8 Plant Communities and Species Distribution in Water Conservation Areas 2A and 2B of the Northern Everglades

John G. Zahina
204 Springdale Circle, Palm Springs, Florida 33461; zahina@mindspring.com

Abstract

A summary of the macrophyte species and their distribution within Water Conservation Areas 2A and 2B is presented. Nearly 300 plant species were identified, with the highest numbers belonging to the Poaceae (13%), Asteraceae (12%), and Cyperaceae (10%). Approximately one-fifth of the species found were non-native. Nine distinct habitats and associated vegetation are described within these Water Conservation Areas. Of the habitats present, three are man-made and are associated with the construction of perimeter levees and water control structures. Levees were found to carry the greatest diversity of plant species, most of which are associated with dry, disturbed sites and probably did not constitute a part of the historic vegetation of the area.

Introduction

Water Conservation Areas (WCA) 2A and 2B are remnants of the historic Everglades, an area that once stretched from Lake Okeechobee to Florida Bay. These WCAs border the Everglades Agricultural Area (EAA) to the southwest, Loxahatchee National Wildlife Refuge (also referred to as WCA 1) to the north, WCA 3A to the west, and urban Broward County to the east and southeast. WCA 2A and WCA 2B cover an area of 450 and 96 km^2, respectively. The plant communities of these WCAs have been only generally surveyed since approximately the first half of the 20th century (Harshburger 1914; Davis 1943; Loveless 1959). Today, these areas are under more intense study related to issues of eutrophication, hydrology, and the spread of non-native species. In spite of this, a complete review of the plant species present and the habitats they occur in is lacking.

The purpose of this paper is to present an overview of a survey of the macrophyte species found in WCA 2. The survey was conducted by the author from 1991

through 1998 to characterize the distribution of the flora relative to the habitats within the area, and discuss factors that affect species distribution. Specimens were collected, dried, and stored with the author. Verification of species identification was provided by Dr. David Black, South Florida Water Management District.

Regional and Historical Background

Climate

The climate of southern Florida is more like that of the Caribbean basin than the continental United States. The area has generally high temperatures and humidity, with a distinctive annual pattern of wet and dry seasons. Prevailing southeasterly winds make the area warmer than the 18°C winter isotherm, placing it within a subtropical climate. Average daily maximum temperatures are usually above 27°C from April through October, and average daily minimum temperatures rarely fall below 10°C throughout the winter (Thomas 1974). In some years, frosts may sweep through the area with the passage of winter cold fronts.

Annual precipitation for the WCAs averages 132 cm (MacVicar 1983), with approximately 60% falling from June through September. Rainfall, primarily from thunderstorms during the rainy season and from cold continental fronts during the winter, accounts for the bulk of the water entering the WCAs. Tropical cyclone events occur sporadically and can drop significant amounts throughout the system over a period of several days.

Evapotranspiration is the primary mechanism by which water is exported from the system. Estimates range from 70 to 90% of the total annual rainfall (Kenner 1966; Black, Crow, and Eidsness 1974; Dohrenwend 1997) for south Florida wetlands. These high estimates can be accounted for by the high mean annual temperatures, flat topography of the area, and slow movement of water through the system.

Terrain

Excluding man-made structures, e.g., levees, little variation of soil surface elevations is characteristic of this region. In the WCAs, ground elevations within the marsh ranges from approximately 4 m above mean sea level in the north to 3 m in the south. This topographic gradient is on the order of 2 cm/km, but larger variations may be found on smaller spatial scales.

History of the Area

The Everglades consists of a mantle of peat overlying a flat limestone formation of

recent marine origin. Formation of the oldest Everglades peat began on a large scale about 5000 years ago (Gleason et al. 1974). Age estimates for soils within these WCAs varies considerably moving from north to south. Using radiocarbon techniques, Gleason et al. (1974, 1975) dated the oldest basal peats from northern WCA 2A and central WCA 1 at 4800 $\pm$ 100 and 4860 $\pm$ 170 years before present, respectively. Those in WCA 2B were dated as considerably more recent, ranging from ca. 2000-1500 years before present.

The first major drainage efforts of the Everglades began with the creation of the Everglades Drainage District in 1907. By 1917, four major canals dissected the Everglades from Lake Okeechobee to the Atlantic Ocean. Two of these, the North New River Canal and the Hillsboro Canal, form the western and northern boundaries of WCA 2A. A series of eastern perimeter levees was installed during the period 1952-54, which now form the eastern boundary of the WCAs; they range in height from 9 to 18 ft. Today this levee forms the final barrier to urban and agricultural development, which has progressively expanded from the east.

During the period 1954-59, additional canal and levee construction added the northwest boundary to WCA 2A. During 1960-1963, three gates were installed (S-10A, S-10C, and S-10D) to allow the passage of water from the Hillsboro Canal in WCA 1 into WCA 2. Because the southeastern portion of WCA 2 is located over the Biscayne aquifer, it was considered too porous to hold surface water as needed for water storage. This prompted the construction of another levee and canal that compartmentalized WCA 2 into two section (WCA 2A and 2B) with three inflow gates between them (S-144, S-145, and S-146).

Early vegetation studies of the area

Much of the Everglades remained virtually unstudied until the middle of the 19th century. One of the earliest botanists to study the north-central Everglades was who John Harshburger conducted his phytogeographic study of the area around the newly-constructed North New River canal (Harshburger 1914). Davis (1943) provided the first comprehensive map of Everglades vegetation and offered general descriptions of the plant community assemblages after large-scale drainage efforts had been effected. Loveless (1959) further detailed the major plant communities of the area and attempted to assess the changes associated with drainage and the successive droughts that occurred during the 1940s and 1950s.

Vegetation of WCA 2A and WCA 2B

Modern floristics

The current flora of WCA 2A and 2B reflects a number of natural and anthropogenic processes. The composition of Everglades plant communities has been

changing since the ecosystem began to form, as species are introduced from outside regions and distributed according to a variety of influences. The elements of a subtropical climate, infrequent frost events, a distinct cycle of inundation and drought, and low topography all shaped the historic plant communities that reside within this area. Recent changes to the system have resulted in alterations to historical species distribution, as well as the creation of new habitats with distinctive plant communities.

This survey documented 292 vascular and 2 non-vascular macrophyte species (*Chara* and *Nitella*). Of the vascular plant families, the Poaceae (13%), Asteraceae (12%), and Cyperaceae (10%) were most represented. Table 1 shows the distribution of species by taxonomic group.

Interestingly, only a relatively small number of species present in WCA 2 are facultative or obligate wetland species (FWS and OWS at 12% and 25%, respectively; see Table 1). This is surprising given that the vast majority of area is dominated by wetland habitats. The relatively low percentage of FWS and OWS species indicates that the majority of species present are adapted for drier habitats.

Habitats and Associated Plant Communities

The plant communities found in WCA 2 can be broadly defined by the following habitat types, ranked from highest to lowest mean water depth: deep water, slough, flat, marsh, peat island, tree island, transition-levee, dry levee, and epiphytic. Often, overlap occurs between these communities, and in some situations it is difficult to categorize an assemblage to a specific community type.

Deep water habitat is represented by canals and, more rarely, well-traveled airboat trails. Canals usually lie parallel to the perimeter levees and more rarely intrude into the marsh. Often, the nutrient levels are higher than in the interior marsh as most canals in this area function as water movement and delivery systems, channeling stormwater runoff from the EAA drainage basin southward or eastward. Airboat trails tend to radiate from boat ramps and camps, the most heavily traveled ones being the deepest and devoid of characteristic marsh vegetation. This habitat never dries out and usually has standing water from a depth of 0.5 m or greater. In the northeastern area of WCA 2A, nutrient levels are much higher than elsewhere in the WCAs due to agricultural runoff entering the marsh through the S-10 structures. This increased nutrient status leads to the proliferation of nuisance floating vegetation such as water lettuce (*Pistia stratiotes* L.) and water hyacinth (*Eichhornia crassipes* (Mart.) Solms). Other characteristic vegetation includes *Vallisneria americana* Michx., *Nymphaea* spp., *Najas* sp., and *Hydrilla verticillata* (L.f.) Royle.

Sloughs are the deepest, naturally-occurring habitat found in these WCAs. They

Table 1. Taxonomic distribution of species found within Water Conservation Areas 2A and 2B. FWS, facultative wetland species; OWS, obligate wetland species.

Taxonomic group	No. of spp.	% of total	No. of non-native spp.	% of non-native spp.	No. of spp. FWS	% of spp. FWS	No. of spp. OWS	% of spp. OWS
Pteridophytes	16	5	3	1	6	2	2	1
Gymnosperms	2	1	0	0	0	0	2	1
Monocots	99	34	15-17	5-7	15	5	33	11
Dicots	175	60	30-37	9-14	14	5	37	13
Total	292	100	48-57	18-21	35	12	74	25

typically have standing water all year; however, the water table may recede below the surface during severe drought events. Sloughs predominate in the southern ends of the WCAs and become rarer as one moves northward. This is caused by the pooling of water in the southern areas of the WCAs resulting from the containment levees and past water management practices (Worth 1988; Light and Dineen 1994). Sloughs located closer to the S-10 structures have nutrient levels much higher than in unimpacted areas, resulting in a change in species composition (Vaithiyanathan et al. 1998). Typical species in unenriched sloughs includes *Nymphaea odorata* Sol., *Utricularia* spp. and *Chara* sp. Sloughs that have been impacted by increased concentrations of nutrients are dominated by *P. stratiotes*, *Lemna valdiviana* Phil., *E. crassipes*, and *Typha* spp.

Flats are habitats that occupy the ecotone between the marsh and sloughs. Flat communities, like the sloughs, are more frequent in the southern sections of these WCAs. The dominant vegetation in flats includes *Eleocharis* spp., *Panicum hemitomon* Schult., *Peltandra virginica* (L.) Schott & Endl., *Pontederia cordata* L., *Sagittaria lancifolia* L., *Utricularia purpurea* Walter, and *Hymenocallis palmeri* S. Watson. *Eleocharis elongata* Chapm. and *U. purpurea* have been found to be sensitive to phosphorus enrichment and are absent in areas where nutrient inputs have impacted the marsh (Richardson et al. 1997; Vaithiyanathan et al. n.d.).

The marsh habitat can be roughly divided into two types: nutrient enriched and unenriched. Unenriched marsh is typical of the historic Everglades system and is

dominated by sawgrass (*Cladium jamaicense* Crantz), with other species such as *Eleocharis cellulosa* Torr., *P. hemitomon*, and *S. lancifolia* as lesser-abundant associates. In drier sites where fire has been excluded, *Myrica cerifera* L. and *Salix caroliniana* Michx. have become established. The marsh in the northeastern section of WCA 2A has been impacted by nutrients from agricultural runoff and altered hydrology associated with the operation of the S-10 structures. In this area, the marsh is dominated by *Typha* spp., *Mikania scandens* (L.) Willd., *Polygonum* spp., and *Acrostichum danaeifolium* Langsd. & Fisch. (Urban et al. 1993; Ruchey and Vilcheck 1995; Vaithiyanathan et al. n.d.).

Peat islands are highly specialized habitats that are created when a portion of the peat soil becomes dislodged from a slough bottom and forms a floating mass. This natural phenomenon occurs where open-water unenriched sloughs are found. Revegetation is accomplished by succession through a set of intermediate species (*Cyperus* spp., *Eleocharis flavescens* (Poir.) Urb., *Polygonum* spp., and *Amaranthus australis* (A. Gray) J.D. Sauer), resulting in a climax *Cladium* marsh community or the establishment of a tree island (Worth 1988; Gunderson 1994; J. Zahina, unpubl. data).

Tree islands are found throughout both WCAs and are named for the tree species present. Melaleuca heads, dominated by *Melaleuca quinquenervia* (Cav.) S.T. Blake, are prevalent in WCA 2B. However, eradication efforts have significantly reduced the occurrence of this non-native, invasive species. The second type of tree island, bayheads, are rare in the WCAs today, with only a few persisting in the extreme northwestern part of WCA 2A. These communities have been severely impacted by drought, fire, and flooding events associated with drainage and flood control practices in the past half century (Worth 1988; Light and Dineen 1994). Bayheads are dominated by *Persea borbonia* (L.) Spreng., *Ilex cassine* L., and *M. cerifera.* The third type of tree island, willow heads, often contains a varying mixture of *S. caroliniana* and *M. cerifera.* Usually, these tree islands are but small remnants of bay heads, which once were the predominant tree island type found in this region of the Everglades. Bayheads and willow heads may also contain understory species such as *A. danaeifolium*, *Blechnum serrulatum* Rich., *Ipomoea sagittata* Poir., and *Sarcostemma clausum* (Jacq.) Roem. & Schult.

The transitional-levee habitat is a steep-sided, elongated transitional zone between the deep water canal and dry levee communities. This dynamic habitat was created by the construction of the perimeter levees around the WCAs and is characterized by widely fluctuating water levels and a high degree of disturbance. The soil substrate consists of unconsolidated shell rock fill. Typical species include *Annona glabra* L., *Bacopa monnieri* (L.) Pennell, *C. jamaicense*, *Ludwigia repens* J.F. Forst., *Phragmites australis* (Cav.) Steud., and *Typha* spp. The species present are usually stratified into discreet zones reflecting hydrological conditions.

Dry levee habitat is found on the high embankments and tops of the periphery

levees of the WCAs. The soil is unconsolidated shell rock fill which is extremely well-drained and nutrient poor. The characteristic flora include a large number of grass species (e.g., *Andropogon* spp.), *Bidens alba* (L.) DC., *Sida* spp., and *S. clausum*. This community is the most diverse in terms of species richness.

Epiphytic habitats are restricted to tree islands or transitional-levee areas where arborescent species have an opportunity to become established. Very few vascular epiphytes are found in this survey, those present being mostly of the Bromeliaceae family.

Species distribution as a function of habitat

The habitats found within WCA 2 represent a rough hydrological gradient from permanently flooded (deep water and sloughs) to never flooded (dry levee) habitats. Table 2 shows the number of species which are found in more than one habitat type. Although more than two-thirds of the species within these WCAs are found in two habitats, that number begins to drop quickly as the number of common habitats increases. This indicates that most plant species appear to be associated with specific conditions. Furthermore, the distribution of species among habitats reveals a trend of increasing diversity in less-flooded areas (Table 3), peaking in the transitional-levee habitat. Overall, levees contain the greatest number of species (Table 3), most of which are adapted for dry sites and would be unable to survive wetland conditions.

Table 2. Number of species in common between habitats in WCA 2A and 2B.

Number of habitats	Number of species in common
2	216
3	45
4	20
5	11
6	1
7	2
8	0
9	0

Conclusions

Nearly 300 macrophyte species were documented during a vegetation survey of

Table 3. Species distribution among habitats and percent of species in common between habitats. Habitat abbreviations: DW, deep water; SL, slough; FL, flat; MA, marsh; PI, peat island; TI, tree island; TL, transitional-levee; DL, dry levee; EP, epiphytic.

Habitat	General hydrology	Number of species in habitat	Percent of species in habitat found in other habitats								
			DW	SL	FL	MA	PI	TI	TL	DL	EP
DW	Permanently flooded	18		0.75	0.08	0.12	0.00	0.00	0.00	0.00	0.00
SL	Permanently flooded	20			0.24	0.18	0.08	0.05	0.04	0.00	0.00
FL	9-12 mo. flooded	12				0.03	0.11	0.14	0.10	0.00	0.00
MA	6-9 mo. flooded	38					0.20	0.36	0.06	0.00	0.00
PI	Saturated soil, not flooded	23						0.25	0.40	0.00	0.00
TI	Saturated soil, not flooded	58							0.65	0.06	0.00
TL	Variable hydrology	150								0.15	0.00
DL	Soil never saturated	99									0.00
EP	Aeric	7									

WCA 2A and 2B. Of the vascular plant families present, Poaceae (13%), Asteraceae (12%), and Cyperaceae (10%) were most represented. Nine habitats were identified, three of which (dry levee, transitional-levee, and deep water) were man-made. The transitional-levee and dry levee habitats contained the highest diversity of species, most of which were specifically adapted to dry, rather than wetland, conditions. The construction of the canals, containment levees, and the influx of nutrient from agricultural runoff are significant factors shaping the current distribution of species in these WCAs.

Literature Cited

Black, Crow, and Eidsness, Inc. 1974. *Hydrologic Study of the G.A.C. Canal Network, Collier County, Florida.* Gainesville, Fla.: Black, Crow, & Eidsness, Inc.

Davis, J.H. 1943. Vegetation of the Everglades and conservation from the point of view of the plant ecologist. *Proceedings of the Soil Science Society of Florida* 5-A:105-113.

Dohrenwend, R.E. 1997. Evapotranspiration patterns in Florida. *Florida Scientist* 40:184-192.

Gleason, P.J., A.D. Cohen, W.G. Smith, H.K. Brooks, P.A. Stone, R.L. Goodrick, and W. Spackman. 1974. The environmental significance of Holocene sediments from the Everglades and saline tidal plain. In P.J. Gleason (ed.), *Environments of South Florida: Present and Past.* Memoir II. Coral Gables, Fla.: Miami Geological Society.

Gleason, P.J., P.A. Stone, R.L. Goodrick, G. Guerin, and L. Harris. 1975. *The Significance of Paleofloral Studies and Ecological Aspects of Floating Peat Islands to Water Management in the Everglades Conservation Areas.* West Palm Beach: South Florida Water Management District.

Gunderson, L.H. 1994. Vegetation of the Everglades: Determinates of community composition. In S.M. Davis and J.C. Ogden (eds.), *Everglades: The Ecosystem and Its Restoration.* Delray Beach, Fla.: St. Lucie Press.

Harshburger, J.W. 1914. The vegetation of South Florida. *Transactions of the Wagner Free Institute of Science of Philadelphia* (3):51-187.

Kenner, W.E. 1966. *Runoff in Florida.* Map Series No. 22. Tallahassee: Florida Board of Conservation, Division of Geology.

Light, S.S., and J.W Dineen. 1994. Water control in the Everglades: A historical perspective. In S.M. Davis and J.C. Ogden (eds.), *Everglades: The Ecosystem and Its Restoration.* Delray Beach, Fla.: St. Lucie Press.

Loveless, C.M. 1959. A study of the vegetation of the Florida Everglades. *Ecology* 40:1-9.

MacVicar, T. 1983. *Rainfall Averages and Select Extremes for Central and South Florida.* Technical Publication 83-2. West Palm Beach: South Florida Water Management District.

Richardson, C.J., R.G. Qualls, and P. Vaithiyanathan. 1997. Changes in macrophyte community composition and calcareous mat cover over four years of P additions to Everglades mesocosms. In C.J. Richardson (ed.), *Effects of Phosphorus and Hydroperiod Alterations on Ecosystem Structure and Function in the Everglades, 1996-1997 Biennial Report to the Everglades Agricultural Area Environmental Protection District.* Duke Wetland Center Publication 97-05. Durham, NC.: Duke University.

Ruchey, K., and L. Vilcheck. 1995. Development of an Everglades vegetation map using a SPOT inage and the global positioning system. *Photogrammetric Engineering and Remote Sensing* 60: 767-775.

Thomas, T.M. 1974. A detailed analysis of climatological and hydrological records of South Florida with reference to man's influence upon ecosystem evolution. In P.J. Gleason (ed.), *Environments of South Florida: Present and Past.* Memoir II. Coral Gables Fla.: Miami Geological Society.

Urban, N.H., S.M. Davis, and N.G. Aumen. 1993. Fluctuations in sawgrass and cattail densities in Everglades Water Conservation Area 2A under varying nutrient, hydrological and fire regimes. *Aquatic Botany* 46:203-223.

Vaithiyanathan, P., J.G. Zahina, and C.J. Richardson. n.d. Macrophyte species changes in the Everglades: Examination along the eutrophication gradient. *Journal of Environmental Quality*: In review.

Worth, D.F. 1988. *Environmental Response of WCA-2A to Reduction in Regulation Schedule and Marsh Drawdown*. Technical Publication 88-2. West Palm Beach: South Florida Water Management District.