PALEOENVIRONMENTAL AND PALEOCLIMATE INFERENCES FROM GASTROPOD ASSEMBLAGES IN LAST GLACIAL MAXIMUM LOESS: ILLINOIS, INDIANA, AND KENTUCKY

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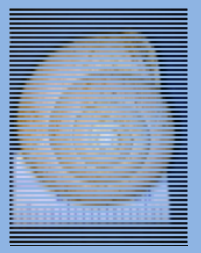

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-- **Andy Nash** analyzed gastropods from New Cottonwood School and Thomas Quarry

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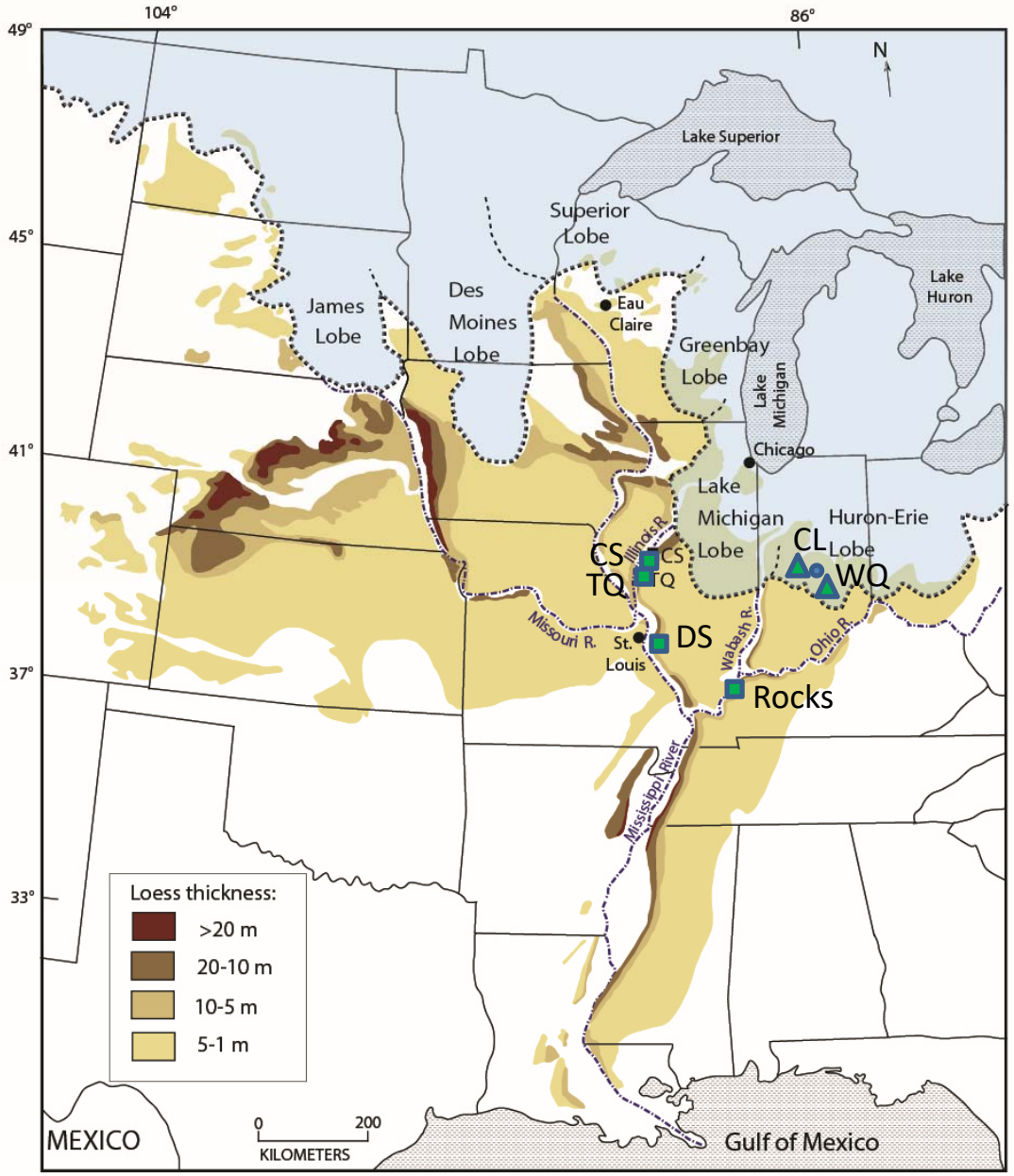


modified from Muhs et al., 2013

Location of Study Area

- loess sites in proximal uplands along the Illinois, Mississippi, and Ohio River Valleys

  (glacigenic loess related to glacial meltwater valleys)

- resedimented loess (silt) between last glacial tills in central Indiana

Research Objectives

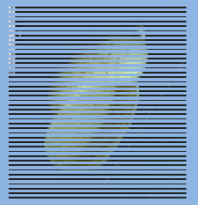
- **high resolution chronology** (using Succineidae; Pigati et al., 2015)
- **paleoecological estimate;** based on terrestrial gastropod assemblage
- **paleoclimate estimate;** based on gastropod assemblage and isotopes
- **spatial and temporal variations in LGM ecology and climate**; comparison to modern analogs

New Cottonwood School Section

on uneroded flat upland

used for radiocarbon dating

Vertigo hubrichti



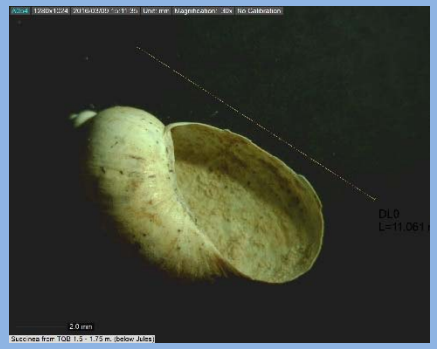
Succinea sp.

- examples of fossil terrestrial gastropod shells in Peoria loess

Thomas Quarry Sections

original TQ section (Grimley et al., 1998)

TQB Section (T.A. Nash, 2016)



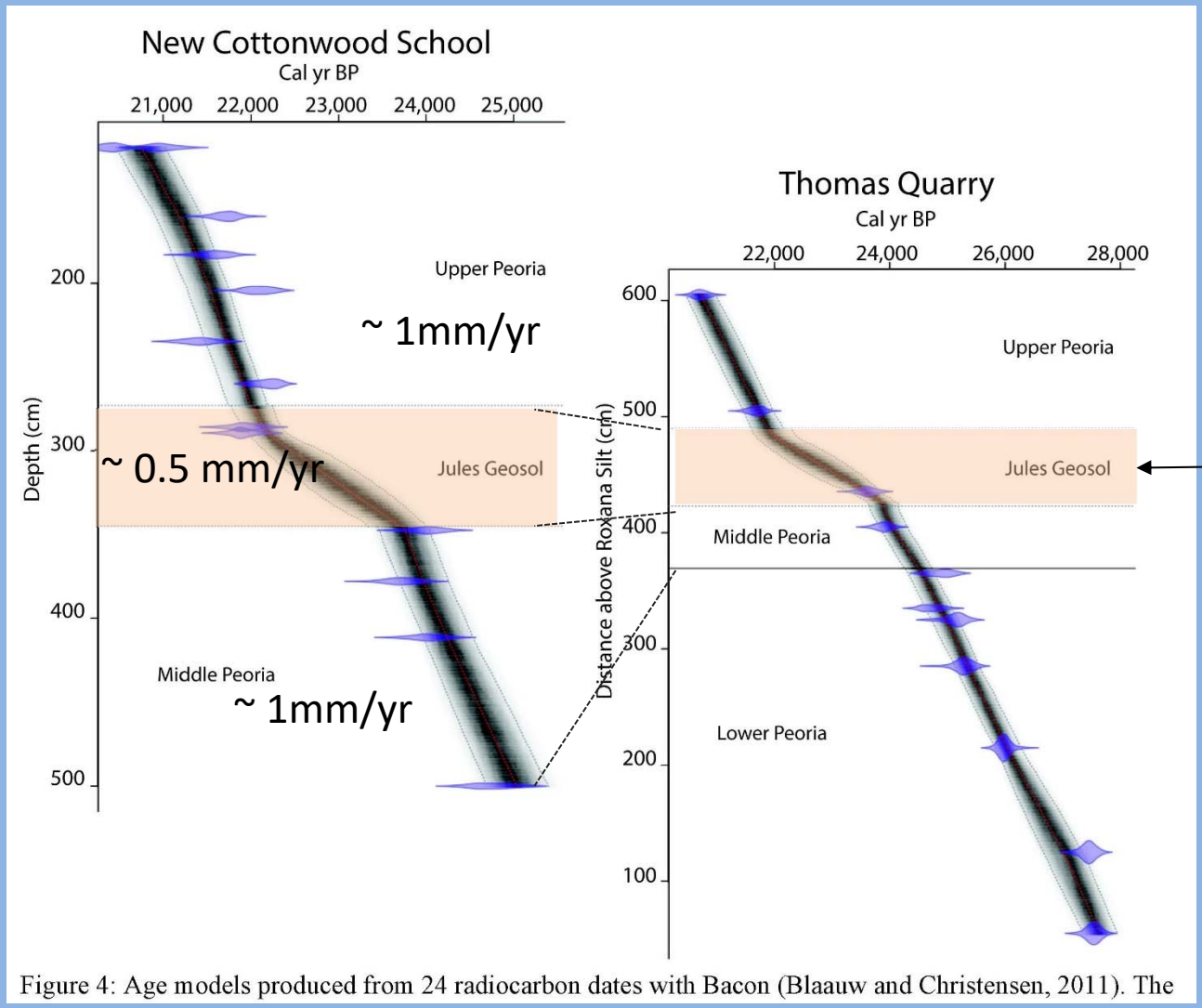
Succinea sp.
TQB 1.5-1.75

V. hubrichti;
TQB 0.5 to 0.75 m

45 cm

lower Peoria Silt; TQA

Chronologic Model (mainly Succineidae)



rare gastropods

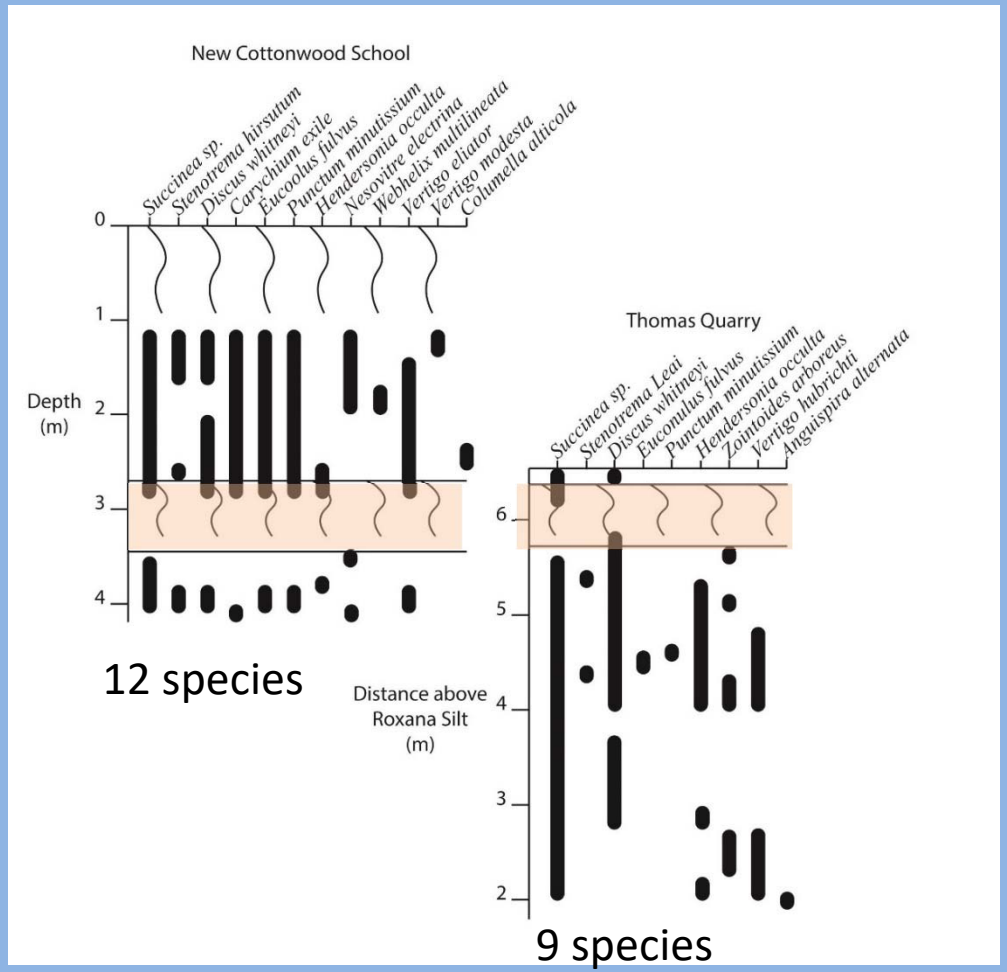
Figure 4: Age models produced from 24 radiocarbon dates with Bacon (Blaauw and Christensen, 2011). The

* Bacon model (**B**ayesian **ac**cumulati**on** histories) using *Succinea* sp. and *Webbhelix multilineata* shells

from Nash et al., 2017, Quaternary Research

Illinois Valley loess: gastropod assemblage

- all terrestrial species
- live mainly in woodlands
- cool-cold boreal climate



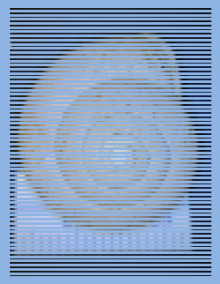
wide distribution

Succinea sp.

cold, boreal

Columella alticola

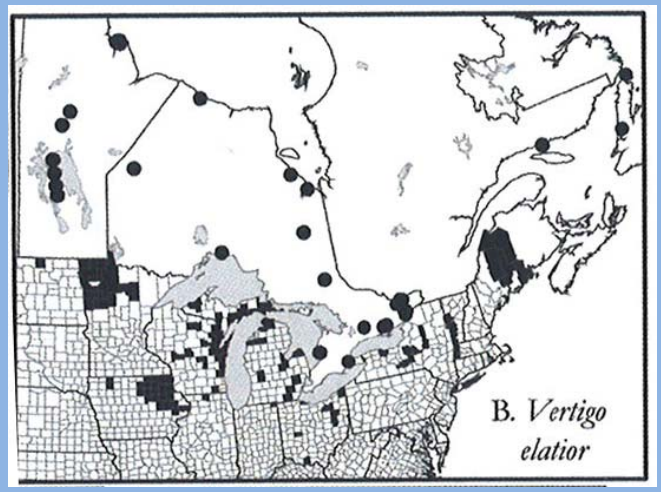
in Midwest today



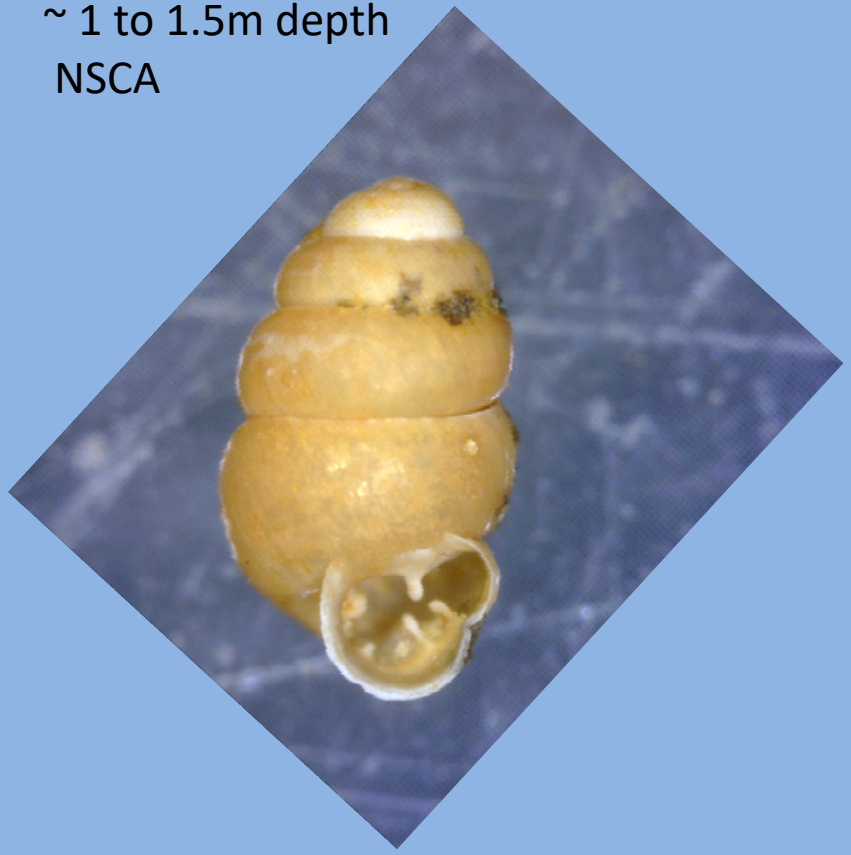
Webbhelix multilineata

from Nash et al., 2017, Quaternary Research

Gastropod Paleoecology



Vertigo eliator:
~ 1 to 1.5m depth
NSCA

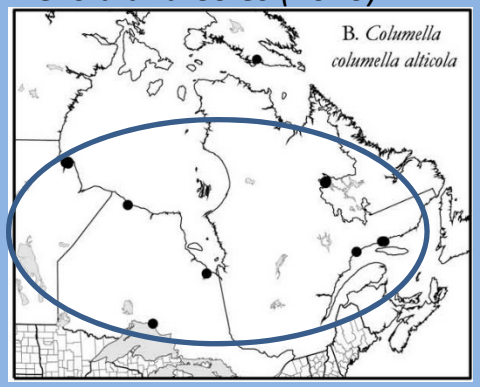


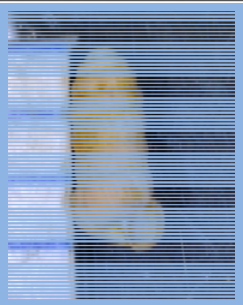
Individuals occur in well-decomposed humid leaf litter in a variety of open and wooded wetland habitats, including wet prairie, fens, wet meadows, tundra, and black ash, tamarack, and black spruce swamp forests.

Nekola and Coles, 2010

Overlapping Range Method: overlap of modern distributions

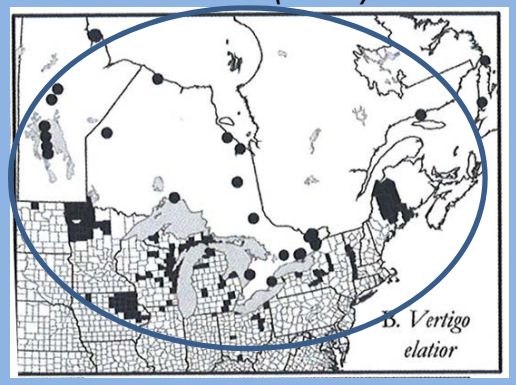
Nekola and Coles (2010)



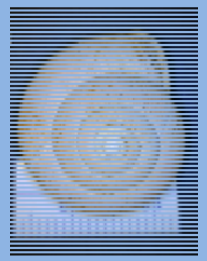


Columella alticola

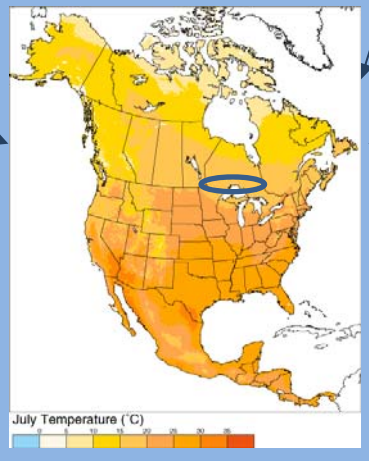
Nekola and Coles (2010)



Vertigo eliator

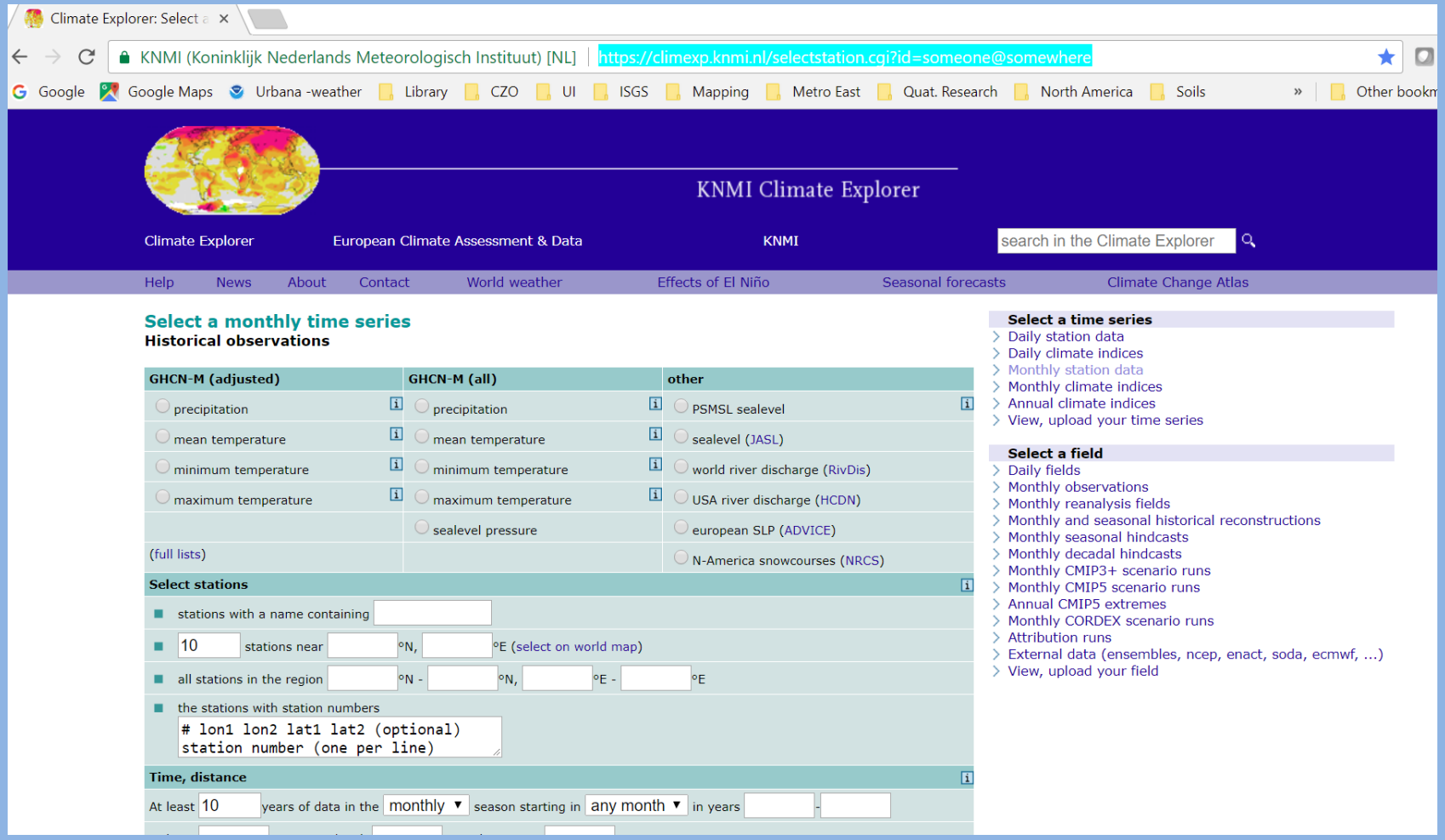


Webbhelix multilineata



approx. mean July
temperature: ~17° to 18° C

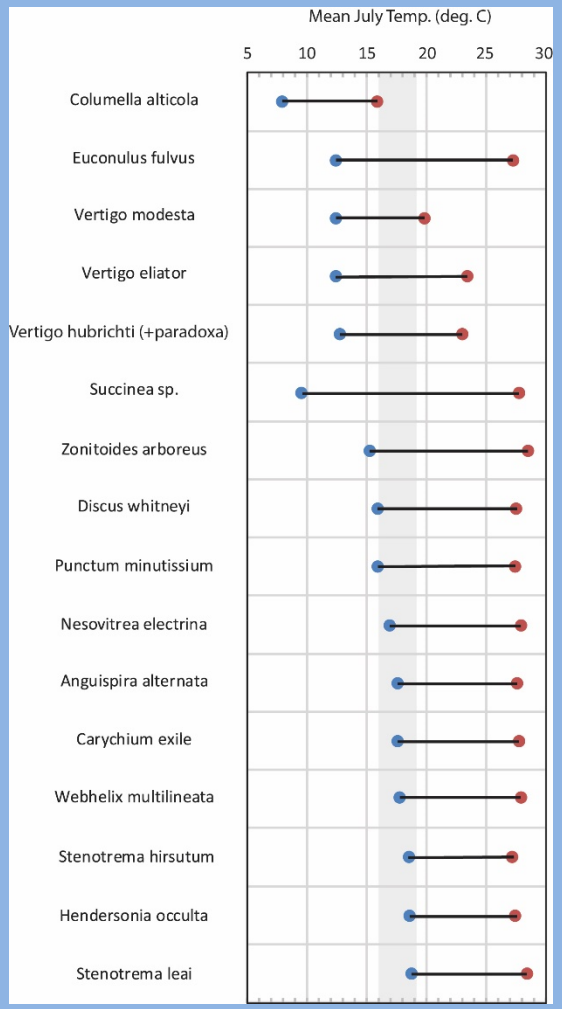
Mutual Climatic Range Method: obtaining climatic data for coldest and warmest modern location by species



https://climexp.knmi.nl/selectstation.cgi?id=someone@somewhere

Mutual Climatic Range Method (non-analog result); Illinois Valley loess

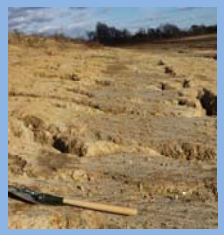
(~ 39.5 to 40 °N lat; ~ 25 to 20 cal ka)

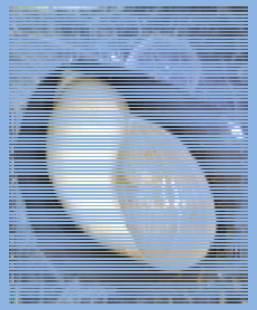


- mean July temp ~ 16 to 19 °C
- LGM ~ 5 to 8 °C cooler than today [24 °C]
- non-analog condition (MCR would be 18 to 20 °C if *Columella alticola* not present)
- either *C. alticola* or other species existed beyond their present-day climatic range (do not coexist together today)

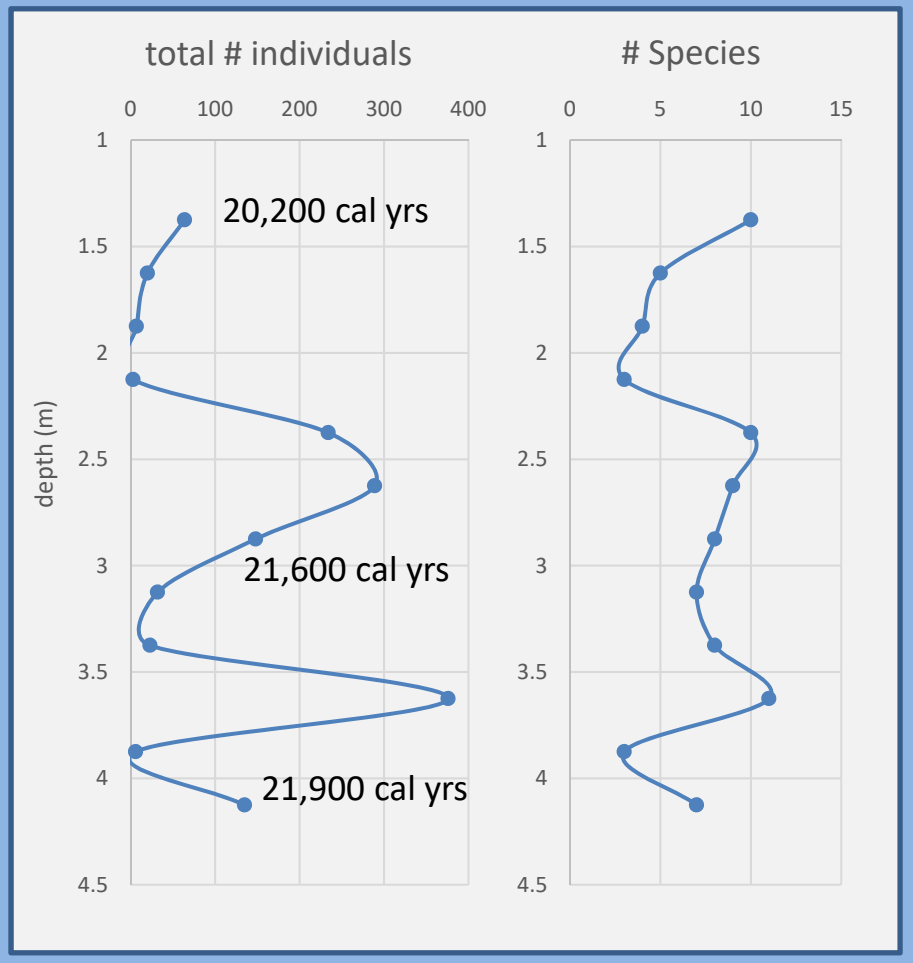
Demazenod Section; Mississippi Valley loess

(~ 38.5 °N lat; St. Louis area; ~ 22 to 20 cal ka)





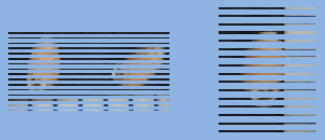
Demazenod Section; Belleville, IL



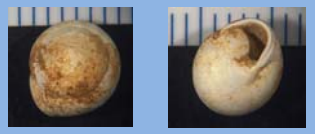
Demazenod Section; MCR

MCR Figure; Demazenod Section (mid-Mississippi Valley)

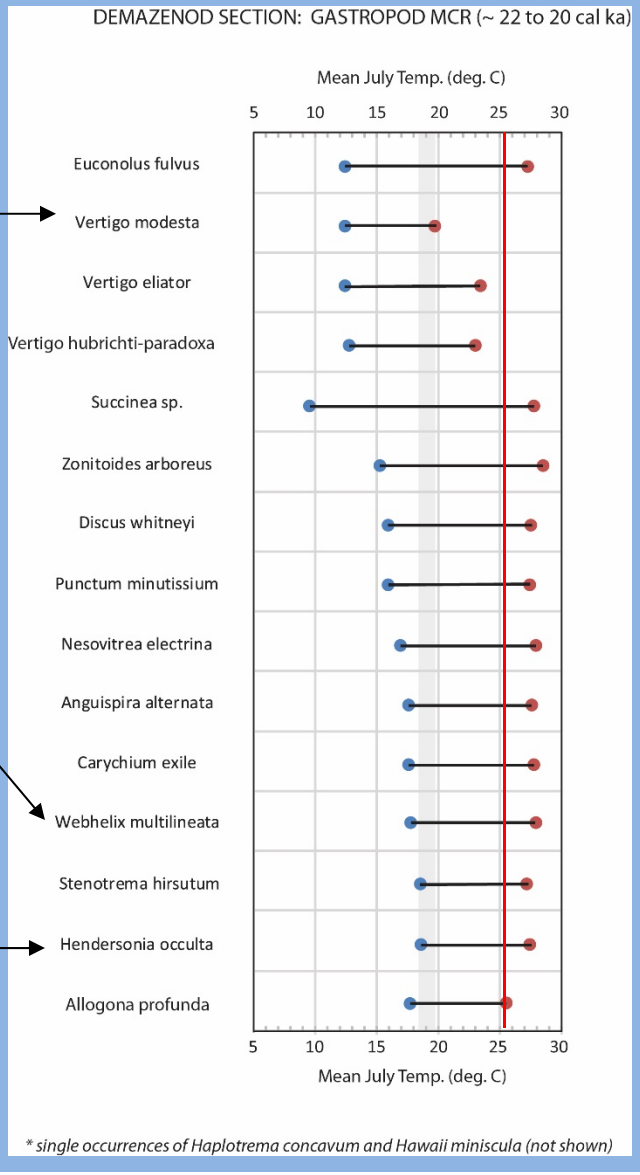
(~ 38.5 °N lat; St. Louis area; ~ 22 to 20 cal ka)



< 19.7 °C
mean July temp.



> 18.5 °C
mean July temp.



estimated LGM mean July temperature:

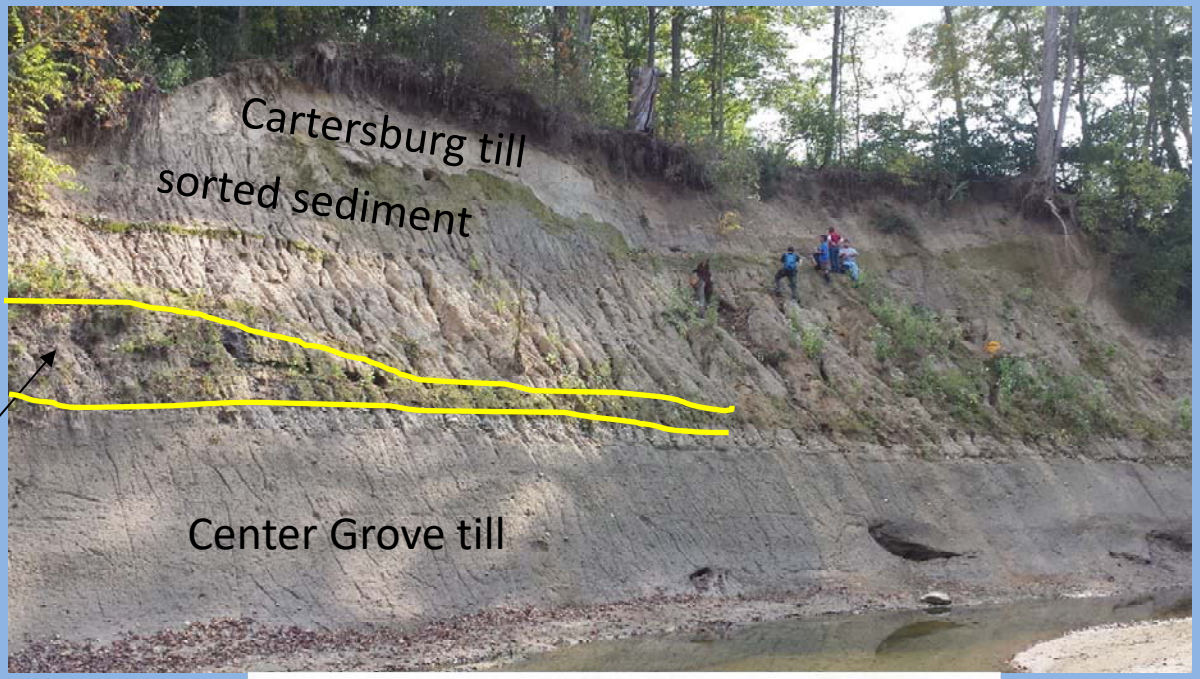
~ 19 °C

Belleville IL mean July temperature (recent):

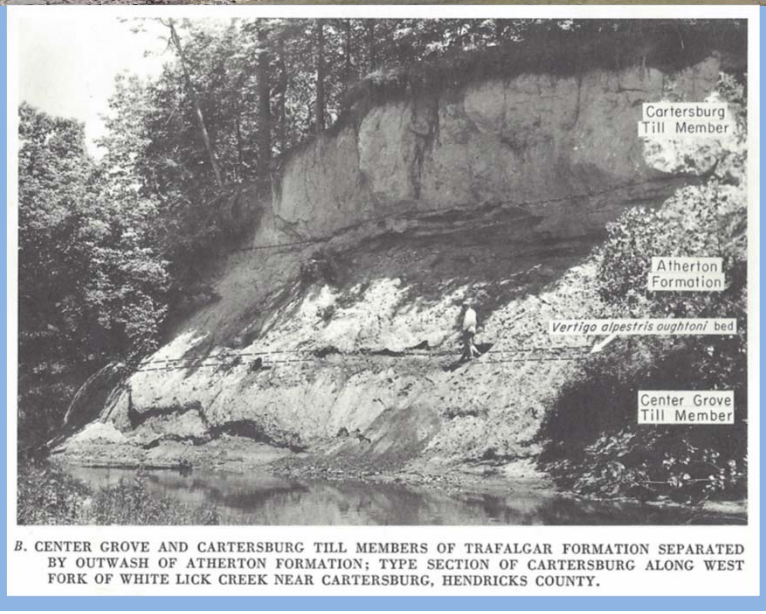
25.5 °C (red line)

LGM was about **6.5 °C cooler than today** in July

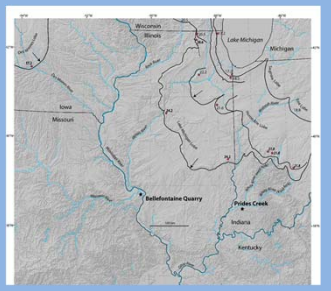
Clayton Section; central Indiana



- fossiliferous silt (resedimented loess)
- with terrestrial snail shells
- ~ 21,800 cal years B.P



B. CENTER GROVE AND CARTERSBURG TILL MEMBERS OF TRAFALGAR FORMATION SEPARATED BY OUTWASH OF ATHERTON FORMATION; TYPE SECTION OF CARTERSBURG ALONG WEST FORK OF WHITE LICK CREEK NEAR CARTERSBURG, HENDRICKS COUNTY.



Terrestrial Gastropod Assemblage: Clayton and Plainfield Sections

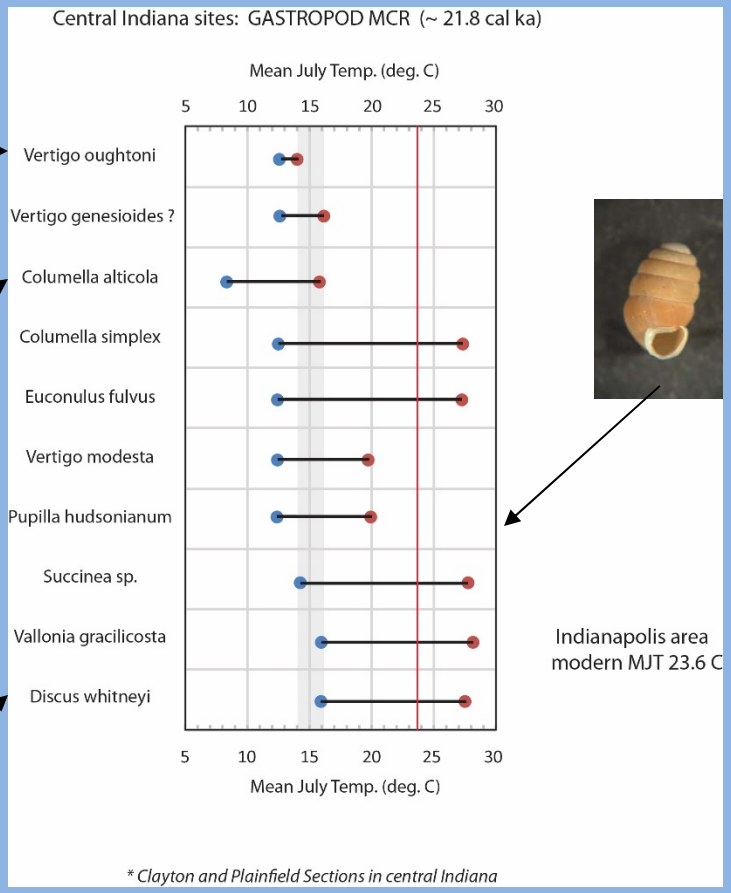
CLAYTON SECTION, INDIANA fauna found between two Wisconsin Episode tills	another 3 meters to till above (ow & silt in between)											
Sample Interval (above base of silt unit; (and gravel lag on till)	Columella alticola	Columella simplex	Discus whitneyi	Euconulus fulvus	Succineidae (Catinella sp.)	Pupilla hudsonianum	Pupilla juveniles	Vallonia gracilicosta	Vertigo modesta	Vertigo oughtoni	juveniles	Total Individuals
80-85 cm (upper)	24	17	34	15	110	29	11	33	75	36	108	492
65-80 cm (middle)	16	1	5	6	144	21	17	12	62	144	13	441
60-65 cm (lower)	1	0	3	0	54	4	0	1	7	20	27	117
Total	41	18	42	21	308	54	28	46	144	200	148	1050
Comments		likely but uncertain			small; shell shape similar to Catinella avara	formerly Pupilla muscorum; Nekola et al., 2014				V. genesioides is new species of Nekola; upcoming paper	juveniles of Vertigo, Discus, Succinea, and Pupilla	

PLAINFIELD SECTION, INDIANA fauna found between two Wisconsin Episode tills; collected by Henry Loope; ids by David Grimley									
Sample Interval	Columella alticola	Discus whitneyi	Euconulus fulvus	Succineidae (cf. Catinella avara)	Pupilla hudsonianum	Vallonia gracilicosta	Vertigo modesta	(?) Vertigo genesioides or oughtoni	Total Individuals
typical size				2 to 6 mm	3 mm		2.5 mm	2 mm	
0-10 cm below till	0	0	0	79	10	0	4	4	97

* boreal forest to mixed boreal tundra environment

MCR Figure; central Indiana silts (loess-derived)

(~ 39.4 to 39.7 °N latitude; Indianapolis area)



Clayton-Plainfield Sections, IN; MCR

estimated mean July temperature (21,500 – 22,000 cal yrs BP) :

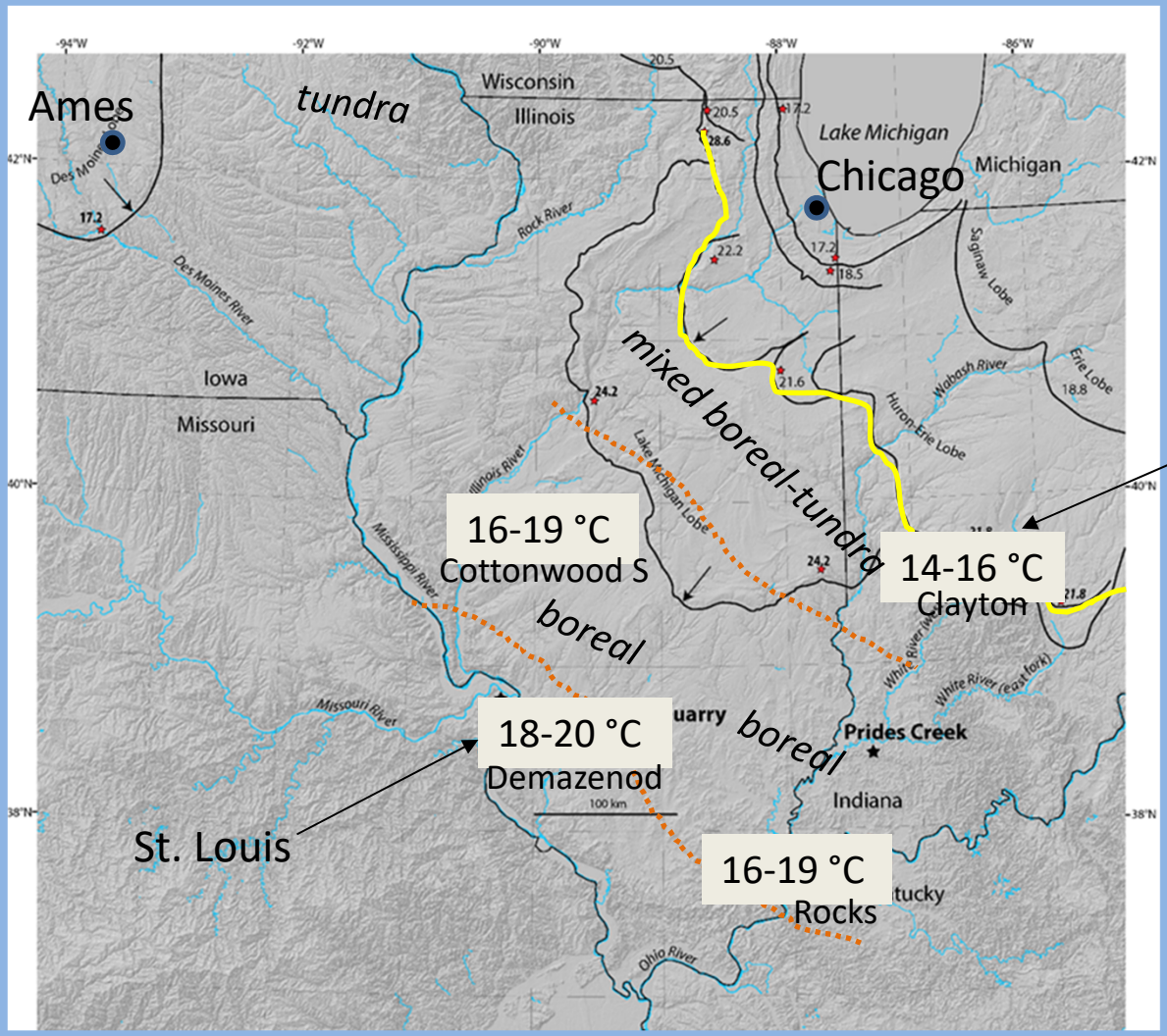
~ 15 °C

Indianapolis mean July temp (recent):

23.5 °C (red line)

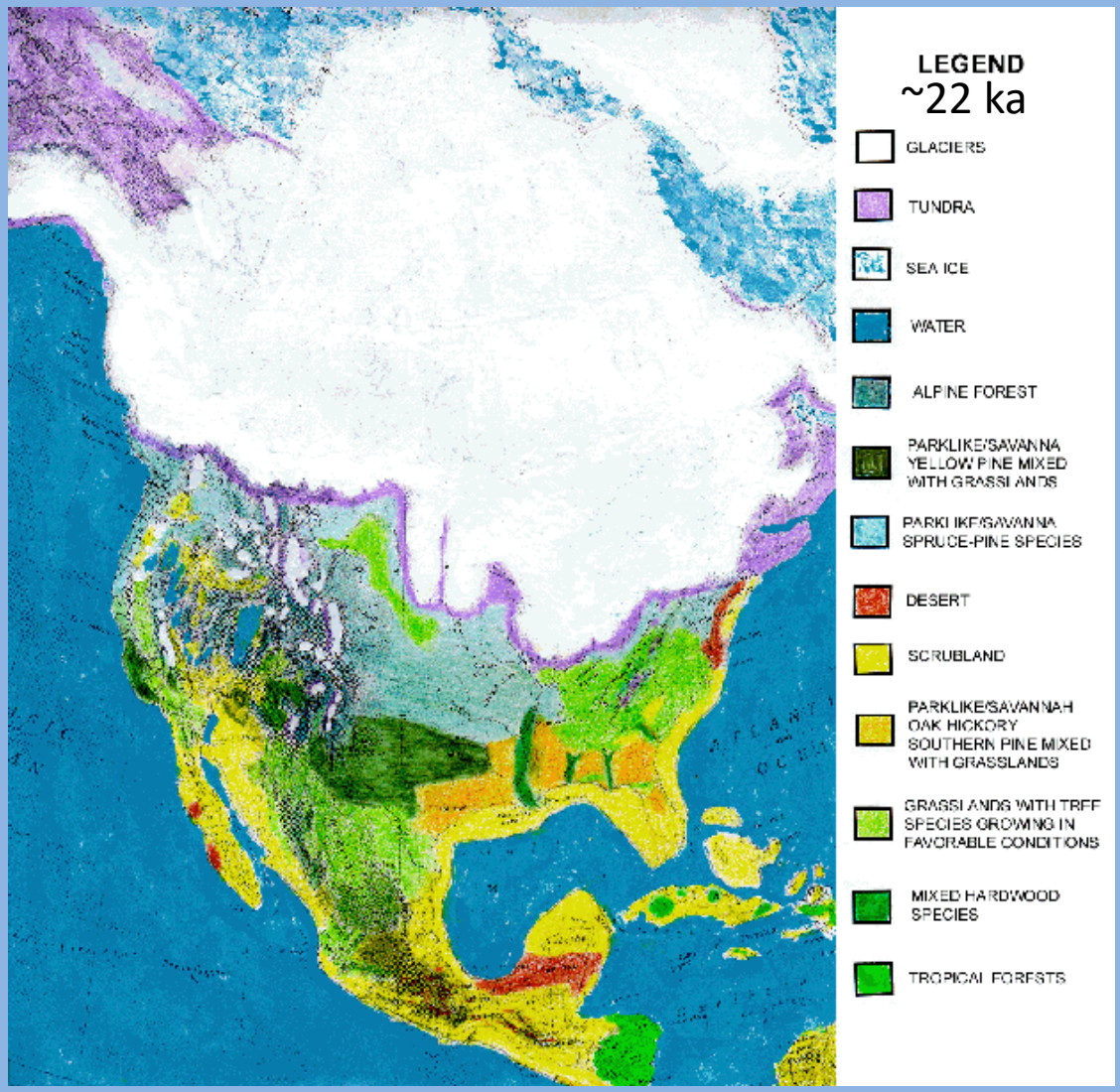
LGM was about **8.5 °C cooler than today** in July

Climatic and ecological gradient: ~ 22,000 to 21,000 years BP



(Rocks Section data from ~ 24,500 cal ka)

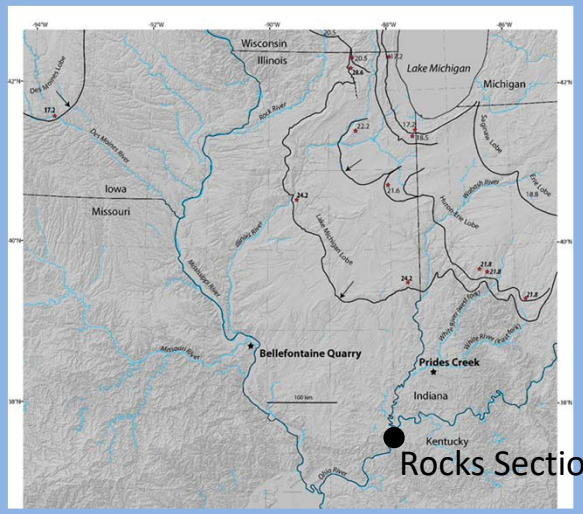
Pollen-based last glacial vegetation map of North America



https://www.srs.fs.fed.us/sustain/report/histry/histry-31.htm
(modified from Delcourt and Delcourt, 1985)

Rocks Section (Peoria loess)

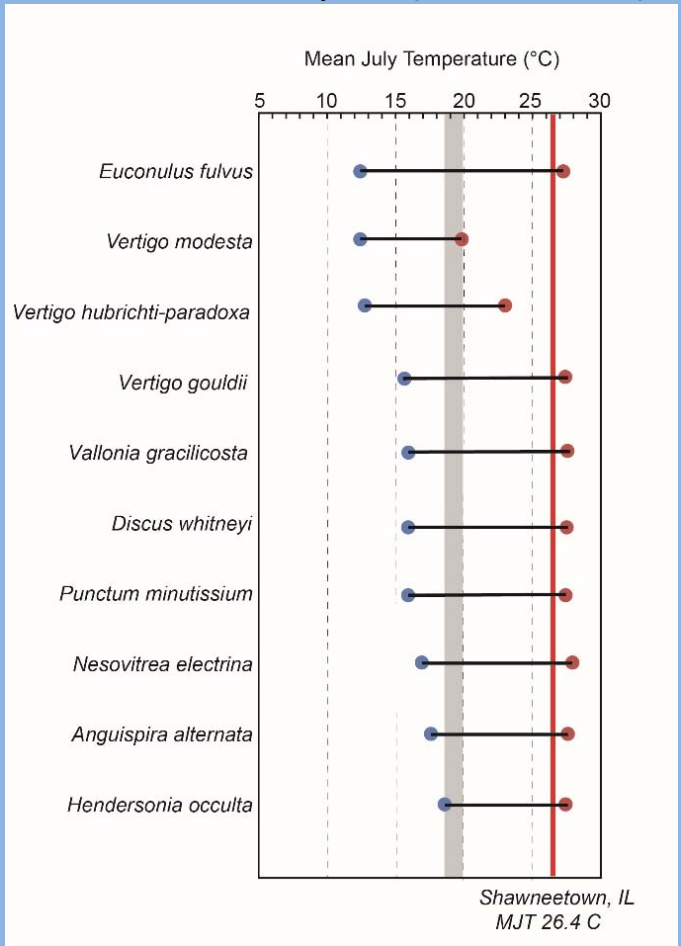
(~ 37.7 deg. N lat; western Kentucky)



MCR; Rocks Section loess (~ 25 cal ka)

(~ 37.7 deg. N lat; western Kentucky)

1.8 to 2.8 m depth (~ 25 cal ka)

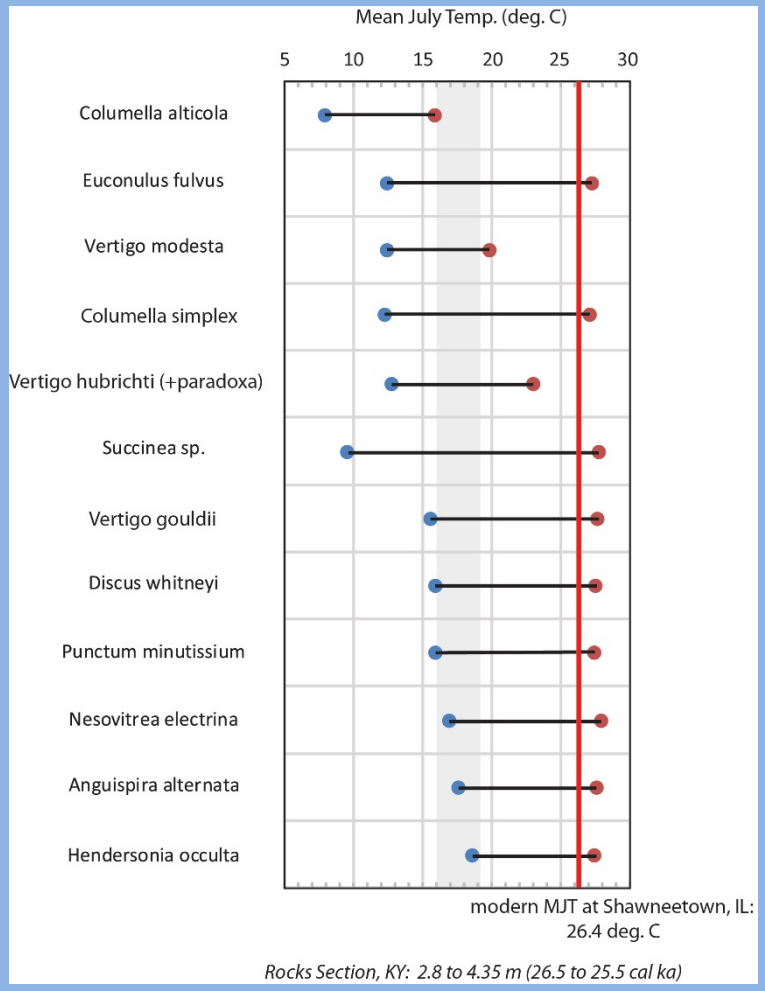


- MJT estimate: **~ 19 °C**
  ~ 24,500 to 25,500 cal yrs ago (LGM)
- about **7 °C** cooler MJT than today (26 °C)

Rocks Section; western KY.....near Shawneetown, IL

MCR; Rocks Section loess (~ 26 cal ka)

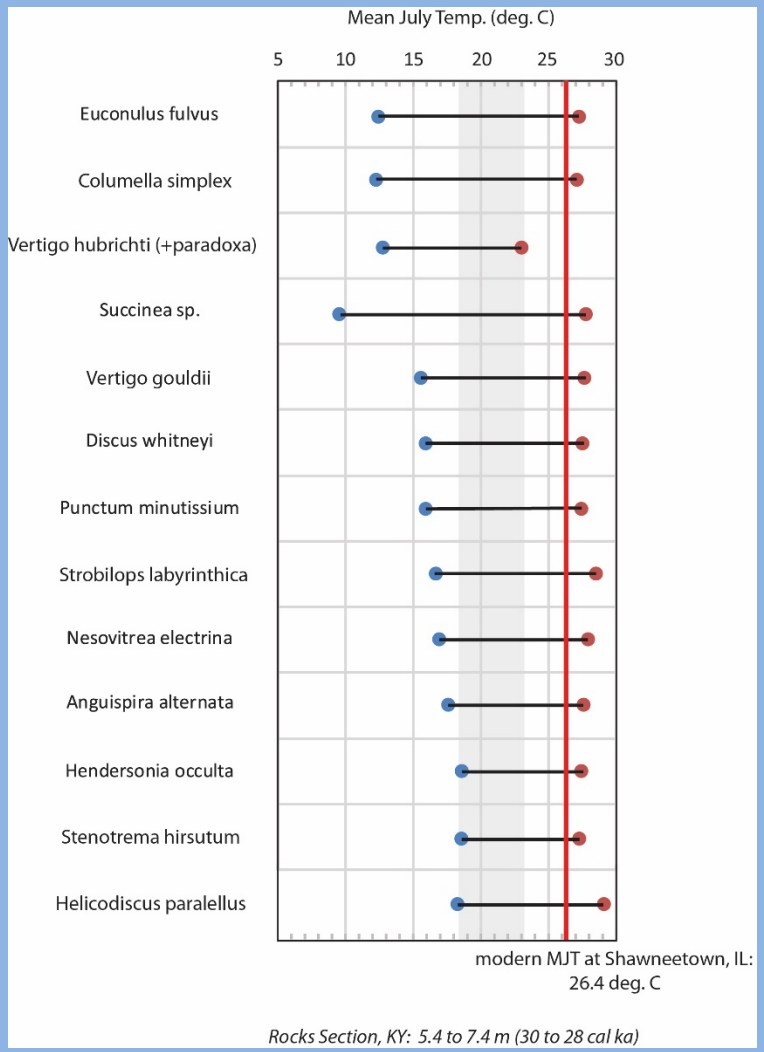
2.8 to 4.35 m depth (~ 26 cal ka)



- MJT estimate: **16 to 19 °C**
  ~ 25,500 to 26,500 cal yrs ago (LGM)
- about **7 to 10°C** cooler July temperature than today (26 °C)

MCR; Rocks Section loess (~ 28 to 29 cal ka)

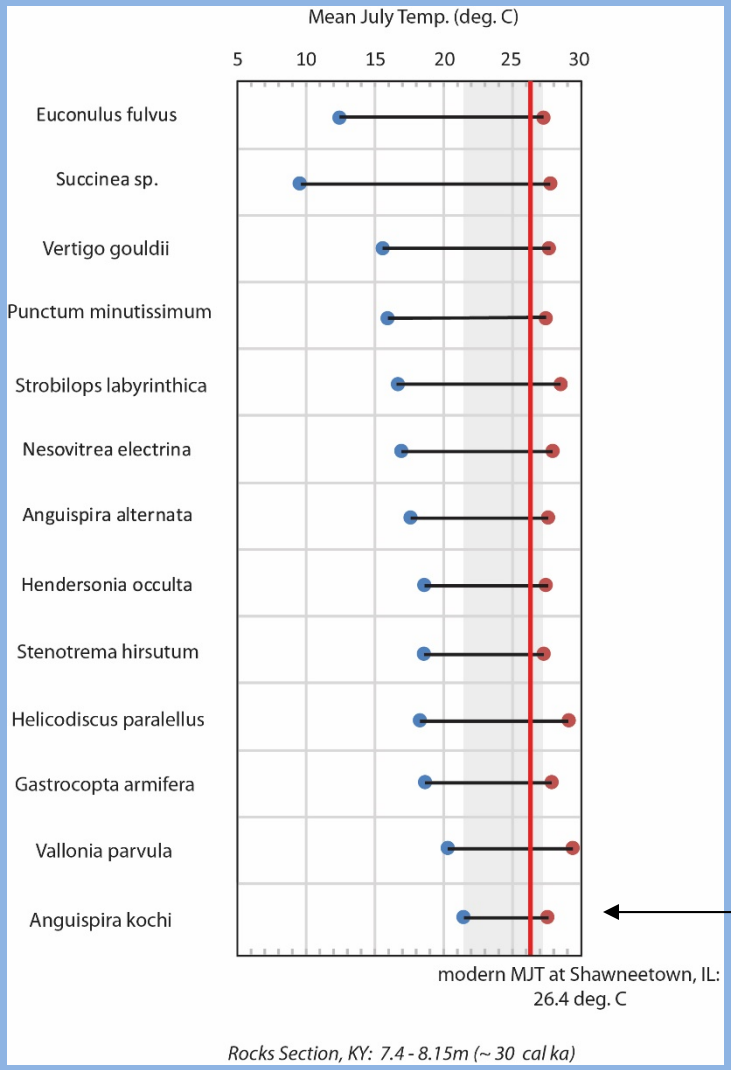
5.4 to 7.4 m depth



- MJT estimate: **18.5 to 23 °C**
  ~ 27,500 to 29,500 cal yrs ago (LGM)
- about **3 to 8 °C** cooler July temperature than today (26 °C)

MCR; Rocks Section loess (~ 30 cal ka)

7.4 to 8.15 m depth



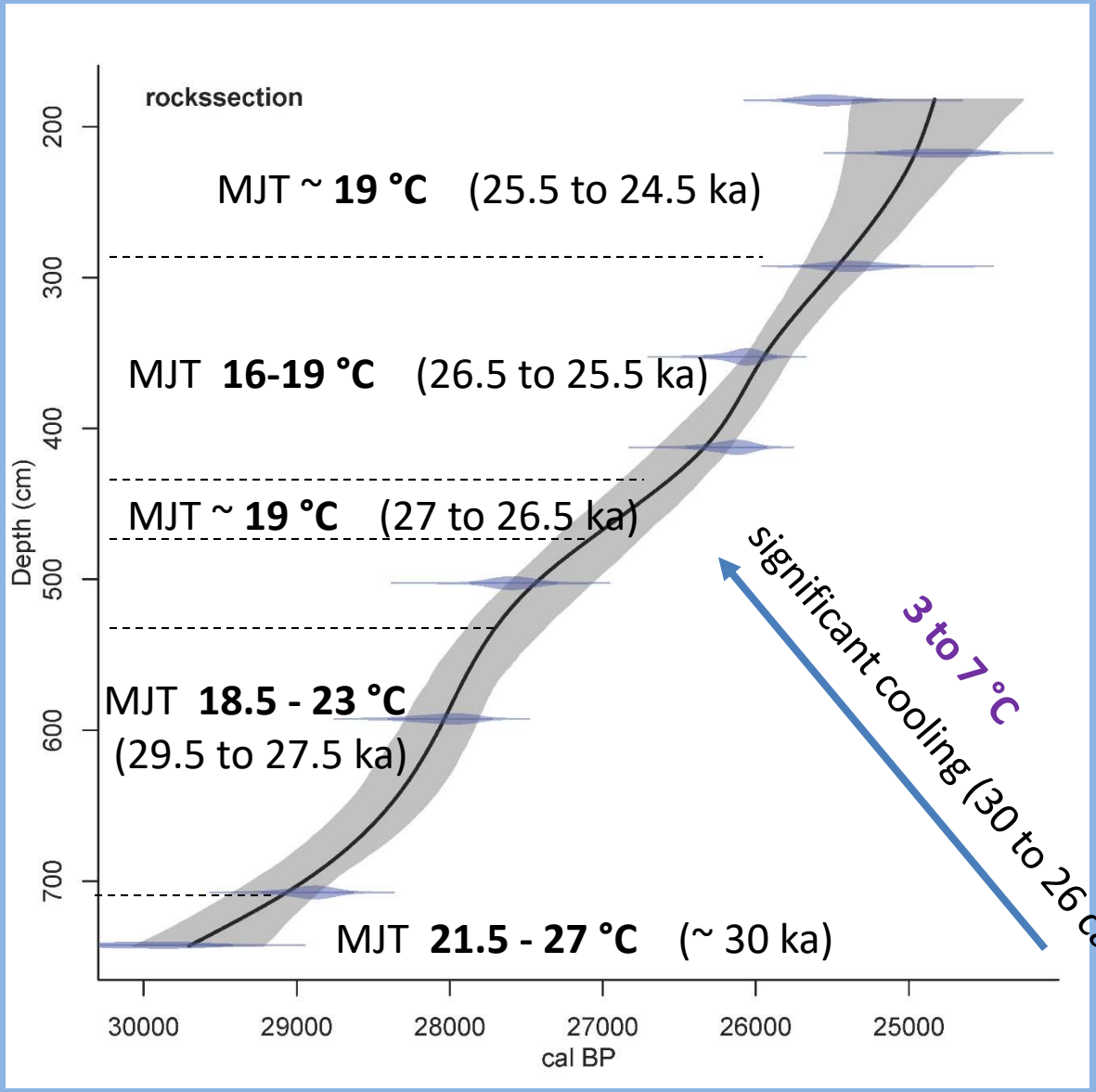
- MJT estimate: **21.5 to 27 °C**
  ~ 29,500 to 30,500 cal yrs ago (LGM)
- about **0 to 4.5 °C** cooler July temperature than today (26 °C)

Anguispira kochi
> 21.4 °C MJT

Rocks Section (western Kentucky) paleoclimate history (30 to 24 cal ka)

Peoria Silt

Peoria-Roxana Silt transition



Summary

- **overall LGM paleoclimate** (~ 22 to 21 cal ka):

  MJT ~ 15 °C (Indianapolis) to ~19 °C (St. Louis)

  today 23.5 °C 25.5 °C

- **~ 6 to 9 °C cooler MJT during LGM than today**
  - regional climatic gradient (NE-SW) about double that of today
  - likely relates to proximity of glacial margin

- **boreal (StL) to boreal-tundra (Indy) ecosystem** (based on snails, plant macrofossils)

- **3 to 7 °C MJT cooling during approach to LGM** (30 to 26 cal ka)

  (based on terrestrial gastropod mutual climatic range method)

- more studies needed along other Midwest valley segments (project ongoing!)

- *David A. Grimley, Caitlin Lebel, Sarah Dendy, Jessica L. Conroy, Henry M. Loope*
-
- High resolution chronologies from terrestrial gastropods in last glacial loess sequences in the midcontinental USA (Peoria Silt; 30–16 cal ka) provide a means to evaluate temporal and spatial variations in sedimentation rates, climate, and environments. From a loess-paleosol section in western Kentucky, stratigraphic changes in gastropod assemblages imply climatic cooling at 29 ka and again at 27 ka, leading into the last glacial maximum. At 30 ka, a temperate summer climate (MJT > 21°C) and forested ecosystem is implied by a diverse assemblage (15 species) that includes *Anguispira kochi–Gastrocopta pentodon–Helicodiscus parallelus*. At 29–27 ka, the assemblage includes *Discus whitneyi*, *Hendersonia occulta* and *H. parellelus*, but lacks *A. kochi* and *Gastrocopta*. After 27 ka, the introduction of *Columella alticola*, *Vertigo modesta*, and *Vallonia gracilicosta* and disappearance of *Helicodiscus* records a shift to substantially colder (MJT 15–19 °C), boreal conditions. Finer-scale variability in species composition, sedimentation rates, and weak paleosol development may record multi-centennial fluctuations in climate and/or glacial lobe margins.

- A strong NE-SW regional climatic gradient at 22–21 cal ka (during last glacial maximum) is suggested by contrasting gastropod assemblages from central Indiana to southwestern Illinois. Resedimented loess between till units in central Indiana (Clayton and Plainfield Sections) contains abundant cold tolerant species *Vertigo modesta-V. oughtoni-Columella alticola,* reflecting boreal to borderline tundra conditions near the ice margin. At the same latitude (40°N) in loess along the Illinois Valley, the assemblage transitions to a more diverse one, with only rare *V. modesta* and *C. alticola* and more southern species. In southwestern Illinois (St. Clair County), the loess fauna has few cold-climate species but contains *W. multilineata*, *Allogona profunda*, and *Stenotrema hirsutum*, suggesting more temperate conditions. We thus envision a steep paleoclimatic gradient from present-day Indianapolis (MJT 14–16°C) to St. Louis, Missouri (MJT 18–20°C). These interpretations are complementary to plant macrofossil and regional pollen records, but enable a more detailed characterization of environmental change across the central USA during the last glacial maximum.