Vegetative Resistance to Flow in South Florida Everglades: Summary of Vegetation Sampling in Water Conservation Area 2A, September 1999

By Nancy B. Rybicki, Justin T. Reel, Patricia T. Gammon, and Mary Keith Garrett

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CONVERSION FACTORS

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch
meter (m)	3.281	foot
kilometer (km)	0.6214	mile
	Area	
hectare (ha)	2.471	acre

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32$$

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ABSTRACT

The U.S. Geological Survey is one of many agencies participating in the effort to restore the South Florida Everglades. In September 1999, vegetation was sampled in Water Conservation Area 2A in the northern part of the Everglades as part of a study to quantify effects of vegetation on water flow. The objectives of the vegetation sampling were (1) to provide detailed information on species composition, vegetation characteristics, and biomass for quantification of the effect of vegetation on water flow, and (2) to use these data in the future to infer flow resistance resulting from similar vegetation communities. Ten vegetation quadrats were sampled to determine the number and width of stems and leaves; the biomass of live and dead standing sawgrass (*Cladium jamaicense*), cattail (*Typha domingensis*) and other plants; and the biomass of dead, fallen litter. The sample data presented here were grouped into six vegetation classes based on both species composition and total biomass.

INTRODUCTION

The Florida Everglades is a vast and diverse wetland ecosystem characterized by small elevation gradients and slowly moving surface waters. A large portion of the Everglades is freshwater marshland with emergent and submersed aquatic vegetation interspersed with tree islands. The South Florida ecosystem has been altered greatly during the last 100 years by a complex water-management system that includes levees, canals, pumps, and water-control structures. This system now regulates flooding and provides a source of fresh water to urban areas and agriculture (McPherson and others, 1976; McPherson and Halley, 1996). Drainage projects have diverted much of the water that originally flowed slowly southward from Lake Okeechobee through the Everglades. Restoration and management of the Everglades ecosystem require understanding and manipulation of the amount and timing of water flow throughout the ecosystem.

The current hydrologic regime in the northern part of the Everglades is the product of extensive re-engineering that has resulted in alterations in the seasonal pattern of water-level fluctuations, changes in timing and frequency of fires, and substantial ecological change. The Water Conservation Area (WCA) (fig. 1) wetlands lie south and east of the Everglades Agricultural Area (EAA) and are managed extensively to accommodate the water needs of the agricultural area, a large and rapidly growing urban area, and the Loxahatchee National Wildlife Refuge (WCA-1). The WCA wetlands are divided into a series of large artificial basins, including the WCA-2A, a 42,000-hectare tract surrounded by levees (Everglades Consolidated Report, 2000) (fig. 1).

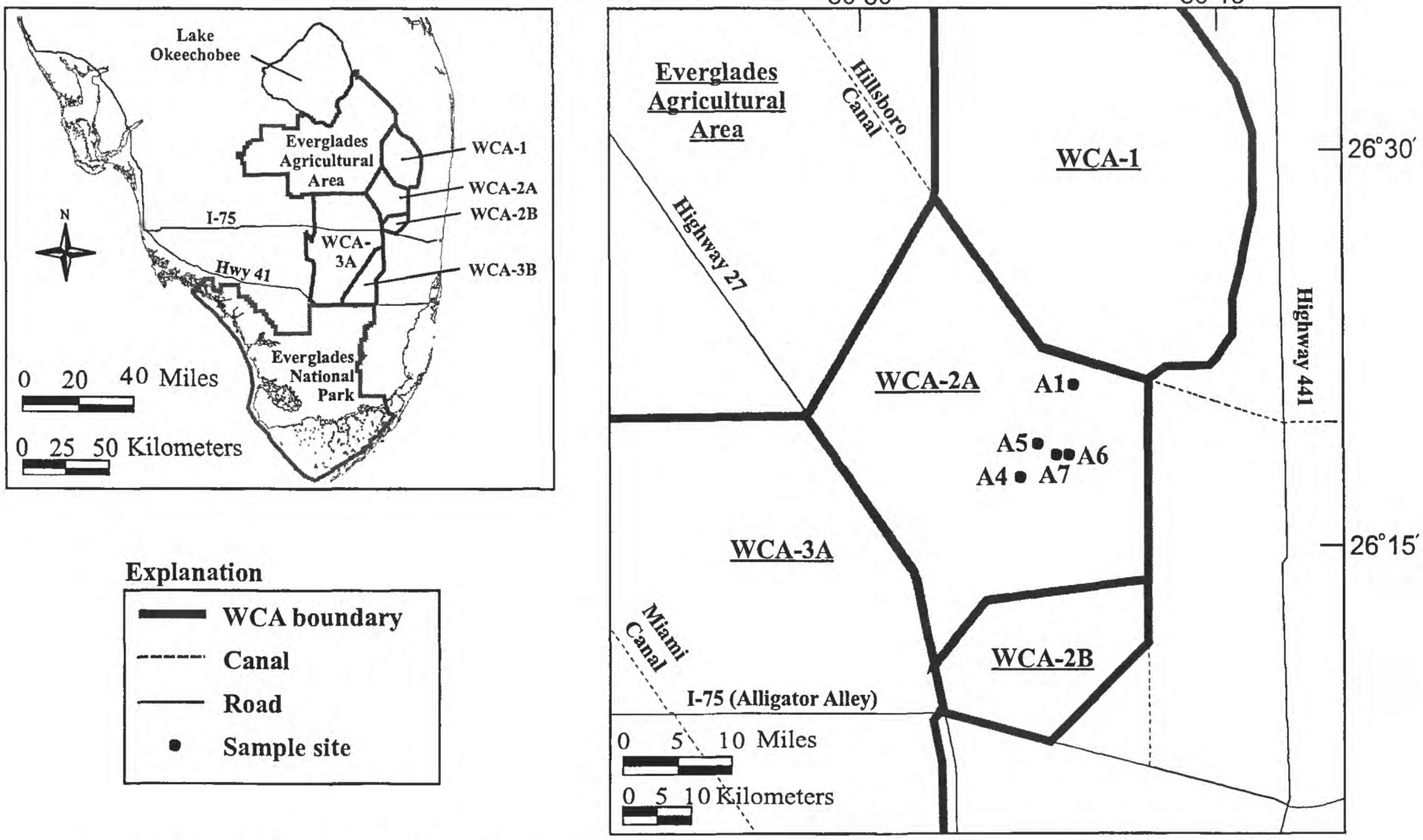

Figure 1. South Florida (left) and Water Conservation Area-2A (WCA-2A) sample sites (right).

U.S. Geological Survey (USGS) scientists are studying the hydrologic processes that will assist water managers in planning and conducting restoration efforts throughout the Everglades (Swain, 1999; Carter and others, 1999c). Among the many factors that affect the hydrologic conditions in WCA-2A, such as flow velocity, flow direction, water depth, and the period of time the ground is saturated, are frictional resistance from vegetation, the wind-sheltering effects of plant communities, topography, and evapotranspiration losses. Vegetation-induced resistance is one of the dominant but least understood forces affecting surface-water flows in the Everglades. Vegetation structure affects the rate at which water moves; living and dead, fallen plant material in the water column creates drag forces on the moving water (Petryk and Bosmajian, 1975; Kadlec, 1990; Rybicki and others, 1997).

The USGS sampled and characterized the vegetation at selected sites in WCA-2A simultaneously with velocity and surface-water slope measurements as part of a study to quantify flow resistance. USGS already has collected vegetation data in Everglades National Park (fig. 1), in both the Shark River Slough (Carter and others, 1999a, b) and Taylor Slough (Rybicki and others, 2001), using similar methods. The objectives of the vegetation sampling in WCA-2A were (1) to expand the previous database on vegetation communities by providing detailed information on species composition, vegetation characteristics, and biomass in an area dominated by cattail (*Typha domingensis* Pers.) or mixed cattail-sawgrass (*Cladium jamaicense* Crantz) communities, and (2) to provide vegetation data that will be correlated with roughness coefficients. Once roughness coefficients are calculated for the vegetation classes and characteristics for this study, the information can be used to assign coefficients for flow in similar conditions and through similar wetland vegetation (Lee and Carter, 1997; Lee and others, 2000, 2001).

STUDY SITE

WCA-2A and 2B are located southeast of the EAA and are bordered by WCA-1 on the north and WCA-3 on the south (fig. 1). The first construction of structures (levees and canals) isolating WCA-2 began about 1920 (Everglades Consolidated Report, 2000). By 1963, WCA-2 was completely compartmentalized by levees and canals, including the split between 2A and 2B. WCA-2 receives large inflows of agricultural water from water control structures located north of sample site A1 (Davis, 1990). Changes in stage that occur in this area result in part from the operation of control structures on the canals and in part from natural processes such as rainfall and evapotranspiration. Research in WCA-2A has documented increased concentrations of nutrients and the transition from a sawgrass wetland to one colonized extensively by cattails over several decades (Davis, 1990; Harvey and others, 2000). The agricultural drainage released from the Hillsboro Canal (fig. 1) results in a gradient of phosphorus concentrations and water flow from north to south (Craft and Richardson, 1993).

METHODS

Vegetation sampling sites (fig. 1) were selected to include the two dominant species and a range of plant densities in WCA-2A. Vegetation samples were collected at the same sites and within 1 day or on the same day as velocities were measured. In order to quantify the variability of vegetation within the vicinity of a velocity measurement, one duplicate (A5) and two triplicate (A6, A7) samples were taken. Visual descriptions of sites where vegetation was sampled are provided in table 1.

Vegetation was sampled in 0.25-m^2 quadrats delimited by four vertical poles marked in 10-cm increments (fig. 2). For each quadrat, a measurement was made of the tallest plant, the litter thickness, and the water level to an accuracy of ± 5 or 10%. Vegetation was cut and bagged in increments (layers) beginning from the top of the tallest plants to the root material. Vegetation taller than 100-cm above the bottom (sediment/water interface) was collected in 100-cm increments. In the interval from 100 to 40 cm above the bottom, the vegetation was cut in 20-cm increments. In the interval below 40 cm (typically within the water column), vegetation was harvested in 10-cm increments above the bottom. Depths of water, vegetation layer, and the litter layer in each quadrat were measured using a 2-cm diameter plastic pole with a 6-cm horizontal piece of pipe located 5 cm from the base of the pole (fig. 2). The horizontal pipe at the foot of the pole penetrated the litter, but not the root network. At the bottom of the vegetation profile, a litter layer sometimes was present and was composed of flocculent particulate plant material, peat, and marl over a denser substrate in which plants were rooted. The depth from the top of this flocculent material to the dense root material was defined as the depth of the litter layer.

Plant material in each layer was sorted by species and by live and dead standing and dead, fallen litter (fragments of vegetation). Live and dead standing sawgrass was separated into leaves and culms (the stem of a sedge); leaves were classified as small, medium, or large, and culms as small or large. Live and dead standing cattails were separated into leaves and culms but not classified by size because of their uniformity. Live and dead standing leaves and culms were counted separately. The widths of six sawgrass leaves and culms in each live and dead size group were measured. The width and thickness of all live and dead cattail leaves and culms were measured. All other plants (such as *Nymphaea odorata* Ait.) were counted as individual stems with attached leaves.

The sorted and measured plant material and the dead litter were dried at 105 °C for 8 to 12 hours and then weighed. Quadrats were sorted into vegetation classes based on species composition. These classes were subdivided further based on total biomass: medium = 500-1,000 gdw m^{-2}; dense = 1,000-2,000 gdw m^{-2}; and very dense = >2,000 gdw m^{-2}.

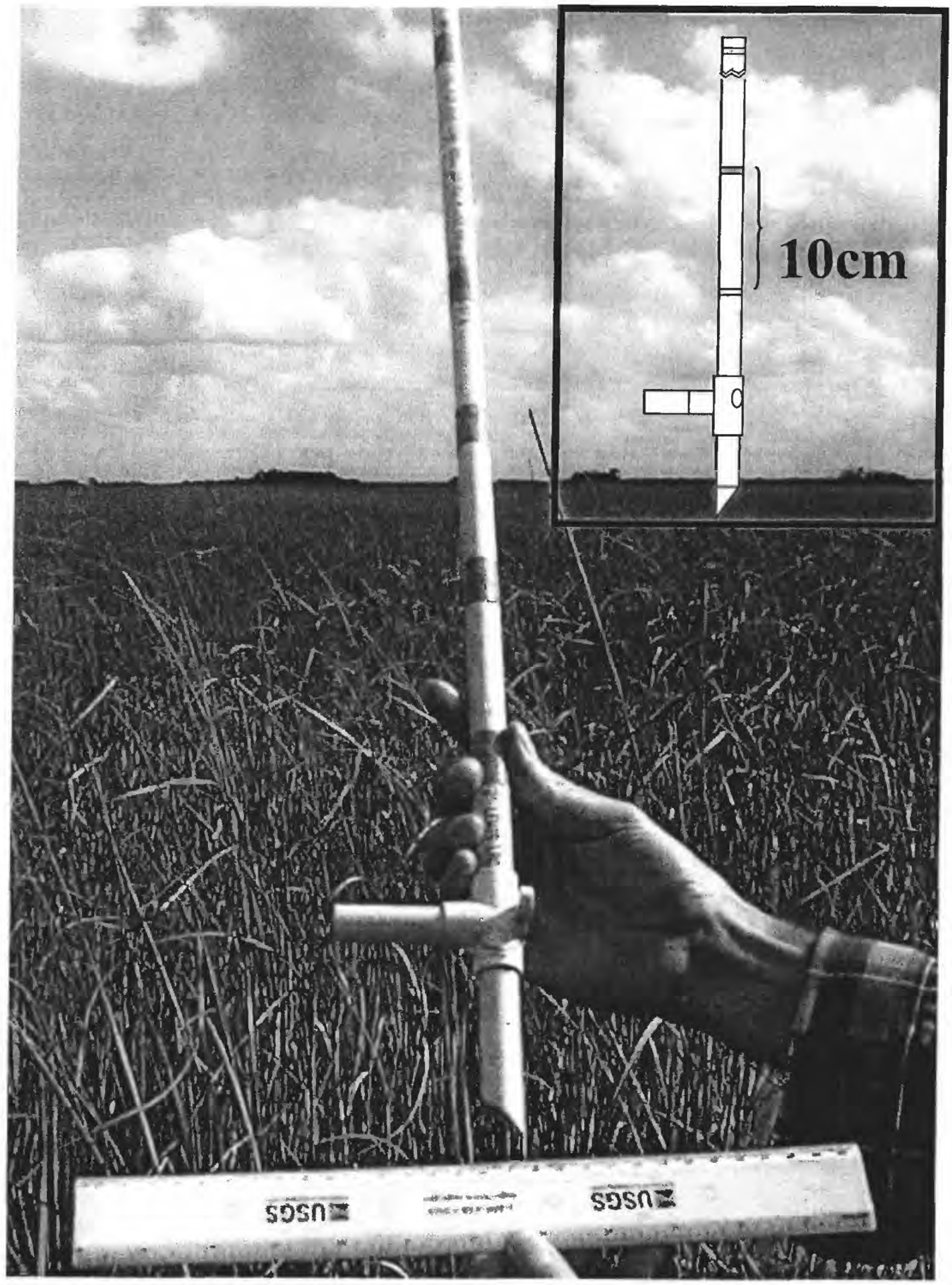

Figure 2. Photograph and diagram of a modified pipe used to measure litter layer and water depth.

VEGETATION DATA

The height of the tallest plants ranged between 2.0 and 3.2 m, the litter thickness was between 0 and 13 cm, and the water was < 60 cm deep in the ten vegetation quadrat sites sampled in WCA-2A in September 1999 (table 1). Six vegetation classes were identified based on both plant biomass and species composition (table 2). The live and total (standing and fallen) biomass data by quadrat site are summarized in table 2. Periphyton was not present (or < 2% cover) in any sample quadrat. Detailed biomass (m^{-2}) data for each quadrat, grouped by vegetation class, are presented in Appendixes A through F. Stem numbers (m^{-2}) and widths for each quadrat, grouped by vegetation class, are presented in Appendixes G through L. These data will be used to compare vegetation class characteristics to calculated roughness coefficients, such as Manning's n and the Darcy-Weisbach friction factor derived from measurements of slope and velocity made adjacent to the vegetation samples.

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Table 1. General description of sampled quadrats in WCA-2A, Everglades, September 1999

Site number	Visual description of vegetation	Plant height (m)	Litter layer (cm)	Water depth (cm)
A1	Very dense cattail	3.2	13	38
A4	Dense sawgrass	2.1	None	38
A5-1	Very dense sawgrass with cattails, 2% periphyton cover	2.0	None	24
A5-2	Very dense sawgrass, no cattail	2.8	None	24
A6-1	Very dense mixed sawgrass and cattail, sawgrass culm bases heavy and woody	2.8	None	40
A6-2	Medium cattail with open areas and water lilies	2.2	None	45
A6-3	Very dense sawgrass	2.9	1	38
A7-1	Very dense cattail, many dead leaves lying horizontally beginning 40 cm above base	2.9	None	58
A7-2	Dense cattail, all dead except for several live leaves bending into sample at top, majority lying horizontally beginning 60 cm above base	>2.0	None	60
A7-3	Very dense cattail, mixture of live and dead with many dead lying horizontally, culms soggy and recumbent at 40 cm and above	3.1	None	60

Table 2. Summary of biomass data by quadrat, arranged by vegetation class, in WCA-2A, Everglades, September 1999
[sg = sawgrass; ct = cattail; biomass in grams dry weight per square meter (gdw m^{-2}); blanks indicate values of 0]

Site	Total biomass	Live sg biomass	Total sg biomass	Live cattail biomass	Total cattail biomass	Vegetation class
A5-1	2013.8	1069.0	1716.8	114.2	133.5	very dense sg
A5-2	2852.5	1796.8	2161.5	323.2	521.5	very dense sg
A6-3	4016.3	1948.0	3733.3	9.0	27.9	very dense sg
A4	1812.3	658.1	1581.4			dense sg
A1	3087.3			1983.4	2653.8	very dense ct
A7-1	2090.1		39.2	633.0	1837.5	very dense ct
A7-3	2051.5			965.1	1873.9	very dense ct
A7-2	1032.6			25.8	832.1	dense ct
A6-2	877.4			369.0	715.3	medium ct
A6-1	2729.1	1087.6	1568.2	533.6	871.1	dense mixed sg/ct

Appendix A: Very Dense Sawgrass Class
All Vegetation Biomass in Quadrats Sampled in WCA-2A, South Florida Everglades

Table A-1. Summary of live and dead standing sawgrass biomass in quadrat A5-1, Water Conservation Area 2A, Everglades, September 1999
[Biomass in grams dry weight per square meter (gdw m^{-2}); water depth = 24 cm; plant height = 2.0 m]

Layer (cm)	Live sawgrass leaves	Dead sawgrass leaves	Total sawgrass leaves	Live sawgrass culms	Dead sawgrass culms	Total sawgrass culms
100-200	108.6		108.6			
80-100	38.8	0.1	38.9			
60-80	64.7	2.5	67.2	3.6		3.6
40-60	56.9	8.7	65.6	33.4		33.4
30-40	19.5	29.7	49.2	37.6	113.1	150.7
20-30	2.0	39.4	41.4	228.5	163.5	392.0
10-20				176.7	261.8	438.6
0-10				298.7	29.0	327.7
Total	290.4	80.4	370.8	778.5	567.4	1346.0

Table A-2. Summary of biomass in quadrat A5-1, Water Conservation Area 2A, Everglades, September 1999
[Biomass in grams dry weight per square meter (gdw m^{-2}); water depth = 24 cm; plant height = 2.0 m]

Layer (cm)	Total standing sawgrass	Live cattail leaves	Dead cattail leaves	Total cattail leaves	Live cattail culms	Dead cattail culms	Total cattail culms	Dead litter	Total biomass
100-200	108.6	40.6		40.6					149.2
80-100	38.9	10.2	5.2	15.5					54.4
60-80	70.8	15.4	2.8	18.2					89.0
40-60	99.0		6.5	6.5	16.0		16.0	6.1	127.6
30-40	199.8		1.8	1.8				37.3	238.9
20-30	433.4		3.0	3.0	14.4		14.4	61.6	512.4
10-20	438.6				10.5		10.5	27.4	476.4
0-10	327.7				7.1		7.1	31.2	366.0
Total	1716.8	66.2	19.3	85.5	48.0		48.0	163.6	2013.8

Table A-3. Summary of live and dead standing sawgrass biomass in quadrat A5-2, Water Conservation Area 2A, Everglades, September 1999
[Biomass in grams dry weight per square meter (gdw m^{-2}); water depth = 24 cm; plant height = 2.8 m]

Layer (cm)	Live sawgrass leaves	Dead sawgrass leaves	Total sawgrass leaves	Live sawgrass culms	Dead sawgrass culms	Total sawgrass culms
200-300	3.8		3.8			
100-200	81.9		81.9			
80-100	49.9		49.9	1.8		1.8
60-80	45.9	17.8	63.7	18.2		18.2
40-60	16.0	23.9	39.9	129.1		129.1
30-40	4.8	7.3	12.1	11.2	166.6	177.9
20-30		3.2	3.2	422.5	32.8	455.3
10-20		0.5	0.5	555.8	41.7	597.4
0-10				455.8	70.8	526.7
Total	202.3	52.8	255.0	1594.5	312.0	1906.5

Table A-4. Summary of biomass in quadrat A5-2, Water Conservation Area 2A, Everglades, September 1999
[Biomass in grams dry weight per square meter (gdw m^{-2}); water depth = 24 cm; plant height = 2.8 m]

Layer (cm)	Total standing sawgrass	Live cattail leaves	Dead cattail leaves	Total cattail leaves	Live cattail culms	Dead cattail culms	Total cattail culms	Dead litter	Total biomass
200-300	3.8	18.5	3.8	22.3					26.1
100-200	81.9	102.5	3.4	105.9					187.8
80-100	51.7	25.5	5.6	31.1					82.8
60-80	82.0	29.7	18.5	48.2					130.1
40-60	169.0		16.6	16.6	42.1	12.0	54.1	20.9	260.6
30-40	190.0		35.8	35.8	21.9	9.2	31.1	29.7	286.6
20-30	458.5				27.2	34.0	61.2	48.3	568.0
10-20	597.9				22.5	39.9	62.4	30.0	690.4
0-10	526.7				33.2	19.6	52.8	40.6	620.1
Total	2161.5	176.2	83.7	259.9	146.9	114.7	261.6	169.5	2852.5

Appendix B: Dense Sawgrass Class
All Vegetation Biomass in Quadrats Sampled in WCA-2A, South Florida Everglades

Table B-1. Summary of live and dead standing sawgrass biomass in quadrat A4, Water Conservation Area 2A, Everglades, September 1999
[Biomass in grams dry weight per square meter (gdw m^{-2}); water depth = 38 cm; plant height = 2.1 m]

Layer (cm)	Live sawgrass leaves	Dead sawgrass leaves	Total sawgrass leaves	Live sawgrass culms	Dead sawgrass culms	Total sawgrass culms
100-200	41.0	16.5	57.5			
80-100	40.8	35.0	75.8			
60-80	52.4	79.8	132.2	16.5		16.5
40-60	69.2	134.1	203.3	27.8		27.8
30-40	32.9	159.6	192.6	65.7		65.7
20-30	26.4	120.1	146.5	55.0		55.0
10-20		137.2	137.2	84.3	2.7	87.0
0-10		88.9	88.9	146.0	149.6	295.6
Total	262.8	771.1	1033.8	395.3	152.2	547.6

Table B-2. Summary of biomass in quadrat A4, Water Conservation Area 2A, Everglades, September 1999
[Biomass in grams dry weight per square meter (gdw m^{-2}); water depth = 38 cm; plant height = 2.1 m]

Layer (cm)	Total standing sawgrass	Dead litter	Other (roots)	Total biomass
100-200	57.5			57.5
80-100	75.8			75.8
60-80	148.6			148.6
40-60	231.1	1.5		232.6
30-40	258.3	26.8		285.0
20-30	201.4	55.1		256.5
10-20	224.2	31.9	11.2	267.2
0-10	384.4	67.3	37.2	488.9
Total	1581.4	182.5	48.4	1812.3

Appendix C: Very Dense Cattail Class
All Vegetation Biomass in Quadrats Sampled in WCA-2A, South Florida Everglades

Table C-1. Summary of biomass in quadrat A1, Water Conservation Area 2A, Everglades, September 1999
[Biomass in grams dry weight per square meter (gdw m^{-2}); water depth = 38 cm; plant height = 3.2 m]

Layer (cm)	Live cattail leaves	Dead cattail leaves	Total cattail leaves	Live cattail culms	Dead cattail culms	Total cattail culms
300-400	3.9	4.2	8.1			
200-300	380.6	73.6	454.2			
100-200	487.5	113.9	601.4			
80-100	26.3	124.5	150.8	102.2		102.2
60-80		55.4	55.4	158.0		158.0
40-60		82.8	82.8	165.9	40.9	206.8
30-40				80.4	6.6	86.9
20-30				88.4	3.7	92.1
10-20				105.5	37.8	143.3
0-10				384.7	127.2	511.9
Total	898.3	454.3	1352.6	1085.0	216.1	1301.2

Layer (cm)	Total cattail	Dead litter	Other (vine)	Total biomass
300-400	8.1			8.1
200-300	454.2			454.2
100-200	601.4		1.7	603.1
80-100	253.0	13.2	1.2	267.3
60-80	213.4	23.7		237.1
40-60	289.6	70.1		359.7
30-40	86.9	323.7		410.6
20-30	92.1			92.1
10-20	143.3			143.3
0-10	511.9			511.9
Total	2653.8	430.7	2.8	3087.3

Table C-2. Summary of biomass in quadrat A7-1, Water Conservation Area 2A, Everglades, September 1999

[Biomass in grams dry weight per square meter (gdw m^{-2}); water depth = 58 cm; plant height = 2.9 m]

Layer (cm)	Total standing sawgrass	Live cattail leaves	Dead cattail leaves	Total cattail leaves	Live cattail culms	Dead cattail culms	Total cattail culms
200-300		107.6	16.4	124.0			
100-200		151.9	270.2	422.1			
80-100			105.9	105.9	30.8		30.8
60-80	16.5		99.2	99.2	56.2	48.7	104.9
40-60	22.7		81.6	81.6	70.4	83.2	153.6
30-40					50.0	39.7	89.7
20-30					47.4	93.2	140.6
10-20					58.5	156.4	214.8
0-10					60.3	210.0	270.4
Total	39.2	259.5	573.3	832.8	373.5	631.2	1004.7

Layer (cm)	Total cattail	Dead litter	Total biomass
300-400			
200-300	124.0		124.0
100-200	422.1		422.1
80-100	136.7		136.7
60-80	204.1	20.2	240.7
40-60	235.2	132.0	389.9
30-40	89.7	22.0	111.7
20-30	140.6	15.9	156.5
10-20	214.8		214.8
0-10	270.4	23.4	293.7
Total	1837.5	213.5	2090.1

Table C-3. Summary of biomass in quadrat A7-3, Water Conservation Area 2A, Everglades, September 1999
[Biomass in grams dry weight per square meter (gdw m^{-2}); water depth = 60 cm; plant height = 3.1 m]

Layer (cm)	Live cattail leaves	Dead cattail leaves	Total cattail leaves	Live cattail culms	Dead cattail culms	Total cattail culms
300-400	7.2		7.2			
200-300	211.0	14.1	225.1			
100-200	294.8	119.2	414.0			
80-100	30.8	82.8	113.6	44.0		44.0
60-80		84.1	84.1	70.2	6.2	76.4
40-60		17.4	17.4	95.6	83.4	179.0
30-40				53.0	75.0	128.0
20-30				52.8	108.4	161.1
10-20				50.2	145.9	196.1
0-10				55.6	172.4	228.0
Total	543.8	317.6	861.4	421.3	591.2	1012.5

Layer (cm)	Total cattail	Dead litter	Total biomass
300-400	7.2		7.2
200-300	225.1		225.1
100-200	414.0		414.0
80-100	157.6		157.6
60-80	160.5		160.5
40-60	196.4	91.7	288.0
30-40	128.0	32.8	160.8
20-30	161.1		161.1
10-20	196.1		196.1
0-10	228.0	53.1	281.1
Total	1873.9	177.6	2051.5

Appendix D: Dense Cattail Class
All Vegetation Biomass in Quadrats Sampled in WCA-2A, South Florida Everglades

Table D-1. Summary of biomass in quadrat A7-2, Water Conservation Area 2A, Everglades, September 1999

[Biomass in grams dry weight per square meter (gdw m^{-2}); water depth = 60 cm; plant height = >2.0 m]

Layer (cm)	Live cattail leaves	Dead cattail leaves	Total cattail leaves	Live cattail culms	Dead cattail culms	Total cattail culms
300-400						
200-300	25.8		25.8			
100-200		338.8	338.8			
80-100		104.6	104.6		26.2	26.2
60-80		35.7	35.7		51.6	51.6
40-60					28.6	28.6
30-40					28.6	28.6
20-30					39.1	39.1
10-20					53.7	53.7
0-10					99.4	99.4
Total	25.8	479.1	504.9	0.0	327.2	327.2

Layer (cm)	Total cattail	Dead litter	Total biomass
300-400			0.0
200-300	25.8		25.8
100-200	338.8		338.8
80-100	130.8		130.8
60-80	87.2		87.2
40-60	28.6	66.9	95.5
30-40	28.6	20.4	49.0
20-30	39.1	24.0	63.2
10-20	53.7	28.2	81.9
0-10	99.4	61.0	160.4
Total	832.1	200.5	1032.6

Appendix E: Medium Cattail Class
All Vegetation Biomass in Quadrats Sampled in WCA-2A, South Florida Everglades

Table E-1. Summary of biomass in quadrat A6-2, Water Conservation Area 2A, Everglades, September 1999
[Biomass in grams dry weight per square meter (gdw m^{-2}); water depth = 45 cm; plant height = 2.2 m]

Layer (cm)	Live cattail leaves	Dead cattail leaves	Total cattail leaves	Live cattail culms	Dead cattail culms	Total cattail culms
300-400						
200-300	1.1	4.9	6.0			
100-200	73.8	28.0	101.8			
80-100	35.8	11.3	47.1			
60-80	39.2	29.6	68.8			
40-60	5.5	95.4	101.0	28.4		28.4
30-40				37.5	7.7	45.2
20-30				40.4	37.8	78.2
10-20				43.6	52.1	95.7
0-10				63.7	79.6	143.3
Total	155.4	169.2	324.6	213.6	177.1	390.7

Layer (cm)	Total cattail	Dead litter	Other (water lily)	Total biomass
300-400				
200-300	6.0			6.0
100-200	101.8			101.8
80-100	47.1			47.1
60-80	68.8			68.8
40-60	129.4	95.2	12.0	236.6
30-40	45.2	11.1	2.9	59.2
20-30	78.2	16.7	2.1	97.0
10-20	95.7	5.6	2.8	104.1
0-10	143.3	11.8	1.8	157.0
Total	715.3	140.5	21.6	877.4

Appendix F: Very Dense Mixed Sawgrass/Cattail Class
All Vegetation Biomass in Quadrats Sampled in WCA-2A, South Florida Everglades

Table F-1. Summary of live and dead standing sawgrass biomass in quadrat A6-1, Water Conservation Area 2A, Everglades, September 1999
[Biomass in grams dry weight per square meter (gdw m^{-2}); water depth = 40 cm; plant height = 2.8 m]

Layer (cm)	Live sawgrass leaves	Dead sawgrass leaves	Total sawgrass leaves	Live sawgrass culms	Dead sawgrass culms	Total sawgrass culms
300-400						
200-300	8.0	0.8	8.8			
100-200	157.4		157.4			
80-100	68.9	2.2	71.0	8.1		8.1
60-80	49.3	48.7	98.0	24.6		24.6
40-60	37.2	158.0	195.2	58.0		58.0
30-40		90.6	90.6	37.4	13.6	51.0
20-30				181.0	45.2	226.2
10-20				204.7	39.3	244.0
0-10				253.1	82.2	335.2
Total	320.7	300.3	621.0	767.0	180.3	947.3

Table F-2. Summary of biomass in quadrat A6-1, Water Conservation Area 2A, Everglades, September 1999
[Biomass in grams dry weight per square meter (gdw m^{-2}); water depth = 40 cm; plant height = 2.8 m]

Layer (cm)	Total standing sawgrass	Live cattail leaves	Dead cattail leaves	Total cattail leaves	Live cattail culms	Dead cattail culms	Total cattail culms	Dead litter	Total biomass
300-400									
200-300	8.8	44.0	4.7	48.7					57.6
100-200	157.4	159.1	24.6	183.7					341.1
80-100	79.1	58.9	26.9	85.8					165.0
60-80	122.6	40.3	84.9	125.2	19.3		19.3	1.9	269.0
40-60	253.2		57.6	57.6	68.0		68.0	49.9	428.8
30-40	141.6		5.5	5.5	36.3	13.4	49.7	18.5	215.3
20-30	226.2				28.6	31.8	60.4	68.2	354.8
10-20	244.0				44.1	32.0	76.1	32.7	352.8
0-10	335.2				34.8	56.2	91.0	118.6	544.9
Total	1568.2	302.4	204.2	506.6	231.2	133.3	364.5	289.8	2729.1

Appendix G: Very Dense Sawgrass Class
Vegetation Characteristics in Quadrats Sampled in WCA-2A, South Florida Everglades

Table G-1. Number and average width of live and dead standing sawgrass leaves and culms in quadrat A5-1, Water Conservation Area 2A, Everglades, September 1999
(Units are counts (m^{-2}) of standing leaves, culms and/or stems; width in mm; Sg = sawgrass; LL = large leaves; ML = medium leaves; SL = small leaves; LC = large culms; SC = small culms; Avg = average)

Water depth = 24 cm; plant height = 2.0 m

Layer (cm)	Sg LL	Avg LL width	Sg ML	Avg ML width	Sg SL	Avg SL width	Sg LC	Avg LC width	Sg SC	Avg SC width
100-200	20	10.8	92	8.7	32	2.7				
80-100	24	10.0	84	7.5	28	2.4				
60-80	12	10.0	136	7.7	32	3.2			12	4.0
40-60	28	12.4	88	8.2	64	3.8			20	7.8
30-40	24	11.7	112	7.6	96	3.0	16	32.5	36	7.3
20-30	40	13.7	44	7.7	44	2.9	28	31.6	48	7.5
10-20							48	22.8	44	7.5
0-10							56	29.4	24	6.8

Table G-2. Summary of standing vegetation in quadrat A5-1, Water Conservation Area 2A, Everglades, September 1999
(Units are counts (m^{-2}) of standing leaves, culms and/or stems; sg = sawgrass)

Water depth = 24 cm; plant height = 2.0 m

Layer (cm)	Total sg leaves	Total sg culms	Total sg
100-200	144		144
80-100	136		136
60-80	180	12	192
40-60	180	20	200
30-40	232	52	284
20-30	128	76	204
10-20		92	92
0-10		80	80

Table G-3. Number and average width of live and dead standing sawgrass leaves and culms in quadrat A5-2, Water Conservation Area 2A, Everglades, September 1999
(Units are counts (m^{-2}) of standing leaves, culms and/or stems; width in mm; Sg = sawgrass; LL = large leaves; ML = medium leaves; SL = small leaves; LC = large culms; SC = small culms; Avg = average)

Water depth = 24 cm; plant height = 2.8 m

Layer (cm)	Sg LL	Avg LL width	Sg ML	Avg ML width	Sg SL	Avg SL width	Sg LC	Avg LC width	Sg SC	Avg SC width
200-300					20	5.2				
100-200			56	7.2						
80-100			76	9.0	32	3.2			8	4.0
60-80			96	8.5	20	3.2	8	10.5		
40-60	36	14.9	24	6.5	80	3.7	12	22.7	12	6.0
30-40			48	6.9	40	3.3	20	28.8	8	6.5
20-30			16	9.0			32	38.8	20	8.2
10-20	4	17.0					44	35.3	24	6.7
0-10							44	34.6	20	6.0

Table G-4. Summary of standing vegetation in quadrat A5-2, Water Conservation Area 2A, Everglades, September 1999
(Units are counts (m^{-2}) of standing leaves, culms and/or stems; sg = sawgrass; ct = cattail)

Water depth = 24 cm; plant height = 2.8 m

Layer (cm)	Total sg leaves	Total sg culms	Total sg
200-300	20		20
100-200	56		56
80-100	108	8	116
60-80	116	8	124
40-60	140	24	164
30-40	88	28	116
20-30	16	52	68
10-20	4	68	72
0-10		64	64

Table G-5. Number and average width of live and dead standing sawgrass leaves and culms in quadrat A6-3, Water Conservation Area 2A, Everglades, September 1999
(Units are counts (m^{-2}) of standing leaves, culms and/or stems; width in mm; Sg = sawgrass; LL = large leaves; ML = medium leaves; SL = small leaves; LC = large culms; SC = small culms; Avg = average)

Water depth = 38 cm; plant height = 2.9 m

Layer (cm)	Sg LL	Avg LL width	Sg ML	Avg ML width	Sg SL	Avg SL width	Sg LC	Avg LC width	Sg SC	Avg SC width
200-300			20	6.0	44	3.7			28	6.7
100-200			188	8.2	60	2.6	8	12.5	12	5.0
80-100	52	13.0	108	8.0	24	3.3	16	13.5	12	6.0
60-80	168	12.4	112	7.8			20	12.8	4	5.0
40-60	244	15.1	76	8.4	24	4.2	20	16.6	4	7.0
30-40							24	41.5	8	8.0
20-30							36	32.9	8	5.0
10-20							44	34.4	4	5.0
0-10							44	38.1	4	10.0

Table G-6. Summary of standing vegetation in quadrat A6-3, Water Conservation Area 2A, Everglades, September 1999
(Units are counts (m^{-2}) of standing leaves, culms and/or stems; sg = sawgrass)

Water depth = 38 cm; plant height = 2.9 m

Layer (cm)	Total sg leaves	Total sg culms	Total sg	Total ct leaves	Total ct
200-300	64	28	92	12	12
100-200	248	20	268	12	12
80-100	184	28	212	12	12
60-80	280	24	304		
40-60	344	24	368		
30-40		32	32		
20-30		44	44		
10-20		48	48		
0-10		48	48		

Appendix H: Dense Sawgrass Class
Vegetation Characteristics in Quadrats Sampled in WCA-2A, South Florida Everglades

Table H-1. Number and average width of live and dead standing sawgrass leaves and culms in quadrat A4, Water Conservation Area 2A, Everglades, September 1999
(Units are counts (m^{-2}) of standing leaves, culms and/or stems; width in mm; Sg = sawgrass; LL = large leaves; ML = medium leaves; SL = small leaves; LC = large culms; SC = small culms; Avg = average)

Water depth = 38 cm; plant height = 2.1 m

Layer (cm)	Sg LL	Avg LL width	Sg ML	Avg ML width	Sg SL	Avg SL width	Sg LC	Avg LC width	Sg SC	Avg SC width
100-200					120	3.5				
80-100			24	7.5	192	3.6				
60-80			136	8.6	200	4.2			28	3.8
40-60			220	8.3	300	4.1			36	4.3
30-40	16	13.3	328	7.8	332	3.7	12	11.3	44	7.8
20-30	120	13.6	216	7.6	136	3.5	16	13.8	40	6.4
10-20	160	16.2	196	7.8	108	3.3	28	15.8	32	6.5
0-10	68	16.2	112	7.8	52	3.5	52	22.0	56	7.4

Table H-2. Summary of standing vegetation in quadrat A4, Water Conservation Area 2A, Everglades, September 1999
(Units are counts (m^{-2}) of standing leaves, culms and/or stems; sg = sawgrass)

Water depth = 38 cm; plant height = 2.1 m

Layer (cm)	Total sg leaves	Total sg culms	Total sg	Other (root)
100-200	120		120	
80-100	216		216	
60-80	336	28	364	
40-60	520	36	556	
30-40	676	56	732	
20-30	472	56	528	
10-20	464	60	524	4
0-10	232	108	340	4

Appendix I: Very Dense Cattail Class
Vegetation Characteristics in Quadrats Sampled in WCA-2A, South Florida Everglades

Table I-1. Number and average width of live and dead standing cattail leaves and culms in quadrat A1, Water Conservation Area 2A, Everglades, September 1999
(Units are counts (m^{-2}) of standing leaves, culms and/or stems; width in mm; Ct = cattail; Avg = average)

Water depth = 38 cm; plant height = 3.2 m

Layer (cm)	Ct leaves	Avg leaf width	Ct culms	Avg culm width	Total ct	Other (vine stem)
300-400	48	9.9			48	
200-300	252	10.5			252	
100-200	208	13.7			208	4
80-100	184	12.3	16	40.0	200	4
60-80	72	12.0	20	48.0	92	
40-60	92	13.2	36	36.7	128	
30-40			28	36.6	28	
20-30			28	37.0	28	
10-20			36	41.0	36	
0-10			32	49.9	32	

Table I-2. Number and average width of live and dead standing sawgrass and cattail leaves and culms in quadrat A7-1, Water Conservation Area 2A, Everglades, September 1999
(Units are counts (m^{-2}) of standing leaves, culms and/or stems; width in mm; Sg = sawgrass; ML = medium leaves; LC = large culms; Ct = cattail; Avg = average)

Water depth = 58 cm; plant height = 2.9 m

Layer (cm)	Sg ML	Avg ML width	Sg LC	Avg LC width	Total sg	Ct leaves	Avg leaf width	Ct culms	Avg culm width	Total ct
200-300						72	13.5			72
100-200						192	13.5			192
80-100						148	14.8	12	23.7	160
60-80	8	9.0	4	12.0	12	148	15.5	24	36.7	172
40-60			4	12.0	4	152	14.7	36	32.1	188
30-40								56	29.1	56
20-30								60	34.0	60
10-20								68	44.1	68
0-10								64	49.1	64

Table I-3. Number and average width of live and dead standing cattail leaves and culms in quadrat A7-3, Water Conservation Area 2A, Everglades, September 1999
(Units are counts (m^{-2}) of standing leaves, culms and/or stems; width in mm; Ct = cattail; Avg = average)

Water depth = 60 cm; plant height = 3.1 m

Layer (cm)	Ct leaves	Avg leaf width	Ct culms	Avg culm width	Total ct
300-400	20	11.6			20
200-300	100	14.4			100
100-200	144	13.8			144
80-100	132	14.7	8	39.0	140
60-80	100	14.7	16	34.3	116
40-60	28	13.3	28	35.0	56
30-40			36	44.1	36
20-30			48	46.2	48
10-20			48	50.9	48
0-10			44	43.4	44

Appendix J: Dense Cattail Class
Vegetation Characteristics in Quadrats Sampled in WCA-2A, South Florida Everglades

Table J-1. Number and average width of live and dead standing cattail leaves and culms in quadrat A7-2, Water Conservation Area 2A, Everglades, September 1999
(Units are counts (m^{-2}) of standing leaves, culms and/or stems; width in mm; Ct = cattail; Avg = average)

Water depth = 60 cm; plant height = >2.0 m

Layer (cm)	Ct leaves	Avg leaf width	Ct culms	Avg culm width	Total ct
200-300	8	17.0			8
100-200	244	14.5			244
80-100	136	13.3	12	19.7	148
60-80	64	13.0	12	36.0	76
40-60			12	29.3	12
30-40			12	33.3	12
20-30			20	22.4	20
10-20			20	36.4	20
0-10			20	36.6	20

Appendix K: Medium Cattail Class
Vegetation Characteristics in Quadrats Sampled in WCA-2A, South Florida Everglades

Table K-1. Number and average width of live and dead standing cattail leaves and culms in quadrat A6-2, Water Conservation Area 2A, Everglades, September 1999
(Units are counts (m^{-2}) of standing leaves, culms and/or stems; width in mm; Ct = cattail; Avg = average)

Water depth = 45 cm; plant height = 2.2 m

Layer (cm)	Ct leaves	Avg leaf width	Ct culms	Avg culm width	Total ct	Other (water lily)
200-300	44	9.3			44	
100-200	84	10.0			84	
80-100	104	10.4			104	
60-80	148	10.7			148	
40-60	144	9.7	12	31.3	156	16
30-40			24	36.8	24	16
20-30			32	40.9	32	16
10-20			32	40.0	32	24
0-10			40	38.3	40	24

Appendix L: Very Dense Mixed Sawgrass/Cattail Class
Vegetation Characteristics in Quadrats Sampled in WCA-2A, South Florida Everglades

Table L-1. Number and average width of live and dead standing cattail leaves and culms in quadrat A6-1, Water Conservation Area 2A, Everglades, September 1999
(Units are counts (m^{-2}) of standing leaves, culms and/or stems; width in mm; Sg = sawgrass;
LL = large leaves; ML = medium leaves; SL = small leaves; LC = large culms; SC = small culms; Ct = cattail; Avg = average)

Water depth = 40 cm; plant height = 2.8 m

Layer (cm)	Sg LL	Avg LL width	Sg ML	Avg ML width	Sg SL	Avg SL width	Sg LC	Avg LC width	Sg SC	Avg SC width
200-300			16	7.0	8	3.0				
100-200			52	7.7	40	3.5				
80-100	44	12.3	28	8.7	4	3.0			8	6.0
60-80	64	12.3	36	7.9			8	13.5		
40-60	72	14.4	8	9.0			8	19.5	4	5.0
30-40	128	17.3					16	19.3	4	4.0
20-30							16	40.3	8	5.0
10-20							16	44.3	8	7.0
0-10							16	47.8	4	8.0

Layer (cm)	Total sg	Ct leaves	Avg ct leaf width	Ct culms	Avg ct culm width	Total ct
300-400						
200-300	24	40	13.7			40
100-200	92	72	11.9			72
80-100	84	116	13.1			116
60-80	108	188	11.3	8	19.0	196
40-60	92	92	12.5	8	55.0	100
30-40	148	12	14.3	16	35.3	28
20-30	24			20	48.4	20
10-20	24			20	48.4	20
0-10	20			20	49.4	20