Effects of Anthropogenic Activity on Riparian Hydric Soils

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Significant changes in land use have occurred during the past 400 years in southern New England

How do these changes affect the riparian zone N sink function?

- Land use shifts can cause lower **carbon** contents in alluvium and other sedimentary and anthropogenic deposits
- Anthropogenic activity may increase runoff, decrease infiltration, lower **water tables,** and limit **anaerobic conditions.**

Study Objectives

I. Document and examine soil characteristics of human-transported materials (HTM) relevant to the N sink function in estuarine riparian settings.

II. Identify alluvial markers of land use change and establish timeframes of deposition in stream-side riparian zones.

III. Evaluate how historic shifts in land use have affected rates of alluvial deposition and carbon characteristics of riparian alluvium relevant to denitrification.

Estuarine riparian zones have been significantly altered by human activity

- Fill materials, which are now termed human transported materials (HTM), are often added to estuarine riparian zones for shoreline development.
- Properties and functional capacity HTM are unknown.

Methods of Investigation

- 11 sites with HTM additions and 4 reference sites;
- Water tables were measured approximately twice a month;
- Multiple auger transects completed at each site;
- Soils were described and sampled from 5 deep soil pits;
- Physical characteristics, soil organic carbon (SOC) content, and morphologic forms of carbon were documented.

Three Classes of HTM Were Identified:

- Fill materials
- Dredge spoils
- Capped dredge spoils

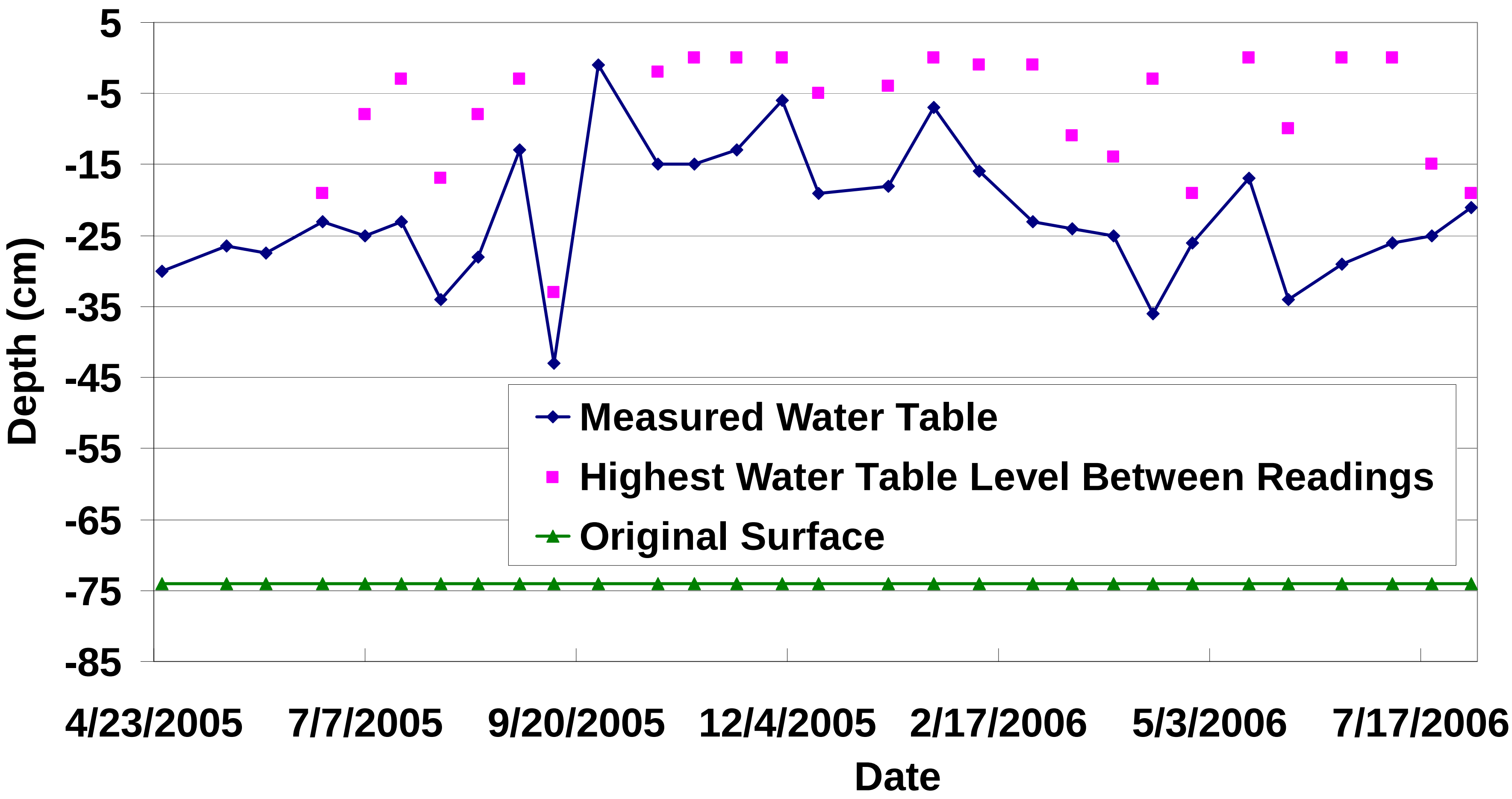
Soils formed in HTM were predominately sandy

Family particle size class of anthropogenic and natural soils of the estuarine riparian zone.

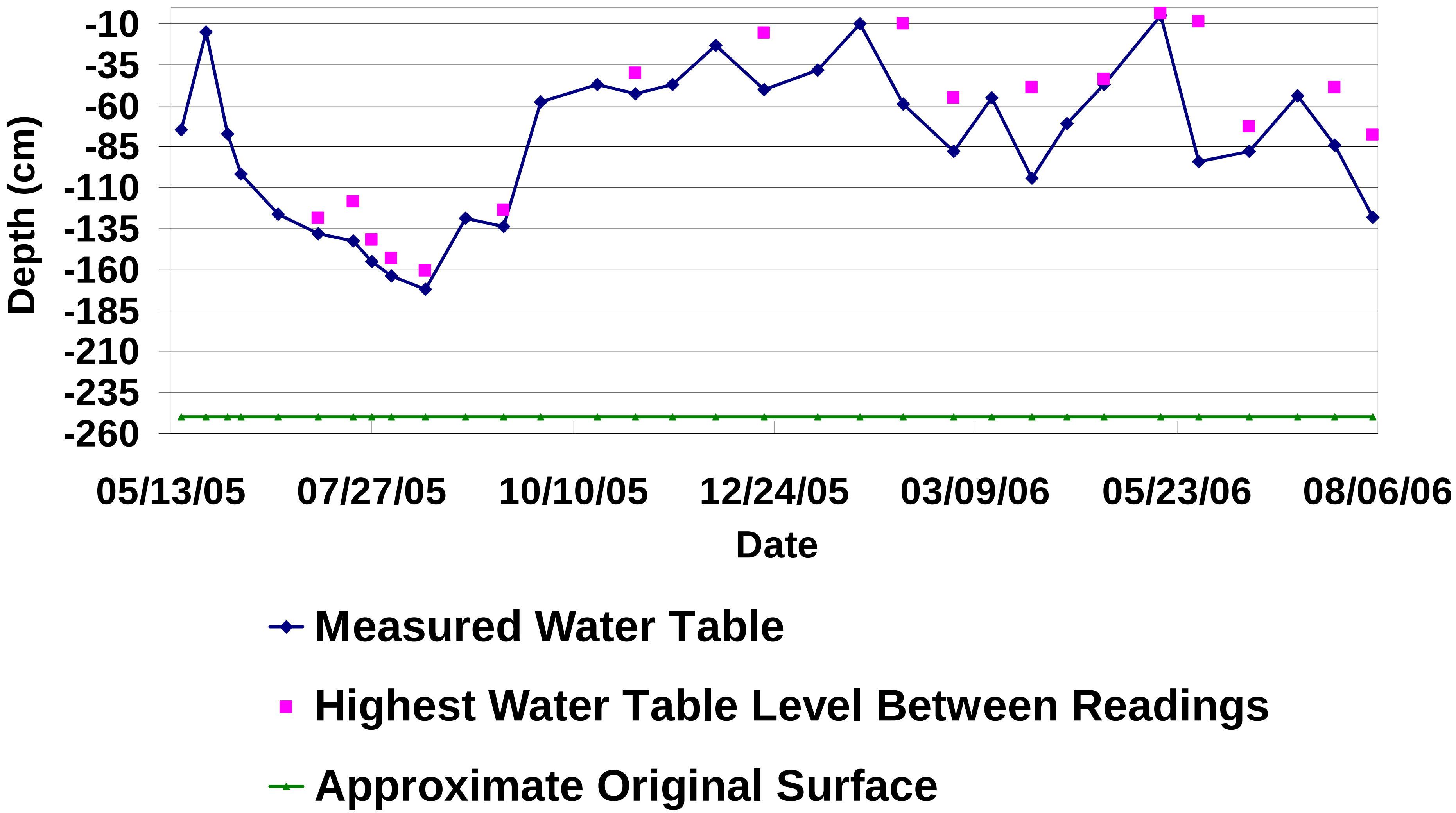
Soil Type	Number of Soils	Sandy	Coarse Loamy	Sandy Skeletal	Loamy Skeletal	Sandy Over Loamy
Fill Materials*	30	15	9	4	1	0
Dredge Spoils	4	0	4	0	0	0
Capped Dredge Spoils	21	20	1	0	0	0
Reworked HTM	6	5	0	0	0	1
Reference Soils***	16	9	2	0	0	2

* One soil was comprised of > 90% artifactual materials, so a particle size family class using Soil Taxonomy was unable to be determined. Three additional soils had > 35% artifacts, but did not meet Soil Taxonomy requirements for a skeletal particle size family class.

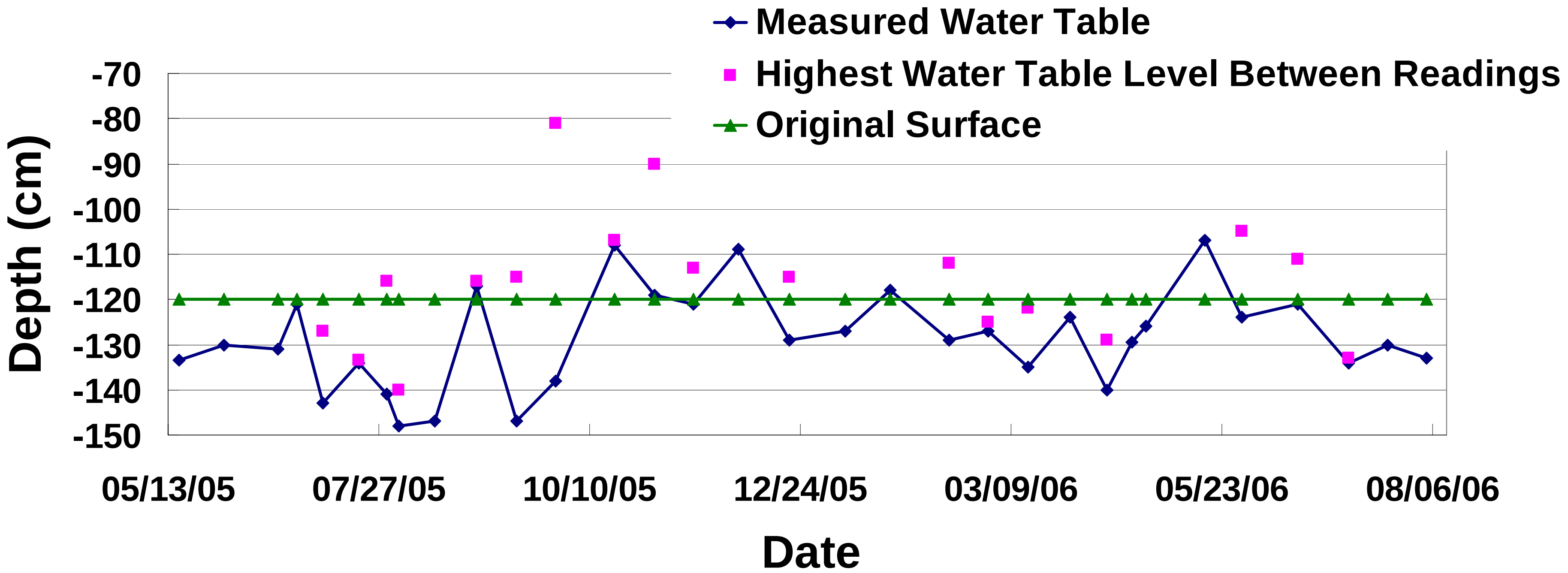
*** Three pedons of organic soil materials were present, so a particle size family class was not determined.



- Water tables rose into the HTM in all 18 monitored locations
- Water tables exhibiting strong tidal influences where directly exposed to estuarine waters
- Soil saturation required for denitrification can occur in HTM



- Example of water table activity in HTM over a tidal creek marsh
- Water tables in HTM with no direct exposure to tidal water exhibited strong seasonal and precipitation influences



- Example of water table activity in HTM over sandy unconsolidated shore
- Water tables frequently rose into the HTM, but did not remain above the buried natural surface
- Characteristics of buried natural soils effected water table activity in the HTM deposits

Carbon Forms Were Abundant Below the Water Table of HTM Deposits

Abundance of carbon forms below the water table within fill and dredge deposits. The depth to the water table was estimated as the equivalent to the first horizon with redoximorphic features.

Type of HTM	Total Number of Soils	Percent of Soils With Carbon Forms Present*						
		Roots	Root Traces	Masses	Lenses	Horizon Carbon	Non-Woody FOM**	Woody FOM**
Fill Materials	**51**	67%	4%	49%	4%	45%	29%	12%
Dredge Spoils	**25**	72%	0%	72%	40%	48%	80%	4%

*Carbon forms defined by Blazejewski et al. (2005).

** FOM: Fragmental Organic Matter

Redoximorpic features demonstrated reducing conditions sufficient for denitrification

The water table in this soil fluctuated from 0-43 cm, and the measured water table was above 25 cm for 63% of the measurements.

Redoximorphic features demonstrate reducing conditions sufficient for microbial denitrification.

Black colors may be the result of sulfidic materials.

Buried fringing marsh surface at 64 cm.

Important Findings: Estuarine Riparian Zones

- With the exception of cases where sandy-unconsolidated shore materials were filled, saturation occurs well above previous conditions;
- Carbon in a number of forms can be found throughout soils formed in estuarine HTM;
- Evidence of reducing conditions were observed in nearly all of the soils suggesting conditions for denitrification exist in these anthropogenic estuarine riparian soils.

Use of Stratigraphic Markers To Establish Timeframes of Alluvial Deposition In Stream-Side Riparian Zones

What can be used as markers of environmental and land use change?

Soil Morphology

- Buried horizons indicate former surfaces
- Artifacts document anthropogenic influences and time periods

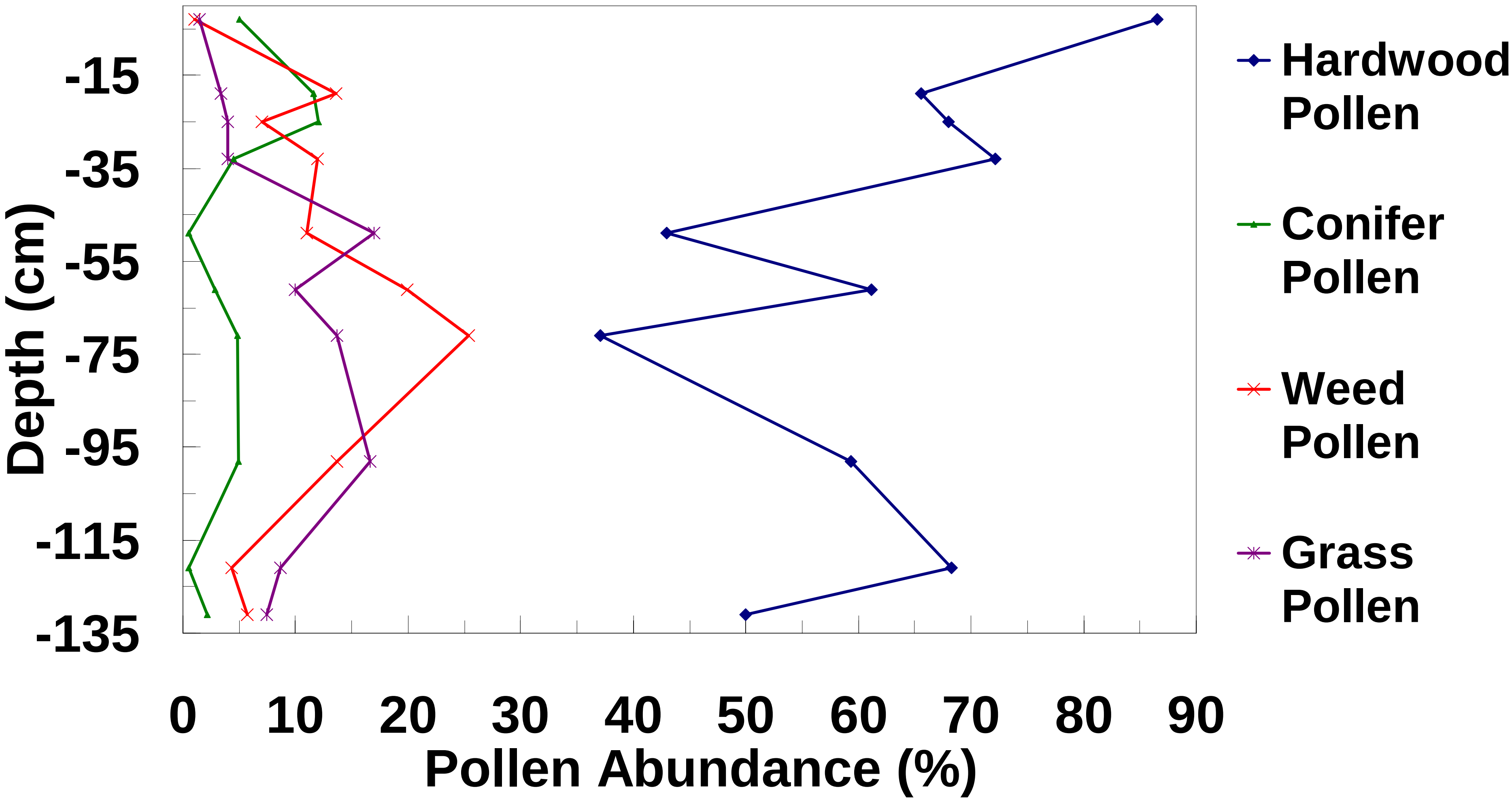
Pollen

- Plant communities have changed dramatically over the past 400 years in the Northeast
- Numerous studies using pollen have been completed regionally in lake sediments and bogs
- Pollen is preserved in the anaerobic hydric soils

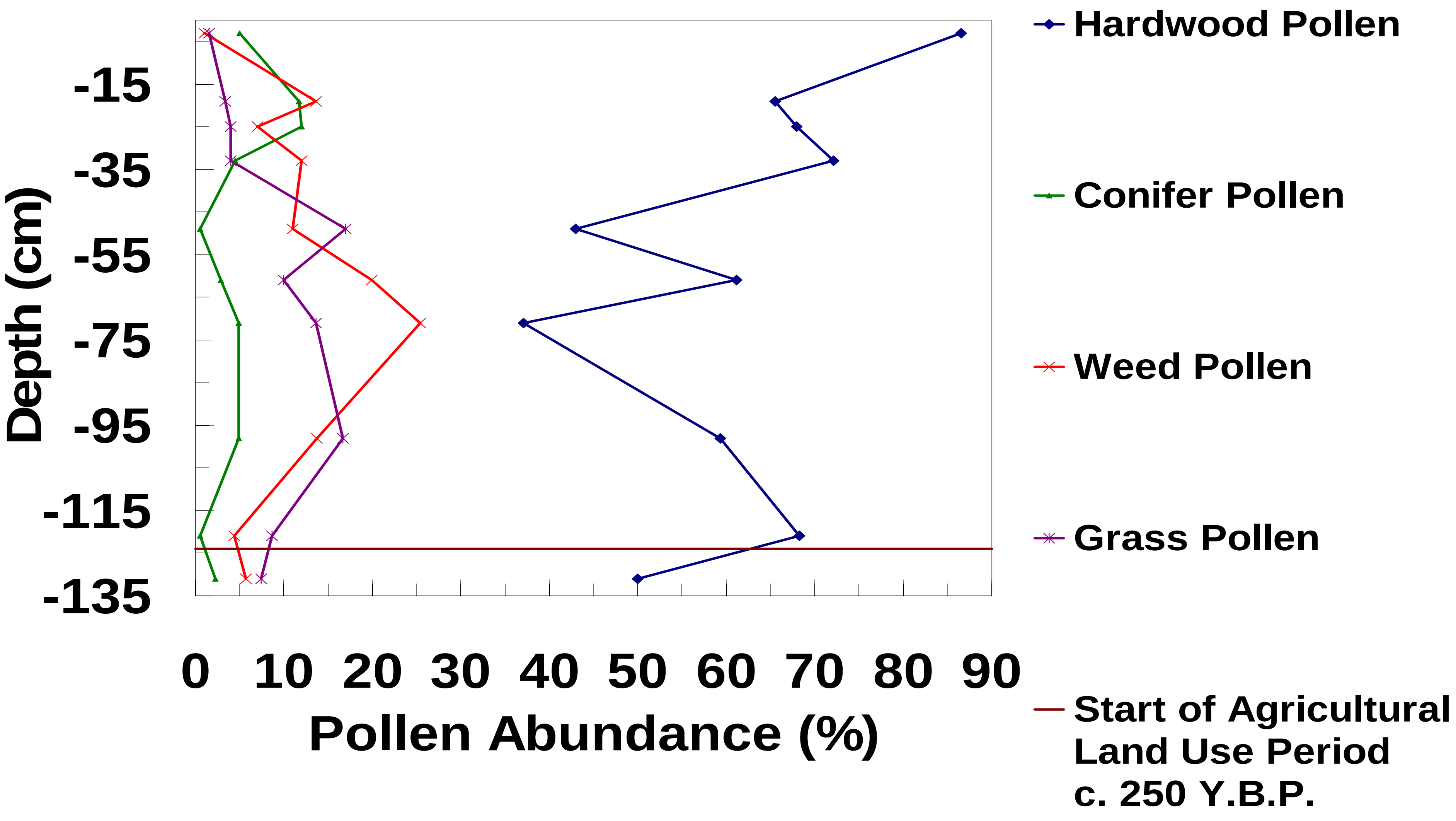
Method of Investigation:

- 6 stream-side riparian study sites
  - 3 agricultural watersheds with growing suburban development
  - 3 suburban-urban watersheds
- Soils described and sampled from deep pits and bucket auger borings
- Samples were processed and analyzed:
  - Isolate and count pollen spores
  - Determine radiocarbon ages
  - Identify artifacts
- Historic aerial photographs were reviewed
- Interpretations were made on timeframes of alluvial deposition

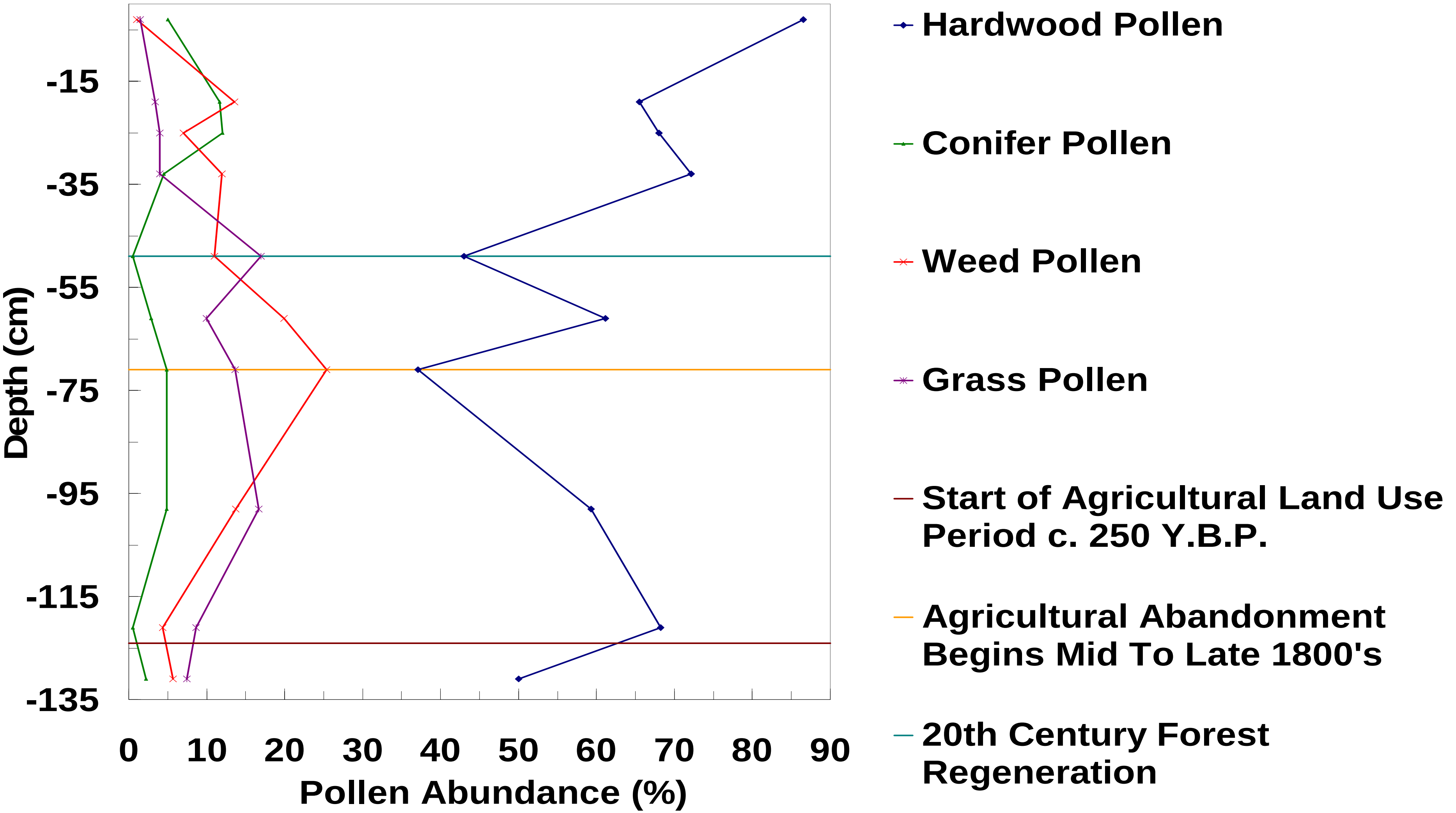
Distribution of pollen with depth in an alluvial soil formed at a natural levee



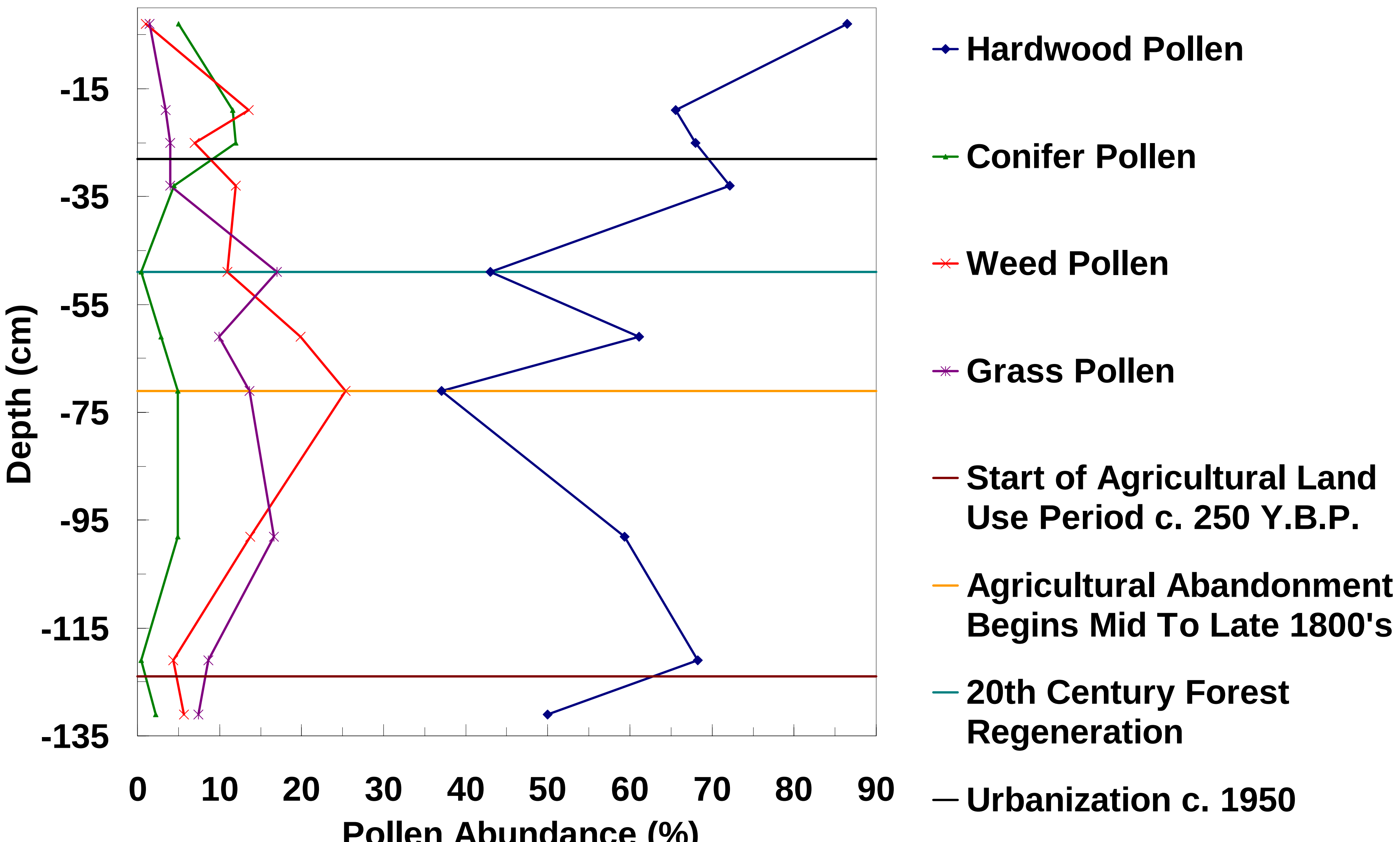
- Soil morphology changes at 124 cm
- Radiocarbon analysis of plant fragments from this portion of the soil had an age of 224 – 287 years before present



- Declines in weed and grass pollen beginning at 71 cm indicate the start of agricultural abandonment.
- Increases in hardwood and conifer pollen demonstrated a period of forest regeneration was underway at 49 cm.



- All horizons above 28 cm contained modern artifacts
- A buried surface horizon was present from 28 to 37 cm



Morphologic Markers of Land Use Change In Riparian Alluvium

- Buried surface horizons were present at 5 of the 6 sites.
- Combination horizons with thin buried surfaces developed during land use shifts at two sites.
- Artifacts were present in alluvium deposited subsequent to 1950 in the three suburban-urban sites.

Effects of Land Use Change on Sedimentation Rates, Soil Organic Carbon, and Permanganate Oxidizable Carbon In Stream-Side Hydric Riparian Soils

Estimated net alluvial deposition rates

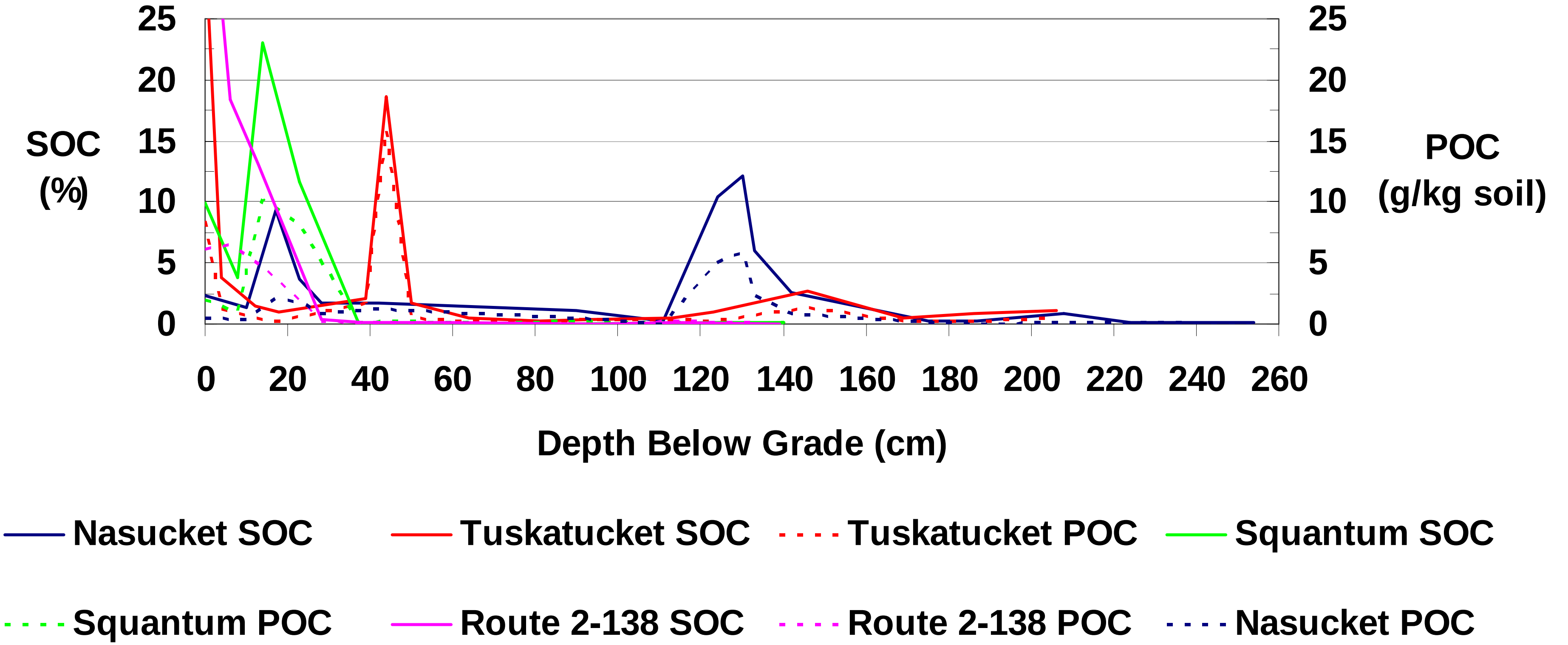
Depth (cm)	Alluvial Age (Y.B.P.)*	Land Use Period	Net Sedimentation Rate (cm yr^{-1})
		Nasucket	
0-28	Present to circa 56	Suburban-Urban	0.50
28-124	Circa 56 to 224 – 287	Agricultural	0.42 - 0.57
124-276+	224-287 to 17,000	Pre-Colonization	> 0.008**
		Tuskatucket	
0-14	Present to circa 56	Suburban-Urban	0.25
14-105	Circa 56 to 306	Agricultural	0.36
105-251	Circa 306 to 17,000	Pre-Colonization	0.007
		Squantum	
0-14	Present to circa 56	Suburban	0.25
14-37	Circa 56 to 17,000	Agricultural and Pre-Colonization	0.001
		Route 2-138	
0-10	Present to circa 250	Agricultural	0.04
10-38	Circa 250 to 17,000	Pre-Colonization	0.001
		Slocum	
0-100	Present to circa 250	Agricultural	0.40
100-112	Circa 250 to 17,000	Pre-Colonization	0.0006
		Pippin Orchard	
0-77	Present to circa 250	Agricultural	0.31
77-92	Circa 250 to 17,000	Pre-Colonization	0.0009

***Y.B.P.: Years Before Present**

How does accelerated alluvial deposition affect the N-sink function?

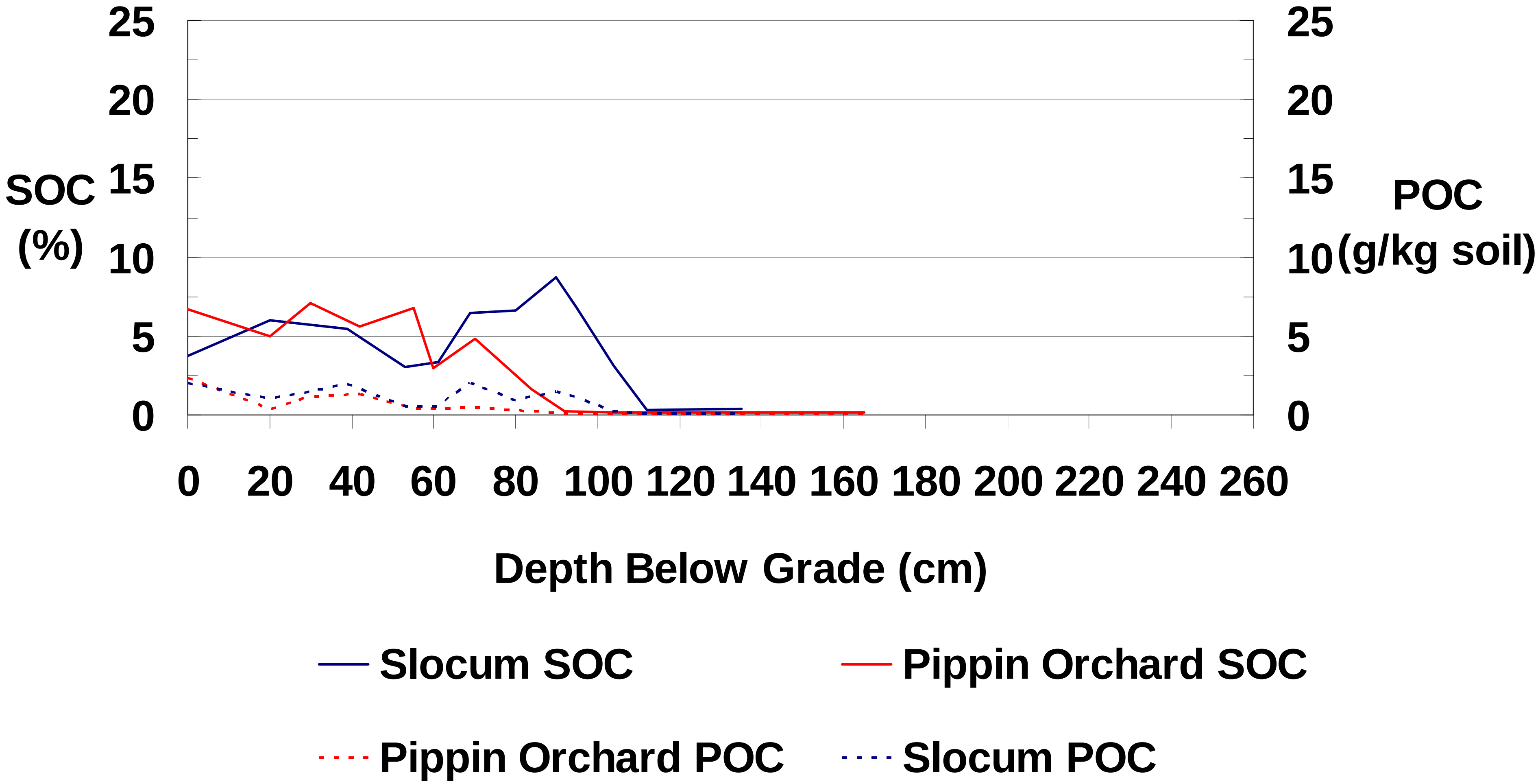
- Soil saturation is required for denitrification
- Accelerated riparian soil deposition has the potential to increase the distance between the riparian surface and the water table
- Evidence of stream channel filling was present, which has offset gains in the riparian surface elevation by raising the hydrologic baseline of the riparian zone and maintained hydric conditions.

Distribution of SOC and POC with depth in four soils with O horizons



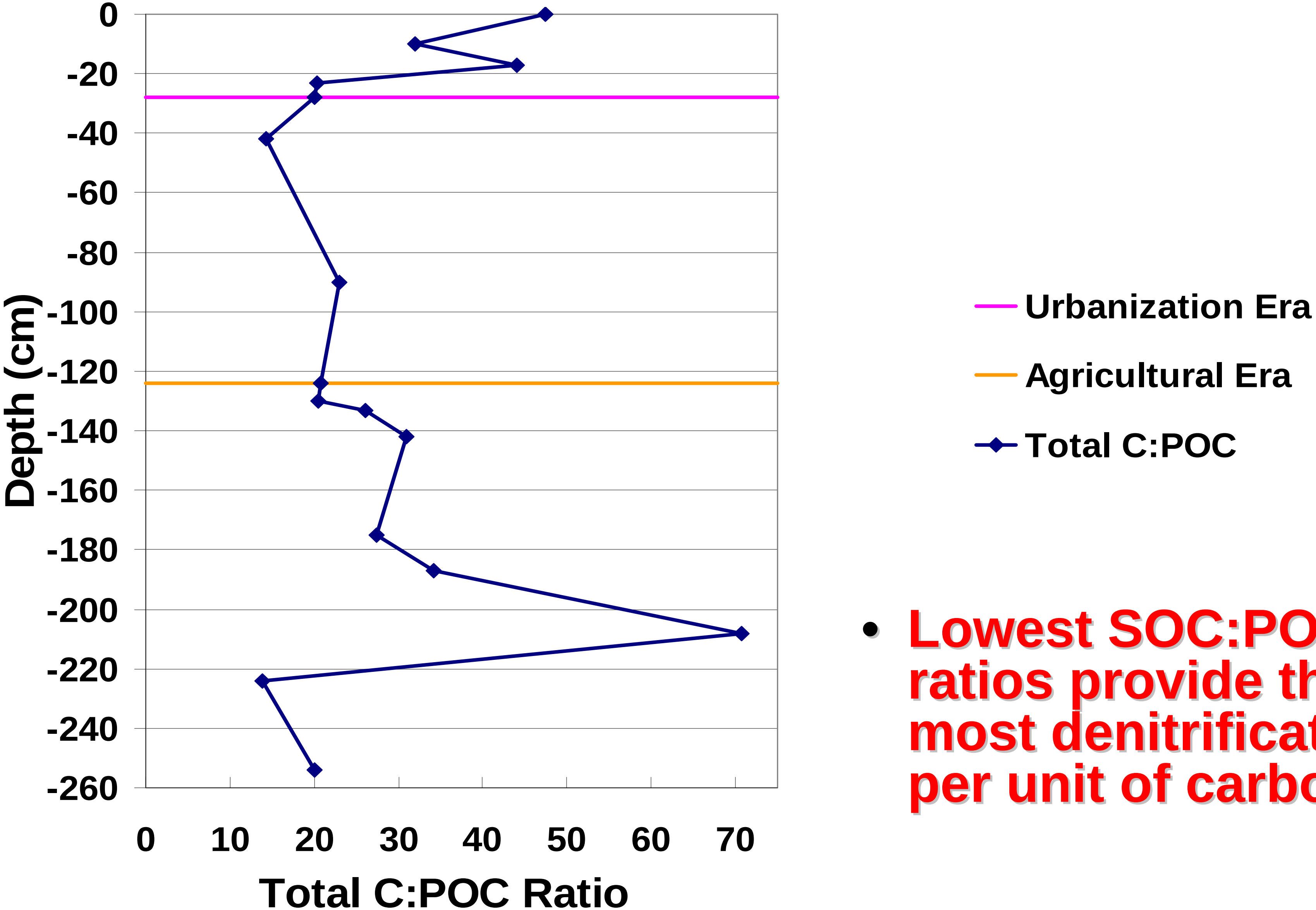
- Buried O horizons were subsurface carbon hotspots that formed during shifts in land use.

Distribution of SOC and POC with depth in the two soils comprised of mineral soil horizons



- In mineral alluvial soils carbon distribution remained relatively steady during shifts in land use.

Example of the distribution of the SOC:POC ratio with depth in riparian alluvium



- **Lowest SOC:POC ratios provide the most denitrification per unit of carbon**

Horizons with morphologic evidence of accumulations of humified carbon had wider SOC:POC ratios

SOC:POC usually <40

SOC:POC usually >40

Important Findings: Stream-side Riparian Zones

- Net riparian sedimentation rates increased substantially as a result of shifts in land use
- Simultaneous channel filling maintained hydric conditions in riparian soils
- Carbon hotspots are a function of alluviation: where carbon is buried as a horizon or enriched during alluvial deposition as a result of shifts in land use


Questions?