

Population Status, Demography, and Habitat Requirements of the Endangered *Harrisia fragrans* (Cactaceae) at Savannas Preserve State Park

Interim Report

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November 30, 2004



Final report submitted by
The Institute for Regional Conservation



Miami, Florida

to Florida Division of Forestry
Tallahassee, Florida

Abstract

Harrisia fragrans is an endemic shrubby cactus listed as endangered by the U.S. Fish and Wildlife Service and the State of Florida. Its current distribution is limited to the Savannas Preserve State Park, an area approximately 13 km long by 0.5 km wide. A previous study conducted between 1988 and 1996 indicated that the population was rapidly declining and would possibly go extinct within 30 years. A study conducted by Bradley et al. (2002) conducted over a four year period found that the population was in fact stable, indicating problems with Rae's findings.

The goals of this study were to continue to monitor the population status of *H. fragrans* at the Savannas State Reserve. Rather than continuing to monitor the entire population at the Savannas, we monitored approximately 300 plants at each of three colonies. Newly discovered plants were tagged and mapped. Data was collected to follow their fates and estimate recruitment, mortality and fruit production.

We are also investigating the historical habitat requirements of *H. fragrans*. It is possible that because of previous pineapple farming the habitat types at the Savannas PSP do not resemble those historically found there. The dominant vegetation may have changed from a community dominated by *Pinus clausa* scrub to the grassy fields with clusters of hardwoods and *Sabal palmetto* that occur there today. Knowledge of the habitat preferences of *H. fragrans* and the historical vegetation structure at the preserve will be useful in guiding habitat management there.

In 2003 the Florida Park Service initiated habitat management in parts of the Savannas PSP. In two locations where *H. fragrans* occurs the vegetation was cleared with a hydro-axe, eliminating above-ground cover of woody vegetation. The sites were to be burned at a later date. We monitored any previously tagged plants that we could relocate in these areas to study the effect of this habitat management technique.

In the summer of 2004 two hurricanes made direct hits on the Savannas. Because the impacts of the storms on *H. fragrans* were unknown, and how the storm damage would effect further field studies was unknown, a field visit to the Savannas was made assessment was made. Impacts on both the species and the habitats were visually evaluated.

Cover image by M.E. Eaton, 1912, from the archives of the Smithsonian Institution

Introduction

Harrisia fragrans Small ex Britton & Rose is a shrubby cactus endemic to Florida, which is listed as endangered by the U.S. Fish and Wildlife Service and the State of Florida. It has been reported from several central-eastern coastal, Florida counties including Brevard, Indian River, St. Lucie and Volusia, (Wunderlin & Hansen 2002). It has also been reported for Big Pine Key and the Flamingo area of Monroe County (Benson 1982). However, reports outside of St. Lucie County may be in error (Austin 1984; Bradley et al. 2002; Gann et al. 2002). Today, all known occurrences of *H. fragrans* are in southeastern St. Lucie County (Rae 1995; FNAI 1997). According to Small (1933), this species was historically found in hammocks on high sand dunes, kitchen middens and coquina ledges; although he may have mistaken the similar *H. simpsonii* for *H. fragrans* in some cases. Small's specimens of *H. fragrans* (8457 NY, 8459 FLAS) are from "Hammock on Sand Dunes" in or near what is now the Savannas Preserve State Park (Savannas PSP). The Institute for Regional Conservation (IRC) reported *H. fragrans* as being frequent at Savannas PSP (Bradley et al. 1999), based on surveys conducted in 1998.

Between 1988 and 1993, and then again in 1996, two subpopulations of *H. fragrans* in and around the Savannas PSP were monitored by Rae (1996). Each summer between 1988 and 1993, Rae recorded mortality, plant size and fruit and flower production for all plants in the two subpopulations. His results showed that both subpopulations suffered serious decline (41.8% & 41.3%) between 1988 and 1993. Later, using a matrix model of population dynamics based on five years of data, Rae & Ebert (2002) predicted the decline and eventual extinction of *H. fragrans* by 2022. They hypothesized that excessive shading as well as overexposure were responsible for such a rapid decline, theorizing that *H. fragrans* prefers partially shaded conditions.

In 1998, preliminary monitoring of the entire population of *H. fragrans* at the Savannas PSP was initiated by IRC and the Florida Department of Environmental Protection (FDEP). During that survey, 802 plants were identified and mapped (Bradley et al. 1999). Although IRC surveyed a slightly larger area than Rae (1996), IRC discovered more plants in Rae's study area than were indicated or predicted by Rae.

IRC expanded monitoring in 1999, tagging and mapping all plants that were found, and collecting data on plant size, reproductive status, and microenvironment. The results of this study were submitted in 2002 (Bradley et al.). The population was found to be stable, contradicting Rae's results. At the end of 2002, 2100 plants were tagged and alive at the Savannas.

The main goal of this study was to continue the monitoring program conducted by IRC since 1998 (Bradley et al. 1999), with changes in sample size and slight changes in methodology. This is being done to examine whether there is any temporal or spatial variation due to light environment in the population dynamics of *H. fragrans*. Of particular interest was an evaluation of whether the population size of *H. fragrans* is declining. In 2002 Bradley et al. used Rae & Ebert's (2002) matrix model of population dynamics to evaluate the long-term trend of the population given recent environmental conditions (1999-2002). This will be done again at the completion of this study.

Methods

Study Site. *H. fragrans* is presently known from a 13 km by 0.5 km section of the Atlantic Coastal Ridge between the cities of Ft. Pierce and Jensen Beach, between the Indian

River and a large swale known as the Savannas. Most of the undeveloped area in this region is now located within the Savannas PSP. This section of the Atlantic Coastal Ridge is transected by the Florida East Coast (FEC) Railway from north to south. The Savannas PSP, and the bulk of the *H. fragrans* population, is on the west side of these tracks. To the east of the tracks, extensive development has occurred and little is in public ownership. An undetermined number of *H. fragrans* occur on private lands east of the tracks. *H. fragrans* is found on St. Lucie sand with 0-8 percent slopes, at elevations between approximately 8 and 12 meters (Watts & Stankey 1980). The area receives 140 cm rainfall/year, with about 62% occurring from June to October (Watts & Stankey 1980).

Before human alteration, the vegetation along the ridge was primarily scrub, dominated by a sand pine (*Pinus clausa*) canopy with an understory of *Quercus* spp., *Ceratiola ericoides*, *Carya floridana*, and *Ximenia americana*, and a sparse forb layer. Xeric hammocks were located primarily on the slopes of the ridge and were dominated by *Quercus* spp., *Carya floridana*, *Ximenia americana*, and *Sideroxylon tenax*. Much of this scrub community is intact along the western edge of the ridge, although those on the eastern edge have been mostly developed. Extensive clearing for pineapple farms occurred from the 19th century through the 1920s (Watts & Stankey 1980; Rae & Ebert 2002). This farming included the use of fertilizers (Watts & Stankey 1980) that may have altered soil properties. Little scrub has regenerated in areas previously farmed; these areas are now dominated by fields of *Aristida gyrans* and *Polygonella robusta*, open sand, isolated or clumped *Sabal palmetto* stands associated with vines (especially *Smilax auriculata*) and stands of *Quercus* spp. and *Carya floridana*.

H. fragrans rarely occupies areas of *Pinus clausa* scrub that do remain at the Savannas PSP. We have found that the species is intolerant of fire, an important component of the scrub ecosystem. It is likely that plants were formerly restricted to the eastern and western edges of this ridge in areas of xeric to mesic hammock where fires rarely occur. *H. fragrans* frequently grows along the edges of *Sabal palmetto* or *Quercus* stands or in the shade beneath them; plants are rarely found in open sun. Given its current distribution, *H. fragrans* may have colonized abandoned pineapple plantations in areas where plants did not formerly occur.

Study Species. *H. fragrans* is a columnar cactus with multiple stems reaching 4 meters. Stems may be 5 cm in diameter and are armed with gray spines that are 2-4 cm long. Branches arise from both the base of the plant and laterally from other stems. White to pink fragrant flowers that are ca. 20 cm long open at night and are presumably moth pollinated (Ted Fleming pers. comm.). The red fruits are globose and 5-6 cm in diameter and can contain ca. 1400 seeds (Rae 1995). Plants may live at least 15 years, as we have monitored plant that were tagged by John Rae in 1988. Few interactions with animal have been observed. A scale insect, *Diaspis echinocati* (Diaspididae) is frequently observed on plants. Birds, gopher tortoises, and raccoons may play a role in dispersal, although this has not been observed.

Sampling. In December of 2003 and January of 2004, data was collected on 1044 previously tagged and newly tagged plants. Plants were sampled in three populations, named A, B, and C. These populations had 492, 274, and 279 plants respectively. Population A contained many more seedlings than the other colonies (169 vs. 33 and 49), explaining the larger number of plants in the colony. Plant locations were recorded using Trimble GPS units that were accurate to within a few decimeters. All plants that were not tagged in

previous years were tagged. For each plant, the number of stem tips, length of the each stem, number of fruits (mature and immature), number of flowers (mature and immature) and light microhabitat (sun, partial-shade, shade) were recorded. It was noted whether new plants represented sexual or asexual recruits or whether they represented older plants that were not seen in previous censuses. During the census, newly discovered plants were tagged and mapped using the GPS unit as well. Plants that could not be located using maps and the GPS unit were recorded as missing.

Results

Long Term Monitoring

In December 2003 and January 2004 we collected data on 1044 plants in three populations. Of the 1044 plants, 946 were alive, with 98 plants having died since the last sampling or were missing and probably dead. Plants occurred over a wide range of microhabitats varying from full sun to almost full shade. Plants were located in areas composed of mostly native vegetation to areas dominated by invasive exotic species such as *Schinus terebinthifolius* and *Callitris glaucophylla*. In some cases, plants were covered by vine blankets of *Smilax auriculata* and/or the invasive exotic *Abrus precatorius*.

The total number of *H. fragrans* plants in population A increased from the previous census. There were previously 253 plants in population A, but 492 were found during the present census. This is due to a massive spike in seedling that were found. The number of plants in populations B and C were similar to that from the previous census. Population B gained 25 plants, from 249 in 2002 to 274 in this census. Population C lost 5 plants, from 284 in 2002 to 279 in this census.

Monitoring of Habitat Management Effects

In late 2002 the Florida Park Service began clearing portions of *H. fragrans* habitat, and nearby scrub that did not contain *H. fragrans*, with a hydro-axe. Some effort was made by the machine operator to avoid plants of *H. fragrans*. This technique cuts down nearly all woody plant cover with minimal soil impact. Dead vegetation is left on the ground, sometimes forming a dense mat of cut stems and leaf litter. These areas were to be burned in early 2003.

The areas that were hydro-axed were colony 4 and part of colony 5 (see Bradley et al. 2002). Colony 4 contained 40 plants in 2002, and the portion of colony 5 that was treated contained 19 plants. In December 2003 and January 2004 we were able to relocate locate 12 of the originally tagged plants, 14 in colony 4 and 0 in colony 5, a survivorship of 63%. Two new plants were also tagged in colony 4.

Damage was done to several of the surviving plants, including almost complete cutting of mature stems. Eight of the plants had been chopped by the hydro-axe. Three of these were resprouting, producing new stems.

We will continue to monitor the surviving plants and search for new recruits in this area to investigate the impact of this management technique.

Historical Habitats of the Savannas Area

Background:

The dominant vegetation along the Atlantic Coastal Ridge from Broward County north to at least Volusia County is scrub dominated by a canopy of sand pine (*Pinus clausa*); a mix of hardwoods, especially oaks (*Quercus* spp.); and a sparse herbaceous layer. The community is pyric, with a fire interval of approximately 50 years (Myers & Ewel, 1990).

While the majority of the ridge at the Savannas PSP is dominated by typical (although fire suppressed) sand pine scrub, some areas of the Atlantic Coastal Ridge in and around the Savannas PSP have a much different vegetation structure than any other area of the ridge we have observed. These unusual areas do not have a sand pine canopy, but are mostly open sunny fields interspersed with isolated heads of oaks, cabbage palms, Brazilian pepper (*Schinus terebinthifolius*), and other woody species. The open fields are dominated by *Aristida gyrans*, with low densities of several other herbs, including *Polygonella fimbriata*, *Polygonella ciliata*, and *Helianthemum nashii*.

Of the approximately 3,000 plants of *H. fragrans*, almost all of them are found in the oak/cabbage palm heads that are interspersed among the aforementioned *Aristida gyrans* prairies. Typically, the *H. fragrans* plants occur on the edges of the oak/cabbage palm clumps; and they are also found in areas somewhat shaded by oaks, and cabbage palms. Only a few dozen *H. fragrans* plants, out of the approximate 3,000 individuals, occur in sand pine associations at the Savannas PSP.

Plants are also known to occur along the eastern edge of the ridge near the Indian River. This area has not been surveyed well because it consists almost solely of private property. The area on the east side of the ridge is thought to have been dominated historically by hammocks. The area is now very disturbed and almost completely developed into riverfront properties.

Some plants of *H. fragrans* also grow along the west edge of the ridge, close to the large freshwater basin formally known as the "Savannas." These plants grow in live oak/cabbage palm hammocks, but are exposed to a greater degree of soil moisture due to the close proximity to the swale. Very few *H. fragrans* plants occur here.

In summary, the bulk of the *H. fragrans* population occurs among open *Aristida gyrans* prairies where it is associated with the shade from heads cabbage palms, live oaks, and other hardwoods and vines. *H. fragrans* essentially does not occur in association with the typical sand pine communities common along the Atlantic Coastal Ridge (except for a few isolated individuals). In addition, we do know that *H. fragrans* plants are killed when burned, making it implausible for them to have grown historically within sand pine communities which burn periodically. Rather, the plants should grow naturally in areas that were not subject to regular periodic fires, such as the hammocks along the banks of the Indian River. It is these riverside areas, where almost all of the *H. fragrans* occurs, that have undergone the most development in the area. With the construction of Indian River Drive and the construction of homes, very few unvegetated areas remain. Those that do remain are usually very disturbed and dominated by exotic plant species.

The *Aristida gyrans* communities at the Savannas PSP are unique among Florida ecosystems. The history of how these communities developed, and furthermore how they should be maintained, remains somewhat of a mystery. The question that has been raised by Rae 1996 and Bradley et al. 2002 is that this may not be a naturally occurring vegetation type. Instead, the community may have formed after pineapple farms were abandoned in the

1920s. It is possible that instead of occurring naturally along the higher parts of the ridge, where it is found today, *H. fragrans* may have formerly been primarily restricted to the historical hammocks along the edge of the Indian River.

It is of key importance to attain a better understanding of the area's natural history in order to conserve it as a whole as well as manage it appropriately as a habitat for endangered species, including *H. fragrans*. Site managers are already embarking on a new management program at the Savannas PSP that involves mechanical vegetation removal and subsequent burning. This process kills any *H. fragrans* plants that are present (Bradley et al. 2002). This investigation was initiated to determine the historical habitat requirements of *H. fragrans* and the historic vegetation structure of the Atlantic Coastal Ridge at the Savannas PSP. This data will be essential in guiding management practices at the Savannas PSP.

Methods:

The methods used to understand the historical habitat preferences of *H. fragrans* and historical vegetation structure in the area of the Savannas PSP entailed, in part, consulting the following sources:

- close-up photos of area both past and present
- local accounts by St. Lucie county residents
- journal articles
- books, including those with pictorial accounts of the history of the area
- published agricultural and early settler's logs, letters, and articles
- information from organizations with a focused interest on understanding the history of this area, such as the St. Lucie County Historical Society
- Review aerial photographs from 1943 and 1944

Results:

Background on the area

H. fragrans occurs only in St. Lucie County, and in order to better understand the history of the habitat of this endangered plant, it is critical to have a general knowledge of the history of St. Lucie County. St. Lucie County was established in 1905, although the area had been previously designated as its own entity under various other names dating back to 1844. This county has had a long history of human activity within its borders, with Indians occupying the area for quite some time before Spaniards and Europeans arrived (Rights 1994). Such early white travelers and settlers have also been in the area for some time, with intriguing early accounts of the area even being available from the famed Jonathon Dickinson dating back to 1696. Many other accounts from settlers and early pioneers range from after that time, through the 1800's and turn of the century.

The region's long history of human habitation, although of invaluable cultural significance, does in fact complicate the effort to understand the natural history of the area because it is difficult to understand the myriad ways in which humans have modified the natural landscape over time. To begin with, the Ais Indians were known to have lived along the Indian River since at least 400 years ago (Rights 1994, Van Landingham 1988, Williams 1963). In addition, other Indian groups such as the Jeagas and Santa Luceros inhabited adjacent lands (Van Landingham 1988). These Indians depended upon the nearby Indian River for much of their food supply, and were known to have gathered wild plants and made use of native wildlife for their livelihoods as well. No records of any uses of native cacti by

the Indians were uncovered, although clearly much remains to be learned about the ancient ethnobotany of the region. The numbers of the Indian inhabitants declined rapidly with the introduction of European and even Cuban diseases (Williams 1963), wars with new settlers, and finally Indian removal campaigns by the US government. By the early 1700s the Ais Indians, the native inhabitants of the region, were thought to have numbered only around 200 (Williams 2003). The newly arrived Creek Indians (later referred to as Seminoles) from north of modern-day Florida, Georgia, and Alabama were also in the St. Lucie County area at that time, in much larger numbers than the Ais people, but also declining due to similar reasons (Williams 2003).

From what can be inferred based upon different sources, there remained to be continued Indian activity in the area for some time although these people were clearly declining in number due to the aforementioned reasons. Then, in the early 1800s there began the heated Indian Wars, with the First and Second Seminole Wars heavily impacting human habitation and activity in the area. With the relative conclusion of the Second Seminole War around 1842, white settlers began further encroaching on historical Indian lands. However, the Act that truly caused the first real permanent settlement by American whites occurred also in 1842: the influential Armed Occupation Act, instituted by the US government. This act helped provide the impetus for the first settlement of the region that is now close to *H. fragrans* habitat pioneers began to truly make their mark on the banks of the Indian River. This critical year brought new settlers also of importance to note is the land-clearing activities they engaged in. This activity would have begun to make significant impacts on the native vegetation, as the Armed Occupation Act itself which allowed for the pioneers to claim land also required that they clear and cultivate at least five acres of it (Van Landingham 1988). This first settlement of pioneers was known as the Indian River Colony, and they were recorded to have vacated the area due to an "Indian scare" in 1849, although some returned in 1850.

Settlers and Pineapple Plantations, and Early Explorers

Evidence revealing the original vegetation communities of the Savannas PSP is scarce. Only a few brief descriptions from early settlers and two military expeditions were found. A few photographs were also located that are somewhat helpful.

In 1854 and 1855 the Savannas region was traversed by two military expeditions led by Major Prince and Lieutenant Hill, respectively. Descriptions of the area made by these expeditions are the first and best observations on the original vegetation of the area.

"The growth on the shore, between the two forts [Fort Capon and Fort Pierce), is pine. South of the latter post the ridge is covered with hammock growth, and, two miles below, rises to the height of forty feet, where is the old Indian Garden....Nine miles south of Indian Garden, there is a high point of the ridge, which is bare and dotted with patches of white sand, ("bleach yard,") and, two miles below, at Mount Elizabeth, pine growth again appears upon the shore; the ridge receding towards the St. Lucie River. Between Mount Elizabeth and Fort Pierce, it borders the river, forming a steep high bank, covered with cabbage, palmetto, and cultivable ground, from which there is, a

rapid descent, inland, to an open country, covered with flagponds, savannas, sawgrass, marshes, and palmetto flats, with a few scattered pines.” (Ives 1856).

The Indian Garden, two miles south of Fort Piece, is still nearly three miles north of the Savannas PSP. Mount Elizabeth is in Martin County just south of the Savannas. So, two important observations were made. Between Mount Elizabeth and Fort Pierce, in which he length of the Savannas lies, much of the area was dominated by hammock, between the Indian River and the wetland swale now known as the Savannas. The mention of the patches of white sand or “bleach yards” appears to be in the vicinity of Walton, a community established along the ridge adjacent to the Savannas. No mention is made of pine forests in the vicinity of the Savannas.

An interesting comment was made by a Floridian during the frenzy of building activity that sheds some more light on the status of the natural area before clearing Wenzel J Schubert commented “Seventy years ago (1898) I stood on Grandfather Tancre’s front porch at Ankona ... and watched a gang of laborers chopping down and grubbing out several fine old trees as they cut the new “county road” right across the middle of our front yard. This narrow, single lane, dirt road that tunneled through the dense river bank hammock growth was Florida’s first East Coast Throughway.” This account described the construction of the Indian River Drive, right along the western shore of the Indian River. A few photographs from the Ft. Pierce area and to the north were found that were taken along the west edge of the river. Based on this evidence it appears that hammocks dominated the eastern edge of the Atlantic Coastal Ridge along the bank of the Indian River.

Later settlers, beginning around the early 1880s, made much more of an impact on the natural habitats of the area as it was them that began intensive land-clearing activities to make way for important cash crops. One of the first and most significant crops to be cultivated in this area was pineapple, first brought to the region by Capt. Thomas E. Richards in 1879 (Van Landingham 1988). His introduction, and other cultivars introduced later, would eventually become the most important cash crop and would, in a short time, come to dominate much of the Indian River bank landscape. According to various reports, pineapple plants were thought to have been numbering around 2 million within ten years time after the first introduction (Williams 2003, St. Lucie Historical Museum website). One description illustrates the extent of the pineapple plantations:

“This is a country of pineapple plantations. They cover that ridge next to the Indian River, clothing it in prickly green lances from the river banks to the savanna behind it, for miles on miles, running north and south (Packard 1912).”

One photograph was found that shows evidence of sand pines along the Atlantic Coast Ridge in the vicinity of the Savannas. This photograph (Figure 1) shows a group of men clearing vegetation with grub hoes in preparation of a pineapple plantation. A small stand of sand pines is seen in the background.



Figure 1

In addition, other species were known to have been cultivated and established for agricultural purposes, with other key cultivated crops including tomatoes and citrus. Fertilizers were used in the area since early on (Watts and Stankey 1980), thus modifying the soil chemistry, but their use declined drastically with the coming of World War 1 and the associated scarcity of products. It was not discovered through our research exactly what fertilizers were commonly used in the area, although people were known to have used seaweed as well as the refuse from their food (such as fish, turtles, etc) (Rights 1994).

Additional disturbance came to the area with the construction of the Florida East Coast Railroad in 1894 and subsequent influx of settlers. It can be clearly understood that the construction of the railroad impacted the area that *H. fragrans* is native to, as even today many plants grow only meters away from the railroad. According to reports (Van Landingham 1988 and Rights 1994) railway stations existed in areas noted as St. Lucie, Ft. Pierce, White City, Eldred, Walton, Eden, Jensen, and Stuart. In addition, spurs were made by the railway companies right into the pineapple fields.

By the 1920s pineapple plantations were declining and being closed. Competition from Cuban growers, scarcity of fertilizer, and a pest caused the farming to be unprofitable. Some other crops were later grown, including citrus and tomatoes, but extensive groves or farms were probably not used on the Atlantic Coastal Ridge because of the xeric conditions. Thus, much of the acreage formerly devoted to pineapple plantations was probably abandoned. Some stands of the tree grand eucalyptus (*Eucalyptus grandis*) are present in the Savannas PSP, but it is unknown whether this is due to recruitment from seed or a relic of some type of plantation.

Aerial Photography

Aerial photography of the Savannas was taken by the U.S. Department of Agriculture in 1943 and 1944. This is the first aerial imagery we have seen from this area. The imagery was of course taken over two decades after the pineapple plantations failed, fifty years after the railway was constructed, and some 60 years after the permanent settlers arrived and started to farm pineapples. Still, the photos do show some important features. It appears that some vegetation was never cleared, or were cleared and allowed to regenerate very quickly. It is clear from these forest fragments that hammock vegetation was present along the banks of the Indian River, east of what is now the railway. The hammock succeeded into sand pine scrub to the west, until the ridge sloped down to the Savannas wetland. In one clear example the hammock extends west about 130 meters from the river at a point where the ridge is

about 590 meters wide. Not enough forest fragments appear on the aerial to determine if this vegetation pattern continued the entire length of the ridge and the range of *H. fragrans*. Some areas where *H. fragrans* now grows that that are xeric hammock were formerly citrus groves. No clear evidence on the ground indicated this. In the next monitoring season we will make additional observations on the present day vegetation at the Savannas, especially where *H. fragrans* now grows, in relation to these aerials.

The Habitat of *H. fragrans*

The results of this study are unfortunately inconclusive. Not enough historical data on the original vegetation of the Savannas PSP was found, despite extensive searching. More importantly no data was found that links *H. fragrans* itself to any particular habitat type prior to pineapple farming was found, so we may still only speculate. Since the area did not develop into a more populous and affluent region like Ft. Pierce to the north and Jensen Beach and Port Saint Lucie to the south, very little research specific to the area has been produced.

The geography of the Atlantic Coastal Ridge at the Savannas may have created a unique environment for *H. fragrans* that is different than other parts of the ridge to the north or south. The large wetland swale immediately behind the ridge and the proximity of the ridge immediately on the Indian River are unique. The geography may have resulted in unique habitats in the area. It is possible that fires along this section of the ridge were rarer than expected. Typically, scrub has a fire frequency of 50-100 years and is necessary for the regeneration of *Pinus clausa*. With the ridge being so narrow (ca. ¼ mile wide), and bordered by a deep wetland and the Indian River, natural lightning strikes igniting fires may have been rare. Thus, *P. clausa* scrub may have been limited in its extent, with xeric hammock being the climax community.

In addition, it has been suggested that the Atlantic Coastal Ridge at the Savannas may have originally been part of a barrier island with the Savannas wetland representing a saltwater lagoon (DEP 2003). If so, then prehistoric habitats here may have been similar to those where *H. aboriginum* grows in southwest Florida, adjacent to mangrove forests on lower barrier islands in hammocks. This may be one reason why *H. fragrans* is limited in distribution. The species may be persisting in this small area despite changes in sea level and changes in vegetation.

More recently, prior to European settlement, the habitat of *H. fragrans* may have been limited to the areas directly within and adjacent to hammocks. These hammocks certainly occurred along the Indian River, and may have extended across the ridge in places, replacing *P. clausa* scrub in the absence of fire. The species could well have grown in the partially and fully shaded areas within such hammocks below cabbage palms and oaks. At least some *P. clausa* scrub did occupy portions of the ridge at the Savannas, but it may have been limited in extent, and historically burned infrequently. We do not believe that *H. fragrans* was typically associated with this community.

Whether the extensive *Aristida gyrans* communities lacking sand pines occurred in the area prior to farming is unknown. The observation of “bare and dotted with patches of white sand, (“bleach yard,”)” in the 1850s in the vicinity of what became Walton is unusual. No pines were mentioned. This could have either been the *Aristida gyrans* community, but is more likely a rosemary (*Ceratiola ericoides*) bald.

The *Aristida gyrans* community is probably a post-farming plant association, not one that was historically at the Savannas. These areas do appear to have denser vegetation now than they did on 1940s aerials, probably because of more hardwoods recruiting into the areas, and a denser cover of herbaceous species.

The mosaic of vegetation communities on the Atlantic Coastal Ridge at the Savannas PSP, i.e. some areas dominated by sand pines, others by *Aristida gyrans*, and still other areas dominated by xeric hammocks, may be the result of different site histories in those areas. Several parts of the pineapple farming process may have influenced post abandonment vegetation succession:

- Original vegetation
- Site preparation
- Period of use
- Fertilizer use
- Random, post abandonment recruitment of seeds

Hurricane Impacts

In September 2004 two hurricanes made direct hits on the Savannas PSP. On September 4 Hurricane Frances made landfall at Sewell's Point just south of the Savannas as a Category 2 hurricane. On September 25 Hurricane Jeanne made landfall on Hutchinson Island just offshore of the Savannas as a Category 3 hurricane. On November 19 a field visit was made to the Savannas PSP to evaluate the impact of the storms on *H. fragrans*.

Overall, the hurricanes appear to have little effect on most *H. fragrans* individuals. Unless a plant was very tall, it was unlikely to have toppled over. Instead, plants lost occasional stems, but typically only if they were taller and had many branches. Plants that did topple over or that lost stems were showing new growth, with new stems appearing at the base of the plants in many cases.

The main impacts were made on surrounding vegetation. Many of the plants growing above and around individual *H. fragrans* plants were defoliated and had shed many branches. *Sabal palmetto* trees had lost many of their dead fronds. Despite the opening of the canopy around most *H. fragrans* plants none of the individuals seemed to show evidence of sunburn or dehydration. One exception to this general pattern is a large colony of *H. fragrans* that is growing under a canopy of the introduced tree *Callitris glaucophylla*. These trees shed many of their branches or toppled over completely. This has completely covered up many plants of *H. fragrans*, including large numbers of seedlings. The full impacts at this station won't be known until the next monitoring is done.

The hurricanes will probably have several impacts on *H. fragrans* over the coming years. The opening of the canopy will probably result in an increase in reproductive activity, since plants in sunnier areas flower and fruit more than those in shade. The increased sun will probably also result in a decrease in seedling germination, since seeds do not germinate in open sun. A third impact will be on the probably increase in asexual reproduction due to fallen stems.

Acknowledgements

We would like to thank FDEP staff Renate Skinner and Dan Griffin, who have supported the project, provided logistical support and field assistance. We would also like to thank Dennis Hardin and Penny Isom of the Florida Division of Forestry for funding this study.

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