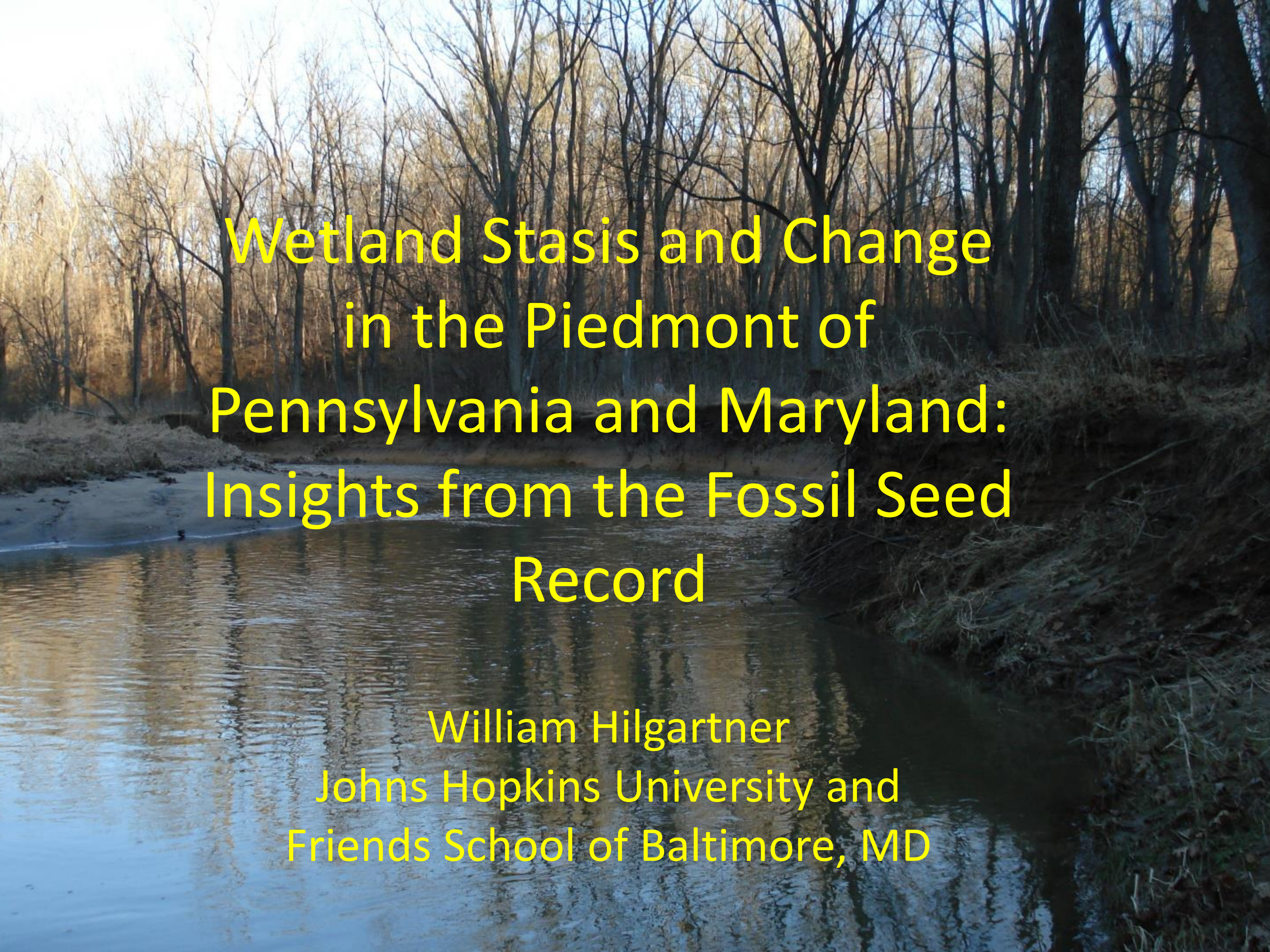


Wetland Stasis and Change in the Piedmont of Pennsylvania and Maryland: Insights from the Fossil Seed Record

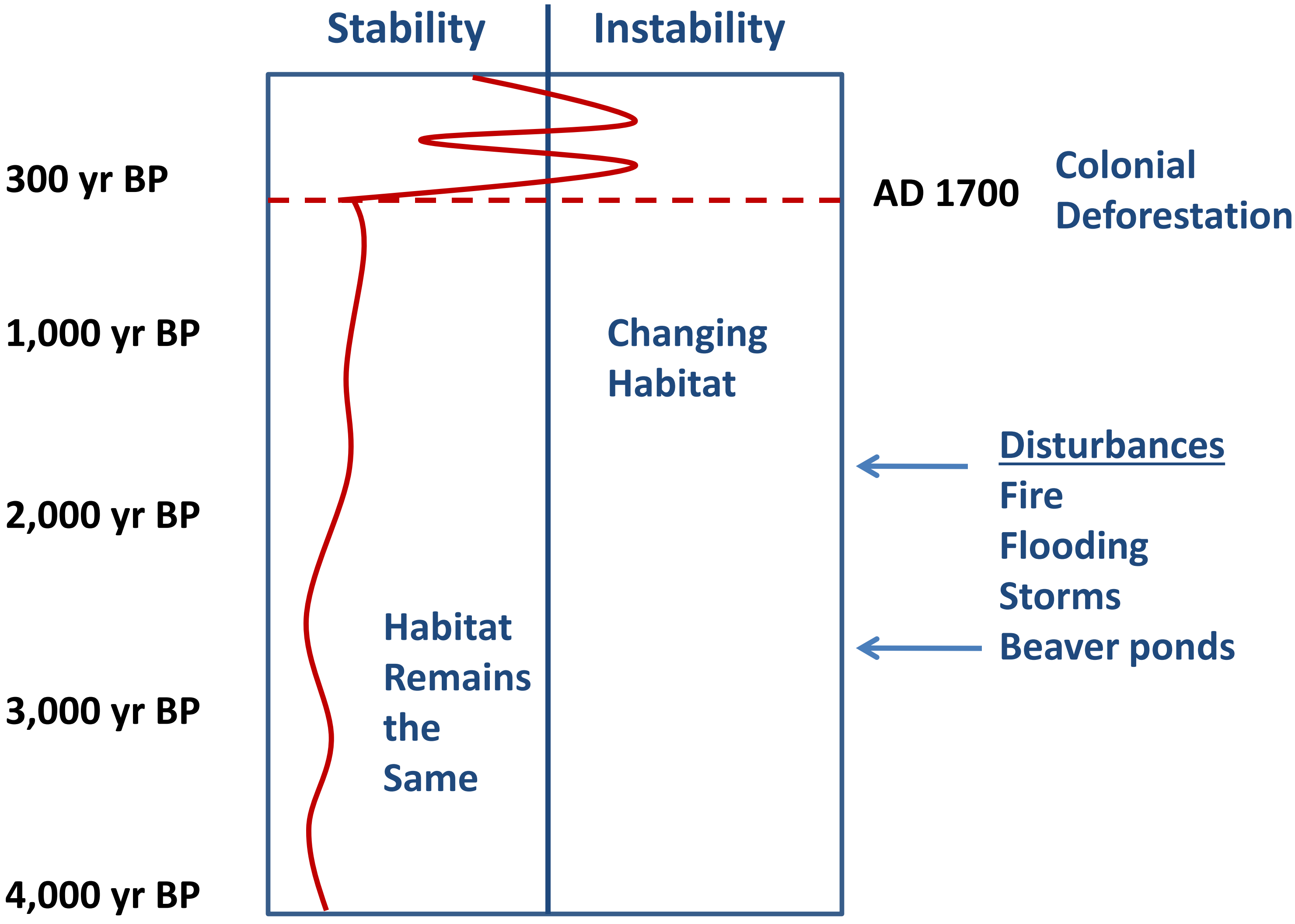
William Hilgartner
Johns Hopkins University and
Friends School of Baltimore, MD

In this presentation…

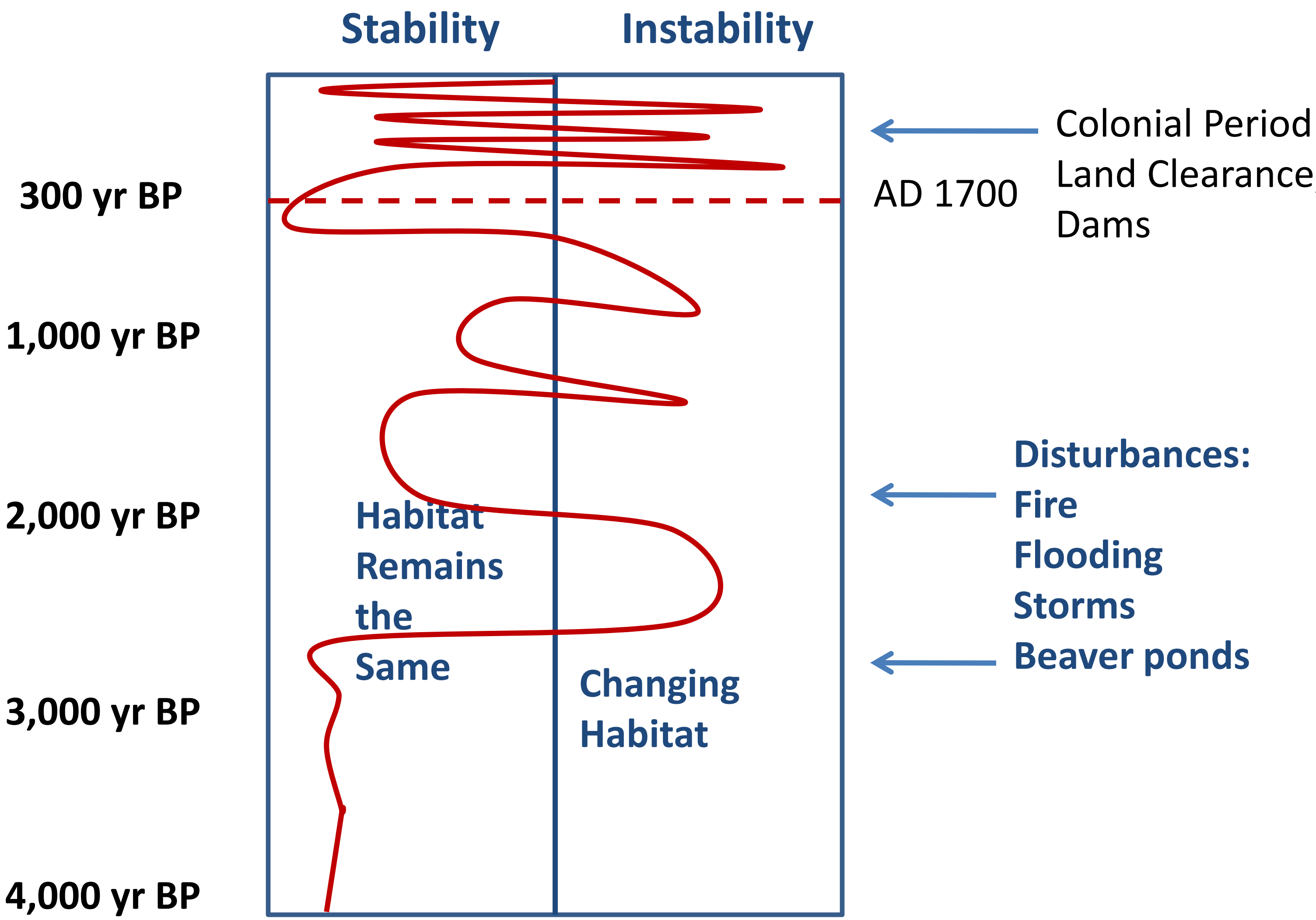
…I will present evidence of wetland stasis before European settlement, instability after settlement (A.D. 1700), and what the fossil record reveals about prehistoric wetland environments in this region of the country:

- **1. Overview of wetland stasis model and definition**
- **2. The fossil seed record and wetland species**
- **3. Three climate-vegetation periods since 20,000 BP**
- **3. Case Study 1: Otter Point Creek, Maryland**
- **4. Case Study 2: Little Falls, Maryland**
- **5. Case Study 3: Big Spring Run, Pennsylvania**
- **6. Bog turtle and sedge wren habitat**
- **7. Native species, non-natives and current riparian environments**

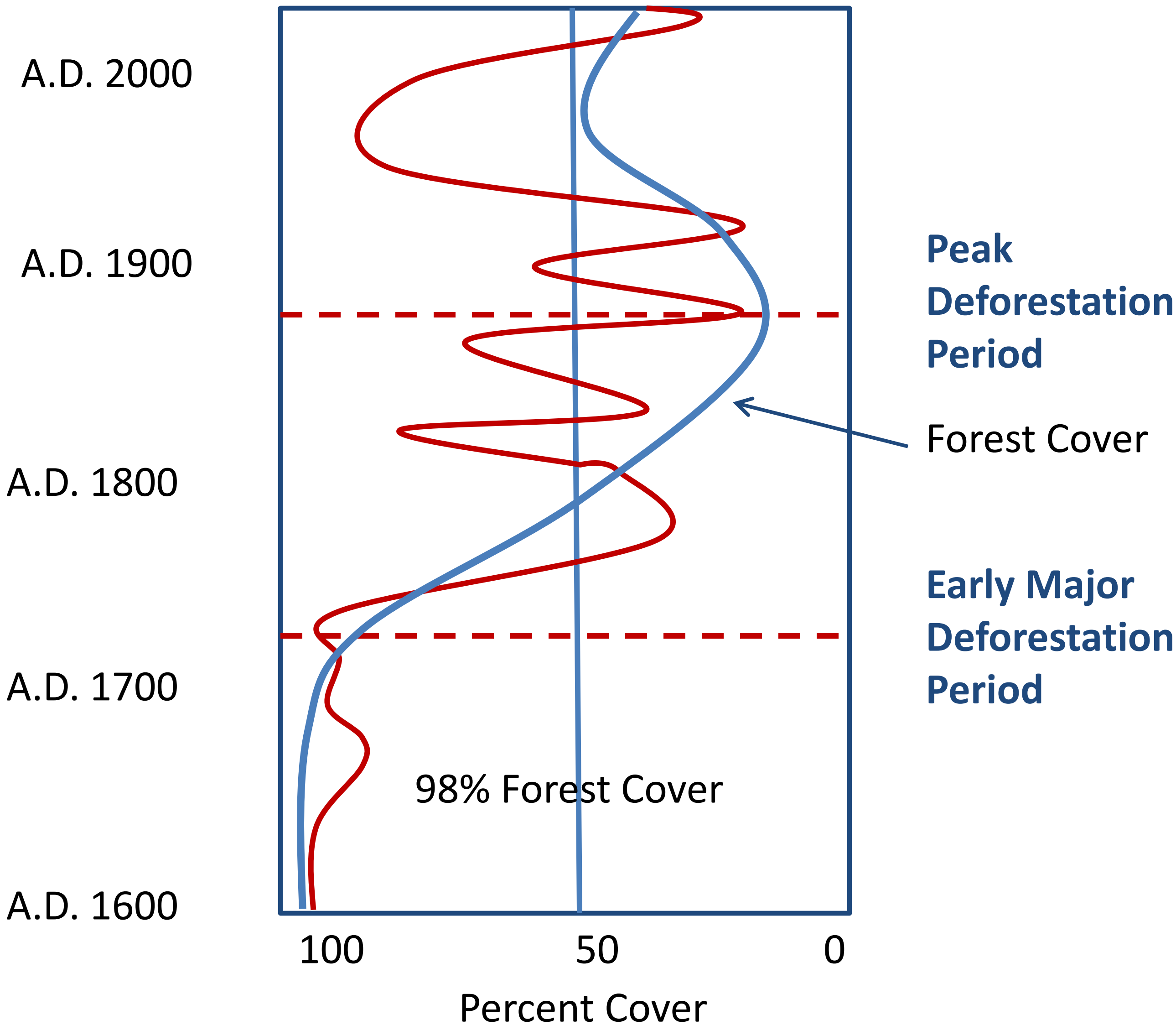
Proposed Habitat Stasis Model Based on the Fossil Seed Record



Whereas the conventional non-equilibrium model might look more like this…



Landscape Change & Forest Cover Past 400 Years



Habitat Stasis Defined

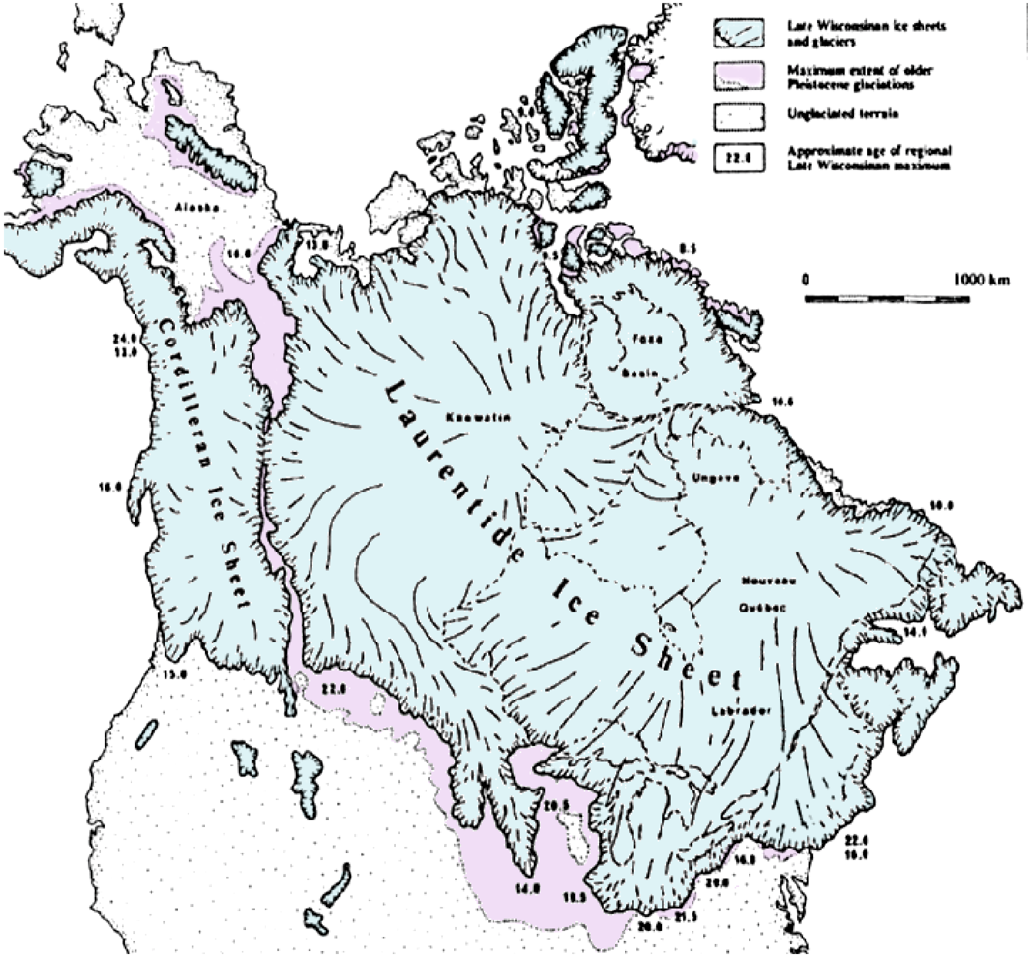
I define *habitat stasis* as an association of species dominated by one to several habitat *indicator species* that persist for an extended period of time.

The *time scale of stasis* based on paleoecological studies is the presence of persistent dominant species and wetland habitats spanning 2000-4000 years.

Habitat Stasis Defined

- In addition to indicator species I use a quantitative definition of stasis with the use of Sorensen's Index of Similarity
- *…habitat stasis exists in the fossil record where the index is ≥ 0.40* (40%) between stratigraphic levels.
- Less than 40% indicates a shift or change in species and therefore habitat change.
- The 40% index has been determined through numerous studies of seeds in surface samples

Glacial Ice Sheet 18,000 BP

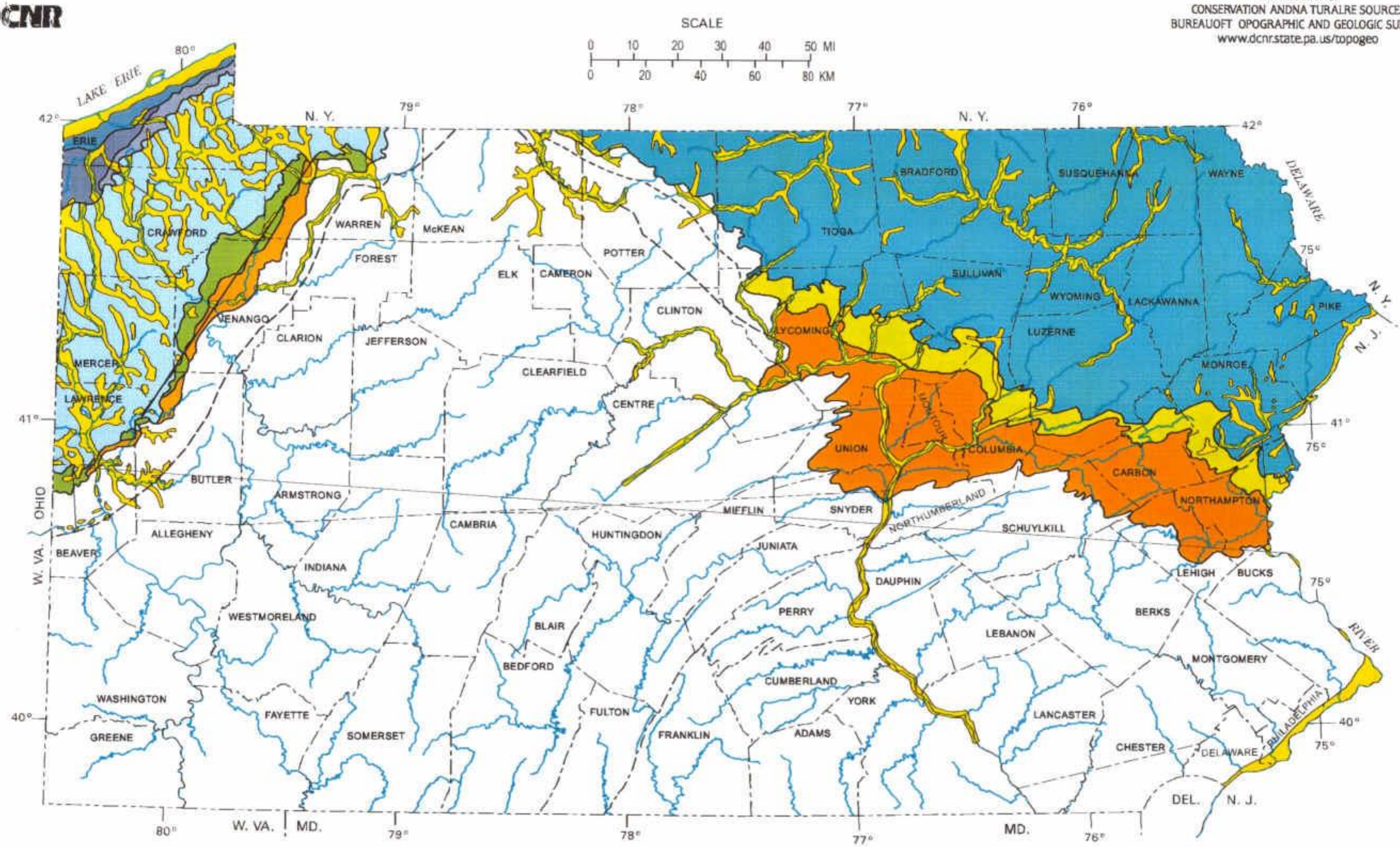


MAP59

DCNR

GLACIAL DEPOSITS OF PENNSYLVANIA

COMMONWEALTHOFP ENNSYLVANIA
DEPARTMENT OF
CONSERVATION ANDNA TURALRE SOURCES
BUREAUOFT OPOGRAPHIC AND GEOLOGIC SURVEY
www.dcnr.state.pa.us/topogeo



EXPLANATION

RECENT TO LATE ILLINOIAN
(0–198,000yrs.)

STRATIFIED DRIFT

Sand and gravel in eskers, kames, kame terraces, and outwash, principally in valleys; silt and clay in lake deposits in formerly ice-dammed valleys; lake clays and beach sands and gravels along Lake Erie; thin (Recent) to thick (late Illinoian) soils.

WISCONSINAN
(17,000–22,000y rs.)

ASHTABULA TILL

HIRAMTI LL

LAVERY TILL

KENTTI LL

Thick, gray, clayey to silty to sandy till covering over 75 percent of the ground; topography is mainly gently undulating, but there is also some knob-and-kettle topography; thin soil.

OLEAN TILL

Moderately thick, gray to grayish-red, sandy till covering 25 to 50 percent of the ground; very thin till covers an additional 25 percent of the ground; topography reflects the underlying bedrock; thin soil.

LATEIL LINOIAN
(132,000–198,000yrs.)

TITUSVILLETILL

UNNAMEDT ILLS

Thin, gray (Titusville) to brown and grayish-red (unnamed), clayey to sandy till covering 10 to 25 percent of the ground; topography reflects the underlying bedrock; moderately thick, well-developed soil.

PRE-ILLINOIAN
(>770,000y rs.)

MAPLEDALE TILL

UNNAMEDT ILLS

Thin, gray, clayey to silty till in patches covering up to 10 percent of the ground; topography reflects the underlying bedrock; thick, well-developed soil, commonly having a yellowish-red color.

SYMBOLS

Southern limitofglacial advance

Approximatel imit of Illinoianadv ance

Approximatel imit of pre-Illinoian advance

ByW. D.Se vonan dD . D.Braun.
SecondEdition ,1997; SecondP rinting, 2000.

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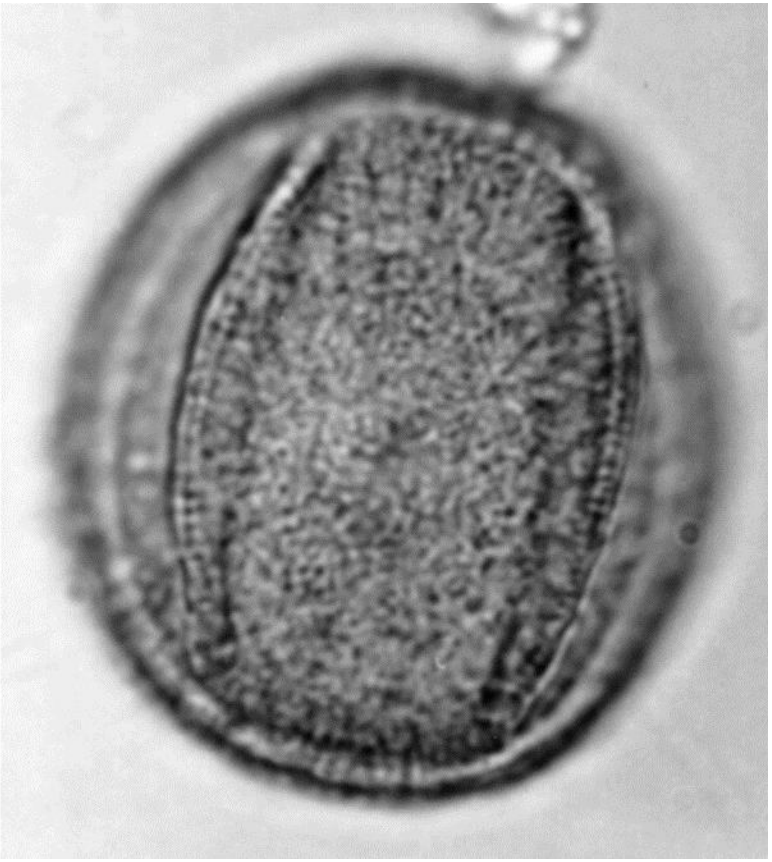
Oak and ragweed pollen



Oak pollen

Ragweed Pollen

Pollen profile from a core taken near Beltsville, MD

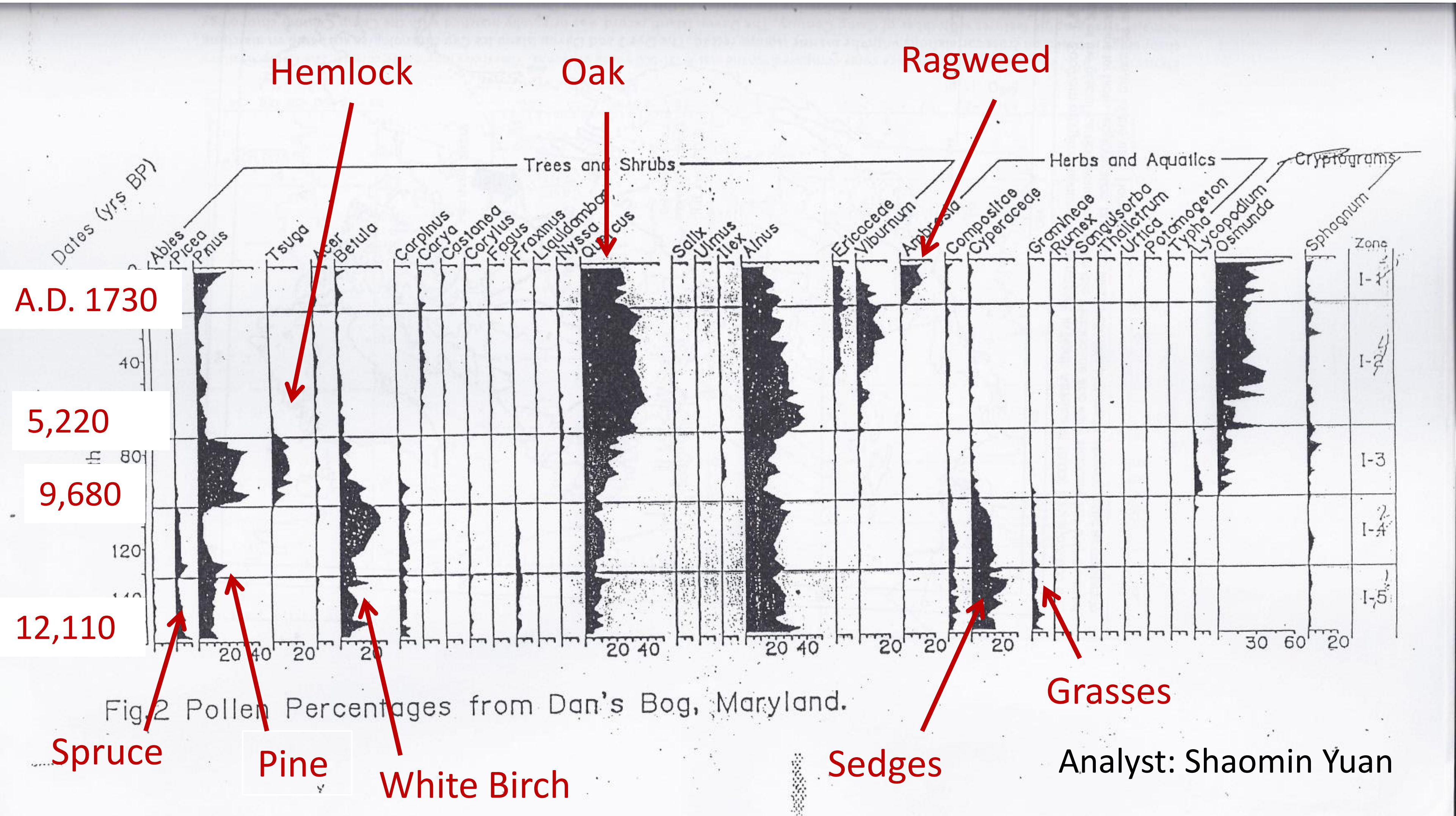
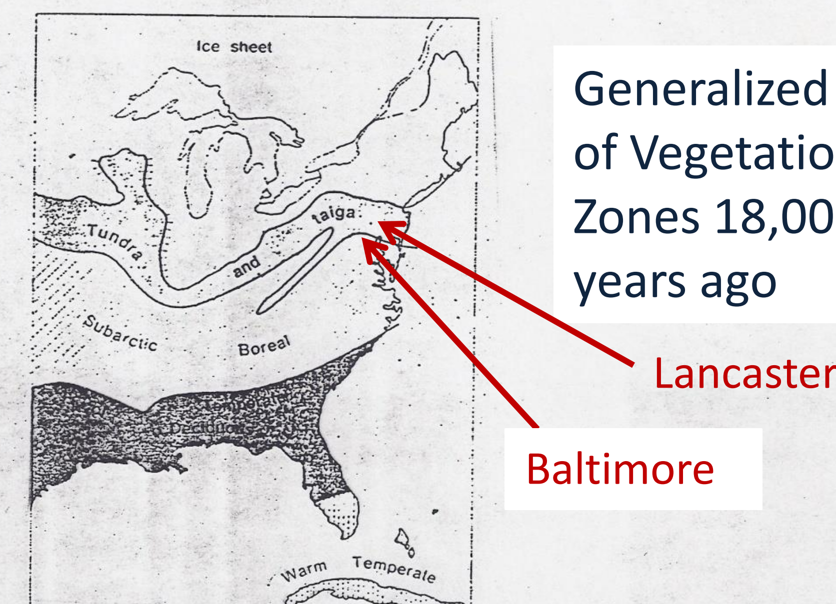


Fig.2 Pollen Percentages from Dan's Bog, Maryland.

The probable distribution, based on studies of fossil pollen, of various plant communities at the height of the last continental glaciation, when sea level was about 330 feet lower than it is today

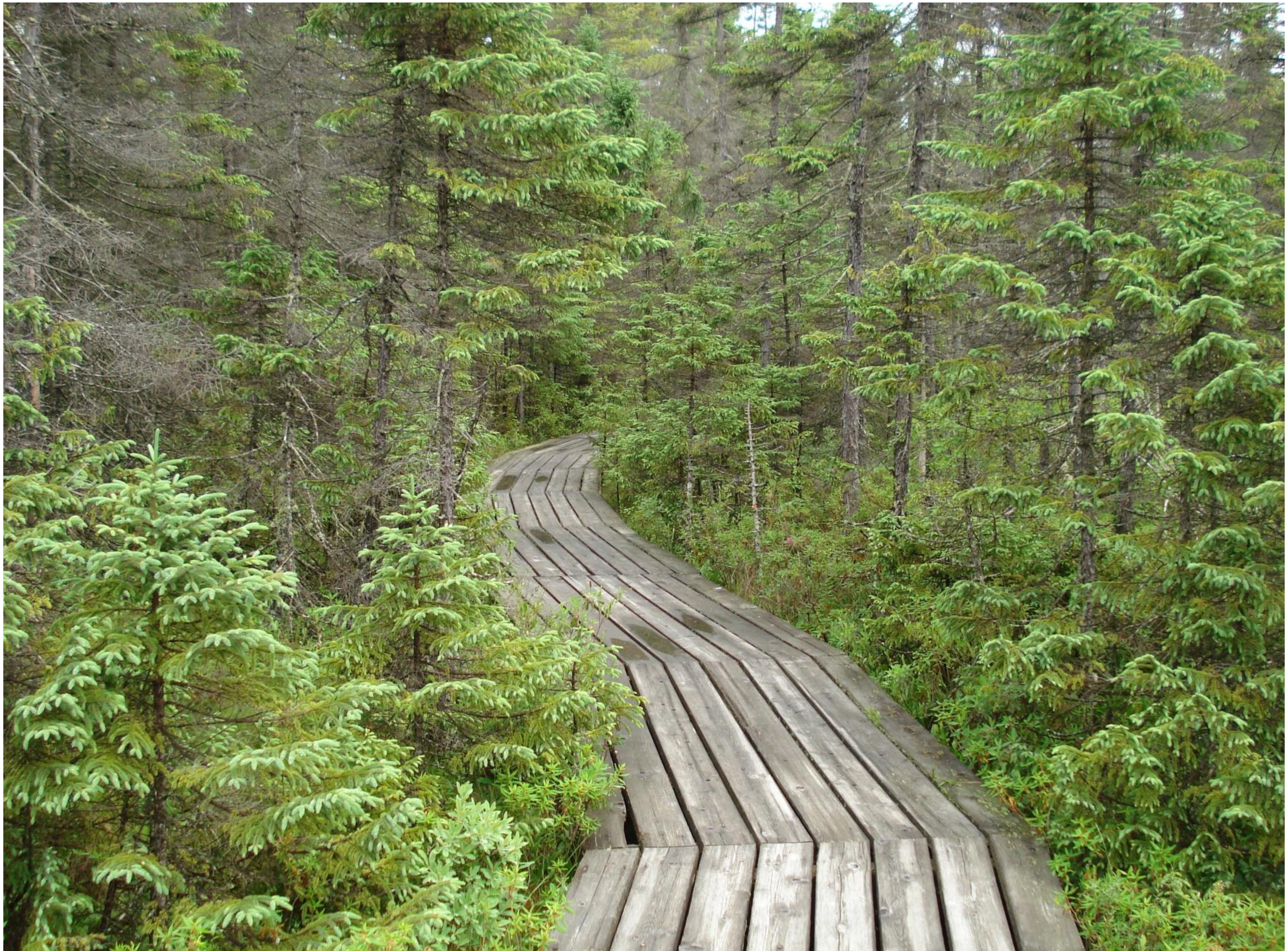


Generalized Map of Vegetation Zones 18,000 years ago

Red spruce (*Picea rubens)* and Great Laurel (*Rhododendron maximum)* in Dolly Sods, WV. A scene analogous to central Maryland 12,000 BP .

Another analog: Peat bog with *Larix* and *Kalmia polifolia* in Mer Bleue Bog, Ontario

Black spruce (*Picea mariana)* – Jonesville Bog, Quebec



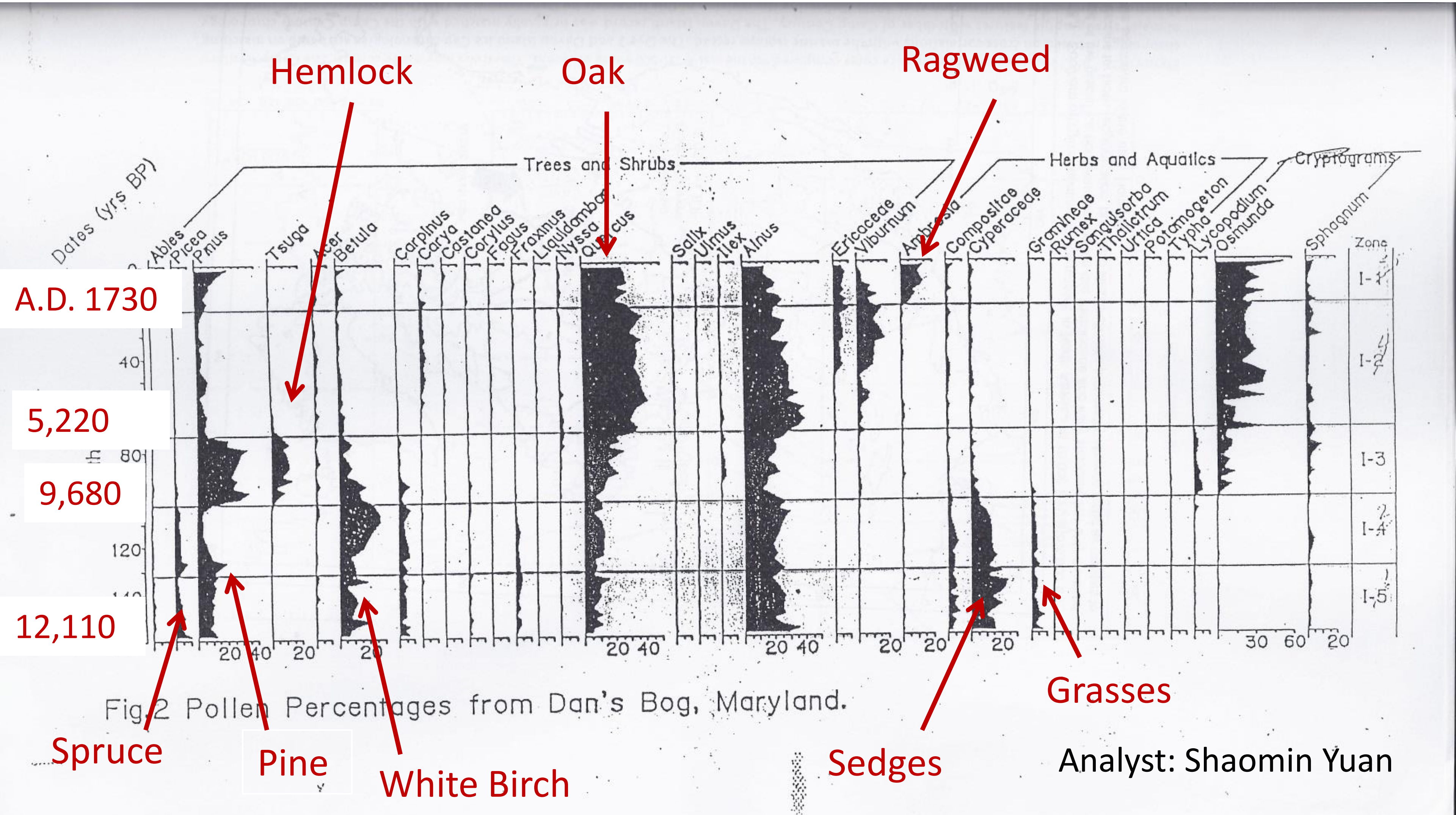
Then between 10,000 and 5,000 years ago a white pine-hemlock-deciduous forest dominated the region, analogous to forests in the Adirondacks of New York

Modern Landscape Species and Habitats –

- Most modern plant species moved into our area ca. 5,000 years ago when modern climate conditions became established
  - The modern oak-hickory forest became established in forested uplands
  - Wetlands also began to stabilize within the next 1,000-2,000 years after sea level rise slowed

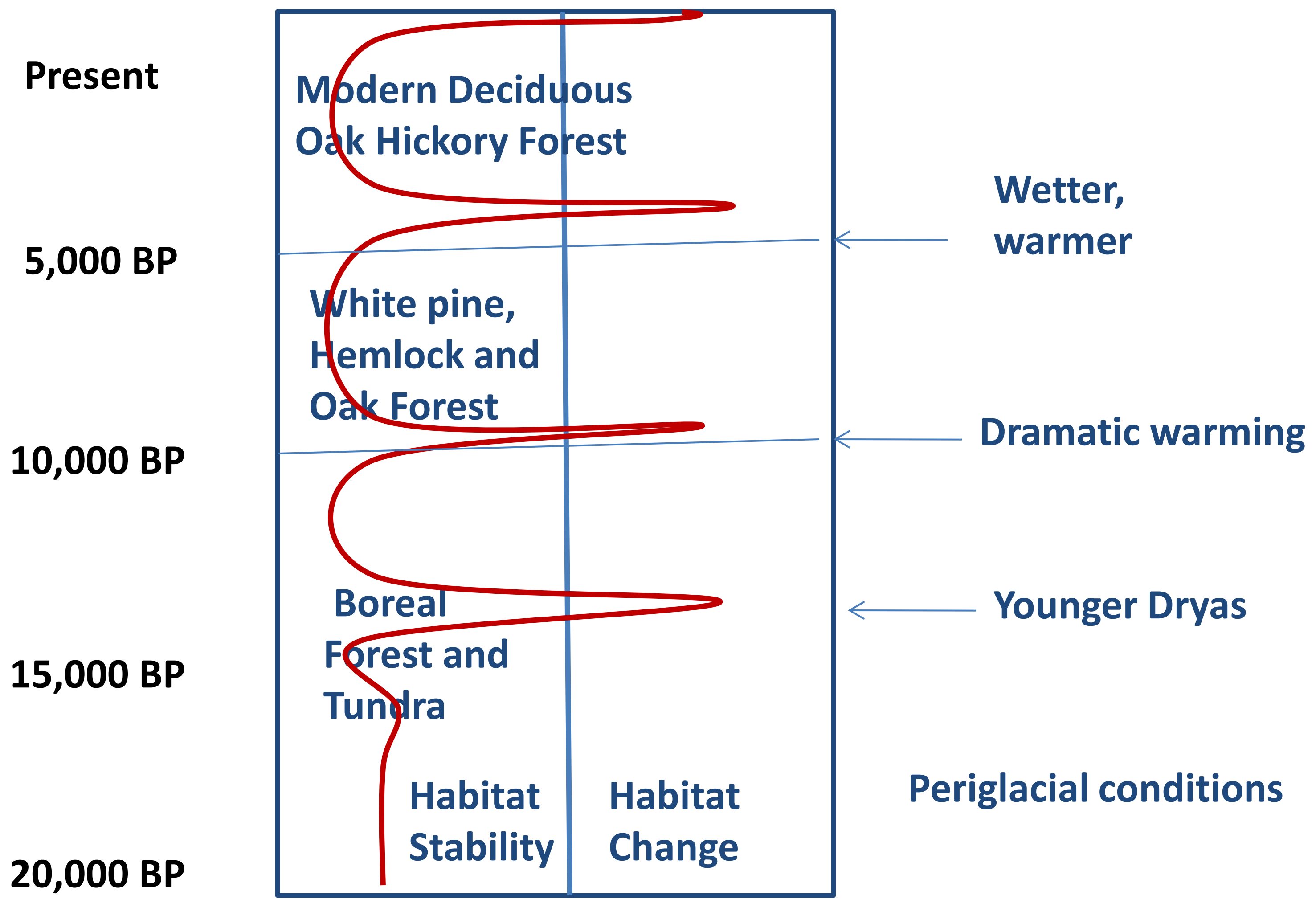
These would most likely be the time when "native species" were established

Pollen profile from a core taken near Beltsville, MD

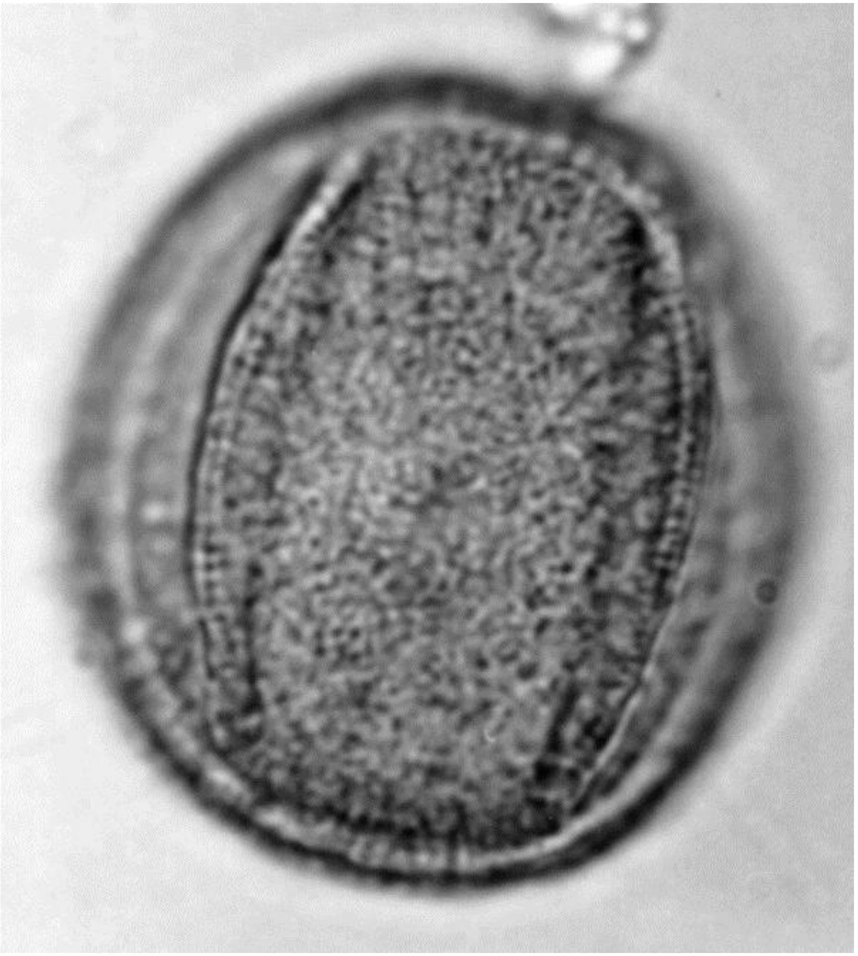


Analyst: Shaomin Yuan

Landscape and Vegetation Change in Southeastern PA and Central MD – Past 20,000 years
Change is Initiated primarily by Climate Change



Pollen is great for identifying groups of species dispersed over a wide area, but most cannot be identified to species level or local plants

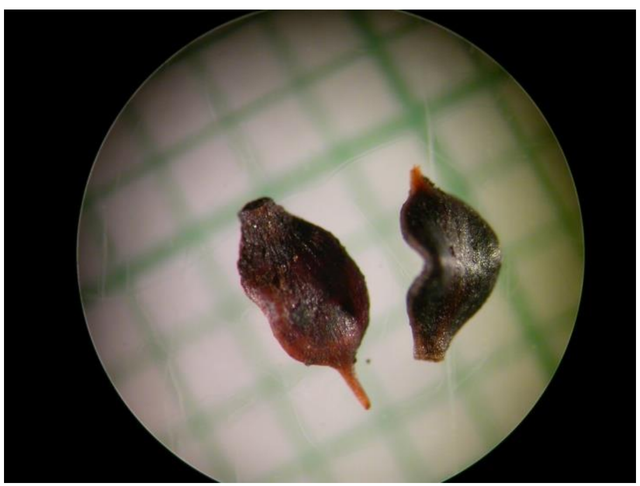


This is the pollen of *Quercus stellata* (Post oak) but this grain can’t be distinguished from other oak species

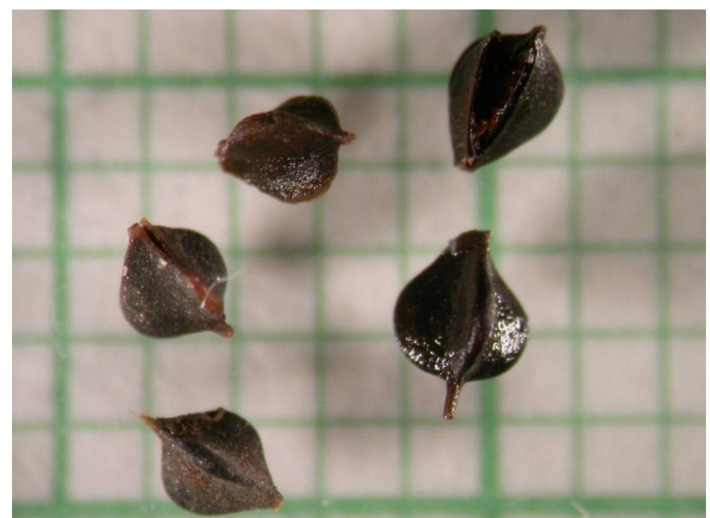
This presentation focuses on recent fossil evidence involving plant macrofossils, mostly seeds but also leaves & stems, spanning the past 5,000 years

Carex stricta

Carex lurida

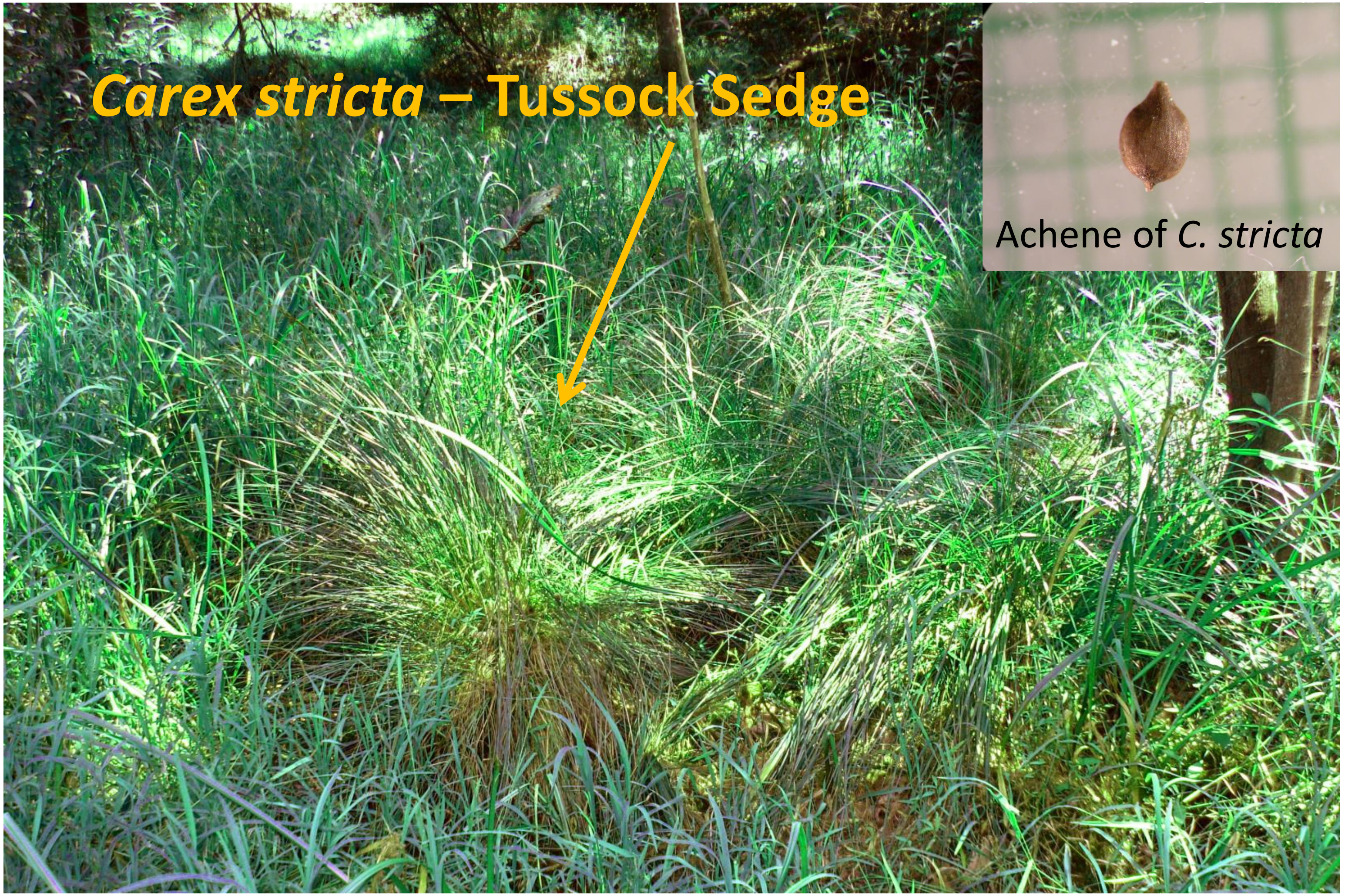


Carex crinita



Carex cf. prasina

Macrofossil seeds can be
---identified to species (unlike pollen)
---generally deposited near the parent plant (within 1-5 meters)
making them very useful for environmental reconstruction



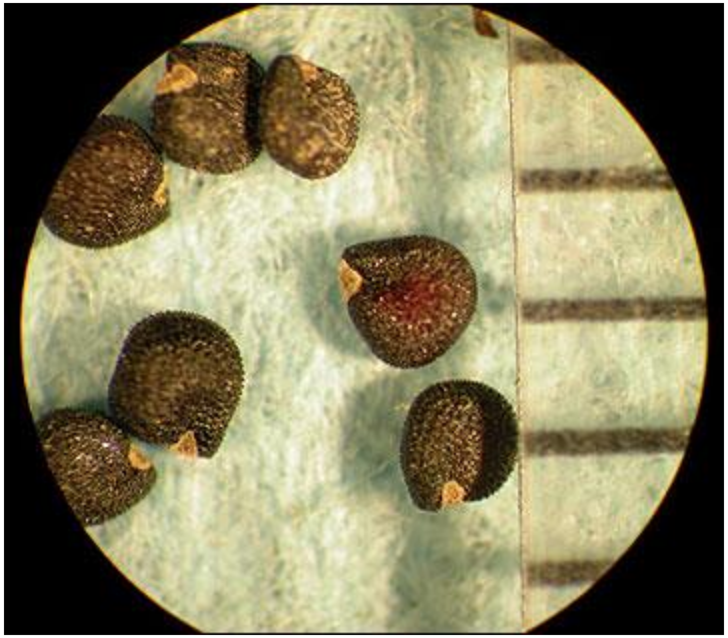
Fossil seeds are primarily isolated from core and sediment samples from wetlands and riverbanks, and from flotation samples at archaeological sites.

Some common weedy species with seeds adapted to long-term preservation in drier soils are found in archaeological sites, such as the seeds of purslane *Portulaca oleracea*

Portulaca before European Settlement?

Fossil seeds of *Portulaca oleracea* have been found in sediments dated 1350-1480 AD in southern Ontario (Byrne and McAndrews 1975).

I have also found *P. oleracea* seeds in an archaeological site in Snyder Co., PA, of Late Woodland age, C-14 date of ca. 1000 AD (Middle Creek).



Questions About Native Species

Portulaca oleracea is listed as naturalized from Europe (Fernald 1970), non-native from Asia (Gleason and Cronquist 1991), and native to Canada but non-native in the US (USDA).

Should it be considered a native since some evidence indicates it was present here before European Settlement?

If Indian populations distributed the plant 1000 years ago into our region would it still be considered native to this region?

Case Study 1: Otter Point Creek, Harford County, Maryland (from Hilgartner and Brush 2006)

Changes in Otter Point Creek from Open Estuary to Sweetflag Marsh (from Core OPC 13)

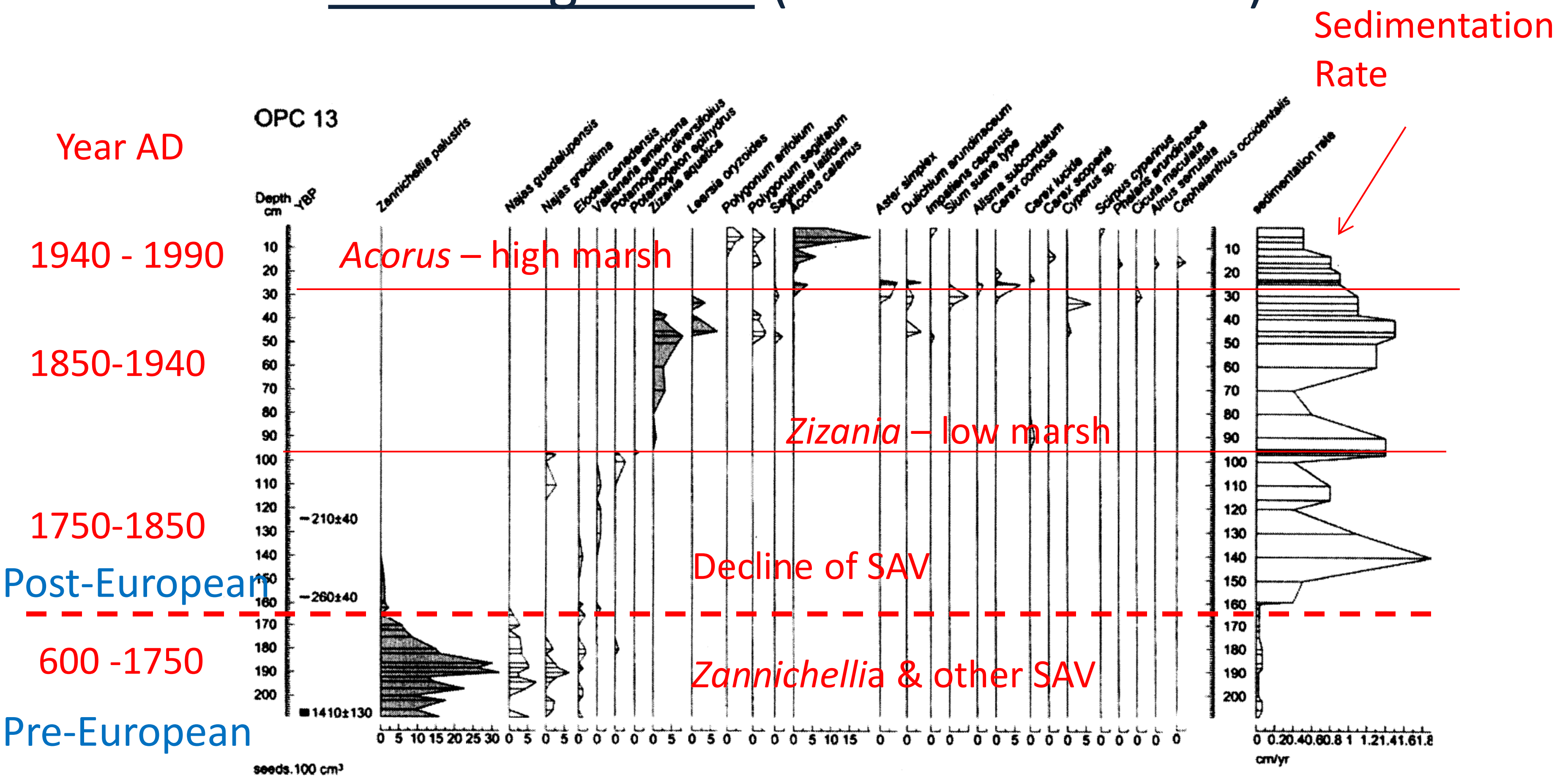


Figure 5 Macrofossil species in OPC13. Read from left to right species and habitats are listed from most flooded to least flooded. Habitats are defined by the following species: subtidal (*Zannichellia palustris*), low marsh (*Zizania aquatica*), middle marsh (*Leersia oryzoides*) and high marsh (*Acorus calamus*)

Wetlands: Species Before extensive European Settlement, ca. A.D. 1700

Otter Point Creek, an estuary of the upper Chesapeake Bay:

Zannichellia palustris	horned pondweed
Najas guadalupensis	southern water nymph
Najas gracillima	slender water nymph
Elodea canadensis	common waterweed
Vallisneria americana	wild celery
Potamogeton diversifolius	water thread pondweed
Potamogeton perfoliatus	redhead grass

Pre-settlement (AD 200 – 1750)

Zannichellia palustris (Horned pondweed), and other submerged aquatic species persisted for 1550 years

1850: *Zizania aquatica* (Wild rice) low marsh replaced the submerged aquatic species

1940: *Acorus calamus* (sweetflag) high marsh, replaced the wild rice marsh

The 1500-year stability of the open estuary was disrupted by sediment from erosion in the uplands from deforestation, farming and mining

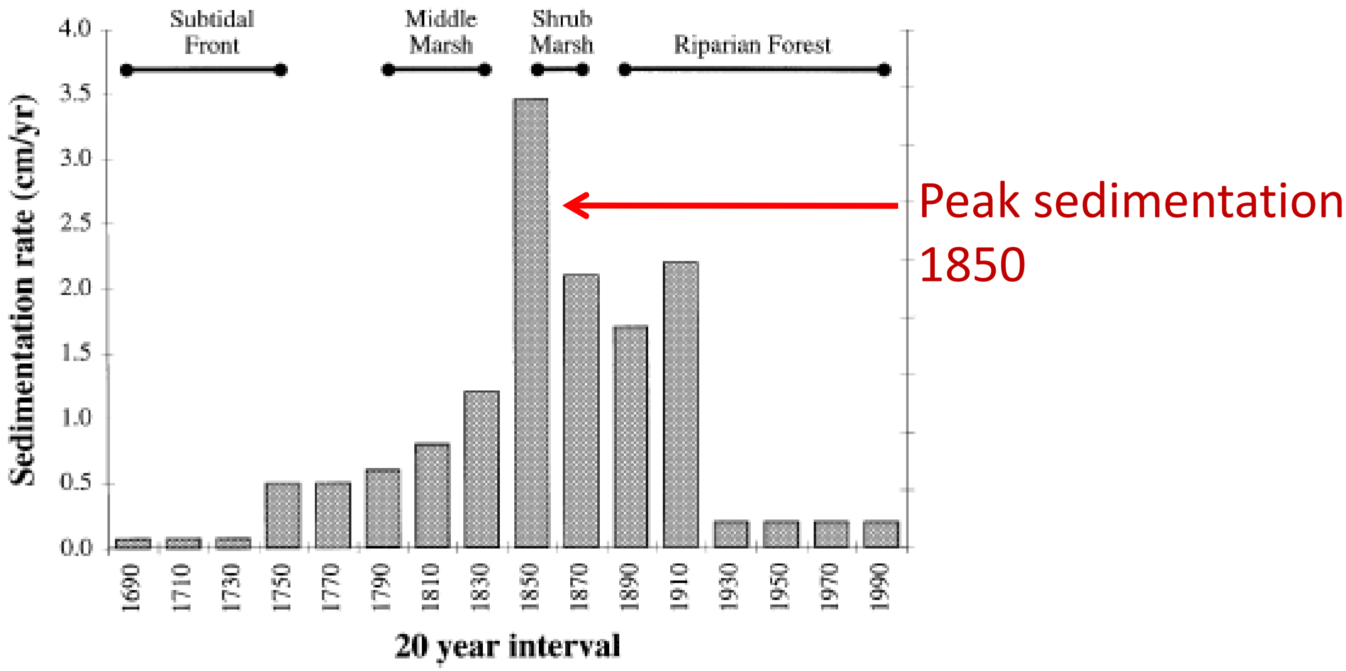
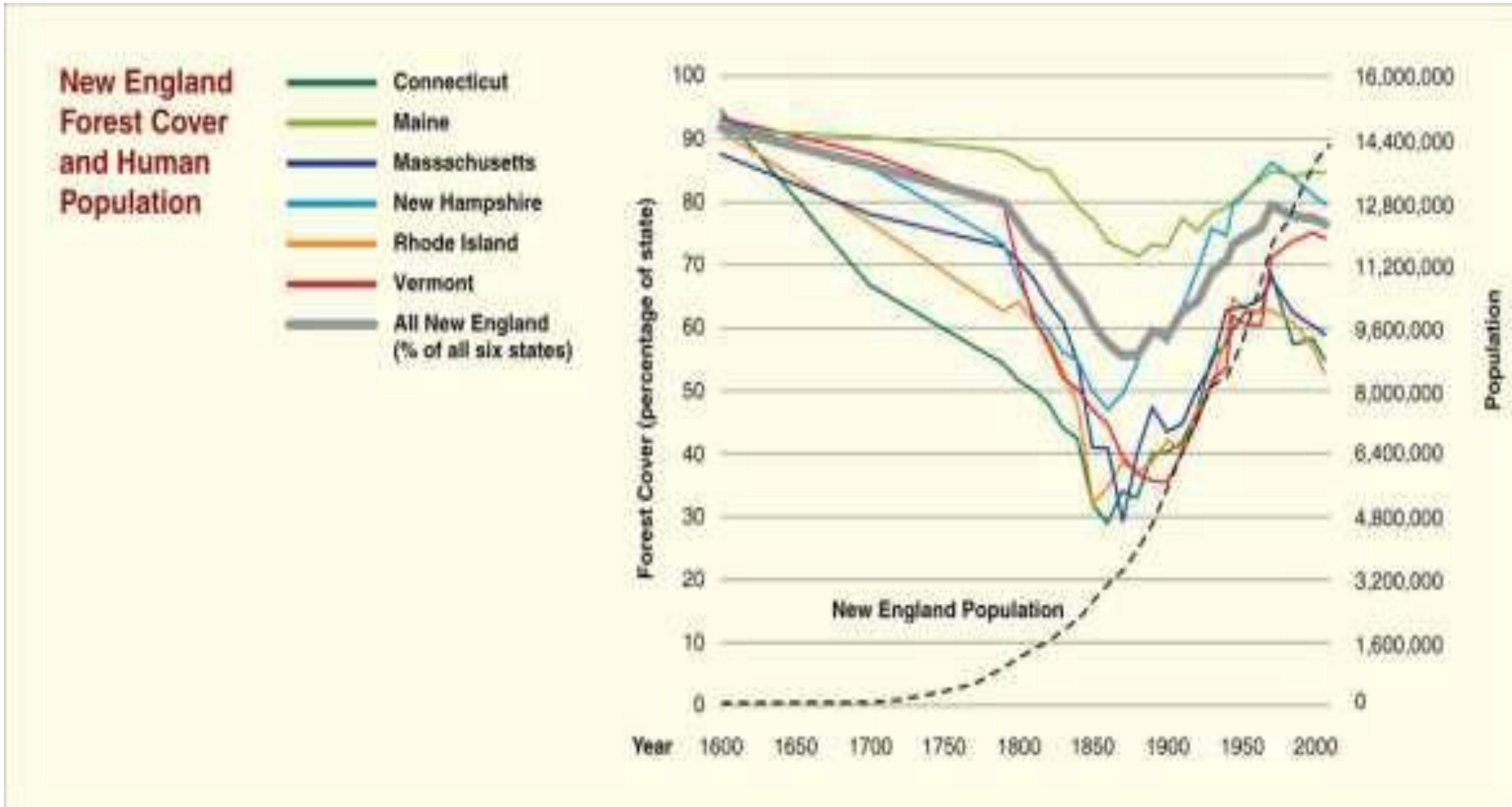


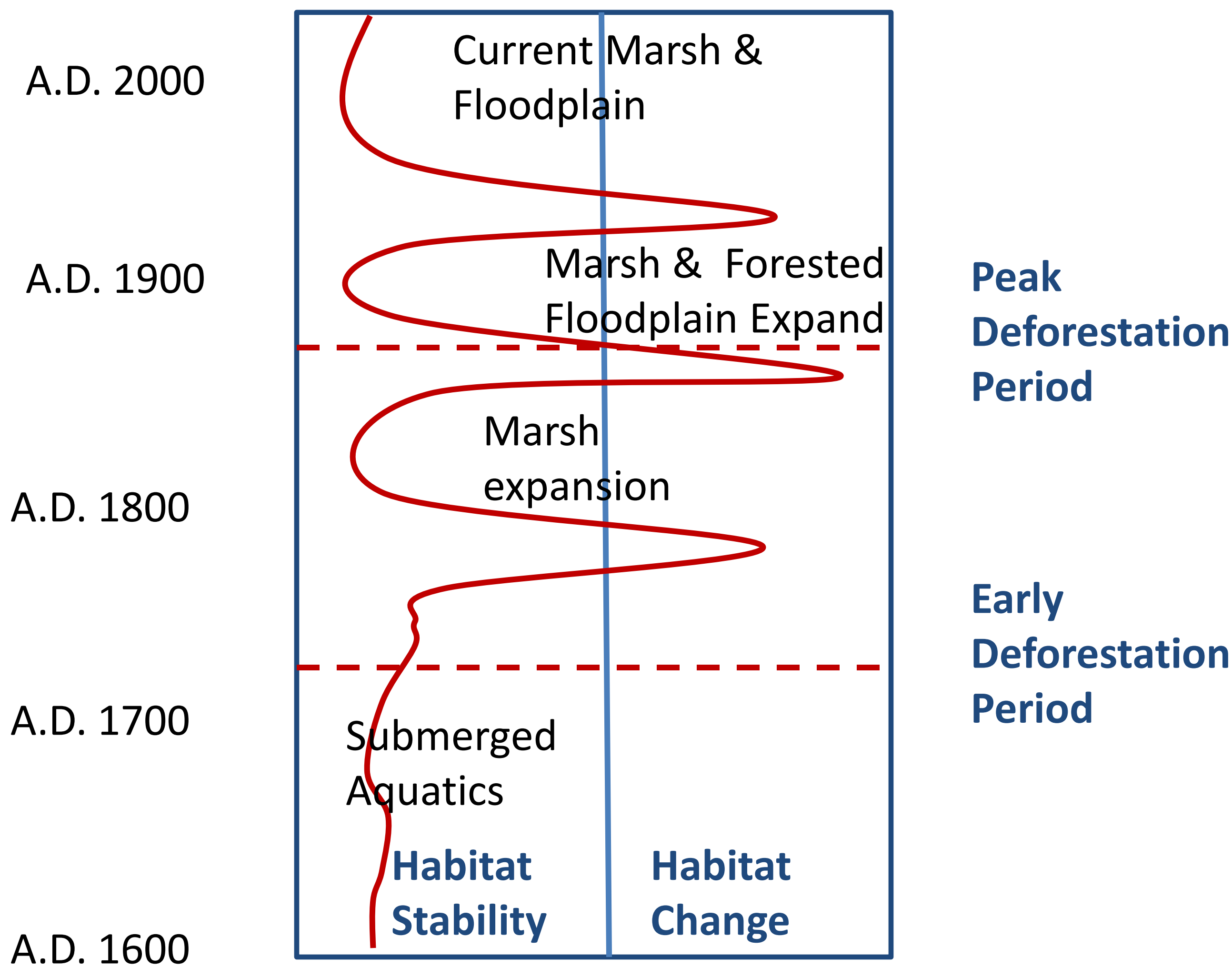
Figure 9. Reconstructed sediment chronology and habitat succession history for Auger 2 based on data from Hilgartner (1995)

Sedimentation Chronology in Auger 2

(from Pasternack, Brush & Hilgartner, 2001)


New England Forest Cover and Human Population
Connecticut
Maine
Massachusetts
New Hampshire
Rhode Island
Vermont
All New England (% of all six states)
Forest Cover (percentage of state)
100
90
80
70
60
50
40
30
20
10
0
New England Population
Year
1600
1650
1700
1750
1800
1850
1900
1950
2000
16,000,000
14,400,000
12,800,000
11,200,000
9,600,000
8,000,000
6,400,000
4,800,000
3,200,000
1,600,000
0
Population

Sedimentation Periods & Habitat Stages in Otter Point Creek Wetland (Harford County) Past 400 Years



Increase in Plant Diversity Since 1700 at Otter Point Creek

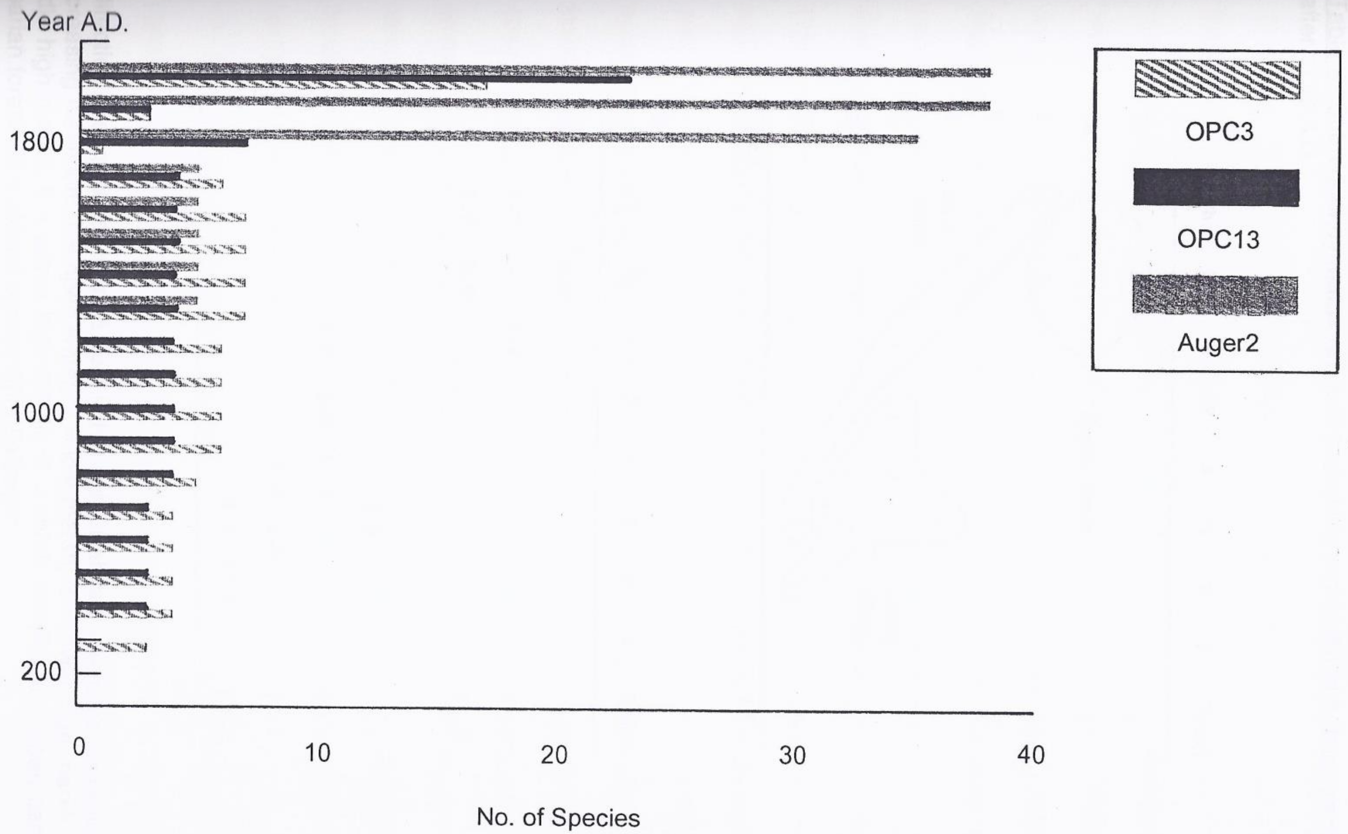
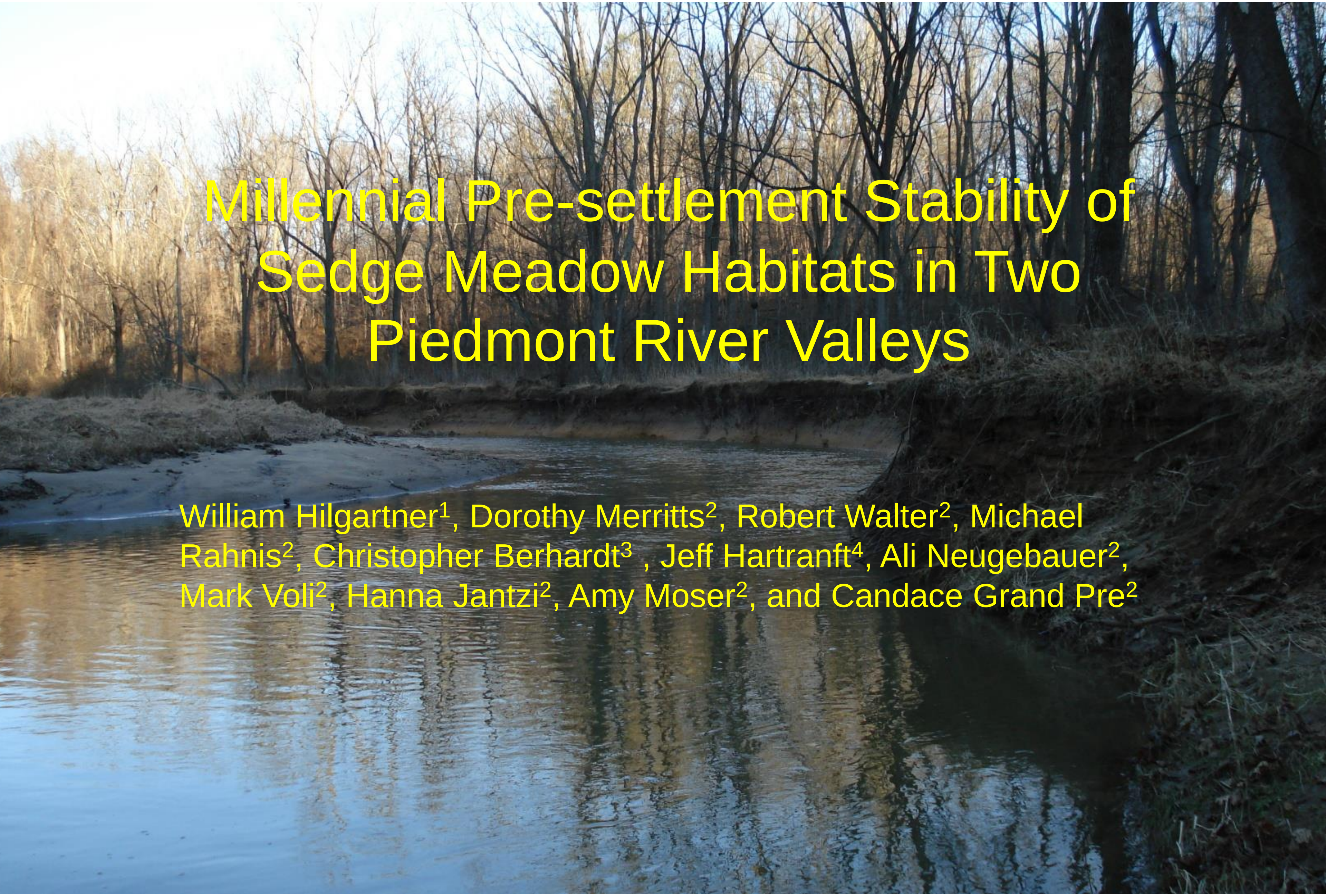
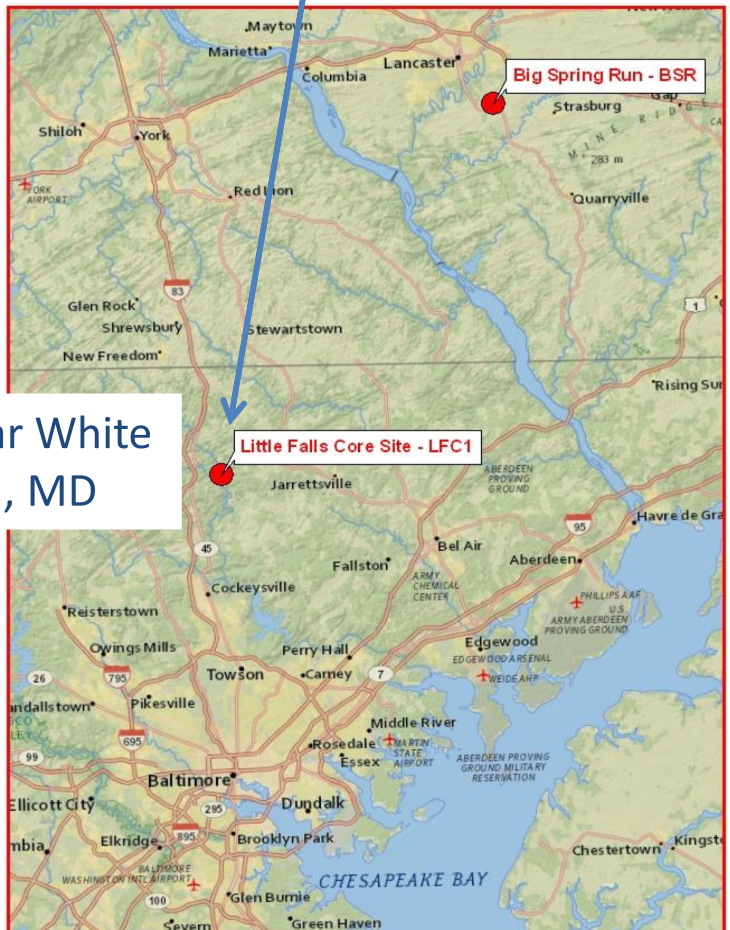


Fig. 3.21. Species richness through time in OPC3, OPC13 and Auger2.

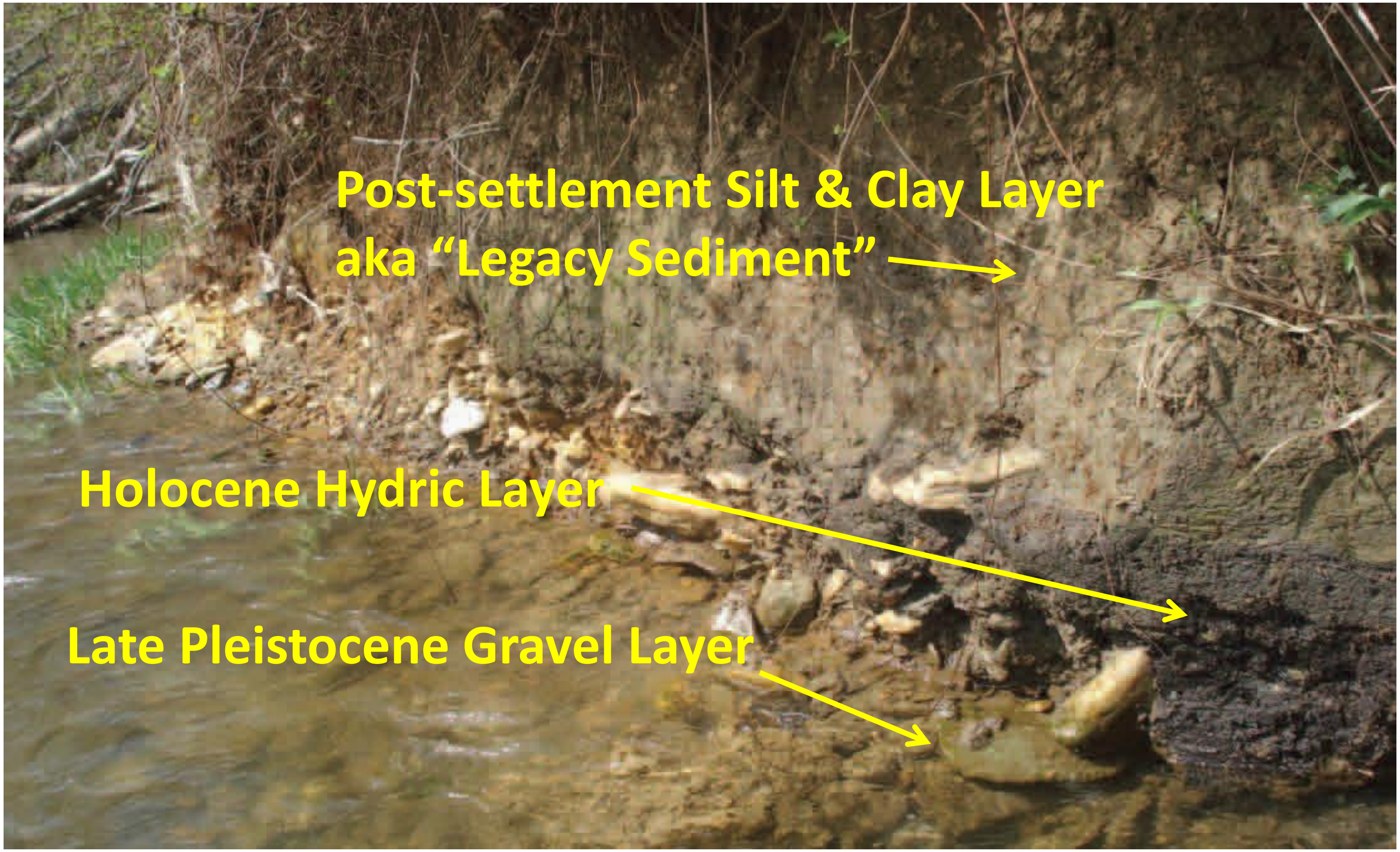

Millennial Pre-settlement Stability of Sedge Meadow Habitats in Two Piedmont River Valleys
William Hilgartner[1], Dorothy Merritts[2], Robert Walter[2], Michael Rahnis[2], Christopher Berhardt[3] , Jeff Hartranft[4], Ali Neugebauer[2], Mark Voli[2], Hanna Jantzi[2], Amy Moser[2], and Candace Grand Pre[2]

Case Study 2: Little Falls, northern Baltimore County, Maryland,

Near White Hall, MD



Little Falls River Bank Stratigraphy



Core LFC 1

0 cm

Black clay &
plant fragments
10 YR 2/1

56 cm

C-14 Date Intercept
Age = 300 yr BP

C-14 Date Intercept
Age = 4,970 yr BP

In the core of Little Falls (LFC1) were seeds of dominant sedge species that persisted for over 4,000 years, indicating a tussock sedge meadow habitat

- *Carex stricta* tussock sedge*
- *Carex stipata* awlfruit sedge
- *Carex scoparia* broom sedge
- *Carex vulpinoidea* fox sedge
- *Cyperus strigosus* strawcolored flatsedge

among other sedges

Also:

- *Polygonum punctatum = (Persicaria punctata)*

dotted smartweed

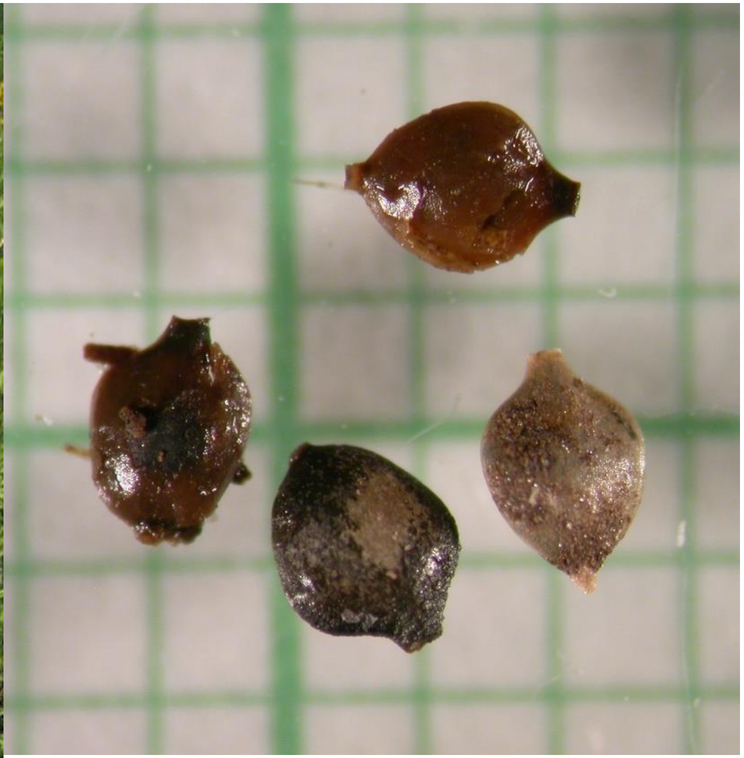
- *Eupatorium perfoliatum* boneset

Carex stricta (tussock sedge) – an indicator species

A tussock sedge meadow requires spring-fed soil saturation and a ground water table near the surface. (Great Marsh, Chester Co., PA)

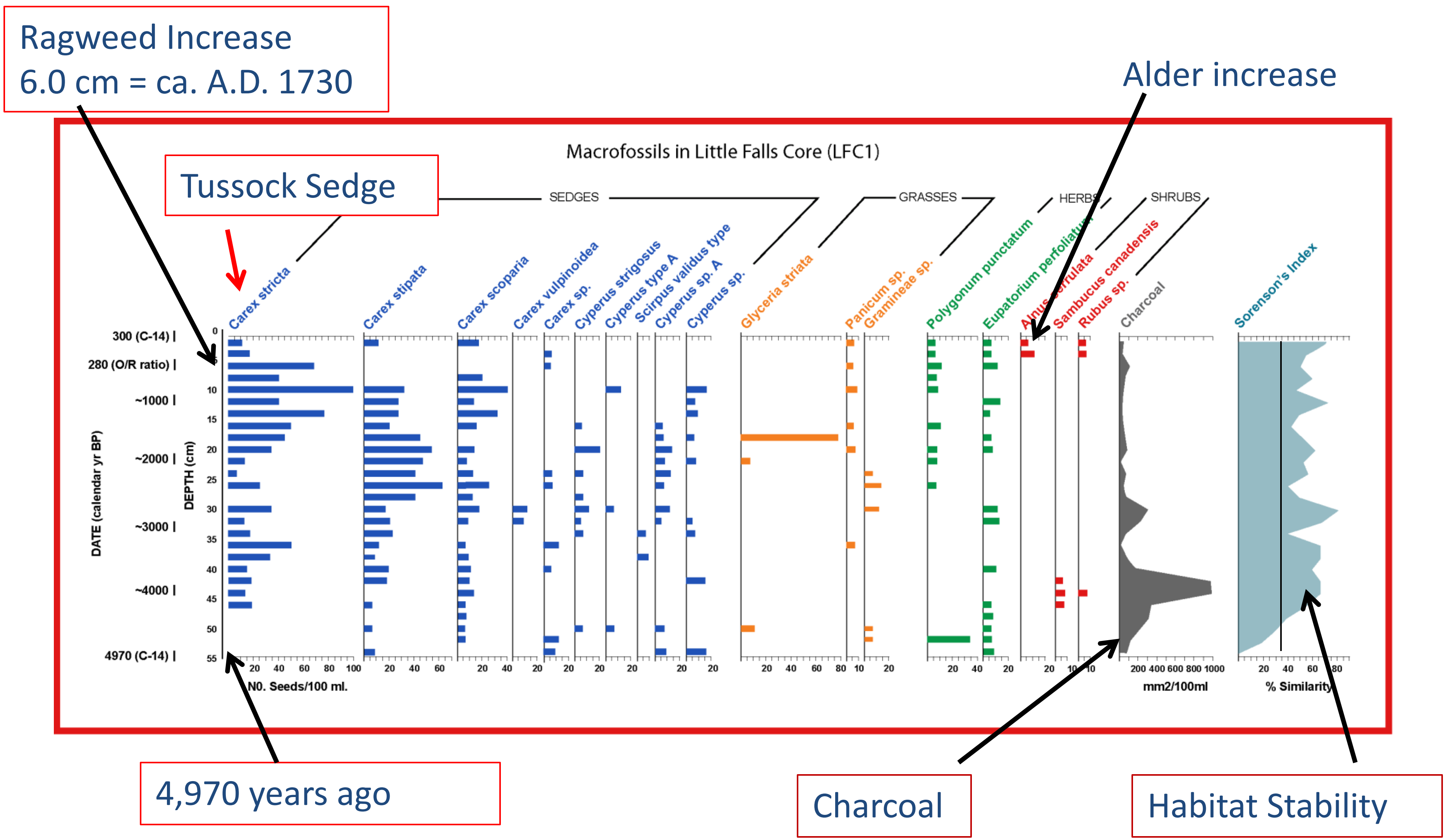
Carex stipata

Carex stipata



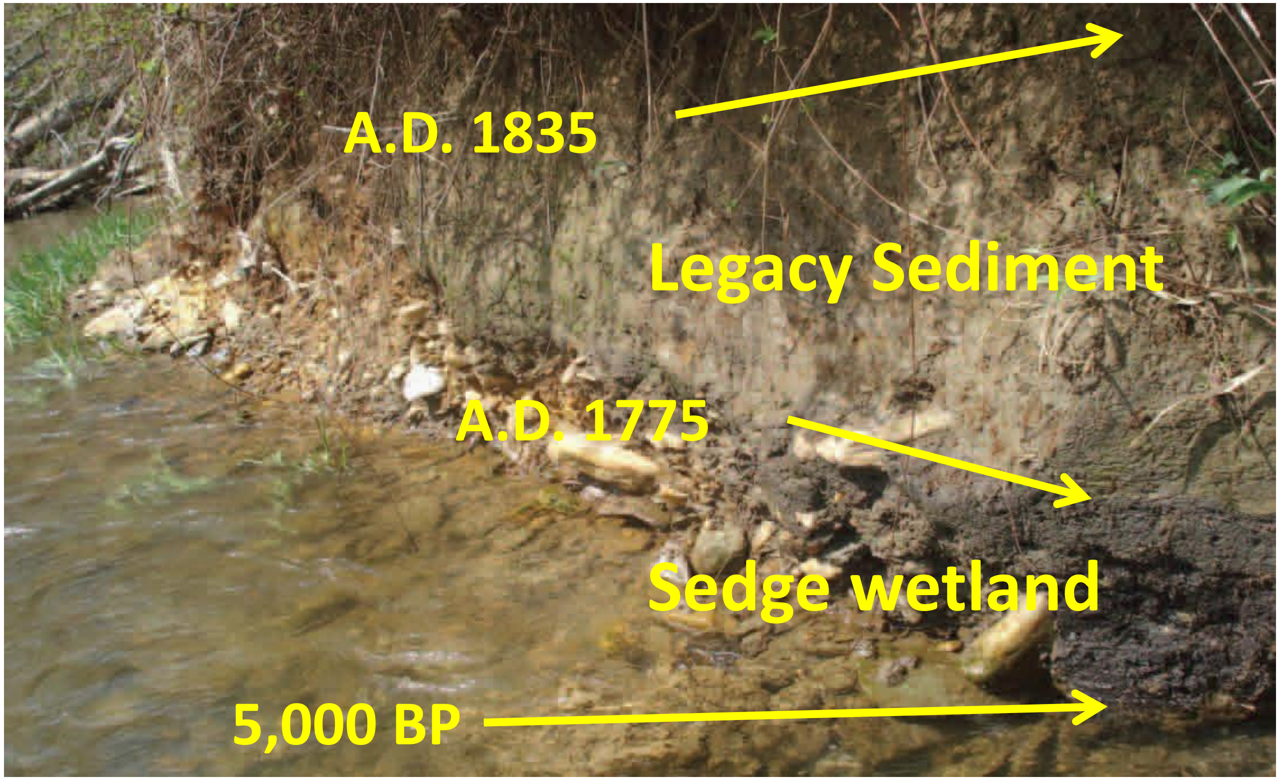
Achenes of *C. stipata* - 2000 years old

Evidence for a Tussock Sedge Wetland at Little Falls: Macrofossil Profile LFC1 (top of core dated A.D. 1775)

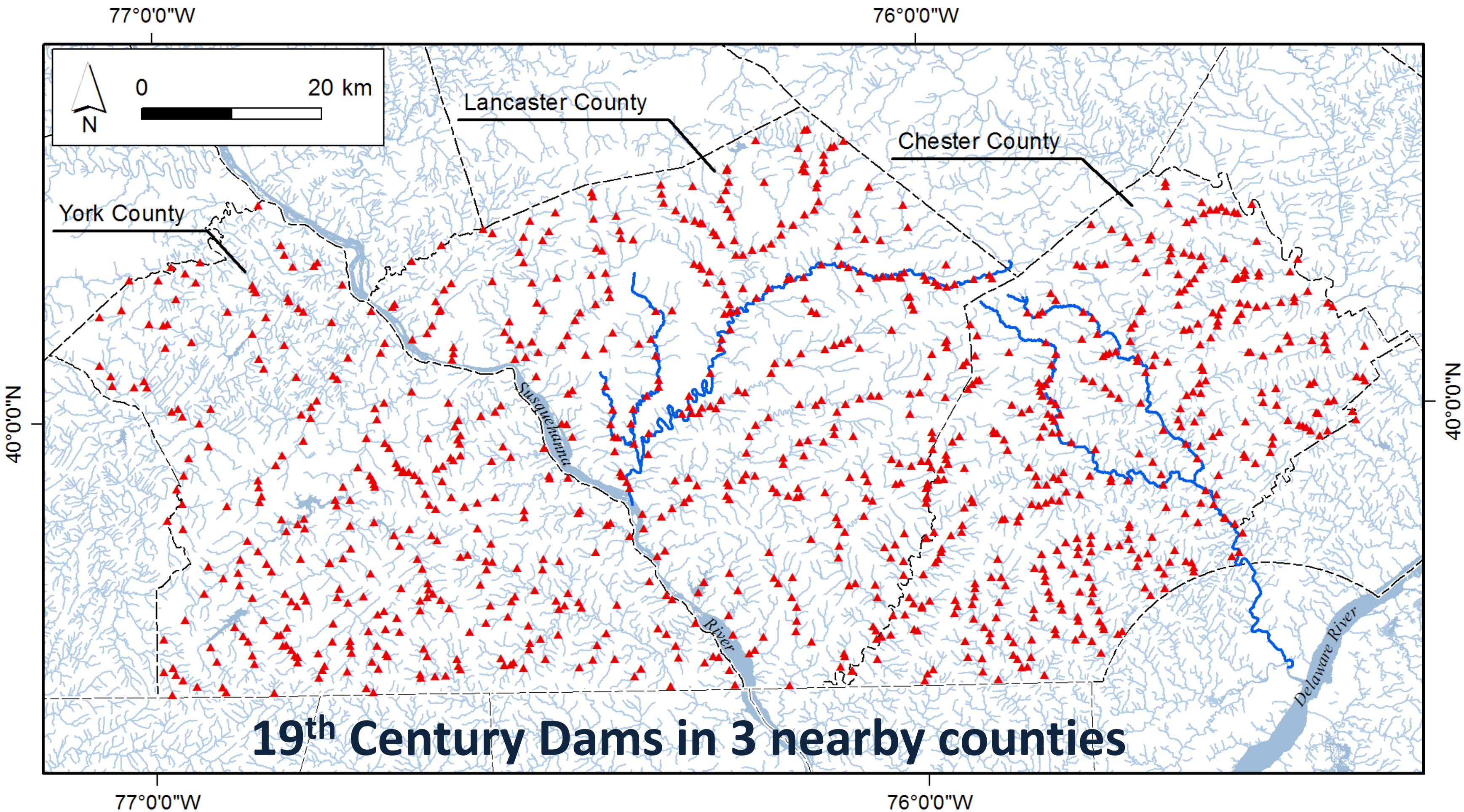


Burial between 1775 and 1835

The tussock sedge wetland was rapidly buried within 60 years between A.D. 1775 and 1835, when 1.0 – 2.0 m of silt and clay sediment (Legacy Sediment) accumulated in a reservoir behind a downstream mill dam.



Between AD 1700 and 1900, dams, sediment from farming and mining, and deforestation altered these once stable habitats



19^{th} Century Dams in 3 nearby counties

Historic Map (1868) of Dams and Millponds along Wissahickon Creek, near Philadelphia, PA

Breach of the mill dam created an incised, high-banked meandering river channel.

This incision exposed the underlying legacy sediment tussock sedge wetland, periglacial gravel, and bedrock.

Modern vegetation of black walnut, spicebush and reed canary grass on 1.5 meters of legacy sediment overlying a pre-1750 tussock sedge wetland

Diversity Increased in the Little Falls Valley after 1700

A decline in sedge abundances (tussock and other sedges reduced to small patches), with an increase in upland species, including non-native species.

Common Herbaceous:

Phalaris arundinacea (reed canary grass, native)

Rudbeckia laciniata (tall coneflower, native)

Polygonum perfoliatum (mile-a-minute tearthumb, non-native)

Microstegium vimineum (Japanese stiltgrass, non-native)

Trees and Shrubs:

Platanus occidentalis (sycamore)

Juglans nigra (black walnut)

Prunus serotina (black cherry)

Lindera benzoin (spicebush)

Summary…..
Pre-settlement Stasis was maintained over 4,000 years despite these disturbances:

1. A high charcoal/drought period, ca. 4,000 - 4200 BP

2. *Presumed* abundance of beaver activity

3. Tropical storms and flooding events

4. Prehistoric human disturbance.

This wetland stasis indicates…

1. Forested watershed in the uplands (98% forest cover) acted as an efficient storm and erosion buffer

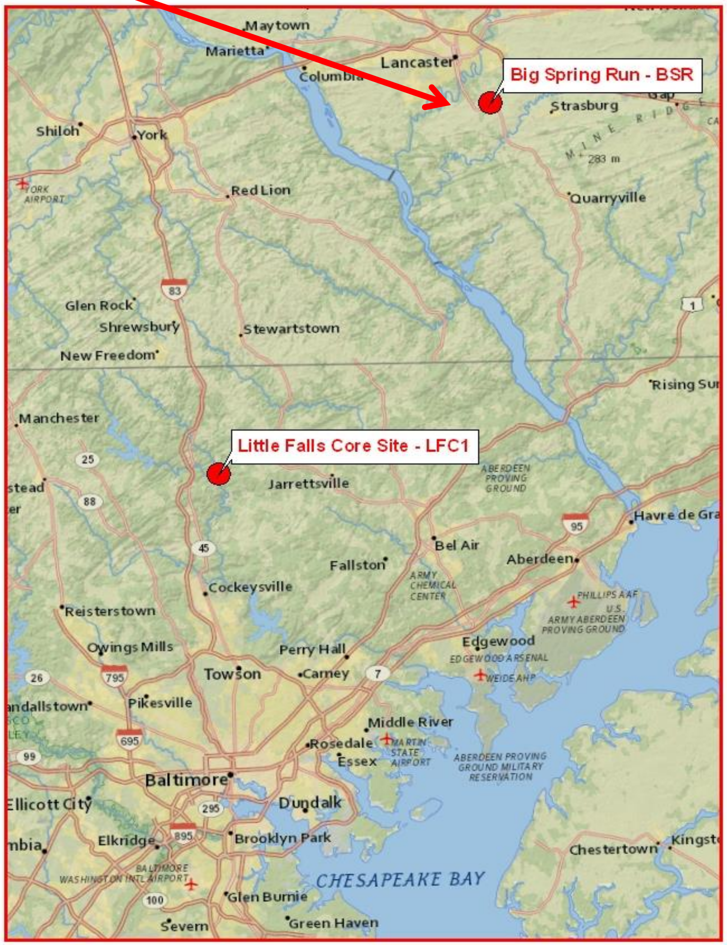
2. Low sedimentation rates entered the valley (0.01 cm/yr)

3. Constant water table level and stable hydrology

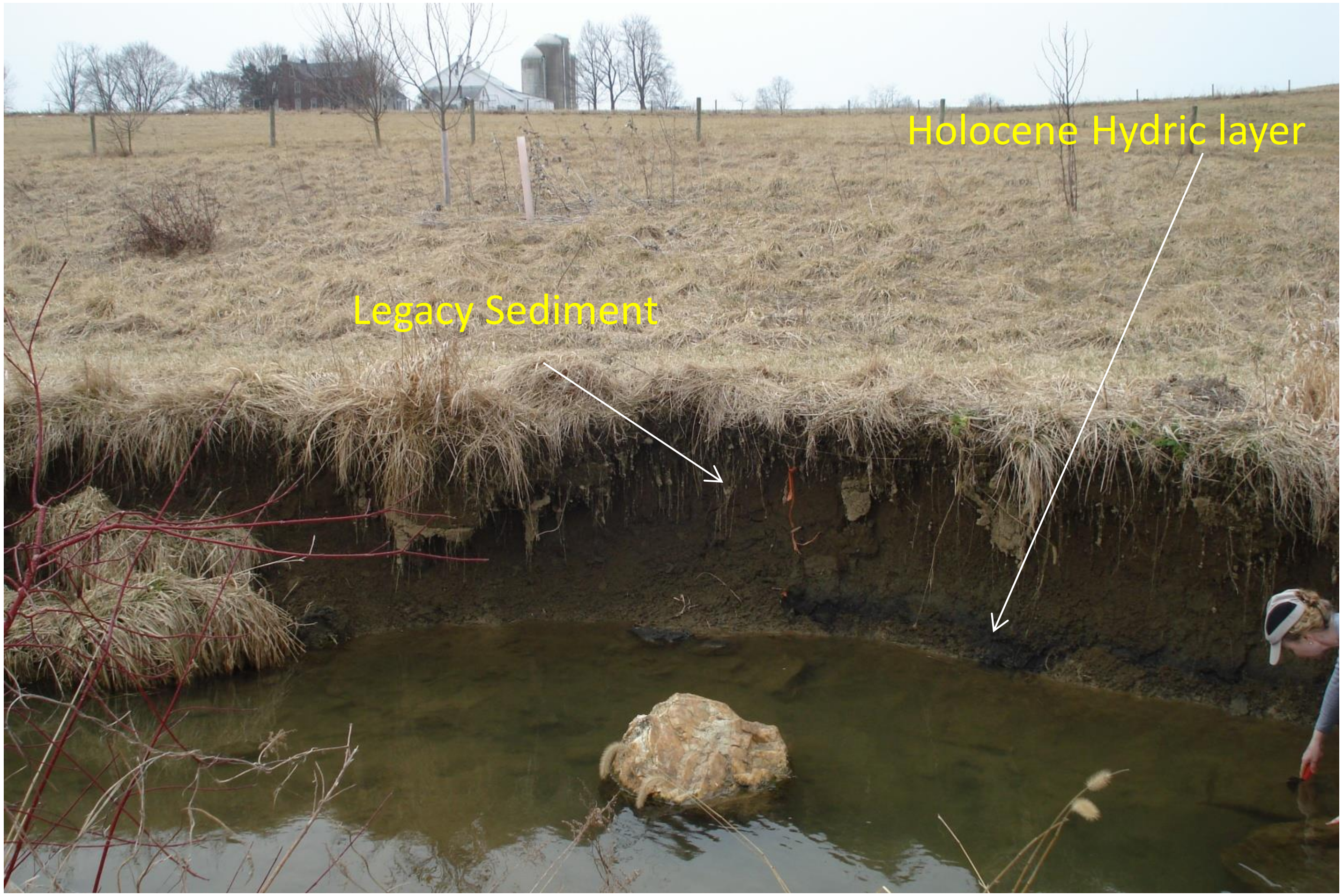
4. No ponding or disturbance from beavers

5. No main channel; instead low flow anastomosing system

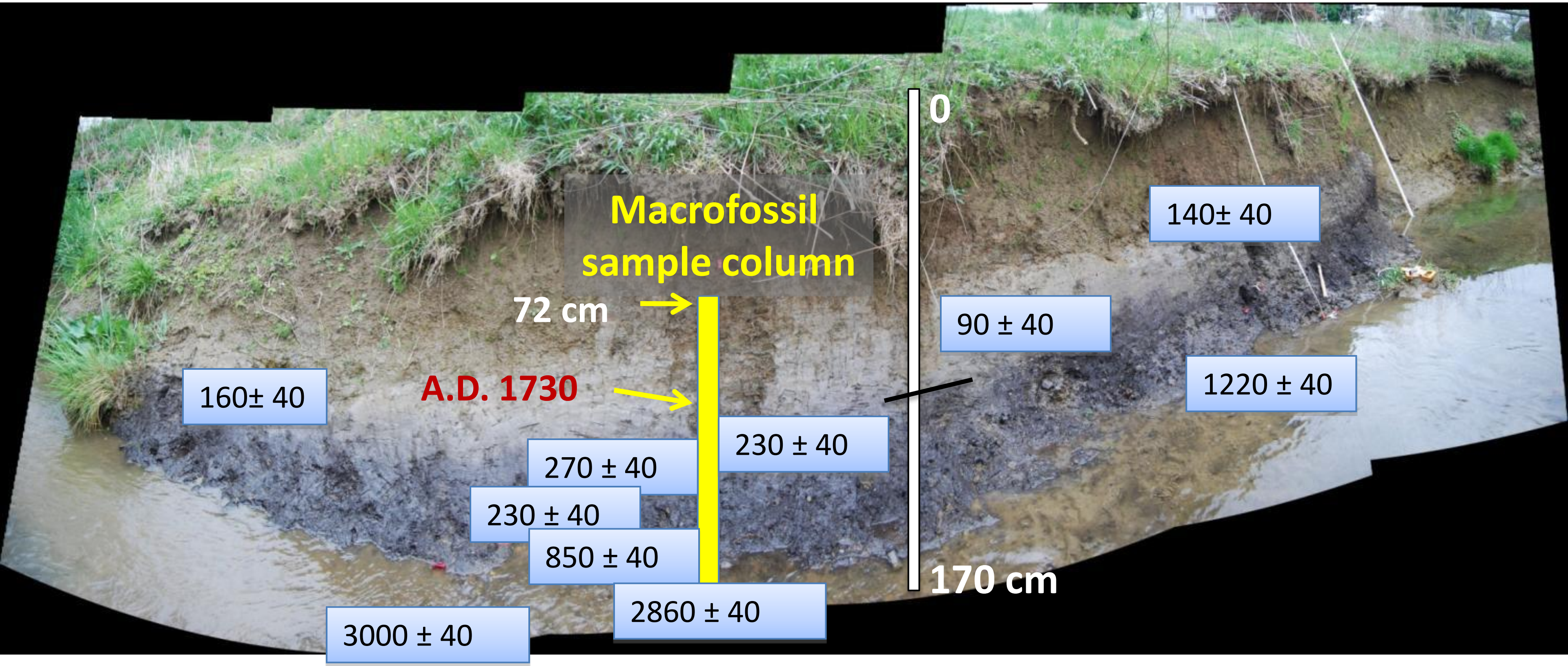
Case Study 3: Big Spring Run, Lancaster Co., Pennsylvania



Big Spring Run, Lancaster Co., PA



Carbon-14 Dates and Pollen Date (in red)



In the hydric layer of Big Spring Run were seeds of dominant sedge species that persisted for 3,000 years indicating a sedge meadow habitat

- *Carex prasina* drooping sedge
- *Carex hystericina* porcupine sedge
- *Carex stipata* awlfruit sedge

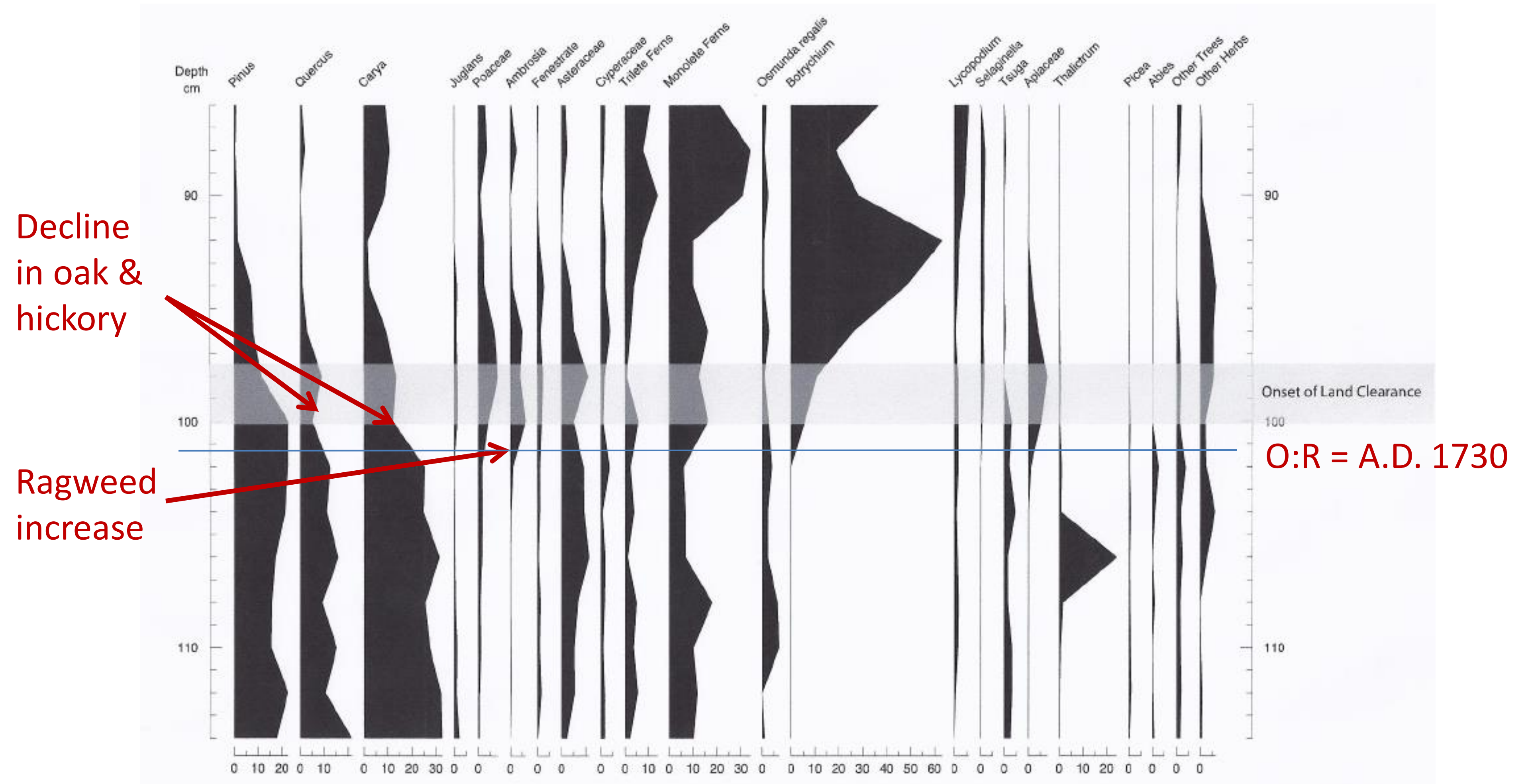
Carex prasina (drooping sedge)

Carex hystericina

Carex hystericina
(Porcupine sedge*)*

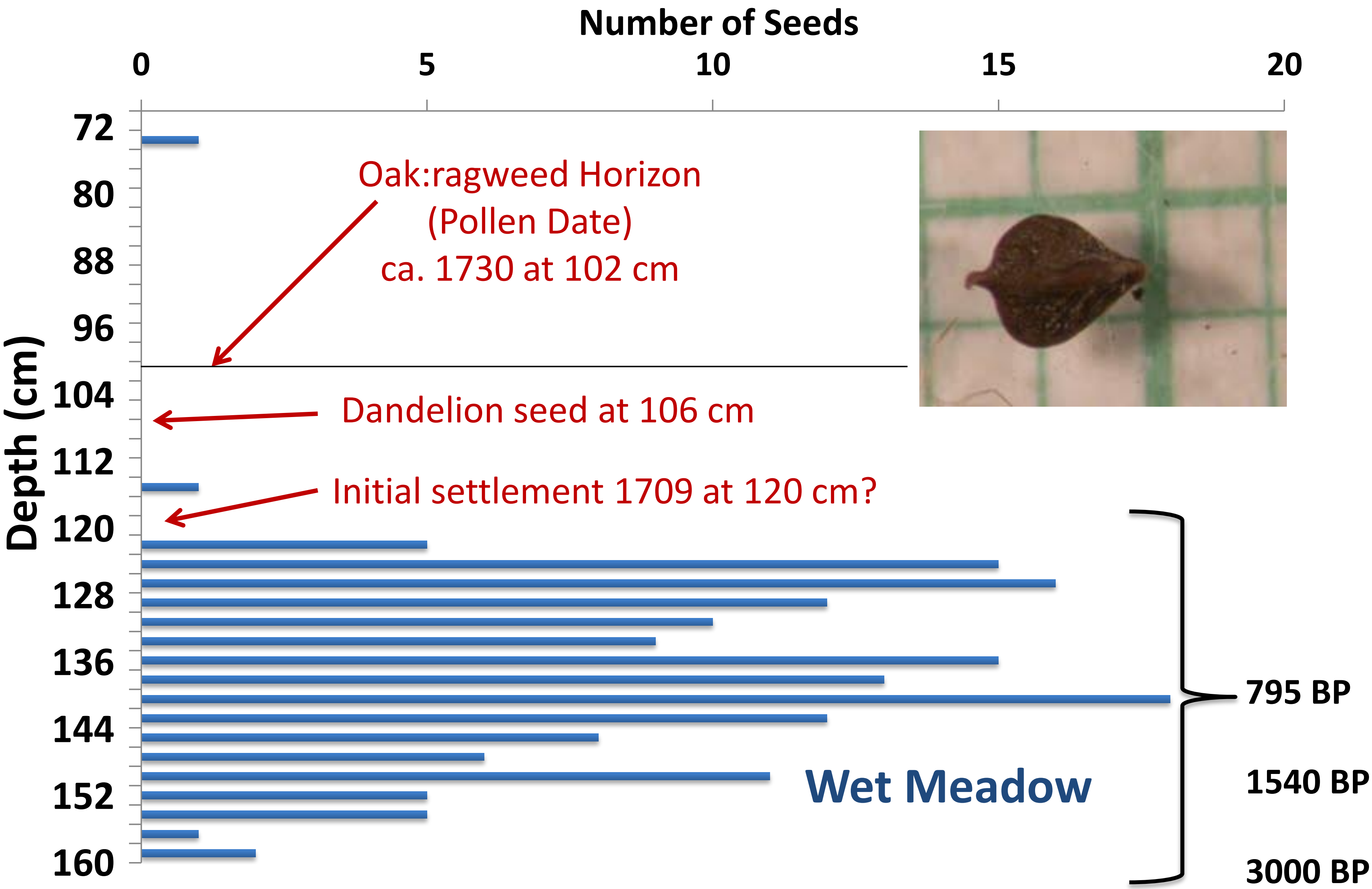
Fossil Seeds (achenes) of *C. hystericina* from Big Spring Run, Lancaster Co., PA

Pollen in upper layers of the sample column (85 cm – 114 cm)

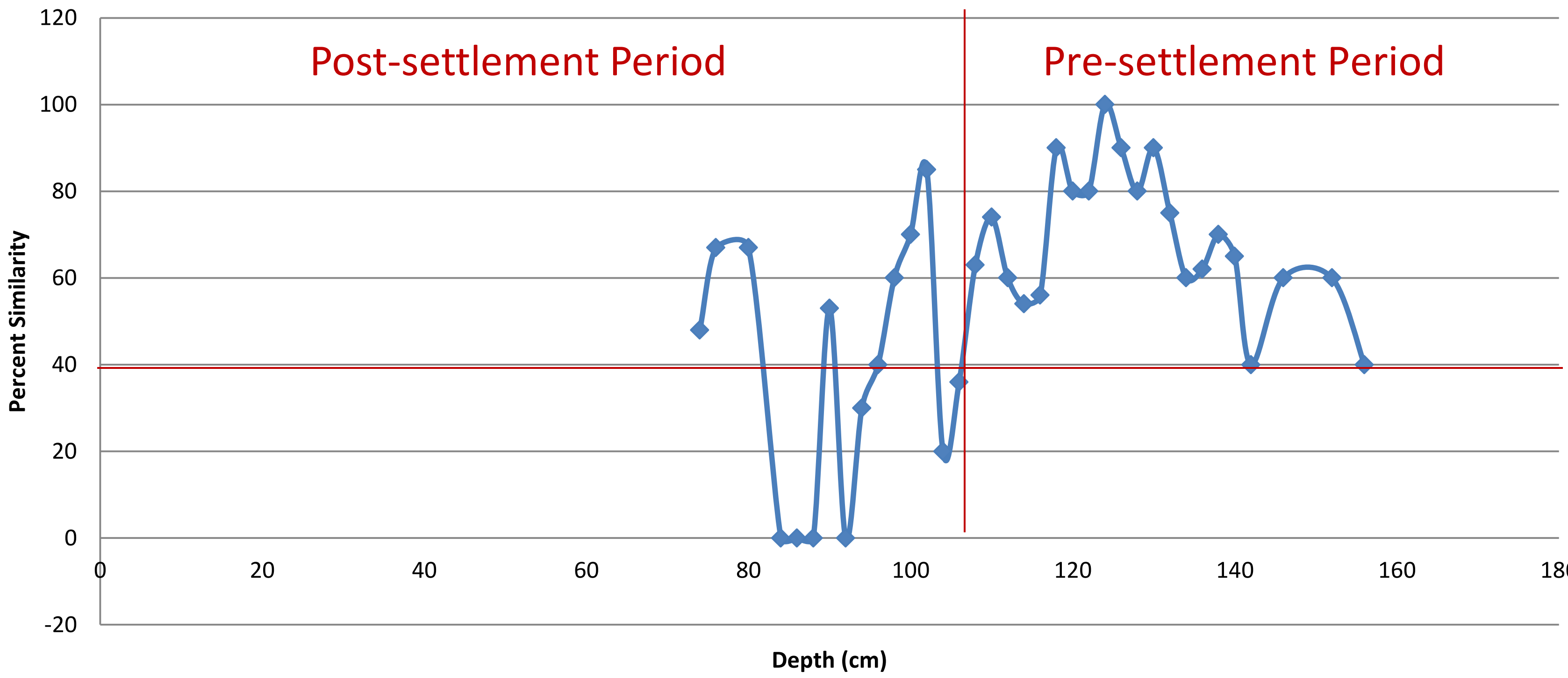


Analyst: C. Bernhardt

Carex prasina type (n =165) -drooping sedge
Obligate wetland perennial



Sorensen's Similarity - BSR Samples



Post-settlement Habitat Change

Rapid sedimentation from deforestation, combined with multiple mill ponds and dams during the 18th and 19th centuries…

First event in 3,000 years to produce succession and decline of the sedge meadow

An upland of agricultural herbs, grasses and cultigens replaced the wetland.

Weedy herbs, grasses and cultigens typical of agricultural fields on legacy sediment at Big Spring Run

Restoration of Big Spring Run, Lancaster Co: Removing of legacy sediment in September, 2011

Big Spring Run channel on left before restoration, same location after legacy sediment is removed

Note the same 3 trees

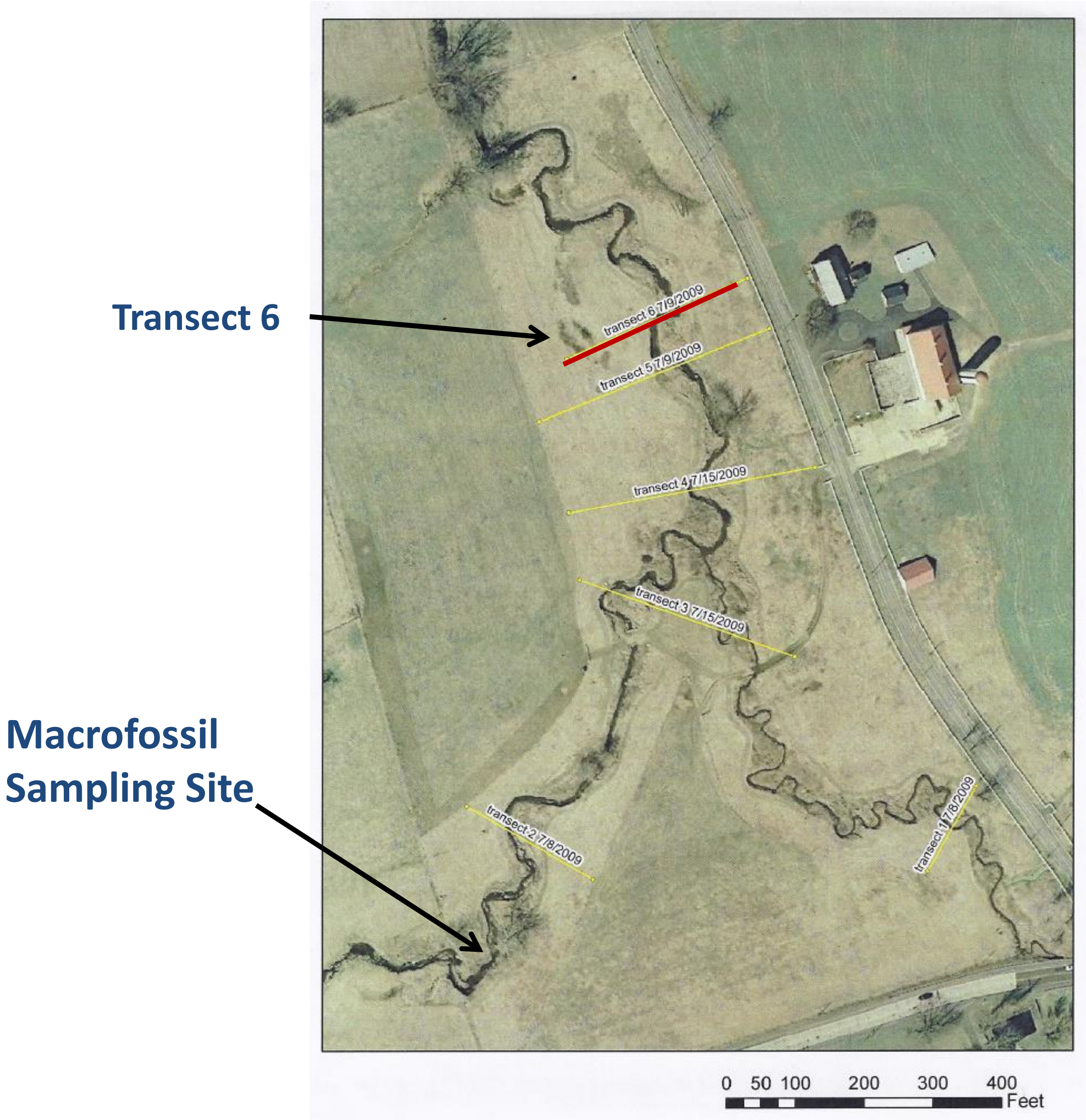
Restoration and sediment removal complete, November 2011

September, 2012: 9 months after restoration

Sagittaria latifolia (duck potato) in the BSR restoration, September, 2012

Schoenoplectus tabernaemontana (aka Scirpus validus, great bulrush*)* at restoration, September, 2012

Big Spring Run



Pre-Restoration Vegetation Sampling, June 2011

Jeff Hartranff and Bill Hilgartner

Transect 6 (5 most important species):

•	*Agropyron repens* (quack grass) 39%	FACU-
•	*Phalaris arundinacea* (reed canary grass) 33%	FACW+
•	*Poa pratensis* (Kentucky Blue grass) 27%	FACU
•	*Festuca elatior* (common fescue) 21%	FACU
•	*Secale cereal* (rye) 14%	Upland

Post-Restoration Vegetation Sampling, August 2012

Jeff Hartranff and Bill Hilgartner

Transect 6: % Relative Importance

Panicum rigidulum (redtop) 41%	FACW	Planted
Leersia oryzoides (rice cut grass) 20%	OBL	Planted
Nasturgium officinale (watercress) 13%	OBL	Colonizer
Ludwigia palustris (water purslane) 10%	OBL	Colonizer
*Phalaris arundina*cea (reed canary) 10%	FACW	Colonizer

Some common sedges and *Alisma* present in the BSR restoration, July, 2014

Sedges

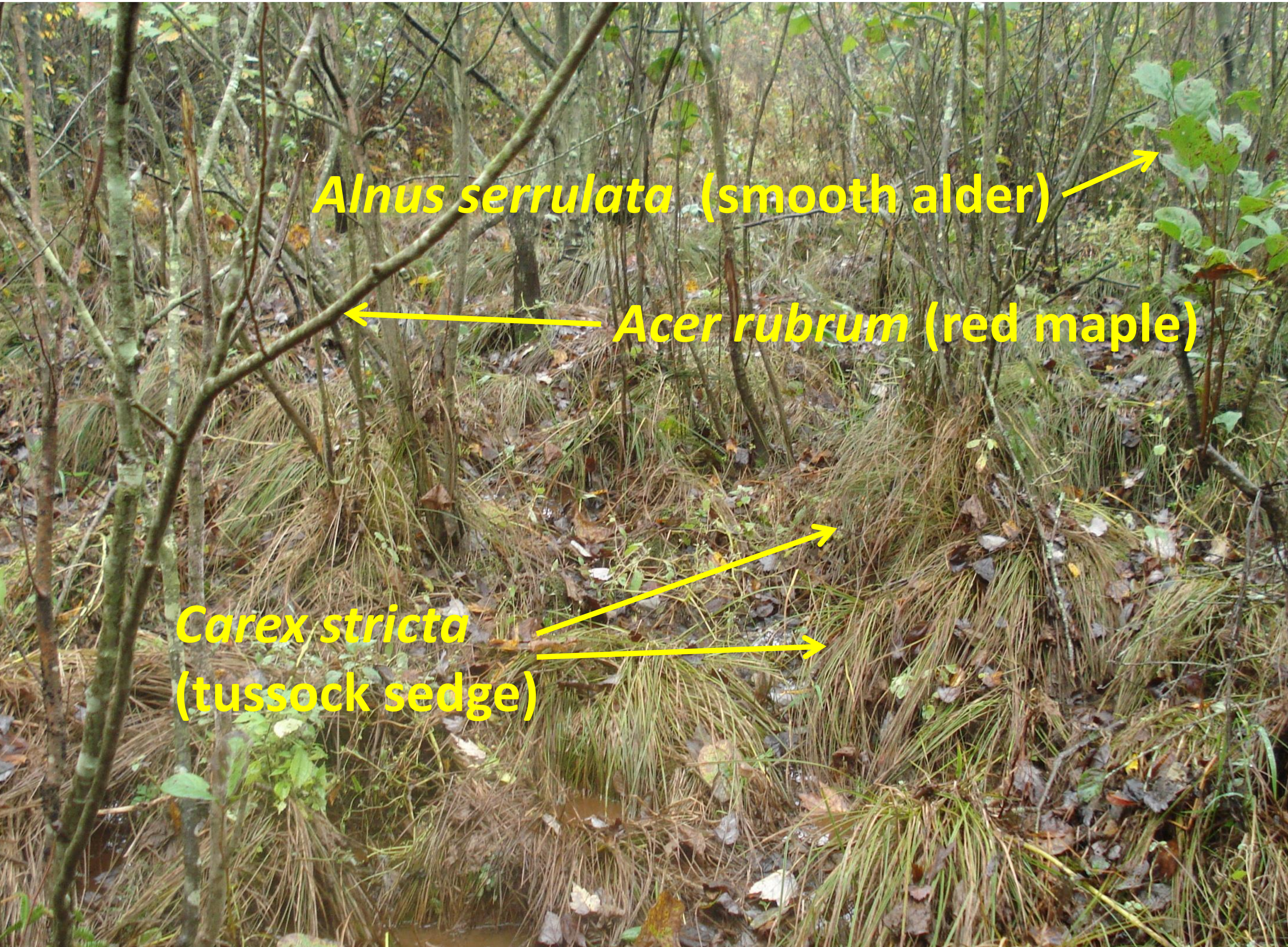
• *Eleocharis tuberculosa (OBL)*	*colonizer*
• *Carex lupulina (OBL)*	*colonizer*
• *Carex lurida (OBL)*	*Planted*
• *Carex frankii (OBL)*	*Planted*
• *Carex vulinoidea (OBL)*	*Planted*
• *Scirpus atrovirens (OBL)*	*Planted*
• *Schoenoplectus tabernaemontana (OBL)*	*Planted*
• *Alisma subcordatum (OBL)*	*Planted*

- (Identified by Jeff Hartranff and Bill Hilgartner)

BSR Restoration, July 2014. Note patches of cattail *Typha latifolia (OBL)* that have colonized the wetland

Carex vulpinoidea (foreground) and *Carex lurida*

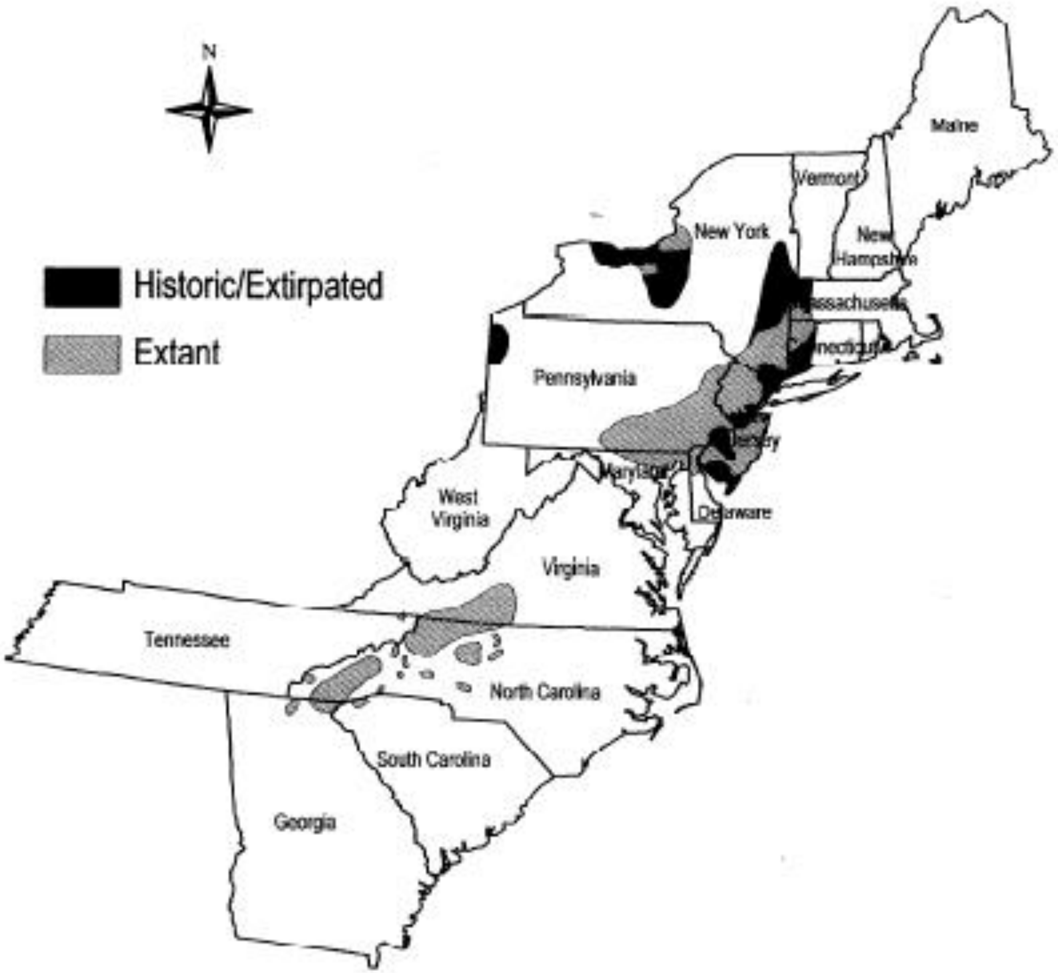
Tussock sedge wetlands, are a favored habitat of the endangered bog turtle (*Glyptemys muhlenbergii*) in Maryland and Pennsylvania


Alnus serrulata (smooth alder)
Acer rubrum (red maple)
Carex stricta
(tussock sedge)


Note saturated soil conditions and space for a turtle to hide at base of tussock sedge
Bog turtle

Decline of Bog Turtle Habitat

The greater extent of prehistoric sedge meadow wetlands and their subsequent reduction by dams and sediment burial may help explain the modern disjunct distribution and decline of the bog turtle.



Sedge meadows are a favorite habitat of the Sedge Wren (*Cistothorus platensis),* listed as Endangered in Pennsylvania and Threatened in Maryland

The available information suggests that sedge meadows, which offer saturated soils, with or without shallow standing water, are optimal nesting habitat…

In New England, Bagg and Eliot (1937 *in* Gibbs and Melvin 1992) suggested "that sedge wrens colonized wet meadows early in the nesting season, but due to summer drying, used permanently wet, tussocky marshland in July for renesting". Palmer (1949) noted that nests were hidden "deep down" in thick sedges, grasses, "or other low herbage, close to the ground, mud, or very shallow water, not more than a foot or two above it at the most".

http://www.fws.gov/r5gomp/gom/habitatstudy/metadata/sedge_wren_model.htm

One solution to the decline in bog turtle and sedge wren habitat is a true restoration…removal of the legacy sediment to expose the underlying sedge meadow wetland.

<u>Native and Non-Native Species</u> - Since AD 1700, habitats have been in a state of change or instability, marked by temporary periods of no change (stability)

This concept has implications for native and non-native species…

The new habitat created since 1700 frequently favors the better adapted non-native species.

Add to this the increased input of atmospheric nitrogen and CO_2 acting as a “fertilizer” and growth and greater diversity is promoted.

Thought to ponder about "invasives" or "non-native species"

---It's not so much that non-natives have been causing declines in the natives; in many cases the declining natives today experienced an increase after 1700

--- The habitat has been altered by sediment and dams and that has caused a decline in natives that today are in fragmented populations

---The non-natives are taking advantage of an altered, more open and drier environment, created, shaped and maintained by human action.

So today with habitats shaped by humans, maybe we should view modern habitats not as long-term natural habitats under stress, but more as recently "installed"

"Legacy Gardens"

For Example: Is this site along Jones Falls a natural riparian floodplain or a “legacy garden”?

Lesser Celandine (*Ranunculus ficaria = Ficaria verna) is a non-native from Europe spreading on this floodplain. But the floodplain itself is an "installed"* system or *artificial habitat, developed on colonial legacy sediment*

According to the USDA lesser celandine is an invasive species

While it is <u>believed</u> that celandine might be replacing native species like violets and trilliums, the fossil evidence shows that violets and trilliums could only have grown in these floodplain wetlands for the past 100-200 years, if at all.

Prior to 1700, the marshy valley that existed before European settlement would not have provided a habitat for violets, trilliums, or lesser celandine.

In conclusion, the fossil record in our region provides a record of …

- **Native species and wetland habitats that were formerly widespread, are now fragmented and reduced in areal extent since 1700**

- **A prehistoric, sedge-dominated wetland stasis on the order of 30-40 centuries existed in valley bottoms before 1700, indicating constant elevation and hydrology**

- **Great change and instability in the landscape after 1700, brought about by major sedimentation events.**

Conclusion continued

- **After 1700 sedimentation events raised surface elevation from ground water levels and drier species, representing a shift from OBL to FAC or FACU species.**

- **Increased diversity with a raised floodplain elevation, while OBL species became locally extirpated, along with associated fauna such as the bog turtle and sedge wren.**

- **The recent evolution of the modern riparian floodplain, which are only about 150-250 years old.**

Recommendations

- **Restoration by legacy sediment removal in selected sites would be a more true approach to the word "restoration", restoring systems that had persisted for 1000s of years.**

- **Restoring sedge meadows, particularly tussock sedge wetlands, by legacy sediment removal would favor conservation of the endangered bog turtle and sedge wren.**

- **Other biodiversity benefits include increasing the potential for uncommon or rare sedges, wildflowers and other wetland plants, as well as other birds and amphibians.**

- **Ecologists and engineers should be aware of the fact that conclusions about patterns and processes based on studies of the modern landscape may well be compromised, because of the instability of the transient and/or recent nature of the modern wetland environment.**