Services Office
Vero Beach, Florida

5-YEAR REVIEW
Four-petal pawpaw/*Asimina tetramera*

I. GENERAL INFORMATION

A. Methodology used to complete the review: This review is based on monitoring reports, surveys, and other scientific and management information, augmented by conversations and comments from biologists familiar with the species. The review was conducted by the lead recovery biologist with the South Florida Ecological Services Office. Literature and documents on file at the South Florida Ecological Services Office were used for this review. All recommendations resulting from this review are a result of thoroughly reviewing the best available information on the four-petal pawpaw. Comments and suggestions regarding the review were received from peer reviews from outside the Service. The public notice for this review was published on April 16, 2008, with a 60-day public comment period (73 FR 20702). No part of the review was contracted to an outside party. Comments received were evaluated and incorporated as appropriate.

B. Reviewers
Lead Region: Southeast Region, Kelly Bibb, (404) 679-7132
Lead Field Office: Marilyn Knight, South Florida Ecological Services Office, 772-562-3909

C. Background

1. FR Notice citation announcing initiation of this review: April 16, 2008. 73 FR 20702.

2. Species status: Stable (2008 Recovery Data Call). New surveys were not conducted over the last year, but visits to some sites in Palm Beach and Martin Counties indicated that the populations remained the same (Cox 2008). Dry conditions precluded burning in fiscal year 2007, leading to an increase in the threat from lack of fire. However, conditions improved in fiscal year 2008 and this no longer seems to be an increased threat.

3. Recovery achieved: 2 (26-50% recovery objectives achieved). Recovery objectives are being achieved through land acquisition, management of invasive species, controlling access to sites containing plants, conducting surveys, protecting plants on public land, conserving germ plasm and maintaining an *ex situ* population, locating potential reintroduction sites and reintroducing plants to protected areas, monitoring reintroduced plants, and conducting demographic studies.

4. Listing history
Original Listing
FR notice: 51 FR 34415
Date listed: September 26, 1986
Entity listed: Species
Classification: Endangered

5. Review History: Five-year review November 6, 1991 (56 FR 56882): In this review, different species were simultaneously evaluated with no species-specific, in-depth assessment of the five factors as they pertained to the different species' recovery. In particular, no changes were proposed for the status of the four-petal pawpaw.
Final Recovery Plan: 1999
Recovery Data Call: 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, and 2008

6. Species' Recovery Priority Number at start of review (48 FR 43098)*:* 11 (a species with a moderate degree of threat and low recovery potential).

7. Recovery Plan
Name of plan: South Florida Multi-Species Recovery Plan (MSRP)
Date issued: May 18, 1999
Dates of original plan: April 5, 1988 (Recovery plan for three Florida pawpaws)

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

B. Recovery Criteria

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

2. Adequacy of recovery criteria.

a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat? 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.

Criteria for when reclassification of four-petal pawpaw from endangered to threatened may be considered are:

1. Enough demographic data are available to determine the appropriate numbers of self-sustaining populations and sites needed to ensure 20 to 90 percent probability of persistence for 100 years.

Very little demographic data are available. Surveys have been conducted intermittently in the past, but trend data is difficult to assess because new sites containing the plants have been discovered, plants on several sites have been destroyed, and knowledge of the species' biology has improved leading to the ability to do more thorough surveys. Based upon the most comprehensive data available, there are approximately 1,800 pawpaw plants located on 21 sites in Martin and northern Palm Beach Counties (Peterson 2008). However, there are some discrepancies with this data as to what constitutes a population, and clarification of some sites is needed. The Florida Natural Areas Inventory (FNAI) suggested that the sites containing plants should be consolidated from 21 to 16 based upon their criterion of 1 km separation distance between occurrences (Johnson in litt. 2008). Because the data consolidating the sites to 16 is not available and the difference in data interpretation does not change the outcome of this review, 21 sites will be used for discussion purposes in this review. Thirteen sites are on public lands and 8 are on private lands. Numbers of plants per site vary greatly, ranging from 1-2 plants on some sites to over 400 on Jonathan Dickinson State Park (JDSP) (Peterson 2008).

Population studies of four-petal pawpaw were conducted at JDSP in 1997 and 2005-2006 (Cox and Shropshire 2007). Researchers noticed slow seedling growth between these two studies, which may suggest that the four-petal pawpaw is a long-lived species. Six distinct life history stages have been delineated, from seedlings to senescing adults (Cox and Shropshire 2006). The population structure of pawpaws that were located at JDSP following the 2004 and 2005 hurricane seasons was determined; however, this sample represented only about 51 percent of that site's plants because pawpaws were difficult to locate beneath hurricane debris (Cox and Shropshire 2007). Because of incomplete sampling, these results varied from those in the 1997 study (Cox and Shropshire 2007). Consequently, this site, although surveyed more than others, has not been tracked consistently enough to determine trend data.

Because consistent annual surveys are needed to evaluate long-term population trends and additional studies need to be completed on population structure across the range

of the species, there is not enough demographic data available to determine the appropriate numbers of self-sustaining populations and sites needed to ensure 20 to 90 percent probability of persistence for 100 years. This criterion addresses listing factors A, D, and E.

2. Sites within the historic range of four-petal pawpaw are adequately protected from further habitat loss, degradation, and fragmentation.

In 1988, 38 percent of the sites containing four-petal pawpaw were in unprotected private ownership, 13 percent were in protected private ownership, and 56 percent were in public ownership (Cox 2004). In 2003, the percentage of unprotected private sites had decreased to 11 percent while that of public sites increased to 68 percent (Cox 2004). The differences in these percentages most likely reflect the loss of plants on unprotected private sites due to habitat destruction and degradation.

Today, approximately 62 percent of the known extant sites are on publicly owned lands and are mostly protected from further habitat loss (Peterson 2008). In parks whose primary focus is on public use, there is some concern that native habitat may be removed to develop additional facilities (Cox 2003). Degradation of habitat on public land has also occurred as a result of damage by feral hogs (*Sus scrofa*) (Engeman et al. 2003, 2004) and herbicide treatment used to control exotic plant species (Cox 2006).

An additional concern for these public lands is that resources for management actions may not always be available and habitat needed to support pawpaws will degrade in the absence of regular management. Exotic plant species control and prescribed fire are important management strategies for maintaining healthy pawpaw populations (Cox 2003). If sites are not regularly maintained through fire or mechanical treatments, the overall health of the ecosystem for this plant may be compromised (Cox 2009).

The 8 sites (6 natural and 2 introduced) where plants occur on private property are not adequately protected from further habitat loss and degradation due to development. At least one of the natural sites has not been surveyed since 2006 and is presumed to have been developed (Cox 2006, Peterson 2008). Six of the 27 known historic locations are extirpated, with at least 3 lost to development. In addition to the risk of habitat loss through development, habitat degradation will occur in the absence of management. Three of the 8 sites on private property are appropriately managed (Cox 2004).

Because of the vulnerability of the species on private sites and the necessity of regular habitat management, most sites are not adequately protected from further habitat loss, degradation, and fragmentation. This criterion addresses listing factors A, D, and E.

3. These sites are managed to maintain the coastal sand pine scrub communities to support four-petal pawpaw.

Some sites with plants are being managed well, while others, even on public lands, are not receiving the management needed to sustain their numbers (Cox 2003). Where exotic plant species, such as Brazilian pepper (*Schinus terebinthifolius*), were not removed, pawpaws experienced severe declines (Cox 2003). One site in Palm Beach County was reduced from 52 plants to 1 (Cox 2003).

The four-petal pawpaw occurs in scrub habitat along ancient coastal dunes on the Atlantic coastal ridge, a low elevation sand ridge along the east coast, which is typically maintained by fire. On many privately owned scrub sites, fire has historically been suppressed and habitat has not received regular maintenance. Because fragmented habitat where these plants occur is interspersed in a developed landscape, burning may also be unlikely due to proximity to neighbors (Peterson 2008). Plants on public sites that are being burned regularly are doing well; these occurrences are at least stable if not increasing (Cox 2006).

A recent scrub and sandhill restoration project has added habitat improvements to JDSP, the site containing the largest extant population (Rossmanith and Nelson 2008). Improvements included mowing over 25,000 feet of firelines, bulldozing over 14,000 feet of firelines, and burning 373 acres of scrub and sandhill habitat (Rossmanith and Nelson 2008). An additional 486 acres of habitat have been prepared for prescribed burning (Rossmanith and Nelson 2008). This is an on-going project that will continue to provide benefits to listed species, including the four-petal pawpaw.

Even though they are not protected from development, there are 3 pawpaw sites occurring on private land that are receiving management, 1 in Martin County and 2 in Palm Beach County (Cox 2004). These sites are comprised of over 100 plants (Cox 2004). Not all of the public and private sites are adequately being managed to maintain habitat to support four-petal pawpaw and, therefore, this objective has not been met yet. This criterion addresses listing factor A.

4. Monitoring programs demonstrate that these sites support the appropriate numbers of self-sustaining populations, and those populations are stable throughout the historic range of the species.

Surveys have indicated that the four-petal pawpaw occurs throughout its historic range, but sites where they occur are fragmented and are primarily in three disjunct areas in Martin and northern Palm Beach Counties (Loring et al. 2003). Surveys have been conducted most frequently on the site containing the largest number of plants located at JDSP; however, monitoring has not occurred on a regular basis at this site or any other.

One-third of the extant sites are comprised of 15 or fewer pawpaws (Peterson 2008). Small populations tend to lack genetic diversity and may not be self-sustaining over time (Ellstrand and Elam 1993). It is likely that these small populations are very

important to the recovery of the species and, therefore, should be the focus of conservation efforts in order to maintain genetic diversity.

Cox and Shropshire (2006) have developed a standard protocol for pawpaw searches and have indicated that population trend data may be obtained from estimates of age structure at a particular time rather than following individual plants over long periods of time because of the longevity of the plants. Life history stages have already been determined for this species, but the age structure necessary for this type of evaluation has not been studied (Cox and Shropshire 2006). Either a consistent monitoring program needs to be established or age structure needs to be determined to demonstrate that sites support the appropriate numbers of self-sustaining populations. This criterion addresses listing factors A and E.

There are no criteria for delisting the four-petal pawpaw.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Abundance, population trends (e.g., increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate), or demographic trends: Based upon data compiled by FNAI and other sources, Peterson (2008) reported approximately 26 historically known sites where four-petal pawpaw occurred. Because 1 of these sites is in both public and private ownership, we are treating it as 2 separate locations for the purposes of this review and, therefore, presuming the total number of sites was 27.

Of these 27 sites, 6 are presumed extirpated (Peterson 2008). Of the 21 remaining, 13 are on public lands and 8 are on private lands. Three of the sites on private lands are currently being beneficially managed (Cox 2004). Of the 5 sites on private lands not being managed, at least 1 has not been surveyed since 2006 and is believed to have been developed (Cox 2006, Peterson 2008). Four of the 21 sites are introduced populations (2 of the four were introduced on private land), 3 in Martin County and 1 in Palm Beach County (Peterson 2008).

Previously, Cox (1998) reported that the total population estimate was 1,000 individuals, which included approximately 300 plants on 6 sites in Martin County and 700 plants on 10 sites in Palm Beach County. Loring et al. (2003) did not provide an estimate of the total population size at the time of their study but indicated that pawpaws occurred on 17 sites in 3 disjunct locations with more than half of the total population located on 2 sites. Cox (2004) reported over 1,200 plants on 19 sites in July 2003. In 2006, the population was estimated to be from 1,800 to just over 2,000 individuals (Cox 2006, Cox and Shropshire 2006).

There are approximately 1,800 extant pawpaw plants in the 21 sites (Peterson 2008). Introduced sites are comprised of approximately 76 individuals (Peterson 2008). Numbers of plants per site range from 1-2 on some sites to over 400 on one of the public sites (Peterson 2008). The apparent overall increase in sites and population sizes over the last 10 years is thought to be due primarily to better survey techniques and discoveries of previously unknown sites rather than an actual population increase. At least three sites have been developed (Cox 2004, 2006).

Efforts have been made to augment the total population through pilot seed planting studies at several sites (Cox 2004, 2005, 2006; Cox and Shropshire 2006). Plants propagated from seed in greenhouse conditions have also been introduced to suitable habitat in both Palm Beach and Martin Counties (Cox 2005). Additionally, 134 plants propagated from seeds collected in Palm Beach County and from plants at Historic Bok Sanctuary were used to genetically supplement an existing site with four plants on federal property at the Jupiter Inlet Lighthouse Outstanding Natural Area (JILONA) in northern Palm Beach County in December 2008 (Cox in litt. 2009). Further augmentation and reintroductions are needed to support the recovery efforts for the species.

Some demographic information has been obtained. Cox and Shropshire (2007) noticed slow seedling growth between 1997 and 2006 at JDSP, which may suggest that the four-petal pawpaw is a long-lived species. Six distinct life history stages have been delineated for the species, from seedlings to senescing adults (Cox and Shropshire 2006). The population structure of pawpaws located at JDSP after the 2004 and 2005 hurricane seasons was determined to be 19.4 percent seedlings, 36.0 percent juveniles, 14.4 percent adults with buds and flowers but no fruit, 23.0 percent reproductive adults with flowers and fruit, and 7.2 percent senescent adults with small flowers but no fruit (Cox and Shropshire 2007). However, this sample represented only about 51 percent of that population because pawpaws were difficult to locate beneath hurricane debris and more are expected to be found after the next prescribed burn (Cox and Shropshire 2007).

b. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding): All occurrences of four-petal pawpaw are distributed along a 30-mile stretch of fragmented coastal scrub in Martin and Palm Beach Counties, and most are thought to be reproductively isolated from one another, possibly producing genotype isolation within each site or small cluster of sites (Peterson et al. 2007). A reduction in genetic diversity may be occurring over time as a result of lack of cross pollination among sites (Peterson et al. 2007).

Leaf tissue collected from 11 sites distributed across the species' range was analyzed using inter-simple sequence repeat markers (ISSRs) to evaluate within- and among-population genetic variation and was compared to 3 sites containing its widespread congener, netted pawpaw (*Asimina reticulata*) (Loring et al. 2003). A total of 38 percent of the molecular variance in the four-petal pawpaw was attributed to differences among sites while 62 percent was due to variance within sites (Loring et al. 2003). In contrast, 97 percent of the molecular variance in the netted pawpaw was explained by heterozygosity within sites (Loring et al. 2003).

Evidence suggests that plants on sites distributed in the northern portion of the range are genetically distinct from those in the southern part of the range (Loring et al. 2003). Although closer in proximity to the southern sites, the plants occurring in the middle of the range are genetically more similar to the plants in the northern-most sites (Loring et al. 2003). Results from this study indicate the importance of retaining small sites for the overall genetic health of the species. For example, a small site containing 22 individuals located in the northern portion of the range in an empty residential lot contained 7 unique alleles not found in any other site (Loring et al. 2003).

Additional genetic research is being conducted using the Randomly Amplified Polymorphic DNA (RAPDs) technique (Peterson et al. 2007, 2008). Phylogenetic trees that were developed from the analysis of 159 leaf samples indicated that plants were grouped into distinct clades and revealed that some sites thought to be outside of pollinating distance from one another were genetically similar (Peterson et al. 2007). Because similar genotypes occur among sites, it is presumed that populations have been cross pollinated in the recent past (Peterson et al. 2007).

Wherever possible, the Service will use genetic information in making decisions regarding the recovery of the species. For example, we will work with our partners to protect smaller sites and sites with a greater number of unique alleles to preserve genetic diversity.

c. Taxonomic classification or changes in nomenclature: The species was first named and described by John K. Small and separated from other species partly on the basis of being tetramerous, or having flower parts in sets of four (Small 1933). Subsequent treatments of taxonomy have been consistent with that of Small (Kral 1960, Wilbur 1970). The Integrated Taxonomic Information System (2008) was also checked while conducting this review and did not indicate any formal changes to the name *Asimina tetramera*.

d. Spatial distribution, trends in spatial distribution (e.g., increasingly fragmented, increased numbers of corridors), or historic range: Historically, four-petal pawpaw occurred in sand pine scrub habitat on the coastal dune system in Martin and northern Palm Beach Counties in

southeastern Florida (Kral 1960). Although the species occurs in disjunct locations within its historic range, most of the suitable habitat has been destroyed or converted for residential housing and commercial activities (Service 1999). Trends in spatial distribution show increasing fragmentation of four-petal pawpaw habitat as the coastal ridge has become developed and fire has been suppressed. Plants remain on sites in Martin and northern Palm Beach Counties along a 30-mile stretch of coastal sand pine scrub, but are highly fragmented on the landscape (Peterson et al. 2007). Loring et al. (2003) reported that plants occur in three disjunct locations, northern Martin County near Jenson Beach, southern Martin County in JDSP, and northern Palm Beach County north of PGA Boulevard. A 13-mile gap separates the sites on the northern and southern ends of the range (Peterson et al. 2007).

The remaining 21 sites are not equally distributed between the two counties; 9 occur in Martin County and 12 in Palm Beach County (Peterson 2008). Of the 6 historical sites presumed extirpated, 3 were in Martin County and 3 were in Palm Beach County (Peterson 2008).

e. Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem): The four-petal pawpaw is found in scrub habitat along ancient coastal dunes only in southeast Florida (Kral 1960). Habitat management is needed to sustain this species and varies by site (Cox 2003). For example, one site is covered with exotic plant species and has experienced a severe decline in plant numbers (Cox 2003). Another site is being maintained, but park development may impact it (Cox 2003). Pawpaw plants on public sites that are being burned regularly are doing quite well (Cox 2006). Habitat restoration projects have improved approximately 373 acres of scrub and sandhill habitat with plans for improving more on JDSP (Rossmanith and Nelson 2008).

Another project undertaken recently at JDSP assessed the four-petal pawpaw plants and their habitat following the 2004 and 2005 hurricane seasons (Cox and Shropshire 2007). Many mature sand pines were broken and blown down by high winds during these storms and few survived more than a year following the storms, but the shrub and ground layers were not greatly impacted (Cox and Shropshire 2007). Over half of the known pawpaw plants at this site were found during this study and most (81 percent) received very little damage (Cox and Shropshire 2007). Less than 6 percent of the plants were crushed by fallen trees (Cox and Shropshire 2007). The low number of adult plants and seedlings found following the storms did not indicate a decrease in plant numbers, but rather was the result of low detection among storm debris (Cox and Shropshire 2007). Other sites with dense pine canopies containing pawpaws in the area received similar damage, while those occurring further to the south were less impacted (Cox and Shropshire 2007).

f. Other: Research is being conducted on the four-petal pawpaw in the areas of pollination (Cox 1998), germination (Peterson et al. 2007, 2008; Cox 1998), tissue culture propagation (Clark and Pence 2001; Peterson et al. 2007, 2008), reproduction (Cox 1998), and effects of fire (Cox and Shropshire 2006, Cox 1998). Reproductive capacity may be limited in the species partly due to pollinator limitations and low fruit set in dense scrub habitat (Cox 1998).

Fire significantly increases flowering, as determined through experiments using burn treatments and cut and burn treatments (Cox 1998). Above-ground stems are typically killed by fire, but below-ground stems re-sprout quickly (Cox and Shropshire 2006). Burning in the spring in mature scrub can stimulate flowering and fruiting without losing individual plants (Cox 1998). Cox (1998) mentioned that if burning occurs before recruitment, we may only be able to maintain rather than grow populations, so management techniques should be implemented in consideration of critical life stages of the species.

The Service, public agencies, private organizations, researchers, and private landowners convened in 2006 to discuss recovery actions for four-petal pawpaw and management needs for its associated habitat (Cox and Shropshire 2006). Protocols for population and habitat monitoring, population introduction and augmentation, and management, including prescribed burning and mechanical treatments (Cox and Shropshire 2006). The Service and our partners are using these protocols to augment sites with additional genetic material.

2. Five-Factor Analysis

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 four-petal pawpaw. Where plants occur on private sites, development has led to both direct destruction of habitat as a result of land clearing and habitat degradation from lack of management. At least one of the private sites that had not been surveyed since 2006 is believed to have been developed (Cox 2006, Peterson 2008). The loss of this site was especially detrimental from a genetics standpoint because this site was found to contain seven unique alleles not found on other sites (Loring et al. 2003). Another site was bulldozed in 2004 leaving only two plants; this site persisted until 2007 but is now extirpated (Peterson 2008).

Cox (2004) reported that 38 percent of the sites were in unprotected private ownership, 13 percent were in protected private ownership, and 56 percent were in public ownership in 1988. In 2003, the percentage of unprotected private sites had decreased to 11 percent while that of public sites increased to 68 percent (Cox 2004). The differences in these percentages most likely reflect the loss of plants on unprotected private sites due to habitat destruction and degradation.

Threats from development and habitat degradation on private sites are expected to continue and increase. Within the range of four-petal pawpaw, the human population is predicted to grow from just over 140,000 to more than 277,000 in Martin County and from just below 1,271,000 to over 2,701,000 in Palm Beach County between 2005 and 2060 (Zwick and Carr 2006).

Even though 68 percent of the sites containing four-petal pawpaw are publicly owned and not at risk of being developed, the plants on these sites may still be vulnerable to habitat degradation from encroachment of exotic plant species and lack of fire or other mechanical treatment. If sites are not properly managed, ecosystem health may deteriorate. Because the sites are fragmented on a developed landscape, fire management may not always be feasible and encroachment by exotic plant species from neighboring properties is likely. Therefore, habitat loss, degradation, and fragmentation due to increasing development and lack of management in sand pine scrub habitat and the encroachment of exotic plants will continue to threaten four-petal pawpaw.

b. Overutilization for commercial, recreational, scientific, or educational purposes: At the time of listing, indiscriminate collecting of four-petal pawpaw was not known. Because it is limited in distribution and population sizes are relatively small, indiscriminate collecting could adversely affect the species. However, overutilization has not been documented.

c. Disease or predation: When listed, herbivory of four-petal pawpaw was not known, but some plants were affected by fungal infections on the branches (Moyroud 1985). Management of habitat through prescribed burns may help to reduce fungal growth (Cox and Shropshire 2006). Larvae of a species of pyralid moth (*Omphalocera munroei*) feed primarily on old leaves of *Asimina* species (Damman 1987) and female zebra swallowtail butterflies (*Eurytides marcellus*) lay their eggs on new growth of *Asimina* species (Damman 1989). Developing larvae eat the leaves and flowers of *Asimina* species and may damage developing shoots (Damman 1989). Cox (1998) also observed larvae of these lepidopteran species on four-petal pawpaws and stated that damage was restricted to flowers, new leaf growth, and portions of old leaves. She noted that new stems and leaves were produced into September as a result of the damage (Cox 1998). Other insects were also reported to attack the pawpaw fruit and seed, and weevils were observed in seeds of young pawpaws (Martin 1988). Although not reported for the four-petal pawpaw, there is a report of consumption of the fruit from a flag pawpaw (*Asimina incarna*) by the Florida mouse (*Podomys floridanus*) (Jones 1989). These occurrences of predation and fungal infections are not known to constitute serious threats to the four-petal pawpaw.

d. Inadequacy of existing regulatory mechanisms: The ESA provides

limited protection for the species and its habitat. Existing federal regulations prohibit the removal or destruction of listed plant species on Federal lands. The four-petal pawpaw is also listed by the Florida Department of Agriculture and Consumer Services (FDACS) as endangered (5B-40.0055 Regulated Plant Index), but this legislation does not provide any direct habitat protection. State regulations 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. However, these regulations afford no protection to listed plants on private lands.

Existing regulatory mechanisms do not appear to be adequate, as several properties with pawpaws on private lands have been developed. Because this plant occurs in habitat along the Atlantic coastal ridge, which is desirable for development due to its elevation, it remains vulnerable to development pressures where it occurs on private property. Where the species occurs on public land, there is protection from development but not necessarily from habitat degradation.

e. Other natural or manmade factors affecting its continued existence: Land management practices such as prescribed fire are vitally important to conserving and working towards recovery of the four-petal pawpaw. Even though some sites are protected from development, habitat degradation may still be a concern. This species occurs in scrub habitat, which is typically maintained by fire. On many privately owned sites, fire has historically been suppressed and habitat has not received regular maintenance. Because fragmented habitat is interspersed on a developed landscape, burning may also be unlikely due to proximity to neighbors (Peterson 2008). If sites are not regularly maintained through fire or mechanical treatment, the overall health of the scrub system may be compromised and flowering and fruit set of four-petal pawpaws may be reduced (Cox in litt. 2009).

Another major threat to pawpaws is the establishment of exotic plant species such as Brazilian pepper, rosary pea (*Abrus precatorius*), guinea grass (*Panicum maximum*), and natal grass (*Rhynchelytrum repens*) in the absence of maintenance, especially where native soil is disturbed. However, herbicides used to control overgrowth, if not properly applied, also pose a threat to the four-petal pawpaw. Broad application of herbicide to remove Brazilian pepper and tall grasses can be especially damaging (Cox in litt. 2009). It is thought that plants on at least two sites have been affected by herbicide treatments (Cox 2006).

Degradation to habitat can also occur from damage by feral hogs (Engeman et al. 2003, 2004). Vegetation restoration and management programs are costly, and the availability of funding is never assured; therefore, habitat modification from inadequate management even on protected lands remains an imminent, though moderate, threat.

The species' restriction to specialized habitat, its limited distribution, and its limited reproductive capacity also renders it vulnerable to random natural events, such as hurricanes and drought. Although the species faired well through the 2004 and 2005 hurricanes, specific conditions such as storm surge and amount of debris dumping following the event vary greatly with each hurricane and may render sites with few plants vulnerable to destruction. Unfortunately, long-term seed storage does not seem to be a viable option for this species, as the seed does not persist (Peterson et al. 2008).

D. Synthesis - The species' recovery plan contains objective, measurable reclassification criteria but does not include delisting criteria. The current range of four-petal pawpaw is limited to Martin and northern Palm Beach Counties. The natural and outplanted sites are fragmented and isolated within the range along the Atlantic coastal ridge. There are approximately 1,800 plants remaining on 21 sites.

The apparent overall increase in sites and population sizes over the last 10 years is due primarily to better survey techniques and discoveries of previously unknown sites rather than an actual population increase. Where habitat remains intact, four-petal pawpaw depends upon active management to persist. Land management practices, especially prescribed fire used for the reduction of dense canopies and the creation of open areas, are extremely important for maintaining the health of scrub ecosystems where this plant resides. The removal of exotic species is especially important for maintaining habitat and preventing competition with four-petal pawpaw. Where some sites have received regular maintenance, habitat conditions have improved, but other sites on private lands have been lost to development. Existing regulatory mechanisms are inadequate on private lands, because this plant occurs in habitat which is desirable for development due to its elevation, and plants have limited protection on private lands. Habitat loss, fragmentation, and changes in land use continue, and conversion of scrub habitat to urban use along the Atlantic coastal ridge is projected to continue over the next 50 years. The species' restriction to specialized habitat, its limited distribution, and its limited reproductive capacity also renders it vulnerable to random natural events, such as hurricanes and drought. Due to the above ongoing threats, 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 ACTIONS

Surveys:

- Continue to survey potential habitat and pursue conservation agreements/implement management recommendations and/or acquire land and investigate incentives to encourage land managers to manage scrub for ecosystem health and listed species.

- Conduct additional surveys for four-petal pawpaw on all known and potentially suitable sites in the two counties of occurrence and provide updated information to FNAI for consistent tracking.
- Continue monitoring for plants on both reintroduced and natural sites.
- Monitor sites of special interest, such as those with altered water tables or in ecotonal areas at lower elevations.

Management:

- Continue management actions to include removal of debris and exotics through careful herbicide application, controlling public access, and the reintroduction of prescribed fire into the ecosystem.
- Portions of sites with four-petal pawpaw and dense sand pines should be burned on a regular basis to prevent accumulation of large fuel loads.
- Focus conservation efforts on marginal and small sites to preserve the genetic diversity of the species.
- Identify additional reintroduction sites and establish reintroduced populations; population augmentations should also be implemented.

Research:

- Conduct research on the response of four-petal pawpaw to fire and fire prescriptions necessary to benefit the species.
- Conduct additional research on the biology, ecology, genetics, and management needs of the species.
- Continue demographic studies to determine the age class structure and long-term viability of the species, especially in areas with active recruitment, and determine critical life stages.
- Compare the viability of the small sites in the northern portion of the range to the much larger southern site.
- Conduct additional life history studies to enhance our understanding of observed genetic variance.
- Continue to evaluate insect pollinators associated with the species over a longer term, and evaluate impacts to pollinators from aerial mosquito spraying, especially in the small, isolated sites in the northern portion of the species' range.
- Continue seed germination studies and make efforts to develop additional outplanting techniques.
- Continue genetic characterizations on sites that have not yet been studied, and apply this knowledge to future introductions and population augmentations.
- Continue to collect germ plasm from the remaining sites not currently represented in the Center for Plant Conservation's National Collection of Endangered Plants.
- Continue propagation efforts.
- Evaluate the effects of climate change on the species, including those that result from precipitation pattern changes and temperature rise.

Other:

- Partnerships should be promoted to share information, conduct collaborative research on coastal scrub habitat conservation, and provide land managers and the interested public with information about the ecosystem, threats, recovery actions, and associated rare biota.
- Conduct an ad hoc meeting to compile new information, discuss recovery actions, share land management strategies, and set and prioritize five- and ten-year goals.
- Seek opportunities to include the media in conservation efforts to provide information about this species to the public.

V. REFERENCES

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Four-petal pawpaw (*Asimina tetramera*)

Current Classification Endangered
Recommendation resulting from the 5-Year Review

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

Appropriate Listing/Reclassification Priority Number, if applicable _____

Review Conducted By Marilyn Knight

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 2-13-09

The lead Field Office must ensure that other offices within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. The lead field office should document this coordination in the agency record.

REGIONAL OFFICE APPROVAL:

The Regional Director or the Assistant Regional Director, if authority has been delegated to the Assistant Regional Director, must sign all 5-year reviews.

Acting
Lead Regional Director, Fish and Wildlife Service

Approve _____ Date 4-6-09

The Lead Region must ensure that other regions within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. If a change in classification is recommended, written concurrence from other regions is required.

Summary of peer review for the 5-year review of four-petal pawpaw (*Asimina tetramera*)

A. Peer Review Method: Peer reviewers were selected by the Service. Three peer reviewers and an additional reviewer were asked to participate in this review. Individual responses were requested and received from two of the peer reviewers and the additional reviewer.

B. Peer Review Charge: See attached guidance.

C. Summary of Peer Review Comments/Report: Peer review comments were substantial and provided insights that were beneficial in conducting this review. Comments and concerns covered a variety of topics including discrepancies in the interpretation of what constitutes a population (site) and the differences in how the number of populations (sites) is reported, clarification in the reporting of natural versus introduced populations, the addition of information regarding a recent population augmentation, clarification on a citation and reference to the five listing factors, the correction of a general statement regarding habitat degradation and its impact on pawpaws and scrub system health, the need to emphasize the threat of invasive species and potential for damage to pawpaws from broadscale herbicide application, and the interest and cooperation of agencies working towards recovery for this species,

Reviewers noted that information provided in this review was thorough and sufficiently represented the listing history of the species; showed the concerns, scientific research, acquisition, management, and recovery actions that have been implemented; showed the interest in the conservation and recovery of the species; covered the recommendations for future actions that need to be implemented for recovery; and conclusions appeared to be reasonable and based upon the data.

Additional recommendations by peer reviewers for future actions that would benefit the four-petal pawpaw included using nurse plants to potentially increase outplanting success, preparing projection matrices as a means to assess population viability, conducting an evaluation of impacts to pollinators from aerial mosquito control spraying on the small sites in the northern portion of the pawpaw's range, conducting a full survey of the species in both counties of its occurrence, comparing viability of plants on small sites in the northern range to those on large sites in the southern range, monitoring plants in areas of special interest such as those where the hydrology of the system has been altered, scheduling an ad hoc meeting to compile new information and discuss recovery and management, providing updated information to FNAI to maintain the species' database, investigating incentives to encourage land managers to manage scrub habitat for the health of the ecosystem and for listed species, monitoring augmented and reintroduced populations, and setting and prioritizing five- and ten-year goals for recovery. A suggestion was also made to move the recommendation for demographic studies and annual surveys to a more prominent position in the list of recommendations for future actions.

D. Response to Peer Review*:* The Service was in agreement with the comments and concerns received from peer reviewers, and comments were largely incorporated. As noted in the review, there are some discrepancies as to what constitutes a site, and clarification is needed. FNAI suggested that the sites should be consolidated from 21 to 16 based upon their criterion of 1 km separation distance between occurrences (Johnson in litt. 2008). Because this update will not be

available until later in 2009 and the difference in the data interpretation does not change the outcome of this review, 21 sites were used for discussion purposes in this review. However, all current and future data will be provided to FNAI to be used to update their database.

Guidance for Peer Reviewers of Five-Year Status Reviews

U.S. Fish and Wildlife Service, South Florida Ecological Services Office

February 20, 2007

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

Peer reviewers should:

1. Review all materials provided by the Service.

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

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

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

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

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

Questions regarding this guidance, the peer review process, or other aspects of the Service's recovery planning process should be referred to Cindy Schulz, Endangered Species Supervisor, South Florida Ecological Services Office, at 772-562-3909, extension 305, email: Cindy_Schulz@fws.gov.