Role of Fe- and Mn- Redox Coupling on the Carbon Cycle in a Mixed Land Use Watershed

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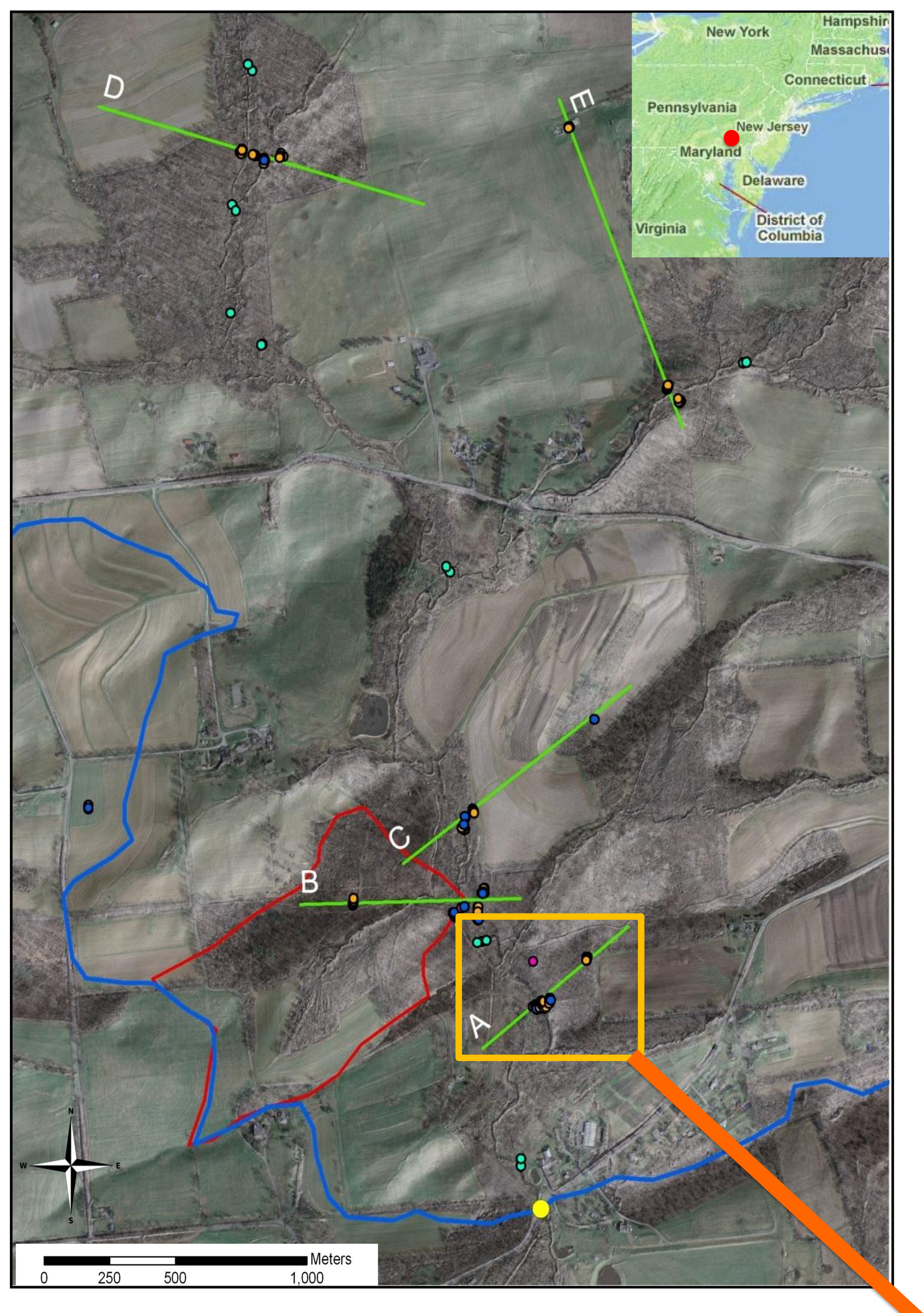
INTRODUCTION

A multitude of scientific publications have emphasized the importance of an organic carbon (C) -mineral complexation mechanism as a crucial factor in C stabilization and sequestration. Carbon-mineral complexation is strongly controlled by mineral surface area, mineralogy, pH, redox, polyvalent cations, ionic strength, and the chemical composition of organic matter. These factors vary spatially as a function of geomorphologic, hydrologic, and microbiological processes. Soil horizons and sediments with abundant Fe and Mn oxides/hydroxides have high mineral surface area and thus a high capacity to complex C, reducing its susceptibility to microbial degradation. Additionally, both sediment and hydrological fluxes transport mineral surface area in both solid and dissolved phases (i.e., Fe can be hydrologically transported in its reduced state and then oxidized to iron oxides with high mineral surface area).

At the Christina River Basin-Critical Zone Observatory (CRB-CZO), one of six observatories located in the Piedmont region of Southeastern Pennsylvania and northern Delaware and funded by the National Science Foundation, we investigate how Fe- and Mn- redox coupling affects the C cycle under varying redox conditions across a wide range of landscape positions and uses, such as floodplain forest, upland forest, and agriculture.

STUDY AREA



Legend:
- Well Locations
- Lysimeters
- Soil Sampling Sites
- Thermo Stream Sites
- Spencer Road Bridge
- Existing Transects
- White Clay Creek Watershed
- CRB-CZO Proposed Sites
- Primary Study Site

Proposed research questions:

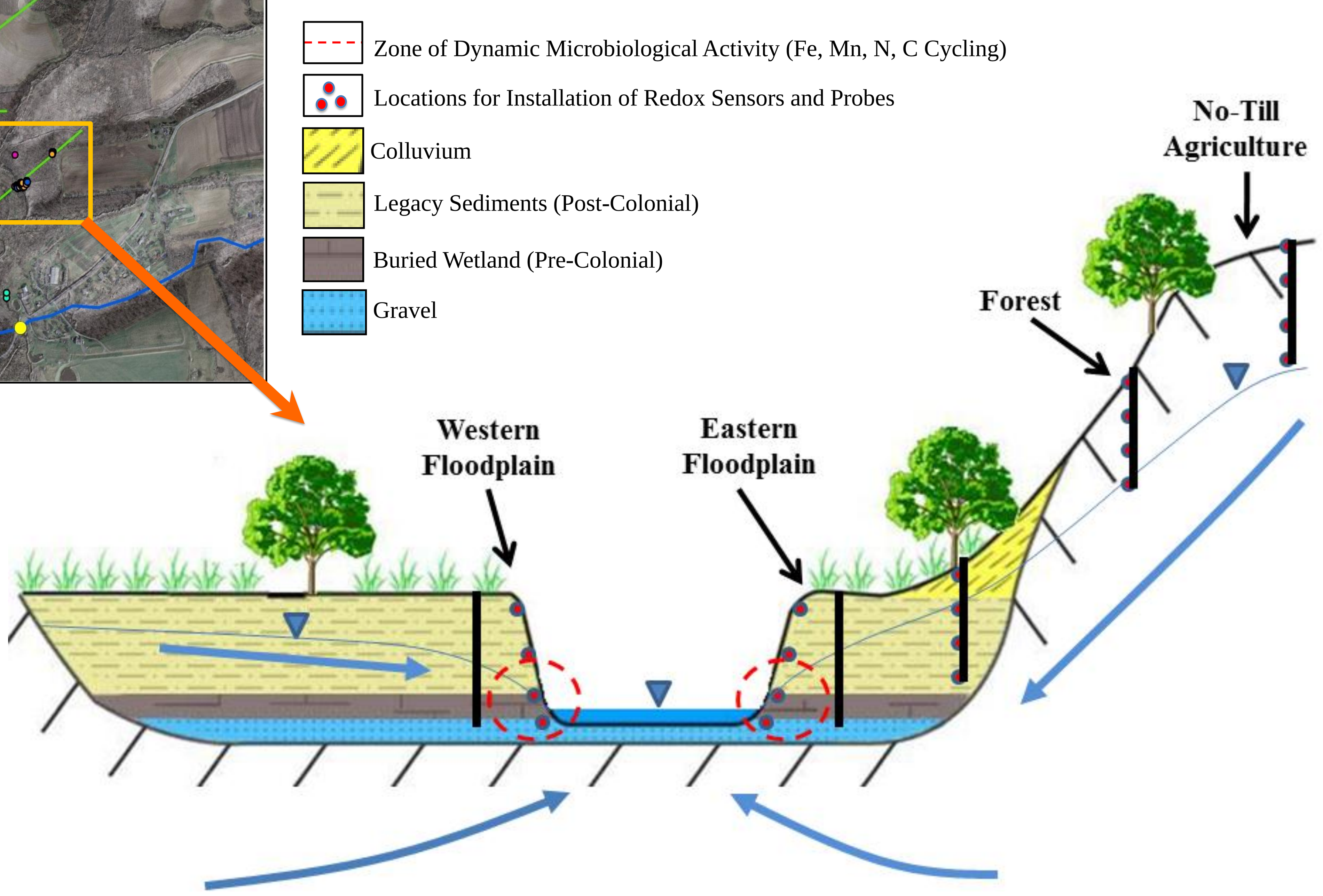
(1) How do redox conditions in soils affect the transport of mineral surface area via the dissolved phase?

(2) How deep and fast does O_2 penetrate through soils under different land use types and landscape positions?

(3) Does O_2 diffusion back into riparian soil/sediments facilitate complexation between C and newly-precipitated Fe- and Mn-oxides in the pore water?

(4) How do soil properties, such as composition, mineralogy, mineral surface area, as well as redox state, vary depending on different types of land use and topographic position?

(5) How do microbial communities within soils and pore and stream water respond to redox gradients and seasons, and what groups of bacteria interact extensively with the C cycling under these redox fluctuations?



Modified from Walter and Merritts, 2008

METHODS

- Installation of in-situ monitoring sensors:
  - Redox sensors
  - Pressure transducers (stream/groundwater)
  - Soil moisture/Temperature probes
  - Gas probes (O_2, CO_2)
  - DO/Temperature sensors
  - Conductivity probes
- Sampling of soil cores, soil pore waters, stream water, and groundwater.
- Water samples will be analyzed for pH, T, DO, Fe^{2+}, conductivity, turbidity, alkalinity, TDS, DOC, TOC, NO_3, C, N isotopes, major anions, major cations, and metals.
- Soils samples will be examined for total chemical composition, C%, C isotopes, and mineral surface area.
- Selected samples will be analyzed by XRD, SEM, EPR, Mossbauer Spectroscopy, and molecular analysis on microbial communities.
- Bench-scale leaching experiments with in-tact soil cores and X-ray computed tomography are also planned along with geochemical reactive transport modeling.

Soil Moisture/Temperature Probe *(Decagon)*
Redox Sensors

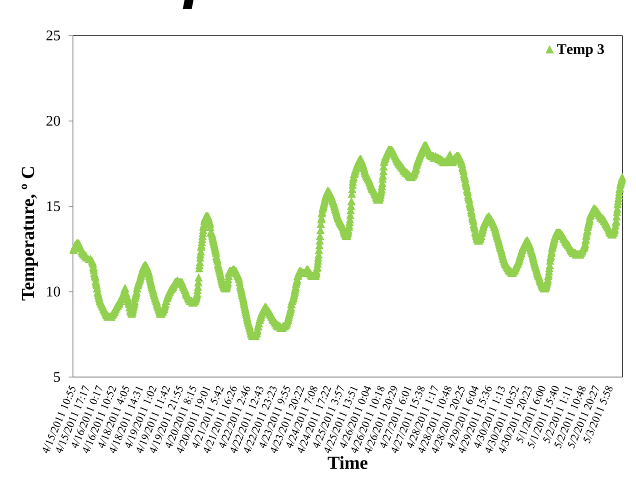
CO_2 Sensor *(Vaisala)*

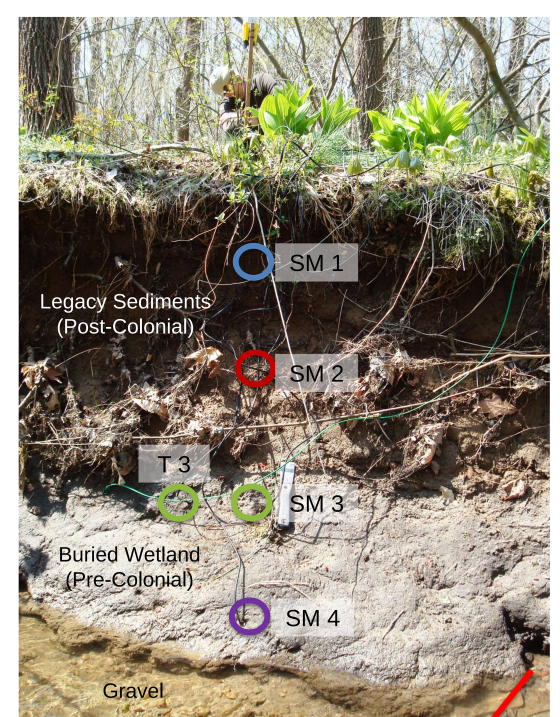
Water Depth Sensor

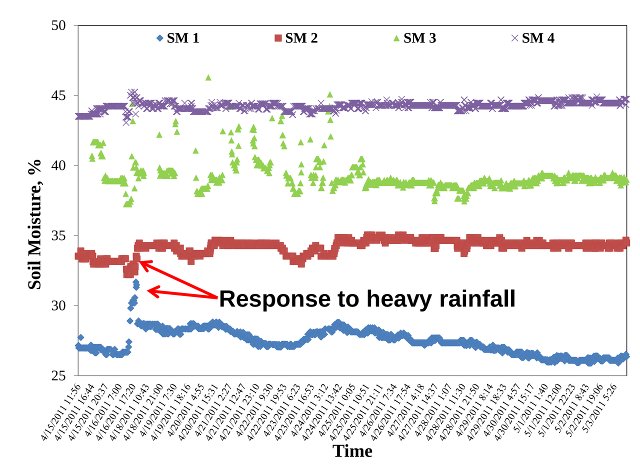
O_2 Sensor *(Apogee)*

PRELIMINARY RESULTS:

Western Floodplain

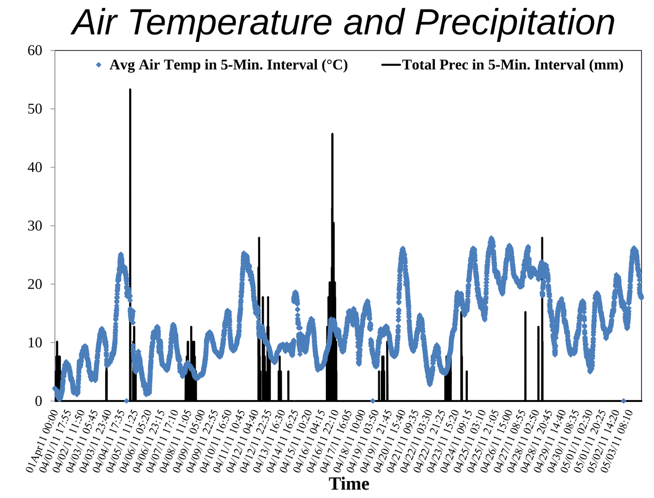




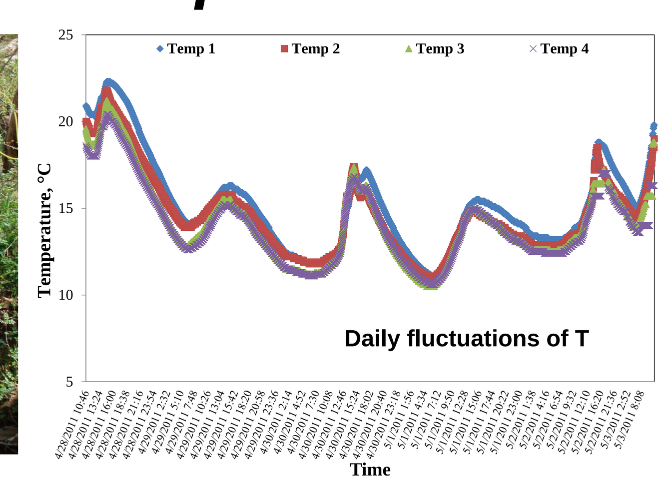


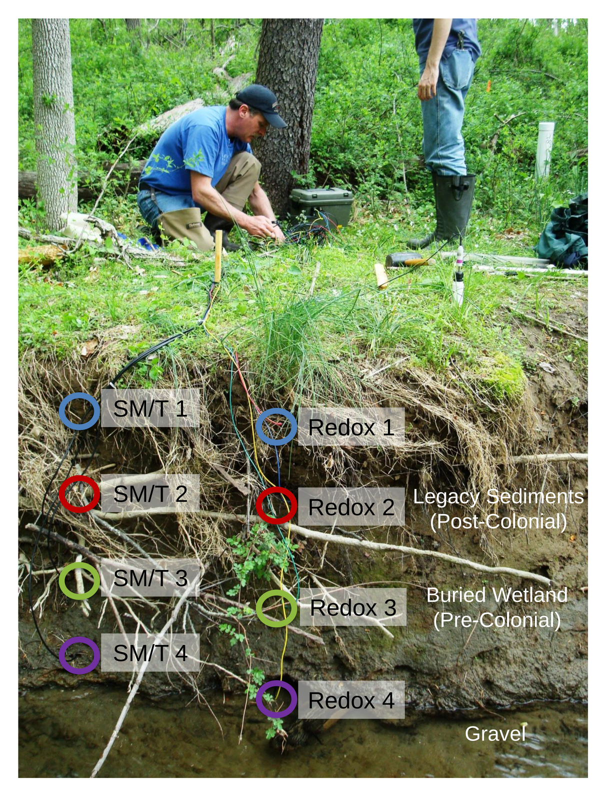
Formation of Fe oxides at the wetland-gravel interface

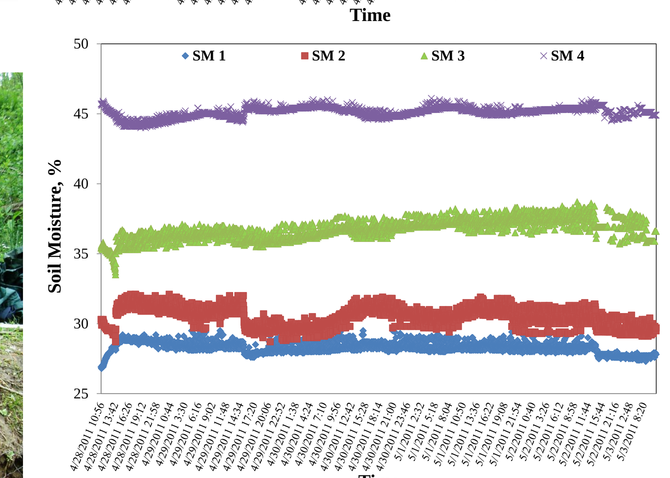
Air Temperature and Precipitation

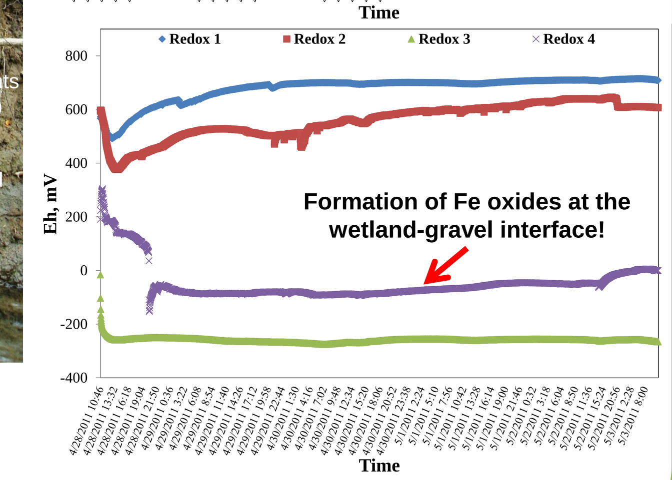


Eastern Floodplain









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