Decadal Variation in Everglades Peat Soil at the Landscape Scale: Results of REMAP 1995-2014

Greater Everglades Ecosystem Restoration (GEER) 2015

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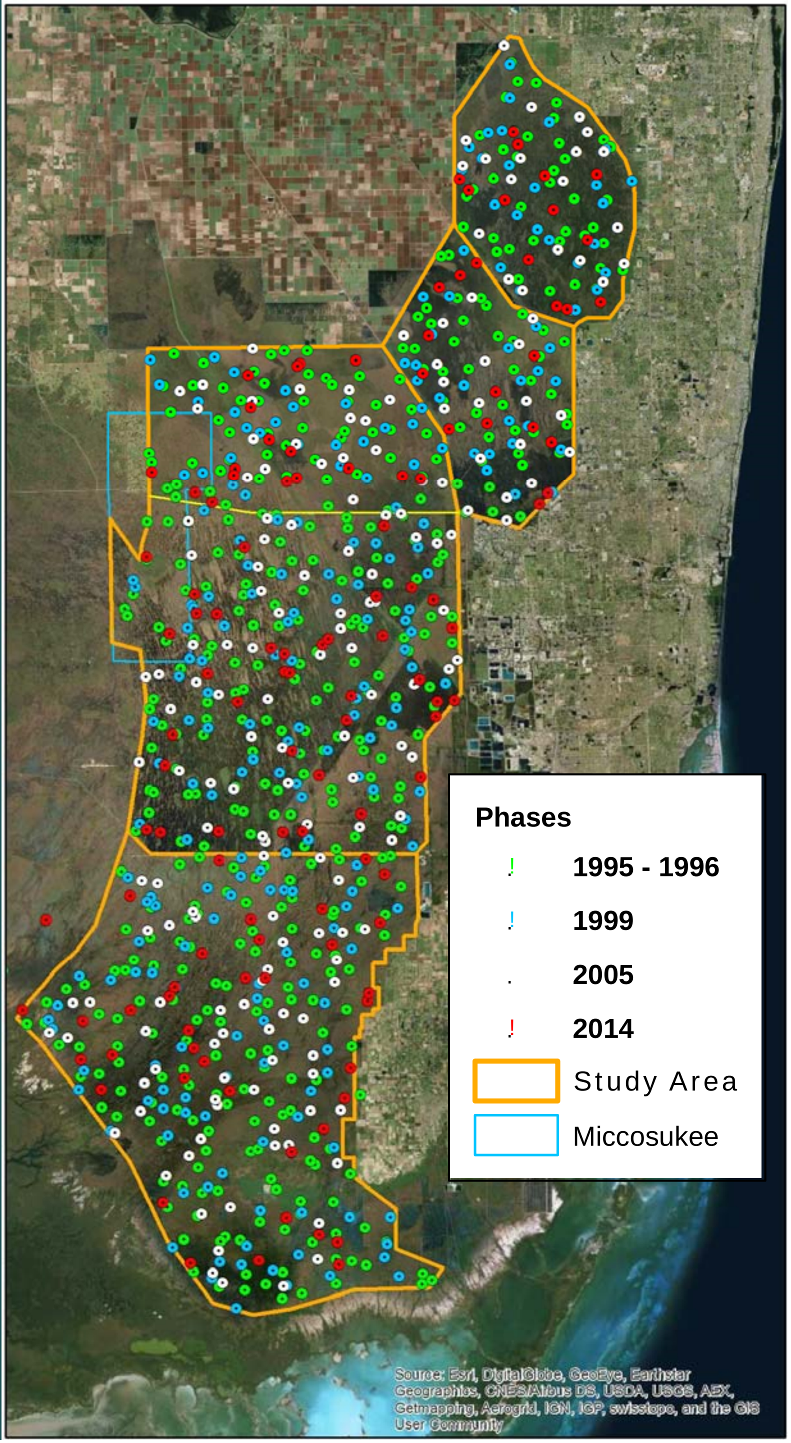
Scientific Approach: REMAP

Regional Environmental Monitoring & Assessment Program

- Random Sampling approach: probability-based design; every point has an equal chance of being sampled.
- Description of the whole by sampling parts.
- Can estimate, with known confidence, the status of ecological resources across the landscape: ie, as of 2005, 25.1 +/- 2.0% of the EPA had soil thickness < 1 foot (Scheidt and Kalla, 2007).
- sampled ~1000 locations from the 1990s to present



Everglades REMAP
Marsh Sampling Events

Soil, Surface Water, Periphyton, Pore Water, Mosquitofish
Performed Macrophyte and Aquatic Food Web Analyses

>100,000 Biogeochemical Analyses

	1995	1996	1999	2005	2013	*2014*	TOTAL
Dry Season	April	May	May	May			
Number of stations*	*102*	*105*	*114*	*109*	-	-	*430*
Wet Season	Sept	Sept	Sept	Nov	Sept	Sept	
Number of stations	*106*	*102*	*112*	*119*	*51*	*119*	*609*
Phase	I		II	III	IV		
Number of stations	*208*	*207*	*226*	*228*	*51*	*119*	*1039*
Big Cypress		55					
*based on soil thickness data							

2014 Sampling Partners

85 people

- EPA Region 4 SESD (30 people)
- EPA Region 4 WPD (6)
- EPA Region 4 OPM (1)
- EPA ORD (2)
- EPA Contractors: ILS / Alion, Inc. (ESAT) (9)
- FIU (18)
- ENP (10)
- NPS (4)
- FWS (2)
- HMC Helicopters, Inc. (3)

Soil Parameters

- Field: measure thickness, pH, redox potential
- Collect 3 cores per site
- Photodocumentation
- Separate the benthic periphyton mat, floc, 0–10 cm soil profile.
- FIU labs determine TP, TN, TC, THg, MeHg, % Organic Matter, Bulk Density, Mineral Content, CH_4, CO_2

Soil Thickness Method

- Insert a metal probe through the soil profile to point of refusal. Measure to 0.05 inches

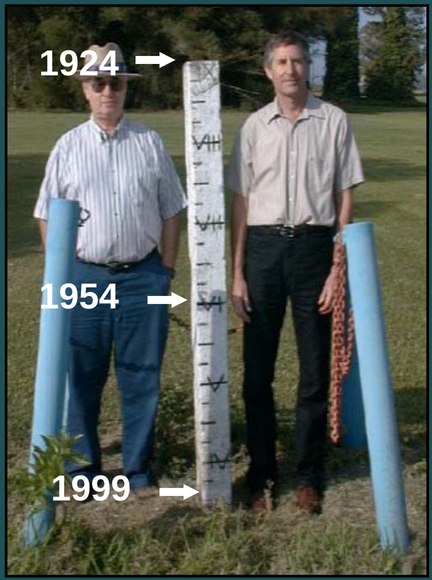
Soil core collection in sawgrass

Everglades Soils

- Peat
  - Derived from decaying plant matter with inundation
  - Forms at ~ 1 inch/100 years
  - Largest expanse of peat soil in the world (Stephens 1956)
- Marl- calcitic mud in shorter hydroperiod portions of Everglades National Park
- Subsidence is the drop in ground surface due to: shrinkage from drying; biogeochemical oxidation; wind; fire; C loss to air as CO_2.
  - Depth of soil surface to water table critical
- Soils are vital to maintenance of wetland vegetation communities and wildlife habitat

Soil Subsidence in The Everglades

- EAA soils and subsidence have been often studied over the last century~ agricultural sustainability.
  - Harper 1910, Baldwin and Hawker 1915, Clayton et al 1942, Neller 1943, Davis, 1946, Jones, 1948, Stephens & Johnson 1951, Allison, 1956, Stephens and others 1950s–1980s, McCollum et al 1976, Forbes 1981, Volk & Schnitzer 1973, Shih and others 1970s – 1990s, Cox et al 1988, Gleason & Stone 1994, Snyder & Davidson 1994, Glaz 1995, Snyder 2005, Aich et al 2013.
  - EAA was established where soil was thickest ~ 17 feet.
  - First canals cut in 1906.
- Public Everglades ~ soil thickness, subsidence have been studied less
  - Davis, 1946, Jones 1948,
  - REMAP 1990s to present [Scheidt et al 2001; Scheidt and Kalla 2007],
  - SFWMD [McVoy et al 2011; Hohner and Dreschel 2015].



Drs. Snyder & Glaz, 1999

- EAA subsidence post- ~5 feet lost from 1924-1984 (1 in/yr).

122 FLORIDA GEOLOGICAL SURVEY—BULLETIN THIRTY

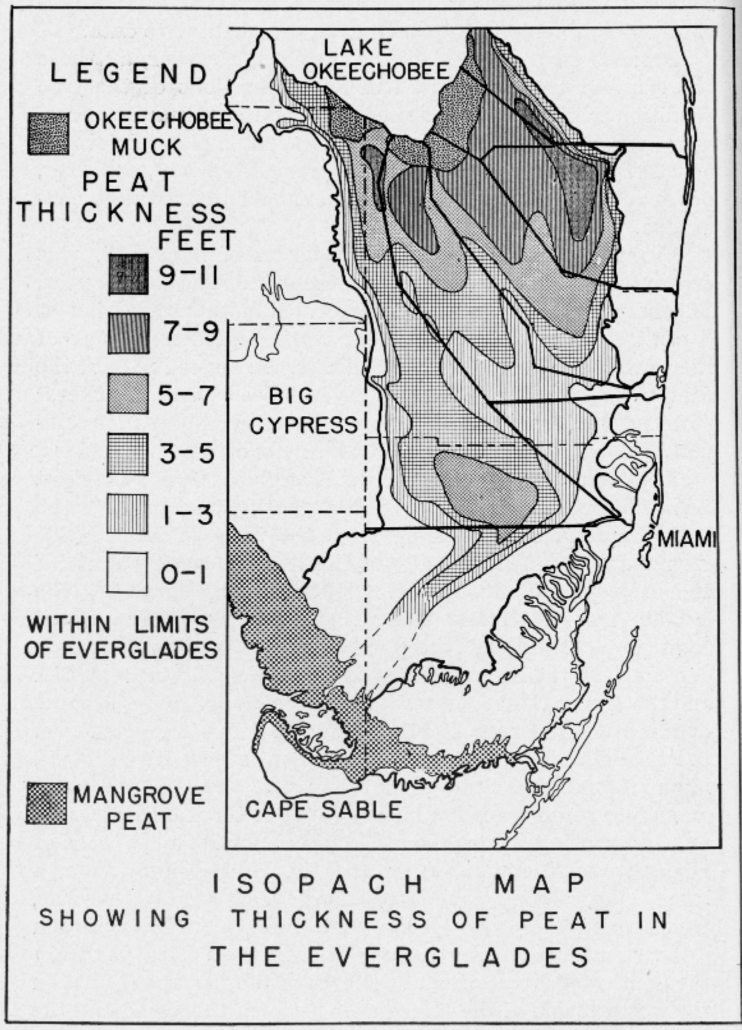


Figure 13.—Isopach map of the Everglades region showing thickness of peat and some muck areas.

John H. Davis, Jr., 1946
The Peat Deposits of Florida:
their Occurrence, Development, and Uses.
Florida Geological Survey, Bulletin No. 30

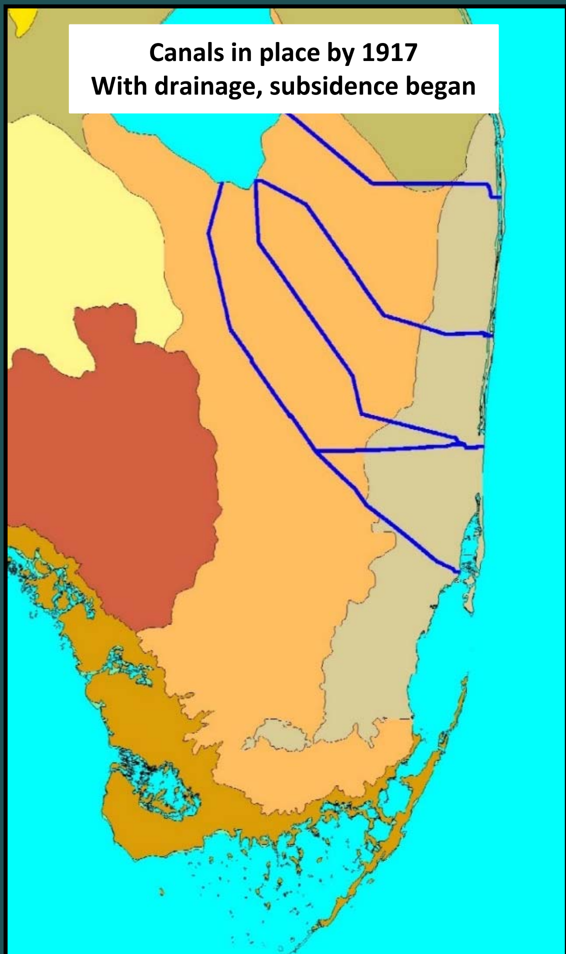
Peat Thickness ~ 1946

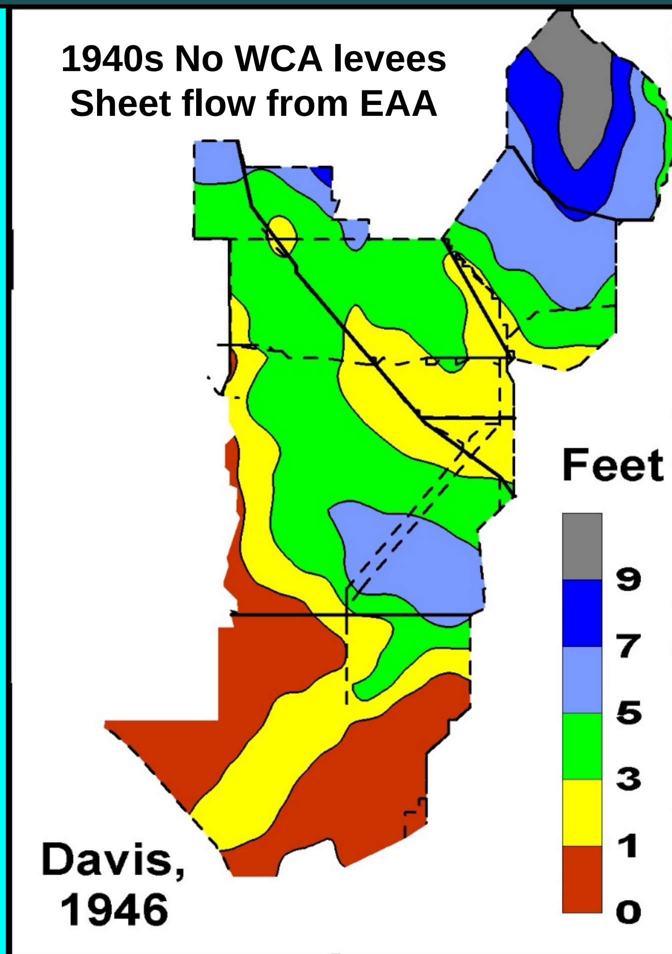
- Earliest quantitative information about soil thickness.
- “several hundred soundings of depth by rods” “reliable enough for general estimates of average conditions.” p. 121.
- Limitation: sampling points and data are not reported.; 2 foot intervals, the best we have.

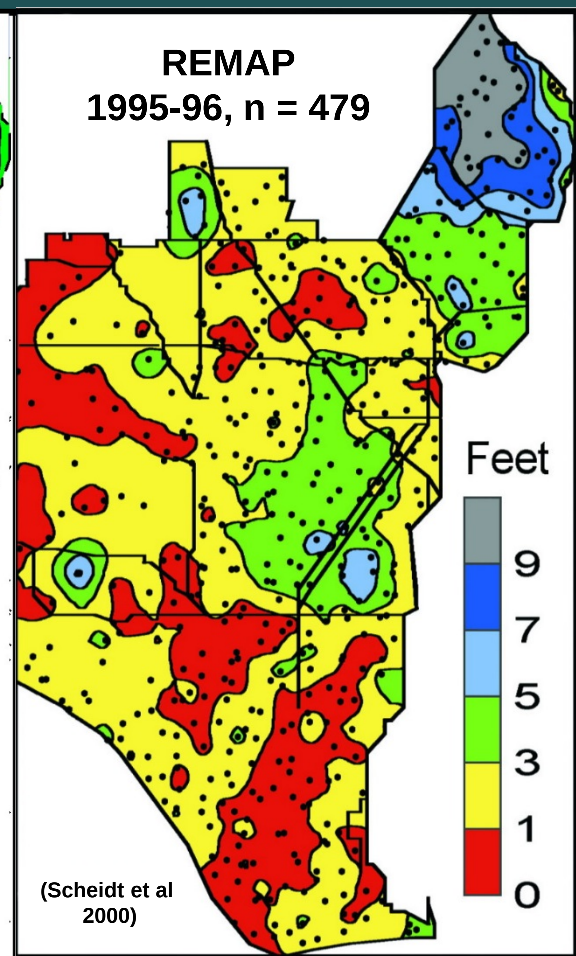
“…experiments to determine whether or not Everglades peat…could be economically used for fuel for generating heat and power, or for making plastics, were undertaken.” p. 1

“…an area in the Everglades of 36 square miles and 6 feet deep peat might be used to develop 23,000,000,000 kilowatt hours. This is enough power to supply a city of 200,000 people over 40 years.” p. 223.

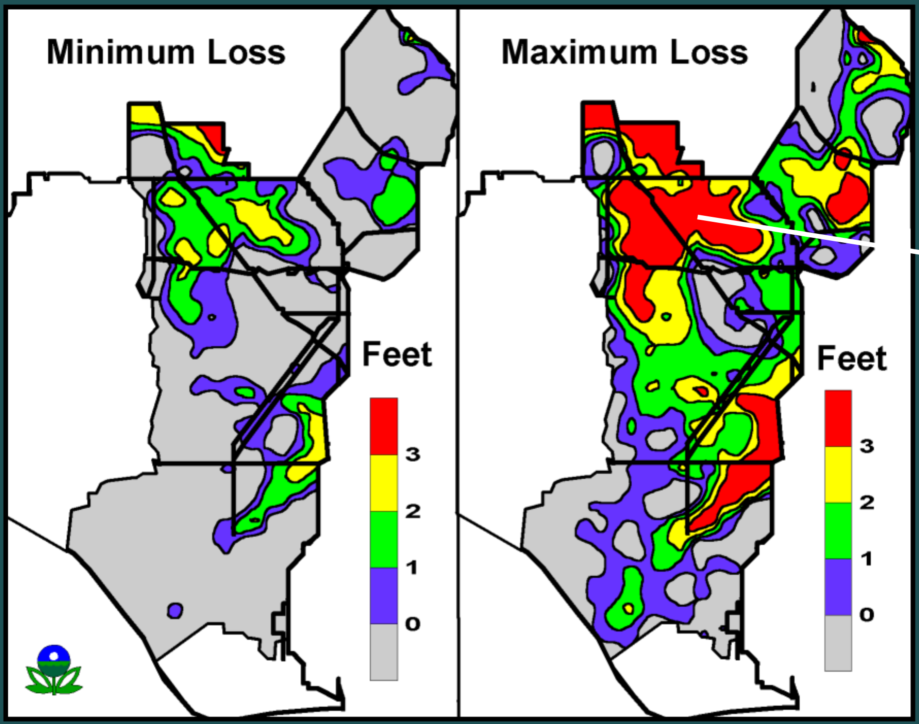
Soil Thickness







REMAP Findings 1999

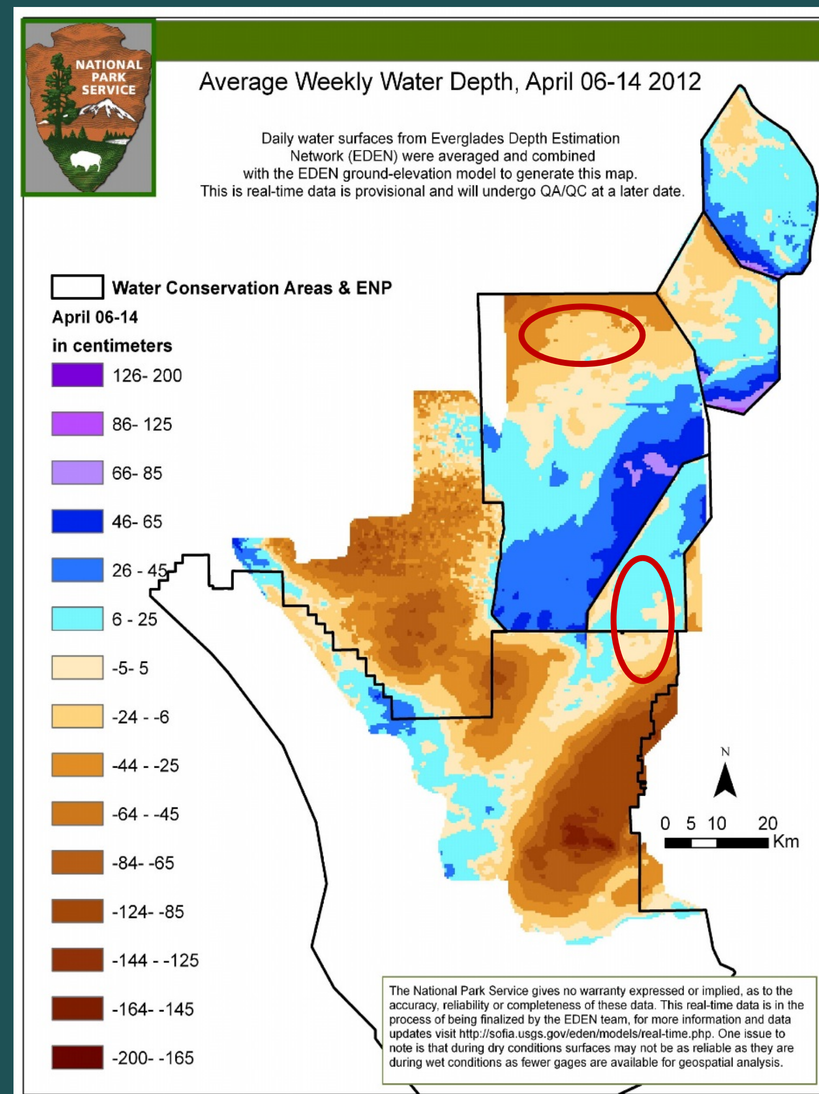


- Soil Subsidence
  - *From 1946 to 1996 northern WCA3A lost 39% to 69% of its soil, depending on assumptions about Davis 1940s depth.*
  - *2 to 6 x 10^8 m^3 loss*
- Decreased inundation leads to
  - Soil subsidence, oxidation
  - Soil becomes less organic, more mineral
  - Relative increase in soil TP due to decrease in soil mass, and volume
  - Vegetation change is associated with higher phosphorus

(Scheidt et al 2000)

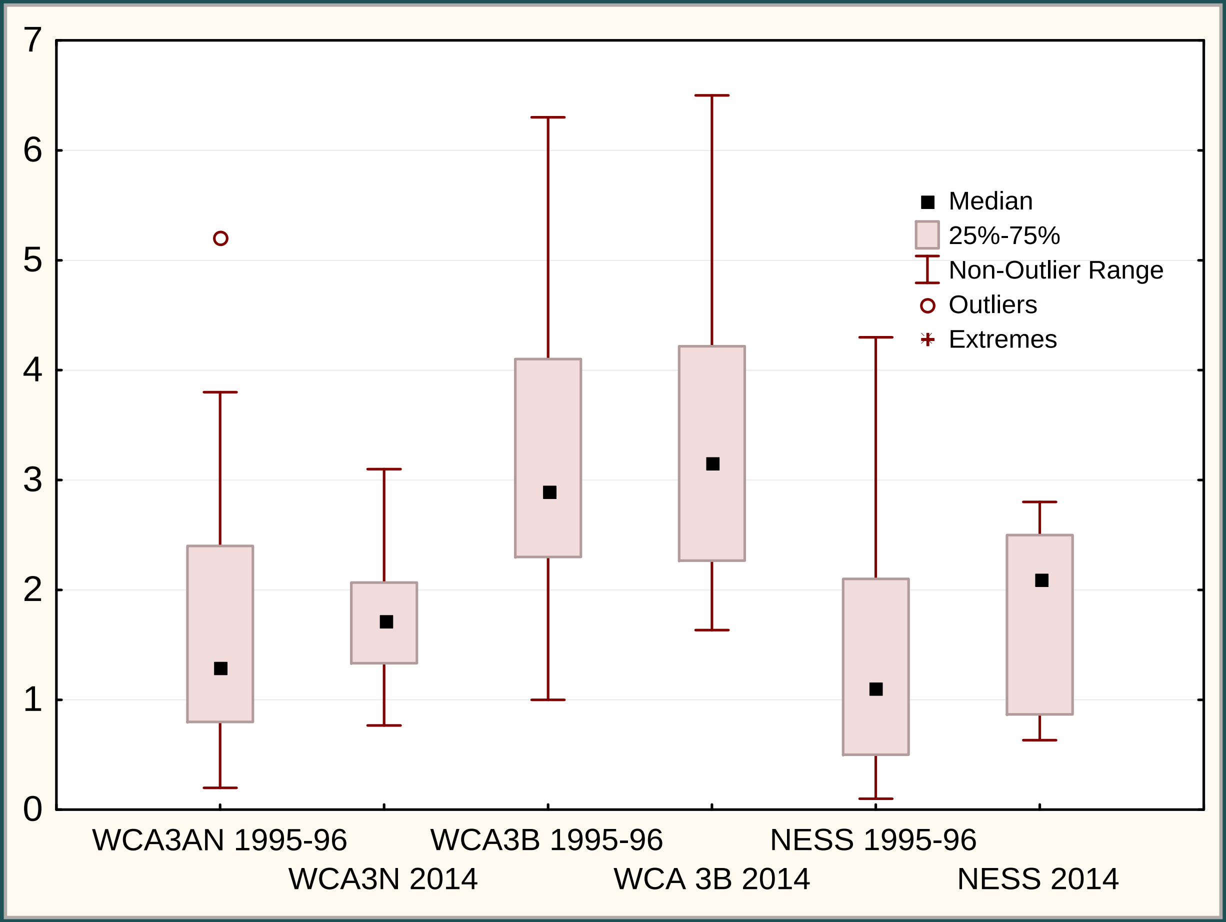
Hydroperiod Restoration

- Brown is dry, April 2012
- A Central Everglades Planning Project (CEPP) restoration goal:
  - Correct over-drainage in Northern WCA3A, WCA3B, Northeast Shark Slough
  - Re-establish *peat accretion*



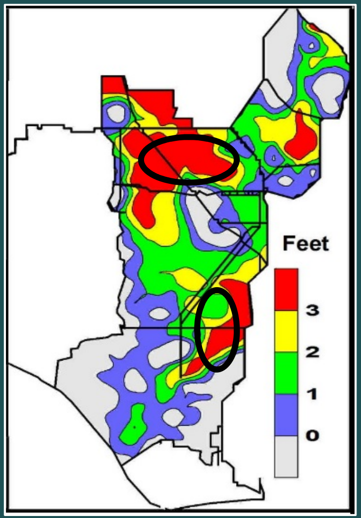
Soil Thickness (feet) 1995-96 vs 2014

Is there evidence of change in areas most vulnerable to subsidence?



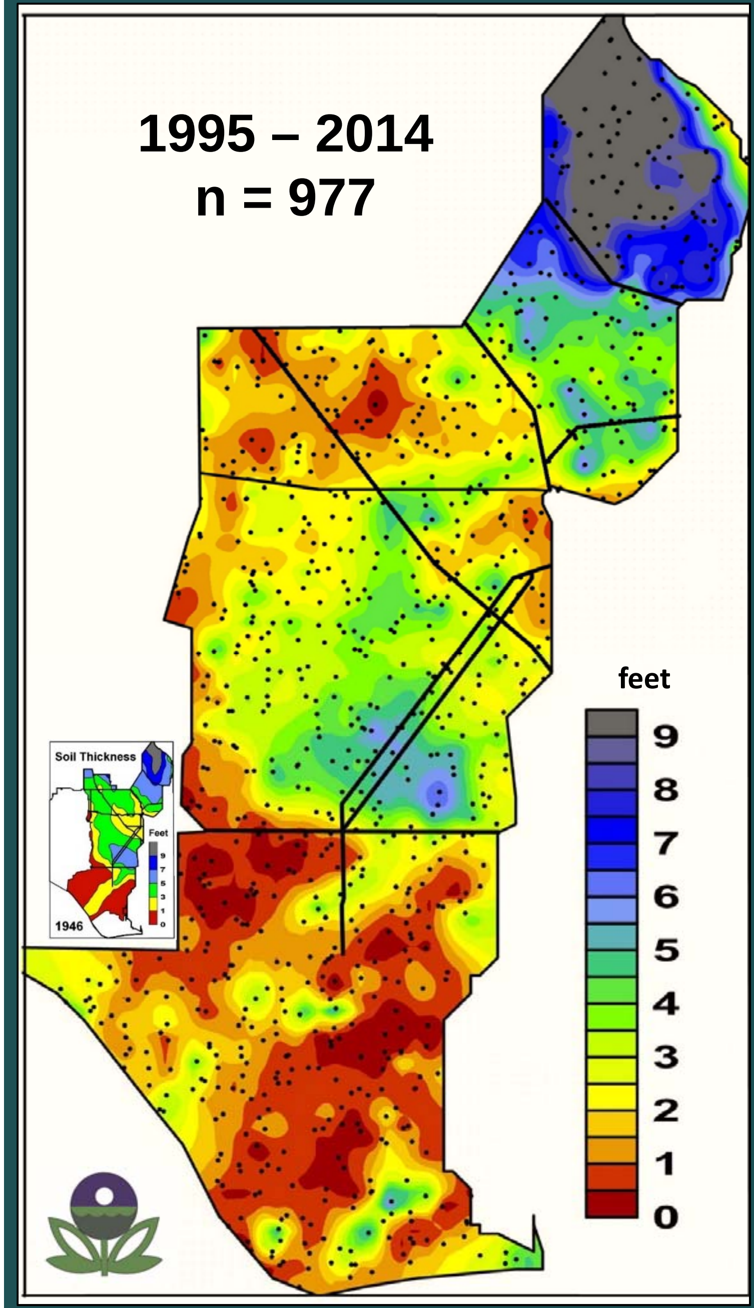
Box and whisker graph shows no indication of further subsidence between 1995-96 & 2014

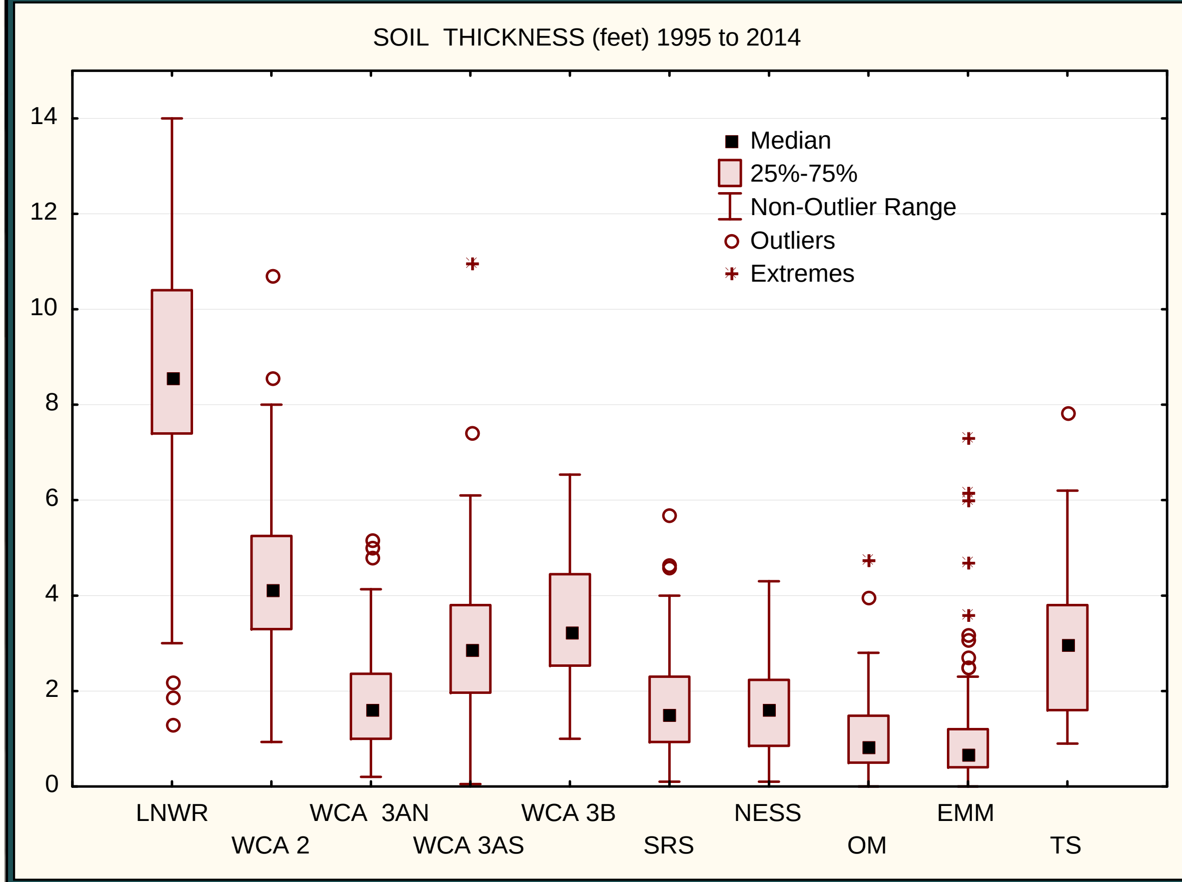
Caveat: smaller sample size in 2014

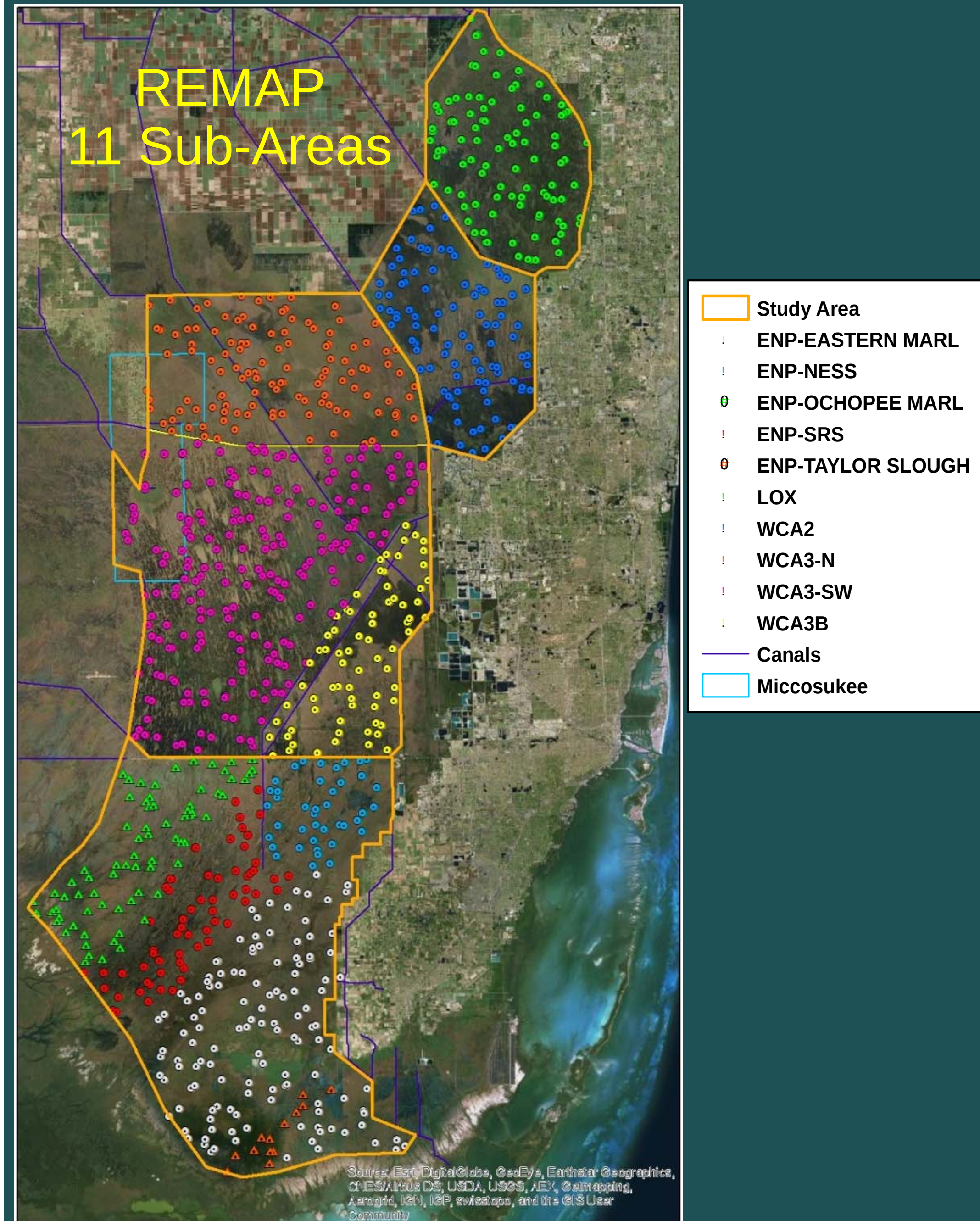


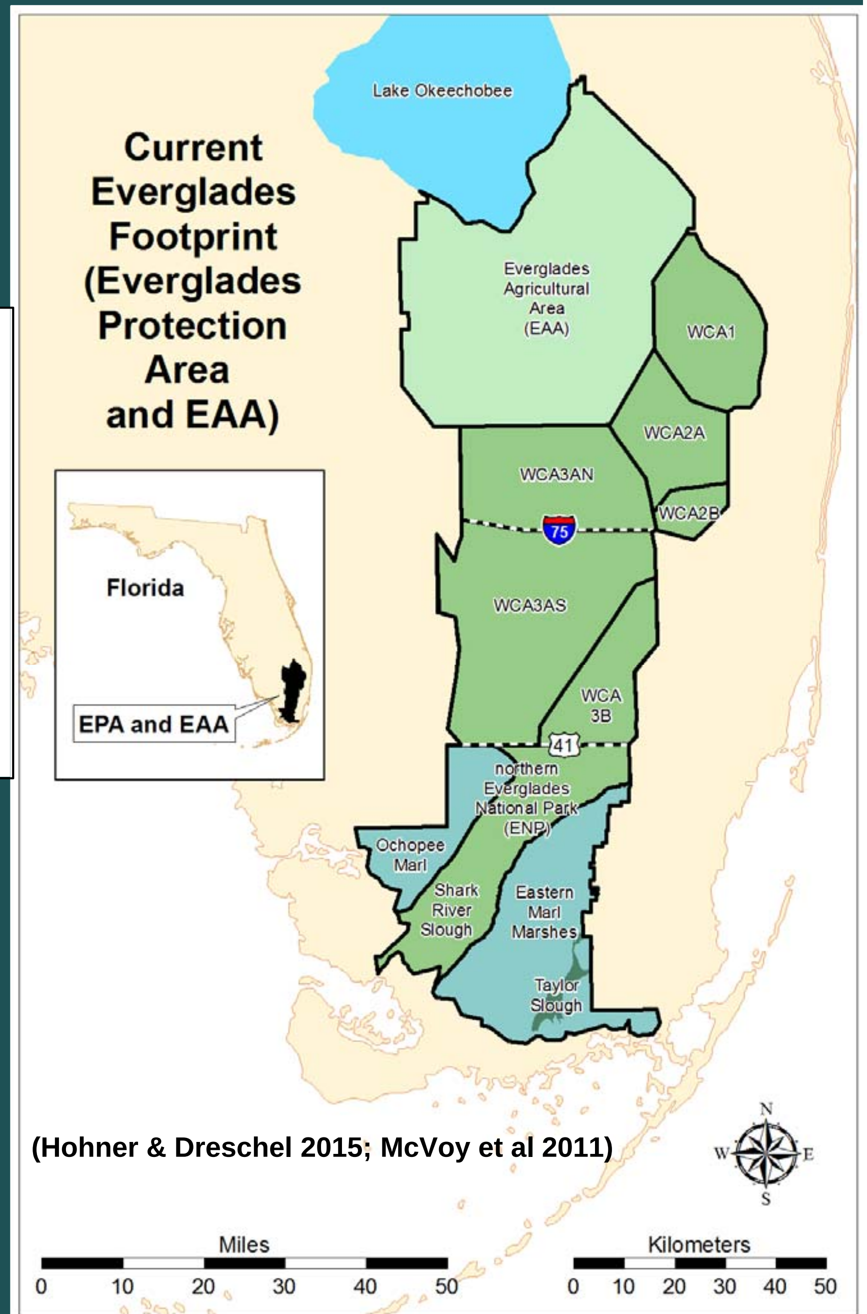
Maximum Soil Loss since 1946

Soil Thickness (feet)






REMAP
11 Sub-Areas
Study Area
ENP-EASTERN MARL
ENP-NESS
ENP-OCHOPEE MARL
ENP-SRS
ENP-TAYLOR SLOUGH
LOX
WCA2
WCA3-N
WCA3-SW
WCA3B
Canals
Miccosukee
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

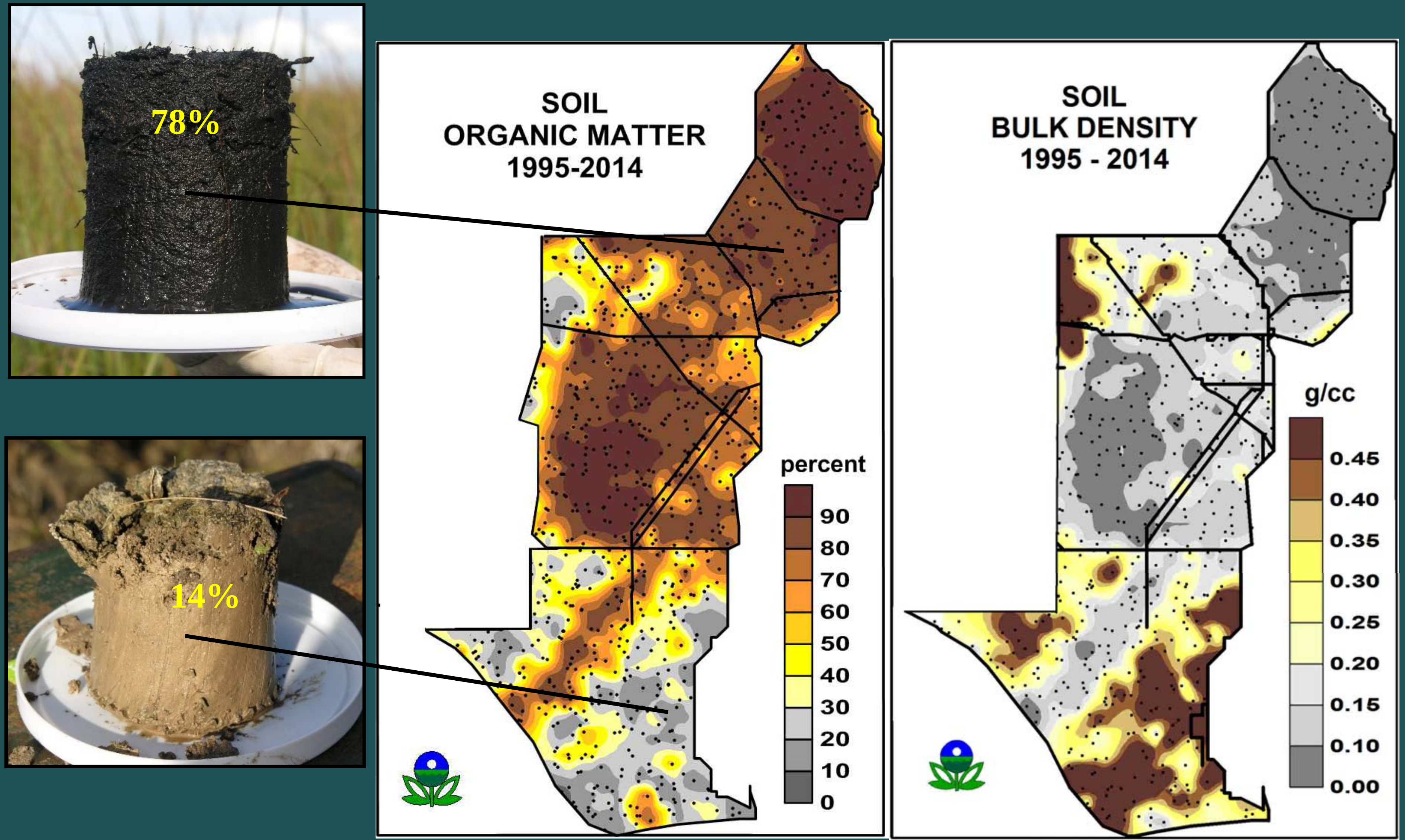

Current Everglades Footprint (Everglades Protection Area and EAA)
Lake Okeechobee
Everglades Agricultural Area (EAA)
WCA1
WCA2A
WCA2B
WCA3AN
WCA3AS
WCA 3B
75
41
northern Everglades National Park (ENP)
Ochopee Marl
Shark River Slough
Eastern Marl Marshes
Taylor Slough
Florida
EPA and EAA
(Hohner & Dreschel 2015; McVoy et al 2011)
N
S
E
W
Miles
0 10 20 30 40 50
Kilometers
0 10 20 30 40 50

Current Soil Volume

- Soil Volume = Area x Median Thickness ~ method A
  - EPA soil volume 4.69 x 10^9 m^3 (n= 977)
- Soil Thickness: median = 2.3 feet

	Area (km^2)	n	Median Soil Thickness (m)	Volume (m^3)
LNWR	567	105	2.62	1.49 x 10^9
WCA2	539	104	1.28	0.69 x 10^9
WCA 3AN	715.8	129	0.49	0.35 x 10^9
WCA 3AS	1288	224	0.88	1.14 x 10^9
WCA 3B	401.4	78	1.01	0.40 x 10^9
ENP SRS	357.6	67	0.46	0.16 x 10^9
ENP NESS	251.1	44	0.49	0.12 x 10^9
ENP OM	437.6	79	0.24	0.11 x 10^9
ENP EMW	693.4	115	0.21	0.15 x10^9
ENP EME	137.1	19	0.21	0.03 x 10^9
ENP TS	59.1	13	0.91	0.05 x 10^9
TOTAL	5447.1	977		**4.69 x 10^9**
Hohner & Dreschel 2015 ~ method B GIS based approach: surface elevation – bedrock elevation				**4.7 x 10^9**

Soil Organic Matter & Bulk Density



Summary

- REMAP Program has documented landscape conditions at ~1000 locations (1995-6, 1999, 2005, 2014)
  - soil charcteristics (thickness, organic matter, bulk density, P, N, C, Hg), & associations with water conditions, macrophytes and periphyton.
- Soil Thickness: median 2.3 feet
- Soil Volume: 4.7×10^9 m^3
- Soil Subsidence: no indication of further subsidence from 1996 to 2014.
- REMAP Program provides CEPP baseline
- REMAP helps satisfy restoration monitoring: status and trends.
- Soil perpetuation is critical to ecosystem restoration, and is a goal of hydrologic restoration efforts

QUESTIONS?

REMAP Program data are featured in over 20 publications.

Over 30 co-authors, many agencies and universities

Environmental Science & Technology; Environmental Pollution; International Journal of Plant Science; Aquatic Botany; Journal of Freshwater Biology; Marine & Freshwater Research; Reviews in Environmental Science & Technology

Acknowledgements: Derek Little, Jon McMahan USEPA; Paul Conrads, USGS EDEN

Sources:

Hohner and Dreschel, 2015. Everglades peats: using historical and recent data to estimate pre-drainage and current volumes, masses and carbon contents . Mires and peat 16:1-15. http://www.mires-and-peat.net/, ISSN 1819-754X.

Scheidt, Daniel, Jerry Stober, Ronald Jones and Kent Thornton. 2000. South Florida ecosystem assessment: water management, soil loss, eutrophication and habitat. United States Environmental Protection Agency Report 904-R-00-003.

Scheidt, D. J. and P. I. Kalla. 2007. Everglades ecosystem assessment: water management, water quality, eutrophication, mercury contamination, soils and habitat. Monitoring for adaptive management: a R-EMAP status report. EPA 904-R-07-001. United States Environmental Protection Agency. Atlanta, Georgia.

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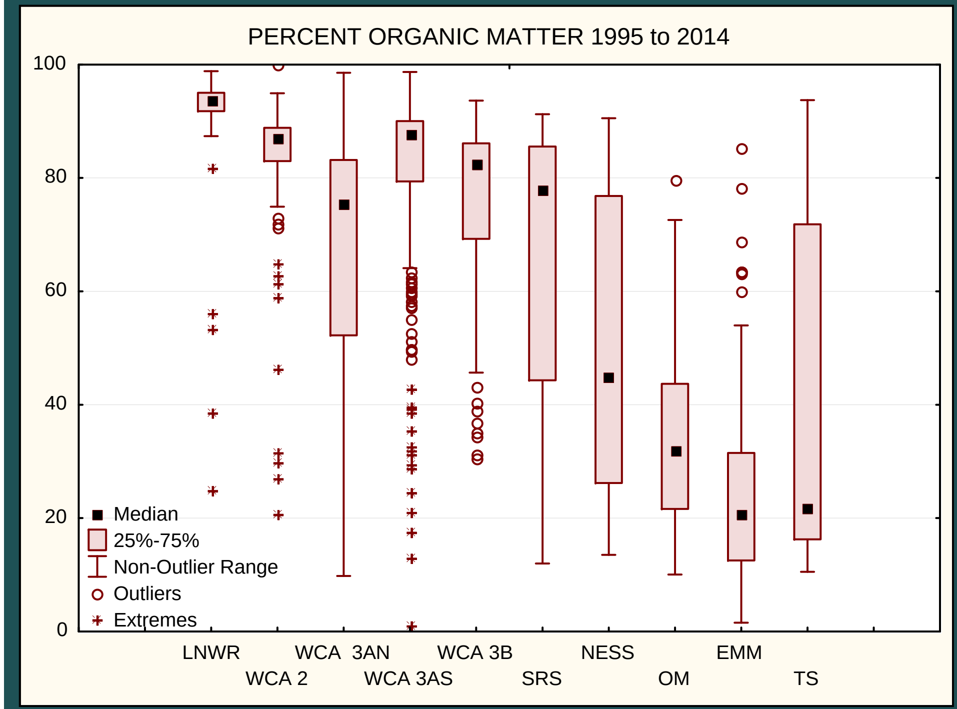
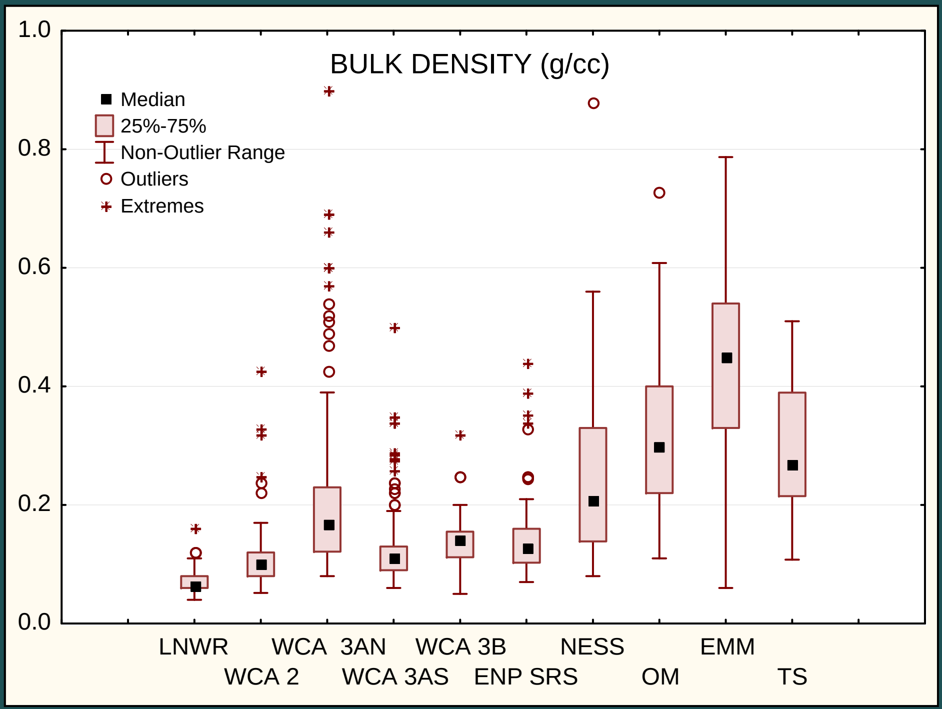
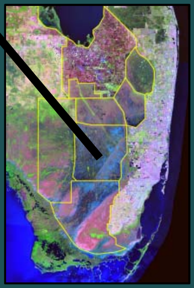
Soil Organic Matter & Bulk Density





WCA3A South

- Soil Thickness = 2.9 ft (median, n=224)
- Bulk density = 0.11 g/cc
- Organic matter = 88%
- Water depth (1991-2014)* = 2.2 ft
- % of days dry* = 0%
- Abundant floculant matter



* Site 65, data from EDEN

Eastern Marl Marsh – Rocky Glades

- Soil Thickness = 0.7 ft (median, n=134)
- Bulk density = 0.45 g/cc
- Organic matter = 21%
- Water depth (1991-2014)* = 0.14 ft
- Days dry* = 42%
- Benthic periphyton mat

* NP206, data from EDEN