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Great Lakes Climate data during Ice ages

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Ancient Tree Ring Archives in the U.S. Great Lakes Region

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Rather than being a seamless transition from Late Glacial Maximum to the start of the Holocene between 15,000 and 8000 years ago, the warming during this period was punctuated by abrupt climatic instabilities. These include the Younger Dryas cold event, the Preboreal Oscillation, and an isolated cooling event around 8200 years ago (see Figure 1, bottom right).

In the Great Lakes area the terrestrial fingerprints of these events are often present in pollen records, yet even greater details of the environmental course of deglaciation during the Holocene transition could be gleaned with high-resolution tree ring proxies. A campaign is under way to locate, sample, and analyze tree rings of surprisingly abundant subfossil wood preserved in the Great Lakes area to improve understanding of past (and possibly future) abrupt climate change in a region where these events may have even been triggered (e.g., by glacial meltwater discharge [Murton *et al.*, 2010]) and where early human and megafauna populations were likely profoundly affected.

Long tree ring chronologies extending from the present back to deglaciation would be ideal for this effort, but they are quite rare worldwide, with the longest being the 12,000-year tree ring chronology of central Europe from oak and pine [Friedrich *et al.*, 2008] and the 8800-year North American bristlecone pine chronology [Ferguson and Graybill, 1983]. In mid North America, such chronologies are currently only about 1000–1500 years long (e.g., eastern red cedar of Buckley *et al.* [2004] and oak of Stambaugh and Guyette [2008]). Fortunately, even without a long tree ring chronology for the Great Lakes area, “floating” chronologies (tree ring sequences not continuous to the present and without an exact calendar year assigned to each ring) from wood relics can be used to infer interannual environmental variability and change. Geological circumstances in the region, such as glaciations, wind and water sedimentation, wetlands and bogs, and lake level rise, have

provided favorable environments to preserve ancient wood (examples in Figure 1) to build these chronologies.

In an ongoing project, archives of wood collections are being developed in the region (see timeline of currently identified sites in Figure 1), supported by U.S. National Science Foundation grants ATM-0213696 and P2C2-1003483 and coordinated through the University of Arizona. Some sites have been reported in the literature, and others have been identified by colleagues who have made collections available to the research effort. Original field sites where wood was readily accessible for observation and collection may no longer exist, but occasionally new exposures and sites have been found. Radiocarbon dating puts chronologies into an absolute time context, accurate to within 10–25 calendar years using radiocarbon “wiggle matching” [Leavitt *et al.*, 2007], which fits fluctuation patterns of radiocarbon in a tree ring series from a sample to the pattern of fluctuations in the absolutely dated, master radiocarbon calibration curve. Floating chronologies are being constructed, which, in exceptional circumstances, afford unparalleled resolution of paleoecology, such as the dramatic tale of establishment, recruitment, and demise of a Younger Dryas event-aged black spruce forest in Indiana (Figure 1) crafted from ring width, microanatomy, and stable-isotope analysis of numerous stumps [Panyushkina *et al.*, 2008].

This initiative seeks more sites and samples over the next 3 years for analysis of tree ring widths and stable carbon and oxygen isotopes and for comparison to new high-resolution pollen records. An individual piece of wood from a site is useful, but multiple wood pieces, and especially stumps, offer the greatest potential for maximizing quality of environmental reconstructions. Environmental variability at individual sites and in the collective network will address the character and pacing of environmental changes during deglaciation through the following questions: (1) How has climate stability in the Great Lakes area changed from

15,000 to 8000 years ago, as indicated by change in variance of tree ring growth or isotopic composition? (2) How do variance trends of modern tree growth from the North American boreal region compare to 15,000–8000 years ago? (3) For a given period, how do patterns of variance change across the region? (4) How might the reconstructed climate variability link to humans, ecosystems, and their distributions?

A summer short course open to undergraduate students is planned in 2012 and 2013 (details to be announced at a future date), including lectures, practical activities, and a 1-day field excursion related to dendrochronology, palynology, paleontology, geology, archaeology, and wood identification, using expertise from an expanding group of collaborators. These collaborators include A. Bettis, L. Clyburn, B. Curry, E. Grimm, D. Hunter, R. Guyette, D. Joyce, J. Knox, T. Lange, T. Lenton, V. Livina, W. N. Mode, M. Scheffer, A. Schneider, S. Shetron, M. Stambaugh, T. Thompson, M. Waters, C. Widga, A. Wiedenhoeft, and J. Zawiskie. To pass along information on prospective relevant new sites and samples or to be apprised of details on the short course as it develops, please contact Irina Panyushkina at ipanyush@email.arizona.edu.

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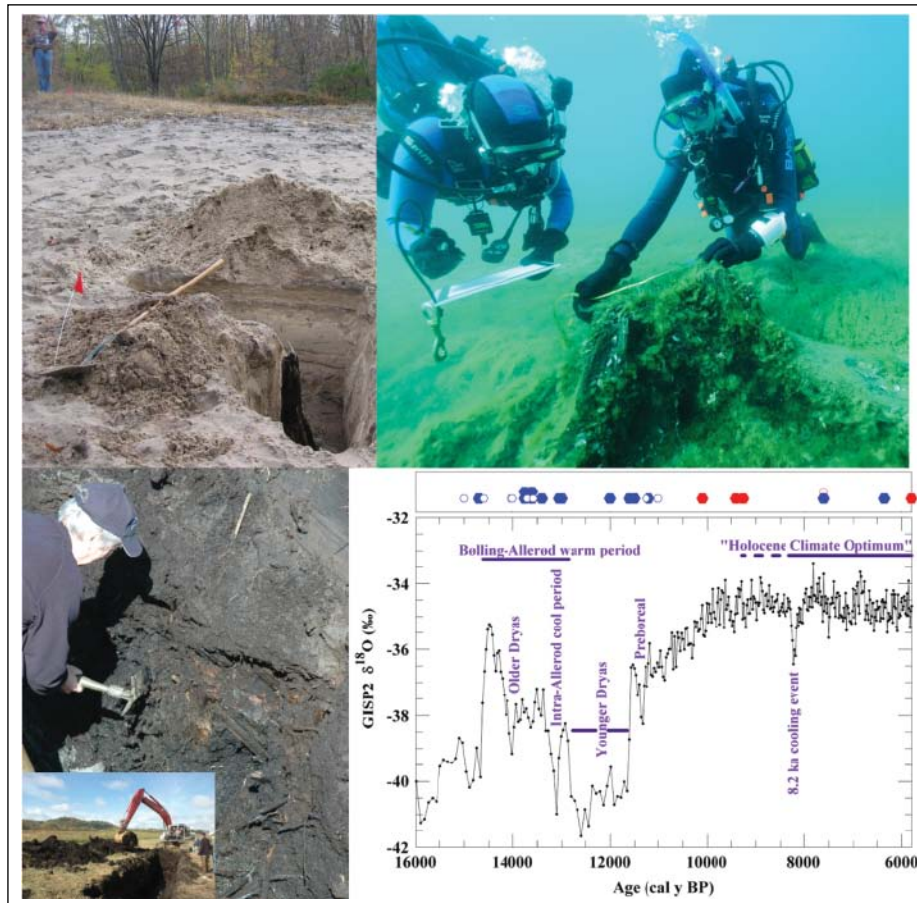


Fig. 1. Piecing together regional climate histories of the transition out of the last ice age from 15,000 to 8,000 years ago involves fieldwork across the Great Lakes region. Samples to build this timeline include (top left) 12,000-year-old spruce stumps buried in sand in northwestern Indiana dating to the Younger Dryas cooling event [Panyushkina et al., 2008]; (top right) 7500-year-old stumps from trees that grew after deglaciation, now submerged in Lake Huron at Thunder Bay, Mich. (photo courtesy of L. Clyburn); and (bottom left) preboreal wood about 11,100 years old buried in a peat layer near Richland Center, Wis. (photo courtesy of J. Knox). The inset in the latter image depicts the trench dug to access the samples. Samples such as these can be fit into the (bottom right) hemisphere-scale history of late glacial to early Holocene climate events defined by oxygen isotope ratios ($\delta^{18}\text{O}$) in the Greenland Ice Sheet Project (GISP2) ice core [after Grootes et al., 1993] (data from the National Climatic Data Center, <ftp://ftp.ncdc.noaa.gov/pub/data/paleo/icecore/greenland/summit/gisp2/isotopes/gispd18o.txt>). Above the ice core chronology is a timeline of calibrated ages from targeted sites in the Great Lakes region. Blue (conifer) and red (hardwood) symbols are open if sites or samples are yet to be collected and prepared.

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