Use of Pollen and Plant Fossils for Wetland Creation, Restoration, and Enhancement

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Wetland Restoration

- Varies with location
- Primarily concerned with:
  - Site selection;
  - Hydrology;
  - Soil amendments;
  - Plant selection;
  - Target ecological functions and societal values; and
  - Success metrics, long-term monitoring and management.

Vegetation

- Undisturbed native habitat is rare
- Few areas in the US have escaped the effects of human impacts
- Plant list typically consists of local native species

Diminished Restoration Benchmarks

Benchmark

Pre-history
Forested

1700s-Present
Scrub-Shrub

Future
PEM-Open Water

Time

The Questions

- Can ecological functions and values be restored to that of historical wetlands?
- Are we constructing and restoring wetlands with a specific purpose in mind or just fulfilling a regulatory requirement?
- Should we aspire to a higher restoration benchmark for vegetation?
- Should there be an attempt to establish historical vegetation benchmarks where appropriate?

Palynology/Paleoecology

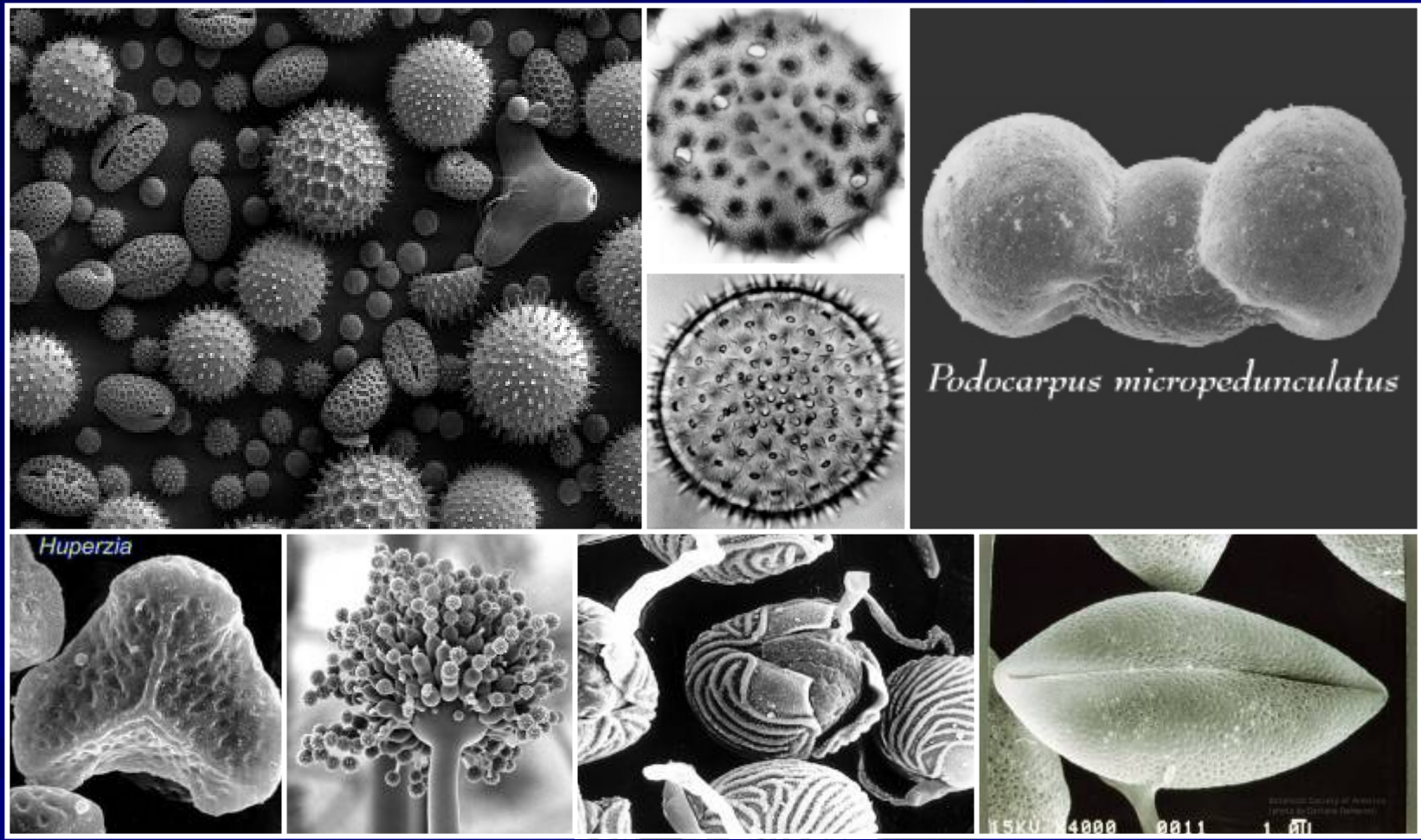
- The use of pollen, spores and macrofossils allow us to:
  - Identify floristic composition and community changes in space and time;
  - Provide insight into factors that influence long-term (10^2-10^6 years) ecological and environmental dynamics; and
  - Provide a better understanding of the relative importance of autogenic (succession) and allogenic (climate, hydrology and disturbance) processes that are specific to the site.

What are pollen and spores?

- **Spores:** the reproductive units of seedless plants (e.g., ferns, mosses, club mosses, horsetails, whisk ferns, fungi)

- **Pollen:** the male reproductive units of seed plants (e.g., conifers and flowering plants)

Pollen and Spore SEM Images



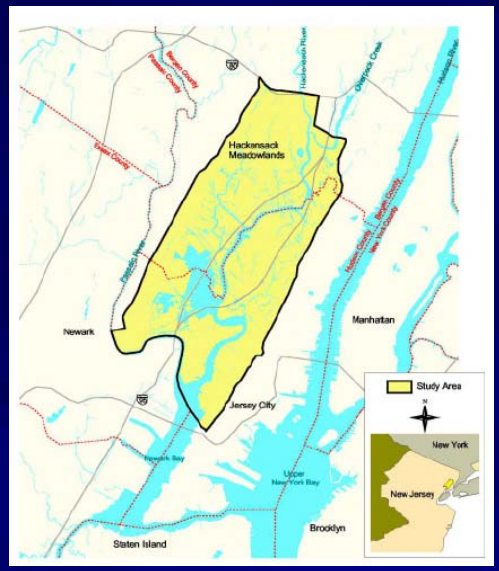
Importance of Pollen and Spores

- **Decay Resistant**: Pollen and spores can be collected from a site millions of years after dispersal and removed from the sediment with minimal damage.
- **Correlation**: Pollen and spores can be correlated with the sedimentary and depositional environment and local hydrogeomorphology.
- **Identification**: Each genus or species commonly produces pollen or spores that are unique and can be identified.

Importance of Pollen and Spores

- **Vegetation**: Provides an approximation of the vegetation that was present in the vicinity of the depositional environment.
- **Resolution**: Can provide a high-resolution snapshot of the local environment.

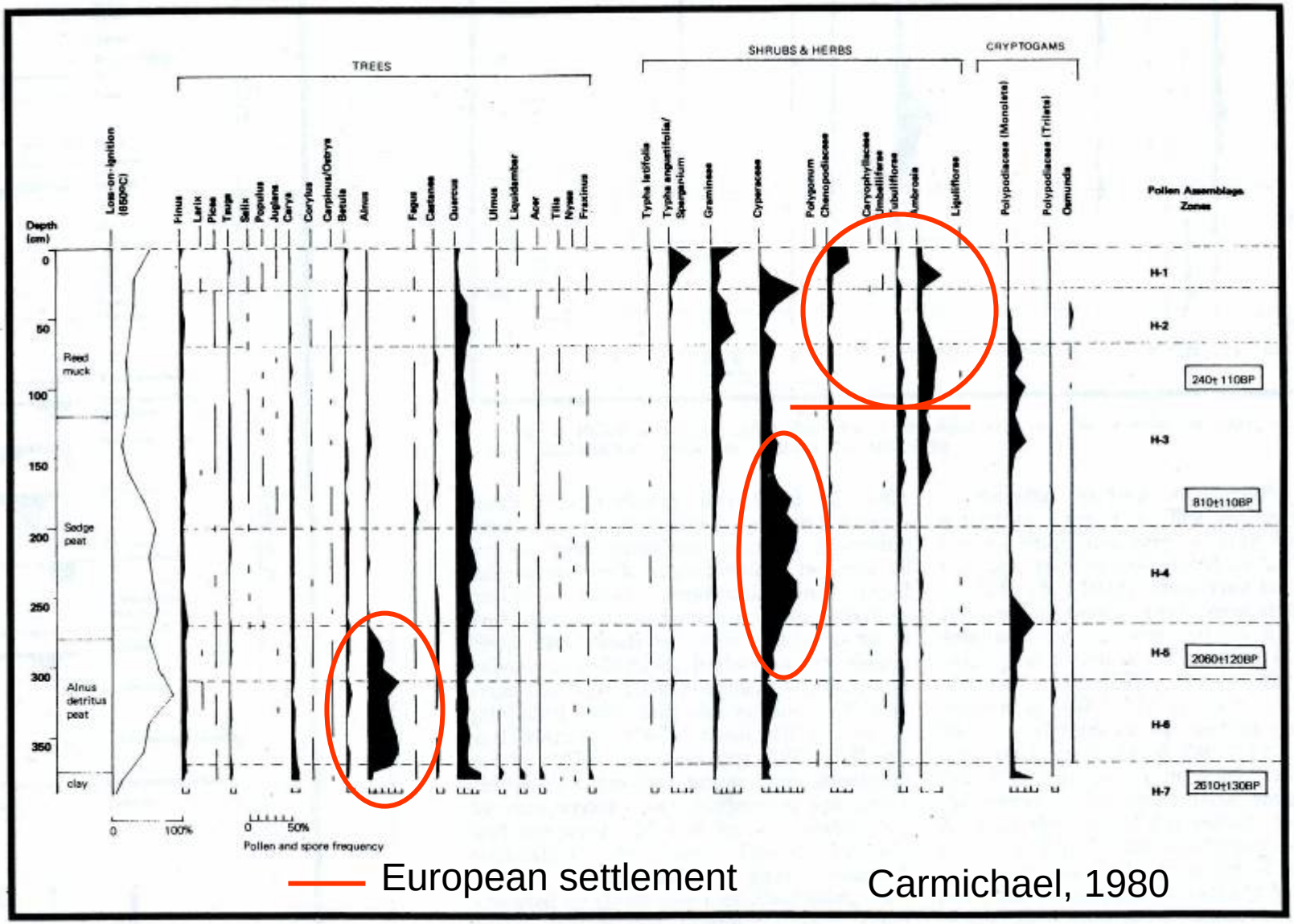
Hackensack Meadowlands, NJ – Example 1



Currently dominated by *Phragmites australis*.

Restored with *Spartina alterniflora*.

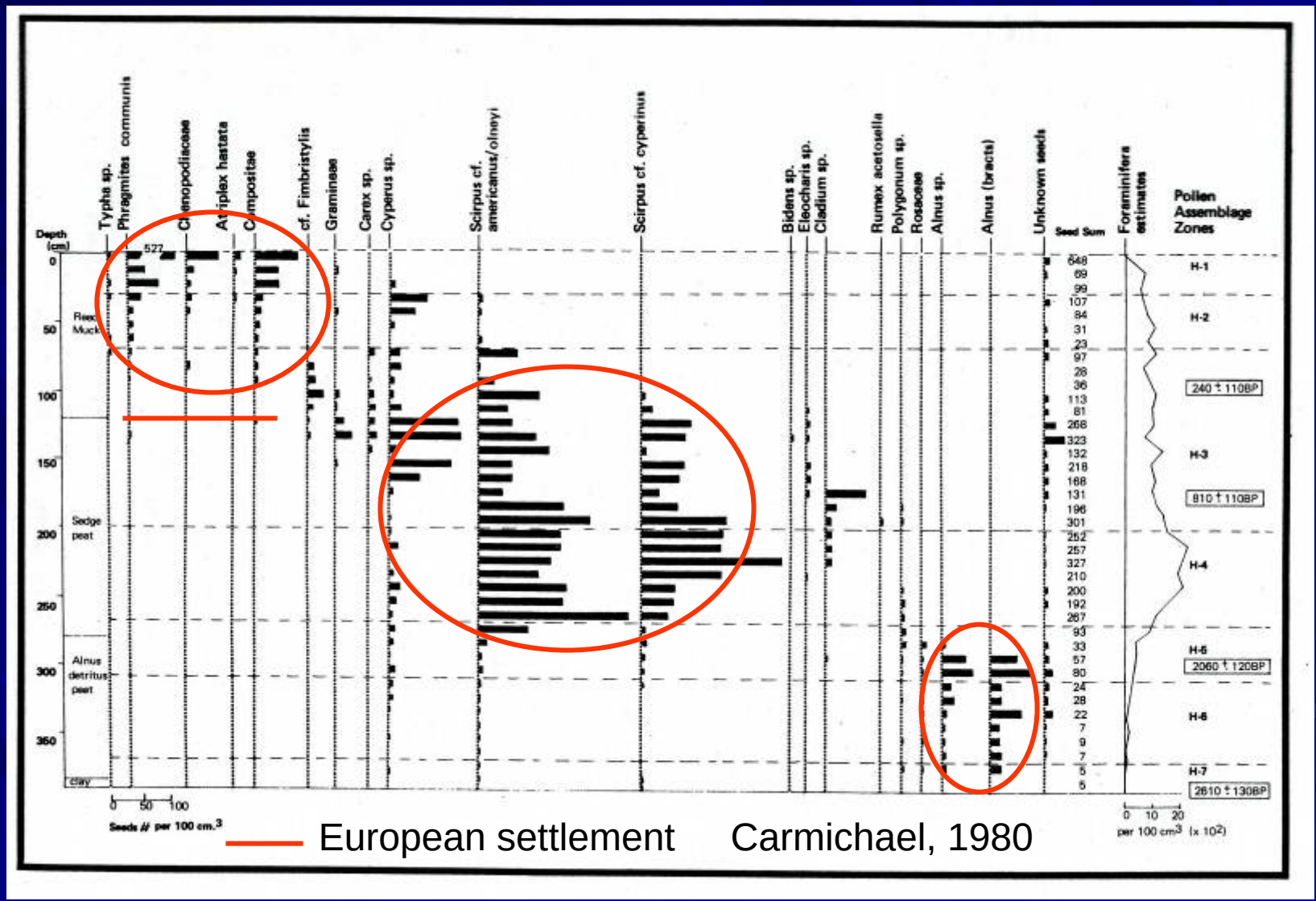
Meadowlands Pollen Spectrum



European settlement

Carmichael, 1980

Meadowlands Seed Spectrum



Meadowlands History

- Pleistocene ice retreated ca. 8,000-10,000 years BP
- Hackensack Lake (glacial) persisted for 2,500-3,000 years
- Area was probably marine until 2,600 years BP - no vegetation, only clays
- Fluctuating brackish-freshwater environments since 2,600 years BP
- Peat accumulation phase 2,600 years BP - *Betula-Alnus-Fraxinus* forest with sedges, *Sphagnum*, and *Typha*

Meadowlands History

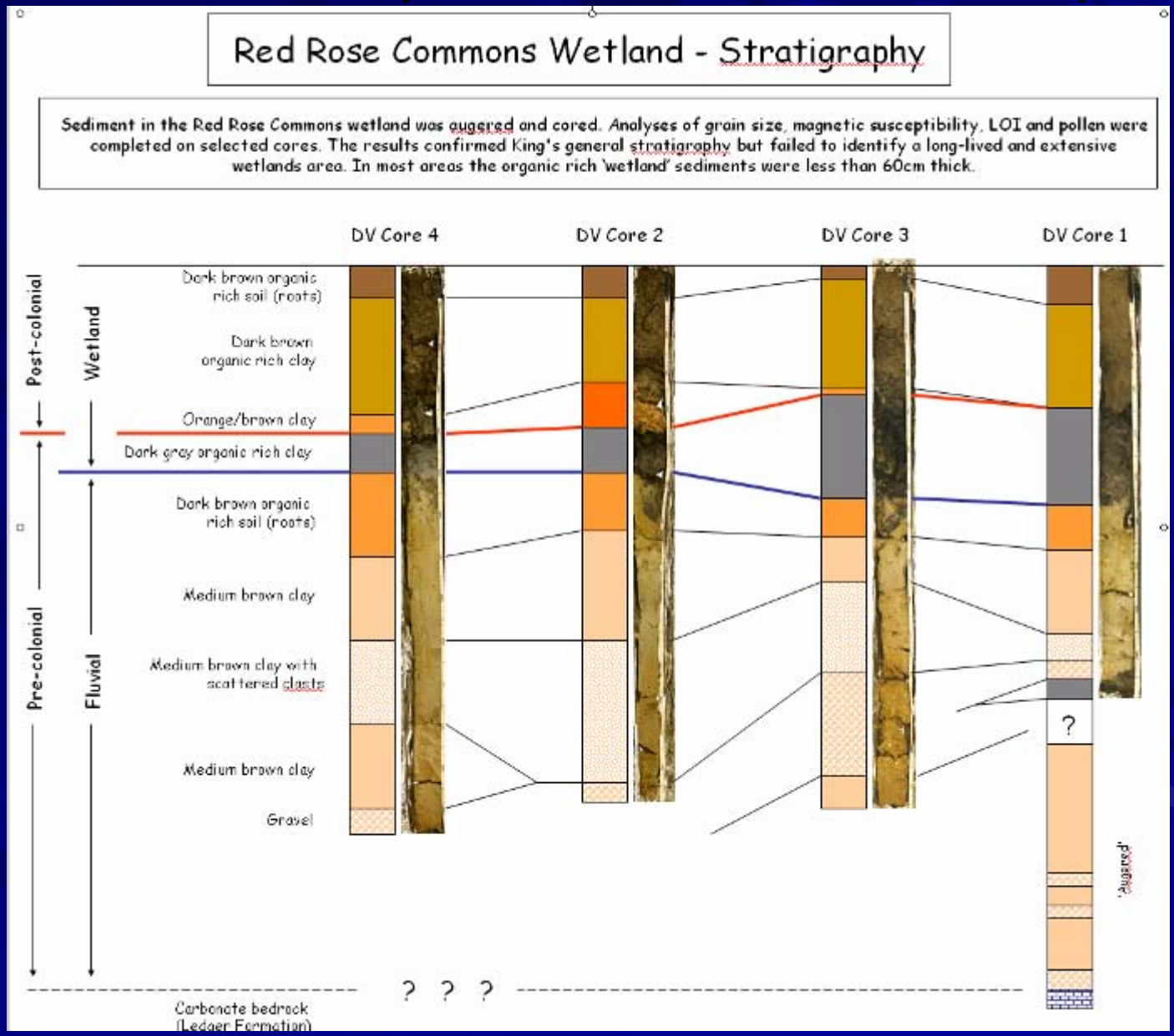
- 2,000 years BP - *Picea-Larix* forest
- 1,300 years BP - 1st occurrence of *Chamaecyparis thyoides*
- Oradell dam built in 1921 changed the hydrology and the freshwater wetlands became estuarine
- *C. thyoides-Larix* disappear ca. 1935 due to fire, ditching, and hydrologic alteration
- Today - *Phragmites*-dominated tidal marsh ecosystem or restored *Spartina* monoculture

Chamaecyparis thyoides
stumps from Mill Creek, NJ

Meadowlands

- Sediments show the geomorphic, hydrologic, and vegetation history is complex due to its position in the landscape (i.e., near sea level)
- Pollen record indicates the vegetation was responding to alternating freshwater and marine conditions
- Anthropogenic influence is pronounced and the pollen record provides evidence of additional complications (e.g., ditching, fire, and diking)
- Pollen, macrofossil and sediment record matches the hydrogeomorphic (HGM) setting throughout the history of the area and provides an excellent example of using pollen/plant fossils to reconstruct past vegetation and the relationship between HGM setting and vegetation

Dillerville Swamp, Lancaster, PA - Example 2



(Data from Dr. C.J. Williams, Franklin & Marshall College)

Dillerville Swamp

- Pollen data indicate the pre-colonial vegetation was dominated by oak, pine, chestnut, hemlock, hickory and willow at the bottom of the section
- Sedimentology indicates most of the area during pre-colonial time consisted of floodplain and riparian forest and the extent of the wetlands was limited
- During colonial times the wetlands became more prevalent as the area was being developed

Dillerville Swamp

- Post-colonial pollen indicative of wetland conditions dominated by *Typha*, *Impatiens*, sedges, hemlock, sycamore, alder, and rushes
- 19th century botanical records indicate the vegetation consisted of a diverse assemblage of facultative to obligate trees, shrubs and herbs and this wetland complex included open water, riparian and floodplain components
- Today these wetlands are small, isolated and dominated by *Typha*

Dillerville Swamp

- The pollen and sediments match the HGM setting of the area
- The pollen history shows the area was not a wetland during pre-colonial time and the wetlands formed in response to human activities

The Challenge

- If possible, project designs should strive to re-establish the dominant HGM of the original wetlands and not an atypical HGM (atypical HGMs support atypical vegetation assemblages) to increase wetland functions (see Gwin *et al.,* 1999; Magee *et al*., 1999; Magee & Kentula, 2005 for supporting data)
- To match the vegetation of a restored or constructed wetland to its HGM equivalent
- Should we implement the use of a historic plant palatte?

Conclusions

- The pollen, plant fossil, and sediment record provide:
  - The ability to correctly identify past HGM settings;
  - A robust spatial and temporal framework of the depositional environment and vegetation (zonation);
  - Evidence of changing hydrologic and vegetation conditions;
  - Clues regarding the types of vegetation that were associated with the hydrology of the original wetlands; and
  - A set of tools that can be used to “tweak” the hydrologic conditions and/or vegetation to potentially improve the ecological functions of restored, created, or enhanced wetlands

Conclusions

- Restored and constructed wetlands should have plant assemblages that correspond to the HGM
- Fossil data provide a mechanism that allows the historical vegetation and corresponding HGM to be identified
- These fossil data therefore provide a useful model that can be used for wetland design and a comprehensive wetland management strategy

Questions ?

Acknowledgements

Chris Williams, Franklin & Marshall College
Marjorie Zeff, URS Corporation
Bruce Bayne, URS Corporation