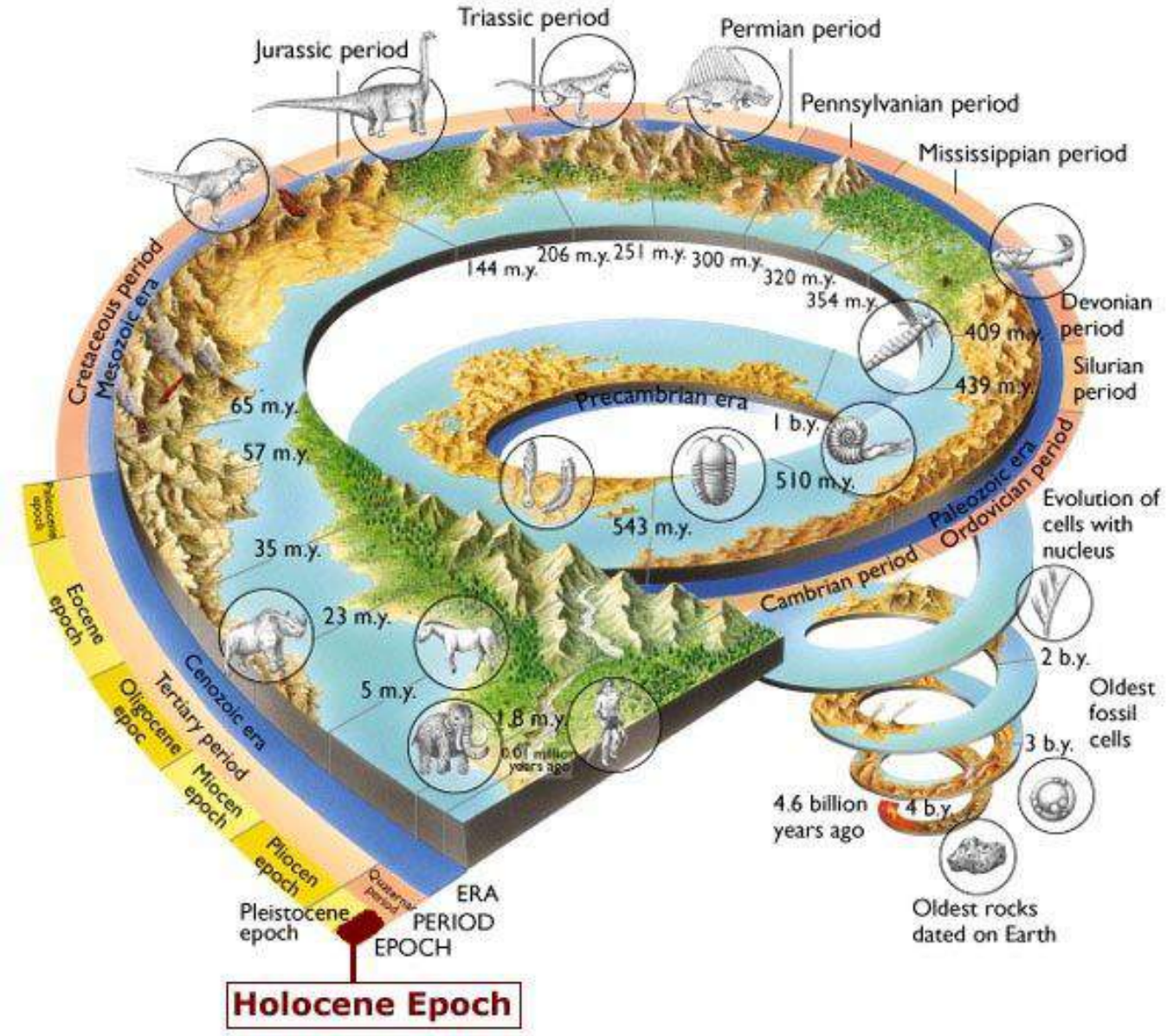
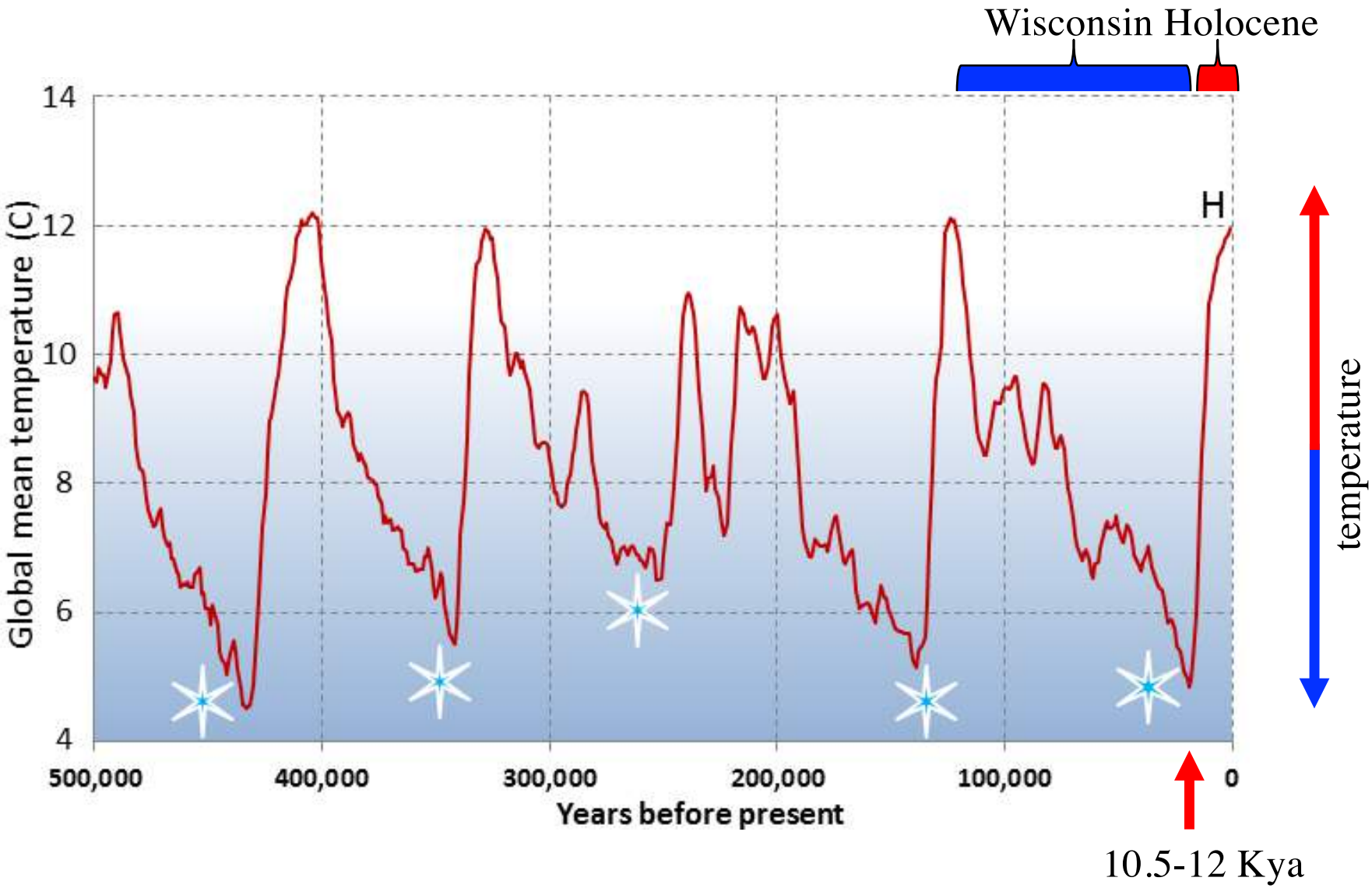
Assembly of the Great Lakes Flora and Vegetation

. . . Pleistocene refugia and the Holocene . . .

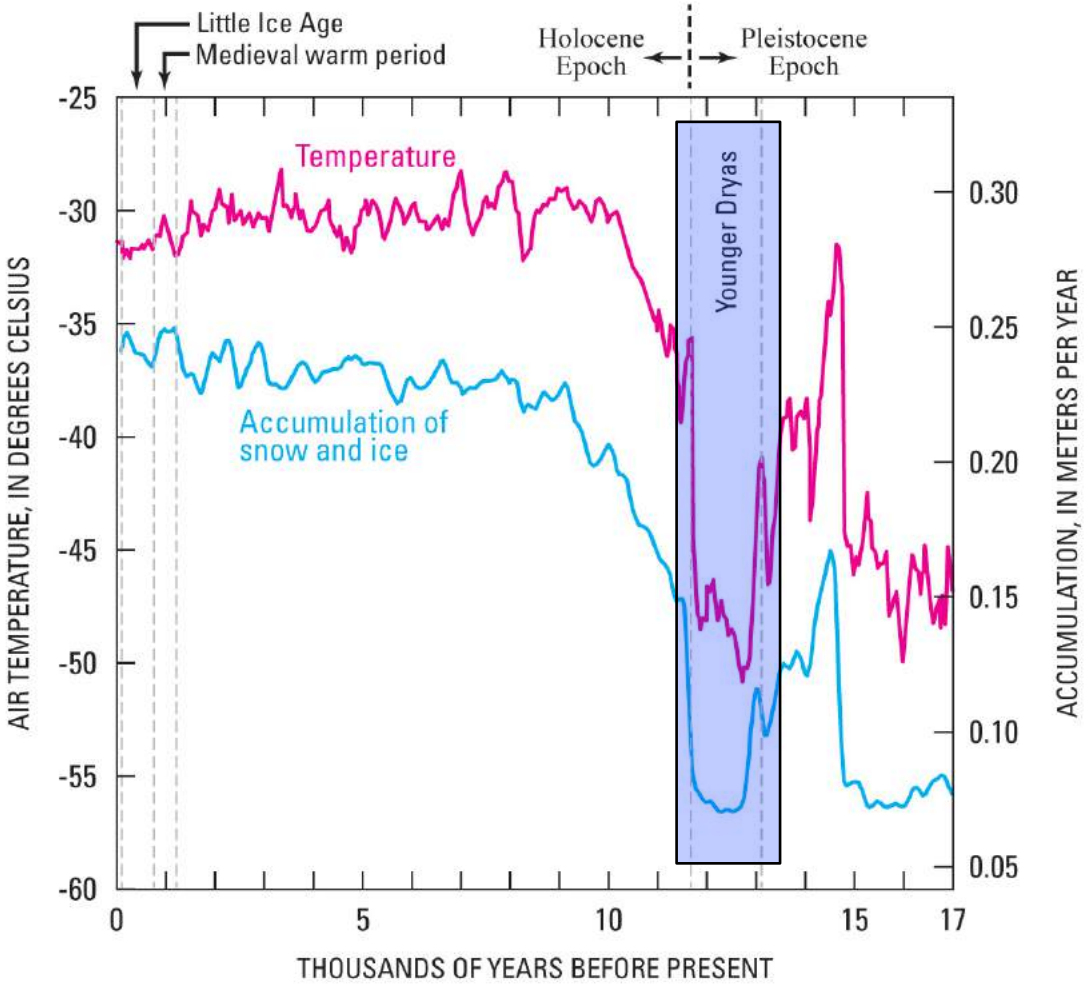
Geological Timeline:
moving onto land and to the Great Lakes



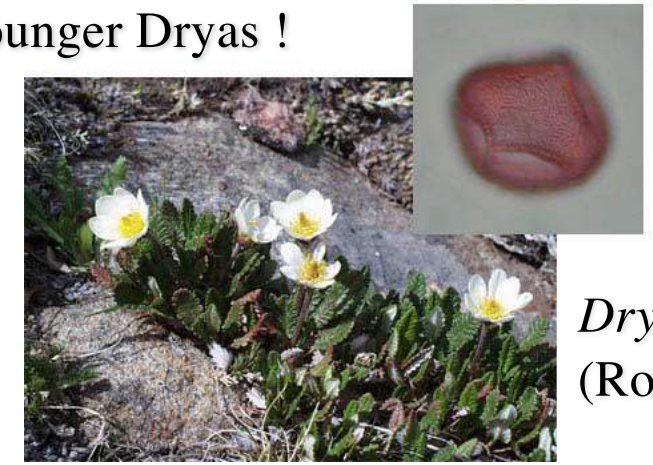
Pleistocene & Holocene Climate



Pleistocene & Holocene Climate



- Younger Dryas !

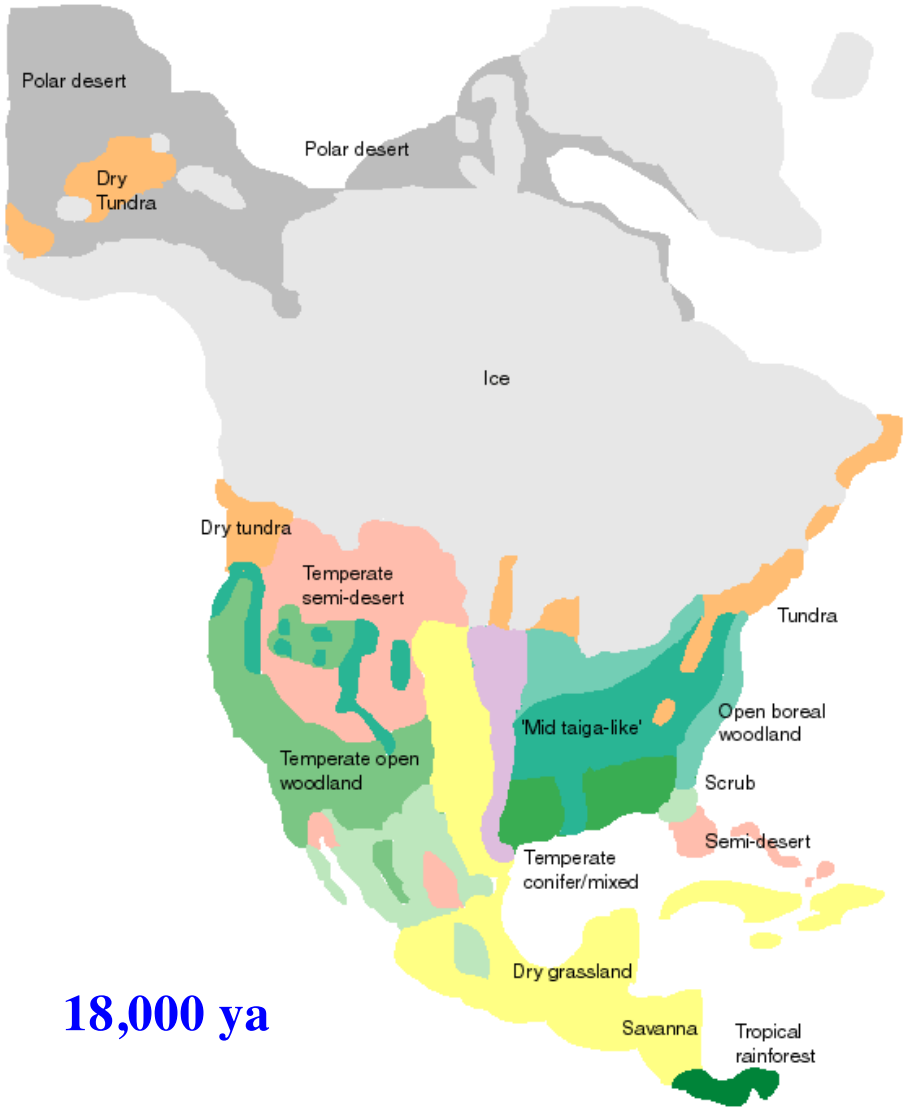


Dryas (Rosaceae)

12,000 ya

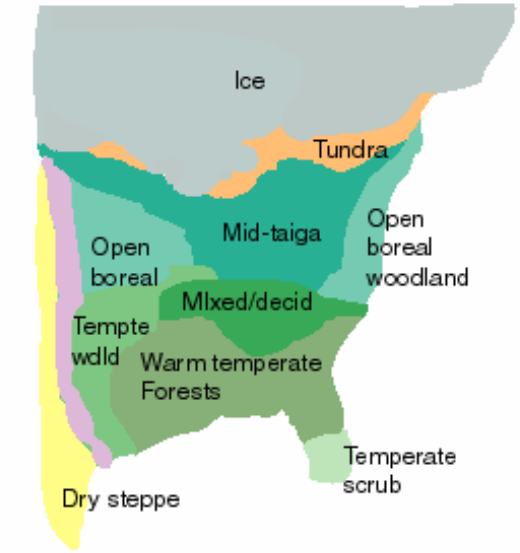
St. Lawrence Seaway exposed for cold melt water runoff

Pleistocene Refugia ?



18,000 ya

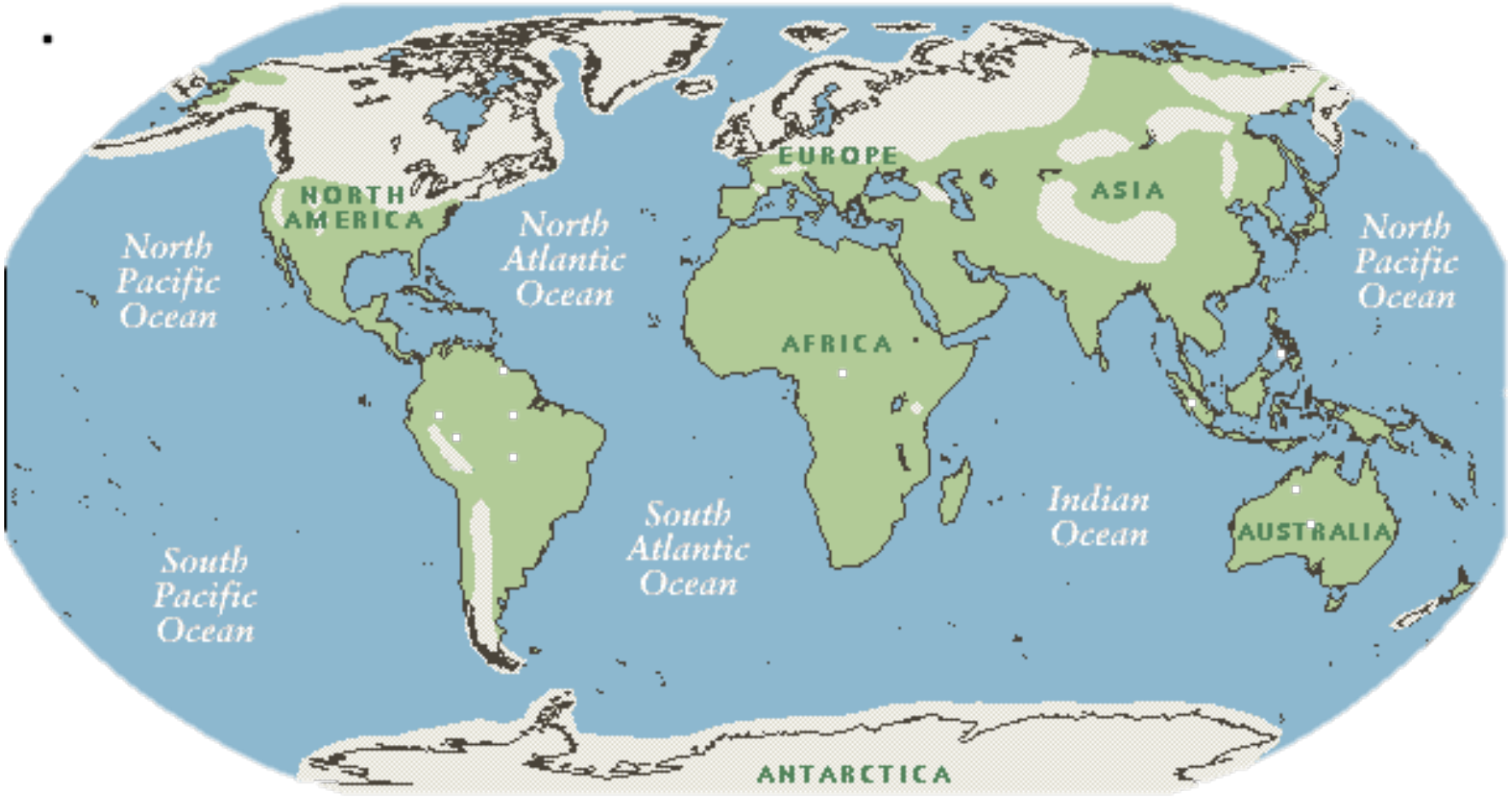
- Extensive boreal forest zone S to 33° N
- Mixed deciduous forest zone near Gulf
- 18,000 ya harshest conditions; zones were further north earlier



28 - 25,000 ya

Pleistocene Refugia ?

Presence of survivia or refugia of these plants and animals *south* of the ice has been a major contention — are there consistent areas of refuge during the Pleistocene?



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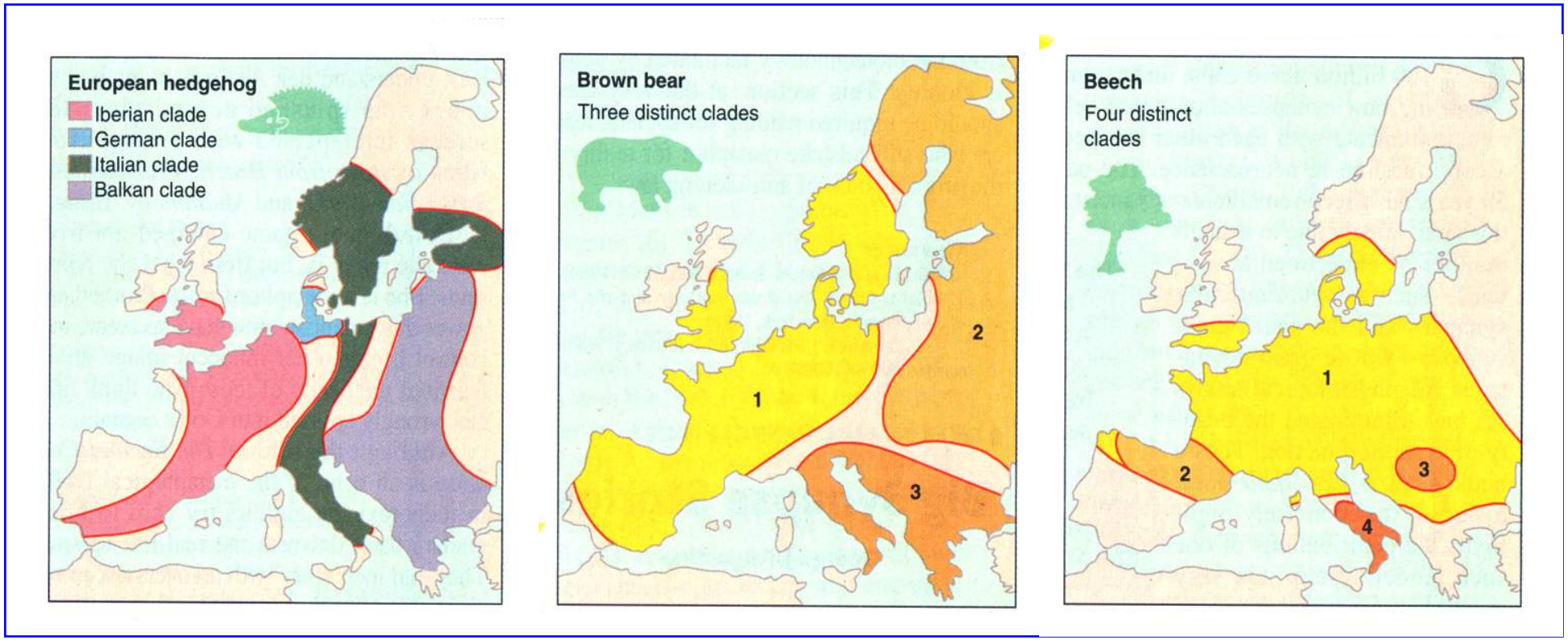


Yes - plant and animal phylogeographic studies provide congruent areas of centers of genetic diversity in Europe

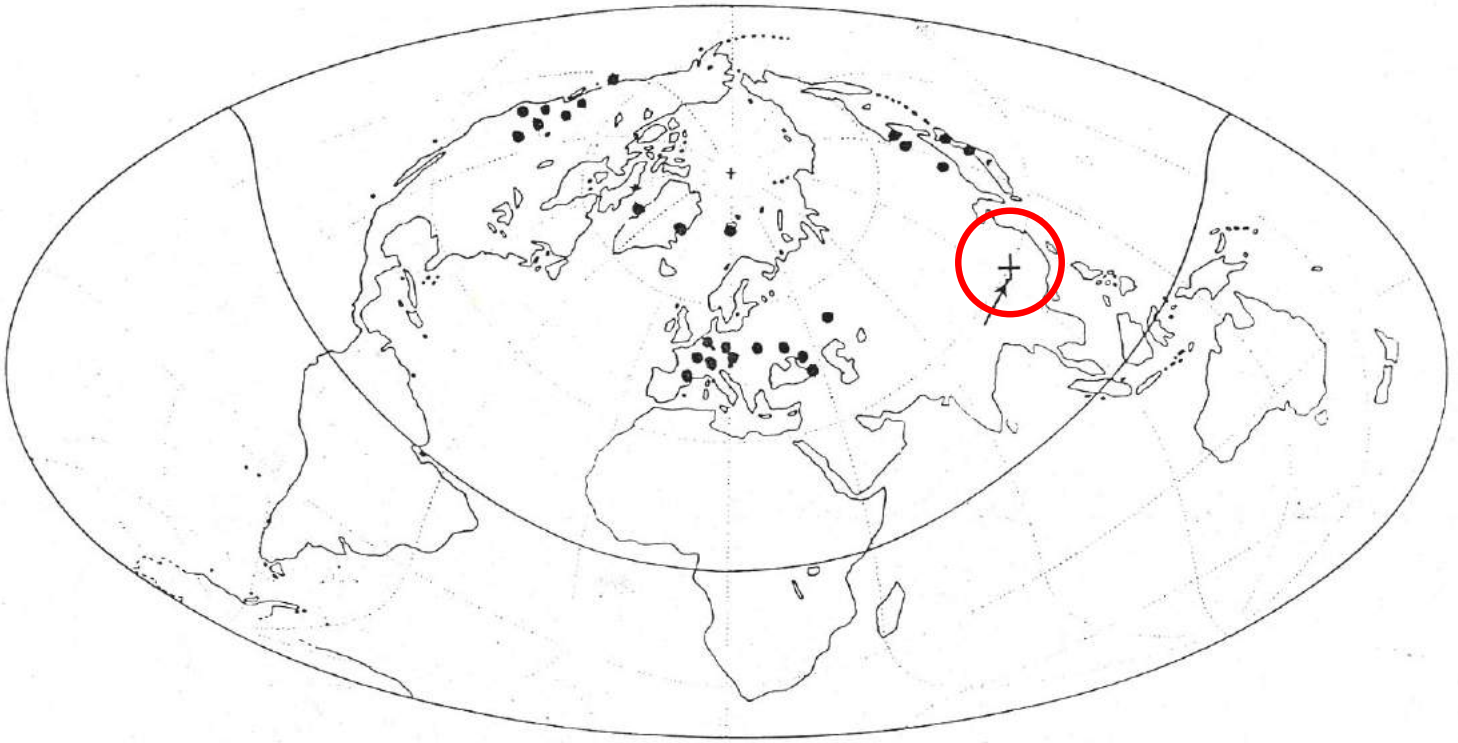
Pleistocene Refugia ?

Phylogeography of a living fossil: Pleistocene glaciations forced *Ginkgo biloba* L. (Ginkgoaceae) into two refuge areas in China with limited subsequent postglacial expansion

Wei Gong [a,b,c], Chuan Chen [a,b], Christoph Dobeš [c], Cheng-Xin Fu [a,b,*], Marcus A. Koch [c,*]

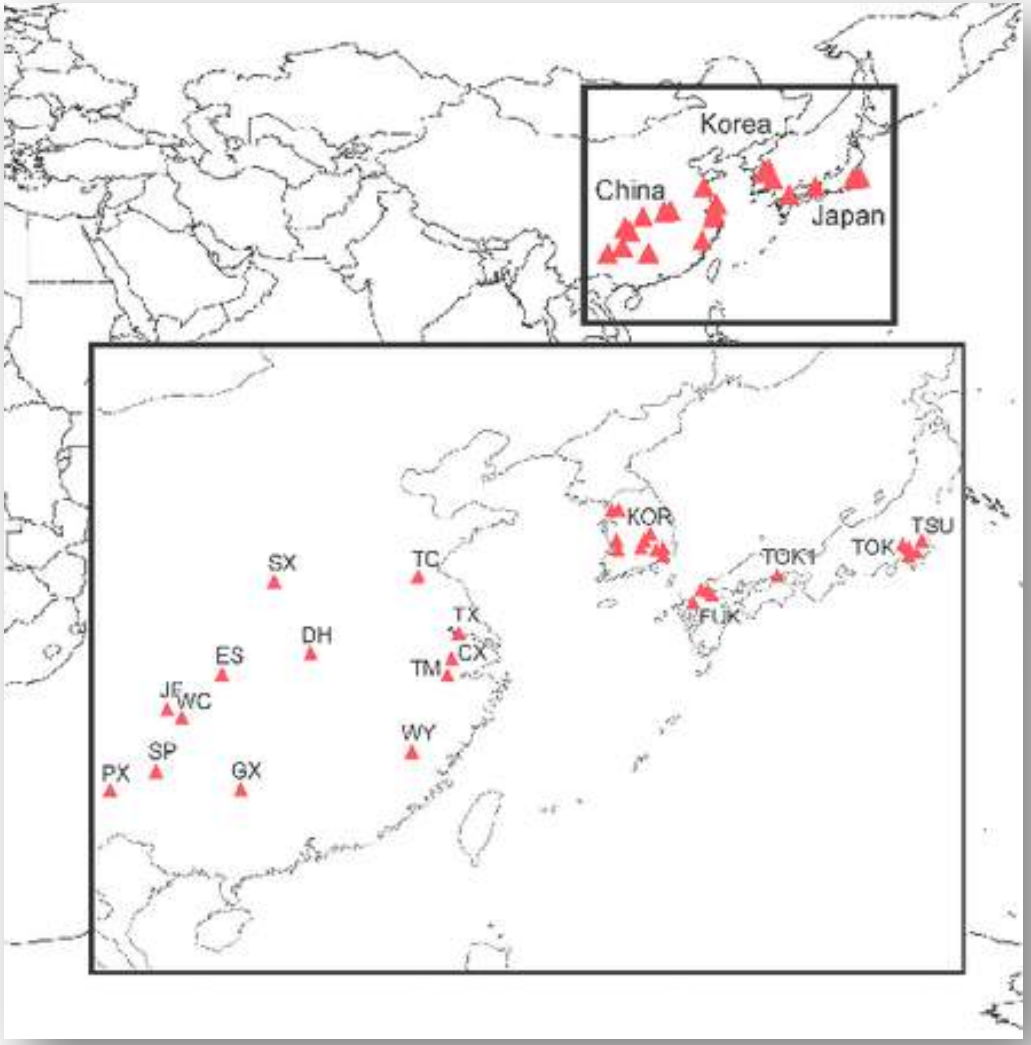
2008 – Molecular Phylogenetics and Evolution

Ginkgo fossil from
Washington, USA – 49 mya



Ginkgo, now confined to China, had a wide Holarctic distribution from the Paleocene into the Neogene as indicated by fossil localities (●)

Pleistocene Refugia ?

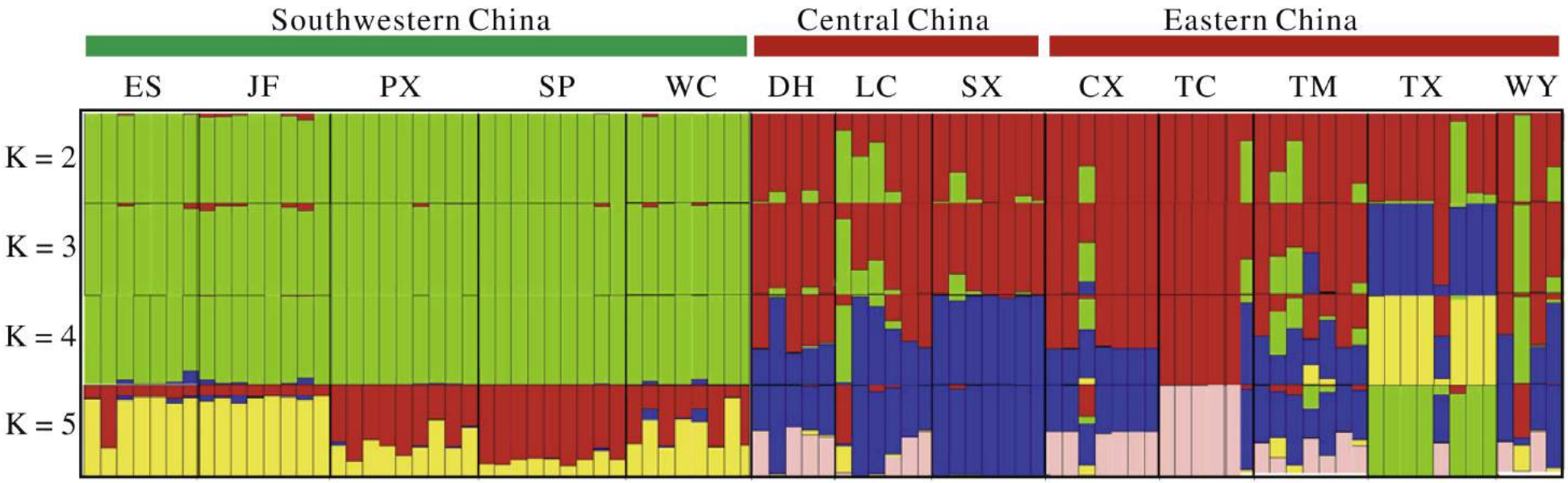


Ginkgo "native" distribution in China and "introduced" distribution in Japan

1,400 year old *Ginkgo* in Gu Guanyin Buddhist Temple in the Zhongnan Mountains, China

Pleistocene Refugia ?

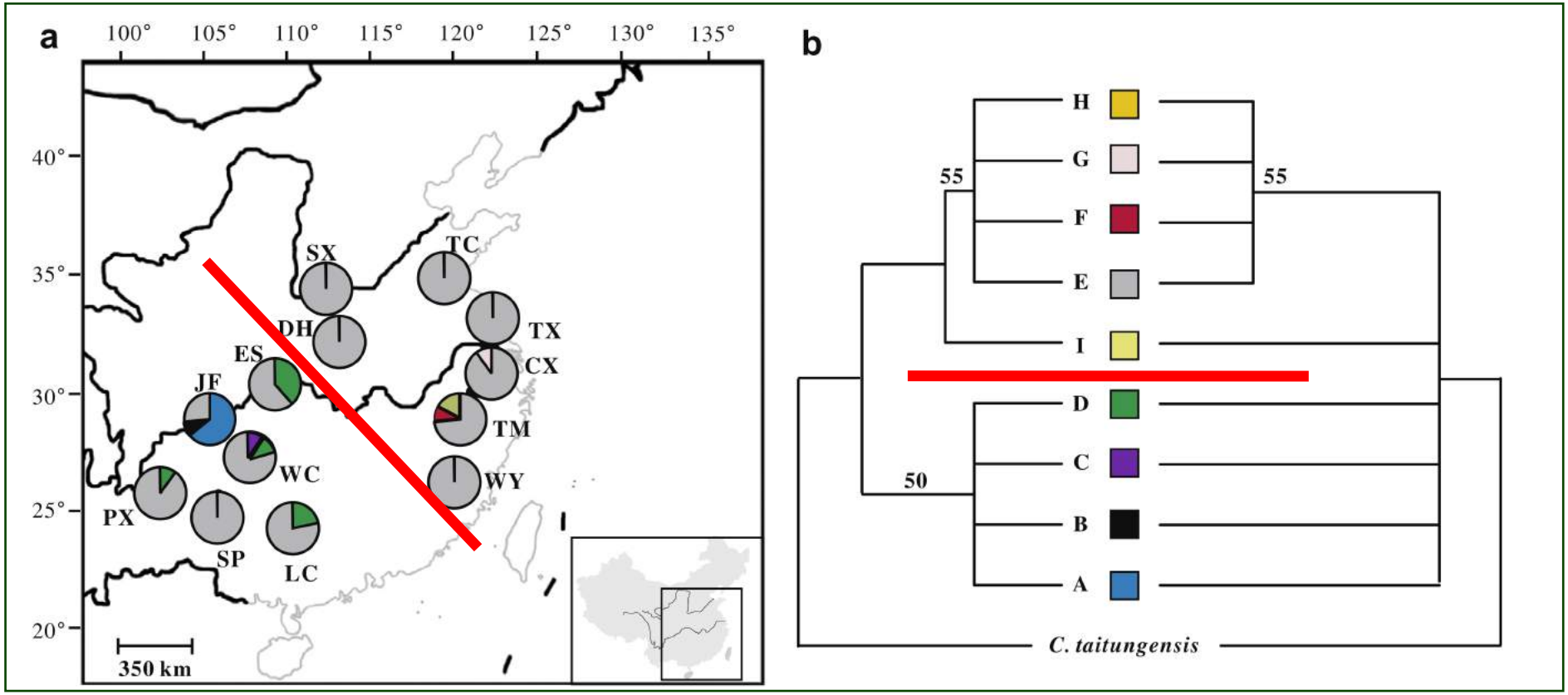
Is there genetic evidence of a Pleistocene refugium?



AFLP variation indicates two strongly differentiated set of populations – southwestern China and east-central China

Pleistocene Refugia ?

Is there genetic evidence of a Pleistocene refugium?

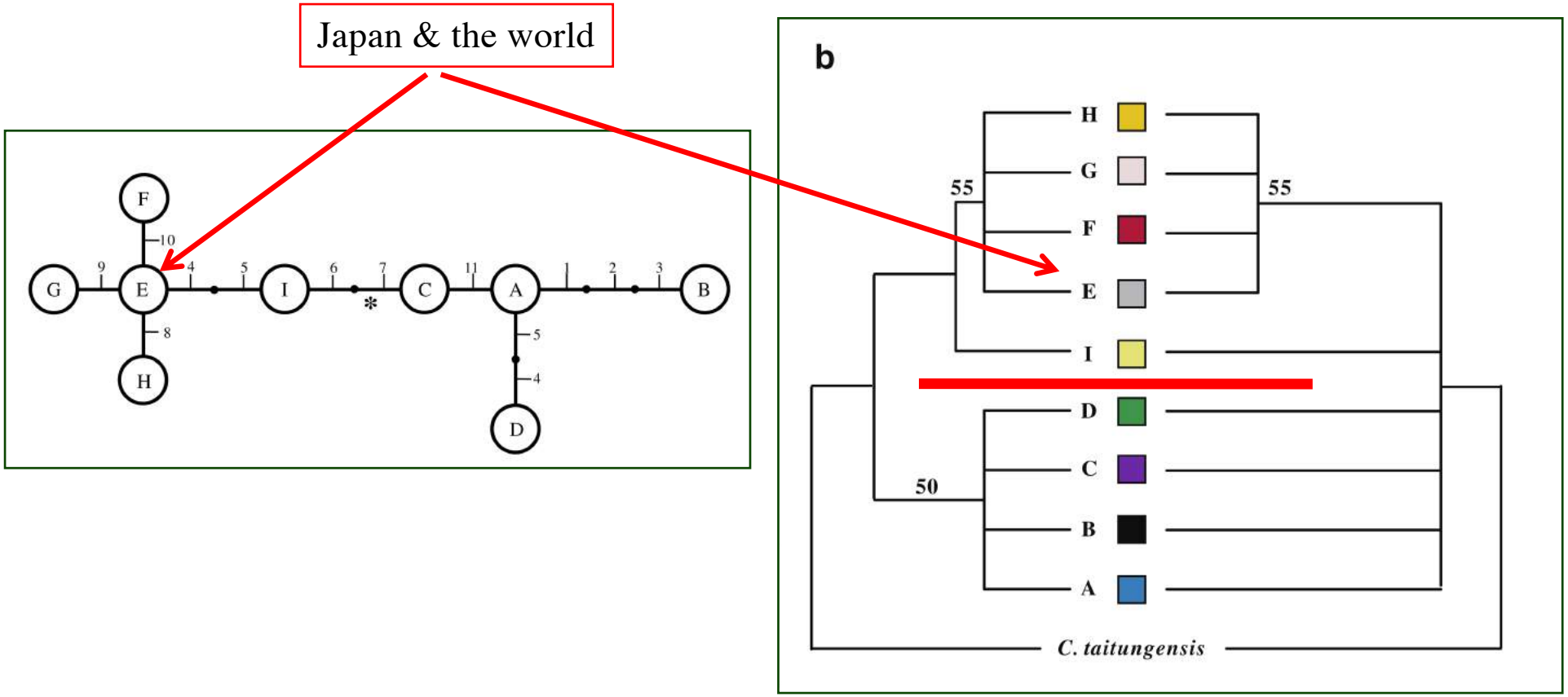


AFLP and cpDNA haplotypes indicate two refugia – southwestern China and east-central China

Pleistocene Refugia ?

Is there genetic evidence of a Pleistocene refugium?

Is there genetic evidence of human movement to Japan and later the world?



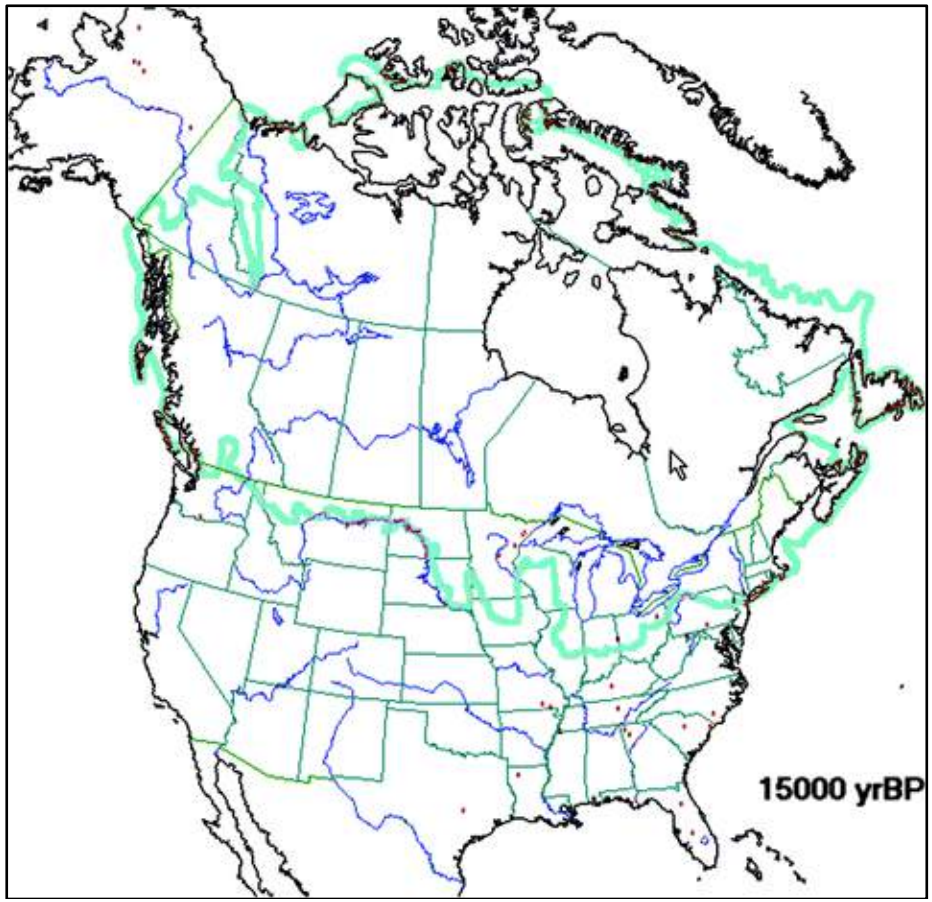
Haplotype E is the only Chinese haplotype found in Japan and the rest of the world – derived originally from east-central China

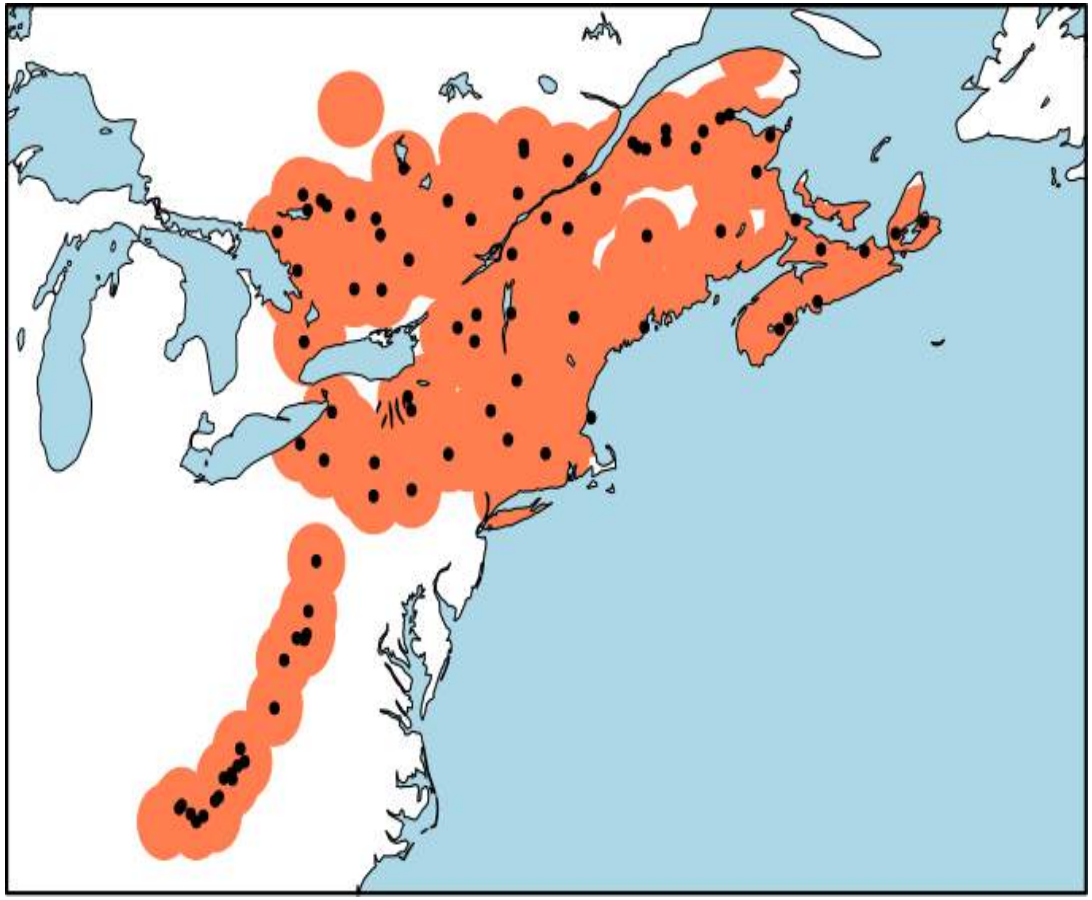
Pleistocene Refugia ?

Phylogeography of a widespread eastern North American shrub, *Viburnum lantanoides*

Brian Park[1,2,3] and Michael J. Donoghue[1]

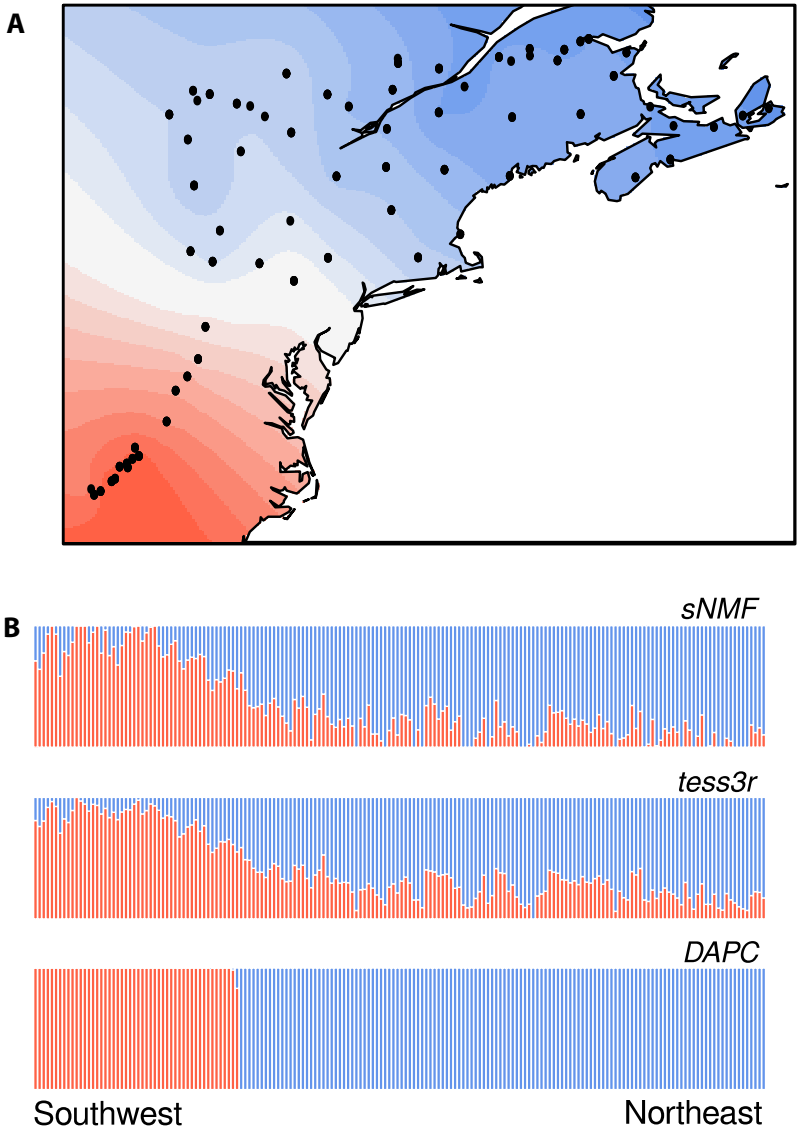
American Journal of Botany 2019



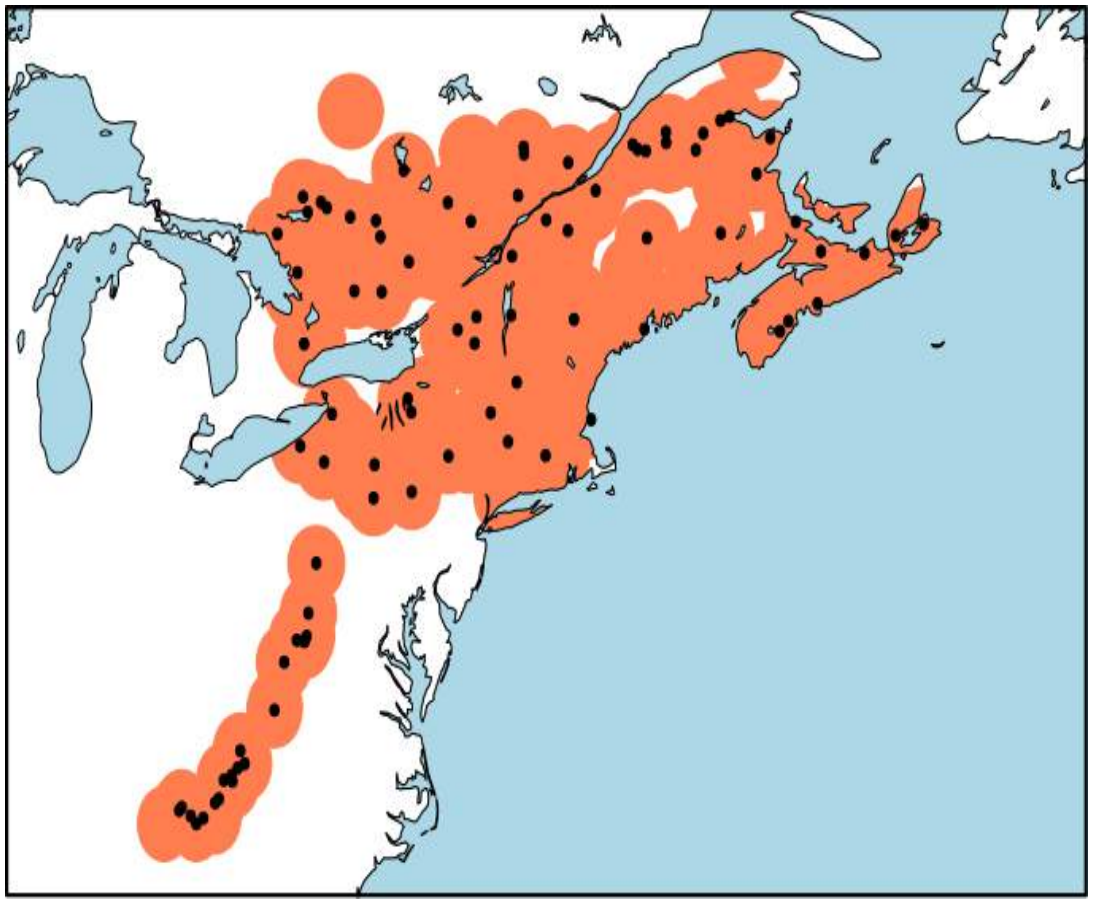


Pleistocene Refugia ?

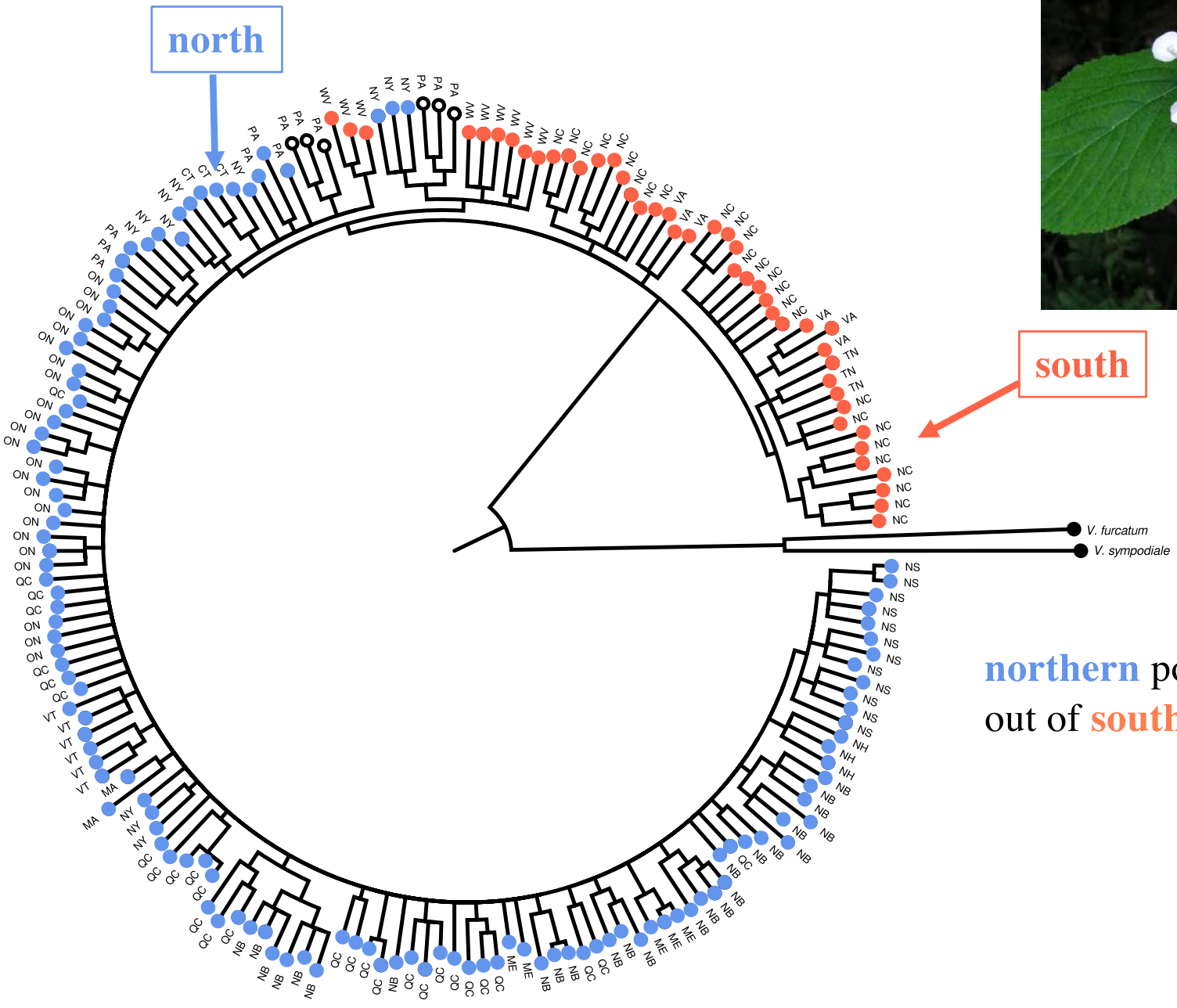
RADseq genetic structure analysis



- **south** - Appalachian
- **north** – mostly glaciated



Pleistocene Refugia ?



northern populations derived out of **southern** populations

Pleistocene Refugia ?

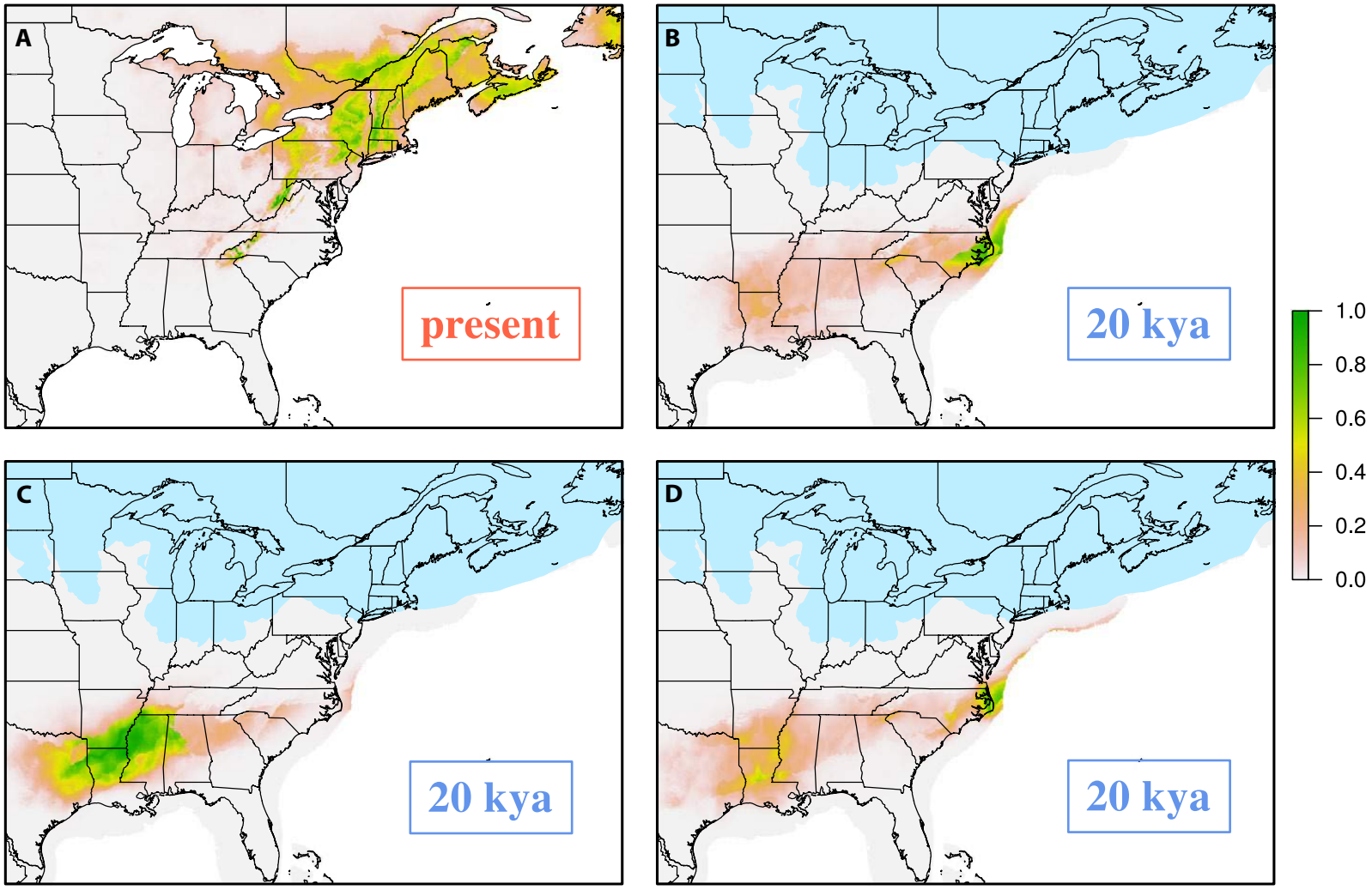
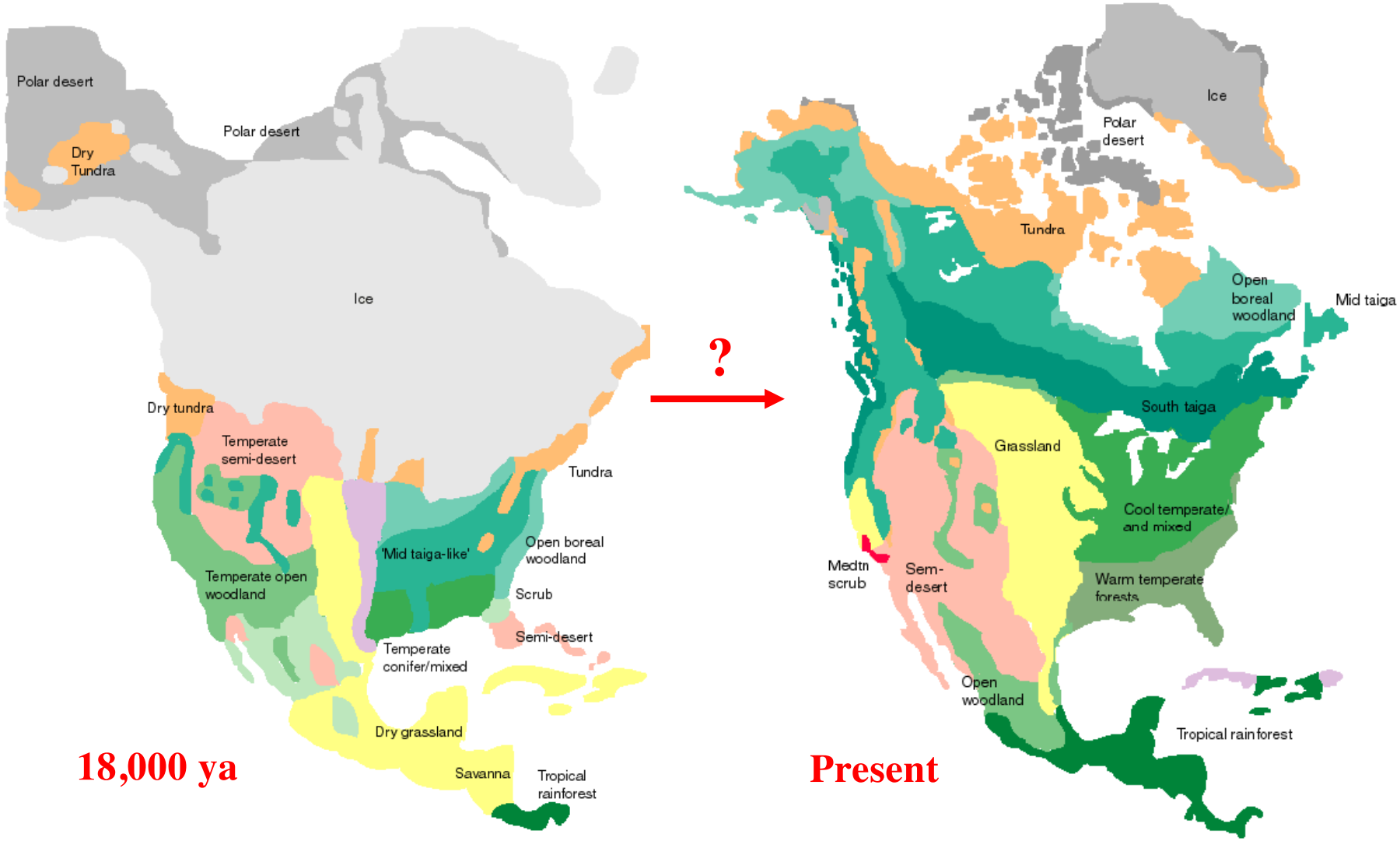


FIGURE 4. Species distribution models for *Viburnum lantanoides* inferred using Maxent. (A) Current climatic conditions. (B–D) Projections into LGM climate models: (B) CCSM4, (C) MIROC-ESM, and (D) MPI-ESM-P. Blue areas denote ice-covered areas during the LGM.

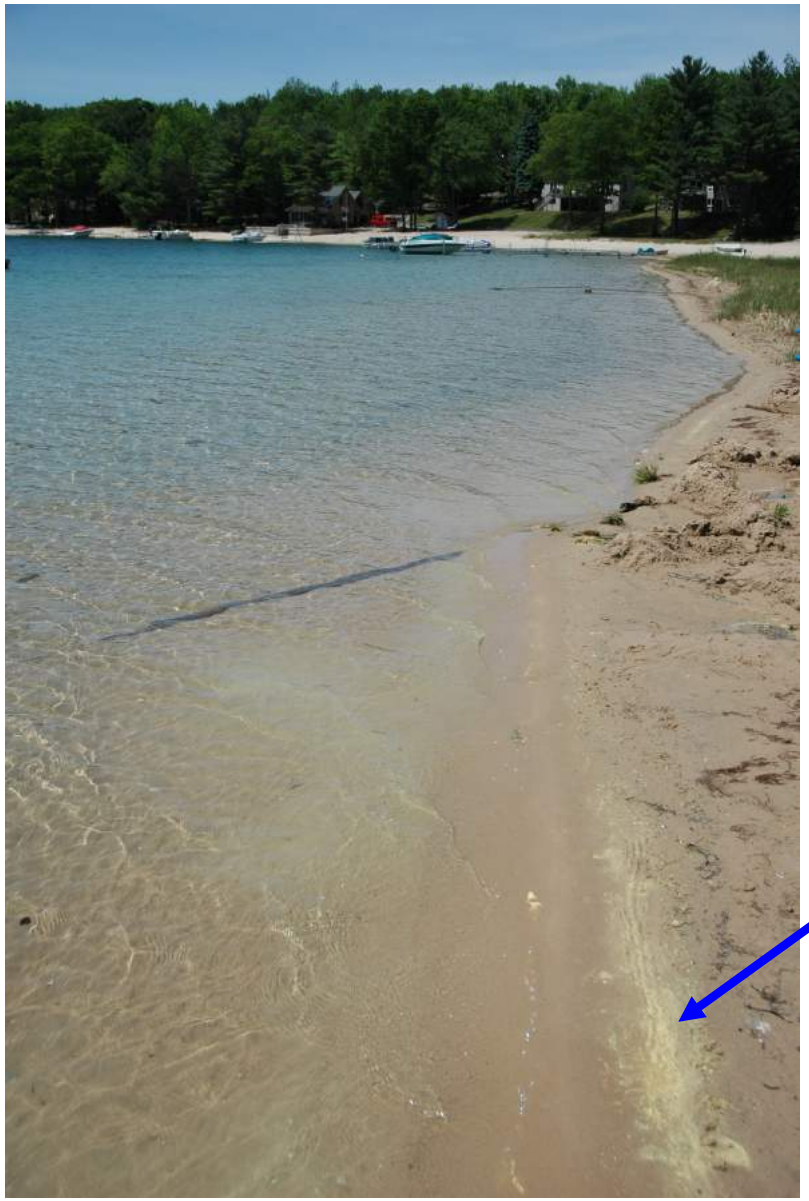
Species distribution models

Assembly of Great Lakes Flora

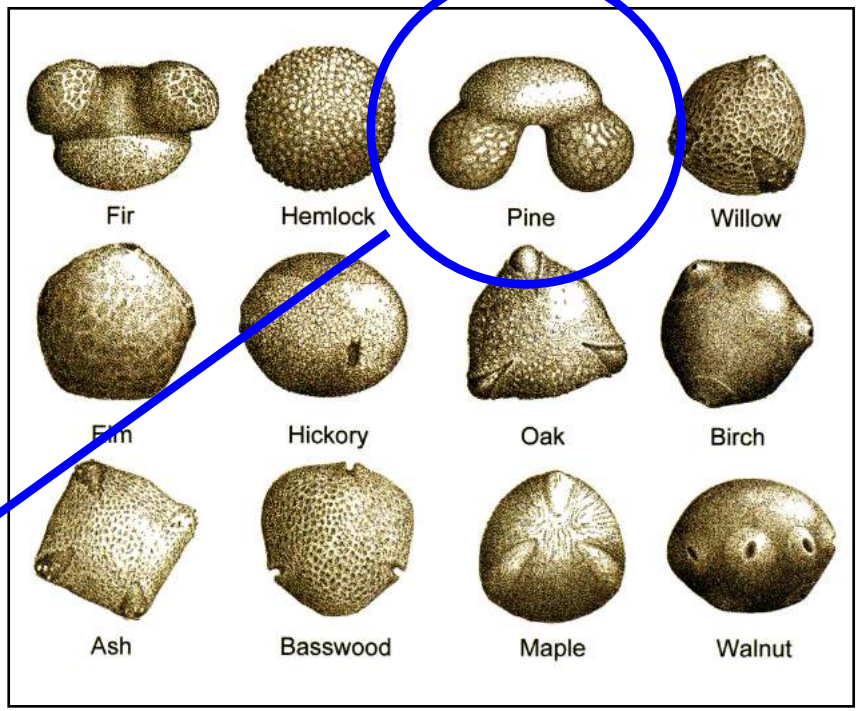
How did the assembly of flora and vegetation in the Great Lakes happen?



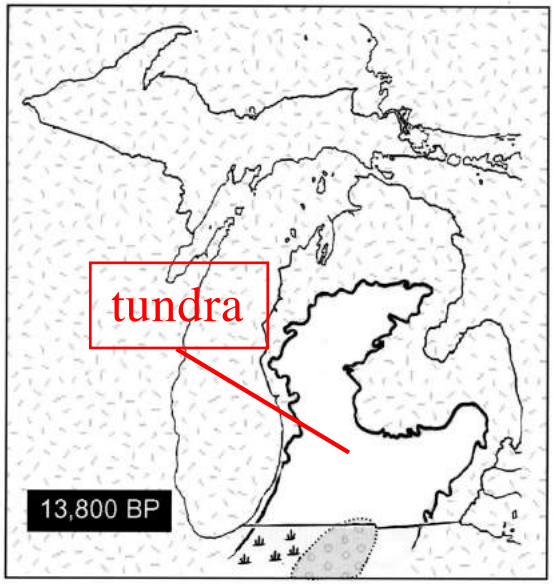
Assembly of Great Lakes Flora

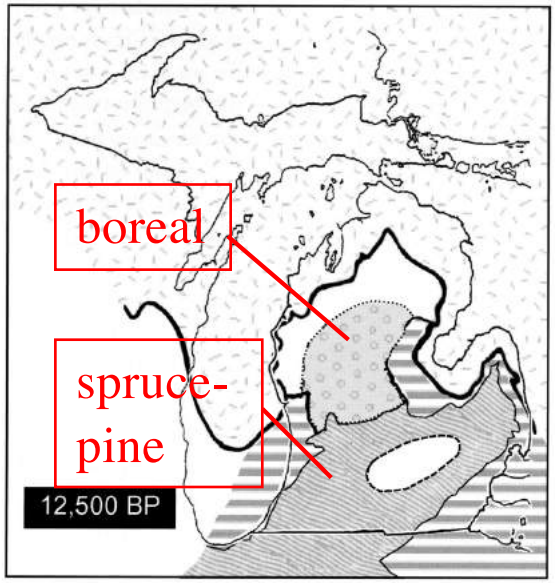


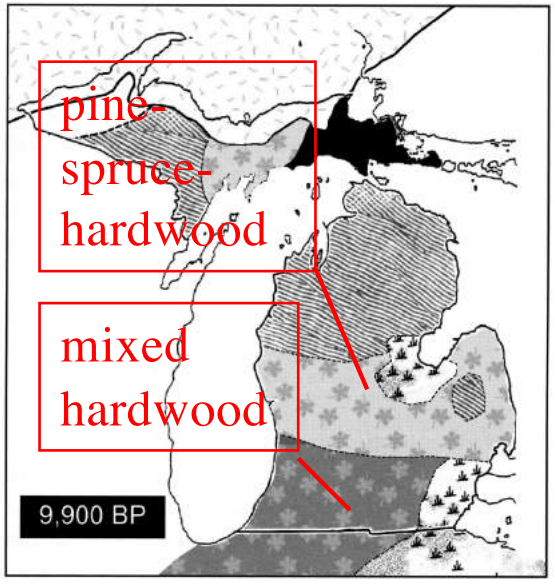
Yearly deposits accumulate in lake bottoms to be covered by silt in layers, or in bog peat strata

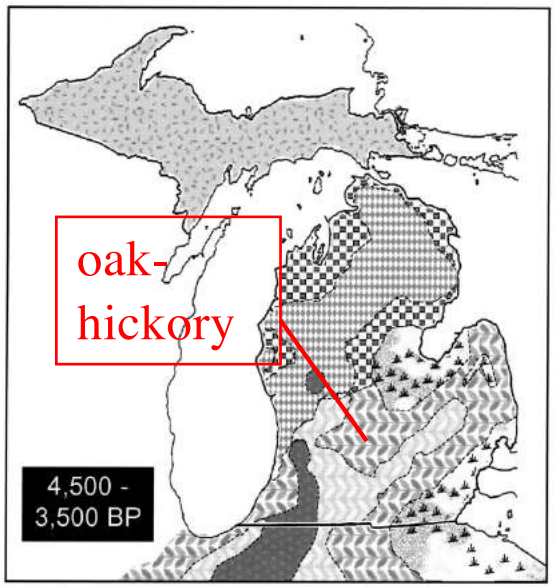


Assembly of Great Lakes Flora

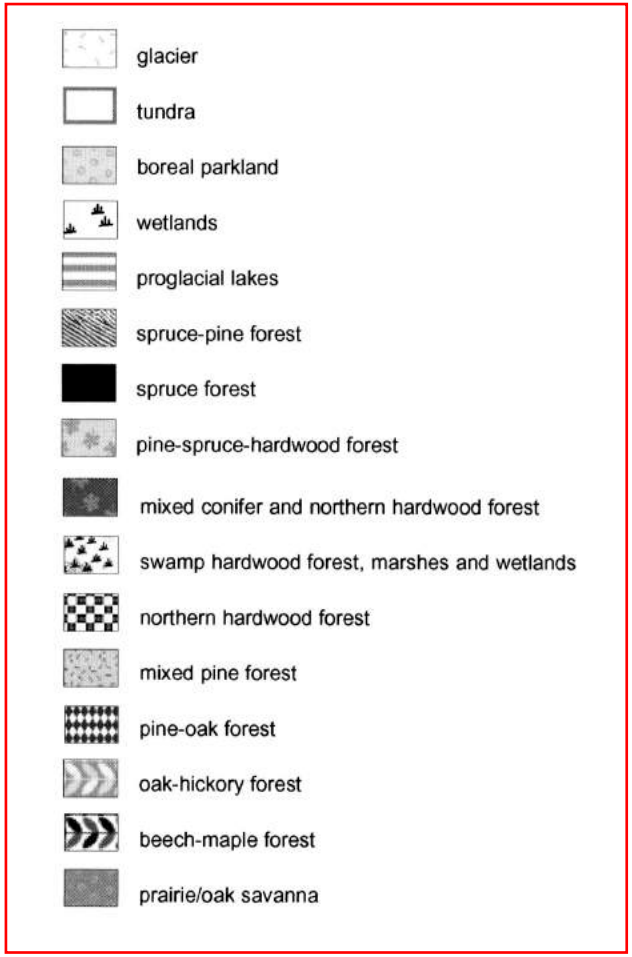




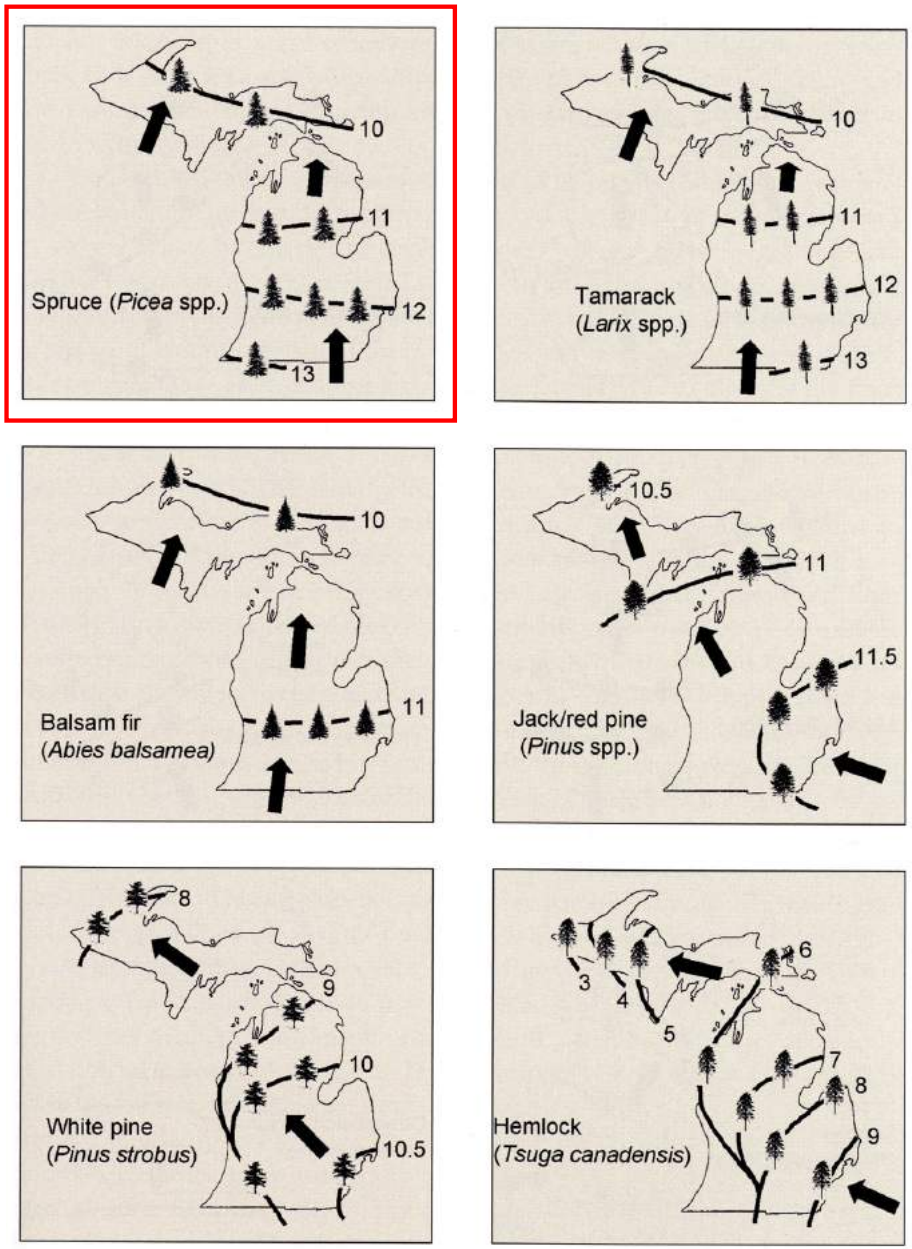




Shifts of vegetation belts starting at about 13,000 ya with tundra, spruce, pine, northern hardwood, pine-oak, and then oak-hickory



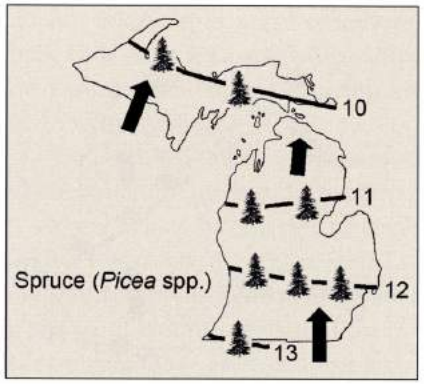
Assembly of Great Lakes Flora

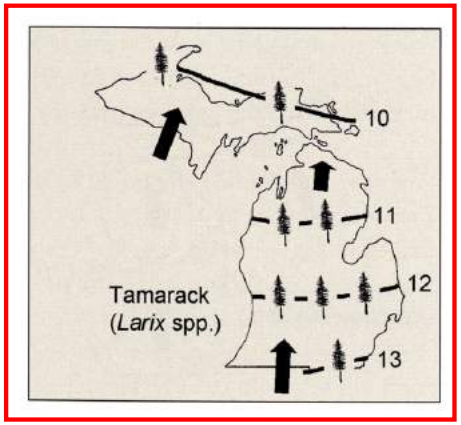


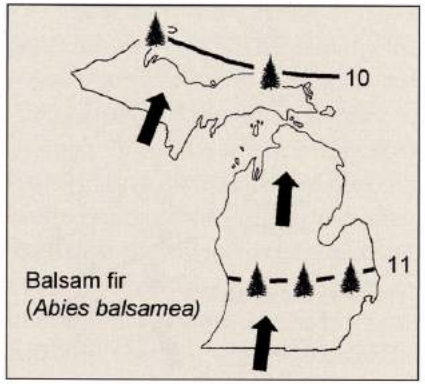
Coniferous species migrated into the Great Lakes region in waves:

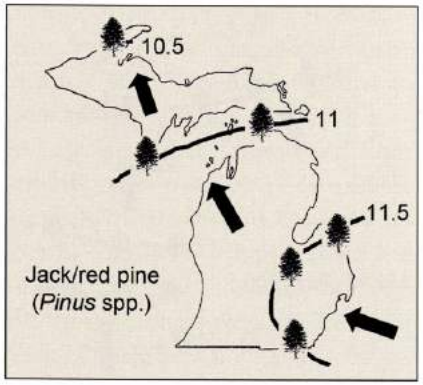
Boreal species like spruce, tamarack, and balsam fir arrived first

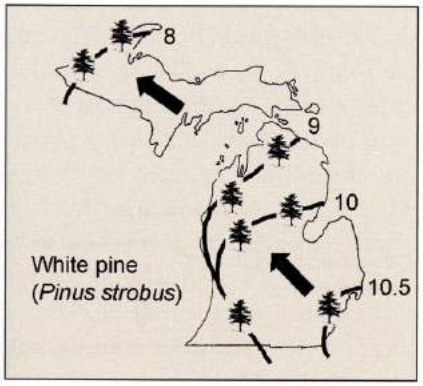
Assembly of Great Lakes Flora

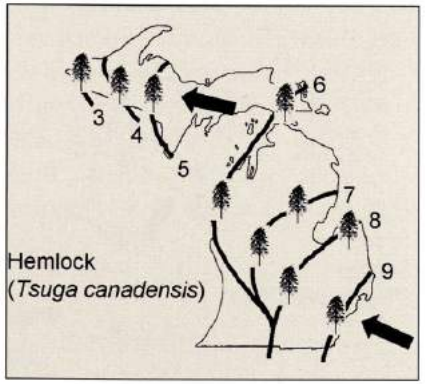








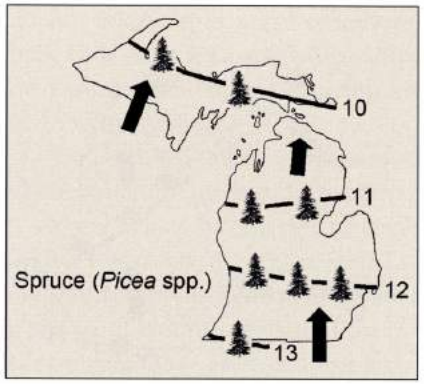


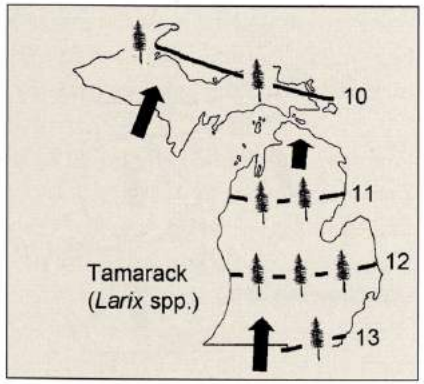


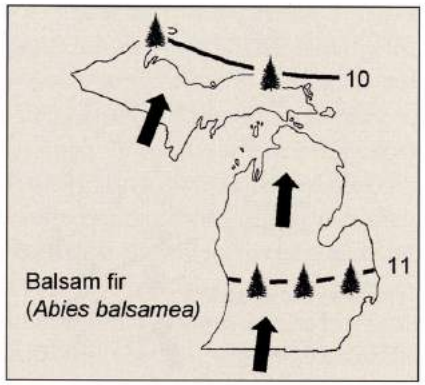
Coniferous species migrated into the Great Lakes region in waves:

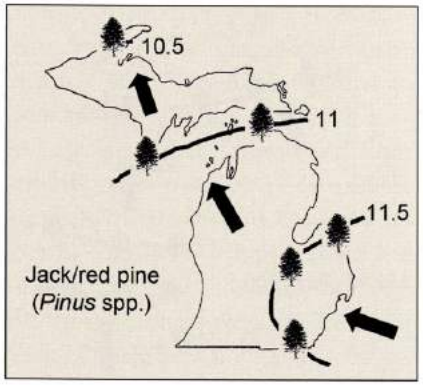
Boreal species like spruce, tamarack, and balsam fir arrived first

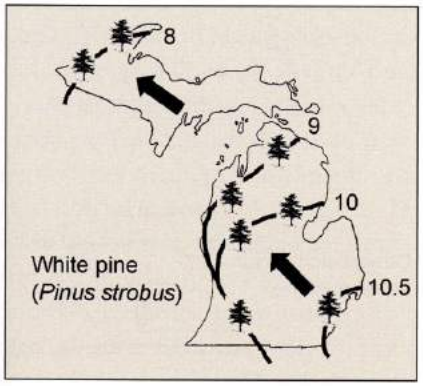
Assembly of Great Lakes Flora

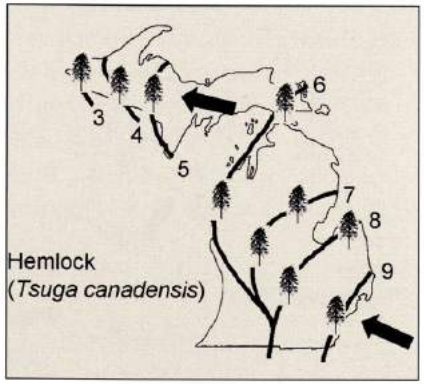








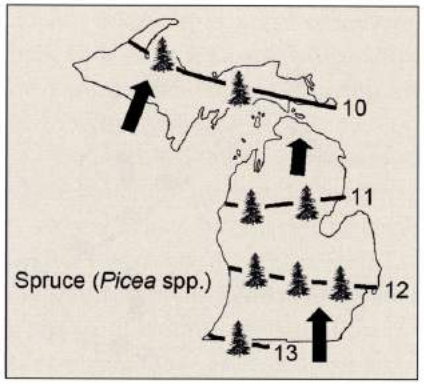


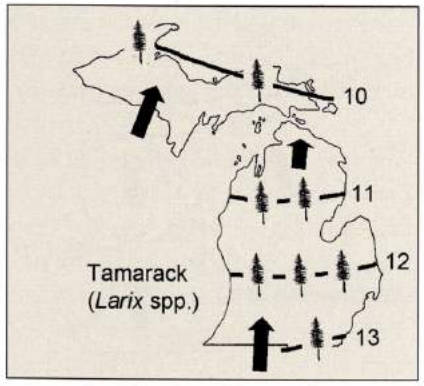


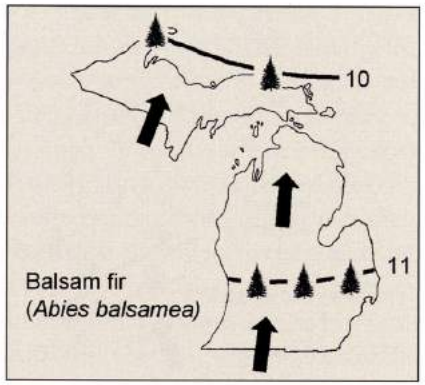
Coniferous species migrated into the Great Lakes region in waves:

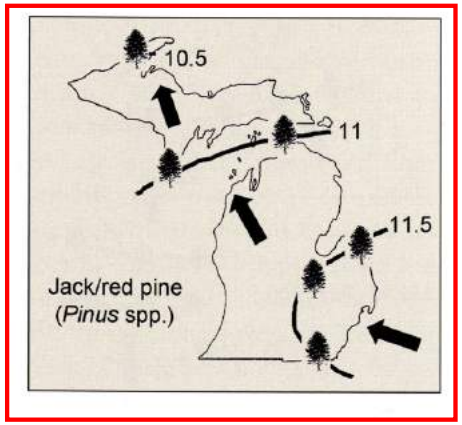
Boreal species like spruce, tamarack, and balsam fir arrived first

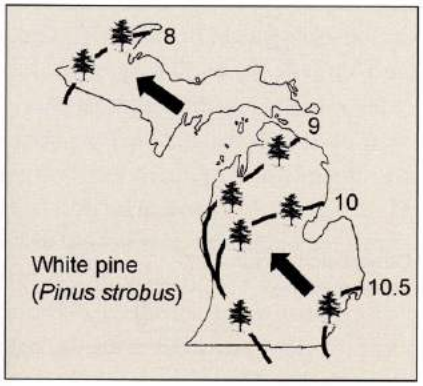
Assembly of Great Lakes Flora

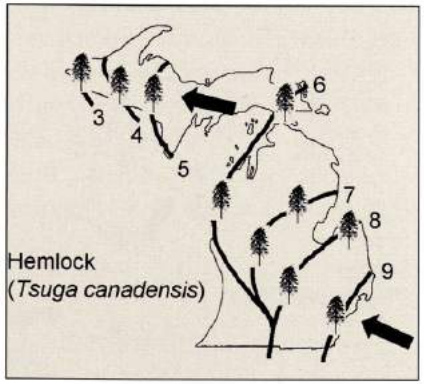








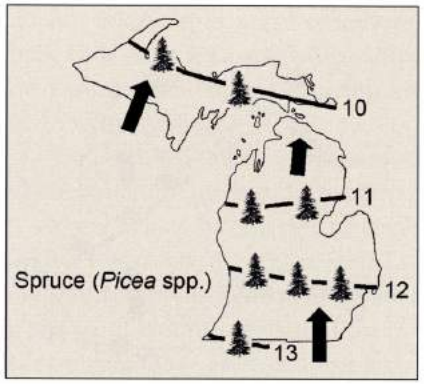


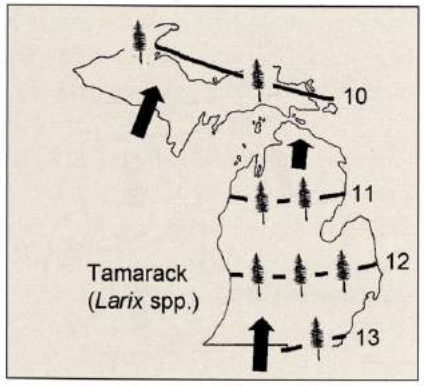


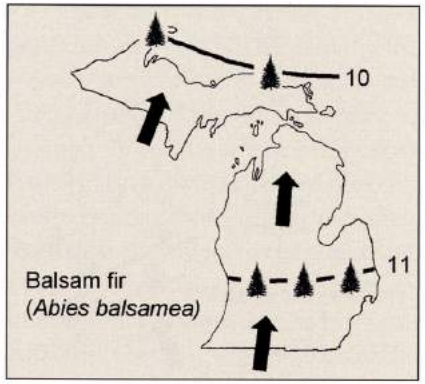
Coniferous species migrated into the Great Lakes region in waves:

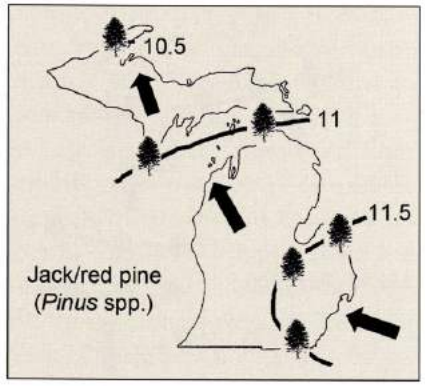
Xeric pine species like jack pine and red pine arrived next

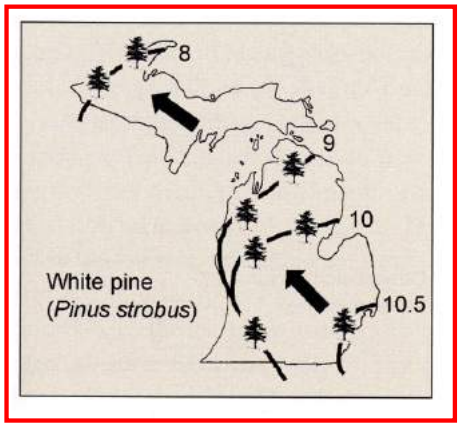
Assembly of Great Lakes Flora

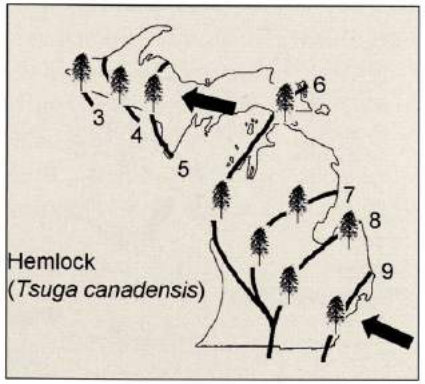








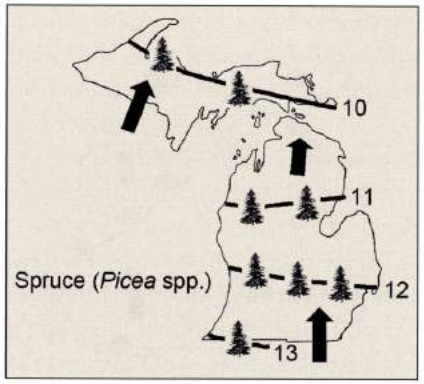


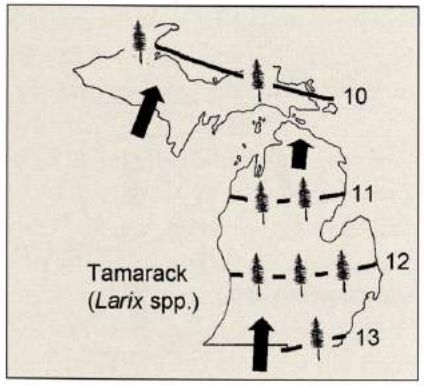


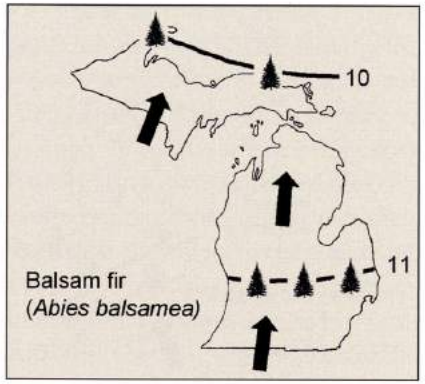
Coniferous species migrated into the Great Lakes region in waves:

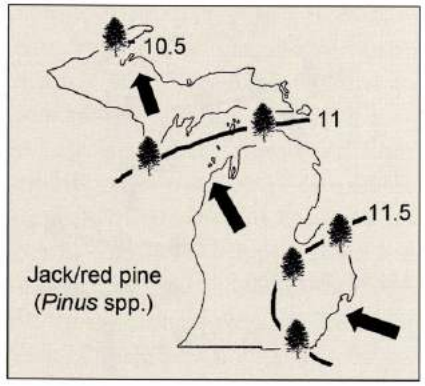
. . . followed by more mesic white pine

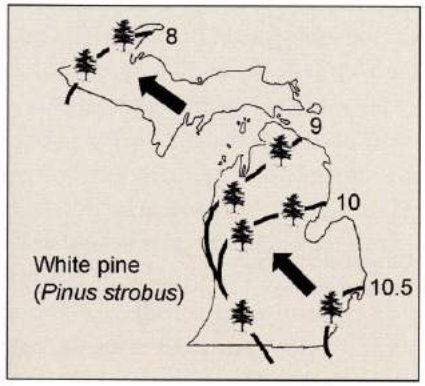
Assembly of Great Lakes Flora

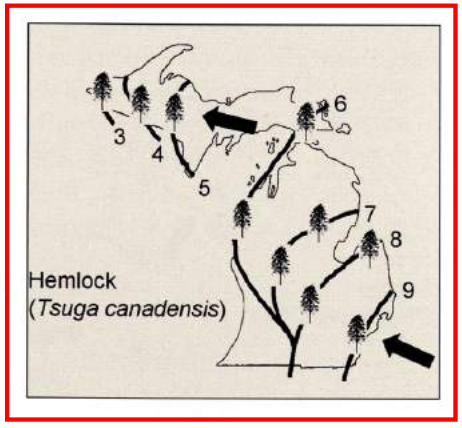








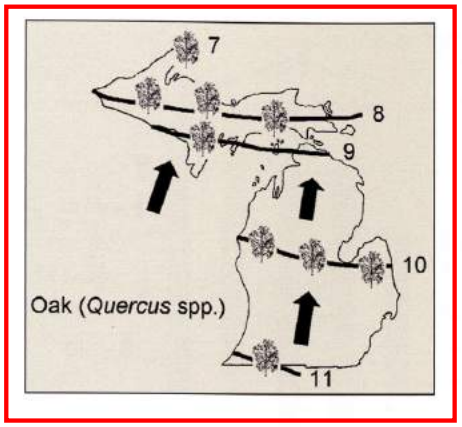


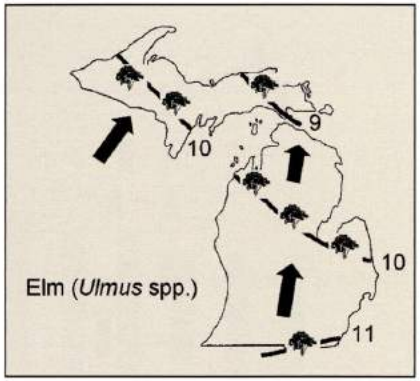


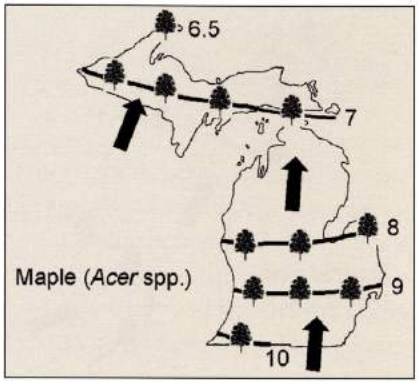
Coniferous species migrated into the Great Lakes region in waves:

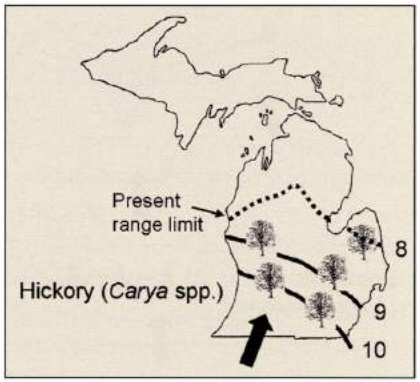
Hemlock, characteristic of mesic Northern Hardwood forests, arrived last

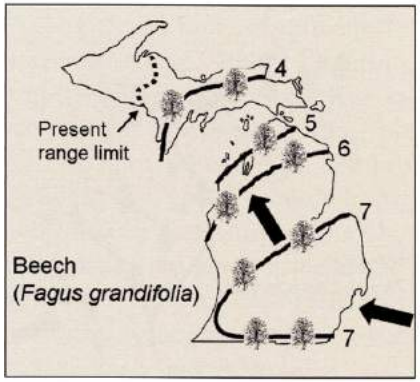
Assembly of Great Lakes Flora

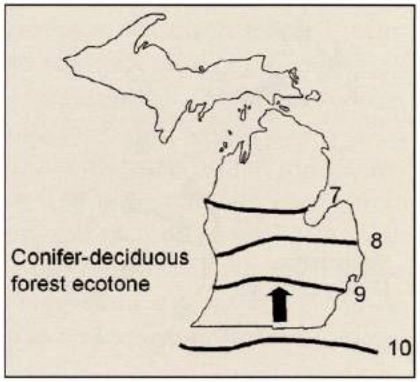








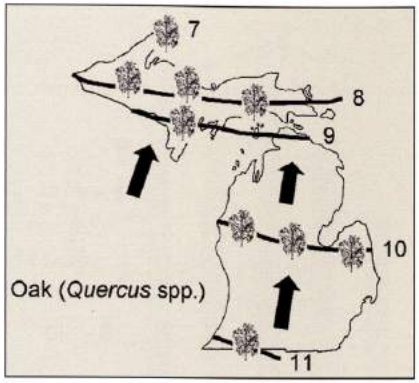


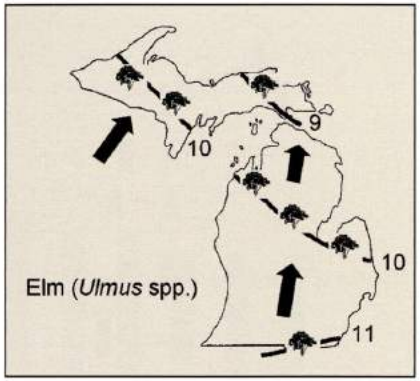


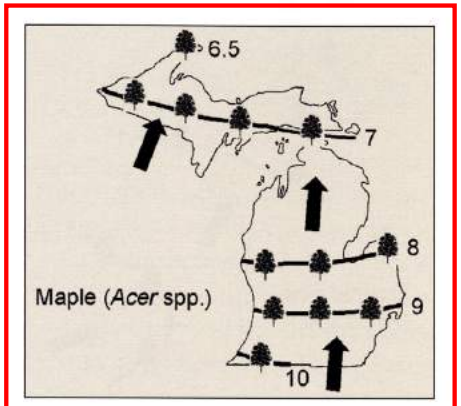
Angiosperm trees migrated into the Great Lakes region in waves towards the end of conifer migration:

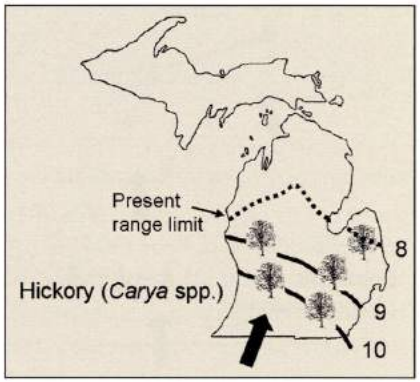
Oaks, hickories and elms arrived first - 11,000 ybp

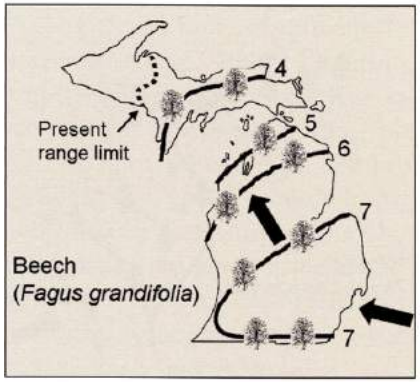
Assembly of Great Lakes Flora

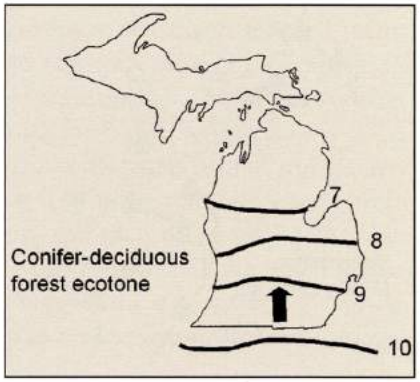






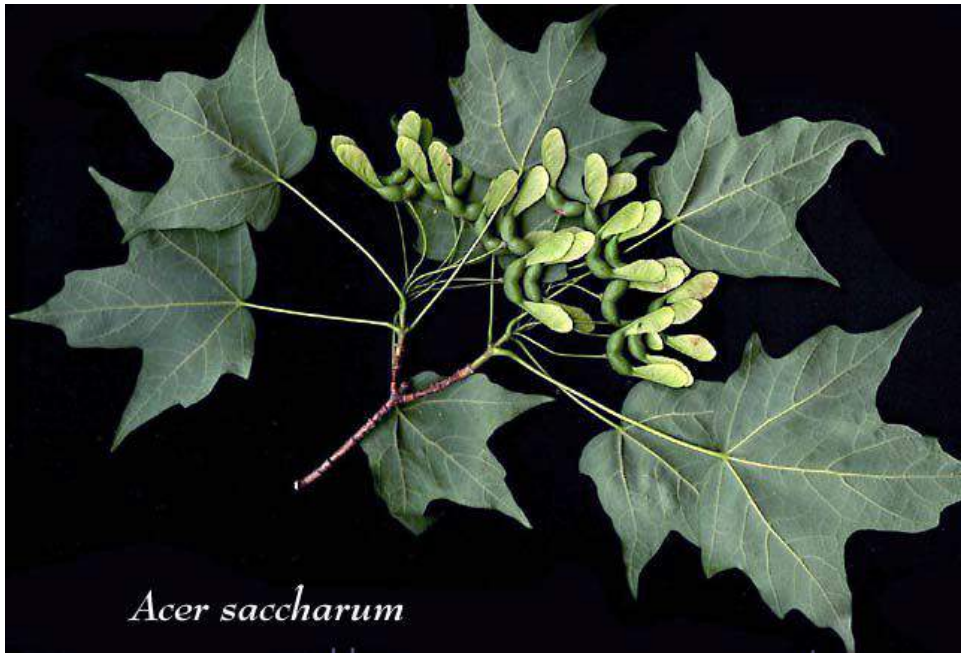




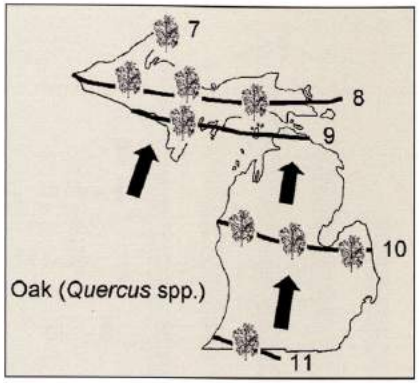


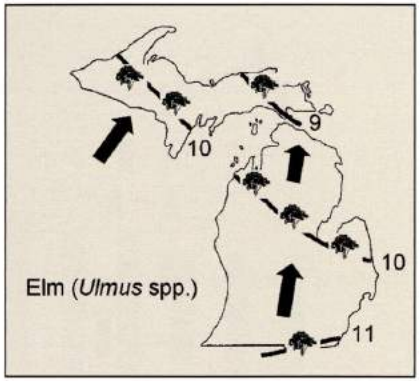
Angiosperm trees migrated into the Great Lakes region in waves towards the end of conifer migration:

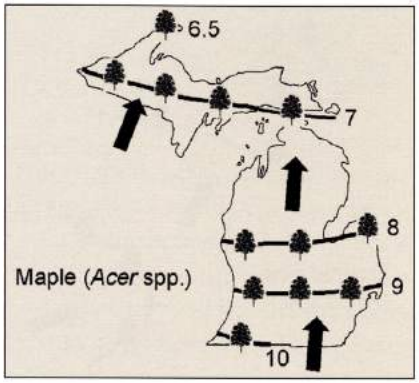
Followed by mesic-loving maples

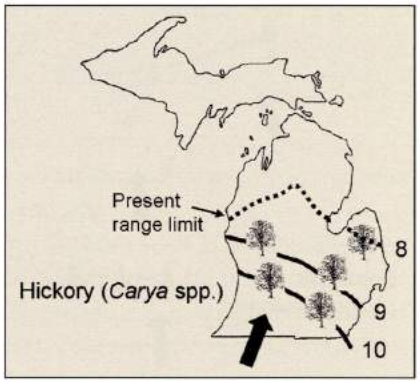


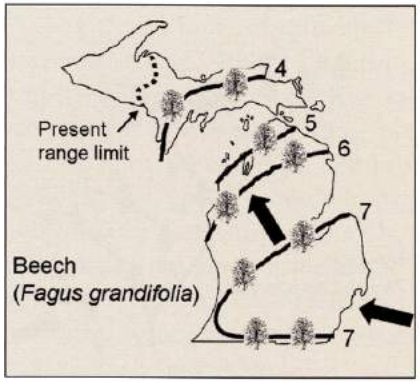
Assembly of Great Lakes Flora

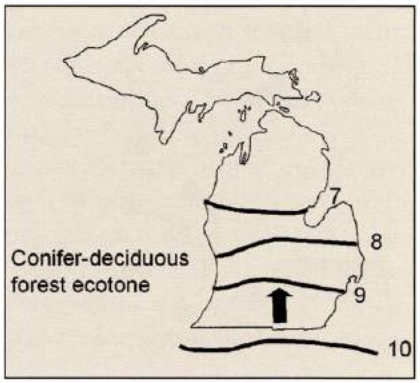










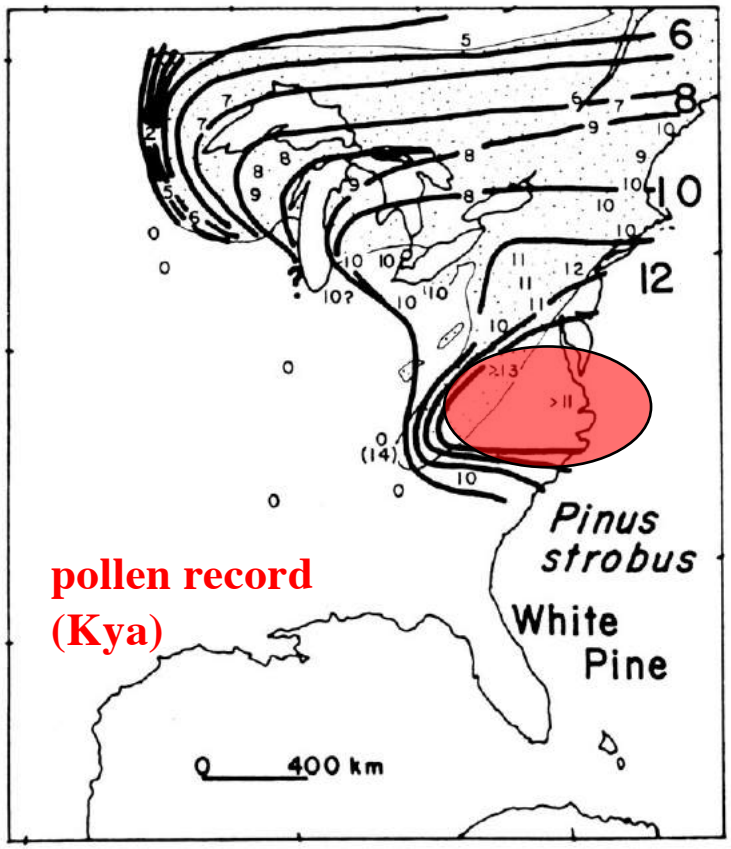


Angiosperm trees migrated into the Great Lakes region in waves towards the end of conifer migration:

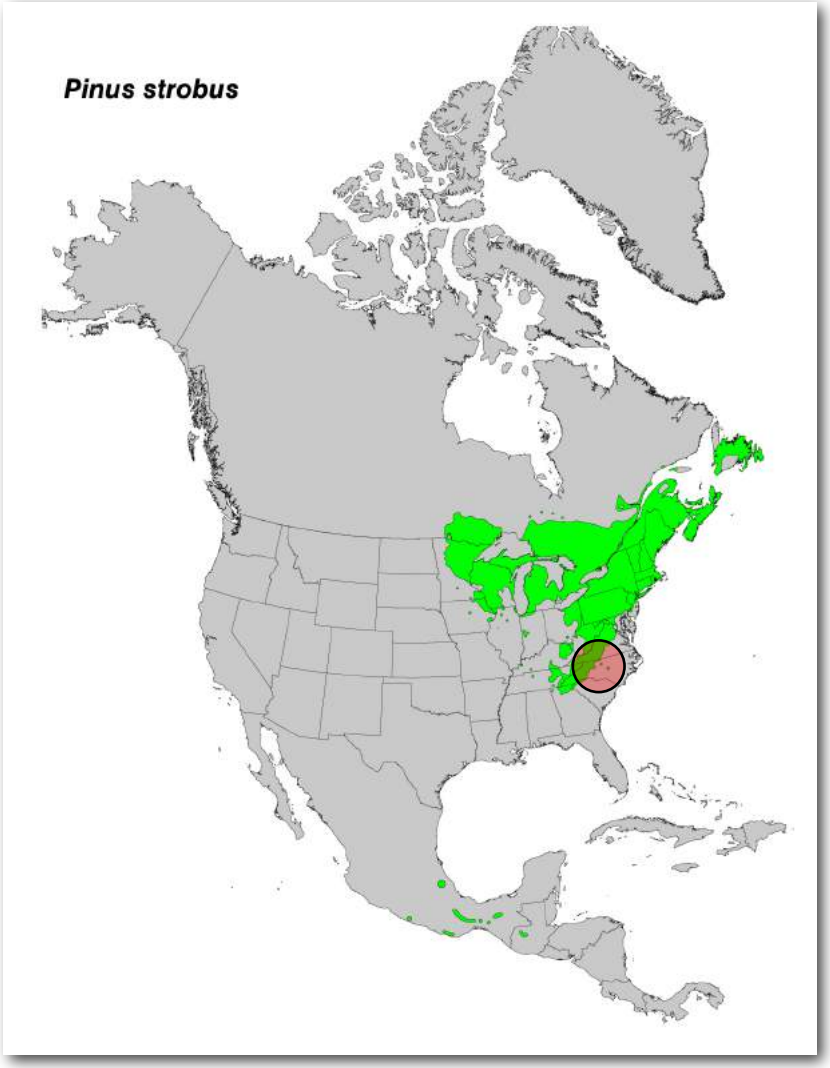
And finally American beech last

Pleistocene Refugia ?

Importantly, the different species of trees (and herbs) entering the Great Lakes region after the glaciers retreated entered via different routes - that is, they came from different refugia or survivia *south* of the ice



White pine from the Alleghenian refugium and present distribution



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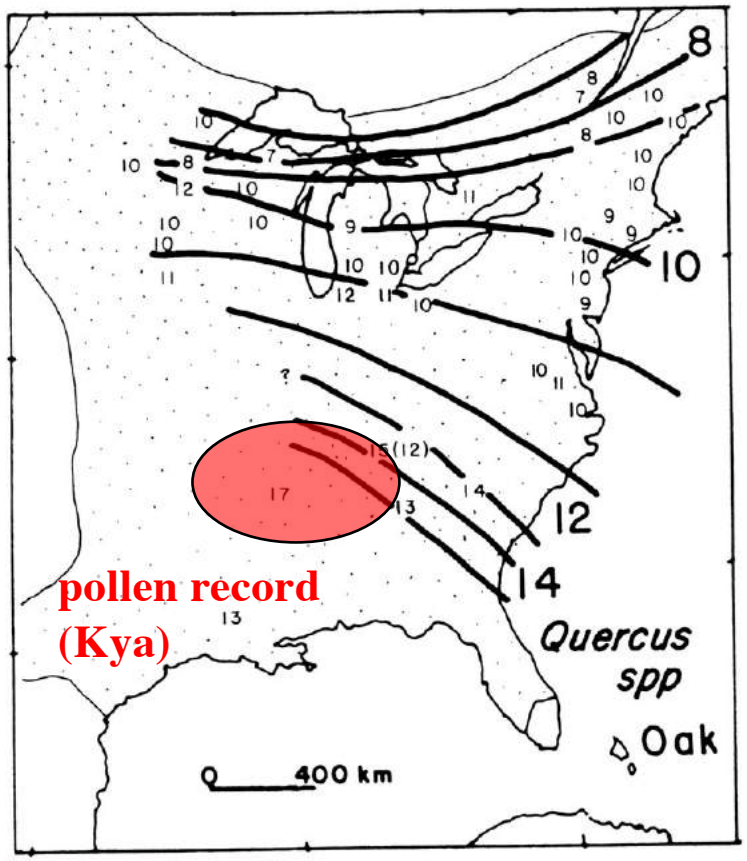


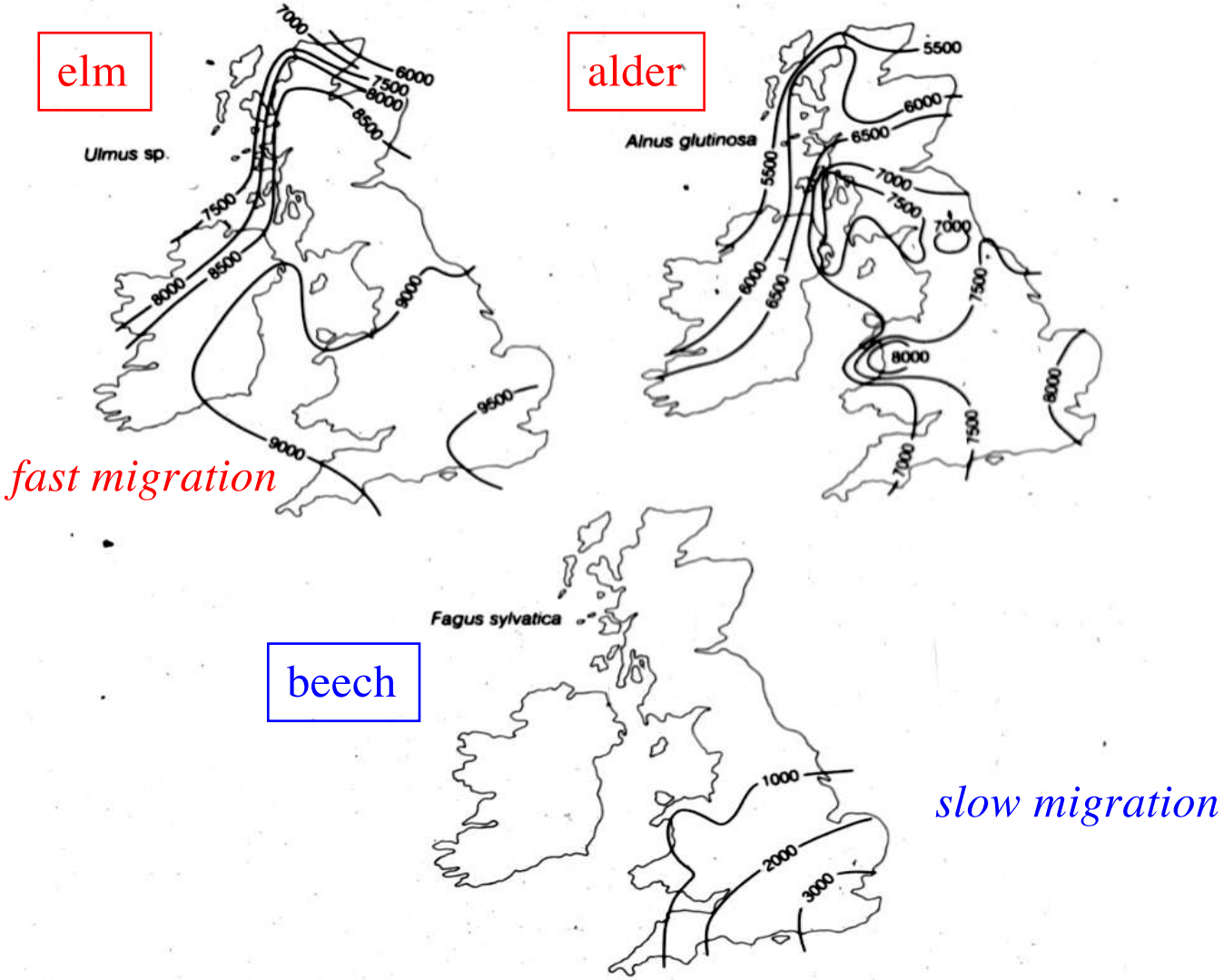
Ozarkian

Alleghenian

Oaks from either the Alleghenian (white oak) or Ozarkian (bur oak) refugia and present overlapping distributions

Pleistocene Refugia ?

The assembly of Holocene flora in northern Europe, especially Great Britain, shows a similar pattern to that in eastern North America

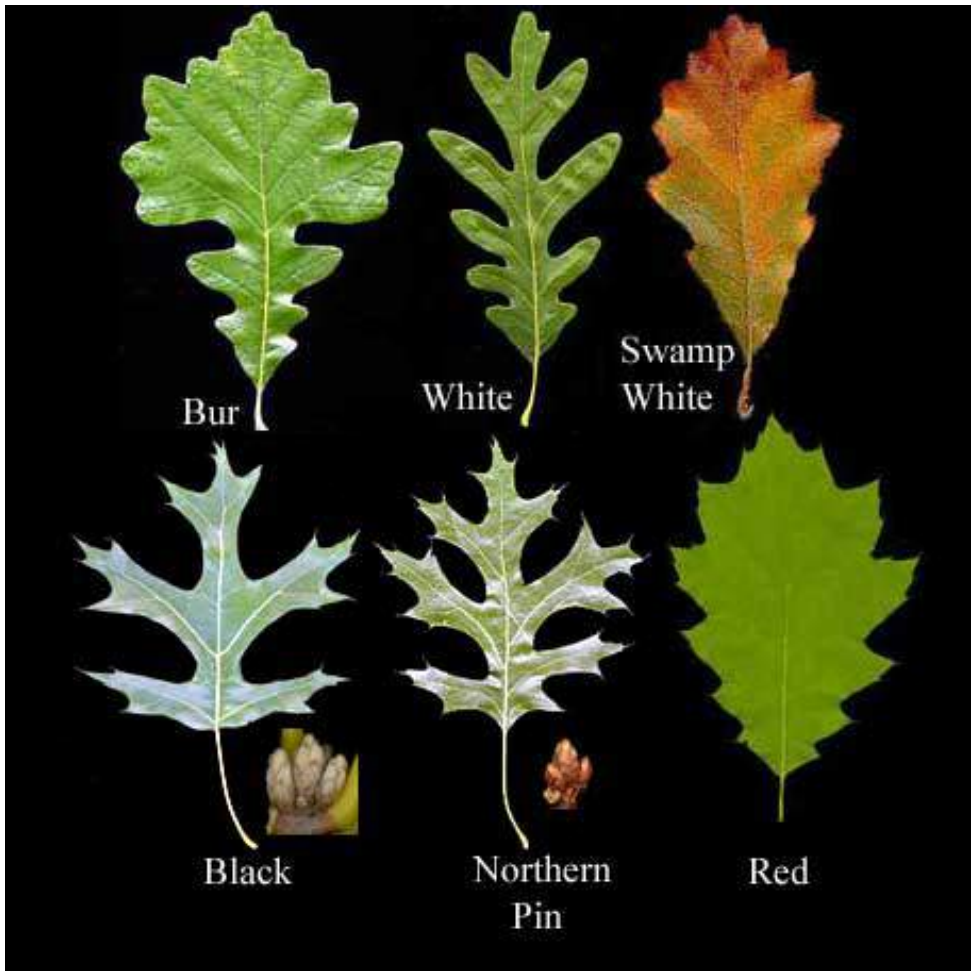


Assembly of Great Lakes Flora

The flora of the Great Lakes can be divided into a number of elements, each of which shares a common geographical origin.

Closely related species (such as oaks) can often be part of different floristic elements.

This is due to both different ecological preferences (such as hydric vs. mesic vs. xeric) and to geographical origin.



Quercus - the oaks

Assembly of Great Lakes Flora

The flora of the Great Lakes can be divided into a number of elements, each of which shares a common geographical origin.

1. Alleghenian: group of species with ranges centered from Cumberland and Great Smoky mountains; dominant in deciduous forests; e.g. white pine, hemlock and basswood; ancient element extending back to the Tertiary

Pinus strobus - white pine

Tsuga canadense - hemlock

Assembly of Great Lakes Flora

1. Alleghenian:

Fagus grandifolia - American beech

Acer sacccharum - sugar maple

Quercus alba - white oak

Tilia americana - basswood

Assembly of Great Lakes Flora

Jeff Rose's pictures from field trip

1. Alleghenian:

Erythronium albidum – trout lily

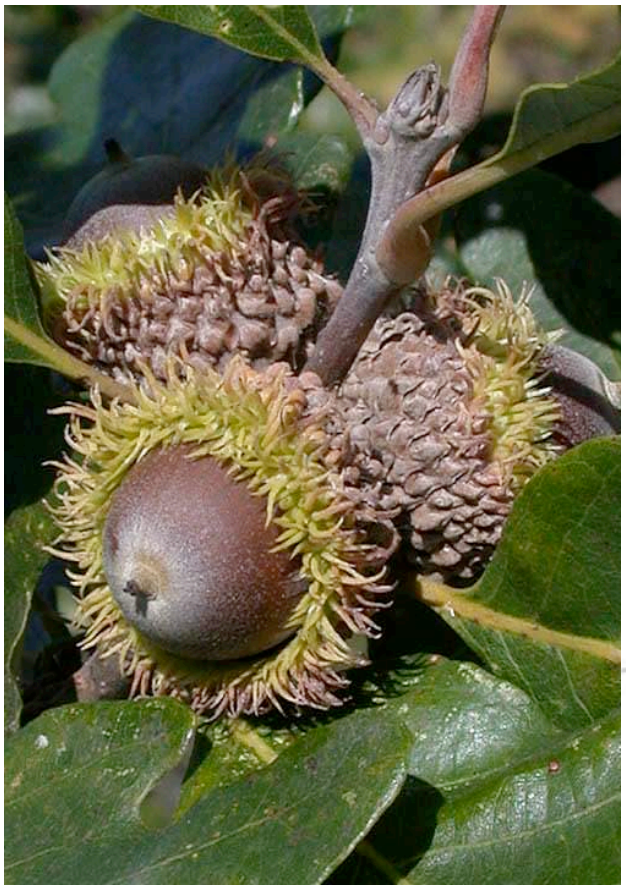
Dicentra cucullaria - Dutchman's breeches

Claytonia virginiana - spring beauty

Assembly of Great Lakes Flora

The flora of the Great Lakes can be divided into a number of elements, each of which shares a common geographical origin.

2. Ozarkian: species grouped around the Ozark Mts. of Arkansas and Missouri; more adapted to xeric or dry conditions, but similar to Alleghenian (many genera, but not species overlapping between the two elements); e.g. bur oak and black oak, hickory



Quercus macrocarpa
Bur oak

Carya ovata
Shagbark hickory

Assembly of Great Lakes Flora

2. Ozarkian:

Phlox divaricata
Blue phlox

Anemonella thalictroides
Rue anemone

Assembly of Great Lakes Flora

The flora of the Great Lakes can be divided into a number of elements, each of which shares a common geographical origin.

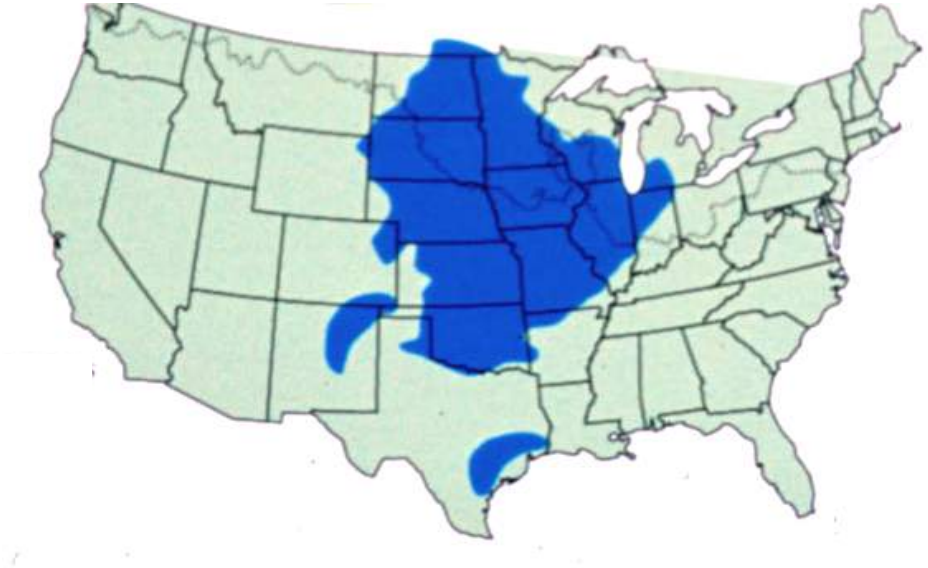
3. Prairie: species whose ranges includes all or part of existing prairies
e.g. needle grass, side oats

Silphium intregiifolium - silphium

Assembly of Great Lakes Flora

3. Prairie:

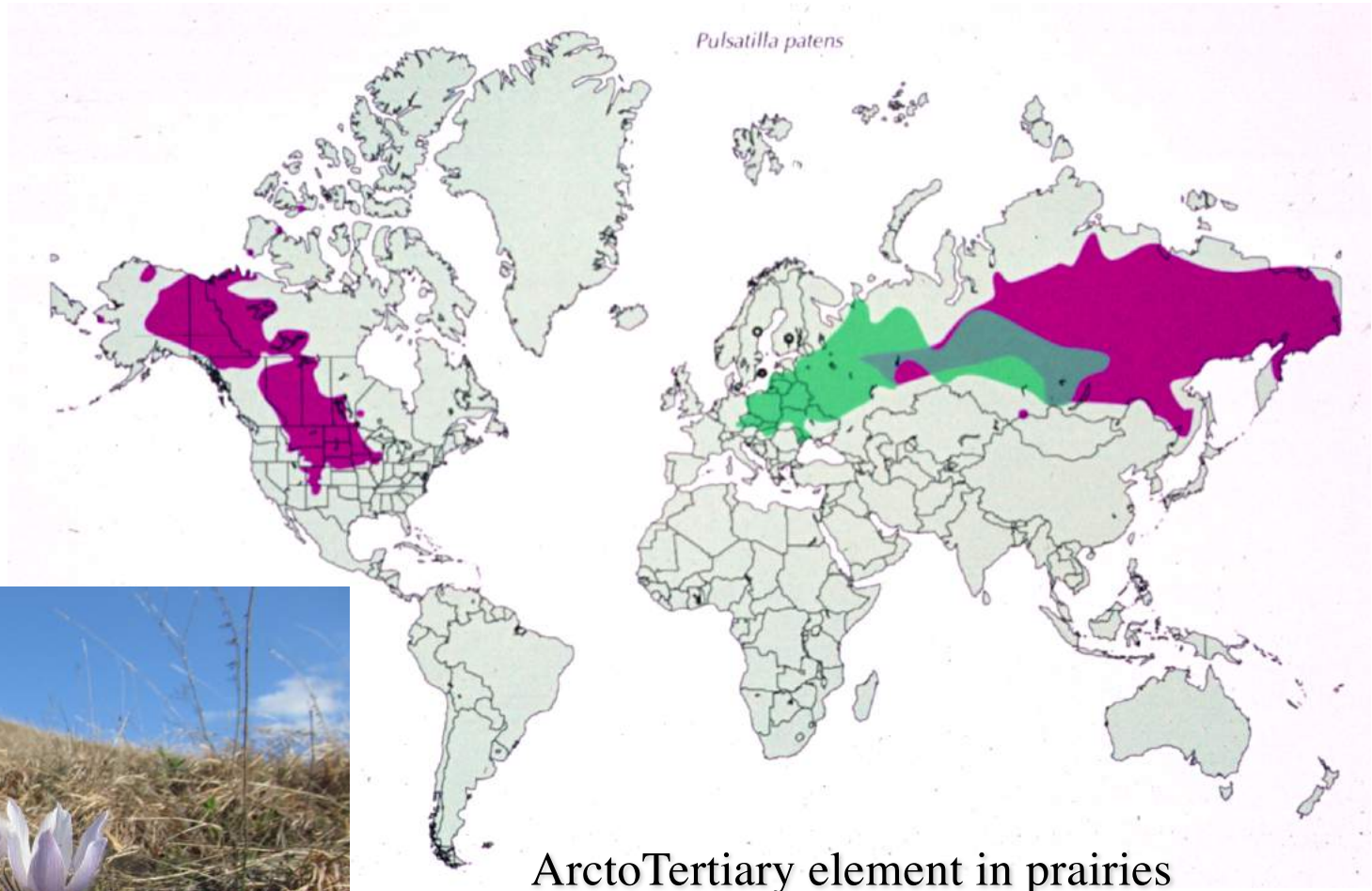
Andropogon gerardii
big bluestem



Amorpha canadense - leadplant

Assembly of Great Lakes Flora

3. Prairie:



ArctoTertiary element in prairies

Anemone patens
Pasque flower
(photo: John Zabosky– Apr 27. 13)

Assembly of Great Lakes Flora

The flora of the Great Lakes can be divided into a number of elements, each of which shares a common geographical origin.

4. Boreal: species w/ranges from Alaska to Upper Great Lakes, many species circumboreal (with ranges in Eurasia) e.g. tamarack, white spruce, and balsam fir

Picea glauca
White spruce

Larix laricina
Larch, tamarack

Abies balsamea
Balsam fir

Assembly of Great Lakes Flora

4. Boreal:

Iris lacustris
Dwarf-lake iris

Linnaea borealis - twinflower

Pyrola rotundifolia
Round-leaved shinleaf

Assembly of Great Lakes Flora

The flora of the Great Lakes can be divided into a number of elements, each of which shares a common geographical origin.

5. Coastal Plain: species with distributions originating from the coastal plain region of SE United States . . .

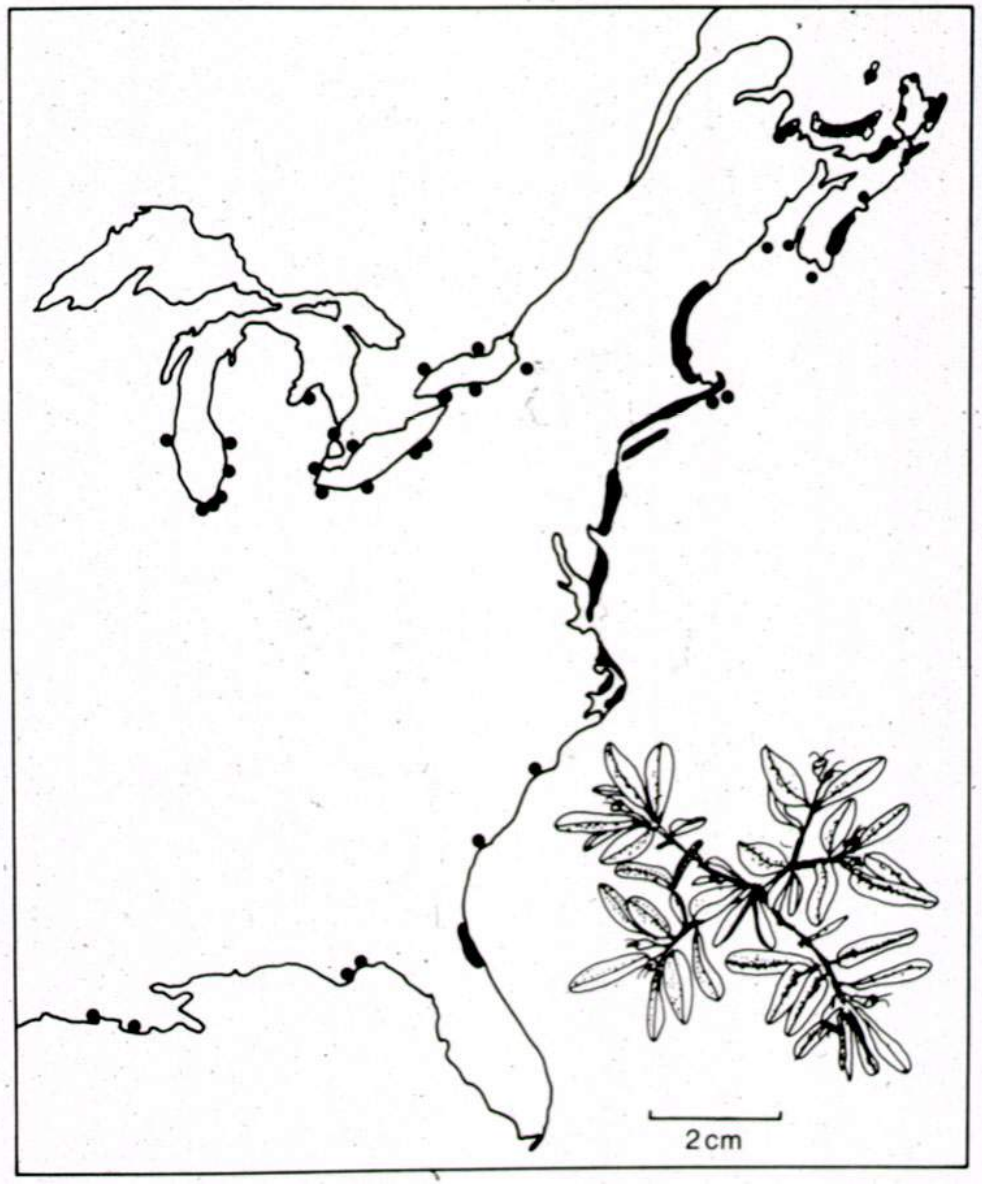
Betula nigra
River birch

Gledistia tricanthos
Honey locust

Assembly of Great Lakes Flora

Chamaesyce polygonifolia
Seaside spurge

5. Coastal Plain: . . . and including species inhabiting water edges of the Great Lakes and maritime regions of the Coastal Plain

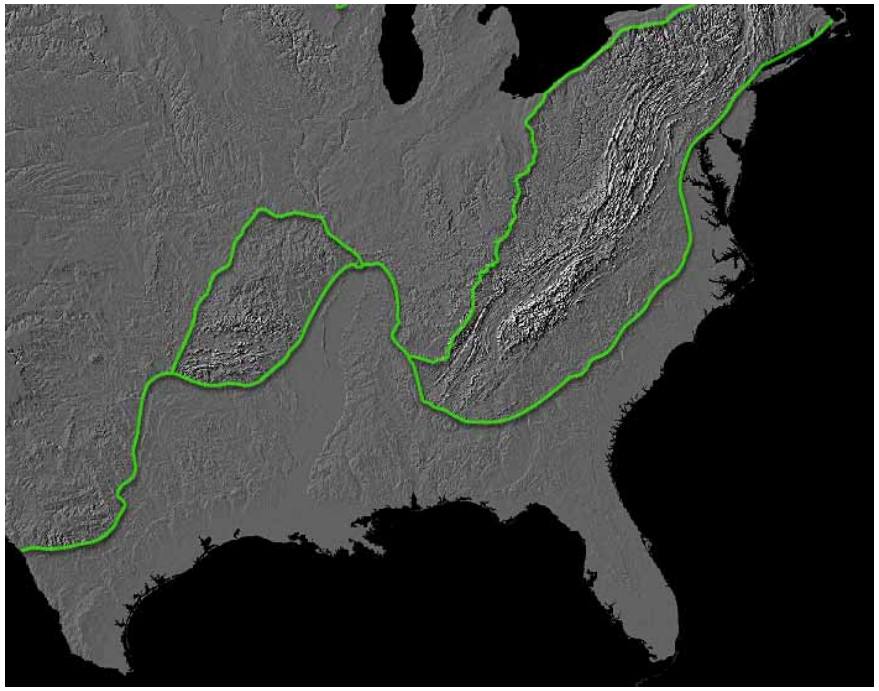


Assembly of Great Lakes Flora

Lathyrus japonicus
Beach pea

5. Coastal Plain: . . . and including species inhabiting water edges of the Great Lakes and maritime regions of the Coastal Plain

Cakile edulenta
Sea rocket



Coastal Plain Marsh

Sandy to peaty-mucky lakeshores, pondshores, depressions, and ditches in and around the bed of extinct glacial Lake Wisconsin may harbor assemblages of wetland species including some which are significantly disjunct from their main ranges on the Atlantic Coastal Plain. There is often a well-developed concentric zonation of vegetation. Frequent members of this community are sedges in the genera *Cyperus*, *Eleocharis*, *Fimbristylis*, *Hemicarpha*, *Rhynchospora* and *Scirpus*; rushes (*Juncus* spp.); milkworts (*Polygala cruciata* and *P. sanguinea*), toothcup (*Rotala ramosior*), meadow-beauty (*Rhexia virginica*), grass-leaved goldenrod (*Euthamia graminifolia*), hardhack (*Spiraea tomentosa*), lance-leaved violet (*Viola lanceolata*), and yellow-eyed grass (*Xyris torta*).

Assembly of Great Lakes Flora

The flora of the Great Lakes can be divided into a number of elements, each of which shares a common geographical origin.

6. Western North America: species with a primary western North America distribution and disjunct occurrence in the Great Lakes region

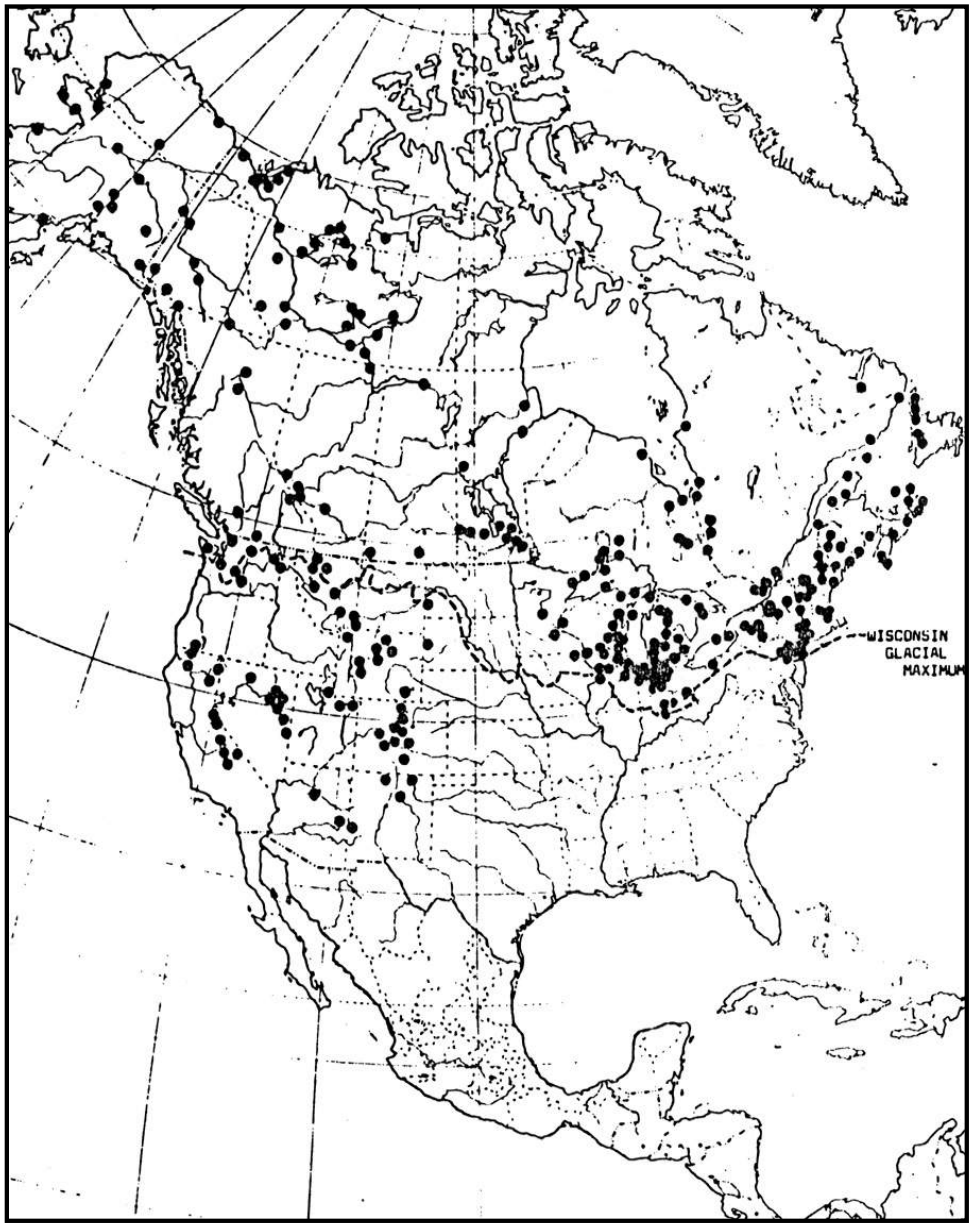
Essentially a variety or subspecies of the western *A. columbianum*

Aconitum noveboracense
Northern monk's-hood

Assembly of Great Lakes Flora

6. Western North America:

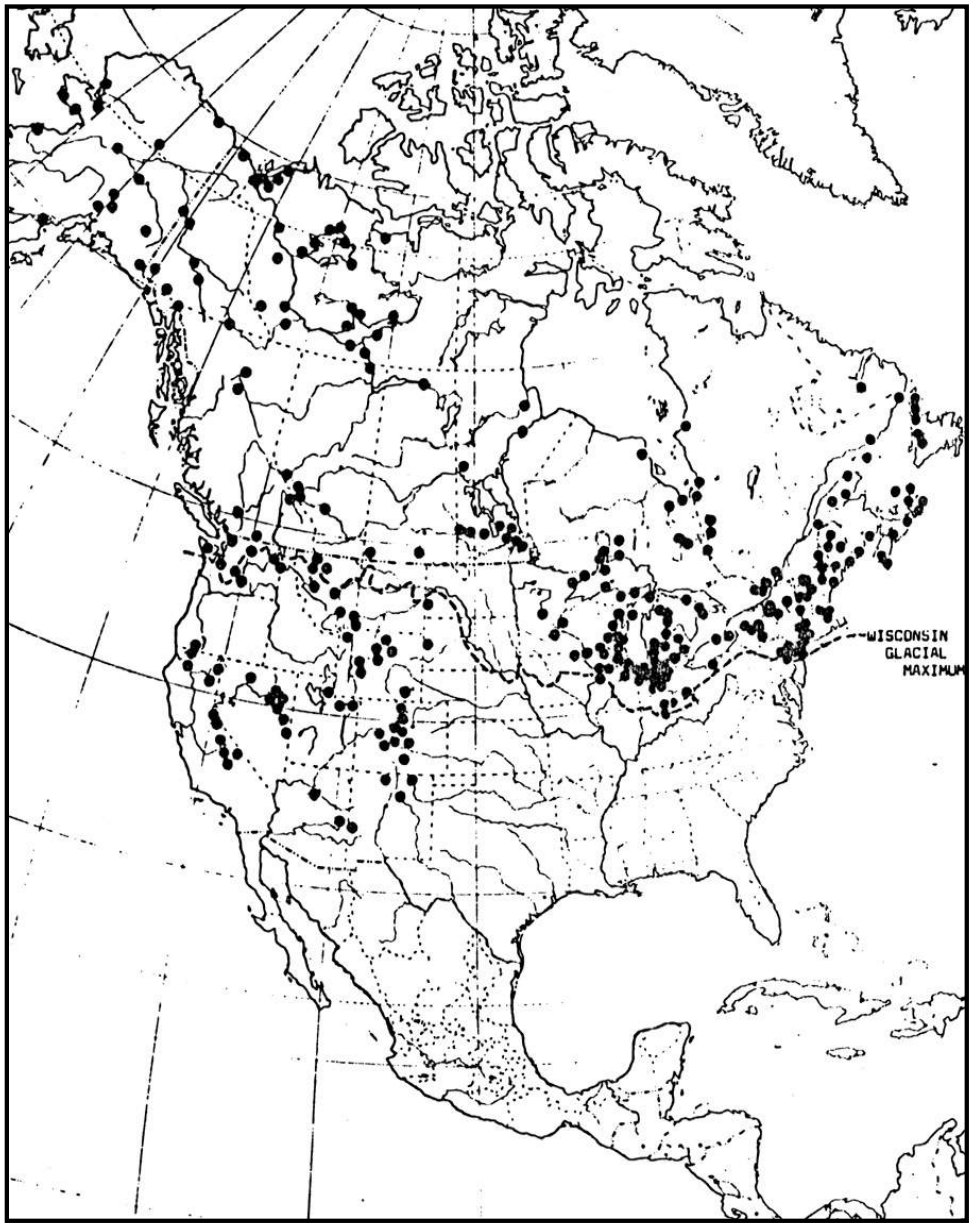
Dasiphora fruticosa
Shrubby cinquefoil



Assembly of Great Lakes Flora

6. Western North America:

- **western** distribution spans both glaciated and unglaciated regions
- **eastern** distribution confined to glaciated regions



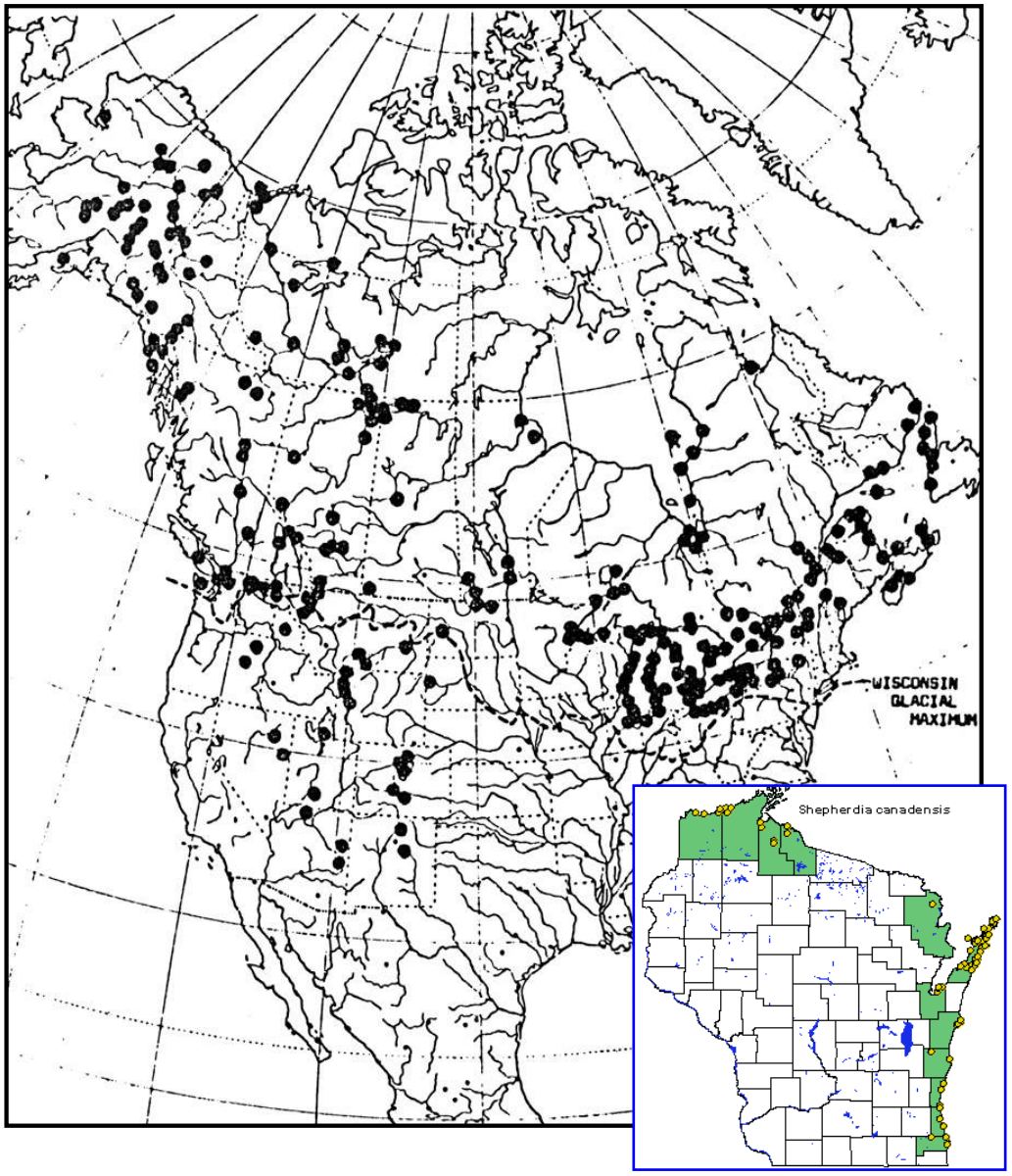
Dasiphora fruticosa
Shrubby cinquefoil

Assembly of Great Lakes Flora

6. Western North America:

Note that the distribution in the east is *north of glacial maximum*

Shepherdia canadensis
Buffalo-berry

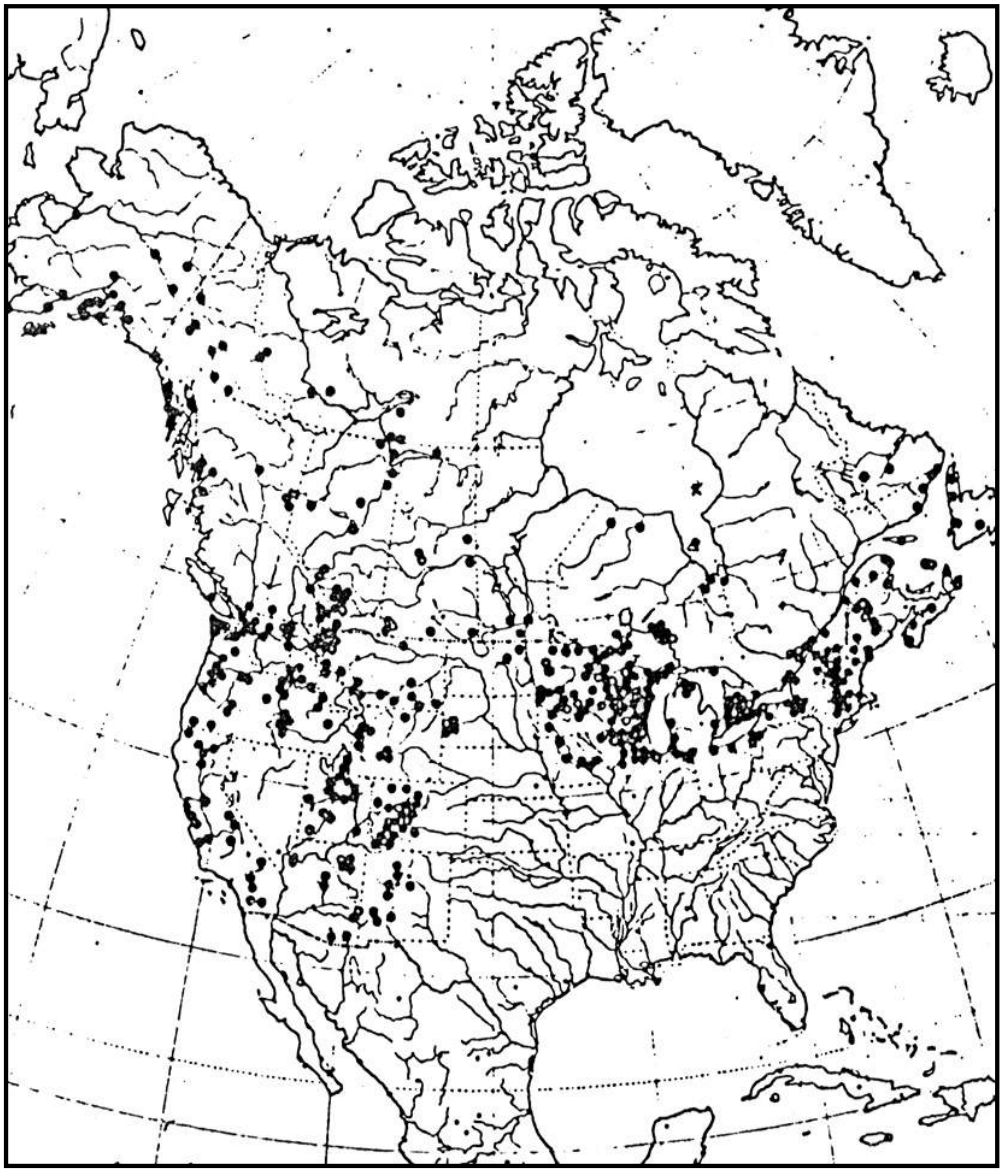


Assembly of Great Lakes Flora

6. Western North America:

Note that the distribution in the east is *north of glacial maximum*

Actaea rubra
Red baneberry

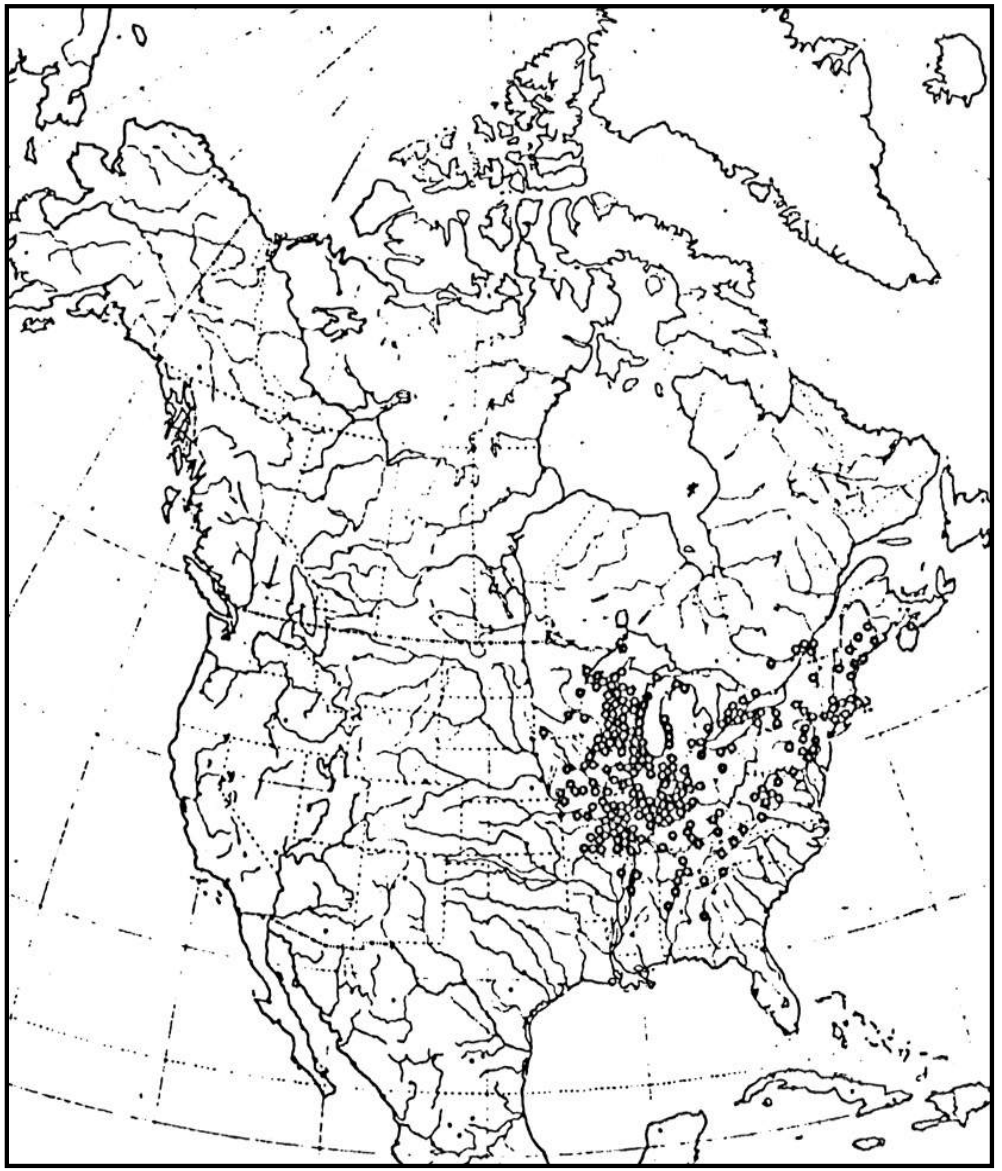


Assembly of Great Lakes Flora

6. Western North America:

Note that a close eastern relative is *not confined to glacial regions*

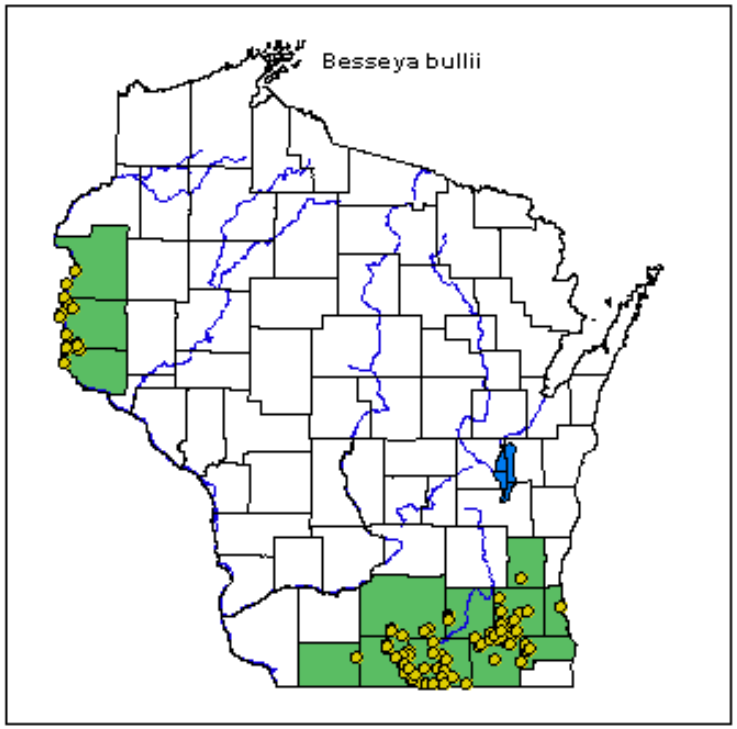
Actaea pachypoda
White baneberry



Assembly of Great Lakes Flora

6. Western North America:

Basically *confined to glacial regions* despite available sites in Driftless Region



Besseya bullii
Kitten's-tail
(Muralt Bluff Prairie)

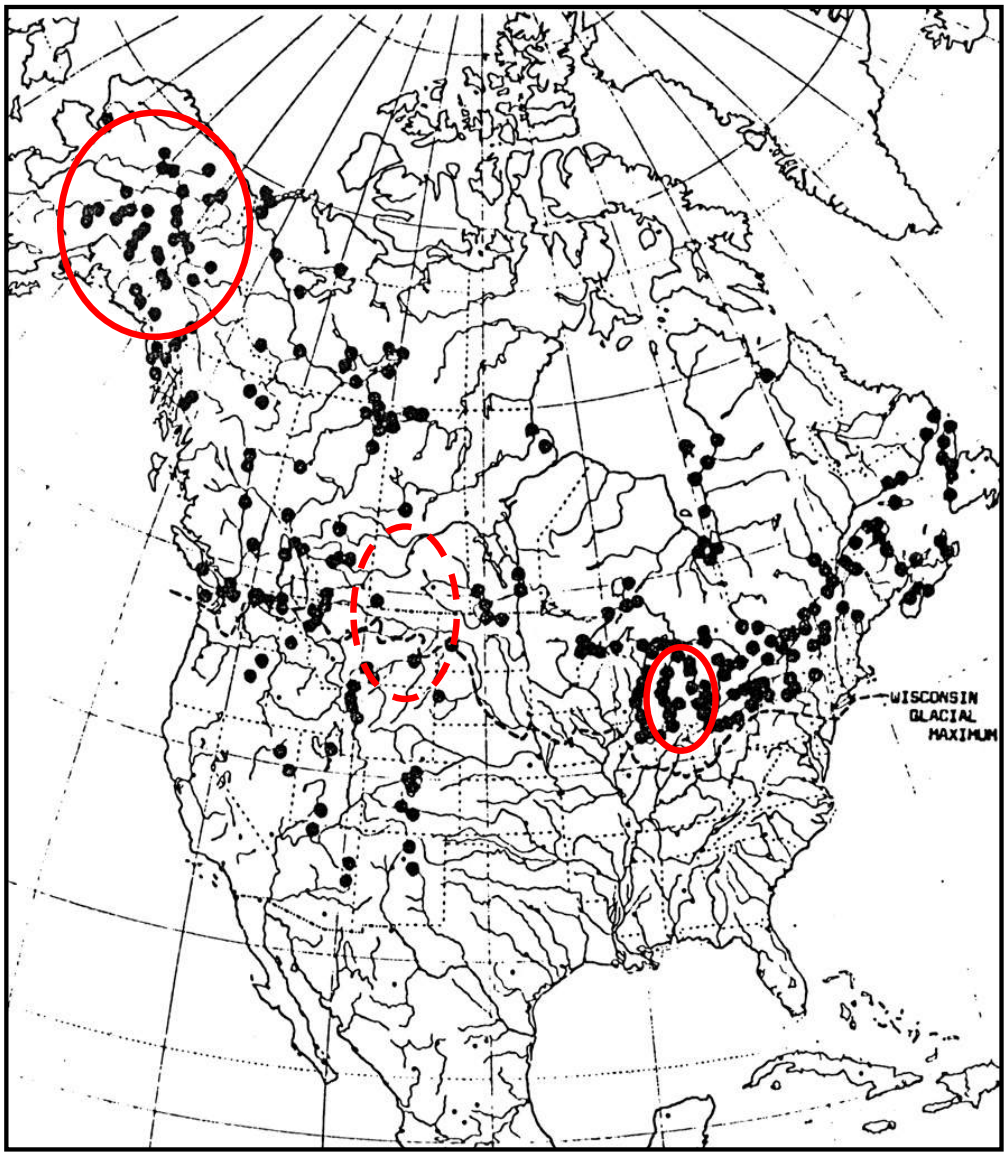
Assembly of Great Lakes Flora

6. Western North America:

A number of western elements are completely disjunct between Alaska (unglaciated areas) and sandy areas of the Great Lakes (beaches, sand outwash)

or with sporadic occurrence in Dakotas, Wyoming, Alberta

Typical western North America — Great Lakes pattern



Assembly of Great Lakes Flora

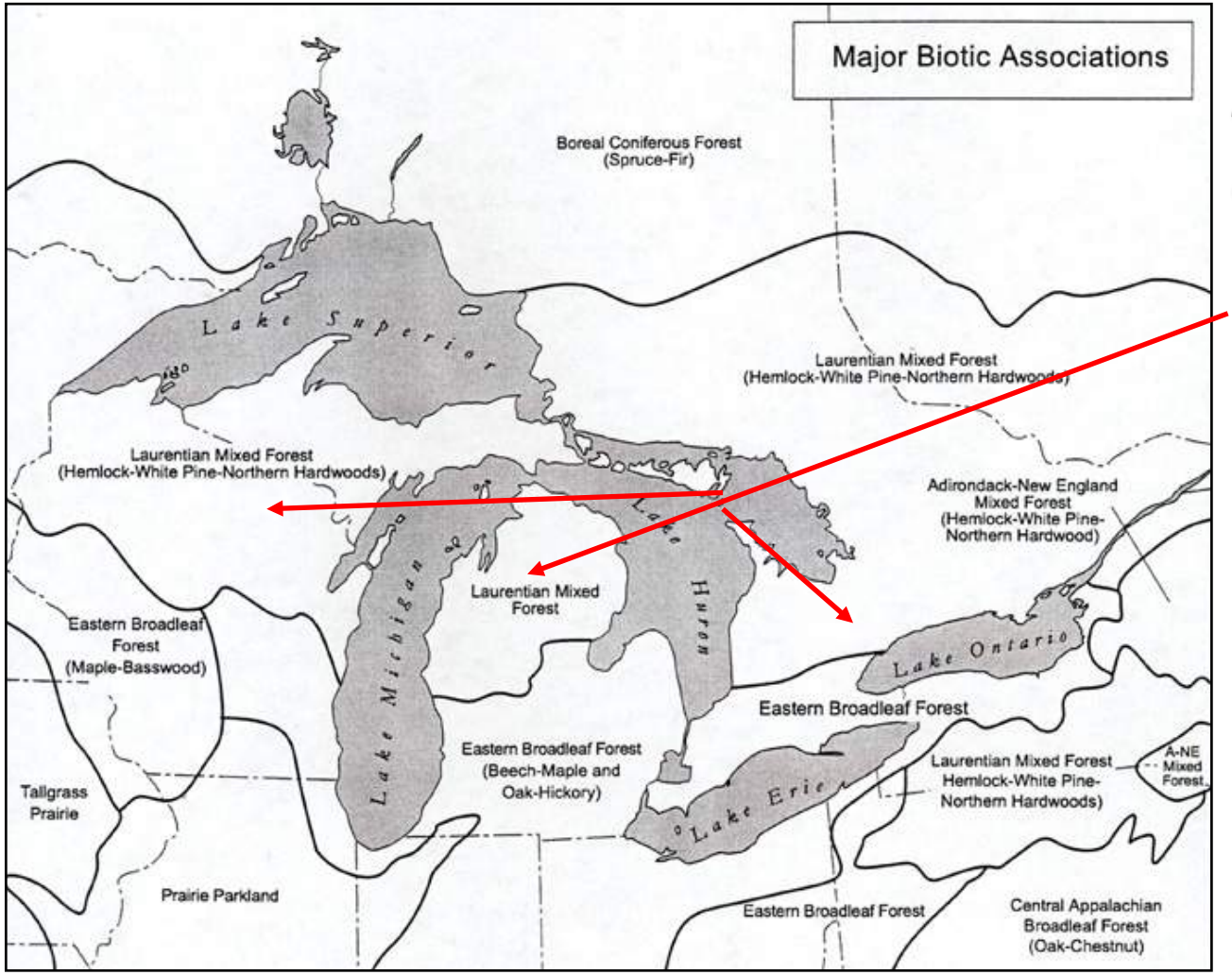
6. Western North America:

Species restricted to beaches of Great Lakes and into Maritime region of eastern Canada. Hulten considered it as a subspecies of the Alaskan and Pacific Northwestern species *T. bipinnatum*.

Tanacetum huronense
Lake Huron Tansy

Assembly of Great Lakes Flora

Species migrating into the Great Lakes region not only came from different places and at different rates, but also ended up in specific regions and associated with specific groups.

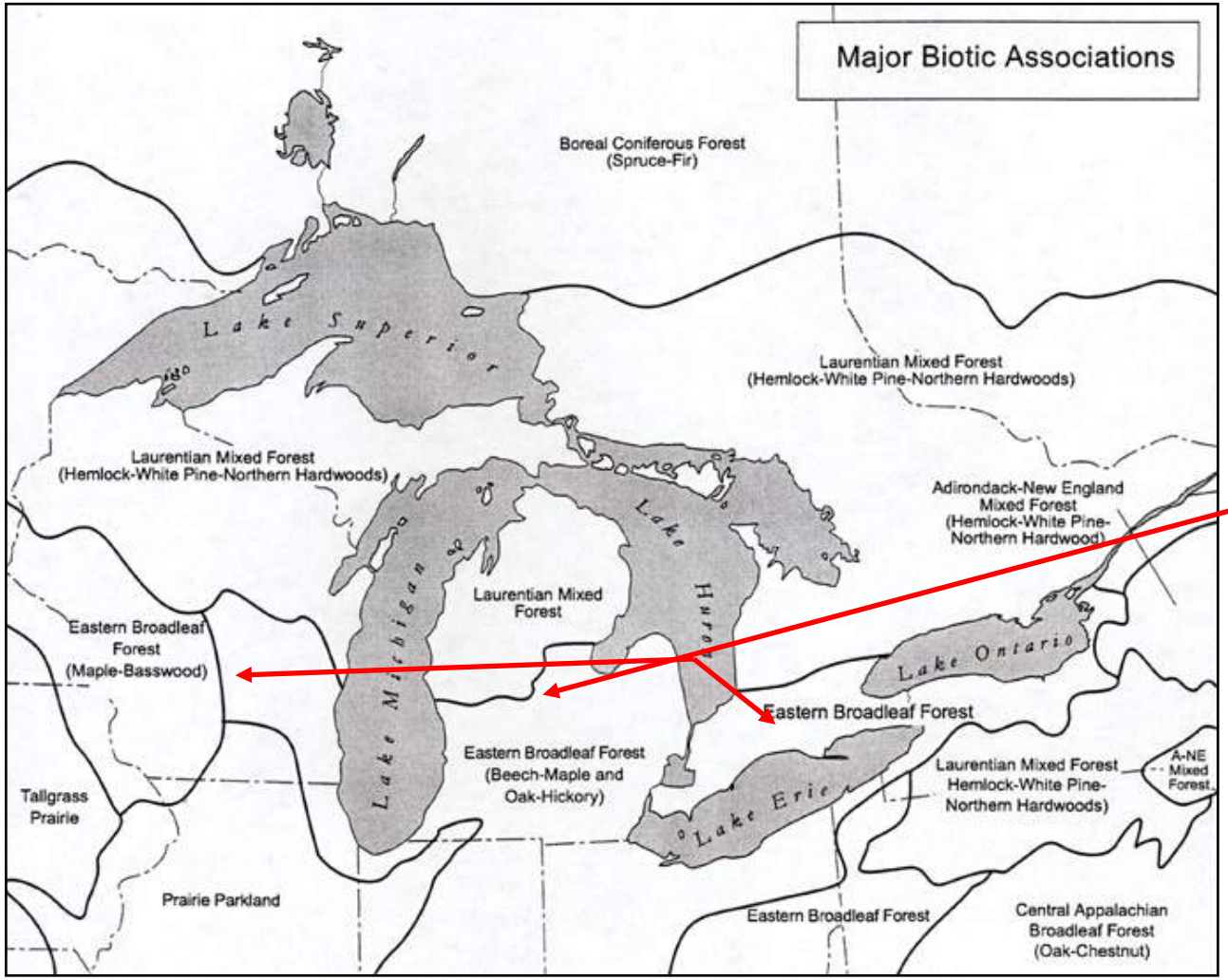


Two major biotic associations exist in the Great Lakes region:

1. northern hardwood-conifer forest

Assembly of Great Lakes Flora

Species migrating into the Great Lakes region not only came from different places and at different rates, but also ended up in specific regions and associated with specific groups.



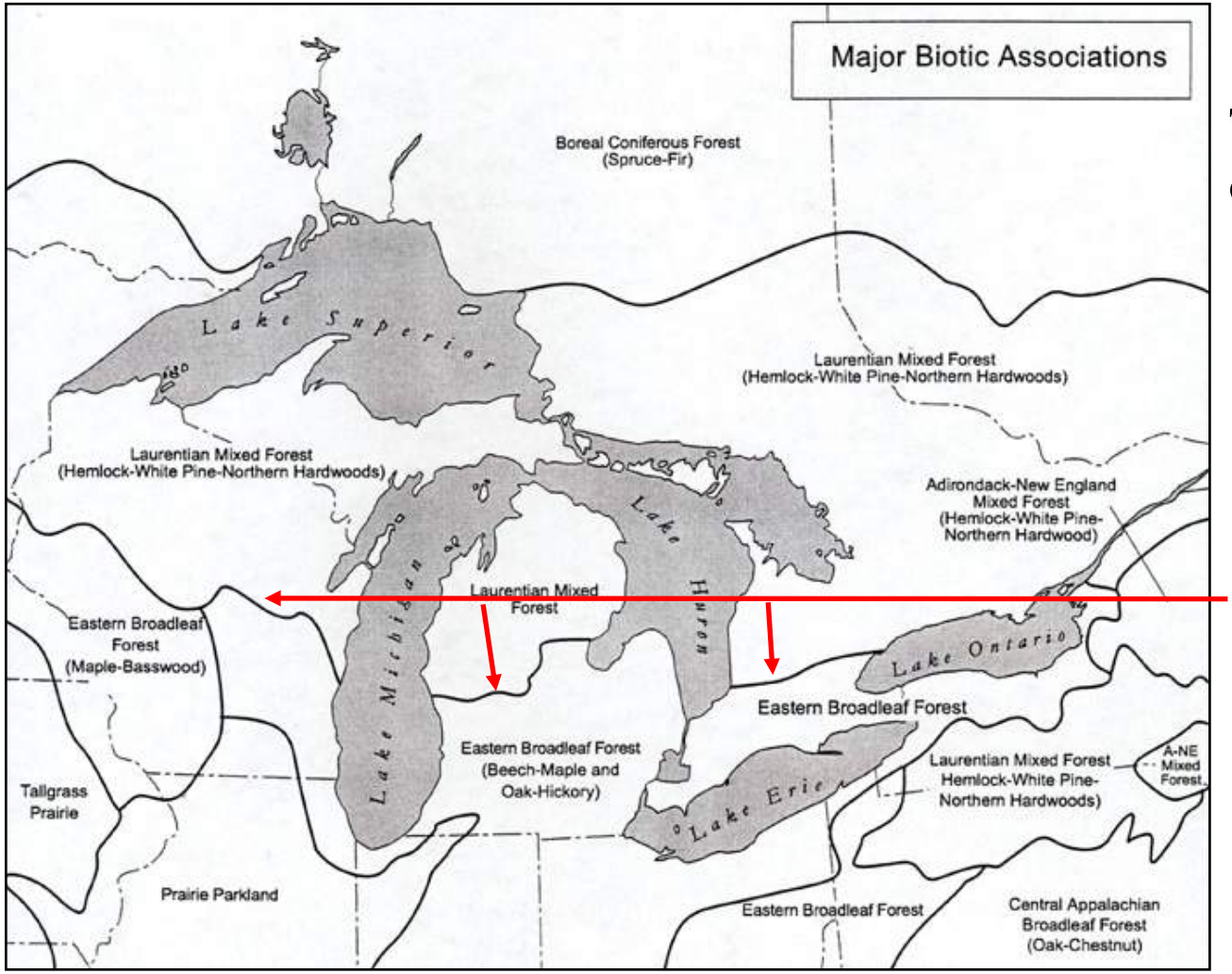
Two major biotic associations exist in the Great Lakes region:

1. northern hardwood-conifer forest

2. eastern deciduous forest

Assembly of Great Lakes Flora

Species migrating into the Great Lakes region not only came from different places and at different rates, but also ended up in specific regions and associated with specific groups.



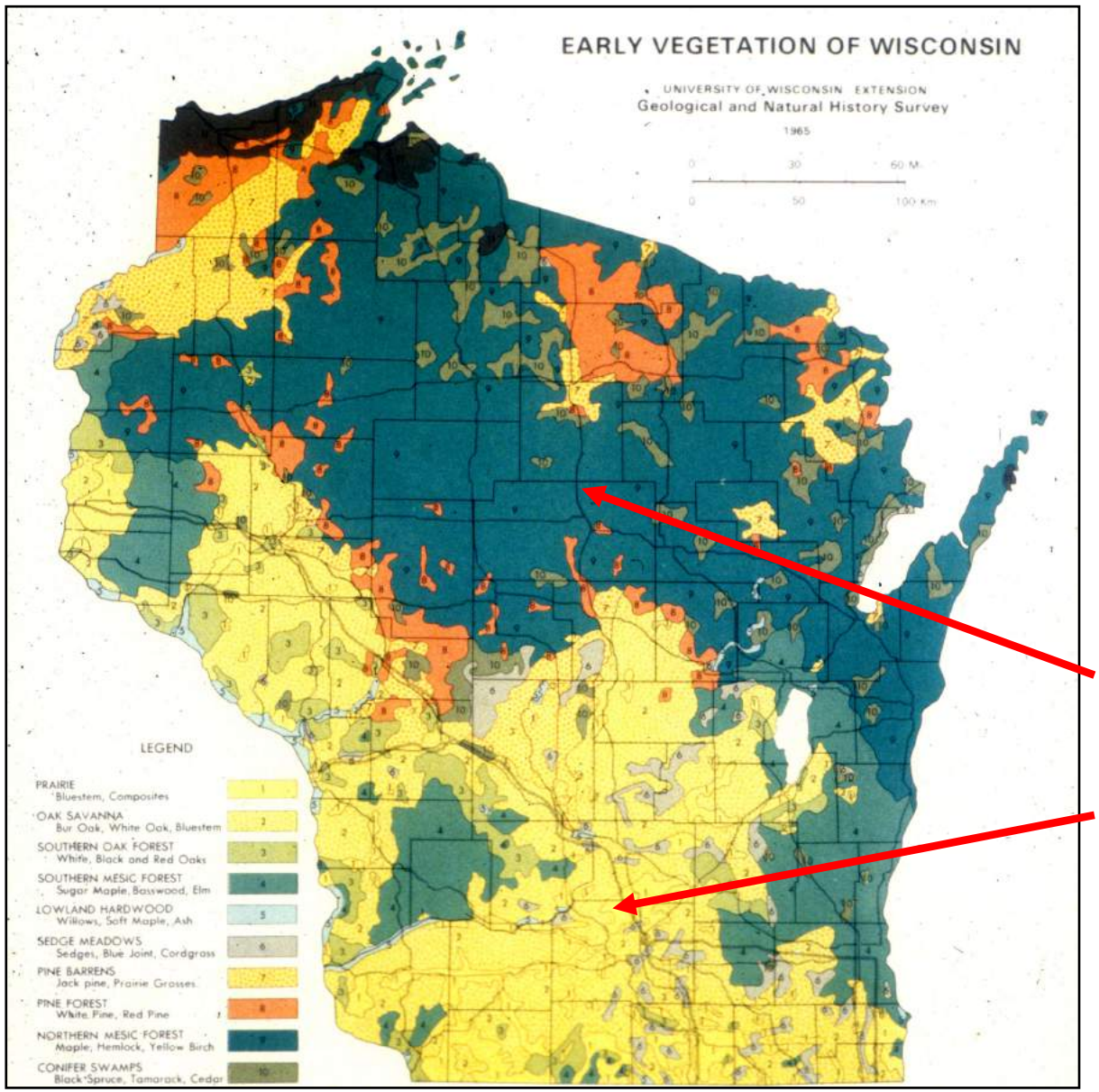
Two major biotic associations exist in the Great Lakes region:

1. northern hardwood-conifer forest

2. eastern deciduous forest

These two associations are separated by a fairly sharp tension line or zone

Assembly of Great Lakes Flora



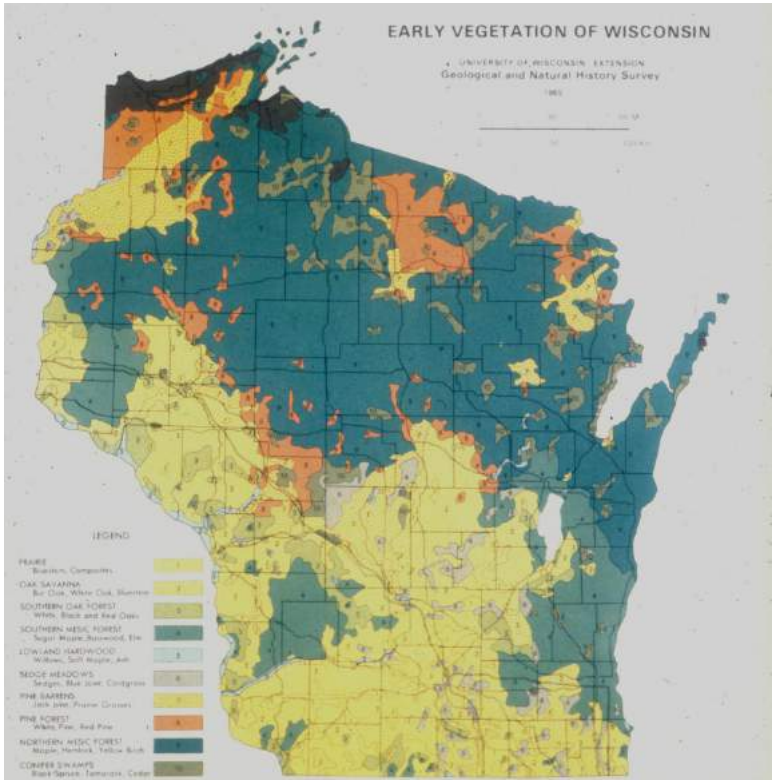
The tension zone is quite obvious just by looking at a pre-settlement vegetation map of Wisconsin

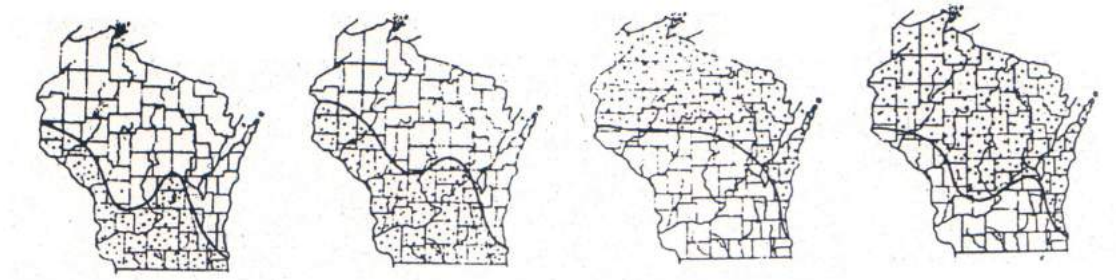
In Wisconsin the two areas are often referred to as two floristic provinces:

- Northern Hardwoods
- Prairie-Forest

Assembly of Great Lakes Flora

The tension zone separating the two provinces is based on the upper and lower distributional limits of the southern and northern species, respectively.





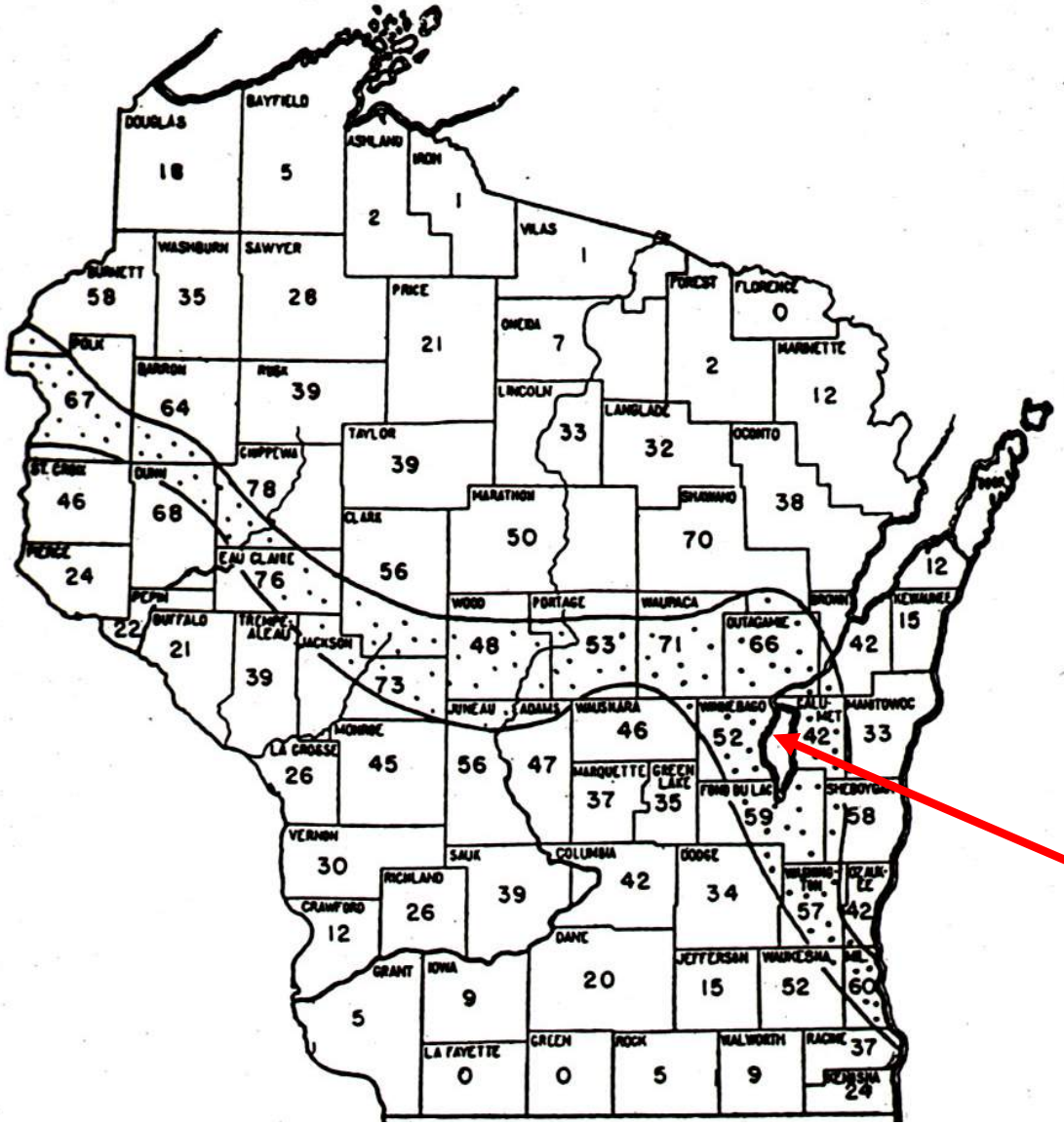
Golden cassia

Wild indigo

Ram's head ladyslipper

Stemless ladyslipper

Assembly of Great Lakes Flora

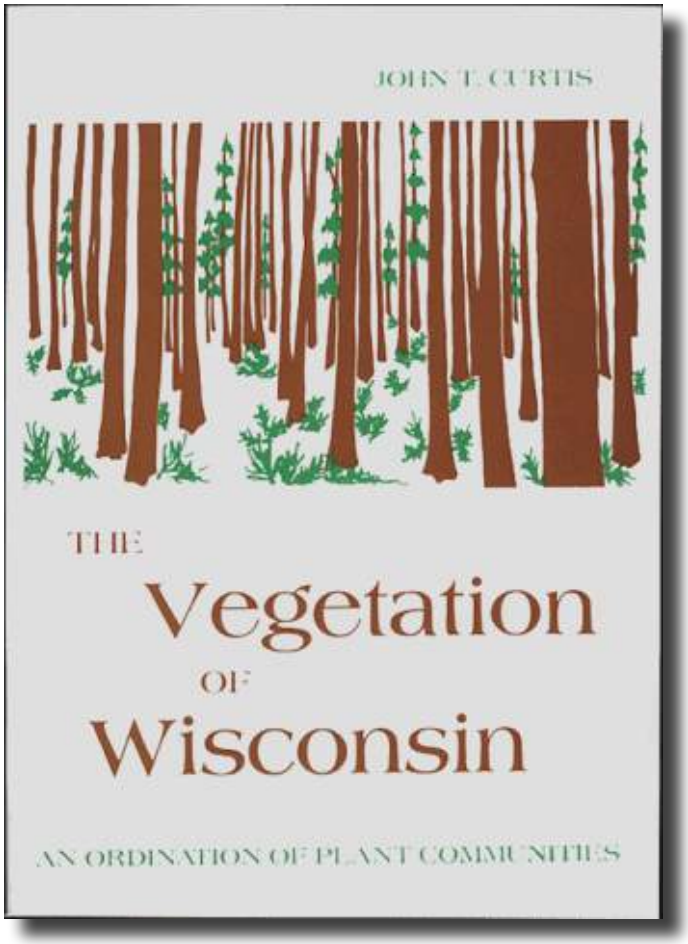


A compilation of the range limits (northern or southern) of 182 species in Wisconsin shows species range limits per county

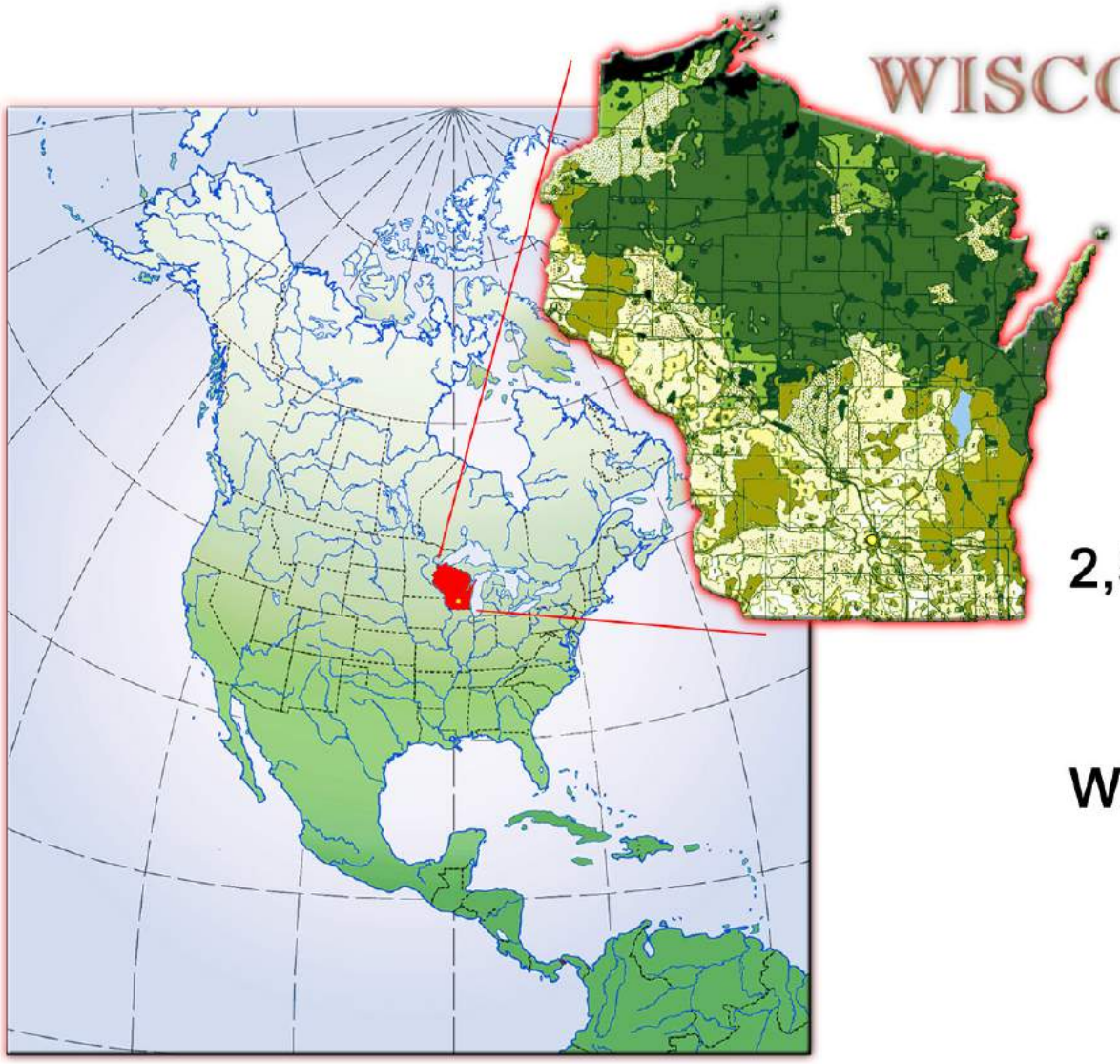
Tension zone

Assembly of Great Lakes Flora

Within each province, there are ecological (not floristic) assemblages of species called plant communities. John Curtis in the *Vegetation of Wisconsin*, described about 35 communities (the subject of Botany 455).



Vascular Flora of Wisconsin . . .
after the assembly . . .



2,570 species—

WIS Herbarium—
300,000 specimens
200,000 databased

Vascular Flora of Wisconsin . . .
after the assembly . . .

Information source: Wisconsin State Herbarium
www.botany.wisc.edu/herbarium/

Arethusa bulbosa
Dragon's mouth
Native species = 1889

Alliaria petiolata
Garlic mustard
Introduced species = 681

158 families 758 genera 2570 species