BAY SWAMP RECLAMATION TECHNIQUES - FLORIDA PHOSPHATE MINES

by

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Abstract: Bay swamps are found throughout Florida. However, agencies are reluctant to approve impacts until wetland reclamation and creation techniques have substantiated that these forested wetland systems can be recreated. Agency concerns seem to be centered around the time lag between impact and successful reclamation of a functioning forested bay swamp system including a mature vegetative structure, adequate hydrology and wildlife habitat. IMC-Agrico has completed construction of several bay swamp reclamation projects on its central Florida reclaimed lands. These projects have utilized a variety of techniques, including the planting of bay trees and other hardwoods in designed wetlands constructed on sand tailings or overburden cap, or planting with a mulched muck layer on sand tailings or overburden cap. A third technique includes bay tree stump and tree transfer with supplemental bay tree plantings in a designed wetland constructed with a mulched muck layer on sand tailings. Site preparation and material utilized in these projects has been observed to be as important as manipulation of hydrology during the establishment phase and proper prediction of the post reclamation hydrology. Preliminary monitoring results suggest that these systems can be reclaimed. Continued research will evaluate the efficacy of the techniques utilized, and perhaps suggest additional techniques to be used in the future.

Additional Key words: *Gordonia lasianthus*, *Magnolia virginiana*, *Nyssa sylvatica*, *Persea palustris*.

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Introduction

Bay swamps are found throughout Florida. The acreage tabulation of bay swamps in Florida, however, depends upon the bay swamp definition utilized, and further upon the method utilized to determine aerial extent. Various definitions for bay swamps exist depending on the reasons for defining such a system, e. g. for regulatory classification or to define mitigation success. One published definition of a bay swamp is: "a hydric community along first order streams where acidic detritus aggrades and is not scoured. A headwater forest characterized by presence of evergreen hardwoods (*Magnolia virginiana* - sweet bay, *Persea palustris* – swamp bay, and *Gordonia lasianthus* - loblolly bay), which grow intermixed with deciduous hardwood taxa" (Clewell, 1990).

Although the above is generally accepted for areas called bayheads, a more appropriate definition may also include: "forests where evergreen hardwoods predominate and *Nyssa biflora* (black gum) is the only important deciduous hardwood" (Clewell 1990). A more general definition has been provided by Monk (1965), who defined bayheads as forests that are dominated by broad-leaved evergreen trees growing on soils high in organic matter and subjected to seasonal flooding.

The Environmental Protection Commission of Hillsborough County (EPCHC) has defined bay swamp mitigation success, and thereby the bay swamp vegetative cover, as any hardwood forested swamp with at least 51% bay trees, including *Magnolia virginiana*, *Persea palustris*, *Gordonia lasianthus* and *Nyssa sylvatica* (EPCHC Correspondence, 12/8/98). Other definitions include *Persea borbonia* (red bay), while others eliminate *Nyssa sylvatica* and *Persea borbonia* (Clewell, 1990; Monk 1965).

The bay swamps, as defined above, occurring on IMC-Agrico property in five southwest central Florida counties (Desoto, Hardee, Hillsborough, Manatee, and Polk) consist predominantly of: connected headwater swamps, interior portions of some hardwood swamps associated with riverine and stream

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floodplains, and isolated bay swamps that have become connected to waters of the State via agricultural ditching practices.

According to Closing the Gaps in Florida's Wildlife Habitat System ("GAP report"; Cox et al. 1994), which utilized remote sensing techniques to categorize vegetative communities, the state of Florida has approximately 53,400-hectares (131,900-acres) of bay swamps. Of this total, Polk County has approximately 2,000-hectares (5,434-acres) of bay swamps. The "GAP report" does not list an acreage value for Hillsborough, Hardee, Manatee and Desoto Counties, presumably since these counties have a bay swamp component less than the 100-hectares (247-acres) per km^2 that the authors of the "GAP report" used as a cutoff. However, the authors of this paper did assume that if the raw data for all four counties were added together, the total area of bay swamp would probably exceed 1-square kilometer (100-hectares or 247-acres) in area. The assumption that some bay swamps are found in these areas is supported by the fact that bay swamps are encountered on IMC-Agrico property in the five southwest central Florida counties listed above. In fact, the acreage of bay swamps that occur on IMC-Agrico property belies the acreage predicted by the "GAP report". This may be partly due to the fact that many of the IMC-Agrico bay swamps are less than five acres in size and may be difficult to differentiate due to the level of precision inherent with remote sensing, as well as the lack of a detailed vegetative community census across the state.

Agencies are reluctant to approve impacts to any wetland type, especially forested wetland systems, until restoration techniques have confirmed that the wetland type to be impacted can be recreated. For bay swamp wetlands, agency concerns seem to be centered on the time lag (e. g. whether it can be recreated, the degree, and length of time required for creation) between impact and successful reclamation of a functioning forested bay swamp system. Typically, a functioning or viable wetland system contains a mature vegetative structure, adequate hydrology and wildlife habitat. Mature vegetative structure, as defined by most mitigation/reclamation permit criteria from the regulatory agencies (Florida Department of Environmental Protection - FDEP and EPCHC), consists of a canopy of trees greater than 10-centimeters (4-inches) dbh and/or greater than 4 to 5-meters (12 to 16-feet) in height that is reproducing successfully. For bay swamps, adequate hydrology can be defined as that hydrology which is necessary to sustain wetland community characteristics with wildlife habitat defined as that which supports and sustains native wetland dependent fauna.

Chapter 62-340, Florida Administrative Code, "Delineation of the Landward Extent of Wetlands and Surface Waters", and "The Florida Wetland Delineations Manual" (Gilbert et al, 1997) provides definitions of several wetland related characteristics, including canopy, sub-canopy, and groundcover. Although these characteristics are utilized for wetland delineation within the state of Florida, these same characteristics when applied to reclaimed wetlands (due to their relatively young ages) often utilize different definitions of the same terms. Trees planted in reclaimed wetlands range from bare root to 38 liter (10-gallon) containerized stock depending on permit criteria. Typical plantings are 3.8-liter (1-gallon) containerized stock 0.5 to 1-meter (2-3') tall and less than 1-centimeter (0.5") dbh. For reclaimed wetlands, canopy is generally defined as any trees greater than 2.5-centimeters (1-inch) dbh and over 2-meters (6-feet) in height. Subcanopy is generally defined as trees greater than a 0.3-meters (1-foot) in height and less than the canopy criteria. The subcanopy layer is often called the shrub layer. All tree species with individuals less than 0.3-meters (1-foot) in height are typically assigned to the groundcover or recruit category.

Several hardwood forested wetland reclamation projects (containing bay swamp components) have been constructed during the past 20-years on IMC-Agrico's reclaimed mine lands in the central Florida phosphate district. These bay swamp reclamation projects have utilized a variety of techniques, segregated generally by reclaimed substrate and planting methods. One technique utilized the planting of bay trees and other hardwoods on a sand tailings backfill topped with overburden. This technique was utilized at the Big Four Mine - Floodplain Demonstration Bay Swamp (AMAX-BF-1) and a portion of the Big Four Mine – South Prong of the Alafia River Bay Swamp (South Prong Sand Tails). A second technique has been to plant bay trees and other hardwoods on a mulched muck layer overlying sand tailings or overburden cap. The mulched muck layer utilized for this technique is comprised of hydric soil, vegetation and vegetative material removed from a permitted wetland impact, direct transferred or stored and then applied to the post reclamation landscape as a growing medium, seed bank or wetland plant source. This technique has been used at both Fort Green Mine - Hardee Lakes Bay Swamp (Hardee Lakes) and a portion of the Big Four Mine - South Prong Bay Swamp (South Prong Muck). A third technique involves the direct transfer of bay trees and stumps--along with supplemental bay tree plantings--on a mulched muck layer, overlying sand tailings. This technique has been utilized at the Four Corners Mine – Alderman Creek Bay Swamp (ACBS), the most recently completed reclamation project of the four sites.

IMC-Agrico's experience on these projects has shown that site preparation, material utilization and scheduling are as important as the prediction and manipulation of post-creation hydrology. Preliminary monitoring results of these four bay swamp reclamation projects support the belief that viable bay swamp wetlands can be reclaimed. It is the intention of this paper to present the different techniques utilized in each of the four case studies and to draw some preliminary conclusions. Due to the various ages of the projects (ACBS - approximately six months old at the time of report preparation; South Prong Sand Tails and Muck - approximately two years old; Hardee Lakes - approximately eight years old; and AMAX- BF-1 - 20 years old), statistical comparisons between the case studies have not been made. Any apparent trends noticed between the various ages of bay swamps have been noted and comparisons are suggested. Reference sites have not been included due to the large variability of bay swamps in central Florida, instead comparisons have been made to published definitions of bays swamps. Continued research will suggest the efficacy of the techniques utilized, and perhaps recommend additional techniques to be used in the future. The following sections summarize pertinent introductory information for each of the four bay swamp reclamation projects.

Site Descriptions

Hardee Lakes

The Fort Green Mine - Hardee Lakes Restoration Project covers a tract of land in Sections 1, 2, 11, and 12, T33S, R23E, Hardee County. The entire tract covers an area 259-hectares (640-acres) in size and includes two large lakes, forested upland greenway corridors, pasture and wetland hardwood forest. Under conditions of the regulatory approvals, IMC-Agrico was required to create wetland forest mitigation and reclamation for dredge and fill permit-related conditions. The bay swamp that is the subject of this report is an area 0.6-hectare (1.5-acres) in size located in the center portion of the wetland hardwood forest mitigation area. Mining of the parcel was conducted from the middle of 1988 through December 1989. Reclamation activities within the entire project commenced in May 1989 and were completed through revegetation in August 1991. Seepage through a sand tailings blanket, in addition to direct input from precipitation, provides the dominant water source supporting the hardwood forested wetland. Groundwater and surface water flow from the hardwood forested wetland are ultimately integrated into the Payne Creek watershed, a tributary of the Peace River.

In March 1990, after achieving the required final graded elevations, muck was transported to the site from another IMC-Agrico wetland permitted for mining disturbance. The "borrowed" muck was applied to the graded areas at depths varying from 2.5 to 30-centimeters (1 to 12-inches). The purpose of the muck base was to provide a seed source and substrate for the newly constructed wetland. All earthwork within the project boundary was completed in early 1991. Since that time, several plantings have been completed in the 0.6-hectare (1.5-acre) bay swamp area. The original plantings were completed in August 1991, with supplemental plantings conducted in 1994 and 1995 to increase the number of species to that typically found in bay systems. Because the entire forested wetland was planted as a collective unit, specific numbers of planted trees for the bay swamp portion cannot be segregated from the total number of trees planted throughout the project.

Nuisance and exotic species maintenance was conducted regularly in the early stages of development, but has not been needed within the last few years. Following establishment of the tree and shrub strata, very little nuisance and exotic species cover has been observed.

South Prong Sand and Muck Bay Swamp

The Big Four Mine - South Prong Bay Swamp is located in Section 35, T31S, R22E, Hillsborough County. Mining of the site was conducted in 1990. The area was back-filled with sand tailings and initial rough grading commenced in 1993. Bay swamp reclamation activities commenced in October 1996 with final earthmoving and grading, including the creation of a seepage slope area parallel to the northern edge of South Prong of the Alafia River. Seepage from the surrounding uplands, in addition to direct input from precipitation, provides the majority of water inflow for the bay swamp. Groundwater and surface water flow from the bay swamp and the surrounding watershed are ultimately incorporated into the South Prong of the Alafia River.

The entire bay swamp project encompasses 4.0-hectares (10.0-acres). Of this, 2.2-hectares (5.5-acres) received a muck cap, while 1.8-hectares (4.5-acres) did not. Viable organic muck material, from a wetland permitted for mining activities, was harvested, hauled to the reclamation site, and spread over the 2.2-hectares (5.5-acres) at varying depths from 2.5 to 30-centimeters (1 to12-inches). Hummocks and furrows were created throughout the bay swamp to simulate the irregular bottom commonly encountered in natural forested wetlands. A total of 10,000 trees of varying sizes from eight different wetland bay and hardwood tree species were planted (approximately 2470-

trees/hectare or 1000-trees/acre) throughout the site in November 1996.

A total of 3,000-trees, or an average of 741-trees/hectare (300-trees/acre) of *Magnolia virginiana* trees, was planted within the site. The site also received an average of 494-trees/hectare (200-trees/acre) or 2,000-trees each of *Gordonia lasianthus* and *Persea palustris*, 247-trees/hectare (100-trees/acre) on average or 1,000-trees total of *Nyssa sylvatica*, and an average of 370-trees/hectare (150-trees/acre) or 1,500-trees total of *Acer rubrum* (red maple). *Ilex cassine* (dahoon holly), *Quercus laurifolia* (laurel oak) and *Quercus nigra* (water oak) were planted at a density of 500-total trees or an average of 124-trees/hectare (50-trees/acre).

AMAX-BF-1

The Big Four Mine - Floodplain Demonstration Bay Swamp (AMAX-BF-1) is located in Section 23, T31S, R22E, Hillsborough County. AMAX-BF-1 was created as Development of Regional Impact (DRI) approved floodplain wetland reclamation to demonstrate that mined floodplains could be reclaimed. Mining related activities were conducted from 1977 to 1978. Reclamation of the AMAX-BF-1 site was completed in 1979 by contouring overburden on lands utilized in the mining process, specifically the recharge ditch and berm along Boggy Branch, a tributary of the South Prong of the Alafia River. Contouring was conducted to create compatible elevations to allow the expansion of the Boggy Branch floodplain. The main hydrologic inputs are derived from precipitation and groundwater seepage, although the area is also subjected to backwater flooding during seasonal heavy rains.

The entire AMAX-BF-1 project consists of 12.6-hectares (31-acres) of mixed hardwood and bay swamp. A 2.4-hectare (6-acre) flag marsh, to be dominated by *Iris virginica* (blue flag) was ringed with *Taxodium distichum* (bald cypress) and *Gordonia lasianthus*. Potted *Taxodium distichum* and *Gordonia lasianthus* saplings 45-centimeters (18-inches) in size were planted at densities equal to 988-trees/hectare (400-trees/acre). Herbaceous vegetation was planted at sufficient densities to provide adequate percent cover.

Alderman Creek Bay Swamp Demonstration Project

The Four Corners Mine - Alderman Creek Bay Swamp Demonstration Project (ACBS) is located in Section 33, T32S, R22E, Hillsborough County. The demonstration bay swamp is a 3.2-hectare (8.0-acre) forested wetland constructed on reclaimed phosphate mine lands. The ACBS area was back-filled with sand tailings and contoured to design elevations in 1997. A seepage slope area was created to parallel the west bank of Alderman Creek, a tributary to the North Fork of the Little Manatee River. The main hydrologic inputs for this system include precipitation and groundwater seepage. This system is part of the Alderman Creek watershed.

Muck, trees, stumps and trunks were direct transferred from a donor bay swamp approved for mining. The muck, trees, stumps and trunks were transferred beginning December 21, 1998 and completed on January 14, 1999. Supplemental transfers of bay trees, primarily *Gordonia lasianthus*, from other donor sites were conducted during February and March 1999.

Study Methods

A 10-meter wide (32.8-foot) belt-transect of varying length was established through two of the sites (Hardee Lakes - 61-meters long (200-foot); AMAX BF-1 - 122-meters long (400-foot)). Four permanent belt-transects totaling 325-meters in length (1065 feet) were established within the South Prong Muck and Sand Bay Swamp. Each of the sand tailed only and muck portions of this bay swamp contain two permanent belt transects. A census of the entire ACBS bay swamp area was conducted in spring 1999. All trees within the belt transect or wetland (ACBS) over 2.5-centimeter (1-inch) dbh were recorded along with the respective height. All woody stems less than 2.5-centimeter (1-inch) dbh (shrub layer) within the belt transect were also recorded. This information allowed the number of stems per hectare (acre) for trees and shrubs to be calculated.

Trees were subjectively separated into several size categories by height and dbh measurements in order to distinguish between original plantings and volunteered or recruited individuals. Trees within the 7.5 to 9+ meter (25 to 30'+) tall and 7.5+ centimeter (3"+) dbh range were assigned to the original planting survival/mature canopy category. Trees within the 6 to 7.5 meter (20 to 25') tall and 5 to 7.5 centimeter (2 to 3") dbh range were assigned to the older recruits or original planting survival/sub-mature canopy category. Trees within the 4.5 to 6 meter (15 to 20') tall and 3.5 to 5 centimeter (1.5 to 2") dbh range were assigned to the second period of recruits/tall subcanopy category. Trees within the 2.5 to 4.5 meter (8 to 15') tall and 2.5 to 5 centimeter (1 to 2") dbh were assigned to recent recruits/short subcanopy category, while shrub layer tree species were assigned to the most recent recruits category.

Observations of fish and wildlife utilization were documented based on visual observation of individuals, detection of their vocalizations or other

sign.

Results

Hardee Lakes

The Hardee Lakes monitoring results indicate that there are 7064-shrubs/hectare (2860-shrubs/acre) within the bay swamp portion of the site. The dominant species within the shrub layer are *Acer rubrum* with 2536-shrubs/hectare (1027-shrubs/acre) or 36% of the total number of shrubs and *Myrica cerifera* (wax myrtle) with 2289-shrubs/hectare (927-shrubs/acre) or 32% of the total number of shrubs. The subdominant species found in the shrub layer is *Magnolia virginiana* with 1696-shrubs/hectare (687-shrubs/acre) or 24% of the total number of shrubs (Table 1). There are 1984-trees/hectare (807-trees/acre) within the bay swamp portion of the site. The dominant tree species within the bay swamp portion is *Magnolia virginiana* with 984-trees/hectare (400-trees/acre) or 50% of the total number of trees. The sub-dominant tree species is *Acer rubrum* with 721-trees/hectare (293-trees/acre) or 36% of the total (Table 2).

The planting and recruit density results (Table 3) suggest that a stratified canopy representing a mature forest has established within this wetland over the past 8 years. Reproduction and/or volunteer recruitment appear to be prevalent within the Hardee Lakes bay swamp. The high density of woody canopy species within the shrub layer suggests that successful reproduction is occurring. The prevalence of recent plantings/recruits larger than those individuals in the shrub layer suggests that there has been a combination of high survival of the 1994 and 1995 planted individuals and high recruitment of saplings from original plantings and/or recruitment from adjacent preservation area individuals.

Results of wildlife observations from 1995 to 1998 indicate a cumulative total of 24 species are utilizing the Hardee Lakes project (Table 4). *Mycteria americana* (woodstork), *Egretta caerulea* (little blue heron), and *Eudocimus albus* (white ibis), all listed by the Florida Game and Fresh Water Fish Commission (FGFWFC) as protected species (Wood, 1996), were observed on-site.

South Prong Sand

The South Prong Sand Tailings Bay Swamp monitoring results indicate that there are approximately 1449-trees/hectare (587-trees/acre) existing within the site (Table 5). *Magnolia virginiana* dominates the sand tailed only portion of the South Prong Bay Swamp with 863-trees/hectare (349-trees/acre) or 60% of the total trees within the sand tailed only area. *Persea palustris* is the sub-dominant tree in the sand tailed only portion with 166-trees/hectare (67-trees/acre) or 12% of the total trees. Data on shrub layer composition is not applicable to this site; due to the relatively young age of the planted trees, the vegetation has not yet separated into different canopy heights. It should be noted that the definition of a tree for this site is "a woody species exceeding the herbaceous stratum in height", which is different from the standard definition of a tree.

South Prong Muck

The South Prong Mucked Bay Swamp monitoring results indicate that there are approximately 761-trees/hectare (308-trees/acre) existing within the site (Table 6). *Magnolia virginiana* dominates the mucked portion of the South Prong Bay Swamp with 408-trees/hectare (165-trees/acre) or 54% of the total trees. *Nyssa sylvatica* is the sub-dominant tree in the mucked portion with 131-trees/hectare (53-trees/acre) or 17% of the total trees. Data on shrub layer composition is not applicable to this site; due to the relatively young age of the planted trees, the vegetation has not yet separated into different canopy heights. It should be noted that the definition of a tree for this site is "a woody species exceeding the herbaceous stratum in height", which is different from the standard definition of a tree.

Results of wildlife observations documented from 1997 to 1998 indicate a cumulative total of eight (8) species are utilizing the South Prong Sand and Muck wetlands (Table 7). This total includes four (4) avian species, three (3) amphibian species and one (1) fish species.

AMAX-BF-1

The AMAX-BF-1 monitoring results indicate that there are 9394-shrubs/hectare (3803-shrubs/acre) found within the bay swamp portion of the site. The dominant species in the shrub layer is *Gordonia lasianthus* with 4701-shrubs/hectare (1903-shrubs/acre) or 50% of the total shrubs. The sub-dominant species in the shrub layer are *Acer rubrum* with 2190-shrubs/hectare (887-shrubs/acre) or 23% of the shrub total and *Myrica cerifera* with 1960-shrubs/hectare (793-shrubs/acre) or 21% of the total (Table 8). There are approximately 976 trees/hectare (397 trees/acres) existing within the bay swamp portion of the site. *Gordonia lasianthus* dominates the bay swamp with 689-trees/hectare (280-trees/acre) or 71% of the total trees. The sub-dominant tree species is *Acer rubrum* with 156-trees/hectare (63-trees/acre) or 16% of the total trees (Table 9).

The planting and recruit density monitoring results indicate that a stratified canopy representing a mature forest has established within this wetland over the past 20-years (Table 10). Reproduction and/or volunteer recruitment appear to be prevalent within the AMAX BF-1 bay swamp. The high density of woody canopy species within the various subjective height and dbh categories, including the shrub layer, suggests that successful reproduction is occurring.

Results of opportunistic wildlife sightings during the Spring 1999 wetland vegetation monitoring indicate that at least four (4) mammalian and one (1) avian species utilize the site (Table 11).

ACBS

The ACBS results presented in this summary include data collected for trees and stumps of nine (9) forested wetland species transferred before the end of March 1999. The species transferred include *Magnolia virginiana*, *Gordonia lasianthus*, *Nyssa sylvatica*, *Persea palustris*, *Persea borbonia*, *Ilex cassine*, *Liquidambar styraciflua* (sweet gum), *Diospyros virginiana* (persimmon), and *Quercus laurifolia*. Tree and stump classifications have been defined as individuals larger than 2.5-centimeter (1-inch) dbh, while those less than that criterion have been classified as saplings.

A total of 969 trees (n=522) and stumps (n=447) were direct transferred from donor wetlands to the demonstration wetland, for approximately 299-trees and stumps transferred per hectare (121-trees and stumps/acre) of demonstration swamp (Table 12a and 12b). The majority of trees and stumps transferred were *Magnolia virginiana*. Preliminary results suggest that 70% of the trees and stumps survived two to three months after the transfer, while 61% to 63% appeared to be surviving six to seven months after the transfer (Table 13a). There are no apparent trends, which is to be expected at this early stage, between stump and tree survival or between species. As evident in Table 14, a stratified canopy and subcanopy were transferred.

A total of 1703 saplings from nine (9) forested wetland tree species referenced above were transferred from two different donor wetlands (Table 12a). Preliminary results suggest that 90% of the saplings survived two to three months after the transfer, while 80% were surviving six to seven months after the transfer (Table 13b). There are no apparent trends, as is expected at this early stage, in regards to sapling survival between species. There are also no apparent trends between tree, stump or sapling survival for all transferred individuals or between species.

Included within the muck and stump/tree transfer were several other wetland species that were not specifically targeted for transfer. As has been documented in past wetland mucking experiments, the vegetative material (including individuals, propagules, seeds, and vegetative structures) present in the muck provide a good source for colonization. The added benefit of utilizing muck in combination with larger material (stumps, trees and root hummocks) includes the increased species diversity that colonizes the reclaimed wetland. An additional sixteen (16) woody trees or shrubs were transferred from donor wetlands to the demonstration wetland via the muck and stump/tree transfer (Table 15). These species include *Acer rubrum*, *Cephalanthus occidentalis* (buttonbush), *Viburnum nudum* (possum-haw), *Itea virginica* (Virginia willow), *Rhus copallinum* (winged sumac), *Serenoa repens* (saw palmetto), *Sambucus canadensis* (elderberry), *Vaccinium corymbosum* (highbush blueberry), *Ilex glabra* (gallberry), *Cornus foemina* (swamp dogwood), *Callicarpa americana* (beauty berry), *Hypericum* sp. (St. John's wort), *Lyonia lucida* (fetterbush), *Myrica cerifera* (wax myrtle), *Pinus elliottii* (slash pine), and *Vaccinium myrsinites* (shiny blueberry).

The results for the ACBS should not be considered definitive, as seasonal stresses during the first year post-transfer may change the percent survival either up or down. *Nyssa sylvatica* individuals were just beginning to leaf out from winter dormancy when the preliminary monitoring occurred, and growing season results may differ. It should also be noted that root sprout incidence may occur even though the tree or stump has no growth associated with it during the monitoring event. Numerous root sprouts/saplings were documented and were included in the results. In addition, numerous flowers and buds were observed for *Magnolia virginiana*, *Gordonia lasianthus* and *Ilex cassine* individuals. Future monitoring events will document flowering and seed production, as well as general reproduction and seed germination success.

In the six-month period of documenting wildlife observations at the ACBS, a total of 30 avian species, two (2) amphibian species, one (1) fish species, and two (2) mammal species were observed utilizing the site (Table 16). Five of the observed species, *Egretta caerulea, Egretta thula* (snowy egret), *Mycteria americana*, *Grus canadensis pratensis* (Florida sandhill crane), and *Ajaia ajaja* (roseate spoonbill), are listed by the FGFWFC as protected species (Wood, 1996). In April 1999 a *Grus canadensis pratensis* nest with two eggs was found within the wetland. The nest was actively maintained and protected by two adult cranes for a duration of one (1) week. During a period of lowering water levels the nest was found abandoned

and the two (2) eggs destroyed apparently due to predation by *Procyon lotor* (raccoon).

Conclusions

Preliminary results indicate that over a period of less than 20 years a bay swamp forested wetland (AMAX-BF-1) can be created in central Florida. Agency reclamation releases of the AMAX-BF-1 site from Hillsborough County and the FDEP, Bureau of Mine Reclamation were granted in 1982, three years after reclamation completion. Although reclamation success criteria have significantly changed since the early 1980s, it would appear that the forested wetland designed to be a floodplain bay swamp was indeed successful after three years when compared to published definitions of bay swamps. The Hardee Lakes bay swamp mitigation site has not been released as successful mitigation or land reclamation at the time of this document preparation. However, the results presented in this document suggest that the bay swamp portion of this mitigation area would have met success criteria after only eight years following planting/ reclamation.

The time lag concerns with mitigation/reclamation forested wetland systems, particularly bay swamps, embrace numerous considerations. Among these are the concerns whether a system can be replaced; if it can be replaced, to what degree will the system be replaced or improved; and what is the actual physical time period that the ecosystem does not receive the benefits of the wetland. While conclusions can be drawn as to the success of reclaimed bay swamp systems in relation to permit conditions, no claims are made as to the successful establishment of bay swamp ecosystems. The trends of AMAX-BF-1, illustrated by the attainment of permit conditions, and Hardee Lakes Bay Swamp, illustrated by its trend towards successful reclamation, support the idea that the time lag related concerns can be partially alleviated. The ACBS appears to have a head start on attaining viable wetland reclamation as governed by permit criteria. The South Prong Bay Swamp - Sand and Muck are in the early establishment phase (2 years) and trends can not be completely discerned at this time. If the AMAX-BF-1 and Hardee Lakes Bay Swamp sites are good litmus tests for reclamation, then the South Prong Bay Swamp - Sand and Tail sites appear to be heading in the right direction. The fish and wildlife species observed at the Hardee Lakes Bay Swamp, the South Prong Sand and Muck Bay Swamp and most notably ACBS, are indicative of highly functional wetlands that provide a broad range of habitat and foraging opportunities for wildlife.

Future plans for these reclamation sites individually are as follows. The AMAX BF-1 Bay Swamp area will continue to self-organize and progress through community succession towards a climax forested wetland community. The Hardee Lakes Bay Swamp area will continue to self organize and future monitoring should show increased tree growth and reproductive success as it evolves into a mature forested wetland. The South Prong Sand and Muck Bay Swamps will receive supplemental tree plantings as needed and will continue to be monitored annually until attainment of success criteria. The ACBS will receive initial plantings of bay trees to attain permit required tree densities and will be monitored annually until attainment of success criteria. All sites will be periodically visited to document reproductive success and make opportunistic wildlife surveys.

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Table 1. Hardee Lakes Bay Swamp Shrub Density.

Scientific Name	Common Name	#/hectare	#/acre	Percent of total
Acer rubrum	Red maple	2535.9	1026.7	35.9
Gordonia lasianthus	Loblolly bay	16.5	6.7	0.2
Ilex cassine	Dahoon holly	32.9	13.3	0.5
Liquidambar styraciflua	Sweetgum	148.2	60.0	2.1
Magnolia virginiana	Sweetbay	1696.1	686.7	24.0
Myrica cerifera	Wax myrtle	2288.9	926.7	32.4
Nyssa sylvatica	Black gum	32.9	13.3	0.5
Persea palustris	Swamp bay	131.7	53.3	1.9
Quercus laurifolia	Laurel oak	65.9	26.7	0.9
Quercus nigra	Water oak	16.5	6.7	0.2
Salix caroliniana	Carolina willow	82.3	33.3	1.2
Sambucus canadensis	Elderberry	16.5	6.7	0.2
	TOTAL	7064.3	2860.1	100.0

Table 2. Hardee Lakes Bay Swamp Tree Density.

Scientific Name	Common Name	#/hectare	#/acre	Percent of total
Acer rubrum	Red maple	721.4	293.3	36.4
Liquidambar styraciflua	Sweetgum	49.2	20.1	2.5
Magnolia virginiana	Sweetbay	983.5	399.9	49.6
Nyssa sylvatica	Black gum	65.6	26.7	3.3
Persea palustris	Swamp bay	82.0	33.3	4.1
Quercus nigra	Water oak	82.0	33.3	4.1
	TOTAL	1983.7	806.6	100.0

Table 3. Hardee Lakes Bay Swamp Planting/Recruit Density (# per hectare/# per acre).

Scientific Name	Original survival 25'+	Original/ 1° recruit 20-25'	2° plant/2° recruit 15-20'	2° plant/ 3°recruit 8-15'	Shrub <8'
Acer rubrum	49.2/20.0	114.8/46.7	229.5/93.3	327.9/133.3	2535.9/ 1026.7
Gordonia lasianthus	--	--	--	--	16.5/6.7
Ilex cassine	--	--	--	--	32.9/13.3
Liquidambar styraciflua	16.4/6.7	16.4/6.7	--	16.4/6.7	148.2/60.0
Magnolia virginiana	229.5/93.3	147.5/60.0	131.1/53.3	475.4/193.3	1696.1/686.7
Nyssa sylvatica	32.8/13.3	16.4/6.7	16.4/6.7	--	32.9/13.3
Persea palustris	--	32.8/13.3	32.8/13.3	16.4/6.7	131.7/53.3
Quercus nigra	16.4/6.7	--	32.8/13.3	32.8/13.3	16.5/6.7
TOTAL (# ha/# ac)	344.3/140.0	327.9/133.4	442.6/179.9	868.9/353.3	4610.7/1866.7

Table 4. Wildlife Observations at Hardee Lakes 1995-1998

SPECIES	COMMON NAME	SPECIES	COMMON NAME
Avian		**Avian**	
Agelaius phoeniceus	Red-winged blackbird	*Hirundo rustica*	Barn swallow
Anhinga anhinga	Anhinga	*Iridoprocne bicolor*	Tree swallow
Ardea herodias	Great blue heron	*Mycteria americana*	Wood stork
Casmerodias albus	Great egret	*Pandion haliaetus*	Osprey
Cathartes aura	Turkey vulture	*Quiscalus major*	Boat-tailed grackle
Ceryle alcyon	Belted Kingfisher	*Quiscalus quiscula*	Common grackle
Colaptes auratus	Common flicker	*Sayornis phoebe*	Eastern phoebe
Egretta caerulea	Little blue heron	*Thryothorus ludovicianus*	Carolina wren
Eudocimus albus	White ibis	*Vireo griseus*	White-eyed vireo
Falco sparvarius	American kestrel		
Amphibian		**Fish**	
Anolis carolinensis	Green anole	*Gambusia affinis*	Mosquito fish
Hyla cinerea	Green tree frog	**Mammal**	
Hyla squirella	Squirrel treefrog	*Procyon lotor*	Raccoon

Table 5. South Prong Sand Tailed Only Bay Swamp Tree Density.

Scientific Name	Common Name	#/hectare	#/acre	Percent of total
Acer rubrum	Red maple	110.9	44.9	7.7
Gordonia lasianthus	Loblolly bay	31.6	12.8	2.2
Ilex cassine	Dahoon holly	142.5	57.7	9.8
Magnolia virginiana	Sweetbay	862.8	349.3	59.5
Nyssa sylvatica	Black gum	110.9	44.9	7.7
Persea palustris	Swamp bay	166.2	67.3	11.5
Quercus laurifolia	Laurel oak	7.9	3.2	0.5
Quercus nigra	Water oak	15.8	6.4	1.1
	TOTAL	1448.6	586.5	100.0

Table 6. South Prong Mucked Bay Swamp Tree Density.

Scientific Name	Common Name	#/hectare	#/acre	Percent of total
Acer rubrum	Red maple	85.7	34.7	11.3
Gordonia lasianthus	Loblolly bay	65.5	26.5	8.6
Magnolia virginiana	Sweet bay	408.3	165.3	53.6
Nyssa sylvatica	Black gum	131.2	53.1	17.2
Persea palustris	Swamp bay	70.6	28.6	9.3
	TOTAL	761.3	308.2	100.0

Table 7. Wildlife Observations at South Prong Sand and Muck 1997-1998

SPECIES	COMMON NAME	SPECIES	COMMON NAME
Avian		**Amphibian**	
Agelaius phoeniceus	Red-winged blackbird	*Bufo terrestris*	Southern toad
Anhinga anhinga	Anhinga	*Hyla cinerea*	Green tree frog
Buteo lineatus	Red shouldered hawk	*Rana grylio*	Pig frog
Casmerodias albus	Great egret	**Fish**	
		Gambusia affinis	Mosquito fish

Table 8. AMAX-BF-1 Bay Swamp Shrub Density.

Scientific Name	Common Name	#/hectare	#/acre	Percent of total
Acer rubrum	Red maple	2190.1	886.7	23.3
Gordonia lasianthus	Loblolly bay	4701.2	1903.3	50.0
Ilex cassine	Dahoon holly	16.5	6.7	0.2
Itea virginiana	Virginia willow	271.7	110.0	2.8
Liquidambar styraciflua	Sweetgum	74.1	30.0	0.8
Myrica cerifera	Wax myrtle	1959.5	793.3	20.9
Pinus elliottii	Slash pine	90.6	36.7	1.0
Quercus nigra	Water oak	8.2	3.3	0.1
Taxodium distichum	Bald cypress	82.3	33.3	0.9
	TOTAL	9394.2	3803.3	100.0

Table 9. AMAX-BF-1 Bay Swamp Tree Density.

Scientific Name	Common	#/hectare	#/acre	Percent of total
Acer rubrum	Red maple	155.9	63.3	16.0
Gordonia lasianthus	Loblolly bay	689.1	280.0	70.6
Liquidambar styraciflua	Sweetgum	41.0	16.6	4.2
Magnolia virginiana	Sweet bay	8.2	3.3	0.8
Pinus elliottii	Slash pine	24.6	10.0	2.5
Taxodium distichum	Bald cypress	57.4	23.3	5.9
	TOTAL	976.2	396.5	100.0

Table 10. AMAX-BF-1 Bay Swamp wetland tree planting/recruit density (# per hectare/# per acre).

Scientific Name	Original survival 25'+	Original/1° recruit 20-25'	2° recruit 15-20'	3° recruit 8-15'	Shrub <8'
Acer rubrum	8.2/3.3	--	8.2/3.3	139.5/56.7	2190.1/886.7
Gordonia lasianthus	213.3/86.7	106.6/43.3	188.7/76.7	180.5/73.3	4701.2/1903.3
Ilex cassine	--	--	--	--	16.5/6.7
Liquidambar styraciflua	8.2/3.3	8.2/3.3	--	24.6/10.0	74.1/30.0
Magnolia virginiana	--	8.2/3.3	--	--	--
Pinus elliottii	24.6/10.0	--	--	--	90.6/36.7
Quercus nigra	--	--	--	--	8.2/3.3
Taxodium distichum	8.2/3.3	--	16.4/6.7	32.8/13.3	82.3/33.3
TOTAL (# ha/# ac)	262.5/106.6	123.0/49.9	213.3/86.7	377.4/153.3	7163.0/2900.0

Table 11. Wildlife Observations at AMAX-BF-1 1999.

SPECIES	COMMON NAME
Mammal	
Diasypus novemcinctus	Armadillo
Odocoileus virginianus	White-tailed deer
Procyon lotor	Raccoon
Sus scrofa x Sus vitatus	Feral hog
Avian	
Dryocopus pileatus	Pileated woodpecker

Table 12a. ACBS Forested Wetland Species Density Transferred from Donor Wetlands.

Scientific Name	Common Name	# trees	# stumps	# saplings	Total	#/ha.	#/ac.
Magnolia virginiana	Sweet bay	387	414	1237	2038	629.6	254.8
Gordonia lasianthus	Loblolly bay	57	9	320	386	119.3	48.3
Nyssa sylvatica	Black gum	28	12	8	48	14.8	6.0
Persea palustris	Swamp bay	20	4	38	62	19.2	7.8
Persea borbonia	Red bay	5	0	6	11	3.4	1.4
Ilex cassine	Dahoon holly	23	7	81	111	34.3	13.9
Liquidambar styraciflua	Sweetgum	0	0	3	3	0.9	0.4
Diospyros virginiana	Persimmon	2	0	0	2	0.6	0.3
Quercus laurifolia	Laurel oak	0	1	10	11	3.4	1.4
	Total	522	447	1703	2672	825.5	334

Table 12b. ACBS Bay Swamp Tree and Stump Density.

Scientific Name	Common Name	# trees	# stumps	Total	#/hectare	#/acre
Magnolia virginiana	Sweetbay	387	414	801	247.5	100.1
Gordonia lasianthus	Loblolly bay	57	9	66	20.4	8.3
Nyssa sylvatica	Black gum	28	12	40	12.4	5.0
Persea palustris	Swamp bay	20	4	25	7.7	3.1
Persea borbonia	Red bay	5	0	5	1.5	0.6
Ilex cassine	Dahoon holly	23	7	30	9.3	3.8
Liquidambar styraciflua	Sweetgum	0	0	0	NA	NA
Diospyros virginiana	Persimmon	2	0	2	0.6	0.3
Quercus laurifolia	Laurel oak	0	1	1	0.3	0.1
	TOTAL	522	447	969	299.4	121.1

Table 13a. ACBS Bay Swamp Tree/Stump Species Survival– 6 Months Post Transfer.

Scientific Name	Common Name	% tree live	% tree dead	% stump live	% stump dead	# grow (per hectare)	# grow (per acre)
Magnolia virginiana	Sweetbay	63.0	37.0	60.9	39.1	496 (153.2)	496 (62.0)
Gordonia lasianthus	Loblolly bay	59.6	40.4	66.7	33.3	40 (12.4)	40 (5.0)
Nyssa sylvatica	Black gum	35.7	64.3	83.3	16.7	20 (6.2)	20 (2.5)
Persea palustris	Swamp bay	60.0	40.0	25.0	75.0	13 (4.0)	13 (1.6)
Persea borbonia	Red bay	80.0	20.0	NA	NA	4 (1.2)	4 (0.5)
Ilex cassine	Dahoon holly	52.2	47.8	100	0	19 (5.9)	19 (5.9)
Liquidambar styraciflua	Sweetgum	NA	NA	NA	NA	0 (NA)	0 (NA)
Diospyros virginiana	Persimmon	0	100	NA	NA	0 (NA)	0 (NA)
Quercus laurifolia	Laurel oak	NA	NA	0	100	1 (3.1)	1 (0.1)
	TOTAL	60.5	39.5	62.0	38.0	593 (183.2)	593 (74.1)

Table 13b. ACBS Bay Swamp Sapling Species Survival-- 6 Months Post Transfer.

Scientific Name	Common Name	% sapling grow	% sapling dead	# grow (per hectare)	# grow (per acre)
Magnolia virginiana	Sweetbay	88.3	11.7	1092 (337.4)	1092 (136.5)
Gordonia lasianthus	Loblolly bay	42.2	57.8	135 (41.7)	135 (16.9)
Nyssa sylvatica	Black gum	62.5	37.5	5 (1.5)	5 (0.6)
Persea palustris	Swamp bay	89.5	10.5	34 (10.5)	34 (4.3)
Persea borbonia	Red bay	50.0	50.0	3 (0.9)	3 (0.4)
Ilex cassine	Dahoon holly	97.5	2.5	79 (24.4)	79 (9.9)
Liquidambar styraciflua	Sweetgum	100	0.0	3 (0.9)	3 (0.4)
Diospyros virginiana	Persimmon	NA	NA	0 (NA)	0 (NA)
Quercus laurifolia	Laurel oak	100	0.0	10 (3.1)	10 (1.3)
	TOTAL	80.8	19.2	1361 (420.5)	1361 (170.1)

Table 14. ACBS Strata Transfer Survival Density (# per hectare/# per acre).

Scientific Name	Mature canopy 25'+	Sub-mature canopy 20-25'	Tall sub-canopy 15-20'	Short sub-canopy 8-15'	Sapling canopy <8'
Gordonia lasianthus	--	0.3/0.1	1.2/0.5	9.0/3.6	41.7/16.9
Ilex cassine	0.3/0.1	--	0.3/0.1	3.4/1.4	24.4/9.9
Magnolia virginiana	9.0/3.6	8.3/3.4	13.9/5.6	44.5/18.0	337.4/136.5
Nyssa sylvatica	0.6/0.3	0.6/0.3	0.3/0.1	1.5/0.6	1.5/0.6
Persea borbonia	--	--	--	1.2/0.5	0.9/0.4
Persea palustris	--	0.3/0.1	0.6/0.3	2.8/1.1	10.5/4.3
Diospyros virginiana	--	--	--	--	--
Liquidambar styraciflua	--	--	--	--	0.9/0.4
Quercus laurifolia	--	--	--	--	3.1/1.3
TOTAL	9.9/4.0	9.6/3.9	20.2/6.4	62.4/25.3	420.5/170.1

Table 15 Additional Woody Wetland Species Composition

Scientific Name	Common Name	# of Indiv.	#/ha	#/ac
Cephalanthus occidentalis	Buttonbush	542	167.4	67.8
Acer rubrum	Red maple	261	80.6	32.6
Itea virginica	Virginia willow	120	37.1	15.0
Viburnum nudum	Possum haw	61	18.8	7.6
Vaccinium corymbosum	Highbush blueberry	28	8.7	3.5
Myrica cerifera	Wax myrtle	21	6.5	2.6
Ilex glabra	Gallberry	6	1.9	0.8
Cornus foemina	Swamp dogwood	5	1.5	0.6
Lyonia lucida	Fetterbush	5	1.5	0.6
Rhus copallinum	Winged sumac	5	1.5	0.6
Serenoa repens	Saw palmetto	3	0.9	0.4
Hypericum sp.	St. John's wort	2	0.6	0.3
Pinus elliottii	Slash pine	2	0.6	0.3
Sambucus canadensis	Elderberry	2	0.6	0.3
Callicarpa americana	Beauty berry	1	0.3	0.1
Vaccinium myrsinites	Shiny blueberry	1	0.3	0.1
	TOTAL	1068	330.0	133.5

Table 16. Wildlife Observations at ACBS, December 1998-May 1999

SPECIES	COMMON NAME	SPECIES	COMMON NAME
Avian		**Avian**	
Agelaius phoeniceus	Red-winged blackbird	*Elanoides forficatus*	Swallow-tail kite
Ajaia ajaja	Roseate spoonbill	*Eriolia* sp.	Sandpiper
Anas fulvigula	Mottled duck	*Gallinago gallinago*	Common snipe
Ardea herodias	Great blue heron	*Grus canadensis pratensis*	Florida sandhill crane
Bubulcus ibis	Cattle egret	*Himantopus mexicanus*	Black-necked stilt
Buteo lineatus	Red shouldered hawk	*Larus atricilla*	Laughing gull
Casmerodias albus	Great egret	*Melanerpes carolinus*	Red-bellied woodpecker
Ceryle alcyon	Belted kingfisher	*Mycteria americana*	Wood stork
Charadrius semipalmatus	Semi-palmated plover	*Pandion haliaetus*	Osprey
Charadrius vociferous	Killdeer	*Parula americana*	Northern parula
Coragyps atratus	Black vulture	*Pelecanus erythrorhynchos*	American white pelican
Corvus brachyrhynchos	American crow	*Plegadis falcinellus*	Glossy ibis
Dumetella carolinensis	Gray catbird	*Quiscalus major*	Boat-tailed grackle
Egretta caerulea	Little blue heron	*Sturnella magna*	Eastern Meadowlark
Egretta thula	Snowy egret	*Zenaida macroura*	Mourning dove
Amphibian		**Mammal**	
Acris gryllus dorsalis	Florida cricket frog	*Odocoileus virginianus*	White-tailed deer
Rana grylio	Pig frog	*Procyon lotor*	Raccoon
Fish			
Gambusia affinis	Mosquito fish		