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

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The paper by Kirwan et al. (2011) proposes an intriguing hypothesis on the formation of a salt marsh in New England (United States). Through the analysis of sediment cores and radiocarbon dates, the authors show that a section of marsh formed after the European settlement in Massachusetts due to deforestation of the area. Although their hypothesis, if true, may have far-reaching consequences for marsh restoration, there are certain discrepancies and apparent inaccuracies in the paper that must be addressed before their hypothesis can be accepted and applied to coastal management. While there are several concerns that should be discussed, space limitations here permit only two. These issues include: (1) major inconsistencies with historical maps, and (2) inadequate explanation of using two age-depth curves to obtain peat ages.

HISTORICAL MAPS

Based on age estimates from a collection of cores, Kirwan et al. have defined a marsh area along the Rowley Estuary that supposedly formed during post-settlement and in response to deforestation of the surrounding region (Fig. 1; Kirwan et al., 2011). Although this marsh area in Plum Island Sound contains a thin veneer (<1.5 m) of tall-form *Spartina alterniflora* saltmarsh organic sediment overlying coarse-to-fine sand, historical maps demonstrate that it was not open water before European settlement. The coast was surveyed with high precision by J.F.W. Des Barres in 1780 (Des Barres, 1780). A side-by-side comparison of historic maps with modern vertical aerial photography (Fig. 1) illustrates that the entire system has lost marshland since the 1700s (only ~8% according to Bromberg and Bertness [2005]) rather than having expanded. More specifically, according to Des Barres' map, the area that Kirwan et al. claim to be post-settlement marsh had, in fact, already existed. A subsequent map by Walker in 1891 (Walker, 1909) also clearly shows that the marsh shoreline near the Kirwan et al. study site was almost identical to the map of Anderson (1830) used by Kirwan et al., as well as today's configuration (± a few meters), which suggests the shoreline has largely maintained its present morphology since at least 1830. It is noteworthy that several ^{14}C dates reported by Kirwan et al. (red dot in their figure 1) are dated after 1780, and therefore post-date the Des Barres map. Thus, they indicate that the marsh emerges around 1875, but the maps show it to have already been in place (Fig. 1).

According to Kirwan et al., the stratigraphic record of core 16 is thought to have recorded sediment from European settlement accumulated atop what they presume to be a mudflat. However, the map of Anderson (1830) used by Kirwan et al. illustrates that the location of core 16 was, in fact, mapped as marshland (Fig. 2). Indeed, a great proportion of the post-settlement marsh outlined by Kirwan et al. overlaps the salt marsh area mapped by Des Barres (1780), Anderson (1830), and Walker (1909).

STRATIGRAPHIC AND AGE RELATIONSHIPS

The pre-settlement boundary indicated by Kirwan et al. (Fig. 1) is unsupported. First, it is unlikely that a large gap existed in the interior of the marsh platform near the mouth of the Rowley River that was subsequently filled with sediment.

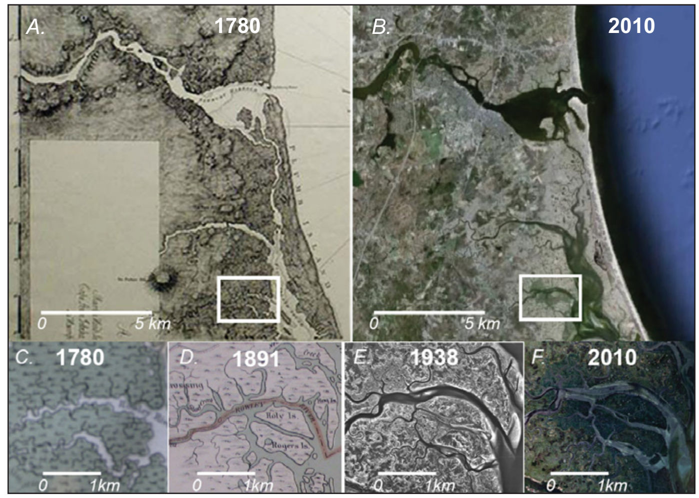

Figure 1. Side-by-side comparison of the Atlantic Neptune map (A) (Des Barres, 1780), and modern imagery (B) (Google Earth™, 2010; image credit Massachusetts Office of Geographic Information Executive Office of Environmental Affairs [MassGIS EOEA] and U.S. Geological Survey). Study area of Kirwan et al. (2011) is outlined by white boxes. C, D: Zoomed-in time sequence of boxed area in A and B. Image credits: C—Des Barres, 1780; D—Walker, 1909; E—aerial photo, unknown publisher; F—MassGIS EOEA.

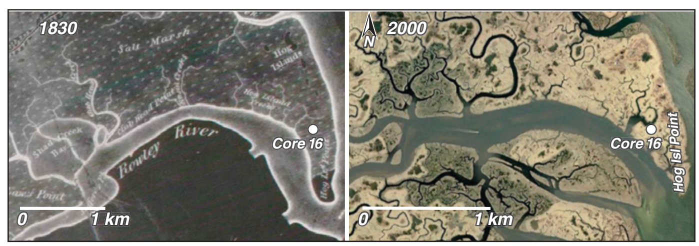

Figure 2. Comparison of the Anderson map (Anderson, 1830) with modern imagery (Google Earth™, 2010; image credit Massachusetts Office of Geographic Information Executive Office of Environmental Affairs [MassGIS EOEA] showing the location of core 16 had been mapped as marsh land in 1830.

In areas where Kirwan et al. have no radiocarbon dates, they use two different age-depth curves to calculate the age of the peat, without explaining how each curve is applied. In their analysis, they assume *a priori* that cores contained within the boundary of their new marsh are younger than surrounding marsh areas. This assumption biases the results, and it is problematic because a peat thickness of 300 cm could produce an age of either A.D. 1498 or 1297 B.C. (calculated using their figure DR3 from the GSA Data Repository item 2011159), and there is significant variability in peat thickness throughout the study area, even for cores that are close together. We suspect, then, that the ages assigned to the McCormick and McIntire and Morgan cores (see Fig. 1; Kirwan et al., 2011) based on age-depth relationships (and the basis for the demarcation of the "colonial marsh" area) may not be reliable.

CONSEQUENCES FOR MARSH DEVELOPMENT ALONG THE EASTERN COAST OF THE UNITED STATES

Even if the hypothesis of Kirwan et al. were true, the new marsh delineated in their study represents less than 10% of the total marshland in Plum Island Sound. Therefore, the data do not fully support their conclusion that many of the expansive marshes that characterize the modern North American coast are the result of anthropogenic sediment delivery rates.

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