UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Possible Reestablishment of Sawtimber Production Following Mining in the Osceola National Forest, An Analysis of the State-of-the-Art

February 9, 1978

By J. Scott Boyce

Open-File Report 79 - 524

1979

CONTENTS

ILLUSTRATIONS

TABLE

Possible Reestablishment of Sawtimber Production Following Mining in the Osceola National Forest, An Analysis of the State-of-the-Art

February 9, 1978

By J. Scott Boyce

ABSTRACT

There is a good possibility that sawtimber production could be re-established on the Osceola National Forest. Engineering technology that is coming on-line should allow the establishment of land/water relationships that meet the requirements of desired tree species. Information available on soil-plant relationships indicate an absence of phytotoxic materials in various mining wastes and that good tree growth is possible.

INTRODUCTION

The question of whether it would be possible to reestablish and manage commercial sawtimber operations on mined lands within the Osceola National Forest is critical in evaluating the costs of mining in terms of renewable resources. This report addresses that question.

If intensive silviculture proves to be feasible, it would be one of many management options for the mined lands. The ecological consequences of the silvicultural possibilities considered are beyond the scope of this document.

No systematic research has been performed on reforestation or forest management techniques on land mined for phosphate in Florida. However, careful observation of the vegetation on mined sites in central Florida, research results from other mine reclamation situations outside of Florida, and the professional opinions of scientists and engineers involved in mining, reclamation, and forestry are available and shed considerable light on the question of whether it would be possible to reestablish commercial sawtimber operations on the Osceola National Forest following phosphate mining.

BACKGROUND INFORMATION

Phosphate mining that is carried out in central Florida and that would be carried out in the Osceola National Forest in north-central Florida are very similar. Both the phosphate ore, commonly referred to as the matrix, and the overburden are unconsolidated. A cross section of the overburden and matrix in the Osceola National Forest is given in Figure 1. The area to be mined is dewatered by means of peripheral wells and ditches, as water tables typically are at or near the surface. The overburden is removed with a dragline. The same dragline removes the matrix and delivers it to a sump where it is broken up with high pressure water jets and then pumped hydraulically to a beneficiation plant where the ore is upgraded by screening and flotation processes. The waste products from the beneficiation plant consist of sand tailings, essentially silicate sands, and clay slimes composed of clay minerals and colloidal phosphate. Disposal of these wastes, and the clay slimes in particular, has been a major problem for the phosphate industry as the clay slimes are very slow to dewater and require a high storage volume; the volume of slimes is typically twice the volume of the matrix removed.

Current mining practice typically creates mined out pits filled with water and windrows of overburden, sand tailing piles, and clay slimes storage areas (typically mined pits with above grade dikes around them). Each of these wastes has its own reclamation characteristics. The mine pits are usually reclaimed to a land and lakes configuration and applied to various uses including agriculture (largely grazing) or sometimes residential development. The slime ponds after several decades are reclaimed to light agriculture, typically grazing, and the tailings sands, if not returned to the mine pits, are stabilized with vegetation. However, new waste handling processes exist that overcome the clay storage problems and should facilitate reclamation of lands mined for phosphate.

ENGINEERING CONSIDERATIONS

To reestablish commercial sawtimber production after mining, it would be necessary to rebuild a land surface and rooting medium that met the requirements of the trees to be grown and also provide access and support for the machinery used in planting, managing, and harvesting the trees. Modern mining and beneficiation methods produce three materials that can serve as resources for rebuilding the land: overburden, clay slimes, and sand tailings. As a result of research into clay slime disposal techniques, three methods have been developed that allow the clays to be returned to the mine pits and covered with overburden (Zellars and Williams, 1978, pp. 73-78). These methods are classified as: 1) sand spraying---sand tailings are sprayed over naturally prethickened clays; 2) flocculation mix---chemical flocculants and thickeners are utilized to dewater the clay slurry; and 3) dredge mix--prethickened clay is dredged from settling ponds, mixed with dewatered sand tailings, and pumped to mined-out cuts. In all of these methods, sand tailings are mixed with clay slimes, thereby disposing of these waste products simultaneously. Additional sand tailings may be buried or used as a surface material as required. The Brewester Phosphate Company of Bradley, Florida, is currently using the sand spraying technique and it appears to be economically competitive with above-ground storage of slimes. It is also anticipated that the flocculation-mix and dredge-mix methods will prove economically feasible. When the clays and sands are returned to the mine pits, the volume of solids in the pits is greatly increased, and the volume of lakes left after mining is proportionately reduced. The materials balance, i.e., ratio of overburden, clay, and sand, will vary with the specific mining situation. However, the revegetation problem is greatly simplified by the fact that none of these materials are toxic to plant growth.

The Final Environmental Statement (U.S. Bureau of Land Management,

1974) and its supplement (U.S. Bureau of Land Management, in preparation) consider two possible mining and beneficiation configurations: one with the beneficiation plant off the Forest, which would preclude returning the slimes and sand tailings to the mine pits (FES 74-37), and the second with two beneficiation plants on the Forest, which would allow the slimes and sand tailings to be returned (Supplement). For the purposes of this analysis, the latter situation is assumed as it represents the Cole Mining Plan (Cole, 1977), which was the basis for USGS (Miller and others, 1978) and FWS (U.S. Fish and Wildlife Service, 1978) reports used in preparing the Supplement. One can easily progress from this case to the more limited possibilities presented by the off-forest beneficiation situation discussed in FES 74-37.

In considering the possible mining of the Osceola National Forest, the following picture of land/water relationships evolves:

1. Soon after mining, the water table will reestablish itself to near its present level, and will become a subdued replica of the surface topography. Any filled pits will become lakes. Annual changes in depth to water tables in reclaimed land areas might be 2 to 3 feet greater than before mining. (Personal communication with several hydrologists familiar with the hydrology of the Osceola National Forest. Also see Miller and others, 1978).
2. All soil hardpans will be eliminated by mining.

3. By varying the volume of lakes, the elevation of the land surface above or below the water table can be adjusted to meet the requirements of the target tree species.
4. The land surface can be engineered to meet the drainage requirements of the target species. Long-term settling of sand/clay fill material is expected and can be compensated for. (Personal communication, Brownwell Engineering Co., Lakeland, Florida) Because the fills will be below the water table, they will not significantly affect soil internal drainage patterns.
5. The land surface can be expected to be composed of overburden, although, it is conceivable that it may be necessary to use sand tailings in lieu of overburden if the latter is in short supply.

In summary, the technology exists to allow the rebuilding of land/water relationships to meet widely varied design criteria; however, field testing of much of the technology has not been carried out.

SOIL-PLANT RELATIONSHIP ON PHOSPHATE-MINED LANDS IN FLORIDA

The combination of nontoxic mining wastes, a well-watered subtropical environment, and a large biological resource, i.e., many different plant species available for recolonization, results in the natural reestablishment of some type of vegetation on mine disturbed areas, and indicates the relative absence of major revegetation problems, such as acid formation, high soil temperatures due to dark coloration, and large competent rocks.

Field observations in central Florida of naturally revegetated forest communities growing on old mine sites, of pine plantations growing on old mine waste disposal areas and native soils, small groves of pines planted in overburden materials for aesthetic reasons, recent trial plantings designed to determine the utility of various tree species in different reclamation environments, various single trees planted under widely varying conditions, and citrus groves on overburden all attest to the utility of overburden and similar mine wastes as a substrate for tree growth. Figures 2 through 7 show examples of tree growth on various mine wastes and native soils. Table 1 gives data on tree growth in a pine plantation on mine wastes and native soils. Taken collectively, these figures and tables indicate that phosphate mine wastes are a reasonably good substrate for tree growth. The data in Table 1 suggest that some mine wastes are superior to native soils for slash pine production (Plot 1 vs. Plot 2). Breedlove and Adams (1977, p. 15) state the oak hammock/longleaf pine communities occurring on the oldest mine sites are characterized by growth rates approximately twice those of unmined areas. These observations are modified by the fact that the history of the sites is not fully known, the characteristics of the wastes have not been rigorously identified, and the characteristics of the mining operations and the wastes have changed over time. On the other hand, the fact that these observations are numerous and have been made over widely varying conditions broadens the applicability of the data base and suggests that no particular problem exists. Zellars and Williams (1978, p. 79) discuss commercial forest plantings on lands mined for phosphate as a foregone conclusion and go on to state that . . . "Commercial forest plantings on reclaimed land have not been popular with the industry in central Florida, as it is not a traditional wood production area . . . . In all probability, commercial forest planting will be a revegetation option infrequently used by the phosphate industry in the southern area, but may be a common designated land use for the northern district." However, they also point out that there are environmental pressures to plant clusters of relatively dense tree stands in areas that are being reclaimed to pasture in order to increase the diversity of habitat.

In considering the mine wastes, some fairly good generalizations can be made concerning their general characteristics and ability to support plant growth and tree growth in particular:

1. Sand tailings--Sterile silicate sands, drouthy when deep; can be very productive under intensive irrigation and fertilization; a small number of sand pines planted in sand tailings in north Florida near the Osceola National Forest are making slow growth. The Eucalyptus shown in Figure 7 are growing on sand tailings in central Florida.
2. Clay slimes--Very fertile, poorly drained clay and colloidal phosphates; low bearing strength; generally considered unsuitable for tree growth in the pure state; a potential source of clays and nutrients to ameliorate the sand tailings.

3. Overburden--A heterogenous material varying from sand to clayey sand that typically contains more clay, has a higher pH level and contains more exchangeable bases than native upland soils; it has, however, proven to be an acceptable growth medium for many species of plants. The pines in Figure 6 are growing on overburden produced by present day mining methods. These trees have probably benefitted from fertilization of the adjacent pasture.

4. Debris--A waste material derived from the phosphate matrix and produced prior to modern flotation methods. It is sandy and essentially consists of the phosphate matrix less the pebble. Although no data are available, it is anticipated that debris is somewhat higher in available phosphate than overburden. The fact that the phosphate mineral is largely apatite indicates that any increase in available phosphorus would be small. The pines shown in Figures 4 and 5 and the data in Table 1, plots 2 and 3, are thought to be from debris lands.

In considering the biological resource available for reforestation, one generally thinks of various southern pines, as well as native hardwood species; however, even exotic species, such as those of the genus *Eucalyptus*, may have considerable utility. The latter notwithstanding, the general thinking at this time is that reclamation should make maximum use of native species. If a target species or several species are identified, it would be highly desirable to invest in research aimed at quantifying substrate/plant growth relationships. However, in the absence of such research, a good estimate as to how to reforest and manage phosphate lands can be made on the basis of knowledge in the field of forestry, soils, and mine reclamation. For example, if slash pine is the target species, conventional wisdom is that the loss of hardpans would be desirable; that the water table would best be maintained at a depth of several feet, but that the species will tolerate considerable variation in water table depth and is relatively tolerant to periodic flooding; that tree growth, at least initially, would be limited by lack of nutrients, particularly nitrogen; and that fertilization would be desirable, or that perhaps the surface layer of soil should be saved for spreading on the post-mining surface to provide nutrient reserves and microflora populations, as many plants including pines respond dramatically to the proper mycorrhiza innoculum on disturbed sites.

Monk (1968) in his report on the "Successional and Environmental Relationships of the Forest Vegetation of North Central Florida" sheds considerable light on the characteristics of the current plant communities and environmental requirements of the native tree species. He indicates that species such as Pinus elliottii (slash pine), P. taeda (loblolly), and P. palustris (longleaf) are wide ranging successional species and as such are habitat generalists. These contrast with the "climax exclusives" which tend to occupy specific environmental situations.

The three pines listed above are major timber species and dominant members of the pine flatwoods community. It is the pine flatwoods community that produces most of the timber on the Osceola National Forest and which would be affected most by mining. Additionally, Monk's work indicates that a number of other native timber-production species growing in the vicinity are also habitat generalists. Figures 4-6 show slash and loblolly pine growing vigorously in various post-mining situations. This strongly suggests that these timber species would grow well over a range of post-mining situations.

Table 2 gives an idea of the size of the native biological resource available and the plant communities in which the various species are found. The various plant communities represent a broad range of environmental conditions from swamps (mixed hardwood swamps, bay heads, cypress domes) to well drained sites (sand hills) and contain many timber species. The broad adaption of slash pine and longleaf pine is evident. However, the range of environmental conditions over which a species has silvicultural utility may be greater than the range over which they grow naturally, as reproductive, competitive, and other ecological and environmental relationships can be altered by management practices. Trees are grown successfully in many areas where they do not grow naturally; an extreme example of this is the windbreaks and manmade forests of the Great Plains, e.g., Halsey National Forest, Nebraska.

The combination of level terrain, nontoxic overburden, a well-watered subtropical environment, a large biological resource including several habitat generalists that are important timber species, and numerous examples of groups and stands of trees growing on various phosphate mine wastes, all add credence to the idea that forests could be reestablished on lands mined for phosphate within the Osceola National Forest. An evaluation of both the biological and engineering information available indicate that such reforested areas could be managed for sawtimber production. On the other hand:

1. The possibility of large tree plantations on fresh geologic material with at least temporarily impoverished microflora and fauna populations, different soil-water relationships, and different chemical and physical properties carries with it the possibility that some unidentified insect, disease, weed species, or damaging rodent might thrive under these conditions and render the land useless for commercial timber production.
2. Techniques discussed in this report for rebuilding the land/water relationships have not been extensively field tested and represent a level of sophistication greater than that which is common in the mining industry at present.
3. Much of the information available on phosphate mine reclamation was largely gathered in central Florida, where the water table is lower than that on the Osceola National Forest, and where the geologic materials and climate differ to some extent.

However, while it is necessary to recognize the possible existence of unforeseen and potentially devastating problems, the author's experience leads him to believe that the probability of such problems materializing is small.

CONCLUSION

Information currently available indicates there is good possibility that commerical sawtimber production can be reestablished on lands mined for phosphate within the Osceola National Forest.

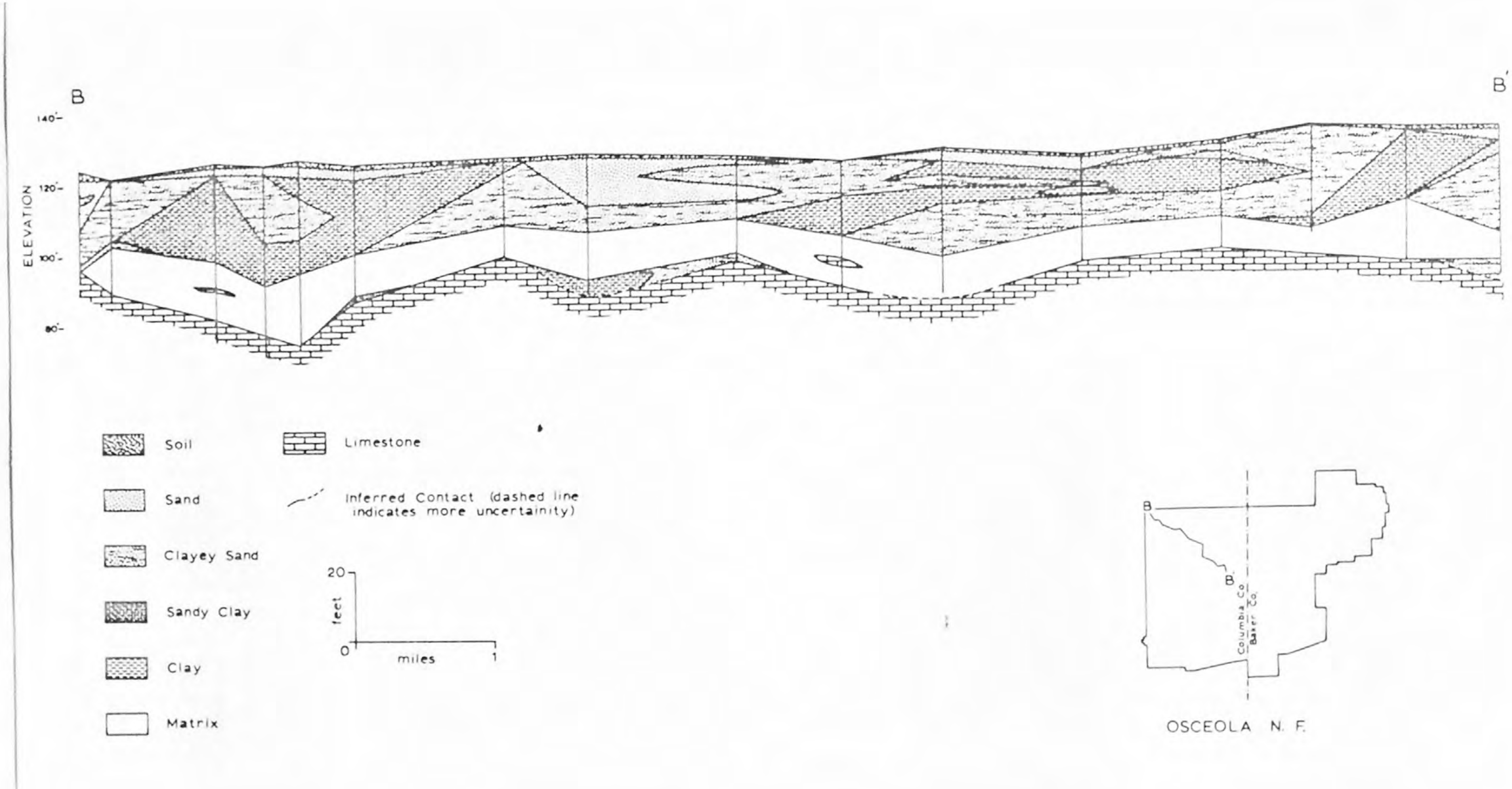

Figure 1. Overburden and matrix, Osceola National Park Forest. After U.S. Bureau of Land Management (1974)

Figure 2. Volunteer hardwoods on an overburden pile. The area was mined about 1910.

Figure 3. Eighteen-year-old slash pines planted on native soils adjacent to mined area shown in Figure 4; area mined in 1929.

Figure 4. Eighteen-year-old loblolly pine planted on mine wastes, probably debris; area mined in 1929.

Figure 5. Thirty-three-year-old slash pine planted on mine wastes, probably debris; date of mining unknown.

Figure 6. Thirteen-year old slash pine planted on overburden along a lake in a mined area reclaimed to a land and lakes configuration. The lake is beyond the trees, with pasture in the foreground.

Figure 7. Four-year-old Eucalyptus growing on sand tailings.

Table 1 - Growth of pines on native soil and mine wastes

(Data provided by Agrico Chemical Company, Mulberry, Florida.)

Plot #1 - 37 Acres - Bedded Slash Pine - 18 years old, planted 6 x 10 feet on native soil - Ground cover: palmetto, wiregrass, dogfennel, grapevine , broom sage, briars.

Avg. DOB* all living trees in 200 planting spaces	6.83 inches
Avg. DOB sample trees (43 samples every 5th)	7.18 inches
Avg. height sample trees	31.14 feet
Avg. DBT* sample trees	1.35 inches
Maximum diameter all living trees	9.80 inches
Minimum diameter all living trees	3.20 inches
Maximum diameter sample trees	9.80 inches
Minimum diameter sample trees	5.00 inches
Maximum height sample trees	40 feet
Minimum height sample trees	23 feet
Survival rate based on 200 spaces	43.5%

Plot #2 - 30 Acres - Bedded Slash Pine - 18 years old, planted 6 x 10 feet on land mined 1926 - Reclamation method unknown - Ground cover: Russian nettle, grapevine, guava bushes.

Avg. DOB all living trees in 200 planting space	7.41 inches
Avg. DOB sample trees (42 samples every 5th)	8.05 inches
Avg. height sample trees	44.24 feet
Avg. DBT sample trees	1.22 inches
Maximum diameter all living trees	10.70 inches
Minimum diameter all living trees	4.50 inches
Maximum diameter sample trees	10.70 inches
Minimum diameter sample trees	5.00 inches
Maximum height sample trees	52 feet
Minimum height sample trees	36 feet
Survival rate based on 200 planting spaces	42%

Plot #3 - 26 Acres - Bedded Loblolly Pine - 18 years old, planted 6 x 10 feet on land mined 1926 - Reclamation method unknown - Ground cover: Russian nettle, grapevine, guava bushes.

Avg. DOB all living trees in 200 planting spaces	7.56 inches
Avg. DOB sample trees (44 samples every 5th)	8.03 inches
Avg. height sample trees	50.05 feet
Avg. DBT sample trees	1.10 inches
Maximum diameter all living trees	12.10 inches
Minimum diameter all living trees	4.80 inches
Maximum diameter sample trees	12.10 inches
Minimum diameter sample trees	5.10 inches
Maximum height sample trees	60 feet
Minimum height sample trees	39 feet
Survival rate based on 200 planting spaces	50.5%

*DOB: Diameter outside bark
*DBT: Double bark thickness

Table 2. Precent of occurence of tree species (potential to reach a 4-in dbh size) in each of six forest community types in north central Florida. Data are based on 60 southern mixed hardwoods, 24 mixed hardwood swamps, 9 bayheads, 15 cypress domes, 32 flatwoods, and 16 sandhills. After Monk, 1968.

Species	Southern Mixed Hardwoods	Mixed Hardwood Swamps	Bay-heads	Cypress domes	Flat-woods	Sand-hills
Acer barbatum	21	---	---	---	3	---
A. negundo	8	4	---	---	---	---
A. rubrum	33	100	22	53	53	---
Aesculus pavia	13	---	---	---	---	---
Alnus serrulata	---	4	---	---	---	---
Aralia spinosa	46	---	11	---	---	---
Aronia melanocarpa	---	29	---	---	---	---
Betula nigra	2	4	---	---	---	---
*Bumelia lanuginosa	23	---	---	---	---	---
*B. tenax	3	---	---	---	---	---
Carpinus caroliniana	52	38	---	---	---	---
Carya aquatica	3	21	---	---	---	---
C. glabra (inc. tomentosa)	77	8	---	---	3	19
Celtis laevigata	33	---	---	---	3	---
Cephalanthus occidentalis	7	83	33	67	3	---
Cercis canadensis	23	---	---	---	---	---
Chionanthus virginicus	7	---	---	---	3	---
*Cinnamomum camphora	2	---	---	---	12	---
Cornus florida	38	---	---	---	3	6
Crataegus marshallii	11	---	---	---	---	---
C. uniflora	15	---	---	---	---	25
*Cyrilla racemiflora	2	---	11	---	---	---
Diospyros virginiana	41	4	---	---	34	69
Fraxinus profunda	34	---	---	---	3	---
F. caroliniana	---	92	---	---	---	---
Gleditsia aquatica	2	29	---	---	---	---
*Gordonia lasianthus	2	---	78	20	28	6
Ilex ambigua	23	---	---	---	---	---
*I. cassine	10	88	44	53	28	---
I. decidua	3	---	11	---	---	---
*I. opaca	79	4	---	---	9	---
*Illicium floridanum	---	---	22	---	---	---
*Juniperus virginiana	38	8	---	---	---	---
*Leucothoe sp.	---	---	22	---	---	---
Liquidambar styraciflua	77	71	33	20	34	6
Liriodendron tulipifera	---	---	11	---	3	---
*Lyonia ferruginea	28	---	---	---	56	19
*Magnolia grandiflora	85	---	22	13	25	6
*M. virginiana	13	21	100	60	37	---
Morus rubra	51	---	---	---	---	6
*Myrica cerifera	39	75	56	93	84	31
Nyssa aquatica	2	---	---	---	---	---
N. sylvatica (inc. biflora)	41	88	56	100	47	---

Table 2--Continued

Species	Southern Mixed Hardwoods	Mixed Hardwood Swamps	Bay-heads	Cypress domes	Flat-woods	Sand-hills
*Osmanthus americanus	52	---	11	---	---	---
Ostrya virginiana	48	---	---	---	---	---
*Persea borbonia	79	---	---	---	---	12
*P. palustris	13	63	100	53	47	---
*Pinus clausa	2	---	---	---	6	19
*P. elliottii	18	---	44	93	72	50
*P. glabra	25	---	---	---	---	---
*P. palustris	2	---	---	---	59	100
*P. taeda	26	17	11	---	12	31
*P. serotina	---	---	11	---	41	---
Prunus angustifolia	15	---	---	---	---	---
*P. caroliniana	50	---	11	---	3	---
P. serotina	48	---	---	13	9	25
Ptelea trifoliata	5	---	---	---	---	---
Quercus chapmanii	8	---	---	---	22	19
Q. durandii	30	---	---	---	---	---
Q. falcata	7	---	---	---	3	37
Q. incana	---	---	---	---	22	37
Q. laevis	2	---	---	---	19	100
*Q. laurifolia	100	38	22	13	50	6
Q. lyrata	5	---	---	---	---	---
Q. michauxii	33	---	---	---	---	---
*Q. myrtifolia	8	---	---	---	12	19
Q. nigra	72	83	33	---	50	---
Q. shumardii	10	---	---	---	---	---
Q. margaretta	2	---	---	---	---	56
*Q. virginiana	92	---	---	---	53	69
Rhamnus caroliniana	8	---	---	---	---	---
*Sabal palmetto	52	88	---	7	19	---
Salix caroliniana	---	13	---	20	3	---
Sambucus simpsonii	---	41	11	---	---	---
Sapindus marginatus	8	---	---	---	---	---
Sassafras albidum	---	---	---	---	---	6
Taxodium distichum	8	88	11	---	---	---
T. ascendens	---	---	---	100	19	---
Tilia floridana	48	---	---	---	---	---
Ulmus alata	36	---	---	7	---	---
U. floridana	33	83	---	---	6	---
*Vaccinium arboreum	61	25	44	13	22	---
Viburnum obovatum	---	17	11	---	---	---
Zanthoxylum clava-herculis	25	---	---	---	3	6
Number of tree species	71	30	27	18	42	26
Number of species/stands	20	14	10	8	10	8
Percent evergreen/stand	56	11	76	18	91	44

*Evergreen species.

REFERENCES CITED

Breedlove, B. W., and Adams, S. R., 1977, Natural systems occurring on mined lands of the central Florida phosphate district, in Environment of the Central Florida Phosphate District: Southeastern Geological Society Publication 19, p. 15-29.

Cole, A. T., 1977, Water demands of two logical phosphate mining units, Osceola National Forest: U.S. Bureau of Mines, 33 p.

Miller, J. A., Hughes, G. H., Hull, R. W., Vecchioli, John, and Seaber, P. R., 1978, Impact of potential phosphate mining on the hydrology of Osceola National Forest, Florida; U.S. Geological Survey Water-Resources Investigation 78-6, 159 p.

Monk, C.D., 1968, Successional and environmental relationships of the forest vegetation of north central Florida: American Midland Naturalist, v. 79, no. 2, p. 441-457.

U.S. Bureau of Land Management, 1974, Final environmental statement, phosphate leasing on the Osceola National Forest in Florida: FES 74-37.

U.S. Fish and Wildlife Service, 1978, Osceola National Forest phosphate extraction and processing: impacts on federally listed threatened or endangered and other species of concern: 414 p.

Zellars, M. E., and Williams J. M., 1978, Evaluation of the phosphate deposits of Florida using the minerals availability system: Bureau of Mines, 196 p.