FORESTED WETLAND RECLAMATION SUCCESS CRITERIA DEVELOPMENT IN NORTH FLORIDA[1]

by

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Abstract. Criteria for determining successful reclamation of forested wetlands in North Central Florida were established in 1987 by a Multi-Agency Group represented by federal and state environmental agencies, environmental action groups, and Occidental Chemical Company (OxyChem). OxyChem mines phosphate in North Central Florida and requires dredge and fill permits to mine in wetland areas. Three milestones were established for 4 demonstration sites for monitoring to be conducted quarterly and evaluated every two years. The 1989 data show the results of the first milestone monitoring period for ten criteria including tree density, tree diversity, growth rate, ground cover, seed production, hydrology, water quality, wildlife abundance, wildlife richness and soils. Vegetational monitoring employed belt transects (elongated line-strip quadrats), hydrology by water level recording, water quality by standard chemical methods, wildlife abundance and diversity by macroinvertebrate sampling and soils by percent organic matter. Results indicate the achievement of the Milestone 1 criteria as established by the Multi-Agency Group.

Additional key words: wooded wetland restoration, phosphate wetland reclamation.

Introduction

Occidental Chemical Corporation *(OxyChem)* conducts surface mining of phosphate in North Central Florida. The two mines, Suwannee River and Swift Creek, can produce 3.0 and 2.5 million tons of phosphate rock per year. Suwannee River Mine began operation in 1965 and Swift Creek Mine in 1975. Approximately 6300 hectares (ha) (15,567 ac.) have been mined to date at the two sites. The operations are located in Southeastern Hamilton County, which is just below the Florida/Georgia border.

The area is generally classified as pine flatwoods interspersed with cypress domes and bayheads. Approximately 25 to 30 percent of the area would be classed as wetlands, mostly forested wetlands.

Land reclamation in Florida for phosphate mining has been mandatory since 1975. Companies mining phosphate are required to submit programs prior to mining and reclamation cannot begin until the programs are approved. The Florida Department of Natural Resources (FDNR) is the regulatory agency for mine reclamation activities.

In 1986, the U.S. Army Corps of Engineers completed an Environmental Impact Study *(EIS)* of the area within OxyChem's existing mining operation. As part of an agreement on the permit issued as a result of the *EIS*, a Memoranda of Understanding *(MOU)* was developed with success criteria for forested wetland establishment. These criteria were developed by members of the Multi-Agency Group including personnel from U.S. EPA (USEPA), U.S. Army Corps of Engineers (COE), Florida Department of Environmental Regulation (FDER), Florida Department of Natural Resources (FDNR), Florida Game and Fresh Water Fish Commission (FG&FWFC), U.S. Fish and Wildlife Service (USF&WS), Suwannee River Water Management District (SRWMD), Florida Defenders of the Environment (FDE) and OxyChem. The Multi-Agency Group was responsible for the final decisions on the success criteria. A subset of the Multi-Agency Group called the Success Criteria Working Group was composed of representatives of COE, FDER, USEPA, FG&FWFC, and OxyChem. The working group was responsible for working out the details on specific criteria and forwarding recommendations to the larger group. More than a dozen meetings of the two groups were held in Tallahassee and White Springs and many criteria were suggested, discussed, considered, sometimes initially rejected and later considered again prior to adoption of the final set of criteria.

Criteria that were considered had to be *(1) measurable, (2) reasonable, and (3) good indicators of wetlands.* The ability to make valid measurements of the criteria was important to all parties involved. Many suggested criteria were considered important characteristics of wetlands but had no quantiative measurement. Many aesthetic indicators of wetlands, while important to all, were difficult to measure to any reliable degree and were therefore rejected. Past experience of the mining industry was researched along with work done at the Center for Wetlands at the University of Florida in Gainesville. Advice was obtained

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Table 1. Wetland Reclamation Success Criteria for Project Areas

PARAMETER	MILESTONE I (No later than 11/30/89)				MILESTONE II (No later than 11/30/91)				MILESTONE III (No later than 11/30/93)			
	SP4	SR8	GA	SA1	SP4	SR8	GA	SA1	SP4	SR8	GA	SA1
Density (trees/acre)	200	200	300	500	200	200	200	450	200	200	200	400
Diversity												
% Taxodium	N/A	N/A	75-80	50-60	N/A	N/A	75-80	50-60	N/A	N/A	75-80	50-60
% Nyssa[1]	N/A	N/A	N/A	20-25	N/A	N/A	N/A	20-25	N/A	N/A	N/A	20-25
% other	N/A	N/A	20-25	20-25	N/A	N/A	20-25	20-25	N/A	N/A	20-25	20-25
Growth Rate[2] (% increase)	100	200	50	50	200	300	100	100	300	400	200	200
Ground Cover[3] (areal (extent)	70	N/A	70	70	70	N/A	70	70	70	N/A	70	70
Seed Production (% of Taxodium producing seed)	N/A	5	N/A	N/A	5	10	N/A	N/A	10	10	5	5
Hydrology[4]	N/A	N/A	N/A	note 4	N/A	N/A	N/A	note 4	N/A	N/A	N/A	note 4
Water Quality[5]	N/A	N/A	--see note 5--		N/A	N/A	--see note 5--		N/A	N/A	--note 5--	
Wildlife Abundance[6]	---	N/A	--see note 6--		---	N/A	--see note 6--		---	N/A	--note 6--	
Wildlife Richness[6]	---	N/A	--see note 6--		---	N/A	--see note 6--		---	N/A	--note 6--	
Soils (% organic matter in top 5 cm)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	1	1	1

1. N. sylvatica var. biflora and N. aquatica shall each comprise at least 5% of the trees in the SA-1 demonstration area. Together, Nyssa shall comprise at least 20% of the trees in the demonstration area.

2. Mean growth rate based on assumption that all plantings were 18 inches when planted for SP4 and SR8 projects. Green Area and SA1 projects will have initial seedling height measurements when planted. Growth rates will be averages across all species; however, Taxodium and Nyssa must each show at least 20% growth.

3. Cover is based on areal extent by species on the Section 17-4.022, FAC, wetland vegetation list. Permanent open water bodies will not be included in this calculation.

4. The entire wetland area in SA1 (approximately 10 acres) will be inundated for at least 90 days per year, of which at least 30 days will be consecutive. For one period of at least 30 consecutive days per year, at least 50% of the wetland area will not be inundated more than 12 consecutive hours.

5. TSS, TDS, turbidity, chlorophyll a, orthophosphate, total phosphate, ammonia nitrogen, nitrate/nitrite, and total nitrogen will be measured and evaluated based on applicable Chapter 17-3, FAC, Class III standards.

6. Macroinvertebrates will be used to measure faunal success based on the Shannon-Weaver diversity index value as defined in Section 17-3.021(24), FAC. The station will be sampled until at least 100 organisms are obtained or the sample will not count towards demonstrating success.

   The criteria will be deemed successful once the Shannon-Weaver diversity index values from the individual reclamation areas average at least 2.0, 2.25 and 2.5 for Milestones I, II, and III, respectively, for four consecutive sampling periods.

   Corps, EPA, and DER staff will be invited to participate in selection of sampling stations. Two stations will be sampled in SA1. Four stations will be sampled in the SP4 project, two in each portion of the wetland areas in the SP4 project. Six stations will be sampled in the Green Area.

   The raw data, diversity, equitability, total number of organisms, and total number of species will be provided to the Corps, EPA, and DER. Macroinvertebrate diversities will be used to assess the quality of the macroinvertebrate communities in the wetland demonstration areas. They will not be used to apply DER's biological integrity standard for class III waters. The generated diversity values will be utilized in determining restoration success and will not be used as a direct measure of water quality.

from university researchers as to expected growth characteristics of natural wetlands. Whether a criterion was a good indicator of wetland success was debated a great deal. Individuals have different opinions as to what makes a good indicator. If wildlife species, for example, are to be used, which one will be chosen? In many cases, a new wetland provides many benefits although a selected wildlife species may not be initially present. It may be present in later development of the wetland. All of these considerations made the exercise a challenge and provided some valuable insight into the concerns of those on all sides of the mining and reclamation issue. It certainly made everyone appreciate the difficulty in establishing realistic criteria.

In July 1987, the Regional Administrator for EPA and the Secretary of the Florida Department of Environmental Regulation accepted the criteria and the schedule for implementation of three milestones. *(See Table 1.)* Four demonstration plots were established on recently planted or soon to be planted areas. The areas were described and transects established. They are the wetland portions of:

1) Settling Area No. 1 (SA-1),
2) Special Project OCC-SR-SP(4) (SP-4),
3) Land and Lakes Project OCC-SR-8 (SR-8), and
4) The Green Area Project OCC-SR-83(2) (GA)

Study Area

The total SA-1 area is approximately 40.5 ha (100 ac.). It has been used as a phosphatic clay settling area since 1965. As the area was exhausted (filled with clays) a portion of the area, approximately 36.4 ha (90 ac.), was capped with approximately 2.4 m to 3.1 m (8 to 10 ft.) of sand tailings, creating a higher well drained upland area. The wetland area of approximately 4.05 ha (10 ac.) had not been disturbed since 1980 and was dominated by large willows (Salix nigra) and red maple (Acer rubrum) some reaching 15 to 20 cm (6 to 8 in.) diameter at breast height (DBH) and 6 to 7.6 m (20 to 25 ft.) tall. In order to compare the affect of the established canopy on young planted seedling, half the area was cleared in strips across the wetland. Tree seedlings were then planted in both the cleared and uncleared portions. Each strip was approximately 30.5 m (100 ft.) wide and three fertilization treatments were used on the trees. Figure 1 reports the results for this area.

The SP-4 area is a sand tailings fill project consisting of a total of 200 ha (494 ac.) including approximately 40.5 ha (100 ac.) of wooded wetlands constructed in 1984 and 1985. Species planted in SP-4 in 1985 and 1986 include cypress (Taxodium sp), red maple, sweetgum (Liquidambar styraciflua), river birch (Betula nigra) and blackgum (Nyssa sylvatica). The wetland areas are split into two areas of approximately 20.2 ha (50 ac.) each on the east and west sides of the project. Figure 2 compares the growth rate on SP-4 between Bald cypress (Taxodium distichum) and Pond cypress (Taxodium distichum var. nutons) which are both native to the area.

The SR-8 project is 160 ha (396 ac.) in size and was constructed in 1981 and 1982. This is a land and lakes project with approximately 60 percent land and wetlands and 40 percent lake. The wetlands associated with SR-8 are within the *zone of fluctuation* of the lake. As the lake level fluctuates, the wetlands are at times inundated and at times dry mainly depending on rainfall. The wetland area totals approximately 4.05 ha (10 ac.) and was planted in 1982 with cypress.

The GA project is also a land and lakes project. Approximately 70 percent of the 117 ha (290 ac.) area is wetlands which was constructed from 1985 through 1988. Due to the planting date of 1987 only 8.1 ha (20 ac.) of the area are used for the demonstration area. The wetland area receives sheet flow from the lake and upland area to the west to maintain the wet and dry cycle.

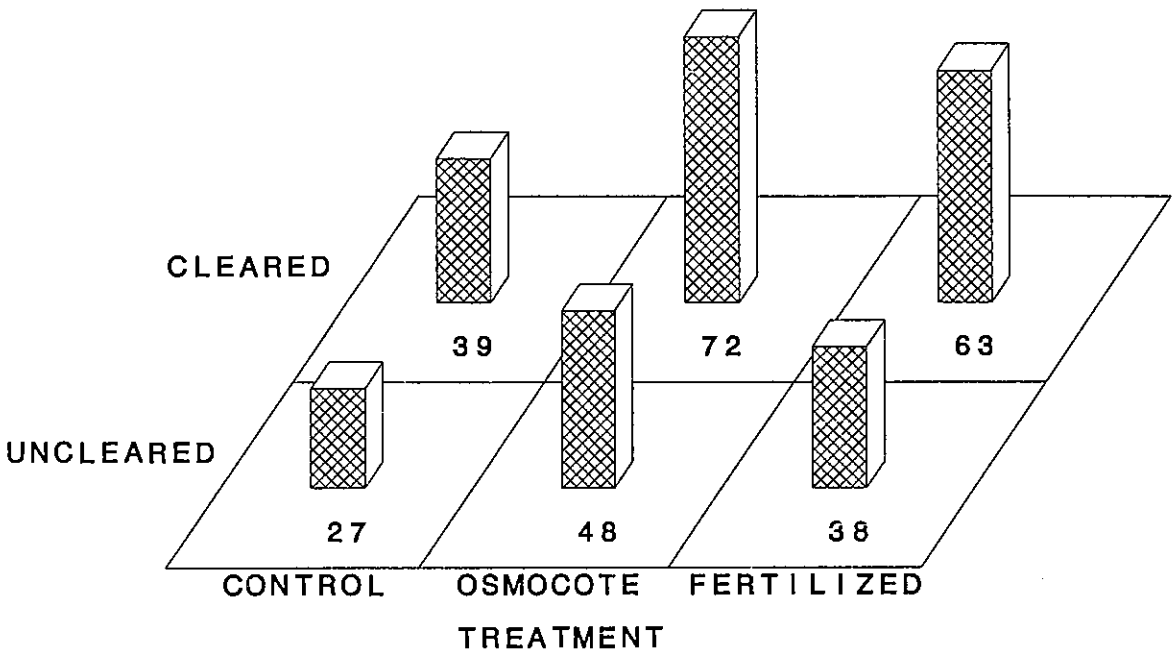

Figure 1. Comparison of tree growth in SA-1 in cleared and uncleared areas - growth in cm OSMOCOTE (50% 14-14-14 50% 18-6-12) Fertilized (22-8-2).

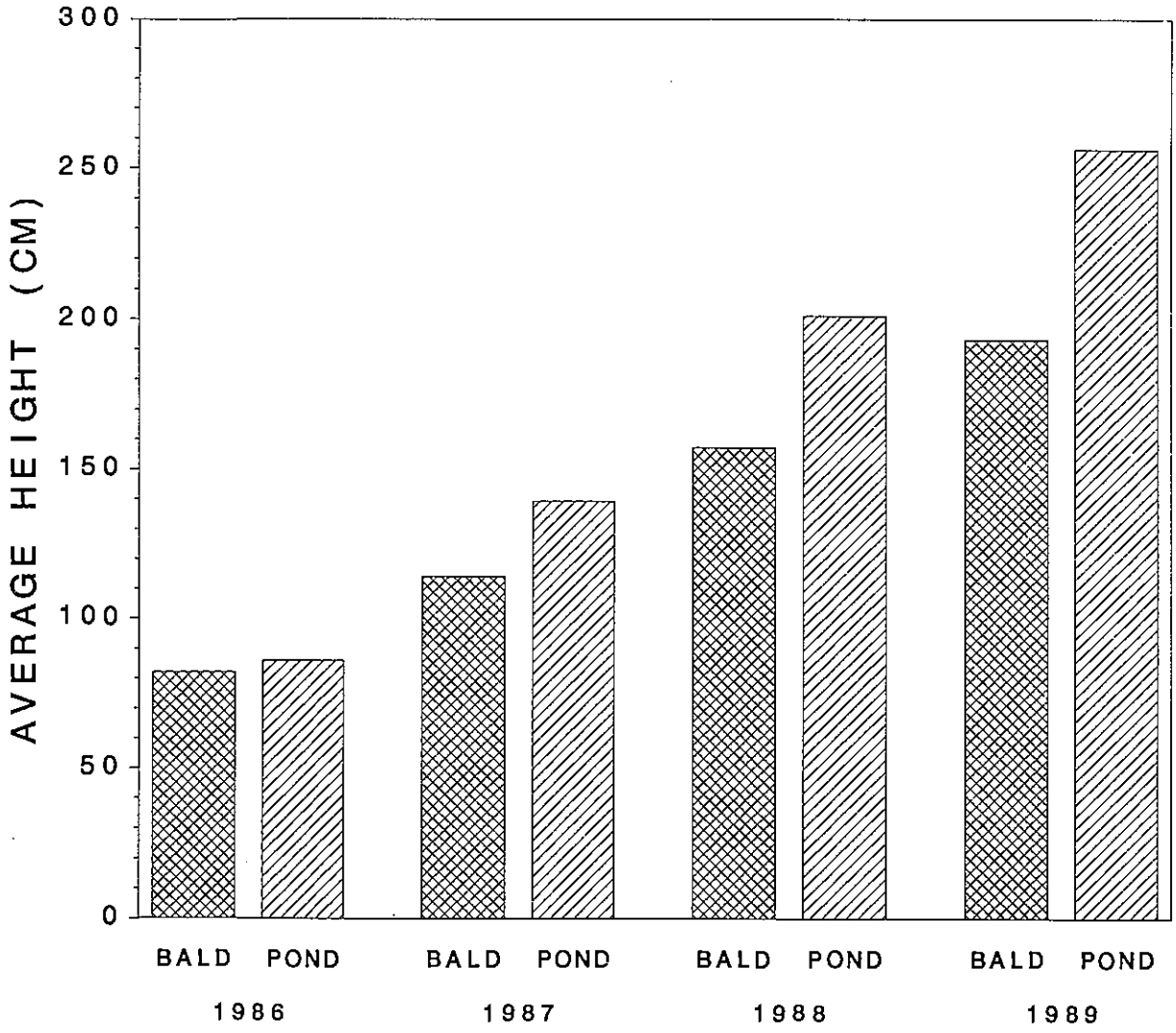

Figure 2. Comparison of growth rates of bald cypress and pond cypress in SP(4).

Methods

Tree Monitoring

Belt transects (*elongated line-strip quadrats*) were used to measure tree density, tree diversity and growth rates. The transects were laid out across the wetland areas along gradients from the upland edge through the wettest areas. Each transect was 10 m (32.8 ft.) wide. Sufficient numbers of transects were used to sample at least 5 percent of the demonstration areas. Trees within the belt transect were mapped using a grid system so that monitoring data could be established for a specific tree. The two categories in Table 2 were used to assess tree conditions. In addition, the following data were recorded:

1) tree species
2) tree height
3) water depth, if present.

Each demonstration area was divided into four quarters. Each quarter was surveyed to determine how many trees produced seed balls (*cypress only*). Once a tree was found to produce seed balls, the tree was flagged and labeled with a permanent aluminum tag and its approximate location mapped. Success was based on finding some evidence of cypress seed ball production in each quarter of the demonstration areas and finding the appropriate percentages listed in Table 1 within the entire demonstration area.

Table 2. Tree assessment categories for monitoring of success criteria.

Category	Description
Live	Tree appears to be in a generally good condition.
Dead	A decision as to whether a tree is dead is generally made when a tree is in such poor condition that survival is unlikely.

Ground Cover

Ground cover was measured using a modified line-strip quadrat method. The method consists of observations of plant species occurring along an elongated quadrat extending through the study area. The quadrat was divided into continuous 3.05 m (10 ft.) intervals, each of which was .61 m (2 ft.) wide. The 3.05 m (10 ft.) intervals were further divided into five .61 x .61 m (2 x 2 ft.) intervals. Species cover was determined on the basis of the percent cover occupied within each 3.05 x .61 m (10 x 2 ft.) cover interval. Seven cover categories were assigned to estimate ranges of percent cover that were usually determined (Table 3). In addition, frequency was determined on the basis of occurrence within each .61 m (2 ft.) interval. Therefore, a maximum value of 5 was possible for each 3.05 m (10 ft.) interval. Data were tabulated and summarized by species, as follows:

1. Total Frequency = the total number of .61 x .61 m (2 x 2 ft.) intervals where the species occurred.

2. Relative Frequency = the total number of occurrence intervals in relation to the total number of possible .61 x .61 m (2 x 2 ft.) intervals.

3. Average Occurrence Cover Value = the average cover category value assigned on all 3.05 x .61 m (10 x 2 ft.) intervals were species occurred.

4. Average Occurrence Percent Cover = the percent cover for each species calculated for only where it occurred.

5. Total Area Covered = the total square foot coverage exhibited by the species.

6. Total Percent Cover = the percent of the total transect area that was covered.

Table 3. Cover value categories and assigned ranges (%) for each classification.

Category	Range (%)	Assigned Cover Values	% Range Category
1	<1	1 = 1%	> 1
2	1-10	2 = 10%	> 10
3	11-30	3 = 30%	> 20
4	31-50	4 = 50%	> 20
5	51-70	5 = 70%	> 20
6	71-90	6 = 90%	> 20
7	91-100	7 = 100%	> 10

Hydrology

Hydrology success criteria applied only to the SA-1 project. A standard water level recorder was placed in a deep pool area near the outfall to measure water depth in the demonstration area. The recorder was surveyed in to allow calculation of the amount and duration of inundation over the demonstration area. Any low areas >.04 ha (0.1 acre) within the demonstration area were connected to the pool in which the recorder is located, a connection was made via a small drainageway. Rainfall in the area was measured by an existing rainfall gauge at the Suwannee River Mine office approximately .8 km (.5 mi.) away.

After half the area was cleared, the demonstration area was resurveyed as necessary to document the existing elevations within the wetland area. This survey information, in conjunction with the water level recorders, was then used to determine inundation percentages and durations.

Water Quality

Water quality was measured in the GA and SA-1 demonstration areas. Samples were taken quarterly near the discharge from each of the areas. The samples consisted of grabs integrated over the water column. The samples were taken in accordance with the procedures outlined in Handbook for Analytical Quality Control in Water and Wastewater Laboratories (EPA 1979) or in Standard Methods for the Examination of Water and Wastewater (APHA et al. 1985).

Occidental's standard chain-of-custody and quality assurance procedures, which have been approved by EPA as part of an ongoing EPA study, were followed. The analyses were performed by either Occidental's environmental laboratory or a commercial laboratory with a DER-approved Quality Assurance Program that conformed to DER Guidelines for Preparing Quality Assurance Plans (DER 1986). The analyses were performed by an approved EPA method cited in 40 CFR Part 136. The sampling was concluded after four successive samples showed compliance with the applicable Section 17-3.121, Florida Administrative Code (FAC), water quality standards.

Faunal Criteria

Macroinvertebrate samples were used to measure faunal success. Quarterly, qualitative samples were collected in the SP-4, SA-1, and GA demonstration areas. The samples consisted of collecting three, at least one-man-hour replicates at each station, using various methods such as dip nets, screens, forceps, pipettes, and ~15 cm (5.9 in.) diameter cores ~5-10 cm (2.0 - 4.0 in.) deep. Specimens from all the sampling methods were composited to form a single sample for each replicate at each station. The samples were handled and in compliance with a FDER approved Quality Assurance Plan (DER) (DER 1986).

Diversity was calculated based on the definition in Section 17-3.021(24), FAC. Macroinvertebrate diversities were used to access the quality of the macroinvertebrate communities in the wetland demonstration areas. They were not used to apply DER's biological integrity standard for class III waters. The generated diversity values were utilized in determining restoration success and were not used as a direct measure of water quality.

The stations were located in permanently inundated areas to the extent practicable. Two stations were located in SA-1, four in SP-4, and six in the GA. The four stations in SP-4 were divided between the two wetland areas in the project.

Sampling began during the first growing season following tree planting. The sampling was discontinued once the diversity criteria outlined in Table 1 were met or exceeded for four consecutive sampling periods.

Soils Criteria

Soils criteria were based on the percentage of organic matter found in the top 5 cm (2.0 in.) (Table 1). At least 20 samples were collected in each demonstration area. The samples were composited or analyzed

individually at Occidental's option. If they were analyzed individually, the success criteria were compared to the average of the samples from each demonstration area.

The samples were taken by brushing away the litter accumulation on the surface and then taking the cores. The samples were handled in accordance with standard procedures and were subject to the same chain-of-custody procedures as the water quality samples. The samples were analyzed using the Walkley-Black method as described by Jackson (1958). Samples were taken annually, beginning at the end of the first growing season following tree planting. Sampling ceased once the criteria were met.

Results:

The following data represents the first milestone period which ended on November 30, 1989. Data are presented for those parameters which apply to each demonstration plot. (See Table 4.)

All criteria for Milestone I for the four demonstration areas were met with the exception of tree diversity in SA-1. (See Table 1.) Tree diversity numbers were not within the ranges specified but considering the stand density the removal of specific species would bring the diversity within the ranges without vioaltion of the tree density requirements. Survival rates on some of the hardwoods were greater than anticipated at planting time, causing the resultant diversity to be outside the range.

Conclusions

These efforts to establish success criteria for forested wetlands in Florida have proven beneficial for the environmental agencies, environmental action groups and the mining company. Each party received information about the concerns of the other and yet were provided a forum to express their opinions and thoughts on the subject of forested wetland reclamation. It became a group effort working together to accomplish a common goal.

Table 4. Results of Success Criteria Monitoring - as of November 30, 1989.

SP(4)

Parameter	Milestone I	Value
Density (trees/acres)	200	425
Growth Rate (% increase)	100	346
Ground Cover (area/extent)	70	75
Wildlife Abundance	2.00	4.15
Wildlife Richness	2.00	4.15
Soils (% organic matter in top 5 cm)	.5	1.64

Green Area (GA)

Parameter	Milestone I	Value
Density (trees/acres)	300	594
Diversity		
% Taxodium	75-80	77
% Other	20-25	23
Growth Rate (% increase)	50	161
Ground Cover (area/extent)	70	77
Water Quality	Chapter 17-3 Standards	Met All Applicable Standards
Wildlife Abundance	2.00	3.88
Wildlife Richness	2.00	3.88
Soils (% organic matter in top 5 cm)	0.5	0.57

SR(8)

Parameter	Milestone I	Value
Density (trees/acres)	200	331
Growth Rate (% increase)	200	599
Seed Production (% of Taxodium producing seed)	5	22
Soils (% origin matter in top 5 cm)	0.5	1.59

Settling Area 1(SA1)

Parameter	Milestone I	Value
Density (trees/acres)	500	671
Diversity		
% Taxodium	50-60	58
% Nyssa	20-25	25
% Other	20-25	17
Growth Rate (% increase)	50	114
Ground Cover (area/extent)	70	72
Hydrology	90 Days Inundate/Yr 30 Days Consecutive 30 Days 50% Not Inundated	Achieved
Water Quality Standards	Chapter 17-3 Applicable Standards	Met All
Wildlife Abundance	2.00	3.40
Wildlife Richness	2.00	3.40
Soils (% organic matter in top 5 cm)	0.5	5.21

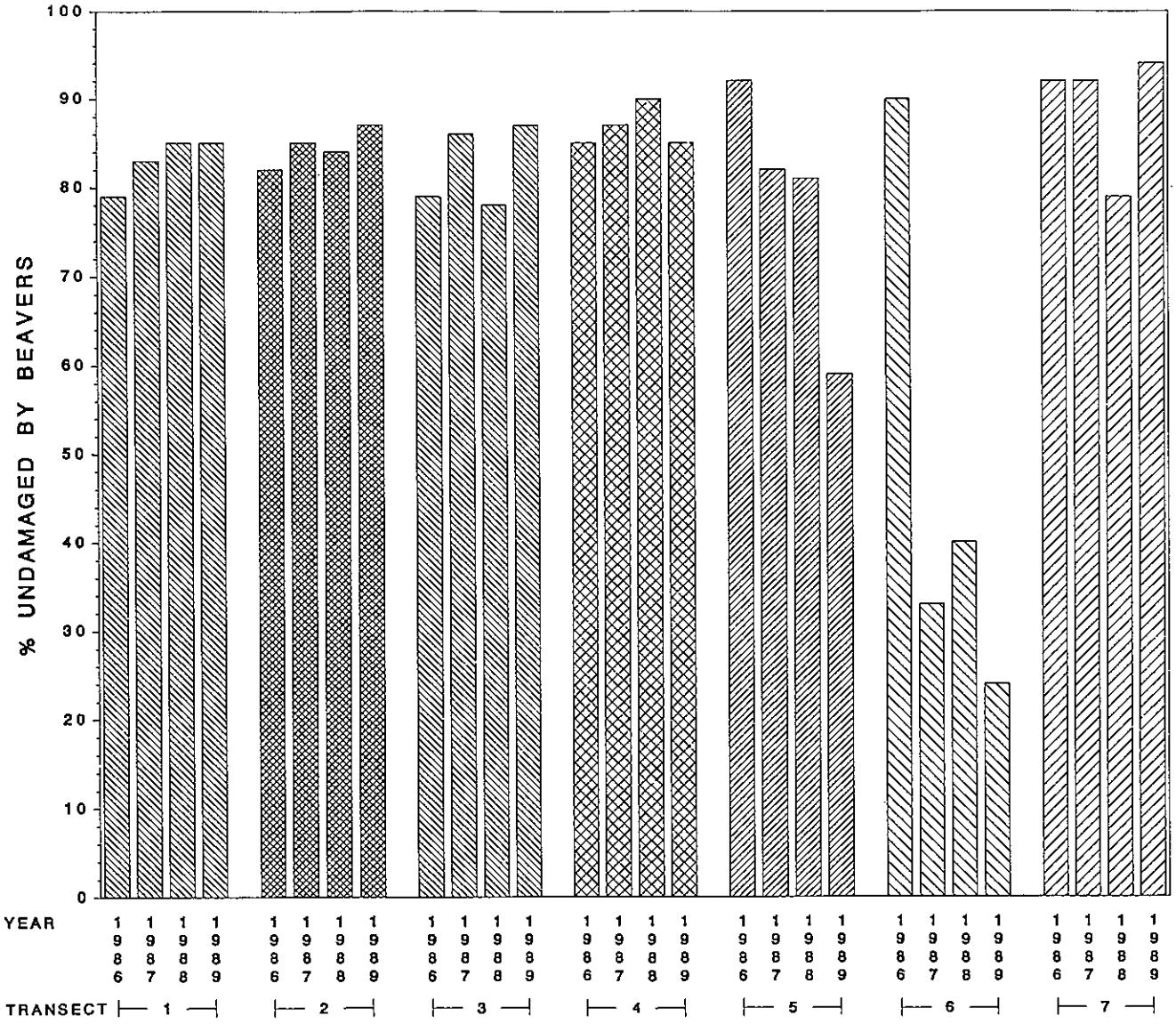

Figure 3. Effect of beaver damage on cypress in SP(4).

As a result of the monitoring performed, several things became noticeable that had not been considered at the time the success criteria were developed. Two of these are worth mentioning here, knowing that they may not be the only unforeseen things to occur in this type of activity. They are tree survival rates and animal damage.

Tree survival rates are less predictable for some species, especially hardwoods. A goal for a specific range of densities may not be met because of better than expected survival rates. Increased planting density will allow for adequate numbers of specific species if manipulation of the densities is really desired.

Animal damage both from rabbits and large rodents, including beavers, has also been an unforeseen problem. While the presence of wildlife species provides good evidence of the success of the reclamation, they also may dramatically affect the monitoring results, such as significant effect on growth rate determinations based on increase in height. Beavers have caused a major impact on one transect. While the presence of the beavers are positive indications of suitable habitat we experienced significant losses of cypress trees as a result of their activities. (See Figure 3.)

Future milestone reporting will occur in 1991 and 1993. Indications at this time are that the criteria will be met or exceeded. Results to date would verify that the criteria selected were measurable, reasonable and good indicators of wetland success.

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