June 28, 2023

To: Jonathan Putnam
Office of International Affairs
National Park Service
1849 C Street NW
Washington, DC 20240

jonathan_putnam@nps.gov
(202) 354-1809

Re: Nominating Okefenokee NWR for UNESCO World Heritage List, Docket Number NPS-WASO-OIA-DTS-35557, PPWODIREI0-PIN00IO15.XI0000-234P104215

Dear Mr. Putnam,

As Suwannee Riverkeeper and for our umbrella organization WWALS Watershed Coalition, Inc., I thank the U.S. for submitting a nomination for the Okefenokee National Wildlife Refuge (ONWR) from the U.S. World Heritage Tentative List ("Tentative List") to the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage List. https://whc.unesco.org/en/tentativelists/5252/

The vast majority of the Okefenokee Swamp is in the Suwannee River Basin, and some 85% of the outflow of the Swamp goes down the Suwannee River, which continues through Georgia and across Florida, where it is the subject of the state song, to the Gulf of Mexico.

In addition to our previous letter of January 26, 2021 (attached), please accept the comments in the present letter.

Operational Guidelines

Here are a few suggestions for some of the items in the Operational Guidelines

3.1.c. Statement of Integrity:

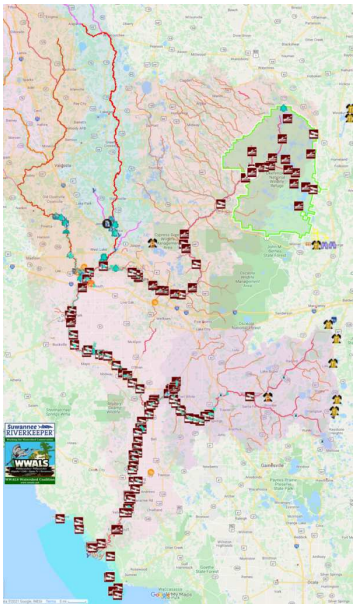
The ONWR includes 92% of the Okefenokee Swamp and thus includes all elements of Outstanding Universal Value and is of adequate size to represent the features and processes of the property's significance. The ONWR suffers adverse effects of development: see 4.b (i).

3.1.e. Protection and management requirements

The ONWR has federal legal protecitons as a Wilderness Area and a National Wildlife Refuge. Further protections are needed to fend off development beyond the boundaries of the ONWR. See 4.b. (i).

4.b (i) Development pressures and management response:

For the second time in twenty years, a titanium dioxide strip mine threatens the Okefenokee Swamp, this time within three miles of the southeast border of the ONWR, organized by coal miners from Alabama. The U.S. Army Corps of Engineers has abdicated oversight, leaving only the Georgia Environmental Protection Division (GA-EPD), standing between the miners and the Swamp. https://epd.georgia.gov/twin-pines GA-EPD has received more than 100,000 comments on the five permit applications, the overwhelming majority against the mine. The ONWR Manager testified in uniform for the Swamp and against the mine in a Georgia legislative hearing about a bill that would prohibit further mining on Trail Ridge east of the Swamp.[1]



PO Box 88, Hahira, GA 31632
850-290-2350
wwalswatershed@gmail.com
www.wwals.net
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est. June 2012

WWALS Watershed Coalition WWALS advocates for conservation and stewardship of the surface waters and groundwater of the Suwannee River Basin and Estuary, in south Georgia and north Florida, among them the Withlacoochee, Willacoochee, Alapaha, Little, Santa Fe, and Suwannee River watersheds, through education, awareness, environmental monitoring, and citizen activities.

Suwannee RIVERKEEPER® is a program and a paid staff position of WWALS.

[1] Early County News, March 21, 2023, "Okefenokee Swamp mining debate reaches legislature," https://www.earlycountynews.com/articles/okefenokee-swamp-mining-debate-reaches-legislature/

4.b (ii) Environmental pressures, natural disasters and risk preparedness

Fires in and around the Okefenokee Swamp are an increasing risk beyond natural prevalence, because of drought and land use. Wildfires in 2007 put some people in the hospital 70 miles away, and sent smoke as far west as Mississippi, as far north as North Carolina, and as far south as Fort Lauderdale. Wildfires in 2015 required assistance from counties throughout south Georgia. This is all in addition to adverse local effects such as destruction of trees and other wildlife habitat. Dewatering of the land around the Swamp or lowering of the water level of the Swamp itself would increase fire pressures. The proposed strip mine near the Swamp could cause such dewatering or water level change, thus increasing the prevalence of wildfires. Public and private landowners around the Swamp cooperate in firebreaks and other measures to minimize wildfire risks. Prohibiting mining near the Swamp would also help.

Ten Criteria

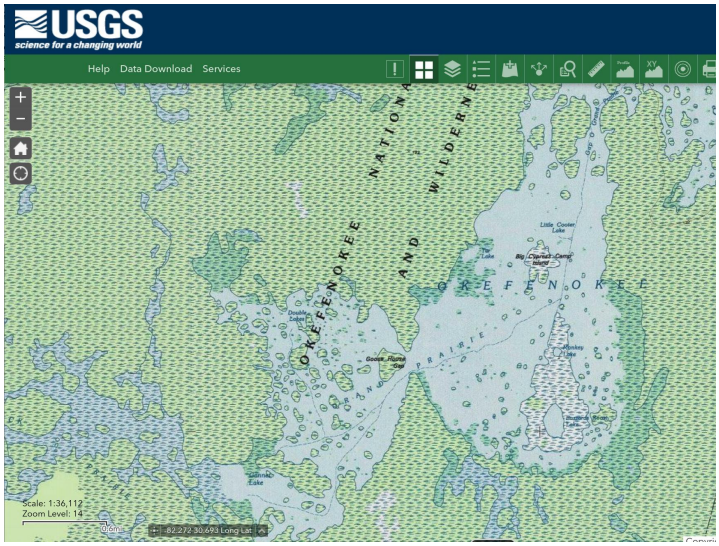
In our previous letter, we addressed each of the ten Criteria. Here are a few more notes.

(x) to contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation

Our previous letter includes many examples, with some drawn from the application that made the ONWR a RAMSAR wetland of international importance since 1986.
https://rsis.ramsar.org/ris/350

In addition, the Okefenokee Swamp includes old-growth cypress trees more than 400 years old.[2]

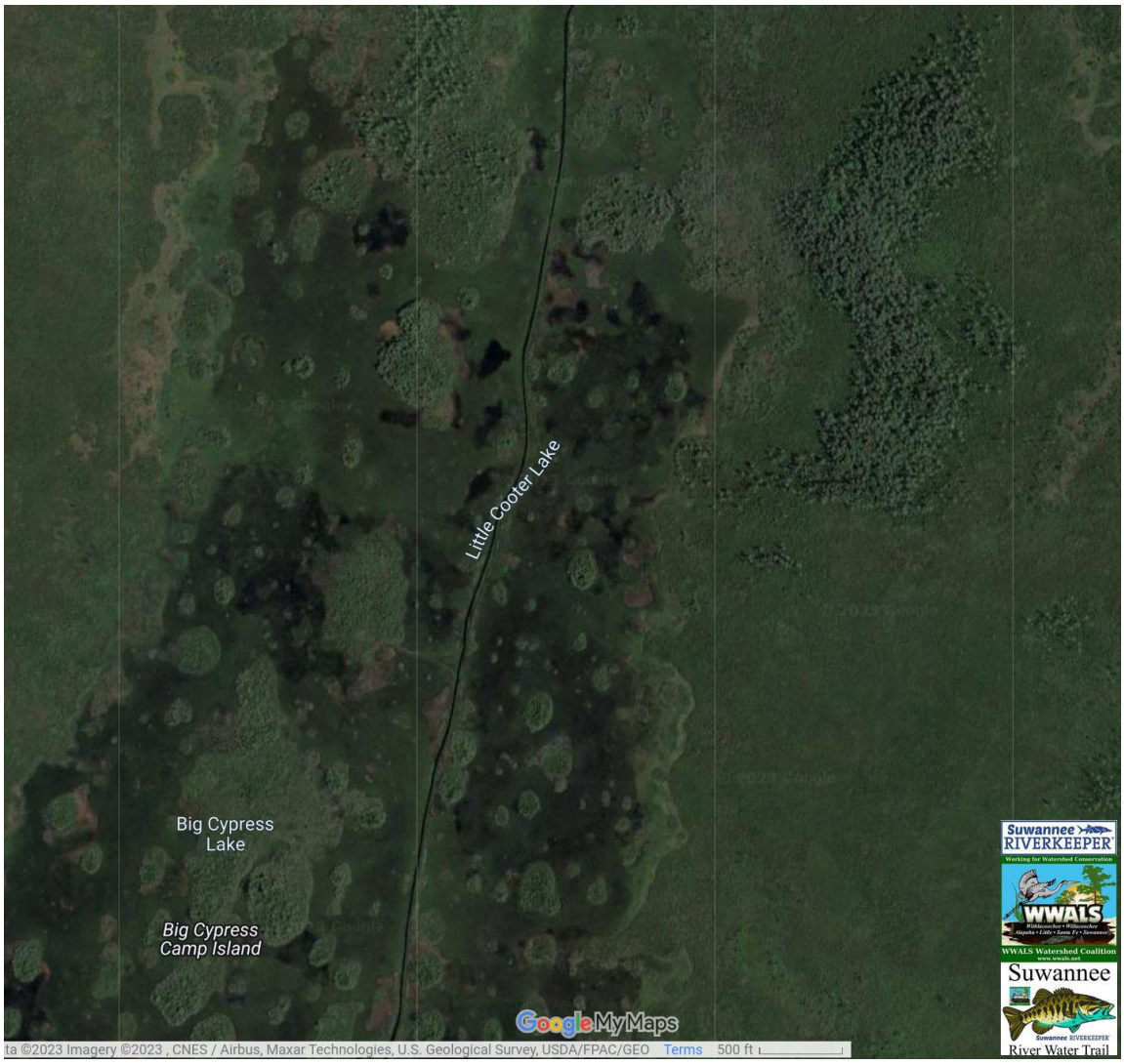
There is "a unique remnant stand of old-growth pond cypress (*Taxodium ascendens*) occuring in a shallow peaty area of the Okefenokee. Apparently, the community has not been sufficiently disturbed in the last few centuries to alter its natural succession to a bay swamp dominated by broadleaf evergreen hardwoods…. The stand lies on the northeastern perimeter of Grand Prairie in the southeastern section of the Okefenokee Swamp, Georgia."



Grand Prairie in USGS The National Map

[2] G. Ronnie Best, et al., "An Old-Growth Cypress Stand in Okefenokee Swamp," University of Florida, 1984.
https://cfw.essie.ufl.edu/wp-content/uploads/sites/312/2020/07/Best-etal-1984-OldGrowthCypressStandInOkefenokeeSwamp-BookChapter.pdf

"The stand appears to be an undisturbed remnant of a more extensive *Taxodium*-dominated swamp forest in the eastern portion of the Okefenokee. Duever (1979),[3] who treated the site as an example of a large "tree house" (a peat-formed island), estimated the size of the area to be about 1000 m in diameter. Canopy trees in the site range between 30 and over 90 cm in diameter at breast height and over 30 m in height, suggesting the area was most certainly spared from logging in the early part of the century. Several of these canopy trees are 400-500 years old or older (Duever, 1979)."



The old-growth pond cypress described appear to be visible northeast of Grand Prairie.[4]

More specifically, "The larger Taxodium in the stand are rather old with estimated ages of 445, 528, and 587 years for three individuals cored by Duever (1979). Duever states that ring quality for Taxodium is "fair-good" (based on a sample size of 126 trees over all of Okefenokee Swamp). Therefore, it is safe to assume that at least several of the older Taxodium have been present in the site for over 400 years. If one assumes some reliable correlation between age and diameter, and given that the 587-year-old Taxodium is 96 cm dbh, then the younger Taxodium must be older than 100-150 years."

[3] Duever M. J. (1979), "Ecosystem analysis of Okefenokee Swamp: Tree ring and hydroperiod studies," Okefenokee Ecosystem Investigations, Technical Report No. 5. University of Georgia, Athens. 72 pages.
[4] Map of the WWALS Suwannee River Water Trail.
https://www.google.com/maps/d/u/0/viewer?mid=19oUN8HLVR1q8sc7oHEgOiWDzNRT5hfFQ&ll=30.68863718368294%2C-82.20187547775997&z=16

Forty four years later, those three trees are now 489, 572, and 631 years old. Older pond cypress exist elsewhere, but they are rare.

Even though this old-growth cypress stand is deep in the Swamp, it is still threatened by wildfires.

“Fire scars on the iarger trees and several of the younger understory trees indicate that the area has been burned, though not severely, during recent fires. Numerous completely burned trunks exist on the outermost perimeter of the forest facing Grand Prairie indicating the forest may have covered a greater area than it presently does.”

This is a practical fire risk: “Under drought conditions, peat fires that burn below the surface of the organic soil may kill the roots of cypress trees, thus killing the plant. A peat fire in the Okefenokee swamp in Florida killed 97 percent of the cypress trees in a 3,000-acre plot (1,214 ha).”[5]

Listing as a UNESCO World Heritage site would encourage legislation and other protections to lower the risk of wildfires.

Conclusion

For all these reasons I recommend that the U.S. nominate the Okefenokee National Wildlife Refuge as a World Heritage site this year.

We continue to support the ONWR through paddle trips into the Okefenokee Swamp, through support of legislation to protect the Swamp, through opposition to the titanium dioxide strip mine proposed far too close to the Swamp, and through support of this nomination.

Thank you for your consideration.

For the rivers and the aquifer,

John S. Quarterman
Suwannee RIVERKEEPER®
/s
WWALS Watershed Coalition, Inc.
contact@suwanneeriverkeeper.org
www.suwanneeriverkeeper.org

Attachments:

- WWALS letter of January 26, 2021
- G. Ronnie Best, et al., “An Old-Growth Cypress Stand in Okefenokee Swamp,” University of Florida, 1984.

[5] USDA Fire Effects Information System (FEIS), Index of Species Information, SPECIES: Taxodium ascendens, T. distichum, https://www.fs.usda.gov/database/feis/plants/tree/taxspp/all.html#14 which cites Cypert, Eugene. 1961, “The effects of fires in the Okefenokee Swamp in 1954 and 1955,” American Midland Naturalist. 66(2): 485-503. [11018]

January 26, 2021

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Re: Nominating Okefenokee NWR for UNESCO World Heritage List, Docket Number NPS-WASO-OIA-31249 PIN00IO14.XI0000

Dear Mr. Putnam,

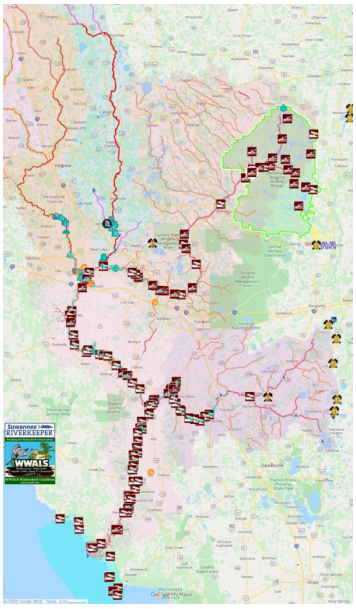
As you know, the Okefenokee National Wildlife Refuge (ONWR) is on the UNESCO Tentative List for the United States, and thus is eligible for the U.S. to submit an ONWR nomination file. https://whc.unesco.org/en/tentativelists/5252/

As Suwannee Riverkeeper and for our umbrella organizsation WWALS Watershed Coalition, Inc., I would like to encourage you to nominate ONWR this year. The vast majority of the Okefenokee Swamp is in the Suwannee River Basin, and some 85% of the outflow of the Swamp goes down the Suwannee River, which continues through Georgia and across Florida, where it is the subject of the state song, to the Gulf of Mexico.

WWALS member Bobby McKenzie sums it up from his perspective:

"As a world traveler for the past 20 plus years I must say that the Okefenokee Swamp holds its own when it comes to enchantment. I never would have thought I would have used the term enchantment to describe a swamp, but it happens to be the best one. My adventures have taken me to many places, each with their own charm and enchantment and history. I recall my first experience outside the United States, it was to the Chagos Archipelago part of the British Indian Ocean Territory. The crystal-clear waters of the islands and the sanctity of the massive coconut crabs and the hawksbill sea turtles. Soon I found myself living in South Korea and experiencing the Buddhist temples embedded in the cliffs of the East Sea (more well known as the Sea of Japan) and the fishing islands of Sunyu-do in the yellow sea. At Jeju Island with its botanical gardens, lava tubes, and extinct volcano, I ascended the stairs of Mt Sanbanggulsa Temple where a spring drips from the ceiling pools into the temple cave and had a ceremonial sip. Years living in Europe showed me the awe of the Dolomites, the Carpathian Mountains, the Iron Gates, the Danube Delta and the switchback road of Transfagarasan. I have met the wonders of the Black Forest, I've skied Mount Blanc, Matterhorn, and the Zugspitze and swam in the ocean at Vilamoura in Algarve with its ocean caves. I dove the cliffs of Ischia and enjoyed the hot thermal springs of the Mediterranean. I've hiked miles through the Ardennes Forests and the ancient vineyards along the Mosel River. I have witnessed the famed White Cliffs of Dover, the puzzling Stonehenge, the North Sea, English Channel, and the beaches of Normandy. My time in Hawaii introduced me to the many natural phenomena such as the Makapu Tide Pools, the Queen's Bath at Moku Nui, and the Mermaid Caves in Nanakuli. The pill boxes at Lanikai, Coco Head along with the Hidden Lagoon offered breath-taking views of the island of Oahu.

"There are many places I that I can recall that I have not mentioned. But all these places share one thing in common, they are amazing places that most people have never heard of or will see in their lifetime. They are all wonderous and inspiring places in their own right. This is true with the Okefenokee Swamp. I first learned of the Okefenokee as I was planning my move to South Georgia from Hawaii. I was searching for outdoor activities and the first thing I came



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across was a website talking about 120 miles of water trail and multiple camping options in the swamp. I immediately wanted to do this trip or at least a portion of it. I have since made a handful of trips into the swamp and learned about the history of Billy's Island, the Sill, the timber operation and among other stories. My most recent trip into the swamp was with the WWALS Watershed Coalition. We paddled 8 miles out to camp at Floyds Island. The entire journey was just so peaceful. However, when we made the turn onto the green trail from Stephen C. Foster State Park, the swamp became extraordinarily enchanting. The cathedral-like tunnel that we paddled through for miles until we reached Floyd's Island was like a portal to a fairytale dimension. In many instances, the colors of the fall, the canopy formation of the trees and the mirrored reflections were hypnotizing, we could have paddled this natural tunnel for hours and still want more. Upon reaching the camp site, everyone in our party was just magically delighted about the spiritual connection that the swamp bestowed upon us. The return trip the next day was even more mesmerizing. I never would have thought that I would have used the word enchanting to describe a swamp, but it was just that. I am glad to add the Okefenokee Swamp to my long list of must-see places. As with all of the places listed above, I never knew that I needed to experience them until I did. The Okefenokee is no different, it's an enchanting place that you never knew you needed to experience."

Yet for the second time in twenty years, a titanium strip mine threatens the Okefenokee Swamp, this time organized by coal miners from Alabama. The U.S. Army Corps of Engineers has abdicated oversight, leaving only the state of Georgia, with decisions on five permit applications, standing between the miners and the Swamp. https://wwals.net/?p=54459 The Swamp and the ONWR can use all the protection they can get.

While the Okefenokee National Wildlife Refuge most obviously satisfies number x of the ten Selection Criteria, and it may be necessary to satisfy only one of them, the ONWR actually has significant features of all ten criteria.

(i) to represent a masterpiece of human creative genius;

While the Okefenokee Swamp is primarily a wild ecosystem, ONWR carefully prunes paddle trails into tree tunnels that continue to enable almost religious experiences for paddlers. One of our very experienced paddlers recently on the way to Floyd's Island was overwhelmed with awe at the way the tree tunnel trail framed the natural swamp; see above testimonial by Bobby McKenzie. The paddle trails and sleeping platforms in general make the Swamp accessible to paddlers without unduly disrupting the ecosystem that paddlers come to experience.

(ii) to exhibit an important interchange of human values, over a span of time or within a cultural area of the world...;

Fifty years ago, WWALS President Tom H. Johnson Jr. grew up driving 57 miles to Stephen C. Foster State Park, fishing and looking there all day with other high schoolers. He says, "I never dreamed that what I took for granted, could or would seem like religious experience to others." We can not take the Okefenokee for granted; we must preserve it for future generations. The Okefenokee Swamp is especially important to south Georgia and north Florida, which form a cultural area unlike the rest of either of those states. Yet when the Swamp is threatened, as it is now by another proposal to strip mine for titanium, the supporters of the culture of appreciation of nature, boating, birding, and fishing, with hunting nearby, represented by the Okefenokee Swamp, turn out to be from all over the U.S. and the world.

(iii) to bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared;

The Okefenokee Swamp was long a refuge for native Americans, first Timucuans from the Spanish, then Creeks during the American Revolution. Billy's Island is named for Billy Bowlegs, an Indian who lived there until he was murdered by cattle rustlers, who were later caught. White settlers arrived in the nineteenth century and formed a Cracker Culture, documented in its late stages by naturalist Francis Harper. Many of their descendants still live not far away. Even the logging culture with its swamp railroads was a very unusual cultural tradition now gone.

(iv) to be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history;

Several stages of American history are represented in (iii), some of them unusual, if not unique to the Okefenokee. The Chesser Island homestead is maintained by ONWR, and the Lee Cemetery on Billys Island, as well as a cabin on Floyd's Island and other relics.

(v) to be an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change;

The logging culture or exploitation of the Okefenokee ended with exhaustion of the reachable tree supply, and that end became irreversible with the formation of the ONWR. Similarly, the white settler Cracker Culture was overtaken by the loggers, and then the creation of the ONWR resulted in all of them leaving the Swamp, partly due to depredations of their livestock by wildlife they could no longer stop.

(vi) to be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance. (The Committee considers that this criterion should preferably be used in conjunction with other criteria);

Francis Harper's records of the swamp culture are as much artistic and literary works as scientific. Musician Walter Parks continues the tradition of the haunting swamp hollers people used to use to communicate far across the Swamp, recorded among others by the Library of Congress. https://www.youtube.com/watch?v=2xZVOf_nGYg Plus there is Walt Kelly's Pogo comic strip, which in its heyday was the conscience of America.

(vii) to contain superlative natural phenomena or areas of

exceptional natural beauty and aesthetic importance;

This is why people come to the ONWR from all over the world: to see the birds, alligators, fish, raccoons, black bears, dragonflies, spiders, and other wildlife of the Okefenokee Swamp, among their native cypress, blackgum, maple, and pine trees. The ONWR has been a RAMSAR wetland of international importance since 1986. https://rsis.ramsar.org/ris/350 "The swamp is a mosaic of habitats from wet marshes, lakes, scrub-shrub, cypress forests, and islands of oak and pine. Fire and water define the swamp's habitats. Habitats provide for endangered and threatened species such as red-cockaded woodpeckers, wood storks, indigo snakes and a wide variety of other wildlife species. It is world renowned for its diverse amphibian populations."

(viii) to be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features;

The eastern dam of the Okefenokee Swamp is Trail Ridge, which is hypothesized to be ancient shoreline beach dunes, and certainly dates from as far back as the Cretaceous era, 65 million years ago, when much of the current Southeast U.S. Coastal Plain was under the sea.
https://www.researchgate.net/publication/275619883_Heavy-Mineral_Mining_in_the_Atlantic_Coastal_Plain_and_What_Deposit_Locations_Tell_Us_about_Ancient_Shorelines
The depression now housing the Swamp itself is hypothesized to have been formed by waves bouncing off Trail Ridge when it was offshore barrier islands.
https://www.georgiaencyclopedia.org/articles/geography-environment/natural-history-okefenokee-swamp
Trail Ridge also contains significant deposits of titanium dioxide, coveted for white paint and other uses. Most sections north and south of the Swamp having already been mined, now for the second time in two decades miners are attempting to exploit Trail Ridge within miles of the Swamp.

(ix) to be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals;

The Okefenokee Swamp is characterized by dynamic disclimax, most easily illustrated by it plant communities: "The successional climax community would be southern mixed hardwoods, but it is never realized due to continuous natural and anthropogenic disturbance. The model for plant community succession is from open marsh to cypress, or from shrub swamp to broad leafed evergreen or mixed hardwood forests (Hamilton, 1982; Glasser, 1986). Plant succession is routinely set back by such factors as historically frequent fires (INR Progress Report, 1987), the upwelling of peat batteries due to outgassing of 266 methane from peat decomposition (King et al., 1981), and the influence of the fluctuating water table (Greening and Gerritsen, 1987). In the early 1900's, canals were dug and the swamp was logged of its dominant cypress communities, further altering evapotranspiration, water flow and community structure. These recurring disturbance regimes lead to a heterogeneous and ever changing "disclimax" ecosystem with a mosaic of habitats."
https://smartech.gatech.edu/bitstream/handle/1853/44153/BergstedtA-97.pdf

(x) to contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation

Almost every species of bird and mammal of the U.S. Southeast can be found in the Okefenokee Swamp at some season of the year. The sheer diversity of finding them all there makes the ONWR a most important and significant habitat for conservation. The 2006 RAMSAR update notes: "The wetlands are used as a feeding ground by nationally endangered wood storks (Mycteria americana), while the Alligator Snapping Turtle (Macroclemys temminckii) (Vulnerable; IUCN, 2006 and CITES Appendix III) are found year-round within the waters of the Okefenokee NWR. The communities of native longleaf pine (Pinus palustris), considered vulnerable by IUCN, are being restored on the uplands of the refuge and also support the nationally-endangered and IUCN-vulnerable Red-Cockaded Woodpecker (Picoides borealis); and the Gopher Tortoise (Gopherus polyphemus), this last one considered nationally threatened, IUCN vulnerable and included in CITES Appendix II…. The site is world renowned for the diversity of amphibians and reptiles that are found here, which are biological indicators of global health…. With its diversity of habitats, Okefenokee NWR is home to over 620 plant, 39 fish, 37 amphibian, 64 reptile, 234 bird and 50 mammal species…. The Florida sandhill cranes (Grus canadensis pratensis) are non-migratory and are considered to be isolated from other populations in the southeast. In the mid-1980's the population at the refuge was estimated at 403 individuals. Since this time, it appears that there has been a decline in the population, which nevertheless still exceeds the 1% threshold of 50 Florida sandhill cranes. During the winter, large numbers (up to 1,000) of greater sandhill cranes (G. canadensis) migrate to the swamp and overwinter."

For all these reasons I recommend that the U.S. nominate the Okefenokee National Wildlife Refuge as a World Heritage site this year.

Thank you for your consideration.

For the rivers and the aquifer,

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AN OLD-GROWTH CYPRESS STAND IN OKEFENOKEE SWAMP

G. Ronnie Best

Center for Wetlands, University of Florida, Gainesville, FL 32611.

David B. Hamilton[1] and Gregor T. Auble

Institute of Ecology, University of Georgia, Athens, GA 30602.

ABSTRACT - A remnant stand of old-growth pond cypress in Okefenokee Swamp, Georgia, was studied. The rooting media is a shallow-flooded, strongly acid, deep peat soil. Cypress is the dominant feature of the old-growth community towering well above the subcanopy of broad-leaved evergreen trees. Although Taxodium has the greatest basal area for trees, its importance value in the tree class is superceded by Gordonia >> Taxodium >> Persea ~ Magnolia > Nyssa. However, Taxodium dominates overall community structure in basal area (35.18 m^2/ha for Taxodium; 60.06 m^2/ha for community) and importance value (20.6%). Tree diversity ($\bar{H}$), based on six species, for the community is 1.80 with a maximum possible diversity of 2.58. Taxodium replacement is lacking indicating its eventual demise as the community dominant. Replacement predominantly by Gordonia and secondarily by Magnolia and Nyssa appears to be the successional trend for this old-growth cypress community.

INTRODUCTION

Few areas exist in the Southeast where man's activities have not disturbed natural areas. Even the once pristine Okefenokee Swamp has been drastically altered during the past century through extensive logging (Hopkins, 1947; Izlar, 1984b) and canal digging (Hopkins, 1947). Natural perturbations by fire have often been complicated by man's intervention (Cypert, 1961; Izlar, 1984a). Nonetheless, isolated areas do exist where perturbations by man have had little impact on natural communities. This paper describes such a community, a unique remnant stand of old-growth pond cypress (Taxodium ascendens) occurring in a shallow peaty area of the Okefenokee. Apparently, the community has not been sufficiently disturbed in the last few centuries to alter its natural succession to a bay swamp dominated by broadleaf evergreen hardwoods. This bay swamp represents a variation of the bayhead community that Monk (1966) considered to be climax on seasonally flooded areas.

Description of the Study Area

The stand lies on the northeastern perimeter of Grand Prairie in the southeastern section of the Okefenokee Swamp, Georgia. The stand appears to be an undisturbed remnant of a more extensive Taxodium-dominated swamp forest in the eastern portion of the Okefenokee. Duever (1979), who treated the

[1]Present address: U.S. Fish and Wildlife Service, Ft. Collins, CO 80526.

site as an example of a large "tree house" (a peat-formed island), estimated the size of the area to be about 1000 m in diameter. Canopy trees in the site range between 30 and over 90 cm in diameter at breast height and over 30 m in height, suggesting the area was most certainly spared from logging in the early part of the century. Several of these canopy trees are 400-500 years old or older (Duever, 1979). Fire scars on the larger trees and several of the younger understory trees indicate that the area has been burned, though not severely, during recent fires. Numerous completely burned trunks exist on the outermost perimeter of the forest facing Grand Prairie indicating the forest may have covered a greater area than it presently does.

METHODS

A detailed census of woody plants was conducted on two separate occasions during the summers of 1978 and 1979. The 1978 census was part of an intensive site-specific study on this unique stand, whereas the 1979 census was part of a comprehensive survey of major woody communities in Okefenokee Swamp. During both surveys, large quadrats with smaller nested quadrats were used to survey the larger and smaller classes of individuals. Vascular plant nomenclature follows Radford et al. (1968).

During the 1978 census all woody plants greater than 1 m in height were measured by tree, sapling, or seedling classes. The tree size class (individuals with a 10 cm or greater diameter at breast height [dbh]) was sampled in nine 10-m x 20-m plots. The sapling size class (2-10 cm dbh) was measured in four 5-m x 10-m plots nested within the first four tree quadrats. Seedlings (woody plants $\geq$1 m in height but <2 cm dbh) were sampled in four 2-m x 4-m plots also nested within the larger 10 quadrats. Species and breast height diameter were recorded for all individuals greater than 1.3 m (standardized "breast height" for this study). Species and height were recorded for plants between 1 and 1.3 m in height.

The 1979 census was part of a more comprehensive survey of all major woody plant communities throughout the swamp. Two quadrat sizes were used for all size classes. Individuals with a dbh of less than 5 cm were sampled in eight 2-m x 4-m plots located randomly within a larger bounded 20-m x 40-m quadrat randomly placed well within the stand to minimize forest edge effect. Woody plants larger than 5 cm dbh were sampled in four 10-m x 20-m plots also located within the larger bounded quadrat. Species, breast height diameter, and whether or not the trees were live or dead were recorded for all individuals. Data in this report are based only on live individuals.

Importance values were calculated for woody plants by summing data on relative frequency, density and dominance (basal area), and converting to a basis of 100%. Importance values were calculated for trees (which included all individuals with the potential to attain upper canopy stature) and shrubs as separate size classes, and for all woody plants as a whole. Species diversity ($\overline{H}$) for the tree size class was calculated as follows:

$$\overline{H} = \sum \rho_i \log_2 \rho_i \qquad (1)$$

where p_i is the sampling probability. The statistic used for calculating diversity was:

$$H' = c/N \left(N \log_{10} N - \sum n_i \log_{10} n_i\right) \quad (2)$$

where N is the total number of all individuals, n_i is the total number of individuals of each species, and c = 3.321928 to convert from $\log_{10}$ to $\log_2$ (Lloyd et al., 1968). The maximum diversity possible (H'_{max}) for the site was calculated using the function:

$$(H'_{max}) = \log_2 N. \quad (3)$$

Since the diversity of a community depends on the number of species and their pattern of distribution (i.e., clumped, even, etc.), a measure of site homogeneity, or evenness (J'), was calculated using the following method as described by Zar (1974):

$$J' = \frac{\overline{H}}{H'_{max}}. \quad (4)$$

Tree species data from the 13 10-m x 20-m quadrats were used for diversity calculations.

RESULTS

The old-growth cypress stand in the Okefenokee Swamp is characterized by three relatively distinct tiers of woody plants. The lower stratum is dominated by shrubs that generally do not exceed 4 m in height. The dominant shrubs are Lyonia lucida (fetterbush), Clethra alnifolia (sweet pepperbush), Smilax laurifolia (laurel greenbrier), and Itea virginica (virginia willow). Vaccinium arboreum (sparkleberry), Leucothoe racemosa (sweetbells lencothoe), Rhus radicans (poison ivy), Vitis spp. (wild grape), and Lyonia ferruginea (staggerbush) are also present, but to a much lesser extent. Numerous tree seedlings and saplings also occupy this stratum. This layer, although occasionally patchy, is relatively continuous throughout.

The middle stratum covers a large zone, ranging from 4 m to slightly over 15 m in height, and, like the shrub layer, is relatively continuous. This layer is dominated at the lower level by Ilex cassine (including coriacea) (dahoon) (generally treated as shrubs except when used to parallel data presented by others on diversity), and at the upper level by Gordonia lasianthus (loblolly bay) and an occassional large Magnolia virginiana (sweet bay). Persea palustrus (red bay) and Nyssa sylvatica var. biflora (black gum) are also common components in the middle stratum.

A large void approximately 10 m wide separates the middle tree stratum from the upper tree stratum. This stratum consists solely of Taxodium ascendens. The Taxodium canopy generally occupies a span between 20 and 30 m. The upper canopy distribution is very spotty, with usually one or two and sometimes four or five Taxodium merging their canopies.

Additional descriptive information used to characterize the old-growth cypress stand is presented in Table 1. In this study woody plants are treated either as trees or shrubs based on their potential to attain upper canopy status. Gordonia is the most frequently encountered tree individual as reflected in its high frequency and density. However, its dominance relative to structure is overshadowed by Taxodium with a basal area of 35.18 m^2/ha, almost triple that of Gordonia (13.46 m^2/ha). Persea, Magnolia, and Nyssa combined contribute less than 15% to the total basal area of trees in the site. The relative contribution to the community by individuals in the tree stratum as expressed by importance value (sums of relative frequency, density, and dominance converted to a basis of 100%) is dominated by Gordonia followed by Taxodium >> Persea ~ Magnolia > Nyssa.

Total stem density for woody plants greater than 1 m high is 27,339 stems/ha, quite similar in density to the 28,386 stems/ha reported by Schlesinger (1978) for a relatively unique deep-water cypress community in the western portion of Okefenokee Swamp. However, in Schlesinger's site Taxodium comprises 8% of all woody plants, whereas only 0.5% of the woody plants are Taxodium in the old-growth community. In both sites composition of the remaining individuals is dominated by several commonly shared shrub species. A cypress community in the Great Dismal Swamp, Virginia, has a density of 1560 stems/ha for individuals with a breast height diameter greater than 2.54 cm (Dabel and Day, 1977). That compares to 1739 stems/ha for the same size distribution (excluding shrubs) in the old-growth community.

The apportionment of individual species contribution to basal area is often used to assess community dominance since it is a measurement of the utilization of resources by a species (Whittaker, 1970). Total basal area for the site (Table 1) is 60.06 m^2/ha with 94% (56.25 m^2/ha) in tree species and 6% (3.91 m^2/ha) in shrubs. Schlesinger's (1978) deep-water cypress community has a community basal area of 80.35 m^2/ha with 8.6 m^2/ha in standing dead yielding a comparable live plant basal area of 71.75 m^2/ha. Dabel and Day's (1977) cypress community has a basal area of 59.3 m^2/ha. These basal areas are remarkably similar considering that the basic similarity between the communities is that they are occasionally or regularly flooded swamps with Taxodium as the dominant canopy species. Dissimilarities in community structure is apparent when one realizes that Taxodium comprises 86% of the basal area in the Okefenokee deep-water cypress community (Schlesinger, 1978), 47% in the cypress community in the Great Dismal Swamp (Dabel and Day, 1977), and 59% in the old-growth Okefenokee cypress community (Table 1). Based on these data, it is apparent that the old-growth cypress community is more similar to the more distal and younger (~130 years; personal communication: F. P. Day) cypress community in the Great Dismal Swamp, probably because of a similarity in flooding regime, than to the more proximal deep-water cypress community in Okefenokee Swamp.

The understory consists of a dense layer of woody vegetation. The denseness of the shrub layer is more apparent when one realizes there are, on the average, almost 2.5 stems/m^2. Most species of this layer are broad-leaved, mostly evergreen shrubs. Ilex, treated as a shrub though intermediate in stature between shrubs and trees, dominates the shrub component primarily because of its moderately high density and high basal area relative

to other shrub species. Based on importance value, Ilex > Lyonia ∿ Clethra >> Smilax >> Itea as significant contributors to the shrub layer.

When all woody plants within the community are considered as a whole, there is a shift in the relative importance value of certain species. Taxodium replaces Gordonia as the dominant tree, and Ilex shares its dominance in the shrub layer with Clethra and Lyonia. When viewed from the whole community perspective the dominance of basal area by Taxodium supercedes the higher frequency and density of Gordonia, resulting in Taxodium having a 25% higher community importance value than its nearest competing tree species, Gordonia, or any other dominant woody plants. Ilex also shifts in significance in the shrub layer becoming more similar in importance value to Clethra and Lyonia.

The reproductive success of the tree species may be ascertained by comparing the densities (Table 2) of seedlings (<2 cm dbh and >1 m high), saplings (2-10 cm dbh), and trees (>10 cm dbh). Gordonia, Persea, and Magnolia have sufficient numbers in both the seedling and sapling size class to sustain their potential contribution as canopy species. Considering that about 14% of the trees are Nyssa, the complete absence of Nyssa seedlings and the relatively few saplings is not understood. It is questionable whether or not there are sufficient numbers in the smaller size class to establish Nyssa in the canopy. However, even as a potential contributor to the upper canopy, Nyssa is still an immature tree with most of its representatives in the smaller size class of trees. The lack of reproductive success for Taxodium is quite apparent especially since there are no individuals smaller than the 26 cm dbh size class (actually the smallest Taxodium individual recorded was 30 cm dbh). In fact, the mean breast height diameter for Taxodium sampled during the surveys was 53.1 cm (standard error [S.E.] ± 9.6 cm).

Only six tree species (i.e., woody plants with 10 cm dbh) occur in the site, though a few large slash pine (Pinus elliottii) are clumped near the outer edge. These are Taxodium, Gordonia, Magnolia, Nyssa, Persea, and Ilex. Ilex is, in this case, treated as a tree since it has a few individuals in the tree size class and is often treated as such by other authors. Tree diversity ($\bar{H}$) (Table 3) in the site is 1.80 (S.E. ± 0.09); considering there are only six species, the maximum diversity (H'_{max}) possible for this community is 2.58. For the plant community described, the estimated evenness (J') of the population distribution pattern is 0.70. These data correspond more closely to diversity values for bayheads ($\bar{H}$ = 1.75) than for cypress domes ($\bar{H}$ = 1.16) (Monk, 1966, 1968), although the similarity in species numbers and composition more closely match those for cypress domes. Partial accounting for these discrepancies lies in the fact that the old-growth cypress community in the Okefenokee is more similar to a floodplain cypress community than to cypress dome communities. In fact, Taxodium dominates cypress dome communities, accounting for 60% of the average importance value (based on the sum of relative frequency and density) with the other species common to the old-growth community accounting for only 16% of the average importance value (Monk and Brown, 1965). A comparison of similar data (Table 1) for the old-growth community reveals that Taxodium contributes only 7% to the average importance value.

DISCUSSION

The old-growth cypress stand in the Okefenokee Swamp consists of an overstory of tall, rather widely spaced Taxodium and a three-tiered understory. The subcanopy has a relatively uniform distribution, is of medium height, and is dominated by Gordonia. The canopy of Ilex melds the subcanopy with the dense shrub layer. The dense shrub layer, although patchy, covers much of the ground surface.

The larger Taxodium in the stand are rather old with estimated ages of 445, 528, and 587 years for three individuals cored by Duever (1979). Duever states that ring quality for Taxodium is "fair-good" (based on a sample size of 126 trees over all of Okefenokee Swamp). Therefore, it is safe to assume that at least several of the older Taxodium have been present in the site for over 400 years. If one assumes some reliable correlation between age and diameter, and given that the 587-year-old Taxodium is 96 cm dbh, then the younger Taxodium must be older than 100-150 years. This figure corresponds with the estimated time of encroachment of the bay species. Selected individuals of Gordonia, a community codominant with Taxodium, have estimated ages of 67, 73, and 91 year for three of the larger trees (ring quality, fair-good; N = 38) (Duever, 1979). Three larger Magnolia have estimated ages of 122, 124, and 145 year. However, ring quality for Magnolia is "poor-fair" (N = 58), and can be used to estimate site age only in conjunction with the other species. The few Pinus elliottii observed at one edge of the site have ages of 98, 124, and 140 year (ring quality, good; N = 32). These are in the upper limits of known ages for P. elliottii (Pomeroy and Cooper, 1956; Hebb and Clewell, 1976). Therefore, based on estimated ages (Duever, 1979) and size class distribution (Table 2), it is apparent that successful establishment of Taxodium has not occurred in the last 100-200 year, indicating long-term succession towards a community dominated by evergreen hardwoods, locally known as bay swamps. This trend concurs with the succession model suggested by Hamilton (1978, 1984) for Okefenokee Swamp and by Monk (1968) for woody swamps in north-central Florida.

Taxodium presently dominates the stand in stature, basal area, and overall community importance. However, Gordonia has already gained a dominant position of importance as a tree species and is replacing Taxodium in community importance. Gordonia currently comprises 22.4% of the community basal area. This plus its significance as a dominant component of the canopy, as reflected in its high frequency and density, makes Gordonia a serious competitor as the potential single community dominant to replace Taxodium. This trend differs considerably from the successional trend of cypress-to-bay communities for this region as noted by Monk (1968) where bay communities are codominated by Magnolia and Persea and to a lesser extent Gordonia. Even a slash pine-to-bay successional community in the panhandle of Florida is becoming dominated by Magnolia with Nyssa and Persea as secondary codominants. Gordonia are not even present in this latter community (Hebb and Clewell, 1976).

The significance of Gordonia as a dominant community component is not well understood, and may be related to numerous factors. However, the process through which terrestriallike communities develop in Okefenokee Swamp

results in the creation of numerous variable-sized peat islands scattered throughout the swamp (Cypert, 1972). By being somewhat isolated from terrestrial communities, plant species invasion would be restricted. Gordonia seeds, much like P. elliottii seeds, are wind disseminated, increasing the potential for dispersal to remote areas. These species are expected to gain an early advantage in encroaching on habitable sites. Seeds of Persea, Magnolia, and Nyssa, on the other hand, are much larger and are probably restricted to dispersal primarily by animals or on rare occasion by floating to a site during flood events. Based on the apparent restricted water flow pattern in this section of the Okefenokee, seed transport to this site by flooding is highly improbable. Although mature, seed-producing individuals do occur in the site, it is still not known whether or not Persea, Magnolia, or Nyssa will become codominants in the canopy. Magnolia has a sufficient number of seedlings and saplings and may eventually share canopy dominance with Gordonia. The trend for Nyssa is not clear, yet evidence suggests it will not secure a dominant role in community structure. However, based on our observations and on those of Duever (1979) regarding Persea, it appears that Persea is stressed in communities in the Okefenokee. Almost all individuals of Persea observed in the present study, except for seedlings and a few small saplings, consisted of only one or two small live apical branches; the primary bole was generally dead. This concurs with observations of Duever (1979). He states "the larger red bay (Persea) were invariably hollow..." (p. 32). Thus, Persea is not expected to increase in importance in the community, even with the eventual demise of Taxodium, and may eventually be all but eliminated from the site.

CONCLUSIONS

The apparent eventual demise of Taxodium as the community dominant and the replacement with evergreen hardwood species in this old-growth cypress community supports the successional scheme for these swamp communities (Hamilton, 1978, 1981; Monk, 1968). The old-growth cypress stand cannot be perpetuated without major disturbance because there are no Taxodium in the understory to succeed it. Disturbances of the last 100-200 years, including numerous fires and attempts to drain the swamp, have not been of sufficient magnitude to alter the successional trend in the community. This stand will eventually be a Gordonia-dominated bay swamp, a variation of the red bay–sweet bay community type occurring within the peaty swamp series described by Penfound (1952).

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