AN ASSESSMENT OF WETLANDS ESTABLISHMENT TECHNIQUES AT A FLORIDA PHOSPHATE MINE SITE

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ABSTRACT

The Florida Game and Fresh Water Fish Commission is cooperating with International Minerals and Chemical Corporation and the U.S. Fish and Wildlife Service in conducting a three year project to determine techniques for establishing wooded and herbaceous wetland habitat on a 55-acre phosphate mine site in Central Florida. Study site selection, design and final contouring, plant material selection, and the planting effort were directed toward evaluating the growth and survival of wetland and transitional plant species in response to geo-physical and hydrological conditions found after phosphate mining. Preliminary results of the first year's monitoring activities are presented for the study site, including surface and subsurface hydrology, water quality, soil chemistry, invader plants, wildlife utilization, and the survival of planted tree seedlings and freshwater marsh plants.

INTRODUCTION

Wooded and herbaceous Central Florida wetlands associated with lakes, ponds, streams and depressions include wet prairies, freshwater marshes, hardwood swamps, cypress swamps, and bayheads. These communities are important in terms of life support, productivity, and potential benefit to society. In addition to providing important fish and wildlife habitat, they serve to stabilize bottom sediments, reduce stream turbidity and siltation, and assimilate nutrients and pollutants. Wetlands also store surface water; have aesthetic, recreational, and educational value; and may provide groundwater recharge.

Central Florida phosphate miners stripmine approximately 2,478 hectares (6,000 acres) of land each year resulting in the total onsite disruption of existing soils, topography and drainage features, plant communities and wildlife populations. Due to economic considerations, past reclamation programs have resulted in extensive lake systems and well drained land managed as improved pasture. Reclamation of wetland habitats could serve to partially mitigate long-term mining impacts on fish and wildlife populations, but definitive procedures for restoring habitat values and beneficial ecological functions of mined lands are non-existent.

Therefore in July 1978, the Office of Environmental Services of the Florida Game and Fresh Water Fish Commission began a three-year study to develop and demonstrate procedures for establishing functional, self perpetuating wetland habitats and transitional areas on phosphate mined land. Our objective was to design and construct a wetland test area on mined land to: (1) evaluate the growth and survival of introduced plant materials and document natural plant invasion; (2) document wildlife utilization and evaluate the habitat quality of the emerging community; (3) describe interrelated components of the system including soil properties, surface and subsurface hydrology, water quality, and rainfall; and (4) evaluate the wetland site design in terms of future improvements, application, and recommendations. This paper is a report of progress covering the first 20 months of study from July 1978 to March 1980. A formal scientific report covering all aspects of the project will be delivered to the U.S. Fish and Wildlife Service in late December 1980, while a handbook on wetland habitat reclamation will be completed by July 1981. This study is funded by the U.S. Fish and Wildlife Service and is being performed in cooperation with International Minerals and Chemical Corporation (IMCC).

AREA DESCRIPTION

The wetland test area was constructed on a 22.3 hectare (55 acre) tract adjoining the Peace River south of Bartow, Florida (Figure 1).

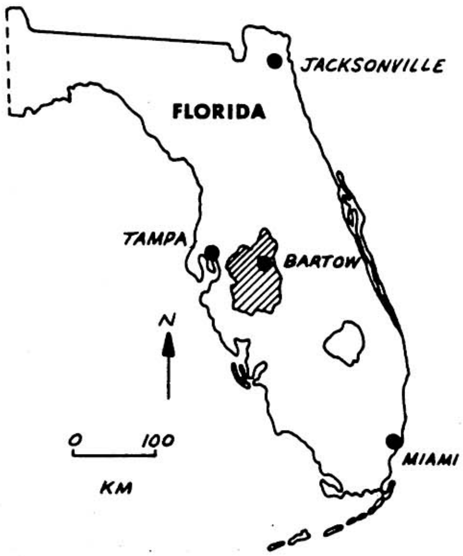

Figure 1. Central Florida land-pebble phosphate district showing study site location at Bartow, Florida.

The site was mined between October 1967 and March 1968 and selected due to its proximity to a source of native plant materials, sloping topography, and broad range of surface soil material. The Peace River floodplain borders the site on three sides. Low-lying hydric areas in the floodplain are dominated by bald cypress (*Taxodium distichum*), and pop ash (*Fraxinus caroliniana*), which grade into transition areas characterized by red maple (*Acer rubrum*), Florida elm (*Ulmus americana* var. *floridana*), cabbage palm (*Sabal palmetto*), water oak (*Quercus nigra*), sweetgum (*Liquidambar styraciflua*) and sugarberry (*Celtis laevigata*). Xeric sites are dominated by live oak (*Q. virginiana*), laurel oak (*Q. hemisphaerica*), southern magnolia (*Magnolia grandiflora*), and mockernut hickory (*Carya tomentosa*).

METHODS AND MATERIALS

The IMCC reclamation section completed test site construction during November 1978, following a design to allow testing of wetland plant establishment. Spoil piles were leveled in the summer of 1978, and the site's lowland area contoured to create distinct northern and southern basins connected by a shallow meandering channel at normal water levels. A 0.2 hectare (0.5 acre) pond excavated in the northern basin provides a continuous sanctuary for aquatic life during low water. An earthen berm/access road was constructed around the lowland area for surface water storage, and outfall pipes were installed to fix the normal high water line. An adjacent 80.9 hectare (200 acre) reclaimed pasture also serves as a drainage area for the site.

Monitoring equipment installed included rainfall gauges, surface water level staff gauges, a continuous water level recorder, and nine regularly spaced piezometers (shallow wells) which were drilled to a depth of 9.1 meters (30 feet). Four permanent water quality stations were also located. A final topographic map of the completed site was prepared (Figure 2) and the test area was divided into a permanent grid of 176, 30.5 meter (100 foot) square plots. Composite soil samples were collected and analyzed.

The test plots selected for planting represent the range of site conditions including soil differences and potential soil moisture regimes or inundation zones. The biology of individual species was also considered in making plot assignments.

A total of 10,400 tree seedlings representing 16 species were planted during January and February 1979 in 26 multispecies plots. Four to five species were planted at 1.5 meter (five-foot) centers in each plot according to a planting guide which randomly assigned each species. Approximately 2,100 seedlings were also randomly planted at appropriate elevations throughout the site. The wetland and transitional species were planted in as many plots as possible to evaluate their success over the full range of site conditions. Bare-root seedlings purchased from the Florida Division of Forestry were used since we required large numbers of each species of the same age class.

Herbaceous freshwater marsh plants were also transplanted to the site from nearby wetland habitats. A total of 12, 6.1 meter (20 foot) square marsh test plots were planted in May 1979 with the following species and numbers of clumps (1-4 individual plants): arrowhead (Sagittaria lancifolia) 52, pickerelweed (Pontederia lanceolata) 57, maidencane (Panicum hemitomon) 42, and softrush (Juncus effusus) 23. Approximately 5,000 maidencane rhizomes were also planted in January 1979.

A monitoring program (Table 1) was initiated in early June 1979 to

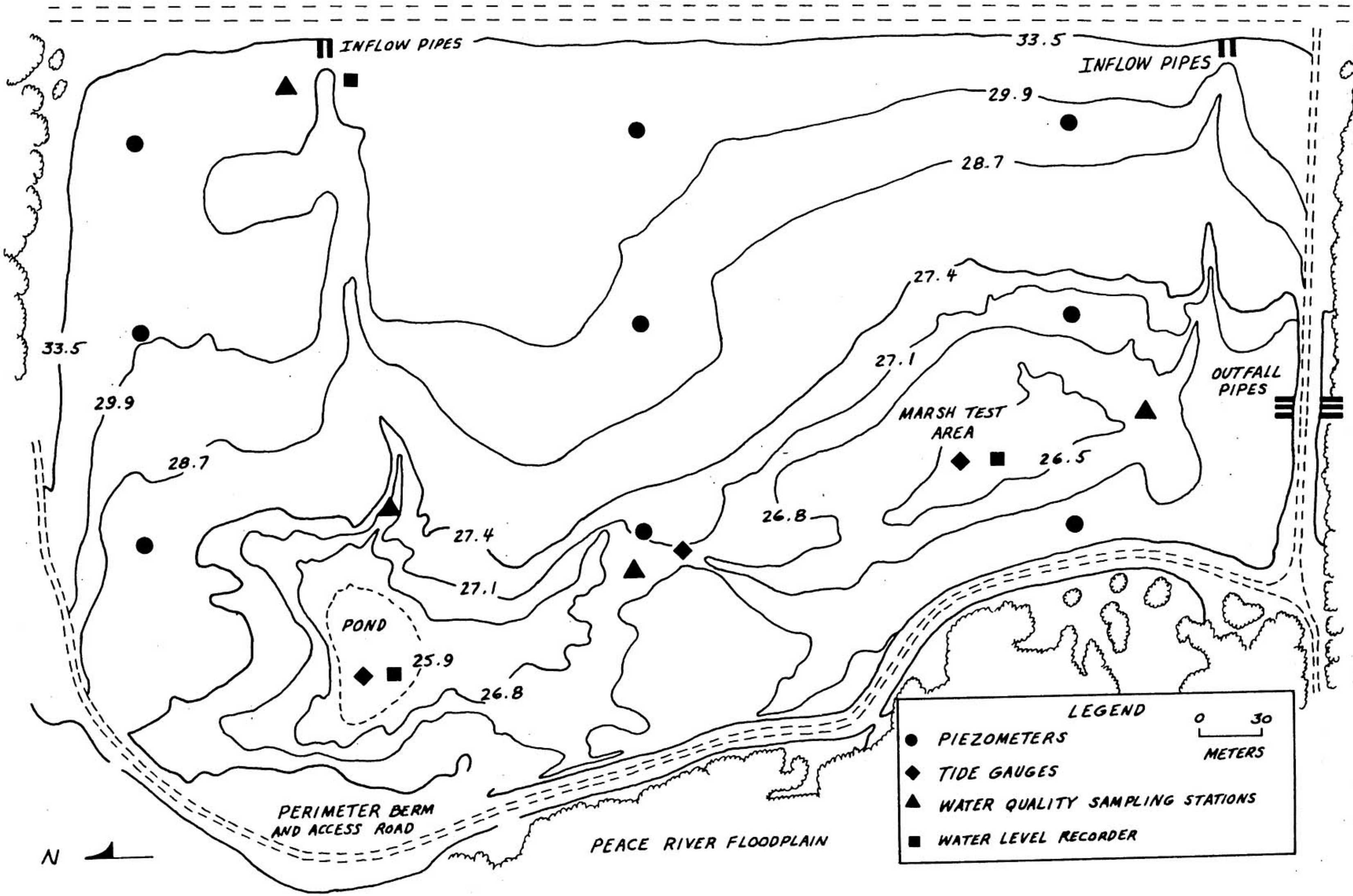

Figure 2. Wetland test site showing abbreviated topographic features and monitoring locations.

Table 1. Monitoring schedule on Peace River wetland test site.

	D	2W	W	BW	M	Q	A
WATER							
Rainfall Gauges	X						
Surface Water Levels	X						
Piezometers				X			
Water Quality			X				
VEGETATION							
Natural Plant Invasion					X		
Marsh Test Plots					X		
Tree Seedlings							X
WILDLIFE							
Bird Surveys		X					
Small Mammal Trapping						X	
Reptiles & Amphibians		X					
Fish						X	
Wildlife Use (Qualitative)	X						
Photographic Stations					X		

D=Daily
2W=Twice weekly
W=Weekly
BW=Bi-weekly
M=Monthly
Q=Quarterly
A=Annually

characterize: (1) the survival and growth of the various plantings, (2) natural plant succession trends, (3) surface and subsurface hydrology, (4) surface water quality, and (5) trends in wildlife utilization.

Information on natural plant invasion was gathered by recording percent coverage by species using replicated hoop drops, while all planted plots were surveyed to document survival of tree seedlings and marsh plants. Birds were surveyed by recording the total number of individuals and species during timed walks of the area. Small mammal species were recorded using Sherman live trap transects while information on reptiles and amphibians was gathered using two pitfall traps with sheet metal drift fences. Fish were sampled using a dip net and a 15.2 meter (50 foot) seine net; and tracks, scats, and other wildlife sign were also recorded. Monthly photographs were also taken at 16 stations on the site to document water level and vegetational changes.

RESULTS

Soils

Soils data compiled from all planted plots on the study site are given in Table 2. The analysis was performed by IMCC's Agronomic Services in Terre Haute, Indiana following a computer program designed to evaluate soil properties for shade tree culture. The pH values ranged from 5.9 to 8.4, and no lime was needed. Available phosphorus values were all above the upper limit of routine reporting. All potassium results were very low; calcium and nearly all magnesium levels were very high; while sulfur levels were adequate. Therefore high application rates of potash were recommended to enhance plant growth.

Although most samples were generally low in manganese, iron, copper, zinc, and boron, no additional applications were recommmended since most trees and shrubs are very efficient in obtaining these elements. Since the percentage of organic matter was very low in most samples, frequent applications of nitrogen were recommended to maintain steady plant growth.

Hydrology

Changes in surface and ground water levels were closely correlated with rainfall (Figure 3). A natural drawdown event which lasted approximately 50 days exposed the bottom of the southern basin and created drying conditions from late March through early May 1979.

Table 2. Soils data from planted test plots on wetland study site.

	Kilograms per Hectare									
	P	K	Ca	Mn	Mg	Fe	Cu	Zn	S	B
Mean	538.7	47.3	11198.8	17.2	870.2	51.1	1.2	16.9	68.5	.64
Minimum	508.9	24.7	11198.8	3.4	213.0	2.2	.6	2.2	37.0	.22
Maximum	560.5	67.3	11198.8	32.5	2226.1	16.6	1.7	43.7	140.0	1.35

	Percent Organic Matter	Cation Exchange Capacity	Cation Saturation Percent				-----Percent-------		
			K	Ca	Mg	pH	Sand	Silt	Clay
Mean	.4	29.8	.17	84.0	10.5	7.1	85.7	3.7	10.7
Minimum	.1	27.2	.1	75.0	2.8	5.9	78.0	2.0	4.0
Maximum	.9	33.3	.2	91.8	24.9	8.4	94.0	9.0	20.0

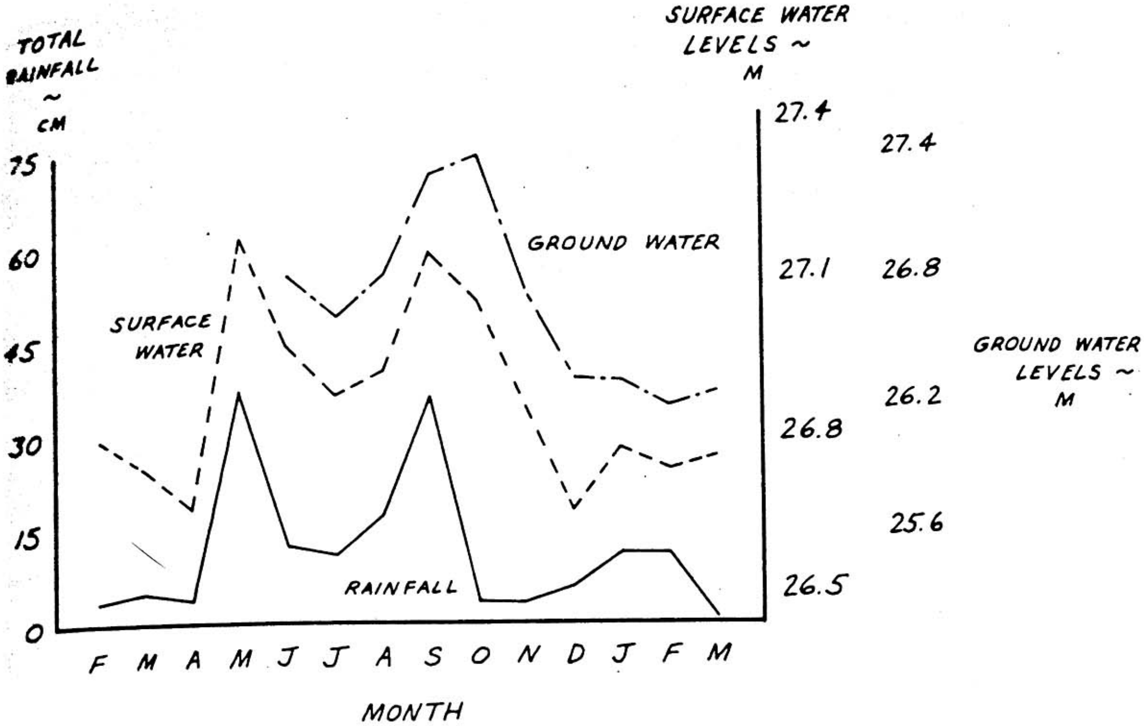

Figure 3. Relationship between total rainfall and average surface and ground water level changes on wetland test site from February 1979 to March 1980.

During 366 days of observation these elevations in meters (feet) above mean sea level were inundated the following percentage of the study period: 27.6 (90.5) 0.3%, 27.3 (89.5) 2%, 27.0 (88.5) 29%, 26.7 (87.5) 85%, and 26.4 (86.5) 94%. Extremely high water levels caused by abnormal rainfall events associated with a low pressure area storm and Hurricane David were recorded during the months of May and September 1979, respectively.

Water Quality

The overall water quality data (Table 3) from the wetland test site indicate an alkaline situation as the average pH value ranged from 7.1 to 10.6 with a mean of 8.9. Alkaline conditions are probably due to an abundance of rocks and sediment containing calcium carbonate which has been deposited on the surface as a result of mining.

Table 3. Water quality data taken at the wetland test site from June 1979 through March 1980.

	Fluoride mg/l	Phosphorus mg/l	Kjeldahl Nitrogen mg/l	Nitrate Nitrogen mg/l
Mean	1.5	3.8	1.6	.14
Minimum	.5	.4	.3	.1
Maximum	2.7	21.3	7.7	.8

	pH	Turbidity	Suspended Solids mg/l	Total Akalinity ppm CaCo3
Mean	8.9	38.6	30.6	38.9
Minimum	7.1	2.6	2.0	12.1
Maximum	10.6	330.0	159.0	71.5

Vegetation

The preliminary survival data of planted tree seedlings is given in Table 4. Figure 4 gives the predicted survival model versus elevation for bald cypress, based on our data. Several species including bald cypress, red maple, and sweetgum, show promise as candidate plants for reclamation use, especially when plot specific survival is considered. At the conclusion of the study, recommendations will be made to maximize growth and survival of individual species based on potential inundation zones and other related factors.

Our preliminary data shows close to 100 percent survival of the transplants in our marsh test plots coupled with vigorous growth, flowering, fruiting, and dissemination and recruitment of new individuals. We

Table 4. Survival of planted tree seedlings on wetland test site.

Species	Overall Survival	Plot specific Survival Minimum	Plot specific Survival Maximum
Bald cypress (*Taxodium distichum*)	84.5	56.1	97.5
Red maple (*Acer rubrum*)	61.5	20.0	90.1
Green ash (*Fraxinus pennsylvanica*)	85.4	57.5	99.0
Sweetgum (*Liquidambar styraciflua*)	72.3	27.6	90.0
Tupelo gum (*Nyssa aquatica*)	29.5	5.6	65.2
Catalpa (*Catalpa bignonioides*)	79.1	58.4	91.0
Cottonwood (*Populus deltoides*)	19.8	0.0	50.0
Sycamore (*Platanus occidentalis*)	68.0	51.0	80.2
Live oak (*Quercus virginiana*)	28.0	19.0	41.4
Longleaf pine (*Pinus palustris*)	6.5	1.0	14.9
Loblolly pine (*Pinus taeda*)	43.9	26.0	61.4
North Florida slash pine (*Pinus elliottii* var. *elliottii*)	58.4	45.9	73.0
South Florida slash pine (*Pinus elliottii* var. *densa*)	29.2	25.3	33.3
Sand Pine (*Pinus clausa*)	54.0	45.0	60.6
Spruce pine (*Pinus glabra*)	70.3	37.8	90.9

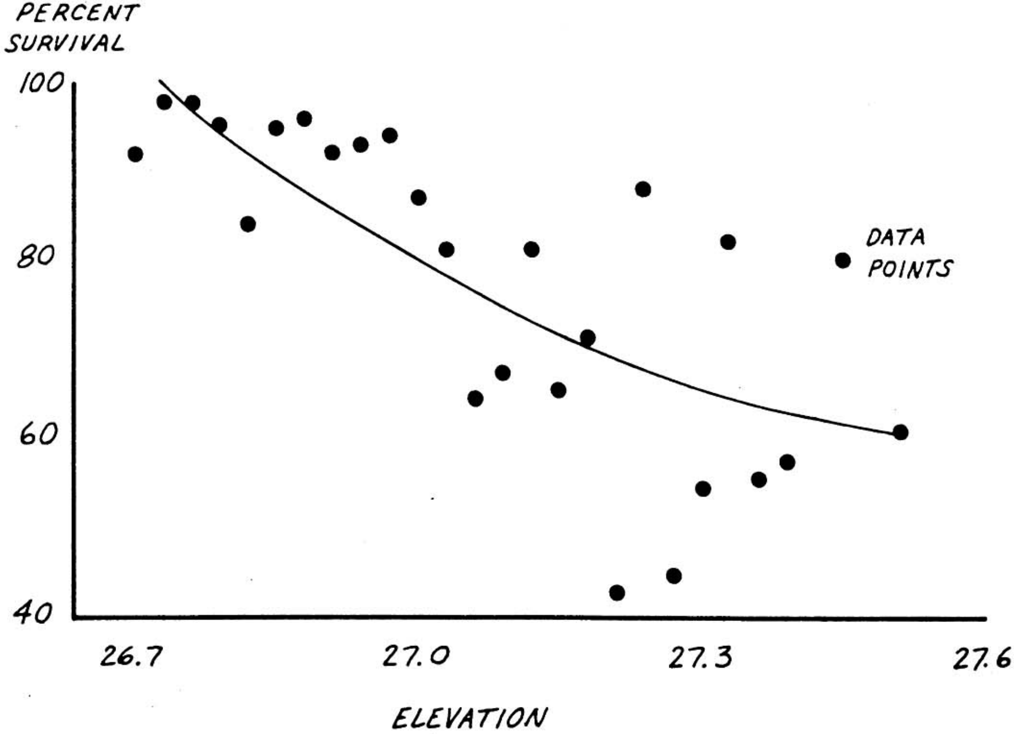

Figure 4. Bald cypress seedling survival relative to elevations on the study site.

recorded approximately 470 new arrowhead and pickerelweed plants scattered in the previously inundated transition zone around the southern basin at the end of the first growing season. We suspect these new plants were disseminated from our marsh test plots since: (1) the new plants were the same species planted in the marsh study plots, (2) all new plants were found in the southern basin where the marsh plots are located, and (3) the marsh test plots contained some of the highest concentrations of new plants.

Plant invasion of the wetland area was rapid during the first growing season (Figure 5). Table 5 lists some of the typical species recorded on the test site.

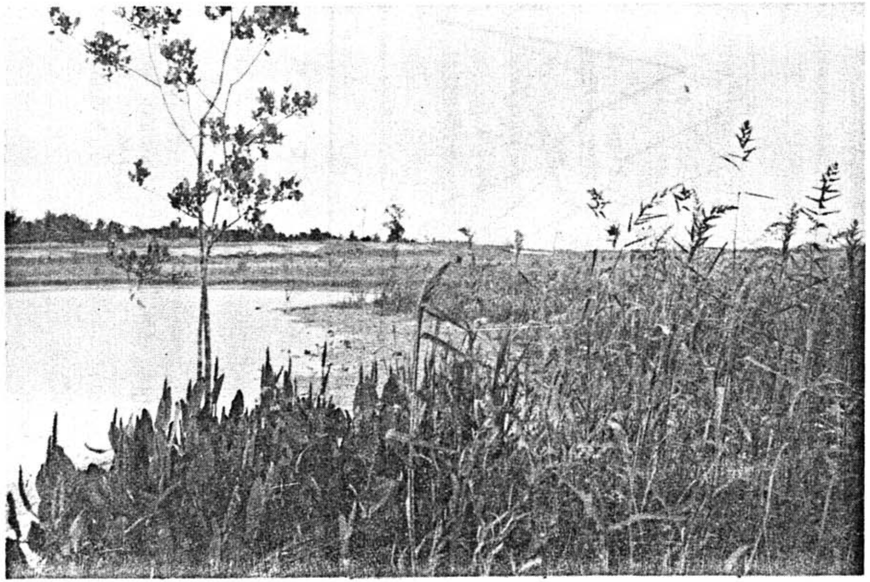

Figure 5. Wetland study site showing Density of Vegetation in May, 1980.

Table 5 Typical invader plants recorded from wetland and transitional areas on the test site.

Acer rubrum	Red maple
Alternanthera philoxerioides	Alligator weed
Cephalanthus occidentalis	Buttonbush
Cyperus retrorsus	Sedge
Cyperus iria	Sedge
Cyperus globulosus	Sedge
Cyperus haspan	Sedge
Cyperus surinamensis	Sedge
Cyperus distinctus	Sedge
Eichhornia crassipes	Water hyacinth
Fimbristylis autumnalis	
Hydrocotyl umbellata	Water pennywort
Juncus effusus	Soft rush
Lemna sp.	Duckweed
Ludwigia palustris	
Ludwigia decurrens	
Ludwigia octovalis	
Ludwigia repens	
Lindernia anagallidea	False pimpernel
Najas guadalupensis	Naiad
Paspalum urvillei	Vasey grass
Paspalum repens	Torpedo grass
Panicum dichotomiflorum	
Pistia stratiotes	Water lettuce
Polygonum punctatum	Water smartweed
Sacciolepis striata	
Salix caroliniana	Carolina willow
Scirpus validus	Bulrush
Thalia geniculata	Fireflag
Typha lattifolia	Cattail

Wildlife

Wildlife use of the study site during the first year was excellent (Table 6) in terms of both the kinds of species and numbers of individuals represented. The following species and numbers of individuals observed during single surveys include: wood stork (32), hooded merganser (44), blue-winged teal (35), wood duck (2), Florida duck (4), dowitcher (22), common snipe (19), least sandpiper (20), glossy ibis (15) white ibis (15), American avocet (5), river otter (1), and bald eagle (2).

We found a significant correlation between surface water level changes and wildlife use on the test site. Receding surface water levels result in an increase in the average number of animals observed, mean numbers of species, and diversity index (Figure 6).

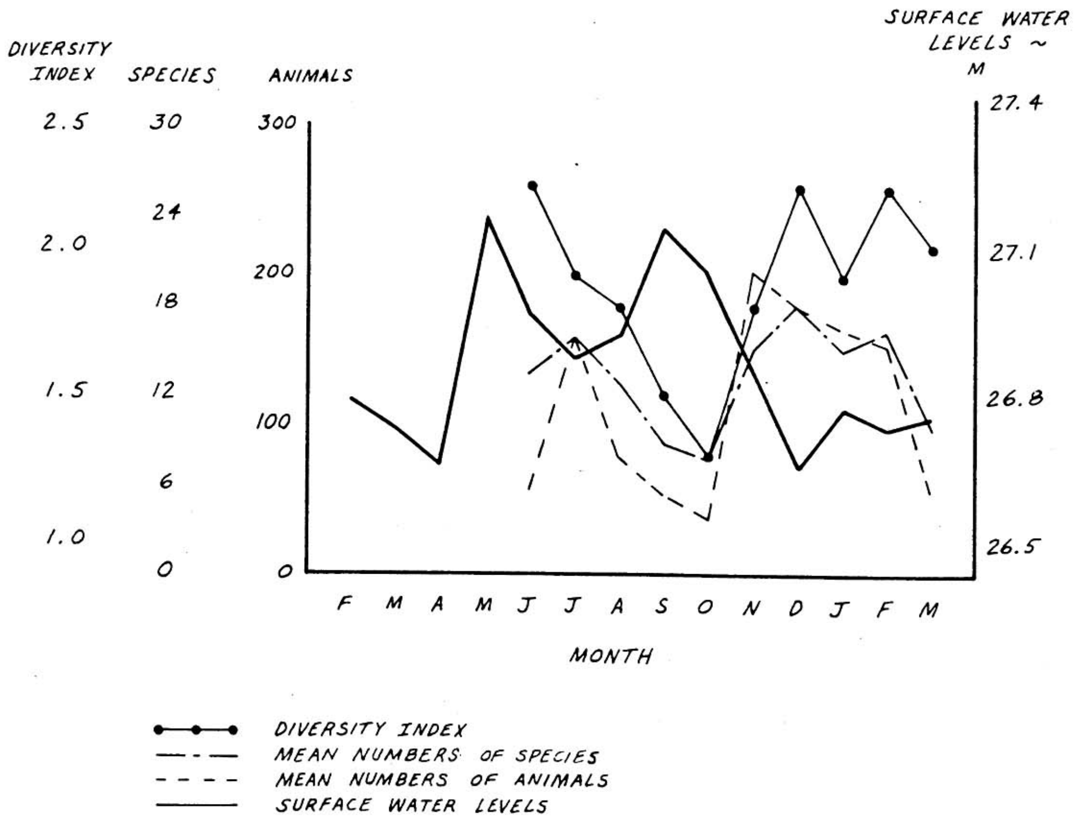

Figure 6. Relationship between surface water level changes, average numbers of animals and species observed, and diversity index.

Table 6. Wildlife species recorded on wetland test site from February 1979 through April 1980

FISHES

Threadfin shad
(Dorosoma petenense)

Golden shiner
(Notemigonus crysoleucas)

Mosquito fish
(Gambusia affinis)

Least killifish
(Heterandria formosa)

Golden topminnow
(Fundulus chrysotus)

Warmouth
(Chaenobryttus gulosus)

Bluegill
(Lepomis macrochirus)

Red-eared sunfish
(Lepomis microlophus)

REPTILES-AMPHIBIANS

American alligator
(Alligator mississipiensis)

Mud turtle
(Kinosternon subrubrum)

Florida softshell
(Trionyx ferox)

Banded water snake
(Natrix fasciata)

Garter snake
(Thamnophis sirtalis)

Black racer
(Coluber constrictor)

Eastern indigo snake
(Drymarchon corais couperi)

Rat snake
(Elaphe obsoleta)

Cottonmouth
(Agkistrodon piscivorus)

Eastern diamondback rattlesnake
(Crotalus adamanteus)

Southern Toad
(Bufo terrestris)

Oak Toad
(Bufo quercicus)

Southern cricket frog
(Acris gryllus)

Pig frog
(Rana grylio)

Southern leopard frog
(Rana pipiens)

BIRDS

Pied-billed grebe
(Podilymbus podiceps)

White pelican
(Pelecanus erythrorhynchos)

Double-crested cormorant
(Phalacrocorax auritus)

Anhinga
(Anhinga anhinga)

Florida duck
(Anas fulvigula)

Blue winged teal
(Anas discors)

Wood duck
(Aix sponsa)

Hooded merganser
(Lophodytes cucullatus)

Turkey vulture
(Cathartes aura)

Black vulture
(Coragyps atratus)

Marsh hawk
(Circus cyaneus)

Red-tailed hawk
(Buto jamaicensis)

Red-shouldered hawk
(Buteo lineatus)

Bald eagle
(Haliaeetus leucocephalus)

Osprey
(Pandion haliaetus)

American kestrel
(Falco sparverius)

Bobwhite
(Colinus virginianus)

American egret
(Casmerodius albus)

Snowy egret
(Leucophoyx thula)

Cattle egret
(Bubulcus ibis)

Great blue heron
(Ardea herodias)

Louisiana heron
(Hydranassa tricolor)

Little blue heron
(Florida caerulea)

Green heron
(Butorides virescens)

Black-crowned night heron
(Nycticorax nycticorax)

Wood stork
(Mycteria Americana)

Glossy ibis
(Plegadis falcinellus)

White ibis
(Eudocimus albus)

Roseate spoonbill
(Ajaia ajaja)

Limpkin
(Aramus guarauna)

Table 6 Continued

American coot
(*Fulica americana*)

American avocet
(*Recurvirostra americana*)

Black-necked stilt
(*Himantopus mexicanus*)

Killdeer
(*Charadrius vociferus*)

Greater yellowlegs
(*Totanus melanoleucus*)

Lesser yellowlegs
(*Totanus flavipes*)

Short-billed dowitcher
(*Limnodromus griseus*)

Long-billed dowitcher
(*Limnodromus scolopaceus*)

Least sandpiper
(*Erolia minutilla*)

Common snipe
(*Capella gallinago*)

Ring-billed gull
(*Larus delawarensis*)

Forester's tern
(*Sterna forsteri*)

Mourning dove
(*Zenaidura macroura*)

Ground dove
(*Columbigallina passerina*)

Smooth-billed ani
(*Crotophaga ani*)

Ruby-throated hummingbird
(*Archilochus colubris*)

Belted kingfisher
(*Megaceryle alcyon*)

Scissor-tailed flycatcher
(*Muscivora forfic*)

Eastern phoebe
(*Sayornis phoebe*)

Barn swallow
(*Hirundo rustica*)

Rough-winged swallow
(*Stelgidopteryx ruficollis*)

Blue jay
(*Cyanocitta cristata*)

Fish crow
(*Corvus ossifragus*)

Mockingbird
(*Mimus polyglottos*)

Robin
(*Turdus migratorius*)

Blue-gray gnatcatcher
(*Polioptila caerulea*)

Water pipit
(*Anthus spinoletta*)

Loggerhead shrike
(*Lanius ludovicianus*)

Myrtle warbler
(*Dendroica coronata*)

Palm warbler
(*Dendroica palmarum*)

Yellowthroat
(*Geothlypis trichas*)

Bobolink
(*Dolichonyx oryzivorus*)

Red-winged blackbird
(*Agelaius phoeniceus*)

Boat-tailed grackle
(*Cassidix mexicanus*)

Common grackle
(*Quiscalus quiscula*)

Brown-headed cowbird
(*Molothrus ater*)

Cardinal
(*Richmondena cardinalis*)

American goldfinch
(*Spinus tristis*)

Savannah sparrow
(*Passerculus sandwichensis*)

Vesper sparrow
(*Pooecetes gramineus*)

Field sparrow
(*Spizella pusilla*)

Swamp sparrow
(*Melospiza georgiana*)

Song sparrow
(*Melospiza melodia*)

MAMMALS

Opossum
(*Didelphis marsupialis*)

Shorttail shrew
(*Blarina brevicauda*)

Raccoon
(*Procyon loter*)

River otter
(*Lutra canadensis*)

Stripped skunk
(*Mephitis mephitis*)

Red fox
(*Vulpes fulva*)

Bobcat
(*Lynx rufus*)

Rice rat
(*Oryzomys palustris*)

Hispid cotton rat
(*Sigmodon hispidus*)

House mouse
(*Mus musculus*)

Eastern cottontail
(*Sylvilagus floridanus*)

Armadillo
(*Dasypus novemcinctus*)

DISCUSSION AND CONCLUSIONS

The phosphate overburden spoils we studied are of sufficient quality to support the establishment of both woody and herbaceous wetland and transitional plant species. Natural plant invasion on our site was rapid and survival of the test plantings was good.

Our sampling program shows that the test site aquatic system developed rapidly producing an abundance of forage organisms including fishes, amphibians, aquatic insects and invertebrates. Wildlife use of the study site was excellent, both in terms of the types of species and numbers of individuals represented.

Our study demonstrates that with proper design and construction, reclaimed phosphate land can provide important habitat for wildlife species which utilize wetlands and transitional areas. The continued protection of important regional wetlands and other habitats coupled with a reclamation policy for wetland habitat restoration, could eventually serve to partially mitigate long term mining impacts on fish and wildlife resources and restore natural systems functioning. A clearer understanding of the ecology of phosphate mined lands, coupled with improvements in disposal methods for mining related waste products will aid in the overall reclamation process.