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Quaternary Research 63 (2005) 238–249
QUATERNARY RESEARCH
www.elsevier.com/locate/yqres

Medieval Warming, Little Ice Age, and European impact on the environment during the last millennium in the lower Hudson Valley, New York, USA

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Received 9 March 2004
Available online 24 February 2005

Abstract

Establishing natural climate variability becomes particularly important in large urban areas in anticipation of droughts. We present a well-dated bi-decadal record of vegetation, climate, land use, and fire frequency from a tidal marsh in the Hudson River Estuary. The classic Medieval Warm Period is evident through striking increases in charcoal and *Pinus* dominance from ~800–1300 A.D., paralleling paleorecords southward along the Atlantic seaboard. Higher inputs of inorganic sediment during this interval suggest increased watershed erosion during drought conditions. The presence of the Little Ice Age ensues with increases in *Picea* and *Tsuga*, coupled with increasing organic percentages due to cooler, moister conditions. European impact is manifested by a decline in arboreal pollen due to land clearance, increased weedy plant cover (i.e., *Ambrosia*, *Plantago*, and *Rumex*), and an increase in inorganic particles to the watershed.

Keywords: Pollen; Charcoal; Climate; Medieval Warming; Little Ice Age; Land use; Hudson Valley; *Phragmites*; *Typha*

Introduction

Prediction of long-term drought has become a major topic at the forefront of climate change research (i.e., Trenberth et al., 2004). Droughts in the Hudson River Valley have been documented for recent centuries (Cook and Jacoby, 1977). However, millennial-scale records for the region are lacking, making it difficult to place the anthropogenic era in historical context. Longer records are crucial for estimating natural variations in climate that affect the Hudson River watershed, which provides water resources for New York City's 8 million inhabitants. Defining a detailed Hudson record of climate change to compare with regional (Cronin et al., 2003; Stahle et al., 1988; Willard and Korejwo, 1999; Willard et al., 2003) and North Atlantic records (Bond et al., 2001; Keigwin, 1996) will improve our understanding of the forcing for these changes along the Atlantic seaboard. The unusually high sedimentation rate (avg. 0.2 cm/yr) in Piermont Marsh, New York is unique among Hudson marshes (Merley and Peteet, 2001; Newman et al., 1987; Peteet and Wong, 1999) and affords an opportunity to investigate the detailed continuous environmental history of the Hudson River watershed at bi-decadal to centennial resolution. Here, we present pollen and spores, charcoal, loss-on-ignition (LOI), and marsh sediment composition data for the last 1350 calendar yr.

Using the Piermont record, we address the following questions: (1) What was the pre-European forest and marsh composition? (2) Is a climate signal present in the shifts in pre-European vegetation and charcoal? (3) How does pre-European variability compare with anthropogenically induced change? (4) How do organic and inorganic

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doi:10.1016/j.yqres.2005.01.001

sediment composition compare with vegetation shifts and the charcoal record?

Study location

Piermont Marsh (41°00′N, 73°55′W), located on the western shore of the Hudson River and approximately 40 km north of the river's mouth (Fig. 1), is one of four National Estuarine Research Reserve (NERR) sites along the river. It measures 110 ha and is bounded by Piermont Pier to the north and the Palisades sill to the west, which rises ~100 m to form Tallman State Park. Mean salinity is 6.0 ppt, and the marsh is categorized as brackish (Winogrond, 1997). Two creeks, the freshwater Sparkill and the brackish Crumkill, meander through the marsh (Fig. 1b). Marsh vegetation is comprised primarily of *Phragmites australis*, but *Spartina alterniflora*, *Spartina patens*, *Spartina cynosuroides*, *Schoenoplectus robustus*, *Schoenoplectus americanus*, *Typha angustifolia*, *Iva frutescens*, *Chenopodium glaucum* (introduced), and *Chenopodium ambrosioidies* (introduced) are present (Blair and Nieder, 1993; Lehr, 1967). Due to the sharp rise of the Palisades Sill to the west, Sparkill Creek to the north, and the river contour to the south, the marsh is circumscribed with negligible marsh fringe. Because it is so limited aerially and cannot "expand" landward, the marsh area and its local wetland contribution are relatively constant over time. It is the northernmost site of *Spartina* in the Hudson Estuary, and no native Chenopodiaceae are found in the marsh flora today. However, dramatic changes in marsh vegetation have taken place over the last 50 yr with the advent of invasive species. *P. australis* colonies have increased their percent coverage of the marsh from 35 to 40% in 1965 to 66% in 1991 (Winogrond, 1997). A detailed doctoral thesis study of Piermont Marsh hydrology demonstrates that our coring site location in high marsh *S. patens*/*Distichlis* is saturated throughout the tidal cycle, in contrast to the creek margin *S. alterniflora* vegetation that is not saturated during ebb tide (F. Montalto, personal communication, 2003). The lack of channel deposits in the section indicates no major changes in the courses of the marsh tributaries at our site.

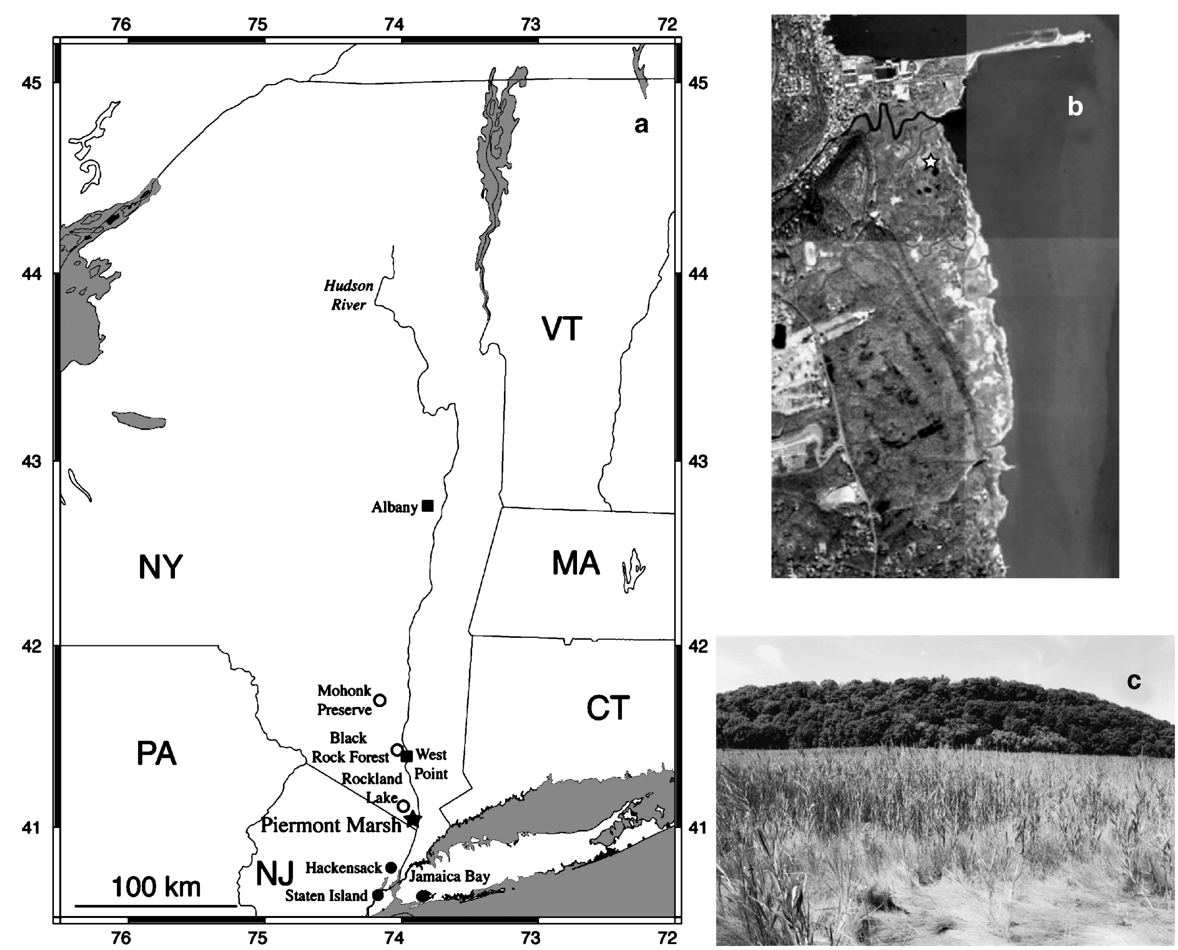

Figure 1. (a) Hudson Valley region with Piermont Marsh marked with a star. Filled circles designate regional marsh records, and unfilled circles mark upland records. (b) Aerial view of Piermont Marsh bounded to the north by the pier built in 1854. A star marks the core location. Sparkill Creek is the large tributary through the northern portion of the marsh. Tallman State Park forms the western boundary to an elevation of ~100 m. (c) Photograph of Tallman State Park from the core site. In the foreground, the remnant *Spartina patens*/*Distichlis* is present with *Typha* and *Phragmites* in the background. Tallman mountain rises to the west.