doi:10.1130/G33827Y.1

Forum Reply

Rapid wetland expansion during European settlement and its implication for marsh survival under modern sediment delivery rates

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We thank Priestas et al. (2012) for the opportunity to further consider the evidence for the timing of marsh development in the Plum Island Estuary (Massachusetts, United States), and its relationship to colonial land-use change. We argue that the existence of multiple age-depth curves is itself evidence for significant marsh expansion, and that historical maps are consistent with a post-settlement origin of expansive marshland.

AGE-DEPTH RELATIONSHIPS

Priestas et al. object to our use of two different age-depth relationships to estimate the age of marsh development in cores collected by previous researchers, for which no radiocarbon dates are available. However, using a single age-depth relationship would only be appropriate under the assumption that the marsh developed simultaneously everywhere, so that vertical accumulation rates at each depth would be spatially uniform. Instead, analysis of our dated cores show that age-depth relationships vary spatially (faster accretion near the top of the cores near the Rowley River), consistent with a prograding depositional environment and a pulse of rapid marsh expansion.

More importantly, our conclusion that European settlement led to marsh expansion would not change even if we excluded estimates of marsh age for undated cores, which rely on the age-depth extrapolations. We directly radiocarbon dated 14 cores. All six cores within the boundary of our young marsh indicate that marsh formation occurred in recent centuries, and seven of the eight cores within the boundary of our old marsh indicate that marsh has been in place for thousands of years. These are not subtle differences, and age-depth relationships on undated cores simply add spatial resolution to our map. Their absence might slightly change the way we draw the boundary of the young marsh, but the existence of a sizeable young marsh does not depend on them.

HISTORICAL RECORD

Priestas et al. point out that maps in A.D. 1780 and 1830 show most of the marshland already in place, which seems inconsistent with our interpretation that a significant portion of the marsh postdates European settlement (Kirwan et al., 2011, their figure 1). However, the maps and stratigraphic record are roughly consistent with each other if marsh expansion began in the 1700s.

Priestas et al. note that several of the ages we report for young marsh date to after A.D. 1780, and therefore postdate the Des Barres map. However, there are two reasons to believe the marsh formed slightly earlier than our reported dates. First, the dates on our map represent only the midpoint of the 2σ calendar year age range, and multiple age ranges exist. For example, in Core 6, we mapped the midpoint of the most likely calibrated age range (1800–1895), but report an almost equally probable age range (1677–1766) in our supplementary material that would mean the marsh developed before the 1780 map. Preistas et al. also argue that our estimated age of marsh formation on Hog Island Point (Core 16, ca. 1875 A.D.) contradicts observations of marsh stenciled in on the 1830 map. Examination of the two historical maps indicates that Hog Island Point developed between 1780 and 1830. Although the midpoint date (1875) would be inconsistent with the historical maps, the most likely age range actually spans A.D. 1802–1938. Thus, the historical maps are consistent with our reported age range for marsh formation in this core, while confirming that formation took place before the midpoint year. Secondly, our criteria for defining the first occurrence of marsh in the cores, while consistent with earlier work (e.g., McCormick, 1968), may have been conservative, missing the lowest (earliest) marsh development.

An 18th century (pre-1780) expansion of marshes at Plum Island is consistent with other aspects of the historical record. The watershed of our study area was settled in the 1630s. There was enough corn planted to justify grist mills on three of the major rivers near Plum Island Sound by 1645, and grist mills and sawmills were common by 1700 (Currier, 1902). Elsewhere in the region, pollen indicates forest clearance began in A.D. 1700 (Parshall et al., 2003). Deforestation occurred especially early in our study area: the town of Rowley passed laws restricting tree cutting in 1660 (Gage, 1840) and nearly 98% of Ipswich's forest was cut by 1831 (Tarule, 2004). Deforestation in the watersheds of small coastal rivers leads to large changes in estuarine sedimentation rates with little lag time (Mattheus et al., 2009).

SIGNIFICANCE OF MARSH EXPANSION

Despite likely slight errors in our estimates of the time of initial marsh formation, our radiocarbon dates establish that a fringing marsh existed for millennia, and that the marsh prograded rapidly into the middle of the local basin in recent centuries (apparently following the earliest pervasive colonial land-use changes on the U.S. East Coast). The young marsh represents an approximate 50% expansion of the marsh, compared to the pre-colonial extent. Priestas et al. mistakenly compare the area of young marsh that we documented to all of the Plum Island Estuary marshes, not to the area of marsh within our study site—which is the only justifiable comparison.

Thus, further examination of the evidence within this particular study area supports the suggestion (Kirwan et al., 2011) that expansive marshes on the North American East Coast might, to a significant degree, be relicts of historical land use.

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