WATER RESOURCES

# IMPACT

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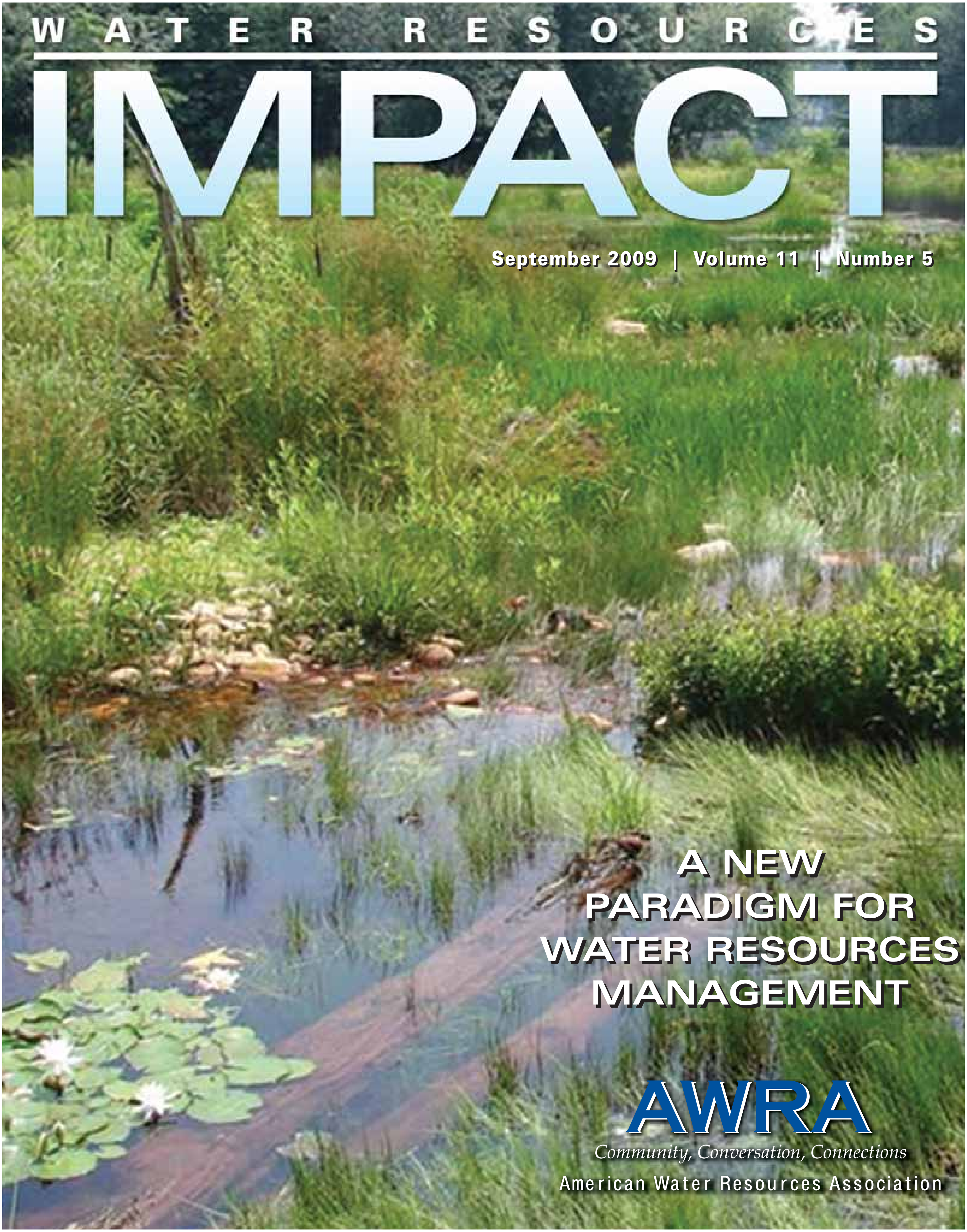

## A NEW PARADIGM FOR WATER RESOURCES MANAGEMENT

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WATER RESOURCES IMPACT

# PRELIMINARY RECONSTRUCTION OF A PRE-EUROPEAN SETTLEMENT VALLEY BOTTOM WETLAND, SOUTHEASTERN PENNSYLVANIA

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## INTRODUCTION

Early accounts of the mid-Atlantic piedmont region by European settlers describe numerous swamps and meadows, abundant springs, and associated wetland plant communities. The Swedish-Finnish botanist Pehr Kalm (1716-1769) described nights in southeastern Pennsylvania as noisy with the sounds of frogs croaking in marshes and meadows, but also noted that settlers converted swamps and meadows to cornfields and pastures (Kalm, 1937). Reports of draining naturally occurring wetlands are frequent in historic literature. Small patches of presettlement wetlands exist today that are remnants of once larger and significantly more widespread naturally occurring wetlands described by early observers.

Since European settlement, numerous anthropogenic impacts accelerated erosion of upland sediment (Jacobson and Coleman, 1986; Langland and Cronin, 2003). Widespread sediment trapping was facilitated by the construction of tens of thousands of low-head milldams during the period of intensive land clearing, farming, and mining of the 18th-19th Centuries (Walter and Merritts, 2008). The slackwater environment of ubiquitous ponds buried and preserved the geologic record of presettlement wetlands, much as volcanic ash preserves an ancient city. The contact between pre-European settlement soils and post-settlement sediment typically is vertically abrupt and laterally continuous, and retains fine pedologic details, such as root structures from plants. The extent and abundance of the naturally occurring presettlement wetlands is long since forgotten, but the evidentiary record remains.

Millponds filled with sediment to the crests of dams and spillways by the late 1800s, but as dams breached throughout the 20th Century the drop in base level resulted in deep incision into the sediment reservoirs (Walter and Merritts, 2008). Incising streams produce three-dimensional views of the buried presettlement landscape, revealing the organic-rich soils.

This study uses macrofossils, specifically seeds extracted from buried organic-rich soils, to identify pre-European settlement wetland vegetation at Big Spring Run, a second-order stream in southeastern Pennsylvania. This report is a precursor to more detailed ecologic, geochemical, and geomorphic analyses that are ongoing in this watershed.

## SITE DESCRIPTION

Draining 15 square km of Paleozoic limestone with quartz veins, Big Spring Run begins at several springs and flows north into Mill Creek, a tributary to the Conestoga River in Lancaster County, Pennsylvania (Figure 1). The Conestoga drains into the Susquehanna River, a tributary to the Chesapeake Bay. A wedge of fine-grained sediment that thickens downstream toward a breached milldam buried the Big Spring valley bottom and many of its springs. The study area encompasses two incised headwater tributaries and the main stem about 1.5 km upstream of the breached dam. Many segments of the Conestoga River, including Big Spring Run, are included on the U.S. Environmental Protection Agency (USEPA) 303d impaired water body list for high loads of suspended sediment and nutrients. Land use for the majority of the Big Spring Run watershed is agricultural. Big Spring Run is the location of a multi-year (2008-2011) research investigation by Franklin and Marshall College, Pennsylvania Department of Environmental Protection, the U.S. Geological Survey, and USEPA to assess a floodplain, stream, and riparian wetland restoration approach to ecological restoration.


Figure 1. Sample Sites (dots) at Big Spring Run, Flowing From South to North in This April 2005 Digital Orthophoto.

## METHODS

Pre-settlement organic soils were identified and sampled at exposed stream banks along 0.5-km of Big Spring Run (see Figure 1), and macrofossils (seeds) were analyzed following the procedures of Hilgartner and Brush (2006). The light yellowish brown (10 YR 6/4 to 2.5 Y 6/4) post-settlement sediment is laminated and fine-grained (>95% silt and clay) and 0.8-1.2 m thick. The underlying pre-settlement soil (20-50 cm thick) is dark gray to black (10 YR 2/1) silt with fine sand and locally abundant angular quartz gravel derived from long-term weathering of bedrock.

Several techniques were used to constrain the age and depositional style of these deposits, including magnetic susceptibility and isotope geochronology. Identifications are made using multiple seed references. Nomenclature follows Gleason and Cronquist (1991). A Nikon binocular microscope fitted with a digital camera is used to photograph seeds.

**As a result of reservoir sedimentation and subsequent incision, a highly unstable channel is migrating rapidly across the valley bottom, eroding both historic sediment and the presettlement wetland soil**

## RESULTS

Radiocarbon dating of wood and seeds from the buried organic-rich soil yielded ages ranging from 690 to 3200 yr BP (dating at Beta Analytic, Inc., Miami, Florida.). Over 300 seeds have been extracted from this stratigraphic unit along Big Spring Run, with typical yields of 10-30 seeds per 30 $cm^3$ of sample. Seeds in greatest abundance were those of *Carex spp.* (including *C. crinita, C. stipata,* and *C. stricta*), *Polygonum spp., Eleocharis spp.* (including *E. ovata*), and *Scirpus spp.* Additionally, we have found several seeds of *Najas flexilis* (nodding water nymph) and *Brasenia schreberi* (watershield) at a buried spring site located along the southern valley margin. These wetland species are found at all depths of the buried presettlement soil.

The majority of the species are those of obligate wetland species, but near valley margins nuts and seeds have been identified from facultative upland species, including *Liriodendron tulipifera* (tulip tree) and *Juglans cinerea* (butternut). Because these nuts and seeds are embedded within dark soil that also contains obligate wetland species, we interpret their occurrence to indicate that they fell into the wetland from an adjacent hillslope.

## DISCUSSION

Macrofossil analysis of specimens obtained from buried presettlement soils provides a paleoecological record of wetland vegetation across the entire valley bottom of the headwaters of Big Spring Run. Species are representative of plants that grow in organic-rich wetland mucks (i.e., hydric soils) or pools of water, as at springs. The modern incised stream crosses the valley at several locations (see Figure 1), and no buried stream channel is observed. The buried hydric soil exists at the current level of baseflow – the seasonal ground water level – indicating that the modern hydrology is not substantially altered from presettlement conditions.

Species from these buried plant communities can be assigned to wetland classification systems that illuminate the paleo-environment just prior to European-American settlement. The buried Palustrine wetlands at Big Spring Run are best classified as Persistent Emergent Wetlands (Cowardin *et al*, 1979), and can be subclassified as a wet meadow herbaceous wetland (Fike, 1999).

We conclude that a wet meadow herbaceous wetland existed from at least 3,200 years ago until its burial beneath historic sediment circa 1730 AD. Stream incision began sometime between 1850 and 1930, based on analysis of historic maps and aerial photographs. As a result of reservoir sedimentation and subsequent incision, a highly unstable channel is migrating rapidly across the valley bottom, eroding both historic sediment and the presettlement wetland soil. A valued seed bank and record of the presettlement landscape are washing downstream along with this sediment.

These results have significant implications for restoration strategies at Big Spring Run and similar sites. The presence of ground water and hydric soil, and the predominance of sedge seeds, indicate that this area was originally a wetland dominated by obligate wetland plant species in or near permanently saturated soil. By contrast, modern plants growing on the surface of the historic sediment fill are predominantly quackgrass (*Agropyron repens*), Canada thistle (*Cirsium arvense*), and orchard grass (*Dactylis glomerata*), species characteristic of mesic wastelands and roadsides. A few isolated patches of obligate wetland species occur near springs at the valley margins. A planting of ~3,000 riparian trees on the historic silt and clay in 2002 had a high mortality rate (>80%). A possible cause of this high mortality is the height of the plant roots above the ground water table (~1 to 1.2 m). A possible implication of this study is that restoring the naturally occurring riparian wetlands buried beneath the historic sediment, rather than stream restoration or riparian tree planting on the historic sediment surface, could be a more effective and sustainable approach to increasing wetland biodiversity and improving riparian habitat and function, while possibly also reducing sediment and nutrient loads downstream.

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## AWRA FUTURE MEETINGS

**2009**

**NOVEMBER 9-12, 2009**
**AWRA'S ANNUAL WATER RESOURCES CONFERENCE**
RED LION ON FIFTH AVENUE
SEATTLE, WASHINGTON
**EARLY-BIRD REGISTRATION DEADLINE OCTOBER 9, 2009**

**2010**

**MARCH 29-31, 2010**
**AWRA's SPRING SPECIALTY CONFERENCE ON GIS**
ROSEN SHINGLE CREEK HOTEL
ORLANDO, FLORIDA
**ABSTRACTS DEADLINE OCTOBER 9, 2009**

**NOVEMBER 1-4, 2010**
**AWRA'S ANNUAL WATER RESOURCES CONFERENCE**
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