

# Climate and Fire in the Midwest Across Millennia - What the Paleorecord Tells Us

David Nelson

*Associate Professor*

*University of Maryland Center for Environmental Science (UMCES),  
Appalachian Lab*

[dnelson@umces.edu](mailto:dnelson@umces.edu)

<https://www.umces.edu/david-nelson>



# Paleo-perspective on the future

## Merging paleobiology with conservation biology to guide the future of terrestrial ecosystems

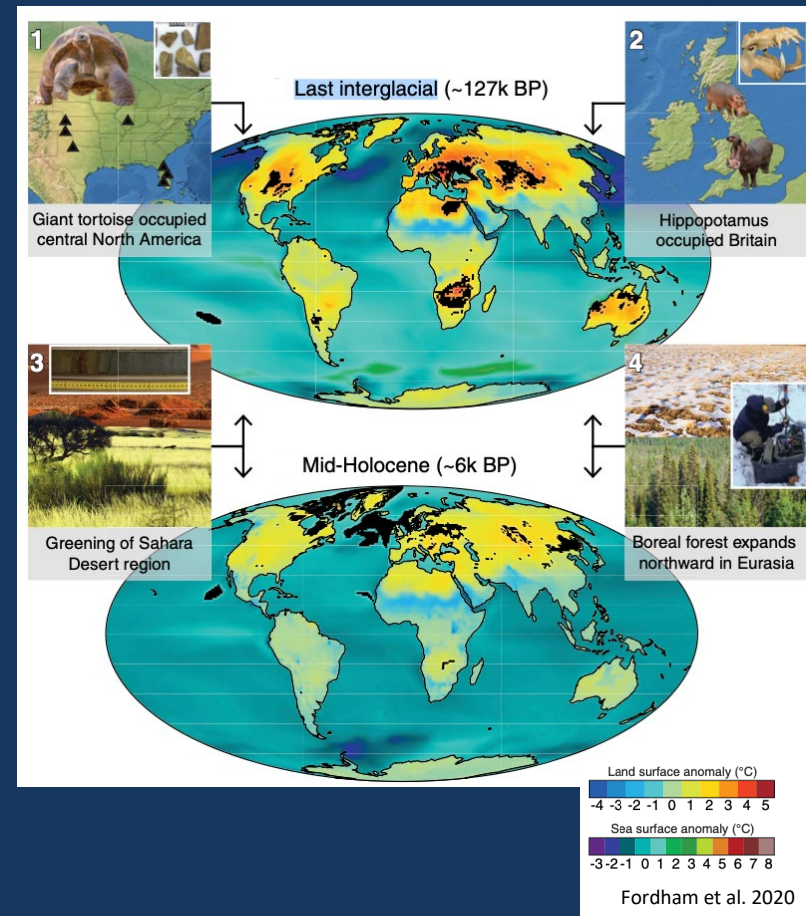
Barnosky et al. 2017

## Conservation Paleobiology: Leveraging Knowledge of the Past to Inform Conservation and Restoration

Dietl et al. 2015

## Using paleo-archives to safeguard biodiversity under climate change

Fordham et al. 2020

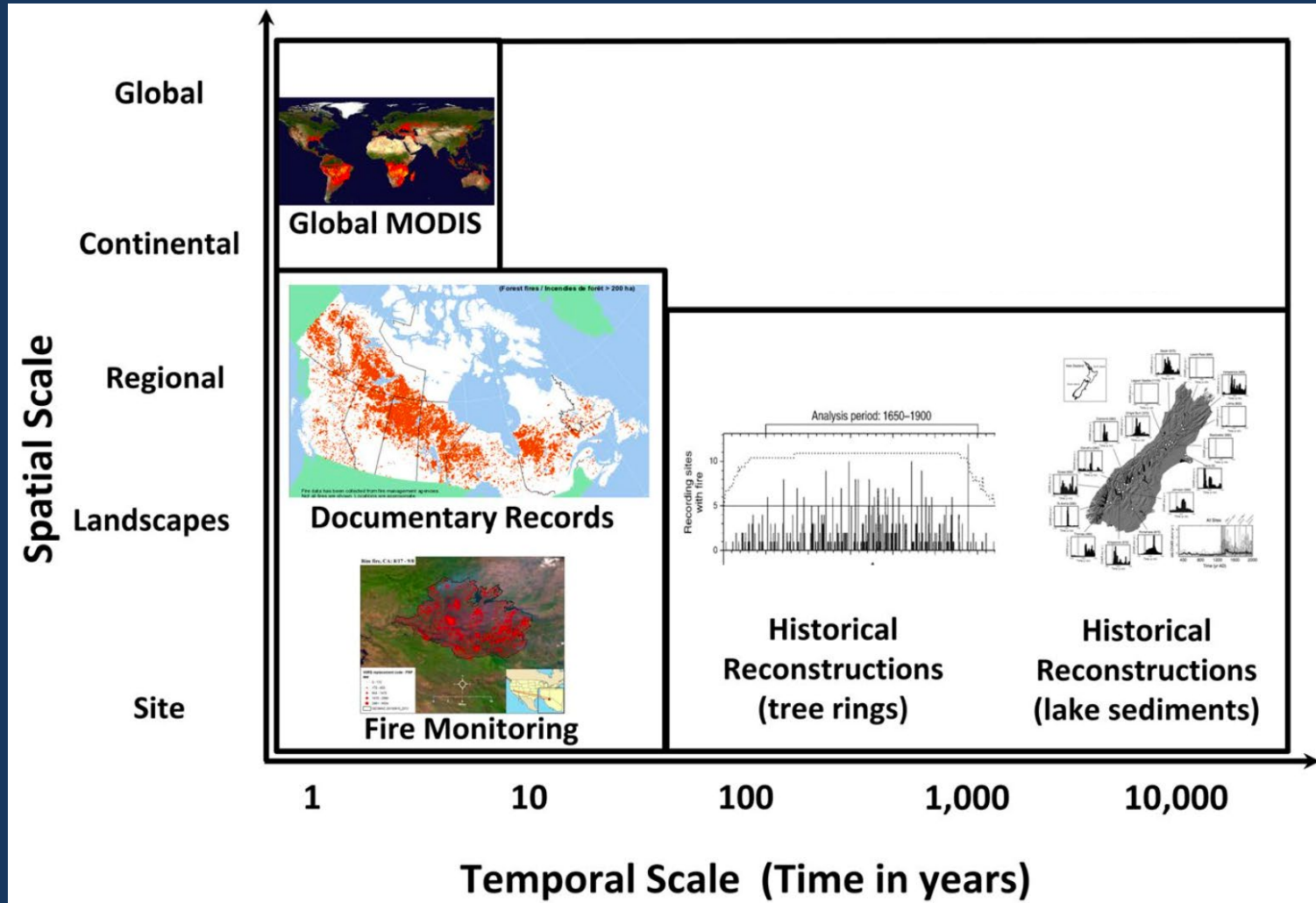


# Fire is a longstanding Earth system process

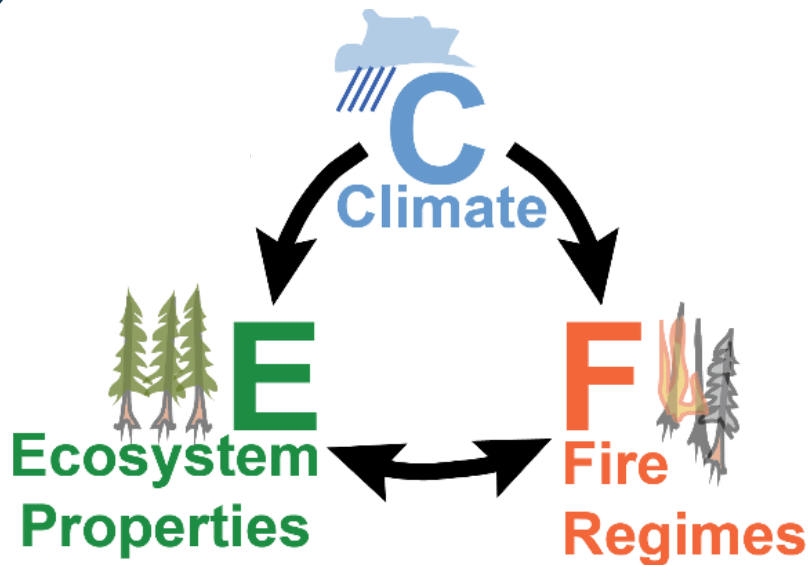


- Millions of years
- Key to understanding
  - Ecosystems
  - Carbon and nutrient cycles
  - Atmospheric chemistry
  - Human activities

# Scales of studying fire



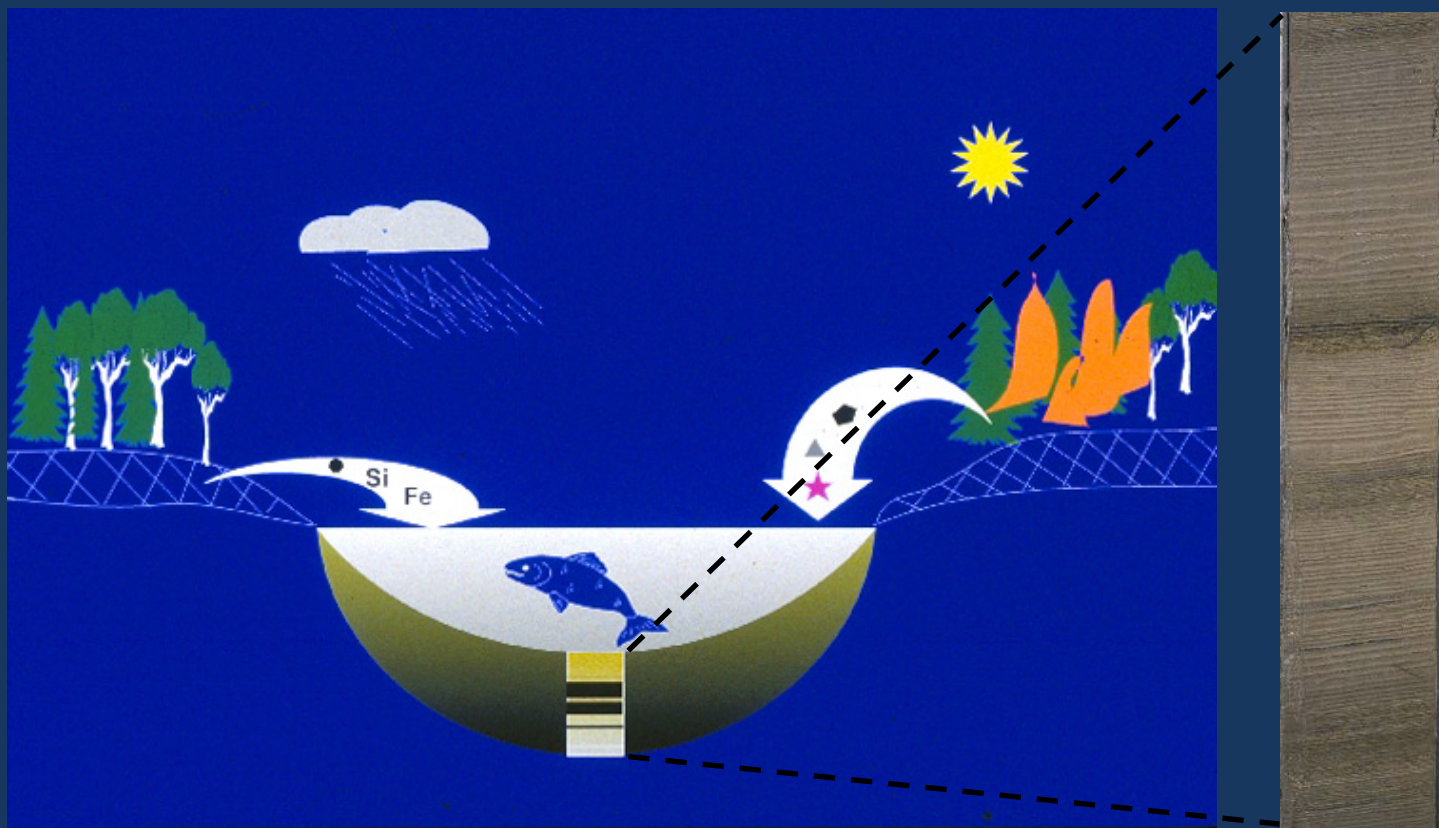
# Questions relevant to fire management that paleoecology can answer



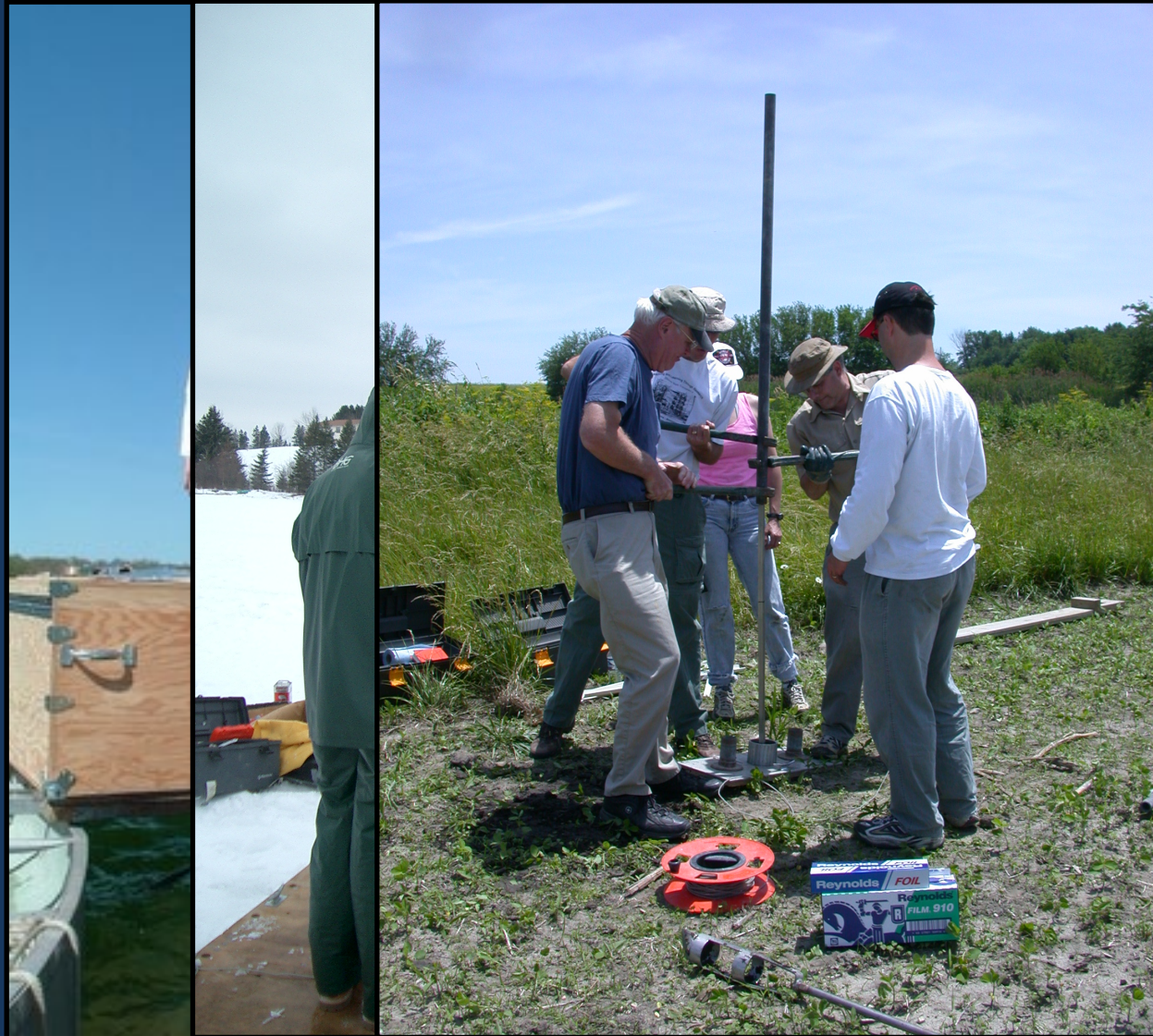
Graphic by B. Shuman

- What is the natural variability of climate, fire, and vegetation?
- Are current fire regimes novel?
- How does vegetation respond to changes in climate and fire? How does landscape context influence these responses?
- How do vegetation & climate influence spatiotemporal variation in fire?

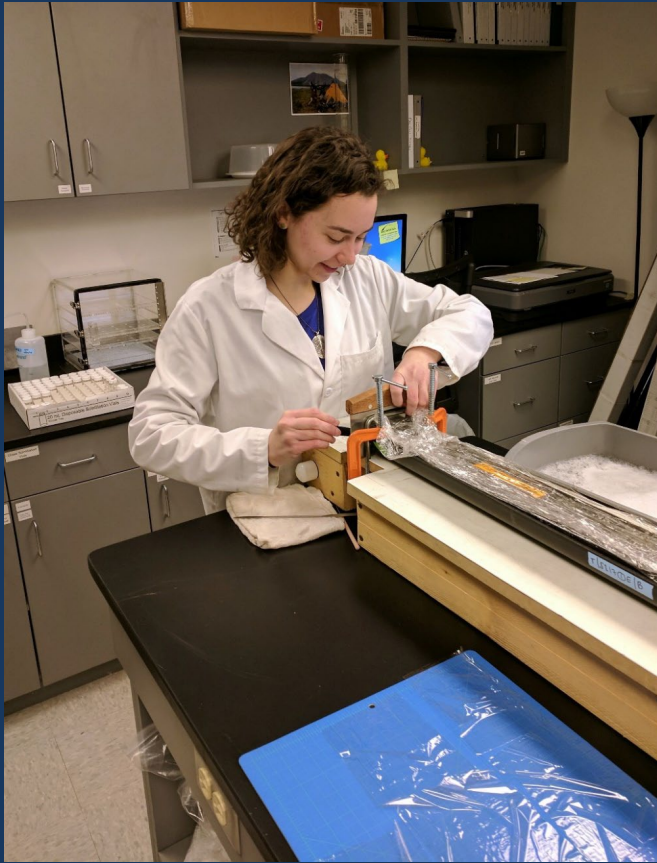
# Lake sediments are ecosystem archives



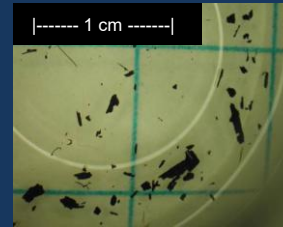
# Lake sediment coring



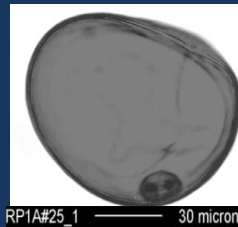
# Paleo-environmental proxies in lake sediments



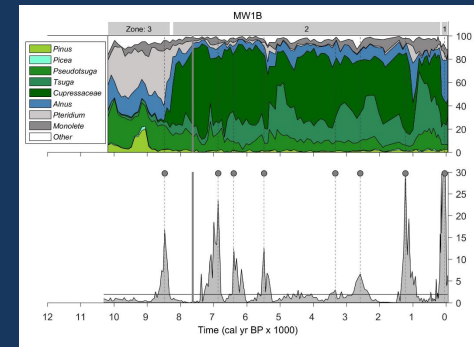
**Charcoal:**



**Pollen:**

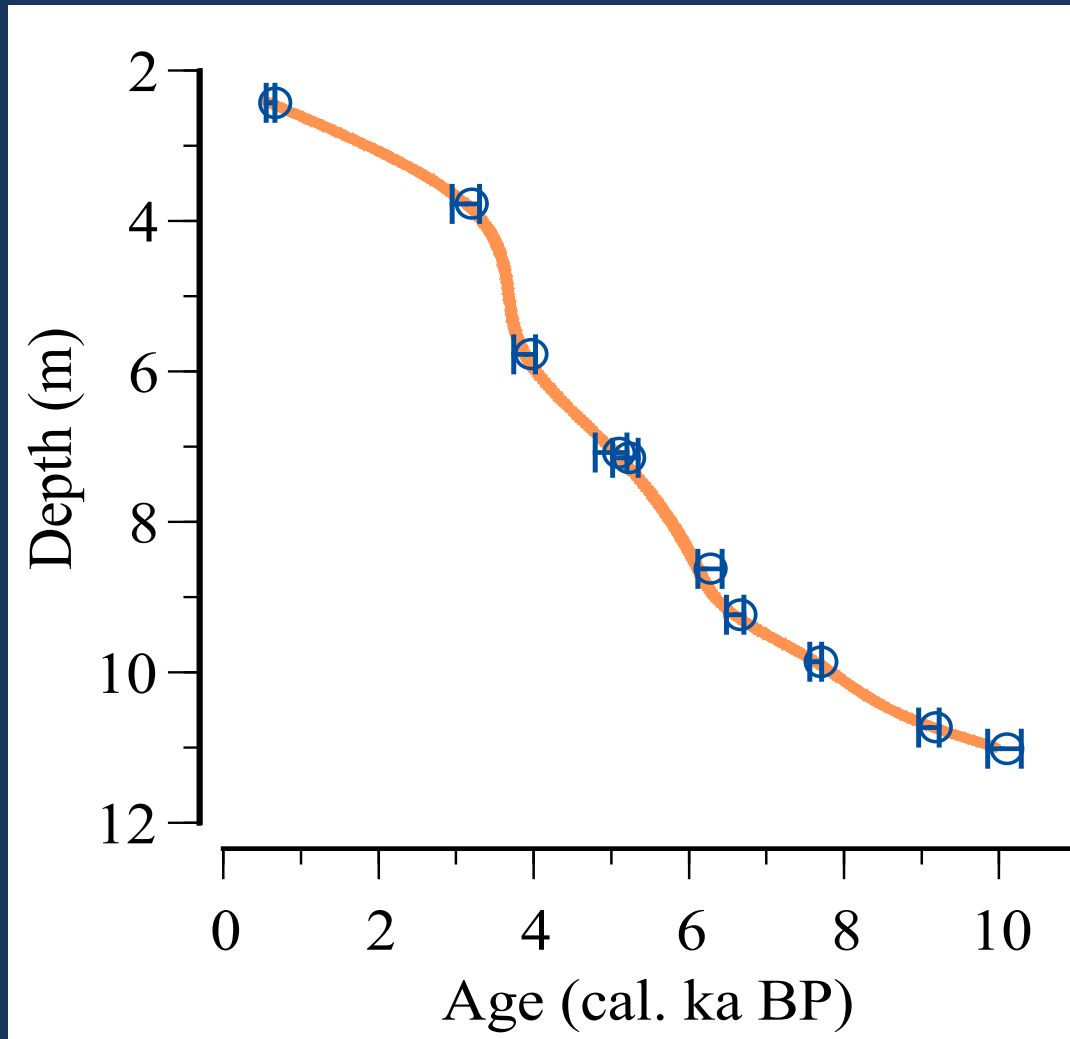


**Climate:**  
diatoms  
minerals  
isotopes  
lake levels

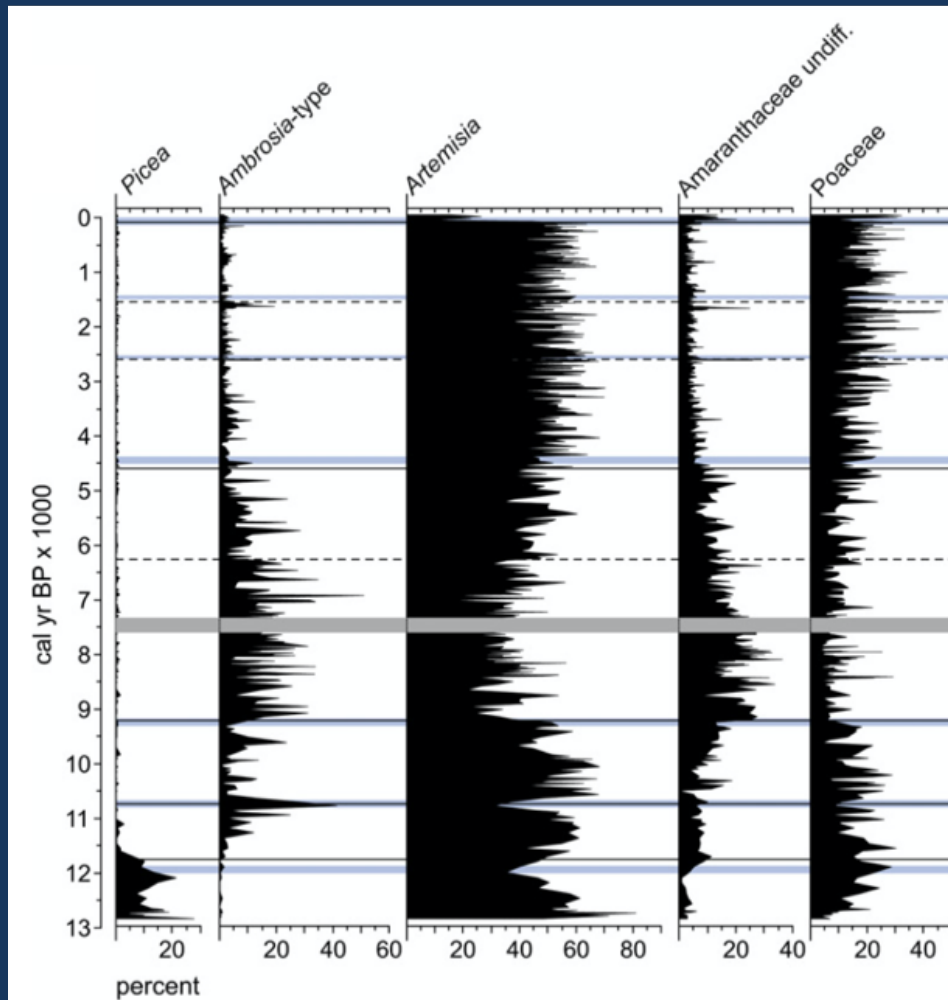




# Lake-sediment dating

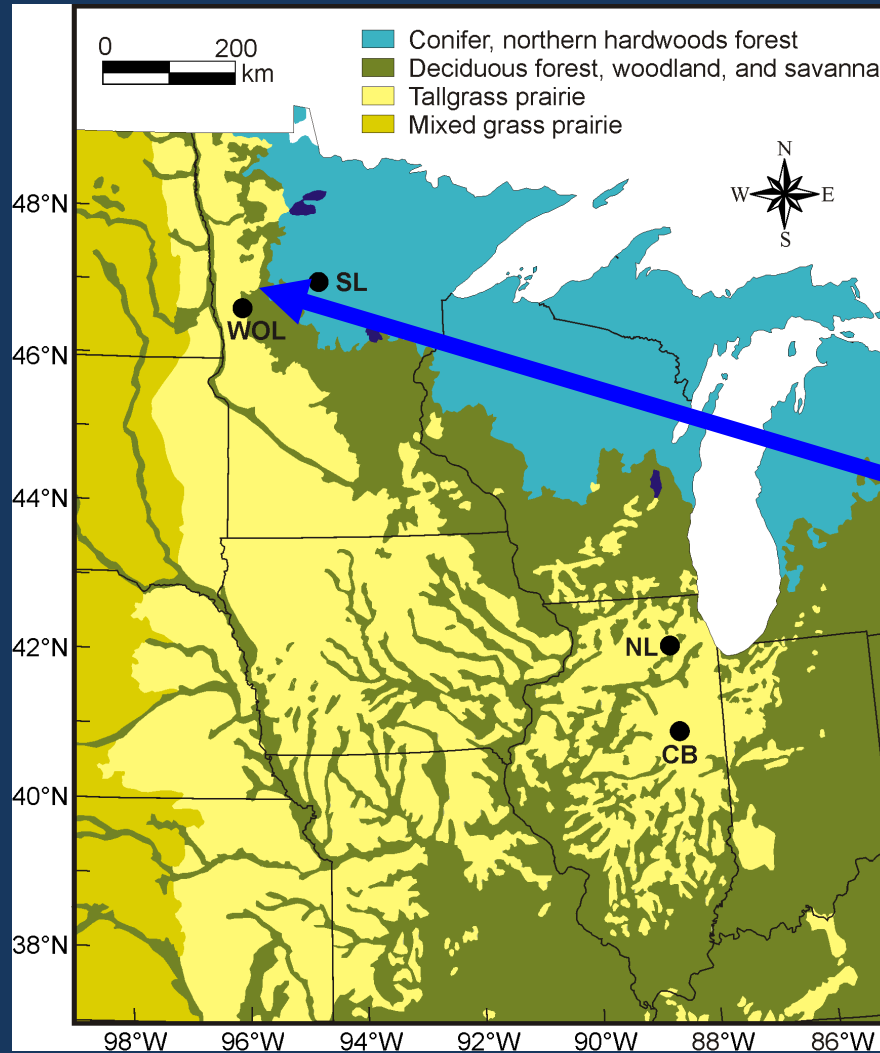


# A high-resolution record of climate variability and landscape response from Kettle Lake, northern Great Plains, North America



- Fuel-dependent fire regime
  - Drought = less grass = less fuel
- Non-analog vegetation during middle Holocene

# How did climate and fire influence development and maintenance of grassland in the Midwest?

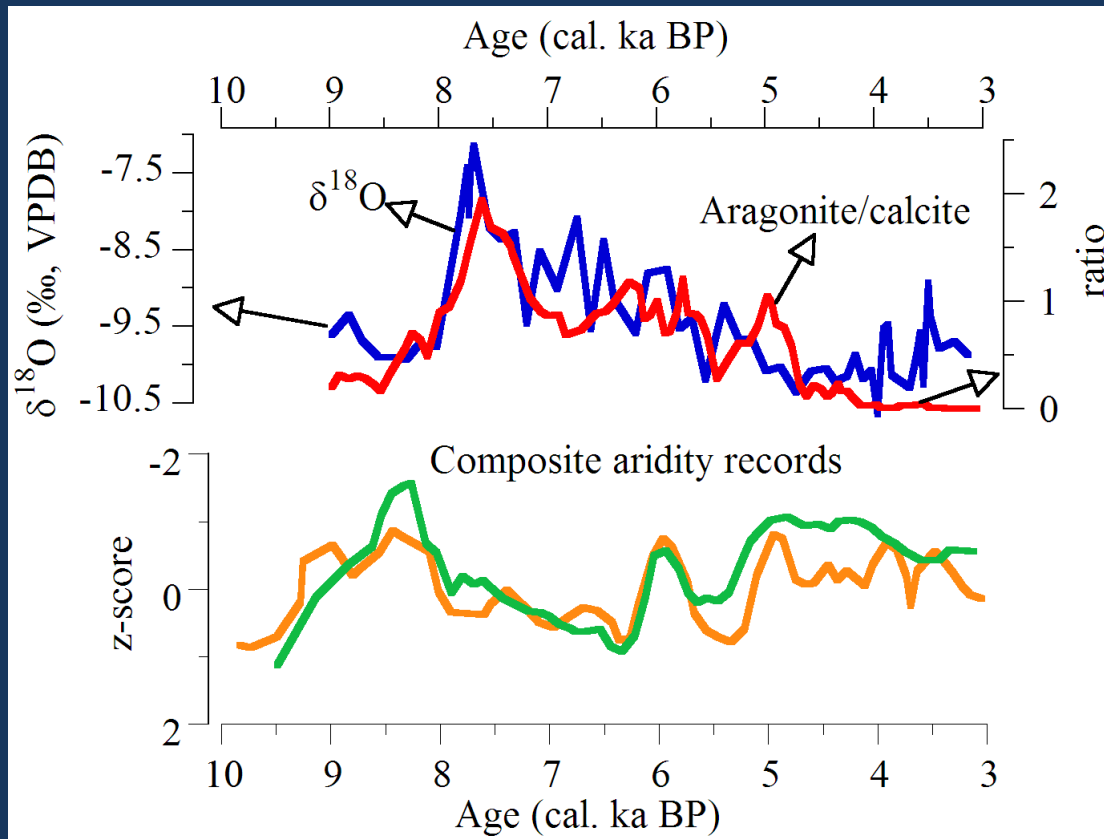


# How did climate and fire influence development and maintenance of grassland in the Midwest?

Minnesota

↑ Dry  
↓ Wet

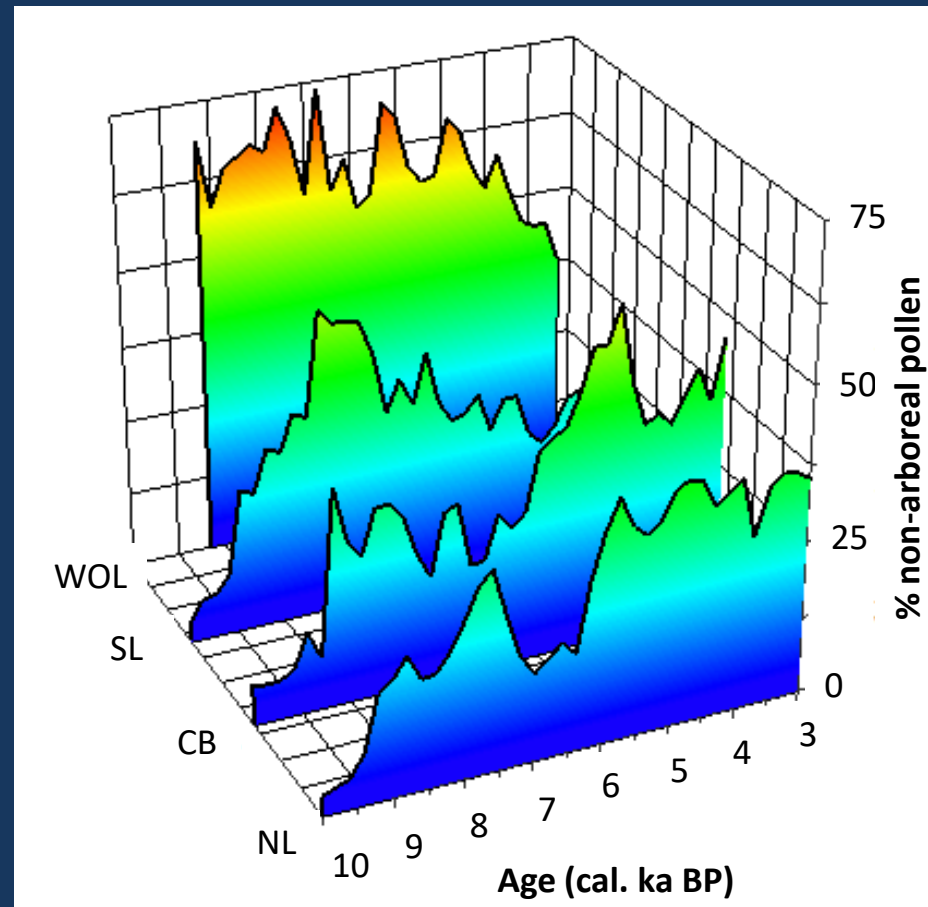
Illinois



# How did climate and fire influence development and maintenance of grassland in the Midwest?

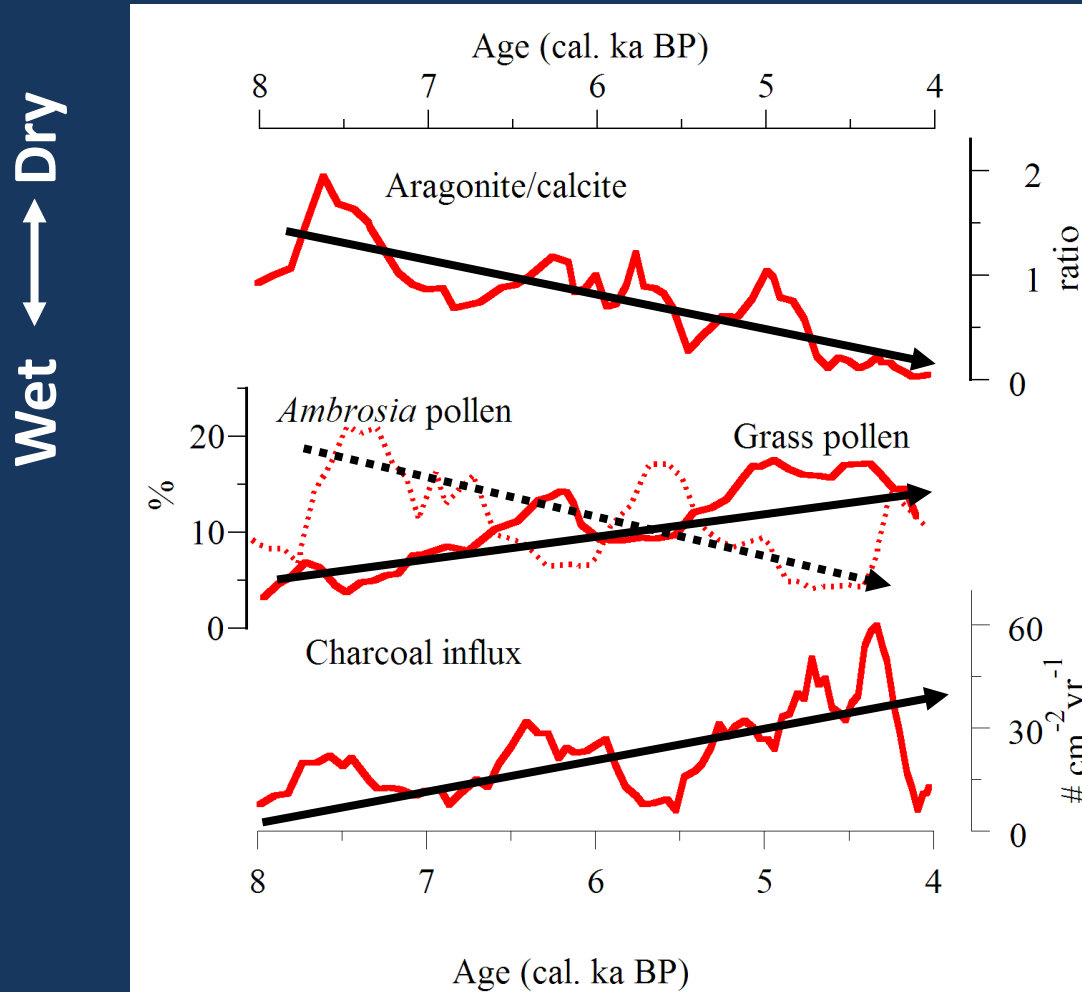
Minnesota

Illinois



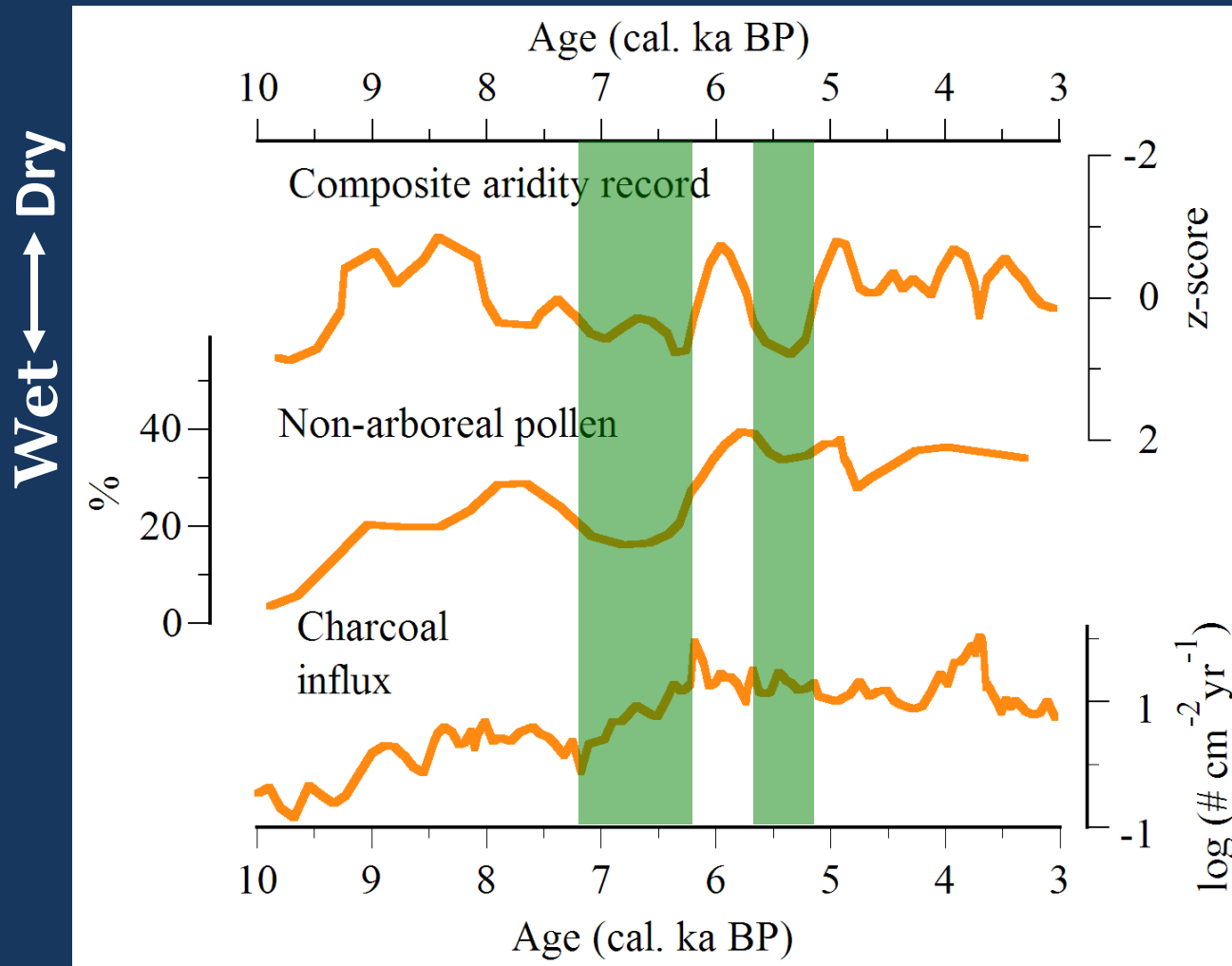
# How did climate and fire influence development and maintenance of grassland in the Midwest?

West Olaf Lake, Minnesota

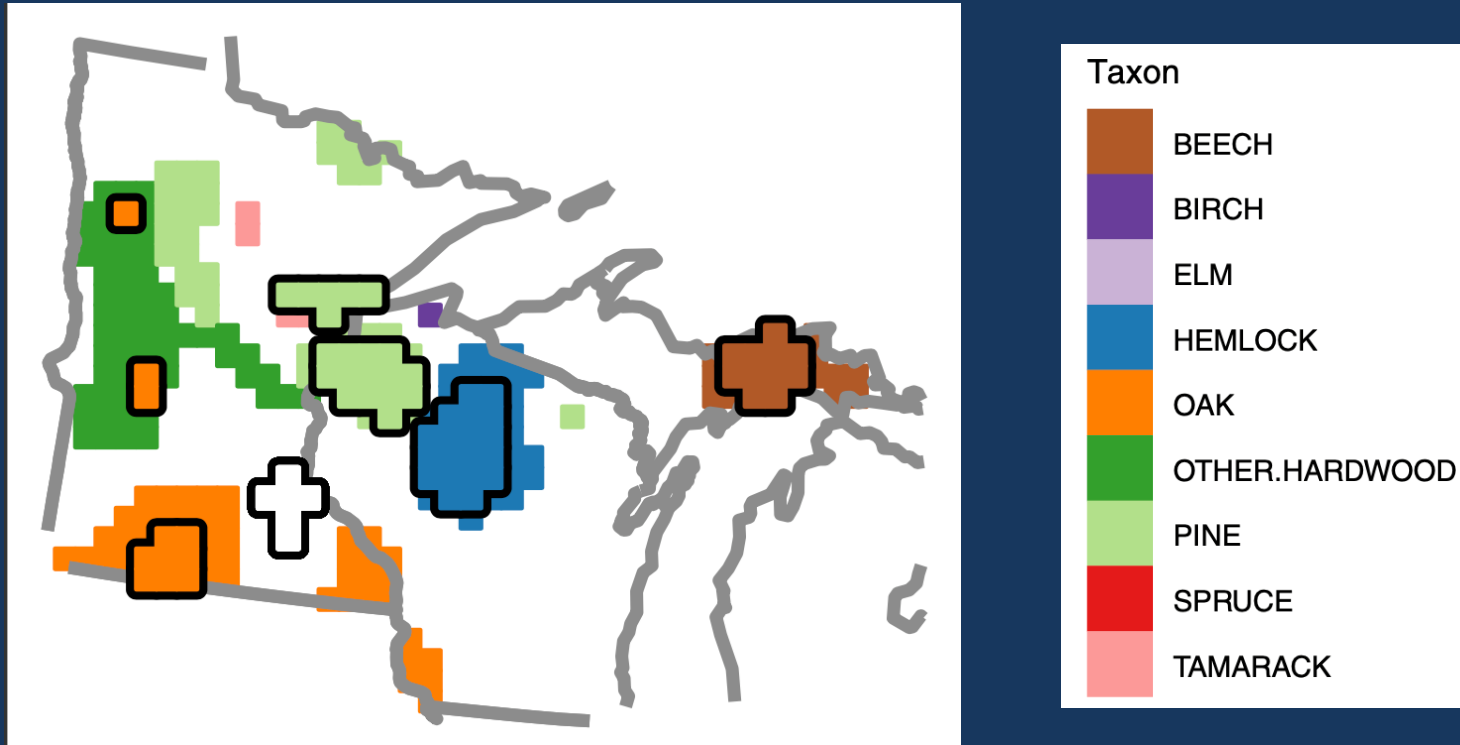


# How did climate and fire influence development and maintenance of grassland in the Midwest?

Nelson Lake, Illinois



# Changes in forest composition in upper Midwest during last ~2,000 years



- Some areas with significant changes in community composition (9% cells)
- Most locations did not experience large change in community composition



# Fire in upper Midwest during last ~2,000 years

**Palaeoecological evidence of state shifts between forest and barrens on a Michigan sand plain, USA**  
Lytle 2015

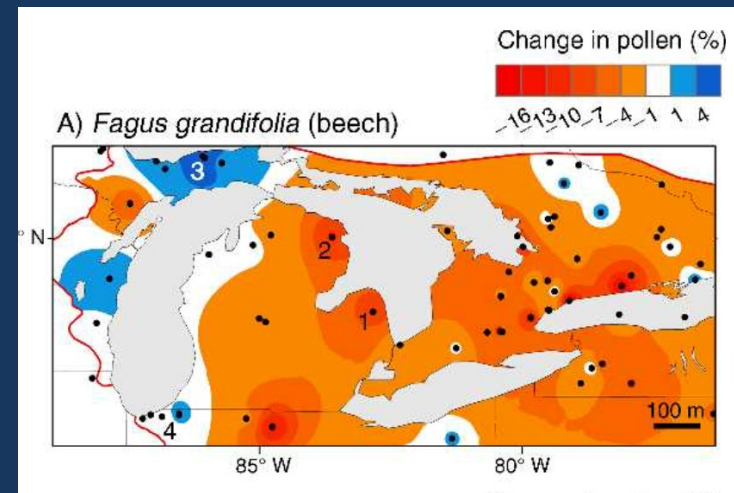
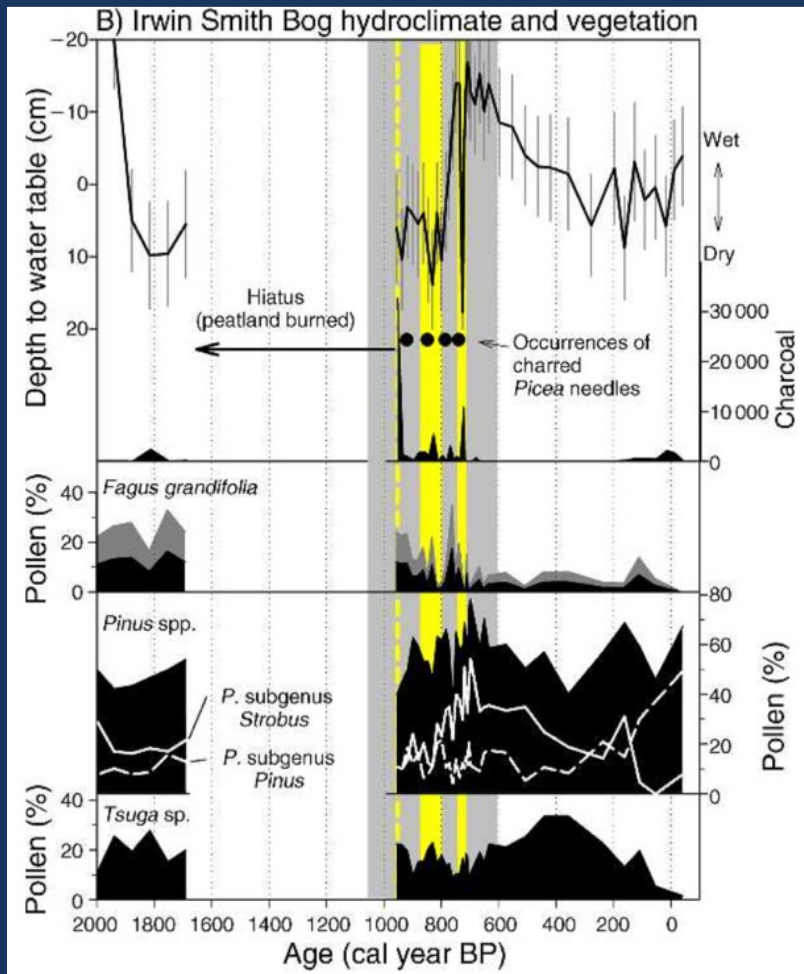
**Late-Holocene climate changes linked to ecosystem shifts in the Northwest Wisconsin Sand Plain, USA**  
Calcote et al. 2015

**Late-Holocene vegetation and fire history from Ferry Lake, northwestern Wisconsin, USA**  
Lynch et al. 2006

Charcoal signatures defined by multivariate analysis of charcoal records from 10 lakes in northwest Wisconsin (USA)  
Lynch et al. 2011

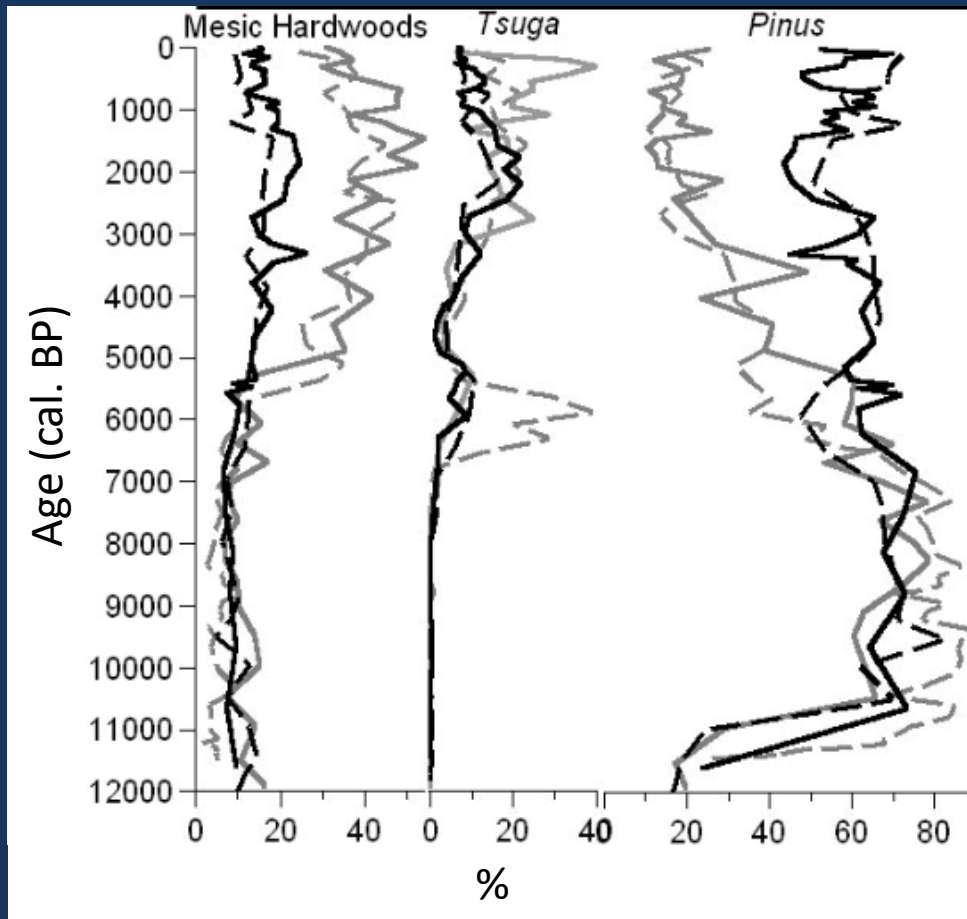
- Occurred throughout late Holocene
- Generally more fire during Medieval Climate Anomaly droughts (~1,000-700 years ago)
- Vegetation largely resilient to fire

# Multi-decadal drought and amplified moisture variability drove rapid forest community change in a humid region



- Drought and fire drove beech decline
- Beech decline largest where drought was strongest
- Region vulnerable to drought

# Influence of snow and landform on vegetation change in upper Michigan during Holocene



- Lake-effect snow developed ~9,500-5,500 years ago ( $\delta^{18}\text{O}$ )
  - favored expansion of mesic trees in snowbelt
- Snowfall stronger control of vegetation change than landform

# Quick recap

- Lake sediments extend our perspective of fire, climate, and vegetation
- Fire directly and indirectly responds to climate variability
- Unique climates create non-analog plant communities
- Midwestern ecosystems may be more sensitive to drought and fire than thought

