

Post-hurricane Field Assessments of
Six Federally Endangered and Candidate Plant Species
FINAL REPORT
Agreement #401815G156

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to

United States Fish and Wildlife Service, South Florida Ecosystem Office
Vero Beach, Florida

List of Chapters

Chapter 1 - Project Overview	003
Chapter 2 - Post-hurricane Field Assessment of Beautiful False Pawpaw (<i>Deeringothamnus pulchellus</i> Small)	005
Chapter 3 - Post-hurricane Field Assessment of Savanna Balm (<i>Dicerandra immaculata</i> Lakela var. <i>savannarum</i> Huck)	032
Chapter 4 - Post-hurricane Field Assessment of Aboriginal Pricklyapples (<i>Harrisia aboriginum</i> Small)	079
Chapter 5 - Post-hurricane Field Assessment of Fragrant Prickly-Apple Cactus (<i>Harrisia fragrans</i> Small ex Britton & Rose)	117
Chapter 6 - Post-hurricane Field Assessment of West Coast Dune Sunflower (<i>Helianthus debilis</i> Nutt. subsp. <i>vestitus</i> (E. Watson) Heiser)	157
Chapter 7 - Post-hurricane Field Assessment of Small's Milkwort (<i>Polygala smallii</i> R.R. Sm. & Ward)	187

Cover Photo: *Pretty false paw-paw* (*Deeringothamnus pulchellus* Small) at Fred C. Babcock-Cecil M. Webb Wildlife Management Area, Charlotte County. Josh M. Mahoney, March 2006.

Chapter 1 - Project Overview

Table of Contents

Introduction	003
Table 1-1: Six federally listed species possibly impacted during the 2004 hurricane season	003
Figure 1-1: Study Regions for Surveys of Six Federally Listed Species Post 2004 Hurricane Season	004

Introduction

The U.S. Fish and Wildlife Service (USFWS) requested an inventory be done of six federally endangered and candidate species in areas impacted by hurricanes Charley, Frances, and Jeanne in 2004 (table 1-1, figure 1-1). Of special concern were areas along the coast between Pinellas and Lee counties on the west side of Florida, and along the coast between Indian River and Palm Beach counties on the east side of Florida. It was unknown whether plants would have been negatively impacted by these altering stochastic events.

Table 1-1: Six federally listed species possibly impacted during the 2004 hurricane season

Scientific Name (with Authors)	Common Names	Federal Status	State Status
<i>Deeringothamnus pulchellus</i> Small	Beautiful false pawpaw, Pretty false pawpaw	Endangered	Endangered
<i>Dicerandra immaculata</i> Lakela var. <i>savannarum</i> Huck	Savanna balm	Endangered	Endangered
<i>Harrisia aboriginum</i> Small	Aboriginal pricklyapples, Prickly applecactus	Candidate	Endangered
<i>Harrisia fragrans</i> Small ex Britton & Rose	Fragrant prickly-apples cactus	Endangered	Endangered
<i>Helianthus debilis</i> Nutt. subsp. <i>vestitus</i> (E.E. Wats) Heiser	West coast dune sunflower	Candidate	
<i>Polygala smallii</i> R.R. Sm. & Ward	Small's milkwort, Tiny polygala	Endangered	Endangered

This document reports work conducted by The Institute for Regional Conservation on the above species between January 2006 and August 2007. A chapter was created for each species. Each chapter is a sub-report and possesses detailed accounts before and after the 2004 hurricane season.

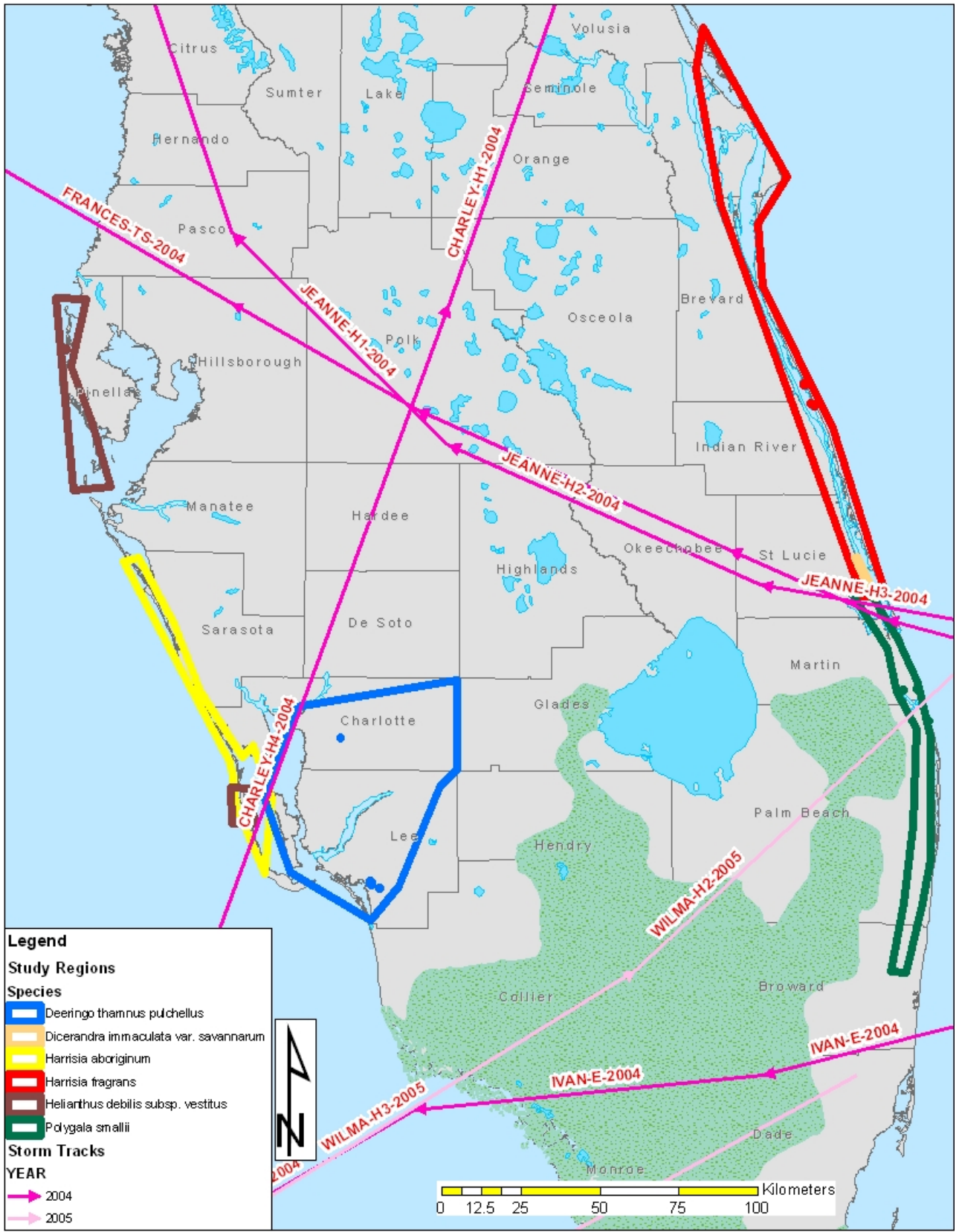


Figure 1-1: Study Regions for Surveys of Six Federally Listed Species Post 2004 Hurricane Season

Chapter 2 - Post-hurricane Field Assessment of Beautiful False Pawpaw
(*Deeringothamnus pulchellus* Small)

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Beautiful false pawpaw at Fred C. Babcock – Cecil M. Webb
Wildlife Management Area, Charlotte County. Josh M. Mahoney, March 2006.

Table of Contents

Introduction	007
Methods	009
Results and Discussion	010
Final Discussion	030
Acknowledgements	030
Citations	031
Tables:	
Table 2-1: Beautiful false pawpaw occurrences	012
Figures:	
Figure 2-1: <i>Deeringothamnus pulchellus</i> Study Area	008
Figure 2-2: <i>Deeringothamnus pulchellus</i> Occurrence Results	011
Figure 2-3: <i>Deeringothamnus pulchellus</i> at Fred D. Babcock – Cecil M. Webb Wildlife Management Area – Oil Well Road	015
Figure 2-4: Tagged Plants of <i>Deeringothamnus pulchellus</i> at Fred C. Babcock – Cecil M. Webb Wildlife Management Area – Oil Well Road	016
Figure 2-5: Tagged Plants up close of <i>Deeringothamnus pulchellus</i> at Fred C. Babcock - Cecil M. Webb Wildlife Management Area – Oil Well Road	017
Figure 2-6: <i>Deeringothamnus pulchellus</i> at Fred C. Babcock - Cecil M. Webb Wildlife Management Area – interior	019
Figure 2-7: <i>Deeringothamnus pulchellus</i> at Babcock Ranch and Private Lands #1	021
Figure 2-8: <i>Deeringothamnus pulchellus</i> at Private Lands #2	023
Figure 2-9: <i>Deeringothamnus pulchellus</i> at Charlotte Harbor Preserve State Park	025
Figure 2-10: <i>Deeringothamnus pulchellus</i> at St. James Creek Preserve	027
Figure 2-11: <i>Deeringothamnus pulchellus</i> surveys at Estero Bay Preserve State Park and Koreshan State Historic Site	029

Introduction

Beautiful false pawpaw (*Deeringothamnus pulchellus*) is a federally endangered species listed by the USFWS (2000) and is listed as endangered by the Florida Department of Agriculture and Consumer Services (Coile and Garland 2003). It is endemic to Charlotte, Lee, and Orange counties in Florida (Wunderlin and Hansen 2006, USFWS 1999). Before the 2004 hurricane season, extant populations of beautiful false pawpaw were reported from 21 sites, 18 of which are in Charlotte and Lee counties and three in Orange County (USFWS 1999). Chafin (2000) reports a total of 28 sites and two conservation areas (not specified) for beautiful false pawpaw. Only three sites are reported from conservation areas and include introduced populations in Lee County at St. James Creek Preserve and Charlotte Harbor Preserve State Park and a naturally occurring population at Fred C. Babcock - Cecil M. Webb Wildlife Management Area in Charlotte County (USFWS 1999).

In 2004 Hurricane Charley, a Category 4* hurricane, crossed the coastal areas of Lee and Charlotte counties with peak winds as high as 150 mph (Figure 2-1). Its damage to human property on these coastal areas was well known, and it was uncertain whether populations of

* on the Saffir-Simpson Hurricane Scale

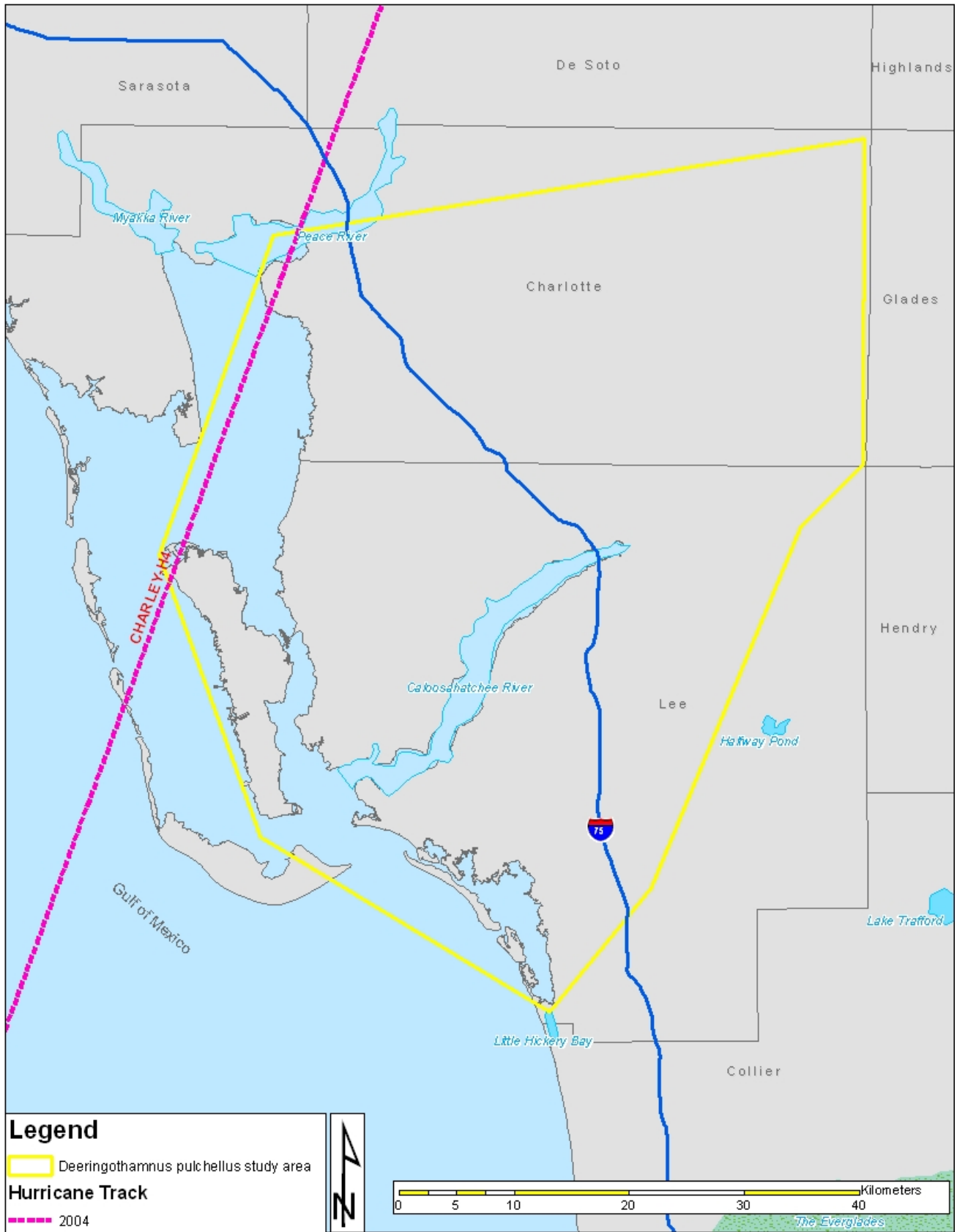


Figure 2-1: *Deeringothamnus pulchellus* Study Area

beautiful false pawpaw would have responded positively or negatively toward this hurricane event. It was surmised that populations could have been negatively impacted by tree falls, storm surge, potential illegal dumping on conservation lands, and possible clearing on private lands. It was deemed necessary to survey as many of these occurrences, as time and budget would allow, to assess the status of beautiful false pawpaw in Charlotte and Lee counties after Hurricane Charley.

Methods

Preparation

Before field assessments were conducted for beautiful false pawpaw, available literature (USFWS 2000, Gann et al. 2002), and herbarium specimen data were compiled, and land managers were consulted. Since beautiful false pawpaw is often only below ground and difficult to detect for up to years, attempts were made to visit sites at a time when beautiful false pawpaw would be most likely be visible. Times when vegetative parts of beautiful false pawpaw are above ground typically occur after fire or ground disturbance (e.g. roller chopping or disking of habitats) and possibly in the spring when plants flower. Conservation areas nearby reported populations were also surveyed.

Site Visit Prioritization

Conservation areas containing beautiful false pawpaw were focused on since it was presumed that fire management needed for seeing beautiful false pawpaw was most likely to occur there. Secondly, conservation areas nearby existing populations were also visited.

Field Assessment

Surveys

Upon visitation at each site, a search for beautiful false pawpaw was conducted. Upon finding beautiful false pawpaw, total number of plants was recorded, recruitment was noted, and habitat(s) following FNAI and FDNR (1990) were recorded including species associates. Overall health of plants was recorded. In addition, hurricane damage was noted for the plants as well as the habitats.

Hurricane damage to plants was ranked as none if there was no direct evidence of the events impacting specific individual plants. Hurricane damage to the plants was ranked as low if little damage to the plants (no mortality for the individual) was directly evidenced as a result of the storms. Hurricane damage to the plants was ranked as moderate if any branches or trunks were known to have fallen and damaged plants and poor health could be attributed to the storm events. Hurricane damage to the plants was ranked as severe if mortality of the individual directly attributed to the storms.

Hurricane damage to the habitat was ranked as none for sites with no direct evidence of the events impacting the habitat. Hurricane damage to the habitat was ranked as low for areas with only a few tree falls and no storm surge (as would be indicated by a die off of the herb vegetation from salt water) surrounding the centroid. Hurricane damage to the habitat was ranked as moderate if there was notable tree falls within the habitat (>five trees) and no storm surge surrounding the population. Hurricane damage to the habitat was ranked as severe if major changes to the habitat (such as majority of canopy trees fell) and/or there was notable storm surge.

Tagging and Mapping

An attempt was made to tag and map plants of beautiful false pawpaw in an area most affected by Hurricane Charley, and an area less affected by Hurricane Charley. A single conservation area was selected as it was the only site with visible plants at the time of the survey which possessed a population large enough to sustain a long term survey. Fifty adult plants were tagged, mapped, and monitored. Measurements taken for beautiful false pawpaw included number of stems, presence of flowers and fruits, hurricane damage (using criteria mentioned above), and general plant health was noted. Light availability was also recorded as either full sun (>90% sunlight), partial sun (10 – 90 % sunlight), and shade (<10 % sunlight).

Data Entry

Survey data was entered and maintained in two geodatabases. The two geodatabases are linked by PointID fields. The GIS geodatabase entitled USFWS_HURSUR_MDB contains coordinate data (in NAD 83 UTM 17N format), Site, Subunit, Associated Taxa, Habitat, Occurrence, and PointID. The second geodatabase entitled USFWS_HURSUR_Datasets contains survey data and was created in Microsoft Access and is linked to the geodatabase by the PointID number. The primary table in this database, which contains one record for each PointID linked by Surveyors and Date, contains all pertinent data from the survey also including Event Number, Comments1, Comments 2, Plant Number, Population Estimate, Site, Site Unit, and Occurrence. Data recorded for mapped and tagged plants is also located in this geodatabase.

Results and Discussion

Sites reported or known to have contained beautiful false pawpaw included: Charlotte Harbor Preserve State Park, Estero Bay Preserve State Park, Fred C. Babcock – Cecil M. Webb Wildlife Management Area, and St. James Creek Preserve. Sites in other conservation areas nearby that were surveyed included: Pine Island Flatwoods Preserve and Koreshan State Historic Site. In conjunction with this project, data from a project involving surveying Babcock Ranch and private portions of the former Babcock Ranch in Charlotte County was incorporated into these results. A map of areas visited during beautiful false pawpaw surveys is in Figure 2-2.

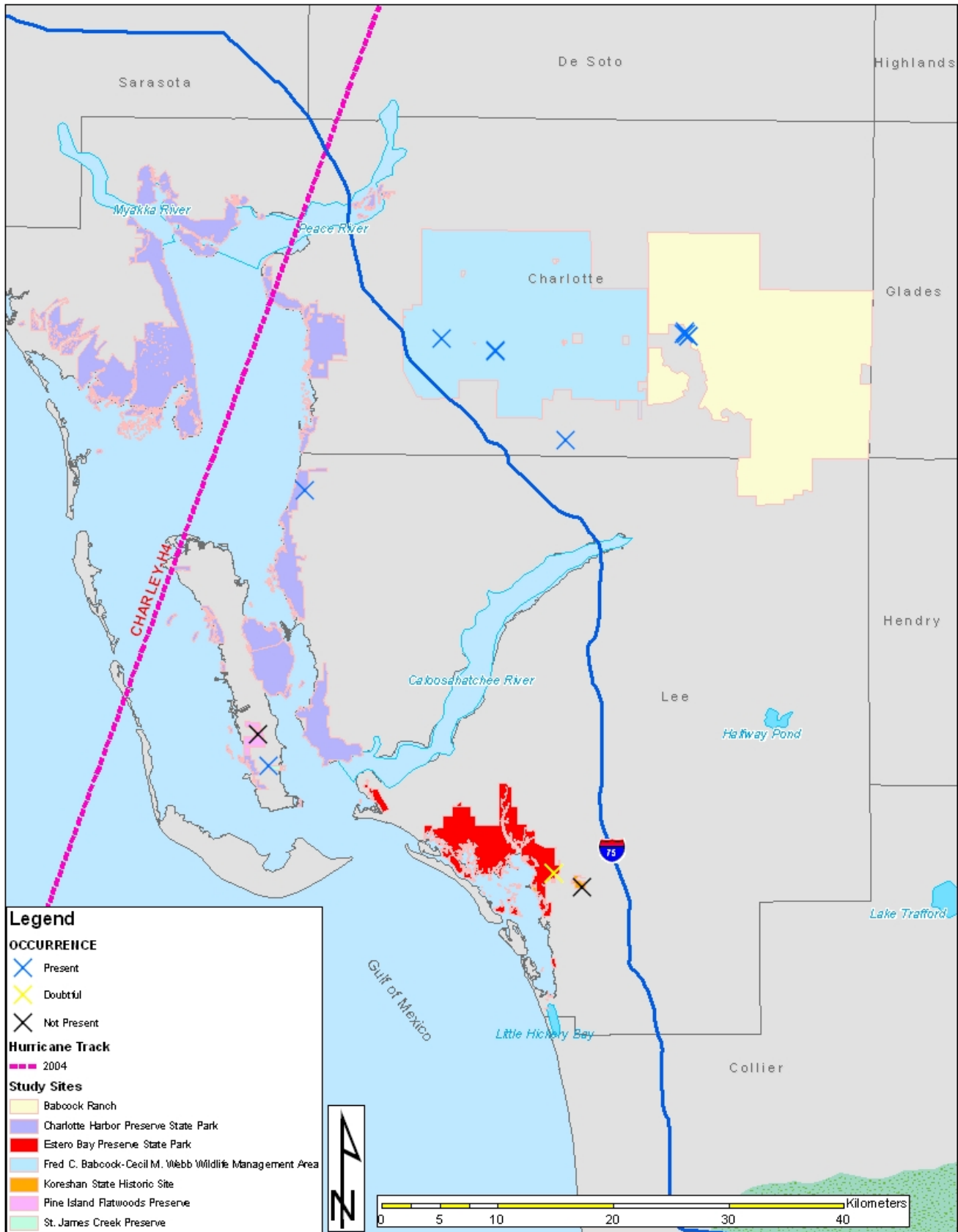


Figure 2-2: *Deeringothamnus pulchellus* Occurrence Results

As a result, five populations of beautiful false pawpaw were visited, one population reported is unverified and listed as doubtful (Table 2-1). These sites are organized into three present and one unverified occurrences. In addition, new areas nearby reported or confirmed populations, were surveyed for beautiful false pawpaw as conditions merited a search. Koreshan State Historic Site, close to Estero Bay Preserve State Park, was searched as flatwoods habitat had recently burned. No plants were observed during surveys. Although much habitat existed at Pine Island Flatwoods Preserve on Pine Island, no plants were observed there, and more surveys, especially after fire, are needed. Hurricane damage for all sites visited was none consisting of no evident storm surge in beautiful false pawpaw habitat, and having few pines that were broken. Shrub and herb layers appeared to be unaffected.

Table 2-1: Beautiful false pawpaw occurrences

Occurrence #	Site Name	Site Unit	Status	Number of Plants in 2006	Hurricane Damage to Habitat	Hurricane Damage to Plants				
1*	Central Charlotte County flatwoods	Fred C. Babcock - Cecil M. Webb WMA – Oil Well Road	P	900	None	None observed				
1	Central Charlotte County flatwoods	Fred C. Babcock - Cecil M. Webb WMA – Interior	P	2	None	None observed				
1	Central Charlotte County flatwoods	Babcock Ranch and Private Lands 1	P	101-1,000	None	None observed				
1	Central Charlotte County flatwoods	Private Lands 2	P	11-50	None	None observed				
2	Charlotte Harbor Preserve State Park	Cape Coral Management Unit, Lee County	P	50-70	None	None observed				
3	Pine Island, Lee County	St. James Creek Park	P**	1	None	None observed				
Unverified	Estero Bay Preserve State Park		D		None	N/A				
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">D = Doubtful</td> </tr> <tr> <td style="padding: 2px;">P = Present</td> </tr> <tr> <td style="padding: 2px;">* plants tagged at this population</td> </tr> <tr> <td style="padding: 2px;">** plants introduced at this site</td> </tr> </table>							D = Doubtful	P = Present	* plants tagged at this population	** plants introduced at this site
D = Doubtful										
P = Present										
* plants tagged at this population										
** plants introduced at this site										

Beautiful false pawpaw Occurrences

Occurrence 1: Central Charlotte County flatwoods

Sub unit: Fred C. Babcock – Cecil M. Webb Wildlife Management Area – Oil Well Road

Owner: Florida Fish and Wildlife Conservation Commission

Status: Present

Hurricane damage to beautiful false pawpaw: none

Hurricane damage to beautiful false pawpaw habitats: none

Background: Beautiful false pawpaw has been known from this station since at least the 1980's (personal communication with Mike Kemmerer). Populations here have been managed by control burning (almost on an annual basis) and roller chopping since 1987.

Site Re-visit: Beautiful false pawpaw was searched for by Woodmansee and Mahoney on March 20, 2006. Habitat consisting of mesic flatwoods, burned approximately a month earlier, was surveyed. An estimate of roughly 900 plants were observed, most of which were in flower. No hurricane damage was evident to any plants or habitat. Mapped and tagged plants (#51-100) were revisited and data was recorded by Woodmansee and Barry on January 9th, 2007. Fewer plants were visible this time, and tags remained on the dead twigs. It is presumed that they lay dormant underground awaiting the next fire.

Site Description: This population of beautiful false pawpaw is located east of Oil Well Road, just north of Tucker's Grade. The mesic flatwoods consisted of few trees of South Florida slash pine (*Pinus elliottii* var. *densa*) with little shrub layer and was dominated by herbs and graminoids.

Vascular plants found within a meter of beautiful false pawpaw included: thin paspalum (*Paspalum setaceum*), saw palmetto (*Serenoa repens*), fringed yellow star-grass (*Hypoxis junceus*), Elliott's yelloweyed-grass (*Xyris elliottii*), Savannah yelloweyed-grass (*X. flabelliformis*), southern wiregrass (*Aristida beyrichiana*), hemlock witchgrass (*Dichantherium portoricense*), glabrescent roughhair witchgrass (*D. strigosum* var. *glabrescens*), yellow hatpins (*Syngonanthus flavidulus*), pink sundew (*Drosera capillaries*), Mohr's thoroughwort (*Eupatorium mohrii*), Nash's blueeyed-grass (*Sisyrinchium nashii*), Coastalplain milkwort (*Polygala setacea*), chalky bluestem (*Andropogon virginicus* var. *glaucus*), lopsided Indian grass (*Sorghastrum secundum*), pineywoods dropseed (*Sporobolus junceus*), Nuttall's meadowbeauty (*Rhexia nuttallii*), wax myrtle (*Myrica cerifera*), dwarf live oak (*Quercus minima*), dwarf huckleberry (*Gaylussacia dumosa*), blackroot (*Pterocaulon pycnostachyum*), spurge nettle (*Cnidocolus stimulosus*), gopher-apple (*Licania michauxii*), whitehead bogbutton (*Lachnanthes anceps*), and Blodgett's ironweed (*Vernonia blodgettii*).

Maps of the population and tagged plants are provided in Figures 2-3, 2-4, and 2-5.

No analysis was conducted on tagged plants for this site. There was no hurricane damage evident during either study session. Data recorded during mapping and monitoring are provided in an accompanying geodatabase.

Recommendations: Continue fire management and exotic pest plant removal at this site. Continue surveys at this location on an annual basis after fires. Conduct more surveys elsewhere at Fred C. Babcock – Cecil M. Webb Wildlife Management Area.

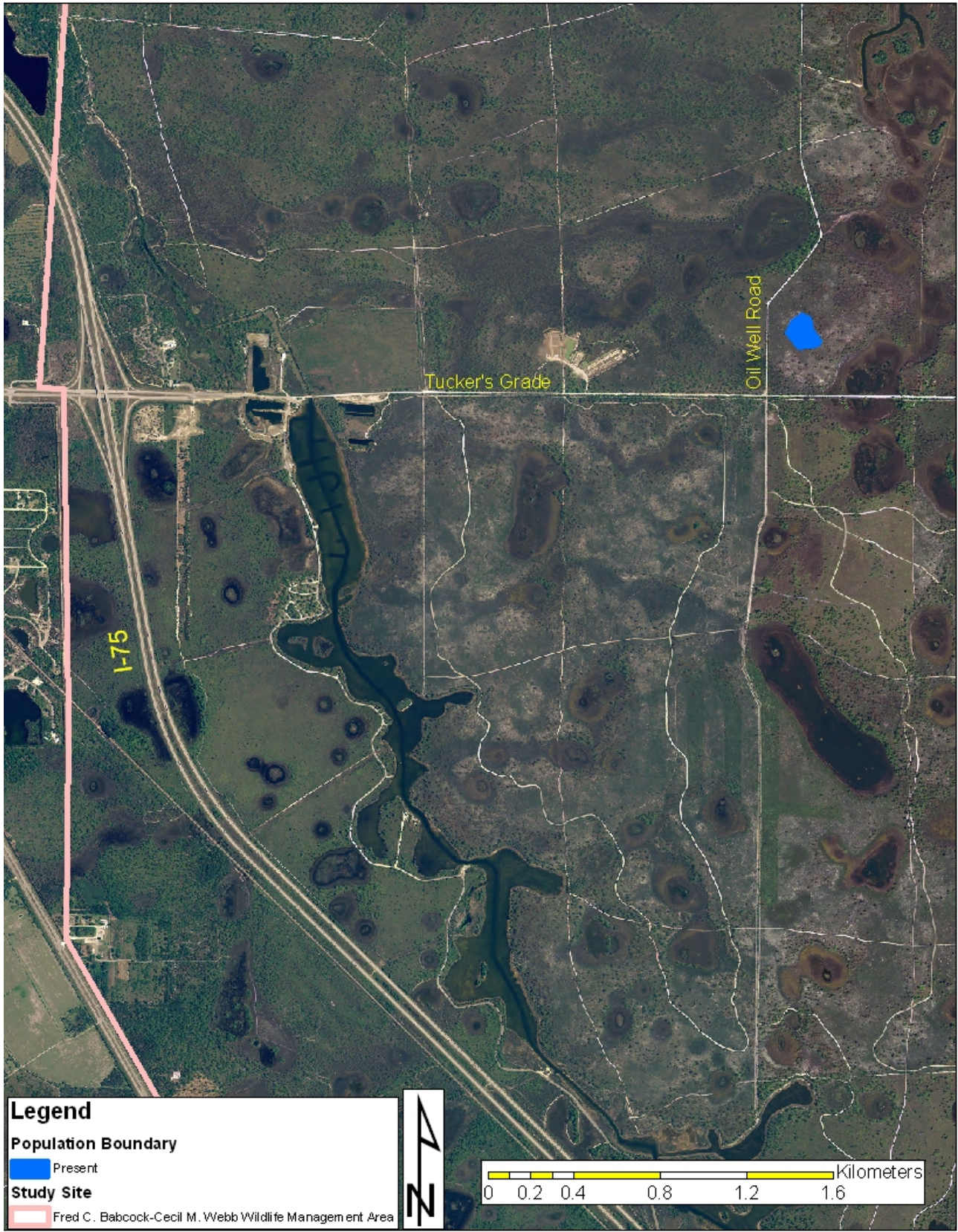


Figure 2-3: *Deeringothamnus pulchellus* at Fred D. Babcock - Cecil M. Webb Wildlife Management Area – Oil Well Road

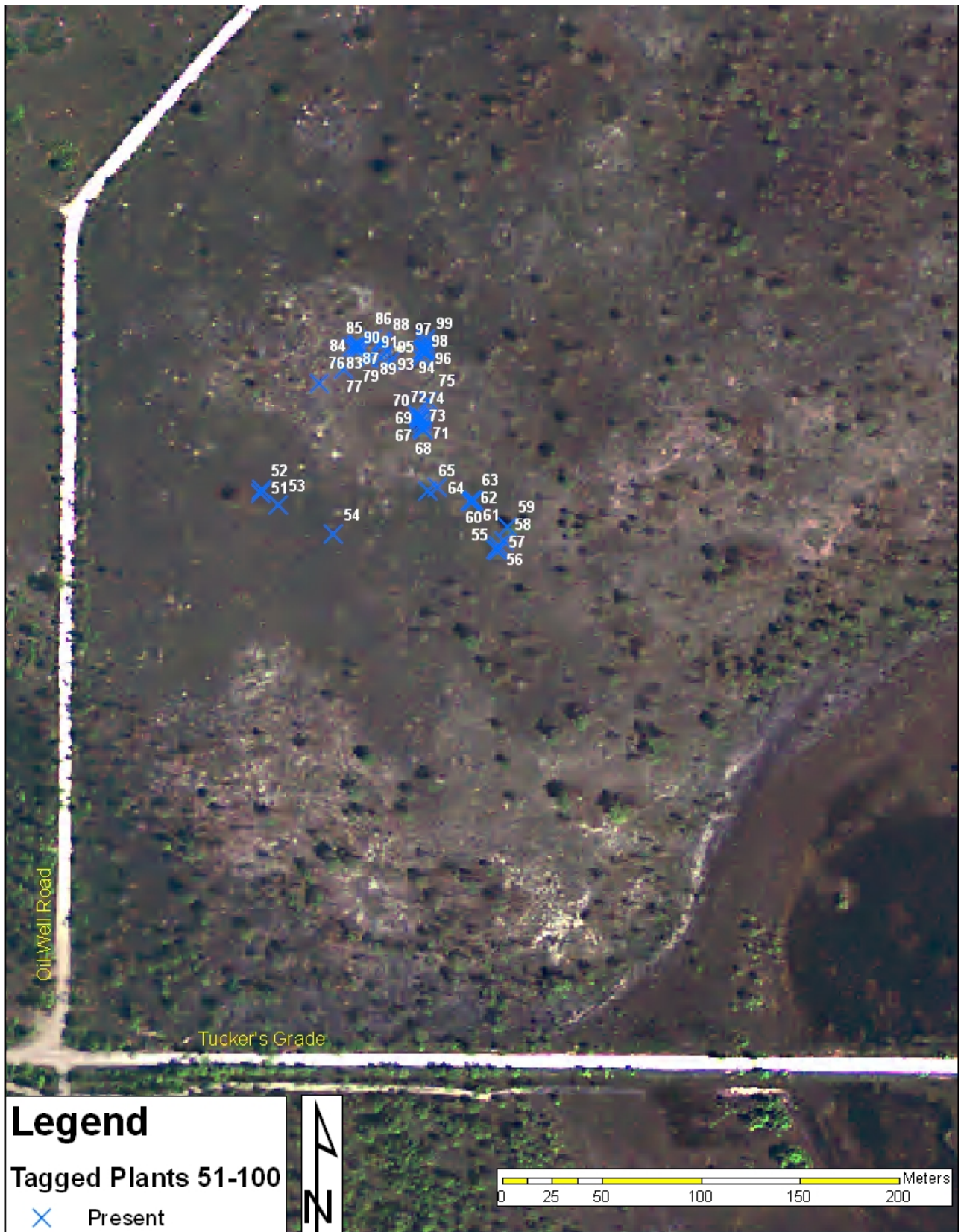


Figure 2-4: Tagged Plants of *Deeringothamnus pulchellus* at Fred C. Babcock - Cecil M. Webb Wildlife Management Area – Oil Well Road

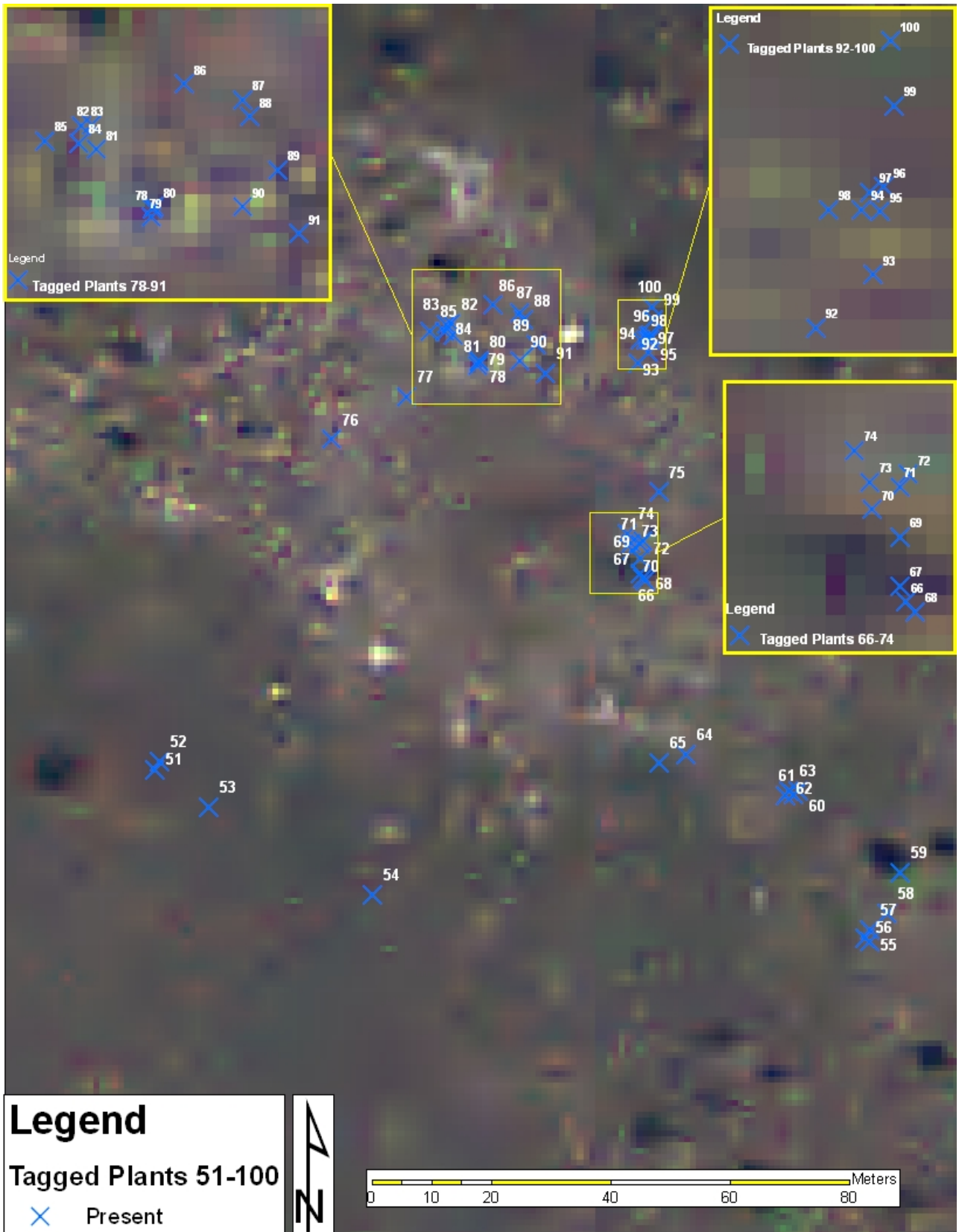


Figure 2-5: Tagged Plants up close of *Deeringothamnus pulchellus* at Fred C. Babcock - Cecil M. Webb Wildlife Management Area – Oil Well Road

Sub unit: Fred C. Babcock – Cecil M. Webb Wildlife Management Area – interior

Owner: Florida Fish and Wildlife Conservation Commission

Status: Present

Hurricane damage to beautiful false pawpaw: none

Hurricane damage to beautiful false pawpaw habitats: none

Background: Beautiful false pawpaw has been known from this preserve, however it is uncertain if it has been known from this exact station since before these surveys.

Site Re-visit: Beautiful false pawpaw was searched for by Woodmansee and Mahoney on March 20, 2006. Habitat consisting of mesic flatwoods and dry prairie, burned approximately a month earlier, was surveyed. Two plants were observed, one individual with six stems and three flowers, the other with three stems and eight flowers. No hurricane damage was evident to any plants or habitat.

Site Description: This population of beautiful false pawpaw is located off of some fire break roads between Seaboard Grade and Powerline Grade, south of Tucker's Grade. The recently burned mesic flatwoods and dry prairie consisted of a few trees of South Florida slash pine (*Pinus elliottii* var. *densa*) with a few clumps of saw palmetto (*Serenoa repens*) and was dominated by herbs and graminoids.

Vascular plants found within a meter of beautiful false pawpaw included: saw palmetto (*Serenoa repens*), southern wiregrass (*Aristida beyrichiana*), hemlock witchgrass (*Dichanthelium portoricense*), and yellow hatpins (*Syngonanthus flavidulus*).

A map of the population is provided in Figure 2-6.

Recommendations: Continue fire management and exotic pest plant removal at this site. Continue surveys at this location on an annual basis and after fires. Survey other locations in similar habitat within Fred C. Babcock – Cecil M. Webb Wildlife Management Area.



Figure 2-6: *Deeringothamnus pulchellus* at Fred C. Babcock - Cecil M. Webb Wildlife Management Area – interior

Sub unit: Babcock Ranch and Private Lands #1

Owner: Florida Fish and Wildlife Conservation Commission and Private land owner

Status: Present

Hurricane damage to beautiful false pawpaw: none

Hurricane damage to beautiful false pawpaw habitats: none

Background: Beautiful false pawpaw has been known from the preserve and the surrounding area however it is uncertain if it has been known from this exact station since before these surveys.

Site Re-visit: Beautiful false pawpaw was searched for by Woodmansee in June 2006. Habitat consisting of disked mesic flatwoods and mesic flatwoods not burned recently. Plants found within Babcock Ranch were in mesic flatwoods and numbered 11-50 individuals at two separate locations. Plants found in the private lands to the west of Babcock Ranch consisted of 101 - 1,000 plants in mesic flatwoods, and 50 – 100 plants in disked flatwoods. All plants were sterile at the time of the visit. No hurricane damage was evident to any plants or habitat.

Site Description: This population of beautiful false pawpaw is located off of some fire break roads 6.5 miles north of Vincent Ave., and 2.5 miles east of State Road 31. The mesic flatwoods consisted of a few trees of South Florida slash pine (*Pinus elliotii* var. *densa*) with a few clumps of saw palmetto (*Serenoa repens*) and was dominated by herbs and graminoids.

A map of the population is provided in Figure 2-7.

Recommendations: Begin fire management at the newly acquired Babcock Ranch. Attempt to gain conservation easement agreements with private land owner to protect portions of mesic flatwoods which possess beautiful false pawpaw. Continue surveys at this location on an annual basis and after fires. Survey other locations in similar habitat within Babcock Ranch.

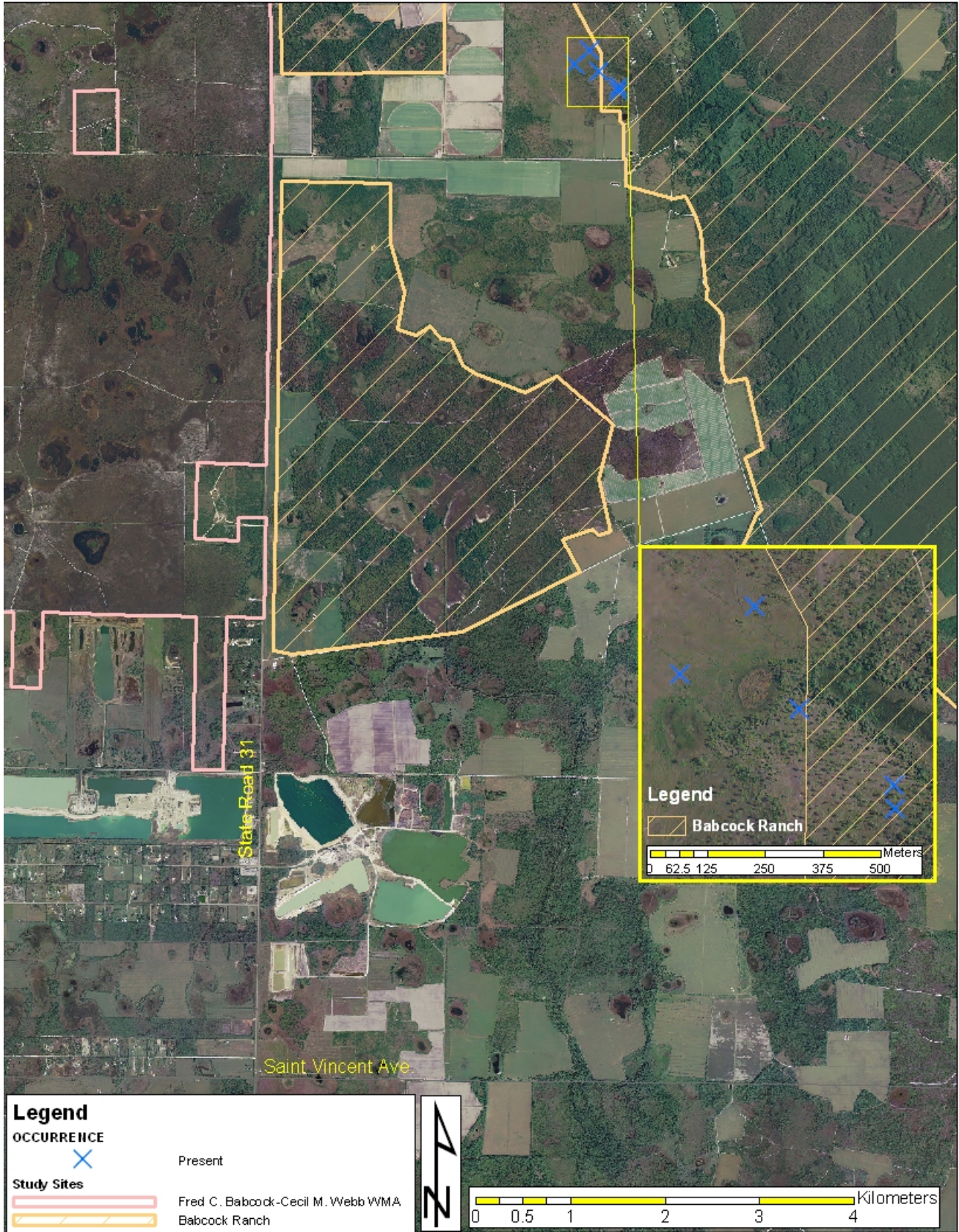


Figure 2-7: *Deeringothamnus pulchellus* at Babcock Ranch and Private Lands #1

Sub unit: Private Lands #2

Owner: Unknown private land owner

Status: Present

Hurricane damage to beautiful false pawpaw: none

Hurricane damage to beautiful false pawpaw habitats: none

Background: Beautiful false pawpaw has been known from the surrounding preserves including Babcock Ranch and Fred C. Babcock – Cecil M. Webb Wildlife Management Area however it is uncertain if it was known from this exact station before these surveys.

Site Re-visit: Beautiful false pawpaw was searched for by Woodmansee in June 2006. Habitat consisted of mesic flatwoods that had not burned recently. Plants found within Private Lands #2 consisted of 11 - 50 plants. All plants were sterile at the time of the visit. No hurricane damage was evident to any plants or habitat.

Site Description: This population of beautiful false pawpaw is located 300 m west of Williams Drive, approximately 1.4 km north of the Charlotte/Lee county line, approximately 5 km northeast of I-75. The mesic flatwoods consisted of a few trees of South Florida slash pine (*Pinus elliottii* var. *densa*) with a few clumps of saw palmetto (*Serenoa repens*) and was dominated by herbs and graminoids.

A map of the population is provided in Figure 2-8.

Recommendations: Attempt to gain conservation easement agreements with private land owner to protect portions of mesic flatwoods which possess beautiful false pawpaw. Continue surveys at this location on an annual basis and after fires.

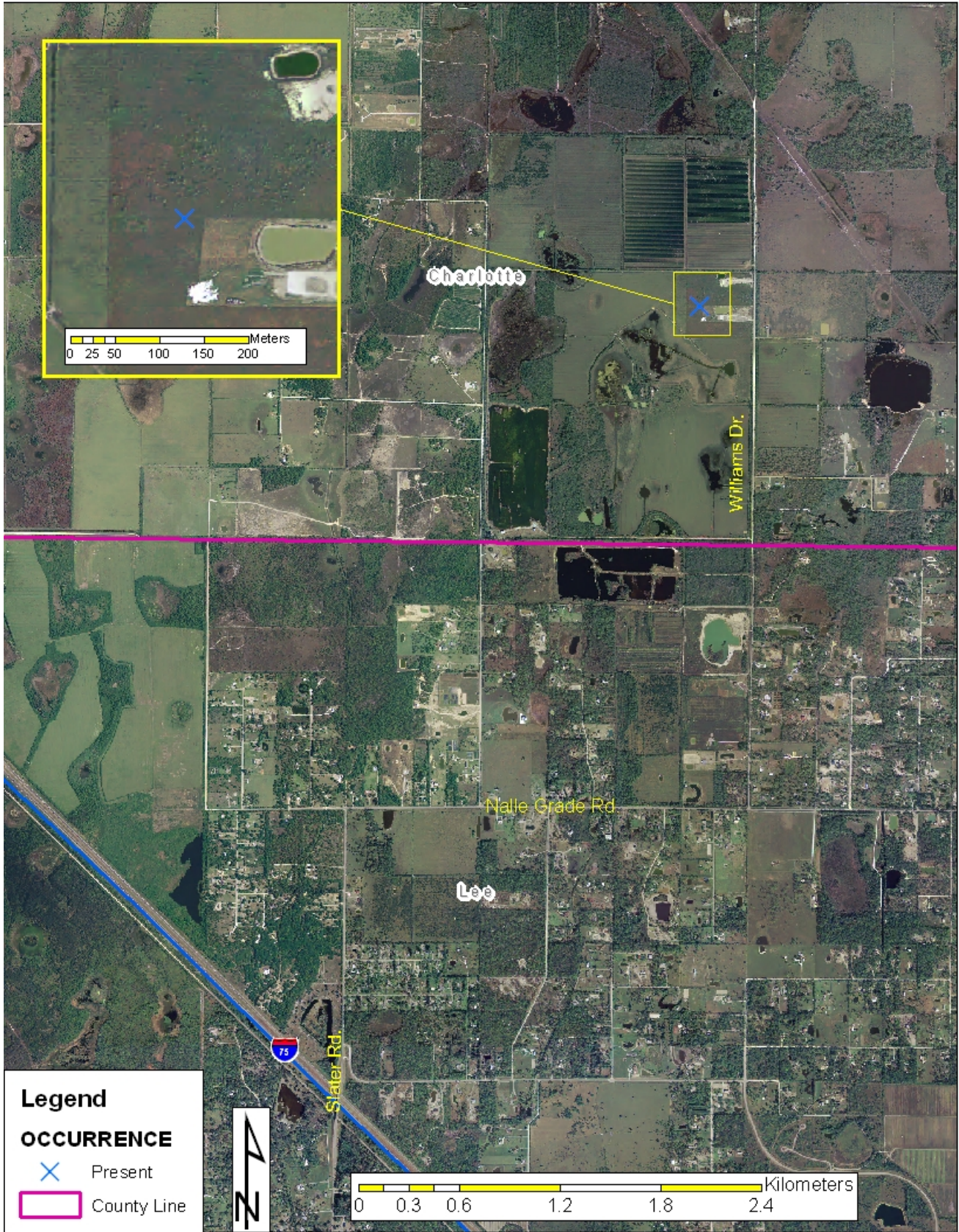


Figure 2-8: *Deeringothamnus pulchellus* at Private Lands #2

Occurrence 2: Charlotte Harbor Preserve State Park

Sub unit: Cape Coral Management Unit, Lee County

Owner: Florida Department of Environmental Protection

Status: Present

Hurricane damage to beautiful false pawpaw: none

Hurricane damage to beautiful false pawpaw habitats: none

Background: Beautiful false pawpaw has been known from this station since at least the 1990's (personal communication with Jay Garner). Populations here have been managed by control burning (almost on an annual basis) since the 1990's.

Site Re-visit: Beautiful false pawpaw was searched for by Woodmansee, Mahoney, and Florida Park Service biologist Jay Garner on March 22, 2006. Habitat consisting of mesic flatwoods, not burned within a year, was surveyed. No plants were observed during this survey. No hurricane damage was evident to the habitat. On May 2, 2006, Garner observed 50-70 plants growing in disked fire breaks, and undisturbed mesic flatwoods at this station.

Site Description: The mesic flatwoods consisted of a few trees of South Florida slash pine (*Pinus elliottii* var. *densa*) with a network of shrub dominated by saw palmetto (*Serenoa repens*) and grassy patches dominated by herbs and graminoids.

Vascular plants found in habitat of beautiful false pawpaw included: southern wiregrass (*Aristida beyrichiana*), Elliott's yelloweyed-grass (*Xyris elliottii*), and yellow hatpins (*Syngonanthus flavidulus*).

A map of the population of plants is provided in Figure 2-9.

Recommendations: Continue fire management and exotic pest plant removal at this site. Continue surveys at this location on an annual basis and after fires.

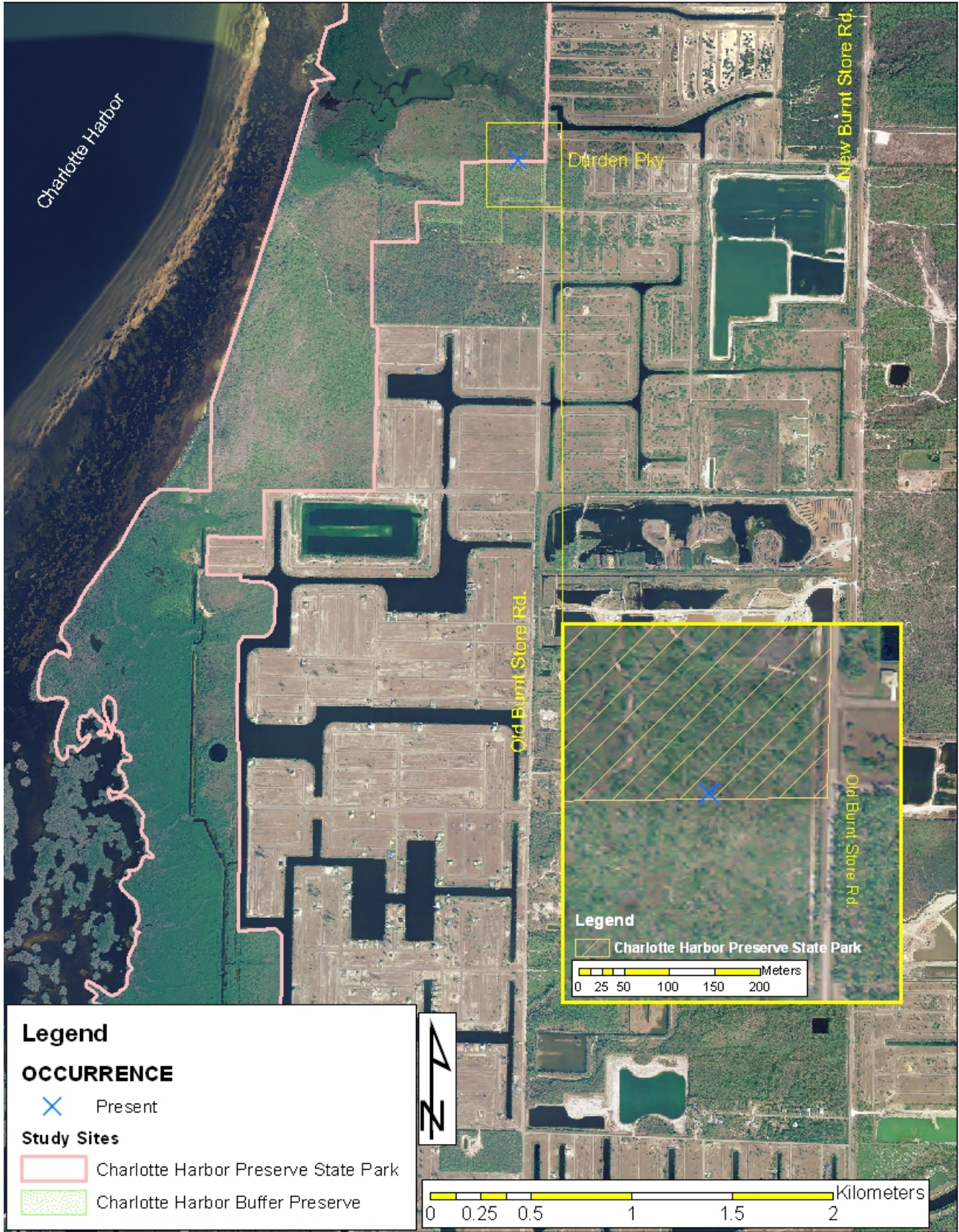


Figure 2-9: *Deeringothamnus pulchellus* at Charlotte Harbor Preserve State Park

Occurrence 2: St. James Creek Preserve

Owner: Lee County Parks and Recreation

Status: Present (introduced)

Hurricane damage to beautiful false pawpaw: none

Hurricane damage to beautiful false pawpaw habitats: none

Background: Beautiful false pawpaw has been known from this station since it was introduced here in 1996-1997 by Barry and other staff from Passarella and Associates (USFWS 1999). Approximately 200 plants were relocated from a privately owned tract of longleaf pine (*Pinus palustris*) dominated mesic flatwoods.

Site Re-visit: Beautiful false pawpaw was searched for by Woodmansee and Mahoney on March 21, 2006. Habitat consisting of South Florida slash pine (*Pinus elliottii* var. *densa*) dominated mesic flatwoods, not burned recently, was surveyed. Despite not burning, a single adult plant with two stems was observed during this survey. Several aluminum tags were observed on the ground at the site, presumed to be where the plants were relocated. No hurricane damage was evident to the habitat or the plant.

Site Description: The mesic flatwoods consisted of several trees of South Florida slash pine with a dense network of shrubs dominated by saw palmetto and a few grassy patches dominated by herbs and graminoids.

Vascular plants within a meter of the introduced beautiful false pawpaw included: wax myrtle (*Myrica cerifera*), dwarf live oak (*Quercus minima*), southern wiregrass (*Aristida beyrichiana*), saw palmetto, Coastalplain staggerbush (*Lyonia fruticosa*), broomsedges (*Andropogon* spp.), arrowfeather threeawn (*Aristida purpurascens*), plumed beaksedge (*Rhynchospora plumosa*), shiny blueberry (*Vaccinium myrsinites*) and candyroot (*Polygala nana*).

A map of the population is provided in Figure 2-10.

Recommendations: Initiate fire management and continue exotic pest plant removal at this site. Monitor this plant on an annual basis and after fires. Continue surveys at the nearby Pine Island Flatwoods Preserve on an annual basis after fires.



Figure 2-10: *Deeringothamnus pulchellus* at St. James Creek Preserve

Other beautiful false pawpaw Study Areas

Unverified Occurrence: Estero Bay Preserve State Park

Owner: Florida Department of Environmental Protection

Status: Doubtful

Hurricane damage to beautiful false pawpaw: none

Hurricane damage to habitats: none

Background: Beautiful false pawpaw was reported to occur at Estero Bay Preserve State Park by Vanasse and Daylor (2001).

Site Re-visit: Beautiful false pawpaw was searched for at portions of Estero Bay Preserve State Park by Woodmansee and Mahoney on March 20, 2006. Habitat consisting of South Florida slash pine (*Pinus elliottii* var. *densa*) dominated mesic flatwoods, burned within the last month, and other flatwoods habitat was surveyed. No plants were found. No hurricane damage was evident to the habitat. Although no records of beautiful false pawpaw exist for Koreshan State Historic Site, it is nearby, and portions had recently burned, so those areas were also searched.

Site Description: The mesic flatwoods consisted of several trees of South Florida slash pine with a dense network of shrubs dominated by saw palmetto and a few grassy patches dominated by herbs and graminoids. However, plant associates generally observed in conjunction with beautiful false pawpaw were not seen during these surveys.

A map of the area surveyed is provided in Figure 2-11.

Recommendations: Continue surveys at Estero Bay Preserve State park in appropriate habitats within one month after fires.

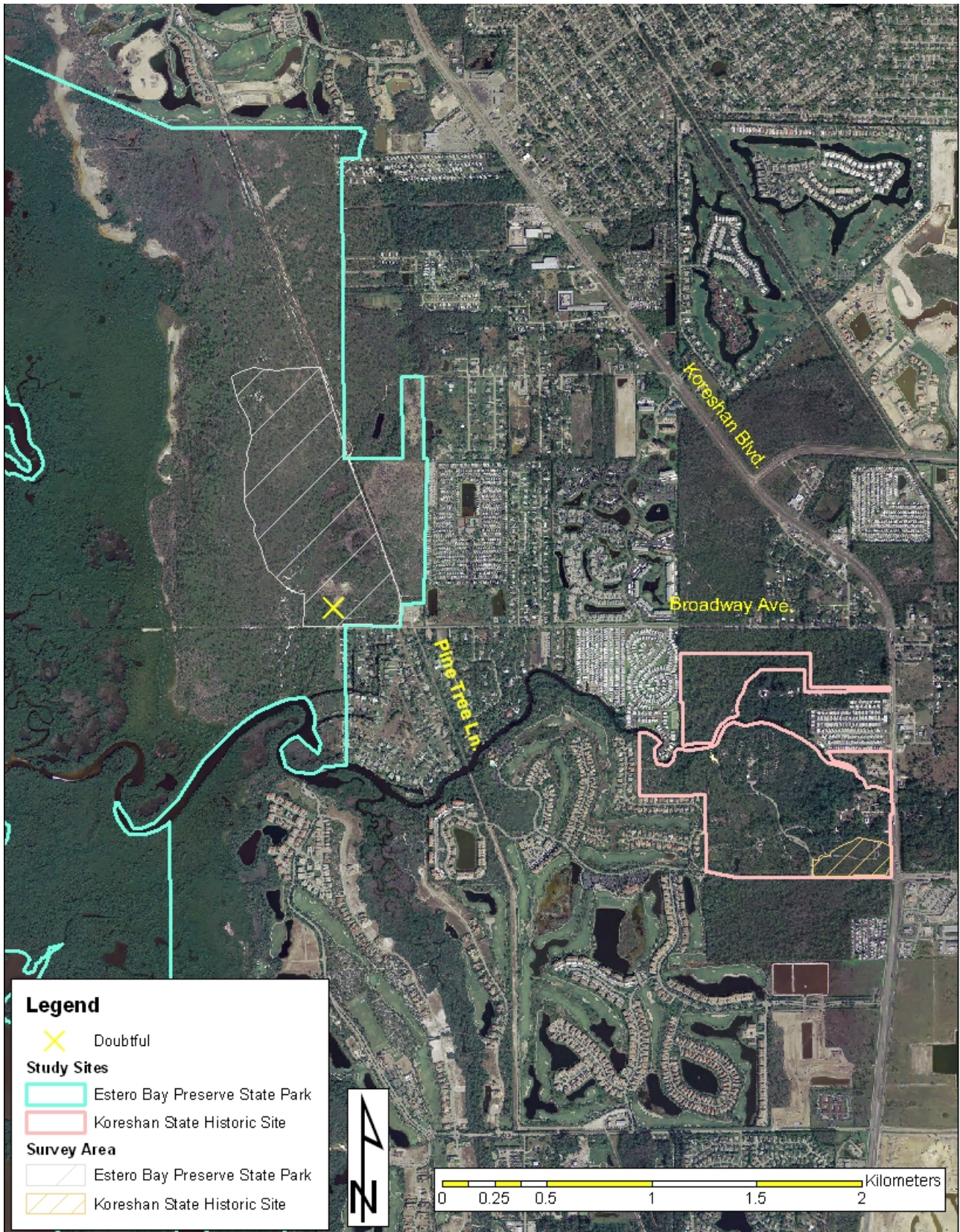


Figure 2-11: *Deeringothamnus pulchellus* surveys at Estero Bay Preserve State Park and Koreshan State Historic Site

Final Discussion

Although Hurricane Charley was a powerful storm event, it showed no impacts to beautiful false pawpaw. No human impacts such as dumping of construction debris were observed. Storm surge, which would have been the most likely destructive force (as is evidenced in pinelands of the Florida Keys, personal observations) did not crest into coastal flatwoods communities containing or possibly containing beautiful false pawpaw on Pine Island, Estero Bay Preserve State Park, or Charlotte Harbor Preserve State Park of Lee County as was hypothesized.

More surveys for beautiful false pawpaw (and other rare plants) are needed at Estero Bay Preserve State Park, Pine Island Flatwoods Preserve, and the newly acquired Babcock Ranch. Management including prescribed fire, exotic plant removal, and feral pig removal should be conducted to protect beautiful false pawpaw.

Acknowledgements

The authors wish to thank Josh M. Mahoney who assisted with field surveys. Mike Kemmerer, wildlife biologist for the Florida Fish and Wildlife Conservation Commission, provided data. Jay Garner, Florida Park Service biologist, assisted with surveys and provided data. We also thank the Florida Department of Parks and Recreation, Florida Fish and Wildlife Conservation Commission, Lee County Parks and Recreation, and Johnson Engineering Inc. for granting us permission to access properties within the study area. Kirsten Hines assisted with edits and provided valuable advice on this report.

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**Chapter 3: Post-hurricane Field Assessment of Savanna Balm
(*Dicerandra immaculata* Lakela var. *savannarum* Huck)**

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Savanna balm on private parcel, St. Lucie County, Keith Bradley, 2006.

Table of Contents

Background	034
Introduction	034
Methods	034
Results	036
Discussion	039
Acknowledgements	043
Citations	044

Tables:

Table 3-1: Associated taxa observed at the known population of Savanna balm.	038
Table 3-2: Summary of Private Landowners Contacted and Parcels Surveyed	041

Figures:

Figure 3-1: <i>Dicerandra immaculata</i> var. <i>savannarum</i> study area	062
Figure 3-2: Location of Known Population of Savanna balm	063
Figure 3-3: Close up of Known Population of Savanna balm	064
Figure 3-4: Location of Initial Relocation Site for propagated plants	065
Figure 3-5: Known Population Site in 1940's	066
Figures 3-6 – 3-16: Parcels Surveyed for Savanna balm	067
Figure 3-17: Survey Track for Martin County	078

Appendices:

Appendix 3-1: Summary for IRC on work done by Historic Bok Sanctuary on Savanna balm (<i>Dicerandra immaculata</i> var. <i>savannarum</i>) April 02, 2007, Cheryl L. Peterson, Conservation Program Manager	045
Appendix 3-2: Summary of Field Notes for Parcels Surveyed for Savanna balm	051

Background

Savanna balm (*Dicerandra immaculata* var. *savannarum*) is listed as endangered by the U.S. Fish and Wildlife Service and the Florida Department of Agriculture and Consumer Services (Coile and Garland 2003). This taxon is known from only two small colonies of plants, both immediately west of the Indian River. Two colonies occur just north of the Martin County line in southern St. Lucie County on the Atlantic Coast Ridge. One colony occurs at Savannas Preserve State Park while the other occurs on private lands along Indian River Dr. Both of these colonies have been declining in recent years.

Savanna balm was discovered in 1995 by George Gann and Keith Bradley at both the private site and Savannas Preserve State Park who listed it as *Dicerandra* aff. *immaculata*. On October 26, 1996, Robin Huck made an herbarium specimen at Savannas Preserve State Park (#5492, FLAS). Huck (2001) reported two populations of some 200 individuals. The Savannas Preserve State Park population was again visited by Gann, Bradley, and Woodmansee again in 1998 and eleven plants were observed to be flowering in shade, and more plants were observed in the railroad tracks nearby.

Introduction

In September 2004 hurricanes Jeanne and Frances's paths crossed the vicinity of the border between Martin and St. Lucie counties. Upon landfall, Hurricane Jeanne was ranked as a Category 3* and Hurricane Frances a Category 2*, both of which had substantial winds. Both hurricanes were sizable, and covered much of peninsular Florida. The impacts of these storms occurred as far north as Volusia County. Their damage to human property on these coastal areas was well known, and it was uncertain whether populations of savanna balm would have responded positively or negatively toward this hurricane event. It was surmised that populations could have been negatively impacted by wind induced breakage, tree falls, tidal surge, and potentially illegal dumping or clearing on both private and conservation lands.

Savannas Preserve State Park and other public properties nearby have been surveyed extensively for Savanna Balm, and yet only one small colony exists on public land. It was hoped that other colonies of savanna balm may exist on private lands, and it was deemed necessary to conduct more surveys in appropriate habitat on private properties east of Savannas Preserve State Park.

Methods

Two objectives were met with differing survey methodology. First, the area of the known population of savanna balm (*Dicerandra immaculata* var. *savannarum*) was monitored and inventoried. Second, private parcels were identified to the north and south along the same dune ridge and surveyed in search of other potentially existing un-documented populations.

Survey of Known Population

Permission was sought to survey parcels at the Eden Creek subdivision where the only known natural population occurs. Originally the landowners were non-responsive to both

* on the Saffir-Simpson Hurricane Scale

first and second mailings. These parcels were accessed through permission sought by telephone request resulting in 2 parcels (4509-807-0014-000-2 and 4509-807-0004-000-9) to survey at the site of the known population, the first of which has Savanna balm and the landowners, Glenn D. Hanger and Lauren Hanger of Middlebrook Virginia, have been cooperative both with us and Cheryl Peterson of Historic Bok Sanctuary. A final parcel (4509-807-0015-000-9) at the known population was surveyed accidentally while inspecting the adjacent parcel due to lack of boundary posting and is now one of only two parcels remaining with Savanna balm. No contact has thus far been successful with the owner of this parcel either by The Institute for Regional Conservation or Historic Bok Sanctuary.

In the field, plants were counted and population size estimated based on these surveys. All Savanna balm locations in this area were recorded with GPS and tagged individuals were recorded. General condition of plants and phenology was noted. Notes on habitat condition, light conditions (i.e. sun/partial/shade) and plant associates were also recorded. In addition, soil pH was recorded using the Hellige-Truog Soil Reaction (pH) Tester.

Survey for Additional Savanna Balm Populations

Private parcels in St. Lucie County with potential for Savanna balm based on geography, soils, and vegetation types were identified using aerial photography and knowledge of the area. Priority was also given based on distribution of the mapped soil type of the known population, Welaka variant sand, 0-5 percent slopes (Watts and Stankey 1977). Similar soils (Paola sands also have yellow sand close to the surface) are known to support other species *Dicerandra* more than St. Lucie Sands (white sand) (Menges 1992). The majority of these parcels are accessible from Indian River Drive north of County Line road and south of Midway road. The landowners of these parcels were then identified using the GIS data acquired from St. Lucie County and contacted through a series of letters and phone calls.

Once access was granted, one or two biologists from The Institute for Regional Conservation surveyed any suitable habitat within the parcel on foot. If any Savanna balm had been located, individuals were to have been counted and notes taken on general health, phenology, conditions (i.e. sun/partial/shade), habitat, disturbance, and associates. If any fragrant prickly-apple cactus (*Harrisia fragrans*) were encountered, similar data was also collected (see Chapter 5). Coordinates were systematically taken for individuals of fragrant prickly-apple cactus. When possible, a track log of actual survey path was recorded.

Actual habitat descriptions of parcels surveyed were recorded for most but not all parcels even if neither Savanna balm or fragrant prickly-apple cactus were located. This was most detailed for the parcels surveyed in 2007 and included presence or absence of yellow sand similar to the known population of Savanna balm to facilitate any future survey or relocation work. General description of dominant plant species and habitat condition were included.

Additional areas were surveyed in Martin County along the dune ridge south to the tip of Sewall's point. First, undeveloped parcels were identified on aerial photography. Because most of the area is developed or highly disturbed, no attempt to contact landowners was made prior to field work. Once in the field, these areas were visited to determine if potential habitat existed. A GPS track log was taken during the entire survey. If possible, permission to enter a parcel was sought from landowners on site or if not posted and evidence of public

access (i.e. off road vehicle trails) existed, the site was surveyed. After field reconnaissance survey was completed, notes were taken and access may be pursued in the future for potential habitat observed

Data Entry

Survey data was maintained in two databases. The first database was a personal geo-database created in ArcMap 9.2 which contains the parcel data (polygons) from St. Lucie county property appraiser's office. This file contains multiple polygons referenced by the parcel ID number with landowner's name and address, acreage of each portion (parcels usually broken into several parcels by road/railroad easements), and miscellaneous real estate information. The second database was created in Microsoft Access and is linked to the geo-database by the parcel ID number. The primary table in this database, which contains one record for each parcel ID contacted for survey, contains all pertinent data from the survey including method of contacting the landowner, whether or not access was granted, phone numbers, permission for collection, date surveyed, observers, habitat description, number of Savanna balm or fragrant prickly-apple cactus (Chapter 5) observed, population description (if present) and associated taxa observed.

Results

Overview

The existing population in and around the subdivision of Eden Creek lane continues to decline due to habitat destruction (lot clearing). Cheryl Peterson of Historic Bok Sanctuary has successfully harvested and propagated some of these plants and one relocation site has been established within the Savannas Preserve State Park (SPSP) in cooperation with biologist Greg Kaufmann, However, some of the harvesting further reduced the existing natural population, including the elimination of the only plants naturally occurring within SPSP.

No additional populations of Savanna balm were located. Over 100 acres from 53 parcels of private land along the Atlantic coastal ridge from Midway Road south to County Line road in St. Lucie County were surveyed for Savanna balm. Additional areas in Martin County along the ridge south to Sewall's point were also surveyed.

Survey of Known Population

The known population was counted and re-surveyed for a final evaluation for this report on May 4, 2007 and are presented in Figures 3-1 - 3-3. Currently, plants are only known from two parcels (4509-807-0014-000-2 and 4509-807-0015-000-9), and a narrow strip which contains a transformer between the curb and the above parcels. Only with parcel 4509-807-0014-000-2 we have had direct contact with the landowner, Glenn and Lauren Hanger, currently living in Virginia. They have been cooperative with our survey efforts and collection efforts by Cheryl Peterson of Historic Bok Sanctuary. The latter parcel was surveyed in error as the boundaries are not posted so the parcels were surveyed together with meandering transects between the cleared parcel to the south, the road to the east, the home to the north, and the railroad to the west. Despite repeated attempts both by The

Institute for Regional Conservation and Historic Bok Sanctuary, no contact with this landowner has been made.

The total number of plants at the only remaining naturally occurring population site at Eden Creek was 81 individuals on May 4, 2007. Two clusters totaling 10 plants were located on parcel 4509-807-0014-000-2. The 48 plants around the transformer box are considered to be just in front of parcel 4509-807-0015-000-9. A total of 23 plants were found scattered in 3 general clusters from the interior of this parcel (4509-807-0015-000-9).

These two parcels combined total 1.01 acres. The clearings within the parcels which actually have savanna balm include 6 clusters totaling only 0.05 acres, which at this point are the only naturally occurring savanna balm plants. Per the St. Lucie County Property Appraiser website (<http://www.paslc.org/>) on June 6, 2007, parcel 4509-807-0014-000-2 (0.5 acres) has an assessed value of \$143,200 while parcel 4509-807-0015-000-9 (0.51 acres) has an assessed value of \$126,700.

Plants were previously reported for parcel 4509-807-0016-000-6 (adjacent to 4509-807-0014-000-2 to the south) by IRC biologists Josh Mahoney and Steven Green on August 8, 2006 are now gone as the parcel has been completely cleared for development. Cheryl Peterson of Historic Bok Sanctuary was able to harvest these plants (12 plants) for her propagation/reintroduction project prior to the clearing. Additional plants (8 plants) previously known from the edge of FEC railroad right of way and just inside SPSP (to the northwest of the Eden Creek plants on the west side of the railroad tracks) were also harvested by Cheryl Peterson in 2006. No plants have been found at this location during surveys in 2007. The plant rescue and propagation project status is summarized in Appendix 3-1 in a report prepared by Cheryl Peterson.

Access was denied repeatedly onto parcel 4509-801-0009-010-9 owned by The Florida Inland Navigation District across the railroad tracks from the known population. The occurrence of Savanna balm on this parcel in the past has been reported verbally from biologists over the past ten years, but we were unable to confirm its continued presence. It is very likely present on this parcel. Unfortunately they are well into the permitting process to utilize this area for spoil deposition from the Indian River.

Survey for Additional Savanna Balm Populations

Initial mailing resulted in 25 parcels to survey (20%) and 5 parcels denied (4%). Second mailing resulted in 5 additional parcels to survey (9%). However, of these 5 parcels, 2 were actually no response but access was granted verbally while surveying neighbor's parcel and 2 additional landowners at Eden Creek subdivision were contacted and access was granted by telephone. Third mailing resulted in 14 parcels to survey (18%). Telephone contact was made for 5 additional parcels contacted in the third mailing owned and managed by FPL and access was granted in an email.

After each mailing for the St. Lucie county portion of the survey, when permission to access a number of parcels had been received, the areas were surveyed in the field between August 8, 2006 and May 4, 2007. During that time attempts to gain permission to access high probability parcels with no response on the first two mailings were also made, resulting in

later survey times. Below the results of the mailings and survey effort are presented in Table 3-1.

Table 3-1: Summary of Private Landowners Contacted and Parcels Surveyed

Letter request Date	Number of Parcels	Number Parcels w/access denied	Number Parcels w/access granted and Surveyed	Acres Surveyed
7/11/2006	125	5	25	41.2
10/5/2006	53 (6 parcels from 1 st mailing included again)	0	7 (4 of 7 verbal)	7.6 (1.9 verbal by phone)
2/27/2007	78	0	19 (5 phone FPL)	70.7
Verbal on site w/no mailing			2	1.7
Total:	250 (256 including 6 landowners contacted twice)	5	53	121.2

Parcels actually surveyed are presented in Figures 3-6 – 3-16. Below in Appendix 3-2 are the results of the 53 parcels (121 acres) surveyed. Included are the habitat descriptions and numbers of Savanna balm or prickly apple cactus located. Savanna balm was not located outside of the known population off Eden Creek lane in St. Lucie County. A total of 56 prickly apple cactus were located on 15 parcels scattered throughout the parcels between Midway road and county line road. In addition, two clusters of false sisal (*Agave decipiens*) and several clusters of dildo cactus (*Acathocereus tetragonus*) were located on the parcel owned and managed by Florida Power and Light (FPL) where the power lines pass from the power plant on the other side of the lagoon. This is the northernmost known occurrence of False sisal on the east coast of Florida.

The survey track in Martin County is presented below in Figure 3-17. A variety of habitats were accessed March 7, 2007 by senior biologist Mike Barry and volunteer John Stegmier but no additional populations of Savanna balm were located. Many undeveloped areas were visited, however most, including all sites in the Rio area (high sand pine scrub), appeared significantly different from the habitats where the known population occurs. Three areas of interest for potential future more detailed survey were located, as denoted in Figure 3-17. From south to north, an undeveloped parcel in Sewall’s point was surveyed after a neighbor walking his dog on the parcel as he had for years invited us to accompany him. No plants were found but a relatively intact tropical hardwood hammock with scrub hickory (*Carya floridana*) on the interior portion was observed indicating that potential habitat may at one time have occurred all along this area of Sewall’s point. It was indicated that this parcel would be developed soon.

The next area of potential for Savanna balm occurred across the road to the west from Indian Riverside Park to the north of the assisted-living facility. This site was accessed via a well worn foot/bike trail from the sidewalk. Yellow sand typical of the known population location was present along with similar mesic to xeric hammock species. Finally, another undeveloped area between skyline drive and the Jensen Beach Bridge, adjacent to a trailer park to the north showed potential. These areas exhibited similar vegetation to the known population but due to disturbance and invasion by Brazilian pepper (*Schinus terebinthifolius*) access to the interior would be slow and permission should be sought prior to survey. No plants were observed while completing a survey of the edge of the parcel on foot from public trails and the trailer park where residents gave us permission to pass. Because of invasion by exotics, it is doubtful that a new population would be located here, but it seems possible that in the past Savanna balm may have been in the area.

Discussion

The existing population in and around the subdivision of Eden Creek lane continues to decline due to habitat destruction. No additional populations of Savanna balm were located. Cheryl Peterson of Historic Bok Sanctuary has successfully harvested and propagated some of these plants and one relocation site has been established within the Savannas Preserve State Park (SPSP). However, some of the harvesting further reduced the existing natural population, including the elimination of the only plants naturally occurring within SPSP.

The plants previously known from the edge of FEC railroad right of way and just inside SPSP were harvested by Cheryl Peterson in 2006. None were located in the area on March 23, 2007 even though the habitat remains intact and the area was surveyed intensively within a minimum radius of 50 meters. The two locations where plants were harvested were marked with wire flags by biologist Greg Kaufmann of SPSP. These flagged locations were recorded by IRC using a GPS unit to facilitate future re-survey in case of future germination from any existing seed bank. Although the harvesting of the Eden Creek plants on private property prior to clearing was timely, we question the validity of calling this location at risk. Instead of relocation, habitat management could have encouraged the expansion of this sub-population, such as exotic control, hardwood (oak) management, or fencing to prevent debris dumping. These were the only savanna balm plants naturally located on preserved land and without any remaining plants this sub population may have been eliminated prematurely and now there is little chance of its recovery here unless seeds exist in the soils or we have missed plants here while surveying the area.

The initial relocation site is located to the north of the known population west of the FEC railroad right of way (Figure 3-4). Greg Kaufmann of The Savannas Preserve State Park (SPSP) was the lead on the location of the experimental plantings. Several factors went into the site choice, especially the abundance of yellow sand at or close to the surface. Also the site is not too far north of the known site to avoid the potential of introducing it out of range where other yet undiscovered natural populations of *Dicerandra* spp. may occur. Additionally, the site is early successional (It was nearly completely cleared on the 1940's aerial photograph) so no prescribed burning will be necessary for quite some time giving the seed bank time to become established. There are also a variety of light conditions available for planting (i.e. Shade, partial sun, full sun). From an "operations" point of view Greg also considered the location to be fairly safe from illegal ATV use common in other areas.

Vegetation/Habitat Description

Understanding the habitat formerly occupied by Savanna balm will be essential for the success of reintroduction. However, because so much of the area has been disturbed, this is a difficult task at best. An assessment of the general area was described in an earlier report on prickly apple cactus by The Institute for Regional Conservation (Bradley et al. 2004). Much of this general history and ecological discussion applies to Savanna balm.

Vegetation associates recorded at the known population site at Eden Creek Lane were recorded in Table 3-2. The area was cleared prior to the 1940's and planted into a fruit tree grove which was most likely mango (*Mangifera indica*) based on the persistent old mango trees scattered through the area (Figure 3-5). Pineapple (*Ananus comosus*) farming very likely also occurred here prior to the 1940's, likely from the late 1800's to the mid 1920's (Williams 2003, St. Lucie Historical Museum website, Packard 1912). The subsequent abandonment of agriculture has resulted in current re-vegetation from a mix of mesic/tropical hammock species and xeric oak scrub/xeric hammock species with a preponderance of invasive exotic species. Because plants were only found at this one previously disturbed location, it would be dangerous to assume the native vegetation associates recorded represent a "typical" association of Savanna balm. However, it is all we have to go by presently for clues to selection of relocation sites or to prioritize parcels for survey, besides observations of other species of *Dicerandra*.

Discussions with Greg Kaufmann (also based on his communication with Eric Menges of Archibold Biological Station and Cheryl Peterson of Bok Tower Gardens) suggest that one hypothesis may be that this plant was more of a scrub opening species such as Lakela's mint (*Dicerandra immaculata* var. *immaculata*). This suggests that maybe the vegetation observed at the known site has changed with disturbance (farming) or perhaps the scrubby areas with yellow sand close to the surface that have been cleared in the past (such as the relocation site) once had Savanna balm. This is largely based on work with other species of *Dicerandra*, however, based on success of relocation of Lakela's mint at Hobe Sound it is a likely hypothesis (Menges 1992, Race 1994).

An alternate hypothesis could be that it was a plant of areas down slope from the scrub, nearer to the Indian River Lagoon (outside The Savannas Preserve State Park). This would include areas with yellow sand close to the surface associated with openings in the upper edge of the tropical hardwood and xeric hammock where these habitats transition to scrub, similar to the site of the known plants. However, this is precisely the zone where the most development has occurred along the ridge. Either hypothesis (or even both) at this point may be valid. Regardless of hypotheses of preferred habitat of this plant, it is undoubtedly an evolutionary result of the unique geomorphology and location of this Atlantic dune ridge which probably was significantly isolated periodically from the mainland during interglacial times.

Table 3-2: Associated taxa observed at the known population of Savanna balm

Scientific Name	Status	EPPC	Comments
<i>Abrus precatorius</i>	Exotic	I	common
<i>Carya floridana</i>			some mature individuals
<i>Catbaranthus roseus</i>	Exotic		scattered, especially on edges
<i>Chiococca alba</i>			few
<i>Cocoloba uvifera</i>			scattered
<i>Eugenia uniflora</i>	Exotic	I	abundant in understory
<i>Harrisia fragrans</i>	Endangered		present
<i>Kalanchoe pinnata</i>	Exotic	II	abundant in openings
<i>Mangifera indica</i>	Exotic		remnants from cultivation
<i>Panicum maximum</i>	Exotic	II	scattered dense patches
<i>Persea borbonia</i>			scattered
<i>Pisonia aculeata</i>			scattered
<i>Quercus geminata</i>			only at the harvest plants location west of the FEC easement
<i>Quercus myrtifolia</i>			few
<i>Quercus virginiana</i>			some large individuals
<i>Sabal palmetto</i>			common, mature individuals
<i>Serenoa repens</i>			few scattered
<i>Schinus terebinthifolius</i>	Exotic	I	Scattered; not found in dense <i>Schinus</i>
<i>Simarouba glauca</i>			scattered
<i>Solidago odora</i> var. <i>chapmanii</i>			abundant
<i>Zanthoxylum clava-berculis</i>			Scattered, mostly small

Biologist Greg Kaufmann is considering additional relocation sites within SPSP (personal communication). One promising location is just west of the known population on the western slope of the ridge on the other side of the FIND tract near the park manager's residence. This is an excellent suggestion based on its close proximity to known plants and Greg's observations of yellow sand. It may also be worth while to find a willing landowner down slope towards the Indian River from the Savannas Preserve State Park to attempt relocation. One possibility may be the FPL power line easement across the lagoon from the power plant. Locations outside of SPSP, of course, should be considered secondary if they are not under conservation status.

Soils

Soil types at and around the known plants and parcels surveyed were determined using the NRCS Soil Survey of St. Lucie County Area (Watts and Stankey 1977). The dominant soil type along the Indian River side of the ridge including the location of the known population of Savanna balm is mapped as Welaka variant sand, 0-5 percent slopes. The description of this soil type includes yellow sand averaging approximately 18 inches below the surface,

however, at the known location yellow sand was observed at or just below the surface. These soils, however, may have been significantly disturbed due to historical farming activities. These areas with yellow sand at or close to the surface were consistently found along the ridge to the north of the known population in areas mapped as Welaka Variant sand, 0-5 percent slopes. The dominant mapped soil type higher on the ridge and inland from the known population was St. Lucie sand, 0-8 percent slopes, which is characterized by grey sand underlain by white sand, which is generally consistent with observations west (higher on the ridge) of the known population.

While surveying private parcels for new populations of Savanna balm, if yellow sand was observed at or near the surface resembling the soils at the known locations of Savanna balm, it was recorded in the field notes, except during some of the earlier surveys (Appendix 3-2). Yellow sands were observed on many of the parcels, however they were typically on the eastern half of the parcel which has predominantly been developed leaving the higher white-sand scrub undeveloped. Most notable exceptions of this are a few parcels just to the south of and including the FPL power line easements (across the lagoon from the power plant) where yellow sand covered large areas of parcels though most was previously cleared for agriculture and no plants were found. Yellow sand on the FPL parcels was only observed in disturbed portions but was close to the surface throughout the intact tropical hardwood hammock grading into xeric hammock and eventually scrub on the western portion of the parcels. These areas might be considered for potential relocation sites if exotic control is conducted. Historic (1940's) and current aerial photographs suggest most of these areas were not significantly disturbed.

Because yellow sand was not at the surface in undisturbed areas at the FPL easement parcels yet it was found at the surface in adjacent farmed areas and ruderal areas on site, this suggests that many areas naturally did not have yellow sand at the surface. This is consistent with the description of the Welaka variant sand, 0-5 percent slopes (Watts and Stankey 1977). Perhaps even at the known Eden Creek location yellow sand was not found at the surface before the area was cleared for farming, however because it was so close to the surface, mixing of the upper horizon (formation of an Ap horizon) created the currently observed yellow sands at the surface.

The relocation site chosen by Greg Kaufmann also had yellow sand at or near the surface, which is one of the main reasons he made this choice. The mapped soil type at this location is St. Lucie sand, 0-8 percent slopes, however it may represent an inclusion of Welaka variant per the observations of yellow sand. Current conditions at the site are much more open with sand pine (*Pinus clausa*) and do not resemble the known location vegetatively, however the site had been completely cleared prior to the 1940's aerial photography so it is difficult to tell what vegetation types were present prior to that time. Unfortunately, no areas east of the railroad which more closely resemble the less droughty vegetation of the known locations of Savanna balm (admittedly these areas have been disturbed and invaded by exotics) are under official conservation status.

Greg is also considering a potential relocation site just to the west of the known location at the southernmost portion of SPSP near the park manager's residence, as previously mentioned. This area is down slope from the higher scrub habitats only on the west half of

the ridge. He has observed yellow sand at or near the surface here and will be surveying the area for Savanna balm. This may be the best location for an additional relocation site.

In order to better understand site conditions of Savanna balm, soil pH was recorded at clusters of plants in the known (Figure 3-2). At three clusters within the parcels 4509-807-0014-000-2 and 4509-807-0015-000-9 off Eden Creek lane the pH was measured yielding 7.0 at the FPL box, 7.0 to the interior of the same parcel, and 6.5 in the interior of the adjacent parcel at the cluster by the large gopher tortoise burrow. Soil was also tested at the two flagged locations on the west side of the railroad easement where all plants were removed by Peterson. The pH at the site on the actual FEC property was 7.0, while the flagged location just to the south west, near the change from hammock vegetation to more scrub species was between 6.0 and 6.5. Soil pH was also taken at the relocation site and was found to be 6.5 which is within the range of observations made at the known locations. Interestingly, soil pH taken around dense clusters of prickly apple cactus also fell within this range.

Three locations nearby the known population (west and northwest approximately 20-60 meters of the harvested location along the FEC right of way) with no Savanna balm but with white sand and more scrub vegetation the pH was 5.0, 5.0, and 5.5. The vegetation at these locations consisted of primarily sand live oak (*Quercus geminata*), some myrtle oak (*Q. myrtifolia*), scrub hickory (*Carya floridana*), as well as some mint (*Conradina grandifolia*). This differs greatly from the more mesic and tropical hammock transition to scrub vegetation observed at the known locations.

It is unknown at this time if acidity at these levels, or the potentially more nutrient poor conditions a lower pH may indicate, precludes establishment of Savanna balm. In fact, other species of *Dicerandra* are known to inhabit acid to strongly acid soils (Menges 1992). The soils here were no doubt affected by past pineapple and subsequent farming, however it is unknown how much effect the use of fertilizers had on the soil properties (including pH) at this location (Watts and Stankey 1977).

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**Summary for IRC on work done by Historic Bok Sanctuary on
Savannahs Mint (*Dicerandra immaculata* var. *savannarum*)**

April 02, 2007

Cheryl L. Peterson, Conservation Program Manager

Conservation objectives being pursued by Historic Bok Sanctuary (HBS) for this subspecies are 1). to rescue all existing individuals and/or germplasm, 2). to create a protected population on conservation lands in collaboration with Savannahs Preserve State Park (SPSP) 3). to do germination, propagation and chemical comparisons with Lakela's Mint.

Rescue of existing germplasm of Savannahs Mint

There are only two known natural locations of this subspecies, located roughly a half a mile apart. One site is located within the brush and tree line along the Florida East Coast Railway (FECR). The second site is located across the tracks along an approximately 30 foot long area by a residential road (Eden Creek Lane) within The Oaks subdivision spanning three private properties.

In early 2005 the Conservation Program surveyed land along the railroad along with Florida East Coast Railway personnel and located eight adult plants. The plants were threatened with discarded debris and overgrowth. All eight plants were transplanted into pots and brought back to HBS' greenhouse facilities. Clonal propagation through cuttings was initiated on all eight parent plants. Subsequent surveys at this site by SPSP biologists have revealed no additional plants.

Permitting began in 2005 to rescue individuals and collect seed and cuttings from the Eden Creek Lane site from the three landowners of the occurrence site. Permission was granted by two of the three landowners, and numbering, flagging and cutting collection has proceeded from their lots.

A total of fifty-three plants were located and tagged within those two properties at the Eden Creek site. Twelve plants were located within the southernmost property; these plants were successfully transplanted into pots and reside within HBS facilities. The southernmost property was cleared in late 2006, and all individuals were successfully rescued from the site prior to land clearing.

The second property for which we have permission to access the plants is the northernmost property. All plants located within that property boundary have not been transplanted and rescued, but have been used *in situ* as a source of cuttings for clonal propagation. The third landowner, who owns the land sandwiched between the other two sites, has to date not responded to collection requests, so the plants which reside on that property cannot yet be clonally propagated, counted or rescued. Contact with that landowner will be pursued throughout 2007.

By April 2006, propagation had occurred for all of the FECR individuals, and eleven of the Eden Creek individuals. As of this writing (April 2007), propagation from cuttings is underway for all remaining individuals within the two Eden Creek permitted properties (Table 1).

Clones from all individuals are being used both for the creation of an introduced population within protected lands at Savannas Preserve State Park, and to become part of the National Collection of endangered plants which HBS maintains as part of the Center for Plant Conservation (CPC).

Creation of a protected population on conserved lands

Propagation from cuttings was done according to methods most successful for Lakela's Mint (see Final Report #009707). Approximately 700 cuttings were taken in late January to early March, 2006, and because the subspecies proved to be a very fast grower, 89 plants were ready to be transplanted in June. On June 22, 2006 the first experimental introduction was performed at SPSP, headed up by State Park biologist Greg Kaufmann. Although final plantings may encompass several locations within State Park boundaries, all individuals were planted within one chosen area of scrub habitat which appeared the most suitable for the species and which is out of sight and reach of State Park visitors. Within that planting site, several microhabitats were chosen for plantings in order to accommodate data collection on survivorship of the subspecies. The variables of the microhabitats included leaf litter/no leaf litter and full sun/partial sun with two replicates of each set. Planting was performed by both HBS and SPSP staff and volunteers, and watering was done every two days for a month, then as needed, by SPSP staff (see Final Report #011298).

In September and November of 2006 and again in February 2007 additional plants were transplanted into the site, for a total of 615 plants (Table 2). Propagation is continuing in order to generate clones from all wild individuals which are not represented within the SPSP introduced population, and planting of these clones will be coordinated with SPSP biologists throughout 2007 as plants become ready for transplanting.

In addition to clones, seedlings resulting from germination trials on seed collected from both FECR and Eden Creek were used for the population introduction. A database was created of all individuals to track cutting/sowing date, planting date and location, parent i.d. and survivorship.

Comparisons with Lakela's Mint

Propagation and germination work on Savannahs Mint has made it obvious that this subspecies is very robust in comparison to Lakela's Mint. Rooting of cuttings occurs within 2-6 weeks, compared with up to three months for Lakela's Mint. Approximately 50% of cuttings take root with Lakela's Mint, while 90% of Savannahs Mint cuttings successfully root. Growth is also much faster and the plants recover from stress events more readily. The calyx of Savannahs Mint appears slightly larger, though both Lakela's Mint and Savannahs Mint appear to have an average of 4 seed per calyx.

During mid-flowering season (October 2006) flowers were harvested from clones and parents of both populations, pooled and sent to Delaware State University for Gas Chromatography-Mass Spectrometry (GC-MS) analysis to determine the essential oil profile of Savannahs Mint. The collection and analysis methods were identical to that performed for Lakela's Mint flowers in October 2005. All samples were processed and analyzed by GC-MS at Delaware State University. The analysis of the flower samples of the subspecies, Savannahs Mint, revealed that this subspecies appears to be somewhat chemically distinct from Lakela's Mint. The analysis indicated three compounds present

in Savannahs Mint that were not identified in Lakela's Mint, and the relative abundances of the compounds shared by the species and subspecies differ also (Table 3).

Of the three unique compounds, one was identified as beta-caryophyllene; there was also a compound which the GC-MS identified as beta-caryophyllene which was shared by all three flower samples. It is probable that the compound which is unique to Savannahs Mint which was identified as beta-caryophyllene also, is a different compound and not in the GC-MS library for accurate identification. Therefore, the actual identification of this compound remains unknown.

The other two compounds unique to Savannahs Mint in comparison to Lakela's Mint are 1,8-cineole and (Z)-beta-ocimene. 1,8-cineole, also called eucalyptol, is found in camphor-scented leaves such as eucalyptus, some culinary herbs, and is known to have allelopathic properties (www.ars.usda). (Z)-beta-ocimene is an acyclic monoterpene also common to aromatic plant species. Interestingly, both compounds are monoterpenes that have previously been identified in the related rare mint genus *Conradina* (Peterson 1989).

Summary

All rescued plants that have been transplanted into potted conditions and brought in the greenhouse are thriving. Either the original or clones of all existing individuals are currently being brought into the National Collection, both as living material in a collection bed and as stored seed. All rescued and transplanted FECR and Eden Creek parents are healthy and part of the National Collection. No additional parents will be transplanted from their current natural location until the threat of development is imminent. Clones of all remaining Eden Creek parents are currently under propagation for inclusion into the National Collection. Ongoing work will include continued propagation for population introductions onto State Park lands, continued rescue of all germplasm existing in the subspecies, and ongoing germination and propagation work to further understand basic biology.

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www.ars.usda

Table 1. Parentage and number of clonally propagated individuals which have been planted onto SPSP, and that are currently being clonally propagated from cuttings.

source	parent	# clones outplanted	clones in propagation
FECR	1	105	no
FECR	2	9	no
FECR	3	36	no
FECR	4	13	no
FECR	5	17	no
FECR	6	42	no
FECR	7	36	no
FECR	85	3	no
FECR	seedling	130	n/a
FECR	unknown	81	n/a
Eden Creek	126	2	yes
Eden Creek	127	23	no
Eden Creek	128	18	no
Eden Creek	129	20	no
Eden Creek	132	0	yes
Eden Creek	133	0	yes
Eden Creek	134	0	yes
Eden Creek	135	0	yes
Eden Creek	136	0	yes
Eden Creek	137	1	yes
Eden Creek	138	0	yes
Eden Creek	139	0	yes
Eden Creek	140	1	yes
Eden Creek	141	3	yes
Eden Creek	142	0	yes
Eden Creek	143	2	yes
Eden Creek	144	3	yes
Eden Creek	145	0	yes
Eden Creek	146	0	yes
Eden Creek	147	0	yes
Eden Creek	148	1	yes
Eden Creek	149	4	yes
Eden Creek	150	0	yes
Eden Creek	151	0	yes
Eden Creek	152	0	yes
Eden Creek	153	0	yes
Eden Creek	154	0	yes
Eden Creek	155	0	yes
Eden Creek	156	0	yes
Eden Creek	157	0	yes
Eden Creek	158	0	yes

Eden Creek	159	0	yes
Eden Creek	160	0	yes
Eden Creek	161	0	yes
Eden Creek	162	0	yes
Eden Creek	163	0	yes
Eden Creek	164	0	yes
Eden Creek	165	0	yes
Eden Creek	166	0	yes
Eden Creek	167	0	yes
Eden Creek	168	0	yes
Eden Creek	169	0	yes
Eden Creek	170	0	yes
Eden Creek	171	0	yes
Eden Creek	seedling	65	n/a
Eden Creek	554	0	yes
Eden Creek	555	0	yes
Eden Creek	556	0	yes
Eden Creek	557	0	yes
Eden Creek	558	0	yes
Eden Creek	559	0	yes
Eden Creek	560	0	yes
Eden Creek	561	0	yes
Eden Creek	562	0	yes
Eden Creek	563	0	yes
Eden Creek	564	0	yes

<u>date</u>	<u># plants</u>
June 22 2006	89
Sept 27 2006	280
Nov 10 2006	116
Feb 02 2007	130

Table 2. Planting events of *D. immaculata* var. *savannarum* onto protected lands at Savannas Preserve State Park. 615 individuals have been planted to date.

compound	Lakela's Mint (HF)	Lakela's Mint (HBOI)	Savannahs Mint
alpha-pinene	0.97	0.77	1.06
beta-pinene	0.95	0.69	1.05
sabinene	0.54	0.37	0.66
limonene	1.04	0.70	1.53
1,8-cineole	-	-	0.22
(Z)-beta-ocimene	-	-	0.05
1-octen-3-yl acetate	0.64	0.62	0.09
1-octen-3-ol	3.38	3.30	1.76
menthone	1.32	0.76	0.12
isomenthone	26.44	21.74	6.20
<i>cis</i> -isopulegone	0.49	0.45	0.69
<i>trans</i> -isopulegone	0.62	0.66	0.89
beta-caryophyllene	-	-	1.04
beta-caryophyllene	1.12	2.47	1.12
pulegone	60.89	65.63	83.45
piperitenone	1.60	1.85	0.32

Table 3. Comparison of essential oil compounds between Lakela's Mint and Savannahs Mint. Numbers are % area of peak within the chromatographs. Compounds are listed in order of retention time off the CG-MS column.

Appendix 3-2: Summary of Field Notes for Parcels Surveyed for Savanna balm

PARCELID	Acres	Date	Surveyor	Comments/Habitat Description	Diceimmasa	Harrfrag	Paola Sand	Yellow sand
3401-423-0001-000-6	4.0	3/23/2007	MJB	Cleared by house, disturbed beyond house	0	1	Mostly cleared, some left	By house
				<i>Habitat:</i> Some yellow sand by house; Lots of Kalapinn by house. Beyond (to west) house: Caryflor, Persborb, Kalapinn, grading to Quergemi to the west.		Large (height=7'), 3 stems, 1 Fruit		
3401-604-0002-000-8	1.3	3/23/2007	MJB	Cleared by house	0	2	Not all cleared	No
				<i>Habitat:</i> No yellow sand; Behind (to west) house: Caryflor, Persborb grading to Quergemi, Quermyrt further west; Lots of Exotics- Casuequi, Kalapinn, Sanshyac, Aspadens, Schitere, Psidcatt		Single stemmed individuals, healthy, no fruits		
3401-701-0002-000-6	1.6	3/23/2007	MJB	Permission granted by adjacent landowner (father) on 3/23/2007 in person.	0	2	Mostly cleared, some left	Not in non-cleared/landscaped area
				<i>Habitat:</i> Front yard and around house with a few remnant tropical hardwoods including large Burssima, but mostly disturbed; Beyond house to west Quervirg, Persborb, Caryflor, Kalapinn, Nephcord, Schitere, Eugeunif (abundant);		both were single stemmed individuals approx. 1 meter		
3401-701-0003-000-3	9.3	3/23/2007	MJB	Some remnant tropical hardwood hammock species around house.	0	0	Mostly cleared, some left	Not in non-cleared/landscaped area

				<i>Habitat:</i> Front yard/around house w/ abundant remnant tropical hardwoods- large Burssima, Simaglau, Chryoliv, Psycnerv, Quervirg; Beyond house to west Quervirg, Persborb, Caryflor, Kalapinn, Nephcord, Schitere, Eugeunif (abundant); back is pasture				
3412-502-0003-000-6	1.0	3/23/2007	MJB	Missed areas south of fence delimiting adjacent parcel under same owner and could have surveyed (but did not realize); Also surveyed parcel to north with verbal permission granted from property manager (woman) but parcel nearly all cleared.	0	0	Mostly cleared, some left	No
				<i>Habitat:</i> No yellow sand; Cleared around house except remnant tropical hardwoods including large Burssima. Beyond house hammock remnant w/Schitere grades into Caryflor, Persborb, and eventually Quergemi with abundant Pteraquicaud				
3412-502-0011-000-5	2.0	3/23/2007	MJB		0	2	Cleared	
				<i>Habitat:</i> Some yellow sand by house, but all cleared. Beyond (west) house some hammock remnants, abun exotics such as Bromelia ping., Aechmea sp., Kalapinn, Casaequi; Back (west) half of lot good scrub w/ Quergemi, Pinuclau, Caryflor, Conrgran, Arisgyra			Single stemmed	
3507-323-0001-000-4	5.0	4/1/2007	MJB		0	0	Cleared	Cleared, in east half
				<i>Habitat:</i> Yellow sand in lower half, all cleared. Associates on yellow sand (along edge) includes Caryflor, Kalapinn, Zantclav. Beyond cemetery (west) is white sand scrub w/ Caryflor, Quergemi, Nephcord, Conrgran. Western most is Pinuclau, Quergemi				
3507-702-0001-000-7	3.0	3/23/2007	MJB	Said "happy to preserve" native vegetation; Spoke with landowner 3/23/07 AM, surveyed in afternoon around 1500.	0	0	Mostly cleared, some left	

				<i>Habitat:</i> Excellent habitat beyond house. Remnant tropical hardwoods around house and good diverse tropical hammock (except abundant Schitere) beyond (west) of pole barn. Grades (to west) into Caryflor, Quergemi Xeric hammock/scrub w/Conrgran present				
3518-212-0002-050-9	2.2	3/23/2007	MJB	Rained hard during survey; Husband had returned letter w/out telling wife who was there alone, but allowed me to survey after seeing my photocopy of the letter.	0	0	Mostly cleared, some left	None
				<i>Habitat:</i> No yellow sand observed. Cleared around house; Relatively intact tropical hardwood hammock beyond (to west) of house clearing w/heavy Schitere. Grades to Quergemi, Pinuclau scrub w/Conrgran present				
3518-212-0005-000-5 3518-212-0005-000-5 3518-213-0002-000-7 3518-213-0003-000-4 3518-231-0001-000-6	24	5/4/2007	MJB	FPL Easement across lagoon from power plant. Made contact by telephone; Permission granted by email 4/30/2007 from Aaron Neville, forester for FPL. Surveyed all parcels together. Hammock areas intact on 1940's aerial and today.	0	4	Mostly intact	Only at surface in disturbed areas
				<i>Habitat:</i> In-tact Tropical Hardwood Hammock starting at Indian River Drive grading to Xeric Hammock to west of large line poles, and eventually scrub beyond this. Some disturbed areas, but FPL primarily utilized ruderal areas for poles. Made habitat and exotics map from gps data. Area burned entirely in mid 1980's. Other rare plants observed included Agave decipiens (2 patches at northern most known location on east coast) and Acanthocereus tetragonus (5 patches).				

3518-231-0004-000-7	13.0	4/1/2007	MJB	Old farm house; Family in home is decendants of original farmers	0	4	Cleared	On cleared area only
				<i>Habitat:</i> Yellow sand is abundant in cleared area behind and around house. Scat Quervirg and patchy Panimaxi in yellow sand area. Scrub (disturbed) beyond cleared area (west) w/ Quergemi, Pinuclau		One w/3 stems and 1 FR, Another large (many stems) w/ 1 FR, others 2-3 stems healthy no FR		
3518-233-0001-000-2	2.0	4/1/2007	MJB	Jack Shelton - Turning Point Creations- wood turning artist; Owner gave tour of wood-turning shop	0	1	Cleared	On cleared area only
				<i>Habitat:</i> Yellow sand is abundant around house, mostly landscaped, some Cocodive, Exotpani. Disturbed scrub Quergemi, Pinuclau, Sidetena in back (west) w/ white sand.		few stems, no fruit		
3519-444-0001-010-6	1.0	2/10/2007	MJB		0	0	Entire Parcel including scrub habitat	No data
				<i>Habitat:</i> good scrub behind house; overall lot disturbed				
3519-444-0002-000-0	1.0	2/10/2007	MJB	No response from mailing; Verbal OK given to MJB 2/10/07 in field; Jeanne very interested in propagation of Dicerandra- already she cares for Conradina	0	0	Entire Parcel including scrub habitat	No data
				<i>Habitat:</i> good scrub behind house w/paths and garden; lots of Conrgran, dist. Front				

3519-444-0003-000-7	1.0	2/10/2007	MJB	Permission granted by adjacent landowner (good friends) on 2/10/2007 in person. <i>Habitat:</i> mostly cleared	0	0	Entire Parcel, all Cleared	No data
3519-444-0004-000-4	1.0	2/10/2007	MJB	<i>Habitat:</i> mostly cleared	0	0	Entire Parcel, all Cleared	No data
3519-501-0001-020-3	1.0	4/1/2007	MJB		0	0	Cleared	On Cleared area only
				<i>Habitat:</i> Property is relatively high elevation, Yellow sand only in cleared front of house and near road w/Quervirg canopy. Beyond house (west) is Caryflor w/ abundant Sererepe on white sand. Further west is scrub w/ Quergemi, Pinuclus on white sand.				
3519-503-0006-000-8	1.8	5/3/2007	MJB	4 dogs fenced in- must call before survey. Walked w/owner; Conservation minded- built house around hammock remnants- undisturbed up until construction (intact on 1940's) <i>Habitat:</i> Brown sand at surface only at house; Tropical hammock remnants by house left intact, abundant Petialli. Lots of Eugeunif. Sererep/Quergemi beyond house, Pinuclau in far west portion.	0	2	Mostly cleared, some left	On Cleared area only
3519-505-0001-000-9	0.9	4/1/2007	MJB	Walked w/owners. Also they led me onto neighbors' land to show some potential locations based on my descript of preferred habitat to survey. Owners very conservation minded and at least second or third generation residents of the ridge.	0	0	Cleared	On Cleared area only

				<i>Habitat:</i> Some yellow sand by house w/Quervirg, Eugeaxil. Beyond house (west) white sand w/ Quergemi, Caryflor (large ones), scat Quervirg. Down slope to N on adjacent parcel Caryflor, Quervirg, and lots of Kalapinn, Eugeunif (like Eden Creek population).				
3519-505-0002-000-6	1	4/1/2007	MJB	Surveyed with owners of 3519-505-0001-000-9	0	0	Cleared	On Cleared area only
				<i>Habitat:</i> Some brown sand; Near old home site lots of Quervirg, Caryflor, and Kalapinn but disturbed understory				
3529-231-0003-000-4	1.7	2/10/2007	MJB	Should have surveyed more around house but family was out in yard and did not feel comfortable there so spent more time in scrub	0	0	Cleared	No data
				<i>Habitat:</i> remnant tropical hammock (highly disturbed) around house; good scrub behind house w/ large <i>Carya floridana</i> between scrub and hammock				
3532-413-0002-000-5	4.5	8/9/2006	JM, SG		0	0		
3532-802-0012-000-2	0.3	8/9/2006	JM, SG	<i>Habitat:</i> Scrub	0	8	Entire parcel, mostly cleared some left	No data

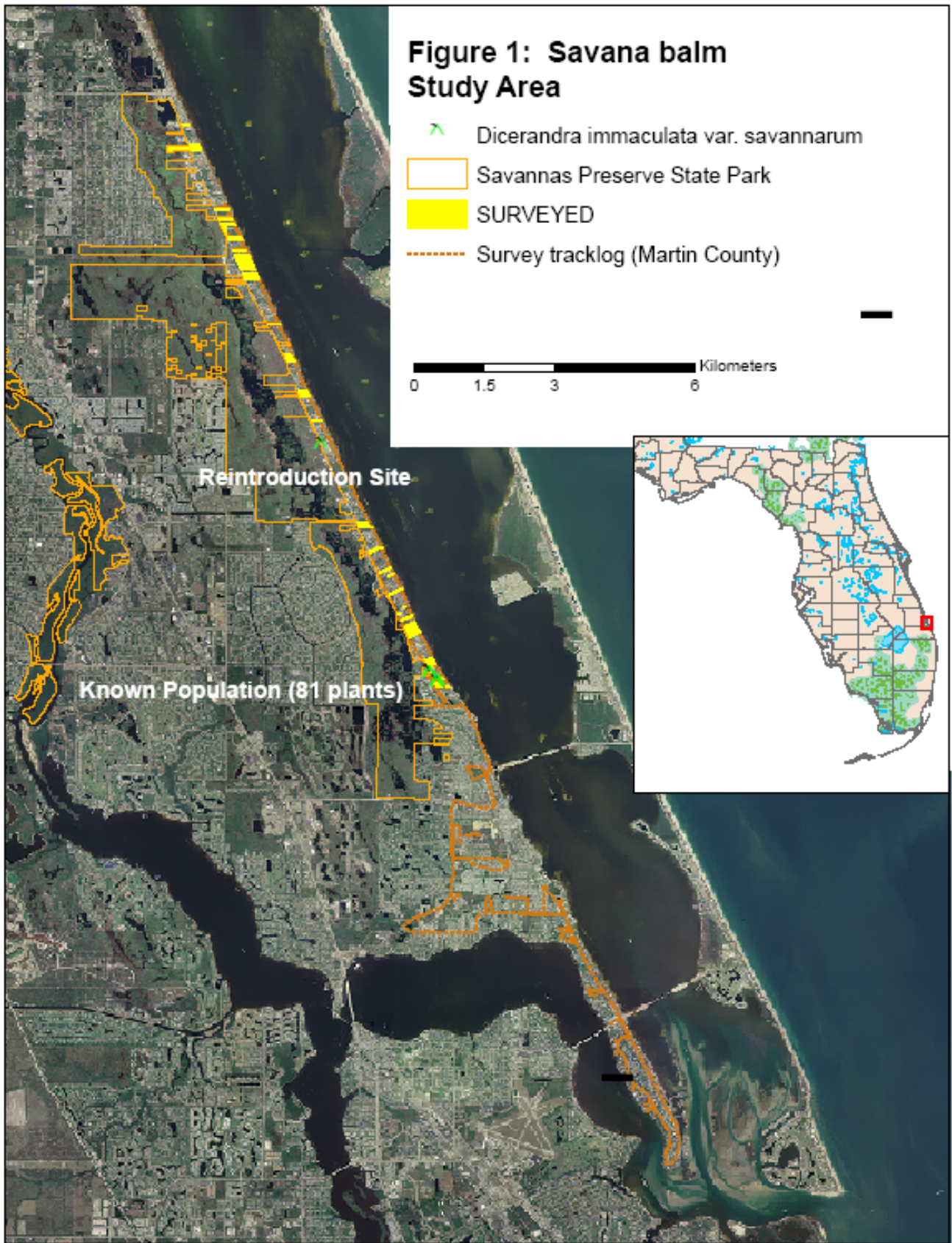
						parcel # "27" in notes- 1 Harrfrag; "26" in notes- 8 Harrfrag; Not sure which parcel has 8		
3532-802-0022-000-5	2.2	8/9/2006	JM, SG	<i>Habitat: Scrub</i>	0	1	Only east portion, not all cleared	No data
						parcel # "27" in notes- 1 Harrfrag; "26" in notes- 8 Harrfrag; Not sure which parcel has 8		
3532-805-0004-000-2	1.7	8/8/2006	JM, SG		0	0	Some not cleared	No data
3532-805-0005-000-9	1.7	8/8/2006	JM, SG		0	0	Some not cleared	No data
3532-805-0006-000-6	1.5	8/8/2006	JM, SG		0	0	None	No data
4504-310-0016-000-6	0.2	8/9/2006	JM, SG	Owner deceased, Marye N. Oswald is widow and current owner.	0	0	Cleared	No data
4504-312-0001-000-4	2.9	8/9/2006	JM, SG	cell phone	0	1	Mostly cleared	No data

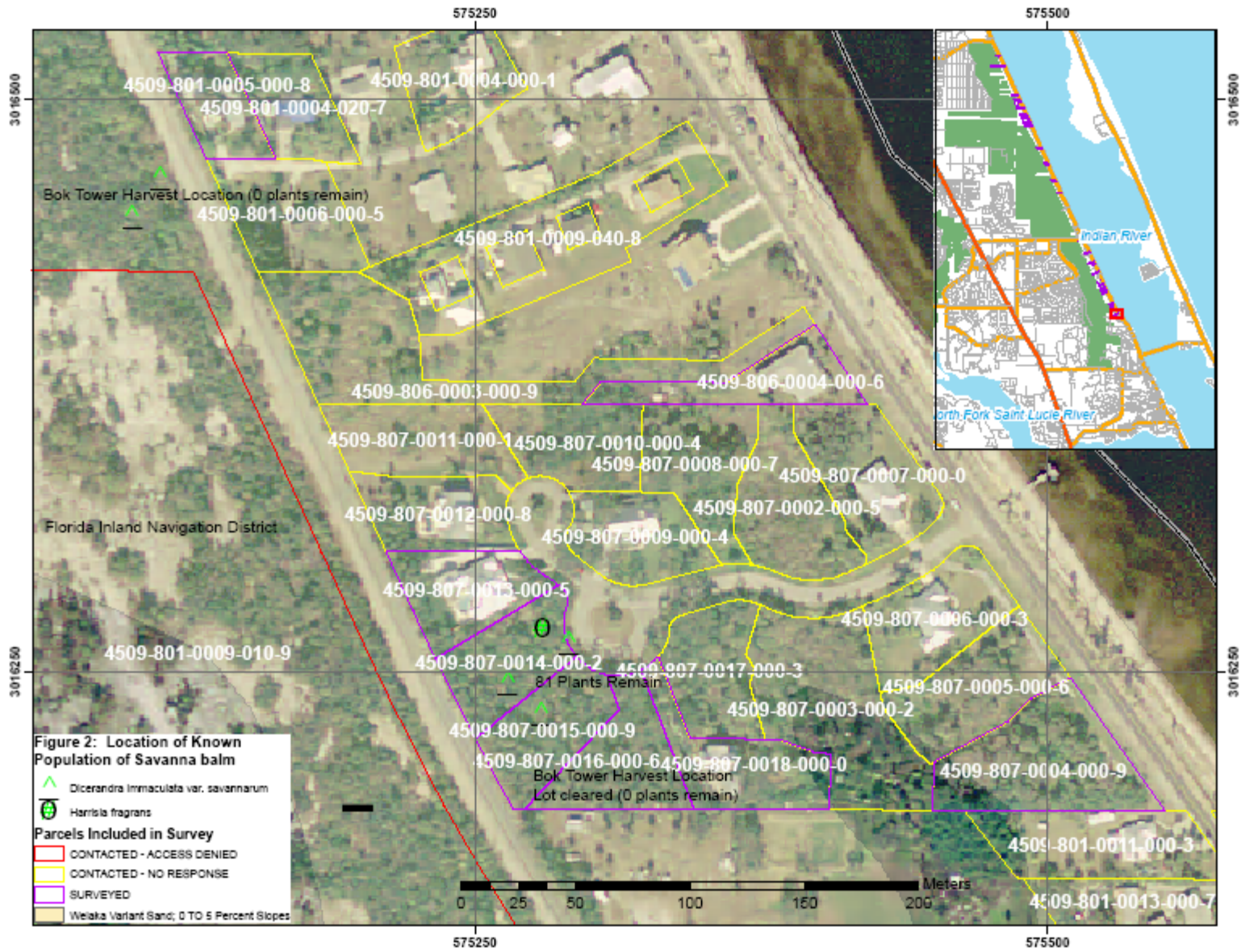
				<i>Habitat:</i> Nice open scrub		1 Harrfrag growing out of construction debris		
4504-340-0004-000-2	2.0	8/8/2006	JM, SG	No phone number / Send picture of plants if found	0	16	Cleared	No data
				<i>Habitat:</i> scrub w/ white sandy clearings		in good condition, w/fruit		
4504-340-0006-000-6	3.0	8/9/2006	JM, SG	No phone number	0	0	Cleared	No data
4504-340-0007-000-3	2.0	8/9/2006	JM, SG	cell- 530-2009	0	0	Cleared	No data
4504-340-0008-000-0	2.0	8/8/2006	JM, SG	William Fish/Co-owner responded. Tenants may be around front of property. Contact owners about details of plant collection.	0	1	Cleared	No data
				<i>Habitat:</i> good habitat- shade w/ sandy open spots		1 immature, 1 adult		
4504-602-0012-000-4	2.0	8/9/2006	JM, SG	No phone number	0	17	On cleared area by house only	No data
				<i>Habitat:</i> Nice open scrub		17 Harrfrag, healthy, mature and seedlings; most in fruit. growing in partial shade		
4504-602-0018-000-6	0.4	8/9/2006	JM, SG		0	0	Cleared	No data

4504-702-0007-000-3	0.5	8/8/2006	JM, SG	Owner insists on accompanying anyone on site. Call first for an appointment. Work (772) 288-3303; Home (772) 229-5134	0	0		
4509-120-0001-000-0	4.5	8/8/2006	JM, SG		0	0		
4509-120-0002-020-3	1.0	8/8/2006	JM, SG	<i>Habitat:</i> small scrub habitat	0	1	Cleared	No data
4509-130-0005-200-1	0.4	8/8/2006	JM, SG	<i>Habitat:</i> soil disturbed, full of exotics	0	0	Entire parcel; disturbed	No data
4509-130-0006-000-6	4.0	8/8/2006	JM, SG	<i>Habitat:</i> soil disturbed, full of exotics	0	0	Entire parcel; disturbed	No data
4509-130-0008-000-0	2.0	8/8/2006	JM, SG	<i>Habitat:</i> soil disturbed, full of exotics	0	0	Entire parcel; disturbed	No data
4509-801-0005-000-8	0.3	8/8/2006	JM, SG	Inform Mr. Hinckley if plants will be collected	0	0	Entire parcel; all cleared	No data
				<i>Habitat:</i> No natural habitat				
4509-806-0004-000-6	0.5	8/8/2006	JM, SG	<i>Habitat:</i> Dense panimaxi, vitirotu; found rattlesnake	0	0		
4509-807-0004-000-9	0.9	3/23/2007	MJB	2/28/2007 spoke with K. Chalupa who gave permission; Called to verify in the morning; Lot cleared since aerial photography	0	0	cleared	present
				<i>Habitat:</i> Lot cleared; Previously appeared to have been mesic hammock w/Quervirg and Sabapalm grading into slough to west; Several dense patches of Lygomir in slough, also dense patch of Hibitili, some Phoerecl				
4509-807-0013-000-5	0.5	8/8/2006	JM, SG	Beware of the dog	0	0	Entire parcel; all cleared	No data
				<i>Habitat:</i> No suitable habitat				
4509-807-0014-000-2	0.5	3/23/2007	MJB	2/28/2007 spoke with Lauren H.; gave permission, husband will call back; also did incomplete survey with John Stegmier on 3/7/2007 (see garmin data)	25	1	Entire parcel, not cleared	present throughout

				<i>Habitat:</i> Former Mango, xeric hammock, exotics abundant;		6 stems, longest 1.5-2 meters, healthy, no fruit, 3 flower buds		
				<i>Associates:</i> Quervirg, Eugeunif (abundant), Kalapinn (abundant), Sabapalm, Sererepe (few), Persborb, Caryflor, Simaglau, Zantclav, Mangindi, Cocouvi, Pisoacul, Chioalba, Panimaxi, Soliodorchap, Abruprec, Quermyrt, Cathrose				
				<i>Population Description:</i> Two patches, 8 plants just beyond panimaxi by road, 17 in back by Gopherus burrow with soil pH=6.5.				
4509-807-0015-000-9	0.5	3/23/2007	MJB	2/28/2007 left message; no response as of 4/5/2007; Property surveyed accidentally while surveying adjacent parcel with garmin. Site not marked in field so impossible to tell parcel boundaries;	48	0	Entire parcel, not cleared	present throughout
				<i>Habitat:</i> Former Mango, Quervirg, Caryflor, Persborb, Eugeunif, tropical hardwoods, exotics abundant				
				<i>Associates:</i> Quervirg, Eugeunif (abundant), Kalapinn (abundant), Sabapalm, Sererepe (few), Persborb, Caryflor, Simaglau, Zantclav, Mangindi, Cocouvi, Pisoacul, Chioalba, Panimaxi, Soliodorchap, Abruprec, Quermyrt, Cathrose				
				<i>Population Description:</i> Includes plants around transformer box along road (26) with soil pH=7.0, just beyond box (10), and one point in interior (12) with soil pH=7.0.				
4509-807-0016-000-6	0.5	8/8/2006	JM, SG	Former location of Savanna balm	0	0	Entire parcel, cleared recently	present throughout

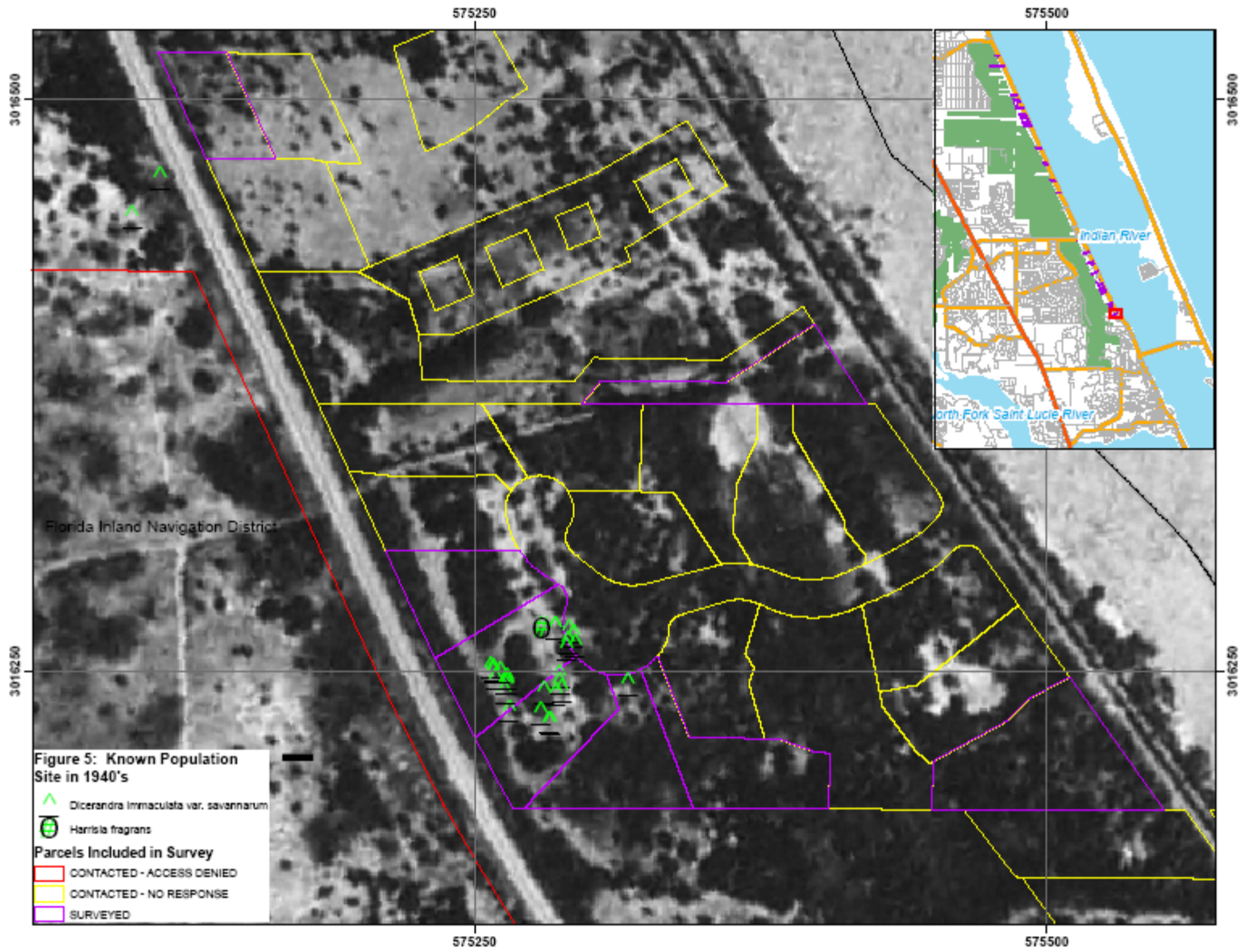
				<i>Habitat:</i> Now cleared, was good habitat; Assumed same as others: Former Mango, Quervirg, Caryflor, Persborb, Eugeunif, tropical hardwoods, exotics abundant				
				<i>Population Description:</i> 11-51 recorded by JM, SG including adjacent lot; Lot subsequently cleared, now 0 (3/2007), Dr. Cheryl Peterson of Bok Tower Gardens rescued 12 plants in late 2006;				
4509-807-0018-000-0	0.6	8/8/2006	JM, SG	No phone number	0	0	Almost Entire parcel, some not cleared	no data
				<i>Habitat:</i> Dense panimaxi, vitirotu				

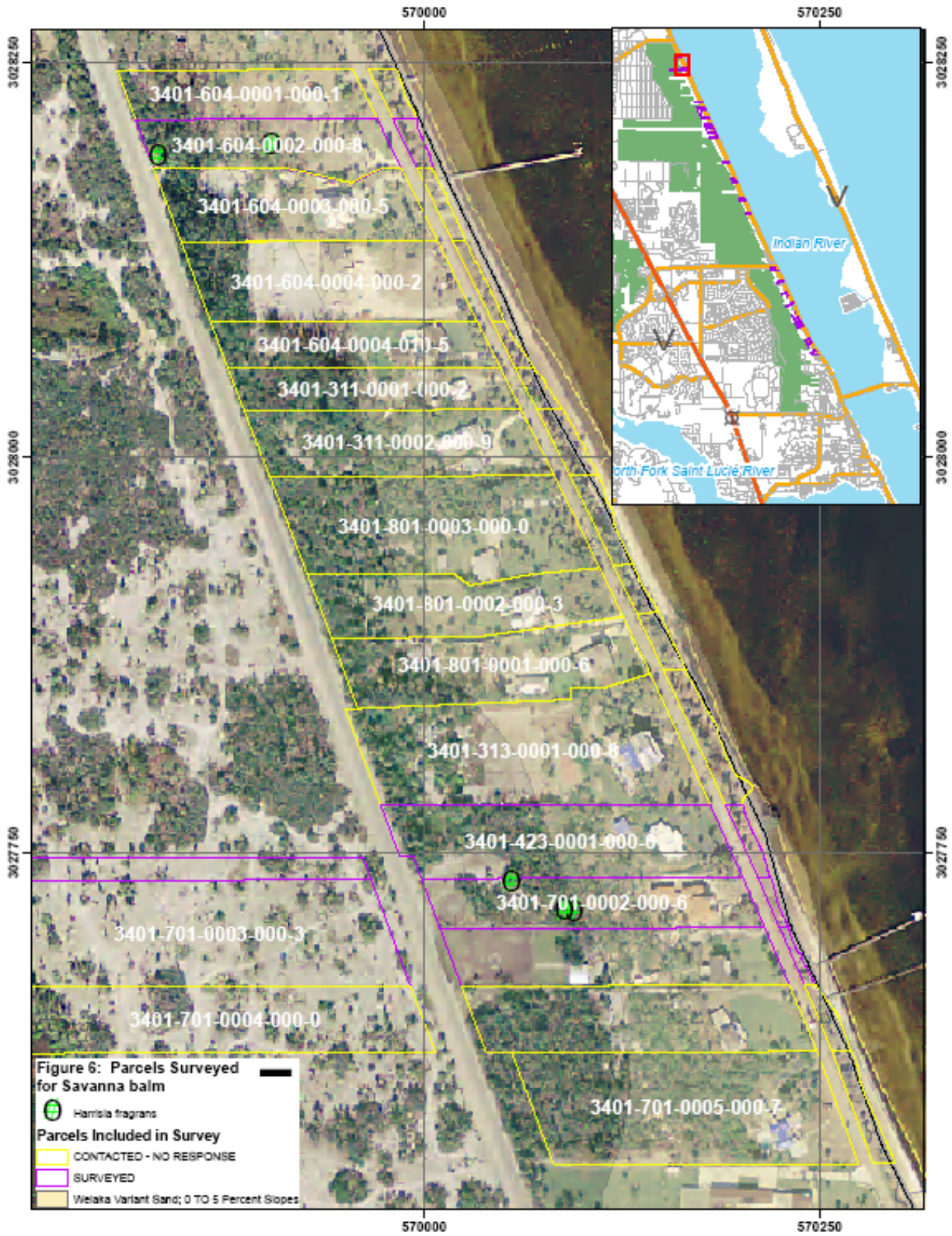


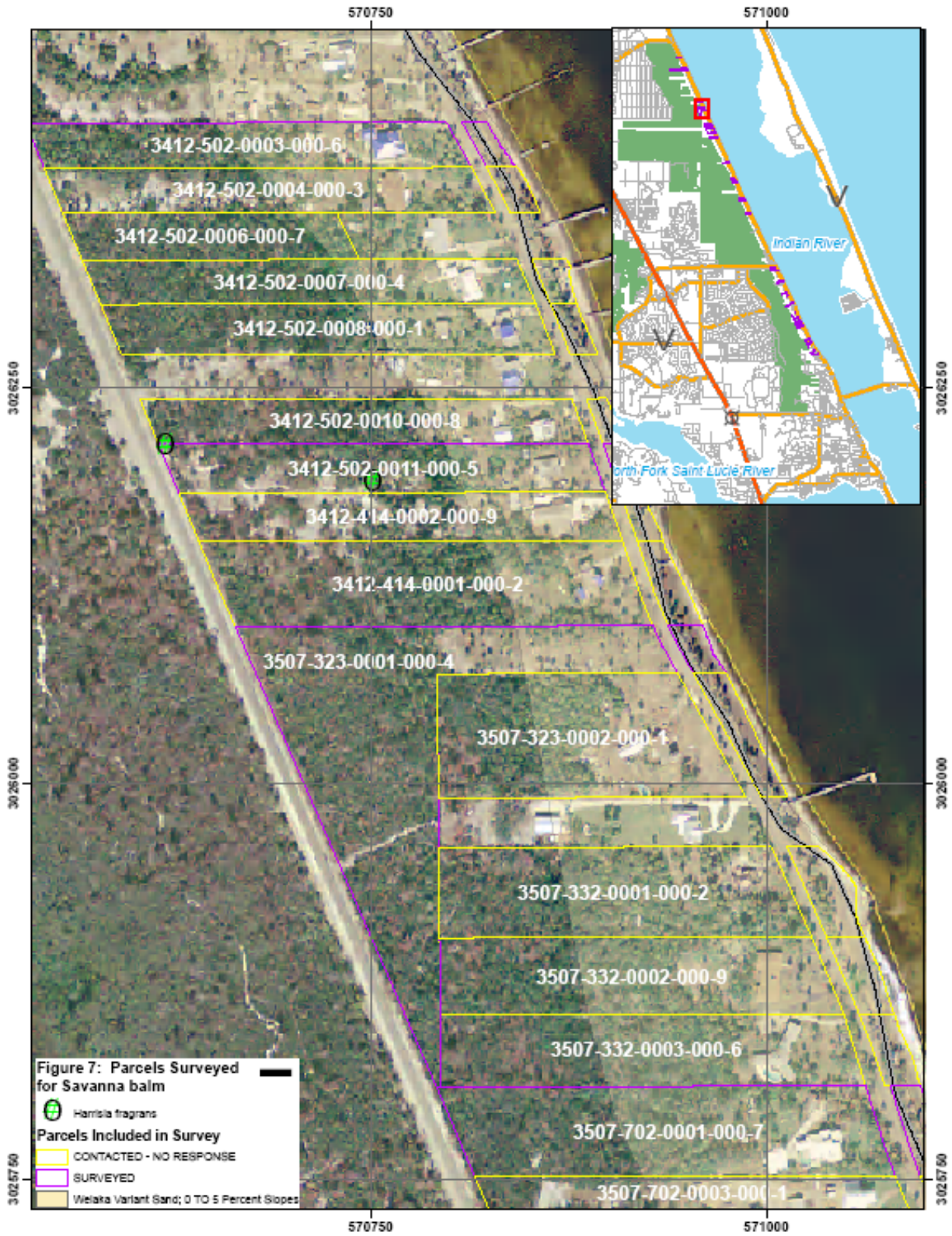


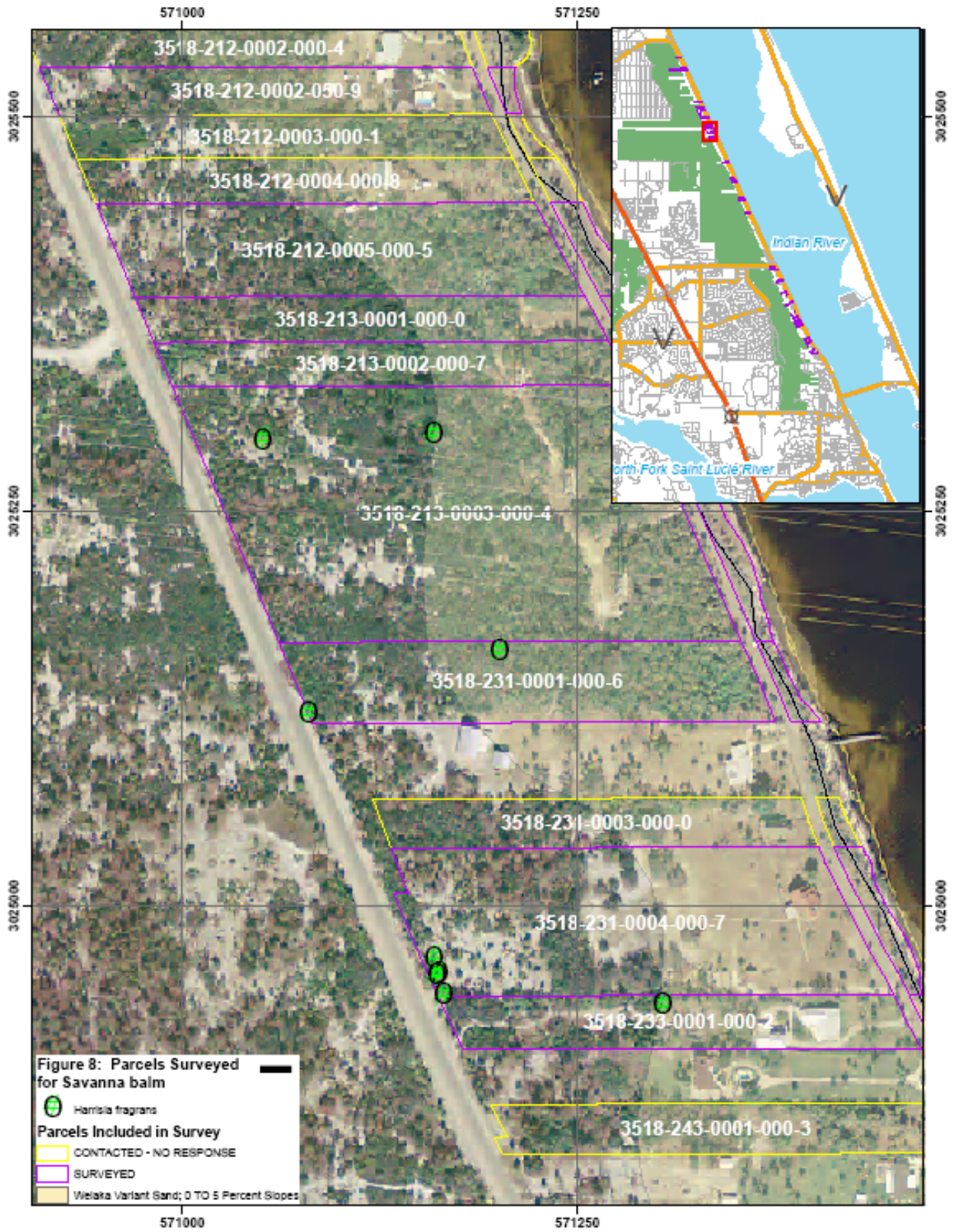


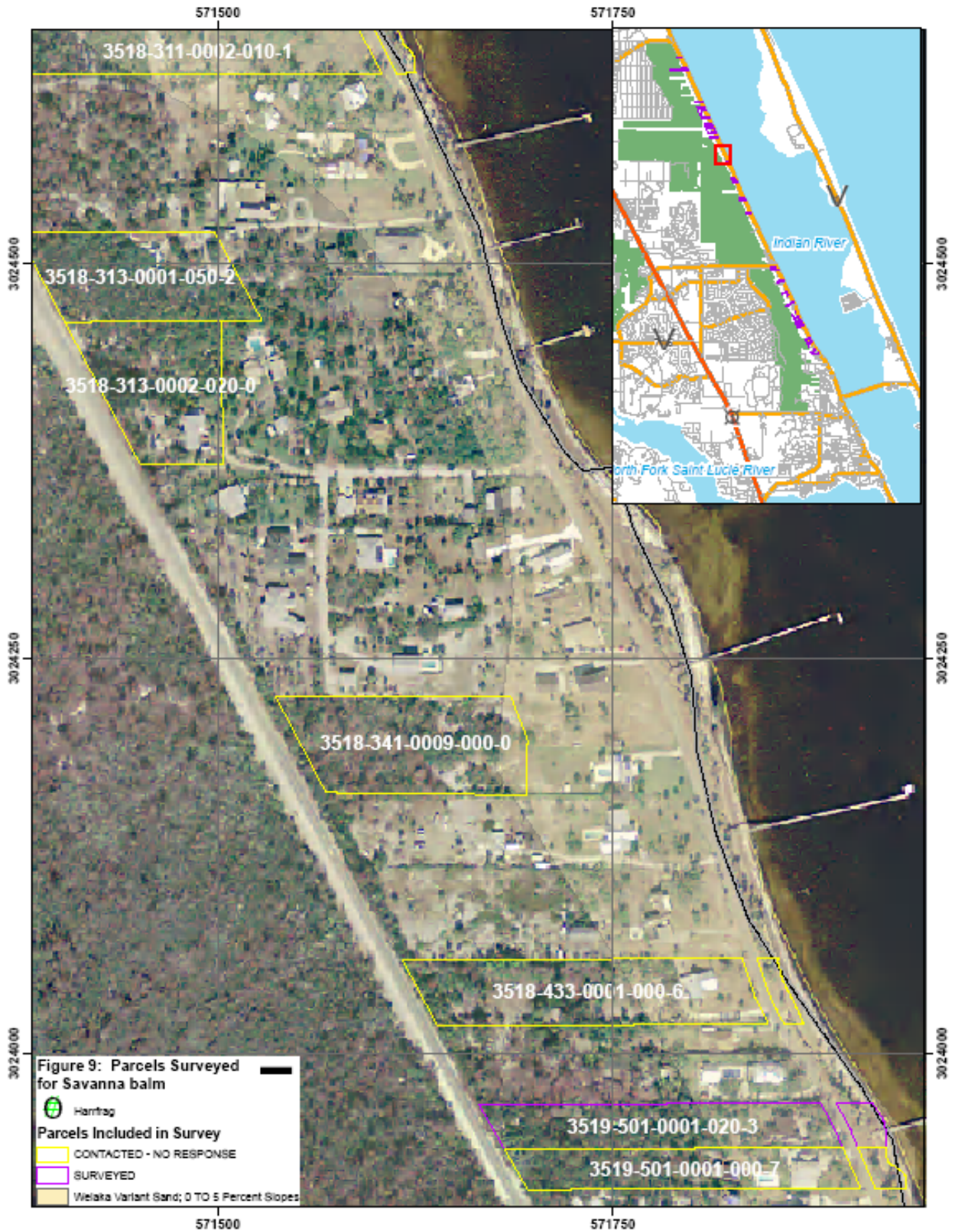


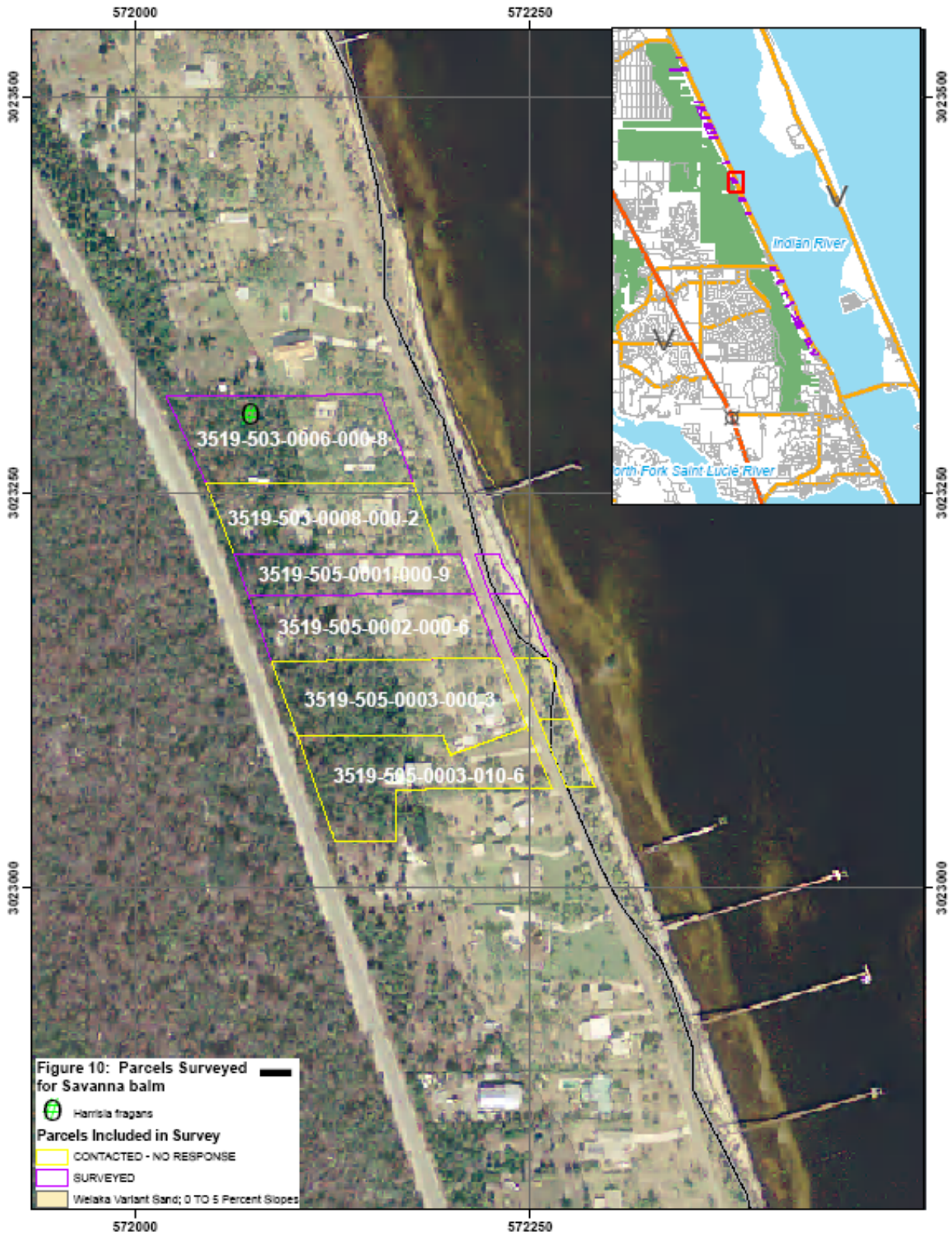


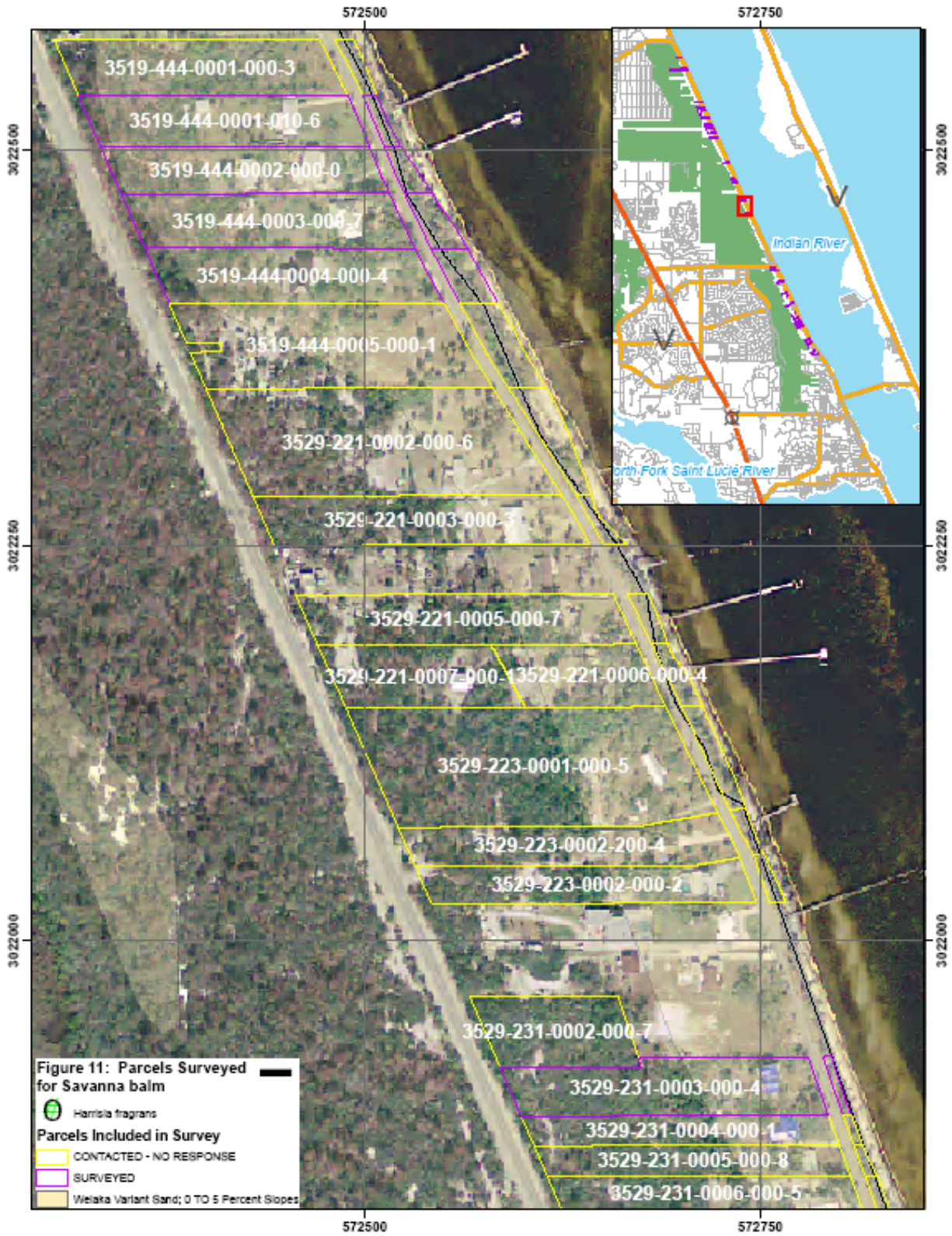


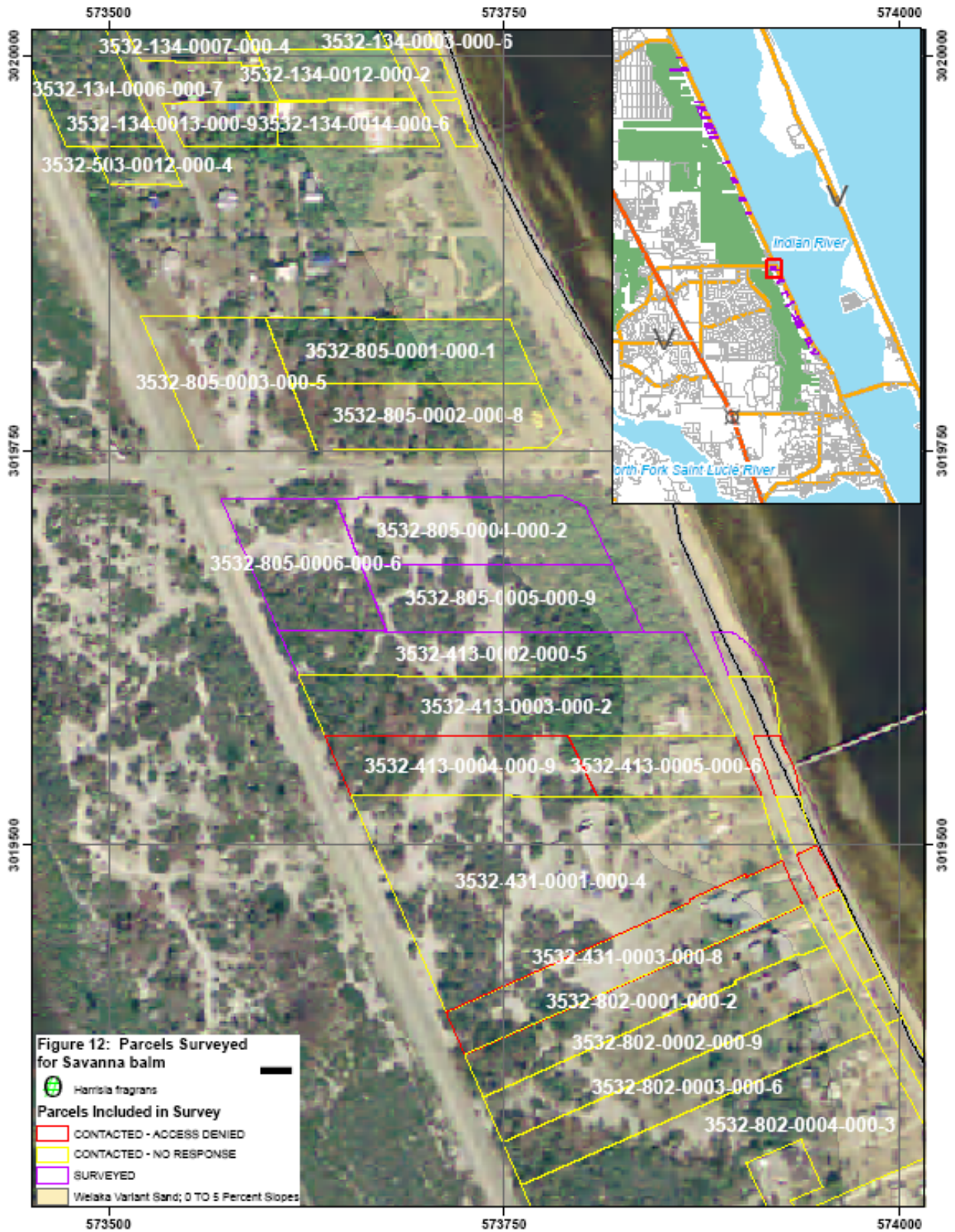


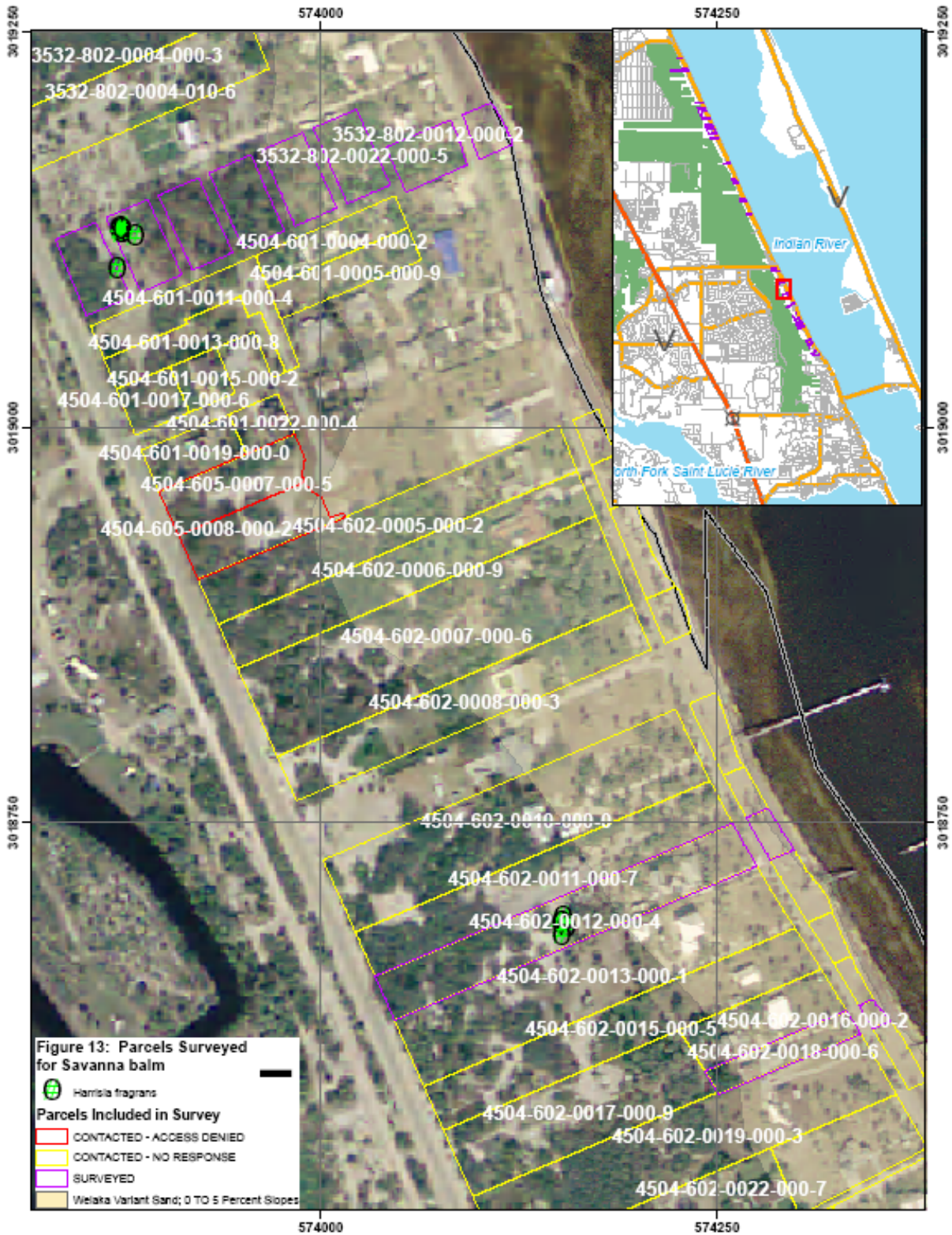




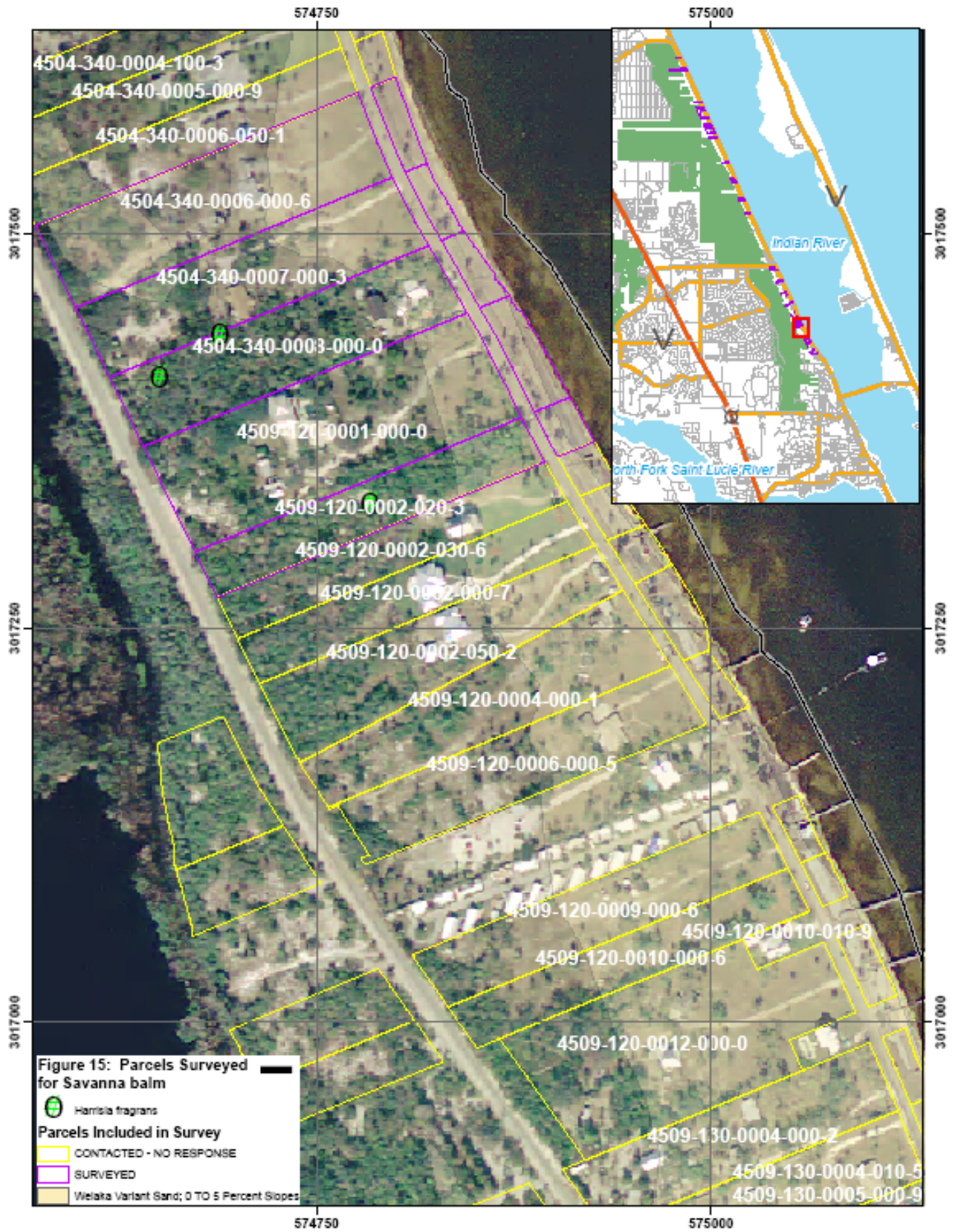


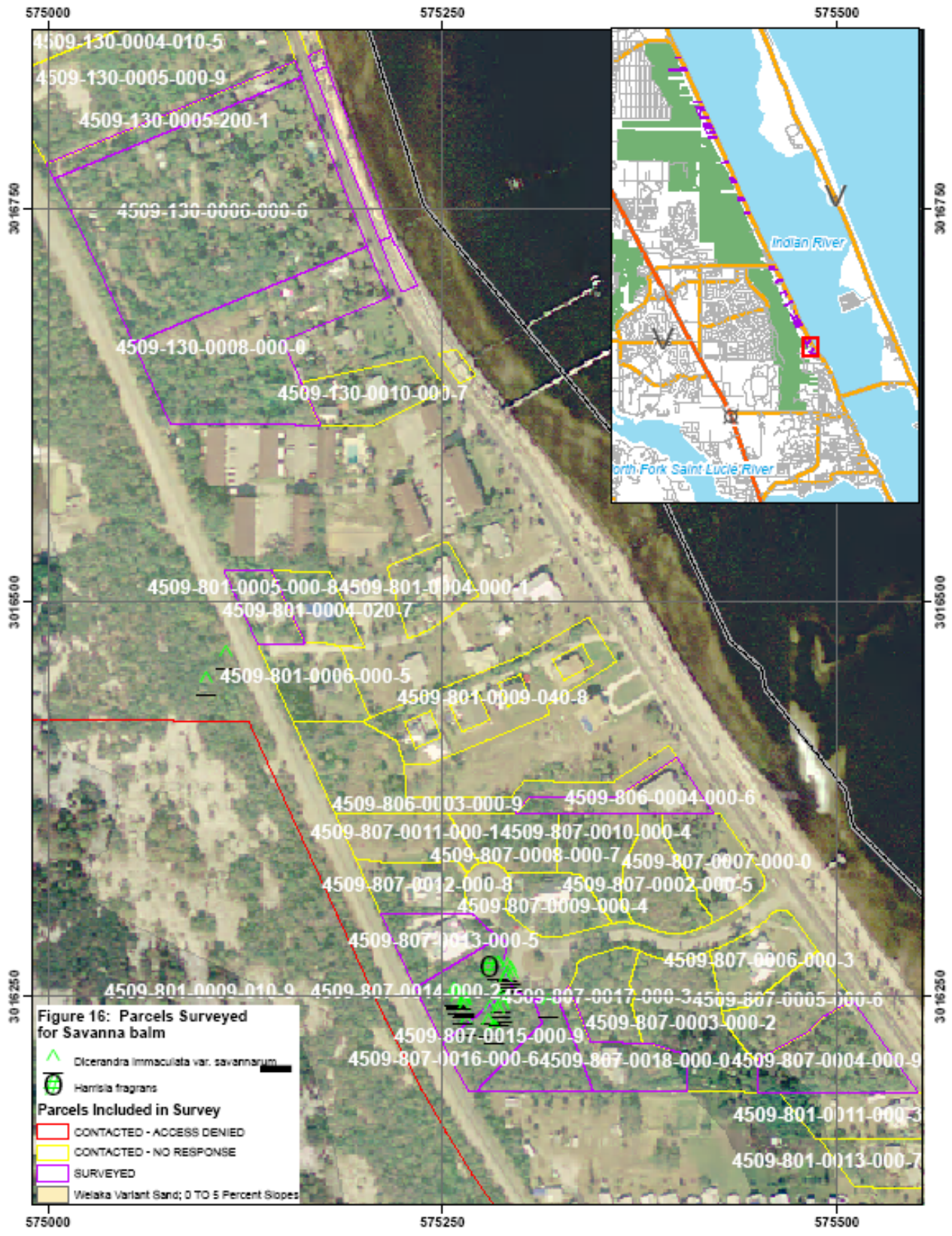












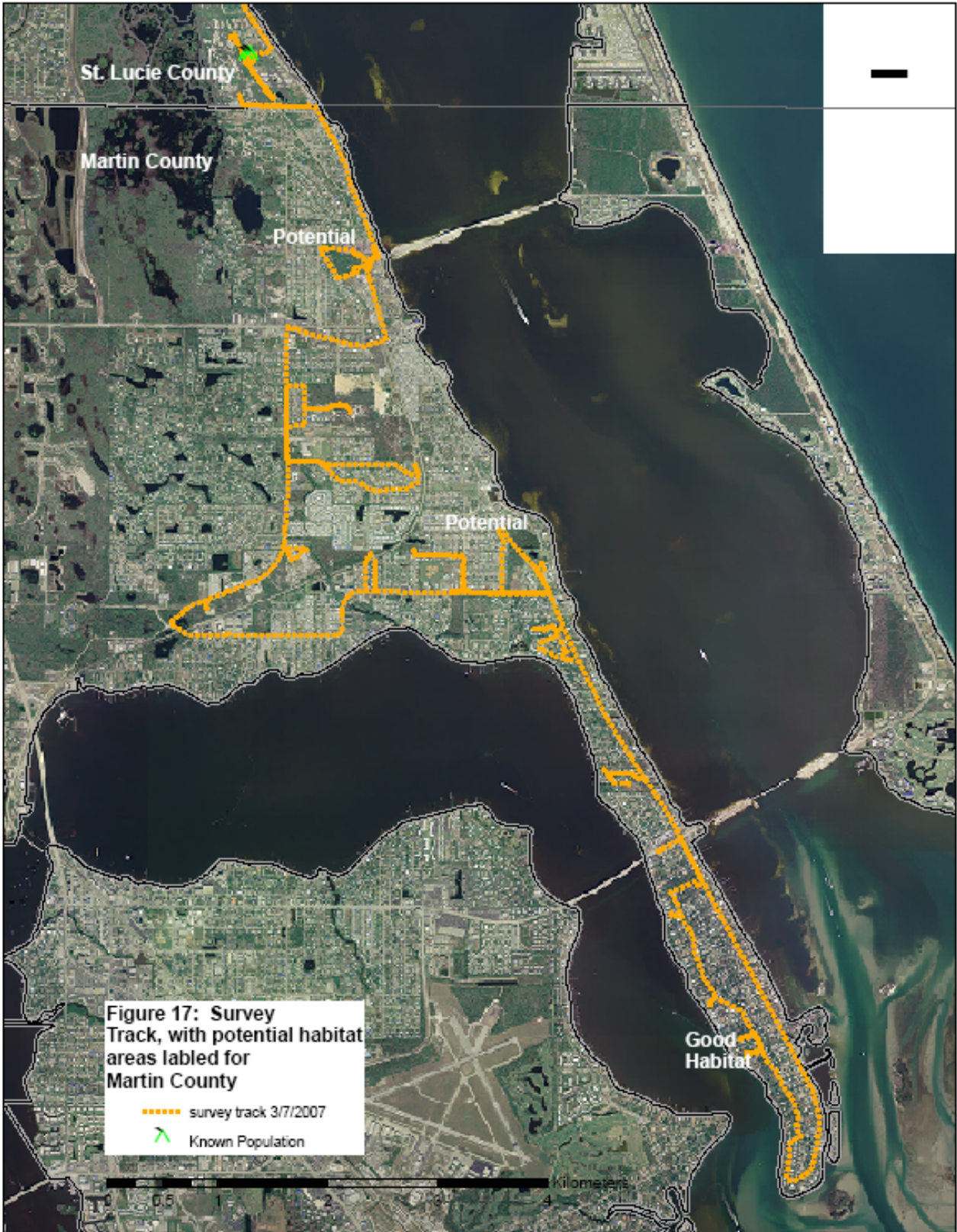


Figure 17: Survey Track, with potential habitat areas labeled for Martin County

- survey track 3/7/2007
- ↗ Known Population

Chapter 4 - Post-hurricane Field Assessment of Aboriginal Pricklyapples
(*Harrisia aboriginum* Small)

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Aboriginal pricklyapples at Boggess Ridge, Charlotte Harbor Preserve State Park, Charlotte County. Steven W. Woodmansee, January 2007.

Table of Contents

Introduction	081
Methods	083
Results and Discussion	085
Final Discussion	115
Acknowledgements	115
Citations	116
Tables:	
Table 4-1: Aboriginal pricklyapples Study Area	087
Table 4-2: Tagged Plants of <i>Harrisia aboriginum</i> at Bocilla Preserve	090
Table 4-3: Tagged Plants of <i>Harrisia aboriginum</i> at Manasota Beach Park	109
Figures:	
Figure 4-1: <i>Harrisia aboriginum</i> Study Area	082
Figure 4-2: <i>Harrisia aboriginum</i> Occurrence Results	086
Figure 4-3: <i>Harrisia aboriginum</i> at Bocilla Preserve	092
Figure 4-4: <i>Harrisia aboriginum</i> at Cayo Costa State Park	094
Figure 4-5: <i>Harrisia aboriginum</i> at Cayo Pelau Preserve	096
Figure 4-6: <i>Harrisia aboriginum</i> at Charlotte Harbor Preserve State Park, Charlotte County	099
Figure 4-7: <i>Harrisia aboriginum</i> at Gasparilla Island South, Mosquito Ditch site, Lee County	102
Figure 4-8: <i>Harrisia aboriginum</i> at Historic Spanish Point, Sarasota County	104
Figure 4-9: <i>Harrisia aboriginum</i> at Water Club Preserve on Longboat Key, Sarasota County	107
Figure 4-10: <i>Harrisia aboriginum</i> on North Manasota Key	111

Introduction

Aboriginal pricklyapples (*Harrisia aboriginum*) is a candidate for listing by the USFWS (2000) and is listed as endangered by the Florida Department of Agriculture and Consumer Services (Coile and Garland 2003). It has been documented from several southwestern Florida counties including Manatee, Sarasota, Charlotte, and Lee (Bradley et al. 2004). Before the 2004 hurricane season, extant populations of aboriginal pricklyapples were known from ten occurrences, totaling 15 distinct populations in all counties mentioned above excluding Manatee (Bradley et al. 2004).

In 2004 Hurricane Charley, a Category 4* hurricane, crossed the coastal areas of Lee and Charlotte counties with peak winds as high as 150 mph (Figure 4-1). Its damage to human property on these coastal areas was well known, and it was uncertain whether populations of aboriginal pricklyapples would have responded positively or negatively toward this hurricane event. It was surmised that populations could have been negatively impacted by wind induced breakage, tree falls, storm surge, potential illegal dumping on conservation lands, and possible clearing on private lands. It was deemed necessary to survey as many of these occurrences, as time and budget would allow, to assess the status of aboriginal pricklyapples after Hurricane Charley.

* on the Saffir-Simpson Hurricane Scale

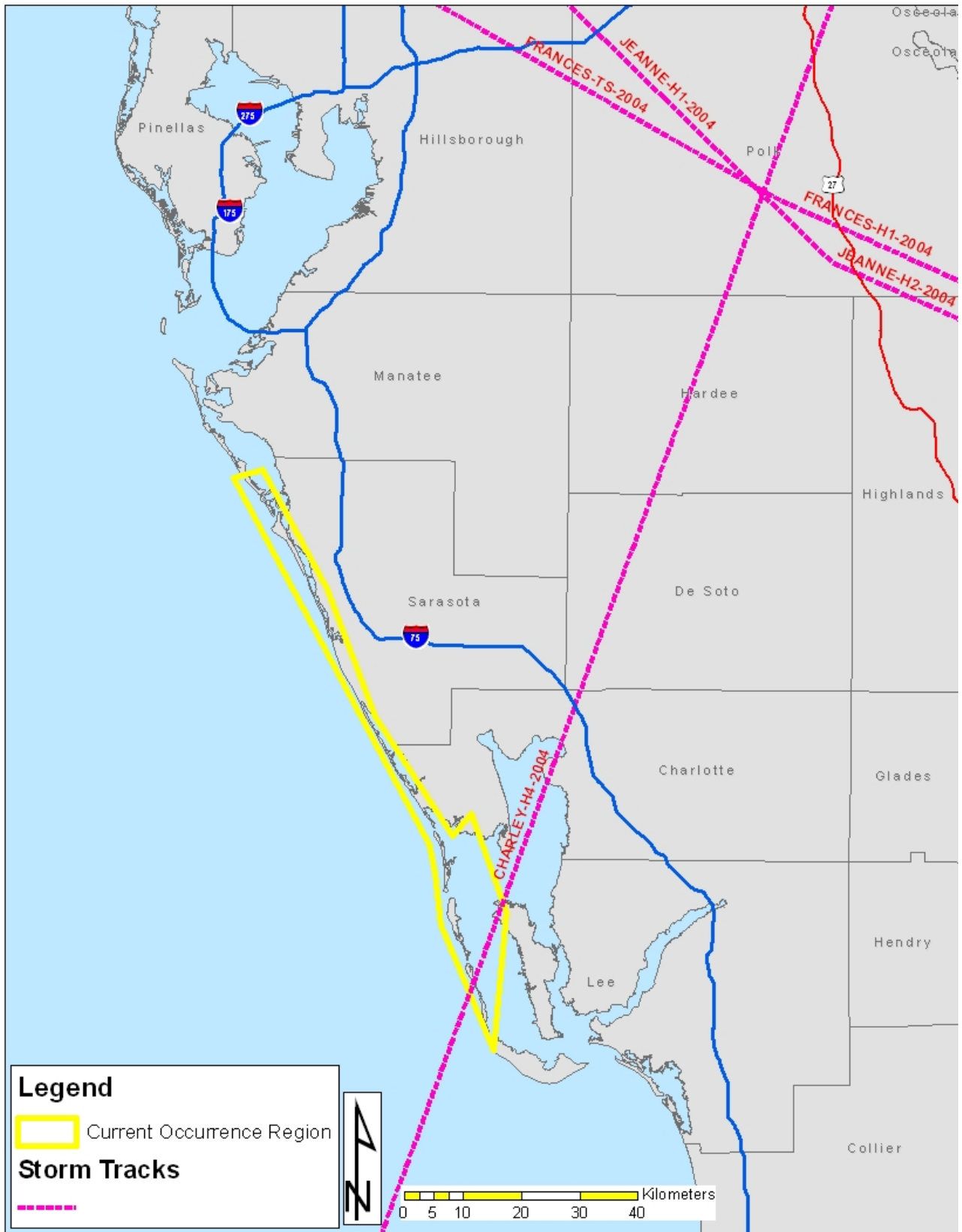


Figure 4-1: *Harrisia aboriginum* Study Area

Methods

Preparation

Before field assessments were conducted for aboriginal pricklyapples, available literature, summarized in Bradley et al. (2004), and herbarium specimen data were compiled, and land managers were consulted.

Site Visit Prioritization

Sites known to have contained aboriginal pricklyapples and were published by Bradley et al. (2004) and were visited. An attempt was made to survey populations of aboriginal pricklyapples in all counties. For comparative reasons, and to better gauge the status of all aboriginal pricklyapples populations, an effort was made to visit both areas surmised to have been most impacted by Hurricane Charley, as well as populations presumed to have been less impacted. Easy accessibility was also taken in consideration when prioritizing sites to survey.

Field Assessment

Surveys

Upon visitation at each site, a search for aboriginal pricklyapples was conducted. Upon finding aboriginal pricklyapples, total number of plants was recorded, recruitment was noted, and habitat(s) following FNAI and FDNR (1990) were recorded, as well as species associates. Overall health of plants was recorded. Dead plants were also searched for. In addition, hurricane damage was noted for the plants as well as the habitats.

Hurricane damage to plants was ranked as none if there was no direct evidence of the events impacting specific individual plants. Hurricane damage to the plants was ranked as low if little damage to the plants (few branches broken, no mortality for the individual) was directly evidenced as a result to the storms. Hurricane damage to the plants was ranked as moderate if any branches or trunks were known to have fallen and damaged plants and poor health could be attributed to the storm events. Hurricane damage to the plants was ranked as severe if mortality of the individuals directly attributed to the storms was observed.

Hurricane damage to the habitat was ranked as none for sites with no direct evidence of the events impacting the habitat. Hurricane damage to the habitat was ranked as low for areas with only a few tree falls and no storm surge (as would be indicated by a die off of the herb vegetation from salt water) surrounding the centroid. Hurricane damage to the habitat was ranked as moderate if there was notable tree falls within the habitat (>five trees) and no storm surge surrounding the centroid. Hurricane damage to the habitat was ranked as severe if major changes to the habitat (such as majority of canopy trees fell) and/or there was notable storm surge.

Tagging and Mapping

Manasota Beach Park and Bocilla Preserve populations were selected for tagging and individual mapping and monitoring of aboriginal pricklyapples. Both populations possessed a population large enough to sustain a long term survey, and it was predicted that both occurrences would have had different degrees of devastation from Hurricane Charley.

Twenty-five adult plants from each population were tagged, mapped, and monitored. Measurements taken for aboriginal pricklyapples included length of longest stem in meters, number of stems, number of flowers and fruits, hurricane damage (using criteria mentioned above), and general plant health was noted (e.g.. plant yellowing, or herbivory/snail damage, etc.). Light availability was also recorded as either full sun (>90% sunlight), partial sun (10 – 90 % sunlight), and shade (<10 % sunlight).

Data Entry

Survey data was entered and maintained in two geodatabases. The two geodatabases are linked by PointID fields. The GIS geodatabase entitled USFWS_HURSUR_MDB contains coordinate data (in NAD 83 UTM 17N format), Site, Subunit, Associated Taxa, Habitat, Occurrence, and PointID. The second geodatabase entitled USFWS_HURSUR_Datasets contains survey data and was created in Microsoft Access and is linked to the geodatabase by the PointID number. The primary table in this database, which contains one record for each PointID linked by Surveyors and Date, contains all pertinent data from the survey also including Event Number, Comments1, Comments 2, Plant Number, Population Estimate, Site, Site Unit, and Occurrence. Data recorded for mapped and tagged plants is also located in this geodatabase.

Results and Discussion

Ten populations of aboriginal pricklyapples were visited between 2006-2007 and included: Water Club Preserve on Longboat Key, Historic Spanish Point, North Manasota Key (Manasota Beach Park, North Manasota Key Private Lot #1, North Manasota Key Private Lot #2), Charlotte Harbor Preserve State Park (Bogges Ridge and Big Mound), Cayo Pelau Preserve, Gasparilla Island South (Mosquito Ditch site), and Cayo Costa Preserve State Park. Aboriginal pricklyapples was extant at each population. Four sites were not visited and included: Casperson Beach County Park, Gasparilla Island North (Gasparilla Island Conservation and Improvement Association Tract A and Kitchen Key) and Buck Key in J.N. "Ding" Darling National Wildlife Refuge. These sites were not visited due to budget constraints. An attempt was made to visit areas throughout the range of pricklyapples, while trying to assess damage to many of the aboriginal pricklyapples populations expected to have the highest impact from Hurricane Charley. Fortunately, based upon field observations of how aboriginal pricklyapples responded to Hurricane Charley in other areas and as no extirpations from any populations occurred, these populations are assumed to be extant.

Hurricane damage to plants observed for all sites visited ranged from none to moderate-severe. Individual plant damage consisted of only slight breakage combined with rot in the population at North Manasota Key Private Lot #2, and of only slight breakage in other populations at Big Mound and Bogges Ridge at Charlotte Harbor Preserve State Park, North Manasota Key, Historic Spanish Point, Cayo Pelau, and Bocilla Preserve. Damage to plants at Bocilla Preserve was also observed due to a tree fall two years after Hurricane Charley made landfall.

Aboriginal pricklyapple population size since Hurricane Charley was reduced at Cayo Pelau Preserve, Bogges Ridge, and North Manasota Key Private Lot #1. Plant population size was unchanged at Cayo Costa State Park, Big Mound, Mosquito Ditch site, North Manasota Key Private Lot #2, and Water Club Preserve. Plant population size increased at Historic Spanish Point. Only Bogges Ridge possessed direct evidence of population reduction (such as the occurrence of dead plants) as a result of impacts of Hurricane Charley. Indirect evidence of general population decrease at three sites tends to suggest that there was more mortality based Hurricane Damage.

Habitat damage from the hurricanes varied from site to site. Habitat damage was severe at Big Mound as much of the tree canopy was damaged and many trees were broken or knocked down. Habitat damage was moderate to severe at Bogges Ridge and Bocilla Preserve which had similar damage to a lesser extent. Habitat damage was moderate at Historic Spanish Point, where many broken limbs of canopy trees was observed. Habitat damage was low at Cayo Pelau Preserve, Manasota Beach Park, and North Manasota Key Private Lot #1. Damage consisted of only minor limb breakage in surrounding habitat or consisted of salt spray damage on North Manasota Key sites, mostly to Brazilian-pepper (*Schinus terebinthifolius*), a non-native species. No hurricane damage to habitats at Cayo Costa State Park, North Manasota Key Private Lot #2, and Water Club Preserve was observed.

A map of the aboriginal pricklyapples population locations is in Figure 4-2. Table 4-1 contains summary data for populations of aboriginal pricklyapples.

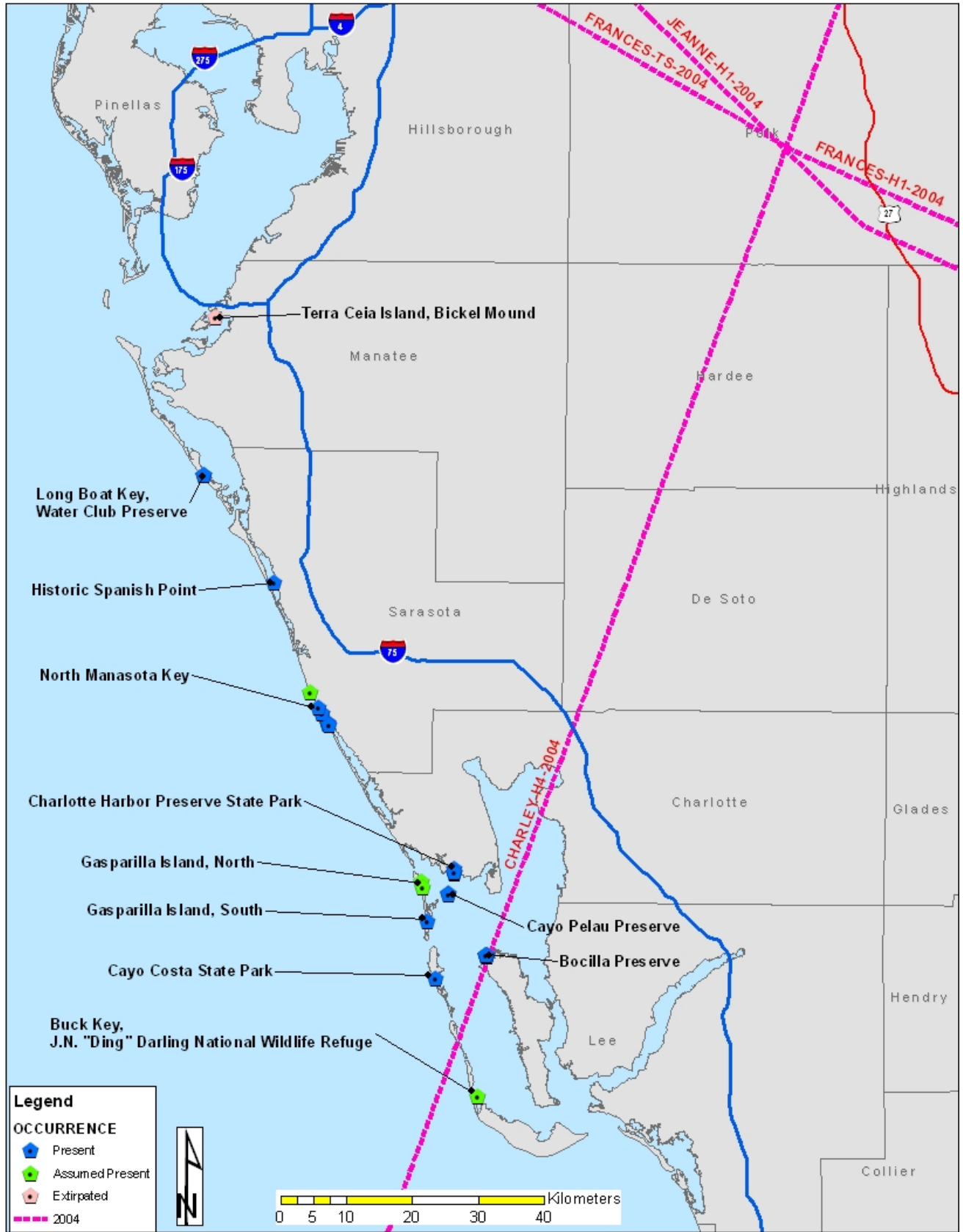


Figure 4-2: *Harrisia aboriginum* Occurrence Results

Table 4-1: Aboriginal pricklyapples Study Area

Occurrence #	Site Name	Site Unit	Status	Number of Plants 2001-2004	Number of Plants in 2006	Hurricane Damage to Habitat	Hurricane Damage to Plants
1	Bocilla Preserve*		P	300-1,000	300-400	Moderate - severe	Low
2	Cayo Costa State Park		P	1	1	None	None observed
3	Cayo Pelau Preserve		P	7	4	Low	Low – moderate
4	Charlotte Harbor Preserve State Park	Bogges Ridge	P	36	24	Moderate – severe	Severe
4	Charlotte Harbor Preserve State Park	Big Mound	P	3	3	Severe	Moderate
5**	Gasparilla Island, North	Kitchen Key	S	2-10	Unknown	Unknown	Unknown
5**	Gasparilla Island, North	Gasparilla Island Conservation and Improvement Association Tract A	S	1	Unknown	Unknown	Unknown
6	Gasparilla Island, South	Mosquito Ditch site	P	1	1	Severe	None observed
7	Historic Spanish Point		P	2	5	Moderate	Moderate
8**	J.N. “Ding” Darling National Wildlife Refuge	Buck Key	S	100-200	Unknown	Unknown	Unknown
9	Longboat Key	Water Club Preserve	P	5	5	None	None observed
10	North Manasota Key*	Manasota Beach Park	P	11-100	50-75	Low	None observed
10	North Manasota Key	North Manasota Key Private Lot #1	P	19	12	Low	Moderate - severe
10	North Manasota Key	North Manasota Key Private Lot #2	P	1	1	None	None observed
10**	North Manasota Key	Casperson Beach County Park	S	≥ 1	Unknown	Unknown	Unknown
11**	Terra Ceia Island	Madira Bickel Mound	E	≥ 1	N/A		

P = Present

E = Extirpated

S = Assumed Present

* plants tagged at this population

** Not surveyed during this project

Twenty-five plants of aboriginal pricklyapples were tagged, mapped, and assessed at Bocilla Preserve in Lee County, and another 25 at Manasota Beach Park in Sarasota County. These sites were visited twice, once in 2006 and once in 2007. A discussion of the results from aboriginal pricklyapples monitoring events is given in each of these site’s occurrence accounts.

Accounts of populations not visited during these surveys are left out of this report. They include Kitchen Key and Gasparilla Island Conservation and Improvement Association (GICIA) Tract A (Occurrence 5), Buck Key at J.N. “Ding” Darling National Wildlife Refuge (Occurrence 8), and Casperson Beach (part of Occurrence 10). An account of the extirpated population at Madira Bickel Mound on Terra Ceia Island is also left out of this report (Occurrence 11). Information regarding these stations may be accessed in Bradley et al. (2004). Accounts of remaining occurrences are detailed in the following sections.

Aboriginal pricklyapples Occurrences

Occurrence 1: Bocilla Preserve, Lee County

Owner: Lee County

Status: Present

Hurricane damage to plants: low

Hurricane damage to plant habitat: moderate to severe

Background: On May 6, 2002, George D. Gann of The Institute for Regional Conservation and others recorded several hundred plants in six patches at Bocilla Preserve (Bradley et al. 2004). Further details of accounts for this station are given in Bradley et al. (2004).

Site Re-visits: On February 14, 2006, Woodmansee and Mahoney surveyed the locations provided in Bradley et al. (2004) and recorded 300-400 plants of aboriginal pricklyapples. Plants appeared to be generally healthy, some in fruit. A portion of the population was tagged and mapped following methods discussed earlier in this chapter. A total of 25 plants were tagged at this location. On January 9, 2007, Woodmansee and Barry returned to the site and re-monitored the tagged population for comparison.

The data collected from tagged plants during the two site visits is listed below in table 4-2. It is important to note that both sampling events are post hurricane. No mortality was found that could be obviously attributed to the hurricanes during the first event. Additionally, no mortality was observed in the tagged plants (all of which were in good health when tagged) between the first and second sampling events.

Most of the plants were in shade or partial shade with about half in each of those categories, only one tagged plant was in full sun in the second monitoring after canopy opened up. In general, this population was not as sunny as the tagged plants at Manasota Beach Park which is found on coastal strand instead of coastal berm surrounded by mangroves as is the case here at Bocilla Preserve.

Hurricane damage in the 2006 monitoring was found in four tagged plants (16%). These plants showed no apparent damage during the second monitoring, and two additional plants showed hurricane damage as a dead tree fell on top of them between monitorings. By the second monitoring, most of the plants remained in good condition. However, three plants without evidence of hurricane damage from before were found to be in fair condition and one plant, in which hurricane damage was observed, was found to be in poor condition. These plants were all in partial shade, though one of the three was found in shade the first sampling then partial shade in the second sampling which may have been a result of the delayed opening of the canopy from the hurricanes. Because nearly all tagged plants were in shade or partial shade, no relationship with decline can be suggested.

Table 4-2: Tagged Plants of *Harrisia aboriginum* at Bocilla Preserve

Tag #	Plant Health:		Hurricane Damage:		Number of Stems:			Length of Longest Stem (meters):			Canopy:	
	2/14/2006	1/9/2007	2/14/2006	1/9/2007	2/14/2006	1/9/2007	change	2/14/2006	1/9/2007	change	2/14/2006	1/9/2007
26	Good	Good	None	None	2	1	-1	0.80	1.50	0.70	Shade	Shade
27	Good	No data	Moderate	None	2	6	4	1.20	1.50	0.30	Shade	Shade
28	Good	Good	Moderate	None	10	1	-9	1.10	0.53	-0.57	Shade	Shade
29	Good	Fair	None	None	2	2	0	1.10	1.20	0.10	Partial Shade	Partial Shade
30	Good	Good	None	No data	3	6	3	0.65	0.80	0.15	Partial Shade	Partial Shade
31	Good	Good	None	None	5	4	-1	0.85	1.20	0.35	Partial Shade	Partial Shade
32	Good	Good	None	None	18	22	4	1.60	1.70	0.10	Partial Shade	Partial Shade
33	Good	Good	None	None	9	6	-3	0.95	1.00	0.05	Shade	Shade
34	Good	Good	None	None	6	4	-2	1.30	1.45	0.15	Shade	Shade
35	Good	Fair	None	None	2	3	1	0.48	0.70	0.22	Shade	Partial Shade
36	Good	Good	Moderate	None	3	2	-1	0.71	0.20	-0.51	Partial Shade	Partial Shade
37	Good	Good	None	None	5	5	0	1.10	1.03	-0.07	Shade	Shade
38	Good	Good	None	None	10	13	3	0.98	0.90	-0.08	Partial Shade	Partial Shade
39	Good	Good	None	None	12	12	0	1.00	1.05	0.05	Partial Shade	Partial Shade
40	Good	Good	None	None	2	6	4	0.49	0.70	0.21	Partial Shade	Sun
41	Good	No data	None	None	11	13	2	0.46	0.67	0.21	Shade	Partial Shade
42	Good	Fair	None	None	12	13	1	0.75	0.90	0.15	Partial Shade	Partial Shade
43	Good	Good	Moderate	None	10	12	2	1.30	1.30	4.77	Partial Shade	Partial Shade
44	Good	Good	None	None	6	9	3	1.85	2.05	0.20	Shade	Shade
45	Good	Good	None	Moderate*	7	8	1	0.45	0.70	0.25	Shade	Shade
46	Good	No data	None	None	3	2	-1	0.68	0.70	0.02	Shade	Shade
47	Good	No data	None	None	4	3	-1	1.05	0.60	-0.45	Shade	Shade
48	Good	Poor	None	Moderate*	3	1	-2	0.75	0.25	-0.50	Partial Shade	Shade
49	Good	Good	None	None	3	5	2	0.98	1.70	0.72	Partial Shade	Partial Shade
50	Good	Good	None	None	8	5	-3	1.05	1.30	0.25	Partial Shade	Partial Shade

* Caused by dead tree fall after first sampling	Mean:	Canopy Combined	6.32	6.56	0.24	0.95	1.03	0.08
		Sun	N/A	N/A	N/A	N/A	N/A	N/A
		Partial Shade	7.00	7.92	0.92	0.94	1.02	0.08
		Shade	5.58	5.08	-0.50	0.95	1.04	0.08
	Mean:	Hurricane damage	5.83	5.00	-0.83	0.92	0.75	-0.17
		No Hurricane damage	6.47	7.05	0.58	0.95	1.11	0.16

The average number of stems observed in the 25 tagged plants at Bocilla Preserve was 6.3. The average was 5.6 stems in shade and 7.0 stems in partial shade in the first sampling. As a result of the second sampling, the number of stems increased in partial shade, while it decreased in shade. This was not evidenced with the tagged population at Manasota Beach Park.

The average number of stems for plants damaged by the hurricanes was 5.8 stems while non-damaged plants exhibited an average number of stems of 6.5. The fewer number of stems on damaged plants was also observed at the Manasota Beach Park tagged population, and it follows to reason as stems and branches may have broken off at a delay from storm damage. Length of longest stem seemed relatively unchanged across all categories.

Site Description: Habitat of aboriginal pricklyapples at Bocilla Preserve is coastal berm, which in this case is surrounded by mangroves and buttonwood. Impacts to coastal berm were moderate to severe as the eye of Hurricane Charley crossed over the population of pricklyapples here. After the storm, canopy was reduced in height and cover, and there were many broken limbs and leaning trees among the aboriginal pricklyapples population. There was no evidence of storm surge or negative human impacts within the aboriginal pricklyapples population. Evidence of exotic plant eradication existed at Bocilla Preserve, especially the treatment of Brazilian-pepper (*Schinus terebinthifolius*).

More site account data pre-hurricane, including plant associates, may be obtained in Bradley et al. (2004).

A map of the population of aboriginal pricklyapples at Bocilla Preserve is provided in Figure 4-3.

Possible causes for lack of population change: Due to imprecise estimates of aboriginal pricklyapples in 2002, it is presumed that the population at Bocilla Preserve is unchanged. Relative to the Hurricane Charley's devastating effects elsewhere, it appears that aboriginal pricklyapples is well adapted to major hurricane events, especially at this site. It appears that plants were sheltered from damaging wind by the surrounding coastal berm habitat. Although coastal, populations of aboriginal pricklyapples appear to be buffered from storm surge by surrounding tidal swamp habitat. Over time, it is expected that the population will benefit from the canopy being more open as plants seem to prefer partial shade. That being said, it is possible that a severely major hurricane (Category 5) could impact the species. Other stochastic events such as freezes may threaten aboriginal pricklyapples.

Recommendations: Exotic pest plant removal at the site has been conducted and should be continued. Monitor this population of aboriginal pricklyapples on an annual basis.

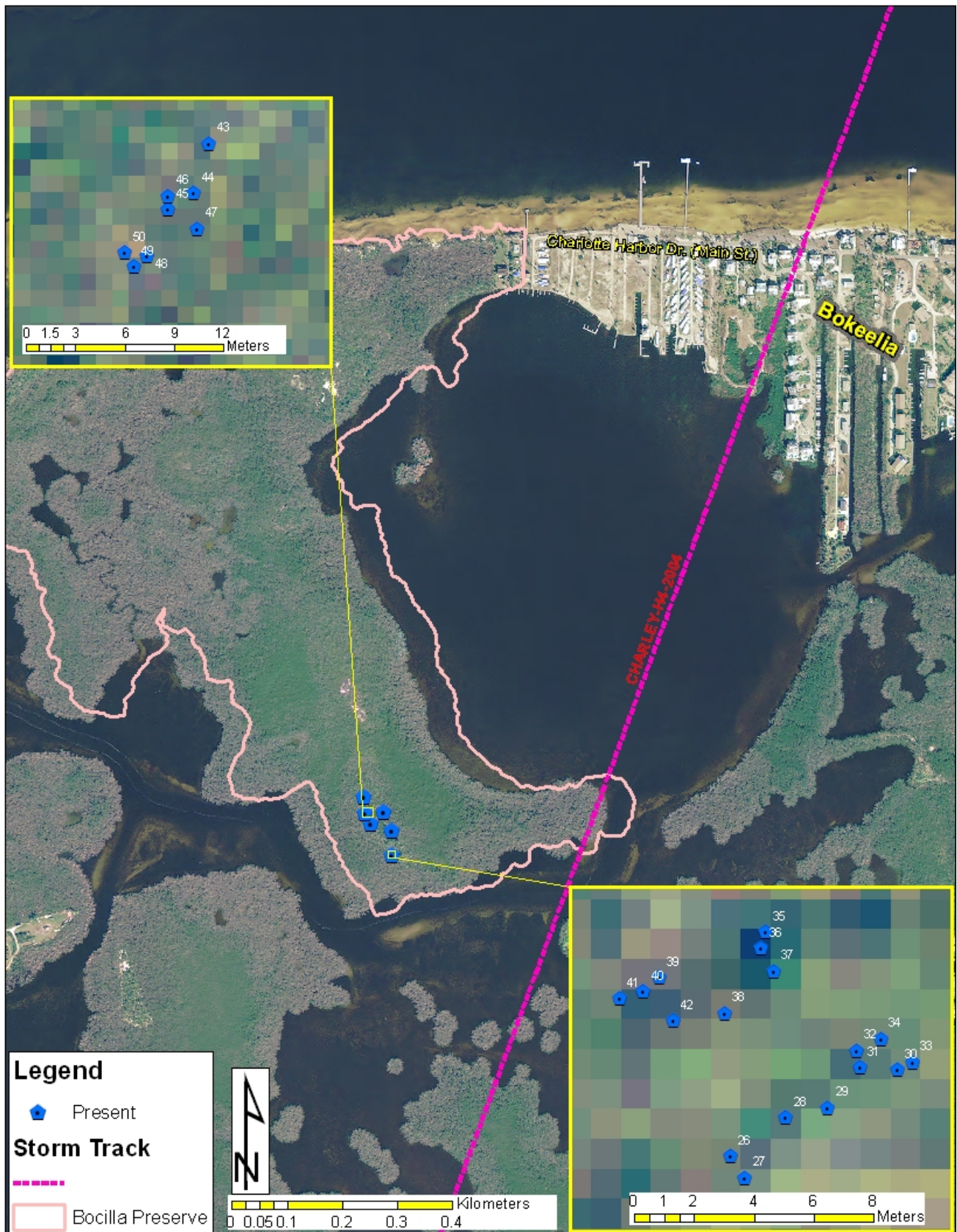


Figure 4-3: *Harrisia aboriginum* at Bocilla Preserve

Occurrence 2: Cayo Costa State Park, Lee County

Owner: Florida Park Service

Status: Present

Hurricane damage to plants: none

Hurricane damage to plant habitat: none

Background: On June 26, 2003 Woodmansee, Jimi Sadle, and Andrea Bishop observed the single individual of aboriginal pricklyapples on Cayo Costa Island in Cayo Costa State Park (Bradley et al. 2004). Further details of accounts for this station are given by Bradley et al. (2004).

Site Re-visits: On February 15, 2006, Woodmansee, Mahoney, and Lee County biologist Jim Green surveyed the location provided in Bradley et al. (2004) and observed the individual aboriginal pricklyapples at Cayo Costa State Park. The plant, already reported to be declining (Bradley et al. 2004) was in further decline with much yellowing. No damage directly attributed to hurricanes was observed.

Site Description: Habitat of aboriginal pricklyapples at Cayo Costa State Park would be coastal grassland, which in this case is bordered by beach dune to the west and mesic flatwoods and maritime hammock to the east. Impacts to coastal grassland were seemingly nonexistent, and conditions of the habitat surrounding the plant were almost identical as the 2003 visit. This was surprising as Hurricane Charley caused a great deal of damage to human property on the island. There was no evidence of storm surge.

More site account data, including plant associates, may be obtained in Bradley et al. (2004).

A map of the population of aboriginal pricklyapples at Cayo Costa State Park is provided in Figure 4-4.

Possible causes for plant survival: It appears that aboriginal pricklyapples is adapted to hurricane events at this site. This plant was sheltered from damaging wind by much of the surrounding coastal grassland habitat. However, it is not expected that this individual will survive, as it has been declining for several years. Stochastic events such as major hurricanes and freezes may cause extirpation of this individual of aboriginal pricklyapples.

Recommendations: Monitor this population of aboriginal pricklyapples on an annual basis. Care should be maintained during fire management in the coastal grassland habitat so as not to negatively impact aboriginal pricklyapples. Consider augmenting plants of aboriginal pricklyapples at the location of this station.



Figure 4-4: *Harrisia aboriginum* at Cayo Costa State Park

Occurrence 3: Cayo Pelau Preserve, Lee County

Owner: Lee County Parks and Recreation

Status: Present

Hurricane damage to plants: moderate

Hurricane damage to plant habitat: low

Background: On September 4, 2003 Woodmansee and Jimi L. Sadle observed seven plants of aboriginal pricklyapples on Cayo Pelau (Bradley et al. 2004). Further details of accounts for this station are given by Bradley et al. (2004).

Site Re-visits: On February 16, 2006, Woodmansee, Mahoney, and Lee County biologist Jim Green surveyed the location provided in Bradley et al. (2004) and recorded four plants of aboriginal pricklyapples at Cayo Pelau Preserve, a 42% reduction. Moderate damage consisting of broken limbs, decumbent plants, and dead limbs was observed in the population, some plants fairing better than other. Of note, one seemingly dead plant, upon closer look possessed a healthy root system and a young shoot coming from the base.

Site Description: Cayo Pelau is an island in Charlotte Harbor in both Lee and Charlotte counties. The northern tip of the island is in Charlotte County, and is owned by Charlotte County Parks and Recreation, the remainder is now a Lee County preserve owned by Lee County Parks and Recreation Department. Habitat of aboriginal pricklyapples at Cayo Pelau would be beach dune and coastal berm, which in this case is bordered by Charlotte Harbor to the west and dense coastal berm and mangroves to the east. Impacts to the habitat were minor although some soil erosion was evident. There must have been some storm surge, as habitat containing plants was at an elevation below one meter. Coastal berm habitat is being invaded by exotic plants including Australian-pine (*Casuarina equisetifolia*) and Brazilian-pepper (*Schinus terebinthifolius*).

More site account, data including plant associates, may be obtained in Bradley et al. (2004).

A map of the population of aboriginal pricklyapples at Cayo Pelau Preserve is provided in Figure 4-5.

Possible causes for population decline: Missing plants may have been swept away by the storm surge. Given the closeness to sea-level, and the little protection to the west, it is astonishing that any aboriginal pricklyapples survived at all. Despite the reduction in population after the storm event, it appears that aboriginal pricklyapples is adapted to hurricane events at this site. This population was sheltered from damaging wind by coastal berm habitat to the east. Exotic pest plants mentioned above compete for space and may further soil erosion. Stochastic events such as major storm events and freezes may threaten this population of aboriginal pricklyapples.



Figure 4-5: *Harrisia aboriginum* at Cayo Pelau Preserve

Recommendations: Monitor this population of aboriginal pricklyapples on an annual basis. Remove exotic pest plants from Cayo Pelau Preserve, and conduct surveys for more aboriginal pricklyapples.

Occurrence 4: Charlotte Harbor Preserve State Park, Charlotte County

Owner: Florida Park Service

Status: Present

Sub unit: Big Mound

Hurricane damage to plants: moderate

Hurricane damage to plant habitat: severe

Background: On July 24, 2003 Woodmansee, Jimi L. Sadle, and Florida Park Service biologists Bob Reppenning and Jay Garner recorded three separate plants at Big Mound in Charlotte Harbor Preserve State Park (Bradley et al. 2004). Further details of accounts for this station are given in Bradley et al. (2004).

Site Re-visits: On January 10, 2007, Woodmansee and Barry surveyed the locations provided in Bradley et al. (2004) and found the three plants of aboriginal pricklyapples on Big Mound in Charlotte Harbor Preserve State Park. Plants appeared to be doing okay, although they were fairly beaten up with broken and broken-off limbs.

Site Description: Habitat of aboriginal pricklyapples at Big Mound in Charlotte Harbor Preserve State Park would be shell mound, which in this case is surrounded by tidal swamp. Impacts to the shell mound were severe. After the storm, canopy was reduced in cover, and many areas were now in full sun, and there were many broken limbs and leaning trees among the aboriginal pricklyapples population. There was no evidence of storm surge or negative human impacts within the aboriginal pricklyapples population. Habitat is threatened by exotics especially Brazilian-pepper (*Schinus terebinthifolius*).

More site account data pre-hurricane, including plant associates, may be obtained in Bradley et al. (2004).

A map of the population of aboriginal pricklyapples on Big Mound at Charlotte Harbor Preserve State Park is provided in Figure 4-6.

Possible causes for lack of population change: It appears that aboriginal pricklyapples is adapted to hurricane events, especially at this site. Despite being broken up by falling tree limbs, it appears that plants were sheltered from damaging wind by the surrounding shell mound habitat. Although coastal, populations of aboriginal pricklyapples appear to be buffered from storm surge by surrounding tidal swamp habitat. High elevation of Big Mound, which in some places exceeds seven meters above sea-level, prevented impacts of storm surge. Over time, it is expected that the population will benefit from the canopy being more open. That being said, it is possible that a severely major hurricane (Category 5) could impact the species. Other stochastic events such as freezes may threaten aboriginal pricklyapples.

Recommendations: Exotic pest plant removal at the site has been conducted and should be continued. Monitor this population of aboriginal pricklyapples on an annual basis.



Figure 4-6: *Harrisia aboriginum* at Charlotte Harbor Preserve State Park, Charlotte County

Sub unit: Boggess Ridge

Hurricane damage to plants: severe

Hurricane damage to plant habitat: moderate - severe

Background: On July 24, 2003 Woodmansee, Jimi L. Sadle, and Florida Park Service biologists Bob Repenning and Jay Garner recorded 36 plants at Boggess Ridge in Charlotte Harbor Preserve State Park (Bradley et al. 2004). Further details of accounts for this station are given in Bradley et al. (2004).

Site Re-visits: On January 10, 2007, Woodmansee and Barry surveyed the locations provided in Bradley et al. (2004) and recorded 24 plants of aboriginal pricklyapples on Boggess Ridge in Charlotte Harbor Preserve State Park, a decrease by one third. An additional two plants were apparently killed by fallen trees. Remaining plants appeared to be doing okay, although they were fairly beaten up with broken and broken-off limbs. No plants were in fruit or flower.

Site Description: Habitat of aboriginal pricklyapples at Boggess Ridge in Charlotte Harbor Preserve State Park would be coastal berm, which in this case is surrounded by tidal swamp on three sides, and scrubby flatwoods to the east. Impacts to the coastal berm were moderate to severe. After the storm, canopy was reduced in cover and many light gaps existed. There were many broken limbs and leaning trees among the aboriginal pricklyapples population. There was no evidence of storm surge or negative human impacts within the aboriginal pricklyapples population. Habitat is threatened by exotics especially Brazilian-pepper (*Schinus terebinthifolius*).

More site account data pre-hurricane, including plant associates, may be obtained in Bradley et al. (2004).

A map of the population of aboriginal pricklyapples on Boggess Ridge at Charlotte Harbor Preserve State Park is provided in Figure 4-6.

Possible causes for population decline: It seems evident that the population of aboriginal pricklyapples declined as a result of Hurricane Charley. Despite this, aboriginal pricklyapples appears adapted to hurricane events. Despite some mortality and being broken up by fallen tree limbs, many plants were sheltered from damaging wind by the surrounding coastal berm habitat. Although coastal, for the most part the population of aboriginal pricklyapples at Boggess Ridge appeared to be buffered from storm surge by surrounding tidal swamp habitat. Over time, it is expected that the population will benefit from the canopy being more open. That being said, it is possible that a severely major hurricane (Category 5) could impact the species. Other stochastic events such as freezes may threaten aboriginal pricklyapples.

Recommendations: Exotic pest plant removal at the site has been conducted and should be continued. Monitor this population of aboriginal pricklyapples on an annual basis.

Occurrence 6: Gasparilla Island South, Mosquito Ditch site, Lee County

Owner: Lee County (not a conservation area)

Status: Present

Hurricane damage to plants: none observed

Hurricane damage to plant habitat: severe

Background: On June 26, 2003 Woodmansee, Jimi L. Saddle, and Clyde Nabors observed a single, but large individual of aboriginal pricklyapples in spoil along a mosquito ditch running through tidal swamp (Bradley et al. 2004). Further details of accounts for this station are given by Bradley et al. (2004).

Site Re-visits: On February 14, 2006, Woodmansee and Mahoney surveyed the location provided in Bradley et al. (2004) and observed the large aboriginal pricklyapples plant. The plant seemed unaffected by Hurricane Charley. No fruits or flowers were observed.

Site Description: Habitat of aboriginal pricklyapples at Gasparilla Island South Mosquito Ditch site would be ruderal, which in this case is surrounded by disturbed tidal swamp. The mosquito ditch berm was dominated by Brazilian-pepper (*Schinus terebinthifolius*), which was severely beaten up by Hurricane Charley. There was no evidence of storm surge.

More site account data, including plant associates, may be obtained in Bradley et al. (2004).

A map of the population of aboriginal pricklyapples at Gasparilla Island South Mosquito Ditch site is provided in Figure 4-7.

Possible causes for plant survival: It appears that aboriginal pricklyapples is adapted to hurricane events at this site. Despite the severe damage to the surrounding Brazilian-pepper thicket, this plant was still sheltered from damaging wind by much of the Brazilian-pepper and the surrounding tidal swamp habitat. Stochastic events such as more major hurricanes and freezes may impact this individual of aboriginal pricklyapples.

Recommendations: Monitor this population of aboriginal pricklyapples on an annual basis. Consider augmenting plants of aboriginal pricklyapples at the location of this station.



Figure 4-7: *Harrisia aboriginum* at Gasparilla Island South, Mosquito Ditch site, Lee County

Occurrence 7: Historic Spanish Point, Sarasota County

Owner: Gulf Coast Heritage Inc.

Status: Present

Hurricane damage to plants: moderate

Hurricane damage to plant habitat: moderate

Background: On September 2, 2003 Woodmansee and Jimi L. Sadle recorded two adult plants at Historic Spanish Point in Sarasota County (Bradley et al. 2004). Further details of accounts for this station are given in Bradley et al. (2004).

Site Re-visits: On February 14, 2006, Woodmansee and Mahoney surveyed the locations provided in Bradley et al. (2004) and found the two plants of aboriginal pricklyapples. Hurricane damage to the plants was moderate as two plants were broken into five. All plants were yellowing, however it appeared that three plants would persist and live on. No fruits or flowers were observed.

Site Description: Habitat of aboriginal pricklyapples at Historic Spanish Point would be shell mound, albeit disturbed. Elevation at the plants exceeded seven meters above sea-level. Habitat was surrounded by the historic homesite on three sides with the Gulf of Mexico to the south. Impacts to the shell mound habitat were moderate consisting of broken limbs from trees. There was no evidence of storm surge or negative human impacts within the aboriginal pricklyapples population. It appears that the immediate area surrounding the plants is being "Managed" as some hardwoods were trimmed. Exotics recorded next to plants include bow-string hemp (*Sansevieria hyacinthoides*) and nightblooming cereus (*Hylocereus undatus*).

More site account data pre-hurricane, including plant associates, may be obtained in Bradley et al. (2004).

A map of the population of aboriginal pricklyapples at Historic Spanish Point is provided in Figure 4-8.

Possible causes for slight increase of population: It appears that aboriginal pricklyapples is adapted to hurricane events, especially at this site. Despite being broken up by falling tree limbs, it appears that plants were sheltered from damaging wind by the surrounding shell mound habitat. Although coastal, populations of aboriginal pricklyapples here are inland from the barrier island and somewhat buffered from storm surge by it. High elevation of Historic Spanish Point prevented impacts of storm surge. The minor affects of Hurricane Charley here increased population as broken limbs of aboriginal pricklyapples regenerated vegetatively, at least in one individual. If not altered by human impact, over time, it is expected that the population will benefit from the canopy being more open. That being said, it is possible that a severely major hurricane (Category 5) could impact the species. Major threats include accidental damage by people due to the population's close proximity to



Figure 4-8: *Harrisia aboriginum* at Historic Spanish Point, Sarasota County

the trail and competition from exotics, especially bow-string hemp and nightblooming cereus. Other stochastic events such as freezes may threaten aboriginal pricklyapples.

Recommendations: Exotic pest plant removal at the site needs to be initiated. Monitor this population of aboriginal pricklyapples on an annual basis. Conduct surveys in shell mound habitat outside the historic residence at Historic Spanish Point.

Occurrence 9: Longboat Key, Water Club Preserve, Sarasota County

Owner: Water Club Condominiums

Status: Present

Hurricane damage to plants: none observed

Hurricane damage to plant habitat: none

Background: On September 2, 2003 Woodmansee and Jimi L. Sadle recorded five adult plants at Water Club Preserve on Longboat Key in Sarasota County (Bradley et al. 2004). Further details of accounts for this station are given in Bradley et al. (2004).

Site Re-visits: On February 14, 2006, Woodmansee and Mahoney surveyed the locations provided in Bradley et al. (2004) and found all five plants of aboriginal pricklyapples. Hurricane damage to the plants was not evident, and plants were in good shape. No fruits or flowers were observed.

Site Description: Habitat of aboriginal pricklyapples at Water Club Preserve on Longboat Key would be maritime hammock. Habitat was surrounded by the Water Club Resort on all sides. No impacts attributable to hurricanes were evidenced in the maritime hammock habitat. There was no evidence of negative human impacts within the aboriginal pricklyapples population.

More site account data pre-hurricane, including plant associates, may be obtained in Bradley et al. (2004).

A map of the population of aboriginal pricklyapples at Water Club Preserve on Longboat Key is provided in Figure 4-9.

Possible causes for lack of population change: It appears that aboriginal pricklyapples was unaffected by any storm impacts at this site as plants and plant habitat were unchanged. A direct hit by a major hurricane could impact the species. Other stochastic events such as freezes may threaten aboriginal pricklyapples.

Recommendations: Exotic pest plant removal is being conducted and should continue. Consider opening up portions of the canopy, especially the maritime hammock surrounding southern plants at this site. Monitor this population of aboriginal pricklyapples on an annual basis. Consider augmenting plants of aboriginal pricklyapples at this site.



Figure 4-9: *Harrisia aboriginum* at Water Club Preserve on Longboat Key, Sarasota County

Occurrence 10: Manasota Key, Sarasota County

Sub unit: Manasota Beach Park

Owner: Sarasota County

Status: Present

Hurricane damage to plants: none observed

Hurricane damage to plant habitat: low

Background: On September 3, 2004, Woodmansee and Jimi L. Sadle estimated 11-100 plants of aboriginal pricklyapples at Manasota Beach Park (Bradley et al. 2004). Further details of accounts for this station are given by Bradley et al. (2004).

Site Re-visits: On February 14, 2006, Woodmansee and Mahoney surveyed the locations provided in Bradley et al. (2004) and recorded 50-75 plants of aboriginal pricklyapples. Aboriginal pricklyapples mortality induced by non hurricane influenced human impacts did occur as evidence of arson amongst a clump of cabbage palms (*Sabal palmetto*) killed at least one plant. Otherwise, most all plants appeared to be healthy, several with fruit and some with flower buds. Interestingly, herbivory by gopher tortoises (*Gopherus polyphemus*) was observed at the bases of some aboriginal pricklyapples. A portion of the population was tagged and mapped following methods discussed at the beginning of this chapter. A total of 25 plants were tagged at this location. On January 10, 2007, Woodmansee and Barry returned to the site and re-monitored the tagged population for comparison.

The data collected from tagged plants during the two site visits is listed below in table 4-3. As mentioned previously, it is important to note that both sampling events are post hurricane. No obvious mortality from the hurricanes was observed. However, nearly half of the tags (12 total) were missing by the second event. Because plants were found in the vicinity of where the tagged plants should have been, and these plants were located adjacent to well utilized trails, it is most likely that the tags were removed by people using the park.

Most of the tagged plants were found in shade (roughly 60%) with three plants (roughly 10%) in partial shade, and seven (30%) in sun. There were more sunny locations than at Bocilla Preserve due to the dominant habitat being coastal strand along the beach.

Hurricane damage was observed in four of the 25 tagged plants (16%), the same proportion observed at Bocilla Preserve. These plants with damage were mostly evenly distributed between shade (two plants) and partial shade (two plants), and one out of seven plants in sun had damage. The sample size is too small to make any meaningful inferences of canopy coverage effects on hurricane damage from these observations.

Table 4-3: Tagged Plants of *Harrisia aboriginum* at Manasota Beach Park

Tag #	Plant Health:		Hurricane Damage:		Number of Stems:			Length of Longest Stem (meters):			Canopy:																																														
	2/14/2006	1/9/2007	2/14/2006	1/9/2007	2/14/2006	1/9/2007	change	2/14/2006	1/9/2007	change	2/14/2006	1/9/2007																																													
1	Good	Fair	None	None	4	9	5	0.76	0.72	-0.04	Sun	Sun																																													
2	Good	Good	None	None	1	1	0	0.38	0.45	0.07	Partial Shade	Sun																																													
3	Good	Good	None	None	1	3	2	0.35	0.63	0.28	Sun	Sun																																													
4	Good		Moderate	None	4	3	-1	1.00	1.1	0.10	Shade	Shade																																													
5	Good	Poor	Moderate	Moderate	11	8	-3	1.80	1.75	-0.05	Shade	Partial Shade																																													
6	Good	Fair	None	None	1	2	1	0.82	0.80	-0.02	Shade	Partial Shade																																													
7	Good	Good	None	None	1	2	1	0.85	1.50	0.65	Shade	Partial Shade																																													
8	Good	Missing	None		5			0.20			Shade																																														
9	Good	Missing	None		6			1.59			Shade																																														
10	Good	Missing	None		7			1.64			Shade																																														
11	Good	Missing	Moderate		6			1.23			Shade																																														
12	Good	Missing	None		2			1.15			Shade																																														
13	Good	Missing	None		5			1.41			Shade																																														
14	Good	Missing	None		2			0.31			Shade																																														
15	Good	Missing	None		2			0.45			Partial Shade																																														
16	Good	Missing	None		3			0.95			Shade																																														
17	Good	Missing	None		5			0.90			Shade																																														
18	Good	Missing	None		5			0.58			Partial Shade																																														
19	Good	Missing	None		18			1.50			Shade																																														
20	Good	Good	None	None	6	10	4	1.00	1.17	0.17	Shade	Partial Shade																																													
21	Good	Fair	None	None	3	5	2	0.86	1.10	0.24	Sun	Sun																																													
22	Good	Poor	None	None	5	5	0	0.59	0.62	0.03	Sun	Sun																																													
23	Good	Good	None	None	3	2	-1	0.43	0.70	0.27	Sun	Sun																																													
24	Good	Fair	None	None	6	6	0	0.97	0.80	-0.17	Sun	Sun																																													
25	Good	Fair	Moderate	Moderate	6	8	2	0.56	1.20	0.64	Sun	Sun																																													
<table border="1"> <tbody> <tr> <td rowspan="6">*Change calculated only for individual plant samplings which crossed both monitoring periods.</td> <td rowspan="4">Mean:</td> <td>Canopy Combined</td> <td>4.72</td> <td>4.92</td> <td>0.92*</td> <td>0.89</td> <td>0.96</td> <td>0.17*</td> </tr> <tr> <td>Sun</td> <td>4.00</td> <td>4.88</td> <td>1.25*</td> <td>0.65</td> <td>0.78</td> <td>0.16*</td> </tr> <tr> <td>Partial Shade</td> <td>2.67</td> <td>1.00</td> <td>0.00*</td> <td>0.47</td> <td>0.45</td> <td>0.07*</td> </tr> <tr> <td>Shade</td> <td>5.47</td> <td>5.00</td> <td>0.40*</td> <td>1.09</td> <td>1.26</td> <td>0.17*</td> </tr> <tr> <td rowspan="2">Mean:</td> <td>Hurricane</td> <td>6.75</td> <td>6.33</td> <td>-0.67*</td> <td>1.15</td> <td>1.35</td> <td>0.23*</td> </tr> <tr> <td>No Hurricane</td> <td>4.33</td> <td>4.50</td> <td>1.40*</td> <td>0.84</td> <td>0.85</td> <td>0.15*</td> </tr> </tbody> </table>													*Change calculated only for individual plant samplings which crossed both monitoring periods.	Mean:	Canopy Combined	4.72	4.92	0.92*	0.89	0.96	0.17*	Sun	4.00	4.88	1.25*	0.65	0.78	0.16*	Partial Shade	2.67	1.00	0.00*	0.47	0.45	0.07*	Shade	5.47	5.00	0.40*	1.09	1.26	0.17*	Mean:	Hurricane	6.75	6.33	-0.67*	1.15	1.35	0.23*	No Hurricane	4.33	4.50	1.40*	0.84	0.85	0.15*
Change calculated only for individual plant samplings which crossed both monitoring periods.	Mean:	Canopy Combined	4.72	4.92	0.92	0.89	0.96	0.17*																																																	
		Sun	4.00	4.88	1.25*	0.65	0.78	0.16*																																																	
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	Mean:	Hurricane	6.75	6.33	-0.67*	1.15	1.35	0.23*																																																	
		No Hurricane	4.33	4.50	1.40*	0.84	0.85	0.15*																																																	

Because of the missing tags, comparisons between the first and second sampling are less valuable for suggesting trends. However, more decline was observed at this site than Bocilla Preserve as five fair and two poor condition plants were observed out of the 13 tagged plants which were resampled.

Average number of stems was 4.7. Of plants found in the shade, the average number of stems was 5.5, and 2.7 stems in partial shade, and 4.0 stems in the sun. This data shows a trend toward preference of shade and sun, which differs from data of Bocilla Preserve which point to partial shade. It is thought that *Harrisia*, in general, prefer partial shade conditions. A few factors may be at play in the trend of better fitness in shade and sun. It must be noted that because of human interruption between sampling periods (*i.e.* tag removal), sampling size was reduced, so results may be skewed. It is possible that partial shade plants may show lower fitness in stem production as these areas may have higher human impact than those of sun or shade conditions, and may be preferred by beach goers. Plants in sun may have better stem production due to other biotic and physical factors such as less competition and lack of recent fires. Growth in length of longest stem showed a trend of higher average values for plants in sun and shade than those in partial shade.

The average number of stems was 6.8 stems in hurricane damaged plants and 4.3 stems in the non-damaged plants. A decline in the number of stems was observed in the hurricane damaged plants (0.7 stem average decline) but increased (1.4 stem average increase) in non-damaged plants, which is similar to the trend observed at Bocilla Preserve. Growth in length of longest stem over time showed a larger increase in hurricane damaged plants than those without damage.

Site Description: Habitat of aboriginal pricklyapples at Manasota Beach Park would be coastal strand, which in this case is bordered by beach dune to the west and coastal berm/fire suppressed coastal strand to the east. Impacts to coastal strand were low as the population of pricklyapples here was rather distant from the eye of Hurricane Charley. There was some evidence of salt spray damage to hardwoods in the coastal strand habitat. There was no evidence of storm surge. In addition, several fire pits were observed in and around the aboriginal pricklyapples, and many trails through the population existed. Exotics found close to aboriginal pricklyapples at Manasota Beach Park included: Brazilian-pepper (*Schinus terebinthifolius*), Madagascar periwinkle (*Catharanthus roseus*), Indian laurel fig (*Ficus microcarpa*), and Natal-plum (*Carissa macrocarpa*).

More site account data including plant associates may be obtained in Bradley et al. (2004).

A map of the population of aboriginal pricklyapples at Manasota Beach Park is provided in Figure 4-10.

Possible causes for lack of population change: It appears that aboriginal pricklyapples is adapted to hurricane events, especially at this site. It appears that plants were mostly sheltered from damaging wind by the surrounding coastal strand habitat. Distance from the worst winds of Hurricane Charley most likely played a role in their protection. Over time, it is expected that the population closer to the maritime hammock habitat will benefit from the canopy



Figure 4-10: *Harrisia aboriginum* on North Manasota Key

being more open so long as human impacts are reduced. That being said, it is possible that a direct hit to Manasota Beach Park by a major hurricane could impact the species. A major threat to aboriginal pricklyapples is human disturbance in the form of hikers and beach goers who use the area. Other stochastic events such as freezes may threaten aboriginal pricklyapples.

Recommendations: Initiate exotic pest plant removal at this site. Consider cordoning off this population from beach goers and hikers. Care should be maintained during fire management in the coastal strand habitat so as not to negatively impact aboriginal pricklyapples. Monitor this population of aboriginal pricklyapples on an annual basis.

Sub unit: North Manasota Key Private Lot #1

Owner: Uncertain (presumed private)

Status: Present

Hurricane damage to plants: moderate to severe

Hurricane damage to plant habitat: low

Background: On September 3, 2004, Woodmansee and Jimi L. Sadle counted 19 plants of aboriginal pricklyapples at North Manasota Key Private Lot #1 (Bradley et al. 2004). Further details of accounts for this station are given by Bradley et al. (2004).

Site Re-visits: On February 14, 2006, Woodmansee and Mahoney surveyed the locations provided in Bradley et al. (2004) and recorded 12 plants of aboriginal pricklyapples, a 36% decrease from before. Three adults were growing in coastal strand and in good health. Nine adults were along the ecotone between coastal strand and maritime hammock. These plants were more damaged than the coastal strand plants, and possessed much breakage and appeared to be rotting. No mortality directly attributed to hurricanes was observed (e.g. dead plants).

Site Description: Habitat of aboriginal pricklyapples at North Manasota Key Private Lot #1 would be coastal strand and maritime hammock edge, which in this case is bordered by beach dune to the west and mature maritime hammock to the east. Impacts to coastal strand were low as the population of pricklyapples here was rather distant from the eye of Hurricane Charley. There was some evidence of salt spray damage to hardwoods, especially Brazilian-pepper (*Schinus terebinthifolius*) in the coastal strand habitat. There was no evidence of storm surge. *Kalanchoe* is still a problem being an aggressive invader in the coastal strand at this site. Other exotics were being treated aggressively, and much of the maritime hammock habitat was opened up.

More site account data including plant associates may be obtained in Bradley et al. (2004).

A map of the population of aboriginal pricklyapples at North Manasota Key Private Lot #1 is provided in Figure 4-10.

Possible causes for population decrease: Damage to plants along the ecotone between coastal strand and maritime hammock could be attributed to breakage caused by the former population of Brazilian-pepper. Now that the Brazilian-pepper is removed it is expected that aboriginal pricklyapples will be better adapted to future hurricane events at this site. Regarding the change in population numbers, it is possible that dead plants had already decomposed or were missed. Some plants may have been damaged by hurricane impacts such as windblown removal, although there was no evidence of this. Dead plants may have been removed by the crew who treated exotic plants there. Hopefully not the case, but it is possible plants were damaged during exotics removal. Over time, it is expected that the population will benefit from the canopy being more open and the Brazilian-pepper removed. That being said, it is possible that a direct hit to North Manasota Key by a major hurricane could impact the species. A major threat to aboriginal pricklyapples is human disturbance in the form of land clearing for development. Other stochastic events such as freezes may threaten aboriginal pricklyapples.

Recommendations: Include *Kalanchoe* removal and continue exotic pest plant removal at this site. Determine ownership status for the site. Monitor this population of aboriginal pricklyapples on an annual basis.

Sub unit: North Manasota Key Private Lot #2

Owner: Uncertain (presumed private)

Status: Present

Hurricane damage to plants: none observed

Hurricane damage to plant habitat: none

Background: On September 3, 2004, Woodmansee and Jimi L. Saddle saw a single individual of aboriginal pricklyapples at North Manasota Key Private Lot #2 (Bradley et al. 2004). Further details of accounts for this station are given by Bradley et al. (2004).

Site Re-visits: On February 14, 2006, Woodmansee and Mahoney surveyed the location provided in Bradley et al. (2004) and observed the same individual of aboriginal pricklyapples. This plant was healthy and possessed no indication of being damaged by the storm.

Site Description: Habitat of aboriginal pricklyapples at North Manasota Key Private Lot #2 would be maritime hammock, which in this case is bordered by coastal strand to the west and Manasota Key Rd. to the east. No impacts to habitat here were observed.

More site account data including plant associates may be obtained in Bradley et al. (2004).

A map of the location of the individual aboriginal pricklyapples at North Manasota Key Private Lot #2 is provided in Figure 4-10.

Possible causes for survival: It appears that this plant survived as it was well away from the gulf coast, and there appears to have been no storm surge across the island. This plant was sheltered from damaging wind by the surrounding maritime hammock habitat. It is still possible that a direct hit to North Manasota Key by a major hurricane could impact the species. A major threat to aboriginal pricklyapples is human disturbance in the form of land clearing for development. Other stochastic events such as freezes may threaten aboriginal pricklyapples.

Recommendations: Contact owner of property and create a land covenant to help protect this individual. Monitor this individual of aboriginal pricklyapples on an annual basis.

Final Discussion

Hurricane Charley was an extremely destructive storm, and at many sites, it appears that aboriginal pricklyapples, at least initially, was negatively impacted (in the form of mortality or plant breakage) by events attributed to Hurricane Charley. Despite this, it is good to see that all populations visited are extant. Fortunately, no illegal dumping or land clearing was observed at any of the populations. Other human induced mortality was observed at Manasota Beach Park as arson occurred in the vicinity of a few plants, killing at least one individual of aboriginal pricklyapples. It is possible, that over long term, hurricanes, in some ways, may actually benefit the aboriginal pricklyapples.

Anecdotal evidence and evidence at Bocilla Preserve suggest that aboriginal pricklyapples, like other *Harrisia*, may do best in partial sun conditions. Bradley et al. (2002) state that fire and overshadowing kill the closely related fragrant prickly-apple cactus (*Harrisia fragrans*), there is anecdotal evidence that suggests the same for aboriginal pricklyapples. Hurricanes open up tree canopy allowing some light to penetrate, thereby possibly creating the necessary conditions needed for aboriginal pricklyapples growth.

Appropriate habitat management at sites where this federal candidate species occurs is needed. These should include the removal of exotic pest plants and the closing off of these areas to human induced disturbances. Careful fire management should be conducted in fire adapted habitats surrounding aboriginal pricklyapples populations so as not to negatively impact them. Reducing canopy in areas where overshadowing exists should be considered. It is recommended that populations of aboriginal pricklyapples at Kitchen Key, GICIA Tract A, Buck Key, and Casperson Beach be surveyed for soon to verify its presence there after storms. Aboriginal pricklyapples occurrences should be monitored at a minimum, on an annual basis.

During the development of this report it was discovered that University of South Florida graduate student Alan Franck will be sampling various *Harrisia* throughout Florida to determine genetic relationships. This may impact the current status if all, or some, of the currently distinct species are found to be the same taxon, or even more separate taxa.

Acknowledgements

The authors wish to thank Josh M. Mahoney who assisted with field surveys. Jim Green of Lee County Parks and Recreation provided boat transportation to Bocilla Preserve, Cayo Pelau, and Cayo Costa State Park. We also thank the Florida Department of Parks and Recreation, Lee County Parks and Recreation, Sarasota County Parks and Recreation, Water Club Condominiums in Sarasota County, and Gulf Coast Heritage Inc. for granting us permission to access properties within the study area. Kirsten Hines assisted with edits and provided valuable advice on this report.

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Chapter 5 - Post-hurricane Field Assessment of Fragrant Prickly-Apple Cactus
(*Harrisia fragrans* Small ex Britton & Rose)

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Fragrant prickly-apple cactus at Canaveral National Seashore in Volusia County.
Steven W. Woodmansee, December 2006.

Table of Contents

Introduction	119
Methods	121
Results and Discussion	122
Final Discussion	148
Acknowledgements	148
Citations	149
Tables:	
Table 5-1: Fragrant prickly-apple cactus Study Area	124
Figures:	
Figure 5-1: <i>Harrisia fragrans</i> Study Area	120
Figure 5-2: <i>Harrisia fragrans</i> Occurrence Results	123
Figure 5-3: <i>Harrisia fragrans</i> at Canaveral National Seashore	127
Figure 5-4: <i>Harrisia fragrans</i> formerly at Dragon Point, Merritt Island	130
Figure 5-5: <i>Harrisia fragrans</i> formerly at Hutchinson Island South, St. Lucie County	132
Figure 5-6: The vicinity of the extirpated occurrence of <i>Harrisia fragrans</i> , 7 miles south of Melbourne Beach	134
Figure 5-7: <i>Harrisia fragrans</i> occurrence for Pine Island, Indian River County	138
Figure 5-8: <i>Harrisia fragrans</i> on private parcels near Savannas Preserve State Park	140
Figure 5-9: <i>Harrisia fragrans</i> on private parcels near Savannas Preserve State Park North end	141
Figure 5-10: <i>Harrisia fragrans</i> on private parcels near Savannas Preserve State Park South end	142
Figure 5-11: The vicinity of the extirpated occurrence of <i>Harrisia fragrans</i> at Sebastian Inlet area, Indian River County	145
Figure 5-12: Area surveyed for <i>Harrisia fragrans</i> at Pelican Island National Wildlife Refuge	146
Figure 5-13: Area surveyed for <i>Harrisia fragrans</i> at Sebastian Inlet State Park	147
Appendix 5-1: A History of the Taxonomy and Distribution of <i>Harrisia fragrans</i> Small ex Britton & Rose including discussion on <i>Harrisia simpsonii</i> ex Britton & Rose	151

Introduction

Fragrant prickly-apple cactus (*Harrisia fragrans*) is listed as endangered by the USFWS (2000) and by the Florida Department of Agriculture and Consumer Services (Coile and Garland 2003). It has been reported from several central-eastern coastal, Florida counties including Brevard, Indian River, St. Lucie and Volusia (Wunderlin and Hansen 2006). Before the 2004 hurricane season, extant populations of fragrant prickly-apple cactus were only known from Savannas Preserve State Park and adjacent private lands (Bradley et al. 2002).

In September 2004, hurricanes Jeanne and Frances's paths crossed the vicinity of the border between Martin and St. Lucie counties (Figure 5-1). Upon landfall, Hurricane Jeanne was ranked as a Category 3* and Hurricane Frances a Category 2*, both of which had substantial winds. Both hurricanes were sizable, and covered much of peninsular Florida. The impacts of these storms occurred as far north as Volusia County. Their damage to human property on these coastal areas was well known, and it was uncertain whether populations of fragrant prickly-apple cactus would have responded positively or negatively toward this hurricane event. It was surmised that populations could have been negatively impacted by wind induced breakage, tree falls, storm surge, and potentially illegal dumping on conservation lands.

Populations occurring at Savannas Preserve State Park are currently being studied and were not visited during these surveys (Hines and Bradley 2007). However, due to unverified reports, both recent and old, of additional populations of fragrant prickly-apple cactus from St. Lucie to Volusia counties, it was deemed necessary to survey these locations to verify these reports and determine hurricane impacts.

* on the Saffir-Simpson Hurricane Scale

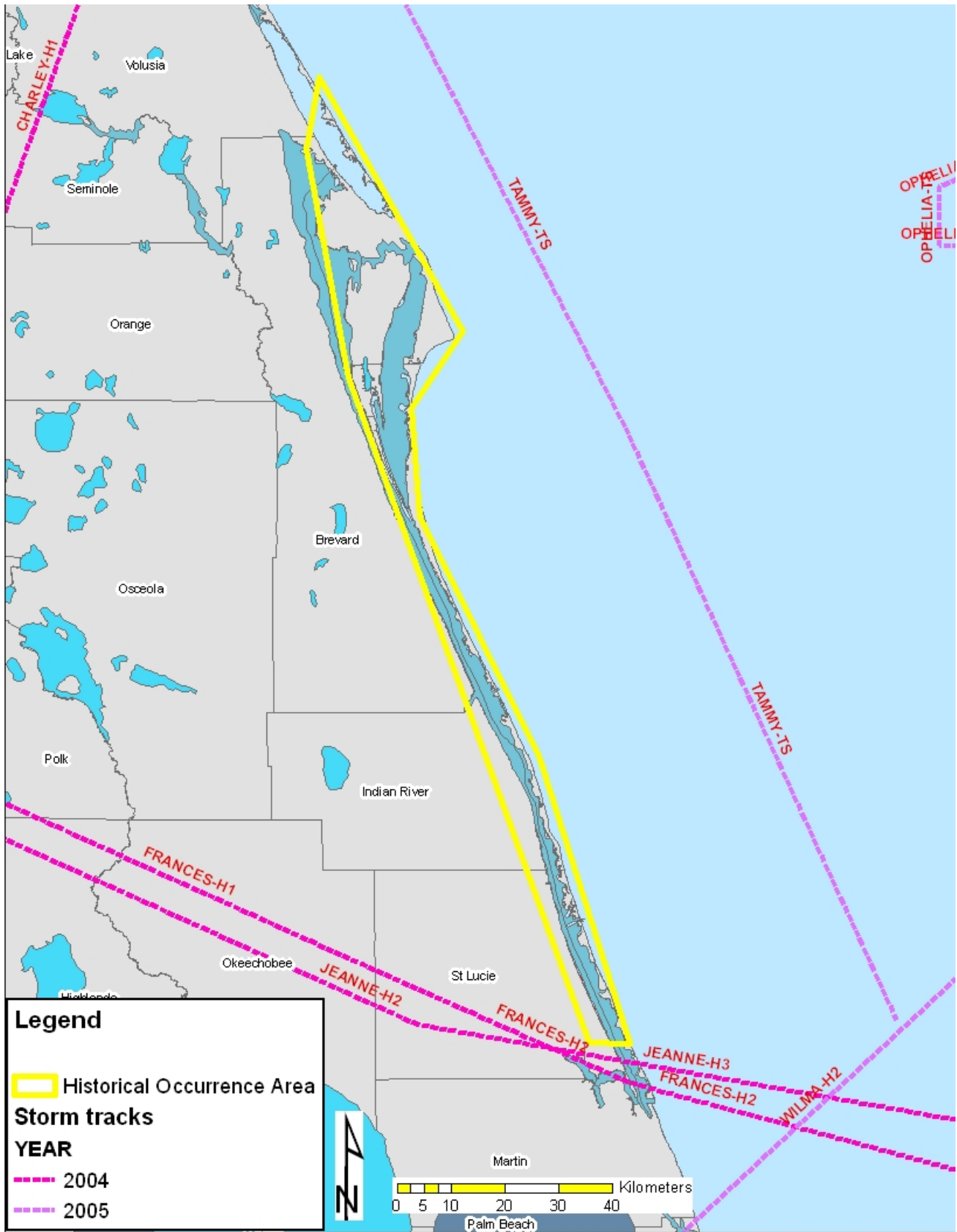


Figure 5-1: *Harrisia fragrans* Study Area

Methods

Preparation

It was decided to use Wunderlin and Hansen (2003) when verifying identity of fragrant prickly-apple cactus. For a discussion on taxonomy and distribution of fragrant-prickly apple cactus and the reasons why Wunderlin and Hansen (2003) was used refer to Appendix 5-1 at the end of this chapter.

Before field assessments were conducted for fragrant prickly-apple cactus, available literature (Britton and Rose 1920, Small 1927, Small 1932, Small 1933, Benson 1982, Austin 1984, Tropical BioIndustries Inc. 1985, Chafin 2000, USFWS 2000, Bradley et al. 2002, Schmalzer and Foster 2003, Ruder 2006), herbarium specimen data, and land managers were consulted with before field assessments were made. Surveys were focused on areas within the historical range of fragrant prickly-apple cactus as cited by Small 1933, Britton and Rose 1920, and Wunderlin and Hansen 2006. In October 2006, permission from land owners or land managers was requested. Two sites were visited before permission was obtained as at the time it appeared that the owners were untraceable. These properties included those at Dragon Point, Merritt Island and Pine Island, Indian River County and were visited and subsequently searched as neither property was posted at the time of the visits. Written permission was obtained before any visits were made to remaining sites.

Field Assessment

A search was conducted at each site that could be visited in the budgeted time. Shell mound, coastal berm, coastal strand, maritime hammock, scrub, xeric hammock or artificial spoil habitats were surveyed as was described by each report account (Small 1927, Tropical BioIndustries Inc. 1985, Ruder 2006, USFWS 2000, Personal Communication with Jim Burch and Jimi Sadle). Upon finding fragrant prickly-apple cactus, total number of plants was recorded, recruitment was noted, and habitat(s) following FNAI and FDNR (1992) were recorded, as well as species associates. Overall health of plants was recorded, and for those plants occurring at Canaveral National Seashore, elevation was estimated. It was decided that plants not be tagged for fear of human vandalism as was evidenced during the tagging and mapping of aboriginal prickly-apple cactus (*Harrisia aboriginum*) (see Chapter 4). However, an attempt was made to measure, monitor, and map individual plants.

Other than not tagging plants, methods in mapping and monitoring fragrant prickly-apple cactus followed those of Hines and Bradley (2007) in order to compare populations with those at Savannas Preserve State Park. Measurements recorded in the field for fragrant prickly-apple cactus included: total stem length in decimeters, number of stems, number of flowers and fruits per plant, and general plant health (e.g. plant yellowing, or herbivory/snail damage, etc.). Light availability was also recorded as either full sun (>90% sunlight), partial sun (10 – 90 % sunlight), or shade (<10 % sunlight).

In addition, hurricane damage was noted for the plants as well as the habitats. Hurricane damage to plants was ranked as none if there was no direct evidence of the events impacting specific individual plants. Hurricane damage to the plants was ranked as low if little damage to the plants (few branches broken, no mortality for the individual) was directly evidenced as a result of the storms. Hurricane damage to the plants was ranked as moderate if any branches or trunks were known to have fallen and damaged plants and poor health could be

attributed to the storm events. Hurricane damage to the plants was ranked as severe if mortality of the individual was observed to be directly attributed to the storms was observed.

Hurricane damage to the habitat was ranked as none for sites with no direct evidence of the events impacting the habitat. Hurricane damage to the habitat was ranked as low for areas with only a few tree falls and no storm surge (as would be indicated by a die off of the herb vegetation from salt water) surrounding the centroid. Hurricane damage to the habitat was ranked as moderate if there was notable tree falls within the habitat (>five trees) and no storm surge surrounding the centroid. Hurricane damage to the habitat was ranked as severe if major changes to the habitat (such as majority of canopy trees fell) and/or there was notable storm surge.

Data Entry

Survey data was entered and maintained in two geodatabases. The two geodatabases are linked by PointID fields. The GIS geodatabase entitled USFWS_HURSUR_MDB contains coordinate data (in NAD 83 UTM 17N format), Site, Subunit, Associated Taxa, Habitat, Occurrence, and PointID. The second geodatabase entitled USFWS_HURSUR_Datasets contains survey data and was created in Microsoft Access and is linked to the geodatabase by the PointID number. The primary table in this database, which contains one record for each PointID linked by Surveyors and Date, contains all pertinent data from the survey also including Event Number, Comments1, Comments 2, Plant Number, Population Estimate, Site, Site Unit, and Occurrence.

Results and Discussion

Site Visit Prioritization

All sites correctly reported¹ to contain *Harrisia* were visited including: Canaveral National Seashore, Dragon Point (on Merritt Island), Pine Island in Indian River County, the Melbourne Beach area, the Sebastian Inlet area in Indian River County, and Hutchinson Island South in St. Lucie County. In conjunction with surveys for *Dicerandra immaculata* var. *savannarum* (Chapter 3), fragrant prickly-apple cacti were also mapped in the vicinity of Savannas Preserve State Park. Occurrence areas are mapped in Figure 5-2.

Four populations were found to be extant (including Savannas Preserve State Park), three populations are considered to be extirpated, one population's status is uncertain and it is listed as reported as more surveys are needed to verify the occurrence (Table 5-1).

¹ See Appendix 5-1 for explanation of reports deemed to be correct by authors.

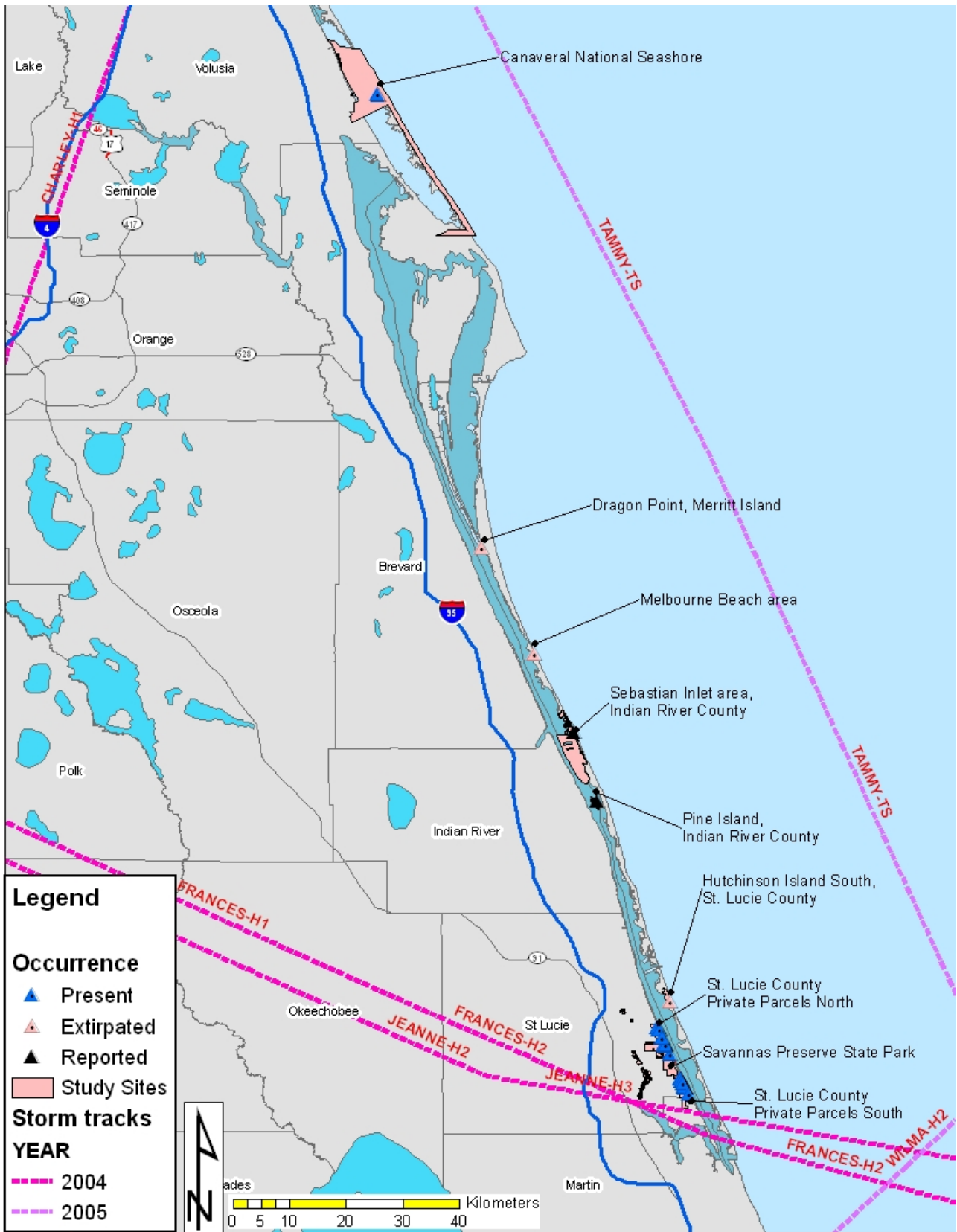


Figure 5-2: *Harrisia fragrans* Occurrence Results

Table 5-1: Fragrant prickly-apple cactus Study Area

Occurrence #	Site Name	Status	Number of Plants in 2006	Hurricane Damage to Habitat	Hurricane Damage to Plants			
1	Canaveral National Seashore, Volusia County	P	96	None	None observed			
2	Dragon Point, Merritt Island	E	0	None	None observed			
3	Hutchinson Island South, St. Lucie County	E	0	Low	None observed			
4	Melbourne Beach area	E	0	None	None observed			
5	Pine Island, Indian River County	P	1	Moderate	None observed			
6	Private Parcels surrounding Savannas Preserve State Park, St. Lucie County	P	62	Moderate	Low			
Unverified	Sebastian Inlet area, Indian River County	R	0	Low	None observed			
<table border="1"> <tr> <td>E = Extirpated (not observed during these surveys or in the past 20 years)</td> </tr> <tr> <td>R = Reported (not verified during these surveys)</td> </tr> <tr> <td>P = Present</td> </tr> </table>						E = Extirpated (not observed during these surveys or in the past 20 years)	R = Reported (not verified during these surveys)	P = Present
E = Extirpated (not observed during these surveys or in the past 20 years)								
R = Reported (not verified during these surveys)								
P = Present								

Accounts of sites surveyed for fragrant prickly-apple cactus are primarily arranged by accepted occurrences followed by reported occurrences. Accounts of each occurrence are detailed in the following sections. An account for Savannas Preserve State Park is left out of this report as much has been well documented and ongoing studies of the population continue (Bradley et al. 2002, Hines and Bradley 2007)

Fragrant prickly-apple cactus Occurrences

Occurrence 1: Canaveral National Seashore, Volusia County

Owner: National Park Service

Status: Present

Hurricane damage to plants: none observed

Hurricane damage to plant habitat: none

Background: Schmalzer and Foster (2003) summarized events up to 2002 in the following quote:

“Norman (1976) reported *Harrisia fragrans* from Turtle Mound in southern Volusia County as did Poppleton (1981), but Norman and Hawley (1995) reported that *H. simpsonii* was eliminated from Turtle Mound by freezes since the original study, indicating that the taxon originally reported should have been *H. simpsonii*.”

Norman summarizes her observations of the population at Turtle Mound (email correspondence with Keith Bradley on August 2, 2007). Norman sent specimens to Lyman Benson who identified it as *Harrisia fragrans*. She also reports that fruits were reddish. Later, as a result with conversing with Dan Austin, she redetermined this population to have been *Harrisia simpsonii*. The population at Turtle Mound consisted of a single plant that disappeared after the freezes of the 1980's, and despite searches was not found again. Schmalzer and Foster (2003) surveyed this station and other stations at Canaveral National Seashore with National Park Service biologist, John Stiner in 2002-2003 and found no plants. National Park Service biologists Jim Burch, Jimi L. Sadle, and Stiner surveyed the northwest part of Turtle Mound for *Harrisia* on March 21, 2006. No plants were observed.

On March 21, 2006, a species of *Harrisia* was found at a station four km southeast of Turtle Mound by Burch, Sadle, and Stiner. They reported three sterile plants on a large shell mound with a canopy dominated by false mastic (*Sideroxylon foetidissimum*) close to the Mosquito Lagoon. A GPS centroid was recorded.

Site Re-visits: On December 2, 2006, Woodmansee and Sadle surveyed the surrounding area. A population estimate of greater than 40 plants, mostly consisting of large adults, were found along a 210 m stretch along shell mound habitat 95 meters to the south of the original population on the east side of Mosquito Lagoon. Most plants were healthy and robust. Plants were keyed out and identified as fragrant prickly-apple cactus based upon trichomes of the areoles on the hypanthium measuring 12 – 15 mm. This was later made into a partial specimen (Woodmansee, 1998, NPS repository at FTG permit #CANA 000-45). In addition, only red spherical fruits were observed at this population, and the longest spine in each cluster measured greater than 3 cm. No hurricane damage to plants and no dead plants were observed.

On March 23, 2007, Woodmansee and Sadle returned to the site after obtaining a plant collecting permit from Canaveral National Seashore in order to better document this station. This station was visited before dawn in hopes of finding fresh flowers. Although fruits and buds were present, no blooms were observed, so no collection was made. Later that morning, Woodmansee and Sadle mapped a total of 96 plants using a GPS with submeter accuracy. The dataset was unfortunately incomplete due to errors in data recording in the field. Nonetheless, these partial data are provided in an accompanying geodatabase.

Upon first visiting the plants at the northern end of the population it appeared that soils had been scraped. However, it may have been erosion, possibly from hurricanes, no other hurricane damage was observed for the site.

It seems likely that the plants from Turtle Mound are the same species as those found at the new station. As was discussed earlier, taxonomy regarding these two taxa is much disputed. Here they are treated as fragrant prickly-apple cactus sensu Wunderlin and Hansen (2003).

Site Description: Fragrant prickly-apple cactus was growing on a large band of shell mound (0.5 – 2 m elevation). Soil consisted of a shelly substrate with only a light layer of humus or bare soil. Most adults were in healthy shape and in partial to full sun. Many adults also had several large fruits. In addition a large population of the state endangered West Indian cock's comb (*Celosia nitida*) was also encountered. **No hurricane damage to plant habitat was observed.**

Associate plant taxa within one meter of fragrant prickly-apple cactus included: torchwood (*Amyris elemifera*), bird pepper (*Capsicum annuum* var. *glabriusculum*), Simpson's stopper (*Myrcianthes fragrans*), false mastic, Paintedleaf (*Poinsettia cyathophora*), limber caper (*Capparis flexuosa*), Florida privet (*Forestiera segregata*), hammock snowberry (*Chiococca alba*), wildlime (*Zanthoxylum fagara*), white stopper (*Eugenia axillaris*), coral bean (*Erythrina herbacea*), buttonwood (*Conocarpus erectus*), saltmarsh-elder (*Iva frutescens*), erect pricklypear (*Opuntia stricta*), sea oxeye daisy (*Borrchia frutescens*), Spanish moss (*Tillandsia usneoides*), and West Indian cock's comb. Three exotic plant species were also recorded next to fragrant prickly-apple cactus and include: Brazilian-pepper (*Schinus terebinthifolius*), Guinea grass (*Panicum maximum*), and Crow's foot grass (*Dactyloctenium aegyptium*).

A map of the population of fragrant prickly-apple cactus at Canaveral National Seashore is provided in Figure 5-3.

Possible threats: Stochastic events such as major hurricanes and freezes may threaten fragrant prickly-apple cactus, as freezes have been attributed to extirpating the population on Turtle Mound (Norman and Hawley 1995). In addition, during surveys by Woodmansee and Sadle, a gas powered soil tiller was detected next to the population, suggesting archaeological looters. This was immediately reported to the park rangers, who are keeping a close watch on the area now. Many plants are in open view from the water, especially those to the south, and it is possible that boaters could impact this population due to soil erosion caused by

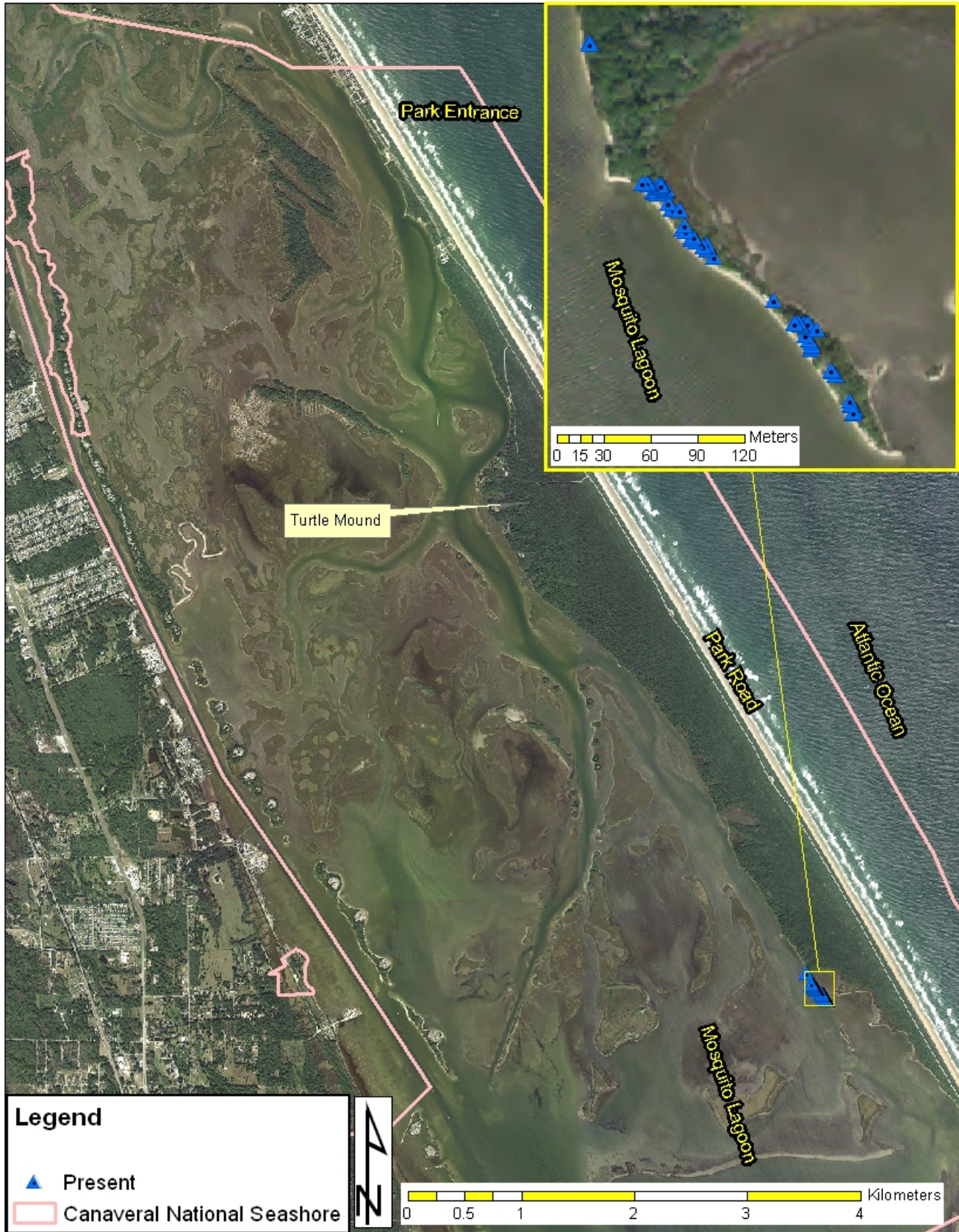


Figure 5-3: *Harrisia fragrans* at Canaveral National Seashore

speeding boats, and possibly recreational activities along the littoral zone. Sea-level rise also threatens plants and their habitat.

Recommendations: Exotic pest plant removal at the site. Consider establishing an ex situ population of germplasm from this population. Continue surveys at this location on an annual basis and after stochastic events.

Occurrence 2: Dragon Point, Merritt Island

Owner: Private

Status: Extirpated

Hurricane damage to plants: none observed

Hurricane damage to plant habitat: none

Background: In the winter of 1922, Small (1927) observed fragrant prickly-apple cactus on the southern tip of Merritt Island, what is today named Dragon Point, named after a large concrete sculpture of a dragon that once existed there. Small describes the habitat for which fragrant prickly-apple cactus was found as a coquina rock formation possessing century plants (*Agave decipiens*, *A. neglecta*), Spanish bayonet (*Yucca aloifolia*), wild-lime (*Zanthoxylum fagara*), prickly pears (*Opuntia stricta*), barbwire cactus (*Acanthocereus tetragonus*), white indigoberry (*Randia aculeata*), and saffron-plum (*Sideroxylon celastrinum*).

Site Re-visit: On December 2nd, 2006, Woodmansee and Sadle surveyed Merritt Island along SR 3 south of King Street. Upon arrival to the area known as Dragon Point, Woodmansee and Sadle surveyed habitat along an unposted private road and an abandoned property at the southern tip of Merritt Island. South of the house, a rundown boardwalk exists along the very narrow (5 – 10 m wide) rocky spit of land that Small (1927) described. Despite searches no fragrant prickly-apple cactus, alive or dead, was found.

Site Description: Habitat that exists here, although disturbed, is perhaps unique to this region of Florida. Soil consisted of solid coquina limestone, with little humus. Much native vegetation remained including: blolly (*Guapira discolor*), century plant (*Agave decipiens*), cabbage palm (*Sabal palmetto*), pigeon-plum (*Coccoloba diversifolia*), Florida privet (*Forestiera segregata*), gumbo-limbo (*Bursera simaruba*), limber caper (*Capparis flexuosa*), Spanish bayonet (*Yucca aloifolia*), saltgrass (*Distichlis spicata*), sea-oxeye daisy (*Borrchia frutescens*), buttonwood (*Conocarpus erectus*), yellow joyweed (*Alternanthera flavescens*), and common fingergrass (*Eustachys petraea*). Exotic plants observed there included: life plant (*Kalanchoe pinnata*), Devil's backbone (*K. daigremontiana*), crowfoot grass (*Dactyloctenium aegyptium*), Mauritius-hemp (*Furcraea foetida*), shrub verbena (*Lantana camara*). The habitat consists of a shortened canopy (2 – 3 m), and is fairly sparse. No damage to plant habitat was observed.

A map of the extirpated occurrence of fragrant prickly-apple cactus at Dragon Point, Merritt Island is provided in Figure 5-4.

Possible Cause for Disappearance: It seems that the primary cause for the disappearance of fragrant prickly-apple cactus is habitat alteration and destruction. As some of the original vegetation remains on portions of Dragon Point, it is possible that past freezes may have caused the extirpation of fragrant prickly-apple cactus.

Recommendations: Consider acquiring southernmost private parcel and reintroduce fragrant prickly-apple cactus there.

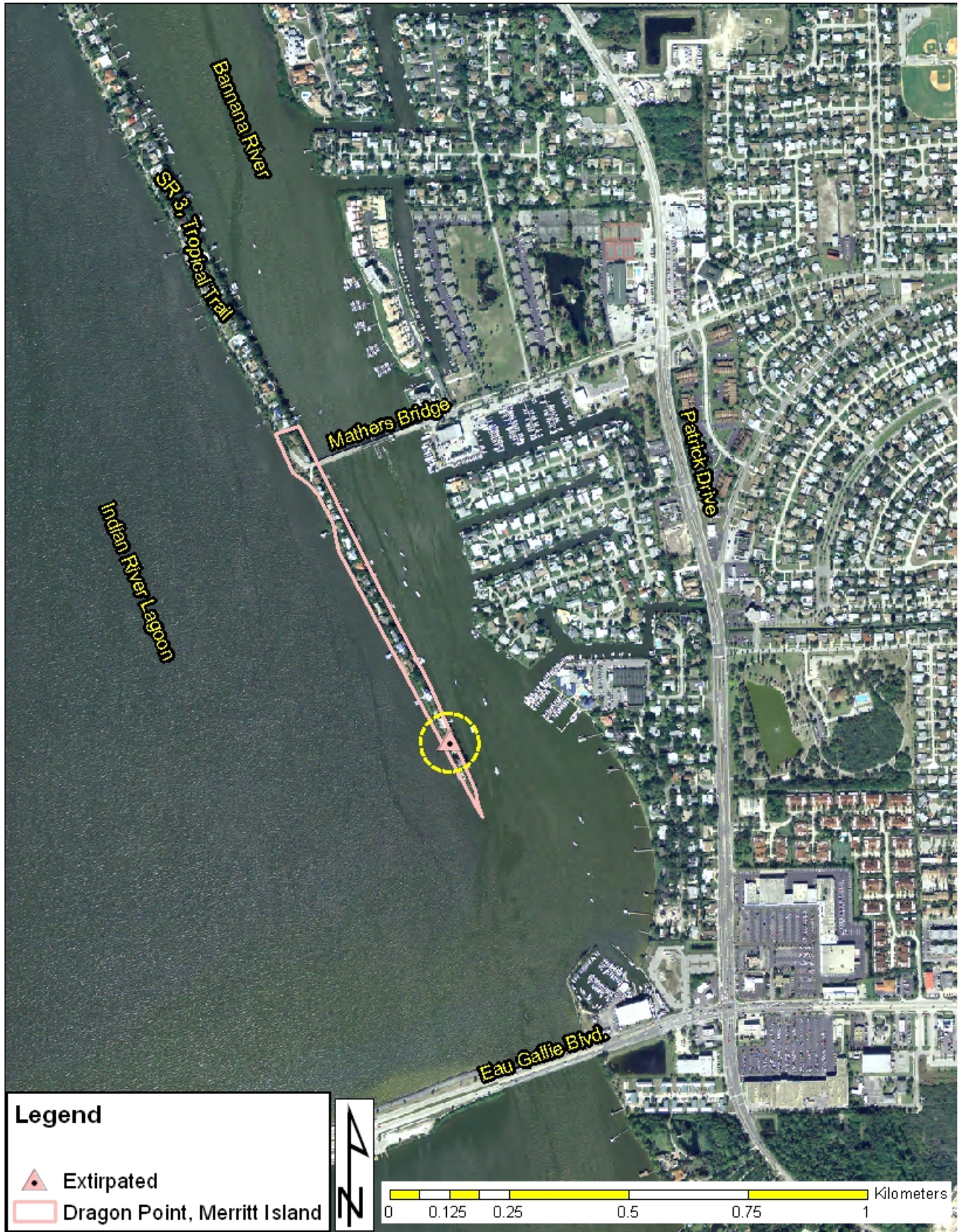


Figure 5-4: *Harrisia fragrans* formerly at Dragon Point, Merritt Island

Occurrence 3: Hutchinson Island South, St. Lucie County

Owner: Uncertain, possibly St. Lucie County

Status: Extirpated

Hurricane damage to plants: none observed

Hurricane damage to plant habitat: low

Background: William L. McCart collected fragrant prickly-apple cactus in 1969 on “fore dune” at a station off of highway A1A 15 miles north of Stuart, Florida (#11289, FTG).

Site Re-visit: On August 5th, 2007, the vicinity of the location of McCart’s collection of *Harrisia fragrans* was surveyed by John Bradford. Bradford visited the St. Lucie County-owned John Brooks Park which occurs exactly 15 miles north of where Ocean Blvd. (just east of downtown Stuart) meets South Ocean Dr. (A1A). Coastal strand dominated by seaoats (*Uniola paniculata*), baybean (*Canavalia rosea*), and beachgrass (*Panicum amarum*) was surveyed by Bradford. No other upland habitats existed there, and no plants, alive or dead, were observed.

Site Description: Original habitat for this station appears to have been coastal strand. No species associates were listed on the herbarium label of McCart’s collection (#11289, FTG). Hurricane damage was determined to be low. Little hurricane damage directly attributed to the coastal strand was observed, however, beach dune habitat appeared to have been eroded.

A map of the vicinity of the extirpated occurrence of fragrant prickly-apple cactus at the Melbourne Beach area is provided in Figure 5-5.

Possible Cause for Disappearance: It is unknown why fragrant prickly-apple cactus is no longer at this station. Coastal strand is a fairly unusual habitat for this species of *Harrisia*, although *Harrisia aboriginum* grows in coastal strand on the west coast of Florida (see Chapter 4). The habitat at the original collection may have degraded, or the population of fragrant prickly-apple cactus may have disappeared due to stochastic events such as fire, which apparently kills fragrant prickly-apple cactus (Bradley et al. 2002). Fragrant prickly-apple cactus may occur in other parts of Hutchinson Island South that were not surveyed during this project.

Recommendations: Continue surveys in other parts of Hutchinson Island South.

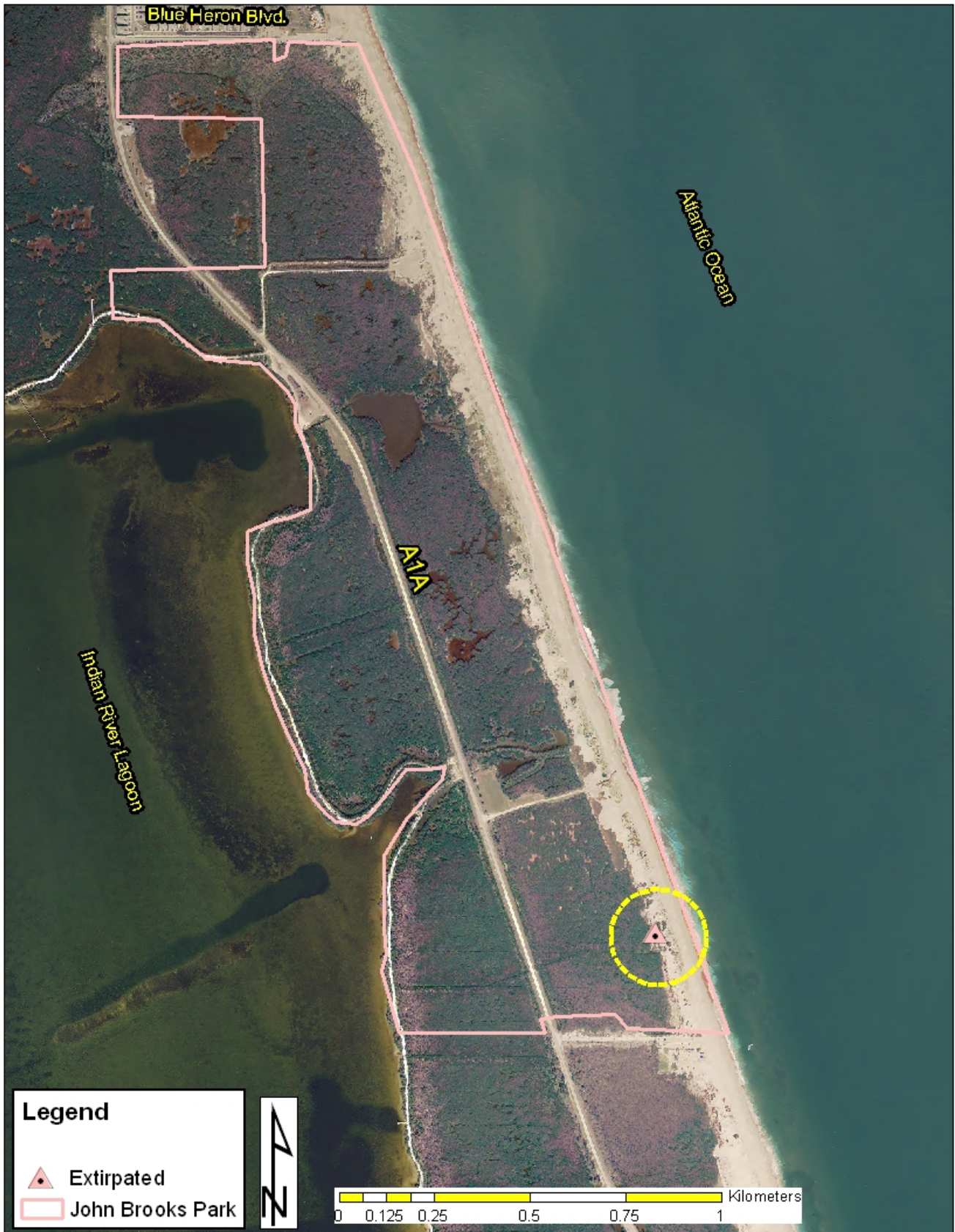


Figure 5-5: *Harrisia fragrans* formerly at Hutchinson Island South, St. Lucie County

Occurrence 4: Melbourne Beach Area, Brevard County

Owner: Private

Status: Extirpated

Hurricane damage to plants: none observed

Hurricane damage to plant habitat: none

Background: USFWS (2000) reports that Poppleton (1981) discovered a population of five to eight plants at a site in Brevard County north of the Sebastian Inlet. Schmalzer and Foster (2003) report a collection of Simpson's prickly-apple cactus (*Harrisia simpsonii*) 6.3 miles north of the Sebastian Inlet made by J.E. Poppleton and A.G. Shuey (#M1822, FTU) on July 26, 1975. A year later Poppleton redetermined this specimen to be fragrant prickly-apple cactus. It is thought that the specimen in Poppleton (1981) is the same station. Poppleton and Shuey (#M1822, FTU) describe the habitat as "disturbed area of coastal scrub vegetation on the west side of A1A". Schmalzer and Foster (2003) reviewed this specimen and confirmed this identification based upon the trichomes on the areoles of the hypanthium measuring 10 mm. This morphological characteristic is very close to the upper range of trichome characteristics for Simpson's prickly-apple cactus in some taxonomic treatments. Schmalzer and Foster (2003) surveyed the area of this collection and found no plants. Ruder (2006) reports that an individual *Harrisia* obtained from an area near the above station (7 miles south of Melbourne Beach) had been rescued from destruction by an unknown friend of Mrs. Eleanor Redding, who was in possession of this cactus. Plants were studied by Ruder (2006) who believed them to be fragrant prickly-apple cactus. Photographs of fragrant prickly-apple cactus from Ruder (2006) were examined by Woodmansee and Bradley, and floral characteristics appeared to align with fragrant prickly-apple cactus.

Site Re-visit: The vicinity of the location described by Schmalzer and Foster (2003) and later Ruder (2006) was searched by Woodmansee and Sadle on March 22, 2007. Habitat described by Poppleton and Shuey (#M1822, FTU) was searched for, in addition to coastal strand and hammock communities, however much of the area was now developed. *Harrisia* plants were searched for at other areas to the south, including Sebastian Inlet State Park and Pelican Island National Wildlife Refuge, without success. No plants, alive or dead, were observed.

Site Description: Original habitat for this station is uncertain, as disturbed coastal scrub could be interpreted as several habitats. No species associates were listed on the herbarium label of Poppleton and Shuey's collection (#M1822, FTU). No hurricane damage to habitat listed for the fragrant prickly-apple cactus was observed. A map of the vicinity of the extirpated occurrence of fragrant prickly-apple cactus at the Melbourne Beach area is provided in Figure 5-6.

Possible Cause for Disappearance: It seems that the primary cause for the disappearance of fragrant prickly-apple cactus is habitat alteration and destruction.



Figure 5-6: The vicinity of the extirpated occurrence of *Harrisia fragrans*, 7 miles south of Melbourne Beach

Recommendations: Fortunately, the germplasm from this original population is still extant, so there is potential for reintroduction to a preserve nearby the original collection. Areas for possible consideration include: Maritime Hammock Sanctuary, Washburn Cove Sanctuary, and Hog Point Sanctuary, all managed by Brevard County.

Occurrence 5: Pine Island, Indian River County

Owner: Private (Lost Tree Village Corporation)

Status: Present

Hurricane damage to plants: none observed

Hurricane damage to plant habitat: moderate

Background: Fragrant prickly-apple cactus was tentatively identified at Pine Island, Indian River County by Dr. Martin Roessler (Tropical BioIndustries Inc. 1985). Roessler reports seeing a colony of plants growing in spoil along a levee near Second Bay in the far northeast corner of the tract (Figures 5-11 and 5-12). Plants found in association with fragrant prickly-apple cactus included: erect pricklypear (*Opuntia stricta*), Carolina sealavender (*Limonium carolinanum*), white stopper (*Eugenia axillaris*), hammock snowberry (*Chiococca alba*), strangler fig (*Ficus aurea*), and Florida privet (*Forestiera segregata*) (Tropical BioIndustries Inc. 1985). Exotics noted for this report included Brazilian-pepper (*Schinus terebinthifolius*) (Tropical BioIndustries Inc. 1985). In 1985, Durbin Tabb collected a piece of this *Harrisia* from this station and gave it to Dr. John Popenoe of Fairchild Tropical Botanic Garden (FTBG). This plant was accessioned at FTBG (FG 85-160) for cultivation there. Popenoe later made an herbarium specimen when the cultivated *Harrisia* flowered (#2411, FTG) and he determined it to be fragrant prickly-apple cactus. In August 2007, The Institute for Regional Conservation biologist Steve Green examined the herbarium specimen at FTG. He reported that hairs surrounding the scales of the flowering tube measured 11-12 mm, and that the shape of the apex of the petals was indeterminate. Despite lack of confirmation of the petal shape, the hairs surrounding the scales of the flowering tube align with morphological characteristics of fragrant prickly-apple cactus (Wunderlin and Hansen 2003).

Site Re-visit: On November 30, 2006, Woodmansee and Sadle surveyed Roessler's station on Pine Island. Mosquito control ditch roads were surveyed primarily on the eastern side of Pine Island. A single sterile plant of *Harrisia* was observed in coastal berm habitat. This plant was growing in partial shade and possessed two stems measuring 0.6 dm and 1.9 dm. This plant possessed the single spine longer than the remainder of the cluster, characteristic of fragrant prickly-apple cactus as mentioned in Chafin (2000) and USFWS (2000) and it is presumed to be so based upon other plants collected at the site. No plants were observed on the levee adjacent to Second Bay. No significant hurricane damage directly attributed to the plant was observed. No dead plants were observed.

Site Description: Coastal berm habitat, east of the mosquito control ditch road, just west of First Bay, 270 meters south of the mosquito road gate near Seacrest Dr. terminus. Soils consisted of sand with a rich layer of humus. Coastal berm habitat was moderately impacted by hurricanes. Some limbs of live oak trees (*Quercus virginiana*) were broken and lying on the ground. In addition, tidal wash was noticeable here as there were many red mangrove (*Rhizophora mangle*) seedlings growing in the coastal berm habitat.

Plants found within one meter of fragrant prickly-apple cactus included: white stopper, live oak, limber caper (*Capparis flexuosa*), torchwood (*Amyris elemifera*), white indigo berry (*Randia aculeata*), and cabbage palm (*Sabal palmetto*). Exotic plants within one meter included Brazilian-pepper. Other plants found in the coastal berm habitat included: blolly (*Guapira discolor*), marlberry (*Ardisia escallonoides*), gumbo limbo (*Bursera simaruba*), black ironwood (*Krugiodendron ferreum*), golden polypody (*Phlebodium aureum*), resurrection fern (*Pleopeltis polypodioides* var. *michauxiana*), Spanish moss (*Tillandsia usneoides*), ball moss (*T. recurvata*), erect pricklypear, and swamp flatsedge (*Cyperus ligularis*).

A map of the population of fragrant prickly-apple cactus at Pine Island, Indian River County is provided in Figure 5-7.

Possible threats: The primary threat to fragrant prickly-apple cactus at this station is development and habitat destruction. Secondly, exotic invasive plants, especially Brazilian-pepper threatens the plant and its habitat. Stochastic events such as major hurricanes and freezes may threaten this fragrant prickly-apple cactus here, especially since only one was observed. Sea-level rise is a likely threat as elevation appeared to be around one meter.

Recommendations: Resurvey location to verify the identity of the plant in question. Continue surveys along remaining mosquito ditches on the southern end of Pine Island, Indian River County. Consider acquiring Pine Island tract, Indian River County. Determine status of Fairchild Tropical Botanic Garden ex situ population of plants from this station.



Figure 5-7: *Harrisia fragrans* occurrence for Pine Island, Indian River County

Occurrence 6: St. Lucie County Private Parcels (near Savannas Preserve State Park)

Owners: Private

Status: Present

Hurricane damage to plants: low

Hurricane damage to plant habitat: moderate

Background: Bradley et al. (2002) document the population of fragrant prickly-apple cactus at Savannas Preserve State Park to be in excess of 2,200 plants. Ongoing studies of fragrant prickly-apple at Savannas Preserve State Park by The Institute for Regional Conservation staff continue (Hines and Bradley 2007). Although fragrant prickly-apple cactus was known to occur on private properties adjacent to Savannas Preserve State Park, to what extent was not known.

Sites Re-visits: Populations of fragrant prickly-apple cactus were searched for on foot by Green and Mahoney on August 8-9, 2006 and by Barry on March 23, April 1, and May 3-4, 2007. Details of how areas were selected and how owners were contacted are further discussed in Chapter 3. A total of 62 plants, many in fruit, were found on 14 privately owned parcels. Plants were mapped and data recorded. Hurricane damage was low as of the 62 plants recorded, only one was observed to have had hurricane damage attributed to it. This dataset is provided in an accompanying geodatabase.

Site Description: Fragrant prickly-apple cactus occurs in patches along a band of parcels west of Indian River Drive, and east of the railroad tracks. The southern end of the occurrence starts less than 500 meters north of the Martin/St. Lucie County border and continues over 13 km north to just south of Midway Road. Fragrant prickly-apple plants predominantly occur on the western side of the private parcels surveyed. Habitats found to contain fragrant prickly-apple cactus include scrub, disturbed upland, and xeric hammock. Maps of the populations of fragrant prickly-apple cactus at St. Lucie County Private Parcels are provided. Figure 5-8 is an overview of all mapped plants. Figures 5-9 and 5-10 provide close-ups of the mapped plants and are arranged north to south.

Hurricane damage observed in habitats of fragrant prickly-apple cactus was moderate, consisting of broken limbs on trees and house debris. Of interesting note, at Savannas Preserve State Park, a single death of a fragrant prickly-apple cactus could be directly attributed to hurricanes. A shed door blown off a building nearby was observed covering and killing the individual.

Possible threats: The primary threat to fragrant prickly-apple cactus on these private parcels is development and habitat destruction. Secondly, stochastic events such as major hurricanes and freezes may threaten fragrant prickly-apple cactus. Sea-level rise is not a likely threat to these populations as the elevation here is greater than two meters.



Figure 5-8: *Harrisia fragrans* on private parcels near Savannas Preserve State Park

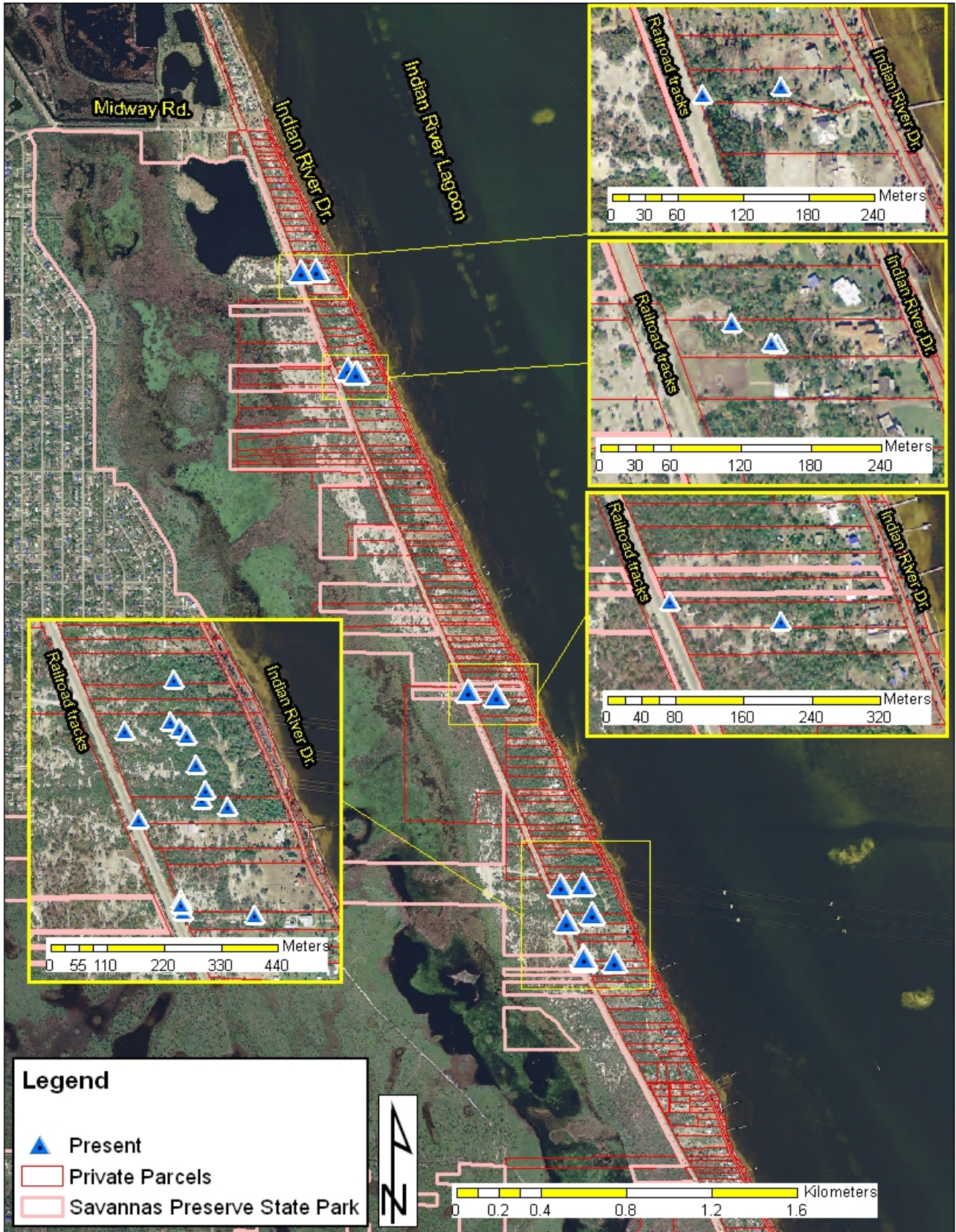


Figure 5-9: *Harrisia fragrans* on private parcels near Savannas Preserve State Park North end

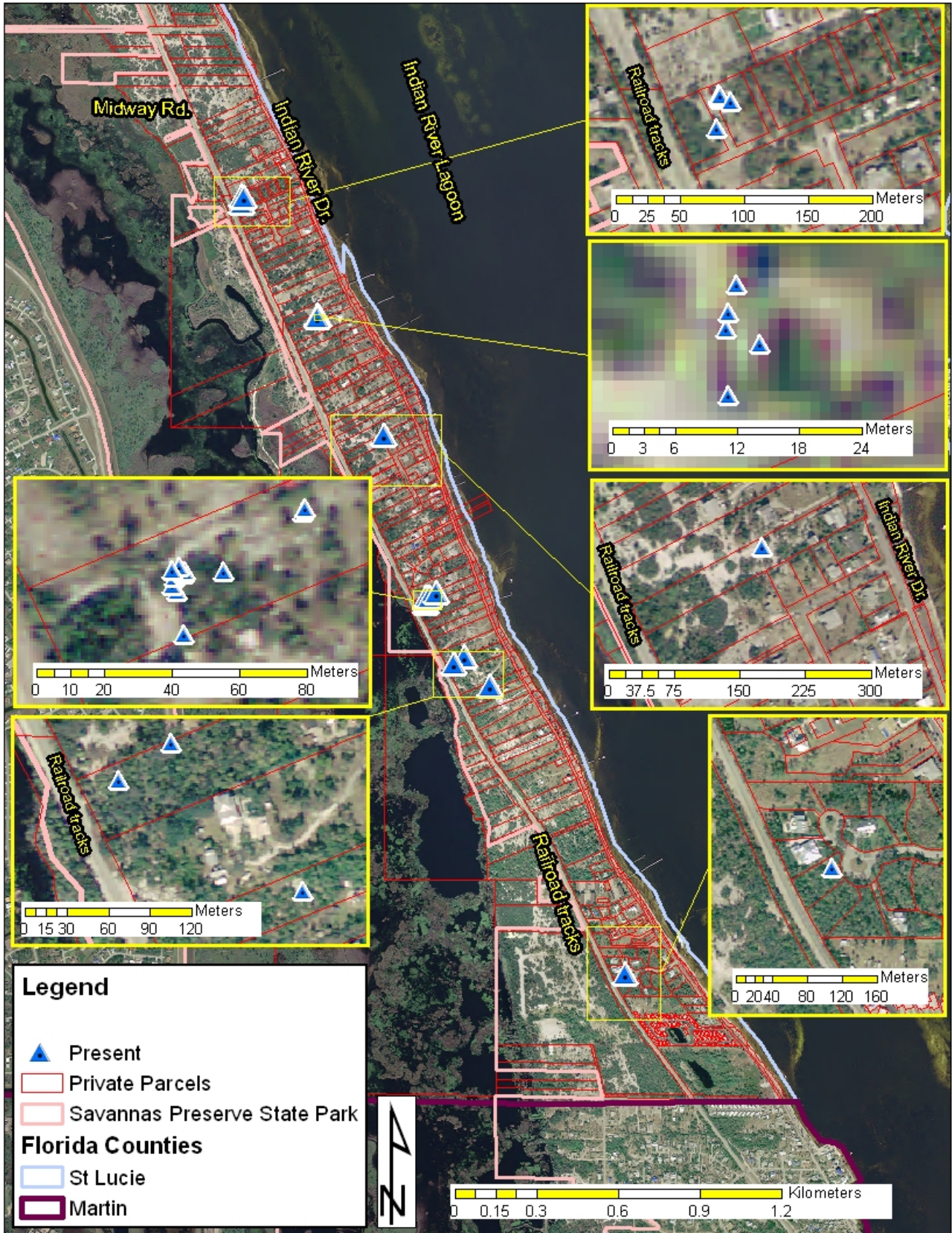


Figure 5-10: *Harrisia fragrans* on private parcels near Savannas Preserve State Park South end

Recommendations: Develop agreements with private land owners to preserve plants of fragrant prickly-apple cactus and their surrounding habitat. Monitor existing populations and conduct surveys for more plants at this location on an annual basis and after fires.

Possible Occurrence: Sebastian Inlet area, Indian River County

Owner: Uncertain

Status: Reported

Hurricane damage to plants: none observed

Hurricane damage to plant habitat: low

Background: Fragrant prickly-apple cactus was reported by Poppleton (1981 in USFWS 2000) for Indian River County just south of Brevard County.

Site Re-visit: On March 22, 2007, Woodmansee and Sadle surveyed portions of Pelican Island National Wildlife Refuge and Sebastian Inlet State Park near Poppleton's station. Woodmansee and Sadle were not aware of the Poppleton station at the time of these surveys, however, based upon the range of fragrant prickly-apple cactus, it was thought appropriate to survey nearby habitats including levees, coastal berm, and maritime hammock at Pelican Island National Wildlife Refuge and Sebastian Inlet State Park. No hurricane damage to fragrant prickly-apple cactus was observed as no plants, alive or dead, were found.

Site Description: It is uncertain what the original habitat for Poppleton's (1981) station of fragrant prickly-apple was. It is hopeful that this report, which is listed as in the files of the USFWS Vero Beach Office (USFWS 2000), may contain specific location data and a description of the plants and their habitat.

Pelican Island National Wildlife Refuge habitat surveyed consisted mostly of levees within tidal swamp habitat and the area along Jungle Trail within the Refuge. There was a portion of maritime hammock near the parking area at the northern side of the preserve that was also searched. Sebastian Inlet State Park habitat surveyed consisted of a large section of maritime hammock, as well as levees within tidal swamp habitat and coastal berm along the Indian River Lagoon, all north of the Sebastian Inlet in Brevard County. Hurricane damage directly attributed to the habitats was low consisting of some broken limbs from canopy trees.

Maps of the general reported location of fragrant prickly-apple cactus at Sebastian Inlet area, Indian River County and of the areas surveyed at Pelican Island National Wildlife Refuge and Sebastian Inlet State Park are provided in Figures 5-11, 5-12, and 5-13.

Recommendations: Using Poppleton (1981) as a guide, continue surveys in appropriate habitat at Sebastian Inlet State Park and Pelican Island National Wildlife Refuge.

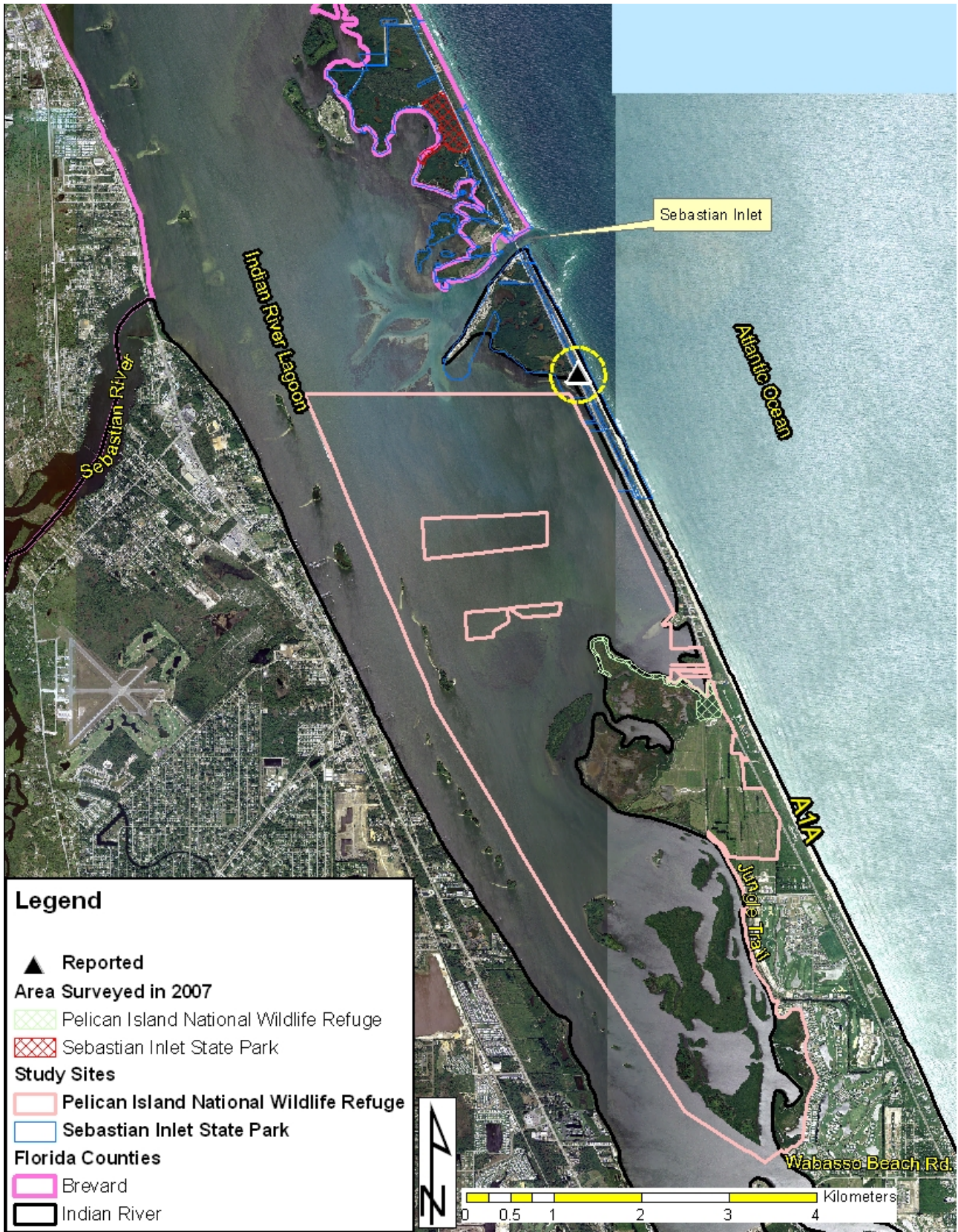
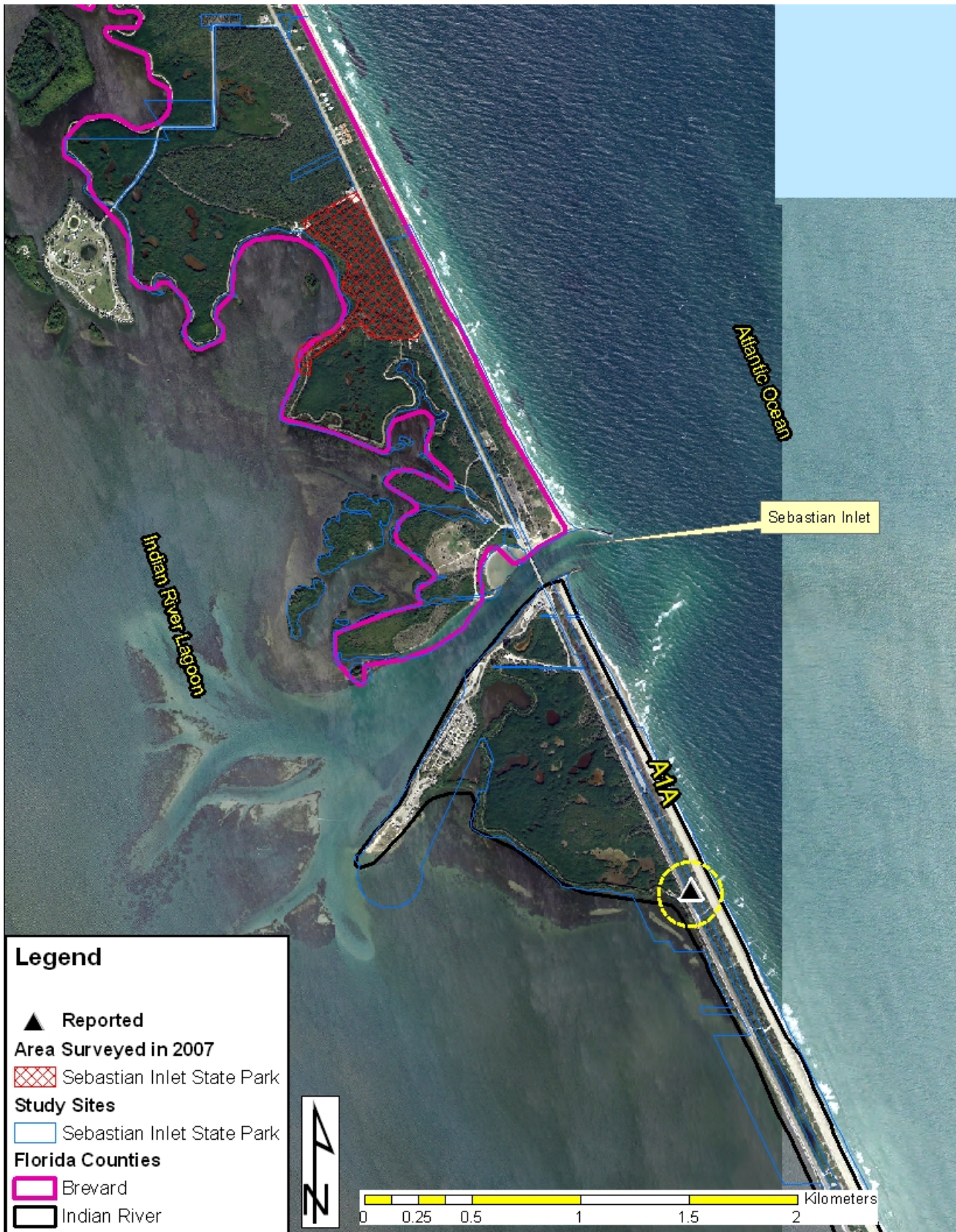


Figure 5-11: The vicinity of the extirpated occurrence of *Harrisia fragrans* at Sebastian Inlet area, Indian River County



Figure 5-12: Area surveyed for *Harrisia fragrans* at Pelican Island National Wildlife Refuge



Legend

- ▲ Reported
- Area Surveyed in 2007
- ▨ Sebastian Inlet State Park
- Study Sites**
- Sebastian Inlet State Park
- Florida Counties**
- ▭ Brevard
- ▭ Indian River

Figure 5-13: Area surveyed for *Harrisia fragrans* at Sebastian Inlet State Park

Final Discussion

It appears that fragrant prickly-apple cactus was not necessarily negatively impacted by events attributed to hurricanes. Fortunately, no illegal dumping was observed at any of the populations, which may have been an issue for those private parcels near Savannas Preserve State Park. It is possible, that over the long term, hurricanes may actually benefit the species. It seems that fragrant prickly-apple cactus may do best in partial sun conditions (Bradley et al. 2002). Bradley et al. (2002) also state that fire and overshading kill fragrant prickly-apple cactus. Hurricanes open up tree canopy allowing some light to penetrate, thereby creating the necessary conditions needed for fragrant prickly-apple cactus growth.

Fragrant prickly-apple cactus may occur elsewhere within its range along the coast between St. Lucie and Volusia counties. Areas for further survey should include spoil islands within the Indian River Lagoon. Very little floristic inventory work has been conducted in St. Lucie and Indian River counties, especially on these spoil islands. Habitat similar to current occurrences exists at these spoil islands, and plants listed as associates should be looked for during fragrant prickly-apple cactus searches.

Appropriate habitat management at sites where this federally endangered species occurs is needed. These should include the removal of exotic pest plants and the closing off of these areas to human induced disturbances, both of which may greatly enhance habitat conditions for this species. Seed germination studies are ongoing to determine what types of habitat fragrant prickly-apple cactus prefers (Hines and Bradley 2007). Careful fire management should be conducted in areas surrounding fragrant prickly-apple cactus populations so as not to negatively impact them. Reducing canopy in areas where overshading exists should be considered. Fragrant prickly-apple cactus occurrences should be monitored at a minimum, on an annual basis.

During the development of this report it was discovered that University of South Florida graduate student Alan Franck will be sampling various *Harrisia* throughout Florida to determine genetic relationships (Rowe 2007). Attention should be paid to the results of this study as it could affect listing status of all *Harrisia* in Florida.

Acknowledgements

The authors wish to acknowledge National Park Service Biologist, Jimi L. Sadle and John Bradford who volunteered their time and skills in the field to assist with this project. Steve Green assisted with herbarium searches and field surveys. Marty Roessler provided data. National Park Service biologists Jim Burch and John Stiner provided data. Suzanne Kennedy of Flora Vista helped with literature searches. We also thank the United States Fish and Wildlife Service, the National Park Service, the Florida Department of Parks and Recreation, Florida Power and Light and many private land holders for granting us permission to access properties within the study area. Kirsten Hines assisted with edits and provided valuable advice on this report.

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Appendix 5-1: A History of the Taxonomy and Distribution of *Harrisia fragrans* Small ex Britton & Rose including discussion on *Harrisia simpsonii* ex Britton & Rose

Steven W. Woodmansee
August 17, 2007

There has been much consternation and disagreement about the taxonomy and distribution of Florida species of *Harrisia*. Aboriginal pricklyapples (*Harrisia aboriginum* Small ex Britton & Rose) occurs only on the western coast of Florida, so is left out of this discussion. The differences between and geographic ranges of fragrant prickly-apple cactus and Simpson's prickly-apple cactus (*H. simpsonii* Small ex Britton & Rose) are much debated. The following is a summary of taxonomic treatments of *Harrisia fragrans* (fragrant prickly-apple cactus) and *H. simpsonii* (Simpson's pricklyapples). Synonyms are not mentioned here. Plant characteristics mentioned below are those typically used to distinguish the two species.

A treatment of Florida *Harrisia* was first published in Britton and Rose (1920). In their treatment, John K. Small describes three new species of *Harrisia* in Florida. The *H. fragrans* type specimen was collected by John K. Small in December 1917 on sand-dunes six miles south of Fort Pierce. Britton and Rose (1920) describe its habitat and range as on coastal sand-dunes in Brevard and St. Lucie counties. Britton and Rose (1920) describe the plants as having spines 9 – 13 per areole, one of each areole longer than the others, mostly 2-4 cm, hairs (trichomes) surrounding the scales of the flowering tube as 10 – 15 mm, petals spatulate, and fruits obovoid or globose and dull red with tufts of long hairs persistent with the scale-bases.

The *H. simpsonii* type specimen was collected by Small in November 1916 between Cape Sable and Flamingo (Monroe County). Britton and Rose (1920) describe its habitat and range as on hammocks of Florida Keys and southern mainland coast. Britton and Rose (1920) describe the plants as having spines 7-14 per areole and 1 – 2.5 cm long, hairs (trichomes) surrounding the scales of the flowering tube as 10 mm or less, petals as erose-denticulate, and fruit depressed-globose and orange-red.

Small (1932a, 1932b, 1933) also provides a treatment for *H. fragrans* and *H. simpsonii*. Small (1932a, 1933) describes *H. fragrans* habitat and range as hammocks on high sand-dunes, kitchenmiddens, and coquina ledges, from Mosquito Inlet to Saint Lucie Sound (Volusia County south to St. Lucie County). Small (1932a, 1933) describes plants as having spines 9-13 per areole, one of each areole longer than the others and 2-4 cm, hairs surrounding the scales of the flowering tube as long and white, petals as spatulate, and fruits obovoid and dull red with tufts of long hairs persistent with the scale-bases.

Small (1932b, 1933) describes *H. simpsonii* habitat and range as hammocks and mangrove swamps, Cape Sable to Ten Thousand Islands and Madeira Bay region and the Florida Keys (Miami-Dade and Monroe counties). Small (1932b, 1933) describes plants as having spines 7-9 per areole and 1-2.5 cm, hairs surrounding the scales of the flowering tube as white, petals as narrowly spatulate of narrowly cuneate-spatulate, erose near apex, and fruits depressed globose and dull red with partly persistent scales.

Ward (1978) makes no mention of *H. fragrans* in his list of threatened and endangered plants, and lumps his treatment of *H. aboriginum* and *H. simpsonii* in his description, together giving them a geographic range of Monroe, Miami-Dade, Collier, Lee, Sarasota, and Manatee counties. His treatment of plant characteristics is left out as a result.

Benson (1982) begins a trend of overlapping the ranges of *H. fragrans* and *H. simpsonii* in his treatment. He describes *H. fragrans* habitat and range as sandy soils of low areas in jungles and woods along the coast (elevation) at 1-4 m, Caribbean tropical forest on the Atlantic Coast from Turtle Mound to St. Lucie Sound (Indian River), Cape Sable, and Big Pine Key (Volusia County to St. Lucie County and Monroe County). Benson (1982) describes plants as having spines 9-13 per areole and 2-3 cm, hairs surrounding the scales of the flowering tube as 10-15 mm and white, petals as narrowly oblanceolate and entire, and fruits smooth, obovoid and orange-red with some wool-like spines.

Benson (1982) describes *H. simpsonii* habitat and range as sandy soils of jungles and hammocks (Caribbean tropical forest) at low elevations along the coast of Cape Sable and Ft. Pierce to the Florida Keys (St. Lucie, Miami-Dade, and Monroe counties). Benson (1982) describes *H. simpsonii* plants as having spines 7-16 per areole and \pm 2.5 cm, hairs surrounding the scales of the flowering tube as 6-8(10) mm and white, petals as oblanceolate and erose-dentate above the broadest area, and fruits depressed globose and orange-red with some persistent hair-like spines.

Austin (1984) confuses range data in his treatment (or more aptly, discussion) of *H. fragrans* and *H. simpsonii*. Austin (1984) states that: "Differences between *H. fragrans* and *H. simpsonii* are subtle, but spine length and fruit shape seem to be the most reliable indices." He provides photographs of two plants of *Harrisia*, but otherwise lists no plant characteristics. Austin (1984) describes the range of *H. fragrans* as within a two mile strip in St. Lucie County and an extirpated station near Malabar (in Brevard County). He describes that plants of *H. simpsonii* have been found in several sites for Miami-Dade County north to Volusia County, and in a later discussion of *H. simpsonii* states that it ranges from Everglades National Park south through the Keys (Miami-Dade and Monroe counties). Austin (1984) also claims that Small (1929) attributed locations of *H. fragrans* to Miami-Dade County and "elsewhere".

Chafin (2000) provides a treatment for *H. fragrans*. Chafin (2000) describes *H. fragrans* habitat and range as scrubby flatwoods and xeric hammocks on the Atlantic Coastal Ridge in Brevard County south to St. Lucie County, and northern Monroe County (Florida Keys), and that it was extant only in St. Lucie County. Chafin (2000) describes plants as having spines as being 9-13 per cluster and 1-1.5 inches (2-3 cm), and that one spine within the cluster is longer than the others, inner petals without teeth on the tip, and fruits usually one per plant, red, round, with wooly spines.

Chafin (2000) describes *H. simpsonii* habitat and range as mangroves, coastal thickets, and strands on FL's east coast in. Chafin (2000) also describes *H. simpsonii* as having spines 7-14 per cluster and <1 inch (<2 cm), all uniform in size, petals are also toothed at apex.

USFWS (2000) provides a description for *H. fragrans*. USFWS (2000) describes *H. fragrans* habitat and range as partial shade of early-successional sand pine scrub habitat from Merritt

Island (Brevard County) south to the St. Lucie River (St. Lucie County^{*}). USFWS (2000) describes *H. fragrans* plants as having spines as being 9-13 per cluster and 2-3 cm, and that one spine within the cluster is longer than the others, hairs surrounding the scales of the flowering tube as 10-15 mm and white, petals are spatulate with unevenly toothed margins, fruits are dull red with persistent white hairs below the scales. USFWS (2000) mentions that the best character for separating *H. fragrans* from *H. simpsonii* is that *H. fragrans* possesses a spine within the areole that is longer than the surrounding spines.

Anderson (2001) also provides a treatment for *H. fragrans* and *H. simpsonii*. Anderson (2001) describes *H. fragrans* range as the Atlantic coast of Florida. Anderson (2001) describes *H. fragrans* plants as having spines 9-13 (per areole) and 2-4 cm, and fruits as ovoid and dull red with tufts of long hair.

Anderson (2001) describes *H. simpsonii* habitat and range as “southern coastal hummocks” of the Keys and mainland of Florida. Anderson (2001) describes *H. simpsonii* plants as having spines 7-14 (per areole) and 1-2.5 cm, floral tubes with soft white hairs, fruits depressed globose and orange-red.

Bradley et al. (2002) state that reports of *H. fragrans* outside of St. Lucie County may be in error.

FNAEC (2003) also provides a treatment for *H. fragrans* and *H. simpsonii*. FNAEC (2003) describes *H. fragrans* habitat and range as oak-red bay scrub on dry sand dunes in Florida (arrows on map point to Volusia County south to S. Lucie County and Monroe County). FNAEC (2003) describes *H. fragrans* plants as having spines 9-13 per areole and 2-4 cm, scales of floral tube with soft white hairs 10-15 mm, fruits obovoid and orange-red.

FNAEC (2003) describes *H. simpsonii* habitat and range as sandy soils of dense thickets and hammocks, mangrove swamps in Florida (arrows of figure point to Brevard County south to St. Lucie County, Miami-Dade, and Monroe counties). FNAEC (2003) describes *H. simpsonii* plants as having spines 7-9 per areole and 1-2.5 cm, scales of floral tube with soft white hairs 6-10 mm, fruits depressed-spheric and dull red.

Wunderlin and Hansen (2006) report that *H. fragrans* and *H. simpsonii* occur on the eastern coast of Florida, each occurring in: St. Lucie, Indian River, and Brevard counties. Wunderlin and Hansen (2003) differentiate *H. fragrans* from *H. simpsonii* using two floral characteristics. *Harrisia fragrans* possess trichomes of the areoles on the hypanthium which measure 10 – 15 mm, and the margins of the inner petals are entire at the apex. Whereas, *H. simpsonii* possess trichomes of the areoles on the hypanthium which measure 6 – 8 mm, and the margins of the inner petals are erose-denticulate at the apex.

It is quite apparent that from the 1970's to the present, confusion and misrepresentation of *H. fragrans* and *H. simpsonii* are endemic, much like the cacti in question. Several taxonomic

* The portion of the St. Lucie River which occurs in St. Lucie County is the north fork, and is approximately five miles west of the known occurrence of *Harrisia fragrans*. Parts of the St. Lucie River that are close to the coast and the Indian River Lagoon are in northern Martin County, and *H. fragrans* has never been documented for Martin County.

treatments provide differing descriptions for both the ranges of these two species of *Harrisia* as well as morphological characters. USFWS (2000) mentions that there has been some taxonomic confusion between fragrant prickly-apple (*H. fragrans*) and Simpson prickly-apple cactus (*H. simpsonii*) leading to questions of historical range.

There seem to be three separate beliefs regarding *H. fragrans* and *H. simpsonii* geographical distribution. The earliest belief was that the two species are separated geographically, as is evidenced by Britton and Rose (1920) and Small (1933) (despite what Austin (1984) stated), who believed that all plants of *Harrisia* in eastern central Florida were *H. fragrans*, and that *H. simpsonii* only occurred in extreme southern Florida.

A second belief, brought on by Benson (1982), Chafin (2000), and FNAEC (2003) is that both *Harrisia* have occurred, or used to occur, with each other throughout most of their ranges (with varying degrees of overlapping). Benson claimed to have actually collected specimens of *Harrisia* on Big Pine Key and on Cape Sable that he attributed to *H. fragrans* (Benson 1982). However, upon contacting the Herbarium Curator at Rancho Santa Ana (RSA-POM) in California (which now houses the collection from POM at Pomona College in California), it was learned that Benson occasionally cited specimens that were never fully deposited, and that there were no specimens of any *Harrisia* for Big Pine Key, Cape Sable, or anywhere else in Florida at Rancho Santa Ana (Keith Bradley email correspondence with Herbarium Curator Steve Boyd, January 24, 2002). The source(s) of *H. fragrans* listing for northern Florida Keys in Chafin (2000) and FNAEC (2003) is uncertain.

Regarding Austin's (1984) claim that Small (1929) erroneously reported *H. fragrans* in Miami-Dade County, no data could be found to support this claim as Small (1929) stated:

“One of these mounds (from a station 2.6 miles south of Coronado in the Mosquito Lagoon area) represents the northern geographic limit of the prickly-apple (*H. fragrans*) first found on the dunes south of Fort Pierce, but since collected at several points along the lower eastern coast where it is endemic....There are three kinds of *Harrisia* in Florida; besides the one above mentioned, one on the western coast of the peninsula and one in the Cape Sable region and on the Florida Keys.”

As discussed earlier, Small (1932a, 1932b, 1933) later published that *H. fragrans* and *H. simpsonii* were geographically separate, and did not have overlapping boundaries. Given the data, Austin's statement seems erroneous.

Leading to a third belief, brought on by Austin (1984) and Wunderlin and Hansen (2003), is that the geographic location of *H. simpsonii* overlaps with *H. fragrans* in central eastern Florida, and that no *H. fragrans* have occurred south of St. Lucie County. Given what is known about specimens of *Harrisia* being absent from Florida at RSA-POM (mentioned above), the record of *H. simpsonii* listed on Wunderlin and Hansen (2006) for St. Lucie County is sourced from Benson (1982), it seems that this county record should be removed. That leaves a curious overlap of *H. fragrans* and *H. simpsonii* in Brevard and Indian River counties.

Further confusion has been brought upon by various contradicting plant descriptions provided by taxonomists treating the genus *Harrisia* in Florida. FNAEC (2003) describe fruits of *H. fragrans* as orange-red, and *H. simpsonii* as dull red, whereas all others mentioned in this review subscribe to the opposite. USFWS (2000) describe flower petals of *H. fragrans* as “toothed” whereas all others who give petal descriptions state that *H. fragrans* petals are entire and that petals of *H. simpsonii* are erose-dentate (toothed). Britton and Rose (1920), Small (1932a, 1932b, 1933), and Wunderlin and Hansen (2003) disagree with Benson (1982) and FNAEC (2003) on the comparative length of the hairs surrounding the scales of the flowering tube in *H. simpsonii*.

It seems likely that in *Harrisia*, spine length and fruit shape could vary based upon plant health or environmental conditions. These characteristics are not necessarily reliable on their own in the field, but should be used in combination with floral characteristics which are typically used to differentiate species. During the development of this report it was discovered that University of South Florida graduate student Alan Franck will be sampling various *Harrisia* throughout Florida to determine genetic relationships (Rowe 2007). Hopefully, this will help resolve the issue.

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Chapter 6 - Post-hurricane Field Assessment of West Coast Dune Sunflower
(*Helianthus debilis* Nutt. subsp. *vestitus* (E. Watson) Heiser)

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West coast dune sunflower at Shell Key Preserve in Pinellas County.
Steven W. Woodmansee, January 2007.

Table of Contents

Introduction	159
Methods	161
Results and Discussion	162
Final Discussion	186
Acknowledgements	186
Citations	186

Tables:

Table 6-1: West coast dune sunflower Study Area	164
Table 6-2: Tagged Plants of <i>Helianthus debilis</i> var. <i>vestitus</i> at Honeymoon Island State Park	174
Table 6-3: Associated plants of west coast dune sunflower at Honeymoon Island State Park	175
Table 6-4: Associated plants of west coast dune sunflower at Sands Key Park	178
Table 6-6: Associated plants of west coast dune sunflower at Shell Key Preserve	183

Figures:

Figure 6-1: <i>Helianthus debilis</i> subsp. <i>vestitus</i> Study Area	160
Figure 6-2: <i>Helianthus debilis</i> subsp. <i>vestitus</i> Occurrence Results	163
Figure 6-3: <i>Helianthus debilis</i> subsp. <i>vestitus</i> at Caladesi Island State Park	166
Figure 6-4: Historical occurrence of <i>Helianthus debilis</i> subsp. <i>vestitus</i> at Cayo Costa State Park	169
Figure 6-5: <i>Helianthus debilis</i> subsp. <i>vestitus</i> at Fort Desoto Preserve	171
Figure 6-6: <i>Helianthus debilis</i> subsp. <i>vestitus</i> at Honeymoon Island State Park	176
Figure 6-7: <i>Helianthus debilis</i> subsp. <i>vestitus</i> at Sands Key Park	179
Figure 6-8: <i>Helianthus debilis</i> subsp. <i>vestitus</i> at Shell Key Preserve	184

Introduction

West coast dune sunflower (*Helianthus debilis* subsp. *vestitus*) is a candidate for listing by the USFWS (2000) and not listed by the Florida Department of Agriculture and Consumer Services (Coile and Garland 2003). It has been documented from several southwestern Florida counties including Pinellas, Hillsborough, Manatee, Sarasota, Charlotte, and Lee (Bradley et al. 2004). Before the 2004 hurricane season, extant populations of west coast dune sunflower were known from six occurrences totaling seven distinct populations in Pinellas and Lee counties (Bradley et al. 2004).

In 2004 Hurricane Charley, a Category 4* hurricane, crossed the coastal areas of Lee and Charlotte counties with peak winds as high as 150 mph and Tropical Storm Frances exited coastal areas just north of Pinellas County in Pasco County with winds as high as 60 mph (Figure 6-1). Damage to human property on these coastal areas was well known, and it was uncertain whether populations of west coast dune sunflower would have responded positively or negatively toward these storm events. It was surmised that populations could have been negatively impacted by wind induced breakage, tree falls, storm surge, and potential illegal dumping on conservation lands. Gann et al. (2005-2007) report that the closely related east coast dune sunflower (*H. debilis* subsp. *debilis*) does not tolerate long-term flooding by salt or brackish water and that although it grows in direct salt wind, it is away from constant salt spray. It was deemed necessary to survey as many of these occurrences, as time and budget would allow, to assess the status of west coast dune sunflower after the 2004 hurricane season.

* on the Saffir-Simpson Hurricane Scale

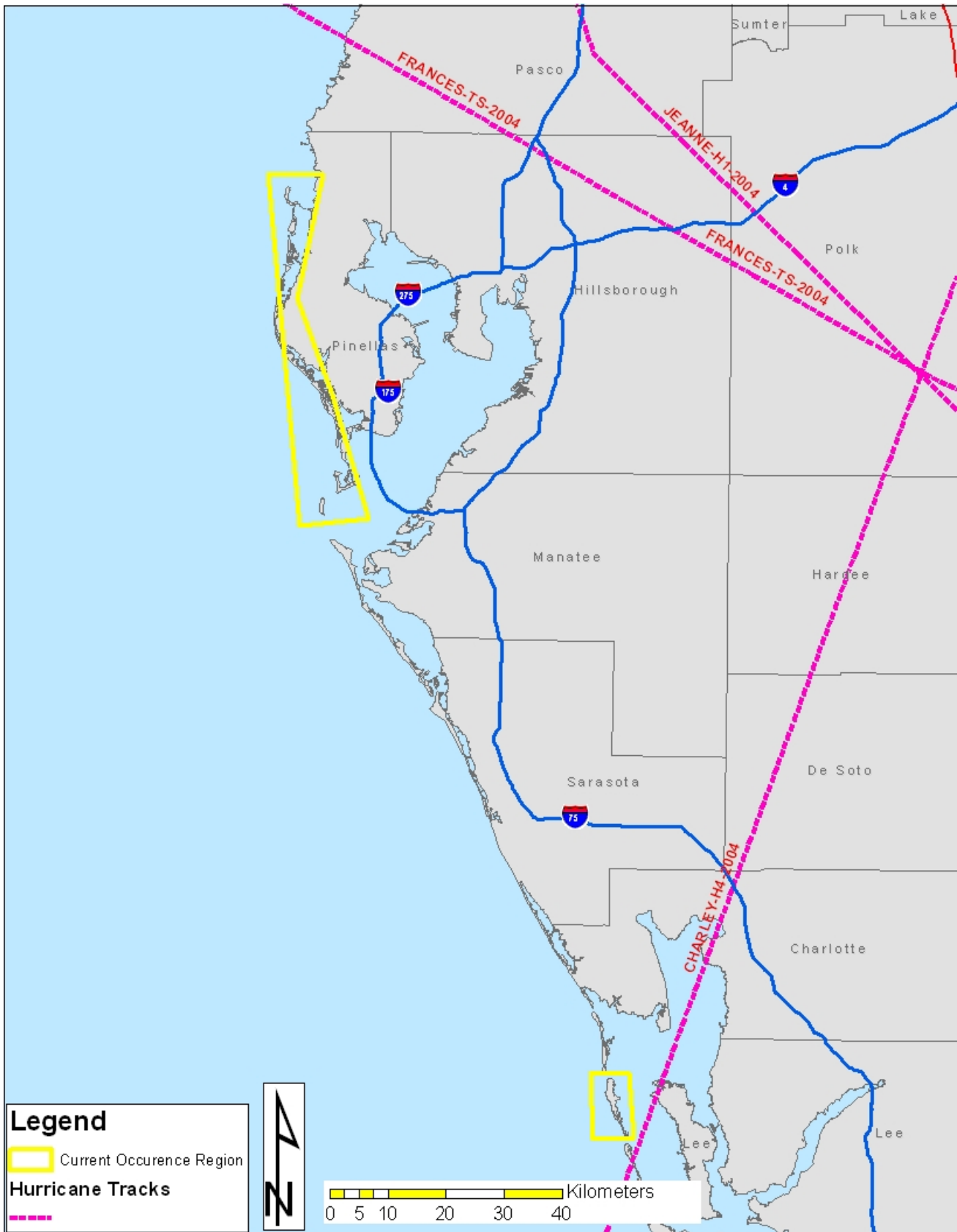


Figure 6-1: *Helianthus debilis subsp. vestitus* Study Area

Methods

Preparation

Before field assessments were conducted for west coast dune sunflower, available literature, summarized in Bradley et al. (2004), and herbarium specimen data were compiled, and land managers were consulted. An attempt was made to survey extant populations of west coast dune sunflower in all counties. For comparative reasons, and to better gauge the status of all west coast dune sunflower populations, an effort was made to visit both areas surmised to have been most impacted by Hurricane Charley and Tropical Storm Frances, as well as populations presumed to have been less impacted. Easy accessibility was also taken into consideration when prioritizing sites to survey.

Field Assessment

Surveys

Upon visitation at each site, a search for west coast dune sunflower was conducted. Upon finding west coast dune sunflower, total number of plants was recorded, recruitment was noted, habitat(s) following FNAI and FDNR (1990) were recorded as well as species associates. Overall health of plants was recorded. In addition hurricane damage was noted for the plants as well as the habitats.

Hurricane damage to plants was ranked as none if there was no direct evidence of the events impacting specific individual plants. Hurricane damage to the plants was ranked as low if little damage to the plants (few branches broken, no mortality for the individual) was directly evidenced as a result of the storms. Hurricane damage to the plants was ranked as moderate if any branches or trunks were known to have fallen and damaged plants and poor health could be attributed to the storm events. Hurricane damage to the plants was ranked as severe if mortality of the individual directly attributed to the storms was observed.

Hurricane damage to the habitat was ranked as none for sites with no direct evidence of the events impacting the habitat. Hurricane damage to the habitat was ranked as low for areas with only a few tree falls and no storm surge (as would be indicated by a die off of the herb vegetation from salt water) surrounding the centroid. Hurricane damage to the habitat was ranked as moderate if there was notable tree falls within the habitat (>five trees) and no storm surge surrounding the centroid. Hurricane damage to the habitat was ranked as severe if major changes to the habitat (such as majority of canopy trees fell) and/or there was notable storm surge.

Tagging and Mapping

Honeymoon Island State Park and Shell Key Preserve (Pinellas Bayway) populations were selected for tagging and individual mapping and monitoring of west coast dune sunflower. Both populations possessed a population large enough to sustain a long term survey, and it was predicted that both occurrences would have had different degrees of devastation from 2004 storm events. Twenty-five adult plants from each population were tagged, mapped, and monitored. Measurements taken for west coast dune sunflower included plant area. This was measured by recording the largest individual plant diameter and then taking a second diameter perpendicularly. General plant health (e.g. plant yellowing, or herbivory/snail damage, etc.) and presence of fruits and flowers were also noted. Light availability was also recorded as either full sun (>90% sunlight), partial sun (10 – 90 %

sunlight), and shade (<10 % sunlight). Upon resurveys, tags were removed from any dead plants.

Data Entry

Survey data was entered and maintained in a geodatabase created using ArcMap 9.2 and a Microsoft Access database. The database and geodatabase are linked by PointID fields. The GIS geodatabase entitled USFWS_HURSUR_MDB contains three tables: One is a point table entitled RarePlantPts. In addition to the PointID field, this table contains TXCode (the first four letters of the genus and the first four letters of the species studied), Site, Subunit, Population, Associated Taxa, Habitat, Disturbance, Occurrence, and coordinate data (in NAD 83 UTM 17N format) . The second table contain polygons of species boundaries.

The database entitled USFWS_HURSUR_Datasets contains survey data and was created in Microsoft Access and is linked to the geodatabase by the PointID number. The primary table in this database, which contains one record for each PointID linked by Surveyors and Date, contains all pertinent data from the surveys including Event Number, Comments1, Comments 2, Plant Number, Population Estimate, Site, Site Unit, and Occurrence. Data recorded for mapped and tagged plants is also located in this database.

Results and Discussion

Six populations of west coast dune sunflower were searched for 2006-2007. Initial results show that only one population of west coast dune sunflower, at Cayo Costa State Park, has become historical possibly due to Hurricane Charley. The remaining populations at Caladesi Island State Park, Fort Desoto Preserve, Shell Key Preserve (Pinellas Bayway), Sands Key Park, and Honeymoon Island State Park are extant, and most appear to be increasing or remain largely unchanged by the recent storm events. One population at Shell Key Preserve decreased since storm events, but it is thought due to non storm related reasons addressed in its Occurrence account.. Two colonies of west coast dune sunflower at Egmont Key National Wildlife Refuge were not visited due to budget constraints. Based upon field observations of how west coast dune sunflower responded to storm events at nearby Caladesi Island State Park, the population at Egmont Key National Wildlife Refuge is assumed to be present. Hurricane damage for all habitats visited was insignificant. A map of the west coast dune sunflower occurrences is in Figure 6-2. Table 6-1 contains summary data for populations of west coast dune sunflower.

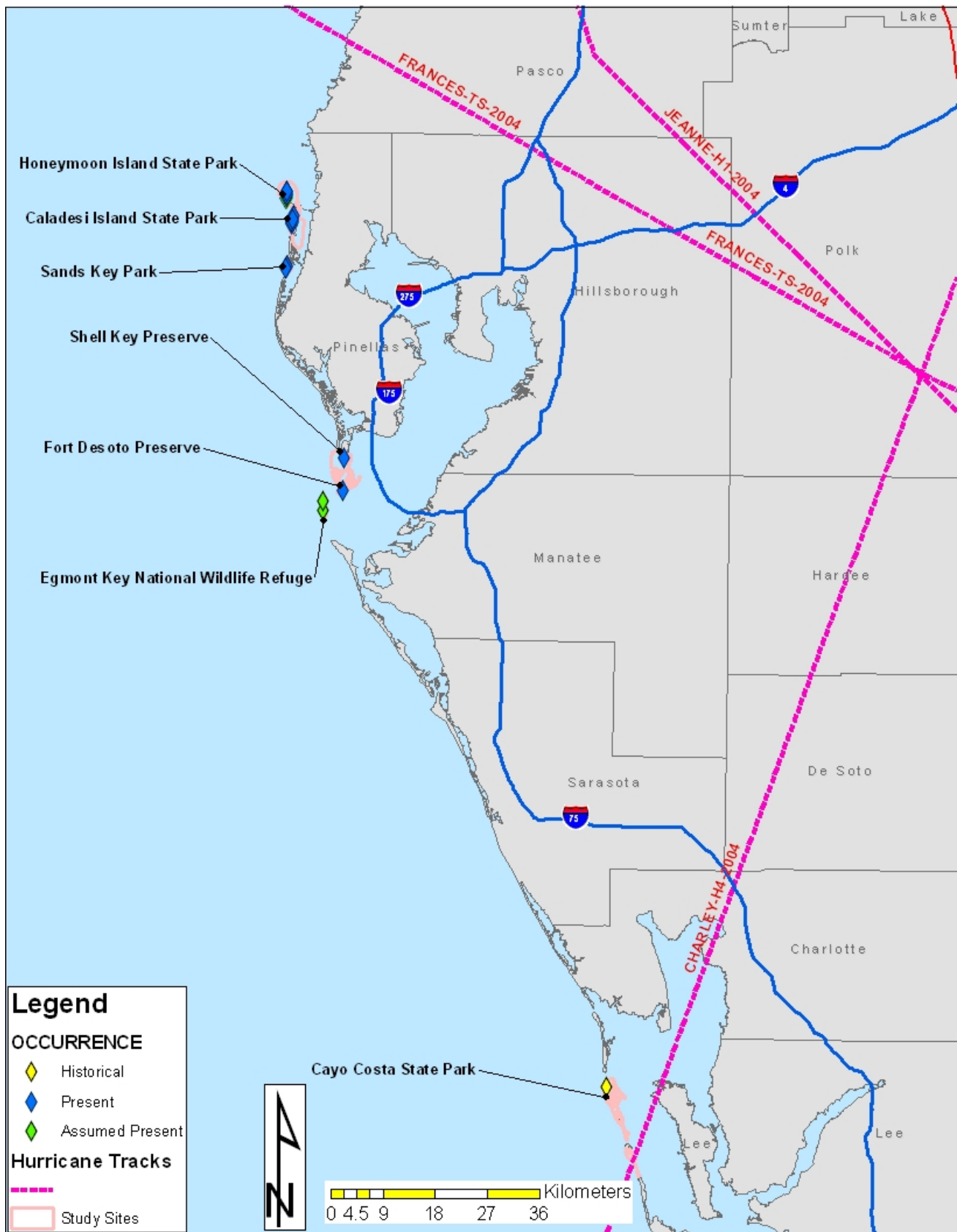


Figure 6-2: *Helianthus debilis* subsp. *vestitus* Occurrence Results

Table 6-1: West coast dune sunflower Study Area

Occurrence #	Site Name	Site Unit	Status	Number of Plants in 2003 (before storms)	Number of Plants in 2006	Hurricane Damage to Habitat	Hurricane Damage to Plants			
1	Caladesi Island State Park		P	1694	2,000-3,000	None	None observed			
2	Cayo Costa State Park		H	<25	0	None	Likely severe			
3*	Egmont Key National Wildlife Refuge		S	25	Unknown	Probably None	Probably None			
4	Fort Desoto Preserve	Mullet Key Dock area	P	11-100	51-100	None	None observed			
5**	Honeymoon Island State Park		P	89	200	None	None observed			
6	Sands Key Park		S	24	1,000+	None	None observed			
7**	Shell Key Preserve (Pinellas Bayway)		S	500+	100	None	None observed			
<table border="1"> <tr> <td>P = Present</td> </tr> <tr> <td>H = Historical</td> </tr> <tr> <td>S = Assumed Present</td> </tr> </table>								P = Present	H = Historical	S = Assumed Present
P = Present										
H = Historical										
S = Assumed Present										
<p>* Not surveyed during this project ** plants tagged at this population</p>										

Twenty-five plants of west coast dune sunflower were tagged, mapped, and assessed at Honeymoon Island State Park in Pinellas County, and another 25 at Shell Key Preserve along the eastern shoulder of the Pinellas Bayway (SR 679) just north of Fort Desoto County Park in Pinellas County. These sites were visited twice, once in 2006 and once in 2007. A discussion of the results from west coast dune sunflower monitoring events is given in each of these site's occurrence accounts.

An account of Egmont Key National Wildlife Refuge (Occurrence 3) is left out of this report as surveys were not conducted there. Information regarding this station may be accessed in Bradley et al. (2004). Accounts of remaining occurrences are detailed in the following sections.

West Coast Dune Sunflower Occurrences

Occurrence 1: Caladesi Island State Park, Pinellas County

Owner: State of Florida

Status: Present

Hurricane damage to west coast dune sunflower: None

Hurricane damage to habitats of west coast dune sunflower: None

Background: The type specimen for west coast dune sunflower was collected at or near this station or at Honeymoon Island State Park by S.M. Tracy in 1900 (#6919, US). As discussed in Bradley et al. (2004), Hog Island once made up Caladesi and Honeymoon islands until a 1921 hurricane cut the two in half. Deborah Chayet made an herbarium specimen of west coast dune sunflower at this site on September 5, 1979. Florida Natural Areas Inventory (FNAI) documented their presence on March 26, 1991. S. Cole and J. Miller made an herbarium specimen of west coast dune sunflower at this station on April 4, 1994 (#C10014, USF). The Institute for Regional Conservation staff (Bradley and Melissa Abdo) and park biologist Sally Braem visited the population and counted 1,694 individuals on August 19, 2003 (Bradley et al. 2004). Bradley et al. (2004) noted that portions of Caladesi Island State Park burned recently.

Site Re-visits: On January 11, 2007, Woodmansee and Barry surveyed the locations provided in Bradley et al. (2004) and recorded 2,000 – 3,000 plants of west coast dune sunflower. Plants were observed on the back dunes of beach dune habitat and in coastal strand. No hurricane damage was observed for plants or habitats.

Site Description: Habitats of west coast dune sunflower at Caladesi Island State Park site are beach dune and coastal strand. These habitats are bordered by the fore dune and Gulf of Mexico to the west grading to pine flatwoods to the east.

Associate plant taxa within one meter of west coast dune sunflower included: sea oats (*Uniola paniculata*), beach-elder (*Iva imbricata*), saw palmetto (*Serenoa repens*), and southern sandbur (*Cenchrus echinatus*).

A map of the population of west coast dune sunflower at Caladesi Island State Park is provided in Figure 6-3.



Figure 6-3: *Helianthus debilis* subsp. *vestitus* at Caladesi Island State Park

Possible causes for population increase: The population of west coast dune sunflower at Caladesi Island State Park almost doubled since 2003. This may be attributed to the relatively mild affects of Tropical Storm Frances combined with prescribed fire in coastal strand habitat. In addition, ongoing efforts of exotic plant management at Caladesi Island State Park may have supported the species. Being a seemingly short lived species, bare soil may be essential in order for it to germinate. The amount of bare soil may have increased since Tropical Storm Frances, control burns, and exotics treatment. This population may not have been hindered by the storm event as little salt spray and storm surge was evident at this site. Tropical Storm Frances crossed over from the east, and pineland buffered the population from catastrophic storm affects.

It may still be possible that threats including stochastic events such as major hurricanes (greater than Category 4) and freezes; invasion by exotic plant species such as Brazilian-pepper and shrub verbena (*Lantana camara*) found next to plants; and human induced disturbances such as hikers going off trail and off-road bicyclists; may impact west coast dune sunflower.

Recommendations: Monitor plants on an annual basis. Exotic pest plant removal at the site has been conducted and should be continued. Prescribed fire should be initiated in order to enhance coastal strand habitat.

Occurrence 2: Cayo Costa State Park, Lee County

Owner: State of Florida

Status: Historical

Hurricane damage to west coast dune sunflower: likely severe

Hurricane damage to habitats of west coast dune sunflower: None

Background: The Institute for Regional Conservation staff (Bradley and Abdo) visited the population and counted fewer than 25 individuals on April 18, 2003 (Bradley et al. 2004). Bradley et al. (2004) surmised that this was a newly established colony.

Site Re-visits: On February 15, 2006, Woodmansee, Mahoney, and Lee County biologist Jim Green surveyed the location provided in Bradley et al. (2004). Despite extensive surveys in coastal grasslands, no west coast dune sunflower was observed. No hurricane damage was observed for plant habitat, and no dead plants were found. Hybrids of west coast dune sunflower and east coast dune sunflower, reported by Bradley et al. (2004), were observed along trails through cabbage palm (*Sabal palmetto*) woodland to the east.

Site Description: Habitat for the former population of west coast dune sunflower at Cayo Costa State Park was coastal grassland, which in this case was bordered by the beach dune and Gulf of Mexico to the west grading to cabbage palm woodland to the east.

A map of the historical population of west coast dune sunflower at Cayo Costa State Park is provided in Figure 6-4.

Possible causes for disappearance: Cayo Costa State Park took much of the brunt of the catastrophic Hurricane Charley. Cabins just to the south of the former population of west coast dune sunflower were wiped out. Unfortunately, there are no records of the status of west coast dune sunflower immediately after the storm. Despite there being no evident damage to the coastal grassland habitat at the time of the surveys, it still seems likely that either storm surge or salt spray from Hurricane Charley was the cause of the disappearance of west coast dune sunflower at this station as plants are not adapted for long periods of direct contact with salt water. It is possible that west coast dune sunflower could reappear on its own at this station as seeds may remain in the soil.

Recommendations: Continue surveys on an annual basis for west coast dune sunflower at Cayo Costa State Park. Remove west coast dune sunflower/east coast dune sunflower hybrids. If no plants are found, consider reintroducing west coast dune sunflower.

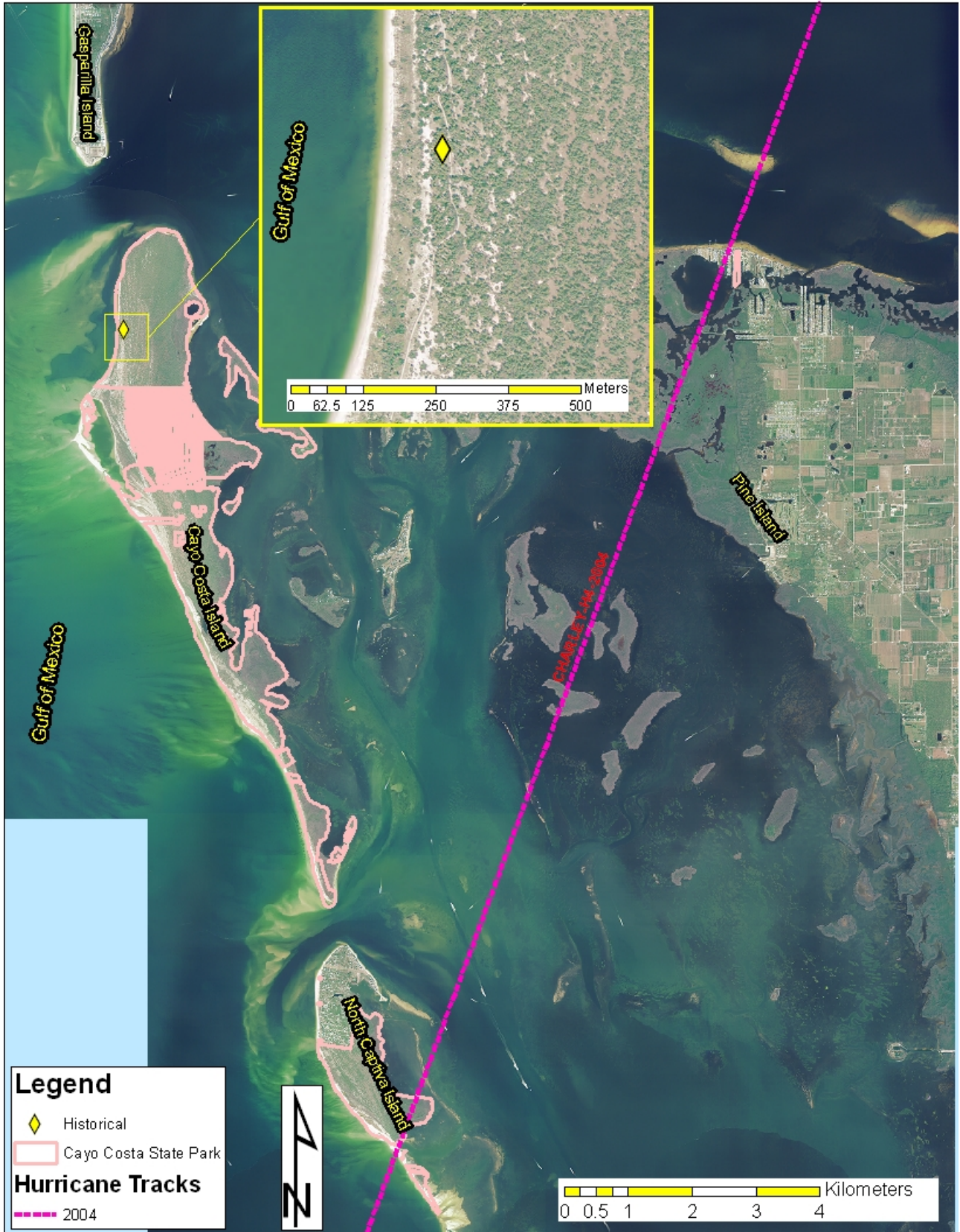


Figure 6-4: Historical occurrence of *Helianthus debilis* subsp. *vestitus* at Cayo Costa State Park

Occurrence 4: Fort Desoto Preserve, Pinellas County

Owner: Pinellas County

Status: Present

Hurricane damage to west coast dune sunflower: None

Hurricane damage to habitats of west coast dune sunflower: None

Background: S. Earle and M. Waas made an herbarium specimen of west coast dune sunflower in the vicinity of this site on March 19, 1955. Bradley visited a population at Fort Desoto Preserve “along the shoreline immediately adjacent to the pier on the south edge of the park” and recorded 25 individuals on March 21, 2003 (Bradley et al. 2004). Bradley et al. (2004) postulated that plants may have been accidentally introduced by visitors to Egmont Key National Wildlife Refuge.

Site Re-visits: On March 22, 2006, Woodmansee and Josh Mahoney surveyed the location provided in Bradley et al. (2004) and recorded 51-100 plants of west coast dune sunflower. Plants were observed in a highly disturbed area in the vicinity of the fishing pier spot and occur in a highly used public area. The entire population encompassed a small area approximately 15' x 25'. No hurricane damage was observed for plants or habitats.

Site Description: Habitat for the Fort Desoto Preserve site is beach dune (albeit disturbed), which in this case is bordered by public beach and Gulf of Mexico to the south, grading to a disturbed picnic area to the east.

Associate plant taxa within one meter of west coast dune sunflower included: beach bean (*Canavalia rosea*), spanish needle (*Bidens alba* var. *radiata*), seaside spurge (*Chamaesyce mesembrianthemifolia*), gray nickerbean (*Caespinnia bonduc*), cut-leaf evening primrose (*Oenothera laciniata*), and coral dropseed (*Sporobolus domingensis*).

A map of the population of west coast dune sunflower at Fort Desoto Preserve is provided in Figure 6-5.



Figure 6-5: *Helianthus debilis* subsp. *vestitus* at Fort Desoto Preserve

Possible causes for population increase: The Fort Desoto Preserve population of west coast dune sunflower increased since 2003. This may be attributed to the relatively mild affects of Tropical Storm Frances. Being a seemingly short lived species, bare soil may be essential in order for it to germinate. Bare soil may have increased since Tropical Storm Frances in addition to human disturbance. This population may also have not been hindered by the storm event as little salt spray and storm surge was evident at this site. Tropical Storm Frances crossed over from the east and the bulk of the island and the pier to the east buffered the population from catastrophic storm affects.

It may still be possible that threats including stochastic events, such as major hurricanes (greater than Category 4) and freezes; invasion by exotic plant species, such as Brazilian-pepper and shrub verbena (*Lantana camara*) found next to plants; and human induced disturbances, such as beach goers trampling plants; may impact west coast dune sunflower.

Recommendations: Monitor plants on an annual basis. Cordon off the population from public beach goers. Consider restoring coastal strand habitat around the existing population of west coast dune sunflower at Fort Desoto Preserve.

Occurrence 5: Honeymoon Island State Park, Pinellas County

Owner: State of Florida

Status: Present

Hurricane damage to west coast dune sunflower: None

Hurricane damage to habitats of west coast dune sunflower: None

Background: The type specimen for west coast dune sunflower was collected at or near this station or at Honeymoon Island State Park by S.M. Tracy in 1900 (#6919, US). As discussed in Bradley et al. (2004), Hog Island once made up Caladesi and Honeymoon islands until a 1921 hurricane cut the two in half. Genelle and Fleming documented plants at this site on December 2, 1971, and again on September 23, 1979. Florida Natural Areas Inventory (FNAI) documented their presence on March 25, 1991 and again on May 4, 1998. The Institute for Regional Conservation staff (Bradley and Melissa Abdo) and park biologist Sally Braem visited the population and counted 89 individuals on August 20, 2003 (Bradley et al. 2004).

Site Re-visits: On March 23, 2006, Woodmansee and Mahoney surveyed the locations provided in Bradley et al. (2004) and recorded 200 plants of west coast dune sunflower. On the same day, they tagged a portion of the population following methods discussed earlier in the chapter. A total of 25 plants were tagged at this location. On January 11, 2007, Woodmansee and Barry returned to the site and re-surveyed the tagged population and mapped it for comparison.

The data collected on tagged plants during the two site visits are listed in table 6-2. First it is important to note that both sampling events are post hurricane. No mortality was found that could obviously be attributed to the hurricanes during the first event. Significant mortality was observed in the tagged plants (all of which were in good health when tagged) between the first and second sampling events, however, none of this can be directly attributed to damage from hurricanes. Nine out of ten tagged adults died (90%), and most (80%) of the 15 tagged seedlings died. This appears to be natural mortality (i.e. the plant is short-lived with high turnover) as fairly high mortality was also observed to a lesser extent at the Shell Key Preserve tagged population. There is also a chance that the plants were indirectly affected by Brazilian-pepper (*Schinus terebinthifolius*) eradication efforts (Brazilian-pepper was treated between the first and second sampling event) though typical control methods do not usually affect herbaceous plants negatively. In addition, several new plants recruited the area nearby the tagged population.

Average size, measured by calculating area covered (in cm²) from length and width, was 5,290 cm² in the ten tagged adults and 58 cm² in the 15 seedlings. Growth rate in the surviving adult was 175%. Growth rates in the three surviving seedlings was exponential (2,151%), increasing to 3,016 cm² in one year.

Table 6-2: Tagged Plants of *Helianthus debilis* var. *vestitus* at Honeymoon Island State Park

Tag #	Area (cm ²)			Condition:		Life Stage:		Flowering:		Fruiting:		
	23-Mar-06	11-Jan-07	change	23-Mar-06	11-Jan-07	23-Mar-06	11-Jan-07	23-Mar-06	11-Jan-07	23-Mar-06	11-Jan-07	
226	1,452	N/A	N/A	Good	Dead	Adult	Adult	No	N/A	No	N/A	
227	2,720	N/A	N/A	Good	Dead	Adult	Adult	Yes	N/A	No	N/A	
228	9,200	N/A	N/A	Good	Dead	Adult	Adult	No	N/A	No	N/A	
229	4,875	N/A	N/A	Good	Dead	Adult	Adult	No	N/A	No	N/A	
230	2,750	N/A	N/A	Good	Dead	Adult	Adult	No	N/A	No	N/A	
231	11,000	N/A	N/A	Good	Dead	Adult	Adult	No	N/A	No	N/A	
232	720	N/A	N/A	Good	Dead	Adult	Adult	No	N/A	No	N/A	
233	360	N/A	N/A	Good	Dead	Adult	Adult	No	N/A	No	N/A	
234	25	N/A	N/A	Good	Dead	Seedling	Seedling	No	N/A	No	N/A	
235	30	N/A	N/A	Good	Dead	Seedling	Seedling	No	N/A	No	N/A	
236	8	N/A	N/A	Good	Dead	Seedling	Seedling	No	N/A	No	N/A	
237	36	N/A	N/A	Good	Dead	Seedling	Seedling	No	N/A	No	N/A	
238	60	N/A	N/A	Good	Dead	Seedling	Seedling	No	N/A	No	N/A	
239	15	N/A	N/A	Good	Dead	Seedling	Seedling	No	N/A	No	N/A	
240	70	N/A	N/A	Good	Dead	Seedling	Seedling	No	N/A	No	N/A	
241	30	N/A	N/A	Good	Dead	Seedling	Seedling	No	N/A	No	N/A	
242	90	4,200	4,110	Good	No data	Seedling	Adult	No	Yes	No	Yes	
243	45	N/A	N/A	Good	Dead	Seedling	Seedling	No	N/A	No	N/A	
244	72	N/A	N/A	Good	Dead	Seedling	Seedling	No	N/A	No	N/A	
245	108	300	192	Good	Dying	Seedling	Adult	No	No	No	No	
246	6,325	17,380	11,055	Good	Good	Adult	Adult	Yes	Yes	Yes	Yes	
247	13,500	N/A	N/A	Good	Dead	Adult	Adult	Yes	N/A	Yes	N/A	
248	204	4,550	4,346	Good	Good	Seedling	Adult	No	Yes	No	Yes	
249	49	N/A	N/A	Good	Dead	Seedling	Seedling	No	N/A	No	N/A	
250	20	N/A	N/A	Good	Dead	Seedling	Seedling	No	N/A	No	N/A	
Growth per plant:								Flowers (adults):	30.00%	75.00%		
adults	5,290.20	17,380.00	11,055.00*	174.78%								
seedlings	57.46	3,016.67	2,882.70*	2151.24%								
% mortality:												
combined	84.00%											
adults	90.00%											
seedlings	80.00%											
*Change calculated only for individual plant samplings which crossed both monitoring periods.												

Flowering of adult plants ranged from 30% of the ten adults in the first event and 75% of the four surviving adults (adult and seedlings in the first event) during the second sampling event. Similarly, fruiting of adult plants ranged from 20% of the ten adults in the first event and 75% of the four surviving adults during the second event. The proportion of plants with flowers for the first event was lower than at the Shell Key Preserve population but comparable during the second event.

Site Description: Habitat for the Honeymoon Island State Park site would be coastal strand, which in this case is bordered by mangroves and buttonwood to the west grading to pine flatwoods to the east.

A list of associate plant taxa within one meter of west coast dune sunflower is provided in table 6-3:

Table 6-3: Associated plants of west coast dune sunflower at Honeymoon Island State Park

Scientific Name	Common Name
<i>Aristida purpurascens</i>	arrowfeather threeawn
<i>Cenchrus echinatus</i>	southern sandbur
<i>Chamaecrista fasciculata</i>	partridge pea
<i>Chiococca alba</i>	hammock snowberry
<i>Cnidoscolus stimulosus</i>	spurge nettle
<i>Commelina erecta</i>	erect dayflower
<i>Galactia</i> sp.	milkpea
<i>Gaura angustifolia</i>	southern beeblossum
<i>Iresine diffusa</i>	bloodleaf
<i>Lupinus diffusus</i>	skyblue lupine
<i>Monarda punctata</i>	horsemint
<i>Oenothera</i> sp.	evening primrose
<i>Opuntia stricta</i>	erect pricklypear
<i>Panicum amarum</i>	beachgrass
<i>Passiflora suberosa</i>	corkystem passionflower
<i>Phyllanthus abnormis</i>	Drummond's leafflower
<i>Physalis walteri</i>	Walter's groundcherry
<i>Sophora tomentosa</i> var. <i>truncata</i>	yellow necklacepod
<i>Spartina patens</i>	marshhay cordgrass
<i>Sporobolus virginicus</i>	seashore dropseed
<i>Toxicodendron radicans</i>	poison-ivy
<i>Uniola paniculata</i>	sea-oats
<i>Verbesina virginica</i>	crownbeard
<i>Zanthoxylum clava-herculis</i>	Hercules club

A map of the populations and tagged plants of west coast dune sunflower at Honeymoon Island State Park is provided in Figure 6-6.

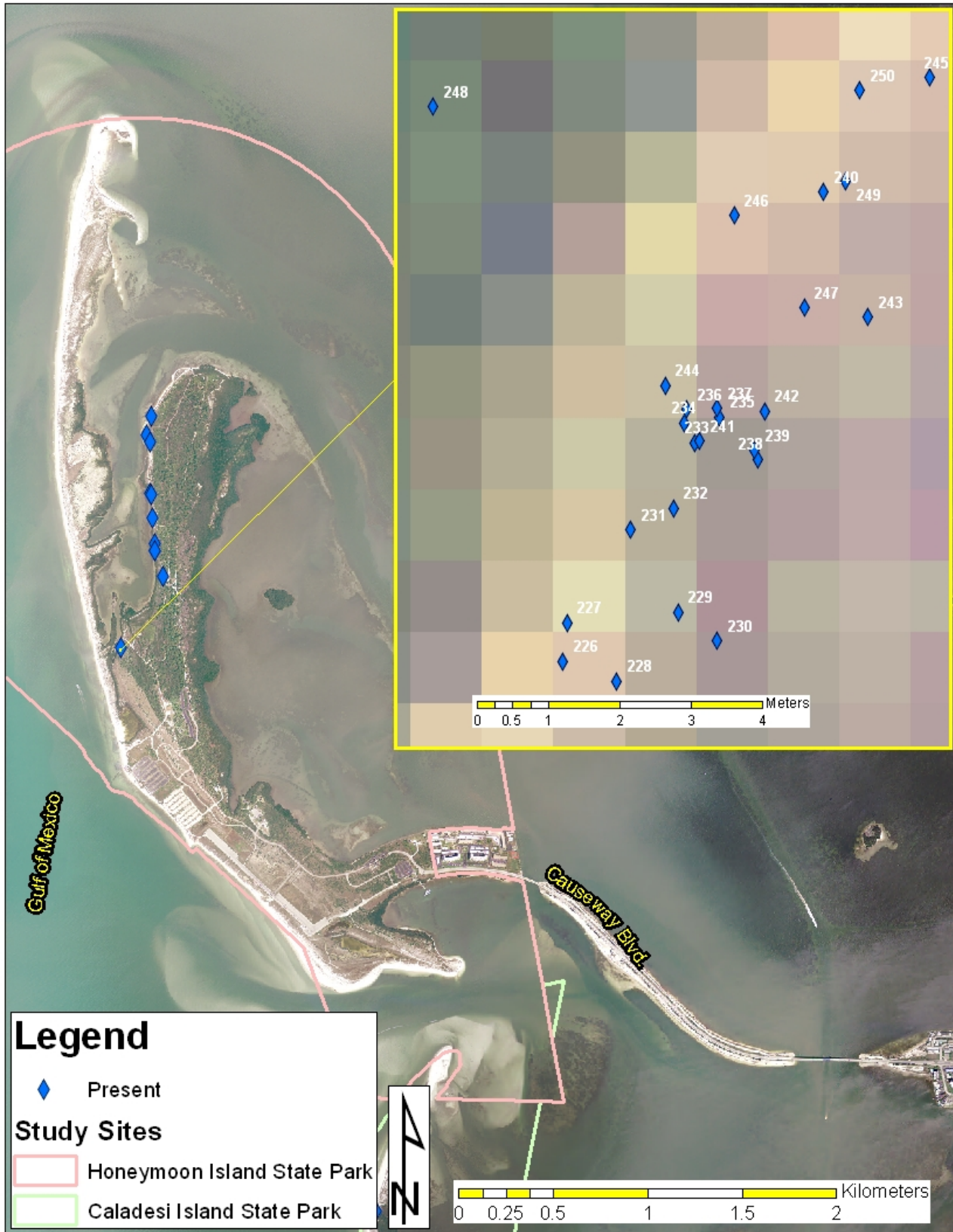


Figure 6-6: *Helianthus debilis* subsp. *vestitus* at Honeymoon Island State Park

Possible causes for population increase: The population of west coast dune sunflower at Honeymoon Island State Park as a whole more than doubled since 2003. This may be attributed to the relatively mild affects of Tropical Storm Frances at Honeymoon Island State Park. In addition, ongoing efforts of exotic plant management at Honeymoon Island State Park may have supported the species. Being a seemingly short lived species, bare soil may be essential in order for it to germinate. Bare soil may have increased since Tropical Storm Frances and exotics treatment. This population may have been insulated from storm affects, such as little salt spray and storm surge, since Tropical Storm Frances crossed over from the east and adjacent pineland protected the population. It is possible that this species may also benefit from other natural disturbances such as fires in coastal strand. If that is the case, fire may be needed in order to create new natural disturbance which, in other areas, this plant seems to thrive on.

It may still be possible that threats including stochastic events such as major hurricanes (greater than Category 4) and freezes; invasion by exotic plant species, such as Brazilian-pepper and shrub verbena (*Lantana camara*) found next to plants; and human induced disturbances, such as hikers going off trail and off-road bicyclists; may impact west coast dune sunflower.

Recommendations: Monitor plants on an annual basis. Exotic pest plant removal at the site has been conducted and should be continued. Prescribed fire should be initiated in order to enhance coastal strand habitat.

Occurrence 6: Sands Key Park, Pinellas County

Owner: Pinellas County

Status: Present

Hurricane damage to west coast dune sunflower: None

Hurricane damage to habitats of west coast dune sunflower: None

Background: Florida Natural Areas Inventory (FNAI) report west coast dune sunflower at this station. The Institute for Regional Conservation staff (Bradley and Abdo) visited the population and counted a few dozen individuals on “dunes and back dunes” on August 20, 2003 (Bradley et al. 2004). Bradley et al. (2004) report that these plants appear to be replanted after beach nourishment.

Site Re-visits: On March 22, 2006, Woodmansee and Mahoney surveyed the locations provided in Bradley et al. (2004) and recorded over 1,000 plants of west coast dune sunflower. A continuous band of plants were observed on the dunes and back dunes of the restored beach. No hurricane damage was observed for plants or habitats.

Site Description: Habitats for the Sands Key Park site would be beach dune and coastal strand, which in this case is bordered by the public beach and Gulf of Mexico to the west grading to coastal strand to the east.

A list of associate plant taxa within one meter of west coast dune sunflower is provided in table 6-4.

Table 6-4: Associated plants of west coast dune sunflower at Sands Key Park

Scientific Name	Common Name
<i>Commelina erecta</i>	dayflower
<i>Croton punctatus</i>	beach tea
<i>Hydrocotyle umbellata</i>	manyflower marsh pennywort
<i>Ipomoea pes-caprae</i>	railroadvine
<i>Iva imbricata</i>	beach-elder
<i>Oenothera</i> sp.	evening primrose
<i>Sabal palmetto</i>	cabbage palm
<i>Scaevola plumieri</i>	inkberry
<i>Uniola paniculata</i>	sea-oats

A map of the population of west coast dune sunflower at Sands Key Park is provided in Figure 6-7.



Figure 6-7: *Helianthus debilis* subsp. *vestitus* at Sands Key Park

Possible causes for population increase: The population of west coast dune sunflower increased exponentially since 2003. This may be attributed to the relatively mild affects of Tropical Storm Frances combined with the natural expansion southward of west coast dune sunflower. Being a seemingly short lived species, bare soil may be essential in order for it to germinate was plentiful since the beach nourishment and habitat restoration. Tropical Storm Frances may have dispersed seeds southward. This population may have been insulated by the storm event as little salt spray and storm surge was evident at this site. Tropical Storm Frances crossed over from the east and more elevated coastal strand buffered the population from catastrophic storm affects.

It may still be possible that threats including stochastic events such as major hurricanes (greater than Category 4) and freezes and human induced disturbances such as trampling by beach goers may impact west coast dune sunflower.

Recommendations: Monitor plants on an annual basis.

Occurrence 7: Shell Key Preserve (Pinellas Bayway), Pinellas County

Owner: Pinellas County

Status: Present

Hurricane damage to west coast dune sunflower: None

Hurricane damage to habitats of west coast dune sunflower: None

Background: On September 30, 1983 FNAI documented the species at a different location within Shell Key Preserve to the south. **On March 21, 2003 Bradley documented “a large colony of over 500 plants...along the eastern shoulder of the Pinellas Bayway (SR 679) just north of Fort Desoto County Park” (Bradley et al. 2004).**

Site Re-visits: On March 22, 2006 Woodmansee and Mahoney surveyed the surveyed the location provided in Bradley et al. (2004) and recorded 100 plants of west coast dune sunflower. On the same day, they mapped and tagged a portion of the population following methods discussed earlier in the chapter. A total of 25 plants were tagged at this location. The population was re-visited on January 11, 2007 by Woodmansee and Barry. Plants growing close to the road shoulder were being mowed. Exotic pest plant removal was also noted for this site.

The data collected on tagged plants during the two site visits are listed in table 6-5. As mentioned previously, it is important to note that both sampling events are post hurricane. No obvious mortality or damage directly attributable to the hurricanes was observed during the first event. Fairly high mortality from the first to second sampling events was observed in the tagged individuals consisting of a 64% reduction. Of the 18 adults in the full sun, 67% died, while 57% of the 7 plants in partial shade died, suggesting little difference in mortality due to canopy conditions. Mortality appears to be natural (i.e. the plant is short-lived with high turnover) as fairly high mortality was also observed to a greater extent at the Honeymoon Island State Park tagged population. Canopy conditions of the tagged population consisted originally of 72% in the full sun and 28% in partial shade.

The average size of the tagged plants, as calculated in cm^2 by measuring the length and width of the plant, was found to be $3,135 \text{ cm}^2$ for all tagged plants combined. This trends toward being smaller than the plants measured at Honeymoon Island State Park. Plants measured in full sun averaged $3,224 \text{ cm}^2$ while in the shade they averaged $2,909 \text{ cm}^2$. Growth of the nine surviving adults was less than two-fold (134%). Growth appears to be better in full sun (174%) compared to partial shade (60%), although sample size is insufficient to confirm.

Phenology was similar to the Honeymoon Island State Park tagged population with a high proportion found flowering, while more flowering was observed at this tagged population during the first sampling, flowering was the same when comparing the second sampling. Approximately 92% of the total 25 tagged plants were flowering in the first sampling event with 89% flowering in the sun and 100% of the plants found in the partial shade flowering.

Table 6-5: Tagged plants of *Helianthus debilis* var. *vestitus* at Shell Key Preserve, Pinellas County

Tag #	Area (cm ²)			Condition (all adults):		Flowering:		Fruiting:		Canopy Condition:		
	22-Mar-06	11-Jan-07	change	22-Mar-06	11-Jan-07	22-Mar-06	11-Jan-07	22-Mar-06	11-Jan-07	22-Mar-06	11-Jan-07	
201	480	7,200	6,720	Good	Good	Yes	Yes	Yes	Yes	Sun	Sun	
202	1,156	4,200	3,044	Good	Good	Yes	No	Yes	No	Partial	Partial	
203	5,115	N/A	N/A	Good	Dead	Yes	N/A	Yes	N/A	Sun	N/A	
204	400	N/A	N/A	Good	Dead	Yes	N/A	Yes	N/A	Sun	N/A	
205	270	N/A	N/A	Good	Dead	Yes	N/A	Yes	N/A	Partial	N/A	
206	782	N/A	N/A	Good	Dead	Yes	N/A	Yes	N/A	Sun	N/A	
207	1,175	N/A	N/A	Good	Dead	Yes	N/A	Yes	N/A	Sun	N/A	
208	1,215	N/A	N/A	Good	Dead	Yes	N/A	Yes	N/A	Sun	N/A	
209	660	N/A	N/A	Good	Dead	Yes	N/A	Yes	N/A	Partial	N/A	
210	264	N/A	N/A	Good	Dead	Yes	N/A	Yes	N/A	Sun	N/A	
211	5,400	N/A	N/A	Good	Dead	Yes	N/A	Yes	N/A	Sun	N/A	
212	12,600	N/A	N/A	Good	Dead	Yes	N/A	Yes	N/A	Sun	N/A	
213	7,200	N/A	N/A	Good	Dead	Yes	N/A	Yes	N/A	Sun	N/A	
214	2,000	N/A	N/A	Good	Dead	Yes	N/A	Yes	N/A	Sun	N/A	
215	5,500	28,800	23,300	Good	Good	Yes	Yes	Yes	Yes	Sun	Sun	
216	3,300	7,500	4,200	Good	Good	Yes	Yes	Yes	Yes	Sun	Partial	
217	2,695	N/A	N/A	Good	Dead	Yes	N/A	Yes	N/A	Partial	N/A	
218	3,600	2,400	-1,200	Good	Dying	Yes	Yes	Yes	No	Sun	Sun	
219	240	N/A	N/A	Good	Dead	Yes	N/A	Yes	N/A	Sun	N/A	
220	2,560	3,500	940	Good	Dying	No	Yes	Yes	Yes	Sun	Sun	
221	2,625	N/A	N/A	Good	Dead	No	N/A	Yes	N/A	Sun	N/A	
222	500	2,000	1,500	Good	Dying	Yes	Yes	Yes	Yes	Partial	Partial	
223	3,575	2,600	-975	Good	Good	Yes	No	Yes	No	Sun	Partial	
224	6,580			Good	Dead	Yes	N/A	Yes	N/A	Partial	N/A	
225	8,500	10,000	1,500	Good	Dying	Yes	Yes	Yes	Yes	Partial	Sun	
Growth per plant:				Flowers:								
combined	3,135.68	7,577.78	4,336.56*	133.79%	combined	92.00%	77.78%					
Sun	3,223.94	8,666.67	5,497.50*	173.47%	Sun	88.89%	100.00%					
Partial	2,908.71	5400	2,014.67*	59.51%	Partial	100.00%	50.00%					
% mortality:				Fruits:								
combined	64.00%			Combined	100.00%	66.67%						
Sun	66.67%			Sun	100.00%	80.00%						
Partial	57.14%			Partial	100.00%	50.00%						
								Canopy:				
								Sun	72.00%	55.56%		
								Partial	28.00%	44.44%		

*Change calculated only for individual plant samplings which crossed both monitoring periods.

In the second event, 78% of the surviving tagged plants were flowering with 89% of the plants found in full sun flowering and 100% of the plants found in partial shade flowering. This changed in the second sampling as flowering was reduced to 78% combined, 100% in sun, and 50% in partial shade. Fruiting was 100% across the board in the first sampling. This changed in the second sampling as plants fruited 80% in sun, 50% in partial shade, 66.67% combined. When compared with the tagged plants at Honeymoon Island State Park, the fruiting trend is similar to the flowering trend with more fruits at Shell Island Preserve during the first sampling, while fruiting frequency was relatively the same during the second sampling.

These data appear to indicate rapid turn-over growth and life stage of west coast dune sunflower.

Site Description: Habitat for the Honeymoon Island State Park site would be Ruderal, which in this case is bordered by paved road to the west grading to mixed cabbage palm woodland to the east.

A list of associate plant taxa within one meter of west coast dune sunflower is provided in table 6-6:

Table 6-6: Associated plants of west coast dune sunflower at Shell Key Preserve

Scientific Name	Common Name
<i>Ambrosia artemisiifolia</i>	ragweed
<i>Andropogon glomeratus</i> var. <i>pumilus</i>	common bushy bluestem
<i>Bidens alba</i> var. <i>radiata</i>	Spanish needle
<i>Phyllanthus abnormis</i>	Drummond's leafflower
<i>Physalis walteri</i>	Walter's groundcherry
<i>Poinsettia cyathophora</i>	painted leaf
<i>Quercus virginiana</i>	live oak
<i>Sabal palmetto</i>	cabbage palm
<i>Smilax auriculata</i>	earleaf greenbriar
<i>Stenotaphrum secundatum</i>	St. Augustine grass
<i>Toxicodendron radicans</i>	poison-ivy
<i>Yucca aloifolia</i>	Spanish bayonet

A map of the population of west coast dune sunflower at Shell Key Preserve is provided in Figure 6-8.

Possible causes for population decrease: It is uncertain why populations of west coast dune sunflower at Shell Key Preserve decreased almost fivefold since 2003. It is possible that when Bradley visited the population in 2003, the road shoulder had not been mowed in some time. Mowing at the time of the surveys by Woodmansee and Mahoney may have decreased the population at that time. West coast dune sunflower may benefit from mowing, if given enough time to reestablish, reproduce and set seed. It is also possible that efforts to eradicate exotic pest plants may have caused off target damage to west coast dune sunflower. If that is the case, it is expected that the population decrease would only be temporary. Another possible cause is competition from other plant species. Being a

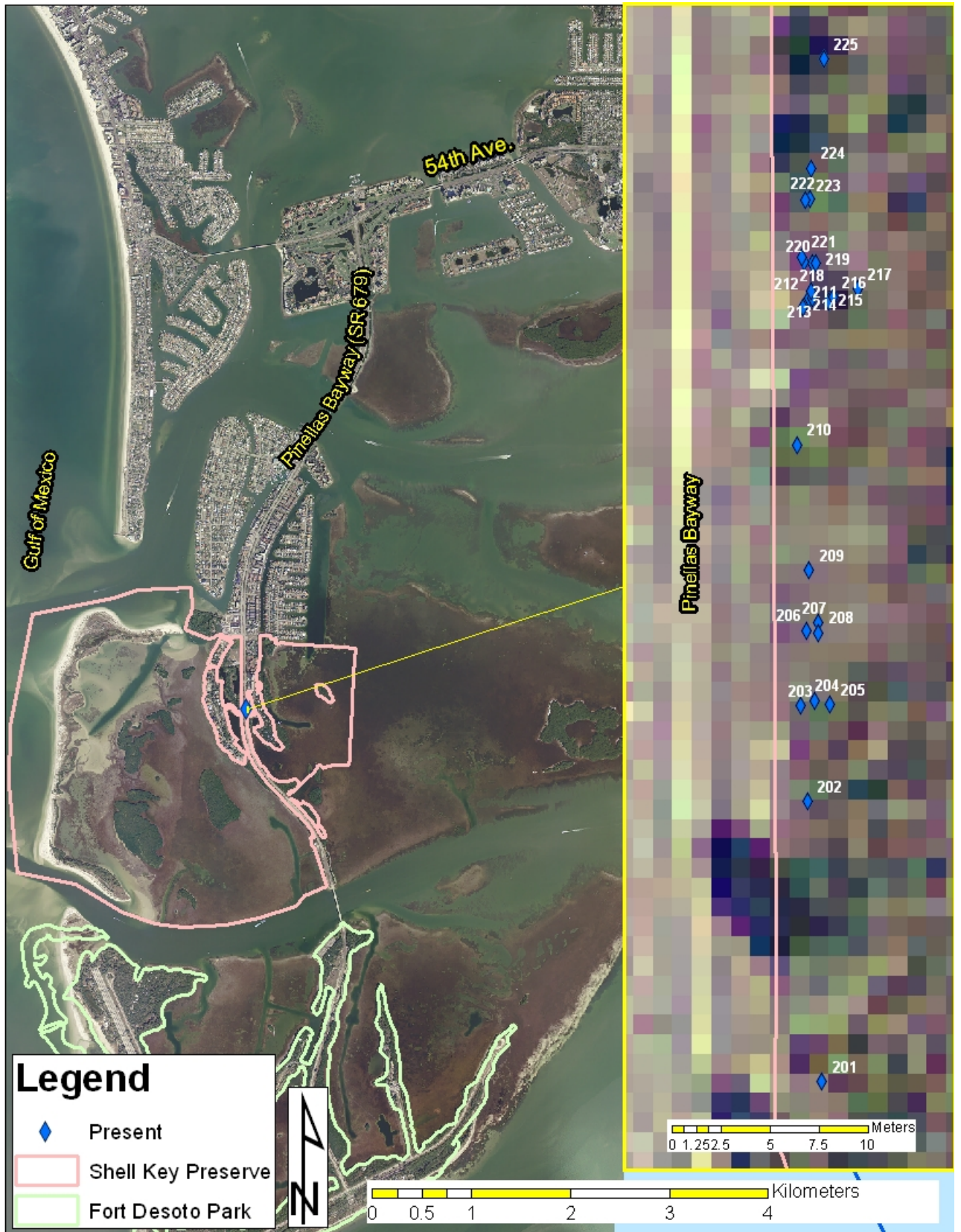


Figure 6-8: *Helianthus debilis* subsp. *vestitus* at Shell Key Preserve

seemingly short lived species, bare soil may be essential in order for it to germinate, which may be difficult in situations of overcrowding.

It is possible that west coast dune sunflower benefits from natural disturbances such as fires in fire adapted upland plant communities. It was thought that the storm events may have helped west coast dune sunflower at this site in the long run. However, this site was insulated from storm events, such as salt spray or soil deposition, by surrounding habitat. It may still be possible that threats including stochastic events such as a direct hit by a major hurricane, and freezes; invasion by exotic plant species, such as shrub verbena (*Lantana camara*), Madagascar periwinkle (*Catharanthus roseus*), Bermuda grass (*Cynodon dactylon*), and Natal grass (*Rhynchelytrum repens*) found next to the population; and human induced disturbances, such as expansion or repair of the Pinellas Bayway; may impact west coast dune sunflower.

Recommendations: Monitor plants on an annual basis. Exotic pest plant removal at the site has been conducted and should be continued, but with caution so as not to impact west coast dune sunflower. The Florida Department of Transportation should be made aware of this population of west coast dune sunflower so that plants may be protected. Consider prescribing fire at the palm woodland to the east and augment populations of west coast dune sunflower there.

Final Discussion

In synopsis, it appears that west coast dune sunflower may have become historical at Cayo Costa State Park as a result of Hurricane Charley, and further surveys are need there in case it reappears. As discussed in each occurrence account, other populations of west coast dune sunflower appeared to have either benefited from the milder Tropical Storm Frances or were unaffected. It is recommended that the population at Egmont Key National Wildlife Refuge by surveyed for soon to verify its presence there after storms. There is still a need to remove non-native populations of east coast dune sunflower and dune sunflower hybrids, especially in areas where both occur (Bradley et al. 2004). Once this is done, restoration of west coast dune sunflower can be implemented at other areas within its historic range from Lee County north through Pinellas County. West coast dune sunflower should be considered for listing by the Florida Department of Agriculture and Consumer Services.

Acknowledgements

The authors wish to thank Josh M. Mahoney who assisted with field surveys. Peter Krulder of the Florida Park Service provided boat transportation to Caladesi Island State Park. We also thank the Florida Department of Parks and Recreation and Pinellas County for granting us permission to access properties within the study area. Kirsten Hines assisted with edits and provided valuable advice on this report.

Citations

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Chapter 7 - Post-hurricane Field Assessment of Small's Milkwort (*Polygala smallii* R.R. Sm. & Ward)

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Small's milkwort at Lynn University Scrub in Palm Beach County.
Steven W. Woodmansee, November 2006.

Table of Contents

Introduction	189
Methods	191
Results and Discussion	192
Final Discussion	219
Acknowledgements	219
Citations	220

Tables:

Table 7-1: Small's milkwort Study Area	194
Table 7-2: Observations of Small's milkwort at Gopher Tortoise Preserve, Broward County	195
Table 7-3: Observations of Small's milkwort at Jonathan Dickinson State Park, Creek Ridge Site, Martin County	198
Table 7-4: Observations of Small's milkwort at Jonathan Dickinson State Park, Gopher Tortoise Burrow Site, Martin County	200
Table 7-5: Observations of Small's milkwort at Jonathan Dickinson State Park, Gator Lake Campground Site, Martin County	201
Table 7-6: Observations of Small's milkwort at Jonathan Dickinson State Park, Sandhill Site, Martin County	204
Table 7-7: Observations of Small's milkwort at Jupiter Ridge Natural Area, Palm Beach County	207
Table 7-8: Observations of Small's milkwort at Lynn University Scrub, Palm Beach County	210
Table 7-9: Observations of Small's milkwort at Savannas Preserve State Park, Lynngate Site, St. Lucie County	212
Table 7-10: Reported Observations of Small's milkwort at Limestone Creek Natural Area, Palm Beach County	215

Figures:

Figure 7-1: <i>Polygala smallii</i> Study Area	190
Figure 7-2: <i>Polygala smallii</i> Occurrence Results	193
Figure 7-3: <i>Polygala smallii</i> at Gopher Tortoise Preserve	196
Figure 7-4: <i>Polygala smallii</i> at Creek Ridge and Gopher Tortoise Burrow sites, Jonathan Dickinson State Park	199
Figure 7-5: <i>Polygala smallii</i> at Jonathan Dickinson State Park, Gator Lake Campground Site	202
Figure 7-6: <i>Polygala smallii</i> at Jonathan Dickinson State Park, Sandhill Site, Martin County	205
Figure 7-7: <i>Polygala smallii</i> at Jupiter Ridge Natural Area, Palm Beach County	208
Figure 7-8: <i>Polygala smallii</i> at Lynn University Scrub, Palm Beach County	211
Figure 7-9: <i>Polygala smallii</i> at Savannas Preserve State Park, Lynngate Site, St. Lucie County	213
Figure 7-10: <i>Polygala smallii</i> Report at Limestone Creek Natural Area	216
Figure 7-11: <i>Polygala smallii</i> False Report at Diamondhead/Radnor Park	218

Introduction

Small's milkwort (*Polygala smallii*) is listed as endangered by the USFWS (2000) and by the Florida Department of Agriculture and Consumer Services (Coile and Garland 2003). Before the 2004 hurricane season, populations of Small's milkwort were known to have occurred in Miami-Dade, Broward, Palm Beach, Martin, and St. Lucie counties. In 2004, hurricanes Jeanne and Frances's paths crossed the border between Martin and St. Lucie counties. In 2005, Hurricane Wilma's path crossed over much of Palm Beach County and tropical storm Katrina's path crossed over southern Broward County (Figure 7-1). It was uncertain whether populations of Small's milkwort would have responded positively or negatively toward hurricane events. In addition, most of the populations had not been checked since 2000 (Fisher 2000). It was surmised that populations could have been negatively impacted by tree falls, storm surge, and potential illegal dumping on conservation lands. An attempt was made to visit known and reported populations of Small's milkwort within its geographic range excluding Miami-Dade County, which was not impacted by hurricanes at the time of the contract proposal.

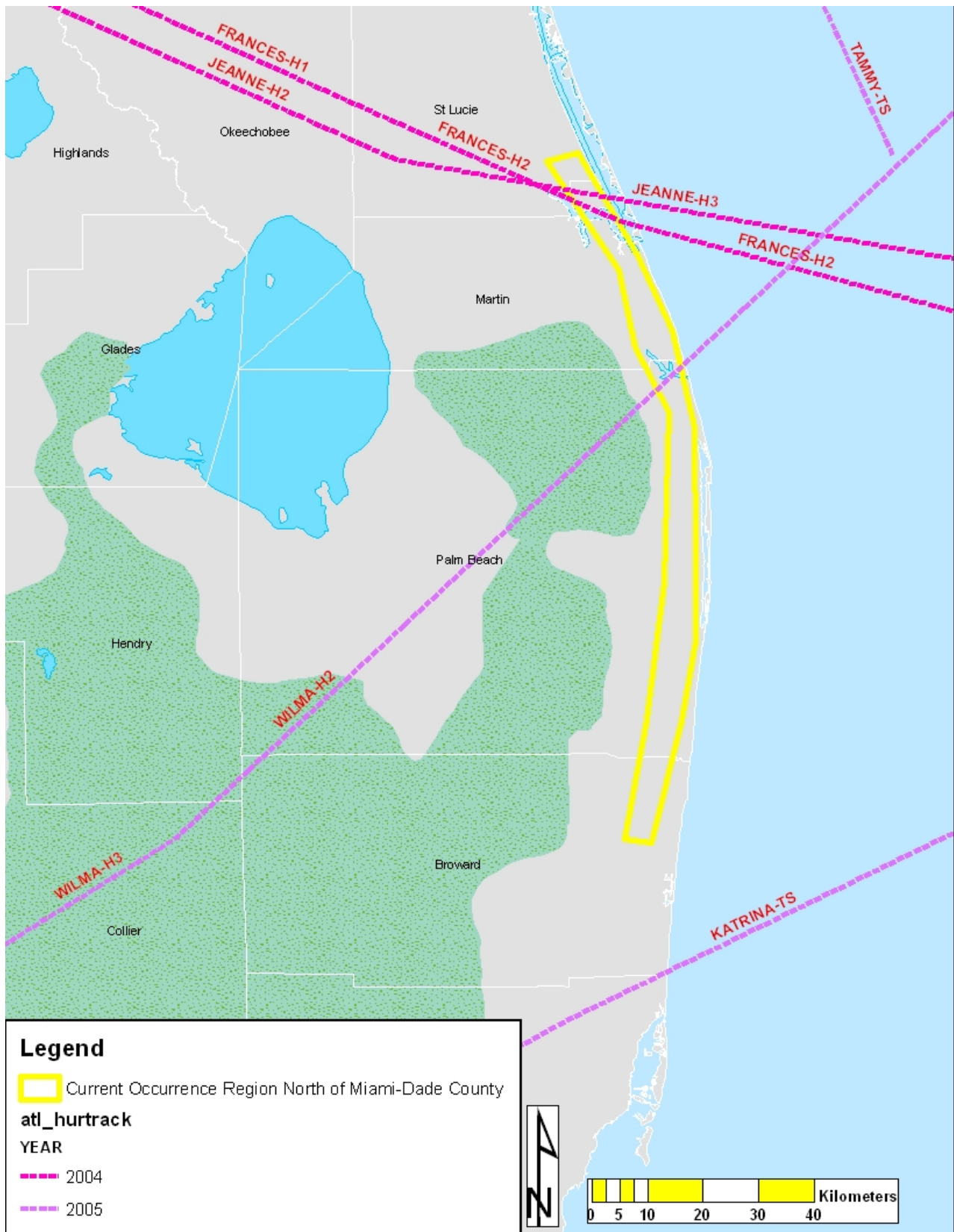


Figure 7-1: *Polygala smallii* Study Area

Methods

Preparation

Before field assessments were conducted for Small's milkwort, available literature (Bradley and Gann 1995; Fisher 2000), herbarium specimen data, and land managers were consulted. Permission from land owners or land managers was obtained before any visits were made.

Field Assessment

Upon visitation at each site, a search was conducted. Open grassy areas within scrub and flatwoods communities were surveyed, as well as areas dominated by saw palmetto (*Serenoa repens*). Upon finding Small's milkwort, total number of plants was recorded, recruitment was noted, habitat(s) following FNAI and FDNR (1990) were recorded, as well as species associates. Upon finding populations, a centroid point was recorded using a GPS unit with five meter accuracy and, in cases of broad populations (greater than a ten meter radius), boundaries of the population were recorded. Notes on individual plant health were also recorded. It was not deemed necessary to tag and monitor individual plants of Small's milkwort since it is known to be short lived. Hurricane damage was noted for the plants as well as the habitats.

Hurricane damage to plants was ranked as none if there was no direct evidence of the events impacting specific individual plants. Hurricane damage to the plants was ranked as low if little damage to the plants (mortality 5-10%) was directly evidenced as a result to the storms. Hurricane damage to the plants would be ranked as moderate if any branches or trunks were known to have fallen on plants and mortality (10-50%) was indicated. Hurricane damage to the plants would be ranked as severe if tree falls and storm surge was evidenced directly to the plants, and mortality measuring > 50% was indicated by this.

Hurricane damage to the habitat was ranked as none for sites with no direct evidence of the events impacting the habitat. Hurricane damage to the habitat was ranked as low for areas with only a few tree falls and no storm surge (as would be indicated by a die off of the herb vegetation from salt water) surrounding the centroid. Hurricane damage to the habitat was ranked as moderate if there was notable tree falls within the habitat (>five trees) and no storm surge surrounding the centroid. Hurricane damage to the habitat was ranked as severe if major changes to the habitat (such as majority of canopy trees fell) and/or there was notable storm surge.

Data Entry

Survey data was entered and maintained in two geodatabases. The two geodatabases are linked by PointID fields. The GIS geodatabase entitled USFWS_HURSUR_MDB contains coordinate data (in NAD 83 UTM 17N format), Site, Subunit, Associated Taxa, Habitat, Occurrence, and PointID. The second geodatabase entitled USFWS_HURSUR_Datasets contains survey data and was created in Microsoft Access and is linked to the geodatabase by the PointID number. The primary table in this database, which contains one record for each PointID linked by Surveyors and Date, contains all pertinent data from the survey also including Event Number, Comments1, Comments 2, Plant Number, Population Estimate, Site, Site Unit, and Occurrence.

Results and Discussion

Site Visit Prioritization

Sites known to have contained Small's milkwort were visited first. These included: Savannas Preserve State Park, Jonathan Dickinson State Park, Jupiter Ridge Natural Area, and the Gopher Tortoise Preserve at Ft. Lauderdale Executive Airport. Coordinates and descriptions of these sites from Fisher (2000) were visited first. As a result of additional literature searches, unverified populations were uncovered for Diamondhead/Radnor Park and Limestone Creek Natural Area were also visited (Email Correspondence with Steve Farnsworth and Frank Griffiths of PBERM with Steve Woodmansee, November 29, 2006). In addition, a location based upon a recently redetermined herbarium specimen collected at the Lynn University campus in Boca Raton was discovered (F.R. Posin, s.n., FTG). A total of seven known, two reported, and one newly recognized populations of Small's milkwort were visited (Figure 7-2).

As a result, four populations are now known to be extant, three populations are considered to be historical, one population was determined to be false, and one population is still considered to be reported as plant verification could not be made as seeds needed for identification were not present at the time of the survey. These sites are organized into three historical, four present, one unverified, and one false Occurrence (Table 7-1).

Accounts of sites surveyed for Small's milkwort are primarily arranged by accepted occurrences, reported occurrences, or erroneous occurrences and secondarily arranged alphabetically. Accounts of each occurrence are detailed in the following sections.

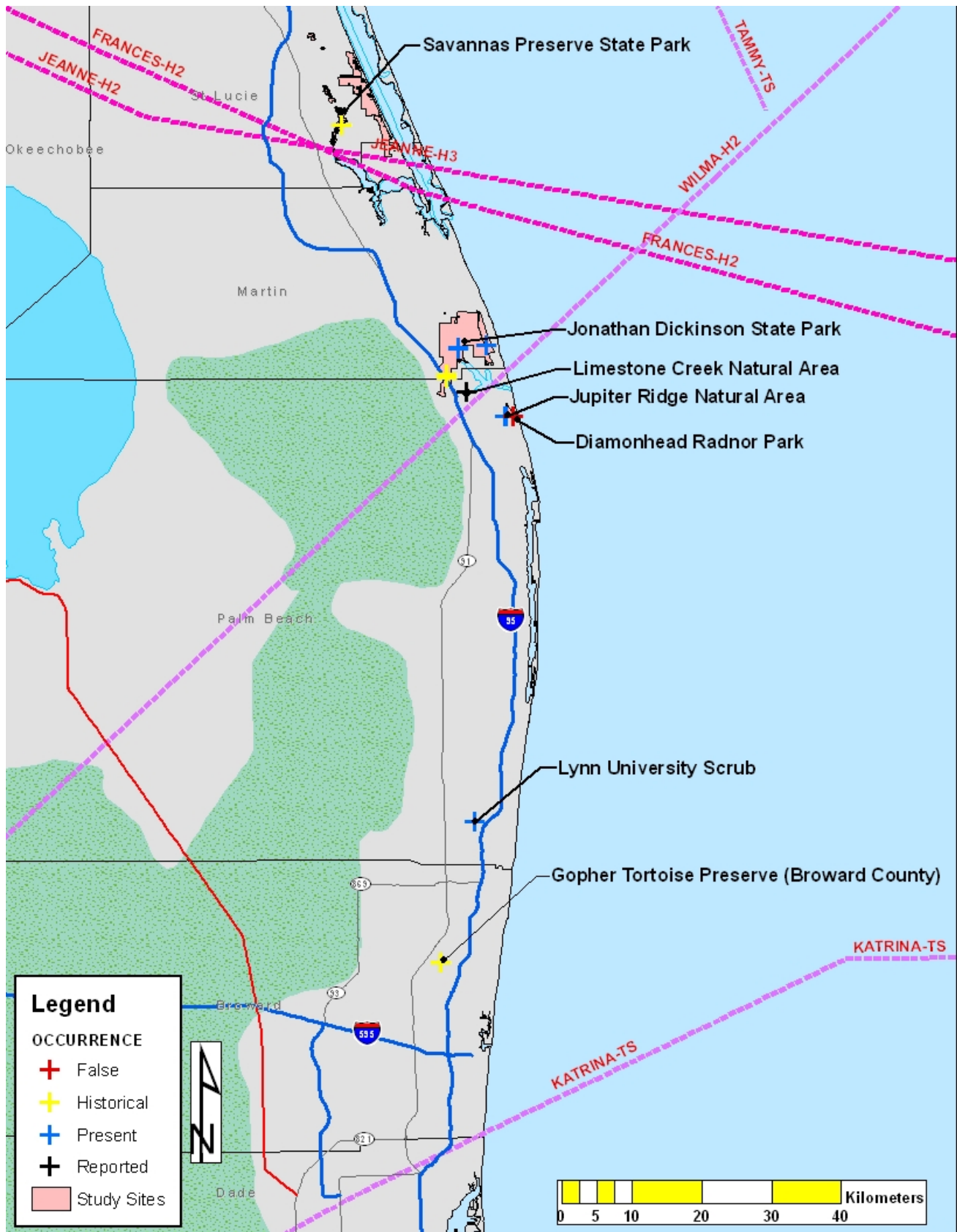


Figure 7-2: *Polygala smallii* Occurrence Results

Table 7-1: Small's milkwort Study Area

Occurrence #	Site Name	Site Unit	Status	Number of Plants in 2006	Hurricane Damage to Habitat	Hurricane Damage to Plants
1	Gopher Tortoise Preserve (Broward County)		H	0	Moderate	None observed
2	Jonathan Dickinson State Park	Creek Ridge	H	0	Low	None observed
2	Jonathan Dickinson State Park	Gopher Tortoise Burrow	H	0	Low	None observed
3	Jonathan Dickinson State Park	Gator Lake Campground	P	8	Low	None observed
4	Jonathan Dickinson State Park	Sandhill	P	44	Low	None observed
5	Jupiter Ridge Natural Area		P	10	Low	None observed
6	Lynn University		P	14	Low	None observed
7	Savannas Preserve State Park	Lynngate	H	0	Moderate	None observed
Unverified	Limestone Creek Natural Area		R	3*	Low	None observed
False	Diamondhead/Radnor Park		F	0	None	N/A

F = False
H = Historical (not observed during these surveys)
R = Reported (not verified during these surveys)
P = Present

* 3 potential (sterile) individuals

Small's milkwort Occurrences

Occurrence 1: Gopher Tortoise Preserve, Broward County

Owner: Ft. Lauderdale International Executive Airport

Status: Historical

Hurricane damage to Small's milkwort: none

Hurricane damage to Small's milkwort habitat: moderate

Background: Small's milkwort was first described from this station by Bradley and Gann (1995). It was again observed by Bradley, Woodmansee, and Fisher in 2000 (Fisher 2000).

Site Re-visit: Small's milkwort was searched for by Woodmansee and Mahoney in July 2006. Habitat encompassing sand pine scrub surrounding the centroid was surveyed. Despite extensive searches throughout the entire site, no plants were found. Gopher tortoise (*Gopherus polyphemus*) burrows were observed close to the historic location. It appears that there was low to moderate hurricane damage here, as there was some tree breakage from storms, but the canopy was still largely intact, and the scrub habitat was in excellent shape. Table 7-2 contains population summary data for each of the three site visits.

Table 7-2: Observations of Small's milkwort at Gopher Tortoise Preserve, Broward County

Survey Date	Surveyors	Count
11/19/1995	GDG, KAB	21
8/9/2000	KAB, SWW, JBF	7
7/19/2006	SWW, JMM	0
KAB = Keith A. Bradley		
GDG = George D. Gann		
JBF = Jack B. Fisher		
JMM = Josh M. Mahoney		
SWW = Steven W. Woodmansee		

Site Description: In brief, Bradley and Gann (1995) describe the habitat as formerly cleared but now restored sand pine/rosemary scrub. A map of the historic population of Small's milkwort at Gopher Tortoise Preserve is provided in Figure 7-3.



Figure 7-3: *Polygala smallii* at Gopher Tortoise Preserve

Possible Cause for Disappearance: It is unknown why Small's milkwort has disappeared from this station. It is doubtful that hurricanes are responsible for Small's milkwort's decline. Drought conditions and lack of fire may have hindered this population. The dominant herb in most of the open areas of scrub (where Small's milkwort is typically observed) by far is sand spikemoss (*Selaginella arenicola*). Very few graminoids and fleshy herbs were observed. In addition, there seems to be a fairly large population of gopher tortoises at this small preserve. It is unknown whether these tortoises would eat Sand spikemoss, but it is suspected that they do not due to its abundance at this site. It may be possible that the gopher tortoises devoured the few remaining plants of Small's milkwort based upon the current vegetation composition.

Recommendations: Fire management and exotic pest plant removal at this site. Continue surveys at this location on an annual basis and after fires.

Occurrence 2: Jonathan Dickinson State Park, Creek Ridge and Gopher Tortoise Burrow Sites, Martin County

Owner: Florida Department of Environmental Protection, Parks and Recreation

Status: Historical

Hurricane damage to Small's milkwort: none

Hurricane damage to Small's milkwort habitat: low

Creek Ridge

Background: Small's milkwort was first documented for this station by Bradley and Woodmansee in 1997 with an herbarium specimen (Bradley and Woodmansee, 262, FTG). It was again observed by Bradley, Woodmansee, and Fisher in 2000 (Fisher 2000).

Site Re-visit: Small's milkwort was searched for by Woodmansee, Mahoney, and Florida State Park Biologist Rob Rossmann in 2006. Habitat encompassing mesic and scrubby flatwoods surrounding the centroid was searched. Despite searches, no Small's milkwort was found. No significant hurricane wind damage was observed here, nor was there any storm surge. Table 7-3 contains population summary data for each of the three site visits.

Table 7-3: Observations of Small's milkwort at Jonathan Dickinson State Park, Creek Ridge Site, Martin County

Survey Date	Surveyors	Count
7/18/1997	KAB, SWW	10
8/11/2000	KAB, SWW, JBF	4
7/19/2006	SWW, JMM, RR	0
KAB = Keith A. Bradley		
JBF = Jack B. Fisher		
JMM = Josh M. Mahoney		
RR = Rob Rossmann		
SWW = Steven W. Woodmansee		

Site Description: Bradley and Woodmansee (Bradley and Woodmansee, 262, FTG) describe it as occurring in mesic/scrubby flatwoods along the edge of a fire management road. A map of the historic population of Small's milkwort at Jonathan Dickinson State Park, Creek Ridge site is provided in Figure 7-4.

Possible Cause for Disappearance: It is unknown why Small's milkwort has disappeared from this station. It is doubtful that hurricanes are responsible as little damage was apparent. Drought conditions and lack of fire may have hindered this population.

Recommendations: Fire management at this site. Surveys at this location should be conducted on an annual basis and after fires.



Figure 7-4: *Polygala smallii* at Creek Ridge and Gopher Tortoise Burrow sites, Jonathan Dickinson State Park

Gopher Tortoise Burrow

Background: Small's milkwort was first documented for this station by Bradley and Woodmansee in 1997 with an herbarium specimen (Bradley and Woodmansee, 261, FTG). It was again observed by Bradley, Woodmansee, and Fisher in 2000 (Fisher 2000).

Site Re-visit: Small's milkwort was searched for by Woodmansee, Mahoney, and Florida State Park Biologist Rob Rossmanith in 2006. Habitat encompassing mesic flatwoods and edges of gopher tortoise (*Gopherus polyphemus*) burrows surrounding the centroid was searched. Despite searches, no Small's milkwort was found. There was no evidence of any recent fires. No significant hurricane wind damage was observed here, nor was there any storm surge. Table 7-4 contains population summary data for each of the three site visits.

Table 7-4: Observations of Small's milkwort at Jonathan Dickinson State Park, Gopher Tortoise Burrow Site, Martin County

Survey Date	Surveyors	Count
7/18/1997	KAB, SWW	11
8/11/2000	KAB, SWW, JBF	5
7/19/2006	SWW, JMM, RR	0
KAB = Keith A. Bradley		
JBF = Jack B. Fisher		
JMM = Josh M. Mahoney		
RR = Rob Rossmanith		
SWW = Steven W. Woodmansee		

Site Description: Bradley and Woodmansee (Bradley and Woodmansee, 261, FTG) describe it as occurring in mesic flatwoods around a gopher tortoise burrow. A map of the historic population of Small's milkwort at Jonathan Dickinson State Park, Gopher Tortoise Burrow site is provided in Figure 7-4.

Possible Cause for Disappearance: It is unknown why Small's milkwort has disappeared from this station. It is doubtful that hurricanes are responsible as little damage was apparent. Drought conditions and lack of fire may have hindered this population.

Recommendations: Fire management at this site. Surveys at this location should be conducted on an annual basis and after fires.

Occurrence 3: Jonathan Dickinson State Park, Gator Lake Campground, Martin County

Owner: Florida Department of Environmental Protection, Parks and Recreation

Status: Present

Hurricane damage to Small's milkwort: none

Hurricane damage to Small's milkwort habitat: low

Background: Small's milkwort was first described from this station by Bradley and Gann (1995) who named the site "Campground Lake". It was again observed by Bradley, Woodmansee, and Jack Fisher in 2000 (Fisher 2000).

Site Re-visit: Small's milkwort was searched for by Woodmansee, Mahoney, and Florida State Park Biologist Rob Rossmanith in 2006. Habitat encompassing sand pine scrub and grading into lake shore surrounding the centroid was searched. A single plant of Small's milkwort was recorded along the slope between the lake shore and the scrub in the vicinity of this centroid. An additional two adults and six seedlings were discovered in the sand pine scrub approximately 65 m south of the centroid. This site was very recently burned (in past month), so little green vegetation existed. It had been over forty years since the last fire here (pers. comm. with R. Rossmanith). Only moderately significant hurricane wind damage to the habitat was observed here and there was no storm surge. However, a recent non-hurricane storm event did blow over some trees. Rebar and tags (not attached to plants, and seemingly unaffected by the recent storms) from an old Fairchild Tropical Botanic Garden study were also observed here. Table 7-6 contains population summary data for each of the three site visits.

Table 7-5: Observations of Small's milkwort at Jonathan Dickinson State Park, Gator Lake Campground Site, Martin County

Survey Date	Surveyors	Count
11/16/1995	GDG, KAB	64
8/11/2000	KAB, SWW, JBF	24
7/19/2006	SWW, JMM, RR	9
KAB = Keith A. Bradley		
GDG = George D. Gann		
JBF = Jack B. Fisher		
JMM = Josh M. Mahoney		
RR = Rob Rossmanith		
SWW = Steven W. Woodmansee		

Site Description: In brief, Bradley and Gann (1995) describe the habitat as the slope between sand pine scrub and (Gator) Lake. A map of the population of Small's milkwort at Jonathan Dickinson State Park, Gator Lake Campground site is provided in Figure 7-5. The single plant occurs near the northern point, the cluster of eight plants along the southern

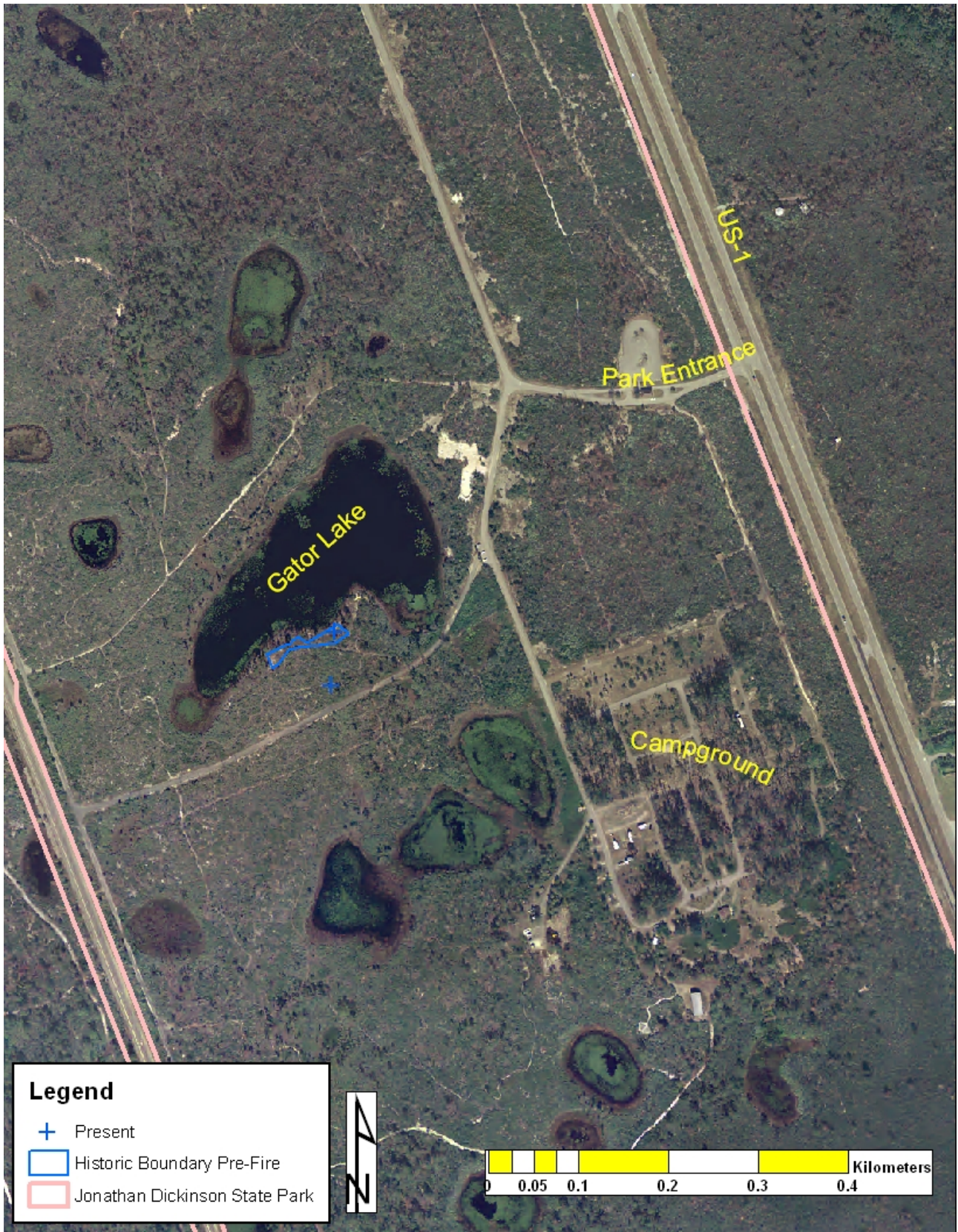


Figure 7-5: *Polygala smallii* at Jonathan Dickinson State Park, Gator Lake Campground Site

point, and the historic population boundary was hand digitized based upon authors' past experiences.

Possible Cause for Population Decrease: Although the data seem to indicate that the population of Small's milkwort is in severe decline, it is expected that fire may benefit this species in the long run. Drought conditions may have also hindered this population. Human disturbance in the form of hikers and off-road bicycles may have also contributed.

Recommendations: Monitor existing population and conduct surveys for more plants at this location on an annual basis and after fires. Study whether area needs to be closed off to humans.

Occurrence 4: Jonathan Dickinson State Park, Sandhill Site, Martin County

Owner: Florida Department of Environmental Protection, Parks and Recreation

Status: Present

Hurricane damage to Small's milkwort: none

Hurricane damage to Small's milkwort habitat: low

Background: Small's milkwort was first described from this station by Bradley and Gann (1995). It was again observed by Bradley, Woodmansee, and Fisher in 2000 (Fisher 2000).

Site Re-visit: Small's milkwort was searched for by Woodmansee and Mahoney in 2006. Habitat encompassing sandhill dominated by turkey oak (*Quercus laevis*) surrounding the centroid was searched. A total of 44 plants of Small's milkwort were recorded, 28% of the count in 2000. No significant hurricane wind damage was observed here, nor was there any storm surge.

An additional area of sandhill habitat located just west of the existing population had burned just before the time of the surveys. This area was searched for Small's milkwort. No plants were found. Table 7-6 contains population summary data for each of the three site visits.

Table 7-6: Observations of Small's milkwort at Jonathan Dickinson State Park, Sandhill Site, Martin County

Survey Date	Surveyors	Count
12/3/1995	GDG, KAB	141
8/11/2000	KAB, SWW, JBF	157
7/20/2006	SWW, JMM	44
KAB = Keith A. Bradley		
JBF = Jack B. Fisher		
GDG = George D. Gann		
JMM = Josh M. Mahoney		
SWW = Steven W. Woodmansee		

Site Description: In brief, Bradley and Gann (1995) describe the habitat as turkey oak sandhill. This site was once listed as the “square lake” population. A map of the population of Small's milkwort at Jonathan Dickinson State Park, Sandhill site is provided in Figure 7-6. The population occurs within the blue polygon plotted between two points collected in the field.

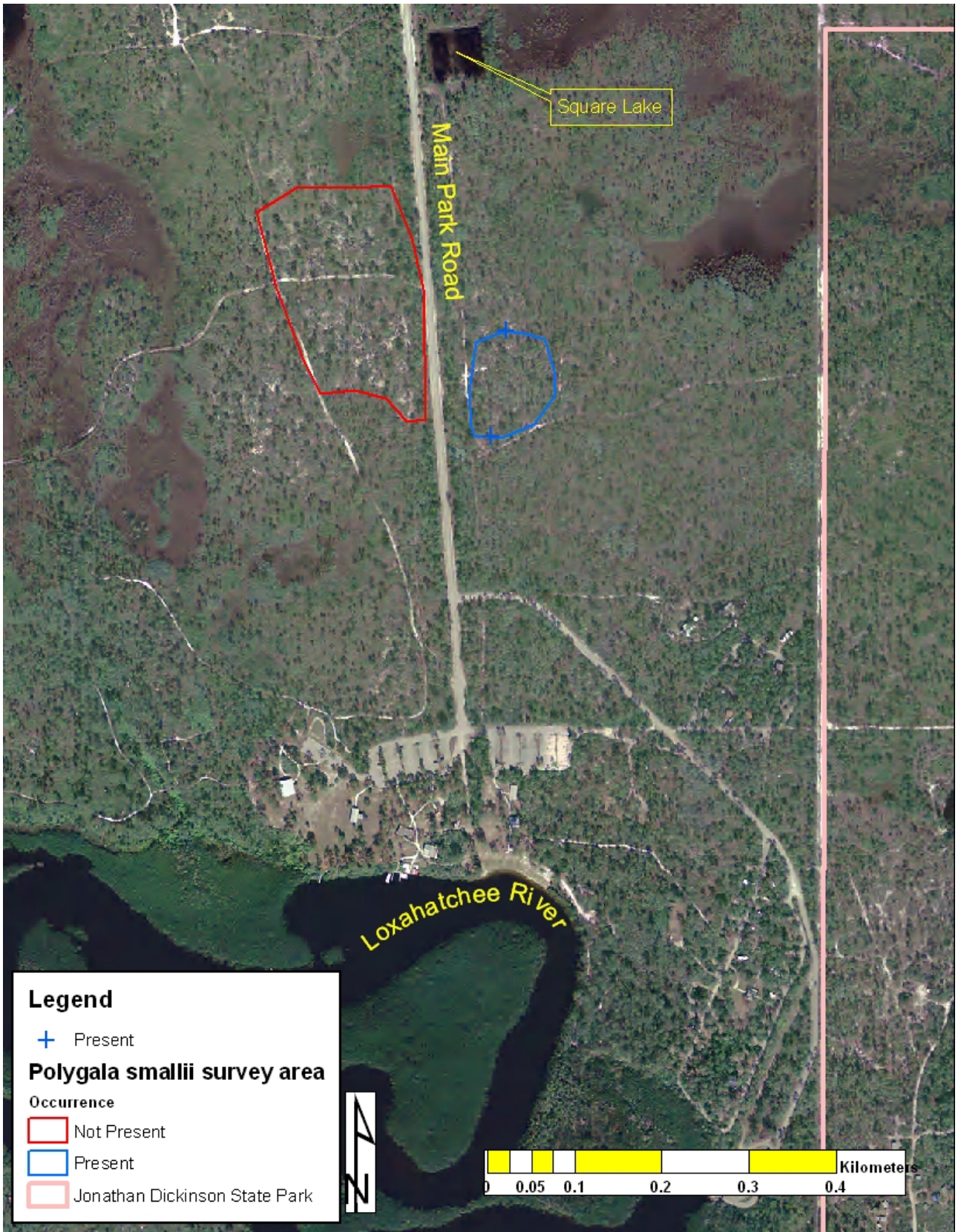


Figure 7-6: *Polygala smallii* at Jonathan Dickinson State Park, Sandhill Site, Martin County

Possible Cause for Population Decrease: It is unclear as to why Small's milkwort appears to be declining at this site. In the past, it may have been more abundant due to its proximity to a fire occurrence. Drought conditions may have also hindered this population. It is suspected that plant populations may increase after fires in the sandhill habitat.

Recommendations: Monitor existing population and conduct surveys for more plants at this location on an annual basis and after fires.

Occurrence 5: Jupiter Ridge Natural Area, Palm Beach County

Owner: Palm Beach County Department of Environmental Resource Management

Status: Present

Hurricane damage to Small's milkwort: none

Hurricane damage to Small's milkwort habitat: low

Background: Small's milkwort was first described from this station by Bradley and Gann (1995). It was again observed by Bradley, Woodmansee, and Fisher in 2000 (Fisher 2000). It has also been visited by Palm Beach County staff persons in 2001, 2004, and 2005 (Walesky 2005).

Site Re-visit: Small's milkwort was searched for by Woodmansee, Mahoney, and Mike Cheek of Palm Beach County Environmental Resource Management in 2006. Habitat encompassing a spoil pile within senescent sand pine scrub and grading into mesic flatwoods near the shore of the Intracoastal Waterway surrounding the centroid was searched. Ten plants of Small's milkwort were recorded at two locations. The northern subpopulation occurs in fire suppressed scrub to the east of the footpath that still exists. No hurricane damage was observed at this locality. The southern subpopulation consists of fire suppressed sandy mesic flatwoods sloping west of the footpath. Some moderate hurricane damage was observed here consisting of fallen branches of South Florida slash pine (*Pinus elliotii* var. *densa*) onto the plants. Surprisingly, no storm surge affecting Small's milkwort was evident. Table 7-7 contains population summary data for each of the six site visits.

Table 7-7: Observations of Small's milkwort at Jupiter Ridge Natural Area, Palm Beach County

Survey Date	Surveyors	Count
11/16/1995	GDG, KAB	84
8/11/2000	KAB, SWW, JBF	5
2001	PBERM Staff	54
2004	PBERM Staff	12
2005	PBERM Staff	86
7/19/2006	SWW, JMM, MC	10
KAB = Keith A. Bradley		
MC = Mike Cheek		
JBF = Jack B. Fisher		
GDG = George D. Gann		
JMM = Josh M. Mahoney		
SWW = Steven W. Woodmansee		

Site Description: In brief, Bradley and Gann (1995) describe the habitat as an 8 x 4 m canopy gap between scrub oaks on a spoil mound. A map of the population of Small's milkwort at Jupiter Ridge Natural Area is provided in Figure 7-7.



Figure 7-7: *Polygala smallii* at Jupiter Ridge Natural Area, Palm Beach County

Possible Cause for Population Fluctuation: The data seem to indicate that the population of Small's milkwort fluctuates dramatically from year to year. It is unknown why populations of Small's milkwort fluctuate so greatly over time. Drought conditions and lack of fire may have hindered populations, as well as overcrowding by other plant species. If this is the case, hurricanes may have, at least initially, positively impacted the populations of Small's milkwort here as postulated by Walesky (2005). He stated that the opening up of the canopy increased light to benefit the species. Heavy downpours may have also distributed seed into new areas through run-off.

Recommendations: Monitor existing population and conduct surveys for more plants at this location on an annual basis and after fires. Due to the severe fire suppression at this site, hardwood reduction will be necessary before introducing fire, or fire could damage Small's milkwort.

Occurrence 6: Lynn University Scrub, Palm Beach County

Owner: Lynn University

Status: Present

Hurricane damage to Small's milkwort: none

Hurricane damage to Small's milkwort habitat: low

Background: Small's milkwort was first documented for this station by F.R. Posin in 1984, with an herbarium specimen (Posin, s.n., FTG). Posin originally collected it and misidentified it as candyroot (*Polygala nana*). In 2001, Keith Bradley re-determined this specimen to be Small's milkwort.

Site Re-visit: Small's milkwort was searched for by Woodmansee and Sadle in 2006. Habitat encompassing sand pine scrub and scrubby flatwoods at the Posin described location was surveyed. Fourteen plants of Small's milkwort were recorded. Gopher tortoise burrows were observed close to the plants. Table 7-8 contains population summary data for each of the two site visits.

Table 7-8: Observations of Small's milkwort at Lynn University Scrub, Palm Beach County

Survey Date	Surveyors	Count
11/4/1984	FRP	Unknown
11/30/2006	SWW, JLS	14
FRP = F.R. Posin		
JLS = Jimi L. Sadle		
SWW = Steven W. Woodmansee		

Site Description: The scrub and scrubby flatwoods in the southern portion of this site was recently burned (in past couple months). Only moderately significant hurricane wind damage was observed here, however, the recent fire killed many of the pine trees. Exotics are currently being managed.

Plants found in association with Small's milkwort at this site include: saw palmetto (*Serenoa repens*), hemlock witchgrass (*Dichantheium portoricense*), myrtle oak (*Quercus myrtifolia*), scrub live oak (*Q. geminata*), wiregrass (*Aristida beyrichiana*), Coastalplain staggerbush (*Lyonia fruticosa*), lovevine (*Cassytha filiformis*), earleaf greenbriar (*Smilax auriculata*), plumed beaksedge (*Rhynchospora plumosa*), sandyfield beaksedge (*R. megalocarpa*), hogplum (*Ximenia americana*), palafox (*Palafoxia* sp.), and sand pine (*Pinus clausa*). Also present but killed by the fire included South Florida slash pine (*Pinus elliottii* var. *densa*).

A map of the population of Small's milkwort at Lynn University Scrub is provided in Figure 7-8.

Recommendations: Continue fire management and exotics removal. Surveys for additional plants at this location should be conducted on an annual basis and after fires.

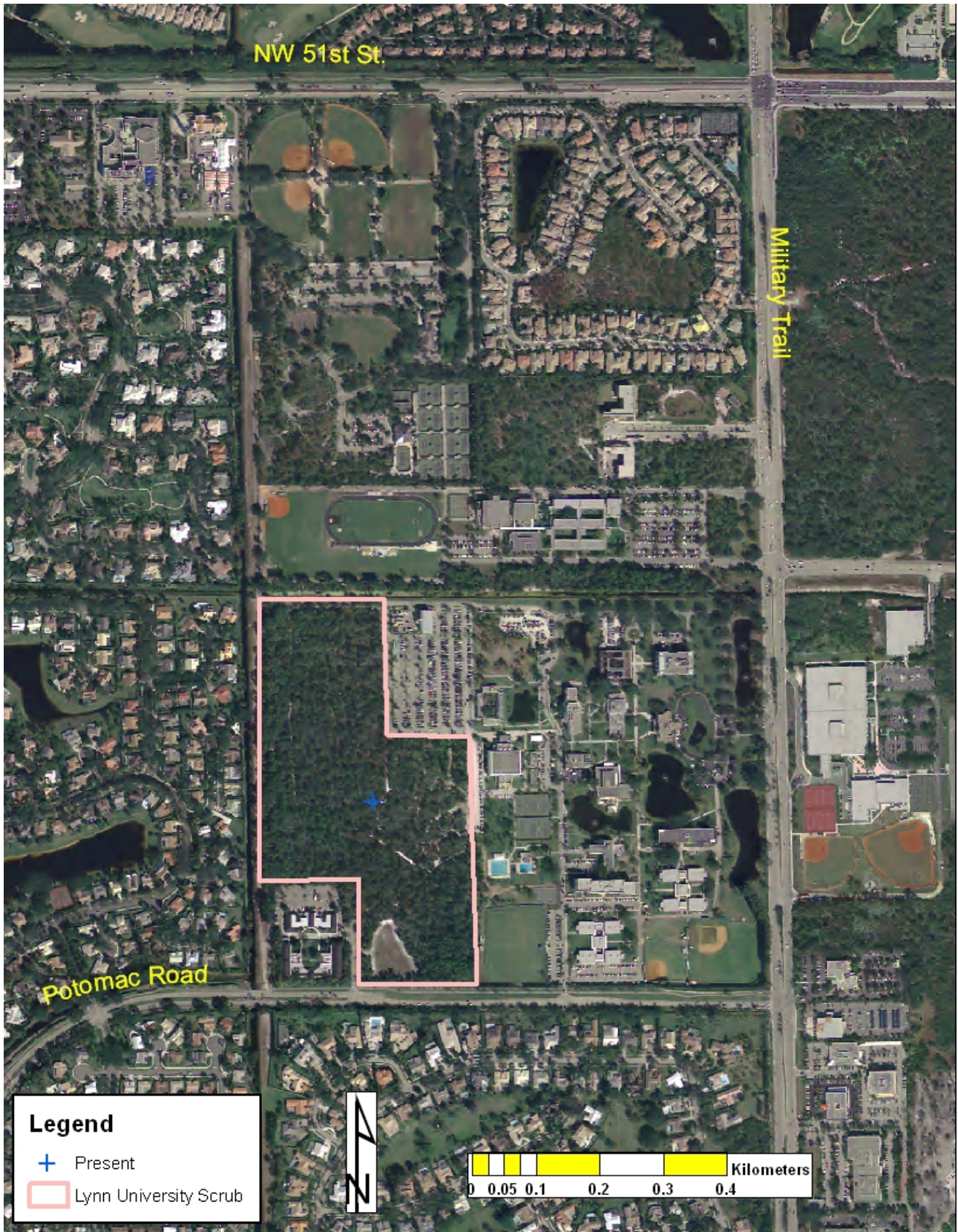


Figure 7-8: *Polygala smallii* at Lynn University Scrub, Palm Beach County

Occurrence 7: Savannas Preserve State Park, Lynngate Site, St. Lucie County

Owner: Florida Department of Environmental Protection, Parks and Recreation

Status: Historical

Hurricane damage to Small's milkwort: none

Hurricane damage to Small's milkwort habitat: moderate

Background: Small's milkwort was first described from this station by Bradley and Gann (1995). It was again observed by Bradley, Woodmansee, and Fisher in 2000 (Fisher 2000).

Site Re-visit: Small's milkwort was searched for by Woodmansee and Mahoney in 2006. Habitat encompassing scrub and scrubby flatwoods surrounding the two GPS points was searched to no avail. Several plants of candyroot (*Polygala nana*) were observed in these localities. Identification of plants was verified by the surveyors using plant keys in the field but also in the laboratory by Bradley. Table 7-9 contains population summary data for each of the three site visits.

Table 7-9: Observations of Small's milkwort at Savannas Preserve State Park, Lynngate Site, St. Lucie County

Survey Date	Surveyors	Count
12/3/1995	KAB, GDG	23
8/9/2000	KAB, SWW, JBF	1
7/19/2006	SWW, JMM, GK	0
KAB = Keith A. Bradley		
JBF = Jack B. Fisher		
GDG = George D. Gann		
JMM = Josh M. Mahoney		
SWW = Steven W. Woodmansee		
GK = Greg Kaufmann		

Site Description: In brief, Bradley and Gann (1995) describe the habitat an elevated area of scrubby flatwoods (being recruited with sand pines (*Pinus clausa*)) surrounded by mesic flatwoods and marshes. This site was once listed as Lynngate Park, and later, South Fork of the St. Lucie Buffer Preserve. It is now managed as part of Savannas Preserve State Park. Woodmansee, Mahoney, and Kaufmann recorded that damage from hurricanes was notable in the form of several tree falls, especially sand pines. No storm surge was evident at the site. The site was notably fire suppressed. A map of the historic population at Savannas Preserve State Park is provided in Figure 7-9.



Figure 7-9: *Polygala smallii* at Savannas Preserve State Park, Lynngate Site, St. Lucie County

Possible Cause for Disappearance: It is unclear as to why Small's milkwort disappeared from this site. Fire suppression over time is a most likely cause. Human disturbance in the form of hikers and off-road bicycles also may have contributed. It is suspected that if fire were reintroduced to the site, plants may reappear.

Recommendations: Surveys at this location should be conducted on an annual basis and after fires.

Other Small's milkwort Study Areas

Possible Occurrence: Limestone Creek Natural Area, Palm Beach County

Owner: Palm Beach County Department of Environmental Resources

Status: Reported

Hurricane damage to Small's milkwort: none

Hurricane damage to habitat: low

Background: Small's milkwort was first reported for this station in 2001 by Steve Farnsworth (Email Correspondence with Steve Farnsworth and Frank Griffiths of PBERM with Steve Woodmansee, November 29, 2006).

Site Re-visit: Small's milkwort was searched for by Woodmansee, Sadle and Bradford in 2007. Habitat encompassing scrubby flatwoods from the described location was searched. Three plants of what could be Small's milkwort were found. Plants were in flower, however there were no seeds present, which are needed to verify identity. Plants may be the similar looking candyroot (*Polygala nana*). No significant hurricane wind damage was observed here. Table 7-10 contains population summary data for each of these two site visits.

Table 7-10: Reported Observations of Small's milkwort at Limestone Creek Natural Area, Palm Beach County

Survey Date	Surveyors	Count
2002-2003	SF	13
3/22/2007	SWW, JLS, JB	3
JB = John Bradford		
SF = Steve Farnsworth		
JLS = Jimi L. Sadle		
SWW = Steven W. Woodmansee		

Site Description: The scrubby flatwoods in the northeastern portion of this site occur along ridges of a former creek and grade into mesic flatwoods to the north. It had not burned in some time. Few open grassy patches needed to support populations of Small's milkwort were observed. Only moderately significant hurricane wind damage was observed here.

Plants found in association with this unverified *Polygala* sp. included: saw palmetto (*Serenoa repens*), Chapman's oak (*Quercus chapmanii*), myrtle oak (*Q. myrtifolia*), scrub live oak (*Q. geminata*), drysand pinweed (*Lechea divaricata*), nodding pinweed (*L. cernua*), pinebarren flatsedge (*Cyperus retrorsus*), and South Florida slash pine (*Pinus elliottii* var. *densa*).

A map of the possible population of Small's milkwort at Limestone Creek Natural Area is provided in Figure 7-10.

Recommendations: Resurvey location to verify the identity of the plants in question.



Figure 7-10: *Polygala smallii* Report at Limestone Creek Natural Area

False Occurrence: Diamondhead/Radnor Park, Palm Beach County

Owner: Palm Beach County Department of Parks and Recreation

Hurricane damage to Small's milkwort: N/A

Hurricane damage to Small's milkwort habitat: none

Background: Small's milkwort was first reported for this station in 2001 by Steve Farnsworth (Email Correspondence with Steve Farnsworth and Frank Griffiths of PBERM with Steve Woodmansee, November 29, 2006). Mr. Farnsworth reported over 50 plants occurring in cleared scrub area in the northwest portion of the preserve.

Site Re-visit: Small's milkwort was searched for by Woodmansee, Sadle and Bradford in 2007. Habitat encompassing cleared scrub as described by Farnsworth was searched. Despite searches, no Small's milkwort was found. It is likely that this report of Small's milkwort is a misidentification of the more common candyroot (*Polygala nana*) as almost 100 candyroot individuals were observed. There was no evidence of any recent fires. No significant hurricane wind damage was observed here, nor was there any evidence of storm surge.

Site Description: The region surveyed consists of large sandy areas among scrub plant associates and some exotics. A map of the region surveyed at Diamondhead/Radnor Park is provided in Figure 7-11.

Recommendations: None.



Figure 7-11: *Polygala smallii* False Report at Diamondhead/Radnor Park

Final Discussion

In synopsis, it appears that Small's milkwort was not necessarily negatively impacted by events attributed to hurricanes. Fortunately, no illegal dumping was observed at any of the populations, which were fairly distant from any public roads. As mentioned in the discussion for Occurrence # 5, hurricanes, in some ways, may actually benefit the species.

Despite branches falling on plants within the population at Jupiter Ridge Natural Area (JRNA), the 2005 count there was as high as it has ever been, marked by a rapid decline in 2006. However, one thing is for certain, Small's milkwort populations vary greatly over time (as is especially indicated by the records for JRNA). Populations appear to be cyclic. It is quite possible that historical populations, with appropriate management, may reappear.

There also appears to be a relationship between gopher tortoises (*Gopherus polyphemus*) and Small's milkwort. Small's milkwort was found close to gopher tortoise burrows in three of the seven occurrences. It was postulated that due to the overpopulation of gopher tortoises at Gopher Tortoise Preserve, Broward County may have hindered the population of Small's milkwort. However, Small's milkwort and gopher tortoises coexisted in 1995, and it may be linked to overpopulation of gopher tortoises in addition to lack of fire management. Plants disappeared at the Gopher Tortoise Burrow site at Jonathan Dickinson State Park as well. Little is known about this possible relationship, and it should be studied in the future.

Appropriate habitat management at sites where this federally endangered species occurs or once occurred is needed. These should include the removal of exotic pest plants, the removal of exotic pest animals (such as pigs), fire maintenance, and the closing off of these areas to human induced disturbances may greatly enhance habitat conditions for this species. In addition, Small's milkwort occurrences should be monitored at a minimum, on an annual basis.

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