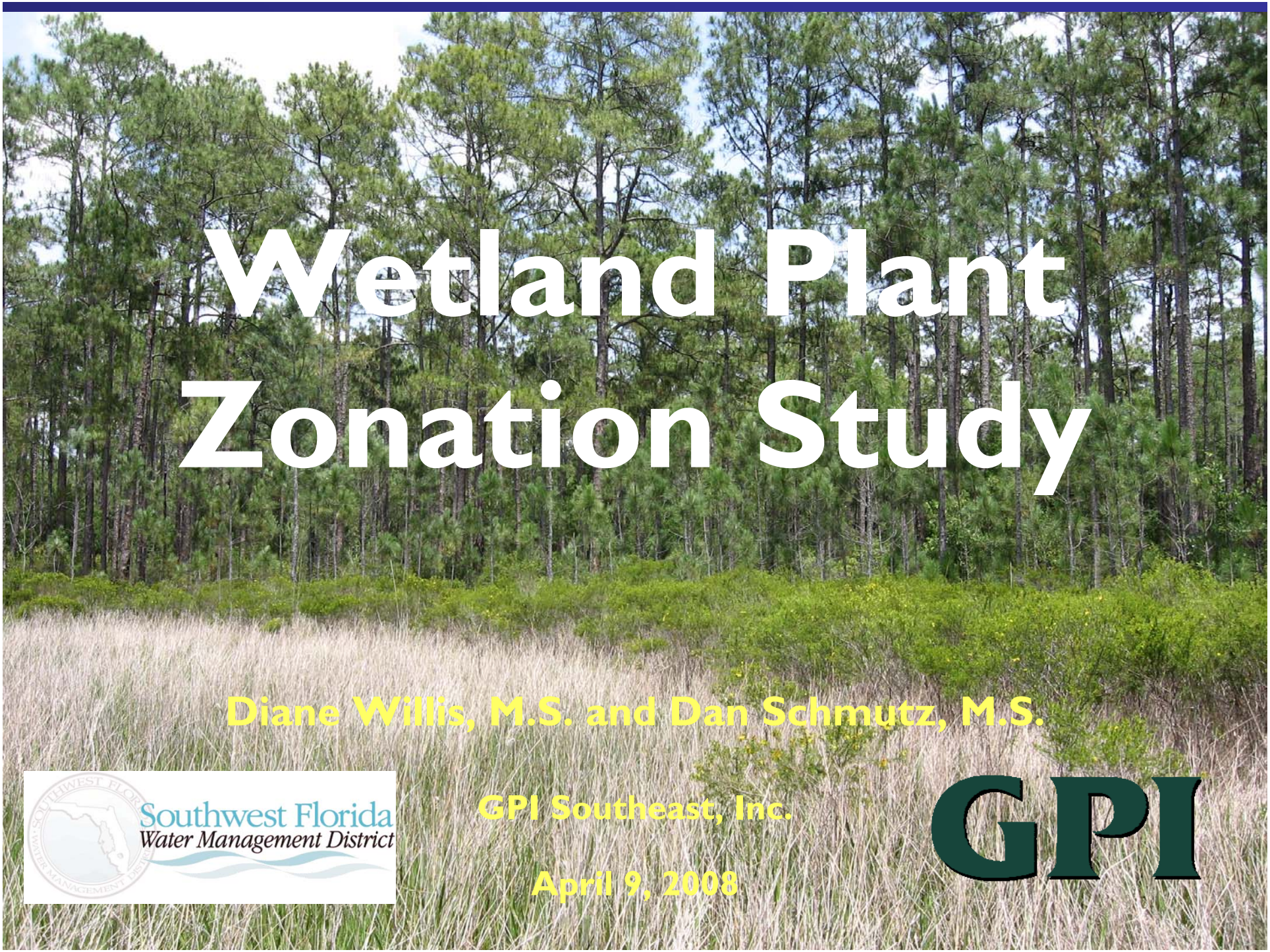

Wetland Plant Zonation Study

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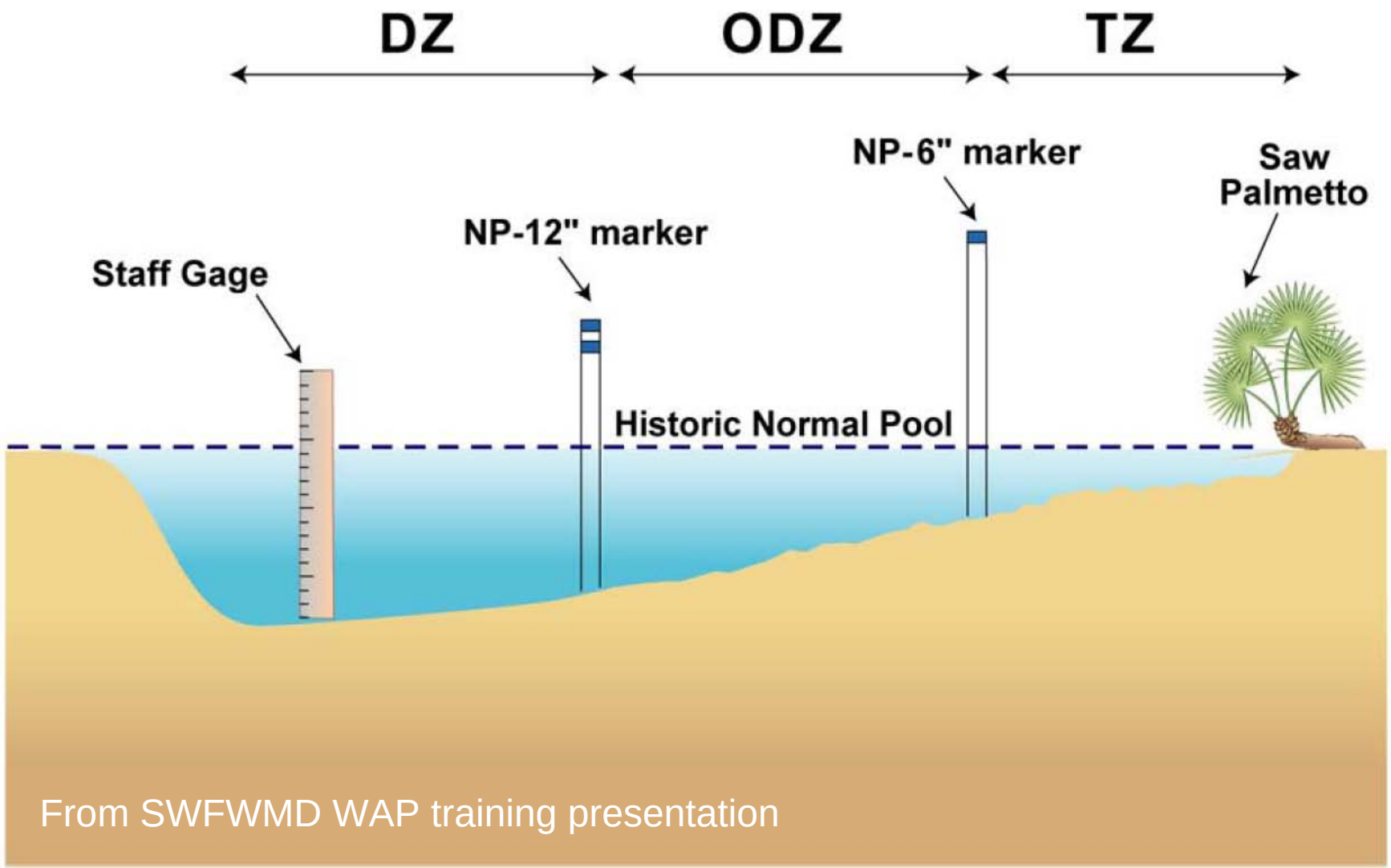
GPI Southeast, Inc.

April 9, 2008

Southwest Florida Water Management District

GPI

Example of Typical WAP Transect



From SWFWMD WAP training presentation

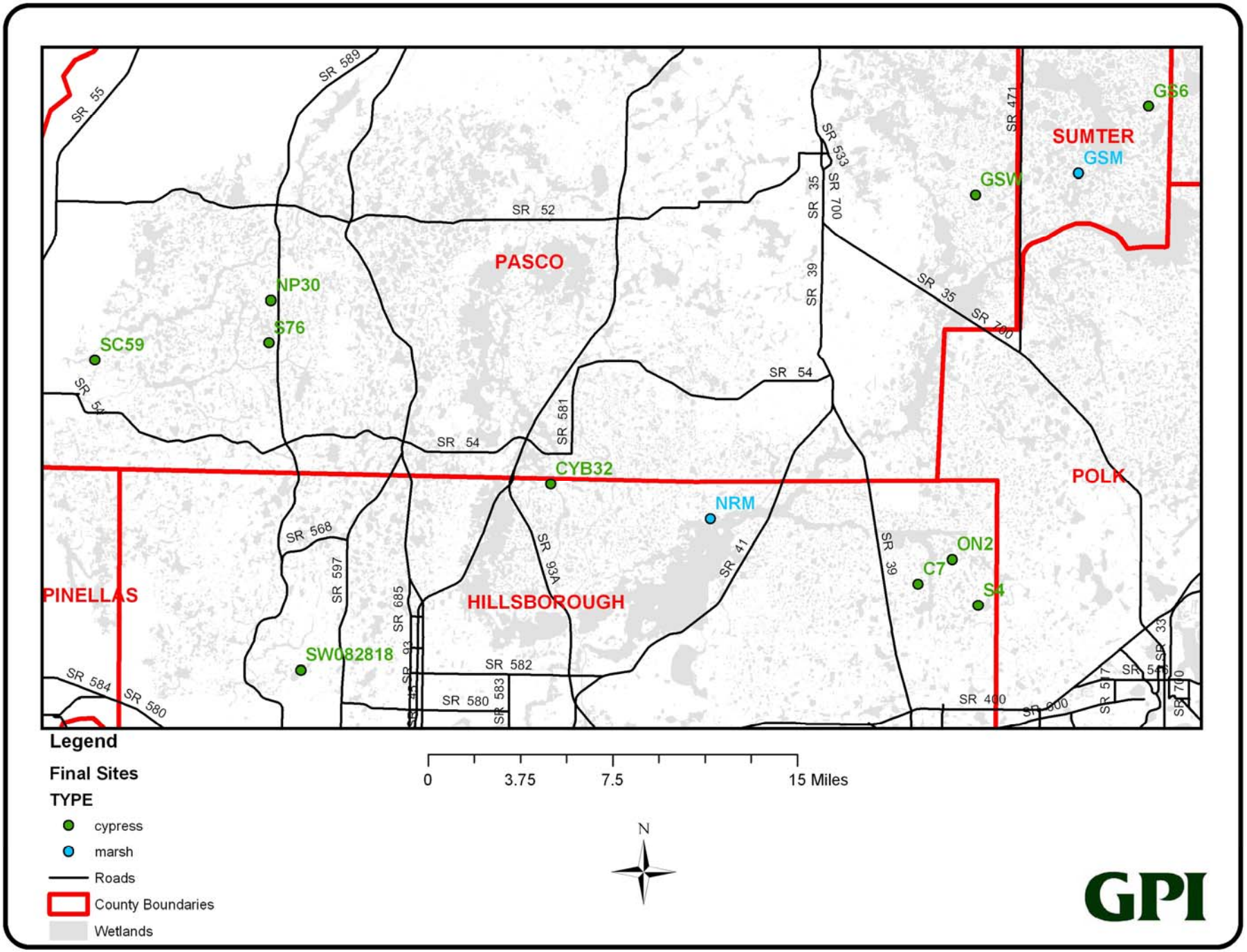
Appendix A. Plant list used for WAP methodology.

Botanical Name	Common Name	Synonymy	Wetland Zone
Acer rubrum	red maple		OD
Amaranthus australis	southern amaranth		T
Ambrosia artemisiifolia	common ragweed		U
Amorpha fruticosa	Bastard indigobush; false indigobush		T
Ampelopsis arborea	Peppervine		AD
Amphicarpum muhlenbergianum	blue maidencane		OD
Andropogon glomeratus	bushy bluestem		T
Andropogon glomeratus var. glaucopsis	purple bluestem		OD
Andropogon virginicus	broomsedge bluestem		AD
Andropogon virginicus var. decipiens	broomsedge bluestem		AD
Andropogon virginicus var. glaucus	chalky bluestem		U
Axonopus spp.	Carpetgrass		AD
Baccharis spp.	silverling, groundsel tree, sea myrtle		AD
Bacopa caroliniana	lemon bacopa; blue waterhyssop		OD
Berchemia scandens	alabama supplejack; rattan vine		T
Callicarpa americana	American beautyberry		U
Campsis radicans	trumpet creeper		T
Carex longii	long's sedge		T
Celtis laevigata	sugarberry; hackberry		T
Centella asiatica	Spadeleaf		T
Cephalanthus occidentalis	common buttonbush		D

WAP plant classifications

- U – Upland, not expected in wetlands
- AD – Adaptive, FAC or U, found in limited numbers in Transition Zone
- T – Transition, found in T zone but no deeper
- OD – Outer Deep, found in T and OD zones, but not in D zone
- D – Deep, found throughout wetland

Methods

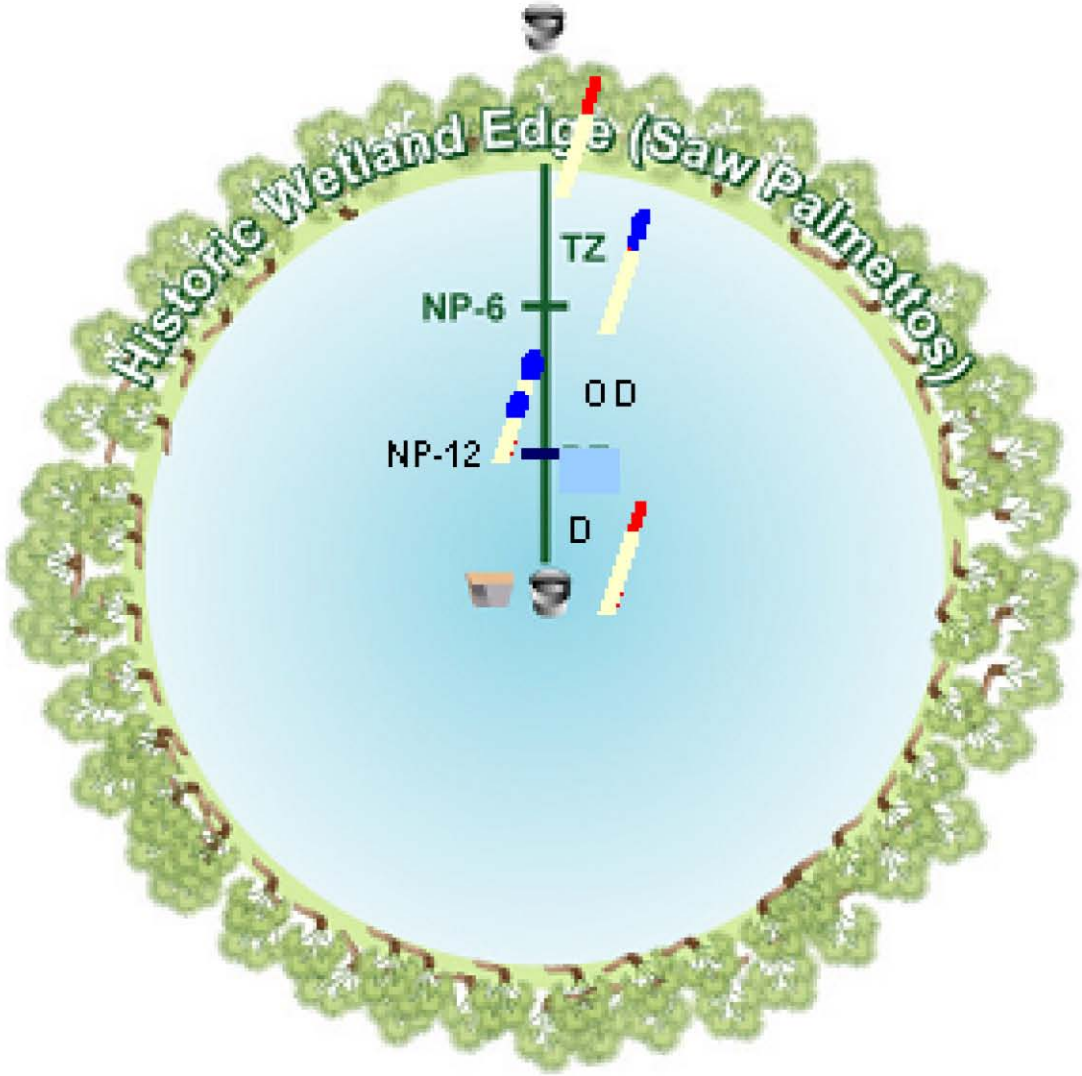

SR 589
SR 55
SR 52
SR 533
SR 35
SR 700
SR 471
GS6
SUMTER
GSM
GSW
PASCO
NP30
S76
SC59
SR 39
SR 35
SR 54
SR 581
CYB32
POLK
NRM
SR 568
SR 597
SR 685
SR 93A
SR 41
SR 39
ON2
C7
S4
PINELLAS
HILLSBOROUGH
SW082818
SR 582
SR 584
SR 580
SR 583
SR 400
SR 517
SR 33
SR 700
0
3.75
7.5
15 Miles
N
Legend
Final Sites
TYPE
cypress
marsh
Roads
County Boundaries
Wetlands
GPI

List of Study Sites with Surrogate Minimum Levels

(time period WY1996 – WY2005)

Sort Order from West to East	Site Abbreviation	Location	Years of Water Level Data	Difference from 10-year Minimum Level
1	SC59	West of Starkey	10+	0.75
2	S76	Starkey	10+	1.15
3	NP30	North Pasco	10+	1.19
4	SW082818	Northwest Hillsborough	10+	0.67
5	CYB32	Cypress Bridge	2.5	0.80
6	NRM	East of Morris Bridge	5	1.25
7	C7	Cone Ranch	10+	1.17
8	ON2	Cone Ranch	10+	1.16
9	S4	Cone Ranch	10+	0.71
10	GSW	Green Swamp	4	1.05
11	GSM	Green Swamp	10+	1.66
12	GS6	Green Swamp	10+	1.25

Transect Set-up



From SWFWMD WAP training presentation

Herbaceous Quadrat

Six Sampling Events

- June 2006
- August 2006
- October 2006
- June 2007
- August 2007
- October 2007

Data Analysis

For each species and sampling event:

- Tabulated occurrences by 1” depths below NP summed across 24 transects in 12 wetlands
- Calculated counts, mean, standard deviation
- Performed Likelihood model comparison

Results

Tree and Shrub Data (June 2006)

	Transitional Zone						Outer Deep Zone						Deep Zone			
Species	NP-1	NP-2	NP-3	NP-4	NP-5	NP-6	NP-7	NP-8	NP-9	NP-10	NP-11	NP-12	NP-13	NP-14	NP-15	≥NP-16
Acer rubrum		1		1						1	1	1	1			
Baccharis halimifolia					1	2	1	2	1							
Decodon verticillatus										1						
Diospyros virginiana	1	2	1					1					2			
Hypericum fasciculatum	1	1	4	1	3	2	5	5	8	3	7	5	2	1	2	6
Hypericum hypericoides						1										
Hypericum myrtifolium								1								
Ilex cassine	2	1		1	1	1		3		1						
Ilex glabra					1	4	1	2			1					
Itea virginica			2													
Liquidambar styraciflua	1		1	1		1										
Ludwigia peruviana		1						1	1	1	1	2	2	2	2	2
Lyonia lucida	2	4		1	1		2	1			1					
Magnolia virginiana								1	2							
Myrica cerifera	3	8	3	6	4	5	1	2	3	2			2	2		
Persea palustris		1	1		1							1	1			
Pinus elliottii		2	2		1	2	2	7	5	4	5	1	3	1	1	
Quercus laurifolia		1														
Sabal palmetto											1					
Salix caroliniana						1			1	1	1	1	1	1	1	2
Sambucus nigra subsp. *canadensis*										1						
Stillingia aquatica			1	2	2	3		2	3	1	3	1	4	2		
Vaccinium corymbosum				1												

Likelihood Paradigm

- Standard statistical hypothesis testing provides no theoretically defensible framework for selecting one statistical hypothesis over another
- An evidential approach in which the likelihood ratio provides an objective measure of the strength of evidence to select between competing statistical models
- Intuitive and powerful method for discriminating between competing hypotheses that theoretically uses all information in the data

Probabilities for Occurrence of Three Species Models by WAP Zone (T, OD, D).

	T	OD	D
UPLAND/ADAPTIVE/ TRANSITION	**0.94**	**0.05**	**0.01**
OUTER DEEP	**0.45**	**0.50**	**0.05**
DEEP	**0.25**	**0.25**	**0.50**

Calculating the Log Likelihood Function (performed for each of three models)

$$Ln(L) = (Ln(Pr(T))*T\ Counts) + (Ln(Pr(OD))*OD\ Counts) + (Ln(Pr(D))*D\ Counts)$$

Where: Ln(L) = support or log-likelihood

Ln(Pr(T)) = natural log of the probability of occurrence in Transitional Zone

T Counts = count of occurrence in Transitional Zone of all study wetlands

Ln(Pr(OD)) = natural log of the probability of occurrence in Outer Deep Zone

OD Counts = count of occurrence in Outer Deep Zone of all study wetlands

Ln(Pr(D)) = natural log of the probability of occurrence in Deep Zone

D Counts = count of occurrence in Deep Zone of all study wetlands

Example Log Likelihood Calculation

In June 2006, Long's sedge was found 9, 6, and 2 times in the T, OD, and D zones. The zones had slightly different numbers of quadrats (151, 157, 144):

Therefore, the support for the UAT model was calculated as:

-113.1742 = (Ln(Pr(0.94/151))*9) + (Ln(Pr(0.05/157))*6) + (Ln(Pr(0.01/144))*2)

The support for the OD model was calculated as:

-102.7695 = (Ln(Pr(0.45/151))*9) + (Ln(Pr(0.50/157))*6) + (Ln(Pr(0.05/144))*2)

The support for the D model was calculated as:

-107.6133 = (Ln(Pr(0.25/151))*9) + (Ln(Pr(0.25/157))*6) + (Ln(Pr(0.50/144))*2)

Interpreting the Likelihood Difference

For Long's sedge, log likelihood (support):
OD (-102.7695) > D (-107.6133) > UAT (-113.1742)

OD is more likely than D by 4.8438 natural log units or
126.9508 times more likely (very strong evidence).

Guidelines:
Support close to 1 indicates models equally likely (weak)
Support differences > 2.08 units = strong evidence
Support differences > 3.47 units = very strong evidence

Results of Likelihood Analysis for Trees and Shrubs.

Shrub Species	Common Name	Wetland Status	WAP Zone	Jun06 WAP ZONE	Jun06 LLD	Comments
Acer rubrum	red maple	FACW	OD	OD	0.95	Weak evidence, few occurrences.
Baccharis halimifolia	groundsel tree	FAC	AD	**OD?**	**4.54**	Very strong evidence, but most of the occurrences were in a transect disturbed by wild hogs.
Decodon verticillatus	swamp-loosestrife	OBL	--	OD	0.69	Weak evidence, only one occurrence.
Diospyros virginiana	common persimmon	FAC	AD	D?	1.56	Weak evidence, only 6 occurrences, 2 of which were at NP-13".
Hypericum fasciculatum	peelbark St. John's-wort	OBL	OD	**OD**	**4.60**	Very strong evidence, very common.
Hypericum hypericoides	St. Andrew's cross	FAC	-	AD	0.74	Weak evidence, few occurrences.
Hypericum myrtifolium	myrtleleaf St. John's-wort	FACW	T	OD?	0.69	Weak evidence, only one occurrence.
Ilex cassine	dahoon holly	OBL	OD	**OD**	**6.30**	Very strong evidence.
Ilex glabra	gallberry	U	AD	**OD**	**5.53**	Very strong evidence, but the OD zone occurrences in 3 wetlands were on relatively steep slopes.
Itea virginica	Virginia willow	OBL	OD	T?	1.47	Weak evidence, only 2 occurrences below NP in one wetland.
Liquidambar styraciflua	sweetgum	FACW	T	**T**	**2.95**	Strong evidence.
Ludwigia peruviana	Peruvian primrosewillow	OBL	OD	**D**	**13.67**	Very strong evidence, rare in 2 wetlands surrounded by pasture, very common in D zone of one wetland surrounded by development.
Lyonia lucida	fetterbush	FACW	T	**OD**	**3.32**	Strong evidence, relatively common, but half of the occurrences were at or above NP, the few in the OD zone were creeping down off of hummocks.
Magnolia virginiana	sweetbay	OBL	OD	**OD**	**2.08**	Strong evidence, but only a few occurrences.
Myrica cerifera	wax myrtle	FAC	AD	**OD**	**3.50**	Very strong evidence, very common.
Persea palustris	swamp bay	OBL	OD	OD	0.15	Weak evidence, few occurrences, most in T zone.
Pinus elliottii	slash pine	U	AD	**OD**	**9.24**	Very strong evidence, very common in two marshes.
Quercus laurifolia	laurel oak	FACW	T	T	0.74	Weak evidence, most occurrences were at or above NP.
Sabal palmetto	cabbage palm	FAC	--	OD	0.69	Weak evidence, only one occurrence.
Salix caroliniana	Carolina willow	OBL	OD	**D**	**8.15**	Very strong evidence, very common in D zone of one wetland surrounded by development.
Sambucus nigra subsp. *canadensis*	elderberry	FAC	OD	**OD**	**2.18**	Strong evidence, however, only one occurrence.
Stillingia aquatica	corkwood	OBL	D	**D**	**2.18**	Strong evidence, very common.
Vaccinium corymbosum	highbush blueberry	FACW	T	T	0.74	Weak evidence, only one occurrence below NP.

Representative Groundcover Data

		Transitional Zone						Outer Deep Zone						Deep Zone				
Species	Event	NP-1	NP-2	NP-3	NP-4	NP-5	NP-6	NP-7	NP-8	NP-9	NP-10	NP-11	NP-12	NP-13	NP-14	NP-15	≥NP-16	COUNT
Amphicarpum muhlenbergianum	Jun-06	2	7	6	8	16	14	13	9	17	14	9	6		2			123
	Aug-06	2	7	7	9	16	14	13	10	15	14	9	6		2			124
	Oct-06	2	7	7	7	16	15	13	10	16	14	8	6		2			123
	Jun-07	2	7	5	8	14	15	14	10	17	14	11	6		3			126
	Aug-07	2	7	5	8	14	14	14	10	16	14	11	6	1	4			126
	Oct-07	3	7	5	10	13	14	13	11	16	14	13	6	1	4			130
Andropogon glomeratus var. *glaucopsis*	Jun-06	1	1	2	2	4	6	4	5	3	2	2	2					34
	Aug-06	1	1	2	2	5	5	4	7	5	2	2	3	2				41
	Oct-06	1	1	2	2	6	6	5	7	6	2	3	3	2				46
	Jun-07	1	1	3	1	6	8	5	7	7	2	5	4	3				53
	Aug-07	1	1	2	1	6	9	5	8	6	2	4	4	1				50
	Oct-07	1	1	1	1	6	9	4	8	6	2	3	3	1		1		47
Andropogon virginicus	Jun-06	1	4	1	7	2	1	2	3	1			1					23
	Aug-06	1	4	2	8	3	1	3	4	3		1	2					32
	Oct-06	1	4	2	8	4	2	2	3	1			1	1	1			30
	Jun-07	1	3	2	6	2		2	3	2			1	1	1			24
	Aug-07	1	3	2	4	2		2	3	1			1	1	1			21
	Oct-07		3	3	3		1	1	3				1	1	1			17
Eupatorium leptophyllum	Jun-06		2	1			1	1	1	5	1	2	4	2	3			23
	Aug-06		3	2		1	3	3	2	5	4	2	4	3	3			35
	Oct-06		3	2		1	2	1	2	4	2	2	2	2	3			26
	Jun-07		3	1	4	1	3	3	2	4	2	3	5	4	7	1	2	45
	Aug-07	1	2	2	2	2	2	3	1	3	2	4	4	4	5	1		38
	Oct-07	1	1		2	2	2	3	1	3	2	4	3	4	4	2		34

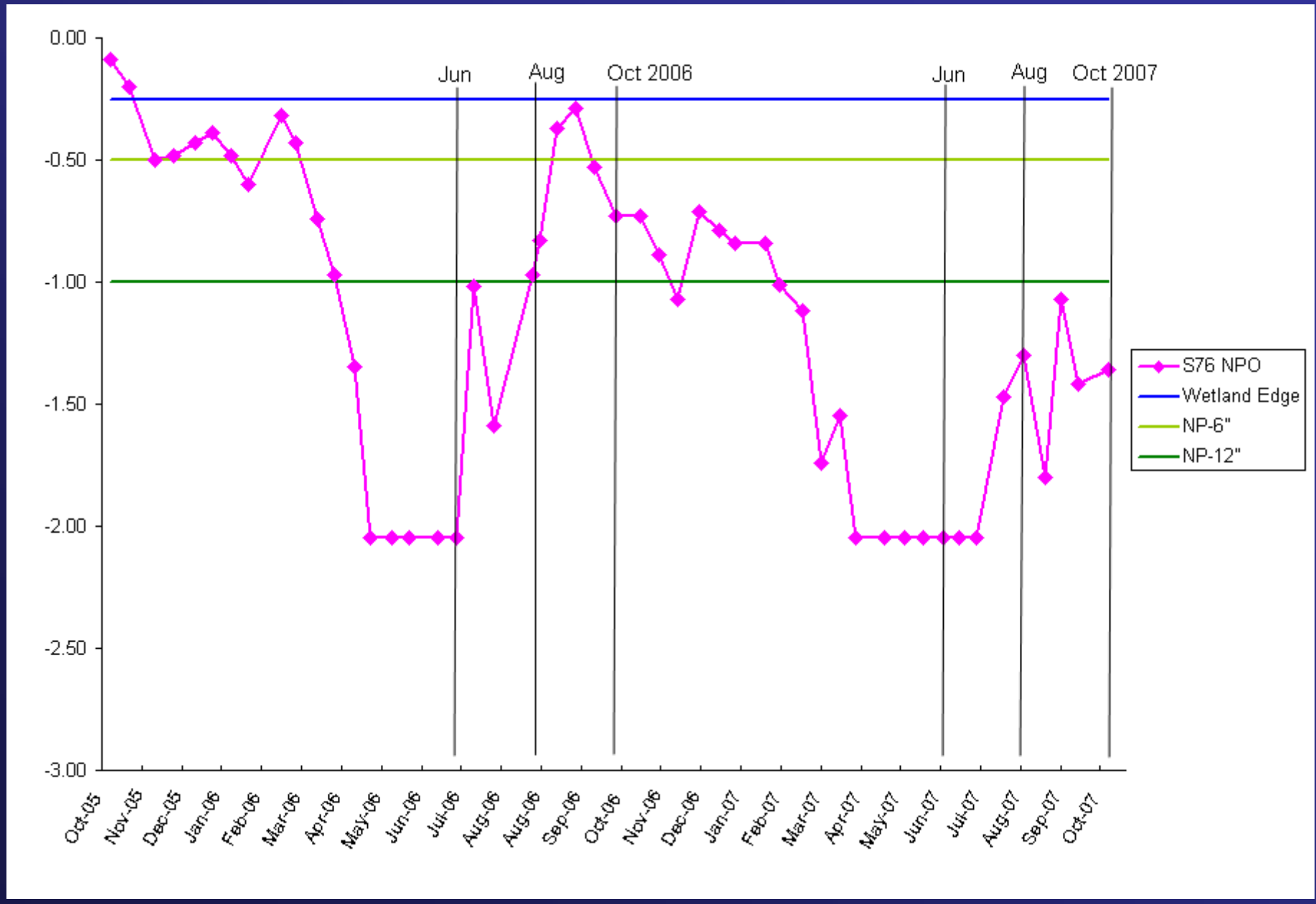
Groundcover Log Likelihood Results by Event

Herbaceous Species	Jun06 WAP Zone	Jun06 LLD	Aug06 WAP Zone	Aug06 LLD	Oct06 WAP Zone	Oct06 LLD	Jun07 WAP Zone	Jun07 LLD	Aug07 WAP Zone	Aug07 LLD	Oct07 WAP Zone	Oct07 LLD
Amphicarpum muhlenbergianum	**OD**	**73.68**	**OD**	**74.16**	**OD**	**73.58**	**OD**	**72.98**	**OD**	**67.09**	**OD**	**69.65**
Andropogon glomeratus var. *glaucopsis*	**OD**	**21.88**	**OD**	**20.74**	**OD**	**24.00**	**OD**	**25.64**	**OD**	**29.55**	**OD**	**24.58**
Andropogon virginicus	**OD**	**4.33**	**OD**	**15.94**	**OD**	**3.87**	**OD**	**9.17**	**OD**	**7.30**	**OD**	**4.74**
Eupatorium leptophyllum	OD	0.54	**OD**	**5.34**	**OD**	**2.20**	**D**	**12.01**	**D**	**4.78**	**D**	**7.23**

LLD = Difference between the log-likelihood of the best and second best model.

Recommendations for Representative Groundcover

Herbaceous Species	Common Name	Current WAP Zone	Recommended WAP Zone	Comments
Amphicarpum muhlenbergianum	blue maidencane	OD	OD	Extremely strong evidence, very consistent over 6 events, in spite of dry conditions.
Andropogon glomeratus var. *glaucopsis*	purple bluestem	OD	OD	Extremely strong evidence, very consistent over 6 events, in spite of dry conditions.
Andropogon virginicus	broomsedge bluestem	AD	AD	Even though evidence for OD zone was very strong over 6 events, notes show that even though it was frequent in OD zone, it was present in small numbers. Also, conditions have been abnormally dry.
Eupatorium leptophyllum	falsefennel	OD	OD?	Inconsistent results, strong evidence for OD zone in 2006, but spread into D zone in 2007, when conditions were drier.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-2.50
-3.00
Jun
Aug
Oct 2006
Jun
Aug
Oct 2007
S76 NPO
Wetland Edge
NP-6"
NP-12"
Oct-05
Nov-05
Dec-05
Jan-06
Feb-06
Mar-06
Apr-06
May-06
Jun-06
Jul-06
Aug-06
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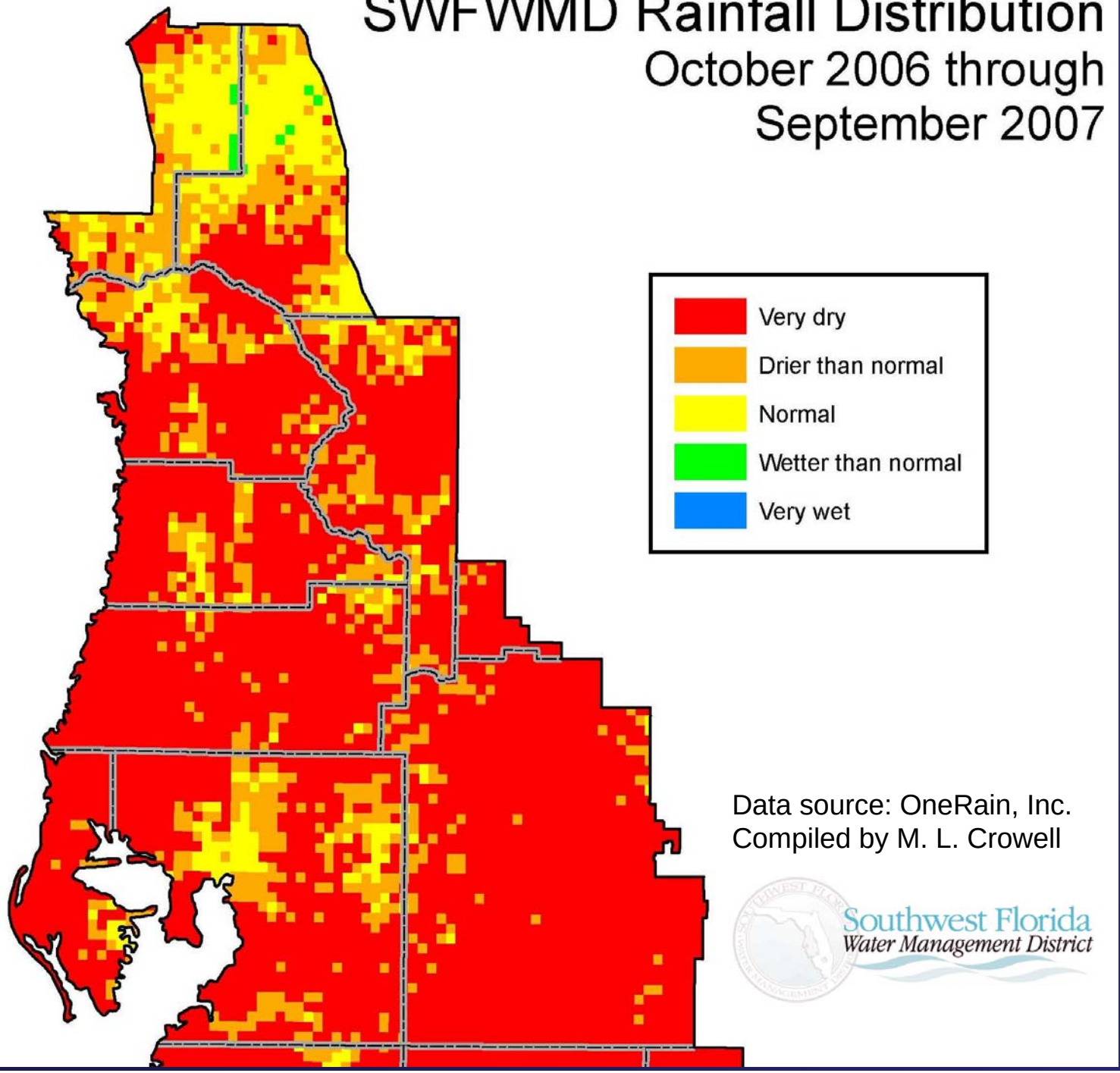
SWFWMD Rainfall Distribution
October 2006 through September 2007



Data source: OneRain, Inc.
Compiled by M. L. Crowell

Southwest Florida
Water Management District

Conclusions

Summary

- 187 Plant Species Analyzed
- 71% of WAP list
- 32 species, current WAP zone supported
- 15 species, more data needed due to dry conditions
- 17 species, could potentially be added to WAP list
- 18 new Deep Zone species
- 3 species, too few occurrences
- 36 species on WAP list not found in study

Recommendations

- Log likelihood statistical analyses worked well for this type of study
- Another year of data collection is needed during a year with normal rainfall

Questions?

suggestions or requests to dwillis@gpinet.com