

# The Geomorphology and Evolution of Lake Michigan Coastal Dunes

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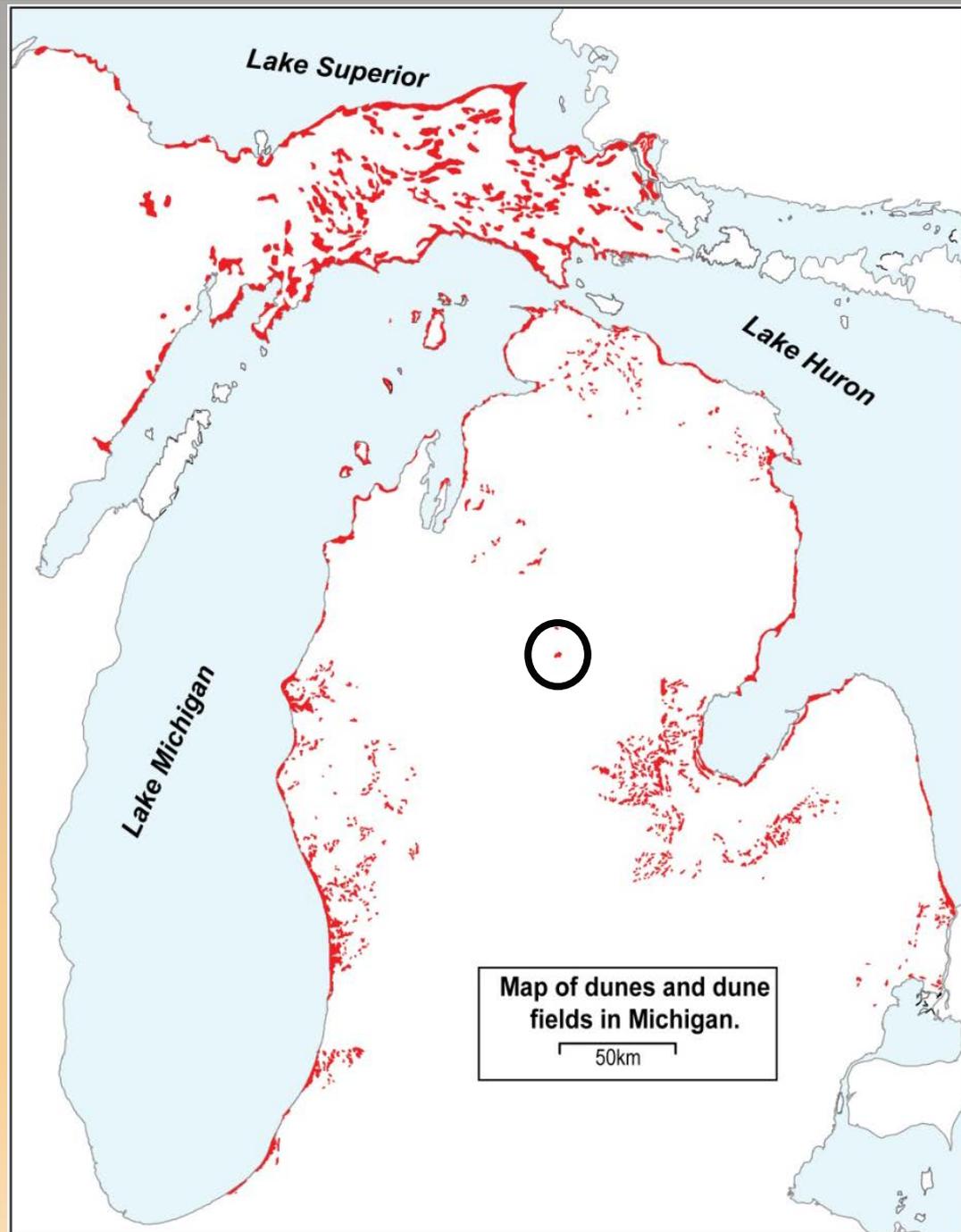


**MICHIGAN STATE**  
UNIVERSITY

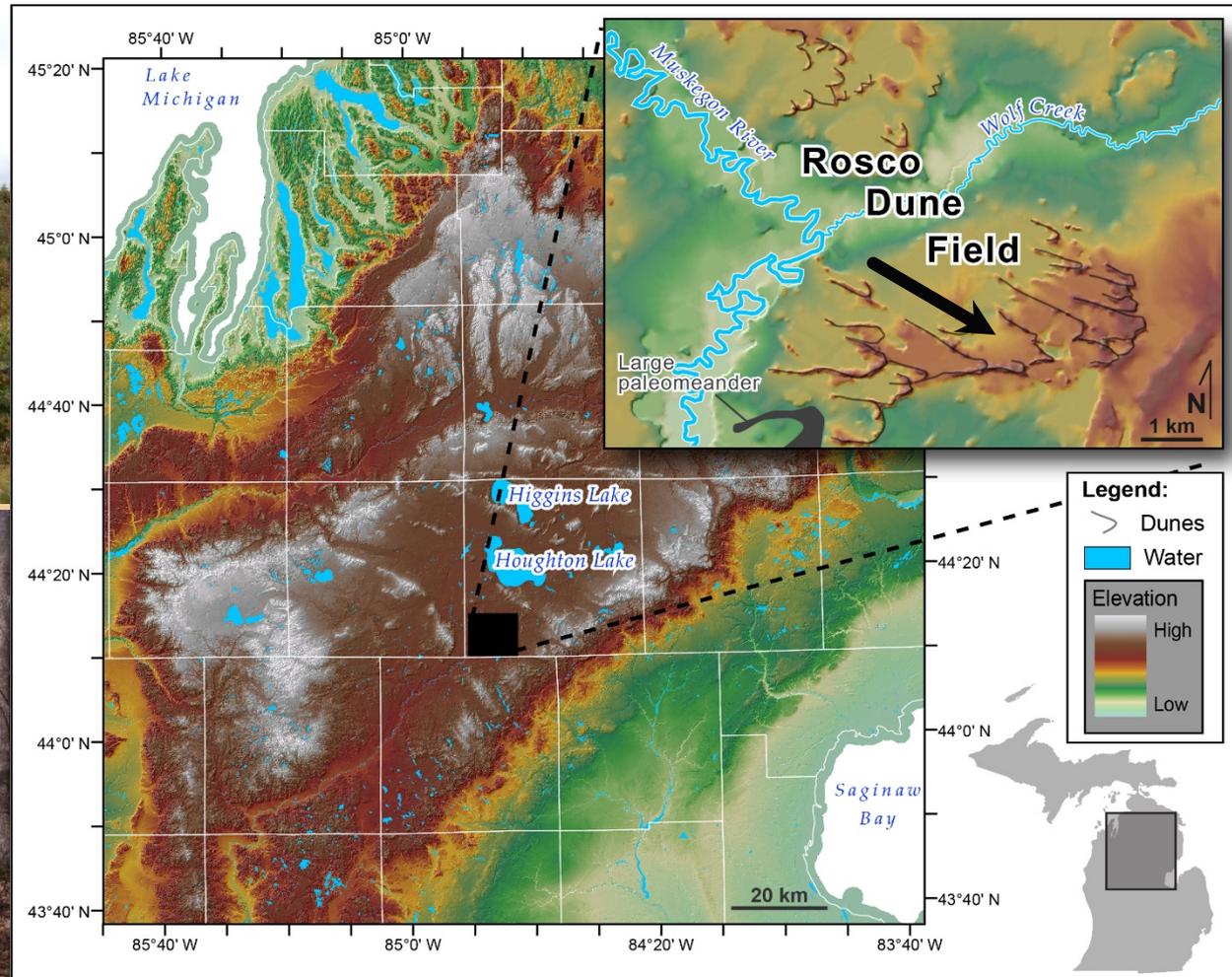
Department of Geography,  
Environment, and Spatial Sciences



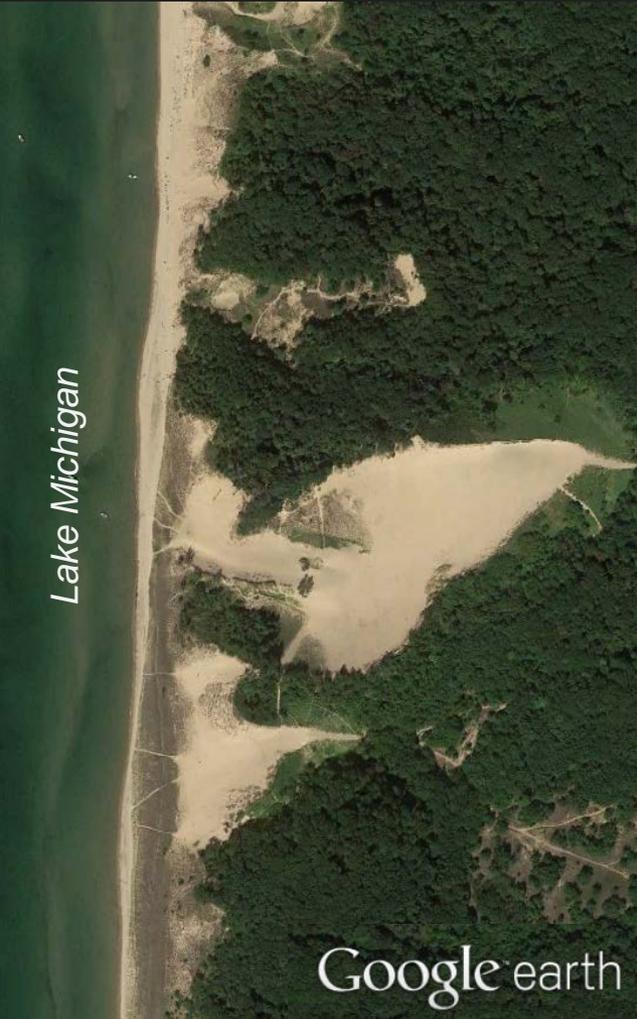
# Dune Fields in Michigan



# Dune Fields on Lake Plains (~14 - 11 ka)



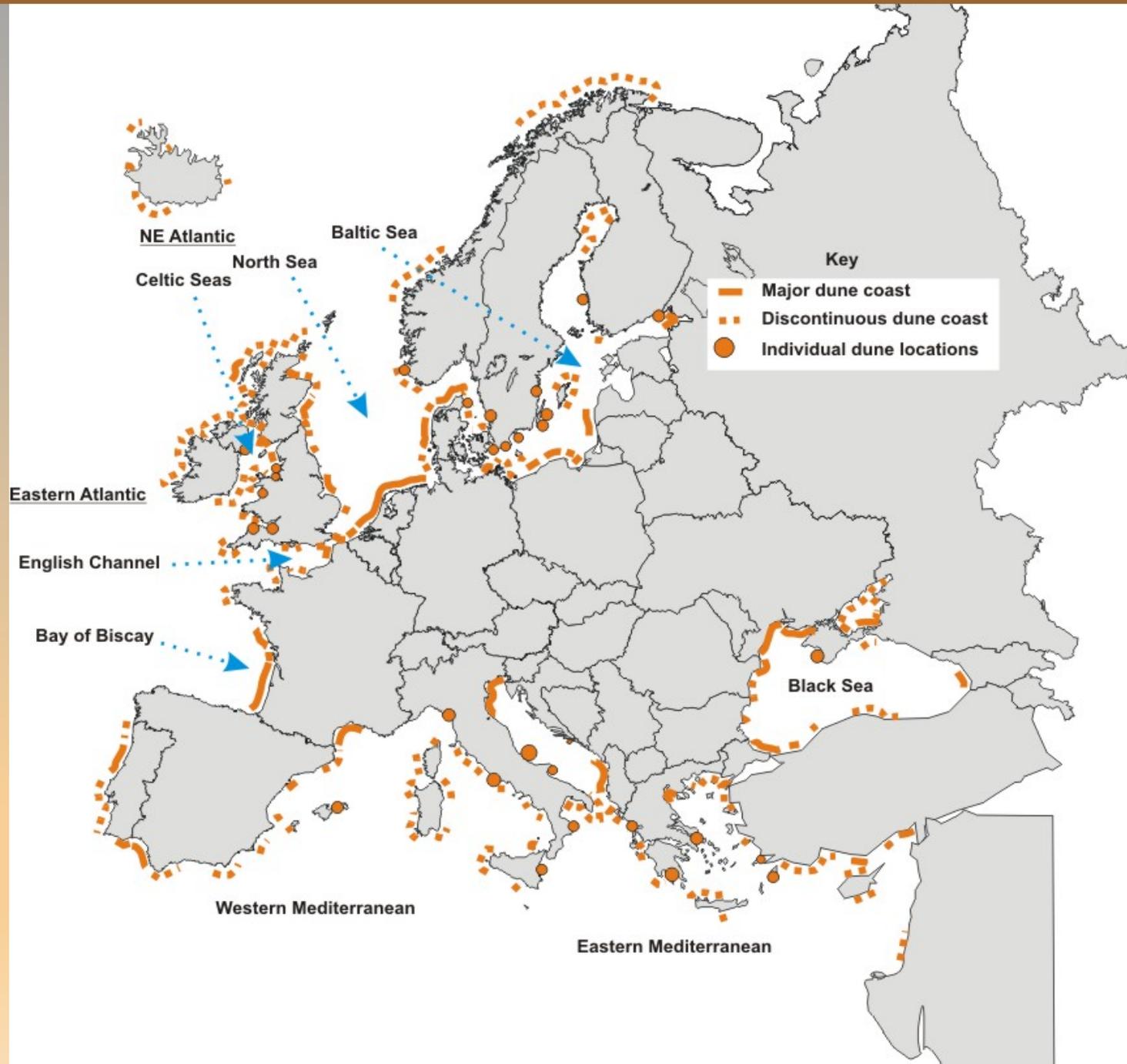
# Coastal Dune Fields - A Different Story



# *West Coast of England*



# Euro Dunes



# *Southwestern Coast of Australia*



***North Island of New Zealand***



***Oregon***



***Lake Michigan***



***Sleeping Bear***



***Camp Minniwanca***



**Ludington**



*Near Holland*



Why??

Lake Superior

Lake Huron

Lake Ontario

Lake Michigan

Lake Erie

1) westerly winds

3) Lots of sand!

2) long fetch across Lake Michigan



# Dunes Are *Heavily* Utilized.....



Recreation Search  
Michigan Department of Natural Resources

Home List Map Events

①

Warren Dunes State Park



②



③



# Sand Dune Protection

- Sand Dune Protection & Management Act in 1976
  - 275,000 Acres Designated as “Sand Dune Areas”
  - First Regulations on Sand Mining
-

# Sand Dune Protection

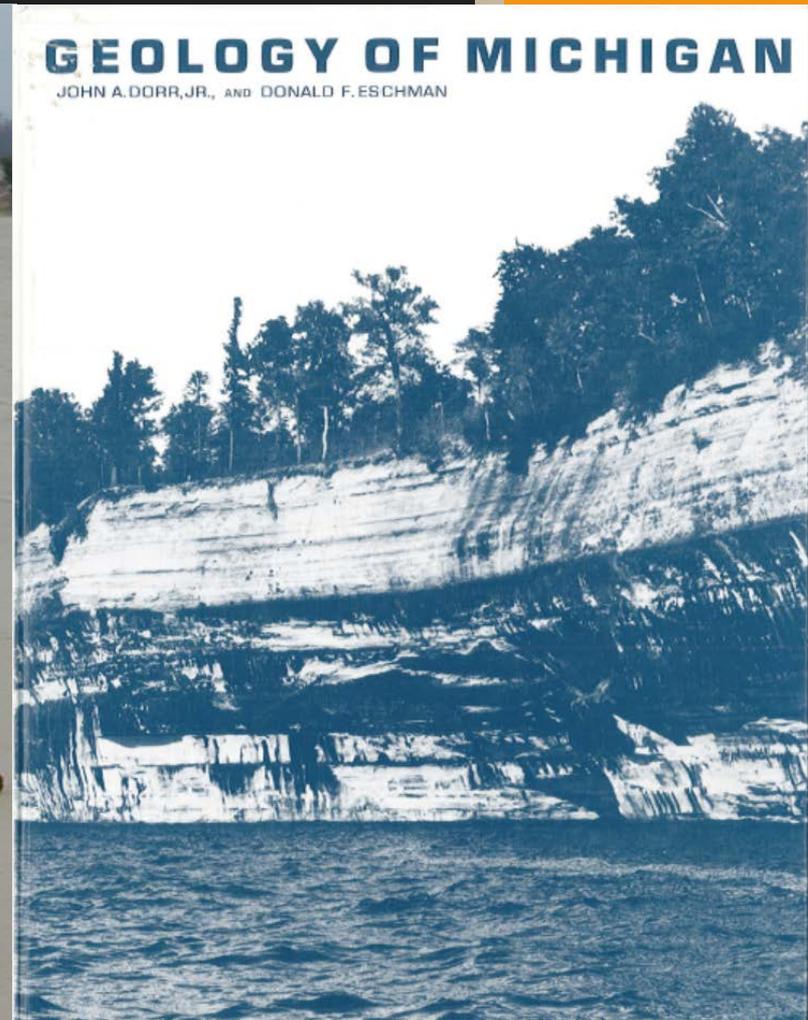
- SDPA Amended in 1989
- 75,000 Acres Deemed *Critical Dunes*
- Additional Regulations Applied to Development

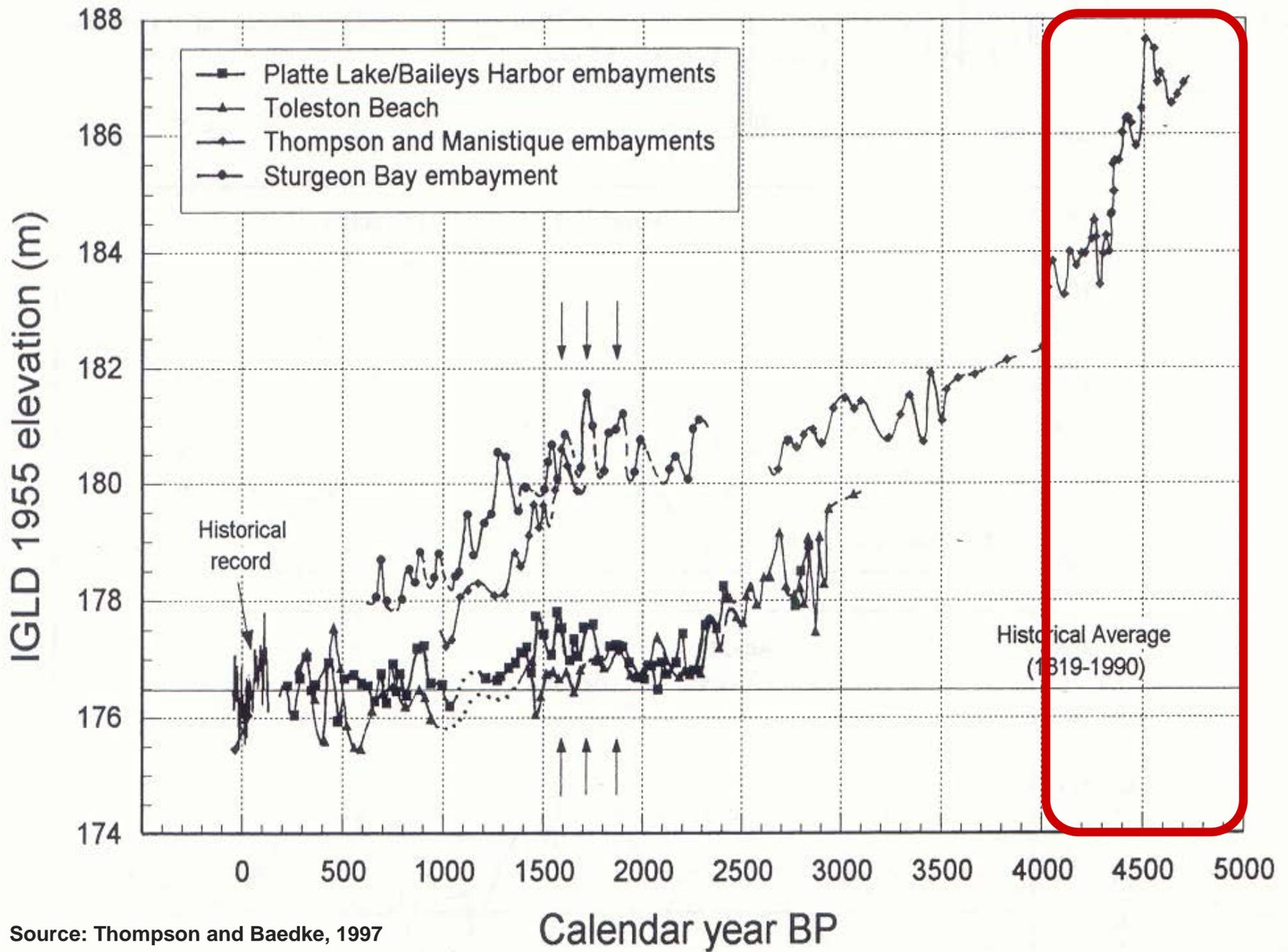
# This is Where I Walk In.....

- Nipissing Dunes

- Formed in a Single Event

- But No Dates!!





Source: Thompson and Baedke, 1997

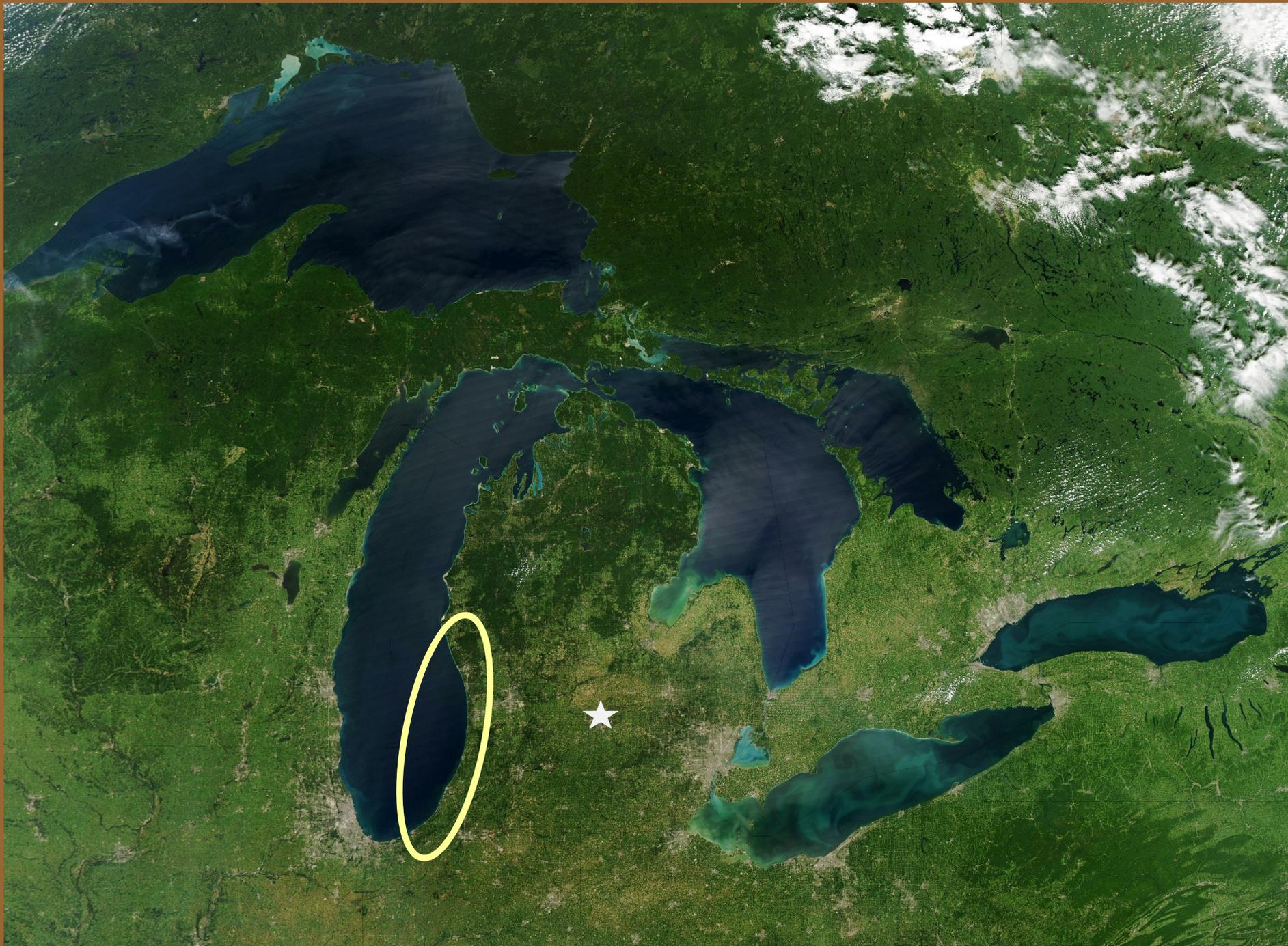
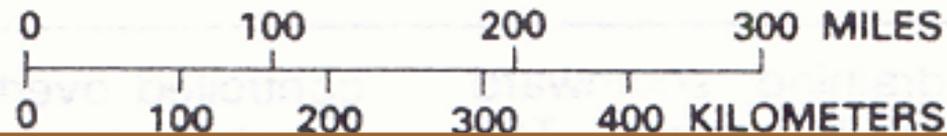




Photo: Ed Hanson

Van Buren State Park



# Isostatically Raised Shorelines

Algonquin



Nipissing



# Perched Dunes



# Little Traverse Bay



Terrain  
View topography and elevation

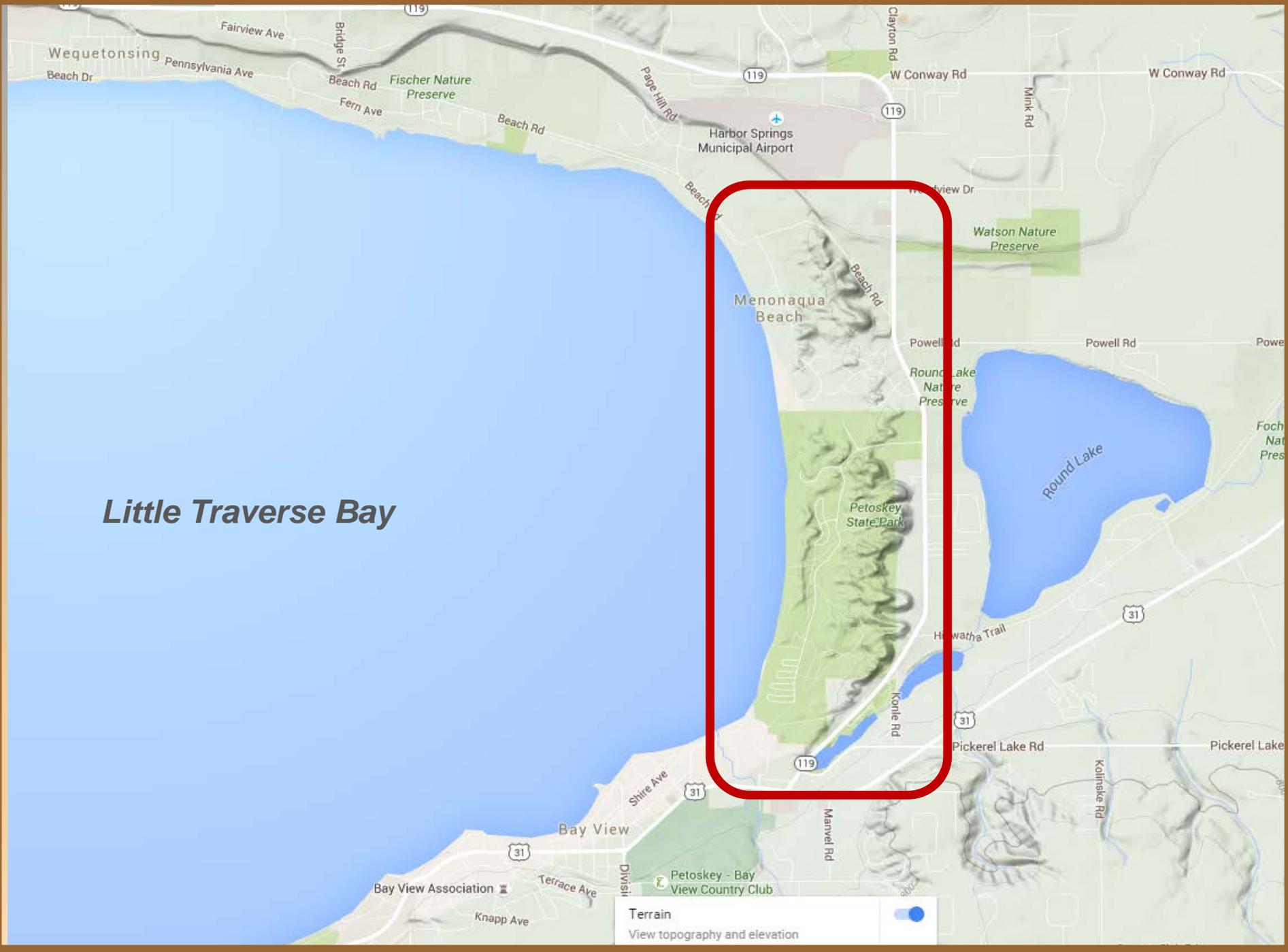




Photo: Maher Collection

# Reconstructing Dune Chronologies

- Optically Stimulated Luminescence (OSL): burial age of eolian sand
- Radiocarbon (C-14): soil organics



**Van Buren State Park**

**2183 - 1868**

**464 - 129**

**159 - 0**

**313 - 0**

**Dune Sand**

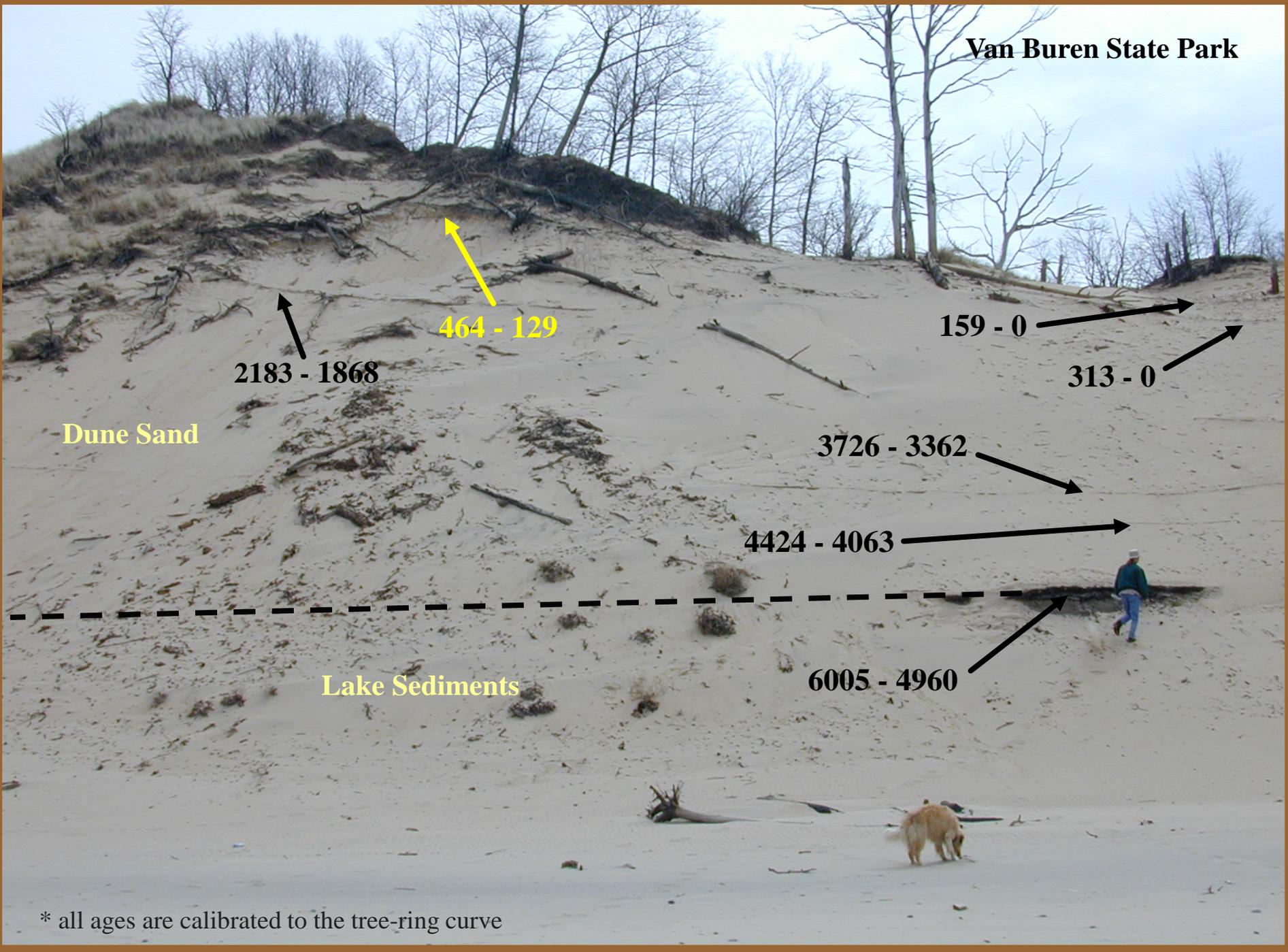
**3726 - 3362**

**4424 - 4063**

**Lake Sediments**

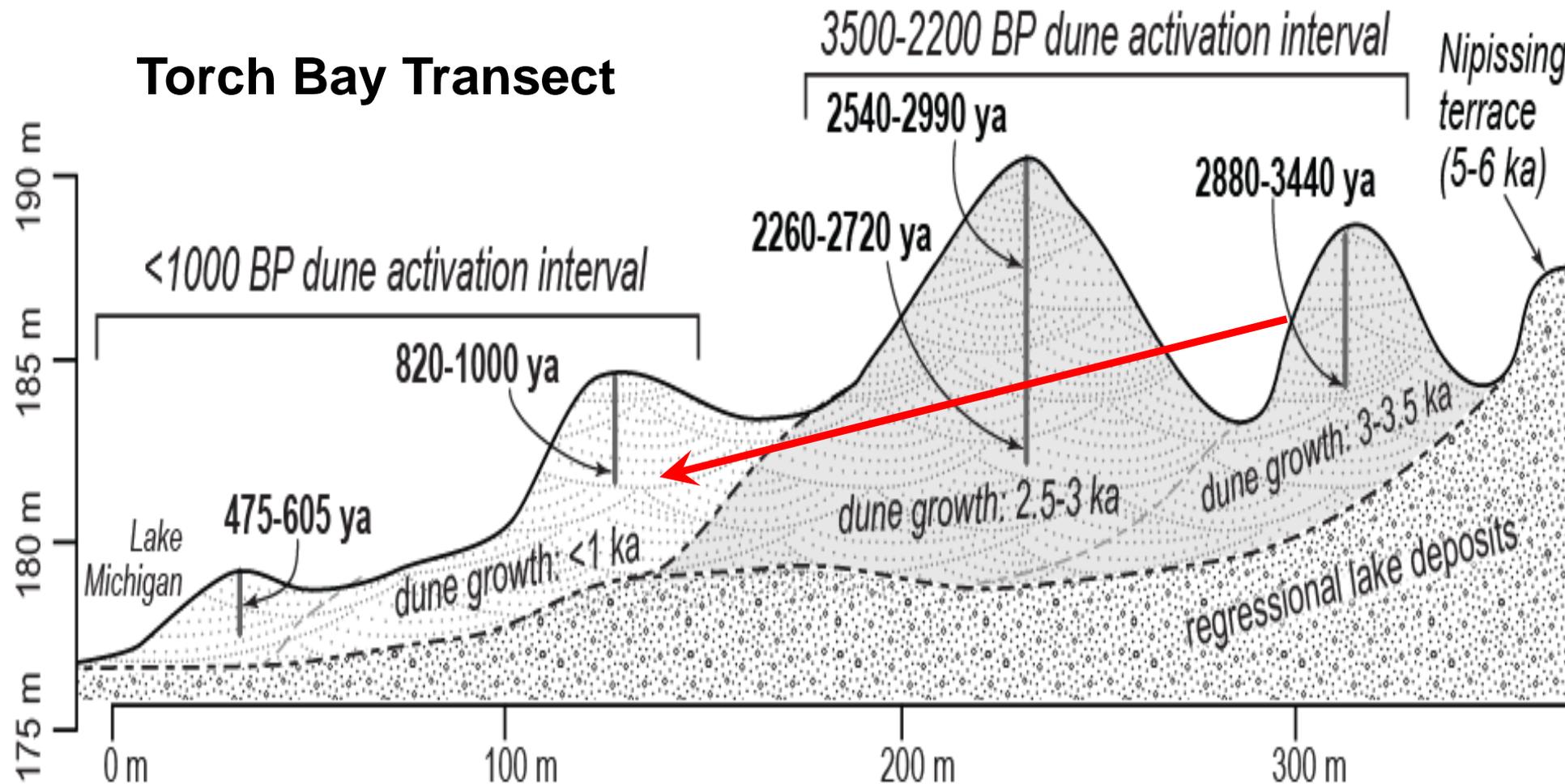
**6005 - 4960**

\* all ages are calibrated to the tree-ring curve

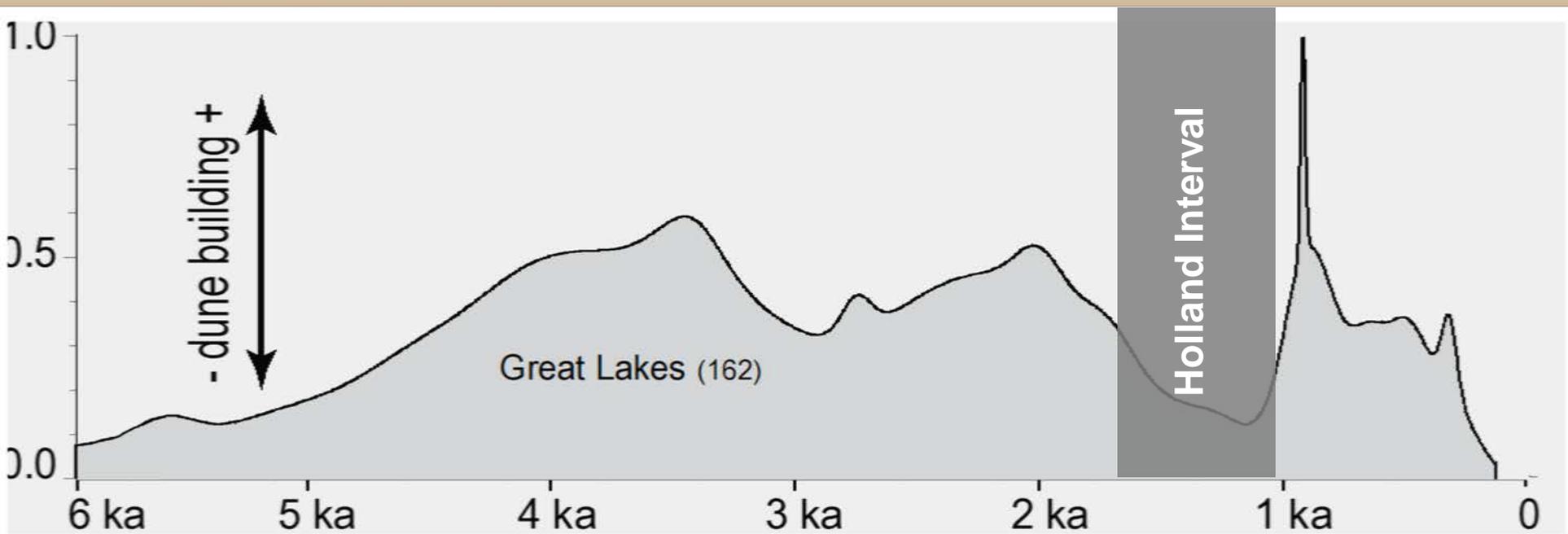


# Above the Hinge Line - Progradation

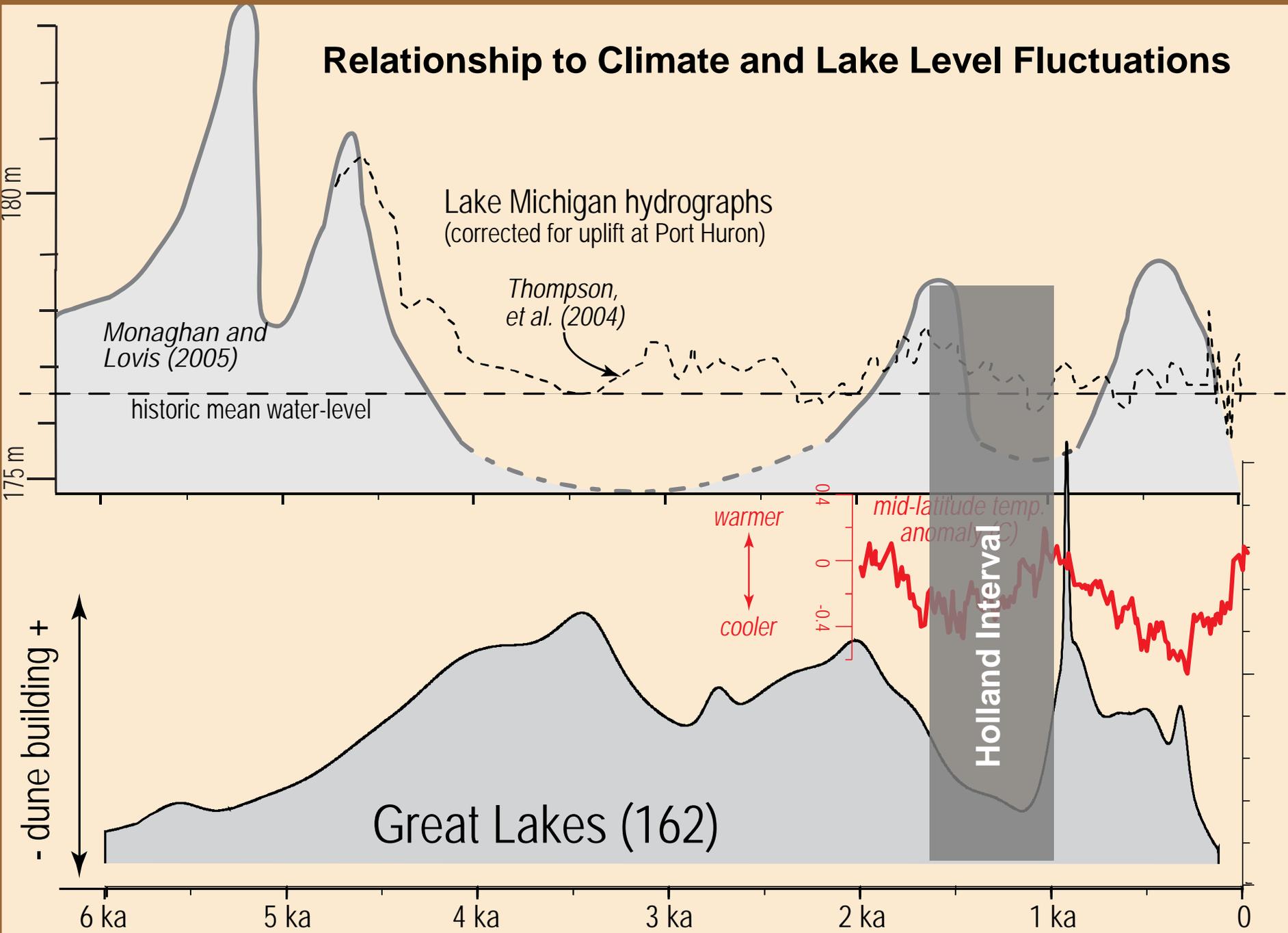
## Torch Bay Transect



# Statistical Analysis of OSL Ages (PDD)

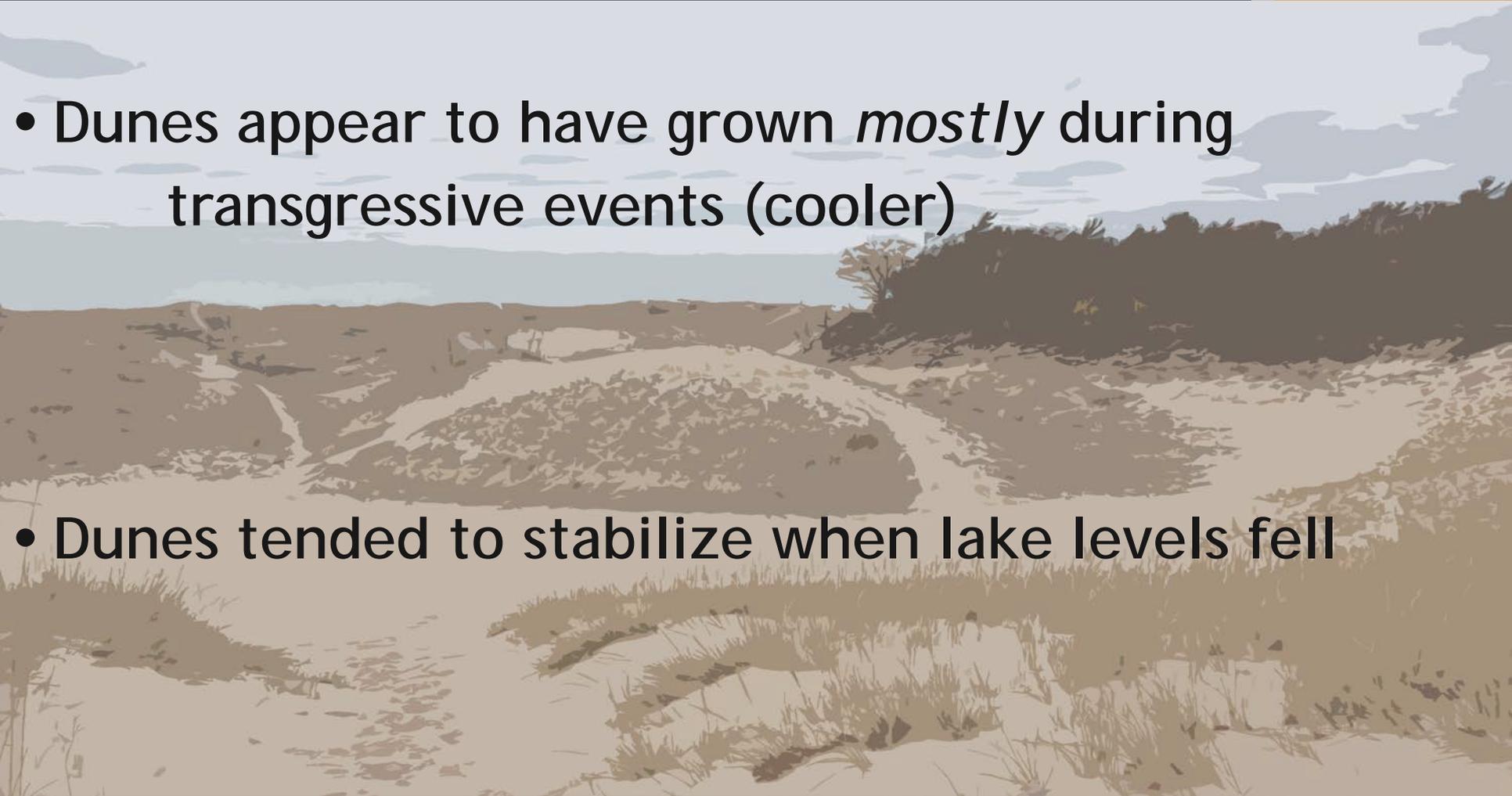


# Relationship to Climate and Lake Level Fluctuations



# Chronological Relationships

- Dunes appear to have grown *mostly* during transgressive events (cooler)
- Dunes tended to stabilize when lake levels fell

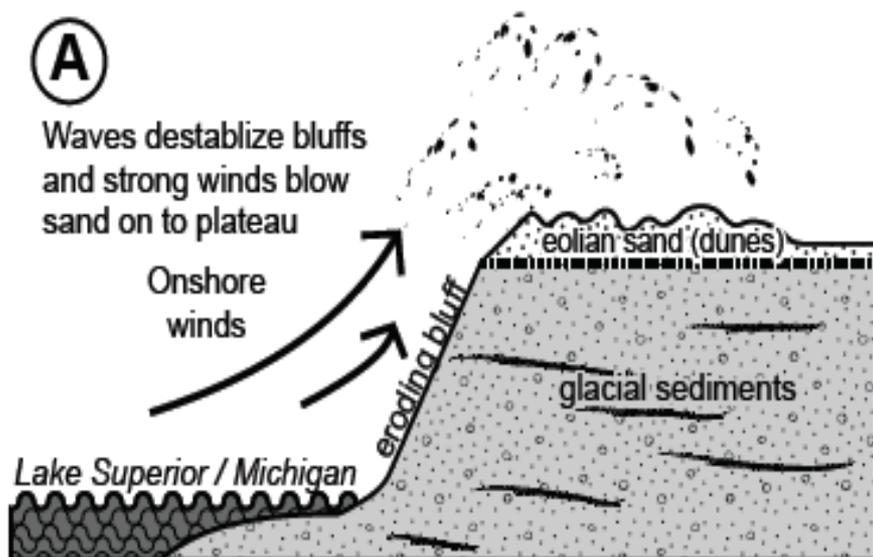


# The Perched Dune Model

**(A)**

Waves destabilize bluffs and strong winds blow sand on to plateau

Onshore winds

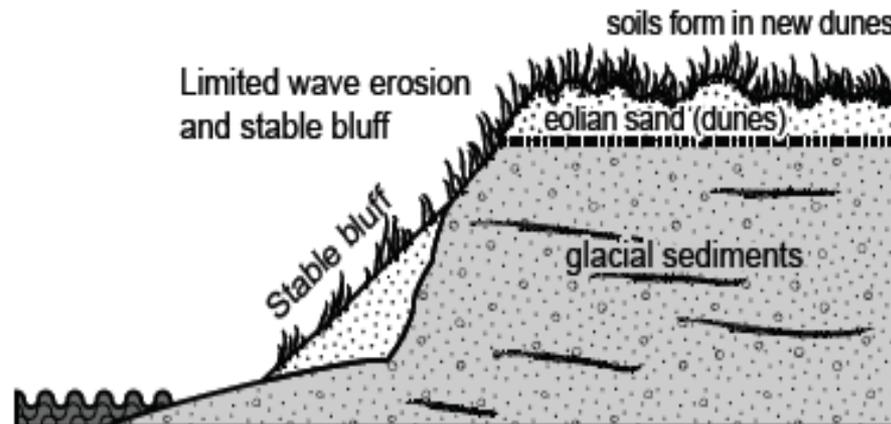


High lake phase

**(B)**

Limited wave erosion and stable bluff

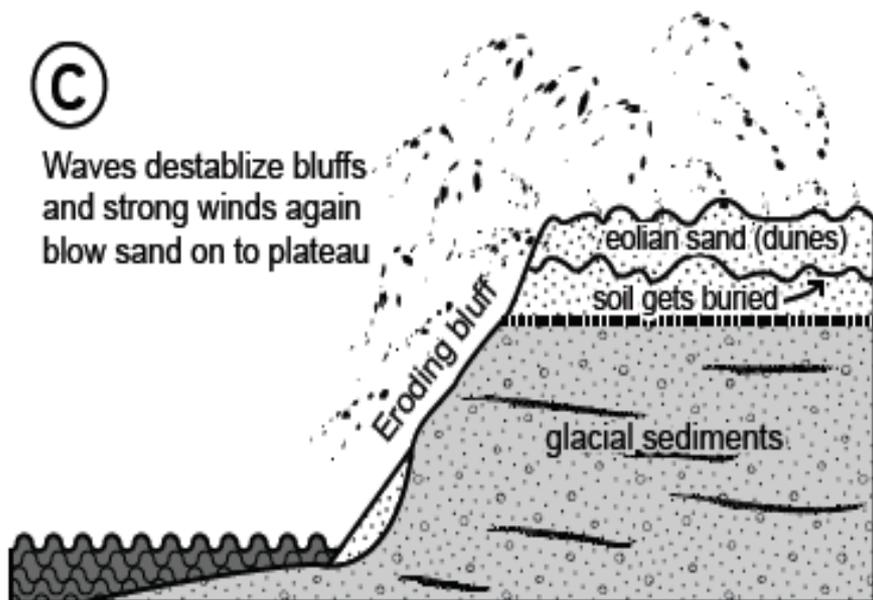
soils form in new dunes



Low lake phase

**(C)**

Waves destabilize bluffs and strong winds again blow sand on to plateau

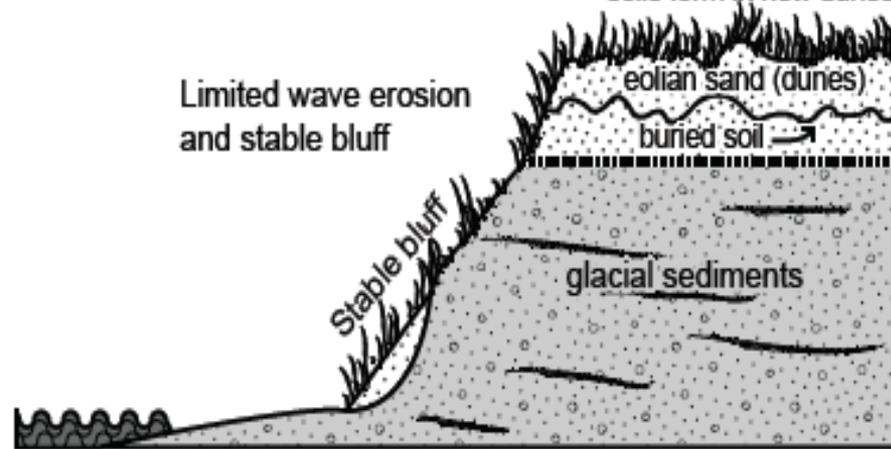


High lake phase

**(D)**

Limited wave erosion and stable bluff

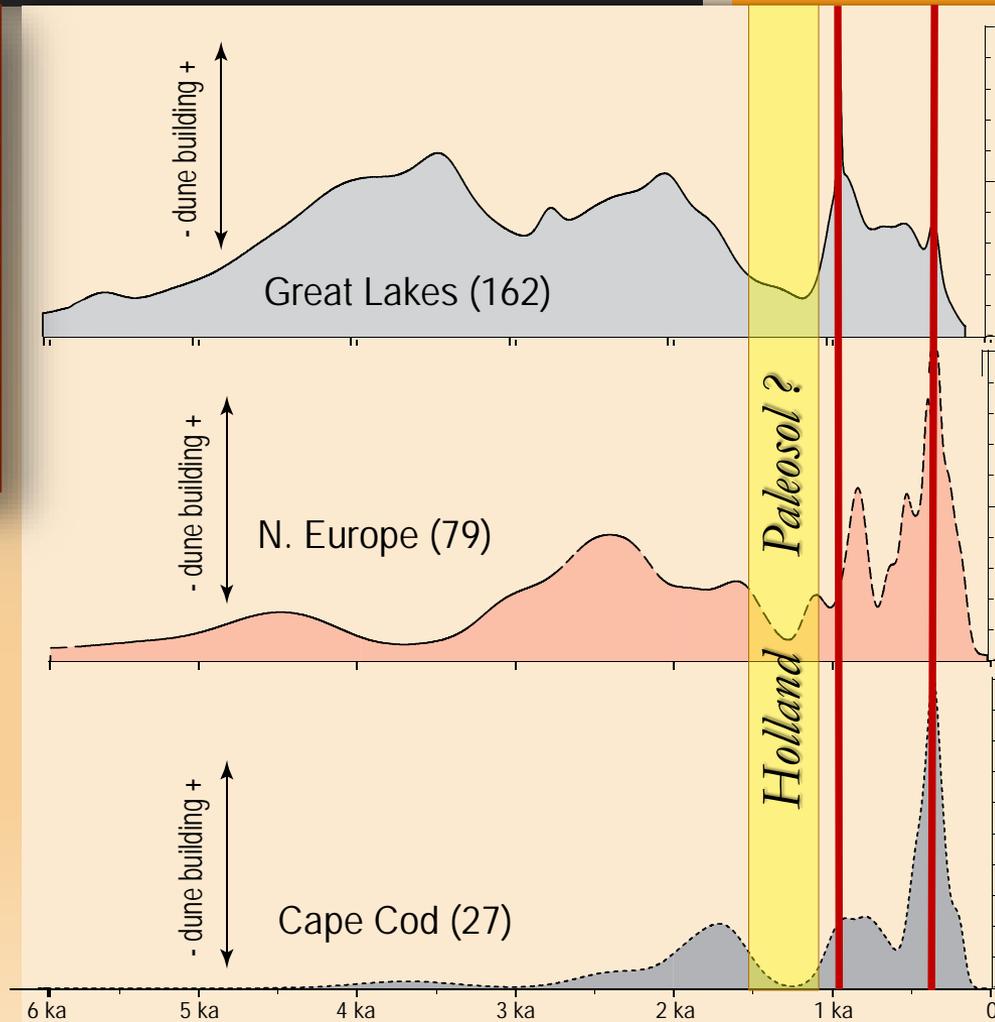
soils form in new dunes



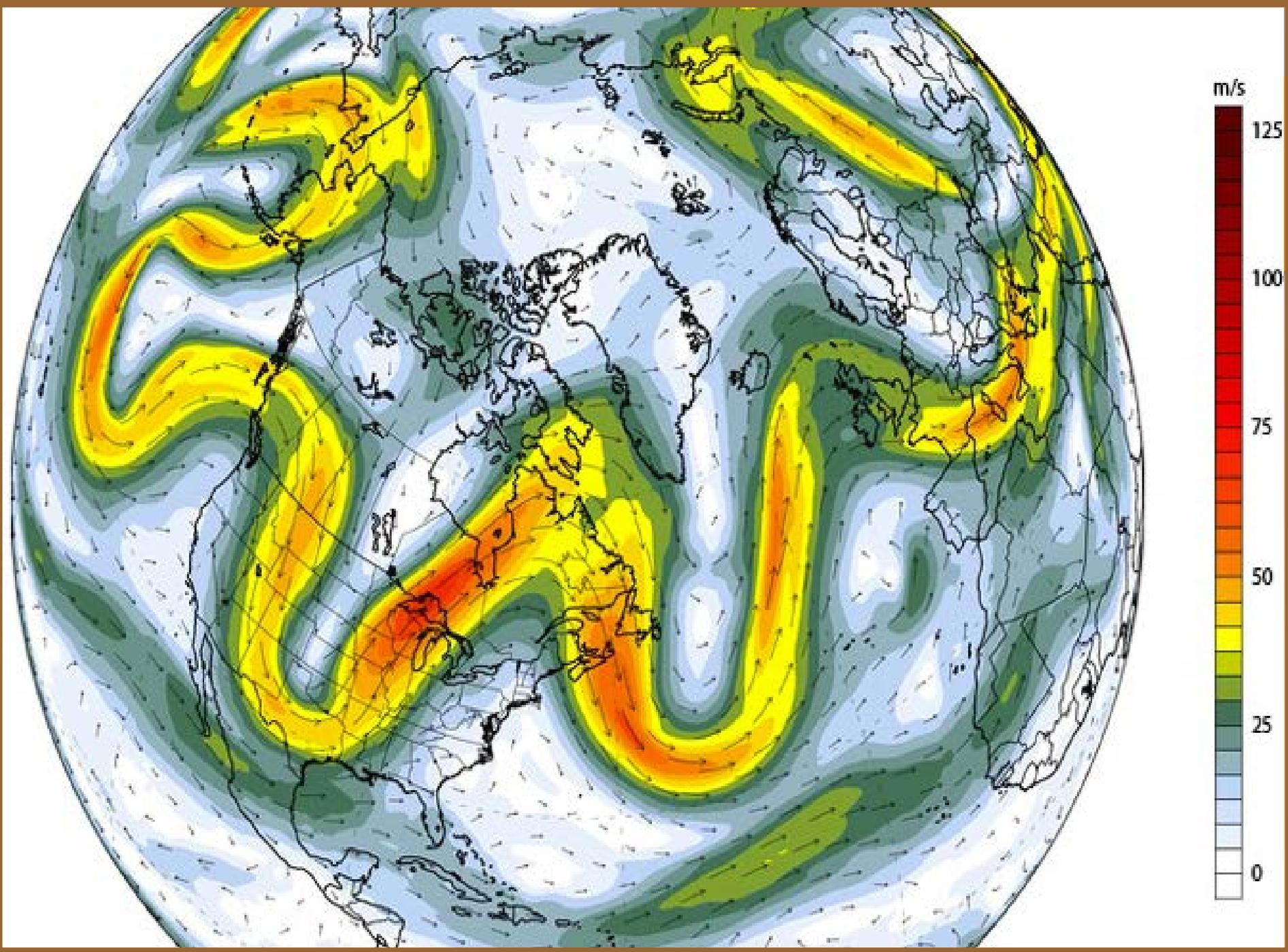
Low lake phase

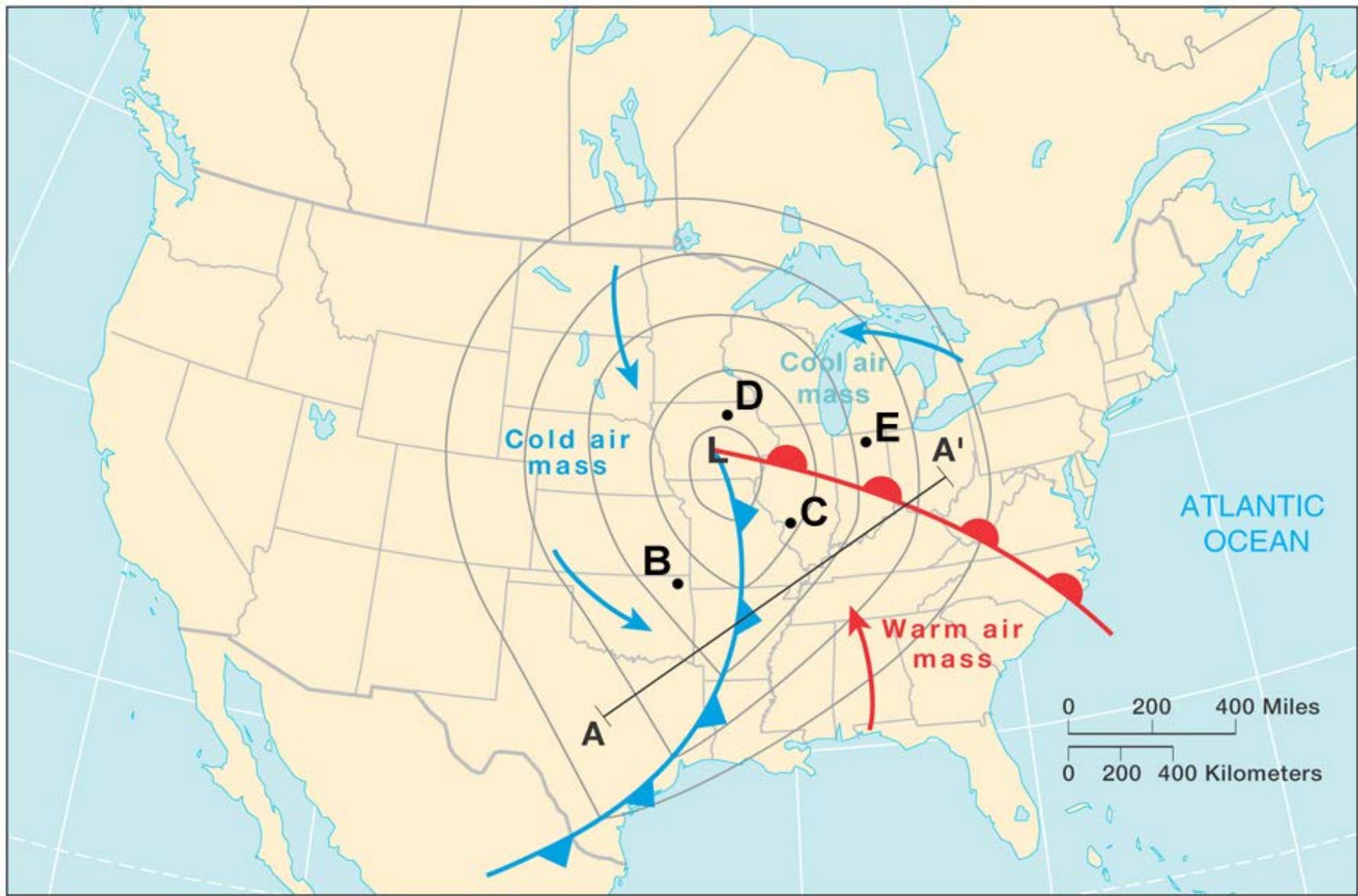
(from Anderton and Loope, 1995)

# Hemispheric Relationships??

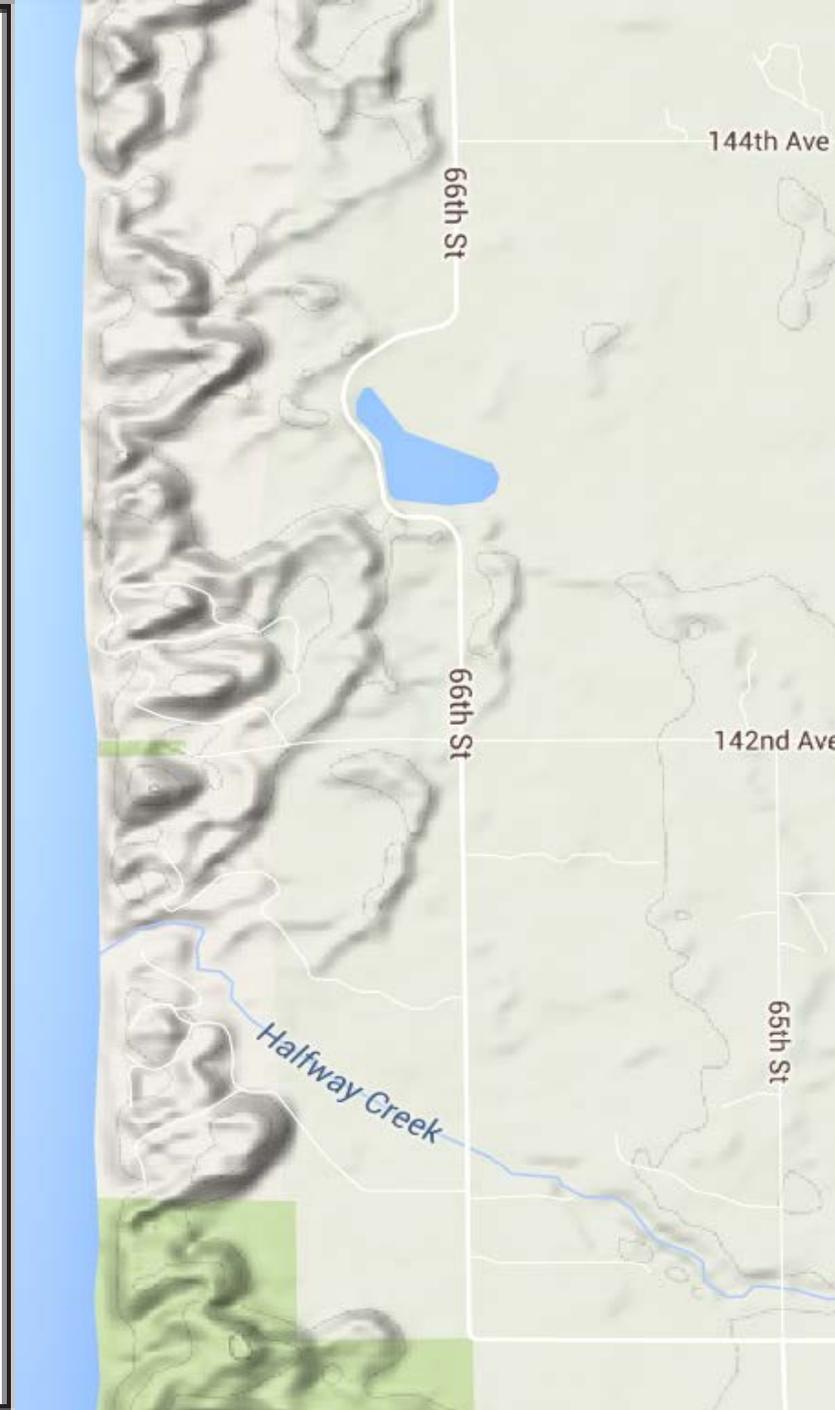
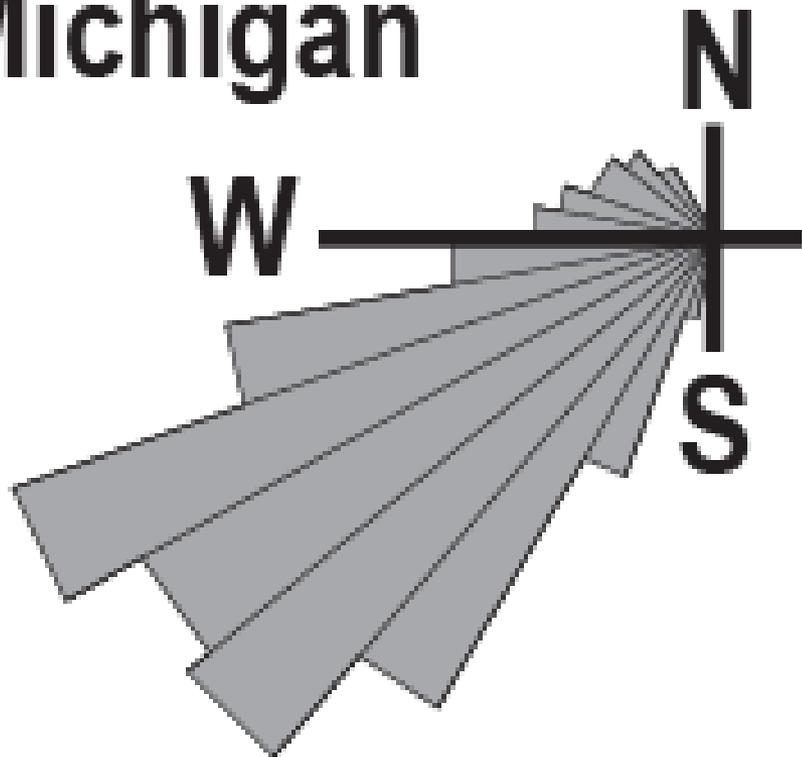


- Can we integrate the large-scale cycles & hemispheric teleconnections by comparing dune cycles from the mid-continent/northeast North America with northern European coastal dunes.





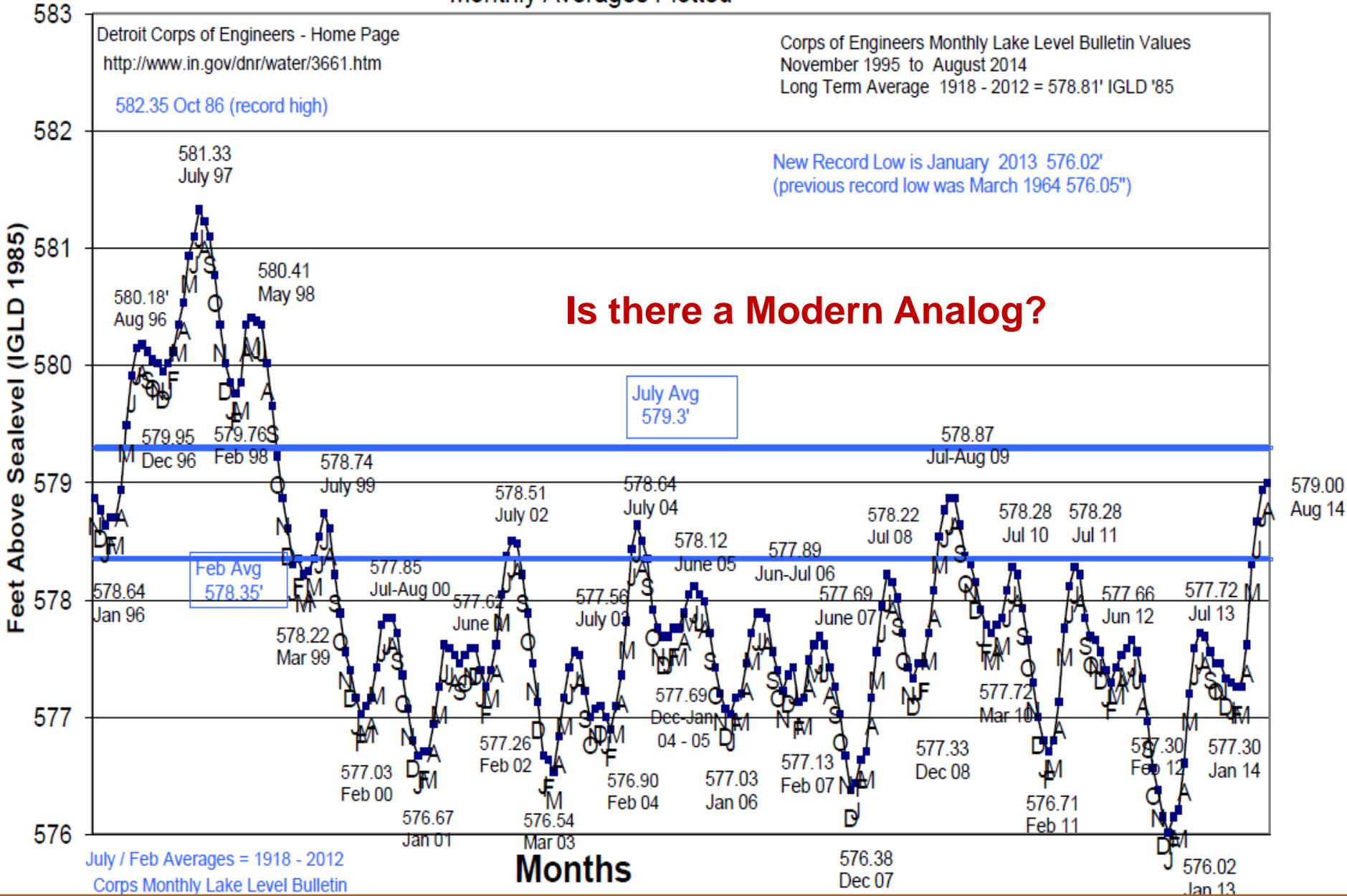
# wind direction for the formation of 1,213 parabolic coastal dunes, L. Michigan



Note: All of these numbers are the average of 6 gages in Lake Michigan and Huron.

# LAKE MICHIGAN LAKE LEVEL 1996 - 2014

Monthly Averages Plotted



# Repeat Photography



Montague

Van Buren State Park

Montague, 2001



Montague, 2008



**Montague, 2014**





Photo: Ed Hanson

Van Buren, 1999



Van Buren, 2008

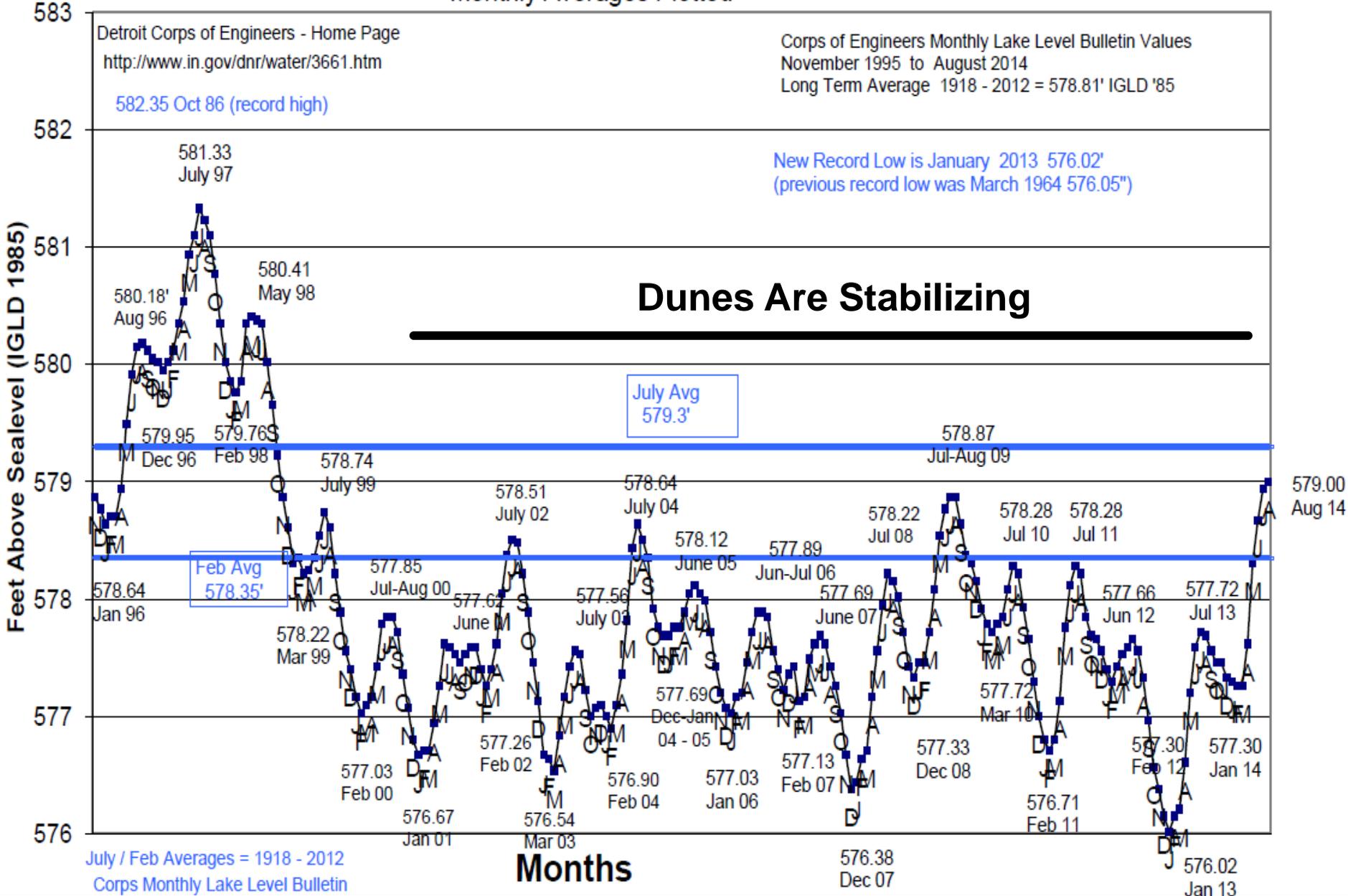
Van Buren, 2014



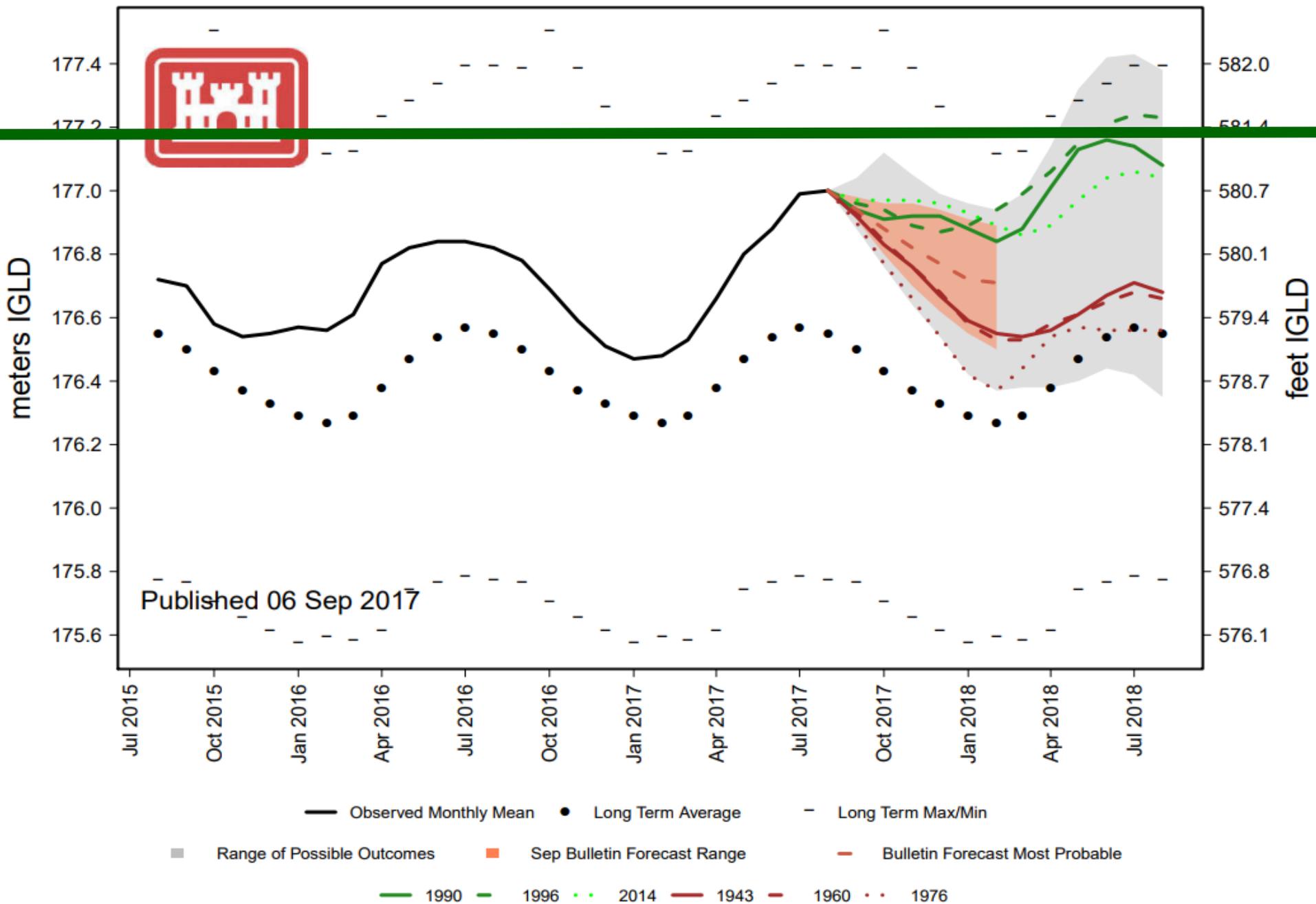
Note: All of these numbers are the average of 6 gages in Lake Michigan and Huron.

# LAKE MICHIGAN LAKE LEVEL 1996 - 2014

Monthly Averages Plotted



# Lake Michigan–Huron Monthly Mean Water Levels



Montague, 2001



Montague, 2008



Montague, 2017



# **The Emerging Science of Coastal Sand Dune Age and Dynamics: Implications for Regulation and Risk Management in Michigan**

Alan F. Arbogast  
Department of Geography  
Michigan State University

Brad Garmon  
Director of Conservation and Emerging Issues  
Michigan Environmental Council

Coastal sand dunes are found in many places along the shores of the Great Lakes. They are particularly common along the western coast of Lower Michigan and the northern shore of Upper Michigan due to three reasons, including 1) the very high supply of fine sand (1-2mm in size) initially deposited during the ice age, 2) the orientation of the shore as it relates to prevailing westerly winds, and 3) the long fetch resulting in unencumbered air flow across Lake Michigan and Lake Superior. The interaction of these variables has resulted in spectacular dune fields that collectively embody the largest complex of freshwater dunes in the world. In fact, they rival any coastal dune systems in the world as far as their size and grandeur is concerned, including those in northern Europe, Australia, New Zealand, and South Africa, to name a few places where prominent coastal dunes occur.

## *Recent Research Challenge Dune Age and Formation Assumptions*

Given the high profile of the dunes, they have been a source of geological and geographical interest for over a century. Early studies (e.g., Cowles, 1899; Dow, 1937; Scott, 1942; Olson, 1958a, b) were largely descriptive in their character and focused on the general physical geography of the dune systems, including the relationship to hypothesized lake levels and the

***Dynamic and Sensitive Landforms!***



*Thanks for Listening!*

