Assessing the Effects of Land Use Change on Riparian Zone Soils in Southern New England

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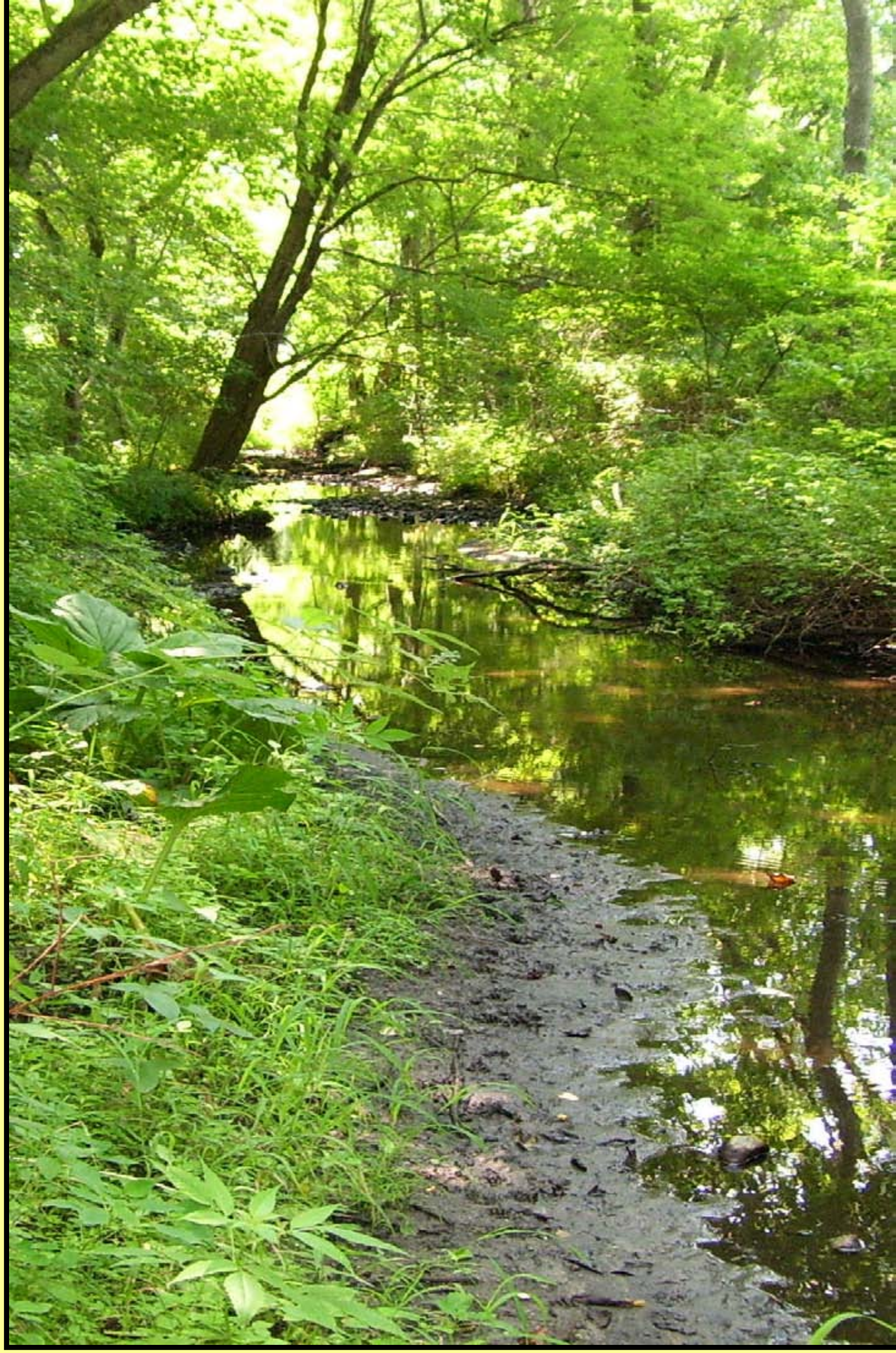
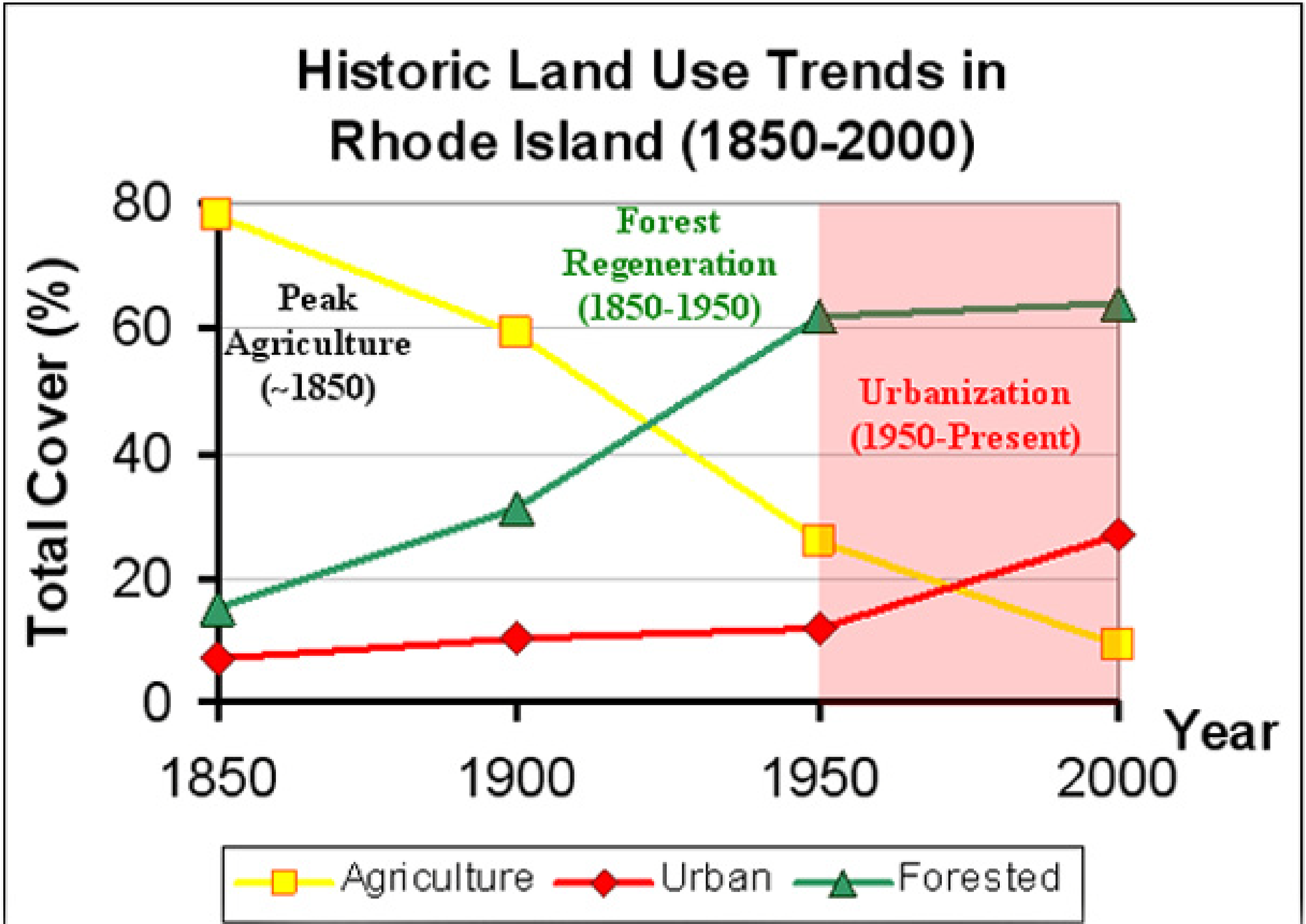


RIPARIAN ZONES

- Important links between upland and aquatic systems
- Provide multiple environmental and ecosystem functions
- Form as a result of episodic alluvial deposition
- Land use change may result in impacts to riparian soil functions

Buried horizon (Ab)



Source: Lucy W. Griffiths. *One Hundred Years of Agriculture in Rhode Island (Statistics and Trends)*. University of Rhode Island, Bulletin 378, January 1965, and RIDEM Division of Agriculture.

Develop Multi-Proxy Indices of Land Use Change for Riparian Soils

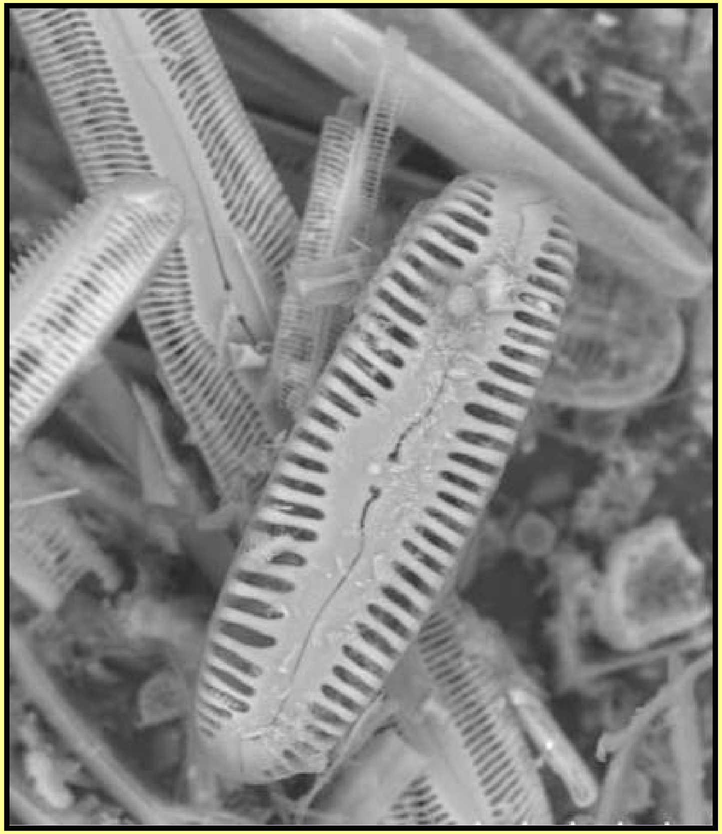
Objectives

1. Establish stratigraphic indices of watershed land use change using a multi-proxy approach

2. Utilize these indices to establish time frames of alluvial deposition

3. Relate riparian sedimentation and carbon sequestration rates to land use

Diatomaceous Earth

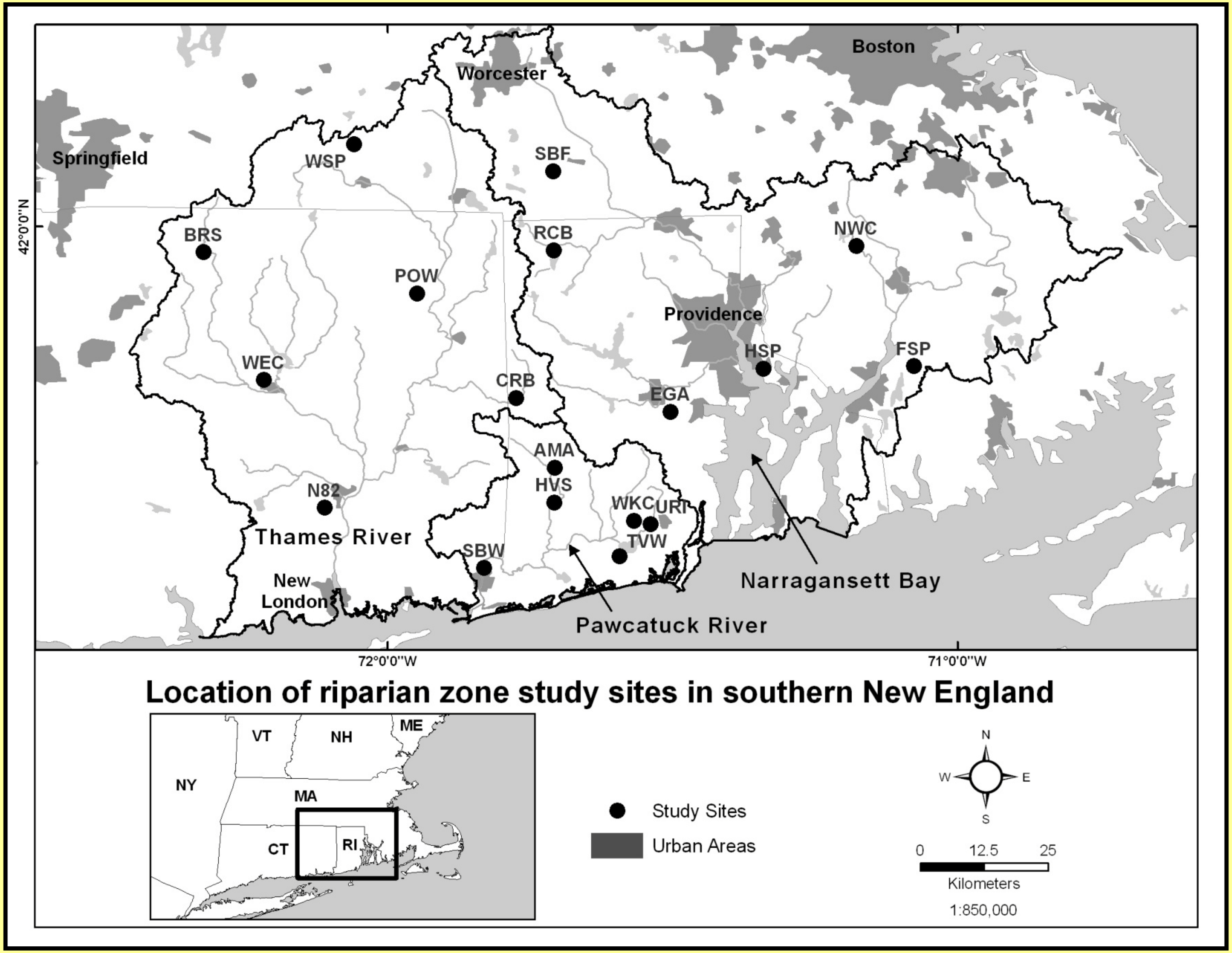


SEM Image
500x Magnification

Methods

- 18 representative headwater watershed riparian sites selected
  - Hydric soils (Inceptisols, Entisols)
    - Formed in alluvium over outwash
    - Raypol, Rumney, Scarboro, and Walpole series
- Varied watershed land use
  - Urban, agricultural, mixed use, forested
- Soil pits dug to 1 m or greater
  - Soils described in field
  - Bulk density
  - PSD
  - Heavy metals
  - Pollen samples by horizon
  - Soil organic carbon (SOC)

Study Watersheds

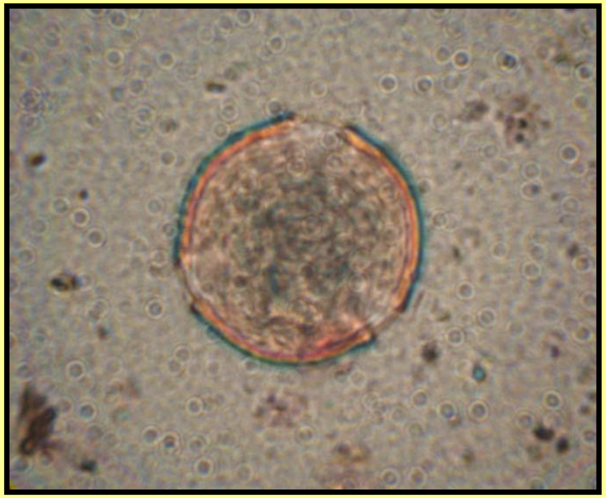


Location of riparian zone study sites in southern New England

4 urban, 4 agricultural, 4 forested, and 6 mixed LU watersheds

General Land Use Periods and Associated Indices

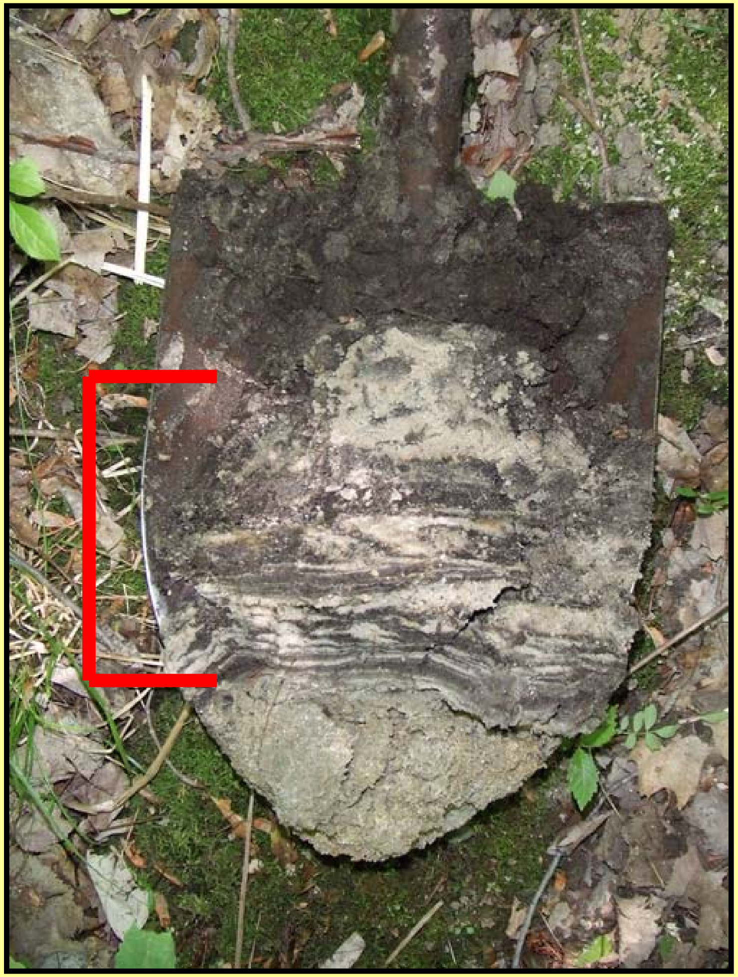
- Constrain riparian soil horizons into three major distinct land use periods
- **Pre-colonial period (17,000 YBP–1650 AD)**
- **Colonial (agrarian) period (1650-1900 AD)**
  - Rise and/or peak **ragweed** and other non-arboreal pollen types
  - Supported by twelve **^{14}C dates**
    - Rise in ragweed dated to **1780±40 AD**
    - Peak ragweed dated to **1850±50 AD**
- **Modern industrial/urbanization period (1900 AD-present)**
  - Increased coarse materials (sand, gravels)
  - Presence of human **artifacts**
  - Rise and peak **pollutant metals** (Pb)
    - Supported by **^{210}Pb cores**



Indices of Land Use Change:

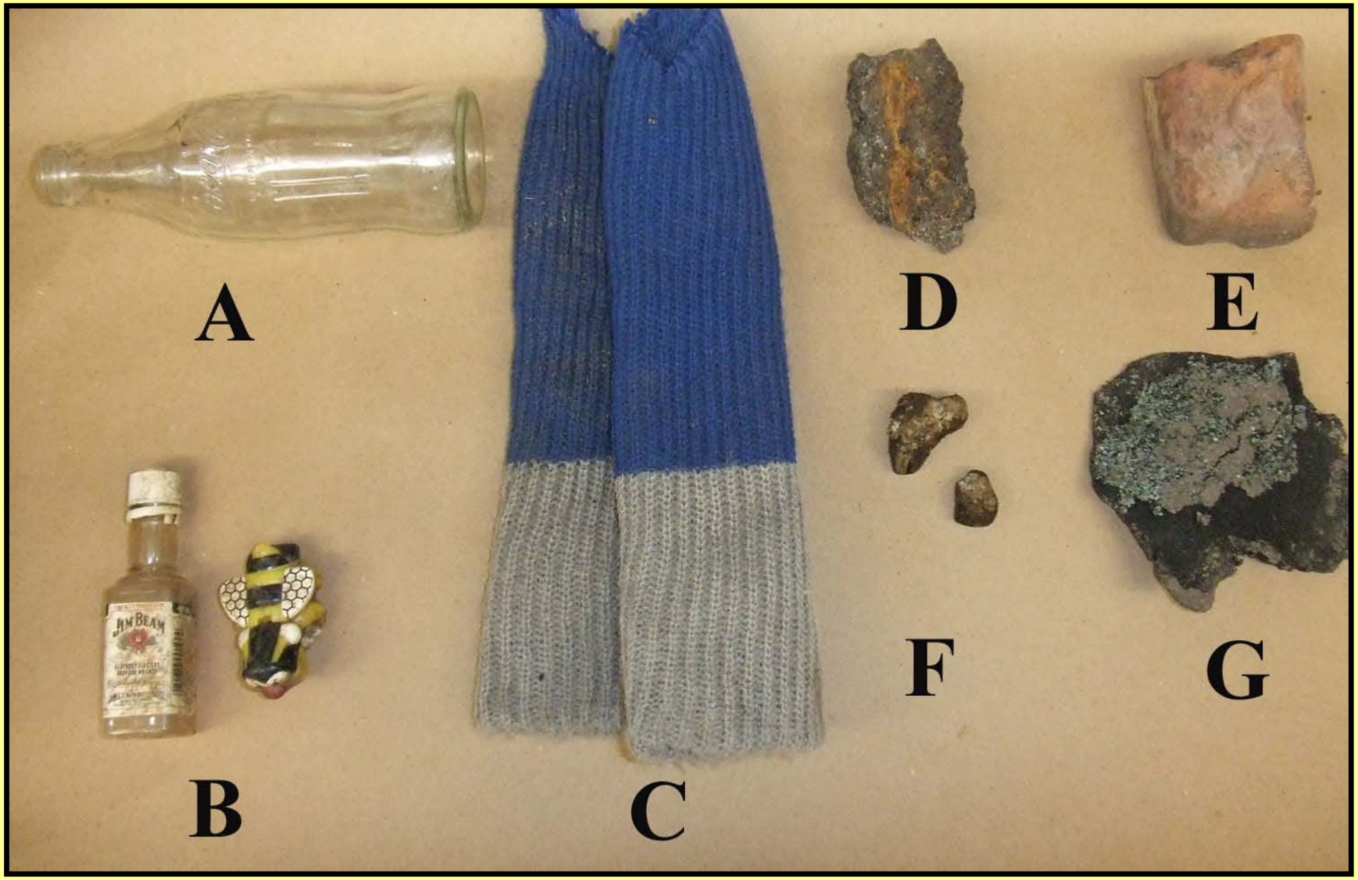
Soil Morphology and Pollutant Metals

- Particle size distribution
  - Coarser deposits as watersheds undergo extensive LU change
- Buried horizons (i.e. Ab)
- Combination horizons (i.e. A/C)
  - Indicative of short term stability
- Human artifacts (i.e. Cu horizon)
  - Indicative of colonial-urban time periods
- Pollutant metals
  - Pb, Cu, Zn, Cd, As above background levels; on average 3 to 6 times higher in surface horizons



Many sand lenses (A/Cg)

Examples of Riparian “Artifacts”
(One Person’s Garbage is Another’s Stratigraphic Marker…)

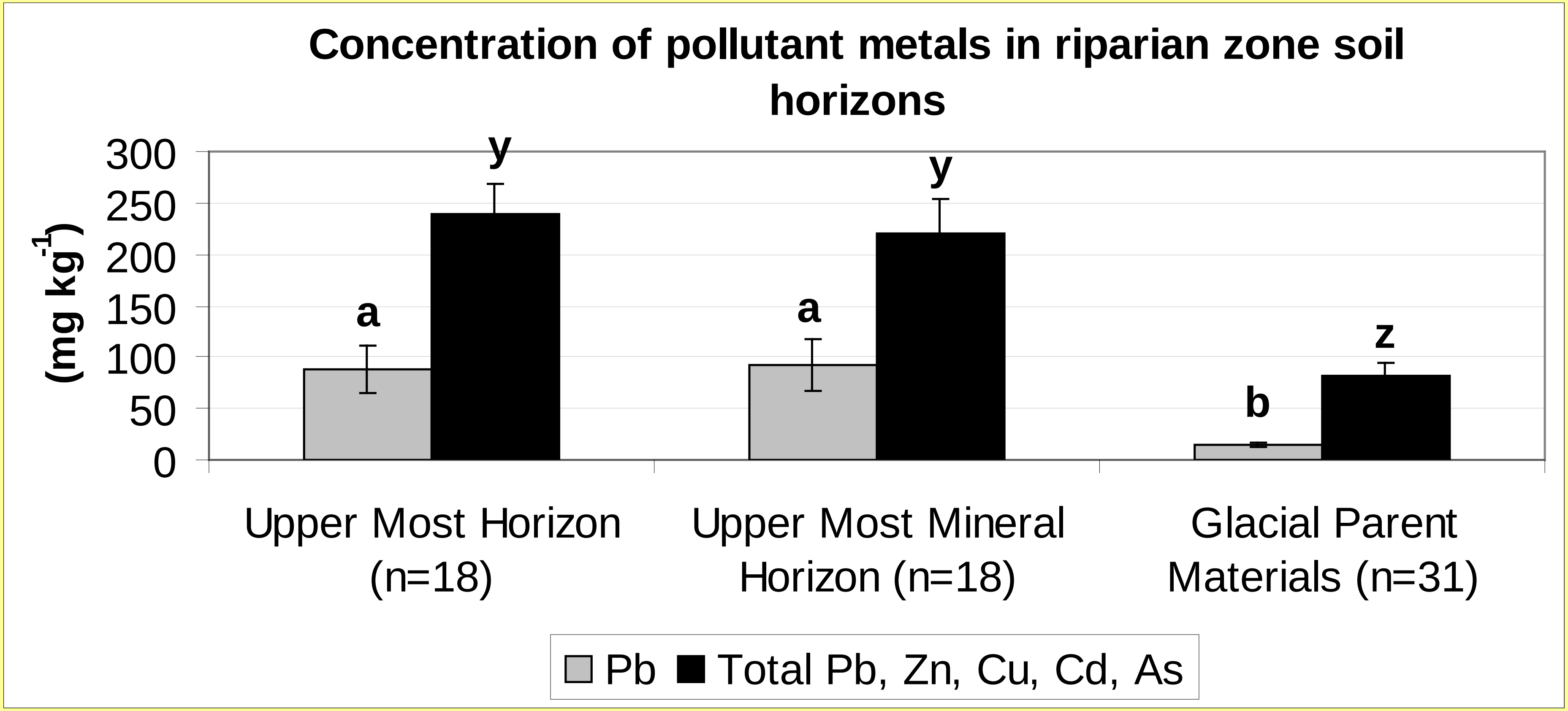


A: Glass	B: Plastic	C: Cloth	D: Asphalt	E: Brick	F: Styrofoam	G: Shingle
50 cm	15 cm	20 cm	30 cm	50 cm	15 cm	40 cm

Pollutant Metals

Indices of Anthropogenic Activities

(1900-present)



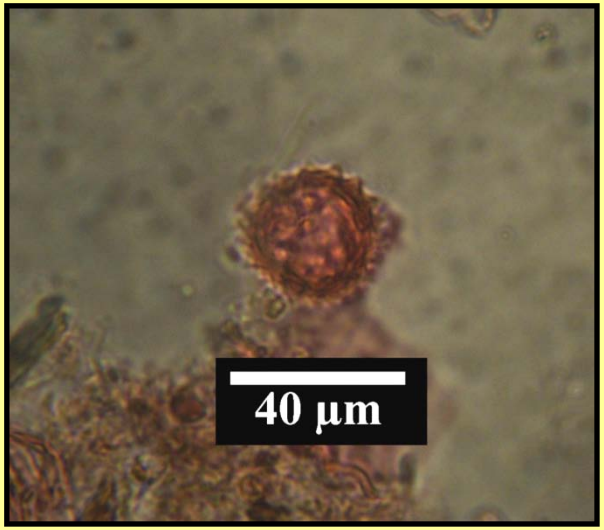
Means with different letters are significantly different (α=0.05)

Metals concentrated near soil surface, likely anthropogenic origins:
1900-present fossil fuel combustion, especially leaded gasoline

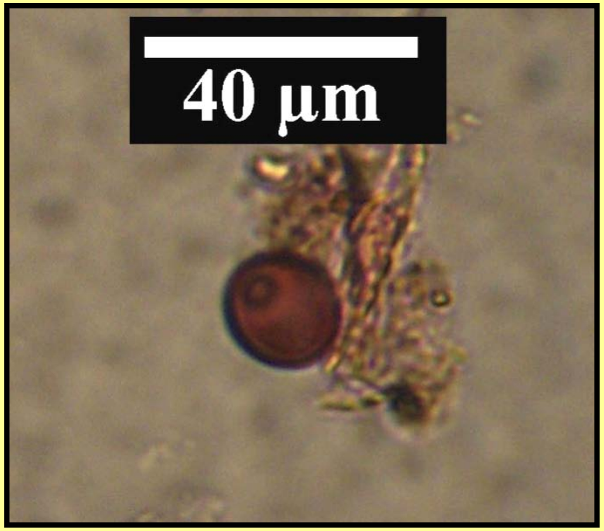
Indices of Land Use Change:

Preserved Pollen (Colonial Period)

- Past land uses affected the vegetation of the region
  - Impacts evident in pollen record
  - Pollen stratigraphy can be used to reconstruct land use
- Pollen indicators, specifically:
  - **ragweed** (*Ambrosia* taxa, family Asteraceae)
  - **grasses** (Poaceae)
  - have been used to date peak land use disturbance in many depositional environments (lakes and ponds)

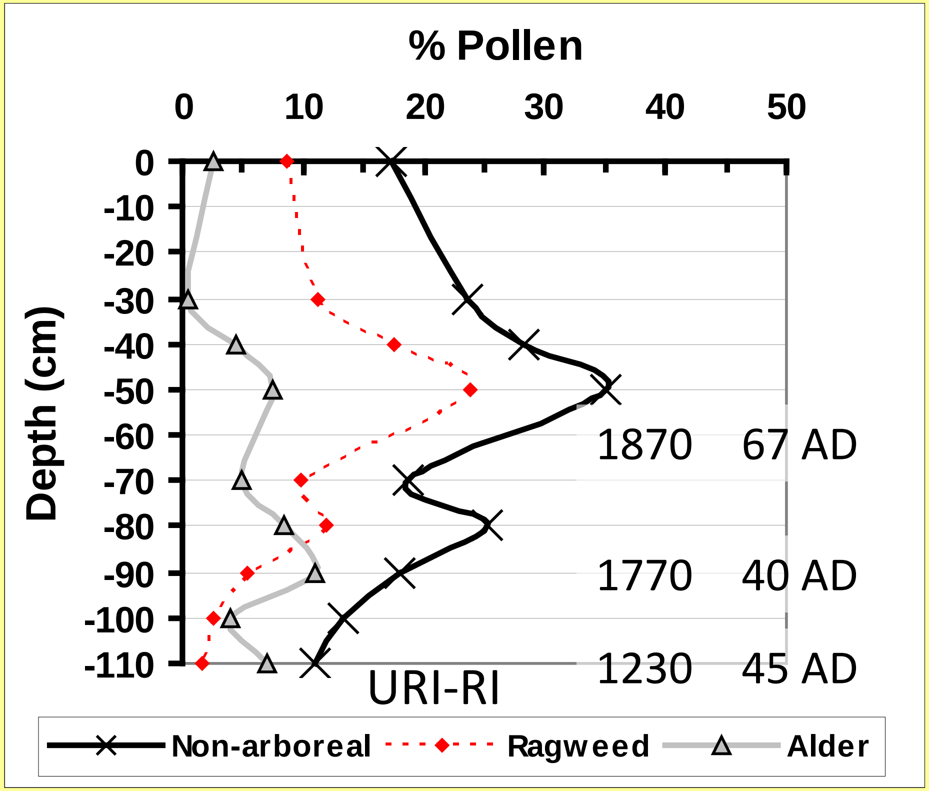


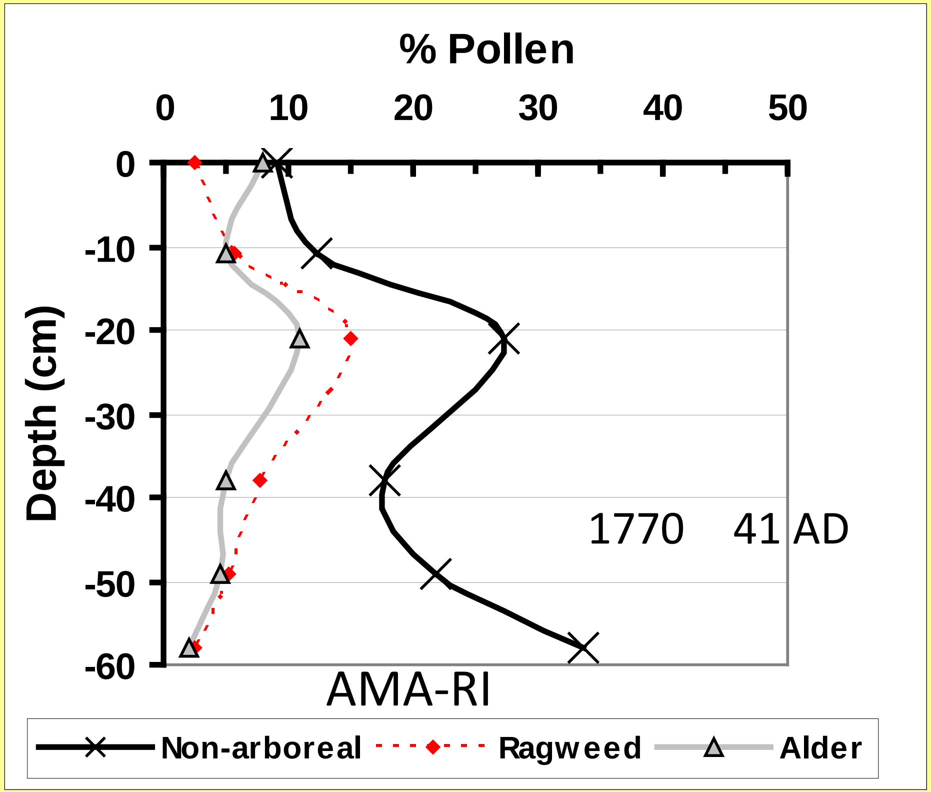
Ragweed pollen (tricolporate, spines)



Grass pollen (monoporate)

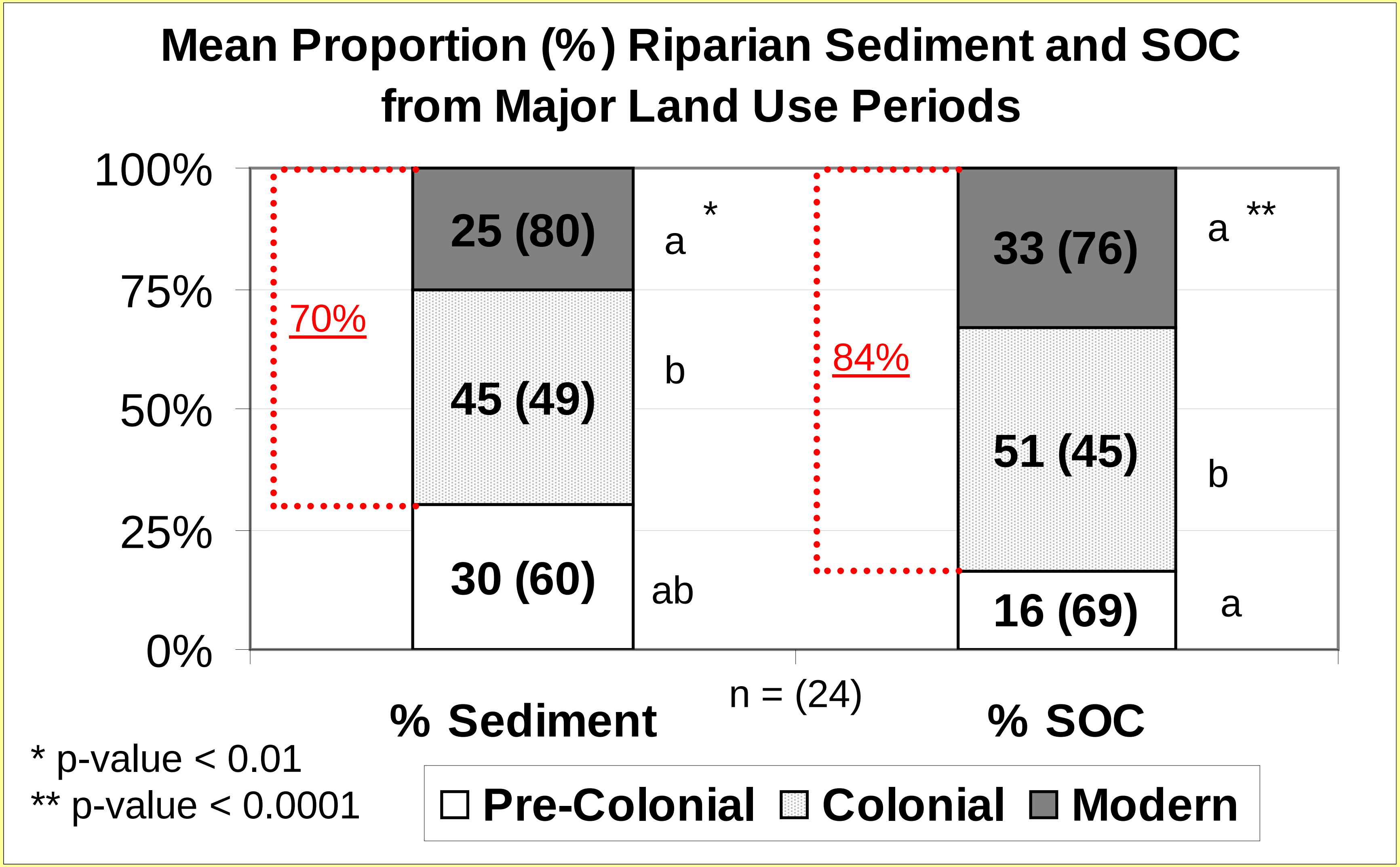
Example Pollen Diagrams



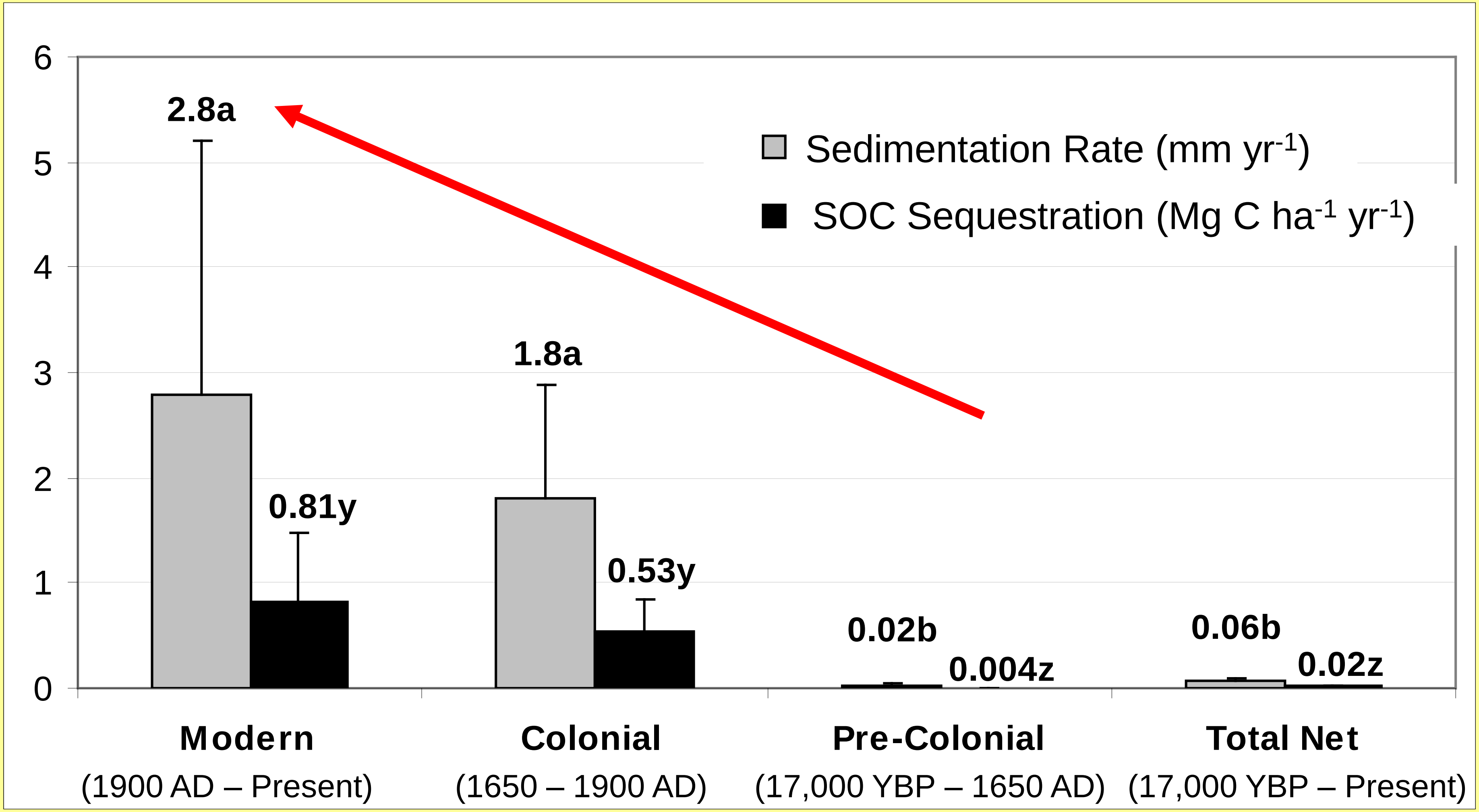


- Moderate to abundant pollen was preserved in subsurface horizons
- Range 300 to >60,000 pollen grains per gram of soil
- Pollen was preserved in horizons dated to >11,000 YBP
- 88% riparian soils contained preserved pollen
- 71% riparian soils contained enough pollen for land use stratigraphy

Average net sediment and SOC distribution by land use period

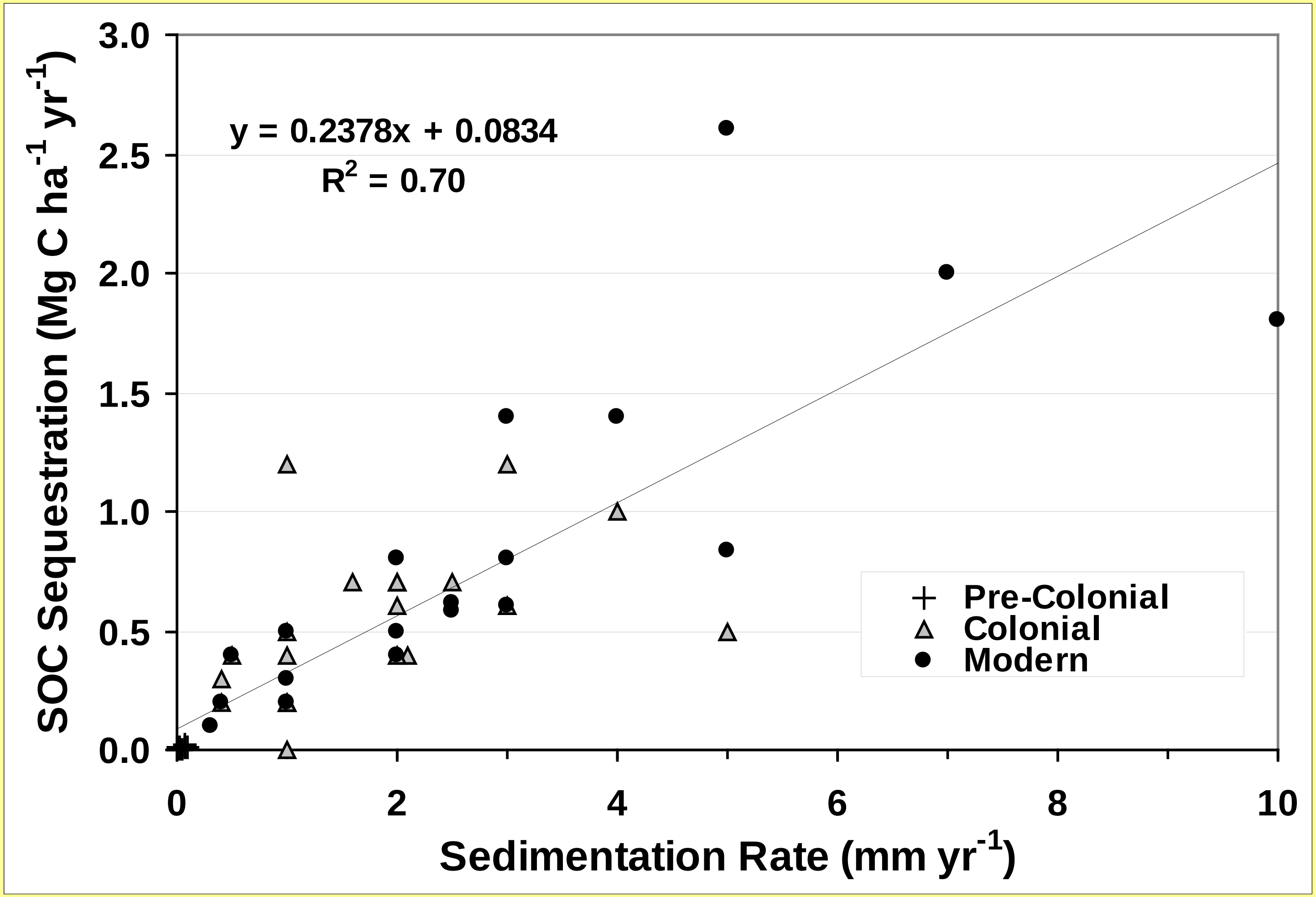


Evaluating Net Sedimentation and SOC Sequestration Rates Utilizing Stratigraphic Indices



- 115x overall increase net sedimentation rates since pre-colonial period
- 225x overall increase net SOC sequestration since pre-colonial period
- Riparian rates for SOC sequestration are 2 to 4 times that of upland forests

Sedimentation and SOC Sequestration:
What is the relationship?



- Suggests sedimentation and SOC sequestration are related.
- Exact driver of this relationship is unclear (burial, C influx, additional surface area?).

Conclusions

- Soil morphology, pollutant metals, and pollen stratigraphy can be used to successfully date riparian soil deposition

- Land use change has had significant impacts on riparian zone sedimentation and C sequestration
  - Riparian zones acting as large sinks for sediment and C
  - Riparian SOC sequestration and sedimentation may be linked processes

Ab horizon

Are riparian zones "hot spots" for SOC at watershed-scale

Methods

--29 representative riparian soil pedons were examined, (Blazejewski, 2003; Donohue, 2007; Ricker, 2010)

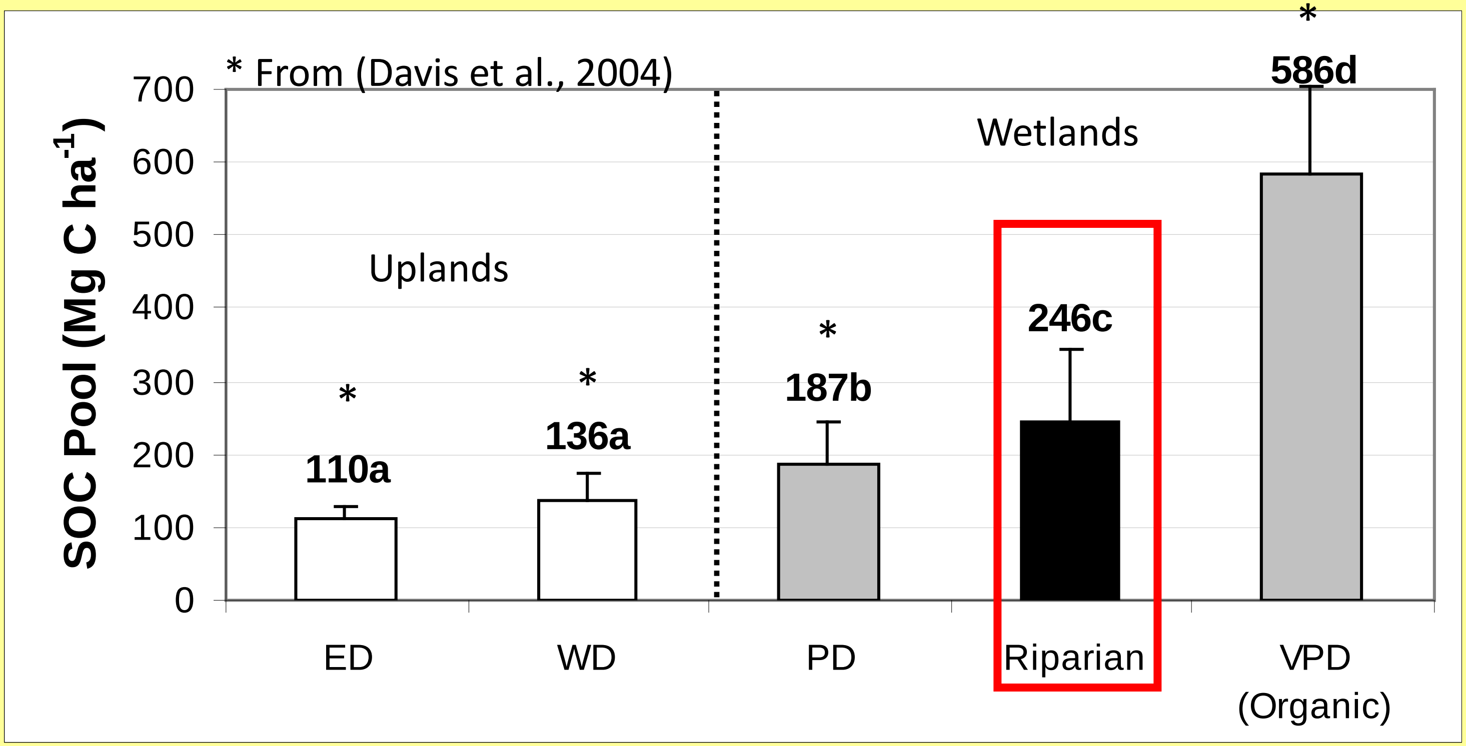
--Soils sampled by horizon to 1 m

- Bulk density
- SOC
- Calculated SOC pools at landscape scale (Mg C ha^{-1})

--Riparian SOC pools compared to published data (Davis et al., 2004) Watershed-scale analysis done in GIS

SOC Pools Across the Landscape

- Mean riparian SOC pool was 246 Mg C ha^{-1}
- SOC pools (to 1 m depth) in riparian zone more than all other mineral soils evaluated by Davis et al. (2004)
- Only Histosols contained more SOC to 1 m



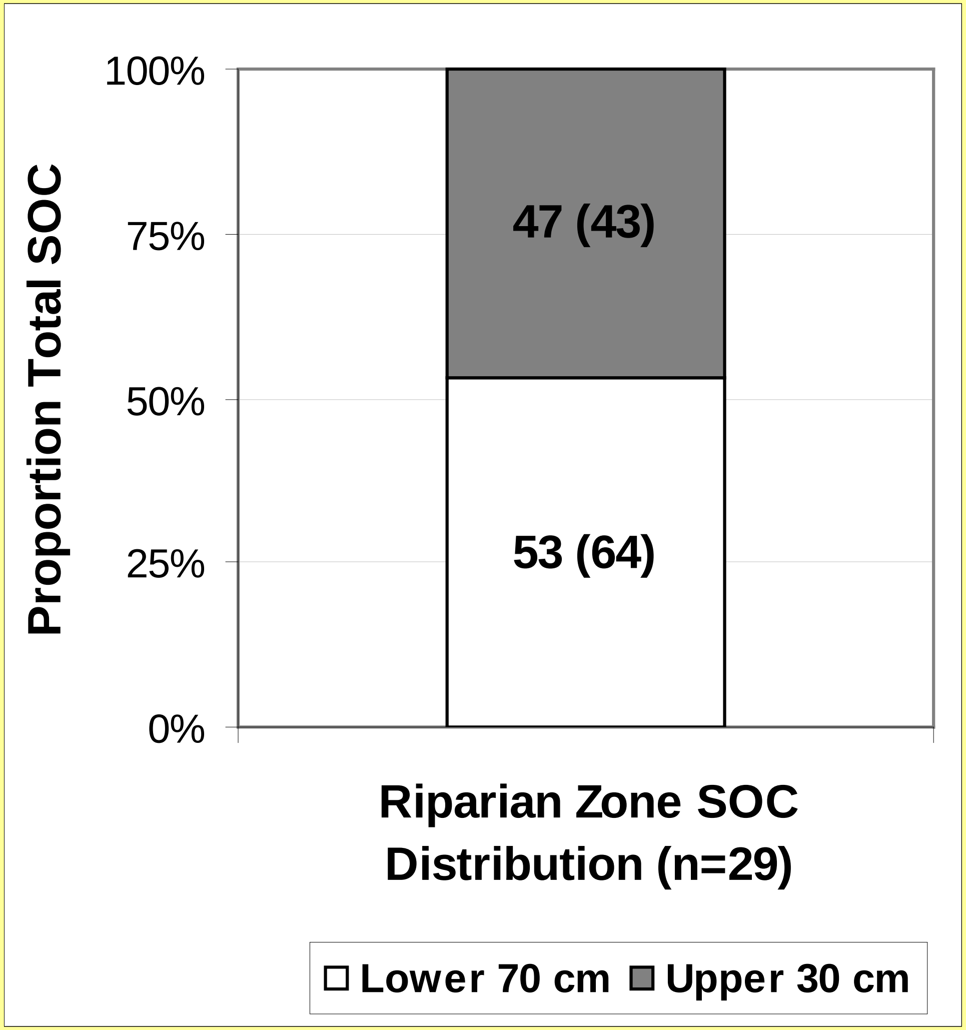
Means with different letters are sig. dif. (α = 0.05)

Error bars = 1 SD

Spatial Distribution of SOC in Riparian Soils

- 53% SOC below 30 cm depth
  - By comparison:
  - ED - 30%
  - WD - 30%
  - PD - 45%
  - VPD - 75%

- In addition:
  - 52% of riparian soils studied had buried SOC rich horizons below 1 m
  - Suggests deep burial of SOC is important in riparian landscapes

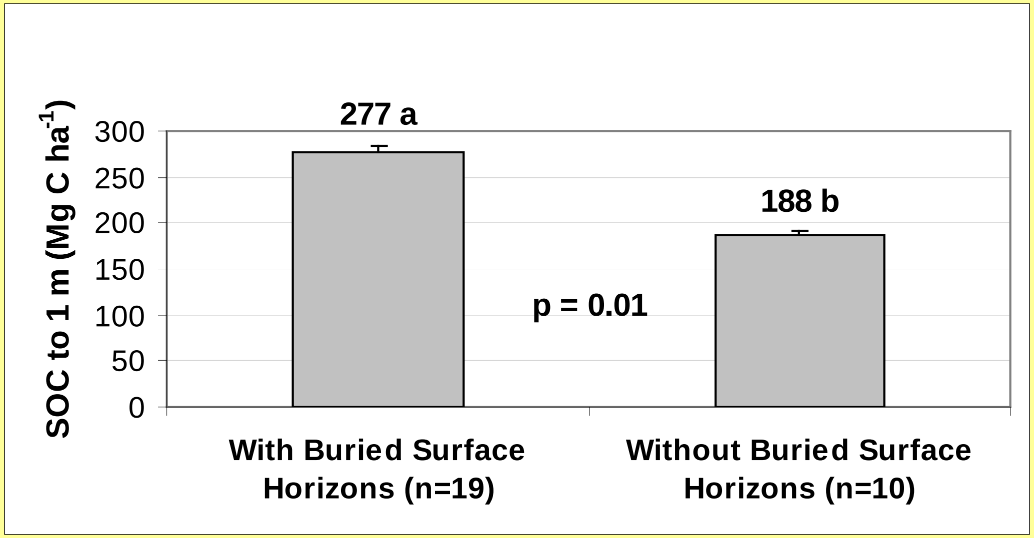


CV (%) in parentheses

Factors Affecting Riparian SOC Pools

Urban Riparian Soil
Norwich, CT

- Many factors tested, none significant
- Differences in SOC with differences in soil morphology
    - Soils with buried surface horizons contained significantly more SOC
    - Suggests riparian soils with high sedimentation contain more SOC



Riparian SOC Pools at a Watershed-scale

Example GIS Map

- On average, riparian zones comprised 8% of the total watershed area

- Contained as much as 20% of the total watershed SOC

- **Riparian zones occupy small portion of the landscape, but represent large sink for SOC at a watershed-scale**