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Letter to the Editor

Comment on "Holocene aridity and storm phases, Gulf and Atlantic coasts, USA" by Ervin G. Otvos, 2005, *Quaternary Research* 63, 368–373

In Goman and Leigh (2004) we interpret pollen and sedimentary data and hypothesize that the Atlantic coastal plain in the southeast USA may have experienced relatively wet conditions during the early Holocene (9000–6100 cal yr BP), contrary to prevailing views of southeastern climate (e.g., Frey, 1951, 1953; Watts, 1980; Hussey, 1993; Watts et al., 1996). We further hypothesize that changes in floodplain moisture may be a function of a regional shift in the position of the Bermuda High (e.g., Forman et al., 1995; Liu and Fearn, 2000). Otvos (2005) disagrees with our interpretation. In this comment we respond to his criticisms and the inaccuracies that he has included in his paper. For convenience our comments are organized under the relevant subheadings from Otvos's paper that specifically target our article (Goman and Leigh, 2004). Please note Otvos has renamed our site "Little River."

Climate and habitat chronology, southeast Atlantic seaboard

At our study site, PAW, we documented an increase in gum pollen percentages (~10–20%) between 9000–6100 cal yr BP (Goman and Leigh, 2004; Fig. 3, Zone 2). We interpret the higher percentage levels of gum pollen to represent a significant increase in the presence of that taxa on the landscape during Zone 2 at PAW, as modern pollen spectra (<2%) is proportional to the basal area data of gum trees (Whitehead and Tan, 1969).

Otvos contends that high gum values from PAW and other floodplain sites are not indicative of wetter climate but may reflect other variables such as "sediment infilling, sea and ground-water level changes, and various edaphic conditions." In references to several studies he states that peaks in gum are diachronic. However, he is in error when he states that Seielstad (1994) "found only minimal amounts [of gum] in certain early Holocene deposits". Rather, gum peaks during the early to mid-Holocene (p. 123) and then "declines to almost zero by 2000 ^{14}C yr BP (p. 127). Further, Lamoreaux (1999) found peak gum values in early to middle Holocene levels of her floodplain sites (CF2 site 8700–4300 ^{14}C yr BP and SRC site 9600 –3800 ^{14}C yr BP) and used these data to infer relatively wet early and middle Holocene conditions. One of Lamoreaux's sites (BCK) contained negligible gum pollen and is likely not sensitive to long-term floodplain changes (it is situated on a relatively dry hillslope currently fed by lateral groundwater seep). The data from Brook (1996) do show high gum percentages in the late Holocene; however, the earlier record may be compromised by a possible hiatus and/or poor pollen preservation (total pollen concentration is exceedingly low between 1.4 and 1.95 cm).

We contend that floodplain wetland sites such as PAW are more sensitive to changes in regional moisture balance than lake sites, where changes may be masked by the regional pollen signal, which is dominated by pine and oak. Otvos correctly points out that pine and oak cannot be reliably identified to the species level, and thus valuable environmental inferences that might illuminate changes in moisture availability are lost. This is precisely why we feel that the floodplain sites are important and should not be discounted.

Otvos finds puzzling our claim to broad synchronicity between the floodplain sites and two sites examined by Whitehead (1972, 1981); this is because he claims we are comparing Dismal Swamp Zone 3b (6000–3500 ^{14}C yr BP; ~6900–3800 cal yr BP) with Rockyhock Bay 3b (7200–5000 ^{14}C yr BP; ~7800–5700 cal yr BP) pollen zones with very little temporal overlap. However, synchronicity is maintained if Dismal Swamp 3a (8200–6000 ^{14}C yr BP; ~9200–6900 cal yr BP) is considered, as was our intention.

To support his argument that conditions were drier during the early to mid-Holocene, Otvos refers to Fletcher et al. (1993) in the Delaware Bay. Otvos states that conifers dominated the area after the Hypsithermal climatic optimum. This interpretation is problematic as it is not clear there was a conifer-dominated interval (at most pine contributes ~30% while oak is the most consistently important taxa (~30–60%)); second, the early Holocene vegetation at the site is not known as the record only extends back ~6000 years (approximate basal age of WG5).

Otvos implies that we interpret our data to represent an "abrupt" continent-wide climate shift; this is not the case and we would argue that it is not currently possible to make such an assertion. Without a greater number of radiocarbon dates from the various sites, so as to avoid problems with date interpolation, the timing of the southwestward movement of the Bermuda High is open for interpretation.

Coastal plain aridity and dune formation during the wet early- to mid-Holocene

Otvos cites papers so as to emphasize that the early Holocene was drier, including Otvos (2004). He states there were active dunes downstream of the PAW site in the Cape Fear River valley between ~8300–6300 cal yr BP and in coastal Georgia ~9500–4500 cal yr BP (Ivester et al., 2001). It is possible that

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dune reactivation occurred during the wet phase at PAW, and as Otvos points out the PAW site "*lacks explicit aridity indicators.*" However, our interpretation of these data differs from Otvos. The Holocene dune activity in Georgia was interpreted as sporadic and spatially limited reworking of crests of unusually thick riverine dunes and not related to renewed sedimentation of parabolic dune fields (Ivester et al., 2001). Further, the authors "do not know if the Holocene reworking is a result of climate change, localized fires, or human destabilization of the dune surface" (Ivester et al., 2001, pp. 301–302). Otvos implies that there was a long period of dune activity (~5000 yr) in coastal Georgia, but the evidence cited in Ivester et al. indicates sporadic reworking at specific times and places (Flint River: 9260–9020 cal yr BP and Altamaha River: 4830–4570 cal yr BP). Indeed, we have observed that human disturbance has resulted in sporadic reactivation of some riverine dune crests in southern Georgia during the last century, which clearly is not considered an "arid phase" in time; however, such dune reactivation does not necessarily represent a widespread regional change in climate or an "arid phase." Given the existing dates on Holocene eolian sand in Georgia and the Carolinas, and using logic similar to Otvos's, then one might conclude that the entire Holocene was an "arid phase" in the southeast, which is far from realistic.

The radiocarbon ages obtained from dunes in the Cape Fear River Valley are problematic. Daniels et al. (1969) suspected that their Holocene dates may have been contaminated by young carbon, while Soller's (1988) Holocene dune ages in the Cape Fear valley were obtained from unspecified "humate" substances that could include translocated young carbon. In addition, Soller's dates simply indicate that the sand was deposited at sometime after 7700 ^{14}C yr BP and at sometime after 5720 ^{14}C yr BP at another locality, so that both sites could represent dune activity within the late Holocene. Furthermore, Soller (1988) indicated that discussion of climate variation was not within the scope of his report.

Proxy record of tropical cyclones from Little River floodplain

Otvos suggests that sand laminae present in the PAW record may be flood events attributable to factors other than tropical storms. He cites a study of annual precipitation in Mississippi that indicates that hurricanes only slightly enhanced precipitation. It would be difficult to prove without a doubt what sort of meteorological pattern caused the overbank sand layers at PAW; however, in our paper we cite research by Gamble and Meentemeyer (1997) that indicates the most frequent synoptic-scale systems causing floods in the Carolinas are tropical storms and hurricanes. In contrast, they found that for the "Gulf–Atlantic" region, which includes Mississippi, the principal cause of large floods was frontal systems.

Otvos goes on to write that Zone 2 (early to middle Holocene) at PAW was not synchronous with peak midwestern aridity as would be expected if the Bermuda high were located in a more northeasterly position than today. However, Forman et al. (2001) in a paper, which Otvos cites, interpret eolian data as evidence "for a sustained period of dune activity in the early to middle Holocene."

Summary

Regrettably, Otvos misrepresents and misquotes research in his paper. However, most curious and puzzling of all is his inconsistency. In Otvos (2005) he discusses recent TL dates from dune fields and associated sand sheets from localities in the Gulf of Mexico (2004). He determined an active period in eolian activity between 10,500–8500 and 6800–5700 yr ago, which he compared with palaeoecological data and geomorphic data from the midwest and northern Great Plains as indicating drier conditions. Otvos suggests that a cause for the drier conditions along the Gulf of Mexico might be the northward shift of the Bermuda–Azores high-pressure cell, which was accompanied by an eastward displacement of a high-pressure ridge over central and southwestern United States. He writes "Blocking the landward penetration of moisture-laden surface flow from the Gulf…" (Otvos, 2004, p.117). Otvos cites Forman et al. (1995) among other references in this regard.

The above mechanism is *precisely* the one that we invoke to explain the contemporaneous moister conditions at PAW and other sites along the southeastern Atlantic coastal plain.

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