A Comparison of Soil Condition, Vegetation Communities, and Soil Redox Characteristics of Surface Mined Wetlands and Natural Wetlands in Southern Illinois

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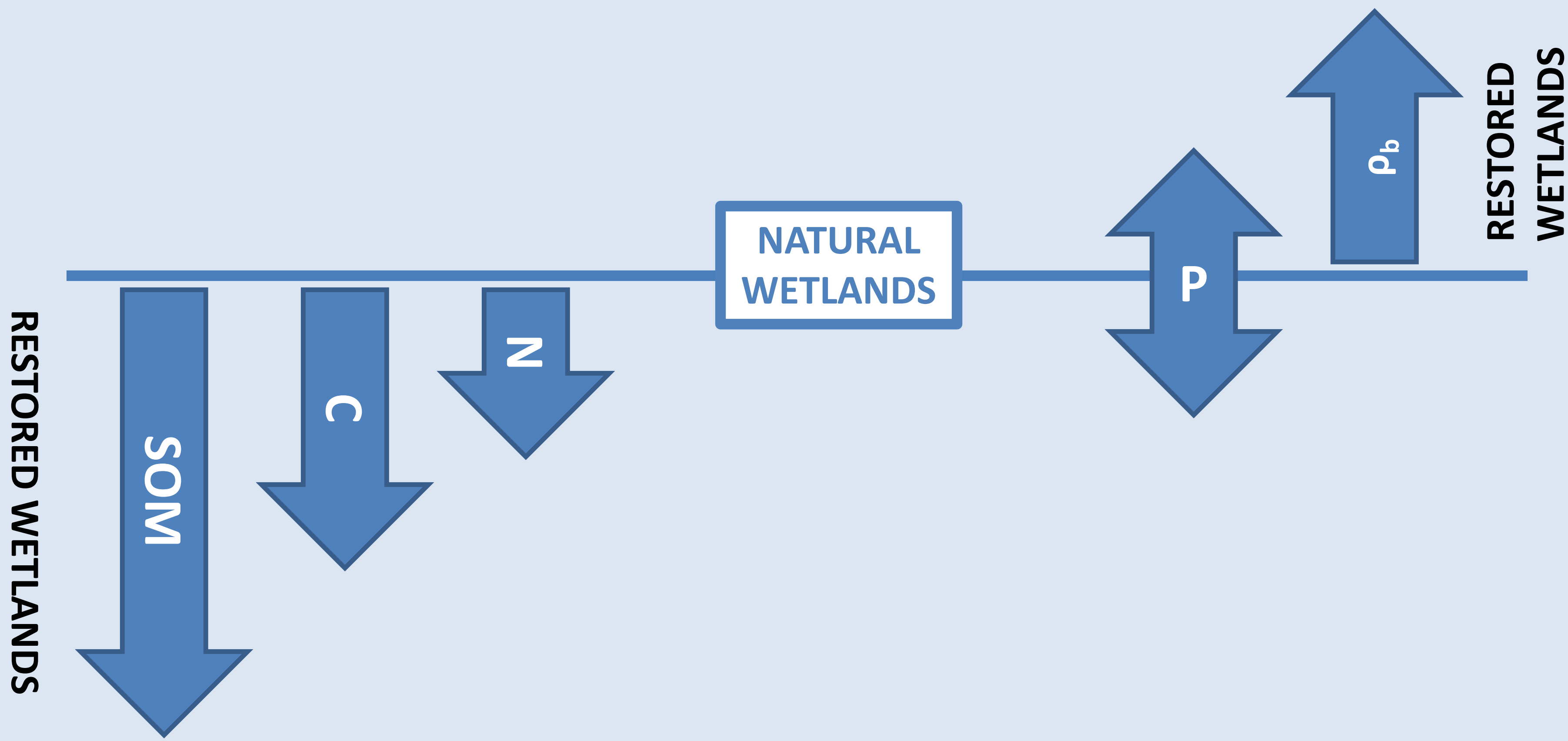
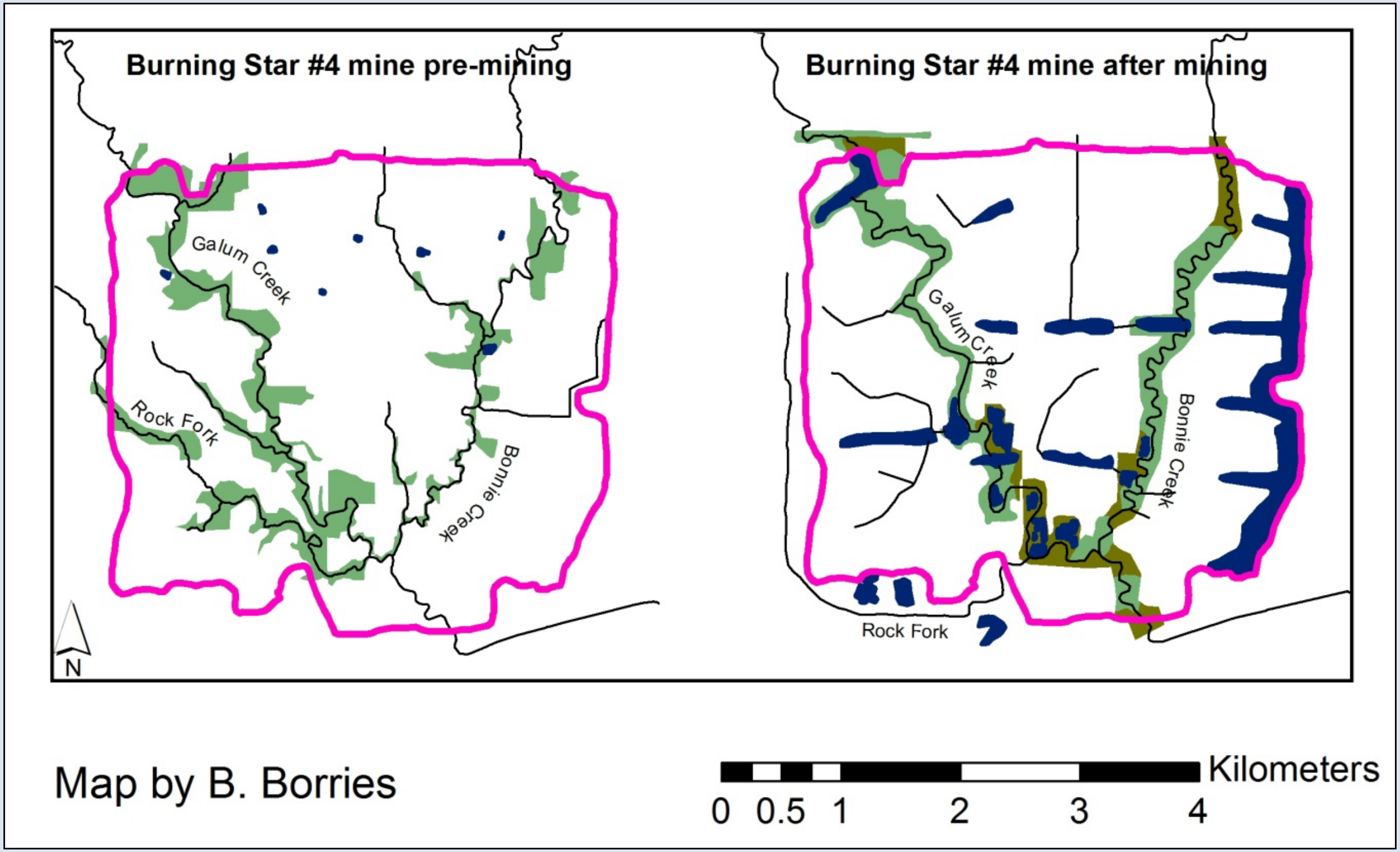
Soil Properties of Restored Wetlands vs. Natural Wetlands



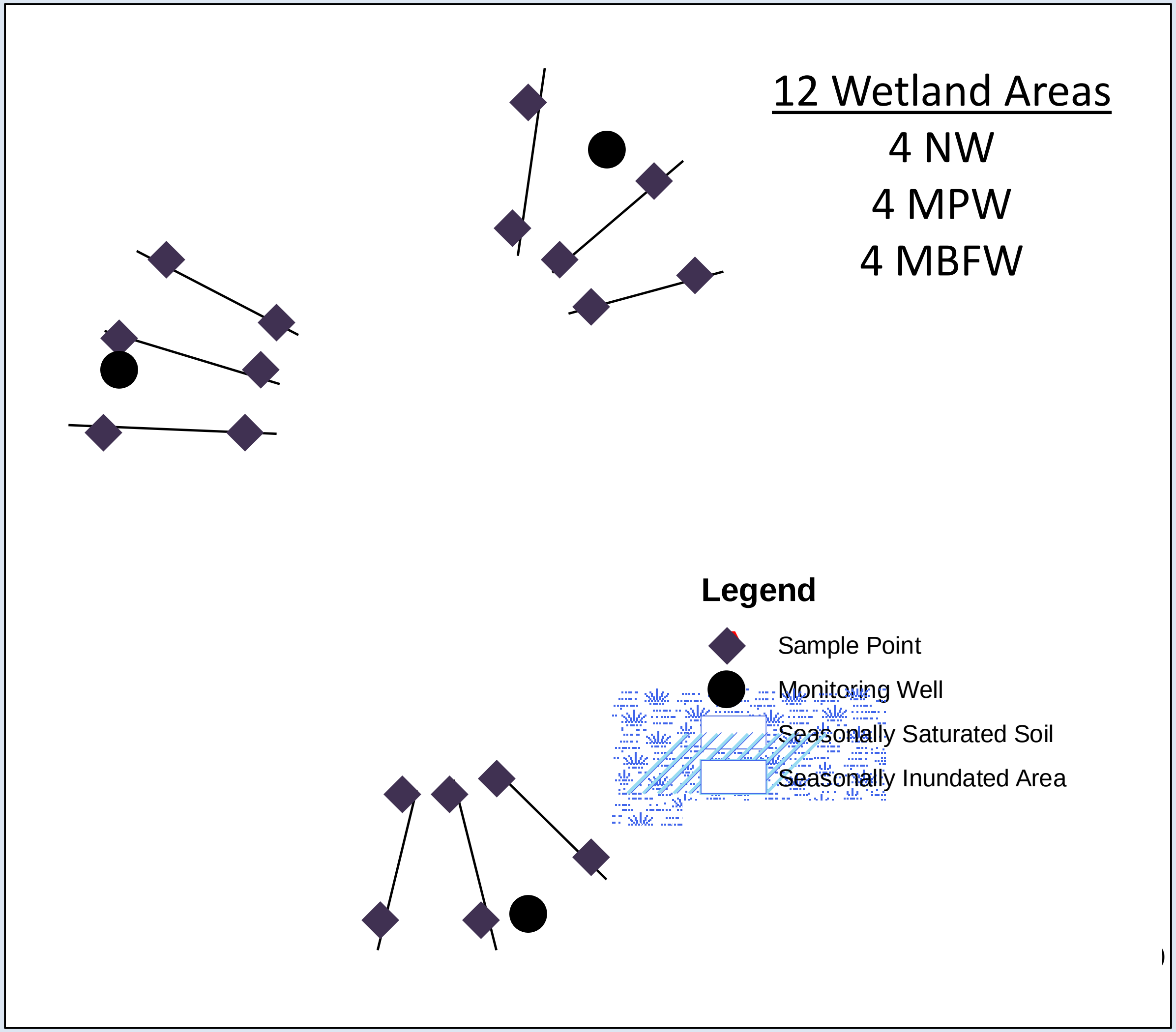
Purpose: Evaluate the soil biogeochemical function and herbaceous vegetation of wetlands restored on surface mines

- Do mined wetland soils retain or recover levels of nutrient and organic matter pools equal to natural wetlands?
  - as measured by the following parameters:
    - Soil Organic Matter (SOM), Soil C, Soil N, Soil P, C/N ratio
- Do soil nutrient organic matter pools change with time in mined wetlands
  - as measured by tests of trends by soil age in the following parameters:
    - SOM, C, N, P, and C/N ratio
- Do mined wetlands have the same hydrology as natural wetlands?
  - as measured by IRIS tubes
  - As measured by the frequency and duration of soil saturation in wetlands
- Do mined wetlands have the same vegetation as natural wetlands?
  - as measured by the following parameters:
    - Taxa richness, Wetland status prevalence index, % bare soil

Study Area: Before and after mining



Study Design: Sampling plan



In each Wetland Area

9 transects

One upper and one lower sample point

36 Soil Samples

Each SP split into 0-15 and 15-30 cm depths

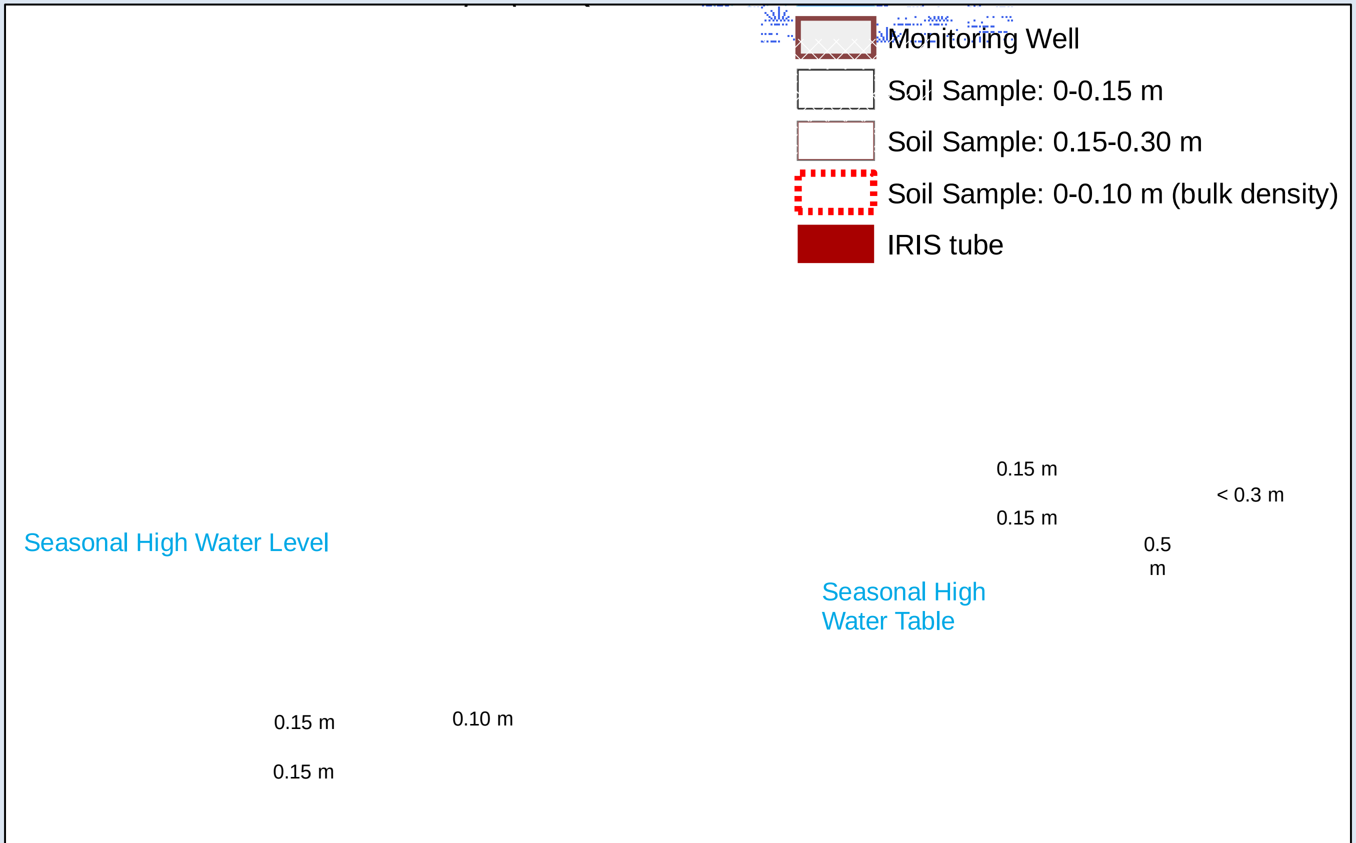
18 vegetation plots

9 IRIS Tubes

3 Monitoring Wells

Study Design: Transect x-section

Soil properties vary depending on topographic position - sampling was split into upper and lower sample points



Methods: Soils

- Samples collected June-August 2012
- ρ_b and gravimetric soil moisture (GSM) collected with an impact driven corer with a known volume
- All other samples were collected with a 5 cm diameter auger, air dried and crushed
- Samples were analyzed for SOM, Bray II P, and CEC by Brookside labs
- C, N, and C/N analyzed with a total C/N analyzer at SIUC
- ρ_b and GSM were measured by oven drying impact corer samples
- Soil texture was measured by hydrometer method

Methods: Vegetation and hydrology

- Percent cover of each herbaceous species and % bare area in a 0.25 m^2 plot was estimated according to Daubenmeier (1954) at each SP
- Canopy cover from densiometer
- Taxa richness (TR) and wetland plant prevalence index (PI) was also calculated
- IRIS tubes created according to Jenkinson and Fransmeier (2005), analyzed with gridded contact paper according to Rabenhorst (2011)
- SP surveyed with total station and tied to RTK-GPS vertical benchmarks

Calculations: Hydrology

- Hydrology variables: inundation (IN) and saturation (SAT) count
  - Functions of groundwater (GW) elevation and difference in elevation between SP and associated monitoring well (well)
  - Assumptions: GW elevation is equal across a block of transects associated with a well

Well GW Depth = Well elevation – depth to GW (*from collar*)

SP GW Depth = SP elevation – Well GW Depth

IN count = # times GW > SP elevation

SAT count = # times GW was within 30 cm of SP elevation

Methods: Statistics

- Data were separated by location (upper or lower) and depth (0-15 cm or 15-30 cm)
  - Treatments were compared using a one-way ANOVA (PROC GLM in SAS) model or the Kruskal-Wallace rank-sum test (soil N and C/N)
  - Trends by soil age in MW were tested using a linear regression test when the same between MPW and MBFW and a step-trend ANOVA/K-W test when different between MPW and MBFW

Wetland area	Treatment Class	Lat (dd)	Long (dd)	Soil Age (years)	Size (km^2)	Watershed (km^2)
GAL1	MBFW	38.080518	-89.546028	28	3.21E-03	4.08E-02
GAL2	MBFW			28	4.65E-03	1.23E-02
GAL3	MBFW			28	1.05E-03	5.25E-02
GALC1	MPW	38.058720	-89.532437	25	9.36E-03	2.87E-02
GALC2	MPW	38.055909	-89.531824	25	3.39E-02	5.51E-02
BON1	MBFW	38.057239	-89.525484	21	8.67E-03	3.47E-02
BONC1	MPW	38.062799	-89.521813	19	1.12E-02	6.72E-02
BONC2	MPW	38.060407	-89.523414	19	1.23E-02	7.87E-01
LGAL1	NW	38.018040	-89.439554	N/A	1.21E-02	3.70E-02
LGAL2	NW	38.017704	-89.436491	N/A	8.73E-03	2.35E-02
LGAL3	NW	38.026255	-89.435087	N/A	2.04E-03	1.26E-02
LGAL4	NW	38.026991	-89.431518	N/A	2.50E-03	1.36E-02

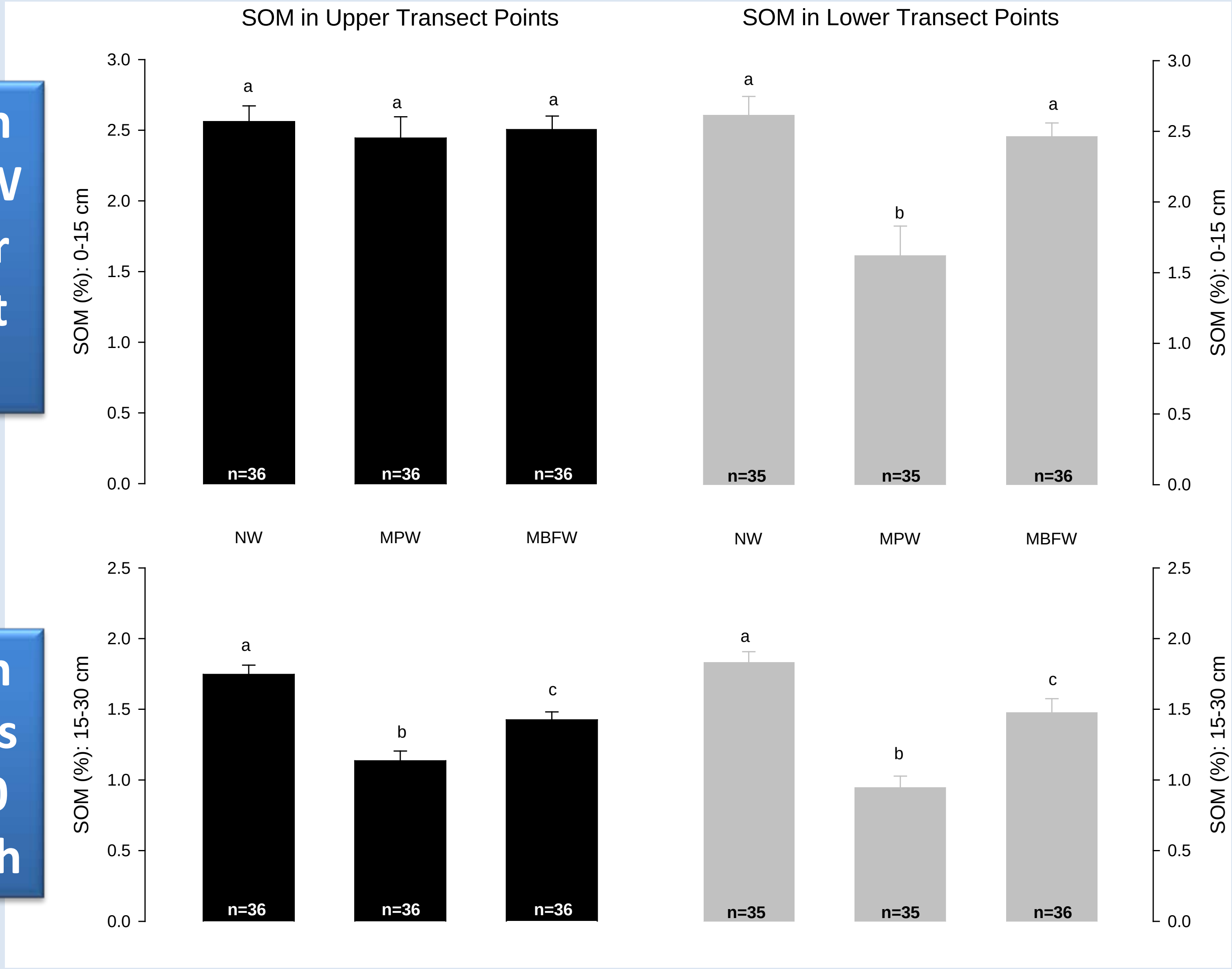
Soil age ranges from 19-28 years


RESULTS/DISCUSSION
Photo: Jack Nawrot

SOM: Comparisons among treatments at different sample locations and depths

<SOM in the MPW at lower transect points

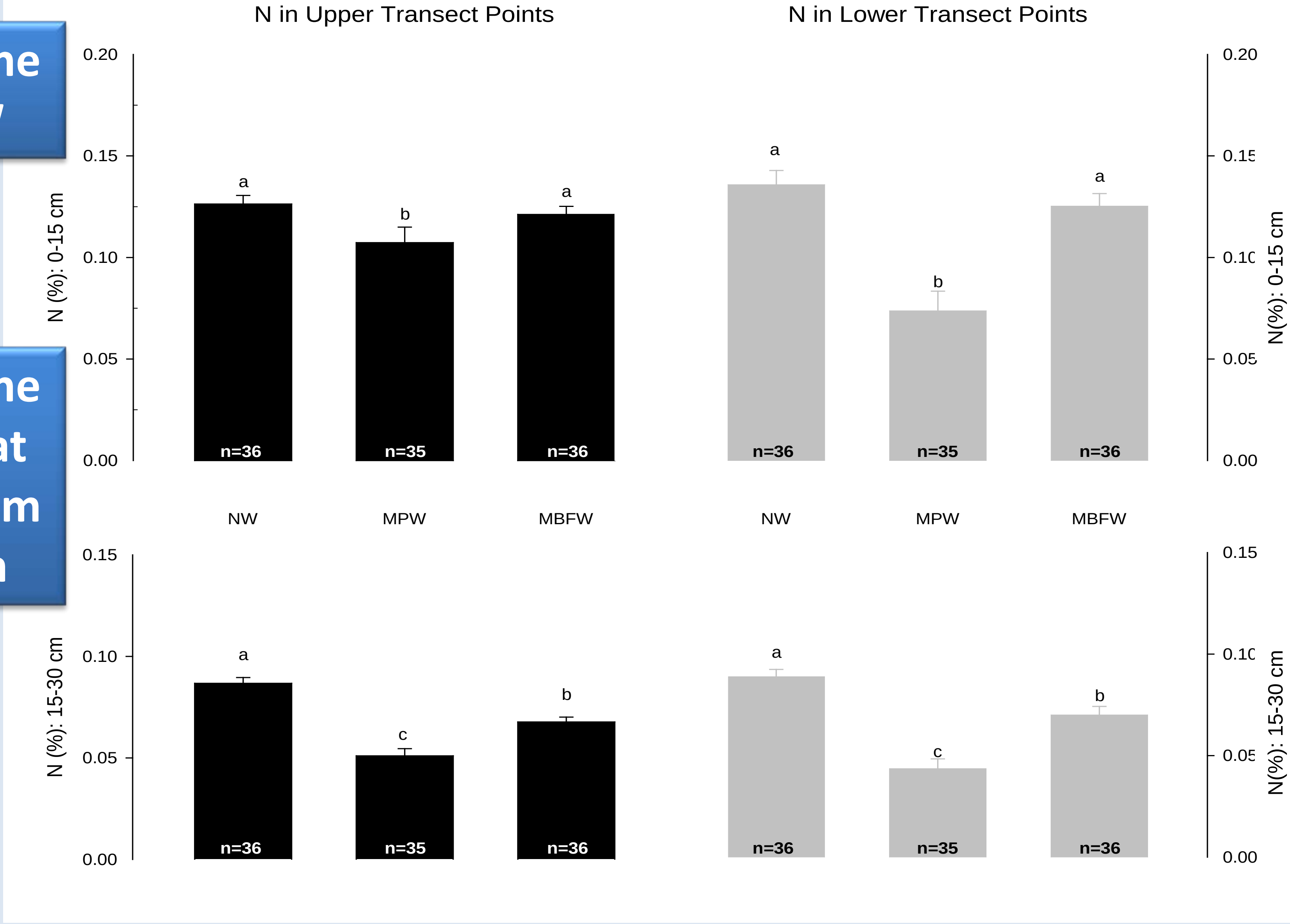
<SOM in the MWs at 15-30 cm depth



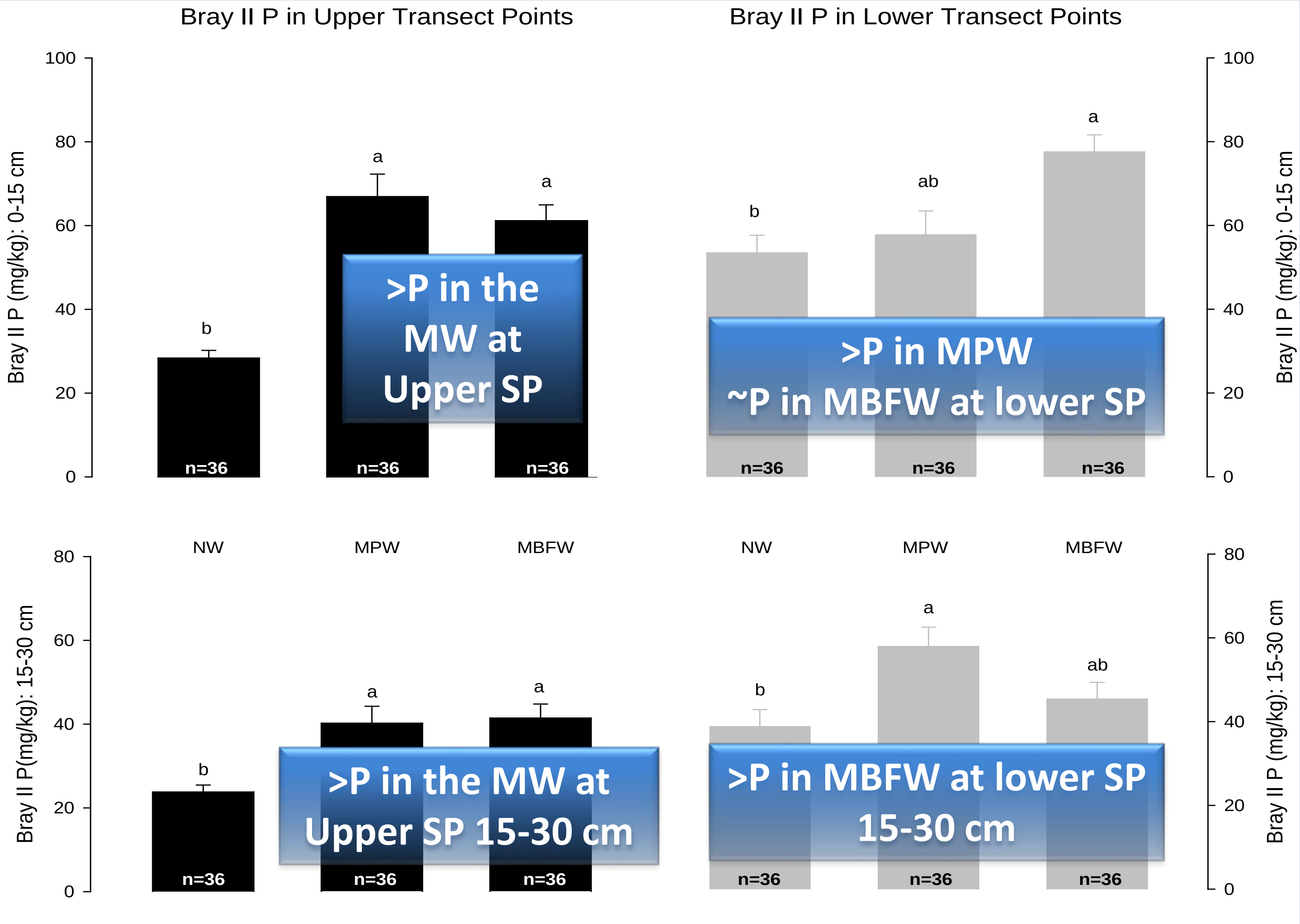
Soil N: Comparisons among treatments at different sample locations and depths

<N in the MPW

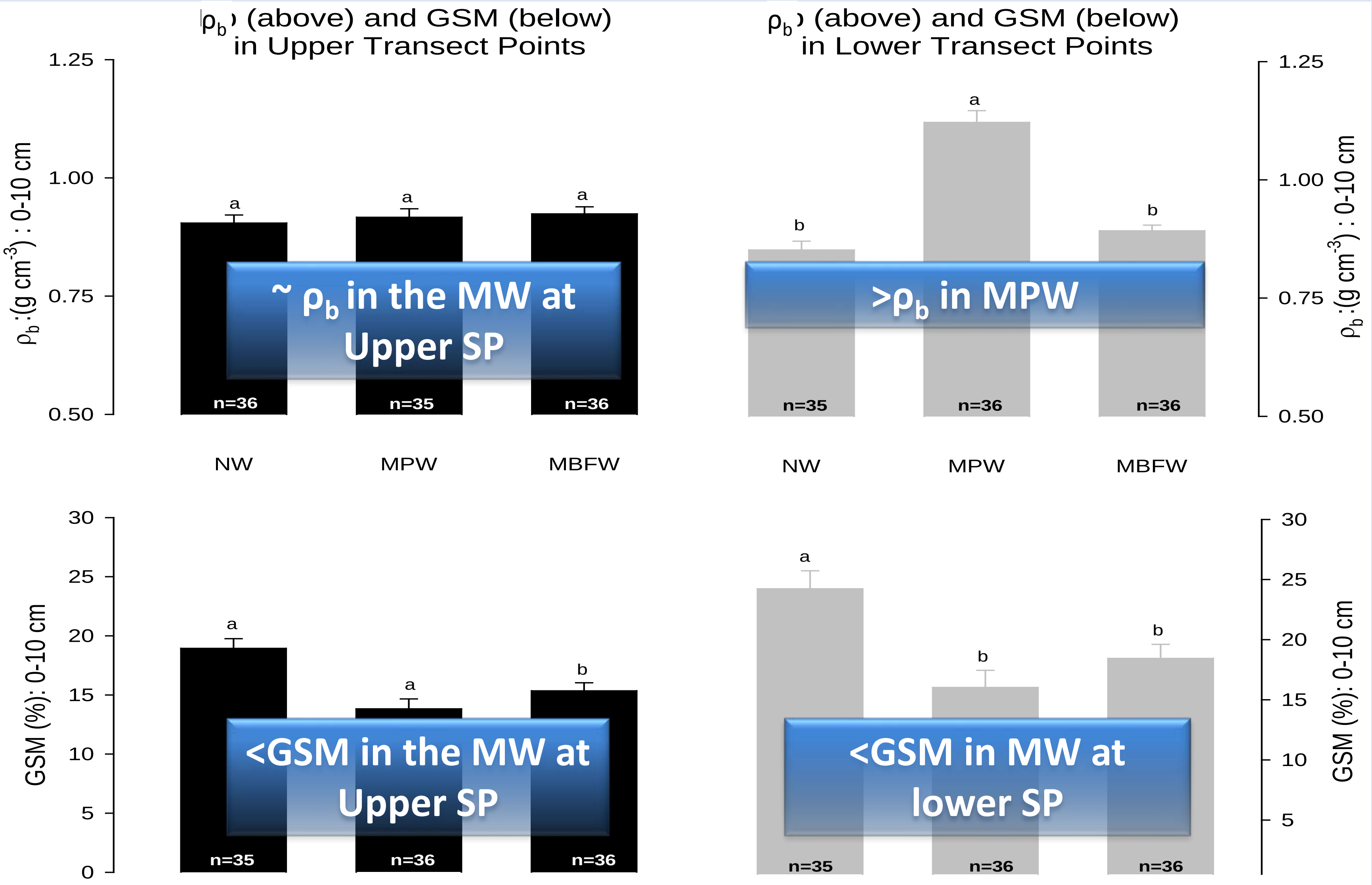
<N in the MWs at 15-30 cm depth



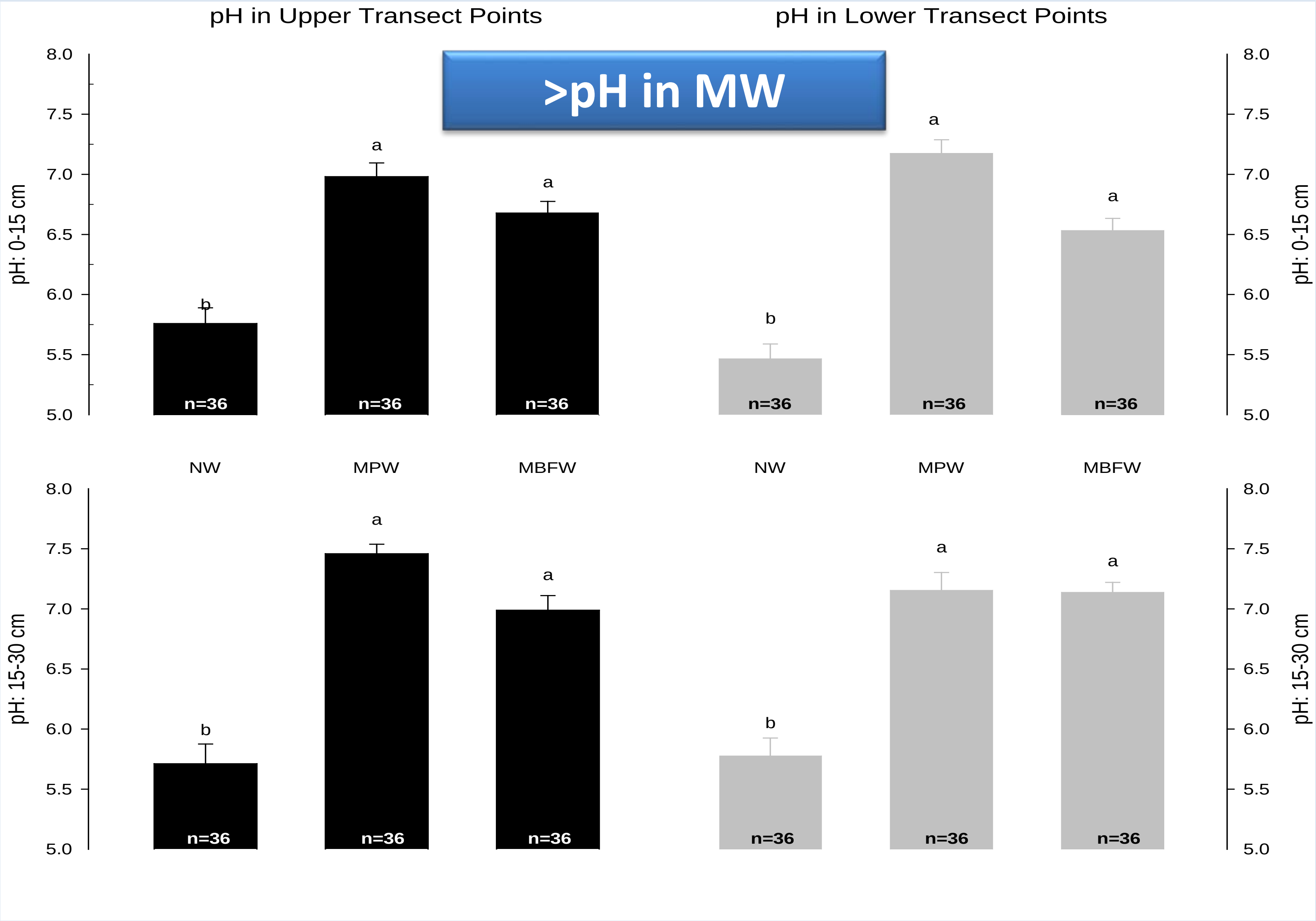
Soil Bray II P: Comparisons to Natural Wetlands at different sample locations and depths



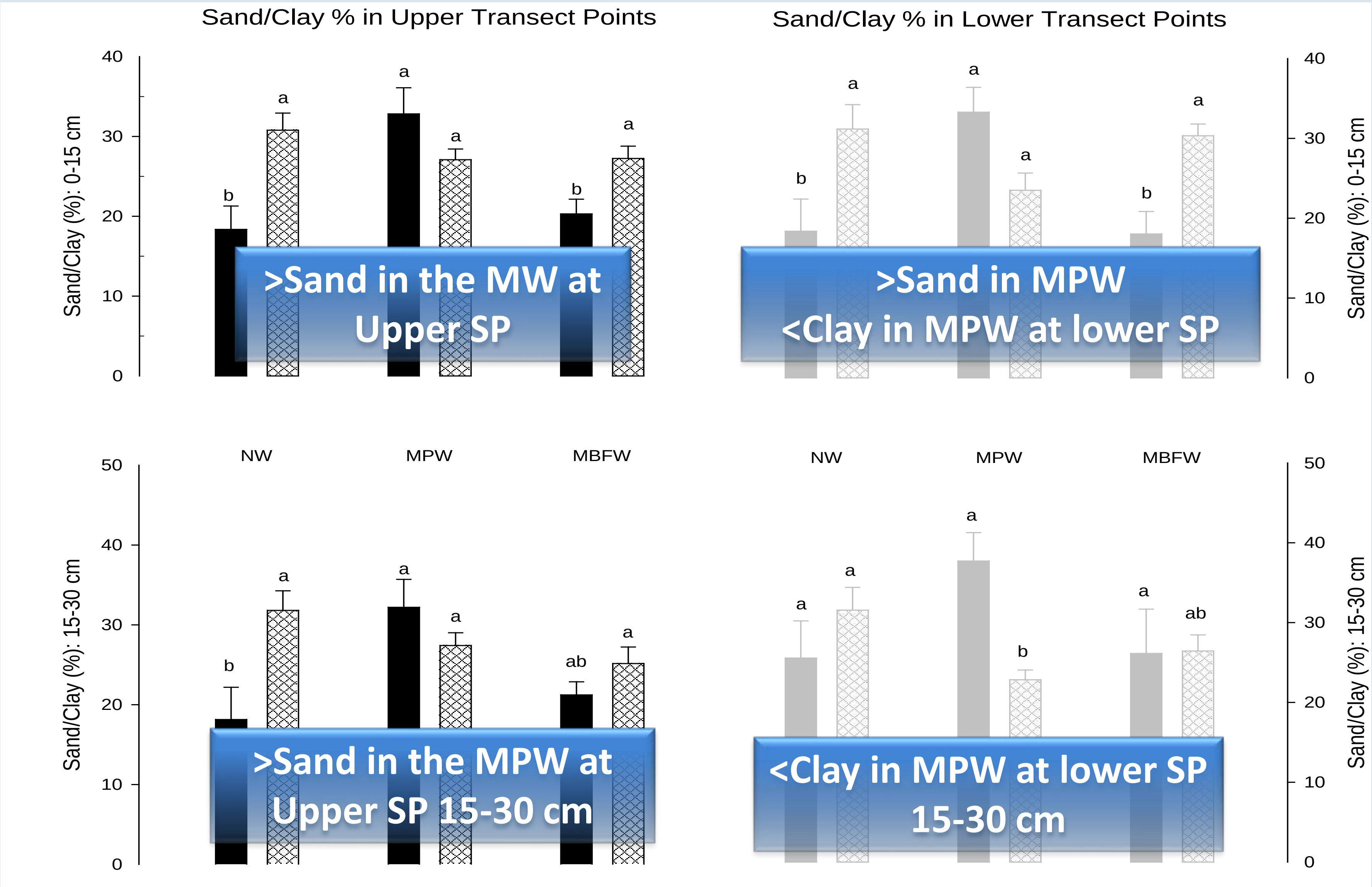
ρ_b and GSM: Comparisons among treatments at different sample locations



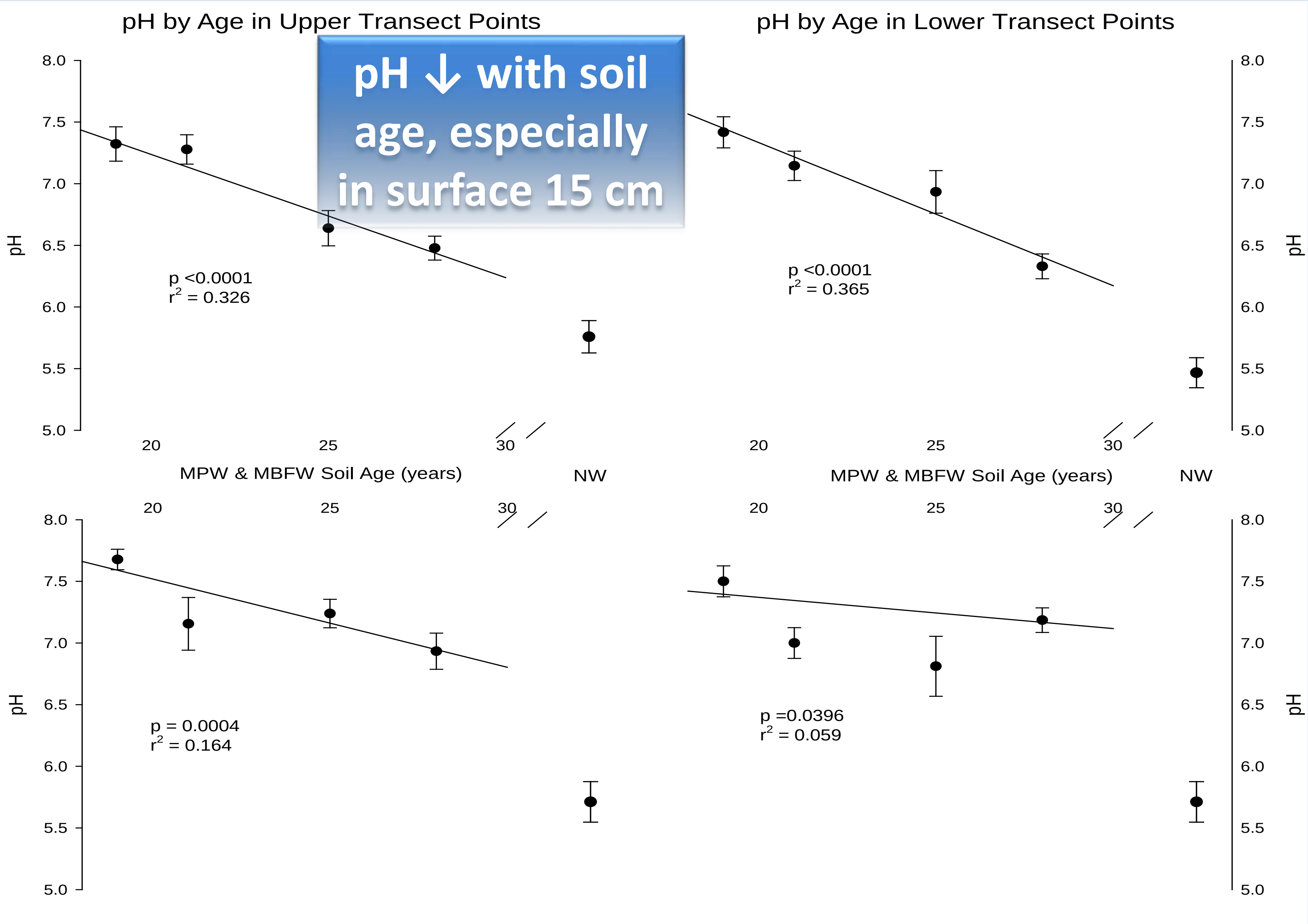
Soil pH: Comparisons among treatments at different sample locations and depths



%Sand (Black) and %Clay (Hash): Comparisons among treatments at different sample locations and depths



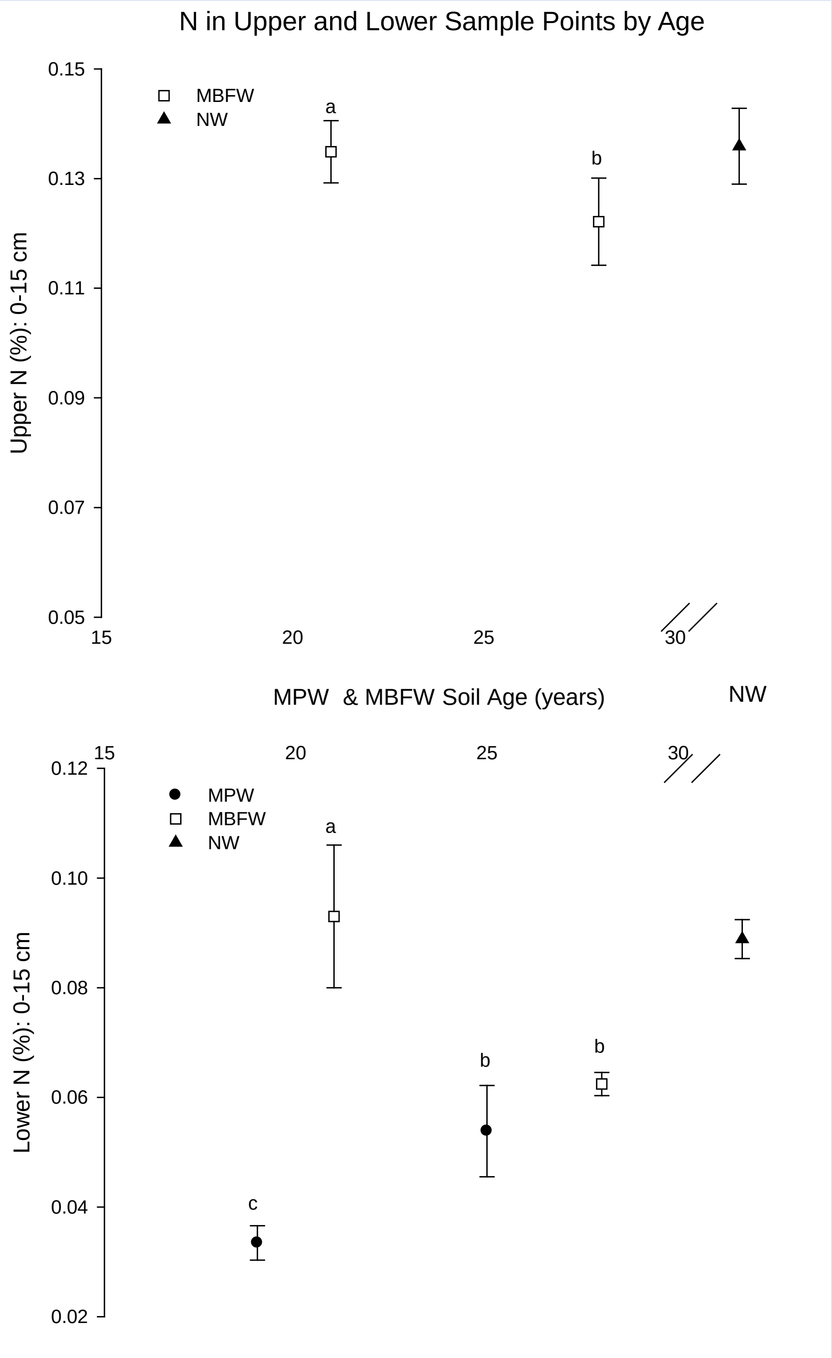
Soil pH: Trends with age at different sample locations and depths



Soil N: Comparisons by age at different sample locations

<N in older soils of MBFW (upper SP)

>N in older soils of MPW (lower SP)
<N in older soils of MBFW (lower SP)



Dominant Species at each wetland type:% of total cover

NW - Upper Sample Points		NW - Lower Sample Points	
Symphyotrichum lateriflorum	28.7	*Symphyotrichum lateriflorum*	11.17
Microstegium vimineum	19.7	*Carex Frankii*	6.22
Elymus virginicus	9.0	*Carex sp.*	5.16
Toxicodendron radicans	6.2	*Lysimachia nummularia*	4.85
Ranunculus hispidus	6.0	*Saururus cernuus*	4.21

MPW - Upper Sample Points		MPW - Lower Sample Points	
Phragmites australis	55.8	*Cyperus strigosus*	51.98
Iva annua	21.5	*Eleocharis acicularis*	15.04
Carex vulpinoidea	12.9	*Cinna arundinacea*	8.62
Eleocharis obtusa	10.4	*Ammannia auriculata*	6.10
Carex Frankii	4.5	*Echinochloa crus-galli*	2.71

MBFW - Upper Sample Points		MBFW - Lower Sample Points	
Carex vulpinoidea	34.3	*Carex vulpinoidea*	16.43
Elymus virginicus	22.4	*Eleocharis obtusa*	15.85
Iva annua	13.5	*Typha latifolia*	9.25
Persicaria virginiana	3.0	*Phyla lanceolata*	8.50
Carex Frankii	2.9	*Iva annua*	5.86

Vegetation: PI, TR, bare area, and canopy cover. Comparisons among treatment groups

- <PI (wetter plants) in MWs
- <TR in MWs in upper SPs
  >TR in MPWs in lower SPs
- < bare area in MWs
- < canopy cover in MWs

		NW	MPW	MBFW
Upper				
Sample Points	p	mean ± s.e	mean ± s.e	mean ± s.e
Prevalence Index	<0.0001	2.55 ± 54.72a	2.11 ± 49.78b	2.22 ± 0.09b
Taxa Richness	<0.0001	3.25 ± 0.22a	1.97 ± 0.24b	1.86 ± 0.18b
Bare (%)	<0.0001	0.08 ± 0.01a	0.01 ± 0c	0.05 ± 0.01b
Canopy Cover (%)	<0.0001	93.58 ± 0.51a	2.25 ± 1.14c	54.72 ± 4.86b
Lower				
Sample Points	p	mean ± s.e	mean ± s.e	mean ± s.e
Prevalence Index	0.0038	2.31 ± 0.19a	1.8 ± 0.07b	1.7 ± 0.13b
Taxa Richness	<0.0001	1.14 ± 0.19b	2.92 ± 0.22a	1.5 ± 0.19b
Bare (%)	<0.0001	0.17 ± 0.02a	0.06 ± 0.01b	0.1 ± 0.02b
Canopy Cover (%)	<0.0001	92.33 ± 0.68a	0.11 ± 0.11c	49.78 ± 4.68b

Conclusions: Wetland soil properties

- Recovery or maintenance of soil nutrient pools to levels equivalent to NWs in the surface 15 cm has occurred for SOM, C, and P in all MWs and for SOM, C, N, and P in the MBFWs
- Pools at the 15-30 cm depth are equivalent for C and P – Some C pools more recalcitrant than SOM; P high in subsoil of alfisols
- Only soil pH is changing with time past 19 years at all MWs – Soils started with existing nutrient pools or accumulation leveled off after <19 years

Conclusions: Hydrology and vegetation

- Based on the 5 dominant species, all three treatment groups had a unique vegetation community
- MWs appeared wetter based on the PI and data inferred from the wells and SP elevations
- TR was higher in the lower SPs in the MPWs due to the open canopy. More vegetation analysis is required to compare diversity on a landscape level

Conclusions: Are wetlands restored on mine soils different from wetlands restored on natural soils?

- In Alabama (Sistani et al 1996) and Southern IL (Cole & LeFebvre 1991): equal SOM and C in mined wetland soils compared natural wetlands
- BS4N reclamation was able to use soils which had been under forest cover – Most wetland restoration occurs on soils depleted by row-crop agriculture
- Hydrology controlled by channel dimensions resulting in more regular overbank flooding

Management Implications: Design and soil source important for successful restoration

- Sand% was neg. correlated with every soil nutrient and organic matter stock – signaled a different soil source for the MPWs than the MBFWs
- Prolonged inundation restricted plant growth and buildup of nutrient pools at the MPWs
- Dominance by *Phragmites australis* occurred where conditions were supportive – reduced diversity

Acknowledgements

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Questions?