Towards a soil-property-based index of wetland "harm"

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Overview

- Problem statement and hypothesis
- Sample collection and processing
- Results and discussion
- Conclusions
- Future directions (?)

Problem Statement

- Groundwater pumping causes declines in WT
- Wetlands are impacted by loss of water
- SWFWMD balances demand with ecosystem health
- SWFWMD needs definitions of “harm” vs “significant harm”

Background

- Wetlands defined
- Cypress domes in west-central Florida
- SWFWMD Normal Pool
- Soil organic carbon (SOC)

Three definining characteristics of wetlands:

- Saturated for long periods
- Establish hydrophytic vegetation
- Develop hydric soils

Wetlands in west-central Florida

Cypress Domes - Pond Cypress trees (*Taxodium ascendens*)

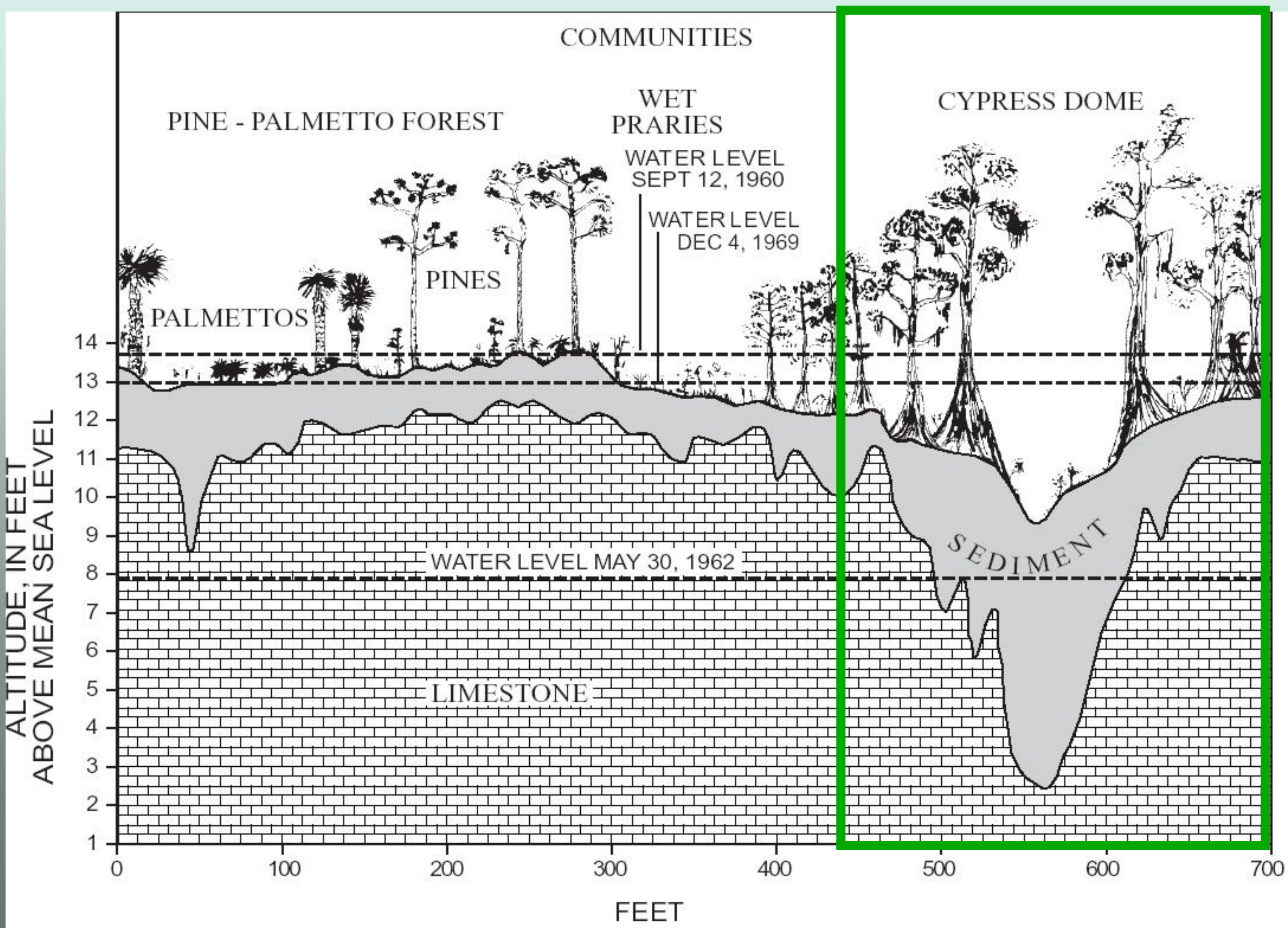
Larger trees growing in the center and tapering off towards the outer edges

From UF WEC http://www.wec.ufl.edu/extension/gc/harmony/history/natural.htm

Wetlands

Cypress Domes have thicker organic soils in the center

Vertically exaggerated



From USGS Circular 1134

Normal Pool Elevations

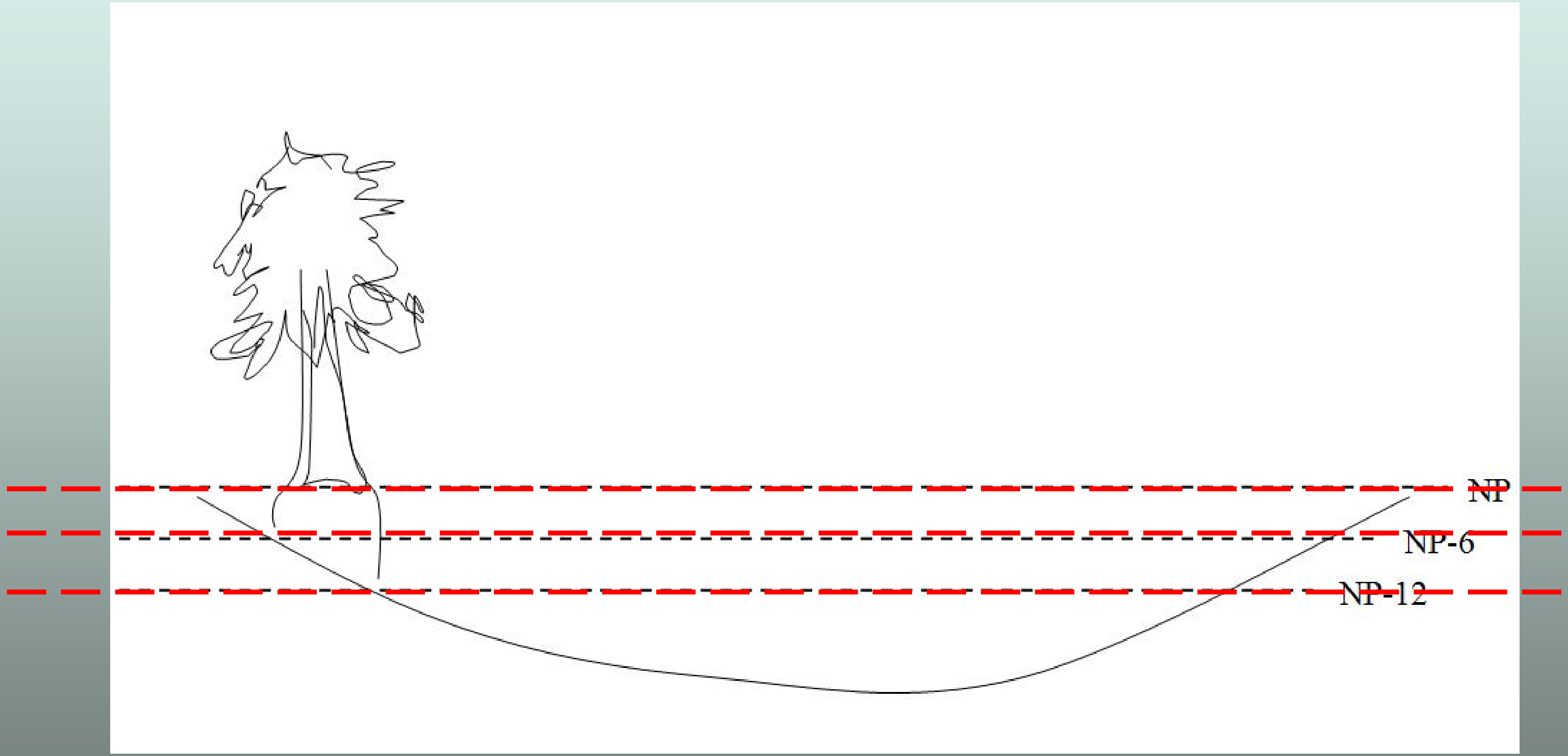
SWFWMD uses biological indicators to determine long term hydrology in wetlands

Buttress inflection and moss collars

From Carr et al., 2006

Normal Pool Elevations

Used to indicate historic high water stands



From Carr et al., 2006

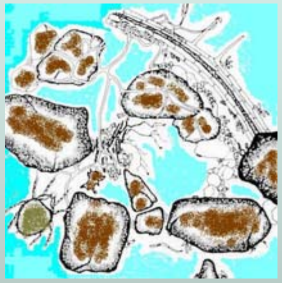
Hydric Soils

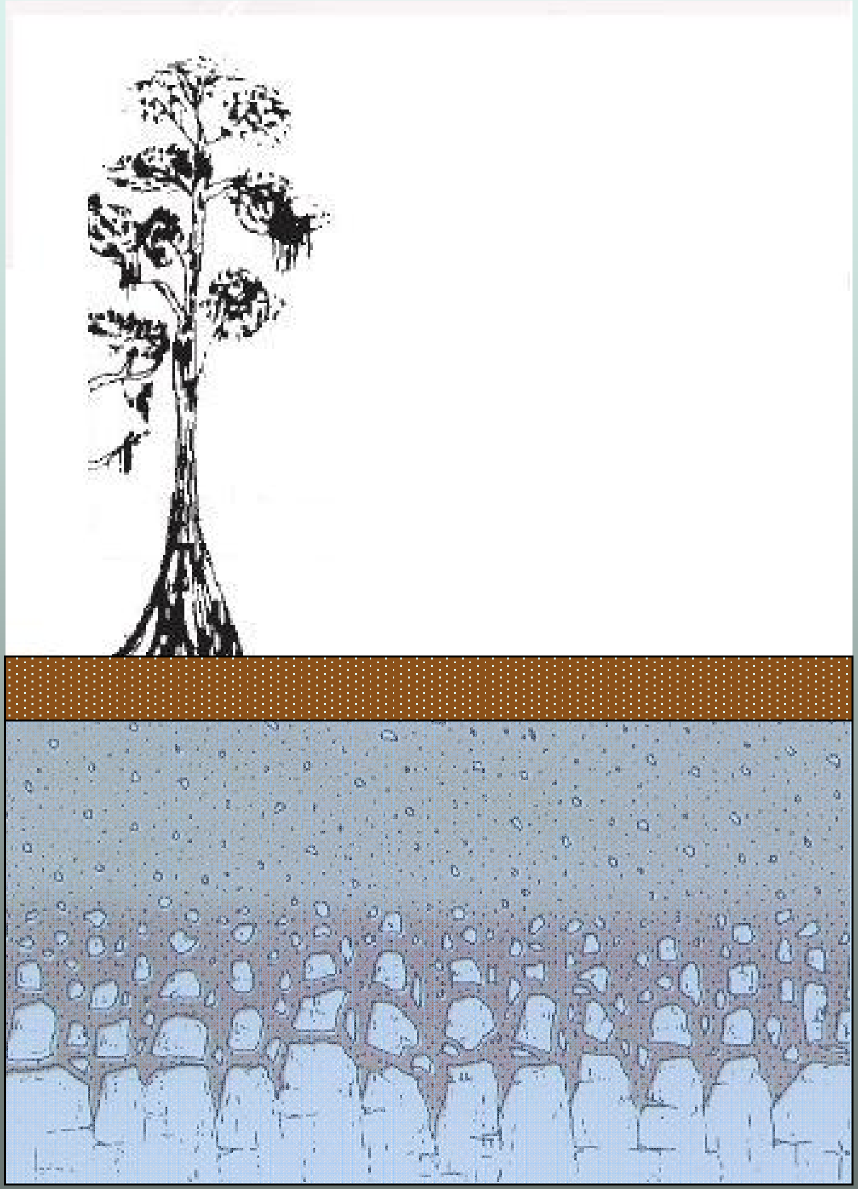
"formed under conditions of saturation, flooding or ponding long enough during the growing season to develop *anaerobic* conditions in the upper part."

(NRCS, 2008)

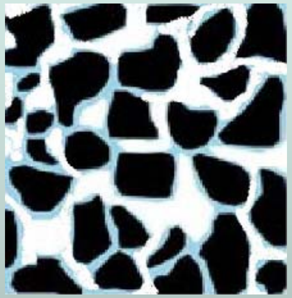
Soil Organic Carbon

Organics





Sand/Loam



Degree of Harm

"Healthy"

VS

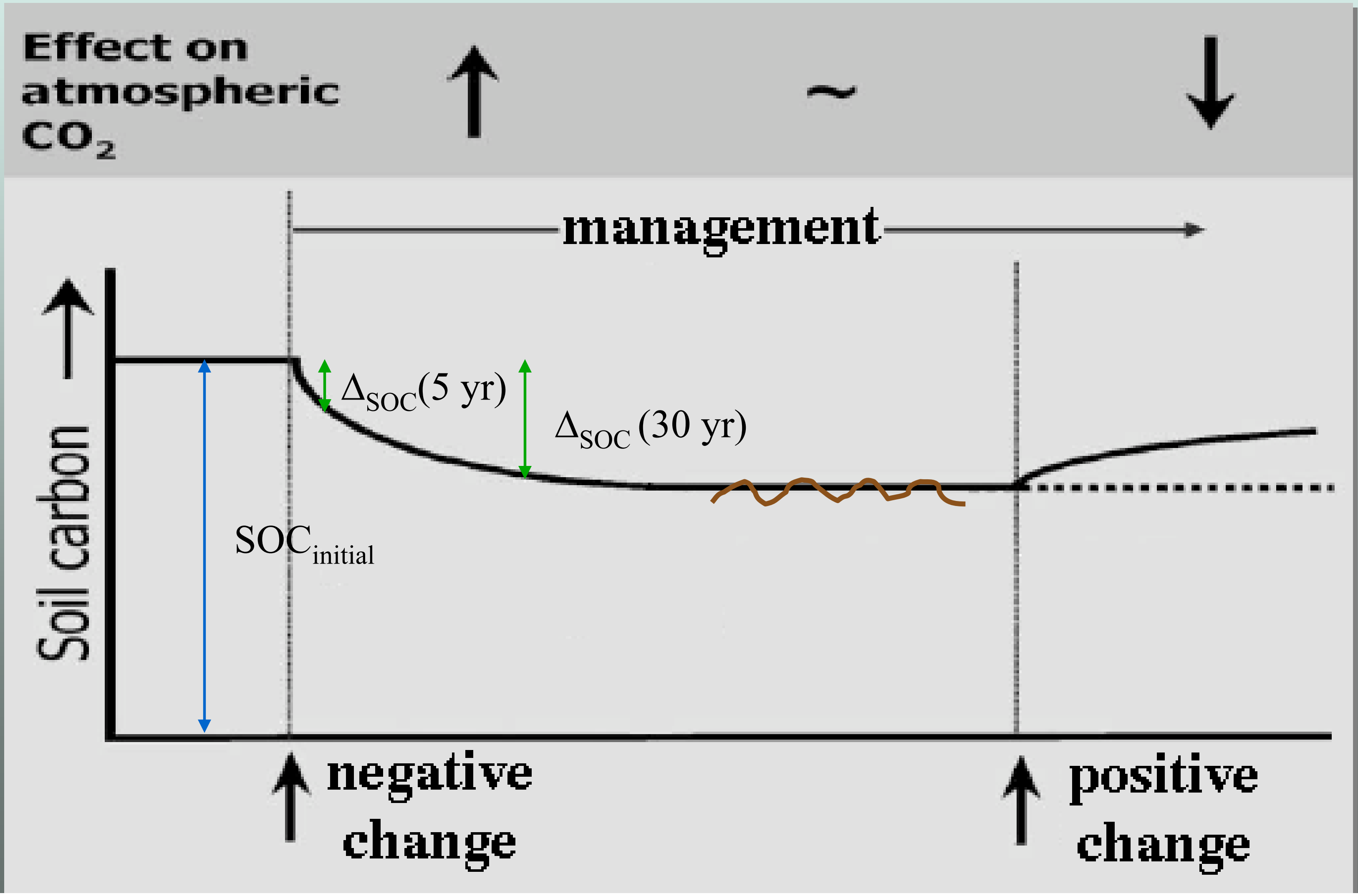
"Harmed" or
"Significantly Harmed"

Hypothesis

Differences in SOC content will be reflected across the spectrum of “healthy,” “harmed,” and “significantly harmed” cypress domes.

Two fundamental problems in detecting Δ_{SOC}

Δ_{SOC}(30 yr) / SOCinitial = small fraction (a few % of total)
Δ_{SOC}(5 yr) / SOCinitial = even smaller fraction.



Two fundamental problems in detecting Δ_{SOC}

QuickTime™ and a decompressor are needed to see this picture.

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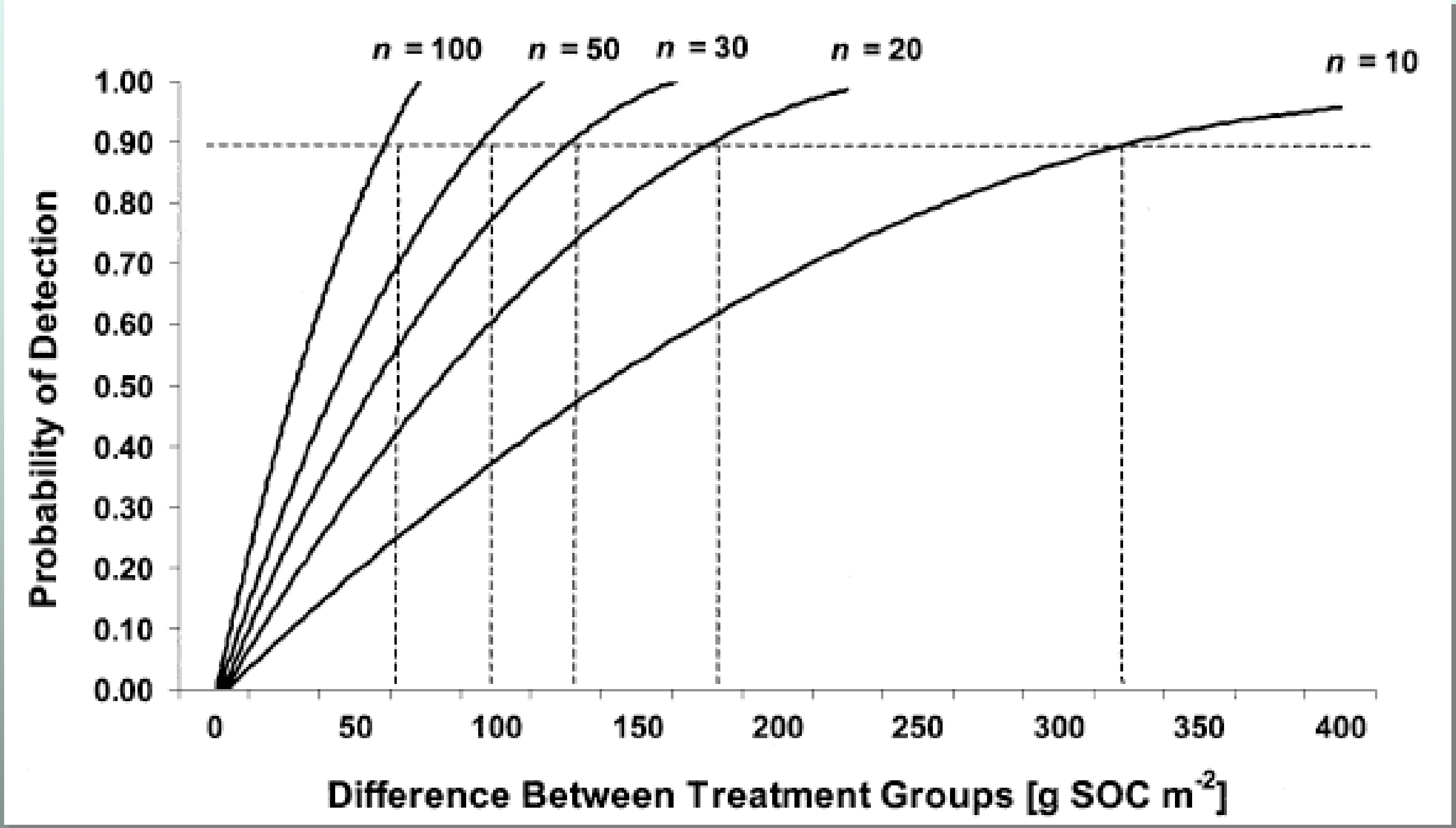
Antle, J.M., S.M. Capalbo, S. Mooney, E.T. Elliott, and K. Paustian. 2003. Spatial heterogeneity, contract design, and the efficiency of carbon sequestraton policies for agriculture. Journal of Environmental Economics and Management 46:231-250

Statistical significance of stratified sampling



How much C is in 1 g m^{-2}?

•Typical Healthy wetland, NP-12 : 18000 g m^{-2}

•Typical Healthy wetland, NP : 7200 g m^{-2}

Poussart et al., Verification of Soil Carbon Sequestration: Environmental Management 33, S416

Detecting a change of 100 g m^{-2} amounts to Δ_{SOC} of ~0.5% to 1.5%

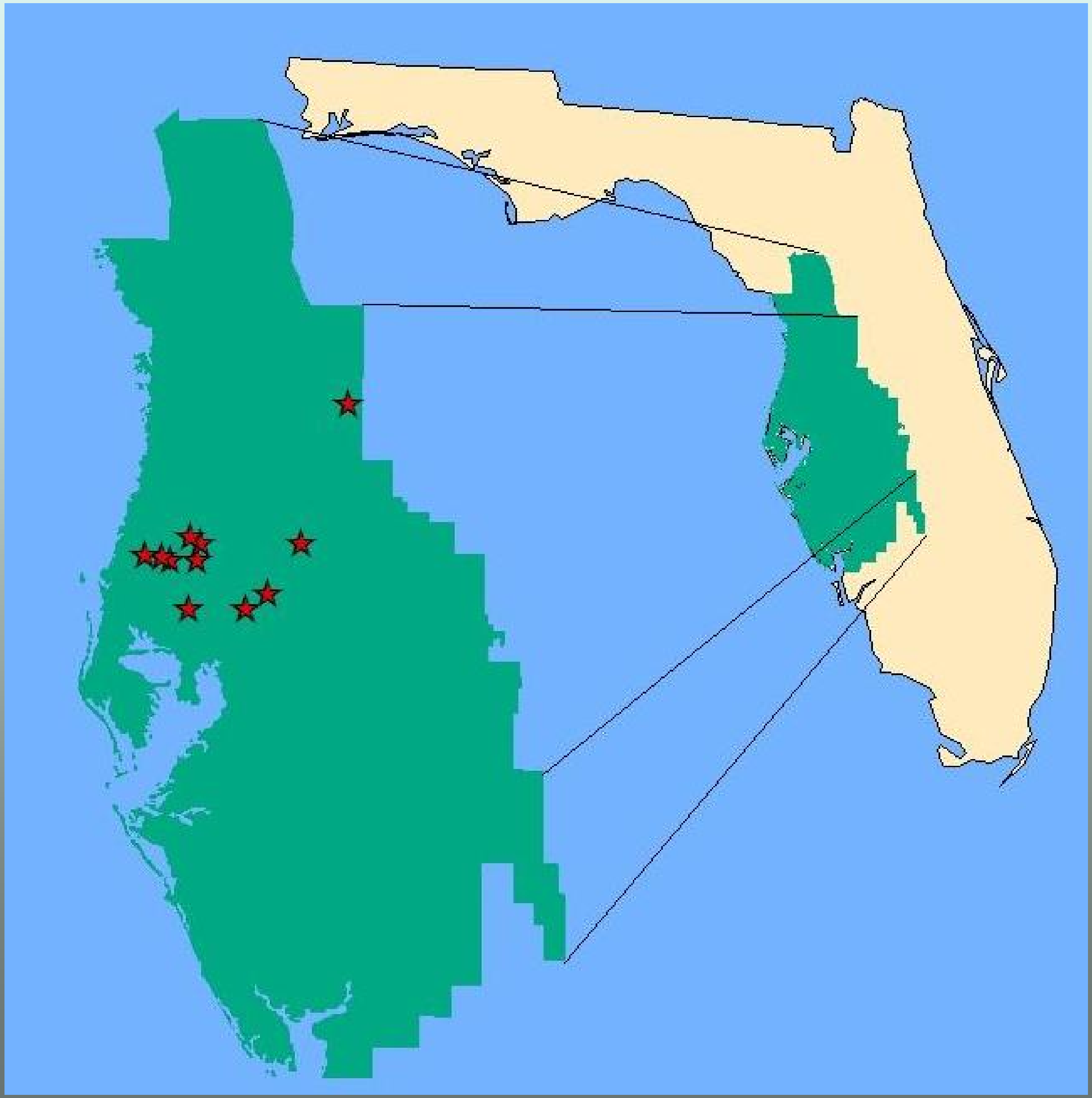
Methods and Materials

- Study Area
- Soil collection
- Sample preparation
- IRMS Analysis

Study Area

Research on bio indicators conducted by Dr. Scott Emery

11 Cypress domes sampled between Dec 2007 – Apr 2008



Soil Collection

• Sampling locations within each wetland were surveyed and flaggged

• Fifteen (15) soil cores for each NP elevation

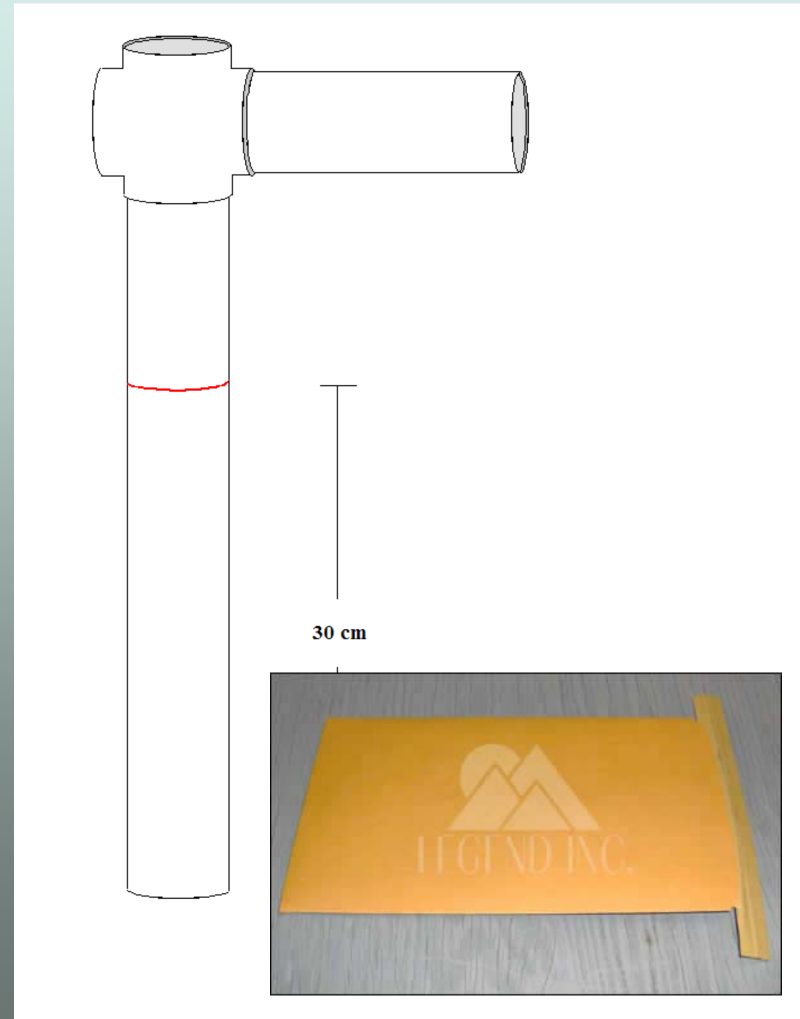
• 45 soil cores per site

465 cores!

• New River the exception, sampled the NP-12 elevation only

Soil Collection

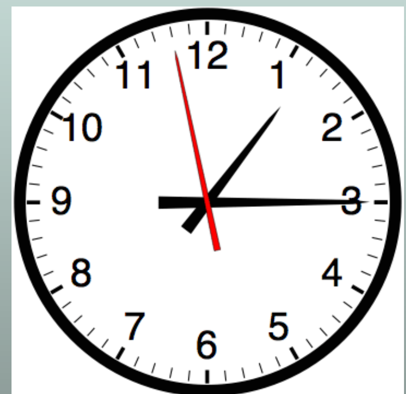
Custom PVC soil corers



Sample Preparation

Weigh samples…

…load on the rack and air dry



Weigh *DRY* samples…

Purpose of stratified sampling

Increase # of samples to maximize probability of detecting relatively small Δ_{SOC}

Decrease # of analyses to minimize analysis cost (analyist time)

Retain some information on natural variation in SOC (statistical significance)

	Bulk A: 1/5 of samples 1-5	Bulk B: 1/5 of samples 6-10	Bulk C: 1/5 of samples 11-15	Bulk-Bulk:
NP				1/3 Bulk A 1/3 Bulk B 1/3 Bulk C
NP-6				1/3 Bulk A 1/3 Bulk B 1/3 Bulk C
NP-12				1/3 Bulk A 1/3 Bulk B 1/3 Bulk C

Sample Preparation

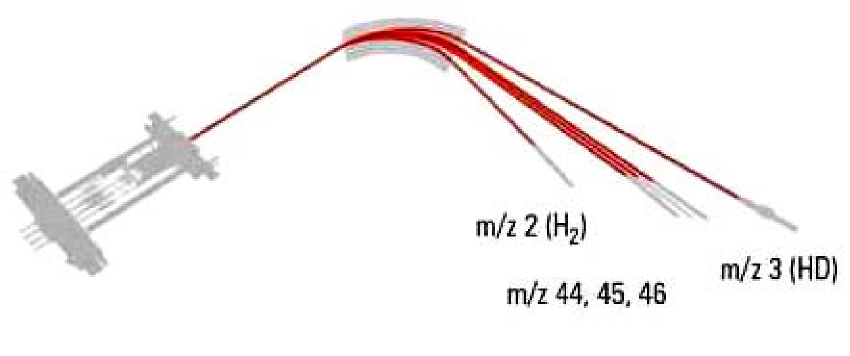
Homogenized samples by bulk in the soil splitter…

…powdered in shatterbox and soil mill…

…and placed in glass vials

Elemental (and isotope) Analysis

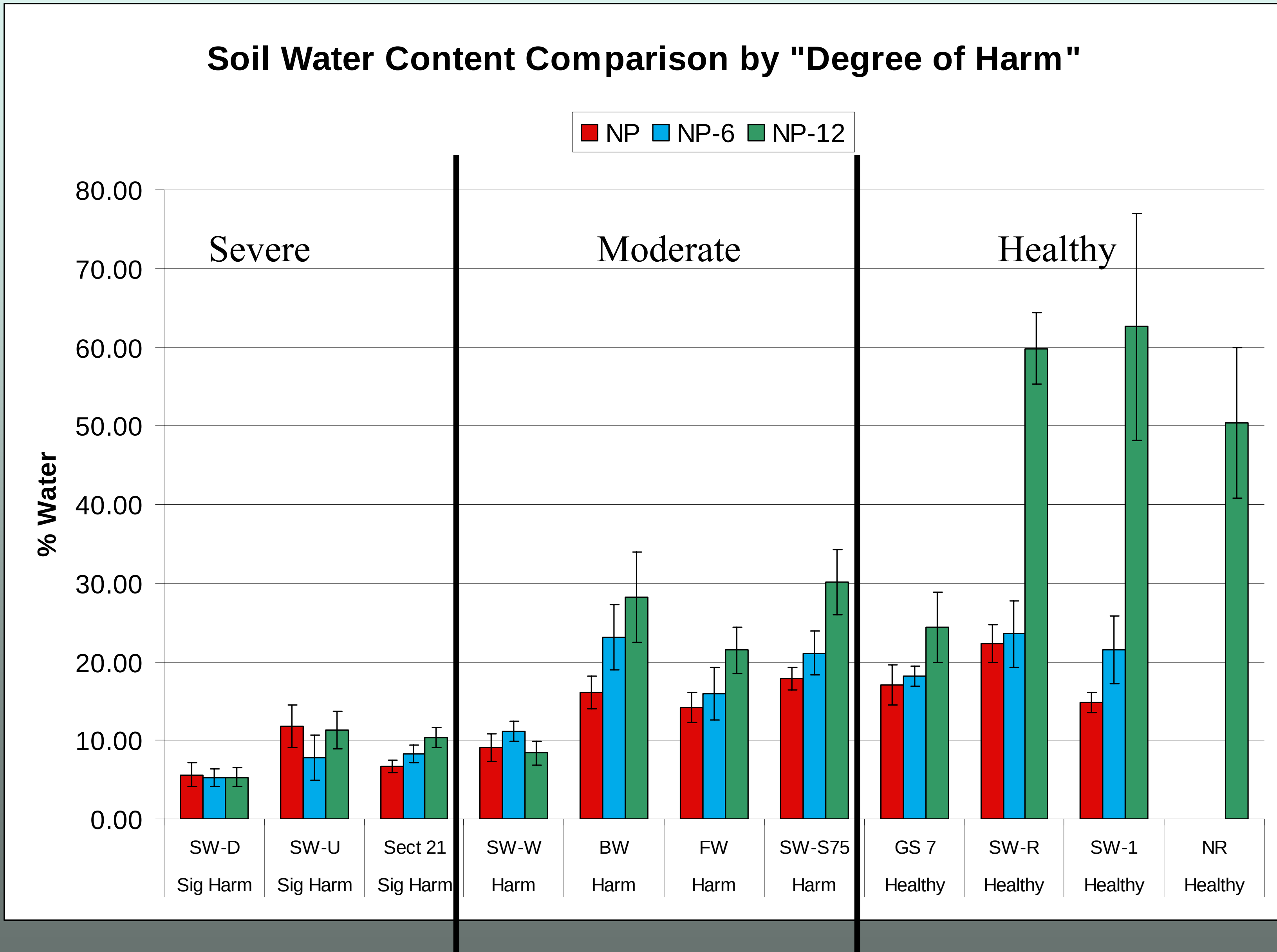
QuickTime™ and a
decompressor
are needed to see this picture.



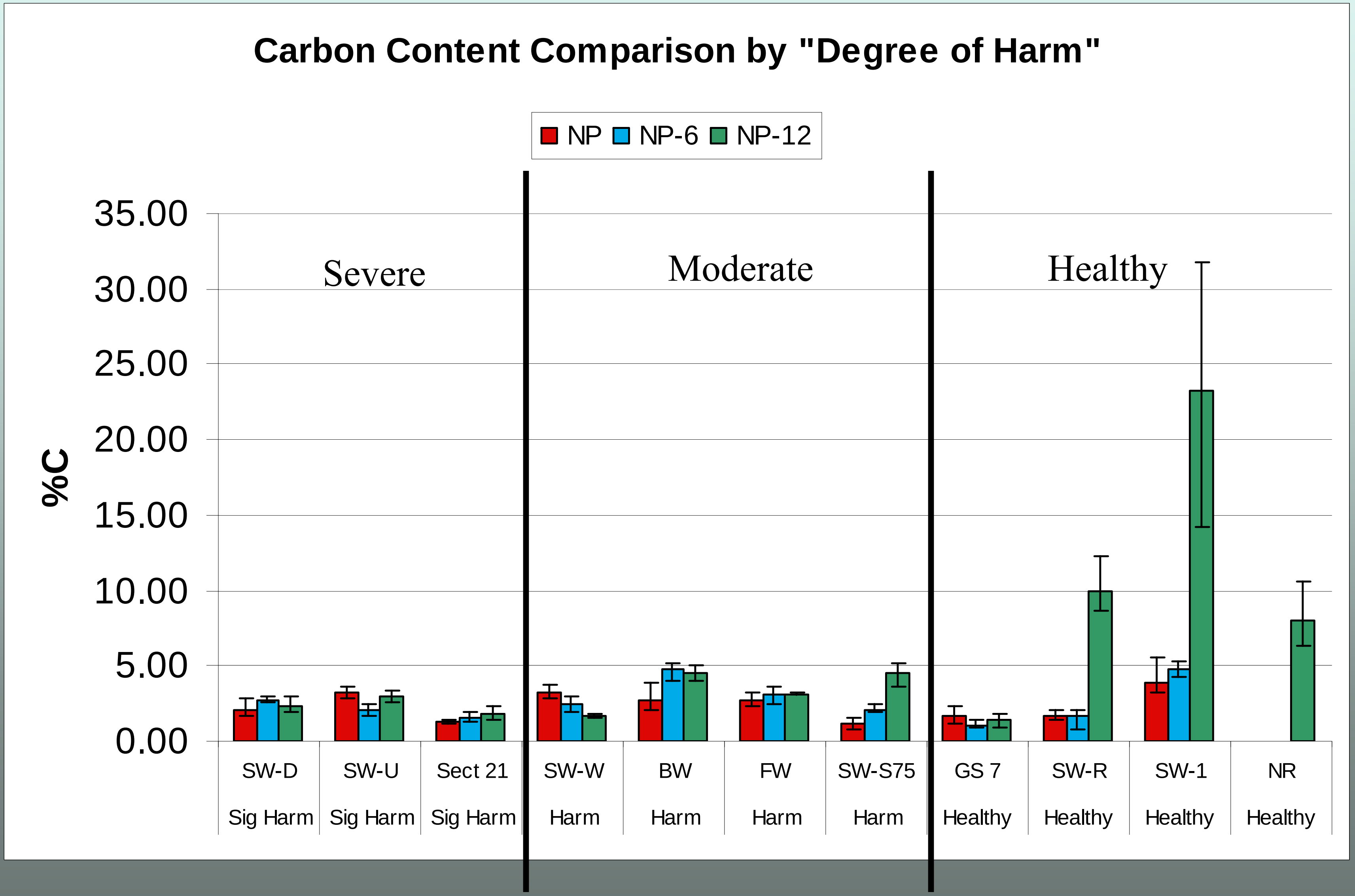
Results and Discussion

- Soil Water Content
- Soil Carbon Content
- Water vs %C
- Bulk Density vs %C
- Nitrogen and C:N ratio
- Soil Moisture Meter
- Stable isotopes
- Conclusions
- Follow-up—Future directions

Soil Water Content

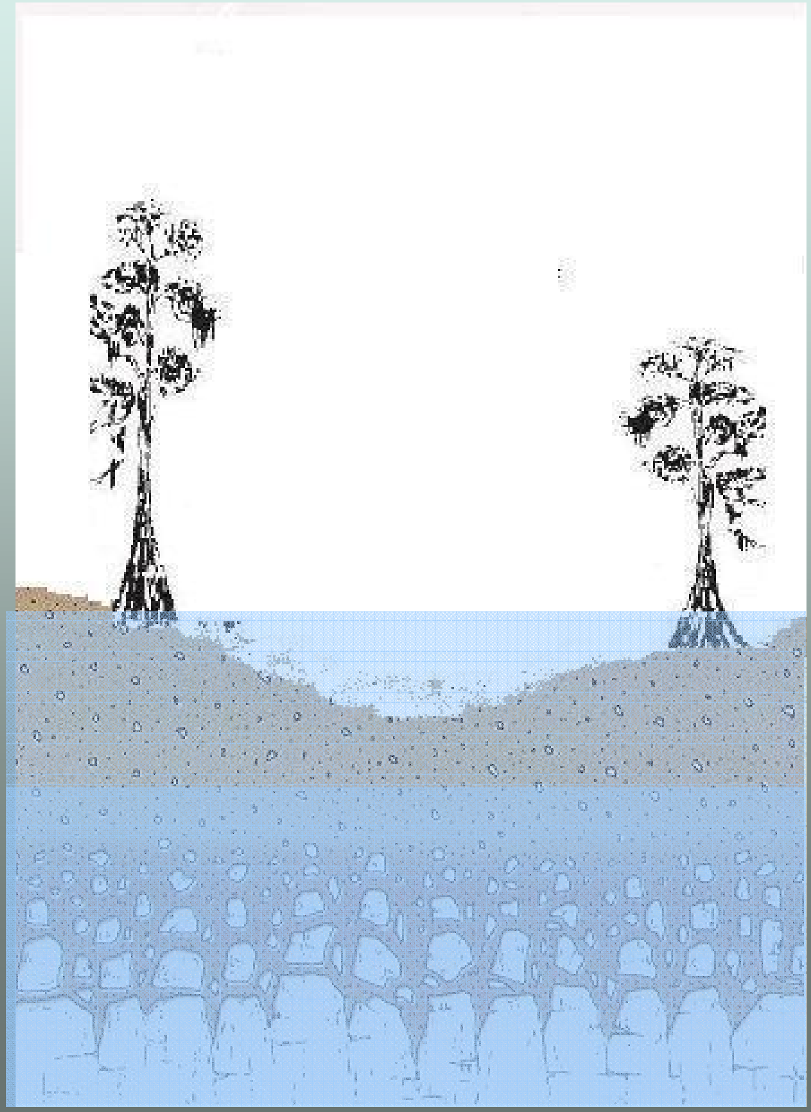


Carbon Content

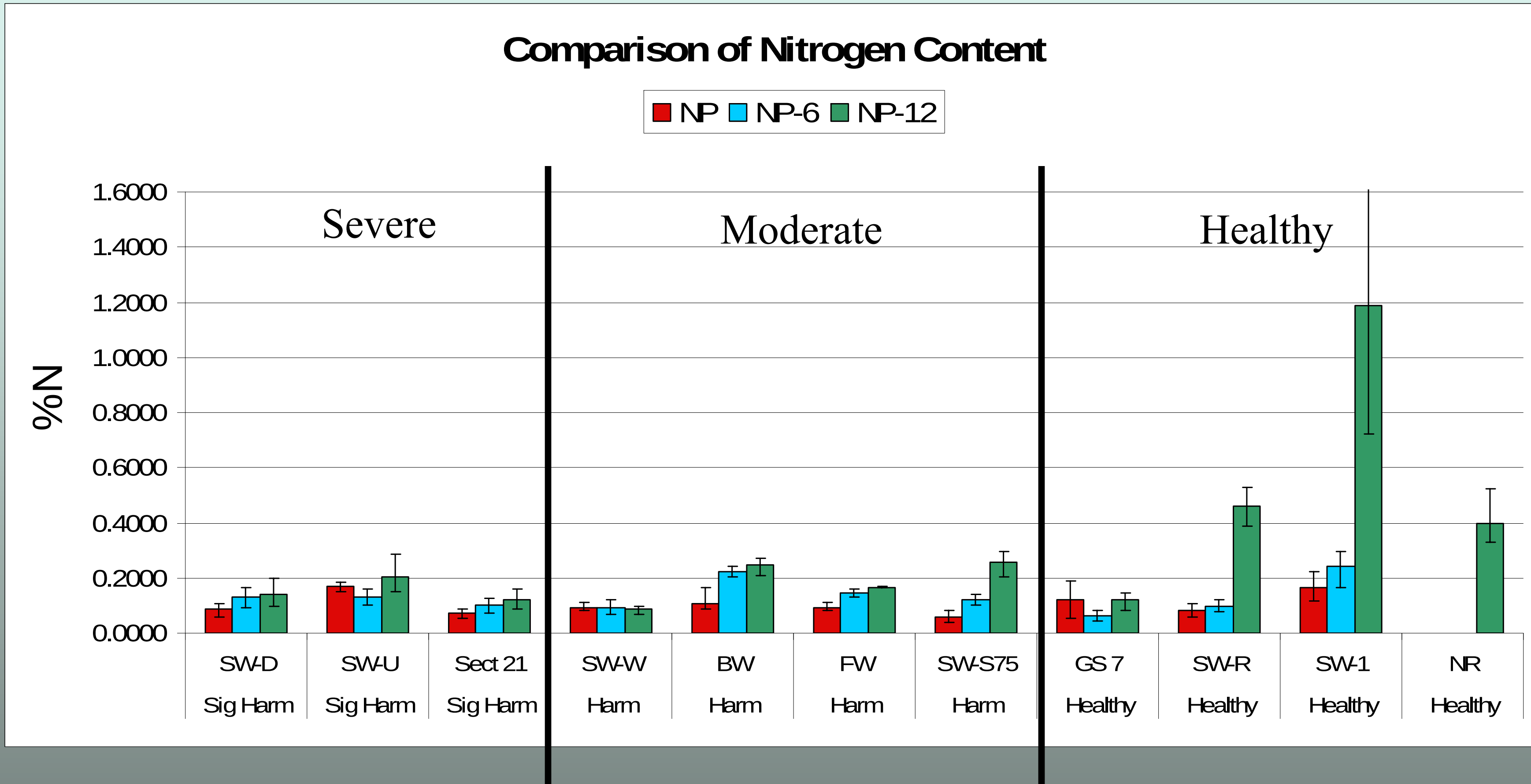


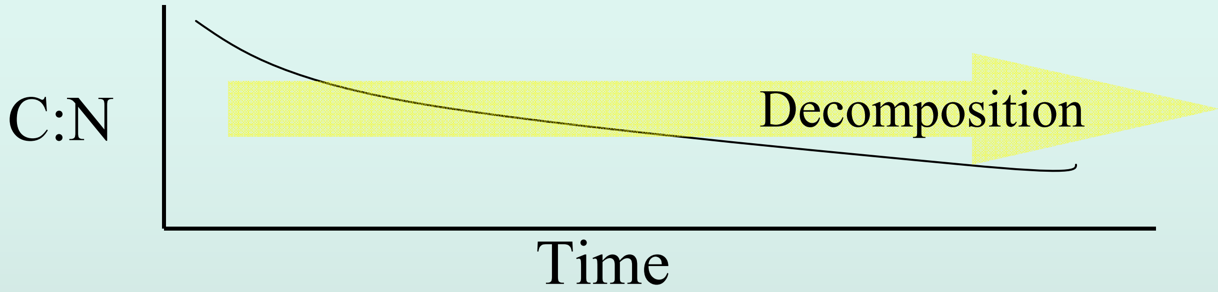
Healthy wetland soils accumulate organics in the center and sequester carbon

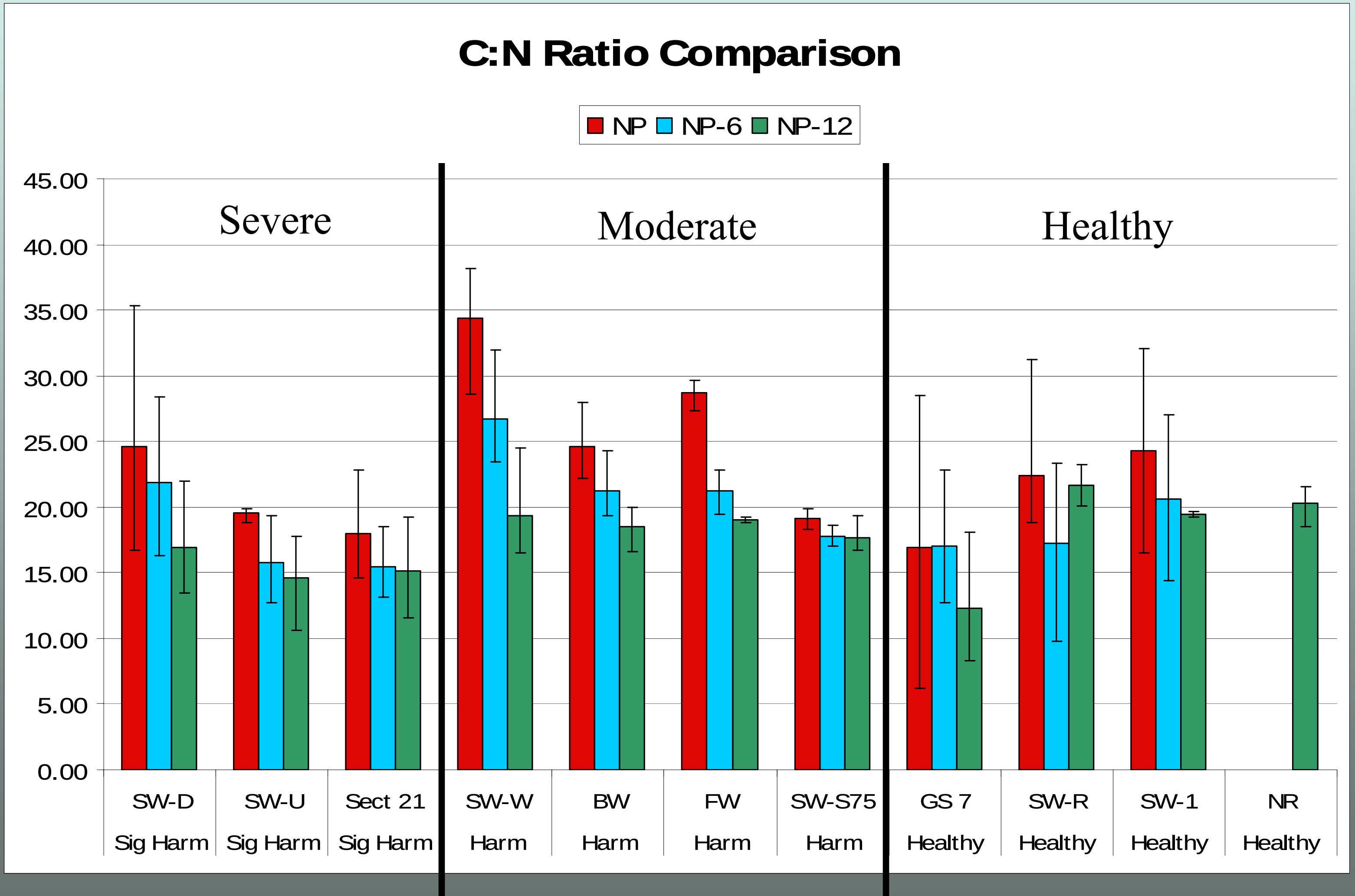
Impacted wetland soils lose stores of carbon



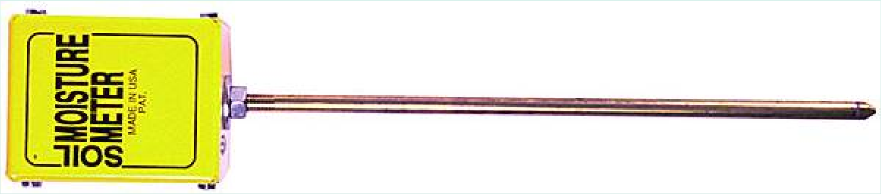
Nitrogen

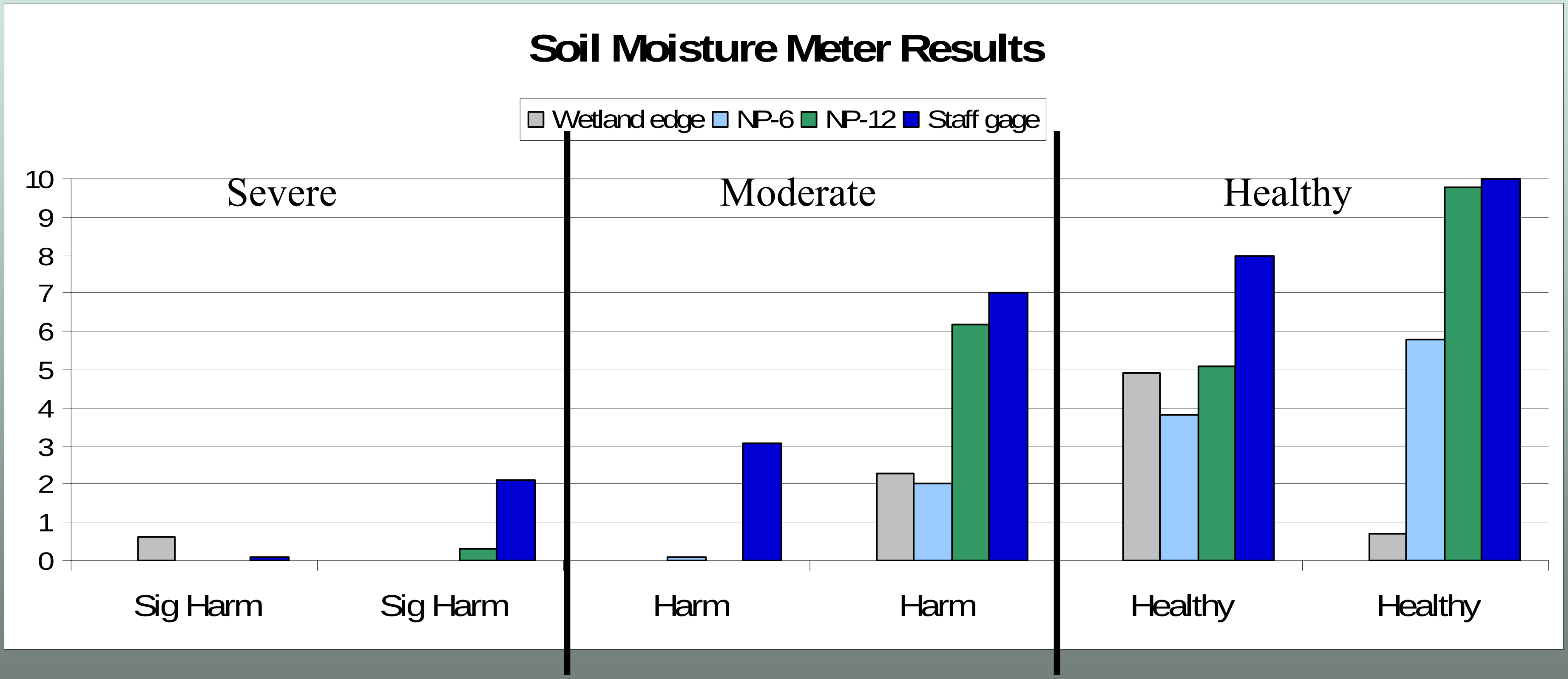

Comparison of Nitrogen Content
NP
NP-6
NP-12
%N
1.6000
1.4000
1.2000
1.0000
0.8000
0.6000
0.4000
0.2000
0.0000
Severe
Moderate
Healthy
SW-D
Sig Harm
SW-U
Sig Harm
Sect 21
Sig Harm
SW-W
Harm
BW
Harm
FW
Harm
SW-S75
Harm
GS 7
Healthy
SW-R
Healthy
SW-1
Healthy
NR
Healthy


C:N
Decomposition
Time


C:N Ratio Comparison
NP
NP-6
NP-12
Severe
Moderate
Healthy
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
SW-D Sig Harm
SW-U Sig Harm
Sect 21 Sig Harm
SW-W Harm
BW Harm
FW Harm
SW-S75 Harm
GS 7 Healthy
SW-R Healthy
SW-1 Healthy
NR Healthy

Soil Moisture Meter





Conclusion

- There is a connection between soil water content, SOC, and wetland health
- SOC higher in the center of a cypress wetland and more pronounced in the healthier sites.
- Soil moisture is elevated due to higher water retention in SOM
- A soil moisture meter may be a proxy for soil carbon stores.

Follow-up

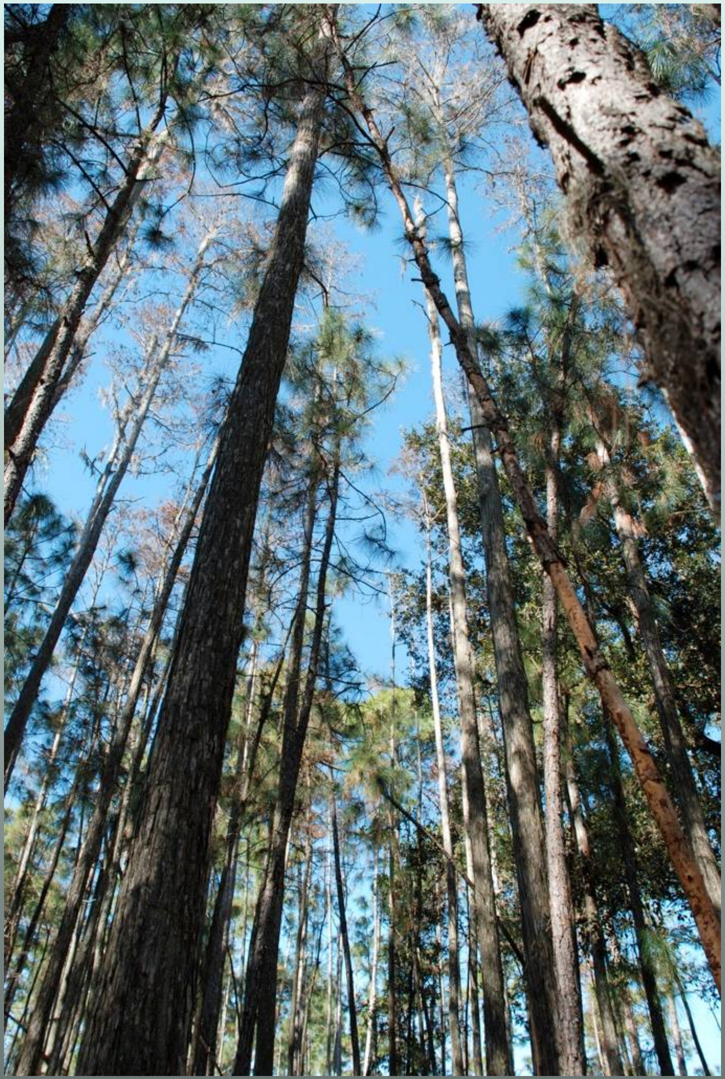
-Increase number of sample sites; focus on NP-12 elevation (most sensitive to “harm”)

- Explain the “healthy” outlier

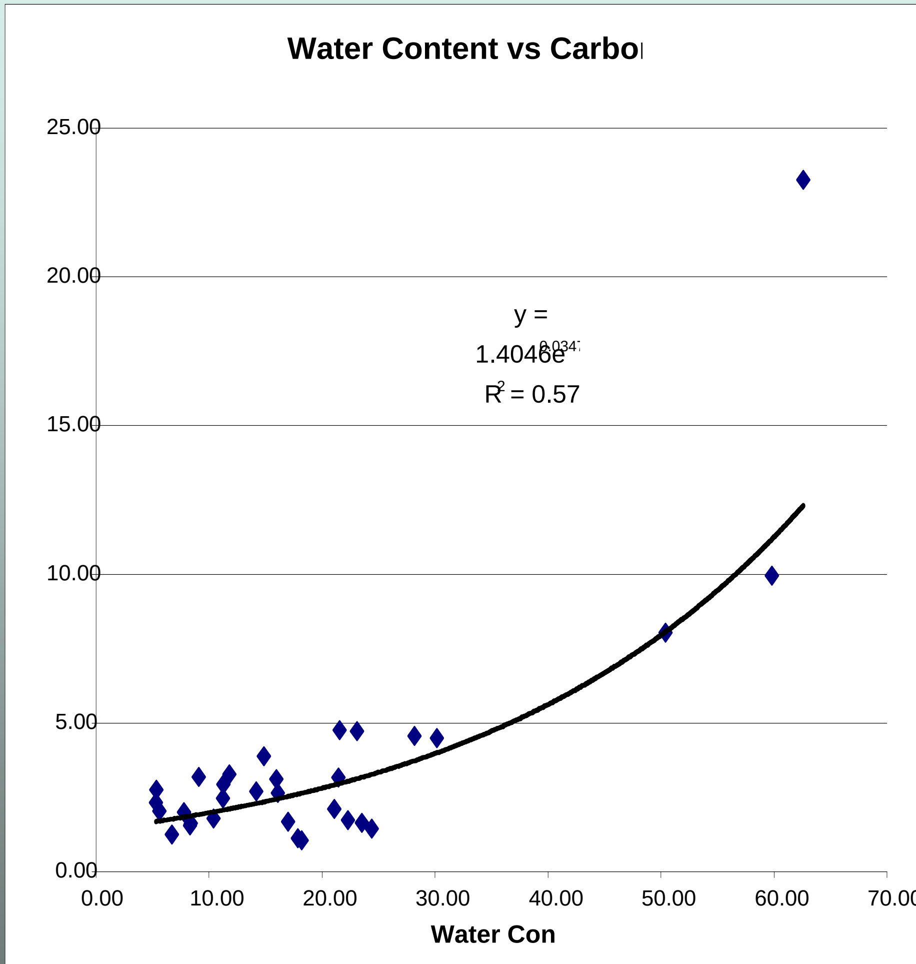
- Develop the soil moisture meter sampling protocol

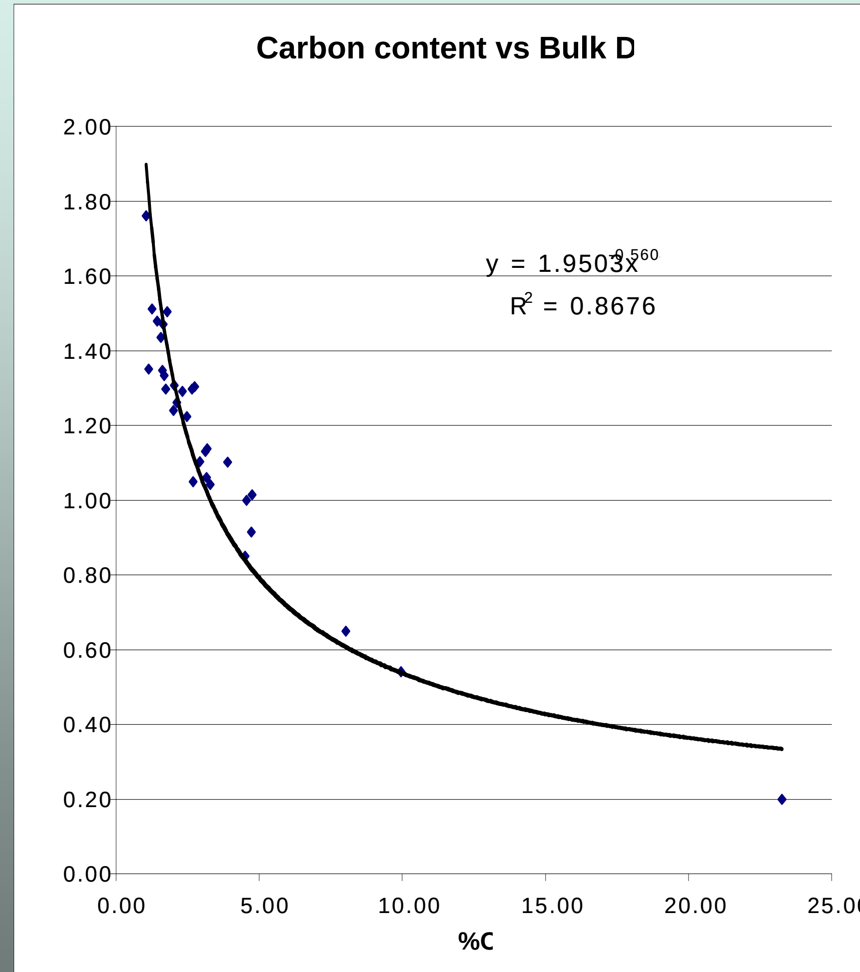
- Further analysis of C and N isotopes ($\delta^{13}C$ and $\delta^{15}N$)

- Examine %N values and SON

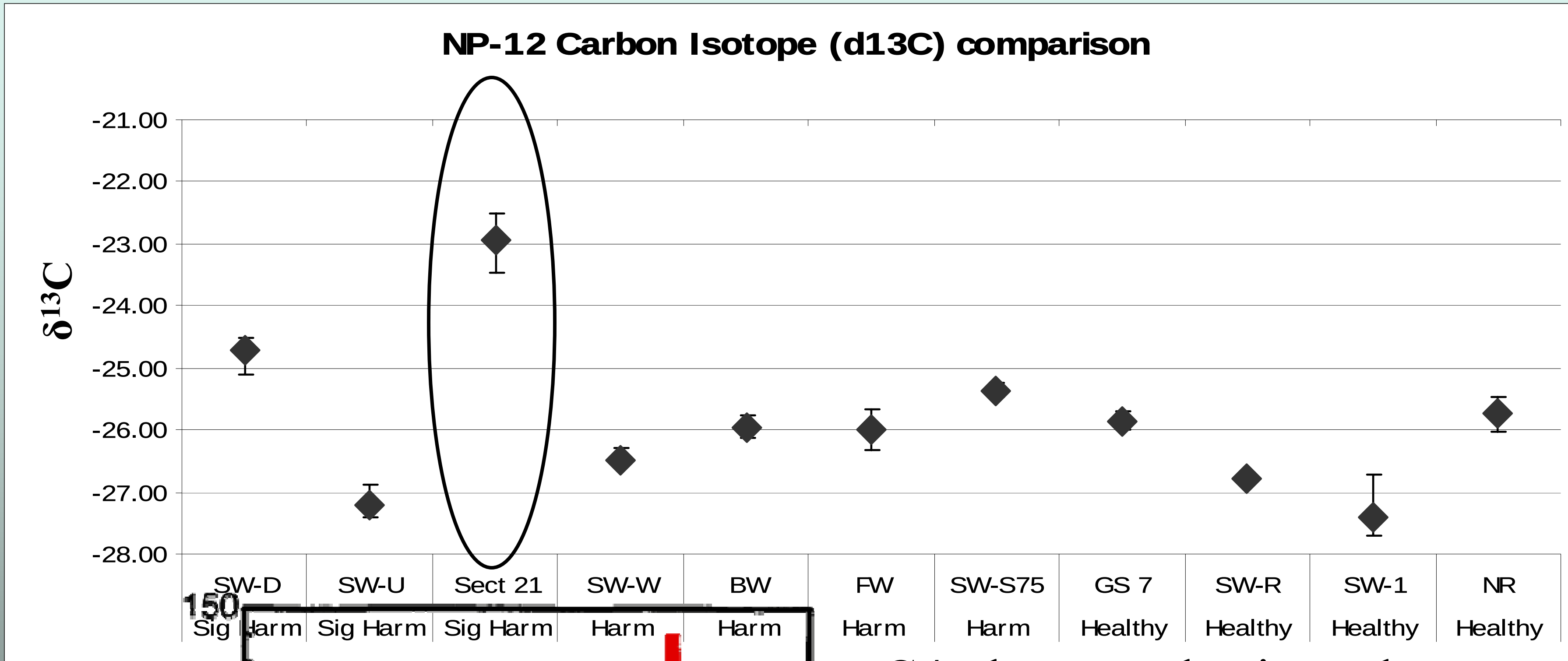


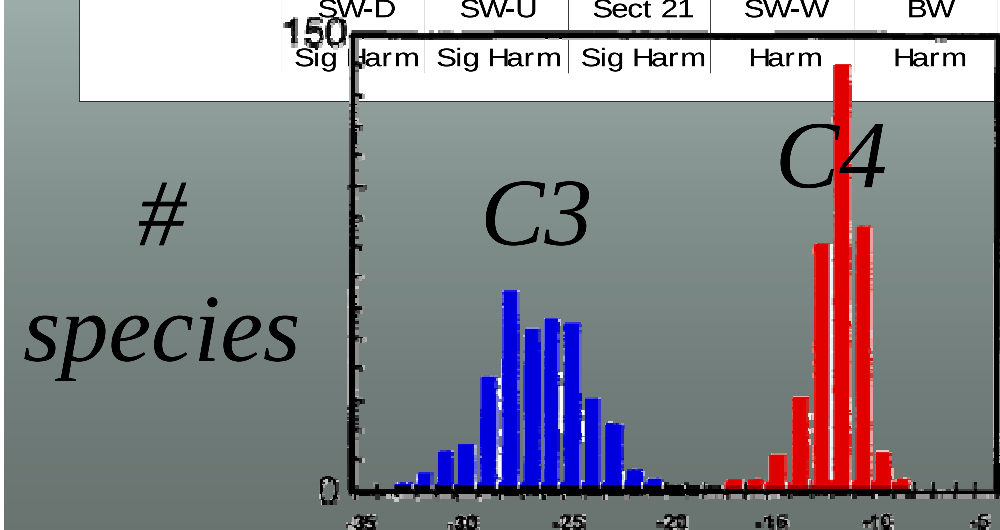
Relationships between SOC and other properties





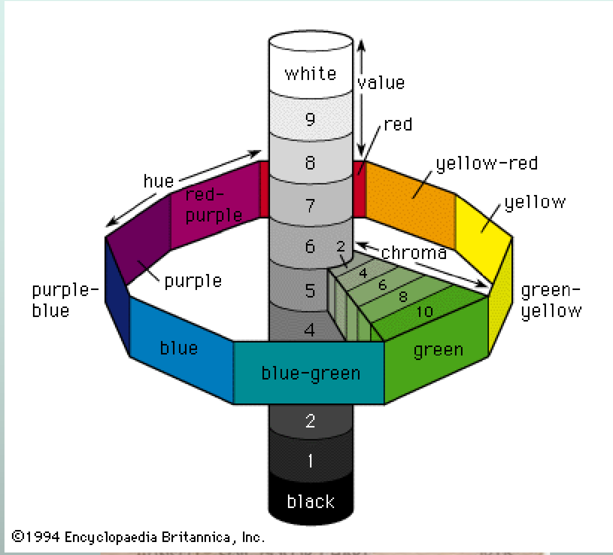
Carbon Isotopes

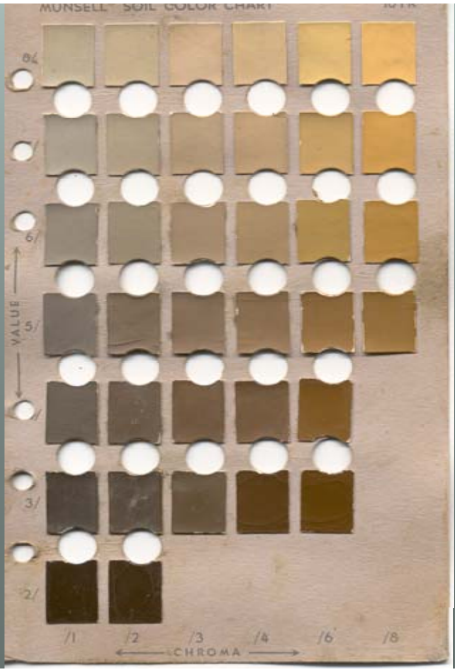


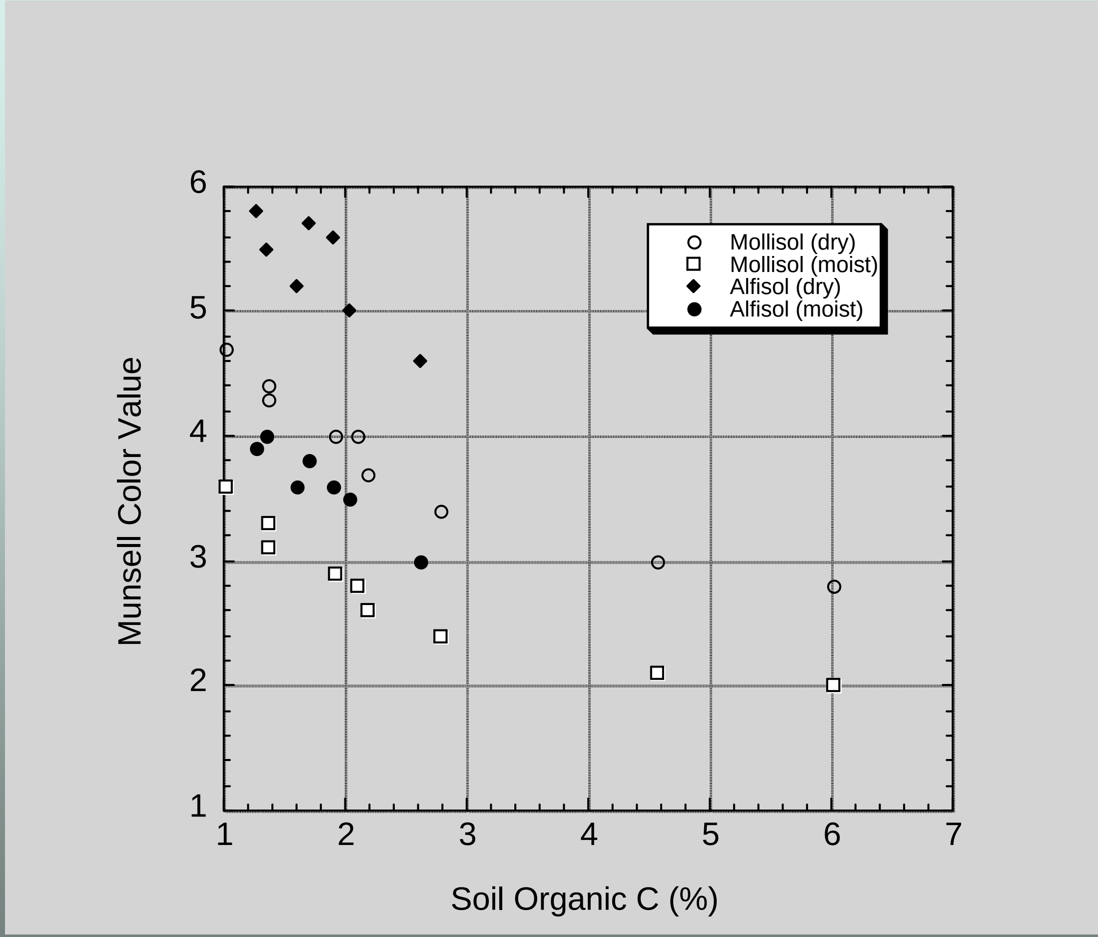


C4 photosynthesis: only occurs in tropical grass and forb families specifically adapted to low water availability (dry season).

Soil Color as Soil Carbon Proxy

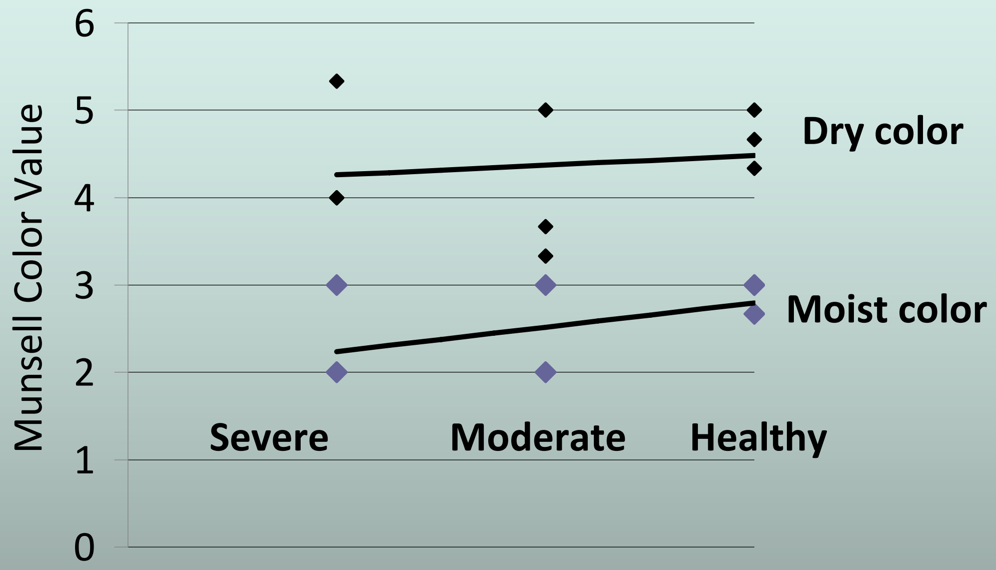


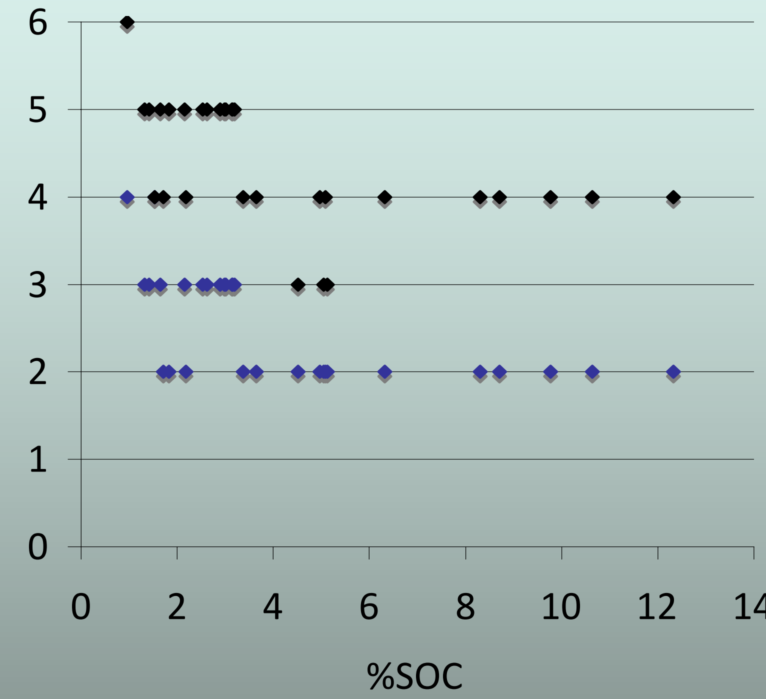




From R. Amundson, *Treatise Geochem.*

Soil Color as Soil Carbon Proxy





Organic Matter Decomposition Factor

(Hauer et al. 2002)

- Developed for use in rapid assessment procedures on floodplains in the northern and southern Rocky Mountains
- Reference sites scaled from 0 (low function) to 1 (high function) based upon a variety of measured or observed attributes
- Organic matter decomposition function calibrated to similarly scale reference sites based solely upon rapid measurements of soil characteristics

Organic Matter Decomposition Factor

(Hauer et al. 2002)

$$\text{OMDF} = \left[\left(\text{O - horizon depth}\right) + \left(\frac{\text{SMS - horizon depth}}{\text{Soil color value}} \right) \right]$$

where

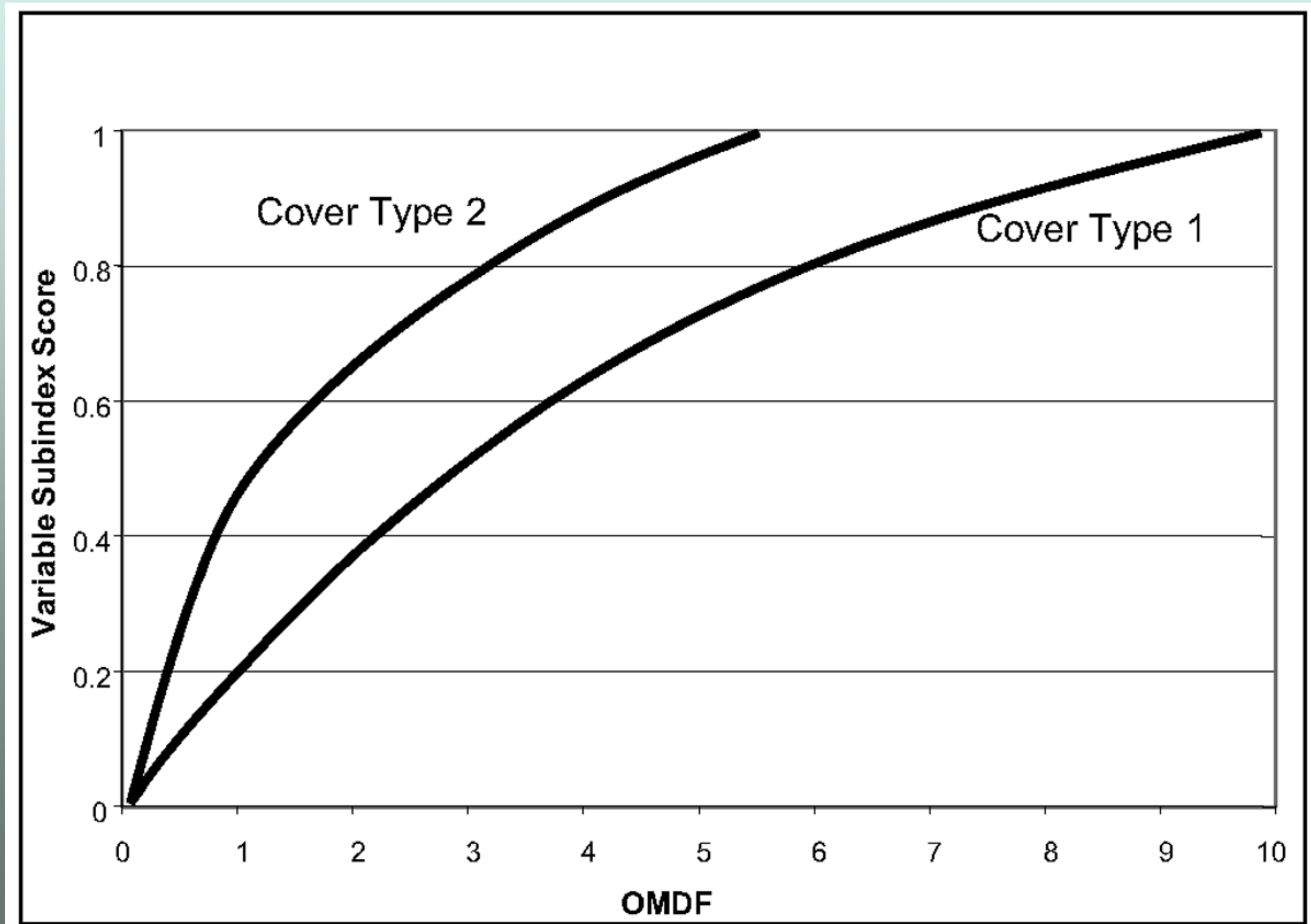
OMDF = Organic matter decomposition function

O - horizon depth = Thickness of the O - horizon

SMS - horizon depth = Total thickness of the A - and E - horizons

Soil color value = Value of a moist bulk sample of the SMS - horizon

Organic Matter Decomposition Factor



Organic Matter Decomposition Factor