HYDROLOGICAL REGIME IMPACTS ON MACROPHYTE COMMUNITIES OF STORMWATER TREATMENT WETLANDS

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INTRODUCTION

Created Wetlands (CWS):

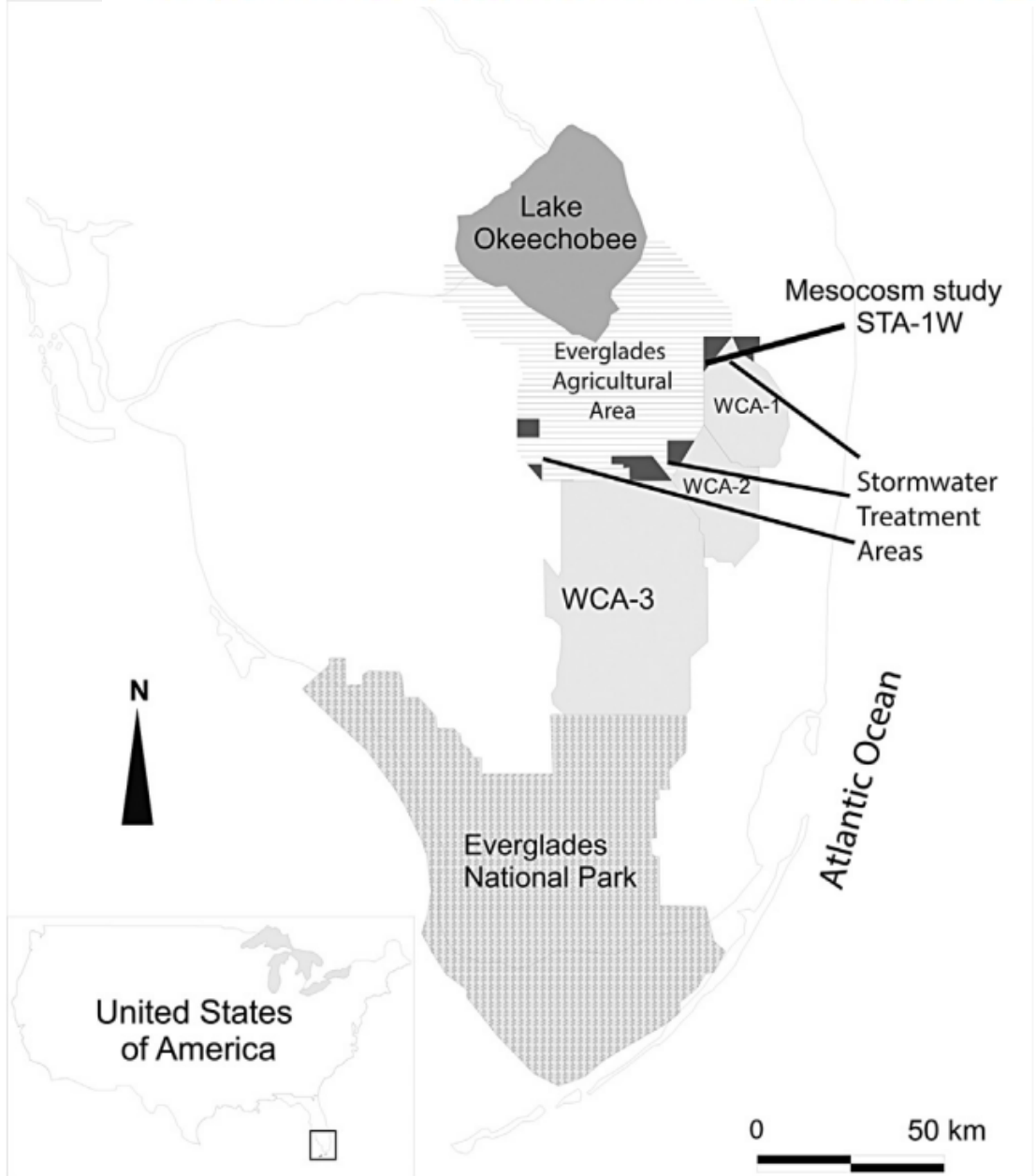
- provide a range of ecosystem services and also habitats for a range of biota, aquatic plants and animals (Greenway 2017; Mitsch and Gosselink, 2015; Mitsch et al, 2014 and 2012; Costanza et al., 1997)
- remove 10-90% N and P (Griffiths and Mitsch, 2017; Adyel et al., 2017; Merrimana et al., 2016)
- reduce possible flooding and mass loads (Greenway 2017; Mitsch and Gosselink, 2015; Mitsch et al, 2014 and 2012; etc.)

INTRODUCTION

Also for Stormwater Treatment Wetlands:

- inundation depth influences shoot density, photosynthesis and nutrients of plant community dominated by *Typha* spp. (Chen et al. 2014)
- low DO and macrophyte senescence were found in dry season (Adyel et al. 2017 and Greenway 2017)
- plant community health is a critical factor for the sustainable performance (Chen et al. 2014)

Ecological Engineering 80 (2015) 8–19



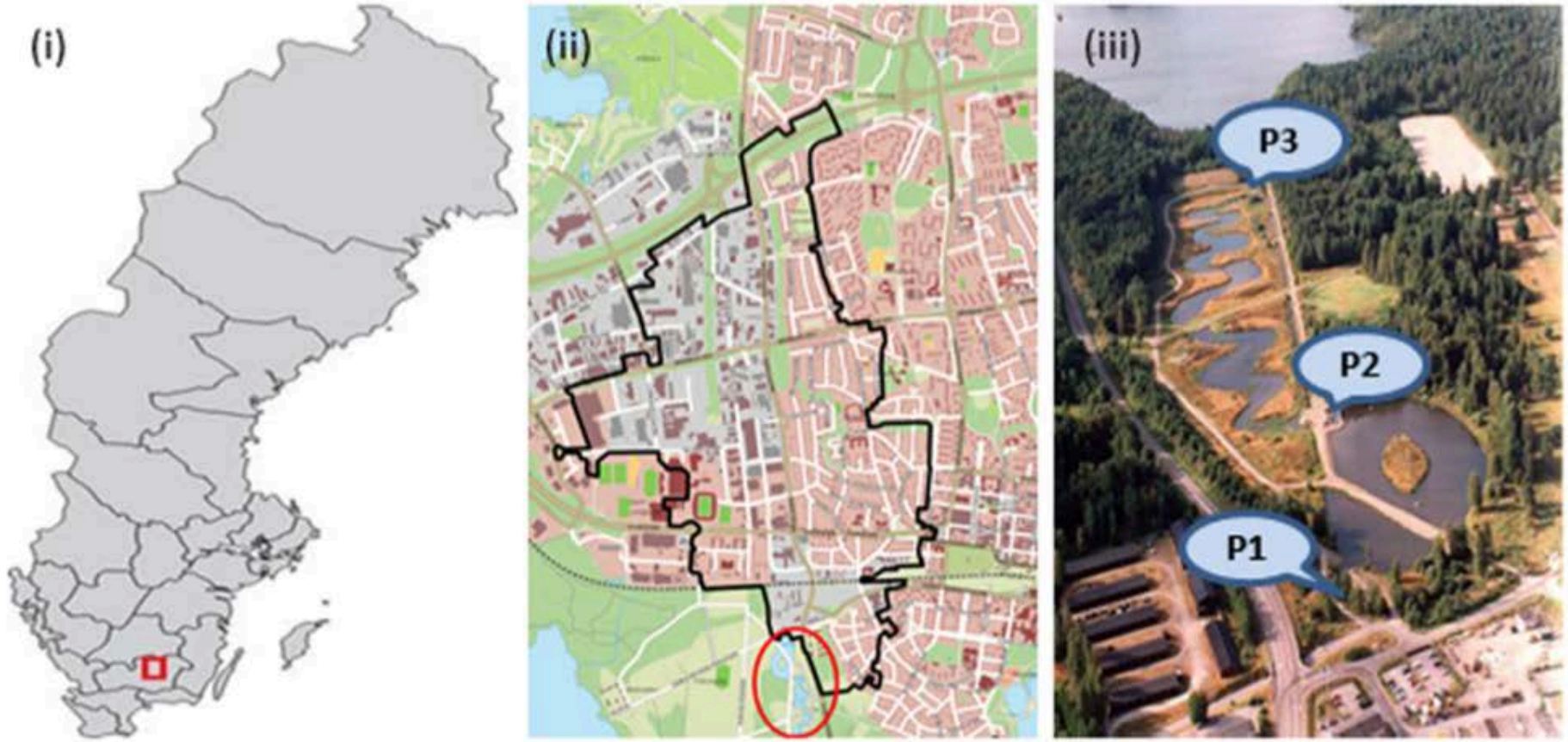


Fig. 1. Study area of the CSW: (i) map of Sweden showing the city of Växjö, (ii) the contributing catchment borders (solid line), and (iii) aerial view of the CSW with locations of the monitoring stations (P1, P2, and P3), Photo from Växjö Municipality.

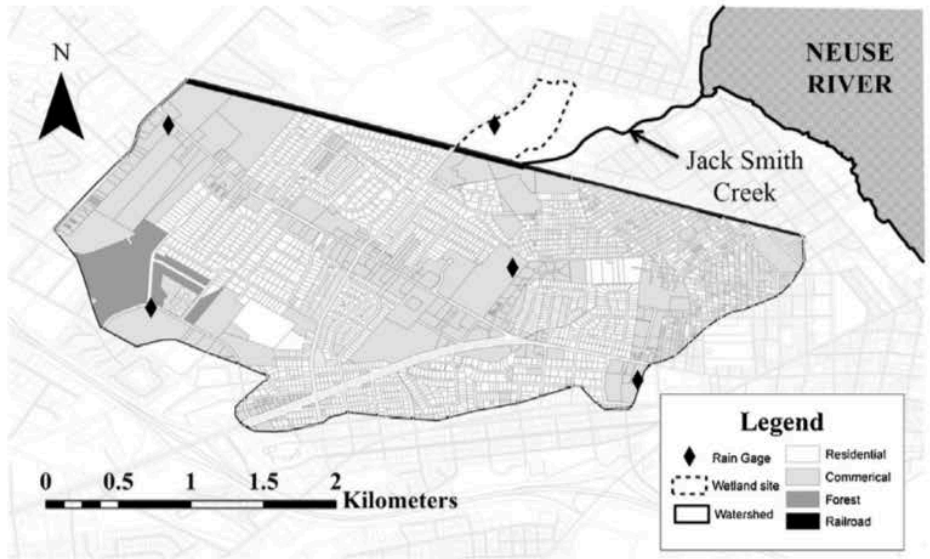


Fig. 1. Jack Smith Creek CSW contributing watershed and installed rain gauge locations in New Bern, North Carolina, USA.

Fig. 3. The labyrinth weir used as the flow control structure at the Cell B Outlet.

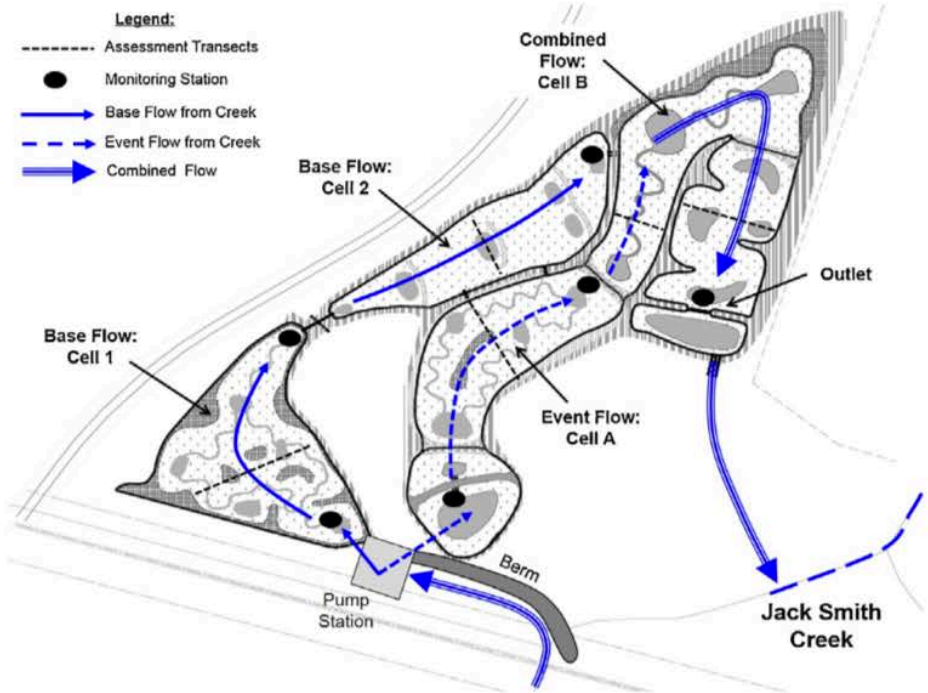


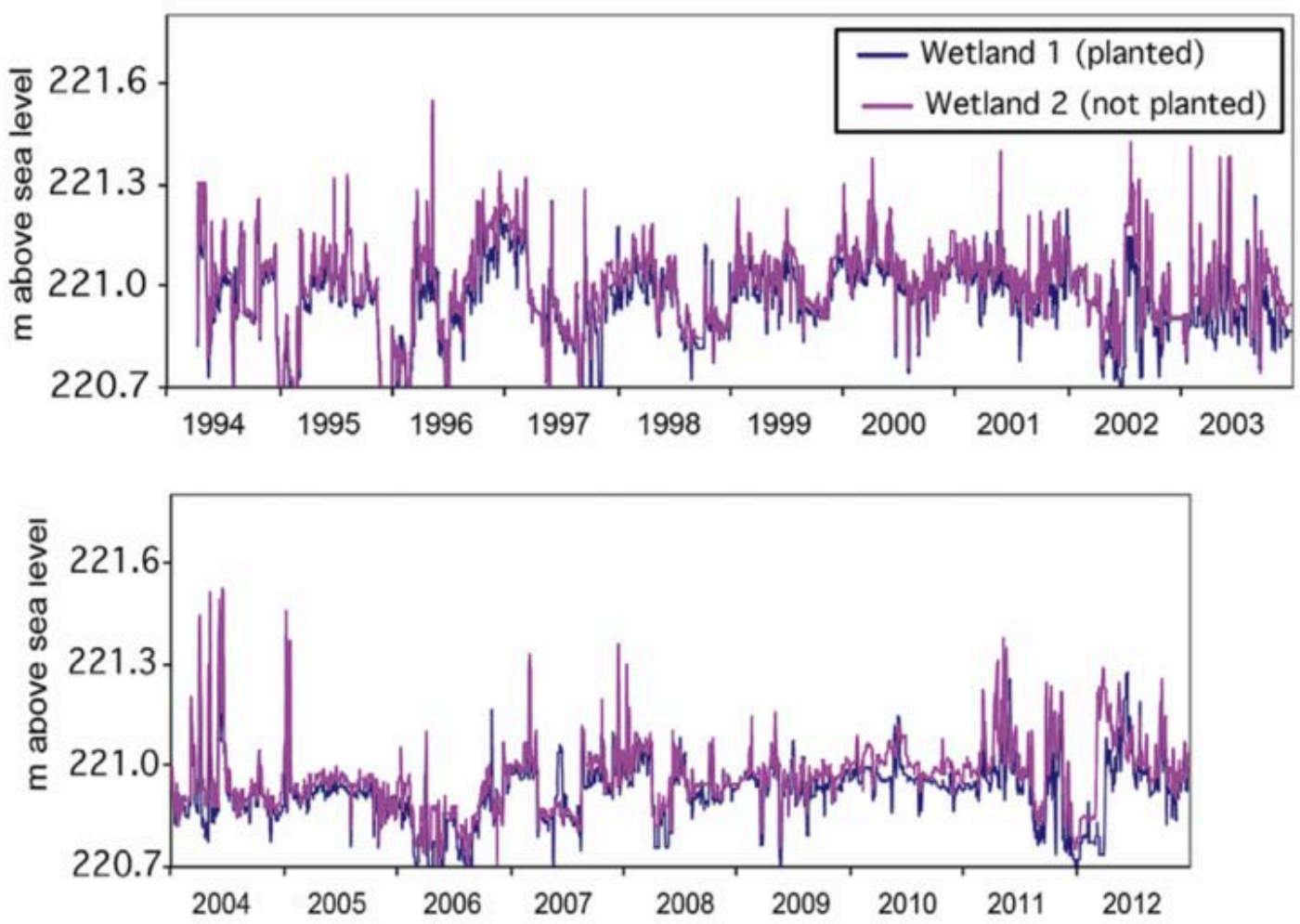
Fig. 2. Schematic of Jack Smith Creek constructed stormwater wetland.

Fig. 2. Aerial view of the Bridgwater Creek constructed wetland system: Bowie's Flat Wetland showing sampling sites (P1out:Pond1-sediment basin; P2: Pond2; P3:Pond3; P4:Pond4; P5:Pond5; P6out:Pond6). The white arrows depict base flow and stormwater flow during 'average rainfall' events. The red arrows depict stormwater flow during 'high intensity rainfall' events. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

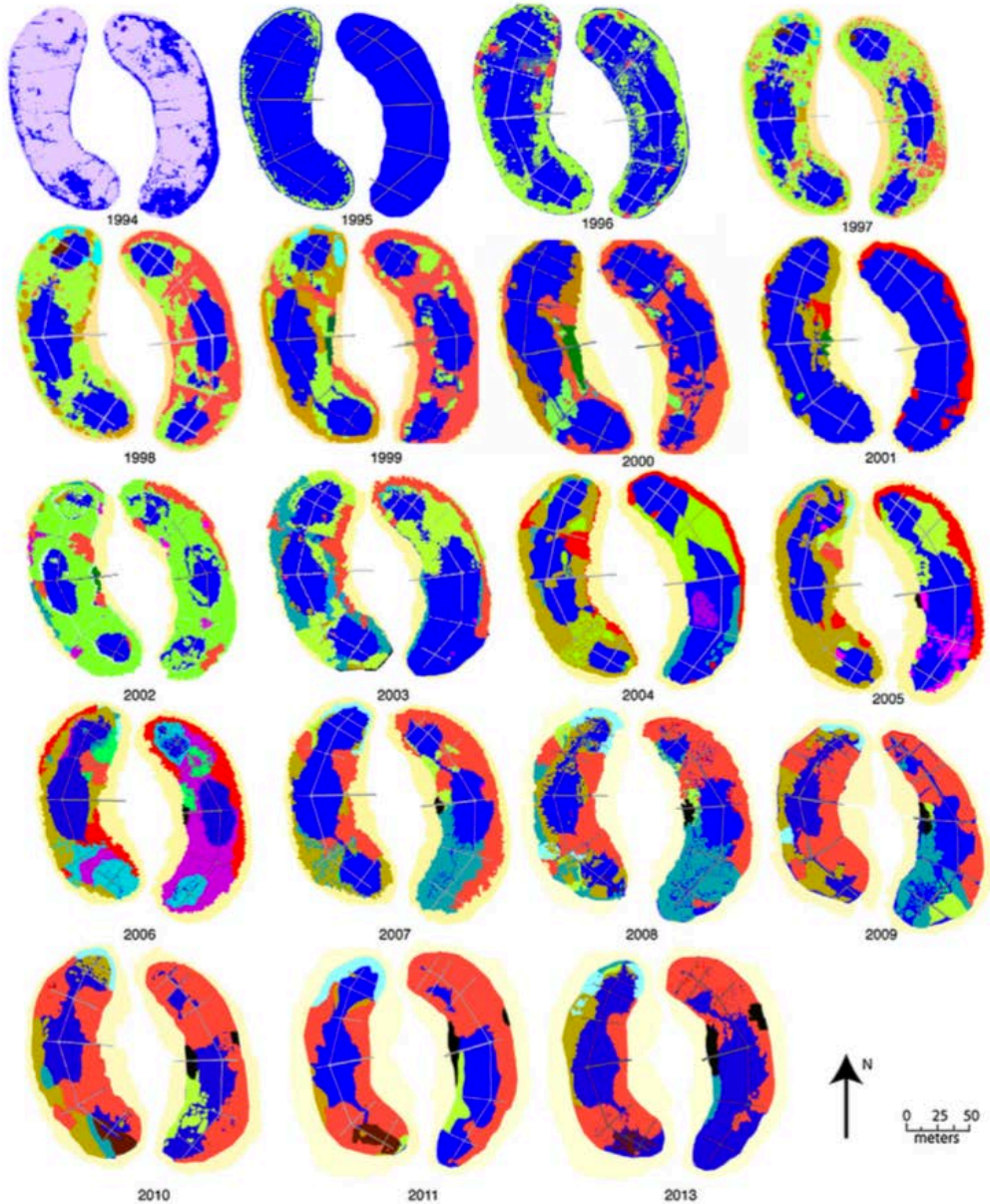
Olentangy River Wetland Research Park: The Ohio State University, Columbus, Ohio

August, 2015

Mitsch et al. Ecological Engineering 72 (2014) 11–24



Water elevations above sea level (hydroperiods) of the experimental wetlands at the Olentangy River Wetland Research Park, central Ohio, for 1994 through 2012


1994
1995
1996
1997
1998
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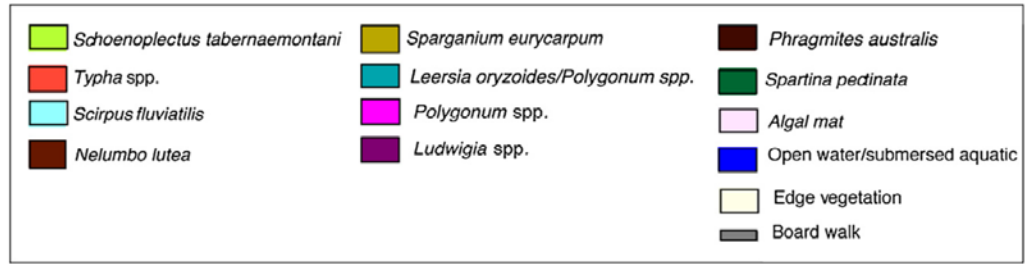
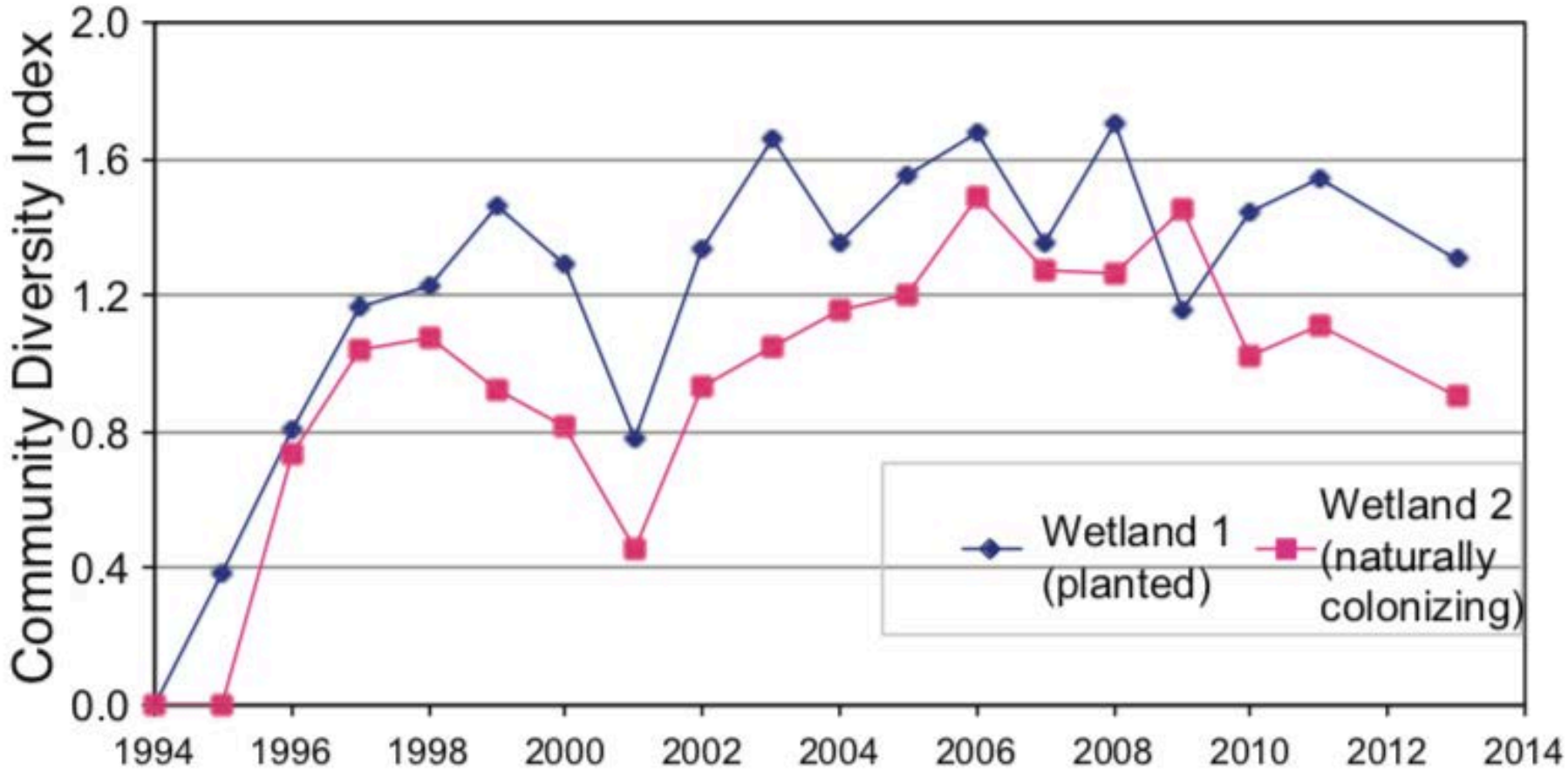
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2013
N
0 25 50
meters


Schoenoplectus tabernaemontani
Typha spp.
Scirpus fluviatilis
Nelumbo lutea
Sparganium eurycarpum
Leersia oryzoides/Polygonum spp.
Polygonum spp.
Ludwigia spp.
Phragmites australis
Spartina pectinata
Algal mat
Open water/submersed aquatic
Edge vegetation
Board walk

Mitsch et al. Ecological Engineering 72 (2014) 11–24



Community diversity index (CDI) of vegetation in the planted and naturally colonizing experimental wetlands, 1994–2013

Employing ecosystem models and geographic information systems (GIS) to investigate the response of changing marsh edge on historical biomass of estuarine nekton in Barataria Bay, Louisiana, USA

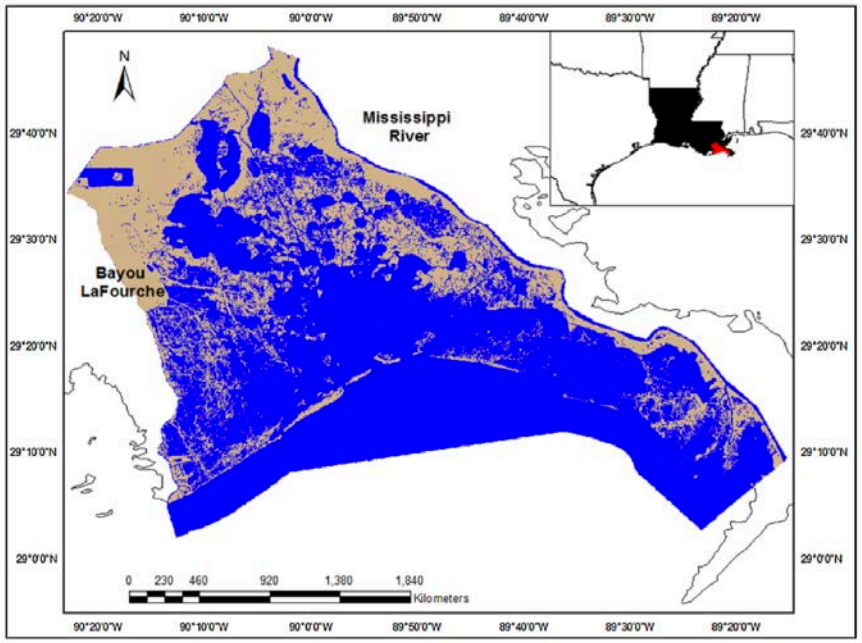


Fig. 2. Barataria Bay, LA, USA, bordered on the east by the Mississippi River and on the west by Bayou LaFourche (Couvillion et al., 2011).

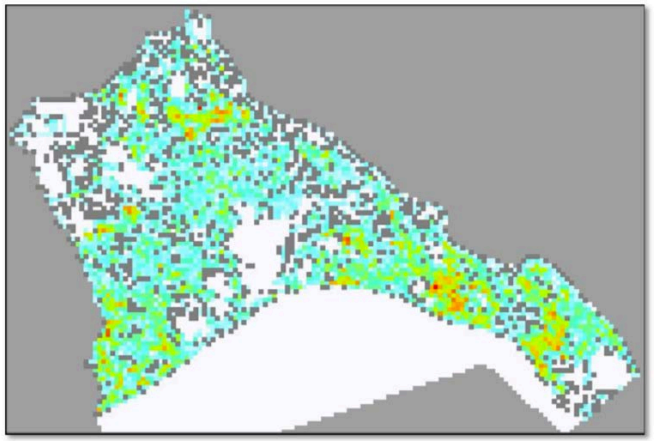


Fig. 5. Marsh edge Ecospace initialization map. Warm colors indicate higher values of marsh edge in the cell. Gray cells indicate inactive (land) cells. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

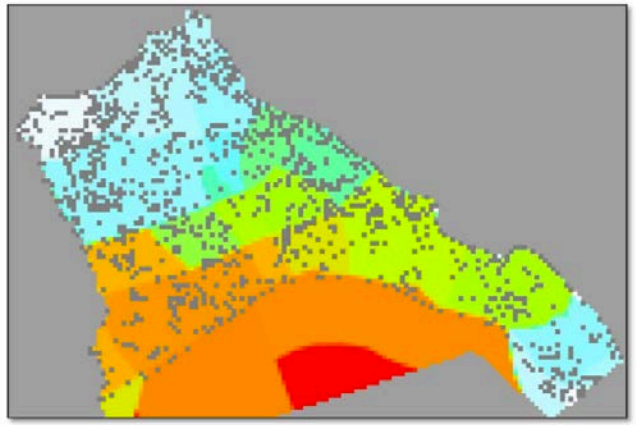


Fig. 6. Salinity Ecospace initialization map. Warm colors indicate higher values of salinity in the cell. Gray cells indicate inactive (land) cells. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

OBJECTIVE

- to determine macrophyte communities during dry and wet seasons
- to investigate distributions from macrophyte communities during hydro-periods
- to understand hydrologic process for stormwater treatment wetlands in the subtropics

HYPOTHESES

- Community diversity index of the macrophyte communities may be different between dry and wet seasons for stormwater treatment wetlands;
- if the hydrology plays a key role for dynamics of the vegetation communities for stormwater treatment wetlands in subtropics

MATERIALS AND METHODS

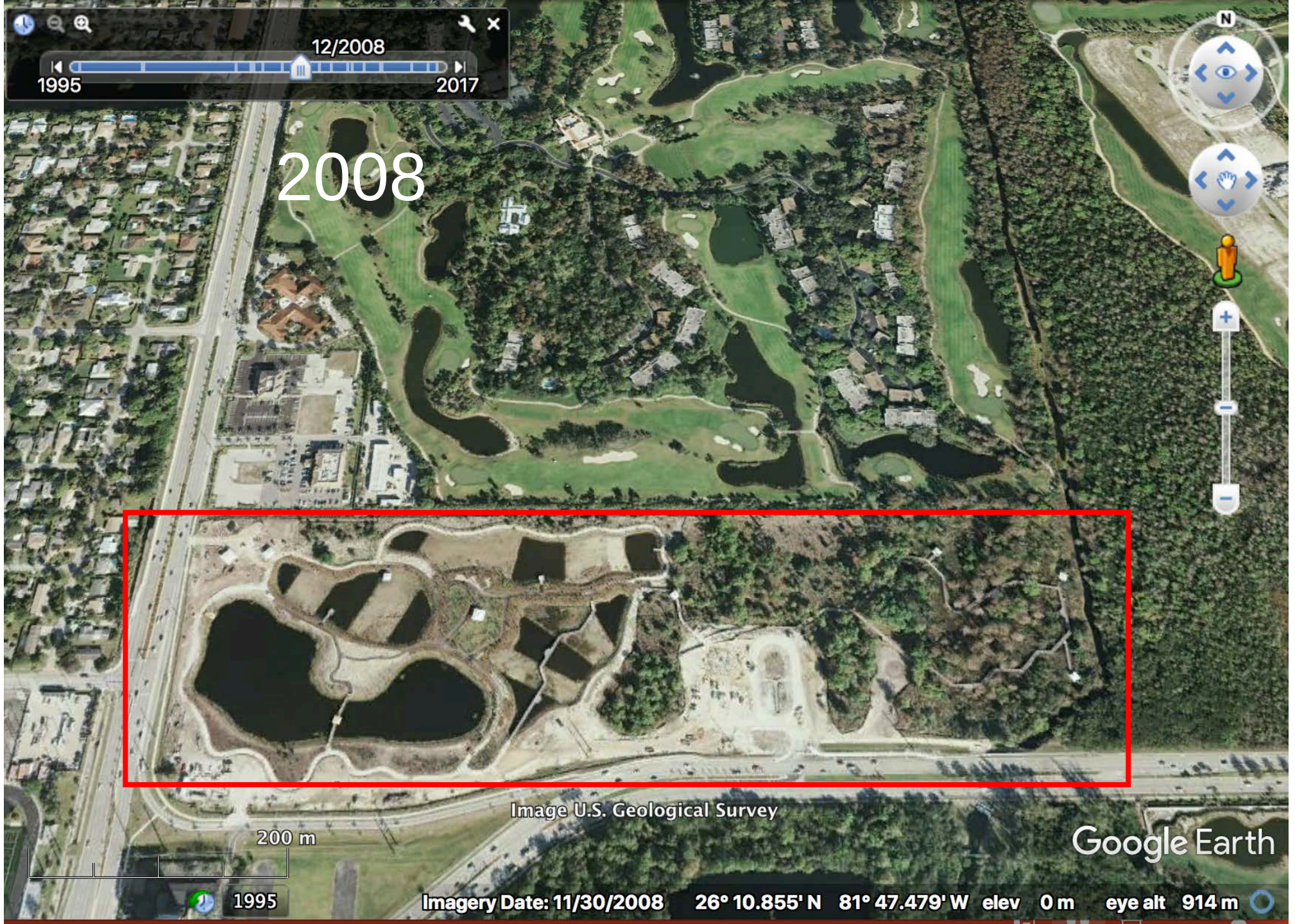
Study Site


CANADA
Edmonton
Vancouver
Regina
Winnipeg
Québec
Seattle
Olympia
Washington
Montana
Helena
North Dakota
Bismarck
Minnesota
Ottawa
Montréal
Maine
Augusta
Salem
Oregon
Idaho
Boise
South Dakota
Pierre
St. Paul
Wisconsin
Michigan
Toronto
Montpelier
Vt.
N.H.
Concord
Albany
Boston
New York
Mass.
Providence
Wyoming
Madison
Lansing
Hartford
R.I.
Conn.
Detroit
Pennsylvania
New York
Iowa
Chicago
Philadelphia
Trenton
New Jersey
Cheyenne
Nebraska
Harrisburg
Dover
Sacramento
Carson City
Salt Lake City
Des Moines
Ohio
Md.
Delaware
Lincoln
Illinois
Indiana
Columbus
West Virginia
Annapolis
Washington, D.C.
San Francisco
Nevada
Utah
Denver
Springfield
Indianapolis
Richmond
Topeka
St. Louis
Charleston
California
Colorado
Jefferson City
Frankfort
Virginia
Las Vegas
Kansas
Missouri
Kentucky
Raleigh
Nashville
North Carolina
Los Angeles
Arizona
Santa Fe
Oklahoma
Tennessee
Memphis
Columbia
North Pacific Ocean
Oklahoma City
Arkansas
Atlanta
South Carolina
Phoenix
New Mexico
Little Rock
Mexicali
Mississippi
Georgia
Dallas
Montgomery
Jackson
Louisiana
Alabama
Texas
Tallahassee
Baton Rouge
Austin
New Orleans
Houston
Florida
Hermosillo
Chihuahua
MEXICO
Gulf of Mexico
Miami
THE BAHAMAS
Nassau
Monterrey
★ National capital
U.S. State
State capital
Scale 1:13,500,000
Albers Equal-Area Projection
0
500 Kilometers
0
500 Miles

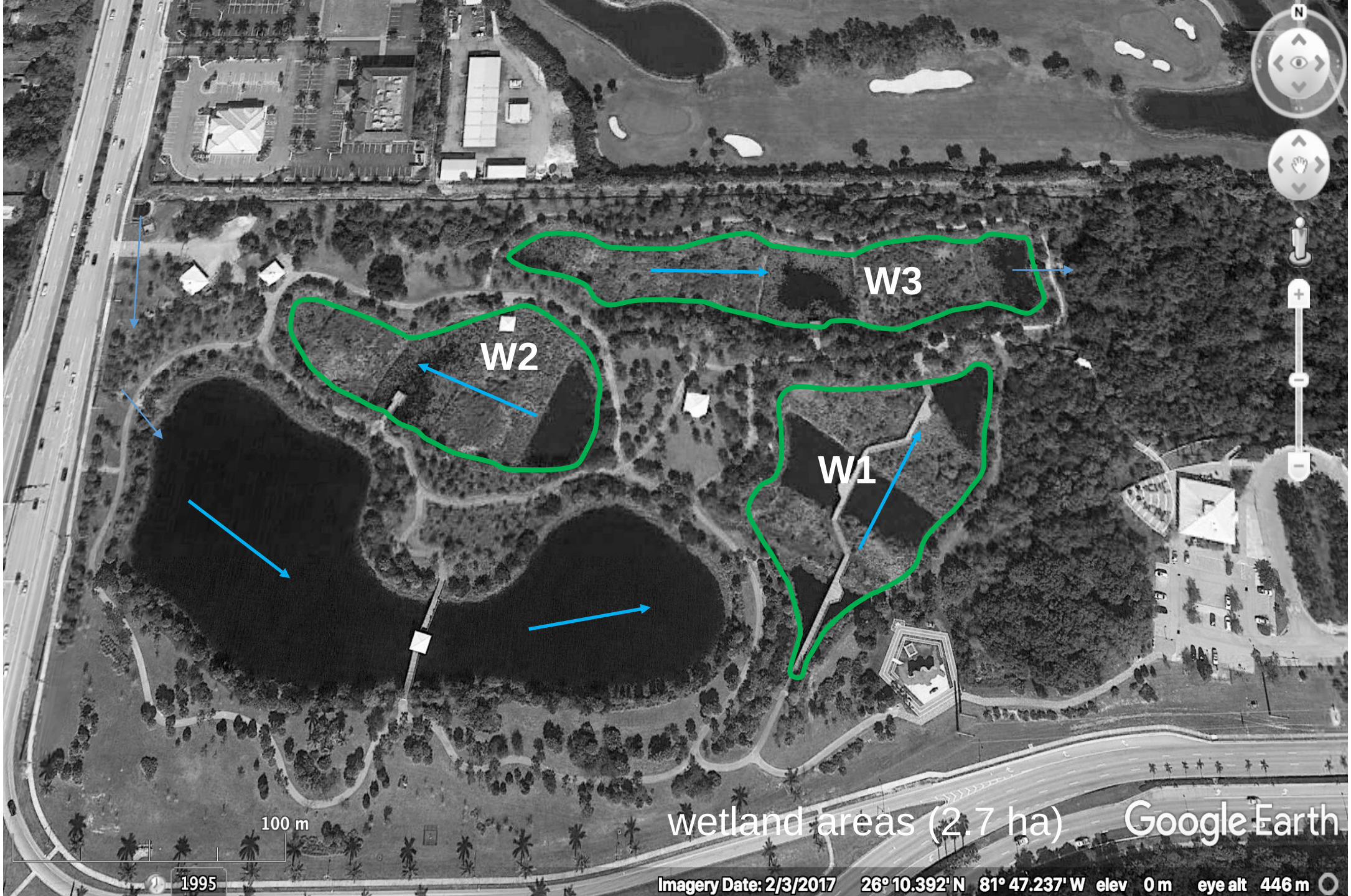

1/1995
1995
N
Image U.S. Geological Survey
200 m
1995
Google Earth
Imagery Date: 1/26/1995 26° 10.666' N 81° 47.517' W elev 0 m eye alt 914 m


11/2005
2005
Image U.S. Geological Survey
200 m
1995
Google Earth
Imagery Date: 10/31/2005 26° 10.472' N 81° 47.340' W elev 0 m eye alt 914 m


11/2007
2007
Image USDA Farm Service Agency
200 m
Google Earth


12/2008
1995
2017
2008
Image U.S. Geological Survey
200 m
Google Earth
1995
Imagery Date: 11/30/2008 26° 10.855' N 81° 47.479' W elev 0 m eye alt 914 m


4/2010
2010
200 m
1995
Google Earth
Imagery Date: 4/1/2010 26° 10.628' N 81° 47.386' W elev 0 m eye alt 914 m


W3
W2
W1
100 m
1995
wetland areas (2.7 ha)
Google Earth
Imagery Date: 2/3/2017 26° 10.392' N 81° 47.237' W elev 0 m eye alt 446 m


dry season (aerial photo in March 2017)


wet season (aerial photo in Oct 2017)

Planted

Scientific Name	Common Name
Cladium jamaicense	Saw-grass
Eleocharis cellulosa	Spikerush
Juncus effusus	Softrush
Nuphar lutea	Spatterdock
Nymphaea odorata	White water-lily
Peltandra virginica	Arrow-arum
Pontederia cordata	Pickcrel weed
Sagittarria lancifolia	Duck potato
Thalia geniculata	Fireflag

METHODS

- Defining plant communities by the aerial photos and ArcGIS 10.4
- Defining community diversity index by (Mitsch et al., 2012): *CDI*

$$CDI = -\sum_{i=1}^{n} p_i ln p_i$$

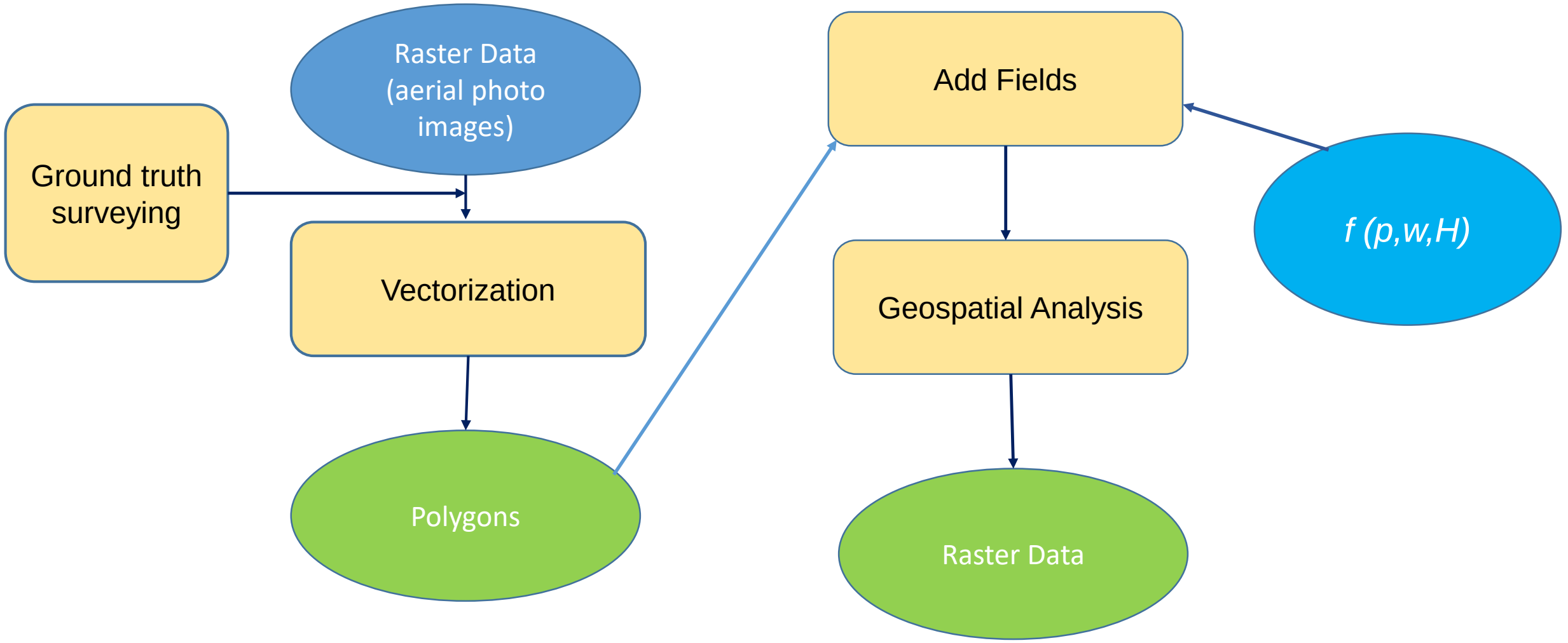
where *n*: total number of plant community;

p_i: proportion of n made up of the *i*th dominant community

- Modelling potential diversity index by geostatistical analysis

P(*x,y,z*) = *f* (p, w, *CDI*)

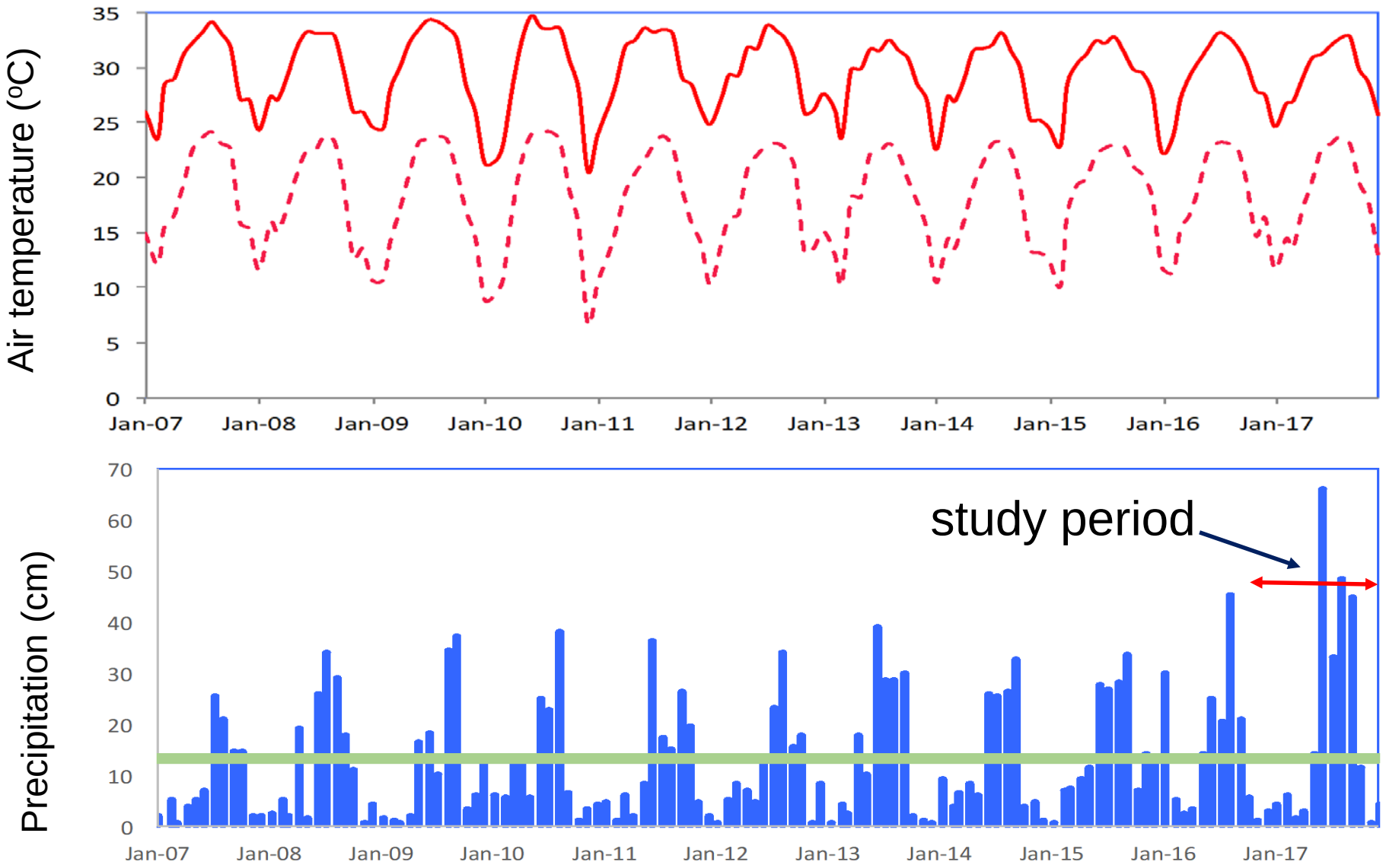
where *p: position (x, y, z)*; w: water level (cm); *CDI*: community diversity index

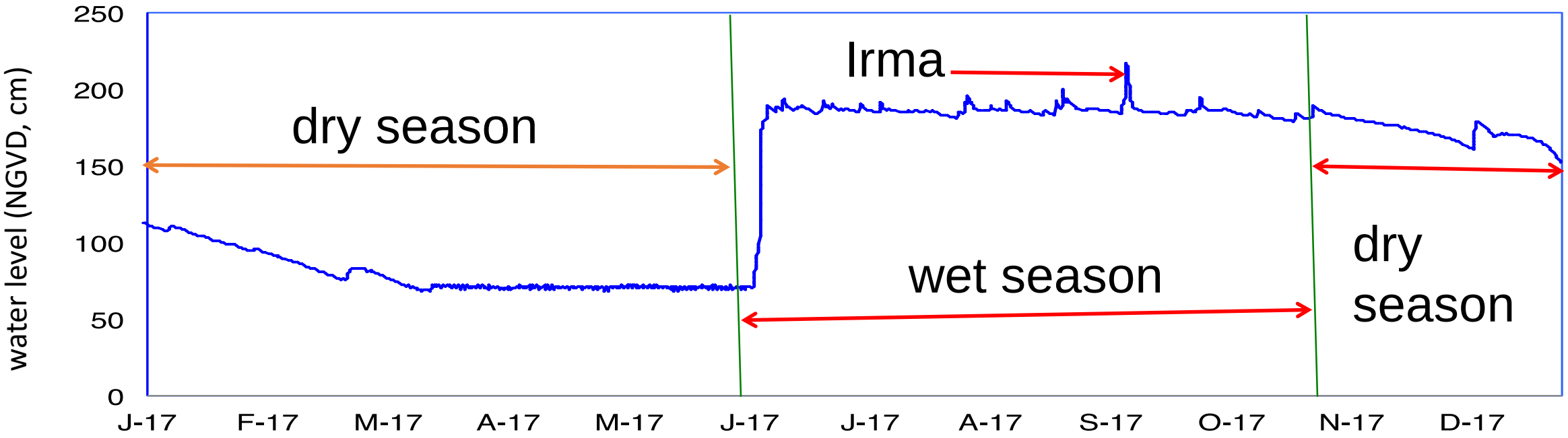


spatial modelling process for *CDI* and potential *CDI*

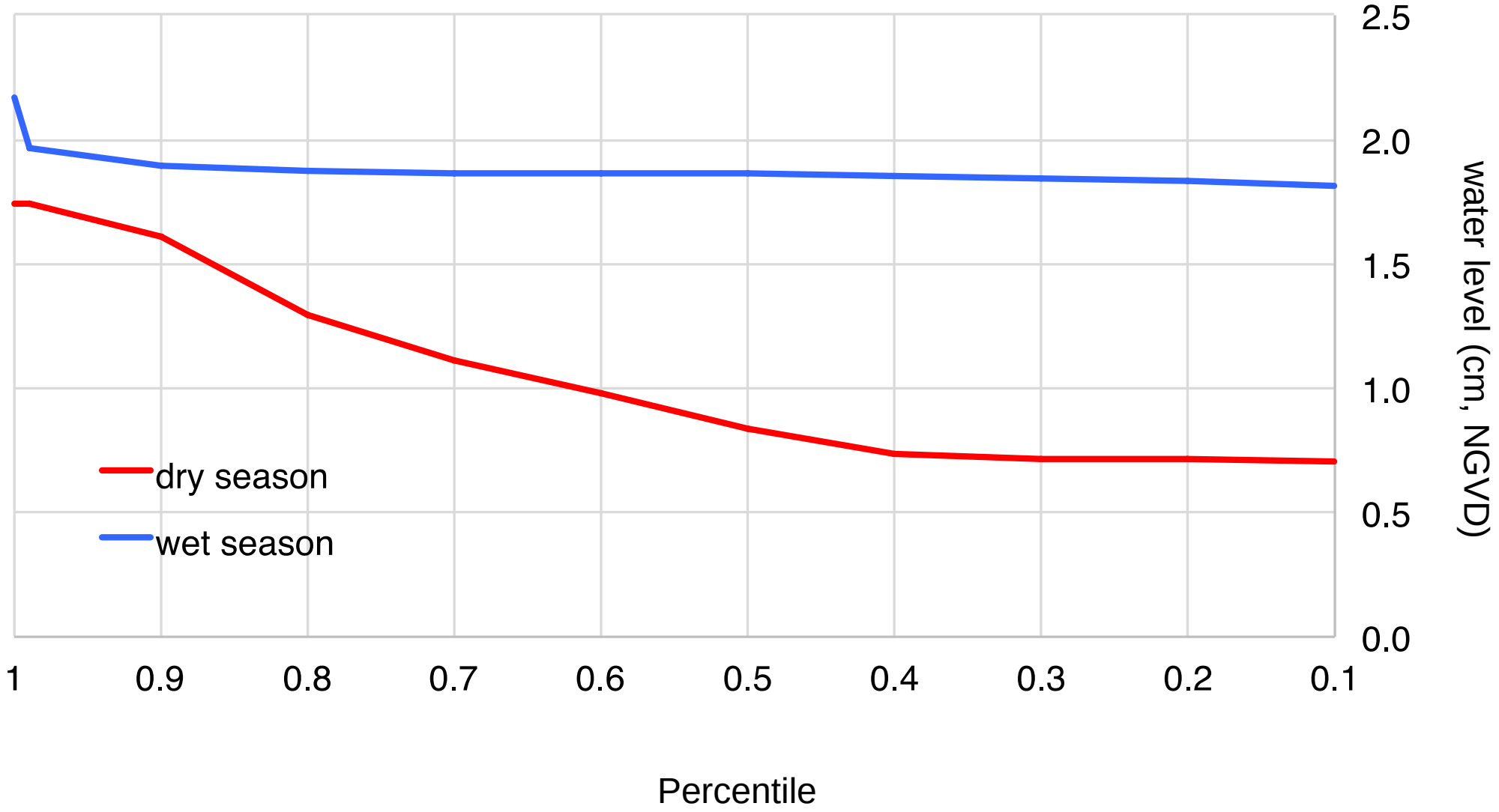
RESULTS

Monthly air temperature (ºC, Max. Min.) and monthly precipitation (cm) and during 2007 -2017





water level (1-hr interval, NGVD cm) reading in 2017 at the outflow from wetland real-time monitoring station in Freedom park



water level exceedance curves during the dry and wet seasons at the outflow of wetland 3

percent coverage of plant communities in the three treatment wetlands (W1, W2, W3) at Freedom Park for a) dry season (March 2017) and b) wet season (October 20, 2017)

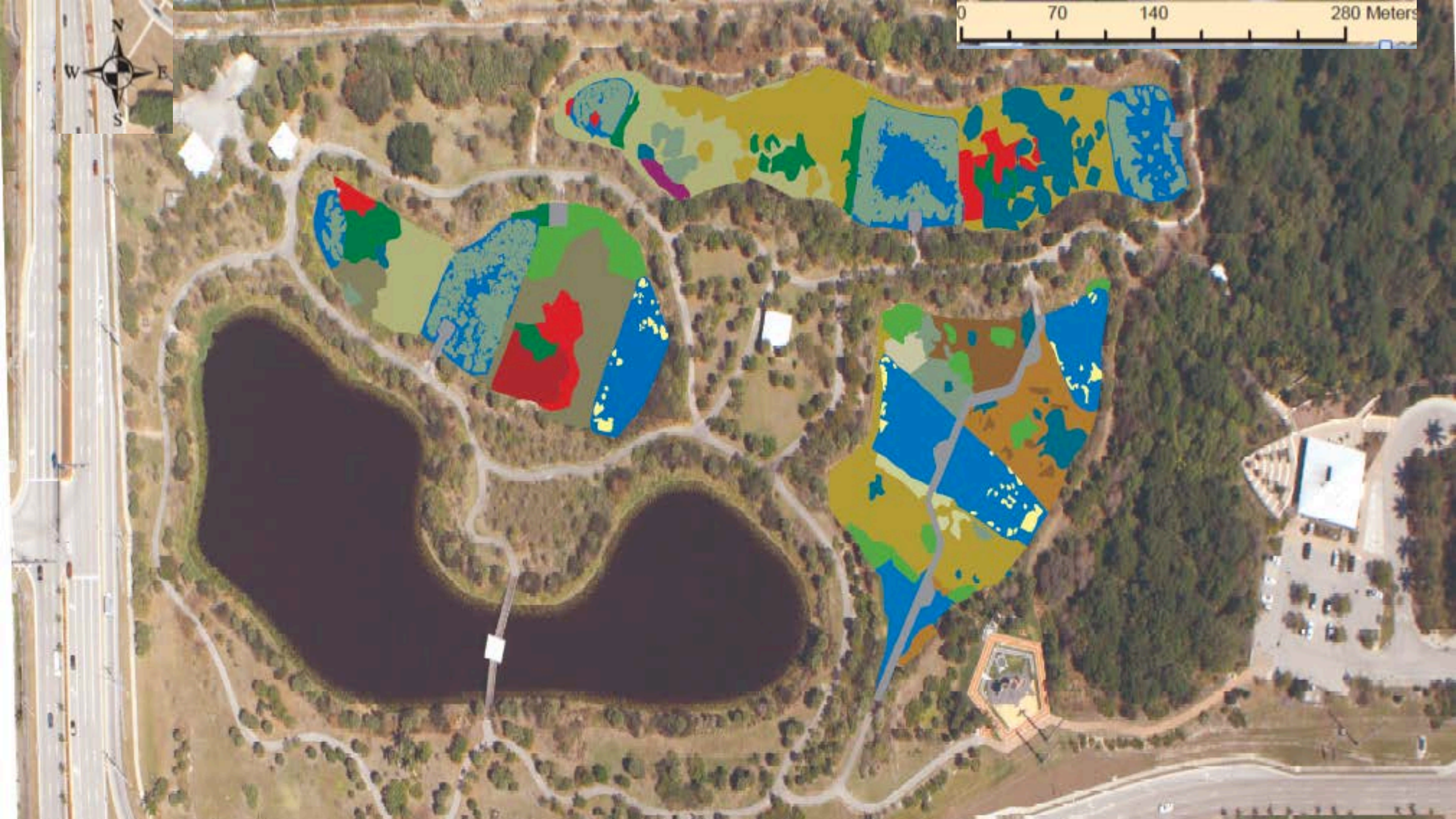
a)

Scientific Name	Common Name	W1	W2	W3
		% of coverage		
Cladium jamaicense	sawgrass	3.0	7.3	3.8
Eleocharis cellulosa	spikerush	1.7		
Mikania scandens	Climbing hempvine		22.9	
Mikania scandens/Eleocharis cellulosa	Climbing hempvine/spikerush	19.7		31.3
Mikania scandens/Pontederia cordata	Climbing hempvine/Pickerel weed		10.7	29.8
Nuphar lutea	Spatterdock	2.0	1.2	
Nymphaea odorata	White water-lily		13.8	11.4
Pontederia cordata	Pickcrel weed			0.7
Thalia geniculata	Fireflag	5.4	8.8	
Thalia geniculata /Mikania scandens	Fireflag/Climbing hempvine	4.4	0.5	1.5
Thalia geniculata /*Pontederia cordata*	Fireflag/Pickerel weed	2.3		
Typha spp.	Typha spp.		7.0	2.8
Dead *Typha* spp.	Dead Typha spp.		6.6	
Panicum repens	Torpedo grass	14.5		
Mikania scandens/Panicum repens	Climbing hempvine/Torpedo grass	9.1		
Salix caroliniana	Carolina willow	4.9	0.5	8.4
% of open water		33.0	20.7	10.2
% of total vegatation		67.0	79.3	89.8

b)

Scientific Name	Common Name	W1	W2	W3
		% of coverage		
Cladium jamaicense	sawgrass	3.4	7.7	4.5
Eleocharis cellulosa	spikerush	2.5	5.0	0.9
Eleocharis cellulosa/Pontederia cordata	spikerush/Pickerel weed			5.5
Eleocharis cellulosa/Thalia geniculata/Pontederia cordata	spikerush/Fireflag/Pickcrel weed			2.3
Ludwigia repens/Panicum repens	Red Ludwigia /Torpedo grasses	0.9		
Mikania scandens	Climbing hempvine	0.3	0.5	
Mikania scandens/Eleocharis cellulosa/Polygonum hydropiperoides	Climbing hempvine/spikerush /Wild water-pepper		2.4	
Mikania scandens/Pontederia cordata	Climbing hempvine/Pickerel weed	5.3		
Mikania scandens/Sagittarria lancifolia	Climbing hempvine/Duck potato			1.4
Mikania scandens/Sagittarria lancifolia/Polygonum	Climbing hempvine/Duck potato/Wild water-pepper		6.0	
Nuphar lutea	Spatterdock	0.4	3.3	3.0
Nymphaea odorata	White water-lily		8.1	7.1
Polygonum hydropiperoides	Wild water-pepper	0.3		
Polygonum hydropiperoides/Sagittarria lancifolia/Juncus effusus	Wild water-pepper/Duck potato/Softrush			6.3
Polygonum hydropiperoides/Sagittarria lancifolia/Ludwigia repens/Juncus effusus	Wild water-pepper/Duck potato/Red Ludwigia/Softrush			10.5
Pontederia cordata	Pickcrel weed	2.9		
Pontederia cordata/Panicum repens	Pickcrel weed/Torpedo grasses	14.3		
Sagittarria lancifolia/Juncus effusus	Duck potato/Softrush			3.4
Scirpus americanus	Bulrush	1.6		
Thalia geniculata	Fireflag	5.2	22.6	1.6
Thalia geniculata /Mikania scandens	Fireflag/climbing hempvine	3.4		
Thalia geniculata /*Pontederia cordata/Mikania scandens*	Fireflag/Pickerel weed/climbing hempvine	2.5		
Thalia geniculata/Panicum repens	Fireflag/Torpedo grasses	3.6		
Typha spp.	Typha spp.		9.7	1.3
Dead *Typha* spp.	Dead Typha spp.		0.5	
Panicum repens	Torpedo grass	2.0	1.2	0.3
Panicum repens/Nuphar lutea/Pontederia cordata	Torpedo grass/Spatterdock/Pickcrel	0.6		
Mikania scandens/Panicum repens	Climbing hempvine/Torpedo grass	1.7		2.6
Salix caroliniana	Carolina willow	9.1	0.8	20.0
Taxodium ascendens	pond Cypress	0.7		
% of open water		39.5	32.3	29.5
% of total vegatation		60.5	67.7	70.5

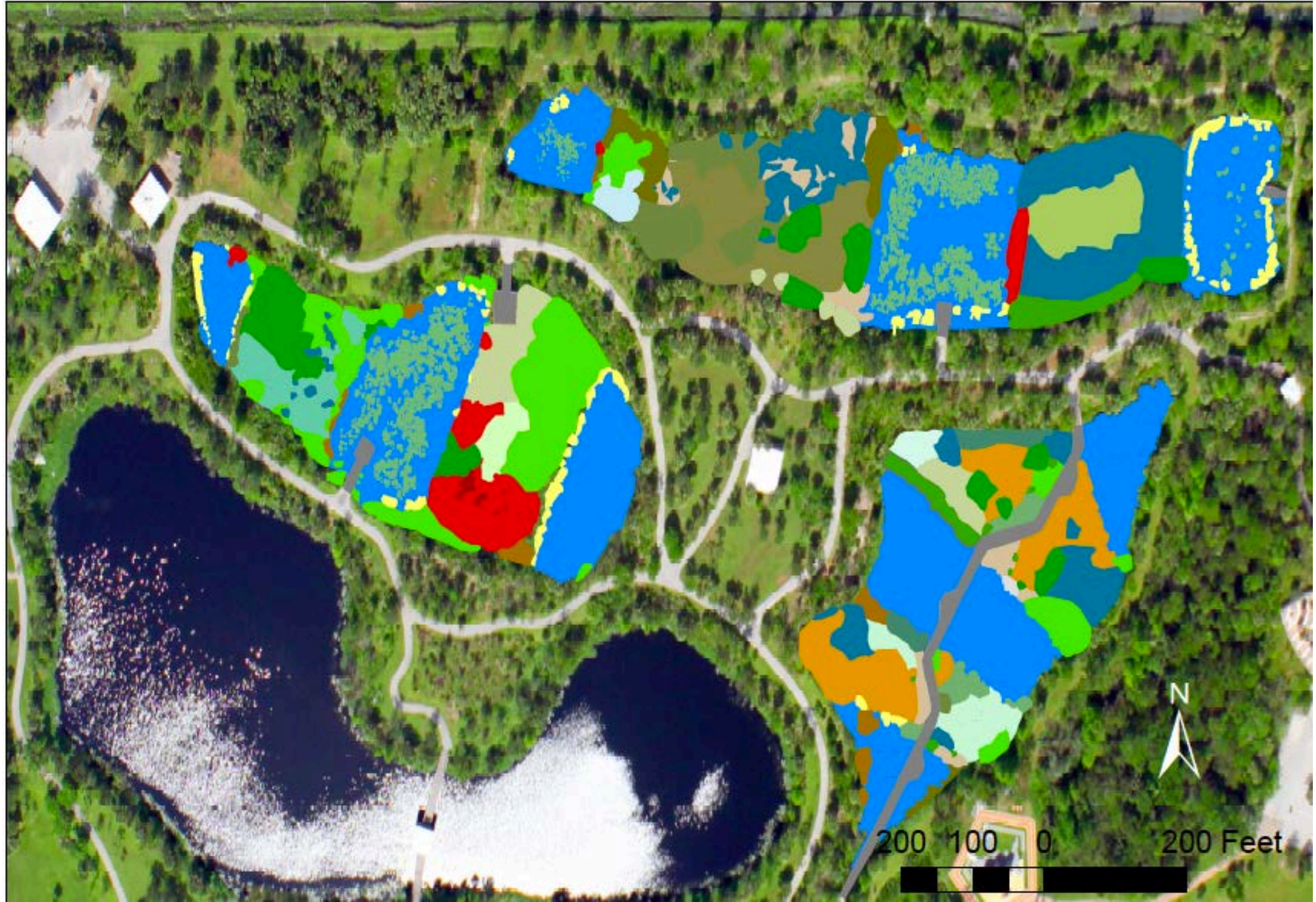
* 17 plant communities for dry season and 29 plant communities for wet season


N
W
E
S
0
70
140
280 Meters

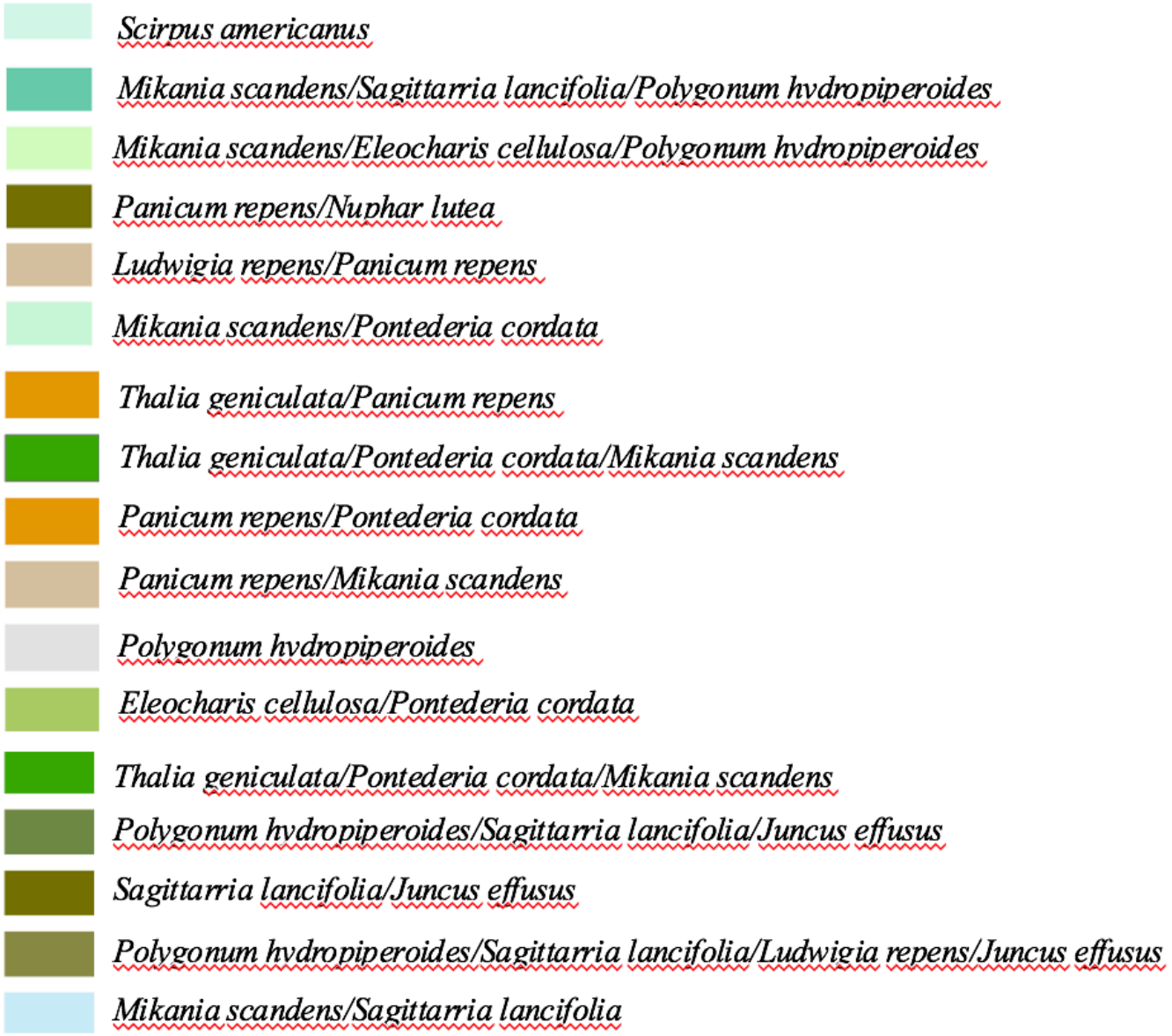
LEGEND


Thalia geniculata
Cladium jamaicense
Thalia geniculata/Mikania scandens
Mikania scandens
Mikania scandens/Eleocharis cellulosa
Mikania scandens/Pontederia cordata
Pontederia cordata
Typha spp.
Dead *Typha spp.*


Eleocharis cellulosa
Thalia geniculata/Pontederia cordata
Nymphaea odorata
Nuphar lutea
Panicum repens
Panicum repens/Mikania scandens
Salix caroliniana
Taxodium ascendens
Open water
Boardwalk

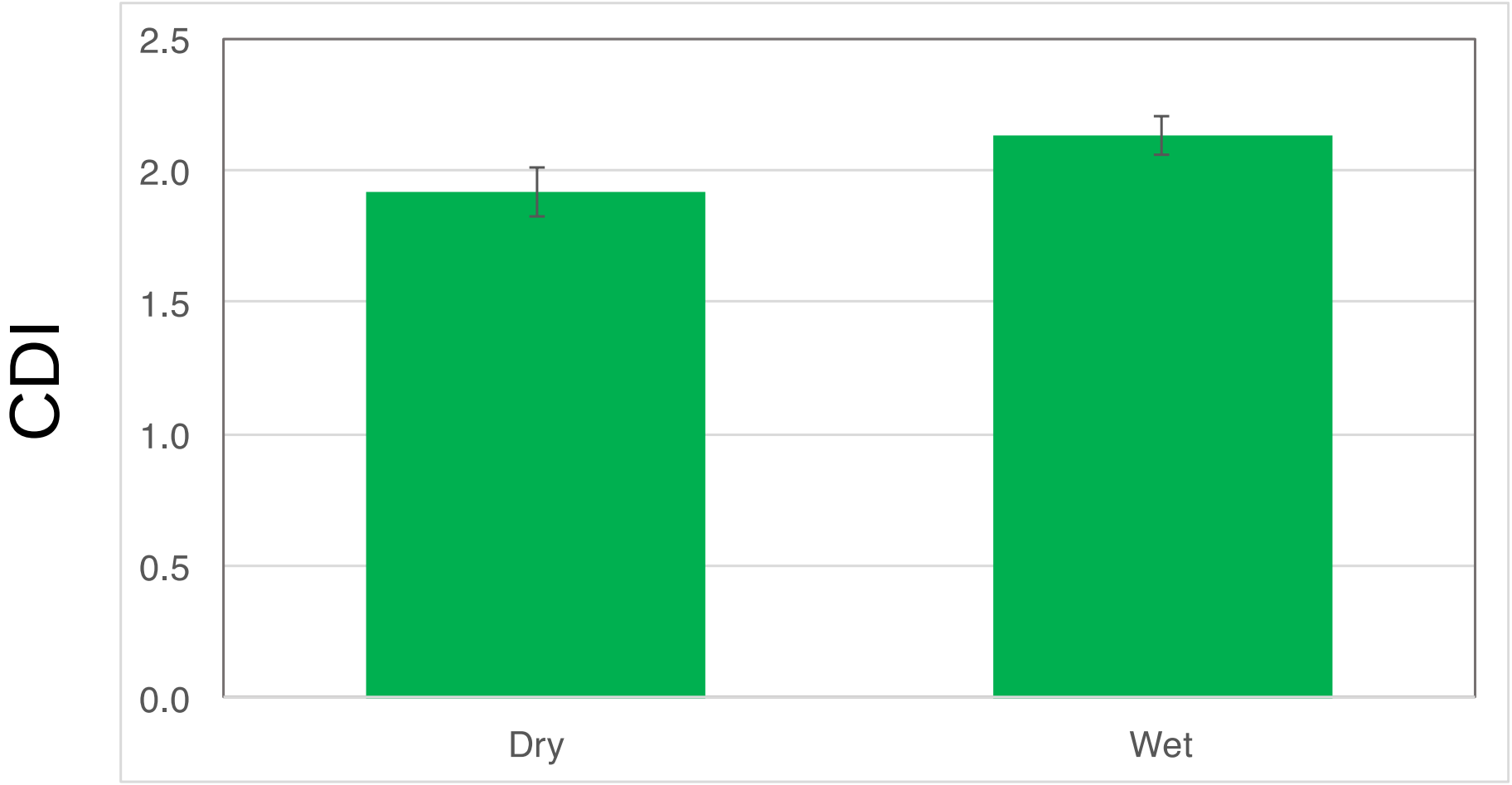

N
200 100 0 200 Feet

LEGEND

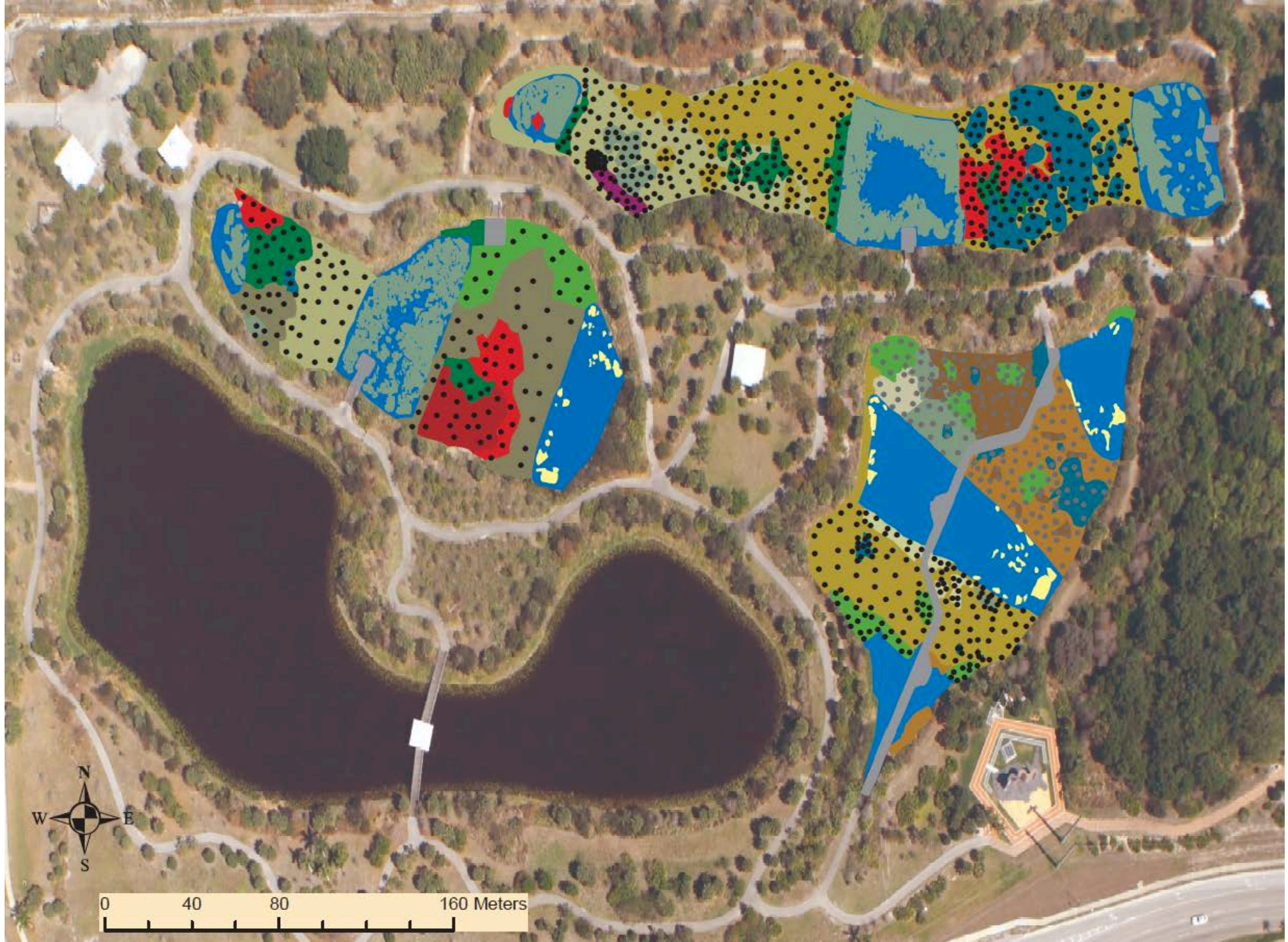

Scirpus americanus
Mikania scandens/Sagittarria lancifolia/Polygonum hydropiperoides
Mikania scandens/Eleocharis cellulosa/Polygonum hydropiperoides
Panicum repens/Nuphar lutea
Ludwigia repens/Panicum repens
Mikania scandens/Pontederia cordata
Thalia geniculata/Panicum repens
Thalia geniculata/Pontederia cordata/Mikania scandens
Panicum repens/Pontederia cordata
Panicum repens/Mikania scandens
Polygonum hydropiperoides
Eleocharis cellulosa/Pontederia cordata
Thalia geniculata/Pontederia cordata/Mikania scandens
Polygonum hydropiperoides/Sagittarria lancifolia/Juncus effusus
Sagittarria lancifolia/Juncus effusus
Polygonum hydropiperoides/Sagittarria lancifolia/Ludwigia repens/Juncus effusus
Mikania scandens/Sagittarria lancifolia

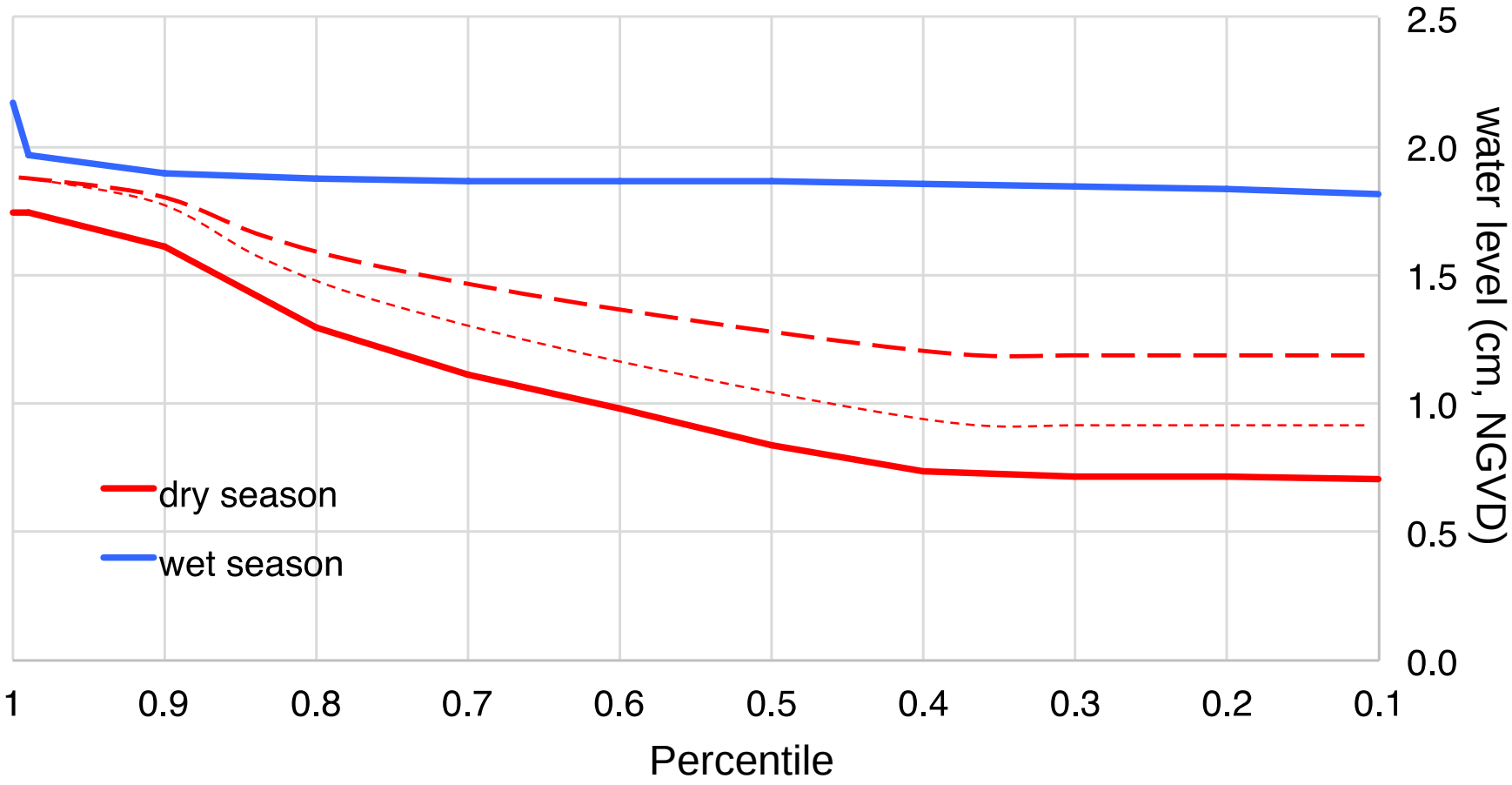
CDI in three stormwater treatment wetlands (W1, W2, W3) at Freedom Park for dry season (March 2017) and wet season (October 20, 2017)

WETLAND	DRY	WET
W1	1.97	2.18
W2	2.05	1.99
W3	1.74	2.22

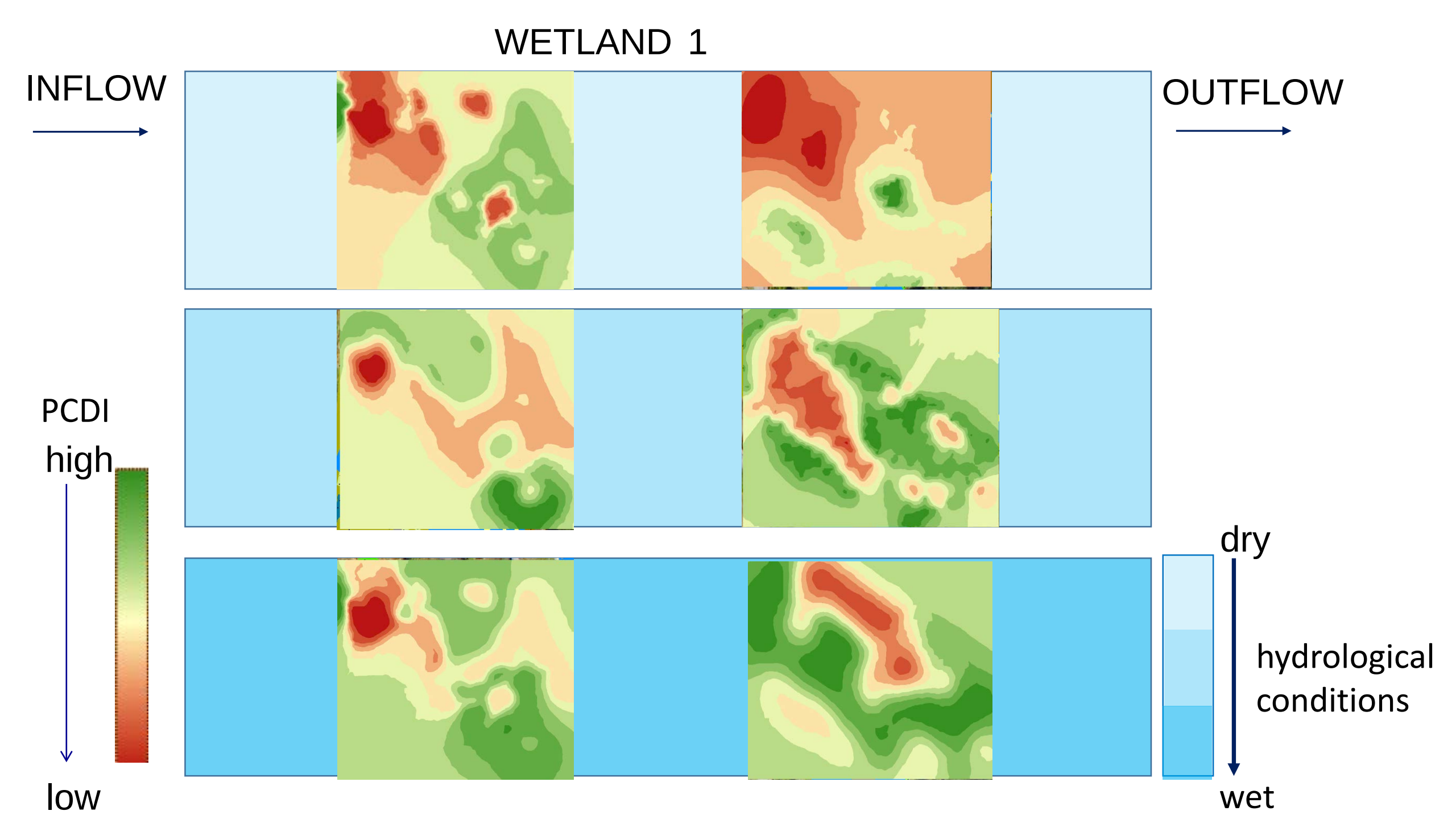


CDI for dry and wet seasons in the wetlands


N
W
E
S
0
40
80
160 Meters



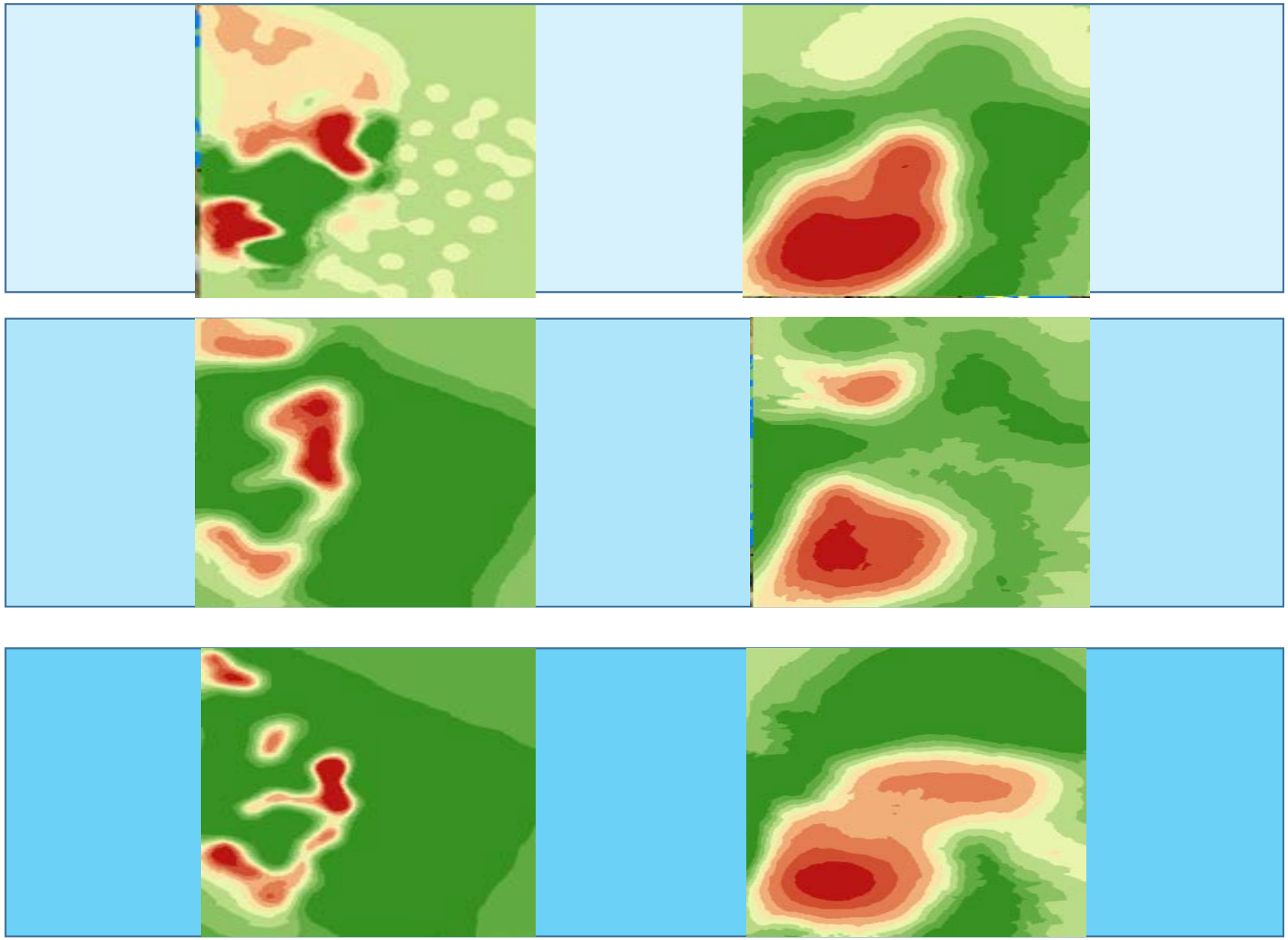
potential water level exceedance curves during the dry season at the outflow of wetland 3


WETLAND 1
INFLOW
OUTFLOW
PCDI
high
low
dry
hydrological
conditions
wet

WETLAND 2

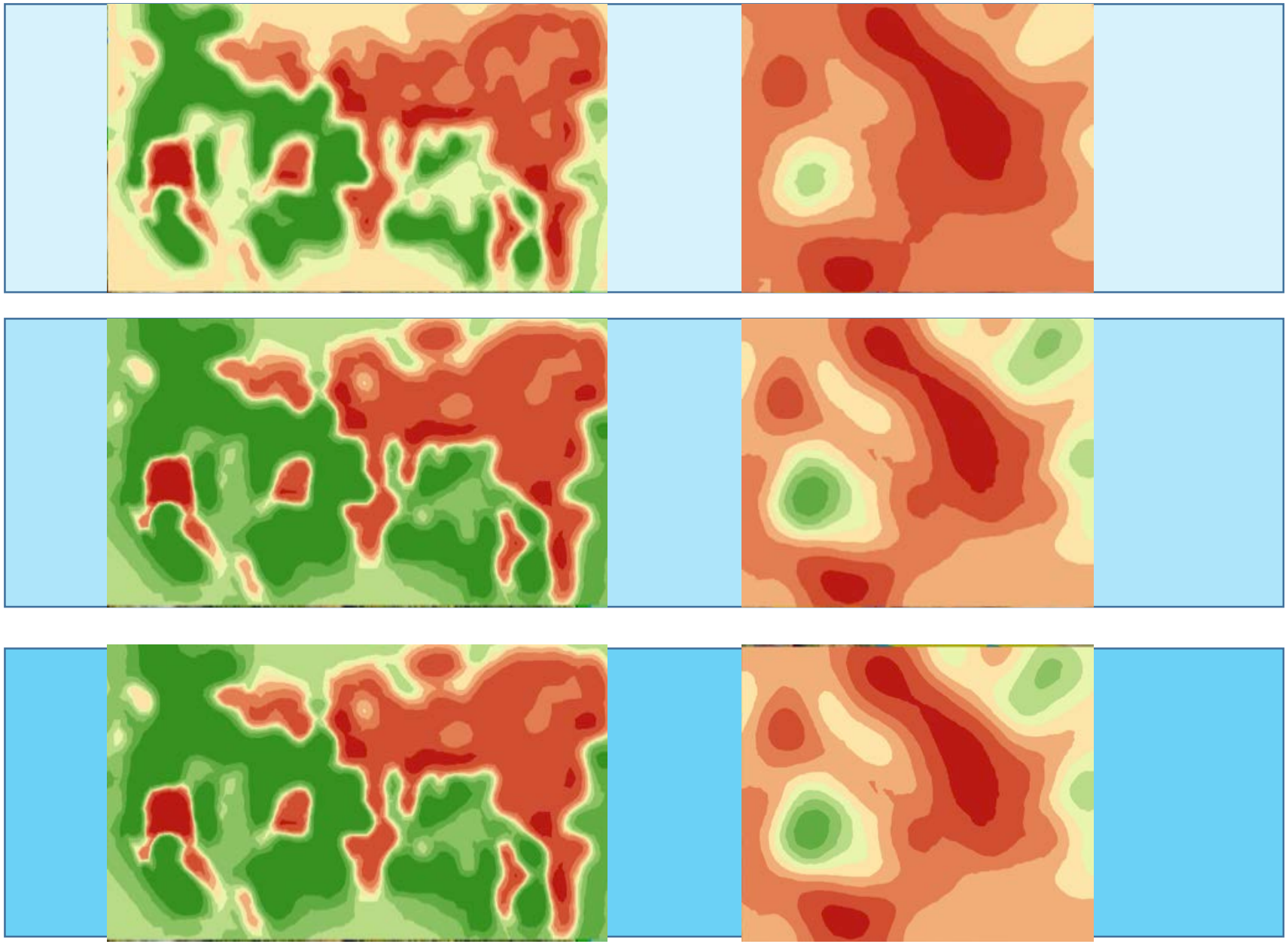
OUTFLOW

INFLOW

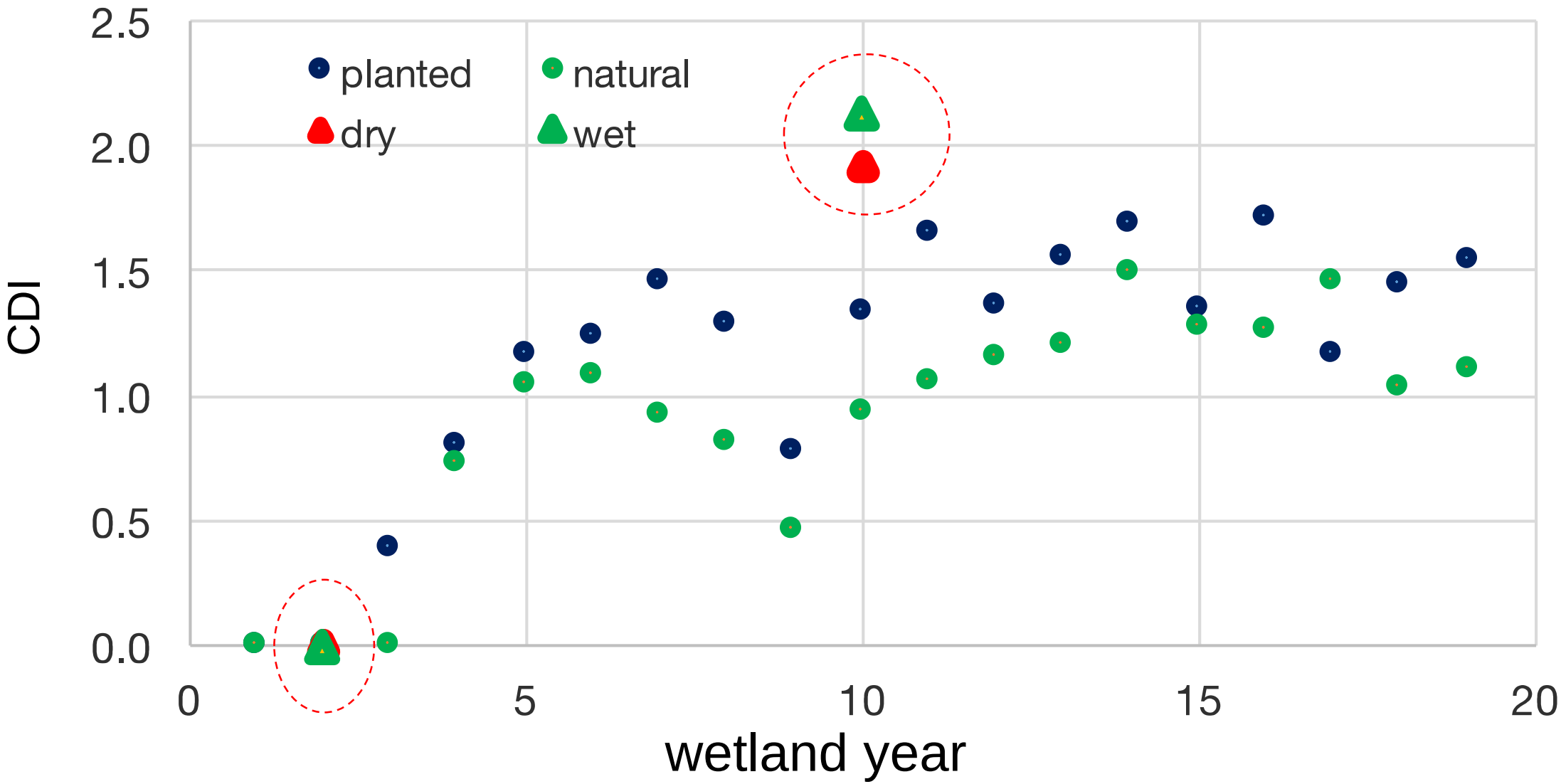


WETLAND 3

INFLOW



OUTFLOW


2.5
2.0
1.5
1.0
0.5
0.0
CDI
planted
natural
dry
wet
0
5
10
15
20
wetland year

CONCLUSIONS

- provide significantly seasonal patterns of macrophyte communities for understanding hydro-periods in subtropics
- become a reference for stormwater treatment wetlands which will benefit to the scientific, agency, and educational communities
- suggest to have a possibility to develop a long-term vegetation study for better understanding ecosystem dynamics and functions of stormwater treatment wetlands in subtropical Southwest Florida

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