Edaphic Response to Bottomland Hardwood Forest Wetland Restoration in Arkansas

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Introduction

Southern bottomland hardwood wetlands (BLHW) are known to be highly productive ecosystems, driven by hydrologic fluctuations at the transition between upland and deepwater habitats. These wetlands provide valued functions including flood attenuation, water quality enhancement and wildlife habitat. Historic wetland losses in the Lower Mississippi Alluvial Valley (LMAV) and increased awareness of these characteristics has made restoring wetland ecosystems a national and state level priority. Reestablishing wetland structures and functions in new conservation areas is a priority. It has been suggested that recreating variable microtopography, swales and hummocks, positively influence wetland biogeochemical processes and should be included in wetland restoration design.[1,2,3]

Objectives:
This research is evaluating reestablished microtopograpic features 12-years after restoration activities on former cropland. In particular, we investigate total organic carbon, total nitrogen, and vegetative cover. We also developed reference soil density and texture maps.

Figure 1. Restored microtopographic features: Swale (A), Flat (B), Hummock (C)

Materials & Methods

Study Area:

- Owned and managed by the University of Arkansas at Monticello and enrolled in the USDA WRP
- Soils are poorly drained, mapped within the Perry Clay (Very-fine, smectitic, thermic Chromic Epiaquerts), 0 to 3% slopes, 32- to 34- m elevation.
- Irregular swales and spoil mounds were excavated throughout (Figures 1 and 2).

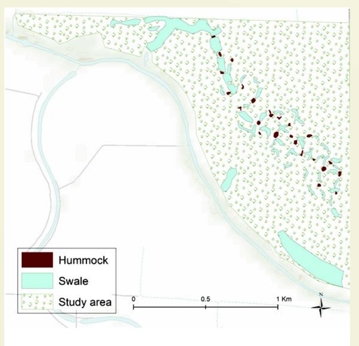


Figure 2. Study area boundary including swale and hummock features.

Soil Density and Texture:

- November 2012: 135 cores (90- cm) were taken using a Giddings probe (Giddings Machine Co. Fort Collins, CO).
- Soil bulk density was determined after drying at 105ºC.
- Soil texture was determined through the Gee and Bauder modified hydrometer method.[4]

Soil Carbon and Nitrogen:

- April and October 2013: a composite of three 15 cm depth soil cores were taken from hummock (10), flat (10), and swale (10) features (treatments).
- Soil was air dried and sieved to 2mm
- Total organic carbon (TOC) and total nitrogen (TN) were determined by combustion, Vario Max CN
- Treatments were compared using a repeated measures ANOVA (SAS Institute Inc. 2008). Season was not considered an effect.

Vegetation:

- Vegetation percent cover was observed with randomly placed nested plots on each treatment sampled, 1 m^2 (herb) and 3 m^2 (shrub/sapling).

Results

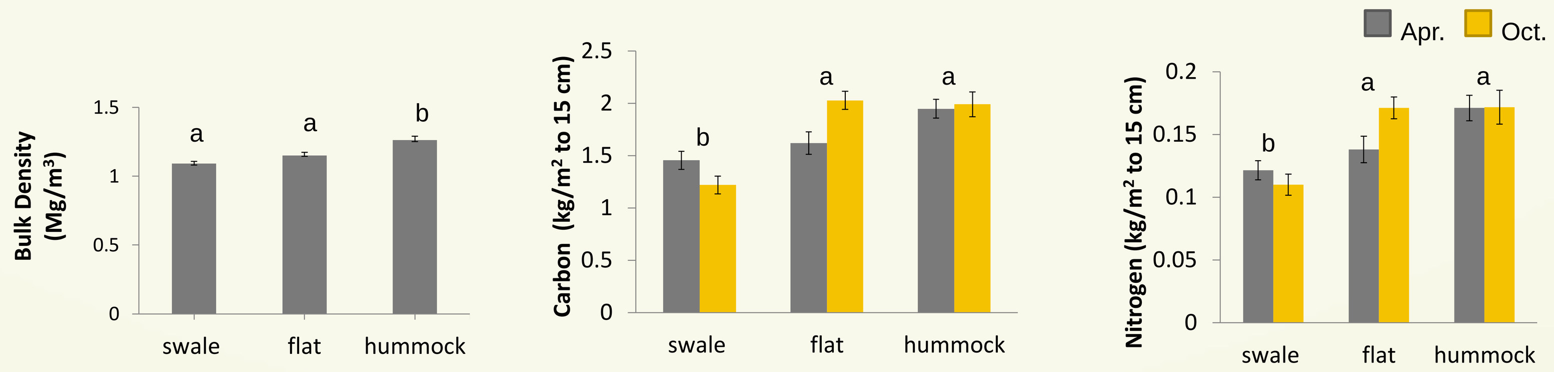
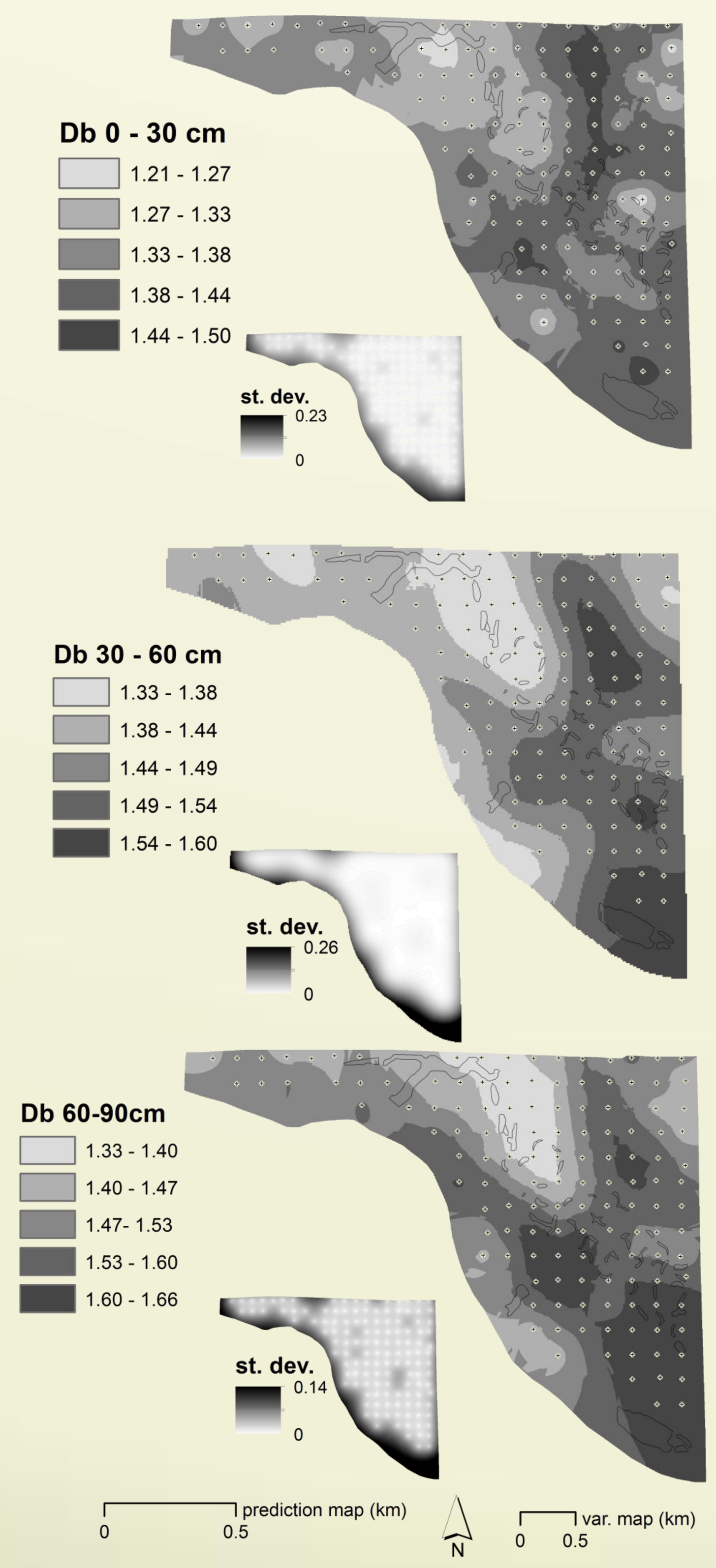


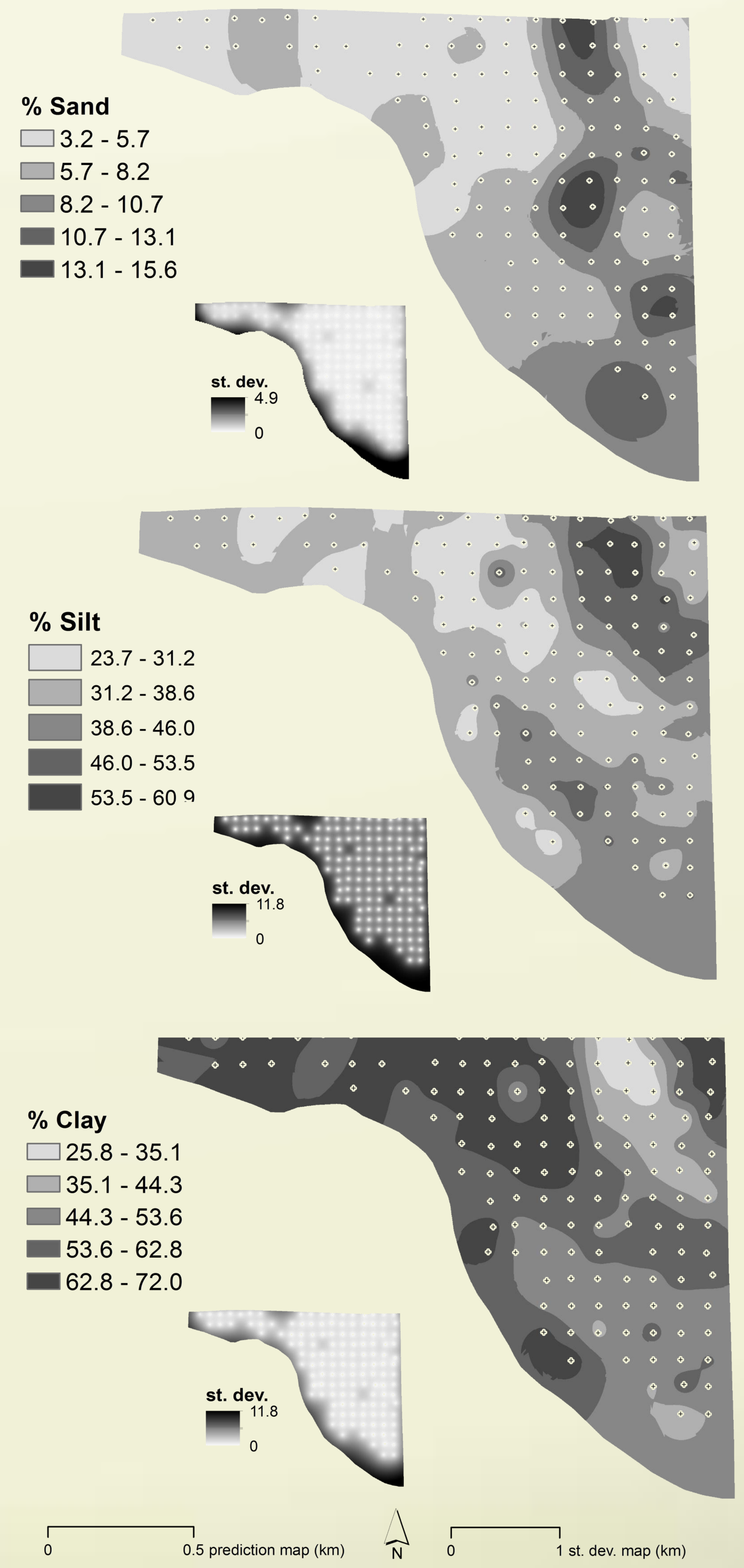
Figure 3. Observed bulk density, total organic carbon (TOC), and total nitrogen (TN) from 0- to 15- cm. Letters denote significant differences at p<0.05.

- Mean swale TOC is 27% and 32% lower than flat and hummock treatments respectively.
- Mean swale TN is 25% and 32% lower than flat and hummock treatments respectively.
- Average vegetation cover: Swale 68.4%, Flat 53.4%, Hummock 88.8%

Figure 4. Maps of soil bulk density (D_b) (Mg m^{-3}) and standard deviations at fixed depths produced by ordinary kriging. Scoured depressions are superimposed (black lines) over each image to show swale features.

Figure 5. Maps of soil texture, 0- to 30-cm soil depth and standard deviations produced by ordinary kriging.



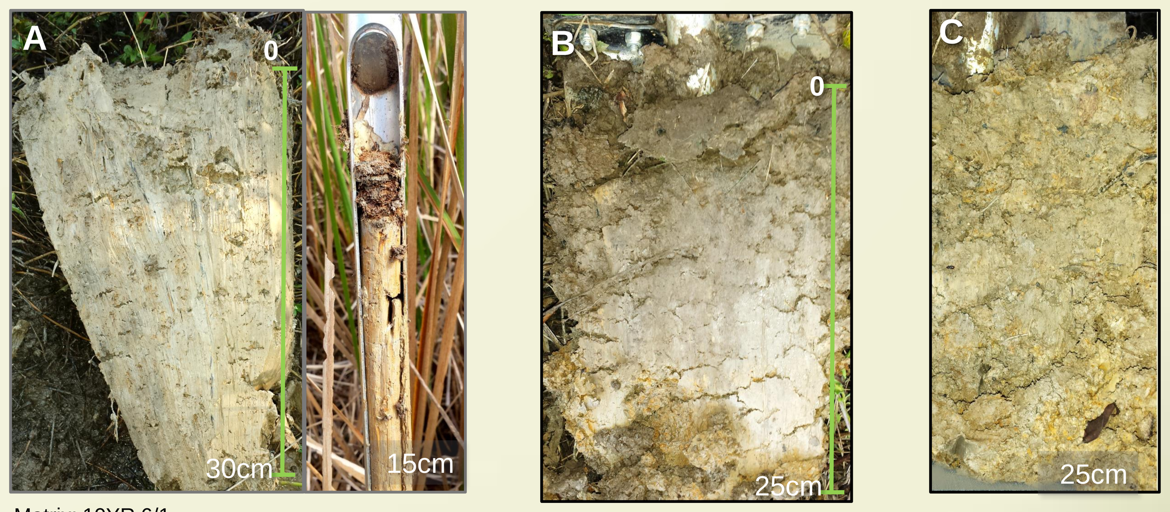


- Bulk density distribution is uniform with depth and increases from clay to stilly clay loam textures (Figure 4).
- Significant relationships were observed between silt, clay, and distance to adjacent streams. P <0.05. R^2 = ≤0.12 (Figure 5).

Discussion

- Semi-permanently inundated swales are expected to accumulate soil organic matter. This is not exhibited compared to less frequently inundated flats and hummocks.
- Significantly lower swale TOC and TN is likely due to:
  - Surface soil removal, 0.5- to 1.0- m, from swale treatments
  - Differing vegetation cover and leaf litter inputs from 0- to 12- years
- Bulk density decreases with saturation but is not distributed throughout the site as expected (Figure 4).
- Similar studies (Bruland and Richardson (2005); Simmons et al. (2011)) found no significant difference in soil organic matter and TOC between these treatments after a short time period, <5 years.
- Edaphic responses such as those observed here are known to lag behind initial vegetative responses to restoration.
- Excavating swales and contouring irregular hummocks can be considered a best practice, creating a gradient of anaerobic conditions throughout the year (Figure 6).

Figure 6. Soil profiles 0- to 30- cm: Swale (A), Flat (B), Hummock (C)



Matrix: 10YR 6/1
Mottle: 10YR 5/6

Matrix: 10YR 4/2
Mottle: 10YR 5/6

Matrix: 10YR 4/2
Mottle: 10YR 4/6

Summary

- Reestablishing swales and hummocks created a carbon and nitrogen gradient with inter-annual variation.
- These feature provides benefits for leveed off wet-flat sites when complete riparian reconnection is not feasible.
- Future wetland restoration monitoring will is necessary to show whether this gradient remains consistent over time.
- Landowner objectives determine whether these restoration methods are employed.

Acknowledgements

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[1]Bruland, G. L., and C. J. Richardson. 2005. Hydrologic, edaphic, and vegetative responses to microtopographic reestablishment in a restored wetland. Restoration Ecology 13:515-523.
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[4]Gee G. W., and J. W. Bauder. 1986. Particle-size Analysis. P. 383 - 411. In A. L. Page (ed.). Methods of soil analysis, part 1, physical and mineralogical methods. Second Edition, Agronomy Monograph 9, American Society of Agronomy, Madison, WI.