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Below the disappearing marshes of an urban estuary: historic nitrogen trends and soil structure

Cathleen Wigand,[1,8] Charles T. Roman,[2] Earl Davey,[1] Mark Stolt,[3] Roxanne Johnson,[1] Alana Hanson,[1] Elizabeth B. Watson,[1] S. Bradley Moran,[4] Donald R. Cahoon,[5] James C. Lynch,[6] and Patricia Rafferty[7]

[1]*U.S. EPA Office of Research and Development, National Health and Environmental Effects Research Lab, Atlantic Ecology Division, Narragansett, Rhode Island 02882 USA*
[2]*National Park Service, North Atlantic Coast Cooperative Ecosystem Studies Unit, University of Rhode Island, Narragansett, Rhode Island 02882 USA*
[3]*Department of Natural Resources Science, 112 Kingston Coastal Institute, 1 Greenhouse Road, University of Rhode Island, Kingston, Rhode Island 02881 USA*
[4]*Graduate School of Oceanography, University of Rhode Island, Narragansett, Rhode Island 02882-1197 USA*
[5]*United States Geological Survey, U.S. Geological Survey, Patuxent Wildlife Research Center, 10300 Baltimore Avenue, BARC-East, Building 308, Beltsville, Maryland 20705 USA*
[6]*National Park Service, Northeast Coastal and Barrier Network, 4598 MacArthur Boulevard NW, Washington, D.C. 20007 USA*
[7]*National Park Service, Northeast Region, 120 Laurel Street, Patchogue, New York 11772 USA*

Abstract. Marshes in the urban Jamaica Bay Estuary, New York, USA are disappearing at an average rate of 13 ha/yr, and multiple stressors (e.g., wastewater inputs, dredging activities, groundwater removal, and global warming) may be contributing to marsh losses. Among these stressors, wastewater nutrients are suspected to be an important contributing cause of marsh deterioration. We used census data, radiometric dating, stable nitrogen isotopes, and soil surveys to examine the temporal relationships between human population growth and soil nitrogen; and we evaluated soil structure with computer-aided tomography, surface elevation and sediment accretion trends, carbon dioxide emissions, and soil shear strength to examine differences among disappearing (Black Bank and Big Egg) and stable marshes (JoCo). Radiometric dating and nitrogen isotope analyses suggested a rapid increase in human wastewater nutrients beginning in the late 1840s, and a tapering off beginning in the 1930s when wastewater treatment plants (WWTPs) were first installed. Current WWTPs nutrient loads to Jamaica Bay are approximately 13 995 kg N/d and 2767 kg P/d. At Black Bank, the biomass and abundance of roots and rhizomes and percentage of organic matter on soil were significantly lower, rhizomes larger in diameter, carbon dioxide emission rates and peat particle density significantly greater, and soil strength significantly lower compared to the stable JoCo Marsh, suggesting Black Bank has elevated decomposition rates, more decomposed peat, and highly waterlogged peat. Despite these differences, the rates of accretion and surface elevation change were similar for both marshes, and the rates of elevation change approximated the long term relative rate of sea level rise estimated from tide gauge data at nearby Sandy Hook, New Jersey. We hypothesize that Black Bank marsh kept pace with sea level rise by the accretion of material on the marsh surface, and the maintenance of soil volume through production of larger diameter rhizomes and swelling (dilation) of waterlogged peat. JoCo Marsh kept pace with sea-level rise through surface accretion and soil organic matter accumulation. Understanding the effects of multiple stressors, including nutrient enrichment, on soil structure, organic matter accumulation, and elevation change will better inform management decisions aimed at maintaining and restoring coastal marshes.

Key words: belowground biomass; carbon dioxide emissions; computer-aided tomography (CT) imaging; eutrophication; Jamaica Bay; marsh loss; peat swelling; radiometric dating; sea level rise; shear stress.

Each soil has its own history. Like a river, a mountain, a forest, or any natural thing, its present condition is due to the influence of many things and events of the past.

—Charles E. Kellogg (1956)

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[8] E-mail: wigand.cathleen@epa.gov

Introduction

The extent of the Jamaica Bay salt marsh islands was about 950 ha in the 1950s with only about 355 ha remaining in 2003 (National Park Service 2007). Marsh loss rates have accelerated in recent decades, averaging 13 ha/yr from 1989 to 2003 (National Park Service 2007). Many stressors are proposed to contribute to marsh loss in the Jamaica Bay Estuary including wastewater inputs, dredging and filling activities, groundwater removal, and global warming with its