Habitat delineation for Florida bristle fern (*Trichomanes punctatum* ssp. *floridanum*) in and around the Jumper Creek Tract of the Withlacoochee State Forest

Grant Agreement # F11AP00625

Craig van der Heiden

Final Report

January 19, 2016

Submitted by:
The Institute for Regional Conservation
100 East Linton Blvd
Suite 302B
Delray Beach, FL 33483

Submitted to:
US Fish and Wildlife Service
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

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Introduction

The Institute for Regional Conservation (IRC) was contracted by the United States Fish and Wildlife Service (USFWS) to conduct field surveys for the Florida bristle fern (*Trichomanes punctatum* ssp. *floridanum*) under Grant Agreement # F11AP00625- Mod 3. The endangered and endemic Florida bristle fern is found only in two Florida counties; Sumter and Miami-Dade counties (Nauman 1986, Gann et al., 2002). The USFWS listed the fern as an endangered species under the Endangered Species Act of 1973 on October 6, 2015.

The genus *Trichomanes* belongs to the family Hymenophyllaceae, one of the most hygrophilous (growing in wet or moist environments) groups of land plants. Hymenophyllaceae is comprised of more than 600 species, most of which occur in humid tropical forest with the distribution extending to moist shady areas of temperate regions (Iwatsuki 1990, Kromer 2006). The genus, *Trichomanes,* shares anatomical and physiological characteristics commonly associated with aquatic vegetation which restricts most of its individual species to very humid environments (Schuster 1971, Chen et al., 1999, Zots and Busche 2000, Shreve 1911). The majority of *Trichomanes* spp. are characterized by small, thin, delicate leaves. Lacking a cuticle makes the fern susceptible to desiccation without the capability of regulating water loss (Zots and Busche 2000, Kromer 2006, Parra et al., 2009). *Trichomanes* receives its common name, bristle fern, from the bristle-like structures projecting from the involucres, which are cup-like spore receptacles protruding from the fern fronds. After the spores have been shed, the bristle-like structure remains protruding from the involucres.

The Florida bristle fern (FBF) is a small mat-forming fern. True to the hygrophilous characteristics of Hymenophyllaceae, it grows under shade in high humidity environments (van der Heiden and Johnson 2013). FBF is almost exclusively epiphytically associated with limestone outcrops. In Miami-Dade County, the fern is established within older limestone solution holes. The fern has also been observed growing on the roots of a Brazilian pepper tree (*Schinus terebinthifolius*) extending into the solution holes (personal observation). In Sumter County, two documented populations of FBF are located within Withlachochee State Forest’s Jumper Creek Tract. Both Sumter County populations are found on limestone boulders in elevated mesic hammocks (rarely flooded) with substantial canopies and surrounded by hydric hammocks (often flooded) dominated by bald-cypress (*Taxodium distichum*). Mesic hammocks are transitional uplands associated with hydric hammocks and wetlands.

Maintaining suitable habitat for threatened and endangered plant species allows for the management of natural environments close to the historical state of the environment which gave rise to the rare species. Identifying the set of environmental conditions and their balance adds valuable information to the managers’ toolset. To realize the microconditions of humidity and temperature within hammocks which support the growth ideals for FBF, IRC used data loggers to capture their gradients around the locations of the two known populations.

The purpose of this project was to delineate suitable habitat (including substrate) for FBF in the Withlacoochee State Forest Jumper Creek Tract and on selected adjacent private lands if possible. IRC primarily surveyed for FBF within mesic hammocks having suitable boulder substrate. However, because mesic hammocks are found interspersed within hydric hammocks and these two habitat types often occur as intermixed stands, the majority of the surveys were conducted in hydric hammocks while we searched for suitable boulder habitat. In addition, we searched for additional populations and documented associated species within the hammocks described.

Methods

Surveys

The field surveys were conducted in Sumter County, Florida in the Jumper Creek Tract (JCT) of the Withlacoochee State Forest (Figure 1) from October, 2014 to March, 2015. To search JCT for FBF habitat, we walked transects through prior demarcated areas looking for mesic hammock habitat with boulders. Boundaries for the surveys were identified by the USFWS and encompassed mesic hammock, hydric hammock, and mixed wetland hardwood habitats as classified by the Florida Natural Area Inventory Cooperative Land Cover Map (FNAI CLC; version 2.3). The initial survey area (as identified by USFWS) was approximately 4,000 acres of potential habitat. All data were mapped in ArcMap 10.2 (ESRI).

Private Land Access

Land parcels adjacent to JCT were identified on the Sumter County Appraisers website and land owners addresses were recorded. Letters were written to land owners asking permission to access their land and search for FBF. Because there were no phone numbers recorded on the Sumter County Appraisers website, we also attempted to contact landowners by personally driving to their residence to request permission to access their land. In addition, Colleen Werner and Randy Davenport from the Florida Forest Service provided contact information for private land where the FFS has permission to access JCT through private land.

Soil

Vegetation is often associated with certain soil types, and since we were searching for hammocks with boulders, we obtained a soil map from U.S. Department of Agriculture, Natural Resources Conservation Service titled Soil Survey Geographic (SSURGO) Database For Florida - June 2012. Using ArcMap (ESRI), spatial joins were done with boulders and the soil map to determine other areas that could potentially contain boulders that were not included in the initial survey area.

Habitat

We used a combination of ground survey data and satellite imagery interpretation to demarcate hammock habitat.   A variety of images were utilized including Florida Department of Transportation Sumter County (Sum2014), USGS Digital Orthophoto Quarter Quadrangles (DOQQ) for 2010, and the base layer imagery in ArcMap. Demarcated habitat was classified as mesic hammock or hydric hammock, except a small number of areas which were classified as elevated hydric hammock due to a rise in ground elevation. These elevated hydric hammocks were not classified as mesic hammock because they lack the hardwood oak canopy and may still flood in times of higher rainfall.

We conducted ground surveys through potentially suitable habitat (based on canopy and hydrology), looking for boulders, as suitable substrate for FBF. When boulders were found, they were each visibly searched for FBF. Boulders that were in hydric hammocks but were not submerged for long periods as evident by the vegetation growing on the boulders (i.e., ferns, forbs, graminoids) were also included.   Boulders in conditions considered too dry for FBF as evident by the lack of moss, bryophytes, lichens, and ferns growing on boulders were not included. The locations of suitable boulders were marked with a hand held GPS. Due to the time it took to accurately mark each rock with the GPS, when the boulders covered an area exceeding approximately 100 m^2, we instead recorded the outer perimeter of boulders but still searched all rocks.

The GPS locations of boulders were imported into an ArcMap shapefile, and a boundary encompassing a 300 meter (m) buffer was drawn around their locations using the Buffer (Analysis) tool in ArcMap. Based on field observations in a prior project (van der Heiden and Johnson 2013) in JCT, the healthier and more robust FBF subpopulation is within a hammock with a distance of at least 300 m from the hammock to the cleared pasture. What we ascertain is the population that lives closer to the edge (at approximately 100 m) in the large hammock has visible signs of stress. It appears more desiccated and has less reproductive bristles. Therefore, to maximize restoration efforts, ideal growing habitats must include a sizeable buffer that allows for the crucial balance of micro-conditions including humidity, canopy, temperature, and substrate within the hammock to increase the fern's probability of successful survival and or reintroduction. The 300 m buffer represents the distance from the pasture edge to the hammock where we have observed healthier FBF.

Where the ArcMap buffer included habitat lacking suitable canopy, or were bisected by major roads or other large vegetation breaks, we deleted these unsuitable areas from the final buffered boulder layer.

Data loggers

FBF is extant in two hammocks within the JCT; Rocky Hammock and Tree Frog Hammock (van der Heiden and Johnson 2013). HOBO U23 (Onset) data loggers, used in a previous habitat study for FBF (van der Heiden and Johnson 2013), had been left to collect temperature and relative humidity (RH) data. In each hammock, 8 HOBO data loggers were previously positioned as an array with four sensors positioned in cardinal directions N, S, E, and W along the outside perimeter near the ecotone of the hydric and mesic hammock. An additional four sensors were positioned in each hammock NE, SE, SW, NW whose placement was staggered towards the interior with respect to the four edge sensors (Figure 2). An additional sensor was positioned directly adjacent to an FBF patch. In Rocky Hammock, a data logger was also placed at the center of the hammock. The data logger that was initially placed in the center of Tree Frog Hammock, from a previous study (van der Heiden and Johnson 2013), was removed and placed near an open cattle pasture adjacent to Rocky Hammock to collect data that could be compared to the interior of the hammocks. The data logger was taken from Tree Frog Hammock because the hammock is smaller than Rocky Hammock and had good coverage from the remaining data loggers (van der Heiden and Johnson 2013). The data logger was approximately 10 m from the edge of the open field but still under canopy trees. All data loggers were placed at a height resembling the average height (~25 cm) at which FBF occurs.

Data from HOBO loggers were initially deployed 9/18/2013 and were downloaded on 3/12/2015. Data loggers were set to record data at two hour intervals. Centered moving means were used to smooth the data and compare average temperatures and RH. To compare both hammocks we took the average temperature of all data loggers from centered moving mean and applied Student t-test to compare the means.

Results

Surveys

Surveys were conducted on both private and public land (Figure 3). Unfortunately, certain private landowners did not respond to inquiry to access their land; therefore, some areas that could have FBF or suitable habitat were not searched. Only a single landowner responded to the letters that were sent out but rejected our application and would not allow us on their land. We did manage to get permission to access JCT through private land from three landowners using contacts from Colleen Werner and Randy Davenport of the Florida Forest Service. One additional landowner allowed access to search his property when we drove to his house to ask permission. The areas on private land that were not searched are both south of JCT; one north of road WC-48 and the other south of the road WC-48 in an area known as Battlefield Slough (Figure 3). An area to the north of road WC-48, called Battlefield Ridge (on private land), was searched. An area on this ridge historically had an artesian spring which has not had water for at least the past 30 years (account from landowner).

The initial agreement indicated 75 acres of private land (located adjacent to and southwest of JCT) to be searched for FBF. We searched 355 acres of private land. We also searched areas on public land (JCT) that were not demarcated in the boundaries from USFWS. These areas were surveyed after analysis of satellite imagery showed potential mesic hammocks. The total area of public land searched was 4,350 acres. The total extent surveyed during this project amounts to 4,705 acres.

The surveys for FBF started off slower than initially expected due to the beginning of hunting season on the property. For safety reasons, we had to delay surveys. Access into Jumper Creek was also an issue as the north of the forest area has only limited access, and privately owned lands surround the entire western, southern and southeastern boundaries of JCT. We eventually did gain access through private land which greatly enhanced our ability to complete the project. The farther away from the access point we surveyed, the longer it took to start subsequent surveys due to the time it took to walk through the swamp.

Soil

Evaluation of the soil substrates under the location of the boulders (Figure 4) showed that of the 21 soil types found in the study area, 16 soil types contained boulders (Table 1). The soil types Floridana-Basinger association, Okeelanta muck, and Malabar fine sand had the majority (58%) of the boulders (Table 1).

Habitat

Through a combination of ground surveys and image interpretation, 1,761 acres of mesic hammocks were mapped within the survey area (Figure 5). Mapped elevated hydric hammocks measured 115 acres (Figure 5). Because the mapping of hydric hammocks were not within the scope of work for this project, we used the FNAI CLC data to map hydric hammocks (2,904 acres) within the survey area.

We mapped 2,466 suitable boulders or boulder groups (as described in Methods above) in the survey area. Suitable boulders were not only found in mesic hammocks (as mapped by IRC), but also in elevated hydric hammocks (as mapped by IRC), and hydric hammocks (as mapped by FNAI CLC data). Suitable substrate was also found in areas that were not classified as hydric hammock in the FNAI CLC data, but that should be considered hydric hammock based on hydrology and vegetation observed by IRC during ground surveys. Suitable boulders in these areas were mapped on elevated substrate. All of these habitats have sufficient canopy to provide the needed conditions for FBF growth and persistence. Based on our surveys, habitat for FBF is defined as the buffered boulder layer (see Methods for criteria), and covers a total of 5,805 acres (Figure 6).

Data loggers

Relative humidity was not statistically different between the two hammocks over the time period of the study when the moving averages were tested with a Student's t-test (Figure 7). The average humidity in both hammocks was 94.8 % throughout the study. Although there was only one data logger on the outside of the hammock near a cleared grazing pasture, there is a statistical difference ($P<0.001$) in relative humidity between both hammock interiors ($x=95\%$) and the field edge ($x=82$ %). This shows a reduction in humidity at the pasture edge when compared to the interior of the hammocks (Figure 7).

The temperatures were also not statistically different between hammocks ($x = 66.2^{o}$ F) (Figure 8). There is no statistical difference in average temperature at the edge of the field and the interior of both hammocks. Average, minimum and maximum relative humidity and temperatures are calculated for Rocky Hammock, Tree Frog Hammock and the field edge (Tables 3 and 4).

Discussion

Despite extensive surveys through 4,705 acres in and around the Jumper Creek Tract, we did not find any additional populations of *Trichomanes punctatum* ssp. *floridanum*. This finding serves as a testament to the rarity of this subspecies. The habitat for FBF was delineated by surveying for limestone boulders in areas having suitable canopy and hydrology. Limestone boulders are determined as a limiting factor for the fern because it grows almost exclusively on limestone. Boulders were located in many diverse areas in mesic hammocks, hydric hammocks, elevated hydric hammocks, where the canopy trees function to provide shade and buffer temperature and humidity. The importance of intact canopy (both above the substrate and surrounding it) to insulating FBF from temperature fluctuations can be seen in the data from the data loggers (Table 2 and 3), where the data logger near the field edge has lower minimum and higher maximum temperatures than the data loggers in the interior of the hammocks. In addition, the relative humidity on the field edge has a lower minimum and maximum than the interior of the hammocks, again showing the insulating effects of the forest (Table 2 and 3). Throughout the wide-ranging survey area, we found 5,805 acres that should be considered suitable habitat for this species within the JCT and surrounding private lands.

Data from the HOBO loggers show no statistical differences in the means of long term temperature and relative humidity between hammocks (Table 2 and 3). However, between the edge of the grazing pasture and the interior of both hammocks, which is a distance of approximately 90 m, a difference in the means of relative humidity is significant. Because there is only one data point for the pasture, the analysis lacks statistical power. However, Figure 7 does show the drastic reduction in humidity adjacent to the cleared habitat. The threshold of relative humidity for FBF is not known, but we do know that the ferns currently grow in relatively high humidity. Determining the range of optimal humidity for FBF is an area of study that needs further experimentation. Knowing details of microconditions for the imperiled plant can greatly aid in proposing reintroduction prospects.

An interesting observation was made in several locations where boulders were found seemingly out of place at the edges of habitats, for instance the edge of a hydric hammock. The pattern became clearer as we surveyed towards Indian Fields. It appears that rocks had been rolled and piled in different areas and commonly around large oak trees (Figure 9). Quite possibly, extensive agriculture on elevated hammocks and surrounding areas of JCT had taken place for some time. Our observation is confirmed by an early description of agriculture on Kettle Island (an area we surveyed) where Seminoles were cultivating corn and rice in 1823 (Mitchem and Weiseman 1987). Agriculture and later the logging of JCT would have had adverse effects on the original distribution of FBF with its hygrophilous nature (Parra et al., 2009). In addition, tree fall, wetland drainage (or other hydrological changes), urban development, and limestone mining have led to the reduction of habitat and decline of FBF. These habitat alterations change microclimate patterns in moisture, temperature, light, and wind (Chen et al., 1999), which are expected to have a significant negative effect on the survival of this sensitive fern. The morphology of the fern restricts it to highly humid and shady niches. Because FBF cannot regulate water loss, any disturbance that changes humidity has an adverse effect on the distribution of the fern. Anthropogenic stressors have severely decreased the number of population accounts for this subspecies throughout Sumter and Miami-Dade counties, possibly enhancing the chances for local extinctions (Matthies et al., 2004).

To further the persistence of FBF in Jumper Creek, augmentation is recommended. As only two populations are known, any anthropogenic or stochastic events could seriously affect the persistence of this subspecies in JCT. This study has demarcated a relatively large area as suitable habitat for FBF. With further study of the microhabitat within specific hammocks, precise locations can be identified, where augmentation by reintroductions of FBF would have the greatest probability of success. This can be accomplished by strategically placing data loggers in candidate hammocks to record conditions. Evaluation of the logged data can lead to the identification of locations on boulders within hammocks that closely resemble the relative humidity and canopy coverage of the two existing populations. In addition, a study to either cultivate new FBF individuals from spores or produce clones of existing plants can aid the augmentation effort. To date, FBF has not been germinated from spores, but some botanists have been successful in growing it vegetatively by fragmentation. Fronds from several ferns in the extant populations should be collected to maintain genetic diversity and grown with the goal of reintroducing the fern into identified hammocks.

Conclusion

This study has identified suitable habitat for *Trichomanes punctatum* ssp. *floridanum* in the Jumper Creek Tract of the Withlacoochee State Forest. Threats to the population of Florida bristle fern in Sumter County include changes in microhabitat, invasive species, drainage or damming of the Withlacoochee River, and changes in land use. Changes in microhabitats could adversely affect the survival of this fern. Drainage of the surrounding hydric hammocks within the Jumper Creek tract could significantly decrease the relative humidity of mesic hammocks hosting the fern by lowering the surrounding air and soil moisture contents. Damming of the river could result in large changes to the Sumter County hydric/mesic hammock hydrology. Downstream effects could result in a loss of water within the Jumper Creek Tract, spatially and temporally, possibly adversely affecting the microhabitat needed by Florida bristle fern. Logging or any activity that deforests the area and increases edge effects would unfavorably affect Florida bristle fern due to changes in wind and moisture content in the hammocks. As a result of Florida bristle fern's rarity and vulnerability within JCT, we propose that augmentation of the fern should begin by identifying hammocks with similar microclimate conditions to the two existing populations, and Florida bristle fern mats should be grown in anticipation of out-plantings.

Acknowledgements

This project was funded by the United States Fish and Wildlife Service Grant Agreement # F11AP00625-Mod 3. Colleen Werner, Florida Forest Service, provided an exceptional amount of logistical support and was indispensible to this work. She contacted land owners and facilitated access to the Jumper Creek Tract through private land and was always willing to lend a hand in the field and identify plants. Randy Davenport, Florida Forest Service, also assisted with obtaining access to Jumper Creek and accompanied us in the field. Clay Newcomb allowed access through C. Herman Beville Ranch Ltd which greatly reduced the walking distances and the time to get to the survey areas. Thanks to Sheryl van der Heiden, who did the statistical analysis of the data from the HOBO data loggers. Jimmy Lange was invaluable with his help in the field and plant identification. Last but not least thanks to the field crew; Bernard Pierre, Allen McCarthy and KC, who worked through the heat, mosquitoes and freezing temperatures (28 °F) and while constantly being wet from walking through flooded forests always maintained a good attitude.

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Figures and Tables

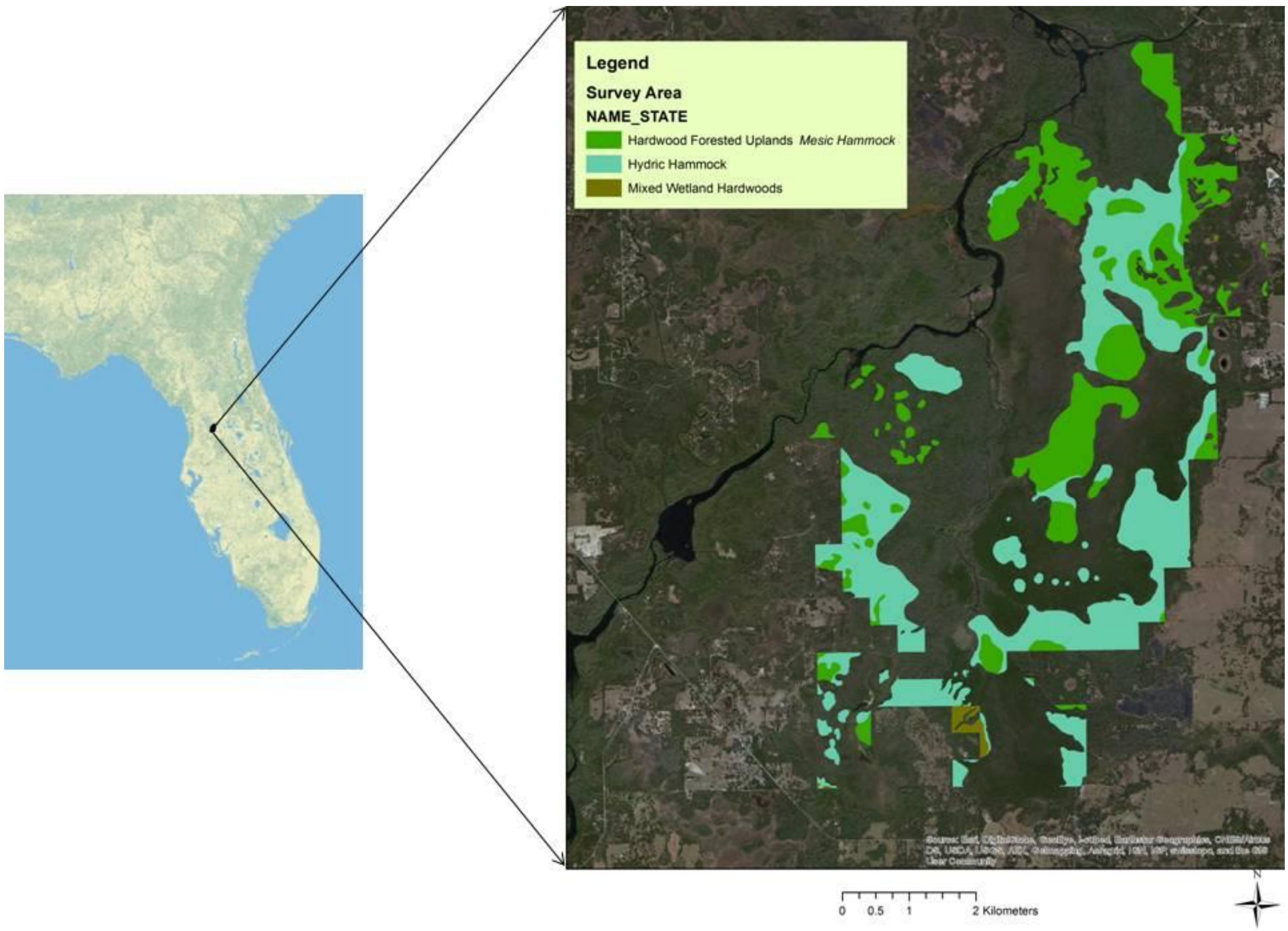

Figure 1. Location of survey area in Sumter County for Florida bristle fern in the Withlacoochee State Forest Jumper Creek Tract. Polygon boundaries show initial survey areas identified by the U.S. Fish and Wildlife Service in mesic hammocks, hydric hammocks and mixed wetland hammocks as classified by FNAI's Cooperative Land Cover layer (version 2.3).

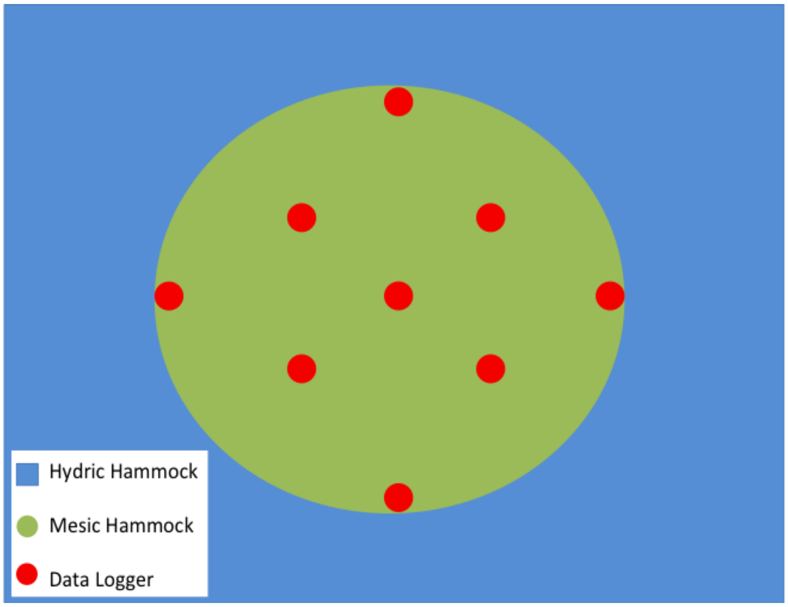

Figure 2. Conceptual diagram of the data logger array for each mesic hammock containing the Florida bristle fern. Both mesic hammocks are surrounded by hydric hammock.

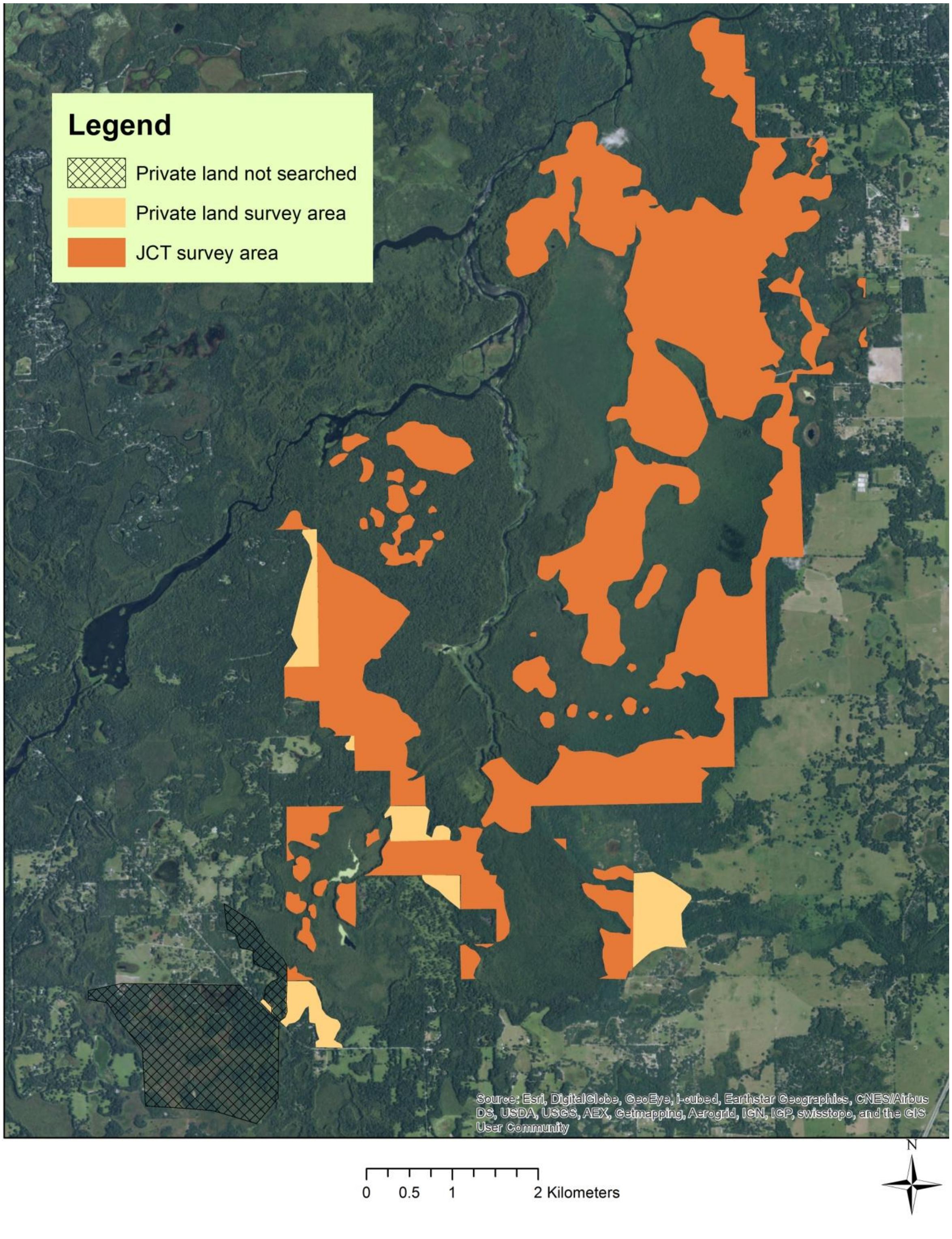

Figure 3. Map of areas surveyed by the Institute for Regional Conservation for Florida bristle fern, showing private lands (355 acres) and public lands (Withlacoochee State Forest Jumper Creek Tract; 4,350 acres) that were searched. Crosshatched areas indicate private lands that could not be searched due to access.

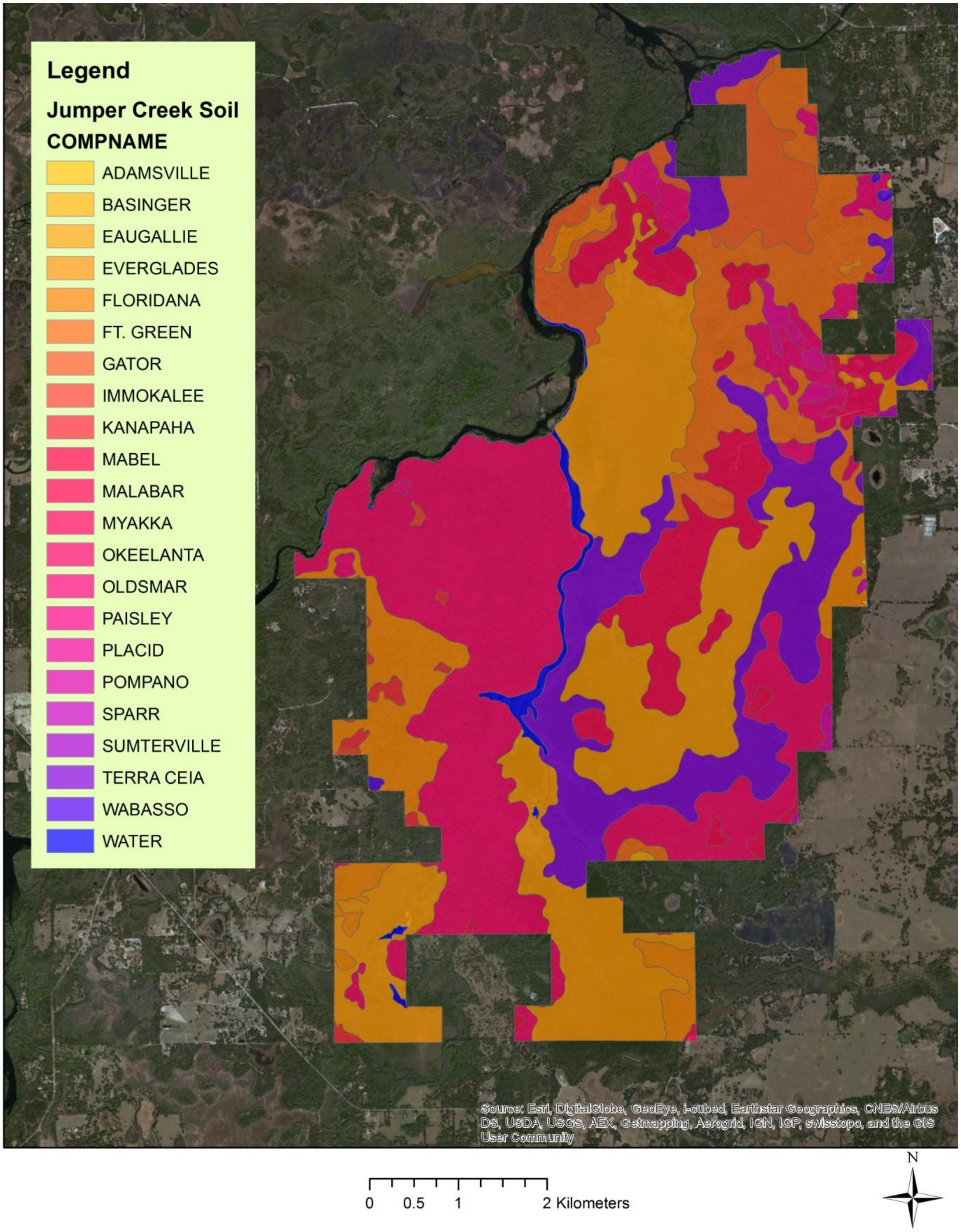

Figure 4. Soil map of the Jumper Creek Tract soil survey data obtained from U.S. Department of Agriculture, Natural Resources Conservation Service.

Table 1. Soil types where limestone boulders were found. Abbreviations are used in the soil map.

Soil Type	Abbreviations	% Boulder locations found on soil type
ADAMSVILLE FINE SAND, BOULDERY SUBSURFACE	ADAMSVILLE	0.08
EAUGALLIE FINE SAND, BOULDERY SUBSURFACE	EAUGALLIE	0.05
EVERGLADES MUCK, FREQUENTLY FLOODED	EVERGLADES	0.85
FLORIDANA-BASINGER ASSOCIATION, FREQUENTLY FLOODED	FLORIDANA	20.28
FT. GREEN FINE SAND, BOULDERY SUBSURFACE	FT. GREEN	15.69
IMMOKALEE SAND	GATOR	1.22
GATOR MUCK, FREQUENTLY FLOODED	IMMOKALEE	0.08
KANAPAHA SAND, BOULDERY SUBSURFACE	KANAPAHA	6.79
MABEL FINE SAND, BOULDERY SUBSURFACE, 0 TO 5 PERCENT SLOPES	MABEL	0.42
MALABAR FINE SAND, FREQUENTLY FLOODED	MALABAR	18.98
MYAKKA SAND	MYAKKA	0.08
OKEELANTA MUCK, FREQUENTLY FLOODED	OKEELANTA	23.33
OLDSMAR FINE SAND, BOULDERY SUBSURFACE	OLDSMAR	2.97
PAISLEY FINE SAND, BOULDERY SUBSURFACE	PAISLEY	5.38
PLACID FINE SAND, DEPRESSIONAL	PLACID	0.05
TERRA CEIA MUCK, FREQUENTLY FLOODED	TERRA CEIA	3.74

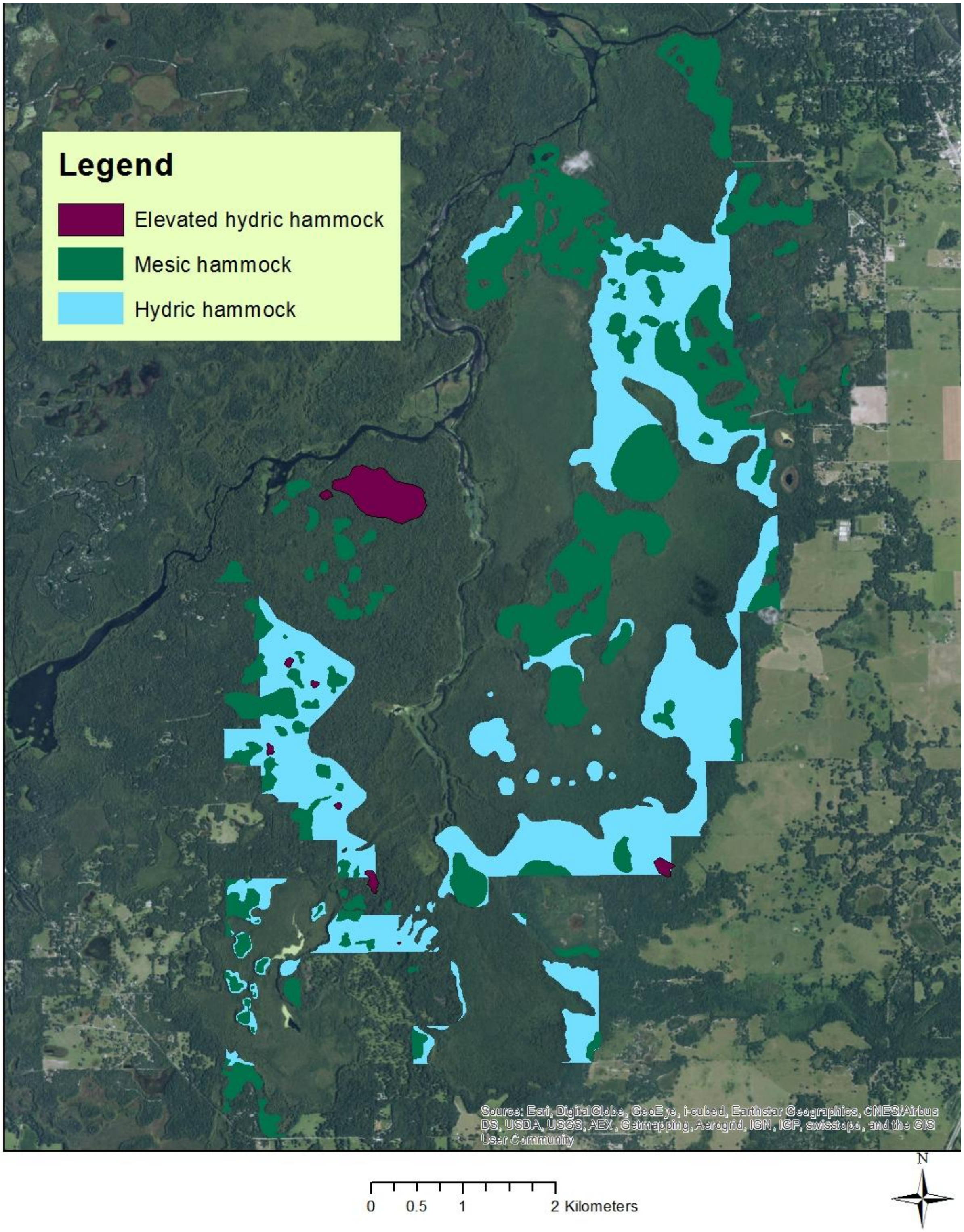

Figure 5. Map delineating mesic hammocks, and elevated hydric hammocks mapped by IRC. The hydric hammock polygon is from FNAI's Cooperative Land Cover layer (version 2.3).

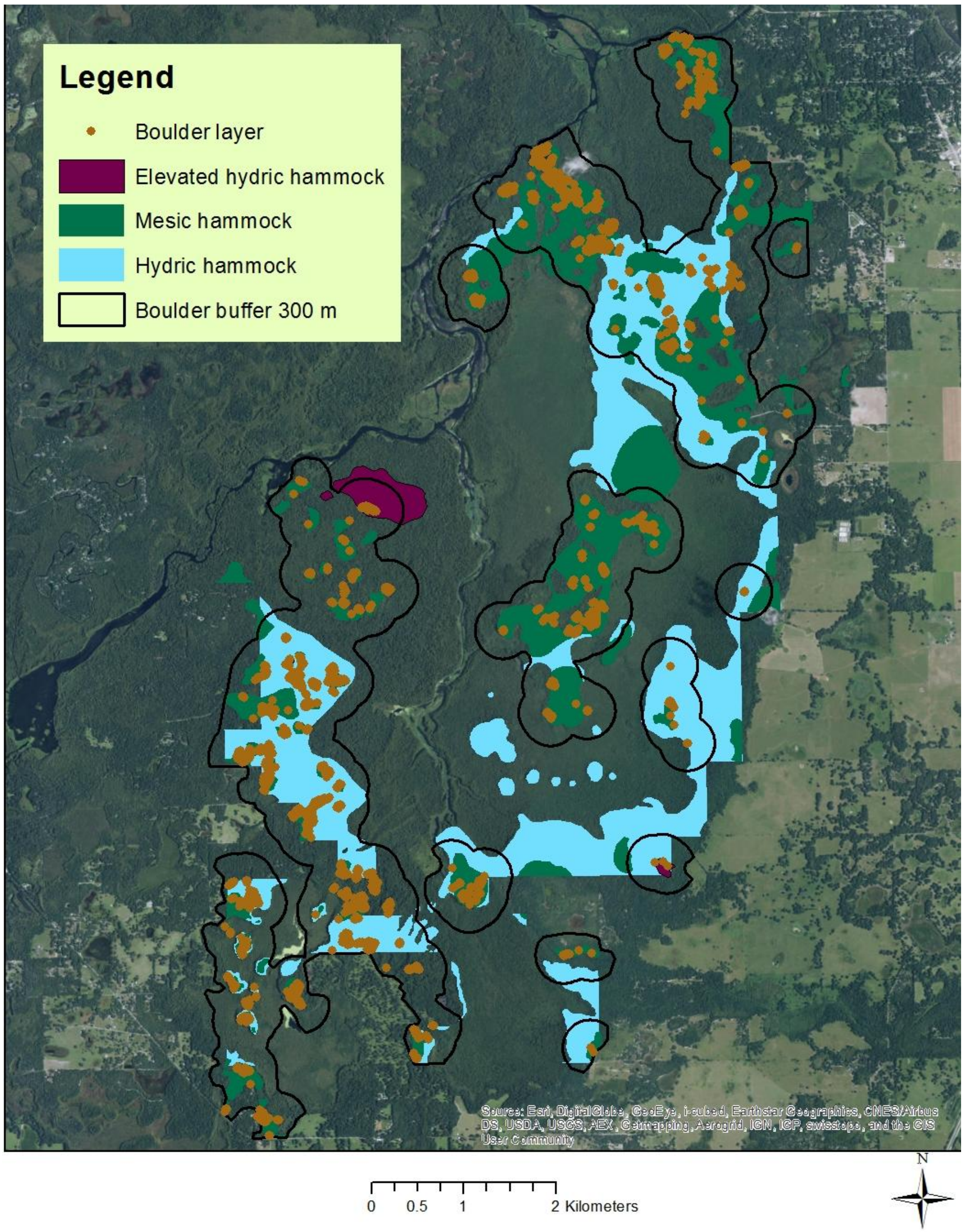

Figure 6. Map of areas in the Jumper Creek Tract where limestone boulders were found, buffered by 300 m in ArcMap to include adjacent habitat required to create and sustain the microconditions required by the Florida bristle fern.

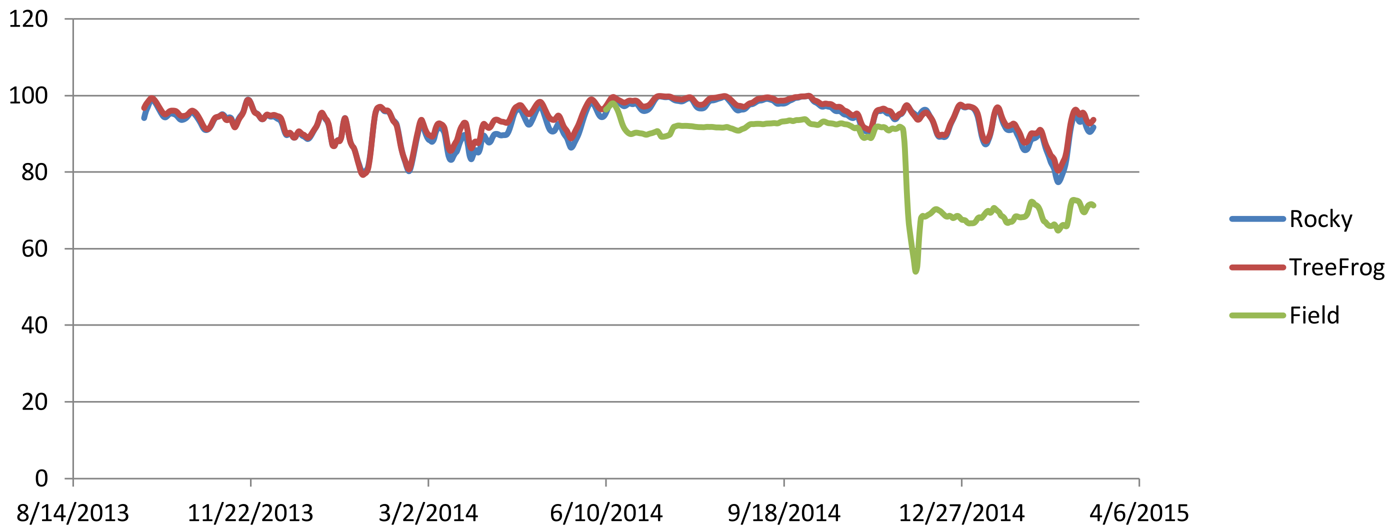

Figure 7. Graph showing relative humidity for Rocky Hammock and Tree Frog Hammock. The green line represents the data logger that was moved to the hammock/open pasture edge (10 m from pasture edge under canopy) on June 10, 2014, and shows a reduction in humidity near the grazed pasture compared to the hammock interiors.

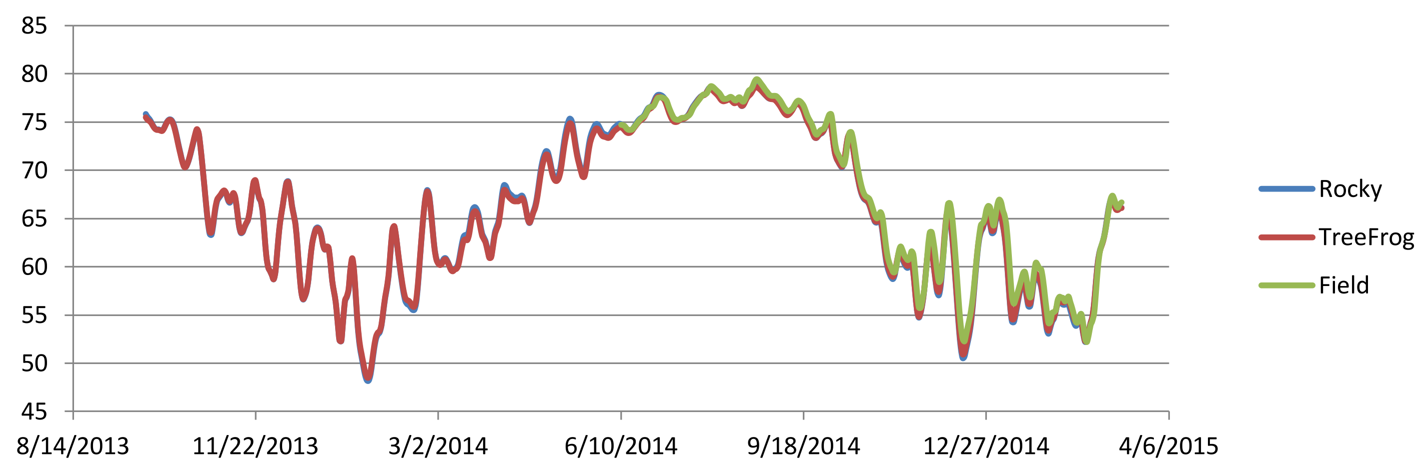

Figure 8. Graph showing similar temperatures for Rocky Hammock and Tree Frog Hammock. The green line represents the data logger that was moved to the hammock/open pasture edge (10 m from pasture edge, under canopy) on June 10, 2014, and shows similar temperatures to those recorded in the hammock interiors.

Table 2. Monthly means of average, minimum and maximum temperature in Rocky and Tree Frog Hammocks and at the field edge.

		Temperature								
Year	Month	Rocky Hammock			Tree Frog Hammock			Field Site		
		Mean ± SD	Min ± SD	Max ± SD	Mean ± SD	Min ± SD	Max ± SD	Mean ± SD	Min ± SD	Max ± SD
2013	SEP	**75.7** ± 1.8	**71.4** ± 2.0	**83.8** ± 6.2	**75.2** ± 1.4	**71.0** ± 1.8	**81.2** ± 2.6			
	OCT	**70.9** ± 5.1	**65.3** ± 6.4	**79.4** ± 5.0	**70.9** ± 5.0	**64.9** ± 6.4	**78.9** ± 4.1			
	NOV	**65.0** ± 5.5	**59.1** ± 7.1	**71.8** ± 4.7	**65.1** ± 5.7	**58.5** ± 7.5	**73.1** ± 5.1			
	DEC	**62.6** ± 6.3	**55.4** ± 7.4	**71.9** ± 5.7	**62.6** ± 6.5	**54.4** ± 7.7	**73.2** ± 6.2			
2014	JAN	**53.2** ± 7.9	**45.6** ± 9.0	**62.8** ± 8.2	**53.2** ± 8.3	**44.9** ± 9.3	**63.7** ± 9.0			
	FEB	**61.2** ± 6.7	**53.2** ± 8.5	**74.1** ± 8.4	**60.9** ± 6.9	**52.6** ± 8.6	**73.0** ± 8.0			
	MAR	**62.7** ± 4.4	**54.6** ± 6.7	**75.3** ± 6.3	**62.1** ± 4.6	**54.0** ± 6.9	**73.0** ± 5.5			
	APR	**67.8** ± 3.7	**60.7** ± 4.9	**78.5** ± 6.2	**67.4** ± 3.8	**60.1** ± 5.0	**76.6** ± 5.1			
	MAY	**71.9** ± 3.4	**65.8** ± 4.9	**80.0** ± 4.0	**72.2** ± 3.5	**65.2** ± 4.9	**80.3** ± 3.8			
	JUN	**74.8** ± 1.6	**70.4** ± 1.7	**80.1** ± 2.5	**75.4** ± 1.8	**70.0** ± 1.8	**82.7** ± 3.7	**75.7** ± 1.6	**70.8** ± 1.5	**82.1** ± 2.5
	JUL	**76.4** ± 1.6	**72.9** ± 1.8	**81.4** ± 2.0	**76.8** ± 1.6	**72.4** ± 1.9	**83.2** ± 2.0	**76.9** ± 1.6	**72.8** ± 1.8	**82.6** ± 2.0
	AUG	**77.5** ± 1.1	**73.7** ± 1.1	**84.2** ± 3.4	**77.8** ± 1.2	**73.4** ± 1.1	**84.9** ± 3.7	**78.0** ± 1.2	**73.7** ± 1.1	**85.8** ± 4.6
	SEP	**75.6** ± 1.8	**72.2** ± 1.5	**82.0** ± 3.4	**75.6** ± 1.7	**71.9** ± 1.5	**81.7** ± 3.1	**75.8** ± 1.6	**72.1** ± 1.5	**82.0** ± 2.8
	OCT	**69.1** ± 4.6	**63.2** ± 6.0	**76.6** ± 3.6	**69.1** ± 4.6	**62.7** ± 6.1	**77.8** ± 3.4	**69.5** ± 4.6	**62.6** ± 6.2	**78.2** ± 3.6
	NOV	**58.4** ± 6.7	**51.7** ± 8.2	**66.5** ± 5.7	**58.5** ± 7.1	**51.0** ± 8.5	**68.8** ± 6.5	**59.5** ± 7.0	**51.2** ± 8.4	**71.1** ± 6.9
	DEC	**60.1** ± 7.1	**54.3** ± 8.8	**68.2** ± 5.8	**60.2** ± 7.2	**53.8** ± 8.7	**69.3** ± 6.3	**61.5** ± 7.0	**53.6** ± 8.9	**78.4** ± 10.2
2015	JAN	**57.4** ± 6.5	**50.2** ± 8.1	**67.0** ± 6.3	**57.1** ± 6.8	**49.4** ± 8.3	**67.2** ± 6.8	**58.9** ± 6.4	**48.8** ± 8.6	**76.1** ± 8.4
	FEB	**56.3** ± 5.7	**47.6** ± 6.9	**69.2** ± 6.2	**55.7** ± 6.1	**46.9** ± 7.1	**67.0** ± 7.0	**56.4** ± 6.2	**46.1** ± 7.4	**68.7** ± 7.4
	MAR	**67.8** ± 4.6	**60.6** ± 6.1	**78.2** ± 5.3	**67.6** ± 4.7	**60.0** ± 6.4	**78.2** ± 4.6	**68.1** ± 5.0	**59.5** ± 6.4	**79.6** ± 5.7

Table 3. Monthly means of average, minimum and maximum relative humidity in Rocky and Tree Frog Hammocks and at the field edge.

		Relative Humidity								
Year	Month	Rocky Hammock			Tree Frog Hammock			Field Site		
		Mean ± SD	Min ± SD	Max ± SD	Mean ± SD	Min ± SD	Max ± SD	Mean ± SD	Min ± SD	Max ± SD
2013	SEP	**88.7** ± 18.0	**78.0** ± 22.3	**95.2** ± 14.2	**95.3** ± 8.8	**87.4** ± 16.1	**99.8** ± 0.8			
	OCT	**95.1** ± 2.4	**81.4** ± 7.2	**99.9** ± 0.6	**95.3** ± 2.4	**81.9** ± 7.9	**100** ± 0.1			
	NOV	**96.5** ± 3.6	**88.6** ± 8.2	**99.6** ± 1.2	**95.4** ± 4.3	**85.2** ± 10.5	**99.7** ± 0.9			
	DEC	**94.0** ± 4.5	**79.2** ± 12.3	**99.8** ± 0.7	**93.1** ± 4.9	**73.6** ± 14.2	**99.9** ± 0.6			
2014	JAN	**90.4** ± 10.3	**74.7** ± 19.6	**98.2** ± 5.4	**89.5** ± 11.0	**70.7** ± 22.1	**98.5** ± 4.0			
	FEB	**91.6** ± 7.1	**68.9** ± 22.0	**99.9** ± 0.4	**91.7** ± 6.8	**69.4** ± 20.3	**100** ± 0			
	MAR	**88.2** ± 8.6	**64.7** ± 18.8	**98.6** ± 5.0	**89.9** ± 8.7	**70.0** ± 18.0	**99.0** ± 4.0			
	APR	**92.9** ± 4.4	**76.9** ± 14.4	**99.7** ± 0.4	**94.6** ± 3.1	**83.2** ± 9.1	**100** ± 0			
	MAY	**94.8** ± 4.1	**84.2** ± 10.6	**99.8** ± 0.4	**93.6** ± 5.0	**82.2** ± 11.7	**99.9** ± 0.3			
	JUN	**98.8** ± 1.5	**95.1** ± 4.9	**100** ± 0	**97.7** ± 2.2	**90.1** ± 8.1	**100** ± 0	**92.5** ± 3.7	**89.9** ± 3.7	**94.3** ± 3.4
	JUL	**99.4** ± 1.2	**97.4** ± 4.0	**100** ± 0	**98.9** ± 1.7	**94.7** ± 6.5	**100** ± 0	**91.0** ± 2.1	**88.3** ± 5.2	**92.9** ± 0.9
	AUG	**98.7** ± 1.4	**94.1** ± 5.9	**100** ± 0	**98.7** ± 1.5	**93.0** ± 6.9	**100** ± 0	**91.8** ± 0.9	**87.7** ± 5.4	**93.6** ± 0.7
	SEP	**99.1** ± 1.3	**94.4** ± 6.3	**100** ± 0	**99.5** ± 0.8	**96.5** ± 4.9	**100** ± 0	**93.1** ± 0.7	**91.0** ± 2.6	**94.5** ± 0.6
	OCT	**97.5** ± 2.2	**89.2** ± 7.0	**99.9** ± 0.2	**97.8** ± 1.9	**89.7** ± 7.7	**100** ± 0	**92.2** ± 1.4	**84.1** ± 6.9	**95.3** ± 1.2
	NOV	**96.1** ± 4.4	**87.7** ± 10.3	**99.7** ± 0.9	**95.9** ± 3.9	**83.4** ± 11.5	**99.9** ± 0.4	**83.4** ± 20.0	**70.3** ± 22.6	**91.4** ± 13.0
	DEC	**96.3** ± 3.2	**85.1** ± 10.3	**100** ± 0	**96.1** ± 3.1	**82.9** ± 11.7	**100** ± 0	**68.3** ± 2.1	**53.8** ± 12.9	**78.4** ± 4.3
2015	JAN	**93.2** ± 5.4	**77.4** ± 13.3	**99.6** ± 1.4	**93.7** ± 5.5	**78.5** ± 12.7	**99.6** ± 1.4	**68.6** ± 3.3	**51.1** ± 12.3	**82.3** ± 3.1
	FEB	**88.1** ± 9.3	**64.6** ± 19.7	**99.0** ± 2.4	**89.4** ± 8.8	**68.5** ± 18.6	**99.6** ± 1.1	**68.9** ± 5.7	**50.8** ± 12.5	**85.1** ± 2.3
	MAR	**93.4** ± 4.3	**76.0** ± 14.4	**99.9** ± 0.3	**94.5** ± 4.3	**80.3** ± 13.4	**100** ± 0	**69.6** ± 4.1	**58.8** ± 5.2	**82.0** ± 5.8

Figure 9. Photographs showing how boulders have been piled up around oak trees, presumably related to historical agricultural activities in the area.

Appendix

Partial list of plant species that were found in the Jumper Creek Tract while surveying for Florida bristle fern.

Scientific name	Common Name	Status	Group
Acer negundo	boxelder	native	tree
Andropogon virginicus var. glauca	chalky bluestem	native	grass
Aralia spinosa	devil's walkingstick	native	shrub
Arisaema triphyllum	Jack-in-the-pulpit	native	herb
Asplenium abscissum	cutleaf spleenwort	native	fern
Asplenium cristatum	hemlock spleenwort	native	fern
Asplenium verecundum	modest spleenwort	endangered-state	fern
Asplenium x curtissii	curtis's spleenwort	endemic	fern
Baccharis glomerulifolia	silverling	native	herb
Bidens laevis	burrmarigold, smooth beggartick	native	herb
Botrychium biternatum	Southern grape fern	native	fern
Callicarpa americana	American beautyberry	native	shrub
Campsis radicans	trumpet creeper	native	vine
Carex bromoides	bromelike sedge	native	sedge
Carpinus caroliniana	American hornbeam, bluebeech	native	tree
Carya glabra	pignut hickory	native	tree
Celtis laevigata	sugarberry, hackberry	native	tree
Cephalanthus occidentalis	common buttonbush	native	tree
Chasmanthium laxum	slender woodoats	native	grass
Cicuta mexicana (C. maculata)	spotted water hemlock	native	herb
Citrus x aurantium	sour orange	not native	tree
Cladium jamaicense	Jamaica swamp sawgrass	native	sedge
Conoclinium coelestinum	blue mist flower	native	herb
Conopholis americana	American squawroot, cancerroot	native	parasite
Dichanthelium spp.	rosette grasses, witchgrass	native	grass
Dryopteris ludoviciana	Southern wood fern	native	fern
Elephantopus carolinianus	Carolina elephantsfoot	native	herb
Elytraria caroliniensis var caroliniensis	Carolina scalystem	native	herb
Epidendrum conopseum	green-fly orchid	native	orchid
Erythrina herbacea	coralbean	native	tree
Eupatorium capillifolium	dogfennel	native	herb
Fraxinus caroliniana	Carolina ash, pop ash	native	tree
Gelsemium sempervirens	yellow jessamina, evening trumpetflower	native	vine

Scientific name	Common Name	Status	Group
Habenaria floribunda	toothpetal false rain orchid	native	herb
Houstonia procumbens	innocence, round leafed bluet	native	herb
*Hydrocotyle sp.**	pennywort	native	herb
Hypoxis curtissii	common yellow stargrass	native	herb
Ilex cassine	Dahoon holly	native	tree
Ilex glabra	inkberry, gallberry	native	tree
Ilex opaca	American holly	native	tree
Iresine diffusa	Juba's bush	native	herb
Itea virginica	Virginia willow, Virginia sweetspire	native	shrub
Juglans nigra	black walnut	native	tree
Limnobium spongia	American sponge plant, frog-bit	native	herb
Lindernia spp.	false pimpernel	native	herb
Liquidambar styraciflua	sweetgum	native	tree
Listera australis	Southern tway-blade	threatened-state	orchid
Lobelia cardinalis	cardinal flower	threatened-state	herb
Lobelia puberula	downy lobelia	native	herb
Ludwigia repens	creeping primrose willow	native	aquatic
Lyonia ferruginea	rusty staggerbush	native	shrub
Lyonia lucida	fetterbush	native	shrub
Macrothelypteris torresiana	Mariana maiden fern	not native	fern
Magnolia grandiflora	Southern magnolia	native	tree
Magnolia virginiana	sweet bay	native	tree
Mecardonia acuminata var peninsularis	axil flower	native	herb
Melanthera nivea	snow squarestem	native	herb
Melothria pendula	Guadeloupe cucumber, creeping cucumber	native	vine
Mikania cordifolia	Florida Keys hempvine	native	vine
Mikania scandens	Climbing hempvine	native	vine
Mitchella repens	partridgeberry	native	vine
Monotropa uniflora	Indian pipe	native	herb
Oplismenus hirtellus	woodsgrass, basketgrass	native	herb
Cartrema americanus	wild olive, American devilwood	native	tree
Osmunda regalis	royal fern	native	fern
Tiedemannia filiformis	water cowbane	native	herb
Panicum hemitomon	maidencane	native	grass
Panicum rigidulum	redtop panicum	native	grass
Parietaria praetermissa	clustered pellitory	native	herb
Parthenocissus quinquefolia	Virginia creeper	native	vine
Pecluma dispersa	rockcap fern, polpody	endangered-state	fern
Pecluma plumila	plume polypody or rockcap fern	endangered-state	fern
Pecluma ptilota var bourgeauana	palmleaf rockcap fern	endangered-state	fern

Scientific name	Common Name	Status	Group
Persea borbonia	red bay	native	tree
Peperomia humilis	low peperomia	endangered-state	herb
Pharus lappulaceus	creeping leafstalkgrass	endangered-state	grass
Phlebodium aureum	golden polypody	native	fern
Pilea microphylla	rockweed, artillary plant	native	fern
Pinguicula pumila	small butterwort	native	herb
Pluchea foetida	stinking camphorweed	native	herb
Polygala nana	candyroot	native	herb
Ponthieva racemosa	hairy shadow witch	native	orchid
Psilotum nudum	whisk-fern	native	epiphyte
Psychotria nervosa	wild coffee	native	shrub
Psychotria sulzneri	short-leaf wild coffee	native	shrub
Pteris vittata	Chinese ladder brake	not native	fern
Quercus geminata	sand live oak	native	tree
Quercus laurifolia	laurel oak	native	tree
Quercus nigra	water oak	native	tree
Quercus virginiana	live oak	native	tree
Rhexia spp.	meadow beauty	native	herb
Rhynchospora inundata	narrowfruit horned breaksedge	native	sedge
Rhynchospora miliacea	milled breaksedge	native	sedge
Rivina humilis	rougeplant	native	herb
Ruellia caroliniensis	Carolina wild petunia	native	herb
Sabal minor	dwarf palmetto, bluestem	native	palm
Sabal palmetto	cabbage palm	native	palm
Sagittaria graminea var graminea	grassy arrowhead	native	herb
Salix caroliniana	Carolina willow	native	shrub
Salvia coccinea	tropical sage, blood sage	native	herb
Salvia lyrata	lyreleaf sage	native	herb
Salvinia minima	water spangles, water fern	not native	aquatic
Sambucus nigra	elderberry, American elder	native	tree
Sapindus saponaria	soapberry	native	tree
Scoparia dulcis	sweetbroom, licorice weed	native	herb
Serenoa repens	saw palmetto	native	palm
Smilax auriculata	ear-leaf greenbriar	native	vine
Smilax bona-nox	saw greenbriar	native	vine
Smilax pumila	sarsaparilla vine	native	vine
Solanum capsicoides	soda apple, cockroachberry	not native	herb
Spartina bakeri	sand cordgrass	native	grass
Spiranthes odorata	fragrant ladiestresses	native	orchid
Symphyotrichum carolinianum	climbing aster	native	vine

Scientific name	Common Name	Status	Group
Taxodium distichum	bald-cypress	native	tree
Thelypteris dentata	downy maiden fern	not native	fern
Thelypteris hispidula var versicolor	hairy maiden fern	native	fern
Thelypteris kunthii	widespread maiden fern, Southern shield fern	native	fern
Thelypteris palustris	marsh fern	native	fern
Tillandsia bartramii	Bartram's airplant	native	epiphyte
Tillandsia usneoides	Spanish moss	native	epiphyte
Toxicodendron radicans	Eastern poison ivy	native	vine
Tradescantia fluminensis	small-leaf spiderwort	not native	herb
Tradescantia ohiensis	bluejacket, Ohio spiderwort	native	herb
Trichomanes petersii	Peters bristle fern	native	fern
Trichomanes punctatum ssp. floridanum	Florida bristle fern	endemic, endangered-federal	fern
Trichostema dichotomun	forked bluecurls	native	herb
Ulmus americana	American elm	native	tree
Utricularia inflata	floating bladderwort	native	aquatic
Vaccinium arboreum	sparkleberry	native	shrub
Vaccinium corymbosum	highbush blueberry	native	shrub
Vaccinium myrsinites	shiny blueberry	native	shrub
Valeriana scandens	Florida valerian	native	herb
Verbesina virginica	white crownbeard, frostweed	native	herb
Vernonia gigantea	giant ironweed	native	herb
*Viola sp.**	violets	native	herb
Viburnum obovatum	Walter's viburnum, small-leaf viburnum	native	shrub
Vitis rotundifolia	muscadine grape	native	vine
Vitis cinerea var floridana	Flroida grape	native	vine
Vittaria lineata	shoestring fern	native	epiphyte
Woodwardia areolata	netted chain fern	native	fern
Woodwardia virginica	Virginia chain fern	native	fern
Carex comosa	longhair sedge	native	fern
Helianthus radula	stiff sunflower	native	herb
Nephrolepis cordifolia	tuberous sword fern	not native	fern
Nephrolepis exaltata	sword fern	native	fern
Rosa palustris	swamp rose	native	herb
Rubus trivialis	Southern dewberry	native	vine
Sagittaria graminea var chapmanii	Chapman's arrowhead	native	herb
Smilax glauca	wild sarsaparilla	native	vine
Tillandsia setacea	Southern needleleaf	native	epiphyte
Tillandisa recurvata	ball moss	native	epiphyte
Sisyrhynchium angustifolium	narrowleaf blue eyed grass	native	herb