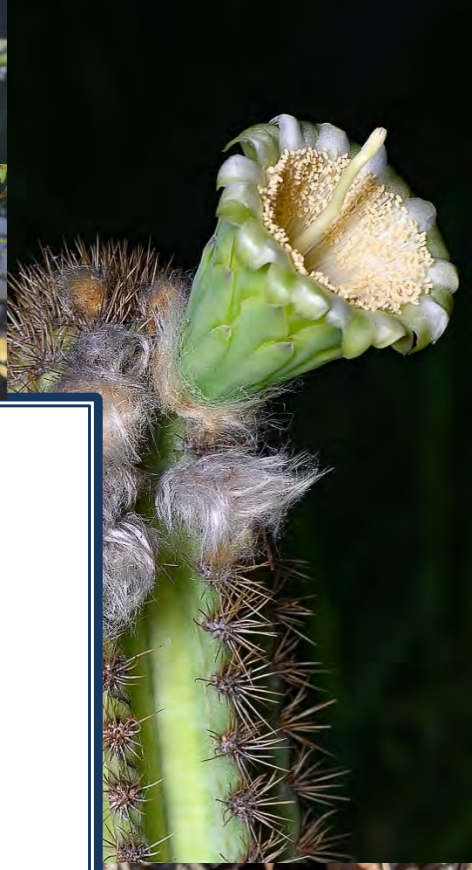
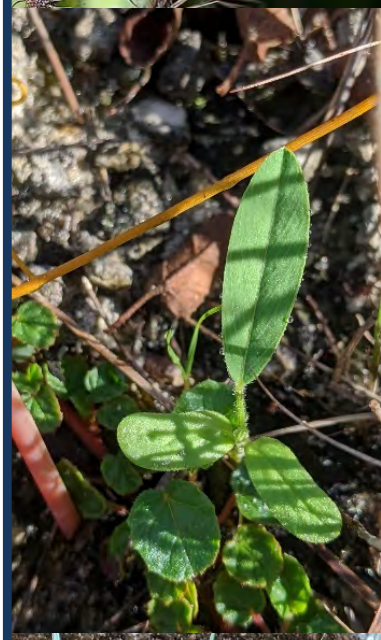
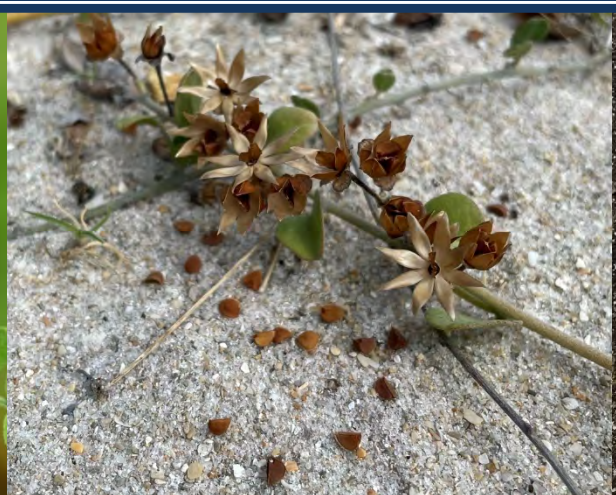









FAIRCHILD
TROPICAL BOTANIC GARDEN

Conservation of South Florida Endangered and Threatened Flora Program

2020-2021

Final Report
Contract #027132

Submitted to:
Florida Department of Agriculture & Consumer Services, Division of Plant Industry
July 30, 2021

Amorpha herbacea var. crenulata
US-Endangered

Plant at Tropical Park in May 2021, responding to heavy pruning one month prior (B. Harding)

Asplenium dentatum
FL-Endangered

Cultivated plant at Fairchild nursery, July 2019 (J. Possley)

Pilosocereus millspaughii
US-Endangered

Rescued fragment flowering in Fairchild Nursery, June 2021 (R. Hammer)

Cover Photo Credits

Bourreria cassinifolia
FL-Endangered

Seedling at Camp Owaissa Bauer, June 2020 (L. Cuni)

Tephrosia corallicola
FL-Endangered

Seeding from seed introduction at Deering Estate, 2021 (L. Cuni)

Dalea floridana
US-Endangered

Cultivated plant in Connect to Protect Network Garden (S. Kolterman)

Jacquemontia reclinata
US-Endangered

Seeds and plant descended from Fairchild's 2001 introduction to Bill Baggs Cape Florida (J. Possley)

Pseudophoenix sargentii
FL-Endangered

Seedlings from ex situ collection in Fairchild's nursery, 2021 (J. Possley)

Conservation of South Florida Endangered and Threatened Flora Program

at

Fairchild Tropical Botanic Garden
2020-2021

Contract #027132

Final report submitted to the Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, FL

Submitted by: Jennifer Possley, Lydia Cuni, Sabine Wintergerst, Jimmy Lange, and Brian Harding. Fairchild Tropical Botanic Garden, 10901 Old Cutler Rd., Miami, FL 33156

Citation: Possley, J., L. Cuni, S. Wintergerst, J. Lange and B. Harding. 2021. Conservation of South Florida Endangered and Threatened Flora: 2020-2021 program at Fairchild Tropical Botanic Garden. Final report for Contract #027132, Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, FL.

AUTHORS

Jennifer Possley, MS
Conservation Program Manager

Lydia Cuni, MS
Field Biologist

Sabine Wintergerst, PhD
Seed Lab Manager

Jimmy Lange
Lead Botanist

Brian Harding
Conservation Horticulturist

ACKNOWLEDGMENTS

We would like to thank the following land managers, agency personnel, and other collaborators who support our conservation of rare plants in South Florida, including: Patti Anderson, Courtney Angelo, Gloria Antia, Jay Arce, Dave Bender, Linda Briggs-Thompson, Gwen Burzycki, Jonathan Carcache, Pat Ceballos, Mike Clausen, Rebecca Collins, Rodell Collins, Jeremy Dixon, Jane Griffin Dozier, James Duncan, Janice Duquesnel, Trudy Ferraro, Peter Frezza, George Gann, Janet Gil, Liz Golden, Joie Goodman, Robin Gray-Urgélles, Dallas Hazelton, Lisa Hill, Eddy Ibarra, Tim Joyner, Kevin Kalasz, Andy Kearns, Joy Klein, Kristie Killam, Kirk Linaje, Hong Liu, Tiffany Melvin, Joe Montes de Oca, Tiffany Moore, Richard Moyroud, Tonya Nimark, Christine Oliva, Nick Paparis, Hector Perez, Cheryl Peterson, Jose Prieto, Frank Ridgley, Eduardo Salcedo, Alex Seasholtz, Michelle Smith, Jason Stanley, Sarah Steele-Cabrera, Christina Stocking, Michel Therrien, Sonya Thompson, Vanessa Trujillo, Alicie Warren, Steven Whitfield, Steve Woodmansee, Keith Wright, Elizabeth Wu, and the Miami-Dade Natural Areas Management (NAM) crews.

Thanks to Fairchild Tropical Botanic Garden staff who make this program possible, especially Tatiana Castro, Dr. Chad Husby, Dr. Brett Jestrow, Dr. Carl Lewis, Brenna McKay, Rose Ricks, Marlon Rumble, Yisu Santamarina, Jemma Peterson, Isabel Sanchez, Mary Neustein, Alba Parra, Marina Guzman, Eric Mills, Jamie Anderson, Amy Padolf, Sara Zajic, and Brian Sidoti.

We thank The Institute for Regional Conservation, the Center for Plant Conservation, and the Dade Chapter of the Florida Native Plant Society for their long-standing support of this program.

We owe a special thanks to those who volunteered their time to assist us with field and nursery work, including: Pedro Basabe, Kim Bavuso, Maria DuQuesne, Andrea England, Cari Eno, Carol Farber, Noah Frade, Alan Franck, Mary Jackson, Sharyn Ladner, Isabel Lamas, Leah Laurel, Ray Morris, Nathan Osbourne, Jim Palma, Patty Phares, Louise Reece, Adair Reeve, Joanne Rose, Judy Stewart, and the many Connect to Protect Network members who donated seed from their home gardens.

Special thanks to Daniela Champney for managing the Connect to Protect Network.

This research was funded by Florida Department of Agriculture and Consumer Services (FDACS Contract #027132). We thank the members of the Endangered Plants Advisory Council (EPAC) for their continued support of our work. Additional funding was received from U.S. Fish and Wildlife Service, Miami-Dade County Dept. of Parks, Recreation and Open Spaces, Broward County Parks, the Center for Plant Conservation, the Florida Native Plant Society, the Helen Clay Frick Foundation, the South Florida Water Management District, the Florida Dept. of Transportation, and individual donors.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Since 2001, support from the Florida Department of Agriculture and Consumer Services' (FDACS) "Endangered and Threatened Native Flora Conservation Grants Program" has been a crucial component of Fairchild Tropical Botanic Garden's nationally recognized, award-winning rare plant conservation program. Through our cooperative efforts, this grant program directly helps to recover dozens of Florida listed plant species. Our long-term monitoring allows us to provide up-to-date information on rare species, which often influences local, state, and federal protection. Experimental trials for cultivation, long-term seed storage, and dormancy breaking ensure that the protocols for propagating rare species are known and that propagules can be effectively stored long-term. Field research offers insights into the biology of rare species and assists land managers with evaluating restoration practices. Rare species reintroductions increase the total number of plants in the wild thereby reducing their extinction risk.

Below we have summarized notable activities conducted in 2020-2021, based upon our original proposal and the revised work plan sent to FDACS in July 2020.

Objective 1. Continue long-term demographic monitoring of wild and reintroduced populations of the rare plants of South Florida, in situ.

- We monitored both introductions of *Amorpha herbacea* var. *crenulata* and the wild population at Tropical Park. Preserve managers are working to remove hardwoods and keep these preserves in a flammable state; now fire needs to be reintroduced and repeated every few years if this endemic taxon is to remain a part of Florida's flora.
- We propagated several dozen *Asplenium dentatum* in anticipation of an augmentation project at Fern Forest in Broward County in summer 2021 and as a reintroduction to a naturally occurring limestone sink within Fairchild Garden.
- Our 2019 introduction of the rare fern *Ctenitis submarginalis* appears successful so far, with all 26 outplants surviving to one year.
- For the 15th year in a row, we monitored demography of *Dalea carthagenensis* var. *floridana* in coastal strand habitat at Crandon Park. This project has revealed wide annual fluctuations in numbers and informs management, whereby low numbers signal a need for vegetation management (hardwood reduction).
- We conducted population censuses of several *Jacquemontia reclinata* populations, revealing dramatic increase by an order of magnitude in two Miami-Dade populations (Bill Baggs State Park and Crandon County Park), and a precipitous drop in populations in Boca Raton where the last complete census in 2001 showed hundreds of plants (Red Reef Park now has 0 plants; South Beach Park, 6 plants).
- We conducted population-wide monitoring of *Pilosocereus robinii* in the Florida Keys and showed that the few remaining large plants continue to die but some smaller plants show healthy growth.
- We introduced 36 additional *P. robinii* to Windley Key. These small-yet-robust, seed-grown plants join 48 surviving outplants from 2012 and 2015 introductions of vegetatively-propagated cacti. We placed plants into mangrove/hammock ecotone, where survival from previous outplantings was highest.
- In what we believe is the first case of a plant species extirpation from sea level rise in the United States, we and partners from multiple agencies extracted the remainder of the *Pilosocereus*

millspaughii from John Pennekamp Coral Reef State Park. Plants are recovering well in the nurseries of FTBG and John Pennekamp.

- We conducted a full population monitoring of *Pseudophoenix sargentii* on Elliott Key, documented 203 wild plants and 7 reintroduced plants, and submitted a peer-reviewed manuscript on this long-term monitoring project to the journal PALMS.
- We introduced *Tephrosia angustissima* var. *corallicola* to the Deering Estate via seed. We used 1820 seed in an experiment designed to provide more information about this species' microhabitat needs as well as the use of fresh vs. previously frozen seed. Ten months later, we have 156 seedlings.

Objective 2. Continue ex situ seed collections and seed research

- We performed dormancy-breaking germination trials with seeds of several listed South Florida species, including *Bourreria cassinifolia*, *Ipomoea microdactyla*, *Ipomoea tenuissima* and *Zanthoxylum coriaceum*.
- We collected seed of more than 60 native species from the wild and from ex situ collections for propagation, germination testing, and long-term storage. Seeds we have deposited into long-term storage are summarized in Table A2, which is an Appendix at the end of this report.
- We successfully germinated seeds retrieved from long-term storage (between 9 and 15 years old) for three species: *Pilosocereus robinii, Pilosocereus milspaughii* and *Jacquemontia reclinata.* Resulting plants will be used in restoration projects and for our ex situ collection. We found that germination rates of our oldest *J. reclinata* seeds was very low; therefore we have applied for funding to renew seed collections across the species' range.
- Together with Fairchild Challenge Coordinator Brian Sidoti we worked with students of Miami's BioTECH @Richmond high school to conduct research on seed germination of *G. monostachia* using different media. A mixture of limestone, Turface and potting soil yielded the highest germination percentage.

Objective 3. Continue to expand the Connect to Protect Network

- The Connect to Protect Network (CTPN) continues to be active and popular. As of July 2021, membership includes 1129 homeowners, 135 schools and 34 other members (typically churches, non-profits, etc.). Members have at least 5 native pine rockland plants on their property in an effort to connect urban Miami's remaining pine rockland fragments for pollination and seed dispersal across developed areas.
- We distributed more than 2,500 free pine rockland plants to Miami homes and schools through CTPN.
- We helped nearly two dozen schools, churches, and other organizations start their own CTPN pine rockland garden.

Objective 4. Promote conservation of Florida rare species through displays and public outreach.

- We made an incredible 23 oral and presentations to public and scientific audiences at local and regional meetings, led 5 educational field trips, and taught 5 native plant-related classes through Fairchild's continuing education program or virtual platforms.
- We published 5 peer-reviewed manuscripts and submitted 2 for review.

- We mentored a high school student from Miami's BioTECH magnet high school, a college student from Florida Atlantic University, and college students from Miami-Dade College.
- We regularly shared rare native plant news and updates on social media.

Additionally, we wrote a Conservation Action Plan for *Bourreria cassinifolia*. This document summarizes all information that is known about the taxon and is included as an appendix to this report.

The Endangered and Threatened Native Flora Conservation Grant has enabled us to further the conservation of many of South Florida's native plant species. We would like to thank FDACS and DPI for their longstanding support, which is truly foundational to our conservation program.

Objective 1. Continue to monitor and conserve the rare plants of Florida in situ

and

Objective 2. Continue to collect and curate *ex situ* conservation collections of the rare plants of South Florida

Taxa included:

Amorpha herbacea var. *crenulata, Asplenium dentatum, Bourreria cassinifolia, Ctenitis submarginalis, Dalea carthagenensis* var. *floridana, Ipomoea microdactyla, Ipomoea tenuissima, Guzmania monostachia*, Jacquemontia reclinata, Pilosocereus robinii, Pseudophoenix sargentii, Tephrosia angustissima* var. *corallicola, Zanthoxylum coriaceum,* and other ferns*

* Not required by contract

Amorpha herbacea Walter var. *crenulata* (Rybd.) Isley

Amorpha herbacea var. *crenulata* (hereafter "*Amorpha*") is an endangered pine rockland shrub endemic to Miami-Dade County. It occurs in plant communities that were historically associated with seasonally hydrated soils and frequent burning, including: wet pinelands, transverse glades, and hammock edges. By 1984, nearly all these communities in urban Miami-Dade County had been destroyed. In addition, fire suppression, invasion by non-native plant species, and hydrological changes have all contributed to the decline of *Amorpha* (USFWS 1999, Gann et al. 2002). The U.S. Fish and Wildlife Service listed *Amorpha* as federally endangered in 1985 (USFWS 1985). Fairchild has been studying and monitoring *Amorpha* since the early 1990s and has conducted three outplantings, one of which (Campbell Drive) was removed after more than a decade. We have cold-stored thousands of *Amorpha* seeds, both at Fairchild and in the USDA National Laboratory for Genetic Resources Preservation (NLGRP). We report below on the status of the two wild and the two remaining introduced populations.

Update on Introduced Populations

Deering Estate

In 1995, Fairchild introduced 190 juvenile *Amorpha* plants clustered into 7 groups into pine rockland at The Deering Estate. We do not have monitoring records from 1995 to 2000, but we began tracking plants closely in the early 2000s and continue to do so. At 25 years, this is one of the oldest surviving plant introductions in the United States! We monitored plants on March 5, 2021. Of the original 190 outplants, 22 (11%) were still alive in spring 2021 (**Fig. 1**). Two of the 7 clusters had no surviving plants. The majority of surviving outplants were at clusters 1 and 4; these are also the areas with much sandier soil.

In addition to the 22 surviving outplants, we documented 38 recruits. The majority of these (36 of 38) were tiny "Stage 2" seedlings (**Fig. 2**) and were only a few centimeters tall. Our monitoring history shows that very few Stage 2 *Amorpha* seedlings will survive to the next year. Average litter depth at each of the plants was 2.54, which is lower than last year (4 cm), but this remains too deep for the population to persist; *Amorpha* seeds need litter depth to be <2cm to germinate and survive (Wendelberger and Maschinski 2008).

Unfortunately, the rate at which new adult *Amorpha* plants are becoming established at the Deering Estate is much lower than the attrition rate; this reintroduction will likely not last two more decades without intervention. Clearly, *Amorpha* is a fire-adapted species that flowers, fruits, and recruits new seedlings prolifically post-fire, as we documented in 2008 (**Fig. 1**) Reinstatement of regular prescribed fire in the Deering Estate pineland will be critical to the persistence of this introduced population.

We are considering the possibility of further augmenting this introduction. Toward that end, we hope to conduct an augmentation in 2022 or 2023. We would introduce plants into low-lying sandy areas in the Deering Estate pineland, as low-lying sandy areas are where the introduced plants have performed best thus far.

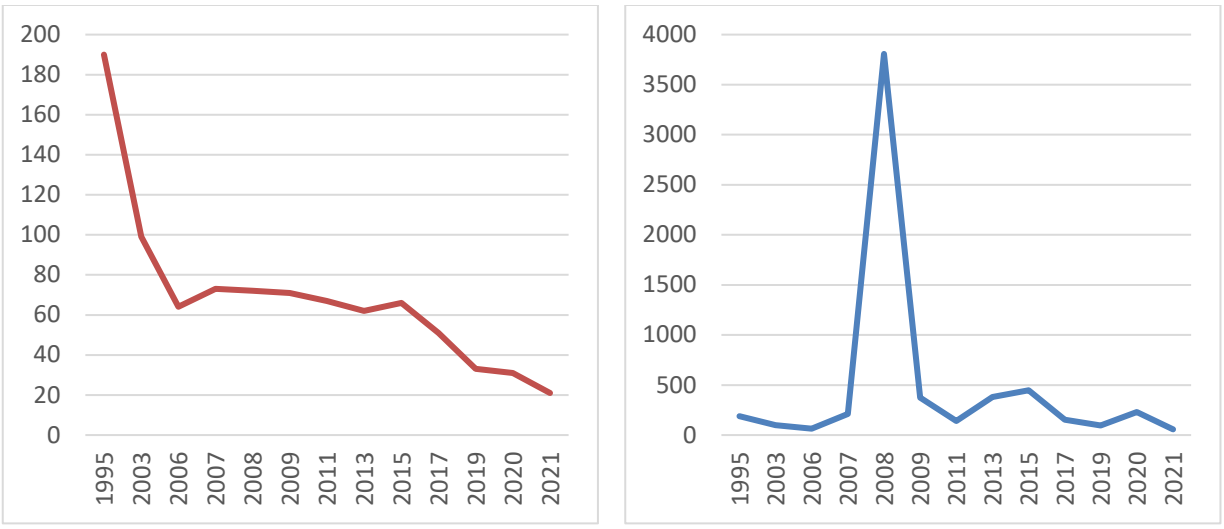


Figure 1. Left: Number of *Amorpha* outplants at the Deering Estate from 1995 (190 plants) to 2021 (21 plants). **Right**: Total population size of the introduced Deering *Amorpha* population over time, including recruits. The peak of nearly 4000 plants in 2008 happened after a prescribed fire.

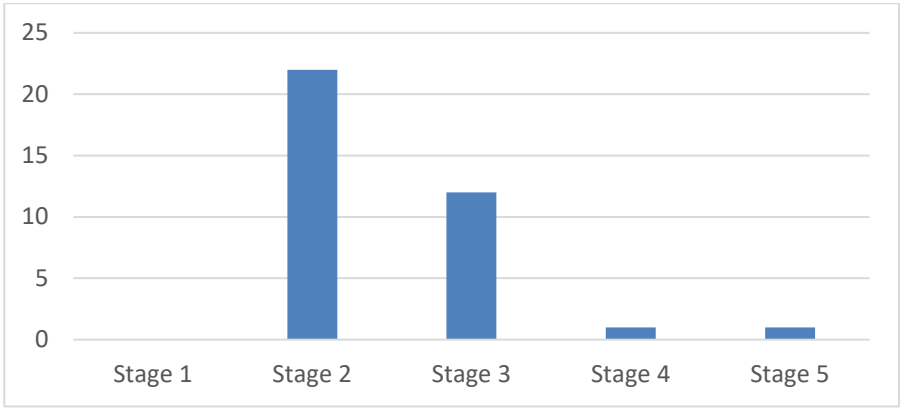


Figure 2. Size class distribution of 36 recruits at the Deering Estate in May 2021. Stage 1 seedlings are fresh germinants with cotyledons still present. Stage 2 are seedlings 2-10cm. Stage 3 are 10-20cm. Stage 4 is >20cm but not reproductive. Stage 5 is reproductive adult.

Martinez Preserve

In 2006 and 2007, Fairchild conducted two plantings of *Amorpha* totaling 344 individuals at Martinez Preserve. We originally introduced plants to four different habitat types (pineland, grassy glade, pine/glade ecotone, and a restoration glade) for which we collected environmental data (see Roncal et al. 2012). Since introduction, visual distinction between the different habitat types has essentially disappeared and most areas can be described as fire-suppressed pine rockland, though some grassy prairie remains as such.

We monitored the 2006/2007 introductions of *Amorpha* at Martinez Preserve in late April 2021. Currently, 125 of the original 344 plants (36%) have survived. Last year we reported 32 seedlings

beneath 3 plants. But by 2021, all but one had died, likely from being smothered by deep leaf litter. Without prescribed fire, this introduction will likely continue to decline.

Update on Wild Populations

Tropical Park

On 11/10/2020, Fairchild staffers Lydia Cuni, Brian Harding, Sabine Wintergerst, Jennifer Possley, and intern Jonathan Carcache monitored the Tropical Park *Amorpha* population. We documented 95 plants; this was 25 more than we documented in October 2019. Of the 95 plants, 57 were woody and >20cm tall. Size class numbers for smaller plants were: 3 <2cm, 22 2-10cm, and 11 10-20cm (**Fig. 3**). For a healthy population, we would like to see many more small plants.

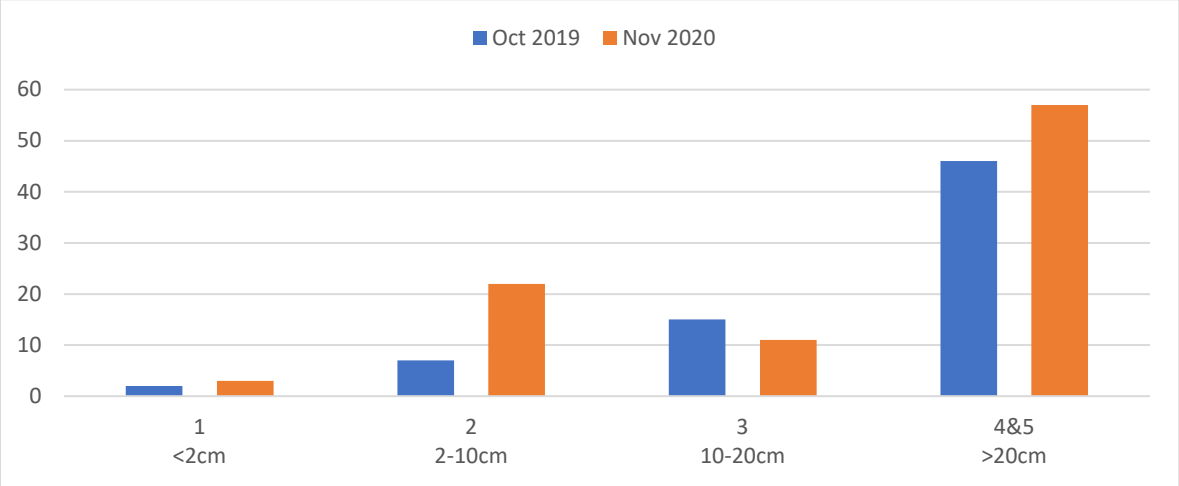
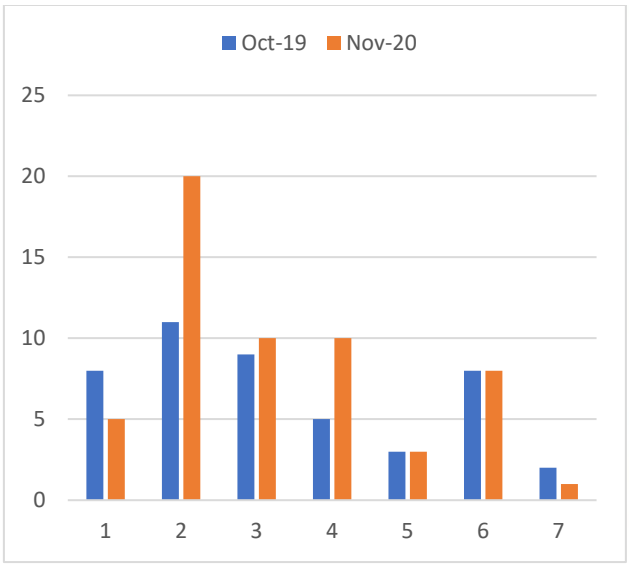


Figure 3. Number of Amorpha per size class at Tropical Park during the two most recent monitoring events.

The trajectory of *Amorpha* varied by location within the park. Subpopulations 2, 3, and 4, which are on the west side of the parcel, had more plants than last year (**Fig. 4**). We believe part of this difference was because the very dense understory weeds were not *quite* as dense in Subpopulations 2, 3, and 4 as they were in the others.



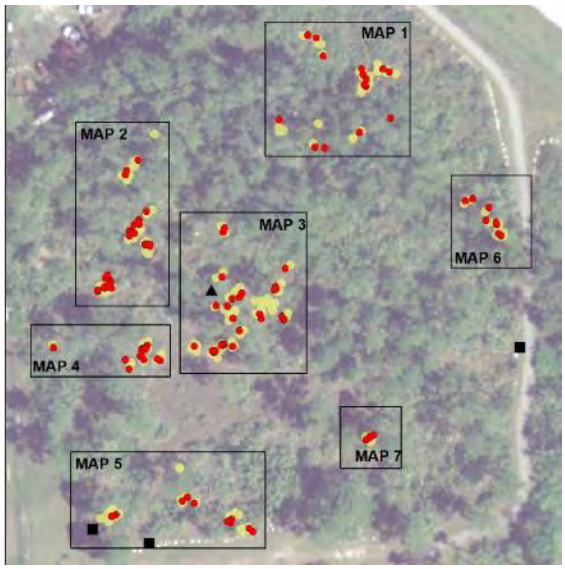


Figure 4. The number of woody *Amorpha* plants at each of 7 subpopulations at Tropical Park in the two most recent monitoring years, and the location of each subpopulation within the park pine rockland.

A piece of good news is that in 2020 we noted many plants (24) had signs of flowering, whereas in 2019 we only noted 6 *Amorpha* with any sign of flowering. This may be due to increased sunlight from the recent sabal palm removal. "Signs of flowering" refers to presence of flowers or fruits as well as the presence of an old infructescence stalk. We do not know for certain whether these plants actually set viable seed. We measured average litter (primarily pine needles) on the forest floor and found it to be 2.5 cm, unchanged from last year. This figure is the upper-limit for appropriate litter depth for seed germination and recruitment of this species (per previous work by Kristie Wendelberger). However, in many cases, weeds were so dense that litter could not accumulate on the ground.

In order to encourage vigorous flowering and fruiting of plants at Tropical Park, we returned in May 2021 to prune several of the largest plants almost to the ground. We coordinated with Miami-Dade Natural Areas Management to clear dense weeds away from each clipped *Amorpha.* Within one month, plants responded with vigorous flowering (**Fig. 5**).

Figure 5. One of the approximately two dozen *Amorpha* at Tropical Park that were hard-pruned one month prior. (B. Harding)

AD Barnes Park

We did not conduct a complete population census of *Amorpha* at AD Barnes Park during this grant cycle. We did, however, stop by the park on several occasions to collect *Amorpha* seed for banking and/or propagation, and to flag plants in restoration areas in order to help protect them from accidental impact during restoration activities.

Ex situ conservation

We continued to care for *Amorpha* plants in Fairchild Garden and in the nursery, and to bank seeds. Activities we conducted during this grant cycle included trimming vegetation away from *Amorpha* in Fairchild's pine rockland demonstration plot and nursery to encourage flowering, bagging fruit, and collecting hundreds of seeds. We also added individuals of known wild provenance to Fairchild's pine rockland plot and banked thousands from plants of known wild provenance at Fairchild. We also have several dozen plants in cultivation that could be distributed to Miami homes and schools through the Connect to Protect Network (CTPN).

Asplenium dentatum L.

Asplenium dentatum, the toothed spleenwort, is a limestone-loving, Florida-endangered fern native to several rockland hammock preserves in Miami-Dade County as well as Fern Forest Nature Center in Broward County and at least one locality in Volusia County. It is thought to be extirpated from Palm Beach County. Outside of Florida, its range includes the West Indies, Mexico, Central America, and northern South America (Gann et al. 2021).

Activities we conducted with *A. dentatum* during this grant cycle consisted of cultivating, separating, and preparing cultivated plants for an augmentation at Fern Forest in Broward County which will occur in July-August 2021. We took an experimental approach; of the 57 total individuals, some are in a limestone mix and some are in a peat/perlite mix. For 7 plants, we tried to encourage them to latch on to natural oolitic limestone chunks; this method seemed successful (**Fig 6**). The medium did not have a strong effect on plants though, as ferns in both soil types are thriving in cultivation. A small pilot planting took place in early July 2021; additional plants will be added later in the summer, in collaboration with Broward County Parks.

Figure 6. Method of encouraging lithophytic fern *Asplenium dentatum* to attach to a rock, in preparation for outplanting. **Left**: In July 2020, a section of fern was removed from a large colony, and its roots were wrapped around a sterilized rock. **Center**: the pot was back-filled with a soil/crushed limestone mixture. **Right**: The same plant in January 2021, overturned to show root growth (J. Possley).

In a closely related project, in July and August 2020, we installed 4 *Asplenium verecundum* at the Deering Estate, immediately adjacent to *A. dentatum*. We did not have cultivated *A. verecundum* attached to rocks, so to introduce it to limestone outcropping at the Deering Estate, we tried cutting away a portion of cultivated plants pots, fastening the pot to the rock face, and then covering the plant with mesh to protect it from raccoons (**Fig. 7**). Miami-Dade and Deering Estate staff watered plants frequently after planting, throughout the ensuing dry season. One plant died, but the other 3 have survived to one year post-installation.

Asplenium verecundum is extirpated from the Deering Estate. When it grows alongside *Asplenium dentatum*, a natural hybrid called *Asplenium* x *biscaynianum* can form; however, the hybrid is also

extirpated from the Deering Estate. We hope to re-establish *A. verecundum* at this preserve so that one day the extirpated hybrid *Asplenium* x *biscaynianum* might return.

Lastly, we provided *Asplenium dentatum* to the USDA IPRL lab in Fort Lauderdale for off-target biocontrol testing for potential *Lygodium* biocontrol insects. Providing rare native ferns to the IPRL lab has been an unanticipated but appreciated use of the rare native fern collection at Fairchild's nursery.

Figure 7. Method of reintroducing lithophytic fern *Asplenium verecundum* to natural limestone at the Deering Estate in August 2020. **Left**: Half of the plastic pot is removed with a scissors. **Center**: The open side of the pot is nestled into a mossy nook in the rock, next to *A. dentatum*, and hardware is used to fasten the pot in place. **Right**: Miami-Dade Biologist Dallas Hazelton fastens hardware cloth over the plant to protect it from raccoons. (J. Possley).

Bourreria cassinifolia (A.Rich.) Griseb.

Bourreria cassinifolia, the little strongbark, is a short- to medium-sized shrub native to Cuba and pine rocklands of Miami-Dade and Monroe Counties, though it may be extirpated in Monroe County (Gann et al. 2020). In Miami, it is known from Everglades National Park and 7 Miami-Dade County Environmentally Endangered Lands (EEL) preserves. The species is not abundant in any of these locations; several populations have fewer than ten plants. In addition to the updates we provide below, we revised our Conservation Action Plan for this species (see **Appendix X**).

Update on wild populations

Several of Miami's *Bourreria cassinifolia* populations are very small, with fewer than 50 plants or even fewer than 10. In the past year, we visited the County's smallest populations at Bill Sadowski Park, Camp Owaissa Bauer, Ingram Pineland, and Seminole Wayside Park to collect fruit for ex situ conservation, and to trim away adjacent vegetation to increase light and encourage flowering. We obtained small amounts of seeds from all populations and are advancing plants to planting size, with the goal of establishing a representative individual from each population at Fairchild and, if quantities allow, augmenting small wild populations.

Update on seed biology

As previously reported (Possley et al. 2020), we have made many attempts to break dormancy in *B. cassinifolia*, an endeavor which has proved quite difficult. Oftentimes, a method tried with one seed lot will yield very different results when conducted with seeds from a different source. The seeds we use for germination research are from the yards and gardens of Connect to Protect Network members (**Fig. 8**); we do not know whether the differences observed are inherent in the different plants, or if it is a result of different degrees of ripeness when fruits were collected.

Currently, we are investigating how wet-dry cycles and the incorporation of native soil might influence germination. The native soil was collected in a hammock-like area at FTBG's nursery. We included the following treatments:

- Treatment A: No treatment, seeds sown in standard potting soil
- Treatment B: Desiccation for 2 weeks in silica gel, seeds sown in standard potting soil
- Treatment C: No treatment, seeds sown in native soil
- Treatment D: Seeds were sown in standard potting soil and left outside the propagation house for 1 month (therefore seeds experienced wet and dry cycles due to sun and rain exposure)
- Treatment E: Desiccation for 2 weeks in silica gel, seeds were sown in standard potting soil and left outside for 1 month.
- Treatment F: Desiccation for 2 weeks in silica gel, seeds were sown in native soil.
- Treatment G: Seeds were sown in native soil and left outside for 1 month.
- Treatment H: Desiccation for 2 weeks, seeds were sown in native soil and left outside for 1 month

We used 100 seeds per treatment, but all seeds of one treatment were sown into one pot due to space limitations. The seeds for this experiment were collected by only one CTPN member and were all from

the same batch to avoid differences in germination rates between collectors as we have observed before.

Across all trials, germination of *B. cassinifolia* never exceeded 40%. The best results were achieved with treatment G (Seeds were sown in native soil and left outside for 1 month) and treatment H (Desiccation for 2 weeks, seeds were sown in native soil and left outside for 1 month). It seems like the combination of native soil and leaving the seeds exposed to wet-dry cycles for one months are crucial to increase germination. Desiccation alone did not increase germination rate and therefore does not seem necessary to break dormancy in this species. Native soil alone did also not increase the germination rate. Leaving seeds sown in standard potting soil (independent of desiccation) exposed to wet-dry cycles for 1 month did increase germination slightly. Therefore we can conclude that wet-dry cycles increase germination, but the effect is much higher if native soil is used.

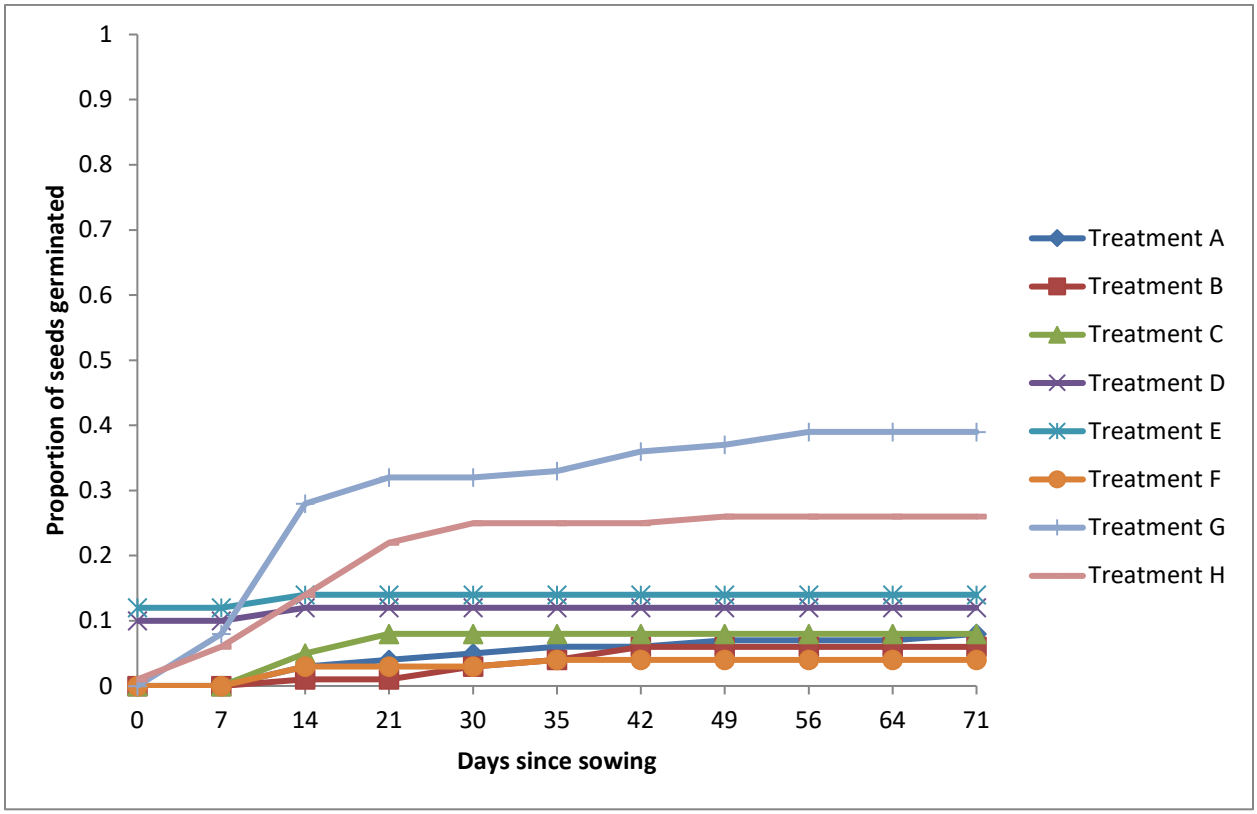


Figure 8: Results of germination trials with *Bourreria cassinifolia*.

Ctenitis submarginalis (Langsd. & Fisch.) Ching

The terrestrial fern *Ctenitis submarginalis* is native to Hispaniola, Mexico, Central and South America, as well as Florida and Louisiana in the U.S. (Gann et al. 2019). It is listed as endangered in Florida and has been vouchered in six central- and south-Florida counties (Wunderlin et al. 2021). In South Florida it is extirpated from at least half of its historical range, currently known only from Fern Forest Nature Center (Broward Co.), the Fakahatchee Strand (Collier Co.), and The Deering Estate (Gann et al. 2019).

As reported previously (Possley et al. 2020), we installed 26 *C. submarginalis* into rockland hammock at the Deering Estate on October 16, 2019. We chose recipient sites that were near the wild location (not far from the pipeline trail, north and south of Cutler Creek), but on higher ground, as recent rehydration projects had flooded the area previously occupied by this species. We assessed the population several times after planting, including in October 2020. At that time, all 26 plants were still alive, although we only rated 9 as being in good health (i.e., >2 fronds, no sign of recent die-back or browning). We will re-assess the population in October 2021.

Other activities conducted with *C. submarginalis* during this grant cycle included providing *Ctenitis submarginalis* to the USDA IPRL lab in Fort Lauderdale for off-target biocontrol testing for potential *Lygodium* biocontrol insects, and a propagation trial with spores that had been stored for 7 years in refrigeration which ultimately proved inviable.

Dalea carthagenensis (Jacq.) J.F. Macbr. var. *floridana* (Rydb.) Barneby

The small shrub *Dalea carthagenensis* var. *floridana* (Florida prairie clover, hereafter called "*Dalea"*) is a federally endangered taxon which is endemic to South Florida and found along the ecotone between hammock and pineland as well as calcareous coastal strand habitat. *Dalea* can be found only in five protected areas: Big Cypress National Preserve, Everglades National Park, and three small Miami-Dade County preserves: the Deering Estate, R. Hardy Matheson Preserve, and Crandon. It is also known to be present in two unprotected private properties in the Cutler Bay area of Miami-Dade County. During this 2020-2021 grant cycle, we continued with the demography study we initiated in Crandon in 2007, along with some additional wild monitoring, seed studies, and conservation horticulture.

Update on wild populations

Crandon Park

Background & Methods - To understand patterns of *Dalea* population growth especially related to seed biology and recruitment, in 2007 we began to track annual growth of the population growing in coastal strand habitat at Crandon Park. We installed a 3x10 meter demographic plot that sampled approximately 75% of the population. In 2014 we expanded the demographic monitoring plot to encompass an additional 3x10 m area because a portion of the 2007 plot has not supported many plants for several years.

Each year we tagged new individuals, recorded location along the X- and Y-axes of the plot and measured height, perpendicular widths 1 & 2, and counted the number of inflorescences. We categorized plants into one of four growth stages: 1) seeds in the seed bank; 2) non-woody seedlings with 10 or fewer leaves, 3) juveniles, which were sterile, woody plants, with > 10 leaves, and 4) reproductive adults.

To estimate the seed bank size, we examined the number of viable seed present within 15 inflorescences by visually assessing the proportion of good seeds and testing their germination and viability in the laboratory. We determined that the average proportion of good seeds within an inflorescence was 0.54. We derived values for adult-seed bank cells with and without germination cues from the formula: flowers/adult*average number of good fruits per inflorescence (.54)*average germination or contribution to seedlings with cue (.96) or without cue (.205).

Results - In February of 2021, we recorded 175 individuals, with 143 in the original transect. These numbers are both up from 2020, when a total of 145 individuals were counted with 129 on the original transect. Of the 143 individuals on the original transect in 2021, 110 were seedlings, 6 were woody but non-reproductive (juveniles), and 27 were flowering adults **(Fig. 9)**. This year we counted 6,330 flowers, the highest count to date, which is a 133% increase from 2020, and a 76% increase from the original high in 2019. Based on previous assessments of seed viability per flower, we estimate a contribution of 3,418 seeds to the seed bank, again the highest value to date **(Fig. 10)**.

Discussion - The *Dalea* population at Crandon has fluctuated considerably, mostly driven by seedlings. It is difficult to say at this point whether the continued increase in seedlings will serve to replace the downward trend in total adult plants. Our hope is with the work Miami-Dade County vegetation management crews did in 2020 to reduce hardwoods around the *Dalea* population, we will see high levels of recruitment following this considerable reproductive effort, and continued survival of seedlings

and juveniles to reproductive age. It is worth noting that while the number of adults is down since 2007 (from 91 to 27), the number of flowers per adult is 872% higher in 2021 than it was in 2007, and perhaps the hardwood reduction contributed to the massive increase in average reproductive effort.

This project is an example of how demographic data collection can inform management needs, by both identifying population reductions, as well as noting recent seedbank contributions that could affect restoration outcomes.

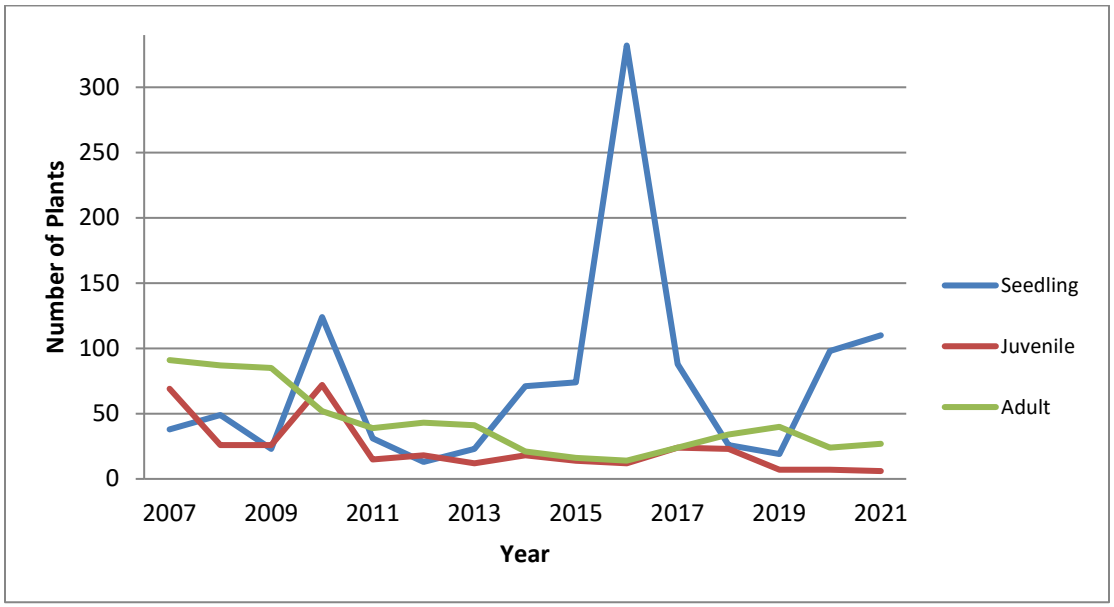


Figure 9. Total number of *Dalea* individuals of each life stage (seedling, juvenile, adult) from original Crandon Park transect between 2007-2021.

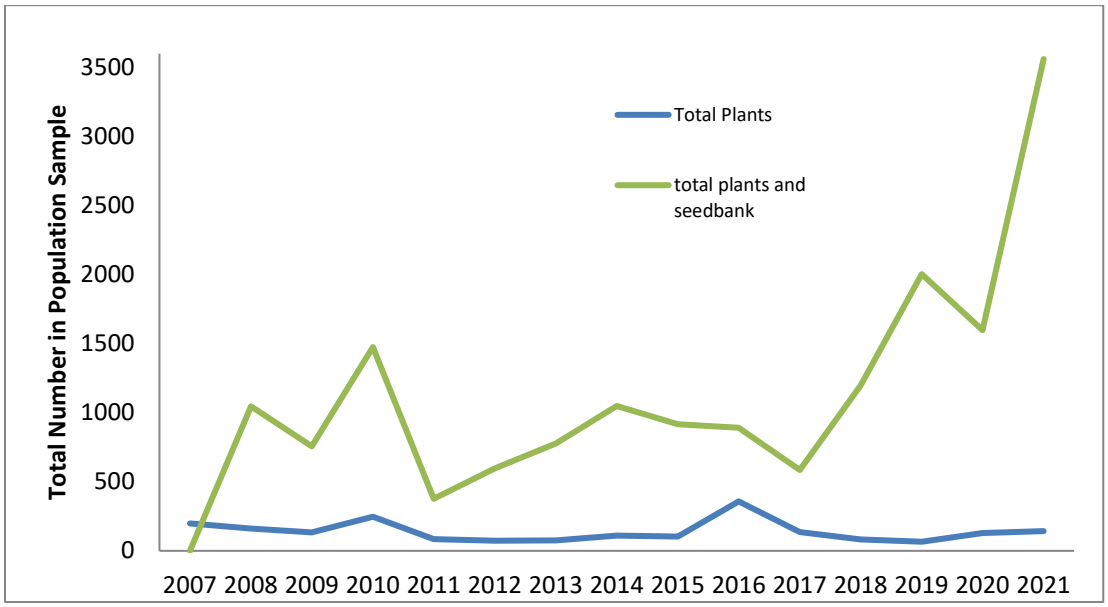


Figure 10. Total number of *Dalea* plants in original Crandon Park transect with and without accounting for the seed bank between 2007-2021.

R. Hardy Matheson Preserve

In September 2020, we made a brief post-fire assessment of plants at R. Hardy Matheson Preserve. The pineland received a prescribed burn on 2/21/2020. Seven months later, hundreds of robust *Dalea* were present. This is wonderful news for a population that was down to just one plant in the early 2000s.

Seed germination research

We conducted a germination trial using 300 seeds (100 per treatment, provenance Crandon Park) that received no treatment (control), dry heat for 5h at 60°C (since previous data showed that this can also improve germination), or desiccation to 33% RH (MgCl) for 3 days and frozen for 5 days. Results confirm that desiccation and freezing is the best treatment (Control: 10%, Dry heat: 11%, Frozen: ~80% germination).

Floral biology research

We worked with FIU intern Jonathan Carcache to study the breeding systems of *Dalea carthagenensis* var. *floridana*. Jonathan identified that flowers are protoandrous, with pollen being dehisced the first day of flowering while petals are white. The following day petals darken to a maroon color and the stigma becomes receptive (**Fig. 11**).

Figure 11. Flowers of *D. carthagenensis* var. *floridana* showing protandry and color change. First-day flowers are white, with the anthers exposed though a split in the keel petals. Second-day flowers are maroon, with the receptive stigma emerging (visible here at top-center). Photo by Susan Kolterman.

Ex situ conservation

We have a healthy ex situ collection of *Dalea carthagenensis* var. *floridana*. This year, we have grown wild-collected plants for installation in Fairchild's pine rockland display garden, for distribution to our Connect to Protect Network, and for the Institute for Regional Conservation's "Restoring the Gold Coast" program, as this taxon is extirpated from Palm Beach County.

Guzmania monostachia (L.) Rusby ex Mez *

(not required by contract)

Guzmania monostachia, the West Indian tufted airplant, is a bromeliad found throughout New World tropics. Its range extends into swamps and hammocks of South Florida, where it is listed as endangered and is threatened by the Mexican bromeliad weevil. The species is present in the large preserves, Fakahatchee Strand Preserve State Park, Big Cypress National Preserve, and Everglades National Park, and is likely extirpated from the Miami-Dade preserves, Camp Owaissa Bauer and Silver Palm Hammock (Gann et al. 2020). A very small population persists in Fuchs and Meissner Preserves, which are adjacent preserves that are owned and managed by Miami-Dade's EEL program.

Update on wild population and ex situ conservation

We monitored the wild Miami-Dade population of *G. monostachia* in early April and late May 2021, at Fuchs and Meissner Preserves. The known number of individual plants at this population is just 19; this includes 2 reproductive plants, 2 larger but non-reproductive plants, and 13 seedlings.

In April of 2021, there were 22 plants, but we made the decision to rescue 3 plants that looked extremely poor (**Fig. 12**). These were on the ground, covered in oak leaf litter, desiccated and chewed. The plants rallied in cultivation and will likely flower and produce seeds in the nursery in the next year or two; we will bank seeds for reintroduction to a new site or to augment this small wild population.

Figure 12. Left, three connect *G. monostachia* on April 8, 2021, rescued from Fuchs Hammock, in poor health. **Right**, the same individuals in cultivation at Fairchild, 3 months later. Photos by J. Possley, B. Harding.

We collected seeds from both of the flowering *G. monostachia* (**Fig. 13**). One plant was located on the west edge of Fuchs Hammock; the other was in Meissner Hammock. The plant at Fuchs was extremely desiccated and was nearly pulled off the host plant (a Krug's holly), presumably by raccoons. Despite flowering, it has not started to make a pup, as a healthy individual would do. The reproductive plant at Meissner was much more robust and is forming a new pup.

On our May visit, we were accompanied by University of Florida graduate student Shelby Krupar, who collected leaf tissue samples from the plants and will investigate whether they are genetically distinct from *G. monostachia* in Fakahatchee Strand Preserve State Park.

Figure 13. *Guzmania monostachia* in Miami-Dade County, 2021. **Left**: the only reproductive plant flowering in Fuchs Hammock in April. **Center**: Seedlings growing in bryophytes in Meissner Hammock in April. **Right**: UF researcher Shelby Krupar in Fuchs Hammock in May (note there is a plant on the tree and one on the ground in front of her; both are sterile).

Ex situ conservation

We maintain an ex situ collection of 7 plants in the nursery and 500 seeds in the seed bank; all are of Fuchs/Meissner Hammock origin. We have withdrawn approximately 1000 seeds from the seed bank in the past year for the research described in the next section.

Seed germination and seedling survival research

Sabine Wintergerst and Fairchild Challenge Coordinator Brian Sidoti worked with students of Miami's BioTECH @Richmond high school to conduct research on germination and seedling survivorship of *G. monostachia* during the 2020-2021 school year. Students Alyssa Cabrera, Gian Comprendio, Ray Rodriguez, Ariela Amador, and Caro Castro conducted experiments to determine the optimal watering regimen and media for germinating seeds (**Figs. 14 and 15**). Watering every other day proved best for seed germination, and a rocky mix was better than sphagnum moss. This was a pilot study that will be repeated with greater rigor during the next school year.

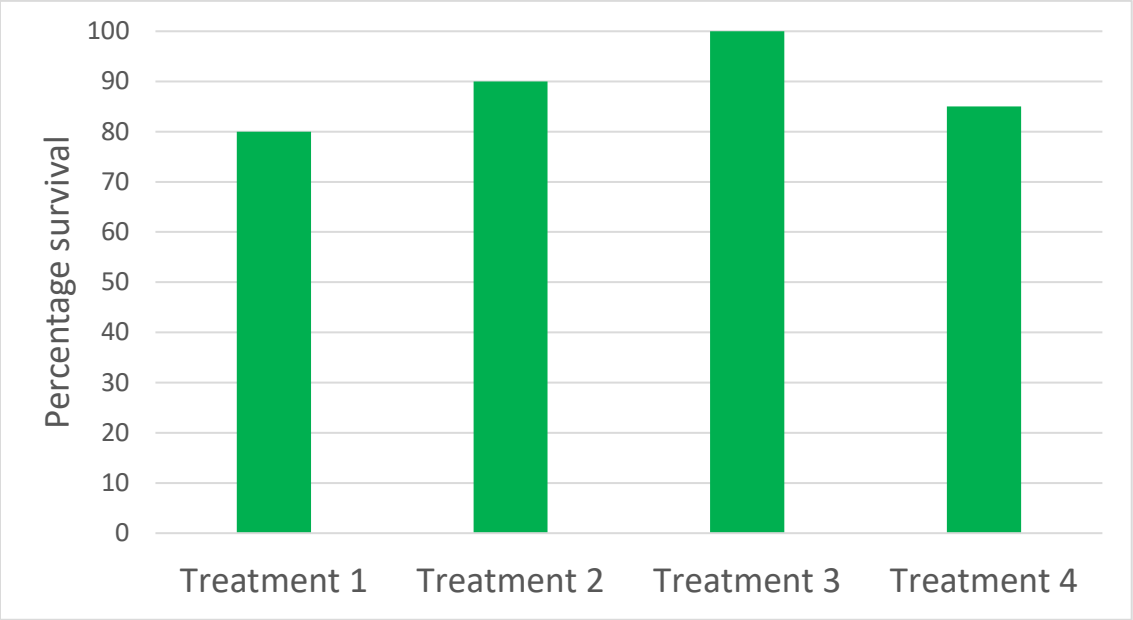


Figure 14. Survival of *Guzmania monostachia* seedlings 2 months after germination (mean of 2 pots). Treatments were as follows: 1-no water, 2-water every day until 75% germination then stop, 3-water every 2 days, and 4-water weekly.

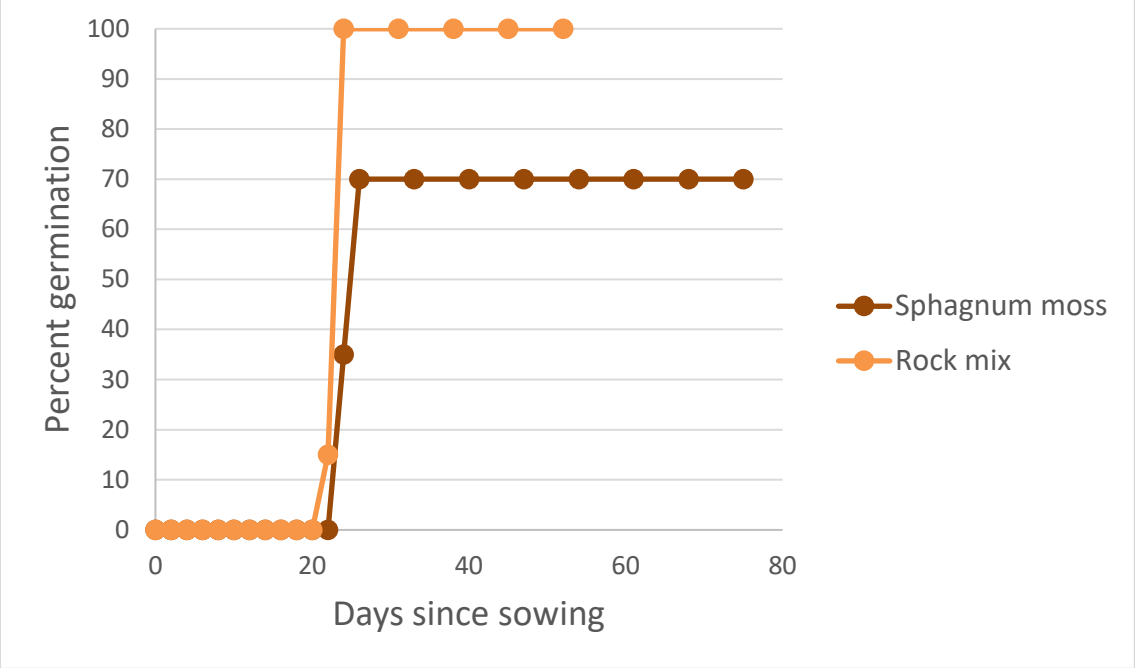


Figure 15. Germination rate of *Guzmania monostachia* on sphagnum moss vs. rock mix

Ipomoea microdactyla Griseb.

Ipomoea microdactyla, the "man-in-the-ground," is a perennial pine rockland vine in the Convolvulaceae family. It is a globally imperiled species listed as endangered by the Florida Department of Agriculture and Consumer Services (Gann et al. 2002, NatureServe 2021). *I. microdactyla* responds favorably to fire, which encourages flowering and, potentially, fruiting (Geiger 2002). Flowers are deep magenta, trumpet-shaped, and nearly 2" wide. Fruit and seed production is dependent upon pollen transfer between individual plants (Geiger 2007).

Update on wild populations

During field surveys, we mapped previously unmapped wild plants at several Miami-Dade County Preserves: School Board Pineland, Camp Owaissa Bauer, and West Biscayne Pineland. We also organized over 20 years of GPS mapping data into one singular GIS map document and shapefile, which is a tremendous aid for population monitoring and seed collections.

Ex situ conservation

We collected 17 seeds from an introduced population and are expecting to collect more seeds this fall from a robust wild population of 20 or more individuals which recently experienced a burn. But otherwise, it has proven to be a challenge to obtain seed of this obligate-outcrossing species.

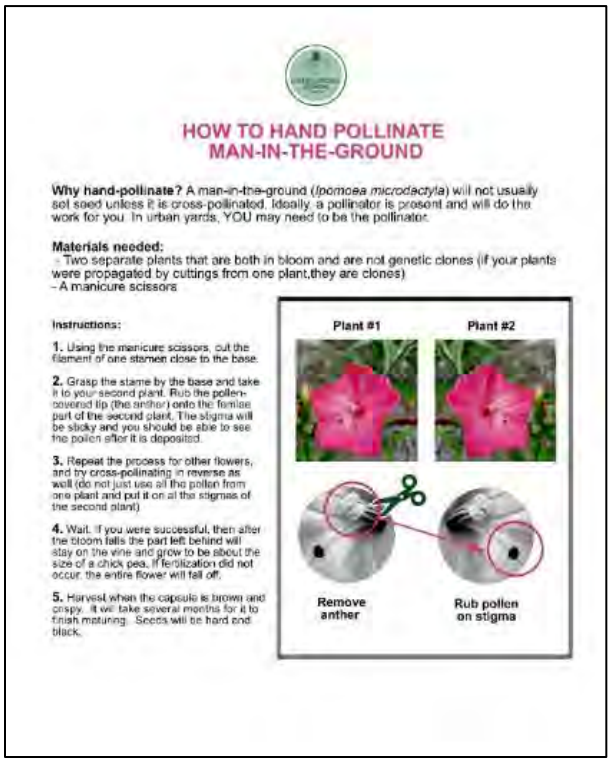
Connect to Protect Network

In order to retrieve more seeds of *Ipomoea microdactyla* for research, storage, restoration projects, and Connect to Protect Network yards, we donated some of our small nursery collection to four "foster gardeners" to help us with hand pollinations and seed collections. The Geiger yard (which was the only yard where the member conducted cross-pollinations by hand) has produced about 50 seeds, some of which he has pledged to share with us.

Beyond foster gardeners, we also appealed to the wider CTP Network to educate members about how to hand-pollinate this species, and to encourage them to share seeds with us, should they harvest any (**Fig. 16a**). Hopefully, this winter, a few additional members will be able to collect seed for us.

Seed germination research

To determine the best method to break dormancy in seeds of *Ipomoea microdactyla*, we implemented a small germination trial with the following seed pre-treatments: sandpaper scarification, 3 seconds of boiling water, and untreated control. Each treatment was only performed with 5 seeds due to very limited seed availability. Sandpaper scarification was the best germination method with 100% germination (**Fig. 16b**). The other two treatments yielded no germination. Interestingly, 3 seconds of boiling water was a very effective method to break seed dormancy in *Ipomoea tenuissima*. Once more seeds are available we might experiment with different times of boiling water exposure to find out if this method is suitable for *Ipomoea microdactyla* as well since sandpaper scarification is very time consuming.



Figures 16a and 16b. *Ipomoea microdactyla*. **Left**: a flyer that we shared with CTPN members to encourage them to hand-pollinate plants and obtain seed which they could then give back to the network. **Right**: Young seedlings in cultivation at Fairchild.

Ipomoea tenuissima Choisy

Ipomoea tenuissima, the "rockland morningglory," is a perennial pine rockland vine in the family Convolvulaceae. It is globally vulnerable and listed as endangered by the Florida Department of Agriculture and Consumer Services (Gann et al. 2002, NatureServe 2021). Plants are coarsely pubescent with sagittate leaves. Flowers are a light pink-purple color, trumpet-shaped, and less than an inch wide (Hammer 2002).

Update on wild populations

We mapped a single *Ipomoea tenuissima* Miami-Dade County's newest EEL preserve, the "School Board Pineland," where this species had not previously been documented. We also mapped two new plants at recently burned Florida City Pineland. The IRC has located this species on site but it had not yet been mapped to our knowledge.

Update on seed germination research

We conducted a dormancy breaking trial for *Ipomoea tenuissima* with different seed pre-treatments; our goal was to find a dormancy-breaking method that is more efficient than the time-consuming method of nicking seeds with a razor blade. Five lots of 30 seeds each received one of these treatments:

- None
- Nicking with razor blade
- Wet heat: 24h in water at 60°C
- Dry heat: 24h at 60°C
- 24h smoke solution

After the above experiment failed to improve germination, we conducted a second dormancy breaking trial during which seeds were submerged in boiling water for 0, 3, 6, 8 and 10 seconds (**Fig. 17**). Treating seeds with boiling water for 3 seconds and then soaking them for 24 hours in water at room temperature increased germination to 67% compared to 3% germination of control seeds. However, exposure to boiling water longer than 6 seconds seemed to damage the seed and did not lead to an increase in germination. This method is a less time-consuming alternative for breaking dormancy in *I. tenuissima*, compared to nicking seeds.

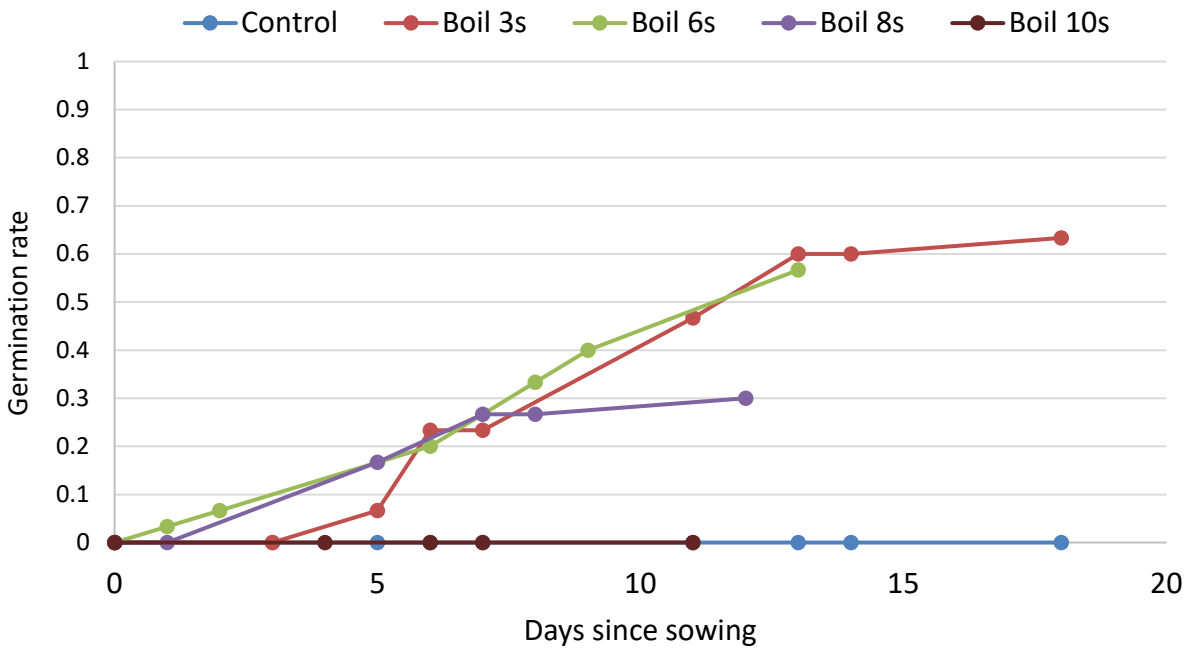


Figure 17. Results of experimental trials immersing seeds of *Ipomoea tenuissima* in boiling water for different time intervals.

Jacquemontia reclinata House

Jacquemontia reclinata is a long-lived, federally endangered trailing vine of the morning glory family, Convolvulaceae, endemic to the coastal dune and coastal strand plant communities on barrier islands of southeast Florida. Rapid and widespread development and transformation of these coastal communities led to a massive reduction in available habitat, threatening the species with extinction. Fairchild has worked closely on the recovery of this species since 1990. During this past grant cycle, we used DPI funding to continue seed germination and horticulture research at Fairchild, and some local population monitoring. Thanks to USFWS Coastal Program funding, we have expanded our focus to restoration and site maintenance, working with land managers to develop and implement long-term strategies.

Updates on Reintroduced Populations

Bill Baggs

We visited the introduced populations in February of 2021 with Park biologist, Liz Golden, five FTBG biologists, and two volunteers (**Fig. 18**). The original introduction at the site consisted of 90 individuals planted in clusters perpendicular to the shore along three transects in 2001. We last visited this population in 2018, shortly after the population had been briefly inundated by storm surge from Hurricane Irma. Park staff noted that some adult plants were killed by the storm, but by the time of our visit there was a mass emergence of seedlings.

Survival of the 2018 seedling emergence was extremely high, and in 2021 we documented a total of 865 individuals in six distinct patches (**Fig. 19**). Of these, 168 were new seedlings and 697 were of reproductive size. Most individuals were prolifically fruiting when we visited, contributing to the seed bank. An overview map of the six patches with XY coordinates and population counts was provided to the Park (**Fig. 20**).

Figure 18. FTBG and Bill Baggs biologists survey backdune habitat for *Jacquemontia*.

Figure 19. Blue pin flags were temporarily placed at all individuals during surveys at Bill Baggs as they were discovered. Flags were then picked up and counted to ensure an accurate census.

Figure 20. Overview map *of J. reclinata* at Bill Baggs Park, showing the location of the 2001 plantings (in red) and the recruits in 2021.

Hollywood North Beach (Broward)

We monitored and provided aftercare for our outplanting of 12 individuals planted at Hollywood North Beach in June 2020. As of 3/4/2021, there is 100% survival and we documented our first seedling recruit. We continue to work to restore other areas for *Jacquemontia* habitat and future outplantings.

Wild populations

Crandon

In March of 2021, with a team of four FTBG biologists and two volunteers, we conducted a census of the wild/augmented population at Crandon Park, searching the entire dune and coastal strand system and documenting 589 *Jacquemontia* individuals, 13 of which were seedlings. Hardwood reduction work by Miami-Dade NAM crews, we believe, is largely responsible for the large current population numbers,

since plants in untreated areas have been observed to become shaded out and eventually die. We took advantage of the population boom by collecting seed, which was plentiful. In total, we collected 327 seeds from 17 maternal lines at Crandon Park; these will be banked to replenish aging stores.

Mizell-Eula Johnson State Park (Broward)

We surveyed for potential outplanting sites in the dune, submitted an augmentation plan to the Florida Park Service, and delivered 19 *Jacquemontia reclinata* to the park. These plants are approximately one year old and are the results of seed storage germination research; the seeds were collected from Crandon Park in 1995. Park biologist John Frosbutter will install plants and provide aftercare once the augmentation plan is approved.

Red Reef and South Beach Parks (Boca Raton)

We surveyed both Red Reef and South Beach Parks in 2021, documenting only six individuals in two patches at South Beach Park. This is a dramatic loss of individuals in the past two decades, when Fairchild found 177 individuals in Red Reef and 245 in South Beach.

During this grant cycle, and with funding from USFWS Coastal Program, we worked with the IRC and volunteers to remove invasive plants and other woody vegetation in one patch in South Beach and one patch in Red Reef seaward of the pavilion.

At the northernmost occurrence at South Beach, we treated for woody/ invasive plants on multiple days. In addition to opening up the habitat there, we also removed Brazilian pepper on the downhill oceanside dune in an attempt to open the area to salt spray as well as create a higher quality dune habitat (**Fig. 21**). We followed up at this patch four different times to control nuisance herbaceous vegetation such as *Bidens* and crowfoot grass.

Figure 21. Environmentally sensitive *Jacquemontia* habitat at South Beach Park before and after initial treatment in October 2020.

Prior to treatment, the patch at Red Reef was dominated by planted seagrape in addition to patches of the invasive Scaevola. We removed a large strip of this woody vegetation on the backdune and replanted with several coastal strand species, including six *Jacquemontia*. Of the six individuals planted, four survived as of May 2021.

Update on seed banking and germination research

We were in need of additional *J. reclinata* plants for restoration projects, and opted to withdraw aging material from our frozen seed bank. We could not only test the viability of seeds in long-term storage, but we could reintroduce any resulting seedlings back to appropriate wild habitat. In spring 2021, we sowed 567 *J. reclinata* seeds from 14 maternal lines. Seeds were collected between 1995 and 2006 at Red Reef Park and Crandon Park. The germination rate was very low (0-7%, with one exception of 30% germination), which might be a sign that these old seed collections should be used and replaced with fresh seed, which we have already begun to do.

Pilosocereus robinii (Lem.) Byles & G.D. Rowley

The Florida Keys are an ecologically unique region of South Florida that supports an unusually high diversity of cactus species. Of the 8 cactus species that are naturally occurring (Gann et al. 2020), the tree cacti (*Pilosocereus* spp.) are by far the largest, capable of reaching heights of 4 meters or more and forming clonal stands several meters wide. The name *Pilosocereus* describes the pilose hairs that arise from areoles (points from which spines grow) on new growth and reproductive portions of the stem.

There are two species of *Pilosocereus* present in the Keys, both of which are protected under the U.S. Endangered Species Act (USFWS 1984). The Keys tree cactus, *Pilosocereus robinii,* is found in the Florida Keys, northwest Cuba, and parts of The Bahamas; the Key Largo tree cactus, *Pilosocereus millspaughii*, is limited to Key Largo in Florida; it is also found in Cuba, The Bahamas, and Hispaniola (Franck et al. 2019, **Fig. 22**). Growing at elevations below 2.15 m in the Florida Keys, both tree cactus species have declined precipitously since the first detailed Florida population census (Adams and Lima 1994). While exact reasons for the decline in the Florida Keys are difficult to pinpoint, what is clear is that hurricanes can have a substantial negative impact on populations and that maintaining ex situ collections of *Pilosocereus* are essential for the species' conservation in Florida.

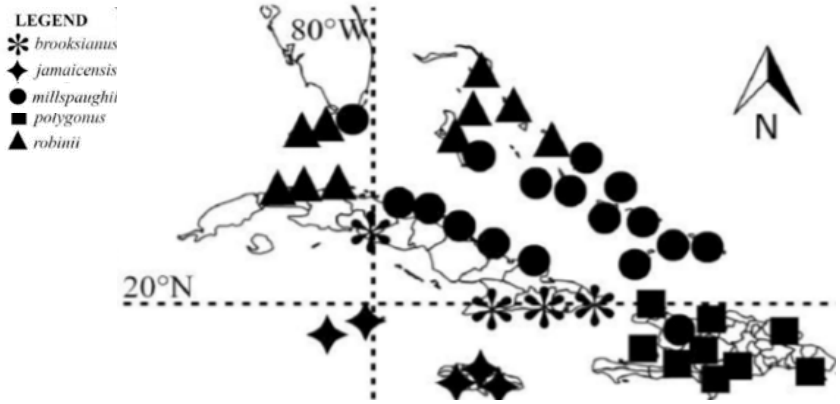


Figure 22. Known current global range of *P. robinii* and *P. millspaughii* with other species of *Pilosocereus* displayed. Adapted from Franck et al. (2019).

Wild populations of *Pilosocereus* are present in thorn scrub/hammock-mangrove ecotone on Big Pine Key, Long Key, Upper Matecumbe Key, and was extant on Lower Matecumbe Key as recently as 2016, but we now consider it extirpated there. *Pilosocereus millspaughii* is present only on Key Largo (**Fig. 25**). In 2007, with a grant from USFWS, Fairchild staff began annual monitoring of all known *Pilosocereus* populations in collaboration with local land managers. Across populations, living individuals (including clonal stems that were once connected to another individual by prostrate stems) have a unique identifying tag. Data collected for each tagged individual include survival, height, length (if horizontal and rooted), and signs of reproduction or disease.

Research into several facets of *Pilosocereus* ecology have contributed to our understanding of the species' conservation needs in Florida. Genetic sampling by Fotinos (2013) suggested there is little variation in genetics between subpopulations, however, that sample size was quite low (20 individuals from Fairchild's nursery). Seed germination and storage research by Salazar et al. (2013) demonstrated

that *Pilosocereus* seeds are capable of surviving orthodox storage (i.e., desiccation and freezing). Goodman et al. (2012) collected data on several environmental factors (including soil salinity, elevation, and canopy cover) near live and recently dead cacti across subpopulations, combined with greenhouse salinity trials. Of the environmental factors, soil salinity and elevation were the primary factors discriminating live vs. dead plants, however, elevation was actually higher at the dead plants. In that same study, greenhouse trials showed a strong correlation between salinity tolerance and maternal line, with plants from the Lower Keys being more salt-sensitive. Additionally, we learned from experimental reintroductions that overall growth and survival of *P. robinii* was highest in thorn scrub, the ecotonal fringe where low hammock meets the mangroves (Possley et al. 2020).

Status of wild and reintroduced subpopulations

As of 2021, we estimate the total number of *Pilosocereus* spp. in natural habitat in the Florida Keys to be 207 separately-rooted plants in 11 separate locations (**Fig. 23, Table 1**). This total is comprised of 148 wild *P. robinii*, 58 introduced *P. robinii*, and 1 introduced *P. millspaughii*.

Fairchild and partners have reintroduced a total of 240 *Pilosocereus* to Windley Key Fossil Reef State Park (on Windley Key) and Crocodile Lake National Wildlife Refuge (on Key Largo). At Windley Key, 36 of the outplants were recently installed in April of 2021 and survival to date is 100%. As for older introductions, as of February 2021, there are 69 surviving individuals (28%) from the 2012 and 2015 outplantings: 58 at Windley Key and 11 at Crocodile Lake NWR. It is worth noting that in 2012 and 2015, we used outplants that were propagated from cuttings, whereas the 2021 outplanting used seed-grown plants. Because seed-grown plants have a much stronger roots system, we are anticipating greater success with this most recent reintroduction effort.

Brief updates on each subpopulation follow. We report on the number of living individual stems with the caveat that this metric may not always be the best indicator of the population health—for example, one tall healthy cactus may be broken into 20 stems which can then root separately. For this reason, we also report on the total vertical height for each population (**Fig. 24**). Adams and Lima (1994) also collected data on stem height and number of stems, but we do not include their data here for comparison, because it is difficult to determine whether they used the same stem-counting methodology as Fairchild, but note that Maschinski et al. (2009) estimated an 80% loss of stems from 1994 to 2009. Clearly, there were many more stems, which were much taller, in 1994.

This year we did not observe signs of fruiting or flowering in any subpopulation of *P. robinii*, wild or reintroduced. Trudy Ferraro, Biological Scientist II at the Florida State Parks, did observe fruiting of *P. millspaughii* at John Pennekamp Coral Reef State Park, shortly before the population was extracted (see the section below on “Key Largo” for more details).

	Parcel Name	Abbreviation	Island	Ownership	Origin
1	Crocodile Lake National Wildlife Refuge	CL	Key Largo	Florida State Parks	Reintroduced
2	John Pennekamp Coral Reef State Park	KL	Key Largo	Florida State Parks	Wild
3	Windley Key Fossil Reef State Park	WK	Windley Key	Florida State Parks	Reintroduced
4	Key Tree Cactus Preserve	KTCP	Upper Matecumbe Key	Village of Islamorada	Wild
5	Choate Tract, Lignum Vitate Key State Park	UMLVK	Upper Matecumbe Key	Florida State Parks	Wild
6	Lindstrom Property	LM	Lower Matecumbe Key	Private	Wild
7	Long Key Borrow Pit	LKBP	Long Key	Private	Wild
8	Layton Trail	LKLT	Long Key	Florida State Parks	Wild
9	Golden Orb Trail	LKGOT	Long Key	Florida State Parks	Wild
10	Cactus Hammock East	NKDRE	Big Pine Key	National Key Deer Refuge	Wild
11	Cactus Hammock West	NKDRW	Big Pine Key	National Key Deer Refuge	Wild

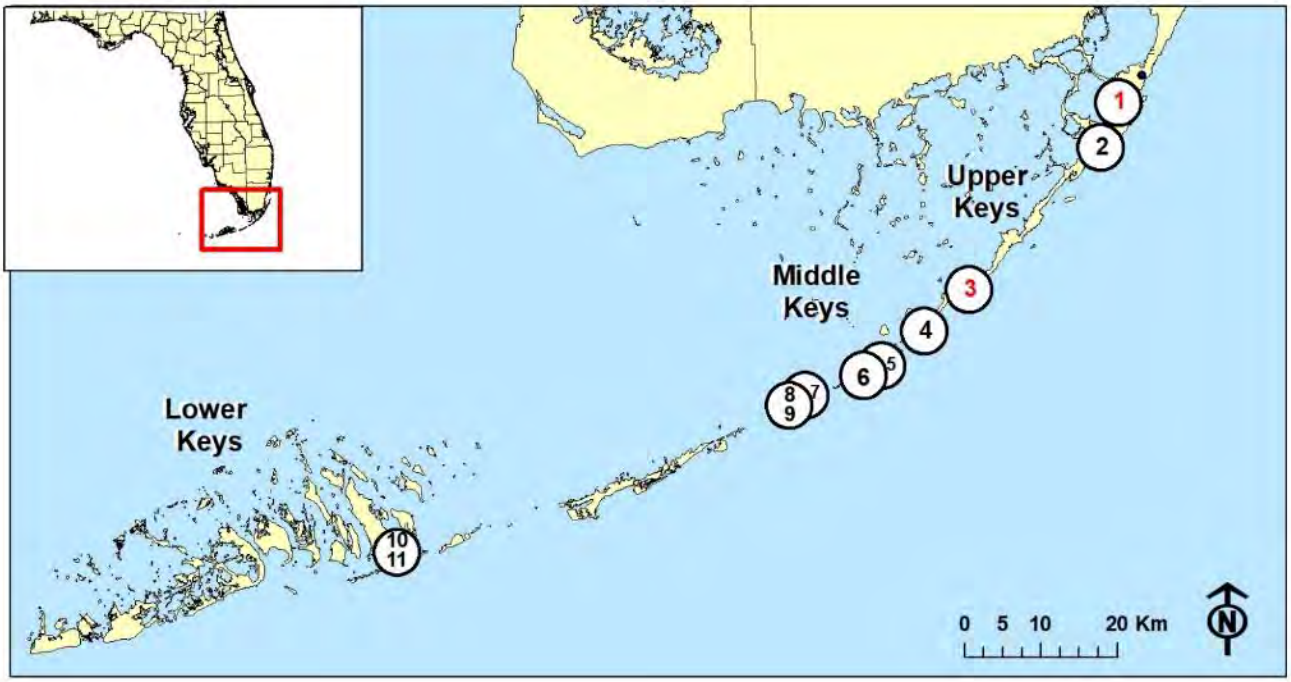


Figure 23. Summary of all current/recently extant Florida *Pilosocereus* subpopulation names and locations from North to South. Populations 1 and 3 are reintroduced. Population 2 is extirpated as of 2021. Population 7 is slated for development. For most subpopulations, more detailed maps are available upon request to Fairchild Tropical Botanic Garden.

Table 1. Number of living stems (including rooted fragments which lack vertical growth) of wild *Pilosocereus* cacti in Florida, from 2007 to present. All subpopulations are *Pilosocereus robinii*, except #2 (Key Largo) is *P. millspaughii*. A double-dash indicates years for which we did not conduct full sampling for that site. The 2012 and 2015 reintroductions at Windley Key are included as separate figures. Note that the number of stems can increase due to fragmentation from wind events or other damage.

	Site	2007	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	**CL**	--	--	--	--	--	--	--	49	48	30	16	14	12	11
2	**KL**	273	98	--	308	--	125	--	60	28	14	11	6	6	0
3	**WK**	--	--	--	--	72	62	54	49+ 89	43+ 74	37+ 45	35+ 32	34+ 29	32+ 25	29+ 19+36
4	**KTCP**	83	50	52	44	38	38	43	31	35	25	26	39	31	35
5	**UMLVK**	25	21	28	29	25	22	--	23	24	24	24	25	25	23
6	**LM**	59	--	--	--	--	--	--	--	3	--	--	--	--	--
7	**LKPB**	--	--	--	--	--	--	--	--	1	--	--	--	--	--
8	**LKLT**	13	13	--	18	--	14	--	10	--	8	--	7	6	3
9	**LKGOT**	78	--	87	--	89	--	37	--	44	--	--	14	34	55
10	**NKDRE**	28	19	17	21	22	33	--	31	32	35	23	23	20	20
11	**NKDRW**	26	14	10	10	12	16	15	9	10	15	10	12	11	12

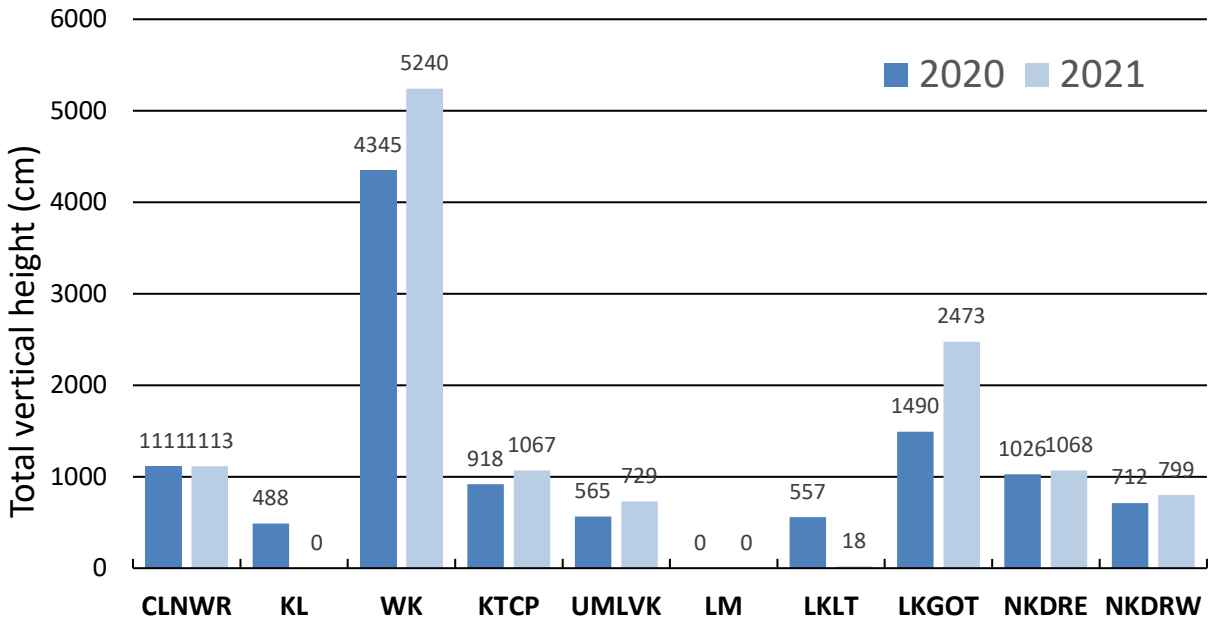


Figure 24. Combined vertical height in centimeters of *Pilosocereus* at each subpopulation in 2020 and 2021.

1. Crocodile Lake (CL) - Reintroduced

We monitored this reintroduced population in February 2021 along with Elizabeth Wu (**Fig. 25**) and Grant Pottash. There were 11 surviving individuals of the 49 we planted in 2015. One died in the past year; it was rated as in poor health in 2020. All but one of the 11 remaining cacti were rated as being in "good/great" health. We did not observe any signs of sexual reproduction.

Figure 25. Elizabeth Wu with *Pilosocereus robinii* outplant #5450 at Crocodile Lake NWR. Photo by Grant Pottash.

2. Key Largo (KL)

This is the only known population of *Pilosocereus millspaughii* in the United States. We previously reported only 6 living stems at this wild population within John Pennekamp Coral Reef State Park (Lange et al. 2019). We monitored the population again in February 2020 with FSP biologist Trudy Ferraro. We relocated 5 of the 6 stems from 2019; Ferraro later located the sixth.

The 6 rooted individuals at this population include one stem that was more than 3 meters tall and has at least 20 branches, but Trudy Ferraro reported that the large individual fell over in late 2020. Mammalian herbivory at the cactus' base and extremely high king tides likely both contributed to the collapse of this last large individual.

Following a virtual meeting of an ad-hoc Key Tree Cactus Working Group in fall 2020, FSP and Fairchild biologists planned to recover all salvageable material from this population-- Florida's last remaining population of *P. millspaughii.* The operation was first scheduled for winter of 2020-2021, but was postponed at the request of Fairchild horticulturist Brian Harding who thought that vegetative cuttings might be best collected in the growing season. Instead, Trudy Ferraro agreed to monitor the colony every few weeks until the summer salvage operation. This turned out to be very fortuitous, because in January 2021, Ferraro noted that a fruit had formed on the large fallen cactus. Along with Fairchild biologist Jimmy Lange, Ferraro covered the developing fruit with a mesh bag and a wire cage to protect the developing fruit from insect and mammal predators (**Fig. 26**). On March 3rd, she collected the fruit along with another smaller one that she encountered on the ground, and drove them to Fairchild's Seed Lab. Sabine Wintergerst, Fairchild's Seed Lab Manager, reported that the smaller fruit did not contain any viable seeds, but the larger one contained 112. Seeds were cleaned, a few were sown for propagation, and the rest were deposited into Fairchild's long-term storage bank.

Figure 26. *Pilosocereus millspaughii.* **Left**: the protective bag and cage placed over the developing fruit at John Pennekamp Coral Reef State Park (J. Lange). **Center**: The ripe fruit split open, revealing seeds (S. Wintergerst). **Right**: view of two seeds through the Seed Lab dissecting scope (S. Wintergerst).

In early May, Ferraro reported that the remaining material was failing rapidly. The group organized an extraction, and on May 25th, 2021, a group of ten staff and volunteers from the Florida Park Service and Fairchild Tropical Botanic Garden removed all salvageable *P. millspaughii* from John Pennekamp Coral Reef State Park (**Fig. 27**). For small cacti, we extracted the entire plant. But for most of the material, we used a hacksaw to cut the formerly large cactus into pieces that were small enough to transport on foot, through mangrove forest. We wrapped cacti in towels and packed them into 5-gallon buckets for transport to the Pennekamp nursery. The material was divided into two groups, with half staying behind at John Pennekamp and the other half going to Fairchild for cultivation.

Figure 27. Removing the last *Pilosocereus millspaughii* from the wild in Florida. Top: Staff gathered around the fallen material, sawing off pieces. **Bottom left**: Towel-wrapped cacti, ready for transport through the mangroves and to the Pennekamp nursery. **Bottom right**: Salvaged material at the nursery.

After rescue, salvaged *P. millspaughii* bloomed at Fairchild and at Pennekamp (**Fig. 28**). At Fairchild, there were two blooms, but both of the fruits aborted. The single bloom at Pennekamp is developing into a fruit and appears likely to produce seed this summer.

Figure 28. Left: Roger Hammer drove up to Fairchild at night to capture his first image of a *P. millspaughii* flower for his new book on Florida Keys wildflowers. **Right**: Developing fruit on *P. millspaughii* at John Pennekamp nursery. Photo by Susan Kolterman.

3. Windley Key (WK) Reintroduced

Fairchild and Florida Park Service collaborated to reintroduce 161 *Pilosocereus robinii* to Windley Key in 2012 and 2015. In 2012, we reintroduced a total of 72 plants to two separate locations, low-elevation hammock vs. hammock/mangrove ecotone. In 2015, we installed 89 plants into canopy gaps in higher-elevation mature hammock. For all outplants, pot size ranged from 1- 3 gallon. All cacti were propagated vegetatively in Fairchild's nursery. Average plant height upon installing in 2012 was 48 cm; in 2015 average outplant height was 78 cm. FPS biologist Janice Duquesnel has been essential to this project, watering plants, helping with all monitoring, and working on post-hurricane recovery. We monitored all three Windley Key subpopulations of *P. robinii* in February 2021 with Janice, Rebecca Collins, Elizabeth Wu, and Grant Pottash. Survival was highest in the mid-elevation ecotone planting. Details for each subpopulation follow. No signs of fruiting or flowering were observed in any subpopulation.

- **WK1: Low-elevation hammock, trailpost 34; 2012**. We planted 36 cacti at this subpopulation into low elevation hammock in 2012. There was one new death this past year, of an individual that we reported as fallen over in 2020. Currently, 12 individuals (33%) remain. Some of these plants experienced heavy herbivory early on but healed over (**Fig. 29**), and recent herbivory does not appear to be an issue. All plants that remain vertical grew, with an average height

increase of 10 cm in the past year. Two plants are completely horizontal. Falling over is likely due in part to the fact that these plants were vegetatively propagated, with root systems that are not as strong as those in seed-grown plants.

Figure 29. 2012 *Pilosocereus robinii* outplants Windley Key low elevation hammock in February 2021. **Left**: Brian Harding, Elizabeth Wu and Becky Collins with a cactus #1190 showing recent vertical growth. **Right**, cactus #1198 was badly chewed after introduction, but the wound healed over and the cactus now appears to be relatively healthy.

- **WK2: Hammock/mangrove ecotone, trailpost 40; 2012.** We planted 36 cacti into this ecotone habitat (the habitat typical of *P. robinii*) in 2012. There were two deaths in the past year; 17 individuals (47%) remain. Average height increase over the past year was 11 cm.
- **WK3: Higher elevation hammock; trailposts 46-50, 2015.** We planted 89 cacti into canopy gaps of higher elevation, mature hammock in 2015. As of February 2020, 19 plants survive (21%), with an average height increase of just 2.5 cm, for plants that remain vertical. This planting performed the poorest out of the three. We believe two factors are primarily responsible for the poorer performance. First, the canopy is denser here, with less light reaching the cacti. Second, plants installed in 2015 were generally larger, more pot-bound and less healthy than those installed in 2012.

On April 21, 2021, Fairchild and Florida Park Service installed 36 additional seed-grown *P. robinii* at Windley Key, into hammock/mangrove ecotone (**Fig. 30**). FPS staff watered plants every few days until regular rains began and replanted two plants that tipped over after planting. We anticipate high survival.


Figure 30. Left: Some of the seed-grown *P. robinii*, packaged for transport, so that they do not injure each other (and potentially introduce a pathogen). **Right**: Mary Jackson and Brian Harding install one of the cacti on Windley Key.

4. Key Tree Cactus Preserve (KTCP)

In September 2020, Fairchild donated 3 *P. robinii* to the City of Islamorada's Key Tree Cactus Preserve for planting (**Fig. 31**). One individual was a 2' tall plant propagated from a cutting that was of unspecific wild Keys origin and was growing (quite root-bound) in a 1-gallon pot. The other two plants were seed-grown, approximately 6" tall, and in quart pots. Their origin was a hand-pollinated cross (at Fairchild's nursery in 2016) between a cutting of Big Pine Key origin and a cutting from Key Tree Cactus Preserve.

Figure 31. Three seed-grown *P. robinii* planted at the City of Islamorada's Key Tree Cactus Preserve in September 2020. Photo by P. Frezza.

We monitored *P. robinii* at the KTCP with Environmental Resources Manager Peter Frezza in February 2021. While this subpopulation had multiple large, reproductive adults just a few years ago, it now consists only of smaller fragments. Excluding the three newly added plants, the number of tagged, living

P. robinii declined from 39 plants in 2019 to 35 in 2021. However, growth is strong in many individuals. In the past year, total vertical height of *P. robinii* at the preserve increased from 918 cm to 1067 cm.

5. Upper Matecumbe - Lignum Vitae Key State Park– Choate Tract (UMLVK)

The Choate Tract population of *P. robinii* has remained fairly stable in recent years, compared to populations on Big Pine and Long Keys. In 2021 we counted 23 separate living plants; two fewer than 2020. Only one large (>3m tall) individual remains in the tract; it appears to be very healthy despite having its apical portion severed in Hurricane Irma. Due to the loss of one of the larger cacti, total height has decreased over one meter since last year, with the current total vertical height in the preserve at 729 cm.

6. Lower Matecumbe – Lindstrom Property (LM)

Fairchild biologists Jimmy Lange and Jennifer Possley last visited this privately-owned property in 2016. At that time, all that remained were 3 unhealthy, loosely-rooted fragments. We searched for additional material but did not locate any. In 2017 and 2018, Lange attempted to seek permission from the Lindstrom family to monitor again, but he was not able to make contact. We discontinued annual monitoring at this population, and consider that *P. robinii* is in all likelihood extirpated from Lower Matecumbe Key.

7. Long Key Borrow Pit

FPS biologist Janice Duquesnel, Lange, and Possley visited this privately-owned property in 2016. In a survey in dense underbrush lasting no more than 2 hours, a single *P. robinii* cactus was found and rescued. This individual, which Lange named “Little Scrappy,” is now about 18” tall and is part of Fairchild’s nursery ex situ collection. The property has been slated for development but has not yet, to our knowledge, been cleared.

8&9. Long Key – Long Key State Park- Golden Orb Trail (LKGOT) and Layton Trail

Pilosocereus robinii along the Long Key Golden Orb Trail once grew in massive multi-stemmed clumps, and was the last large stand of the species in the Keys. Regrettably, this subpopulation was severely impacted by Hurricane Irma in 2017. From 2016 to 2020, the combined total vertical height of all *P. robinii* at LKGOT was reduced by more than 4 meters, from 5903 cm to 1577 cm. By 2021, only two larger individuals survive with heights over 4 m and branch counts for each at 45 and 76. We counted a total of 55 individuals, with several over 1 m in height. Rescue efforts made in 2019 to cut fragments from dense fallen material and spread them along the ground appears to have been largely successful. By 2021, 34 of these fragments were rooted and contained 40 total vertical branches, totaling over 400 cm in height. The population appears to be in good shape in the near term. The total height is 2,473 cm.

The population near the Layton Trail is down to three small individuals, only one of which has a prostrate stem. The two with vertical stems are each 9 cm tall. The outlook for this population is dismal without active intervention. With the closed canopy at the site, we feel that without thinning of trees, this is no longer viable habitat for *Pilosocereus*.

10. National Key Deer Refuge East (NKDRE)

On Big Pine Key, all known *Pilosocereus robinii* are located within "Cactus Hammock"—a relatively higher elevation area located at the island's southeast point. Long Beach Drive bisects the hammock into two portions which we call NKDR East and NKDR West. Both subpopulations continue to decline, but the decline has been more gradual for plants at NKDR East. Differences in conditions between the two sites include sparser vegetation and higher light levels on the east side. Cactus diversity is also much higher on the east side; the rare species *Opuntia abjecta* and *O. ochrocentra* are present only in that east parcel. This population lost several large, reproductive adults following Hurricane Irma.
As of 2021, there are 20 separately-rooted *P. robinii* in NKDR East. Only a single plant is large (~4m tall) and multi-branched. Combined vertical height in this parcel was 1123 cm.

11. National Key Deer Refuge West (NKDRW)

The population of *Pilosocereus robinii* in the western portion of "Cactus Hammock" in the NKDR consisted of thousands of healthy living stems as recently as 1994 (Adams and Lima 1994). Even in 2007, some large stands persisted (**Fig. 32**). But from 2007 to 2021, the number of individuals decreased from 26 to 12 and combined vertical height dropped from 4073 cm to just 799 cm. All large stands of *P. robinii,* some of which remained into the 2000s, are now gone on the west side. Only a few rooted pieces remain.

Figure 32. *Pilosocereus robinii* in "Cactus Hammock," part of National Key Deer Refuge on Big Pine Key. Photo taken in 2007 by Chris Migliaccio.

Ex situ collections

Fairchild continues to maintain an ex situ nursery collection of *Pilosocereus*. In July 2021, nursery collections consist of 192 plants. Approximately 1/2 of this material consists of older plants with the potential to flower; the remainder are young, seed-grown plants. A detailed inventory is not provided, as it is currently in flux, with plants being distributed to reintroduction sites. We intend to reintroduce the remaining seed-grown plants into appropriate Keys habitat in 2021 and/or 2022 and will provide

updates with each annual DPI report. Desert Botanic Garden in Flagstaff, Arizona also has an ex situ conservation collection of *P. robinii* (**Table 2**).

Table 2. *Pilosocereus robinii* at Desert Botanic Garden (total =22). Information provided by Steve Blackwell, DBG.

Accession number	Wild tag	Site	Quantity
2010-0072-01	1303	NKDR, BPK	1
2010-0073-01	490	NKDR, BPK	1
2010-0074-01	1413	NKDR, BPK	1
2010-0075-01	1344/1349	LKSP, GOT	1
2010-0076-01	1373	LKSP, GOT	1
2010-0079-01	1302	NKDR, BPK	1
2010-0080-01	1311	NKDR, BPK	1
2010-0081-01	1357	LKSP, GOT	1
2010-0082-01	1326	NKDR, BPK	1
2010-0084-01	1350	LKSP, GOT	1
2010-0085-01	1374	LKSP, GOT	1
2010-0086-01	1413	NKDR, BPK	1
2010-0087-01	1804	LKSP, LT	1
2010-0088-01	1619	LM	1
2010-0089-01	1638	LM	1
2010-0090-01	1607	LM	1
2010-0091-01	1676	UM, KTCP	1
2010-0093-01	1718	UM, KTCP	1
2010-0094-01	1658	UM, LVKSP	1
2010-0095-01	1747	UM, KTCP	2
2010-0096-01	1766	UM, KTCP	1

Seeds are also an important component of our ex situ holdings, as *Pilosocereus* has been demonstrated to have orthodox seeds that are capable of surviving desiccation and storage (Salazar 2013). Following that, Fairchild has more than 9,000 *Pilosocereus* seeds in frozen storage at Fairchild (**Table 3**), and more than 6468 seeds stored at the USDA NLGRP (**Table 4**). This year we successfully germinated seeds from individuals not yet represented in our ex situ collection that have been stored at FTBG and NLGRP between 6 and 9 years. This means our stored seed collections are still viable and can be used for future restoration projects.

Table 3. *Pilosocereus* seeds stored at Fairchild (total 9710)

Accession number	# seeds	Source	Provenance
2016-0868	481	Ex situ (FTBG)	LM = Lower Matecumbe (Frisbee/Lindstrom property)
2016-0889	713	Ex situ (FTBG)	Mixed: LM (#1622) & NKDRW (#444)
2016-0890	692	Ex situ (FTBG)	Mixed: LM (#1622) & NKDRW (#444)
2016-0891	931	Ex situ (FTBG)	Mixed: KTCP (#1673) & NKDRE (#1413)
2016-0892	402	Ex situ (FTBG)	Mixed: NKDRE (#1420) & KTCP (#1724)
2016-0893	482	Ex situ (FTBG)	KTCP
2016-0894	907	Ex situ (FTBG)	KTCP
2016-0895	288	Ex situ (FTBG)	Florida Keys, exact location unknown
2016-0896	520	Ex situ (FTBG)	Mixed: NKDRE (#1302) X unknown
2016-0897	1118	Ex situ (FTBG)	Mixed: KTCP (#1673) & NKDRE (#1413)
2016-0898	1020	Ex situ (FTBG)	NKDR = National Key Deer Refuge, Cactus Hammock
2016-0899	1160	Ex situ (FTBG)	NKDRW. Cuttings taken from #1036 in 2017

2016-0900*	40	John Pennekamp Coral Reef SP	Accessioned as P. polygonus
2018-0572	400	Ex situ (FTBG)	Unaccessioned seeds found in seed lab in 2019, one envelope says Unk self BPK 4989 seeds, other envelope #1302 selfed BPK
2018-0573	234	Ex situ (FTBG)	#5445 is the tag of a plant introduced to CL (original ML was #2390)
2019-0644	322	Ex situ (not FTBG)	Fruit collected by Bob Ehrig, mother plant from a piece of plant collected from Big Pine Key in 1979. Location "NW Cactus Hammock,

Table 4. *Pilosocereus* seeds stored at USDA NLGRP (total 6121)

Accession number	# seeds	Parent Acc #	Collection site	Provenance
2008-0002	222	n/a	Big Pine Key, NKDR	n/a
2008-1089	155	n/a	Big Pine Key, NKDR	n/a
2009-0596	180	n/a	Ex situ (FTBG)	Upper Matecumbe, Key Tree Cactus Preserve
2011-0504	97	n/a	Big Pine Key, NKDR	n/a
2012-2157	256	2007-0661-1736	Ex situ (FTBG)	Upper Matecumbe, Key Tree Cactus Preserve
2012-2309	385	2008-0522-1622	Ex situ (FTBG)	Lower Matecumbe, Frisbee property
2013-1148	150	2008-0522-1738	Ex situ (FTBG)	Upper Matecumbe, Key Tree Cactus Preserve
2013-1149	150	2010-0208-1413	Ex situ (FTBG)	National Key Deer Refuge, Cactus Hammock East
2013-1150	450	2010-0625-1044	Ex situ (FTBG)	National Key Deer Refuge, Cactus Hammock West
2013-1151	100	2010-0208-512	Ex situ (FTBG)	National Key Deer Refuge, Cactus Hammock West
2013-1152	200	2007-0661-1762	Ex situ (FTBG)	Lower Matecumbe, Frisbee property
2013-1153	30	2008-0522-1762	Ex situ (FTBG)	Lower Matecumbe, Frisbee property
2013-1154	314	2008-0522-1736	Ex situ (FTBG)	Upper Matecumbe, Key Tree Cactus Preserve
2013-1155	185	2009-0325-1738	Ex situ (FTBG)	Upper Matecumbe, Key Tree Cactus Preserve
2015-0085	388	2008-0522-1673	Ex situ (FTBG)	Upper Matecumbe, Key Tree Cactus Preserve
2015-0086	106	2007-0661-1762	Ex situ (FTBG)	Lower Matecumbe, Frisbee property
2015-0087	1155	2008-0522-1622	Ex situ (FTBG)	Lower Matecumbe, Frisbee property
2015-0088	248	2010-0208-1413	Ex situ (FTBG)	National Key Deer Refuge, Cactus Hammock East
2015-0089	350	2008-0522-1738	Ex situ (FTBG)	Upper Matecumbe, Key Tree Cactus Preserve
2015-0090	200	2010-0488-5364	Ex situ (FTBG)	National Key Deer Refuge, Cactus Hammock East
2015-0091	500	2010-0625-1413	Ex situ (FTBG)	National Key Deer Refuge, Cactus Hammock East
2015-0785	300	2010-0208-1735	Ex situ (FTBG)	Upper Matecumbe, Key Tree Cactus Preserve
2008-0003*	167	n/a	Key Largo, JPCRSP	n/a

Stakeholder meeting

Fairchild hosted a virtual Key tree cactus stakeholder summit on September 8, 2020. Attendees included Dave Bender and Jeremy Dixon from USFWS; Trudy Ferraro, Janice Duquesnel, Mark Duncan, and Rebecca Collins from FSP; James Lange, Jennifer Possley, Brian Harding, Lydia Cuni, and Sabine Wintergerst from FTBG; Joyce Maschinski from CPC; Peter Frezza from City of Islamorada; Jeannette Parker from Florida Fish and Wildlife Conservation Commission; Chris Bergh from The Nature Conservancy; Mike Ross from Florida International University; volunteer Susan Kolterman; and Joie Goodman, formerly of FTBG.

During the summit, Fairchild provided a summary of the information presented in this report, and short, virtual tours of the *Pilosocereus* holdings in the seed lab and nursery. Group discussion then addressed next steps, with a focus on ex situ collections and reintroductions. From this, a list of action items was developed (**Table 5**). Aside from the plans to write a peer-reviewed manuscript, all actions are on track.

Table 5. Action items developed during the fall 2020 Key Tree Cactus stakeholder summit

Action	Due date	Personnel
Monitor *P. millspaughii* for reproduction at CLNWR (Tag#s 5466 and 5469), at JPCRSP, and at Fairchild nursery.	Ongoing	Jeremy, Trudy, Janice, Susan, Brian
Monitor *P. robinii* for reproduction in wild; notify Fairchild if fruits are forming.	Ongoing	All preserve managers
Monitor *P. robinii* for downed stems that could be rescued, notify Fairchild if rescue is needed.	Ongoing	All preserve managers
For ex situ *P. millspaughii*, repot individuals to larger pots and put 1-2 cacti in the ground in appropriate habitat at JPCRSP nursery, to potentially stimulate growth and reproduction. Select full-sun planting areas where staff can monitor closely for disease, flowering, and growth. Use 1:1:1 mix of soil, limestone, turface.	12/31/2020	Trudy, Susan, Janice
For wild *P. millspaughii*, collect additional cuttings from JPCRSP to increase ex situ holdings. Collect any viable-looking pieces off the ground and no more than 2 branches from the only remaining standing cactus which has 20 branches	12/31/2020	Trudy, Janice, Fairchild
Characterize ideal habitat for both species. Also describe criteria for "semi-wild" plantings in accessible locations (e.g., near biologist offices) aimed at generating accessible flowers and fruit.	12/31/2020	Jennifer, Joie, Jimmy
Sow more seeds for future plantings, with multi- lineage cohorts of no more than 100 seedlings per cohort?	12/31/2020, then ev 3-4 yrs as needed.	Sabine, Brian
For ex situ *P. robinii*, plant some individuals in semi-wild situations (e.g., near park offices) to help with population monitoring, interpretation, etc. Include KTCP, CLNWR, NKDR, JP, others.	Summer 2021	Brian, Janice, Jeremy, Peter, Rebecca, Chris, Kristie, Jeannette, Lu, Channell, etc.
Compare and rank potential recipient sites. For 5-6 top priority sites, collect more information for further evaluation (tracking down contacts, permissions, gather habitat info, etc.).	Summer 2021	Jennifer, Lydia, Jimmy, preserve managers
Begin work on "Lessons learned" peer reviewed manuscript, synthesizing monitoring and experimental data	Outline by 12/31/2020, Submit by 7/31/2021.	Jennifer, Joie, Jimmy, Joyce, Janice, Jeremy

Annual monitoring. Also coordinate any plant rescues, management needs, and watching for potential reproductive events.	February 2021	All Florida people
Monitor collection at Fairchild for flowering. Hand-pollinate flowers to generate more fruit, seeds. Investigate methods for pollen storage to facilitate hand-pollination of asynchronous flowers.	Summer 2021	Brian, Lydia, Jimmy, Sabine
Coordinate with DBG and others to exchange seeds to diversify each garden's collection (on a per-island basis)	Ongoing	Sabine
Conduct 2-4 reintroductions of no more than 25 plants to high-priority introduction sites.	Summer 2021 if roots ready. If not, fall 2021 or later.	All Florida people
Coordinate reintroductions with CLNWR and others to heat-treat plants for New Guinea flatworm before planting.	Concurrent with reintroductions	All, Jeremy

Pseudophoenix sargentii H. Wendl. ex. Sargent

Introduction

Pseudophoenix sargentii is a slow-growing, long-lived palm found throughout the Caribbean Basin, predominantly in coastal habitats on exposed limestone or dune sand/ coastal berm over limestone. Only a single wild population remains in the United States, on Elliott Key. Many Caribbean populations have been extirpated or are in decline, prompting the IUCN to list the species' status as regionally-endangered and globally vulnerable. As part of a large multi-year project in collaboration with federal and state agencies, Fairchild has investigated the biology, demography, and genetic structure of *P. sargentii*, and has used this information to guide efforts in augmenting wild populations as well as reintroducing populations to historical sites. Here we report details on population demographic structure, recent population trends, and the status of introduced populations.

Methods

Field methods – Information presented in this report was gathered over three trips to Elliott Key. First, in March 2018, Brian Lockwood, Dallas Hazelton, and Jimmy Lange monitored a portion of the *P. sargentii* population while they were visiting the island to map and collect seed of *Aristolochia pentandra*. They made rapid assessments of the wild subpopulations at No Name, Scorpion Bight, Predator South, as well as the outplanted individuals near the Interpretive Trail. As this trip was just five months after Hurricane Irma, they made efforts to clear fallen branches and debris that were impacting *P. sargentii*.
Second, on March 3rd, 2020, BNP biologists Vanessa McDonough and Shelby Moneysmith monitored the *P. sargentii* population with Fairchild biologists Jimmy Lange, and Jennifer Possley. On that date, the goal was rapid assessment of known adult plants (Stage 5) and some of the larger (Stage 4) plants.
Third and most recently, on January 13th and 14th, 2021, all known *P. sargentii* were monitored by the authors and Gonzalez, Hoffman, Moneysmith, Montes de Oca, Wagner, and Wu. Every known individual of *P. sargentii* throughout 9 subpopulations was inspected, with the following data collected: location, tag number, number of leaves, and height in centimeters (from the ground to the tallest photosynthetic tissue, as each plant stood naturally). General comments on plant health were made, when notable (for example: signs of herbivory or other damage).

Regardless of whether an individual *P. sargentii* is wild or planted, each has a round aluminum numbered tag attached around the base of the plant using aluminum or galvanized steel wire. When wire appeared to be damaged or missing, it was replaced. When *P. sargentii* were encountered that had never been tagged, a new tag was attached. For very small plants that lacked pinnate leaves, the tag was attached to an adjacent stainless steel stake instead of wired directly to the plant (**Fig. 33**).

Figure 33. Tag #90 was placed at a palm seedling located within the Scorpion Bight subpopulation. The seedling was too small to identify to species.

Survey methods **–** In order to detect individual *P. sargentii* which were not yet included in the demographic dataset, areas adjacent to known populations were surveyed, if the habitat was appropriate (i.e., upland broadleaf forest). In 2021, surveys for undetected plants focused on habitat between Predator North and Predator South, west of No Name, and in the area surrounding Coon Point (**Fig. 34**). For these efforts, seven persons spent approximately 90 minutes searching.

Mapping – The methods by which Fairchild mapped *P. sargentii* plants have varied over the years. From the 1990s through 2012, submeter accurate methods were used, including a Trimble ProXR GPS and a laser range finder. These tools enabled the creation of highly accurate maps using ESRI ArcGIS software. After 2012, Fairchild lacked a reliable submeter accurate GPS unit, and thus relied on handheld Garmin GPS units (with accuracy typically within 10-20 feet) to record the location of individual *P. sargentii*.

Data entry/storage/analysis – All field data were entered into a Microsoft Excel spreadsheet. All individual *P. sargentii* that have ever been tagged remain a permanent part of this dataset. Microsoft Excel was used to create figures that are in the Results section of this report.

This study continues to follow size classes as assigned in Maschinski & Duquesnel (2007) where regression analysis was used to determine the relationship between height and ontogeny to categorize plants into five non-overlapping stages (**Fig. 35**). It should be noted that newly-emerged *P. sargentii* seedlings with only a single small eophyll (=first leaf or leaves, different in morphology from adult leaves) are difficult to distinguish from newly-emerged *Thrinax radiata,* which is a common palm on Elliott Key. Thus, it is likely that this study underestimates the total number of *P. sargentii* seedlings present on the island. Once a seedling is large enough to have at least one fully developed eophyll, it is possible to tell if it is *Pseudophoenix* or *Thrinax* (**Fig. 36**).

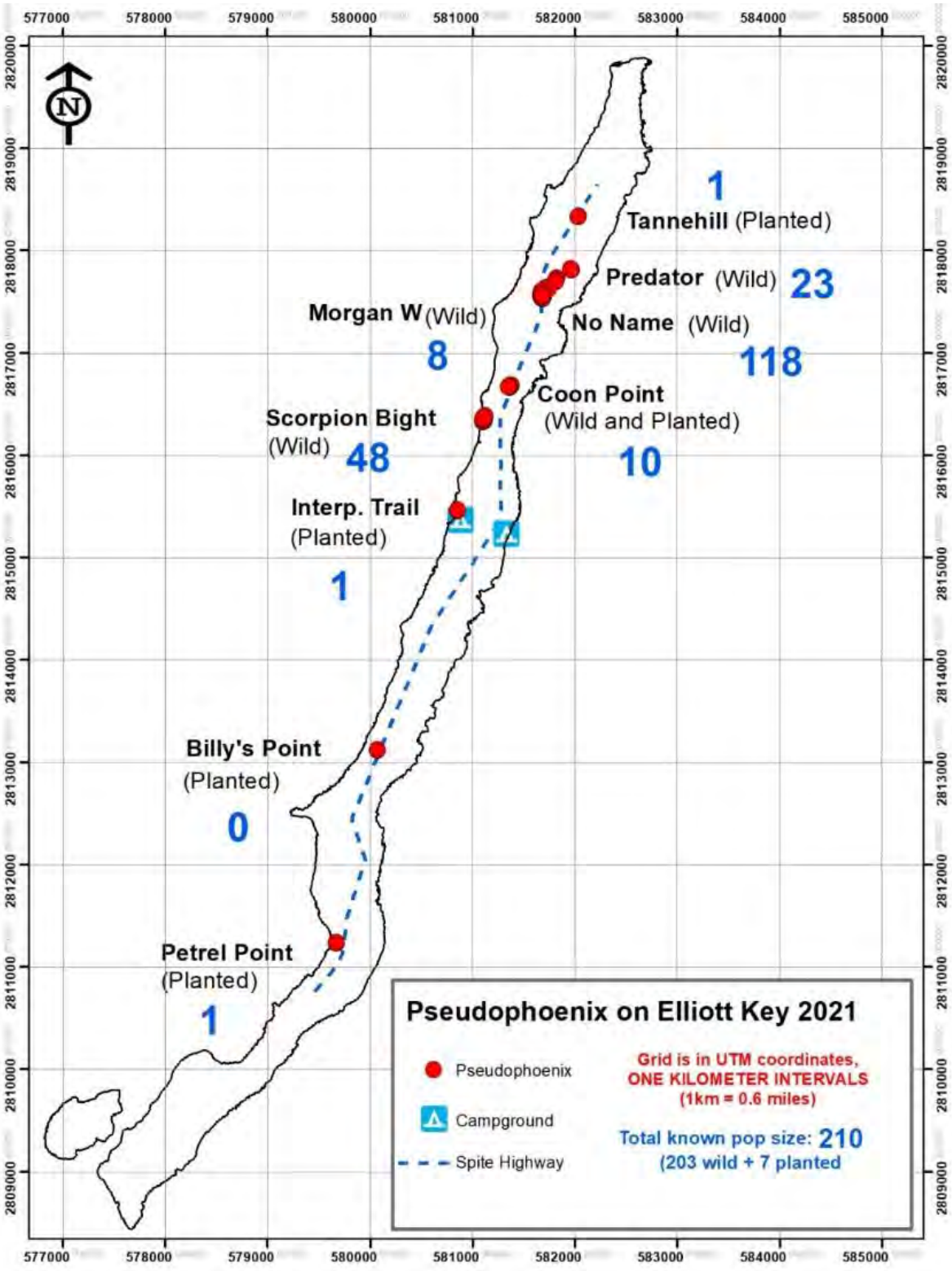


Figure 34. Overview map of wild and reintroduced *Pseudophoenix sargentii* on Elliott Key, as of January 2021. Detailed maps of each subpopulation are not included with this report but are available upon request to BNP and FTBG.

Stage 1 – Seedling with eophylls*, no pinnate leaves
Stage 2 – Small plant with pinnate leaves, up to 0.83 m tall
Stage 3 – Medium plant between 0.83 and 1.6 m tall
Stage 4 – Large palm taller than 1.6 meters but not yet reproductive
Stage 5 – Reproductive adult

Figure 35. *P. sargentii* size classes established by Maschinski & Duquesnel (2007) which are referred to throughout this study.

Figure 36. *Pseudophoenix sargentii* (**left**) vs. *Thrinax radiata* (**right**). By looking at the venation at the base of larger eophylls, it is possible to tell these species apart. In *Pseudophoenix*, veins converge in a line extending from the base of the eophyll. In *Thrinax*, all veins converge at one point at the base of the eophyll.

Ex situ collections at Fairchild – Off-site plant collections can serve as a "back-up" of wild plant populations and are thus an important part of any comprehensive conservation program. In cases involving plants with recalcitrant seeds which cannot be stored (like those of *P. sargentii*), living plant collections are especially important. Fairchild Garden continues to maintain an ex situ population of *P. sargentii* grown from seed collected on Elliott Key, from 1990 to present.

Results

Wild population - As of January 2021, the total known wild *P. sargentii* population on Elliott Key consists of 203 individuals (**Table 6**). Of these, only 3 plants are reproductive adults (i.e., Stage 5). Between 2017 and 2021, two of the five known wild, reproductive *P. sargentii* adults on Elliott Key died. Both individuals were located at the Scorpion Bight subpopulation. Aside from this significant loss, the overall population has remained relatively stable over the past four years. Since 2007, the number of large juveniles (Stage 4) has been increasing (**Fig. 37**). Currently, nearly half of the wild population (87/203 or 42.8%) is in Stage 4. Since regular monitoring began in 2003, the number of large juveniles has increased by 444%.

Table 6. Number of wild *P. sargentii* individuals of each stage by subpopulation documented in 2021 surveys by FTBG and cooperators. Location names correspond with the map in Figure 44, above

	Stage					
	1 (seedling)	**2 (sm. juv)**	**3 (md. juv)**	**4 (lg. juv)**	**5 (adult)**	**Total**
No Name	13	41	37	35	0	**126**
Scorpion Bight	4	1	11	30	2	**48**
Predator South	0	1	4	3	1	**9**
Predator North	0	3	2	9	0	**14**
Coon Point	0	0	1	5	0	**6**
Total	**17**	**46**	**55**	**82**	**3**	**203**

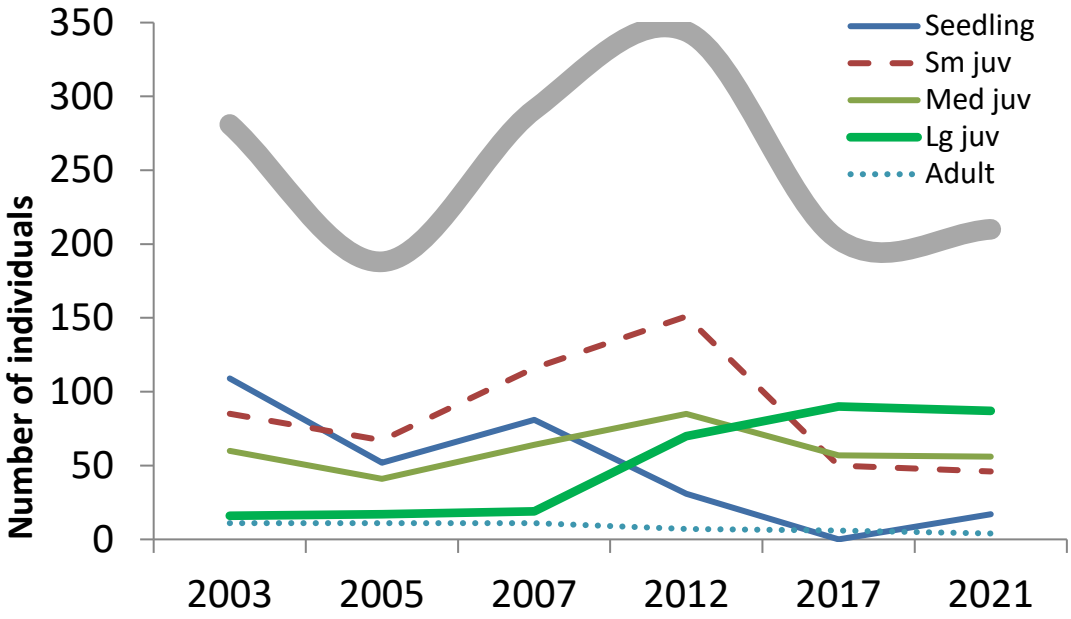


Figure 37: Total number of all *Pseudophoenix sargentii* individuals (wild + planted) on Elliott Key, grouped (gray line) and separated by size class, during censuses conducted by Fairchild Garden between 2003 and 2021.

No Name - The majority of *P. sargentii* individuals on Elliott Key (126/203 or 62%) are located in the "No Name" subpopulation, which also experienced the highest mortality between 2017 and 2021. The number of *P. sargentii* palms in Stages 4, 3, and 2 that died during this interim were 8, 7, and 9 individuals, respectively. Nearly every individual at No Name experienced some level of herbivory, apparently from small mammals, though it is difficult to determine the impacts this has on growth and survival. A number of individuals were observed to have been crushed by falling branches, which resulted in mortality at times.

Interestingly, Fairchild documented 9 new *P. sargentii* seedlings (Stage 1) at the No Name subpopulation in 2021, despite not having a reproductive adult present since 2012 when there was one adult in poor condition. This species is not thought to have a long-lived seed bank per Zona (pers comm.) in Maschinski & Duquesnel (2007), but unpublished data at Fairchild does indicate that some level of dormancy may be possible in *P. sargentii,* since one seed germination experiment carried out in soil showed that germination was higher in seeds that were stored for up to 9 months compared to fresh seeds (Garvue and Carrara, 2001) and that seeds can survive desiccation to 12% and 5% seed moisture content (unpublished data at Fairchild). However, results of these germination trials were highly variable between accessions and further research is needed to determine if seeds can indeed remain viable during long-term storage. It is also possible that seeds may germinate and remain as small, easily overlooked seedlings for years before they begin to produce larger eophylls and, eventually, pinnate leaves.

Scorpion Bight - The "Scorpion Bight" subpopulation has the greatest diversity in *P. sargentii* size classes. Whereas there were 4 reproductive adult palms in 2017, two of them have since died. One apparently died after a large oak branch fell on it; the other likely suffered a similar fate. Several other individuals were impacted by fallen branches from Hurricane Irma in 2017 (**Fig. 38**).

Two robust, reproductive adult palms still survive at Scorpion Bight, along with 30 large juveniles, 12 other juveniles (Stages 2+3), and four new seedlings. One of the adult palms (tag #4740) bore fruit in March 2020 (**Fig. 39**). This individual does appear to exhibit the same fungal pathogen that many adult *P. sargentii* contract, however, it otherwise appears to be healthy.

Figure 38: Two adult *P. sargentii* at Scorpion Bight that were impacted by fallen branches from Hurricane Irma. These branches were removed upon discovery in March, 2018.

Figure 39. Scorpion Bight *Pseudophoenix sargentii* #4740, which has been part of this monitoring study since 2000, when it was first measured as a 2.5-meter-tall juvenile palm. In January 2017, we first noted signs of reproduction, as old infructescenses were present. The cherry-like fruits and black crown shaft shown here were photographed on March 3rd, 2020. Note that in the background of the second photo, a dead adult palm is visible; this is the individual that was damaged by a falling oak branch.

Predator South - The "Predator South" population of *P. sargentii* contains the only other known wild adult *P. sargentii* on Elliott Key. This tree, which has exhibited signs of a fungal pathogen in its crown shaft for at least 5 years, was treated with fungicide by staff from Montgomery Botanical Center and BNP in 2020, but continues to slowly decline and did not show signs of having reproduced in 2020 (it was first noted as being reproductive in 2002) (**Fig. 40**). However, three large juvenile (Stave 4) *P. sargentii* persist in its immediate vicinity, with another nine large juveniles at nearby "Predator North;" these all appear to be in excellent health.

Figure 40. Adult *P. sargentii* #4750 at Predator South, exhibiting poor health with black crown rot and new leaf that appears to have died before fully forming. Photo by Eliza Gonzalez, Montgomery Botanical Center.

Predator North – This subpopulation was discovered by Fairchild staff during systematic searches in 2012. This is the third largest wild population, with 14 plants, the majority of which are robust, large juveniles.

Coon Point – This subpopulation contains both wild (N=6) and introduced (N=4) plants, all of which are in the juvenile stage. Nine plants are Stage 4 and one is Stage 3.

New finds - During surveys for additional undetected *P. sargentii*, 12 new individuals were documented: three north of No Name, eight west of No Name (now dubbed "Morgan W" in honor of Morgan Wagner for finding these plants (**Fig. 41**), and one healthy juvenile (Stage 3) palm was located east of the Coon Point subpopulation. These encouraging finds demonstrate the need for further detailed surveys throughout the island.

Outplanted population - Of the 63 *P. sargentii* that Fairchild and DEP introduced to Elliott Key in 1991-1994, only 7 (11%) have survived to 2021. While this ratio is low, it is notable that two of the outplants, both of which were planted near the Interpretive Trail, have flowered. Five more outplants will be large enough to flower in the next decade, should they survive. These soon-to-be reproductive palms are poised to substantially contribute to the next generation of *P. sargentii* on the island.

Of the two mature outplanted palms along the Interpretive Trail, only one has survived to 2021. The other plant was found to be reproductive during the 2018 reconnaissance mission after Hurricane Irma, however, the tree had been severely damaged by a fallen branch. This individual, which took roughly 30 years to reach maturity, died from the injury (**Fig. 42**).

During the January 2021 survey, the area surrounding both of the Interpretive Trail *P. sargentii* was surveyed for seedlings, but none were located.

The status of each surviving introduced palm is summarized on the next page (**Table 7**).

Figure 41. BNP Biologist Morgan Wagner with previously undocumented *P. sargentii* she discovered.

Figure 42. A *P. sargentii* outplant at the Interpretive Trail photographed after a fallen branch was removed from atop its meristem in March 2018. This individual did not recover.

Table 7: Details on the seven surviving outplanted *P. sargentii* individuals on Elliott Key as of January 2021. The total number of individuals planted in 1991-1994 was 63 palms.

		January 2021 status	
Tag #	**Subpopulation**	**Stage**	**Height (m)**
7	Interpretive trail	**5**	**4**
4314	Petrel point	**4**	**3**
1488	Coon point	**4**	**2**
1489	Coon point	**4**	**3**
1490	Coon point	**4**	**3**
1492	Coon point	**4**	**3.7**
4312	Tannehill	**3**	**1.5**

Ex situ collections at Fairchild

As of 2021, Fairchild's living collections of *Pseudophoenix sargentii* originating from Elliott Key includes 23 trees that were directly collected (as seed) from the wild and 120 seedlings that were grown from two of these trees (**Table 8**). Most wild collections were made between 1990 and 2001, though a single, small seedling was grown from a seed collected from adult #4740 at the Scorpion Bight subpopulation in 2020.

Table 8. Living collections of *Pseudophoenix sargentii* from Elliott Key at Fairchild Tropical Botanic Garden, as of May 2021, including 23 planted palms and approximately 120 potted seedlings. All material was grown from seed.

Year received	**Accession #**	**Collector**	**Origin**	**Location**	**Quantity**
1990	90404	Carol Lippincott (FTBG)	Elliott Key	Garden	1
1991	9170	Ann Deaton (DEP)	Elliott Key	Garden	1
1991	9171	Ann Deaton (DEP)	Elliott Key	Garden	1
1991	9172	Ann Deaton (DEP)	Elliott Key	Garden	1
1991	941066	Unknown	Elliott Key	Garden	1
2001	2001-0082	Dena Garvue (FTBG)	Elliott Key	Garden	4
2001	2001-0920	Dena Garvue (FTBG)	Elliott Key	Garden, Farm	14
2020	2020-0001	Brian Harding (FTBG)	FTBG 941066	Nursery	ca 40
2020	2020-0028	Brian Harding (FTBG)	FTBG 90404	Nursery	ca 80
2020	2020-0212	Vanessa McDonough (NPS)	Elliott Key	Nursery	1

Discussion

Pseudophoenix sargentii is one of the rarest and most charismatic plant species in Biscayne National Park—and in the United States, for that matter. While its status in our flora remains tenuous, the overall population on Elliott Key has remained stable in recent years with a total of approximately 200 individuals and a promising number of large juveniles, many of which will likely reach adulthood in the

next decade. Large juveniles have demonstrated high survivorship in the past (Maschinski & Duquesnel 2007), so we feel it is reasonable to be optimistic, and to expect the number of adult *P. sargentii* on Elliott Key to surpass past figures in the near future.

It is important to note that there is also a healthy reintroduced population of *P. sargentii* on Long Key. While there are no longer any wild plants left on that island, the reintroduction includes 47 palms as of February 2021 (Janice Duquesnel, pers. comm.). All plants were grown by Fairchild and partners, from seed collected from Elliott Key. Plantings occurred in 1991, 1994, and 2019. None of these palms have yet reached reproductive maturity, but like their wild counterparts on Elliott Key, they are poised to do so in the next decade. This reintroduction project is monitored annually by Florida Parks Service district biologist Janice Duquesnel, who noted that plants at "Long Key Point" are the most robust, however, this subpopulation also suffered the worst impacts from Hurricane Irma in 2017.

With this most recent population assessment, there were two threats to the future of *P. sargentii* observed on Elliott Key which could possibly be mitigated. The first of these was herbivory. Many of the seedlings that were documented as having "herbivory" or "heavy herbivory" in 2017 did not survive to 2021. During this most recent survey, there were several dozen plants noted with herbivory, especially those at No Name and Predator. Sometimes, an entire frond of a palm that only had 2-3 fronds to begin with was completely removed, leaving only a chewed-off petiole. It is not known what type of animal was causing the damage. One possibility is that red-bellied squirrels are removing leaves for use in nest building (Tilmant 1980, as cited in Koprowski et al. 2005). However, nothing that appeared to be a squirrel nest was observed in the vicinity of *P. sargentii* during these surveys. FSP biologist Janice Duquesnel stated that herbivory became an issue with reintroduced palms in 1991, shortly after the first plants were installed. As a result, staff caged all but the largest outplants. All cages were removed once palms reached a height of five feet. Duquesnel further noted that she observed a hermit crab climbing a cage in order to access and feed upon a frond.

The second threat to *P. sargentii* observed which could potentially be mitigated was that of falling trees and branches. From 2012 to 2017 and again between 2017 and 2021, healthy large *P. sargentii* were observed at one monitoring period, only to be found dead at the next monitoring period with a fallen tree or branch that had damaged the palm's apical meristem. Recommendations to mitigate these threats and other potential threats are included in the next section of this report.

Fairchild Tropical Botanic Garden's conservation staff hopes to continue to work with Biscayne National Park to monitor this important rare Florida native plant population in perpetuity. As part of that partnership, we have some recommended practices for BNP to continue to safeguard and grow the *P. sargentii* population. Fairchild conservation staff can cooperate with BNP staff to implement any or all of these activities.

Recommendations for conservation of *P. sargentii* on Elliott Key, BNP

- Monitor the 4 known adult reproductive *P. sargentii* at least once per year. Look for signs of reproduction, advancing crown rot disease, or potential damage from adjacent trees that can be mitigated.
- Conduct a complete population census at least every 4 years.
- Survey potential habitat for undetected *P. sargentii* on a regular basis (at least every 4 years).
- Consider installing one or more game cameras at the No Name subpopulation (where the worst herbivory was observed) to determine what animals are causing damage.

- Consider protecting a subset of seedlings from herbivory in mesh cages. If future monitoring suggests that the cages promote survival and growth, then cage additional seedlings.
- Consider augmenting small subpopulations, especially the introduced subpopulations at Petrel Point, the Interpretive Trail, and Tannehill.
- Restrict collecting of fruits. Do not permit an entire fruiting stalk to be cut down or otherwise damaged. Limit seed collection to <10% of annual wild crop, per guidelines from the Center for Plant Conservation.
- Consider trimming trees that are adjacent to adult palms and large (trunked) juveniles, especially if there are large branches that could fall and damage the apical meristem of the palms. If resources are limited, start with the four adult *P. sargentii* and expand trimming efforts to other trees in subsequent years. It should be noted that trimming adjacent vegetation will also likely promote healthy growth and flowering of *P. sargentii* trees. Lippincott (1995) noted that ". . . *Hurricane Andrew severed 19 of the 47 palms on Elliott Key. However, the surviving Sargent's cherry palms are thriving in the open, sunlit hammock."*
- In the event of a tropical storm or hurricane affecting Elliott Key, conduct rapid assessments as soon as it is safe to do so, focusing on adult trees first. Remove fallen trees or large branches if they landed on top of *P. sargentii.*
- Consider borrowing or purchasing a submeter GPS unit to re-map populations to aid future monitoring efforts.

Tephrosia angustissima Shuttlew. Ex Chapm. var. *corallicola* (Small) Isley

Tephrosia angustissima var. *corallicola* is a trailing vine in the Fabaceae family, with light-green, odd-pinnate, pubescent leaves, small pink pea flowers, and small, several-seeded, dehiscent pods. The only known wild population of *Tephrosia angustissima* var. *corallicola* (hereafter, *Tephrosia*) in Miami-Dade County grows in a mowed lawn at the USDA Chapman Field station. Herbarium records indicate that the species formerly occurred in Miami-Dade pine rocklands. Another population was discovered by botanist Jimi Sadle within the past decade, on a shell midden in Everglades National Park. To reduce the extinction risk of *Tephrosia*, Fairchild and cooperators conducted experimental introductions of *Tephrosia* to the Ludlam EEL Preserve in 2003 and 2013, and to the Deering Estate in 2020. These Miami-Dade County Preserves are the two protected natural areas that are geographically nearest to the source population at Chapman field.

Update on 2003 introduction of 141 plants to Ludlam Preserve

We assessed the status of *Tephrosia* at Ludlam EEL Preserve in the fall 2020 and determined that there were 44 plants present throughout the preserve, in all different life stages, resulting from Fairchild's 2003 introduction efforts. Each separate introduction event is explained in further detail, below.

In 2003, Fairchild planted 141 *Tephrosia* at Ludlam EEL Preserve. Plants in gallon pots that were grown from seed collected at Chapman Field were installed into 3 different habitats. Fifty-seven plants each were placed in pine rockland with pine overstory, pine rockland lacking pine overstory, and along the road edge. Plants along the road edge reproduced more and survived longer. All outplants are now dead but monitoring in fall 2020 showed that there are 8 recruits still present along the preserve's south firebreak. Interestingly, all the recruits are located on or directly adjacent to the fire break that is regularly mowed; this fire break also represents the highest soil moisture values of the transplanting microsites.

Another introduction was conducted at Ludlam by Fairchild's Jack Fisher in 2003. He introduced smaller plants (pint- or quart-sized) to a disturbed grassy area near the south edge of the western unit. Unfortunately, we do not know how many plants were initially installed, but it was likely no more than 50. This reintroduction fared much better over time and in fall 2020 we located a total of 31 individuals, of all age classes.

Update on 2013 introduction of 800 seeds to Ludlam Preserve

In July 2013, Fairchild conducted another augmentation of *Tephrosia* at Ludlam EEL Preserve; this time, seeds were used instead of whole plants. The objectives were to (1) augment the 2003 experimental outplanting and (2) continue efforts to identify optimal habitat conditions for different life stages of the species. We sowed seeds into areas of the preserve that were unoccupied by *Tephrosia*. We installed 80 randomly placed seed plots of 10 seeds each (800 seeds). For further details about methodology and environmental variables we tracked, see Maschinski et al. (2014). On August 6, 2020 we monitored this seed augmentation. Although more than 80 *Tephrosia* resulted from this effort early-on, currently only 5 plants remain. In the eastern unit of the preserve, only a single plant remains in a grassy, partially shaded area. In the west unit, only a single plot still has *Tephrosia*, but there were 4 individuals.

Update on 2020 introduction of 1820 seeds to Deering Estate

In September 2020 we implemented an experimental seed introduction of *Tephrosia* to the Deering Estate. We introduced 1820 seeds in groups of 20 into 91 plots. We used circular 50 cm-diameter plots (**Fig. 57**) in four different habitats: pine rockland edge1 (the line where mowing stops), pine rockland edge2 (1m away from the edge), the center of the fire break, and weedy fence edge. Fifty-two of the plots received seeds that were previously frozen while 39 plots received fresh seed. In the firebreak, we installed 10 small plots with 10 fresh seeds each. These were protected from herbivory and serve as indicators for germination (i.e., germination will be much easier to see in these plots).

We monitored the introduction bi-weekly for the first two months then every other month through the first six months. Seed germination started within two weeks of sowing (**Figs. 43, 44**), with a significant difference in germination rates of fresh vs. frozen seed (**Fig. 45**). The highest germination was at the two pine rockland edges with frozen seeds. Seedling mortality was high over the dry season in spring 2021 (**Fig. 45**); future seed introductions should be done earlier in the wet season so that seedlings have more time to grow before the dry season starts. Seed germination was fairly nonexistent through the winter and spring, but once the 2021 rainy season began, additional seeds germinated. As of June 2021, there are 156 seedlings resulting from this introduction.

Figure 43. Left: adding seeds within the 50-cm diameter circular plot. **Right**: A young *Tephrosia* seedling, next to a plastic toothpick used to mark each germinant.

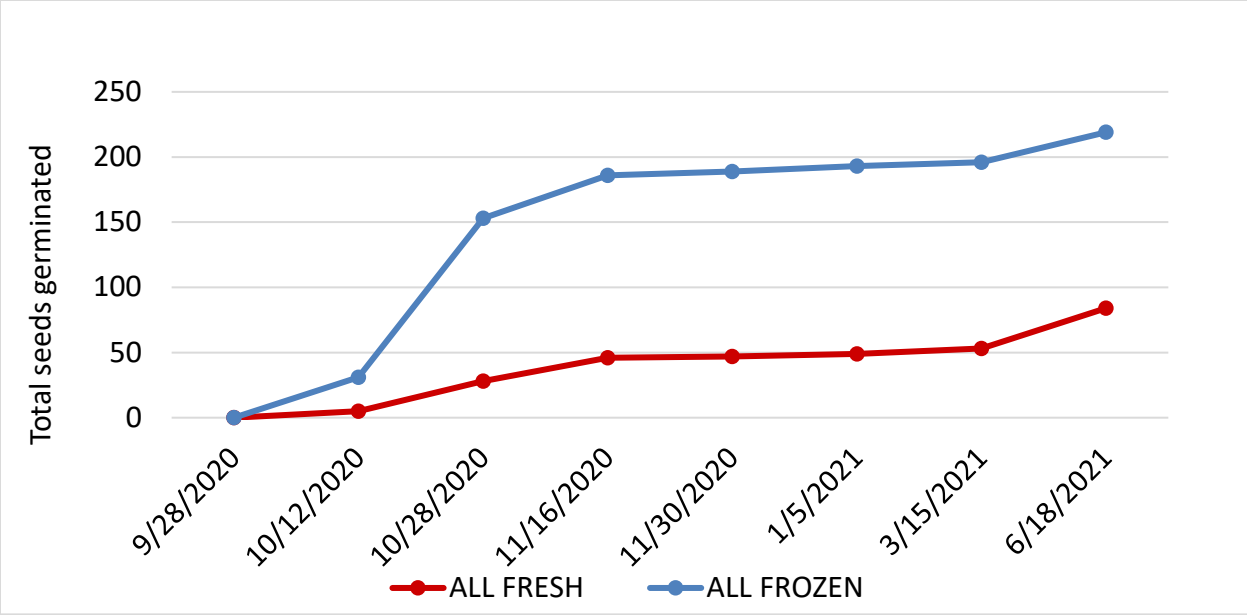


Figure 44. Total number of *Tephrosia* seed germinated since sowing at the Deering Estate.

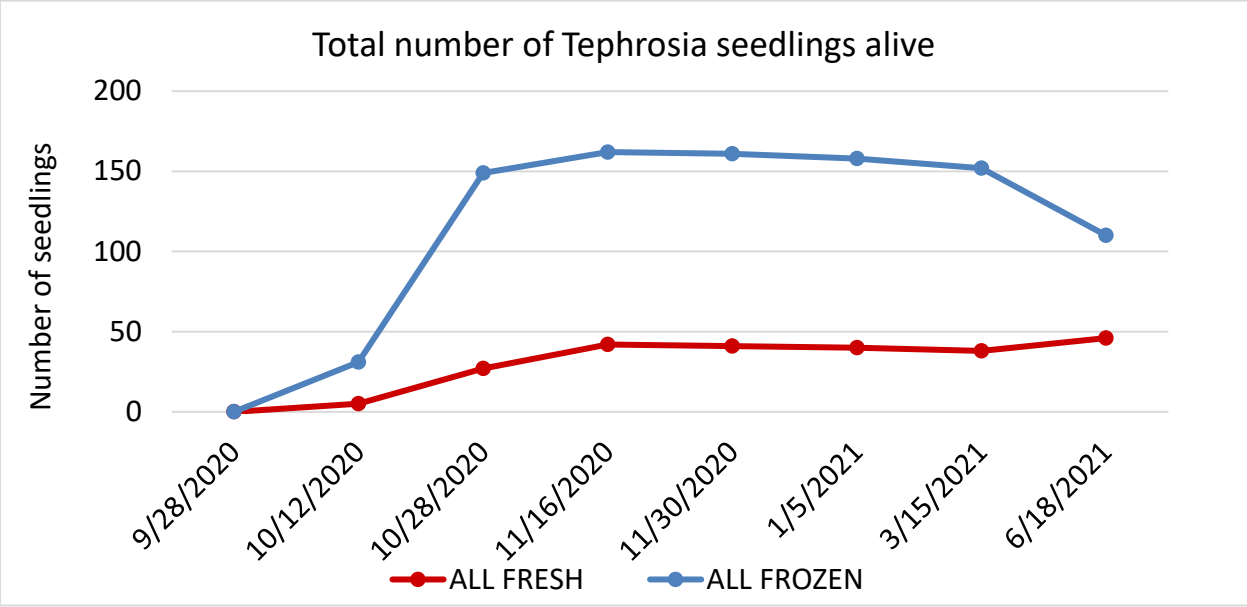


Figure 45. Total number of *Tephrosia* seedlings alive at each monitoring event, since sowing at the Deering Estate.

Zanthoxylum coriaceum A.Rich.

Zanthoxylum coriaceum (Biscayne prickly ash) is a state endangered small- to medium-sized tree. In addition to Florida, it is also native to The Bahamas, Cayman Island, Cuba, and Hispaniola (Dominican Republic and Haiti) (Acevedo and Strong, 2007). In Florida, its primary habitats are coastal strand and maritime hardwood hammock, both of which are vulnerable to urbanization - a past and present major threat (Gann et al. 2002). Due to habitat fragmentation and development along South Florida's coast, suitable coastal hammock habitat for *Z. coriaceum* is extremely limited. Of the trees left in the wild (3 populations), 99% occur at two sites within one mile of each other. The close proximity of the two populations leaves *Z. coriaceum* vulnerable to possible extirpation from one large stochastic event, such as a hurricane or large storm. Fairchild recognizes the need to increase the total numbers of populations and individuals in the wild through outplantings.

We did not conduct a thorough survey of any *Z. coriaceum* populations during this grant cycle, however, we did map some previously unmapped individuals at Crandon Park when we were there for *J. reclinata* work. We also noted seedling recruitment underneath some adult (female) plants.

Update on seed biology

Fairchild's seed bank does not contain any *Z. coriaceum*, and we have not developed seed-storage or seed-propagation protocols for this species. Seeds are difficult to obtain because the plant is so rare in the wild, dioecious, and not usually cultivated. We were unable to obtain wild *Z. coriaceum* seeds to conduct this research, but thankfully Connect to Protect Network member Billy Shores provided all the seeds we needed for trials. We placed organza drawstring bags over developing fruit clusters on trees in his yard and retrieved them several weeks later once the seeds were mature; this resulted in ~1700 seeds.

We conducted germination trials using several different treatments with the goal to break seed dormancy. The treatments were chosen because they had been shown to be successful in other species of the genus Zanthoxylum. We used 100 seeds per treatment divided into 4 replicates with 25 seeds each. This germination trial set was set up in Fairchild's propagation house. Seed pre-treatments were as follows:

- **Control**: no pre-treatment
- **Water: seeds were soaked in water for 24h**
- **Soap**: seeds were soaked in soapy water (300ml water + 1tsp soap) for 30 minutes, rinsed for 15 min and then soaked in water for 24h
- **Soap + GA**: seeds were soaked in soapy water for 30 minutes, rinsed for 15 minutes and then soaked in water with 300 mg/l gibberellic acid for 24h
- **Soap + H2SO4**: seeds were soaked in soapy water for 30 minutes, rinsed for 15 minutes and then soaked in water with 5% (v/v) sulfuric acid for 24h

The germination rate did not exceed 20% with any treatment (**Fig. 46**). Lowest germination was reached in the control and water-only treatments; the difference between treatments was small. The treatment with sulfuric acid was slightly better than all other treatments and these seeds also germinated slightly faster.

One problem with these treatments was that the seeds were only soaked in gibberellic acid for 24h and after that the gibberellic acid was washed away due to watering of the pots in the propagation house. For future treatments, we would sow seeds on a petri dish containing 1% agar infused with gibberellic acid to prolong the exposure. Seedlings resulting from germination trials with *Z. coriaceum* are cared for in our nursery. Currently, we have several small seedlings (from cultivated plants) that could be used for future reintroduction projects.

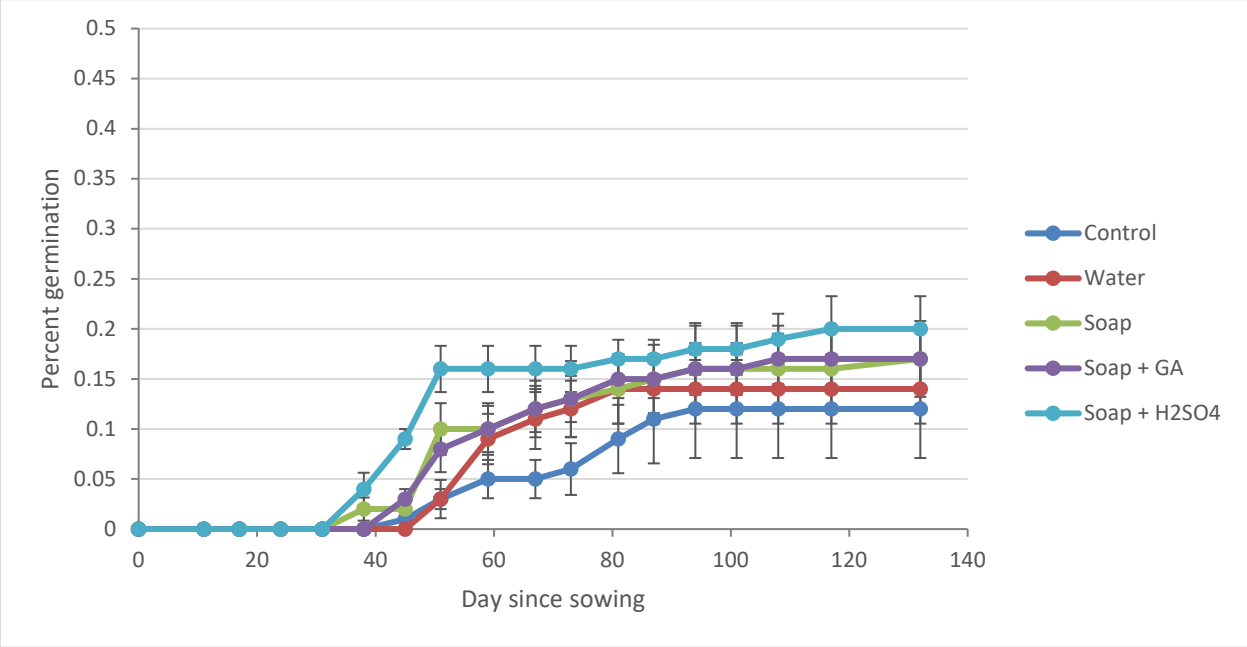


Figure 46: Results of seed germination trials with *Zanthoxylum coriaceum.*

*Other ferns**

(Not required by contract)

Florida is a native fern diversity hotspot within the continental U.S., with more than 120 native species, many of which are listed as endangered or threatened by the state of Florida. Due to the high numbers of rare native ferns, our plant conservation program has a strong fern focus. In this section, we briefly report on work with other rare native fern species which were not part of our FDACS agreement during the 2020-2021 grant period.

We maintain a healthy ex situ collection of several rare fern species from wild sources in Florida, including *Acrostichum aureum*, *Adiantum melanoleucum, Anemia adiantifolia, Anemia wrightii, Asplenium dentatum, Asplenium erosum, Asplenium verecundum, Asplenium x biscaynianum, Campyloneurum angustifolium, Ctenitis sloanei, Ctenitis submarginalis, Dennstaedtia bipinnata, Lomariopsis kunzeana, Microgramma heterophylla, Sphenomeris clavata, Tectaria fimbriata, T. heracleifolia, Thelypteris grandis, T. patens, T. reptans, T. reticulata, T. sancta*, T. *sclerophylla*, and *T. serrata*. These plants are used in reintroductions, displays at Fairchild, and in lectures/demonstrations. We also frequently donate ferns and/or spores to partner organizations. During this grant cycle, we worked closely with Professor Theresa Chormanski at Miami-Dade College, who is starting a fern horticulture program with her students. We provide spores for research projects and for cultivation, with the ultimate goal of making native ferns available for purchase for South Florida home landscapes. We also periodically provide native ferns for Fairchild plant sales; they always sell out. The following is a brief report on rare native fern species that we worked with in this past grant year, but which were not required elements of our grant proposal.

Adiantum melanoleucum
& Thelypteris sclerophylla

- For the past two years, with the help of subcontractor Nathan Osborne, we have been striving to introduce *A. melanoleucum* and *T. sclerophylla* into the Miami-Dade Environmentally Endangered Lands preserve, Silver Palm Hammock. A previous introduction of 102 ferns to this site in 2015 and 2016 failed due to a combination of rotting (we mistakenly chose microsites with high soil moisture), and repeated excavation by raccoons. With this new effort, 48 ferns were planted in 2020 and 2021, and 28 survive to date. Survival was 10/24 for *A. tenerum* and 18/24 for *T. sclerophylla.* Eleven of the ferns were installed inside an exclosure made of lumber and chickenwire, designed to keep raccoons away. Survival inside the exclosure is 10/11 plants (91%) vs. 18/37 (49%) outside of the exclosure.

Anemia wrightii

- We made two trips to Lucille EEL Preserve in January and June 2021 to collect spores of *A. wrightii*. We retrieved spores on both trips, and were especially successful on the latter date. We sowed spores into germination boxes after both visits; we had germination and gametophytes are not present. We sent the majority of spores from the second visit to the National Laboratory for Genetic Resources Preservation for cryogenic banking, as part of a new, donor-funded Florida biobanking project that is being led by the Center for Plant Conservation.

Asplenium erosum
& Asplenium abscissum

- We have received spores from both species from Colleen Werner, DEP biologist with Withlacoochee State Park. Spores of *A. erosum* received in 2018 germinated, produced sporophytes, and we now have approximately a dozen small plants in our nursery that should be ready for reintroduction in summer 2022. Spores of *A. abscissum* were received recently; we have not yet observed any germination.

Thelypteris patens

- In December 2020, we monitored plants at the Deering Estate which Fairchild introduced in 2014. Of the 211 plants introduced, 66 survive (33%). Mortality has been low in this planting for the past two years. Most of the surviving plants are extremely robust and fertile. At least 3 new plants have recruited in the Deering Estate's Pipeline Trail.

OBJECTIVE 3

Continue to expand the Connect to Protect Network

THE CONNECT TO PROTECT NETWORK

For more than 13 years, Fairchild's Connect to Protect Network (CTPN) has inspired South Florida residents to plant native pine rockland plants in order to connect the few remaining isolated fragments of globally imperiled pine rockland. Installing native pine rockland plants in Miami's urban areas increases the probability that bees, butterflies, and birds can find and transport seeds and pollen across developed areas that separate pine rockland fragments, improving gene flow and genetic health of native plant species. During the 2020-2021 grant year, CTPN continued to grow. Despite the COVID-19 pandemic, we engaged members via social media and our newsletter, and we continued to distribute free pine rockland plants to our members via socially-distant, scheduled events. Happily, we were able to resume in-person events in summer 2021.

Membership update

As of June 2021, more than 1500 individuals have enlisted in the Connect to Protect Network, either for their home or as contacts for a school or other organization. In the past 12 months, membership has increased by 289 homeowners, 9 schools and 3 other organizations. Considering members who left the Network, our total numbers as of June 2021 are as follows:

- 1129 homeowners
- 135 schools
- 34 other organizations
- 49 email-only members

We continue to utilize social media and other means to recruit new CTPN members and to spread the word about the program and about native plants in general. Our website (www.fairchildgarden.org/CTPN) continues to serve as a one-stop-shop for information on pine rockland plants as they relate to the Network. Each summer, we update our membership map (**Fig. 47**), which is available on the website.

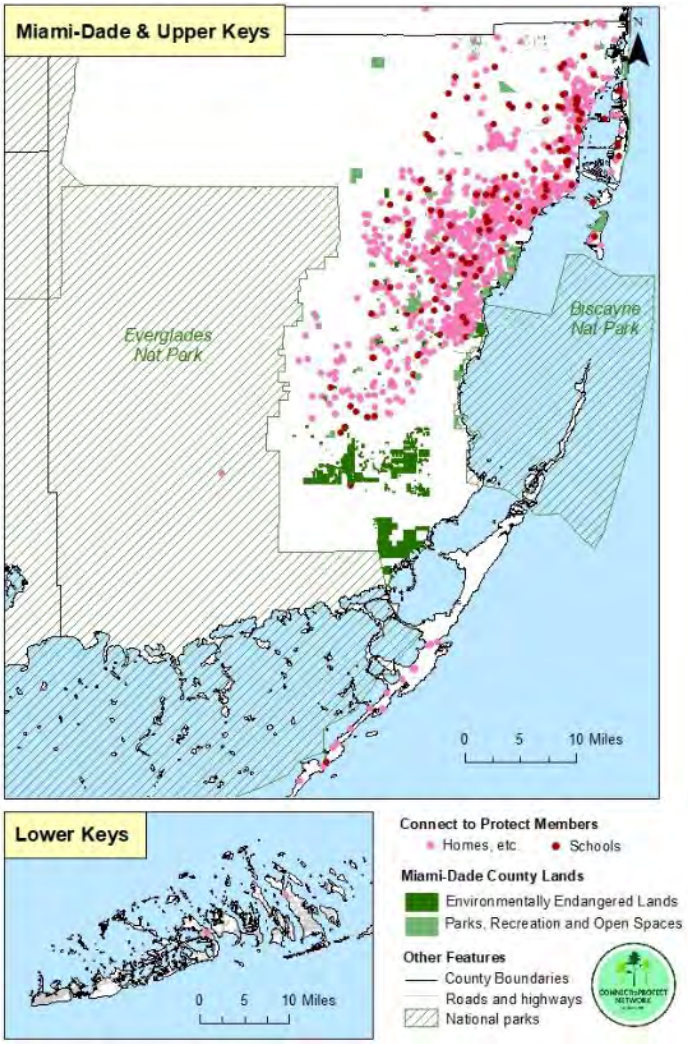


Figure 47. Connect to Protect Network Membership as of June 2021.

Plant distributions

During this 2020-2021 grant cycle, we donated more than 2500 plants of more than 30 different pine rockland taxa to Miami homeowners, schools, and organizations, as part of the Connect to Protect Network. As previously reported (Possley et al. 2020), we followed new protocols we developed for the covid-19 pandemic. Masks were required and strict social distancing was enforced. We developed a new online pre-ordering system whereby Fairchild staff and volunteers could set aside plants ahead of time for rapid pickup. Members were scheduled to ensure no more than two were present in the planting area at any one time. Our annual fall plant giveaway to existing members was reinvented as a drive-through event (**Fig. 48**).

Figure 48. Volunteer Richard Warren working at the "Bonus Kit" drive-through plant Distribution day for existing CTPN members in September 2020. Photo by Brian Harding.

Field Trips

In June 2021, we had our first CTPN field trip in almost two years, with an evening tour to Trinity Pineland, one of Miami-Dade County's Environmentally Endangered Lands (EEL) preserves. Fourteen CTPN members explored the pine rockland with trip leader and EEL biologist Joy Klein (**Fig. 49**). Additional trips are planned—one per month—for the remainder of summer 2021.

Figure 49. Joy Klein talks to field trip visitors at Trinity Pineland EEL Preserve. Photo by Leslie McConachie.

Garden Projects

CTPN Manager Daniela Champney personally works with schools, churches, and other organizations who ask for help installing pine rockland gardens. During this recent grant cycle, she consulted on more than a dozen gardens, helping to connect people with the plants and resources they need. School teachers often say thanks by sending photos of students with the finished garden (**Fig. 50**). One of our more highly visible projects, spearheaded by CTPN member Adam Skowronski, was a planting along a busy roadway in Cutler Bay (**Fig. 51**).

Figure 50. Students at Jesse J McCrary Jr. Elementary School with their new CTPN garden. Photo by Bianca Mijares.

Figure 51. Just one of several dozen native plant installations that CTPN manager Daniela Champney helped bring to fruition; this one is at the entrance to a housing community called "Cutler Creek West," in Miami's Cutler Bay area. Pine rockland plants including muhly grass, saw palmetto, coontie, locustberry and more replaced what was previously turfgrass and weeds. Photo from April 2021.

OBJECTIVE 4

Promote conservation of Florida rare species through displays and public outreach.

RECENT PUBLICATIONS, PRESENTATIONS, AND WORKSHOPS BY FAIRCHILD CONSERVATION STAFF

Newsletters

- We wrote and emailed 11 newsletters to Connect to Protect Network members.

Peer-Reviewed Publications

- Angelo, C.L., D.J. Rosen, and **J.J. Lange**. 2020. *Eleocharis mutata* (Cyperaceae), new to Florida. JBRIT. 14(2):405-410
- Figueroa, A**., J.J. Lange**, S.M. Whitfield. 2021. Seed consumption by gopher tortoises (*Gopherus polyphemus*) in the globally imperiled pine rockland ecosystem of southern Florida, USA. Jour. Chel. Cons. 20(1):27-34.
- **Lange, J.** and C. Angelo. 2020. *Goniopteris moranii* (syn.: *Thelypteris guadalupensis;* Thelypteridaceae), New to Florida and the Continental United States. Am. Fern. Jour. 110 (2): 75-78.
- Noblick, L**., S. Wintergerst**, D. Noblick, J. T. Lima. 2020. *Syagrus coronata* (Arecaceae) phenology and the impact of fire on survival and reproduction of the licuri palm. *SITIENTIBUS série Ciências Biológicas*, *20*. doi: 10.13102/scb4908
- **Possley, J**., J. Duncan, J. Gil and C. Grossenbacher. 2020. Too precious to lose: managing and protecting the Richmond pine rockland tract in Miami-Dade County, South Florida. Cities and the Environment 13(1).

Manuscripts prepared or submitted for peer-review

- **Lange**, J.J., K. Bradley, and J. Sadle. New and Noteworthy Collections for the Flora of Florida. Castanea. In prep.
- **Possley**, J., J. Duquesnel and V. McDonough. 30 years of conserving Sargent's cherry palm (*Pseudophoenix sargentii*) in the Florida Keys. Submitted to PALMS, 6/30/2021.

Presentations

1. **Cuni, L.** Conservation Actions for Five South Florida Endemic Plants: The "Fab 5" Project – Virtual presentation to DCFNPS, 9/22/2020.
2. **Cuni, L.** Vegetation monitoring in the Deering Estate Flow-way. Deering Estate Research Symposium. 2/2/21.
3. **Cuni, L.** Partnering to Safeguard South Florida's Most Vulnerable Plant Species Through Strategic In situ and Ex situ Conservation Measures. FIU Plant Talk. 2/10/21.
4. **Cuni, L**. Seed and plant translocation of federally endangered endemic annual Carter's flax, Linum carteri, into a restored rockland. Presentation at Plant Biologists of South Florida meeting. 4/3/21.
5. **Lange, J**. Keeping an Open Mind to Beach Clustervine. A short presentation for the IRC-organized stakeholder workshop "Seagrapes and Biodiversity", highlighting conservation challenges to rare plants facing woody encroachment in the coastal strand. 12/02/2020.
6. **Possley, J. L. Cuni and S. Wintergerst.** Annual meeting with Miami-Dade County Preserve Managers. Virtual presentation and discussion on 7/17/2020.
7. **Possley, J.** About Fairchild's Connect to Protect Network. Short virtual presentations to teachers participating in the Fairchild Challenge, on five dates in late 2020.
8. **Possley, J.** About Fairchild's Connect to Protect Network. Virtual presentation as part of a webinar on gardening for the Miami organization Debris Free Oceans, 8/27/2020.
9. **Possley, J., S. Wintergerst, B. Harding, J. Lange and L. Cuni.** Key Tree Cactus stakeholder virtual summit, 9/8/2020.
10. **Possley, J**. Fairchild's work in Miami-Dade County's pine rockland preserves. PRWG conference, 10/19/2020.
11. **Possley, J**. All about Fairchild's Conservation program. Virtual presentation to DCFNPS, 11/24/2020.
12. **Possley, J.** Ferns of Seminole County. Monthly meeting of the Florida Native Plant Society, Cuplet Chapter. 1/11/21.

13. **Possley, J.** Update from the Rare Species Subteam of the Pine Rockland Business Plan. 10/30/20.
14. **Possley, J.** Ferns of Seminole County. Monthly meeting of the Florida Native Plant Society, Cuplet Chapter. 1/11/21.
15. **Possley, J**. Ferns of the Florida Keys. Workshop for the Florida Keys Native Plant Workshop. 1/19/21.
16. **Possley, J.** Fairchild's long-term plant monitoring projects at the Deering Estate. Deering Estate Research Symposium. 2/2/21.
17. **Possley, J**. Sargent's cherry palm (*Pseudophoenix sargentii*) in Biscayne National Park. Brown bag lecture series for Biscayne National Park staff and volunteers. 4/12/21.
18. **Possley, J.** South Florida native plants. Keynote presentation at the virtual opening for the "Fruition" watercolor exhibit, Biscayne National Park, 4/18/21.
19. **Possley, J**. Fairchild's Connect to Protect Network. Taller para jovenes: Cambio climatico y la Perdida de diversidad biologica en el Peru. 4/19/21.
20. **Possley, J.** Sargent's cherry palm (*Pseudophoenix sargentii*) in Biscayne National Park. Virtual Florida Rare Plant Task Force 4/24/21.
21. **Possley, J**. Spore stories: Fairchild's rare fern conservation program. Annual meeting of the Center for Plant Conservation. 5/3/21.
22. **Wintergerst, S.** and **B. Harding**. Pine Rockland Working Group. Virtual Field trip to Fairchild's seed lab and nursery, 10/26/2020
23. **Wintergerst, S.** and **L. Cuni**. Optimizing cultivation and increasing the availability of 4 locally rare Asclepias species, an important wildlife-supporting plant. Presentation at the Florida Native Plant Society 40th annual conference. 4/16/21.

OTHER OUTREACH AND EDUCATION

Mentoring

- Jennifer mentored BioTECH@Richmond High student Daniella Lira, using iNaturalist to document biodiversity in Van Smith Park, a small neighborhood park.
- Jimmy mentored FAU college student Nicole Lakman for a research project on germination rates of *Jacquemontia reclinata*
- Brian mentored horticulture interns and Miami-Dade College students Clyde de Quesada and David Fundora, University of Florida graduate Isaac Ballesteros, and The Underline horticultural intern Graciela Martin.
- Sabine and Brian Sidoti mentored students from BioTech @Richmond High with their research on Guzmania monostachia seed germination and seedling establishment.

Field Trips

- **Cuni, L.** Dade Chapter FNPS field trip to Rockdale Preserve, 9/20/2020.
- **Cuni, L.** Field trip to Martinez Preserve with Miami Blue Chapter of North American Butterfly Association, November 2020.
- **Harding, B**. Behind-the-scenes field trip to Fairchild's nursery. Part of Dade Chapter of the Florida Native Plant Society's "Native Plant Field Days." 3/28/21.
- **Lange, J**. Field trip to Ned Glenn Preserve. Part of Dade Chapter of the Florida Native Plant Society's "Native Plant Field Days." 3/27/21.
- **Possley, J**. and J. Klein. Connect to Protect Network member field trip to Trinity Pine Rockland EEL Preserve. 6/25/21.

Workshops & Classes

- **Cuni, L.** Introduction to pine rocklands. A virtual class through Fairchild's education department, 8/12/2020.
- **Lange, J**. Grasses of the Florida Keys. A two-part grass identification workshop for the Florida Keys Native Plant Workshop. 10/20/2020 and 11/17/20.
- **Possley, J.** Save the planet with your yard: A virtual gardening class. A virtual class through Fairchild's education department, 9/12/2020.
- **Possley, J.** Ferns of the Florida Keys. Monthly meeting of the Florida Keys Native Plant Workshop. 1/19/21.
- **Possley, J.** The art and science of growing ferns. Classes at Fairchild. 6/19/21.

Websites

We maintained up-to-date content on two pages hosted by Fairchild. One page features the work of the South Florida Conservation Team; the other is about the Connect to Protect Network.

- www.fairchildgarden.org/ConservationTeam
- www.fairchildgarden.org/CTPN

We started a YouTube Channel to showcase our work:

- https://www.youtube.com/channel/UCqMjojcgZv6ai7TUymhDx-w

Social media

We used social media (Facebook, Twitter, and Instagram) to promote Connect to Protect and rare Florida native plants at least once a month.

LITERATURE CITED

Adams, R.M. and A.N. Lima. 1994. The natural history of the Florida Keys tree cactus, *Pilosocereus robinii*. Unpublished report on file at Fairchild Tropical Botanic Garden.

Benedict, L., Glazer, B., Traxler, S., Bergh, C. Stys, B., Evans, J. 2018. Florida Keys Case Study on Incorporating Climate Change Considerations into Conservation Planning and Actions for Threatened and Endangered Species. A Project Report for USFWS Cooperative Agreement F16AC01213. 152 p.

Fotinos, T. 2013. Genetic Structure of the Florida Key Tree Cactus, *Pilosocereus robinii*, Using Restriction Site Associated DNA (RAD) Markers. Masters Thesis, Florida International University. https://digitalcommons.fiu.edu/cgi/viewcontent.cgi?article=2036&context=etd

Fotinos, T.D., S. Namoff, C. Lewis, J. Maschinski, M.P. Griffith, and E.J.B. von Wettberg, 2015. Genetic evaluation of a reintroduction of Sargent's cherry palm, *Pseudophoenix sargentii*. Journal of the Torrey Botanical Society 142(1):51-62. https://www.jstor.org/stable/43287086.

Franck, A., D. Barrios, K.E St. E. Campbell**,** J. Lange, Z. Rigerszki, J. Haakonsson, G. Gann, W. Cinea, N.M. Howe, J. St. John, S. Moreno, and C.C. Clark. Accepted. Revision of *Pilosocereus* (Cactaceae) in the Caribbean and Northern Andes. Phytotaxa 411(3):129-182.

Gann, G.D., K.A. Bradley, and S.W. Woodmansee. 2002. Rare Plants of South Florida: Their History, Conservation, and Restoration. The Institute for Regional Conservation, Miami, Florida.

Gann GD, Stocking CG and Collaborators. 2001-2021. Floristic Inventory of South Florida Database Online. The Institute for Regional Conservation. Delray Beach, Florida.
URL: http://regionalconservation.org/ircs/database/database.asp.

Garvue, D. and S. Carrara. 2001. Seed storage and germination research at Fairchild Tropical Garden. Final Report IMLS Grant IC-90218-99, Washington, DC.

Goodman, J., J. Maschinski, P. Hughes, J. McAuliffe, J. Roncal, D. Powell, and L. O'reilly Sternberg. 2012. Differential Response to Soil Salinity in Endangered Key Tree Cactus: Implications for Survival in a Changing Climate. PLOS One 7(3). https://doi.org/10.1371/journal.pone.0032528

Geiger, J. 2002. The reproductive biology of *Ruellia succulenta* (Acanthaceae) and the effects of habitat fragmentation. Master of Science. Florida International University, Miami.

Geiger, J. H. (2007). Conservation implications of the reproductive biology of the endangered vine *Ipomoea microdactyla* Griseb.(Convolvulaceae). Doctoral dissertation, Florida International University.

Koprowski, J.L., G.G. Kellison and S. Moneysmith. 2005. Status of red-bellied squirrels (*Sciurus aureogaster*) introduced to Elliott Key, Florida. Florida Field Naturalist 33(4):128-129.

Lange, J., J. Possley, and B. Harding. 2018. Conservation of South Florida Endangered and Threatened Flora: 2017-2018 Program at Fairchild Tropical Botanic Garden. Final report under Contract #024442, Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, FL.

Lange, J., J. Possley, L. Cuni, S. Wintergerst and B. Harding. 2019. Conservation of South Florida Endangered and Threatened Flora: 2018-2019 program at Fairchild Tropical Botanic Garden. Final report for Contract #025243, Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, FL.

Lippincott, C. 1995. Reintroduction of *Pseudophoenix sargentii* in the Florida Keys. Principes 39:5-13.

Maschinski, J. and J. Duquesnel. 2007. Successful reintroductions of the endangered long-lived Sargent's cherry palm, *Pseudophoenix sargentii*, in the Florida Keys. Biological Conservation 134:122-129.

Maschinski, J., J.L. Goodman, and D. Powell. 2009. Assessment of Population Status and Causes of Decline for *Pilosocereus robinii* (Lem.) Byles & G.D. Rowley in the Florida Keys. Final Report to U.S. Fish and Wildlife Service, South Florida Ecological Services Office, Vero Beach, FL.

Maschinski, J., S. Hodges and D. Powell. 2014. USFWS grant final report (Agreement No. F13AP00167) Research and recovery efforts for the endangered Key Tree Cactus (*Pilosocereus robinii*).

NatureServe. 2021. NatureServe Explorer [web application]. NatureServe, Arlington, Virginia. Available https://explorer.natureserve.org/. (Accessed: July 2, 2021).

Possley, J., L. Cuni, S. Wintergerst, J. Lange and B. Harding. 2020. Conservation of South Florida Endangered and Threatened Flora: 2019-2020 program at Fairchild Tropical Botanic Garden. Final report for Contract #026286, Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, FL.

Roncal, J., J. Maschinski, B. Schaffer, S. M. Gutierrez, and D. Walters. 2012. Testing Appropriate Habitat Outside of Historic Range: The Case of *Amorpha herbacea* var. *crenulata* (Fabaceae). Journal for Nature Conservation 20:109-116.

Salazar, A., J. Maschinski and D. Powell. 2013. Ex situ seed conservation of endangered key tree cactus (*Pilosocereus robinii*). Biodiversity & Endangered Species 1(3).

Tilmant, J.T. 1980. Investigations of rodent damage to the thatch palms Thrinax morrisii and Thrinax radiata on Elliott Key, Biscayne National Park, Florida. South Florida Research Center, Everglades National Park.

USFWS. 1984. Final rule to determine *Cereus robinii* (Key tree-cactus) to be an endangered species. Federal Register 49(140):29234.

Wendelberger, K.S. and J. Maschinski. 2008. Linking Geographical Information Systems and observational and experimental studies to determine optimal seedling microsites of an endangered plant in a subtropical urban fire-adapted system. Restoration Ecology 17: 845-853

Wunderlin, R. P., B. F. Hansen, A. R. Franck, and F. B. Essig. 2021. Atlas of Florida Plants (http://florida.plantatlas.usf.edu/). [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.

APPENDIX I: EX SITU COLLECTIONS

Fairchild maintains ex situ collections to safeguard species from extinction, to provide plants for reintroduction or augmentation, and for use in studies of rare species' biology. Our ex situ collection is comprised of both plants and seeds, which we collect with permission from landowners, county, state and federal governments. Below is a summary of Fairchild's plant (**Table A1**) and seed (**Table A2**) ex situ collections as of July 1, 2021.

Table A1: All Florida listed species in ex situ conservation (plants only)

Listed Taxon	FL Rank	Whole Plants	
		Nursery	Garden
Alvaradoa amorphoides	E	X	X
Amorpha herbacea var. *crenulata*	E	X	X
Anemia wrightii	E	X	
Argythamnia blodgettii	E	X	
Aristolochia pentandra	E	X	
Asplenium dentatum	E	X	
Asplenium erosum	E	X	
Asplenium verecundum	E	X	
Basiphyllaea corallicola	E	X	
Bourreria cassinifolia	E	X	X
Bourreria succulenta	E		X
Brickellia mosieri	E	X	X
Byrsonima lucida	T	X	X
Chamaecrista lineata var. *keyensis*	E	X	
Chamaesyce garberi	E	X	
Chromolaena frustrata	E	X	
Cienfuegosa yucatanensis	E	X	
Consolea corallicola	E	X	
Crossopetalum ilicifolium	T	X	X
Crossopetalum rhacoma	T	X	X
Ctenitis sloanei	E	X	X
Ctenitis submarginalis	E	X	
Dalea carthagenensis var. *floridana*	E	X	X
Guaiacum sanctum	E	X	X
Harrisia aboriginum	E	X	
Harrisia fragrans	E	X	
Harrisia simpsonii	E	X	
Ipomoea microdactyla	E	X	
Ipomoea tenuissima	E	X	
Jacquemontia curtissii	E	X	X
Jacquemontia reclinata	E	X	
Jacquinia keyensis	T	X	X
Koanophyllon villosum	E	X	X
Lantana depressa var. depressa	E	X	X
Metastelma blodgettii	T	X	X
Microgramma heterophylla	E	X	X
Mosiera longipes	T	X	

Opuntia abjecta	E	X	
Opuntia ochrocentra	E	X	
Phyla stoechidifolia	E	X	
Pilosocereus robinii	E	X	X
Pteris bahamensis	T	X	X
Scutellaria havanensis	E	X	X
Senna mexicana var. *chapmanii*	T	X	X
Sphenomeris clavata	E	X	X
Tectaria fimbriata	E	X	
Tectaria heracleifolia	E	X	X
Tephrosia angustissima var. *corallicola*	E	X	X
Thelypteris grandis	E		X
Thelypteris patens	E	X	
Thelypteris reptans	E	X	
Thelypteris reticulata	E	X	X
Thelypteris sancta	E	X	
Thelypteris sclerophylla	E	X	
Tripsacum floridanum	T	X	X
Vallesia antillana	E		X

Table A2: All Florida listed species with seeds in long-term storage at Fairchild and/or at the USDA NLGRP. Total number of taxa shown is 79.

Taxon	Rank	Quantity	Years Deposited	Location
Adiantum melanoleucum	E	mass	2011-2017	NLGRP
Aeschynomene pratensis	E	132+35	2019, 2021	FTBG
Ageratum maritimum	E	5000	2018,2019	FTBG
Aletris bracteata	E	6,500+6300	2009, 2019	NLGRP, FTBG
Alvaradoa amorphoides	E	2,745	2007	NLGRP
Amorpha herbacea var. *crenulata*	E	32,038+1878+13,472	2004, 2015, 2019, 2020, 2021	NLGRP, FTBG
Anemia wrightii	E	mass	2016, 2021	NLGRP
Angadenia berteroi	T	300, 13+1,810	2008, 2019, 2020	NLGRP, FTBG
Argythamnia blodgettii	E	568+7600	2007, 2015, 2020	NLGRP, FTBG
Aristolochia pentandra	E	245	2018,2019	FTBG
Asclepias curtisii	E	16	2021	FTBG
Asplenium dentatum	E	mass	2016	NLGRP
Asplenium verecundum	E	mass	2012	NLGRP
Basiphyllaea corallicola	E	mass	2011, 2016	NLGRP,
Bourreria cassinifolia	E	1,880 + ~2000+278	2007-2008, 2020	NLGRP, FTBG
Brickellia mosieri	E	5,869+3447	2008-2016,2019,2020	NLGRP, FTG
Byrsonima lucida	T	612+371	2008,2017,2019	NLGRP, FTBG
Chamaecrista lineata var. *keyensis*	E	773+523	2016, 2019	NLGRP, FTG
Chamaesyce deltoidea ssp. *pinetorum*	E	730	2007	NLGRP
Chamaesyce deltoidea ssp. *serpyllum*	E	504+48	2016, 2019	NLGRP, FTG
Chamaesyce garberi	E	4,440	2007, 2015	NLGRP
Chromolaena frustrata	E	~6000+398	2007-2016,2019	NLGRP, FTG
Colubrina cubensis var. *floridana*	E	~3000	2007, 2016	NLGRP, FTG
Conradina grandiflora	T	25	2019	FTBG
Crossopetalum ilicifolium	T	398	2008	NLGRP
Crossopetalum rhacoma	T	403+365	2008, 2021	NLGRP, FTBG
Ctenitis sloanei	E	mass	2013-2016	NLGRP
Ctenitis submarginalis	E	mass	2016	NLGRP
Cynanchum blodgettii	T	334	2008	NLGRP
Dalea carthagenensis var. *floridana*	E	32,703+44+400	2008-2013,2019, 2020	NLGRP, FTBG
Digitaria pauciflora	E	16,908	2007	NLGRP
Drypetes lateriflora	T	53	2021	FTBG
Evoluvulus grisebachii	E	487	2018	FTBG
Galactia smallii	E	5,559+2733	2008, 2015	NLGRP, FTBG
Guzmania monostachia	E	300	2021	FTGB
Harrisia aboriginum	E	~13000	2019	FTBG
Harrisia fragrans	E	24,522+~7600	2008, 2015	NLGRP
Harrisia simpsonii	E	1,470+274	2015-2016,2019	NLGRP, FTG
Indigofera mucronata var. keyensis	E	992	2021	FTBG
Ipomoea microdactyla	E	4	2009	NLGRP
Ipomoea tenuissima	E	300+566+779	2019, 2020-2021	NLGRP, FTBG
Jacquemontia curtisii	T	1303+1459	2008,2018	NLGRP,FTBG
Jacquemontia reclinata	E	39,582+679+64,000	2004-2013,2018,2019, 2021	NLGRP,FTBG
Jacquinia keyensis	T	32	2009	NLGRP

Koanophyllum villosum	E	2,000+200	2015, 2020	NLGRP, FTBG
Lantana canescens	E	24,172+215	2006-2013, 2020	NLGRP, FTBG
Linum arenicola	E	587+175+18	2016, 2021	NLGRP, FTG
Linum carteri var. carteri	E	~5000+131+23	2004-2017-2019, 2021	NLGRP, FTG
Linum carteri var. smallii	E	438	2009	NLGRP
Melanthera parvifolia	T	908+19+162	2008, 2020-2021	NLGRP, FTBG
Mosiera longipes	T	2647	2008	NLGRP
Passiflora pallens	E	300		NLGRP
Phyla stoechadifolia	E	350	2020	FTBG
Pilosocereus polygonus	E	217+92	2008, 2017, 2021	NLGRP, FTBG
Pilosocereus robinii	E	>17,000 + 2400 * +75	2008-2016,2019, 2021	NLGRP, FTBG
Pisonia rotundata	E	175	2020	FTBG
Pithecellobium keyensis	T	1077	2009	NLGRP
Polygala smallii	E	1,282	2008	NLGRP
Pteris bahamensis	T	mass	2016	NLGRP
Rhipsalis baccifera	E	1,900	2020	FTBG
Sachsia polycephala	T	443	2018	NLGRP, FTBG
Scutellaria havanensis	E	62+227	2008, 2020	NLGRP, FTBG
Senna mexicana var. *chapmanii*	T	3586+244+350	2008, 2019, 2020	NLGRP, FTBG
Smilax havanensis	T	53	2008	NLGRP
Sphenomeris clavata	E	mass	2016	NLGRP
Tectaria fimbriata	E	mass	2016	NLGRP
Tectaria heracleifolia	T	mass	2012, 2016	NLGRP
Tephrosia angustissima var. *corallicola*	E	29,146+1179+248+5,630	2004, 2013,2018, 2020, 2021	NLGRP,FTBG
Tephrosia curtisii	E	436+ 38	2019, 2020	FTBG
Tetrazygia bicolor	T	7710+3,000	2009, 2021	NLGRP, FTBG
Thelypteris grandis	E	mass	2014	NLGRP
Thelypteris patens	E	mass	2011-2012	NLGRP
Thelypteris reptans	E	mass	2011-2016	NLGRP
Thelypteris reticulata	E	mass	2011-2014	NLGRP
Thelypteris sancta	E	mass	2016	NLGRP
Thelypteris sclerophylla	E	mass	2012-2016	NLGRP
Tropidia polystachya	E	mass	2017	NLGRP, FTG
Zanthoxylum flavum	E	234	2021	FTBG

APPENDIX II: CONSERVATION ACTION PLAN

Bourreria cassinifolia

Species Name: *Bourreria cassinifolia* (A.Rich.) Griseb.
Common Name(s): pineland strongbark, smooth strongbark, smooth strongback, little strongbark, little strongback
Synonym(s): *Ehretia cassinifolia* A. Rich., *Morelosia cassinifolia* (A.Rich.) Kuntze
Family: Boraginaceae
Species/taxon description: Evergreen shrub to 2-3 m tall. Leaves alternate, elliptic to ovate, simple, entire, rough to the touch, 1-3 cm long; apices rounded. Flowers white, solitary, tubular, with five lobes, 1-1.5 cm wide. Fruit rounded, orange, one- to four-seeded drupes, to about 7 mm in diameter (Modified from Nelson 1996).

There are two other Florida endangered *Bourreria* species known from extreme South Florida, *Bourreria radula* (Poir.) G. Don and *Bourreria succulenta* Jacq. These species both have much larger leaves than *B. cassinifolia,* and both are larger plants overall; they can grow to about 12 m tall. *B. radula* is known only from rockland hammocks in Key West (Gann et al. 2021, while *B. succulenta*, the Bahama strongbark, is found on hammock margins in the Keys and extreme southern peninsular Florida (Nelson 1994).

Legal Status: Florida endangered

Prepared by: Jennifer Possley, Emily Magnaghi, Sabine Wintergerst.
Last Update: 2021


Photo: J. Possley

Background and Current Status

Range-wide distribution – past and present

Florida: Miami-Dade and Monroe Counties
World: Florida and Cuba (Gann et al. 2021)

Population and reproductive biology/life history

Annual/Perennial: Perennial
Habit: Shrub
Average Life Span: Well-established plants can live for decades.
Pollinators: Butterflies. In South Florida, skippers are especially frequent visitors.
Flowering Period: All year
Fruiting: All year
Annual variability in Flowering: Unknown
Growth Period: Unknown
Dispersal: Unknown
Seed Maturation Period: Unknown
Seed Production: Most fruits have 4 seeds, though the number can vary
Seed Viability: Unknown
Regularity of Establishment: Unknown
Germination Requirements: There appears to be a period of dormancy before seeds will germinate. The dormancy mechanism is not well understood. Untreated seeds can take 6-8 months to germinate, yet seeds beneath fruiting trees seem to germinate readily. Research at Fairchild suggests that alternating wet/dry cycles and possibly the use of native soil (presumably because it contains beneficial mycorrhizal fungi) improve germination, but we have not yet achieved consistent germination above 50% with any treatment method.
Establishment Requirements: Unknown
Population Size: The total population of this species in South Florida is likely between 200 and 300 plants.
Annual Variation: None
Number and Distribution of Populations: There are currently ten populations of *B. cassinifolia* in South Florida (extant sites are shown in bold font in the table below); several more were present but have been extirpated in recent decades. The largest extant population is protected in Everglades National Park (Gann 2015).

	Parcel	Protection	Est. Pop. Size/Comment
1	Bill Sadowski Park	MDC	2 +seedlings
2	Camp Owaissa Bauer	MDC	20-50
3	Castellow #28	MDC	2? Not recently verified
4	Chernoff Hammock	MDC	Possibly extirpated
5	Everglades National Park	NPS	~100 individuals (Gann 2015)
6	Ingram Pineland	MDC	2+ seedlings
7	Larry & Penny Thompson Park	MDC	20-50
8	National Key Deer Refuge	FWS	Possibly extirpated *
9	Ned Glenn Nature Preserve	MDC	9
10	Old Dixie Pineland	NONE	Possibly extirpated

11	Palm Drive Pineland	MDC	Presumed extirpated *
12	Radice Pineland	EEL Cov	Unknown (rept in EEL Covt plant list)
13	Seminole Wayside Park	MDC	20-50
14	USDA Chapman Field	NONE	<10, not recently verified
15	Wilkins-Pierson Pineland	MDC	4

* per IRC

Habitat description and ecology

Type: PINE ROCKLAND, PINE ROCKLAND/HAMMOCK ECOTONE

Physical Features:

Soil: Limestone and/or Redland soil

Elevation: 2-6 m

Aspect: Unknown

Slope: Unknown

Moisture: Unknown

Light: Full sun is preferred. Plants will persist in deep shade but with little growth and no reproduction.

Biotic Features:

Community: Pine rockland, usually not associated with dense stands of slash pine (*Pinus elliottii* var. *densa*) or saw palmetto (*Serenoa repens*); it is found more often in open, frequently burned pineland.

Interactions:

Competition: Unknown

Mutualism: Unknown

Mycorrhizae Associations: Unknown, but suspected based on limited germination trials with native soil that may have improved germination rates

Parasitism: Unknown

Other: Unknown

Animal use: Year-round nectar source for butterflies; a favorite of skippers

Natural Disturbance:

Fire: *B. cassinifolia* appears to favor areas that have had frequent fires (i.e., sparse distribution of pines and palmettos). Established plants resprout vigorously after fires.

Hurricane: Rathcke (2001) showed that hurricanes caused prolific flowering in *B. succulenta* in the Bahamas, but fruit set was then limited by pollination and predation.

Slope Movement: Unknown

Small Scale (i.e. Animal Digging): Unknown

Temperature: Unknown

Protection and management

Summary: *Bourreria cassinifolia* is one of the rarest plants in South Florida, and the species' narrow geographic range makes its conservation even more important. In protected sites, careful management that includes regular prescribed fire is crucial to maintain current populations.

Availability of sources for outplanting: Fairchild Tropical Botanic Garden and a handful of local nurseries have plenty of material available for outplanting. The majority of Fairchild's material is of horticultural origin, and is therefore used in free "Starter Kits" for Connect to Protect Network

members. Increasingly, we are growing plants of known wild origin which will be planted at Fairchild and used to augment small wild populations.

Availability of habitat for outplanting: Miami-Dade County has many suitable outplanting areas within the historic range of this species; many private covenanted lands would also be good candidates for reintroduction. National Key Deer Refuge in the Florida Keys has potential reintroduction habitat.

Threats/limiting factors

Natural:

Herbivory: Rarely an issue due to thick, scabrous leaves
Disease: Unknown
Predators: Unknown
Succession: Fire suppression is a major threat as it reduces available habitat
Weed invasion: Typical pine rockland weeds such as *Neyraudia reynaudiana* are threats, if left unmanaged. Bracken fern grows very densely around the Bill Sadowski population and needs to be manually removed at least once a year.
Fire: This is a fire-adapted species; fire suppression is a threat to its survival.
Genetic: Many of the remaining Miami-Dade populations have fewer than 10 reproductive individuals. Small gene pools at these sites may be decreasing reproductive fitness.

Anthropogenic

On site: Development in both protected and unprotected sites. Many of the remaining *B. cassinifolia* in protected sites grow near the edges of management units where fence and sidewalk construction are possibilities. Fire suppression is also a serious threat, as it may reduce suitable habitat.
Off site: Unknown

Conservation measures and actions required

Research history: We are not aware of any published research on this taxon.

Propagation and cultivation methods: *Bourreria cassinifolia* is difficult to propagate. It does not propagate well via cuttings (some plants may root, but those that do are weak, with few roots). Seed viability appears to be low in *B. cassinifolia*, though seeds are strongly dormant and we do not yet understand how to break dormancy. Methods attempted so far include water soak, smoke solution, sulfuric acid scarification, potassium nitrate, dry heat, alternating wet/dry cycles, gibberellic acid, and combinations of the above.

Significance/Potential for anthropogenic use: In the Bahamas, a tea is made from the related *Bourreria succulenta* to aid weakness and pains of the waistline and improve sexual stamina (Hammer 2004). In South Florida, *Bourreria cassinifolia* is sold at native plant nurseries and is popular among native plant and butterfly enthusiasts.

Management options: In most preserves (with the possible exception of ENP), increasing prescribed fire frequency would be ideal. Augmenting the size of small populations would be an important step in ensuring this species' survival in South Florida.

References

Gann, G., K. Bradley, and S. Woodmansee. 2002. Rare plants of South Florida: Their history, conservation, and restoration. The Institute for Regional Conservation, Miami, FL.

Gann, G. 2015. Vascular Plant Species of Management Concern in Everglades National Park. Final report to Everglades National Park. Link to PDF.

Gann GD, Stocking CG and Collaborators. 2001-2021. Floristic Inventory of South Florida Database Online. The Institute for Regional Conservation. Delray Beach, Florida.
URL: http://regionalconservation.org/ircs/database/database.asp.

Hammer, R. 2004. Florida Keys wildflowers. The Globe Pequot Press, Falcon Guides. Guilford, Connecticut.

Nelson, G. 1994. The trees of Florida. Pineapple Press, Inc. Sarasota, FL.

Nelson, G. 1996. Shrubs and woody vines of Florida. Pineapple Press, Inc. Sarasota, FL.

Rathcke, B.J. 2001. Pollination and predation limit fruit set in a shrub, *Bourreria succulenta* (Boraginaceae), after hurricanes on San Salvador Island, Bahamas. Biotropica 33(2):330-338. Link to PDF.