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Paleoecological Evidence of a Pre-Settlement Sedge Wetland in a Piedmont River Valley

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ABSTRACT

Recent stratigraphic analyses of macrofossil seeds in buried wetlands of the Piedmont of Maryland and southeastern Pennsylvania indicate that these prehistoric wetlands were hydro-climatically stable for several thousand years. At a river site in north central Maryland a core revealed no significant change in the sedge-dominated wetland for 4300 years until A.D. 1730. An environmental shift occurred in the 18th and 19th centuries as a result of burial of the prehistoric wetland by mill pond sediment behind dams, combined with an influx of sedimentation from extensive deforestation. This study examined seeds (macrofossils) from a series of samples extracted laterally from the core from this river bank to determine the lateral extent of the sedge wetland in the prehistoric river valley. Seeds found in the samples belong to obligate wetland species in contrast to the modern stream bank, which is lined by facultative, riparian trees. The dominant species in the prehistoric wetland was *Carex stricta*, the tussock sedge. Tussock sedge wetlands are a primary habitat for the endangered bog turtle (*Glyptemys muhlenbergii*) in the mid-Atlantic region. The hydrologic and vegetative characteristics of the prehistoric wetland offer a guideline on potential wetland restoration goals, including the restoration of critical habitat for the bog turtle.

INTRODUCTION

Dark, organic layers containing fossil seeds of sedges and other obligate wetland species have been recovered from the base of numerous river banks in the Piedmont of Maryland and Pennsylvania, USA (Merritts et al 2011; Hilgartner et. al. 2010; Voli et al 2009; Walter and Merritts 2008). Overlying these buried organic layers are 1.0 to 6.0 meters of silt and clay sediment, referred to as legacy sediment, forming the primary river bank. These studies demonstrate a widespread and dramatic environmental shift during the colonial period from prehistoric low-lying open sedge meadows to post-European high-banked meandering river channels whose banks are dominated by riparian trees or agricultural fields of grasses and weedy herbaceous plants. This environmental shift was the result of burial of the prehistoric wetland by mill pond sediment behind dams constructed during the post-settlement period (Fig. 1), particularly in the 18th and 19th centuries, combined with an influx of sedimentation from extensive deforestation. Merritts et al. (2011) and Walter and Merritts (2008) have well summarized the geomorphic processes and historic evidence so far accumulated for the above

Figure 1: 19th Century Mill Dam (Brown 2011)

scenario. This scenario of mill pond sediment being deposited in river valleys and then incised by a meandering river channel after a dam is breached is a shift in thinking about the geomorphology of Piedmont rivers as they have been described since mid-20th century (Wolman 1955, Wolman and Leopold 1957, Leopold 1973, Jacobson and Coleman 1986). The scenario described in these earlier studies is that a river channel meanders across a valley for 100s or 1000s of years depositing sediment during overbank flow. The new evidence is that first and second order and possibly third order river channels as seen today are no older than 300 years, and that the colonial reservoir sediment buried the original sedge meadow wetlands that had endured since at least the mid Holocene (6,000 yr BP).

Macrofossils of obligate wetland species extracted from these pre-colonial layers indicate that the groundwater table lay near the surface and maintained saturated, anaerobic soils, favoring sedge-dominated assemblages for many centuries (Hilgartner et al 2010) (Fig. 2). At some locations these organic wetland soils can be traced across the entire valley bottom where they overlie quartz-rich gravels. The primary hydrologic control is believed to have been springs emanating from valley margins combined with slow, shallow overflow from upstream regions. The typical Piedmont valley bottom appears to have been a broad hydrologic system resembling an anastomosing stream network harboring obligate wetland species in a surface level water table. There is virtually no evidence of prehistoric stream channels of the kind that presently

exist, with the predominance of rounded sand and gravel sediment.

In the modern river system, a single meandering river channel with high banks resting several meters above the groundwater table incised into an otherwise flat valley is most characteristic. Instead of obligate wetland species the banks are lined by facultative, riparian trees (Hilgartner and Brush 2006; Brush et al. 1980). Recent stratigraphic analyses of macrofossil seeds in buried wetlands of the Piedmont of Maryland and southeastern Pennsylvania indicate that these prehistoric wetlands were hydro-climatically stable for several thousand years (Hilgartner et al. 2010). Scattered samples taken from many locations indicate long-term stability patterns and a recent study found consistent sedge species for 2800 years (Neugebauer 2011). However, detailed studies of these prehistoric wetlands, their lateral extent across the valley, variation in vegetation characteristics and temporal stability, and the influence of natural and anthropogenic disturbance on the wetland is still needed.

In this study, we examined a series of samples extracted from the base of a river bank in north central Maryland, USA with the base of the paleo-wetland radiocarbon-dated at ~5,000 yr BP. The samples span a distance of 0.5 km within a broad river valley. The samples were used to supplement a study of a core from the same river (Hilgartner et al 2010) to provide a broader spatial view of the ancient wetland. Analysis of fossil seeds of local wetland species were combined with geomorphic data of the river channel and banks and historical land use data, which provides a 5000 yr history of a prehistoric wetland and post-settlement river channel. Early analysis of fossil seeds showed a dominance of tussock sedge (*Carex stricta*), an important species indicator of a saturated sedge meadow habitat (Fig. 3). It is hypothesized that

Figure 2: Typical Sedge Meadow Habitat for Bog Turtles

C. stricta covered much of the valley floor before A.D. 1700. This vegetation forms an important habitat for the endangered bog turtle (*Glyptemys muhlenbergii*). Therefore this study has important implications for stream restoration and conservation of the bog turtle.

Figure 3: Carex stricta **(Britton and Brown 1913)**

The macrofossil samples in this study provide a record of the lateral extent of this pre-settlement wetland. It is hypothesized that a sedge meadow wetland occurred throughout the river valley between the valley margins lying at the groundwater table supplemented by springs and gently flowing water. Sedge seeds in these samples provide support for this hypothesis.

Important aspects and goals of this independent study are:

1. Learn to identify wetland indicator macrofossils as a tool to analyze past environments
2. Compile the macrofossil data into a spatial framework relative to the valley dimensions
3. Analyze data using Sorenson's similarity indices
4. Collect additional samples from the field site if needed
5. Explore the importance of the Pre-settlement wetland as a habitat for the endangered bog turtle
6. Analyze the potential of a wetland restoration at this site

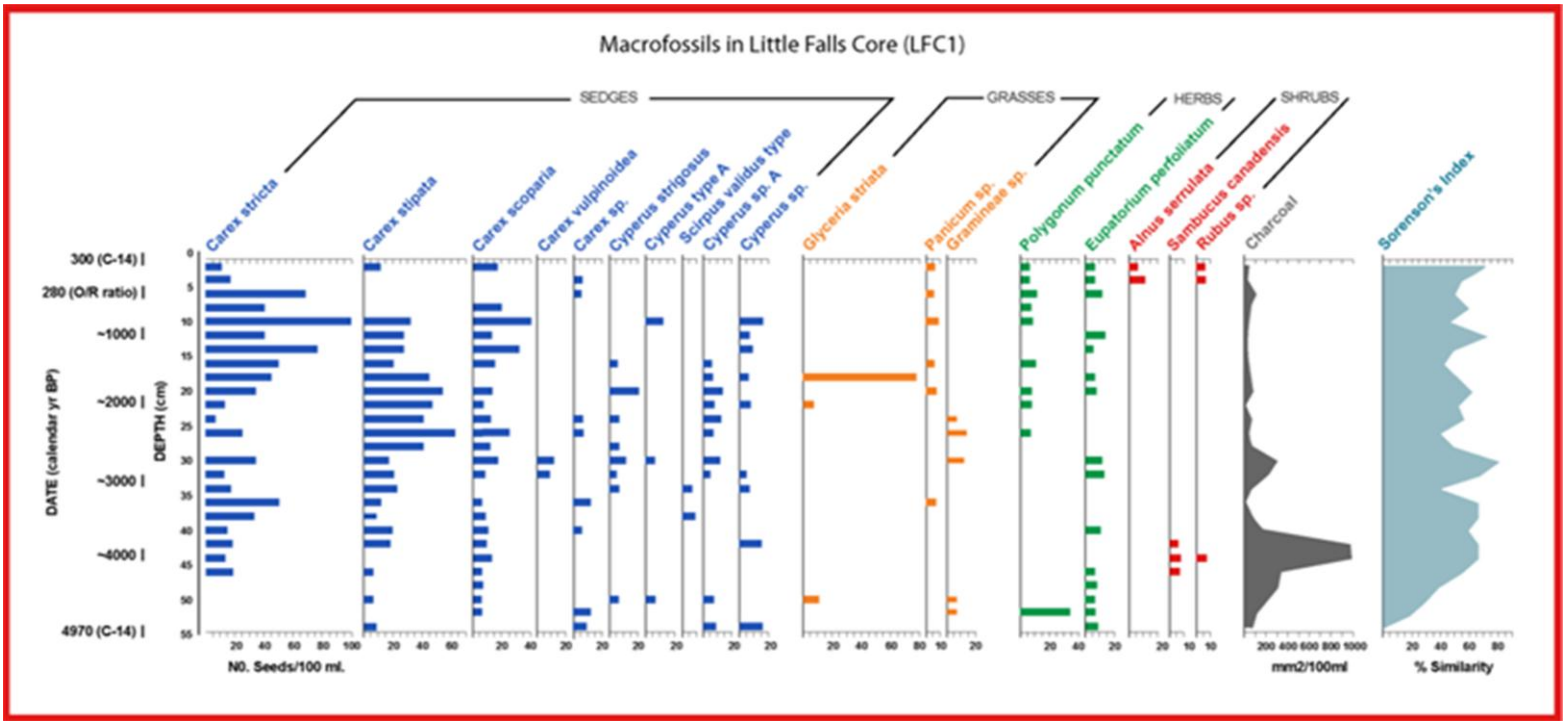
STUDY AREA

The study area is Little Falls, a tributary of the Gunpowder River in northern Baltimore County, near White Hall, MD. USA (76°37'30.329 W, 39°36'47.333 N). The bedrock is primarily schist with chlorite and garnets (Moller 1979), and the surrounding forest is considered to be part of the Chestnut Oak Association (Brush et al. 1980). The stream valley is relatively flat lined by facultative, riparian trees like sycamore (*Platanus occidentalis*), box elder (*Acer negundo*), green ash (*Fraxinus pennsylvanica*) and silver maple (*Acer saccharinum*) (Hilgartner and Hart-Smith; pers. obs.). The valley is surrounded by steep hills, with some sections being walled off by a railroad embankment first constructed during the 1830s (now called the NCR trail). The valley vegetation is a mix of agricultural fields with common grasses such as *Dactylus glomerata* and *Setaria glauca* lining the higher banks, and *Phalaris arundinacea* occurring in lower elevations near the channel. Much of the flat modern valley contains upland weedy vegetation, sometimes with patches of facultative wetland species in swales or in depressions near valley margins Analysis of the silt and clay sediment that characterizes most of the river bank and the valley surface soil indicates that this layer is not older than 300 years and is lacustrine in origin (Hilgartner et al. 2010; Cranmer 2009)..

Figure 4: Little Falls (Google Maps 2012) Arrow points to location of core LFC1

A core (LFC1) was extracted from the base of the river bank about 1.0 km south of Whitehall in 2008 for macrofossil and pollen analysis (Hilgartner et. al. 2010). The core (LFC1) revealed a 5,000-yr history of a tussock sedge (*Carex stricta*) dominated wetland that persisted from 4,300 yr BP until 300 yr BP when a millpond filled with sediment behind a downstream dam buried the sedge wetland (Fig. 5). The 4300 yr period of stability was maintained despite periods of fire

Figure 5: Macrofossil, pollen, and charcoal analysis of LFC1 (Hilgartner et. Al. 2010)



indicated by charcoal peaks, major storm events and prehistoric human activity. The sedge wetland began to shift ca. 1730 when *Carex stricta* declined and alder (*Alnus serrulata*) became established. Within 60 years (between 1775 and 1835) the prehistoric wetland was buried under 2.0 m of silt and clay sediment accumulated in a mill pond behind a downstream dam.

METHODS

Twelve sediment samples extracted for macrofossil analysis were collected upstream from LFC1 on 9/30/2008 at the base of the railroad embankment forming a wall of the river channel. These were collected along a transect at 5.0 m intervals from 0 to 55 m just above the basal gravel zone. Carbon-14 dates were obtained following the collection of the upstream samples providing

dates between 2,000 and 10,000 y BP (Cranmer 2009). An additional sample from the RR embankment, 1 sample at the LFC1 site and 3 samples downstream from LFC1 were collected on 3/17/2012 to augment the current study.

In the lab, a portion of a sediment sample was soaked in warm water for ~2 hours and the volume of displacement was noted to determine the volume of the sediment. The sample was then sieved in two nested sieves washed with warm water, and the remainder was placed in a petri dish with water and a grid. With forceps the sample was searched for seeds, leaves, and other macrofossils. These macrofossils were separated and placed in a separate petri dish for identification. Identification of seeds was undertaken with the guidance and review of Dr. Hilgartner, using his seed reference collection (202 species, 278 specimens), and an assortment of identification guides and the Natural Resources Conservation Service's (NRCS) Plants Database (www.plants.usda.gov)

After seed identification, the abundance of each species was equilibrated relative to the volume of the sample. Seed abundance was used to determine dominant species and variation between samples. Sorenson's Index of Similarity compared seed species composition between samples. Sorenson's Index of Similarity (SI) is determined as:

SI = 2C/A + B, where A = No. of species in sample A, B = No. species in sample B, and C = the number of species common to samples A and B. This in turn was compared to Sorenson's indices in previous surface sample studies (Hilgartner et al 2010; 1995), which permits quantitative analysis of habitat variability.

RESULTS

The upstream samples collected in 2008 revealed no seeds and therefore no direct evidence of a buried wetland deposit lying directly above the basal gravel layer. The new sample collected in 2012 produced 1 *Scirpus validus* seed, establishing the presence of this species in the sediment where it does not presently exist. The downstream samples collected in 2012 however, contained a number of sedge species (Table 1).

Table 1: Seeds Identified Per Site

	LFC1	19MDR	22.3MDR	27.0MDR
Carex scoparia	30 Seeds/100mL		5 Seeds/100mL	
Carex stipata	5 Seeds/100mL			
Cyperus	10 Seeds/100mL			
Unidentified	15 Seeds/100mL			
Carex stricta		5 Seeds/100mL	5 Seeds/100mL	
Sedge unknown			5 Seeds/100mL	
Polygonum punctatum				10 Seeds/100mL
Polygonum				5 Seeds/100mL

The samples at the 19.0MDR and 22.3MDR sites have *Carex stricta* which means that the tussock sedge wetland at the LFC1 site extended at least that far downstream and along the valley wall. The 22.3MDR site also contained *Polygonum punctatum*, and the 27MDR only contained polygonums, which indicates higher ground where polygonums were more common. This allows for an outline of the ancient tussock sedge wetland which extended at least 22.3 meters wide near the valley wall and was established on either side of a periglacial alluvial fan. Thus this tussock sedge wetland was subject to local topographic changes, disappearing or harboring different species on high ground but lingering in equilibrium in low ground.

A Sorenson's similarity analysis shows some limited similarity with some variability (Table 2).

Table 2: Sorensens Similarity Index

Site	LFC1	19.0MDR	23.3MDR	27.0MDR
LFC1	--	0	0.28	0
19.0MDR	0	--	0.50	0
23.3MDR	0.28	0.50	--	0
27.0MDR	0	0	0	--

Comparison of the LFC1 site with 22.3 m and the 22.3 m site with the 19 m site reveals SI > 0.40, consistent with the values from the core LFC1, thus confirming essentially the same habitat (Hilgartner et. al. 2010). However SI = 0 when comparing the 27 m site to other sites indicates the dissimilarity in habitats. This confirms the deduction that the 27 m site was on higher ground

and contained species (*Polygonum* spp. dominant) in a habitat structurally different from the saturated ground level tussock sedge wetland.

DISCUSSION

Carex stricta is a shade intolerant hydro-successional species which grows at or slightly above the water table surface, in a continually saturated substrate, and have the highest survival and grown rates when in saturated soils to standing water of 1cm or less in depth, and flood levels of less than 45cm (USFS 2012; Budelsky and Galawitsch 2004; van der Valk, et al. 1999). Most tussock sedge wetlands persist where springs feed into the wetland from valley walls (Lawrence and Zedler 2011). Thus the prehistoric wetland with the sustained presence of *Carex stricta* was a spring-fed groundwater level wetland for over 4,000 years. Low sedimentation rates of 0.01 cm/yr (Hilgartner et. al. 2010) were maintained in a dynamic equilibrium with perhaps an equal rate of rise in the groundwater table. During this extended time period no successional changes beyond the addition or deletion of a few sedge or grass species occurred. This wetland extended at least 23 m wide and is hypothesized to extend back in a perpendicular line from the current river channel for some distance. Change came only in the 18th century when *Alnus serrulata* (alder) became established as deforestation combined with mill dam construction buried the wetland. Modern studies of tussock sedge wetlands document the eventual successional change to alder and/or red maple (*Acer rubrum*) (Lee and Norton 2011; Morrow et.al 2001). Some studies indicate that the absence of cattle grazing in these wetlands allows for the establishment of woody plants such as alder and red maple (Lee and Norton 2011).

The bog turtle (*Glyptemys muhlenbergii*) occurs in isolated wetland fragments with some of the most important populations found in the Maryland-Pennsylvania region (Fig. 6). The most characteristic habitat is the tussock sedge association (Lee and Norton 2011; Morrow et al. 2001). The persistence and extent of the tussock sedge in the prehistoric wetland at Little Falls indicates that the former habitat of the bog turtle was more extensive, and thus the burial of this wetland helps to explain the decline of bog turtle populations and their current relictual distribution.

The hydrology and plant community of the prehistoric wetland contrasts sharply with the current riparian environment. Macrofossil seeds found in the sediment samples belong almost

exclusively to obligate wetland species, however the modern river bank and floodplain is lined by facultative, riparian trees. It has already been established that the modern 2.0-m bank at Little Falls is a channel that was incised following the breaching of a dam in the early 19th century. The sediment had accumulated behind the mill dam following extensive deforestation and subsequent erosion between 1775 and 1835, burying the ancient wetland. So the modern riparian wetland with sycamore, black walnut, and silver maple is an artifact of post-settlement impact and change and not a natural vegetation for the Little Falls river valley.

Figure 6: Bog Turtle Populations (US FWS 2011)

The characteristic hydrology and wetland vegetation of the prehistoric wetland offers a guideline to potential wetland restoration goals. The greater extent of this wetland might justify restoration by removal of the legacy sediment to expose this ancient wetland, in a manner depicted in the image below. Several river valley restorations where legacy sediment has been removed to restore the prehistoric wetland and groundwater table have been performed in southeastern Pennsylvania. These include Big Spring Run, Conoy River and Banta in Lancaster County, and have been considered successful in reestablishing an herbaceous wetland. In addition, studies have indicated that deliberate re-vegetation of *Carex stricta* via seed planting after hydrological restoration to 1.0 cm of standing water is a successful method for introducing the tussock sedge into wetland restorations under a variety of environmental conditions. (Budelsky and Galawitsch 2004; van der Valk, et al. 1999). While Maryland has not yet undertaken this approach, this study of Little Falls offers a guideline on a Best Management

Approach to wetland restoration in this valley and perhaps other Maryland river valleys.

CONCLUSION

Macrofossil identification and analysis provides an important tool to analyze past environments. In this study macrofossils combined with land use history were used to draw inferences into the spatial dimensions and framework of an ancient wetland relative to the valley dimensions. Sorenson's similarity indices can provide an indication of stability or consistency between macrofossil samples both spatially and temporally and provided some useful data. The importance of the pre-settlement wetland as a habitat for the endangered bog turtle was explored as well as the potential of a wetland restoration at this site.

Future research could include drilling into the floodplain away from the river bank to evaluate the seed macrofossil record and to further define the areal extent of the tussock sedge-bog turtle habitat in the valley perpendicular to the river bank.

Wetland Restoration (Brushy Fork Environmental Consulting, Inc, 2012)

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