For information contact bradley@regionalconservation.org or (305) 247-6547

A Quantitative Plant Inventory of the Big Cypress National Preserve, Florida

Keith A. Bradley, Steven W. Woodmansee, Jimi L. Sadle, George D. Gann
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The Institute for Regional Conservation
22601 S.W. 152 Avenue; Miami, Florida 33170
George D. Gann, Executive Director

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Inventory of Vertebrates and Vascular Plants

Abstract. Between 2002 and 2004 a quantitative plant inventory of the 295,100 ha Big Cypress National Preserve in southern Florida was conducted. To conduct the inventory plant species were recorded at 300 sample stations throughout the Preserve. The data from these transects allowed us to estimate the abundance of each plant taxon within the Preserve. In addition to transects, other areas were searched by the authors. Previous inventories of the Preserve were also assessed on a taxon by taxon basis to determine the validity of each taxons' presence in the Preserve. We recognize 1094 plant taxa as currently or formerly occurring in the Preserve.

Introduction. The Big Cypress National Preserve is a 295,100 ha unit of the National Park Service located in Collier, Monroe, and Miami-Dade counties, Florida, at the southern end of the Florida Peninsula. It is adjacent to other conservation areas, including Everglades National Park, Fakahatchee Strand Preserve State Park, and the Florida Panther National Wildlife Refuge.

The vegetation of the Preserve varies widely, from mangrove tidal swamps on the coast, to freshwater wetlands along the western edge of the Florida Everglades, to tropical hardwood forests and mesic flatwoods. The dominant feature throughout however are freshwater swamps and savannas dominated by a pond cypress (*Taxodium ascendens*), the namesake of the preserve. The structure and species assemblage of the cypress ecosystems varies along a hydrological gradient. Savannas occur in areas of only seasonal inundation and are dominated by a relatively open and short canopy of *T. ascendens* with a variable shrub layer and an herb layer usually dominated by a diverse assemblage of grasses, sedges, and herbs. On the opposite extreme, in areas that have standing water nearly year round are deeper cypress swamps, including sloughs and cypress domes. These communities typically have a much higher canopy of *T. ascendens* with a subcanopy of hardwoods, and a sparse herb and graminoid layer, often with submerged or floating aquatics.

History of Botanical Exploration: The first collections we know of that are definitely from what is now the Preserve were collected by John Kunkel Small in 1916. Collecting activity within the Preserve was very limited until the 1970's, with only sporadic collections being made. It seems that botanists focused on other areas of South Florida at that time, and if they were in what is now the Big Cypress NP they were probably driving through it to go to the Fakahatchee Strand to the west. In the 1970s a number of botanists began collecting in the preserve, including George Avery, Donovan and Helen Correll, John Popenoe, and David and Sally Black. The Blacks conducted several months of field work to prepare the first plant inventory of the preserve (Black & Black 1980) reporting 677 taxa. After this publication collecting was taken up mainly by preserve employees, including John DeLapp who collected extensively, Renee Beymer, Tony Pernas, and Jim Snyder, and a few other mostly local botanists making small collections.

Between September 1998 and December 2000 Jordan Muss and Daniel Austin conducted field work to revise the Black & Black (1980) inventory (Muss et al. 2003). They made weekly visits to the preserve, mainly focusing on the addition lands north of I-75 (Alligator Alley) that were not part of the preserve when Black & Black prepared their list. The Muss et al. list reports an increase of 174 species (26%) over the Black & Black list. Both Black & Black (1980) and Muss et al. (2003) report the abundance of each plant taxon in the Preserve, indicating whether each was common, uncommon, or rare. These values were subjective, based on the authors' field experience.

Discussions between the National Park Service and The Institute for Regional Conservation (IRC) were conducted to determine in 2000 to determine the vascular plant

inventory needs in South Florida's National Park units. The NPS Inventory and Monitoring Program has a goal of detection of 90% of the species in each park unit. Based on the experience of IRC and NPS staff, it was determined that 90% of the preserve's flora had not been recorded yet. IRC staff had recently documented a number of previously unrecorded species in short field excursions to the preserve. In addition, the previously published inventories included only qualitative data on abundance of individual taxa. Thus, this study was initiated to document at least 90% of the plant taxa in the preserve, and to conduct a quantitative assessment of each taxons' abundance.

Methods. The Big Cypress National Preserve was overlain with a 1 km x 1 km cell grid. Each cell was given a unique identifying code. Three hundred sample stations were located throughout the Preserve, with no more than one station within a 1 km x 1 km cell. Two hundred of these sample locations were randomly placed and stratified by the acreage of habitats within the Preserve. The additional 100 stations were placed in gaps missed by the randomization and in areas where, based on the authors' experience, where there was a higher likelihood of encountering plant taxa previously unrecorded for the Preserve. Sample stations were reached by car, foot, ATV, swamp buggy, helicopter, or boat. Field personnel navigated to the pre-selected points with a Garmin GPS unit.

At each survey point two transects were established on randomly chosen compass headings. Each transect was run 250 meters. All plant taxa intercepting the transect were recorded. In addition, each plant taxon at each 2.5 meter intercept was also recorded. All plant species observed within the surrounding 1 km x 1 km cell were recorded, including the species recorded on transects and at intercepts.

Because most of the 300 sample stations were placed in relatively undisturbed habitats we incorporated another technique to sample taxa that may be common in the extremely disturbed roadsides of the Preserve, but rare throughout the rest of the Preserve. In addition to the above transects data was also collected on the Preserve of plant taxa on roadsides within the Preserve. Sixty pairs of belt transects were randomly placed on roadsides in the Preserve[1]. Belt transects were 500 m long ad 2 m wide. A pair of transects were placed adjacent to each other on the sides of randomly selected stretched of roadway. Each plant taxon within these transects was recorded.

Other areas within the Preserve were search as time allowed, including unusual habitats seen on the way to sample points, disturbed areas such as fill pads and old home sites, and placed were unusual species had been previously unrecorded.

An attempt was made to collect two voucher specimens of each plant taxon that was newly recorded for the Preserve. This was done only when fertile or otherwise readily identifiable material was available, and when collecting the specimens did not endanger an occurrence of a native plant taxon.

Some plant occurrences were also recorded outside of the sample cells and road transects. These were almost always plant species that were new to the Preserve. For the most part we collected vouchers of these specimens, but some remained un-vouchered because they were too rare to collect or were sterile.

In addition to the inventories, other botanists and naturalists since the early 1900s have collected or recorded plant taxa in what is now the Preserve. These data have been

[1] US 41 (Alligator Alley) was not sampled. It's shoulders are fenced the Preserve boundary, and the shoulders are maintained exclusively by the Florida Department of Transportation, not the National Park Service as other roads in the Preserve.

compiled by the authors in searches of local and national herbaria, literature, and communication with local naturalists. These data have been incorporated into a relational database using Microsoft Access. Extensive herbarium data collected by Muss et al. (2003) have also been incorporated into our database when we did not also have their data.

Specimen data from 2045 herbarium specimens from 11 herbaria was found, Archbold Biological Station (ARCH), Big Cypress National Preserve (unregistered), Everglades National Park (unregistered), Florida Atlantic University (FAU), Florida State University (FSU), Fairchild Tropical Botanic Garden (FTG), New York Botanical Garden (NY), Marie Selby Botanical Gardens (SEL), University of Florida (FLAS), U.S. National Herbarium (US), and the University of South Florida (USF).

The collection books of John Kunkel Small (1869 – 1938), housed in the archives of the New York Botanical Garden were also examined. Twenty four collections from within the current Preserve boundaries were found in these books and incorporated into our database.

During and following field work all available occurrence data for the preserve was analyzed, including our field data, previous inventories and publications, and other herbarium specimens, as described above. The validity of each plant taxon reported for the preserve was assessed and determined if each taxon was an extant occurrence, not seen recently, probably extirpated, or a doubtful or false record.

Results. Field surveys were conducted between April 2002 and January 2005. Field work was conduced throughout the year, but concentrated in the spring due to low water levels which allowed easier access. In excess of 7,000 person hours were spent in the Preserve. Conducting research in the preserve was a logistical challenge. Areas were accessed on foot, ATV, swamp buggy, canoe, kayak, bicycle, helicopter, and 4x4. Summer months were especially difficult because high water levels rendered trails impassable to most vehicles. Travel to a sample location often took up to several hours, with an equally long trip getting back to a highway. While sampling, field workers encountered many hazards. Water moccasins were often abundant and we were inches away from them (and their open white mouths) on many occasions. Alligators were a constant worry in deeper water, and one of us stepped on one. The most exciting encounter was Sadle being chased up a tree by a mother black bear protecting her two cubs, almost putting him in the books as the first person to be mauled by a bear in the State of Florida.

We recorded 1011 plant taxa in the field. In the 1 km x 1km cells we recorded 863 plant taxa. Intra-cell diversity varied widely, with a maximum of 265 taxa/km^2, a minimum of 24 taxa/km^2, and a mean of 132 taxa/km^2. On 600 transect lines we recorded 631 taxa. On 60,000 intercepts 530 taxa were recorded. On road transects 421 taxa were recorded. We also collected 673 taxa, with many of the collections being taken from outside of sample areas. In addition we recorded 27 taxa that were not in sample areas or for which we collected specimens.

Combining our field data with reliable records from other data sources results in a list of 1094 taxa that are extant or were previously extant in the preserve. This amounts to 243 species over that reported by Muss et al. (2003) and 417 over that reported by Black and Black (1980). There are 1044 plant taxa that are currently extant in the Preserve, and 50 that have not been seen recently and may no longer be extant there. We recorded 96.8% of the extant species ourselves and consider the remainder to be reliable records. Fifty-nine plant taxa that were previously reported for the preserve were determined to be false or doubtful records, and thus have been excluded from the preserve inventory. Correcting for taxonomy

and the excluded taxa, we have records (either our own or other data) for 245 plant taxa previously unreported for the preserve.

The flora of the Preserve is comprised of 813 native plant species and 242 introduced species. Our data also includes 39 species found only in cultivation. Black and Black (1980) found that 11% of the flora was introduced, and Muss et al. (1993) found that 18.5% of the flora was introduced. Of the 1055 native and naturalized taxa we recorded for the Preserve 22.1% are introduced. Of the new taxa we recorded for the Preserve 101 (44.3%) are introduced and 127 (55.7%) are native. Introduced species represent a range from completely ruderal taxa to those that are invasive.

The most frequent exotic plant in the Preserve was *Schinus terebinthifolius*, occurring in 61.7% of cells and 55.6% of road transects. The other exotics that were most frequently recorded were *Pteris vittata* (31.7%), *Spermacoce verticillata* (24.0%), *Urena lobata* (18.7%), and *Panicum repens* (18.0%). Of these 242 exotics, 59 are listed by FLEPPC, 39 as Category I and 20 as Category II. Of particular interest, *Lygodium microphyllum* was found in 8% of cells and was the 14th most frequent exotic in the Preserve.

In terms of cover (from intercepts), the dominant species in the Preserve is *Taxodium ascendens* with a cover of 26.0%. The other species with the greatest cover include *Cladium jamaicense* (12.4%), *Paspalum monostachyum* (9.4%), *Myrica cerifera* (6.7%), *Serenoa repens* (6.2%), *Pinus elliottii* var. *densa* (5.3%), *Blechnum serrulatum* (5.3%), *Fraxinus caroliniana* (5.3%), *Sabal palmetto* (5.2%), and *Schizachyrium rhizomatum* (4.5%). Thirty two species had a cover of 1% or higher.

No plants listed by the U.S. Fish and Wildlife Service under the Endangered Species Act are known to occur in the preserve. Three species *Dalea carthagenensis* var. *floridana*, *Digitaria pauciflora*, and *Sideroxylon reclinatum* subsp. *austrofloridense* are considered as candidates for listing (*Digitaria* and *Sideroxylon* were first recorded for the preserve in this study). In contrast, the Preserve contains 82 species listed as endangered or threatened by the Florida Department of Agriculture and Consumer Services. Another 12 state-listed species are known from the Preseve from reliable records, but were not found by us. These may no longer be present in the Preserve. The Preserve also contains 57 taxa considered to be critically imperiled in South Florida (Gann et al. 2002).

New taxa were found throughout the Preserve and were detected in a variety of situations. Within the 300 km2 sample cells we recorded 152 (62.0%) of the new taxa. Sixty (24.5%) of the new taxa were recorded on transects and 48 (19.6%) on intercepts. Forty-six (18.8%) of the new taxa were found in the road transects.

The number of discoveries of new occurrences of rare plants in his study was extraordinary. We recorded five new native species for the flora of South Florida (south of Lake Okeechobee): *Carex comosa, Euthamia graminfolia* var. *hirtipes, Hypericum punctatum, Polygala verticillata* var. *isocycla*, and *Rhexia petiolata*. We discovered two South Florida endemic species being considered for listing by the U.S. Fish and Wildlife Service that were previsously known only from Miami-Dade County: *Digitaria pauciflora* and *Sideroxylon reclinatum* subsp. *austrofloridense*. We also discovered 25 taxa considered Critically Imperiled in South Florida that were previously unknown from the Preserve. Some examples are *Anagallis pumila* which was previously known only from one private station in northern Collier County, *Carex verrucosa* which is otherwise known from two occurrences in Lee County, *Eragrostis tracyi* which was known only from the southwest Florida coast, *Rhychosia swartzii* which was known from only a few sites in Miami-Dade County, and *Schizaea pennula* which is otherwise known from only two other occurrences.

New stations for rare plant species previously known from Preserve were made. *Campylocentrum pachyrhizum* was collected in the Preserve in 1956 and not seen again until it was found by Sadle not long before this study started. It was discovered at several more stations during this study. *Croton humilis* had not been seen in the Preserve since 1978 but we recorded it in four cells. *Lobelia homophylla* was not seen in the Preserve since a single collection was made at Deep Lake in 1964, but we rediscovered it at the same location 40 years later. *Oncidium ensatum*, previously only rumored to be in the Preserve was found in one cell (and only three plants!). Other similar species include *Clitoria mariana, Dalea carthagenensis* var. *floridana, Ionopsis utricularioides, Isoetes flaccida, Juncus repens, Maxillaria crassifolia, Polygala polygama, and Tillandsia pruinosa.* One of the favorites was the discovery of new stations of the ghost orchid, *Polyradicion lindenii.*

Several exotic plant species were discovered that were new to the flora of South Florida. This includes two as new to the Flora of North America. We found the sedge *Cyperus unioloides* along Loop Road. We found the legume *Stylosanthes guianensis* in newly planted sod at Kirby Storter Wayside Park. It was growing with a *Desmodium* species that we have been unable to identify that seems to be new to the flora of Florida. We are still working on determining this species. Additions to the flora of South Florida south of Lake Okeechobee include *Begonia cucullata, Eragrostis secundiflora* subsp. *oxylepis, Eragrostis unioloides*, and *Paspalum dissectum.*

Discussion. There are several reasons why we recorded and 245 new species in the preserve. One significant factor is the number of time personnel spent in the field during this project. We spent in excess 7,000 person hours in the Preserve during a period of 34 months. Because of this amount of time, the randomly placed sample locations, and the distance covered traveling to sample stations, we were able to survey extensive areas that were previously unexplored by other botanists. We were able to access coastal areas which were almost completely ignored by others, spent a considerable amount of time searching disturbed areas, and covered enough ground to detect some very rare taxa.

We continued to discover new taxa until the end of the study. In fact, on a single field day near the end of the stuffy devoted exclusively to collecting 12 new taxa were recorded. The vegetation and landscape of the Preserve is extremely heterogeneous. There are wide variations in habitat type and quality, and numerous disturbed areas scattered throughout the Preserve. These factors contributed to the great diversity of the Preserve, but also results in many rare, hard to detect species. With more field work new taxa will continue to be found, including both exotic plants that have yet to recruit into the Preserve, but also previously unnoticed native and exotic taxa.

As expected, the diversity of exotic species in the Preserve is increasing. We recorded 242 introduced species, 59 of which are listed by the Florida Exotic Pest Plant Committee. The percentage of exotic species in the Preserve's flora has continued to increase since the first inventory done by Black and Black in 1980. The Black and Black inventory consisted of 11% introduced taxa. The Muss et al. list had 18.5% of species as introduced. Our inventory raised that percentage even higher with 22.1% of taxa introduced.

Of particular interest in this study was the use of transects as part of the inventory. Our use of quantitative sampling to conduct this inventory had both positive and negative aspects. These transects are very labor intensive, and probably took up at least 75% of the time we spent in the field. While running transects, focus was also placed on plants immediately on or adjacent to the transect line, keeping us from seeing many of the other

species that may have been in the area. On transects 60.4% of the plant species in the Preserve were recorded on the transects, and 50.8% were recorded on the intercepts. This is better than we recorded using identical methods in Biscayne National Park, with 52.2% and 42.0% respectively. In addition, of the selected sample cells, 82.7% of the Preserve's taxa were recorded. We believe that if more systematic searches were conducted, rather than running transects, we would have seen more taxa, including new taxa to the preserve. However, transects did offer two definite benefits. One is the generation of quantitative data on abundance. Another benefit is that the random placement of transects forced us to sample areas we would not otherwise have selected often, such as dense areas of exotics or fire suppressed areas with dense hardwoods and palms. This allowed us, for example, to discover *Schizaea pennula* in the Preserve which was growing in a low diversity, dense head of *Serenoa repens*, an area which a botanist normally would pass up for more diverse and easily accessible area.

We also feel that weighting sample points by acreage of habitat has both positive and negative aspects. To quantify the abundance of the species in the preserve is was necessary to use this technique, since the more abundant plant communities must be sampled more. A negative aspect of this weighting, at least in the Preserve, is that we had to spend much more time in the common plant communities, such as marl prairies, that are much more homogenous and we found that they were much less likely to contain new plant species. Rarer habitats, such as hammocks and higher elevation flatwoods, were much more likely to contain new taxa. Areas that were previously given less attention by botanists, such as the coastal areas of the Preserve, were also found to contain more new taxa.

We recommend that in conducting plant inventories a scheme for collecting two types of data be developed independently. One is the documentation of new plants for the sample area. The second is the quantification of the abundance of each taxon in the sample area. These two methods are complementary. Plant taxa in a given area are seldom if ever randomly distributed, often occurring in discrete and sometimes rare habitats. Many species may only be found in a few very small areas relative to the size of the sample area. Conducting a thorough inventory should include some systematic searches of all habitat types including the rarest of habitats, and should also be based in part on the surveyor's experience. For example, in the case of the Preserve, randomly selected cells could have been used to conduct a systematic inventory, with effort being put into a more thorough search of each of those cells. In addition to this, the rarest habitats (those with the smallest acreage) should have been searched, as well as a systematic search of most of the disturbed habitats in the Preserve. This should have been then augmented by other searches of areas we felt to be unique and a likely place to find new species. While not quantitative, this method begins with a systematic approach and is augmented by other techniques, leading to the discovery of the majority of plant taxa. Quantitative techniques, such as transects, can then be used to quantify the abundance of plant taxa, keeping in mind that not all species will be encountered on transects.

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