Dune sand in coastal lakes as a proxy for paleo lake-level change

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Acknowledgments: This poster represents work with many colleagues including Walt Loope, Ed Hansen, and our students.

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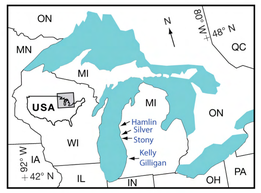
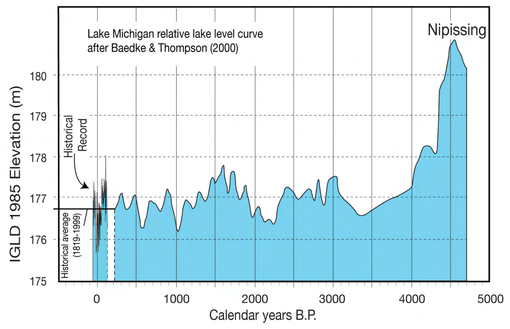


Background

4700 years of lake-level change in the Lake Michigan basin

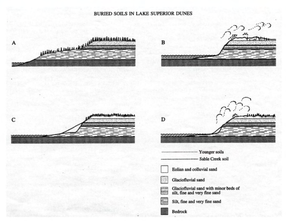
Badke and Thompson (2000) removed differential isostatic rebound from their beach ridge data set, smoothed it, and generated the Lake Michigan relative lake level curve (LMRLLC).

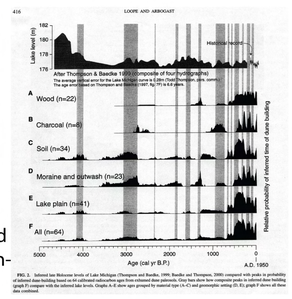
~33 yr cycle of 0.5–0.6m water level change
~160 yr cycle of 0.8–0.9 m water level change



Response of dunes to lake-level change

Anderton and Loope (1995) determined that perched dunes are reactivated when lake level is high (Lk. Superior coast).





Loope and Arbogast (2000) determined that reactivation of perched dunes coincides with a high Lake Michigan.

The perched dune model was linked with lake-level change in the Michigan basin (Loope and Arbogast, 2000).

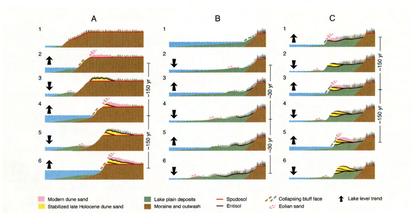
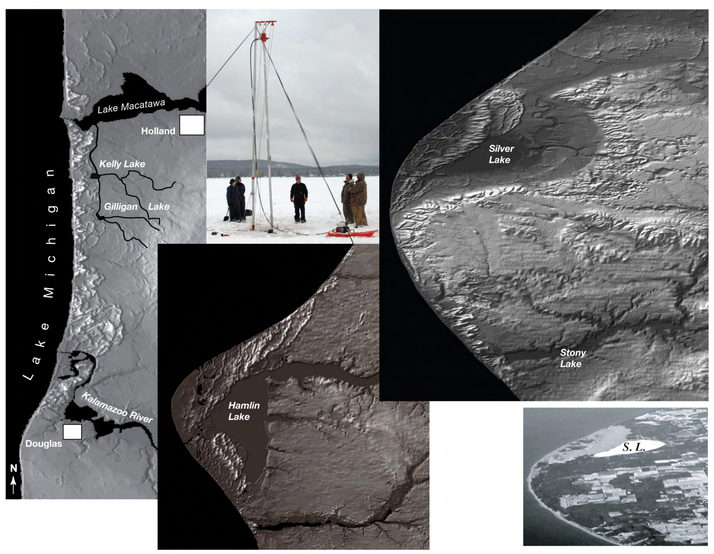


FIG. 4. Mechanisms of sand supply change for various geomorphic surfaces, magnitudes of lake level change, and return periods. (A) Glacial headlands (after Anderton and Loope, 1995). (B) Late Holocene lake plains (~30-yr return period). (C) Truncated late Holocene lake plains (~150-yr return period).

Study Sites



Mid to Late-Holocene Sand Records

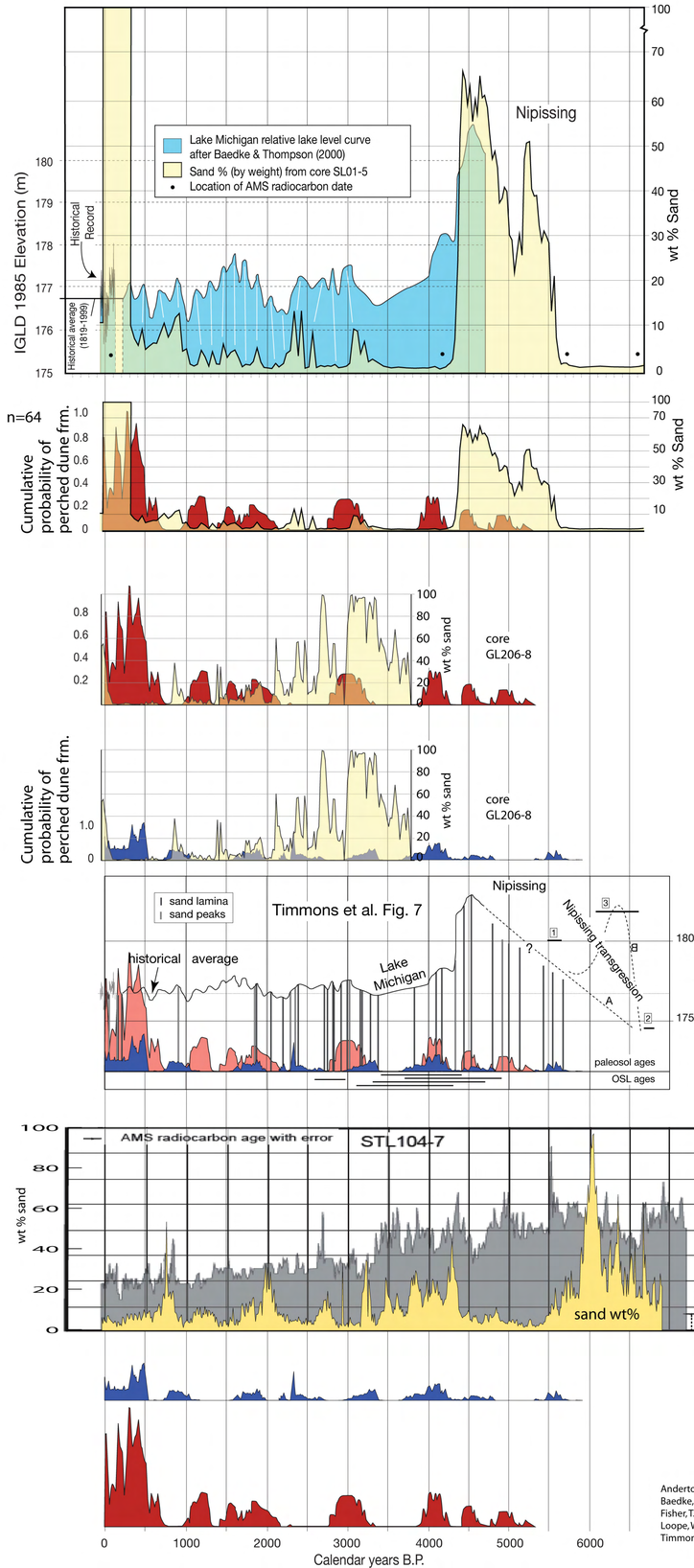
Sand from Silver Lake, MI plotted against LMRLLC. Sand appears to be a good proxy of lake-level change (Fisher and Loope, 2005), with ~200 year cycles well expressed.

Perched dune activity from Loope and Arbogast (2000) is not obviously in-phase with the sand record from Silver Lake.

Or from Gilligan Lake (SW of Holland, MI) Timmons et al. (in prep).

But the sand peaks from core GL206-8 Gilligan Lake and 2 other cores from Gilligan Lake, and 1 core from Kelly Lake correspond very well with paleosols from the dunes immediately west of the two lakes.

Sand from Hamlin Lake (yellow) and magnetic susceptiblity (gray; a proxy for sand) from Stony Lake) are somewhat similar, but not obviously in-phase with paleosol ages from Holland, and along the Michigan coastline.



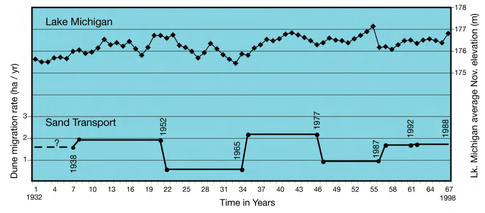
Abstract

Sand dunes respond directly and indirectly to climate variability. Along Lake Michigan, numerous workers have established a relationship between high lake levels and dune reactivation. Lake level indicators in the Michigan basin have primarily relied upon stranded beach ridges as recording quasi-cyclic fluctuations in lake level since the fall from the Nipissing high lake level. Recent work along the western coastline of Michigan has focused on developing lake-level curves from eolian sand in coastal lake sediments. These sand proxies from a variety of lakes in the lee of dune fields correspond well with the beach-ridge record, and have an advantage in that they are: comparatively inexpensive; rapid to collect; offer higher resolution; are continuous; and, extend the record further into the past. The sand record however, provides only relative, not absolute, lake-level change, as the beach-ridge record does. Examples will be given demonstrating how eolian sand records from sediment cores can be used as lake-level proxies on temporal scales of thousands of years, to <100 years.

Niveo-aeolian activity, Silver Lake, winter 2004

< 100 year Sand Records

Plots of fluctuations in lake level of Lake Michigan (November averages) and dune migration rate against time. Note in-phase relationship between the two curves where rising lake levels correspond to increasing dune migration rates. This suggests that the dunes are sensitive to the same climate fluctuations affecting lake level.



Synthesis

The sand record from specific lakes appears to correspond well with the dune history upwind of those lakes. In fact Timmons et al. (in prep) suggest that the lake record provides a more detail dune history than paleosols from the dunes themselves. Dune records relying upon paleosol ages may include maximum ages recording pedogenesis and soil evolution, and not burial.

When an individual sand record is compared with the composite paleosol record along the Michigan coast there is only general agreement.

This begs the question: Are dunes along the Michigan coast active through time independent of each other, only recording local effects, or were most of the dunes along the Michigan coast active at the same time? Support for the latter is their relationship with water levels in the Lake Michigan basin. However, the comparison between the red and blue summed probabilities of paleosol ages show both agreement and independence.

If enough sites were sampled, would the paleosol probability cycles disappear, indicating dunes are episodically active throughout the last half of the Holocene? Or would cycles of greater aeolian activity become more obvious indicating a regional control by lake level (climate)?

Dune history projects involving lacustrine cores may better resolve coastal sand dune histories.

Anderton, J.B., Loope, W.L., 1995. Buried soils in a perched dunefield as indicators of Late Holocene lake-level change in the Lake Superior Basin. Quaternary Research 44, 190-199.
Baedke, S.J., Thompson, T.A., 2000. A 4,700 year record of lake level and isostasy for Lake Michigan. Journal of Great Lakes Research 26, 416-426.
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Loope, W.L., Arbogast, A.F., 2000. Dominance of an ~150-year cycle of sand-supply change in Late Holocene dune-building along the eastern shore of Lake Michigan. Quaternary Research 54, 414-422.
Timmons, E.A., Fisher, T.G., Hansen, E.C., Eisaman, E., Daly, T., Kashgarian, M. in prep. Elucidating aeolian dune history from lacustrine sand records in the Lake Michigan coatal zone, USA