Soil and Groundwater Dynamics within Varying Land Classes of a Proposed Forested Wetland Mitigation Bank

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Research highlights

- Row crop soil structure and nutrient quality was poor
- Soil structure and nutrient quality was similar among developmentally older and younger land classes
- Groundwater dynamics influenced some macro and micronutrients, but not structure

Objectives

- Compare soil structure and nutrient composition among four land use classes prior to wetland forest restoration
- Determine potential changes in nutrient retention and regulation through conversion from row crop or livestock to wetland forest land cover
- Determine effect of water table variability on soil composition

Introduction

- Forested wetlands provide valuable services such as improved water quality, flood protection, carbon sequestration, and enhanced biodiversity
- In the U.S. unavoidable loss of wetlands is permitted through restoration programs, including federal policy that established wetland mitigation banks
- Mitigation often restores and assesses structure rather than function
- A proposed mitigation bank near LSU offers the opportunity to assess pre-restoration soil structure and function among mature forest, non-grazed vegetated fields, active cattle pasture, and active row crop sites

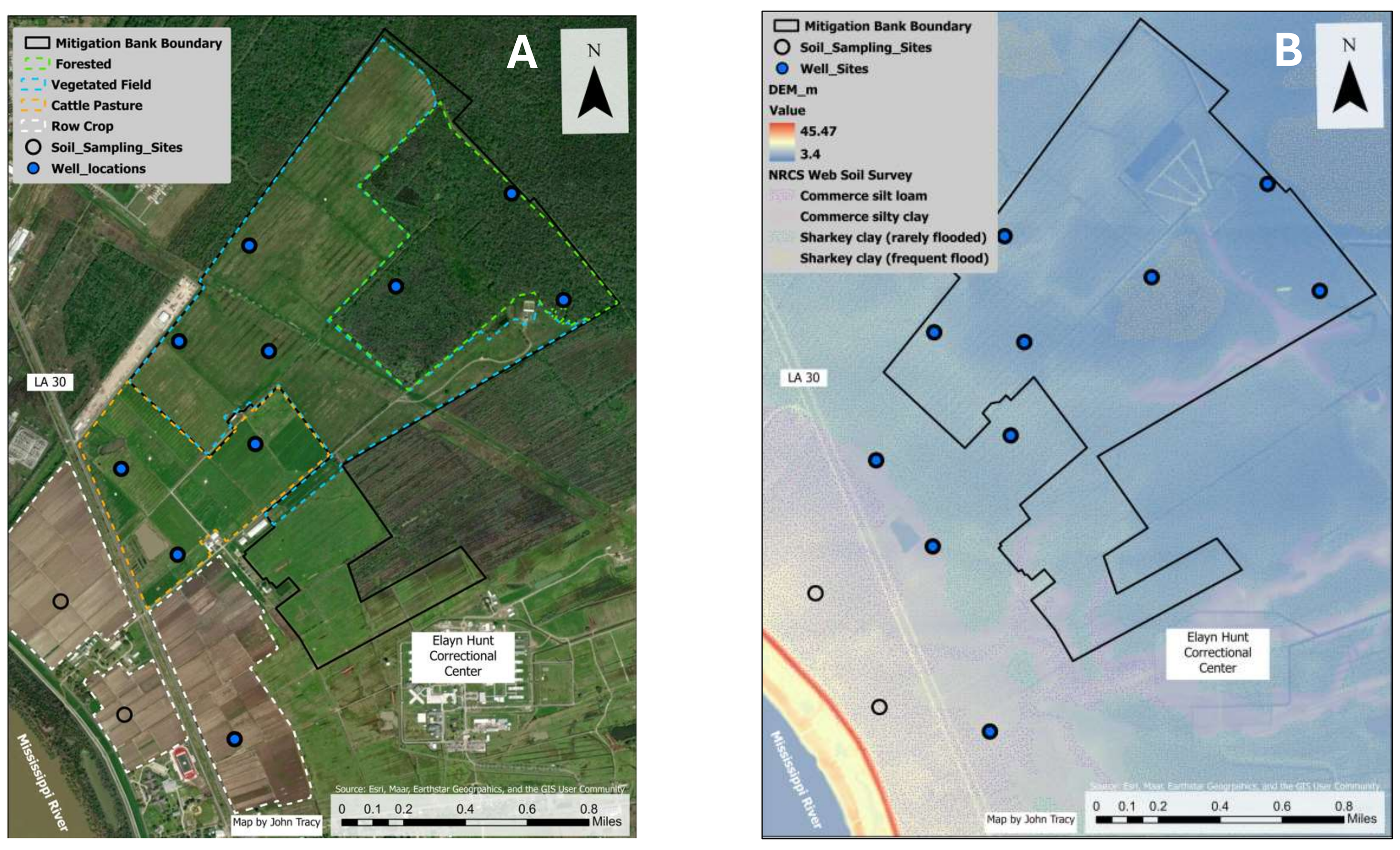

Figure 1. Soil and groundwater monitoring points within four land classes (A) and two soil types (B) surrounding a wetland mitigation bank near St. Gabriel, LA

Materials and Methods

Land Classes

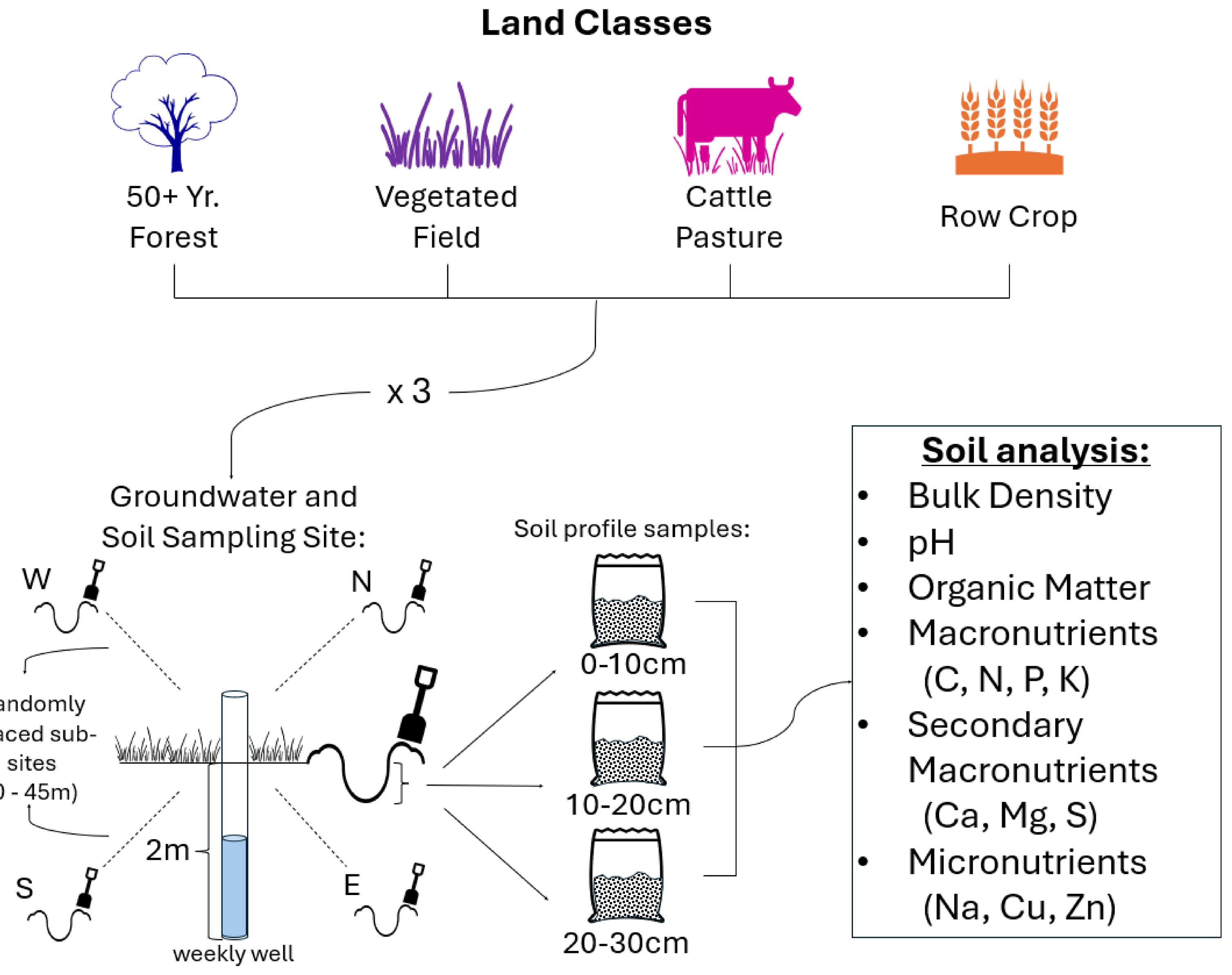

Figure 2. Schematic of soil and groundwater sampling and analysis across four land use classes in a proposed wetland mitigation bank, St. Gabriel, LA.

- Sites included two predominant soil classes: Sharkey (n = 7) and Commerce (n = 5)
- Groundwater classes were either “Low” (n = 7) or “High” (n = 5). Sites where groundwater reached 0.25m from the surface for >10 weeks were classified as “High”. Sampling period between 9/30/2024 and 4/30/2025

Results

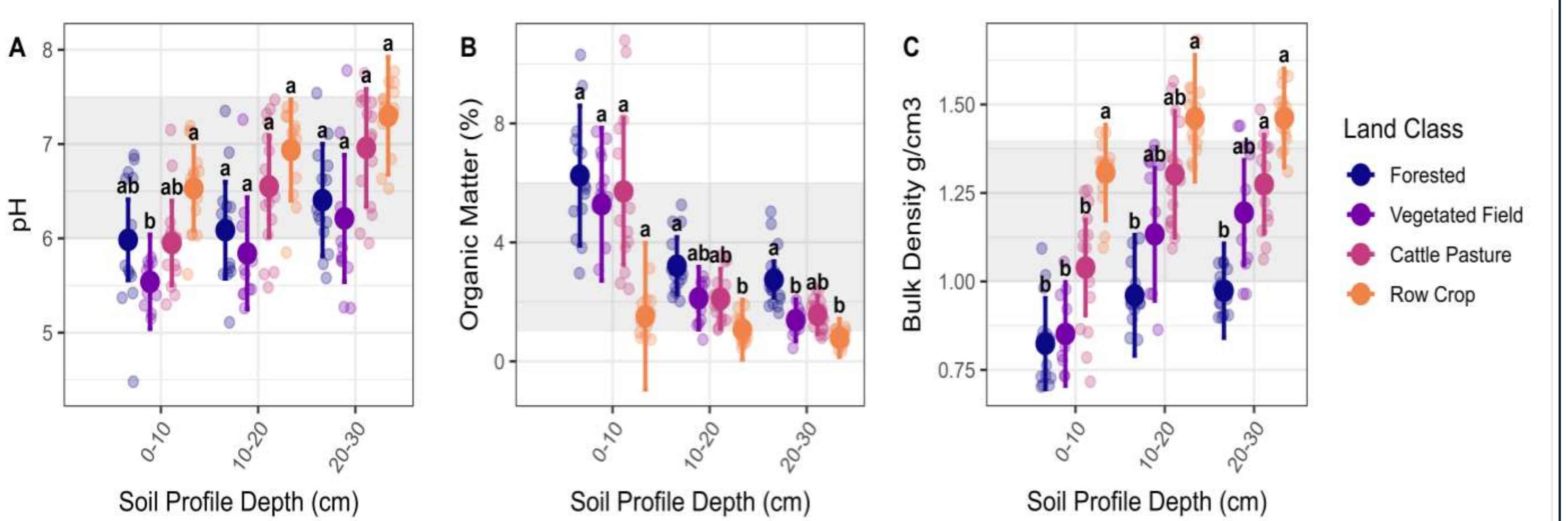

Figure 3. Model predictions (±95% CI) of pH (A), organic matter (B), and bulk density (C) in 10cm soil profiles among four land classes. Predictions not sharing a letter within profiles are different by the Tukey-test ($p \leq 0.05$). Typical ranges in grey.

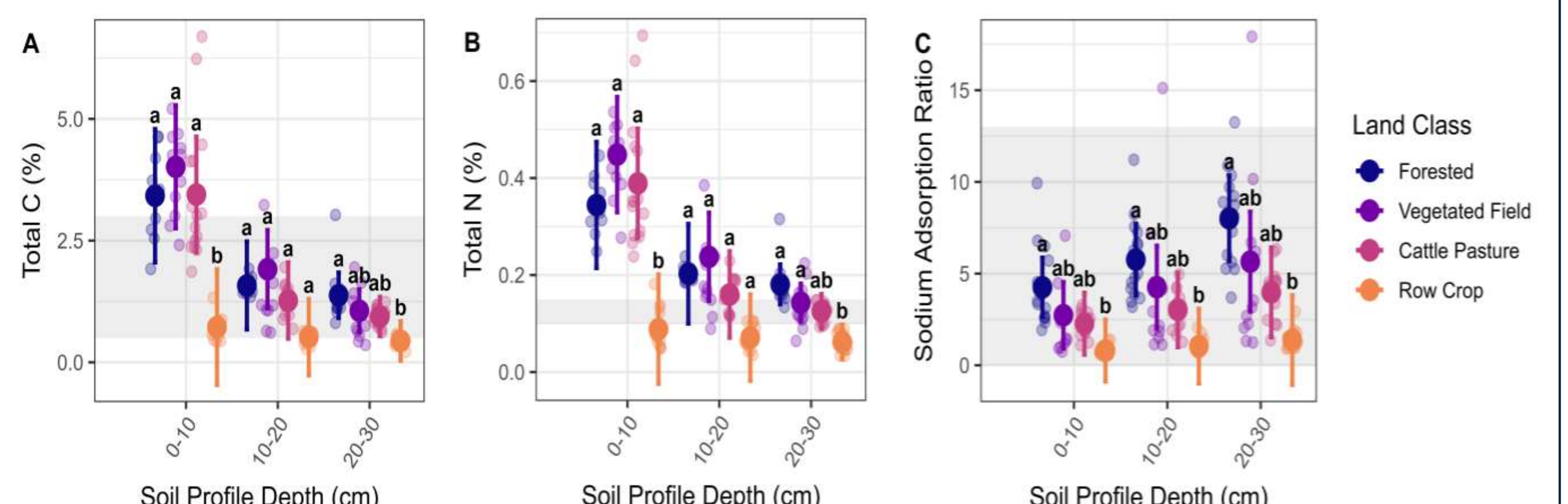

Figure 4. Model predictions (±95% CI) of Total Carbon (A), Total Nitrogen (B), and Soil Adsorption Ratio (C). Predictions not sharing a letter within profiles are different by the Tukey-test ($p \leq 0.05$). Typical ranges in grey.

Table 1. Variation in model predictions explained by fixed effect variables. 0-10cm soil profile only.

Dependent Variable	Fixed-effect Variable	Marginal r^2
pH	Land Class	0.38
	Soils	0.33
	Groundwater Class	0.04
Organic Matter	Land Class	0.76
	Soils	0.73
	Groundwater Class	0.01
Bulk Density	Land Class	0.65
	Soils	0.73
	Groundwater Class	0.12
Total N (%)	Land Class	0.68
	Soils	0.54
	Groundwater Class	0.05
Total C (%)	Land Class	0.61
	Soils	0.57
	Groundwater Class	0.30
P (ppm)	Land Class	0.18
	Soils	0.12
	Groundwater Class	0.01
K (ppm)	Land Class	0.79
	Soils	0.75
	Groundwater Class	0.32
Ca (ppm)	Land Class	0.79
	Soils	0.45
	Groundwater Class	0.35
Mg (ppm)	Land Class	0.72
	Soils	0.50
	Groundwater Class	0.34
S (ppm)	Land Class	0.84
	Soils	0.78
	Groundwater Class	0.80
Na (ppm)	Land Class	0.60
	Soils	0.45
	Groundwater Class	0.50
Cu (ppm)	Land Class	0.32
	Soils	0.01
	Groundwater Class	0.13
Zn (ppm)	Land Class	0.17
	Soils	0.01
	Groundwater Class	0.00
Soil Adsorption Ratio	Land Class	0.39
	Soils	0.25
	Groundwater Class	0.29

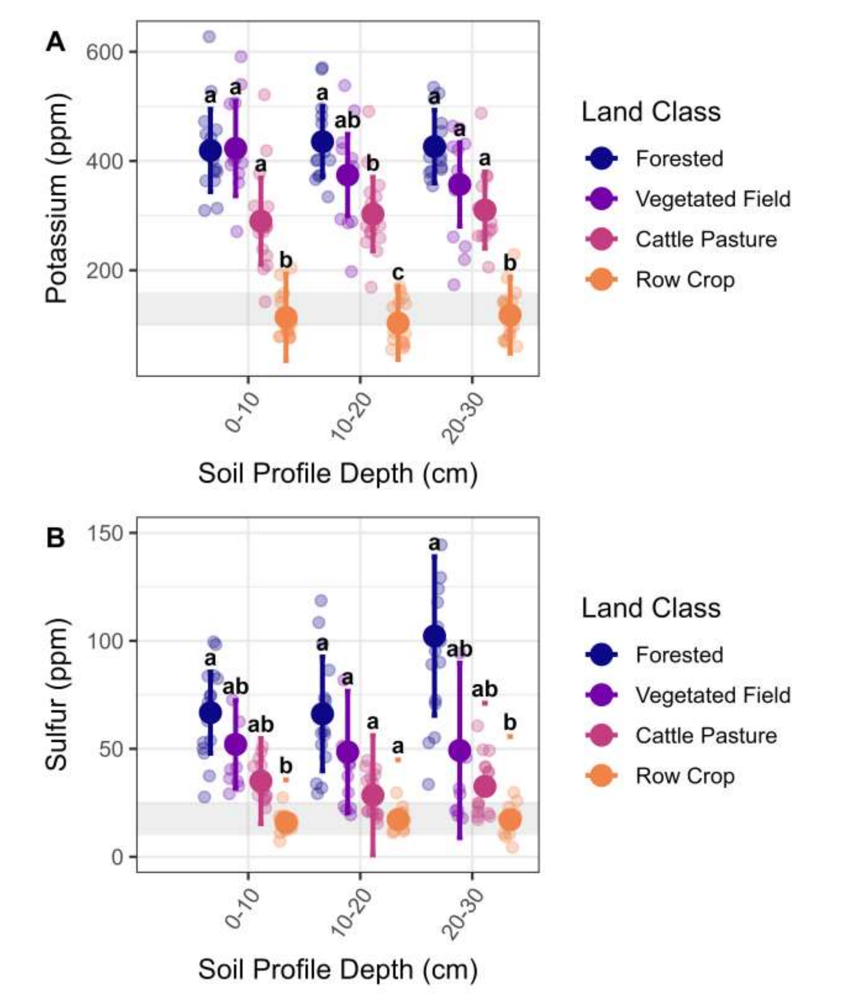

Figure 5. Model predictions (±95% CI) of Potassium (ppm) (A) and Sulfur (ppm) (B). Predictions not sharing a letter within profiles are different by the Tukey-test ($p \leq 0.05$). Typical ranges in grey. Ppm is mg/Kg.

Conclusions

- Row crop sites were mostly deficient of soil nutrients and quality structure, and therefore require intensive management and addition of nutrients to be productive
- Forested, vegetated field, and cattle pasture sites had the highest soil nutrient values and quality soil structure that promote plant growth and offer functions such as nutrient cycling and carbon storage
- Developmentally younger vegetated field and cattle pasture sites had similar soil quality characteristics to much older forested sites
- Allowing pre-restoration sites to vegetate years in advance of planting could improve soil quality and therefore productivity of planted seedlings
- Groundwater class explained ≥30% variation for Total C, K, Ca, Mg, S, and Na
- Restoring active row crop, versus cattle pasture, versus abandoned field sites offers differing values in terms of soil ecological function, which should be quantified and valued in mitigation banking programs

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