Bird Abundance and Distribution in a North Florida Phosphate Mine[1]

David S. Maehr, *Florida Game and Fresh Water Fish Commission, Wildlife Research Laboratory, 4005 South Main Street, Gainesville, FL 32601*

Wayne R. Marion, *Department of Wildlife and Range Sciences, University of Florida, School of Forest Resources and Conservation, 118 Newins-Ziegler Hall, Gainesville, FL 32611*

Abstract: Seasonal bird use in 5 habitat types associated with phosphate mining was examined in Hamilton County, Florida, in 1979 and 1980. Bird densities were highest in late successional settling ponds and lowest in reclaimed habitats. Early successional settling ponds contained the greatest number of species. Conversion of unreclaimed mines or late successional settling ponds to reclaimed habitats resulted in decreases in all abundance and diversity estimates. Creating wetlands in settling ponds and establishing littoral, shoreline, and upland vegetation in reclaimed habitats would encourage use of phosphate mines by birds.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 38:111-120

Phosphate mining has been an increasingly significant land use in Florida since the late 1800s (Wester 1979), causing alterations to over 74,000 ha of land (Hendry 1978, Stowasser 1979). Since Florida is a major world producer of phosphate products (Zellars and Williams 1978, Stowasser 1979), Florida's mining regions will continue to undergo alterations in local flora, fauna, topography, and hydrology as a result of increasing demands for agricultural fertilizers, animal feed supplements, and other products. These alterations may have substantial impact on regional and local bird populations in central and north Florida.

Large, impounded wetlands are a major feature of active phosphate mines in the Southeast. Creation of these impoundments occurs at a time when wide-

[1] Contribution No. 5878 of the Journal Series, Florida Agriculture Experiment Station, Gainesville, FL 32611.

spread draining of natural wetlands in the United States has stimulated concern for species dependent on wetland habitats for all or part of their life cycles (Landin 1978). The potential of these artificial wetlands to replace the fast-disappearing natural swamps, marshes, and estuaries of the southeastern United States (Chamberlain 1960, Montalbano et al. 1978, Sanderson 1977) needs to be evaluated. The few studies conducted on phosphate-mined lands have been oriented toward waterfowl (Montalbano et al. 1978, Montalbano 1980, Wenner and Marion 1981) and terrestrial wildlife communities (Schnoes and Humphrey 1980).

Recent changes in phosphate reclamation regulations in Florida are beginning to require wildlife habitat restoration on lands altered by mining. State reclamation rules prior to 1980 required only a vegetative cover on uplands. Current laws require the establishment of mixed pine and hardwoods over at least 10% of the uplands, the replacement of wetlands equivalent to premining site coverage, and a zone of fluctuation or wetlands around each permanent impoundment. In addition, if benefits to wildlife can be demonstrated, these requirements can be waived in lieu of other habitat enhancement practices. As this industry continues to expand and include a greater proportion of the state, reclamation of these lands takes on more importance because results of reclamation efforts will restrict future land use options.

Birds are useful in determining mining impacts and evaluating reclamation efforts since birds have well documented life histories, and are conspicuous components of wildlife communities. More importantly, some birds have a high degree of specialization and environmental sensitivity which makes them particularly useful as environmental indicators (Plunkett 1979). The purpose of this study was to examine use by birds of a variety of affected and unaffected habitats and use these results as indicators of avian habitat quality.

Appreciation is extended to T. E. O'Meara for valuable suggestions on the manuscript and assistance with study design and data analysis. M. W. Collopy, B. J. Hartman, and J. A. Rodgers provided suggestions for improving the manuscript. Funding for this project was provided by a grant from the Occidental Chemical Company, White Springs, Florida.

Methods

This study was conducted on selected habitats at Occidental Chemical Company's Suwannee River Mine (30°25′N, 82°45′W), Hamilton County, Florida. Five habitats chosen for study were unmined pine flatwoods, unreclaimed mines, early successional settling ponds, late successional settling ponds, and reclaimed. Of the 6,500 ha of land affected since the initiation of large-scale phosphate mining at Occidental, 1,040 ha remained as unreclaimed mines, 1,300 ha were in early and late successional settling ponds, and 570 ha had been reclaimed.

Unreclaimed mines resulted from strip mining phosphate with drag-lines. Resulting landscapes were water-filled pits, dissected by elongate, steep-sided spoil banks. The areas studied were 1 to 2 years old, sparsely vegetated, and typically heavily eroded. Camphorweed (*Heterotheca* spp.) and dog fennel (*Eupatorium* spp.) characterized the sparse vegetation on spoil banks.

The settling ponds were impounded to dispose of large volumes of clay slurry, a by-product of the phosphate extraction process. Early successional settling ponds were characterized by large expanses of open water and scattered mats of water hyacinth (*Eichornia crassipes*). Late successional settling ponds contained dense thickets of Carolina willow (*Salix caroliniana*) with scattered bluestem (*Andropogon* spp.), saltbush (*Baccharis halimifolia*), and small patches of open water. Occurrence of drier-site plant species in late successional settling ponds resulted from water level fluctuations which often exposed bottom substrates.

Reclaimed habitats were created by contouring over-burden piles and developing serpentine lake systems ("land-and-lakes") from abandoned networks of deep mine cuts. Bahia grass (*Paspalum notatum*) and saltbush typically dominated upland reclaimed habitats. Edges of lakes and impoundments were usually constructed with 4:1 slopes.

Pine flatwoods dominated the adjacent unmined landscape and consisted of an overstory of slash pine (*Pinus elliottii*) with a dense understory of saw palmetto (*Serenoa repens*), lowbush blueberry (*Vaccinium* spp.), and wax myrtle (*Myrica cerifera*). Frequent depressions and a high water table in this flat-terrain permitted the scattered occurrence of bald cypress (*Taxodium distichum*), swamp tupelo (*Nyssa biflora*), and other hardwoods. There was no evidence of recent burning.

All habitats were sampled with 2 replicates, except unreclaimed mines where only 1 major area was available. Each replicate contained 4 randomly chosen survey points which were visited 5 times each season. Seasonal periods were: spring migration, 31 March to 13 April 1979; summer, 2 May to 18 May 1979; fall migration, 8 August to 15 October 1979; and winter, 25 January to 6 February 1980. All counts were conducted from 30 minutes before to 3 hours after sunrise. The order in which survey points were sampled was rotated within each season to minimize the effects of time of day on census results. Total count and variable-circular plot surveys (Ramsey and Scott 1979) were used to obtain seasonal estimates of bird densities, species richness, and species diversity (Shannon and Weaver 1963). Playback recordings (Marion et al. 1981) were used to elicit vocalizations of secretive species in willow thickets; i.e., king rails, Virginia rails, and soras (Table 1). Distances to each response location were estimated and included with variable-circular plot survey data.

Cube-root transformations and square-root transformations were used for estimates of density and species number, respectively, to allow use of parametric statistics. Effects of habitats and seasons on species richness, species

Table 1. Common and scientific names of birds appearing in text or Table 2.

Pied-billed grebe (*Podilymbus podiceps*)
White pelican (*Pelecanus erythrorhynchos*)
Great blue heron (*Ardea herodias*)
Great egret (*Casmerodius albus*)
Cattle egret (*Bubulcus ibis*)
Green-backed heron (*Butorides striatus*)
Black-crowned night-heron (*Nycticorax nycticorax*)
Tundra swan (*Cygnus columbianus*)
Snow goose (*Chen caerulescens*)
Blue-winged teal (*Anas discors*)
Ruddy duck (*Oxyura jamaicensis*)
King rail (*Rallus elegans*)
Virginia rail (*R. limicola*)
Sora (*Poranza carolina*)
Common moorhen (*Gallinula chloropus*)
American coot (*Fulica americana*)
Killdeer (*Charadrius vociferus*)
Lesser yellowlegs (*Tringa flavipes*)
Least sandpiper (*Calidris minutilla*)
Ring-billed gull (*Larus delawarensis*)
Tree swallow (*Tachycineta bicolor*)
Northern rough-winged swallow (*Stelgidopteryx serripennis*)
Barn swallow (*Hirundo rustica*)
Carolina wren (*Thryothorus ludovicianus*)
House wren (*Troglodytes aedon*)
Ruby-crowned kinglet (*Regulus calendula*)
American robin (*Turdus migratorius*)
Gray catbird (*Dumetella carolinensis*)
Northern mockingbird (*Mimus polyglottos*)
Northern parula (*Parula americana*)
Yellow-rumped warbler (*Dendroica coronata*)
Palm warbler (*D. palmarum*)
Black-and-white warbler (*Mniotilta varia*)
Common yellowthroat (*Geothlypis trichas*)
Northern cardinal (*Cardinalis cardinalis*)
Rufous-sided towhee (*Pipilo erythrophthalmus*)
Swamp sparrow (*Melospiza georgiana*)
White-throated sparrow (*Zonotrichia albicollis*)
Red-winged blackbird (*Agelaius phoenicius*)
Boat-tailed grackle (*Quiscalus major*)

diversity, and density were determined by 2-way analyses of variance. Habitat and seasonal means were compared with Duncan's New Multiple Range Test (Steel and Torrie 1960), with significance set at the $P < 0.05$ level.

Results and Discussion

During this study, 168 species of birds were identified, including many uncommon transients and species previously unreported for this inland region (Maehr 1980, 1981), Interspersion of landscapes associated with phosphate mining and varying stages of vegetation development provided previously un-

available habitats for birds in north Florida. Larger water birds (diving ducks, snow geese, tundra swans, white pelicans, etc.) used open water habitats found in early successional settling ponds, unreclaimed mine pits and reclaimed "land-and-lakes." Egrets, herons, ibises, and shorebirds were typically seen on shorelines, exposed slimes, and water hyacinth mats. Diurnal birds of prey, crows, and swallows utilized a variety of habitats. Willow swamps in late successional settling ponds were heavily used by migrant and wintering warblers, American robins, and red-winged blackbirds. Common yellowthroats were year-round residents in both willow swamps and flatwoods, using the dense shrub vegetation found in these habitats. Owls, woodpeckers, vireos, and many warblers were found only in the relatively diverse unmined flatwoods vegetation. The 5 most abundant species in each habitat and season are shown in Table 2.

No significant differences ($P > 0.05$) among habitats and seasons with respect to avian density were detected. In all seasons, the greatest densities occurred in late successional settling ponds, and the lowest densities occurred in reclaimed land-and-lakes (Fig. 1). Flatwoods and early successional settling ponds did not differ ($P > 0.05$) from each other; unreclaimed mine densities ranked fourth.

The greatest ($P < 0.001$) species richness occurred in early successional settling ponds in all seasons (Fig. 1). Similarly, reclaimed habitats had the fewest species.

Bird species diversity was greatest in flatwoods and unreclaimed mines during spring (Fig. 2). Early successional settling ponds and reclaimed land-and-lakes had the lowest diversity estimates at this time. In summer, bird species diversity was lower in reclaimed land-and-lakes than in all other habitats; the latter were not significantly different from each other. No significant differences were found among habitats in fall and winter.

The relatively high species diversity in flatwoods resulted from a high evenness component for a moderate number of species. A low diversity index for early successional settling ponds was a result of a low evenness component for many species. American coots and ruddy ducks greatly outnumbered other birds using this habitat. Low to moderate diversity indices for reclaimed land-and-lakes resulted from a high evenness component for only a few species.

Differences in bird use among reclaimed study sites were analyzed since the areas differed in both vegetative cover and time interval since reclamation. The 4-year-old reclaimed area had greater avian densities ($P < 0.001$) and numbers of bird species ($P < 0.001$) than the 1-year-old area. The older site was characterized by established wetlands vegetation, dense growth of 2 m-tall saltbush and willow along the entire shoreline, and by a nearly complete herbaceous cover in upland areas. Reclamation methods were similar on both sites, suggesting that time since reclamation is important in establishing habitat features favored by birds.

Differences in bird abundance among count plots in each reclaimed study

Table 2. Seasonal bird species abundance and composition at Occidental Chemical Company, Hamilton County, Florida, 1979–1980. Listed species are the 5 most abundant per season.

Habitat	Spring		Summer		Fall		Winter	
	Species	Birds/ha	Species	Birds/ha	Species	Birds/ha	Species	Birds/ha
Flatwoods	Gray catbird	2.0	Carolina wren	3.0	Carolina wren	2.6	House wren	1.6
	Ruby-crowned kinglet	3.0	Northern parula	3.2	Black-and-white warbler	2.3	Gray catbird	1.5
	Northern parula	3.6	Common yellowthroat	5.0	Yellow-rumped warbler	2.4	Ruby-crowned kinglet	4.3
	Northern cardinal	3.1	Northern cardinal	4.3	Northern cardinal	4.6	Yellow-rumped warbler	24.0
	Rufous-sided towhee	3.2	Rufous-sided towhee	6.6	Rufous-sided towhee	5.9	Rufous-sided towhee	1.6
Unreclaimed	Double-crested cormorant	4.9	Killdeer	0.7	Double-crested cormorant	1.3	Pied-billed grebe	0.6
	American coot	3.5	Least sandpiper	0.8	Great blue heron	1.0	Double-crested cormorant	0.5
	Ring-billed gull	0.9	N. rough-winged swallow	0.8	Cattle egret	1.1	Great egret	2.4
	N. rough-winged swallow	0.6	Barn swallow	7.6	Tree swallow	2.3	American coot	5.8
	Red-winged blackbird	2.6	Red-winged blackbird	2.0	Red-winged blackbird	3.5	Ring-billed gull	4.3
Early successional settling pond	Double-crested cormorant	3.6	Double-crested cormorant	4.5	Double-crested cormorant	4.6	Double-crested cormorant	6.6
	Ruddy duck	4.5	Common moorhen	1.5	Common moorhen	2.4	Common moorhen	4.5
	Common moorhen	1.5	American coot	3.0	Tree swallow	3.0	American coot	25.4
	American coot	47.6	Barn swallow	2.2	N. rough-winged swallow	2.0	Ring-billed gull	5.7
	Red-winged blackbird	20.4	Red-winged blackbird	2.4	Red-winged blackbird	9.4	Red-winged blackbird	8.9
Late successional settling pond	Sora	3.3	Common moorhen	4.8	Common moorhen	4.8	American coot	4.8
	Yellow-rumped warbler	3.4	Least sandpiper	3.8	Lesser yellowlegs	2.1	American robin	12.7
	Common yellowthroat	8.3	Barn swallow	3.5	Palm warbler	2.3	Yellow-rumped warbler	13.8
	Red-winged blackbird	10.8	Common yellowthroat	8.2	Common yellowthroat	9.0	Common yellowthroat	4.5
	White-throated sparrow	3.1	Red-winged blackbird	13.2	Red-winged blackbird	14.4	Swamp sparrow	10.4
Reclaimed	Green-backed heron	0.3	Great egret	0.2	Pied-billed grebe	0.4	Pied-billed grebe	0.4
	Blue-winged teal	0.2	Killdeer	0.3	Great egret	0.5	Blue-winged teal	2.6
	Least sandpiper	0.4	Northern mockingbird	0.2	Tree swallow	1.0	American coot	5.4
	Red-winged blackbird	2.2	Red-winged blackbird	3.4	Red-winged blackbird	1.3	Yellow-rumped warbler	1.0
	Boat-tailed grackle	1.8	Boat-tailed grackle	1.6	Boat-tailed grackle	0.5	Red-winged blackbird	7.2

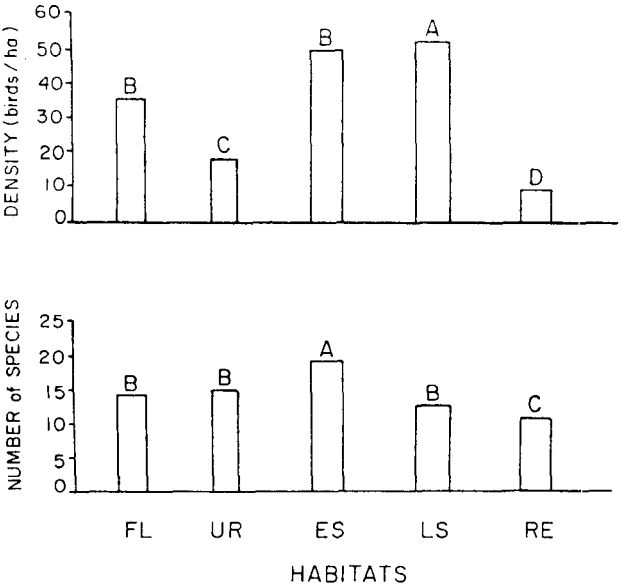

Figure 1. Density and species richness among habitat types at the Suwannee River Mine, Hamilton County, Florida, 1979–1980. Key: FL = Pine flatwoods, UR = Unreclaimed mine, ES = Early successional settling ponds, LS = Late successional settling ponds, RE = Reclaimed mines. Columns with different letters are significantly different.

site also were examined. Abundance parameters did not differ among plots in reclaimed areas. Qualitative differences, however, were observed among the 4 count plots within the older replicate. Plot 4 was the most structurally distinct of all reclaimed count plots as it contained a large delta of deposited sediments. The mudflat-like delta was created by settling calcium particulates contained in recirculated processing plant water. Bird species not seen in other reclaimed sites were often abundant here and included dowitchers, black-crowned night-herons, sandpipers, and common yellowthroats. The steep slopes and narrow littoral zones characteristic of other reclaimed plots apparently restricted use by these species.

In general, natural flatwoods contained the most diverse avian community of the habitats sampled while supporting modest bird densities and species numbers. Mining of flatwoods resulted in a nearly complete taxonomic change in the bird community, while species number and diversity remained the same, and density declined. When flatwoods were converted directly to settling ponds or if an unreclaimed mine was used for clay slurry disposal, bird species richness and density increased, while diversity decreased slightly in winter and spring. As settling ponds consolidated and dried, songbird species increased, whereas wetland birds declined. Consequently, species number was only

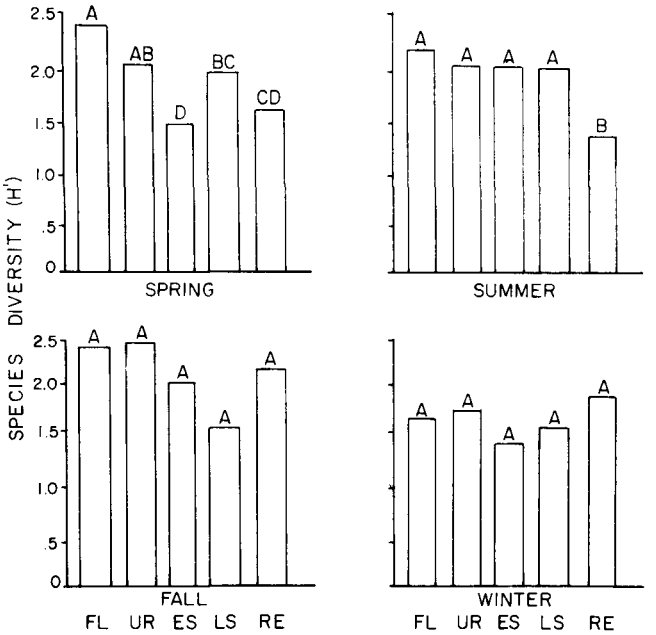

Figure 2. Seasonal species diversity among habitat types at the Suwannee River Mine, Hamilton County, Florida, 1979–1980. Key: FL = Pine flatwoods, UR = Unreclaimed mines, ES = Early successional settling ponds, LS = Late successional settling ponds, RE = Reclaimed mines. Columns with different letters are significantly different.

slightly reduced while bird density and species diversity remained the same. Similar patterns in bird use were reported by Weller and Fredrickson (1973) where water level manipulation caused changes in vegetation and avifauna in a managed glacial marsh and by Ortego et al. (1977) in a Louisiana freshwater lake.

The conversion of unreclaimed mines or late successional settling ponds to reclaimed land-and-lakes generally resulted in decreases in all abundance and diversity estimates. The most dramatic decrease occurred in bird densities, which were lower in land-and-lakes than in any prereclamation habitat studied. However, with the implementation of Florida's strict reclamation rules, these declines may become less dramatic. Further, bird abundance and diversity may exhibit noticeable long-term increases depending upon the rate of vegetation development and succession.

Implications

To maintain diverse avian communities on phosphate-mined lands, habitat diversity also must be maintained. A mosaic of pine flatwoods, reclaimed

grassland, willow swamp, and open water communities provided habitats for more bird species than were found in pre-mining communities. Establishment of self-maintaining wetlands through the creation of artificial watersheds would allow the continued existence of the abundant and diverse avifauna associated with early and late successional settling ponds. Once established, wetland habitats could be maintained with accepted management techniques.

Open water habitats associated with early successional settling ponds would require deeper water to prevent emergent plant invasion. However, certain emergents (e.g., *Typha* spp.) along dike edges provide important food and cover for nesting and wintering birds. Late successional settling ponds also are heavily used by birds. However, these willow swamps eventually become rather unproductive wax myrtle stands (Schnoes and Humphrey 1980). Creating interspersed habitat edges may enhance bird use in these areas. Water level manipulation would encourage diversity in littoral zone plants and stimulate germination and new growth (Weller 1978).

Establishment of shoreline vegetation appears necessary to increase bird use in reclaimed land-and-lakes. Current reclamation practices hinder natural plant succession and discourage bird use. Eliminating mowing on upland sites and requiring shallower, gently sloping bottom substrates in wetlands would enhance the establishment of upland, shoreline, and littoral vegetation. Planting native vegetation for food and cover might establish communities more rapidly than by natural succession.

Literature Cited

Chamberlain, E. B. 1960. Florida waterfowl populations, habitats and management. Tech. Bul. No. 7. Fla. Game and Freshwater Fish Comm. 62pp.

Hendry, C. W. 1978. Phosphate land reclamation study. Commission report to the governor on phosphate mining and reclamation, Tallahassee, Fla. 31pp.

Landin, M. C. 1978. Wading birds and wetland management. Pages 135–141 *in* R. M. DeGraaf, ed. Proceedings of the workshop management of southern forests for nongame birds. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. SE-14.

Maehr, D. S. 1980. Avian abundance and habitat preferences on new habitats created by phosphate mining. M.S. Thesis, Univ. Fla., Gainesville. 122pp.

———. 1981. Bird use of a north-central Florida phosphate mine. Fla. Field Nat. 9:28–32.

Marion, W. R., T. E. O'Meara, and D. S. Maehr. 1981. Use of playback recordings in sampling elusive or secretive birds. Pages 81–85 *in* C. J. Ralph and J. M. Scott, eds. Estimating the numbers of terrestrial birds. Studies in Avian Biol. 6:81–85.

Montalbano, F. 1980. Summer use of two central Florida phosphate settling ponds by Florida ducks. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 35:584–590.

———, W. M. Hetrick, and T. C. Hines. 1978. Duck foods in central Florida settling ponds. Pages 247–255 *in* D. W. Samuel, J. R. Stauffer, C. H. Hocutt, and W. T. Mason, eds. Surface mining and fish/wildlife needs in the eastern

United States. U.S. Dep. Int., Fish and Wildl. Serv. FWS/OBS—78/81, Morgantown, W.Va.

Ortego, B., R. B. Hamilton, and R. E. Noble. 1977. Bird usage by habitat types in a large freshwater lake. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 30:627–633.

Plunkett, R. L. 1979. The importance of birds in forest communities. Pages 4–8 *in* R. M. DeGraaf and K. E. Evans, eds. Proceedings workshop-management of north central and northeastern forests for nongame birds. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. NC-51. Minneapolis, Minn.

Ramsey, F. L. and J. M. Scott. 1979. Estimating population densities from variable circular plot surveys. Pages 155–181 *in* R. M. Cormack, G. P. Patil, and D. S. Robson, eds. Sampling biological populations. Internat. Coop. Publ. House, Fairland, Md.

Sanderson, G. C. 1977. Management of migratory shore and upland game birds in North America. Univ. Neb. Press, Lincoln. 358pp.

Schnoes, R. S. and S. R. Humphrey. 1980. Terrestrial plant and wildlife communities on phosphate-mined lands in central Florida. Fla. State Mus. Spec. Sci. Rep. No. 3, Gainesville. 192pp.

Shannon, C. E. and W. Weaver. 1963. The mathematical theory of communication. Univ. Ill. Press, Urbana. 177pp.

Steel, R. G. P. and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill, New York. 481pp.

Stowasser, W. F. 1979. Phosphate-mineral commodity profiles. Bur. Mines, U.S. Dep. Int., Washington, D.C. 19pp.

Weller, M. W. 1978. Management of freshwater marshes for wildlife. Pages 267–282 *in* Freshwater wetlands: ecological processes and management potential. Acad. Press, New York.

Weller, M. W. and L. H. Fredrickson. 1973. Avian ecology of a managed glacial marsh. Living Bird. 12:269–291.

Wenner, K. C. and W. R. Marion. 1981. Wood duck production on a northern Florida phosphate mine. J. Wildl. Manage. 45:1,037–1,042.

Wester, J. H. 1979. Reclamation activities: phosphate—North Florida. Workshop—reclamation of surface-mined lands in the southeastern coastal plains. Gainesville, Fla. (Abstr.)

Zellars, M. E. and S. M. Williams. 1978. Evaluation of the phosphate deposits of Florida using the minerals availability system. U.S. Dep. Int., Pittsburgh, Pa. 196pp.