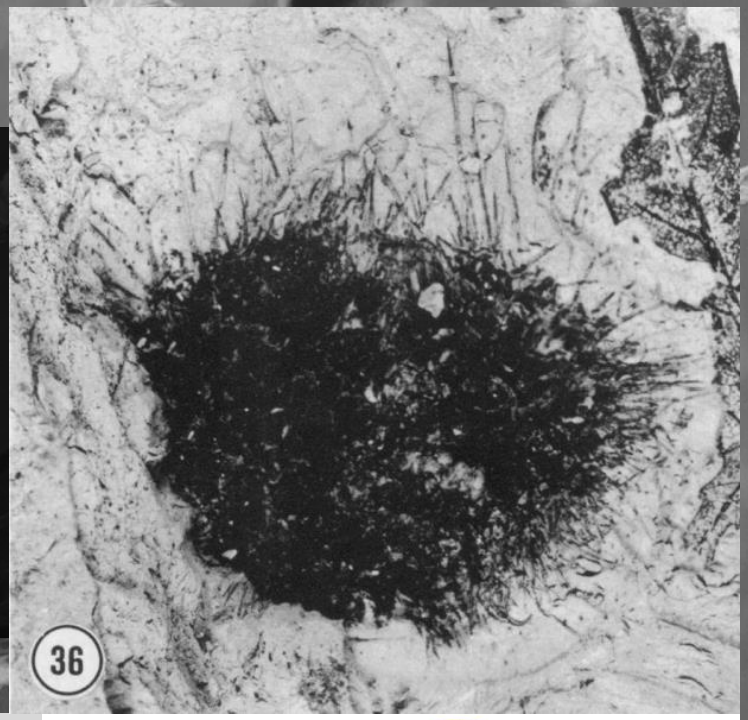
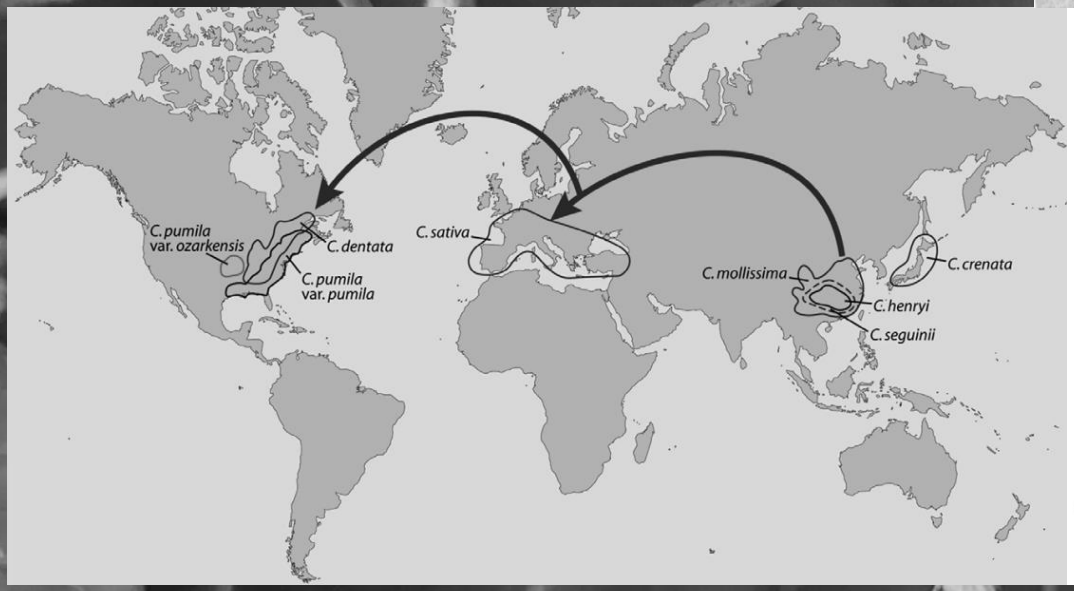
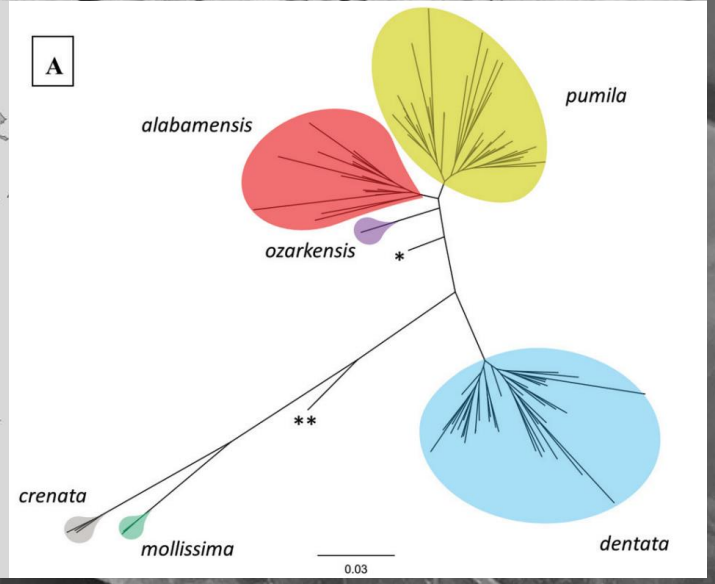
1/21/22
Chestnut Chat:
Evolution of the Genus *Castanea*

Taylor Perkins
The University of Tennessee at Chattanooga







Biological taxonomy (ideally) reflects evolutionary history

Kingdom	Plantae
Phylum	Tracheophyta
Class	Magnoliopsida
Order	Fagales
Family	Fagaceae
Genus	*Castanea*
Species	*Castanea dentata*

Biological taxonomy (ideally) reflects evolutionary history

Kingdom	Plantae
Phylum	Tracheophyta
Class	Magnoliopsida
Order	Fagales
Family	Fagaceae
Genus	*Castanea*
Species	*Castanea dentata*

Two main types of evidence used to study *Castanea* evolution

Fossils

PC: Burke Museum, Univ. Washington

Two main types of evidence used to study *Castanea* evolution

Fossils

PC: Burke Museum, Univ. Washington

DNA sequence comparisons

Indiv 1: AAGGGATGCAAAGAGCTAAAGAACAGGAATTTTAATTTAATAGCATTCT
Indiv 2: AAGGGATGCAAAGAGCTAAAGAAGAGGAATTTTAATTTAATAGCATTCT
Indiv 3: AAAGGATGAAAAGAGCTAAAGAAGAGGAATTTTAATTTAATAGCATTCT

Polymorphisms (*i.e.,* mutations)

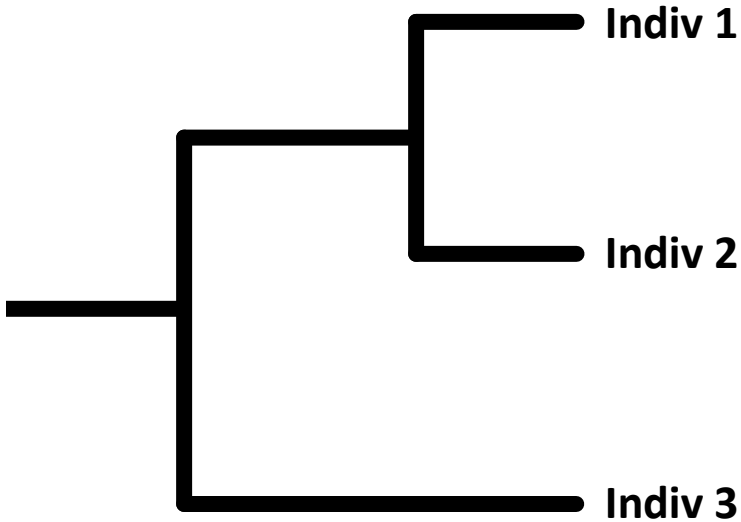
Two main types of evidence used to study *Castanea* evolution

Fossils

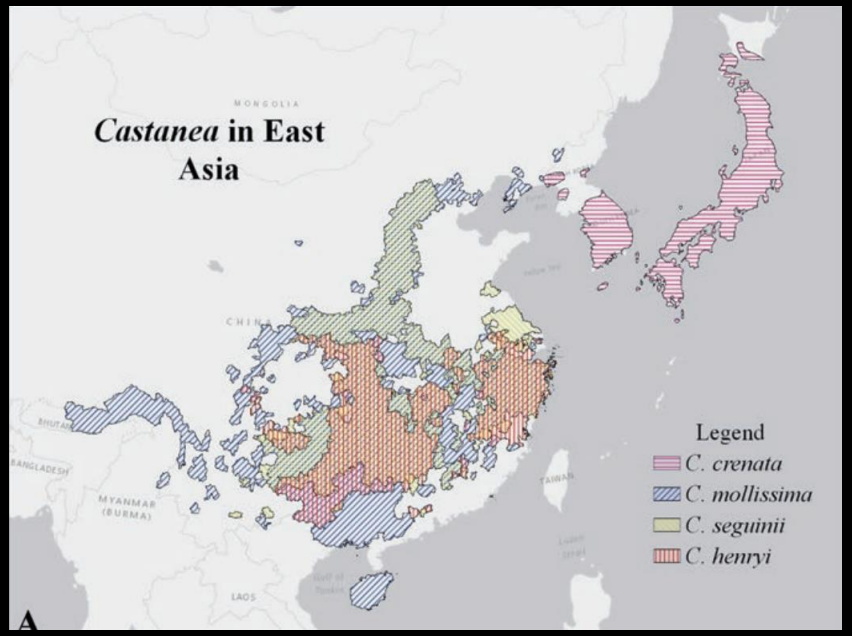
PC: Burke Museum, Univ. Washington

DNA sequence comparisons

Indiv 1: AAGGGATGCAAAGAGCTAAAGAACAGGAATTTTAATTTAATAGCATTCT
Indiv 2: AAGGGATGCAAAGAGCTAAAGAAGAGGAATTTTAATTTAATAGCATTCT
Indiv 3: AAAGGATGAAAAGAGCTAAAGAAGAGGAATTTTAATTTAATAGCATTCT



7-10 *Castanea* species currently exist



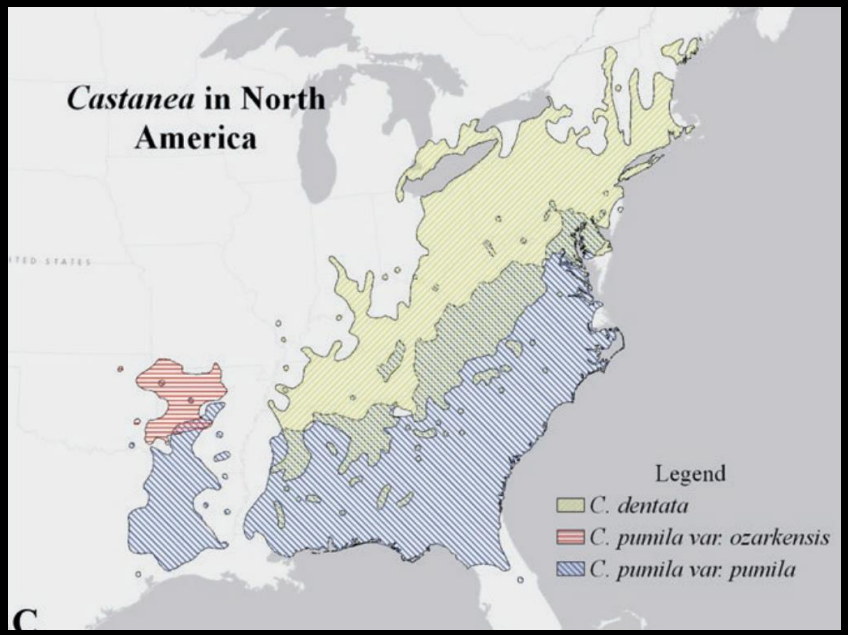
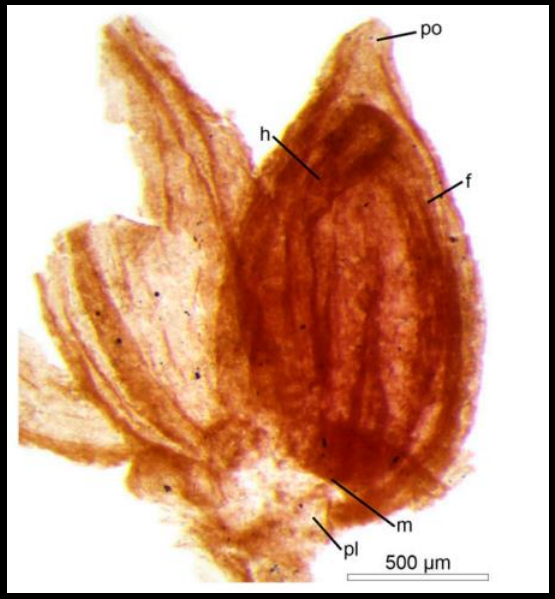


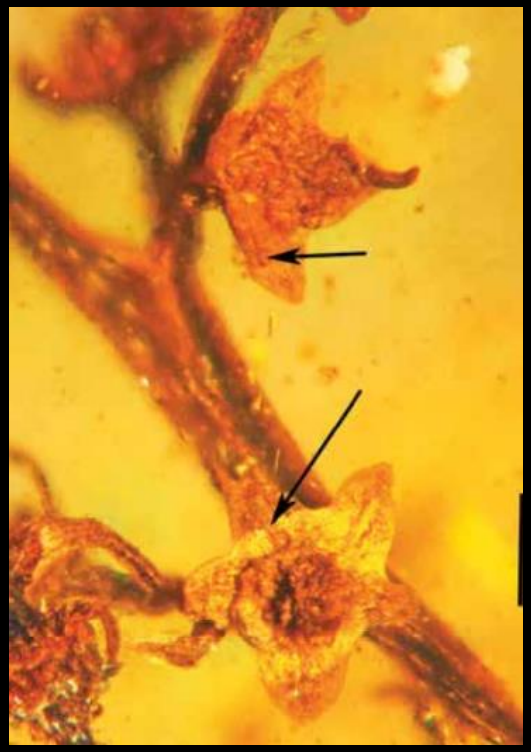
Fig. from Craddock and Perkins (2019)

Angiosperms had appeared by the early Cretaceous, ~130 mya



Montsechia vidalii from 130-125 mya
Gomez et al. (2015)

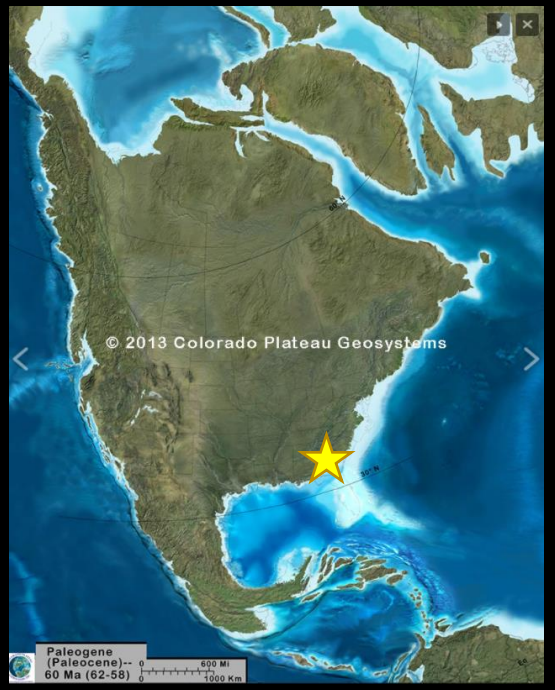
Leefructus mirus from 122.6-125.8 mya
Sun et al. (2011)



Micropetasos burmensis flowers in amber, from ~100 mya
Poinar et al. (2013)

Earliest Fagaceae fossils from:
Late Cretaceous, ~83-72 million years ago;
Paleocene-Eocene boundary, ~56 mya

Protofagacea allonensis,
~83-72 mya



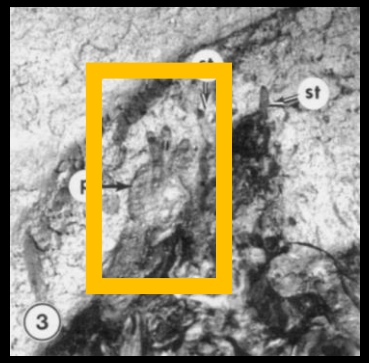
North America ~60 mya
(map by RC Blakey, NAU)

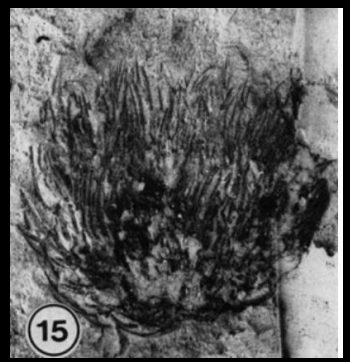
Herendeen et al. (1995) Int. J. Plant Sci 156:93-116; Crepet and Nixon (1989) Am. J. Bot 76:842-855

Earliest Fagaceae fossils from:
Late Cretaceous, ~83-72 million years ago;
Paleocene-Eocene boundary, ~56 mya

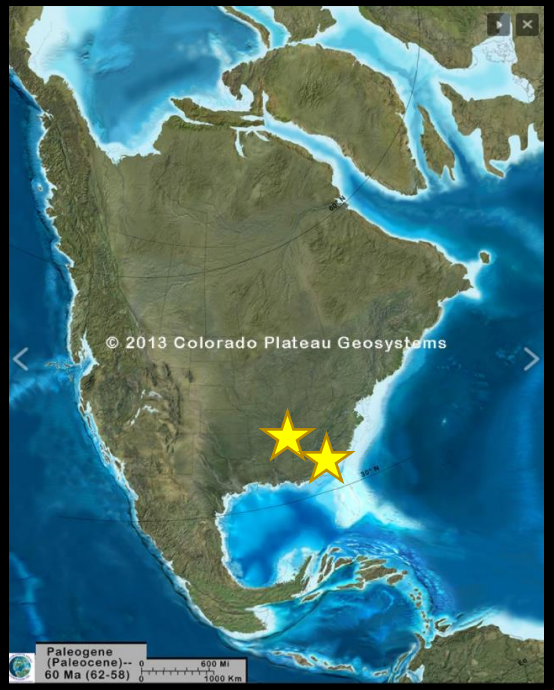
Protofagacea allonensis,
~83-72 mya

Trigonobalanoidea, ~56 mya





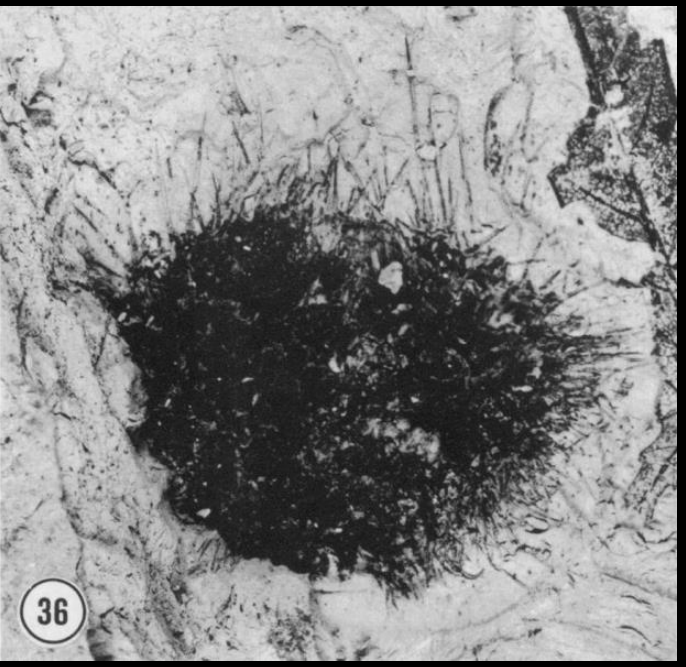
Castanopsoidea, ~56 mya



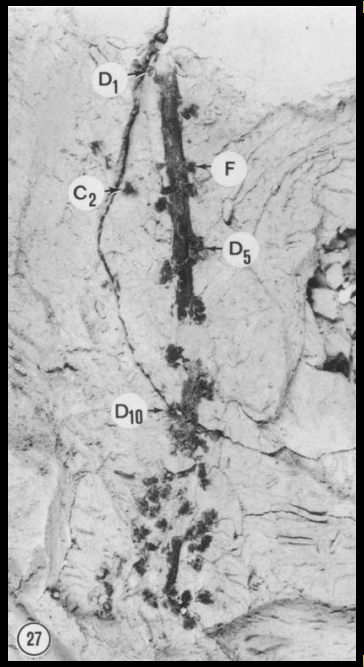
North America ~60 mya
(map by RC Blakey, NAU)

Herendeen et al. (1995) Int. J. Plant Sci 156:93-116; Crepet and Nixon (1989) Am. J. Bot 76:842-855

Castaneoidea puryearensis, the earliest Chestnut-like fossils
From the mid-Eocene, ~50-40 million years ago



Fossil bur



Fossil catkin

North America ~40 mya
(map by RC Blakey, NAU)

Crepet and Daghlian (1980) Am. J. Bot 67:739-757

Castanea occurred in both eastern and western North America during the Eocene

Claiborne Formation, TN

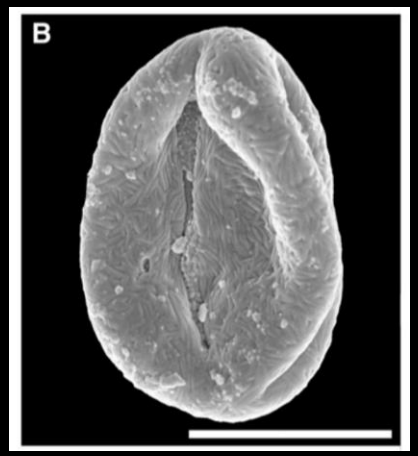
Allenby Formation, BC, Canada

Allenby Fm, BC, Canada

North America ~40 mya
(map by RC Blakey, NAU)

Clarno Formation, Oregon

Renova Formation, Montana

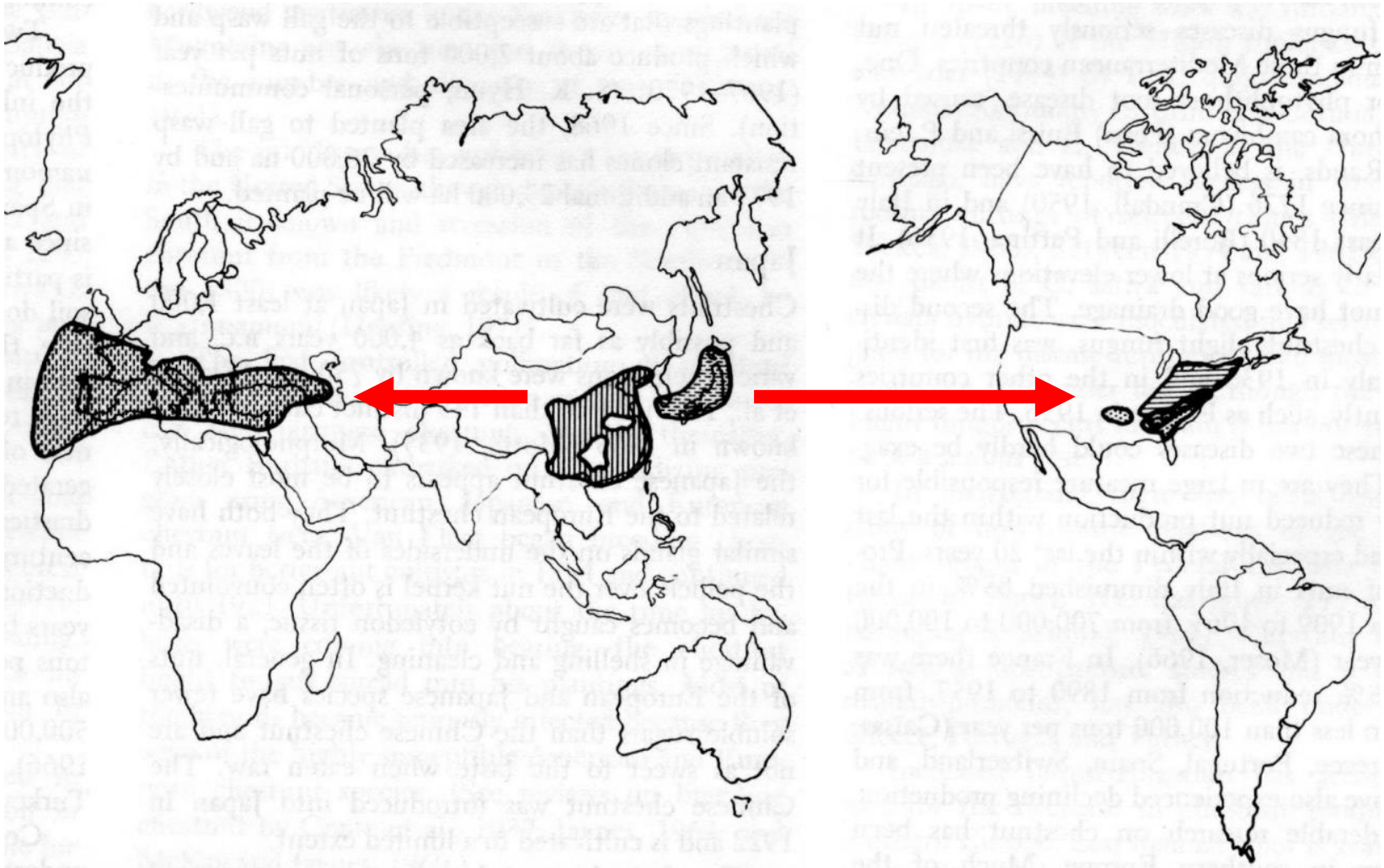


Florissant Formation, Colorado

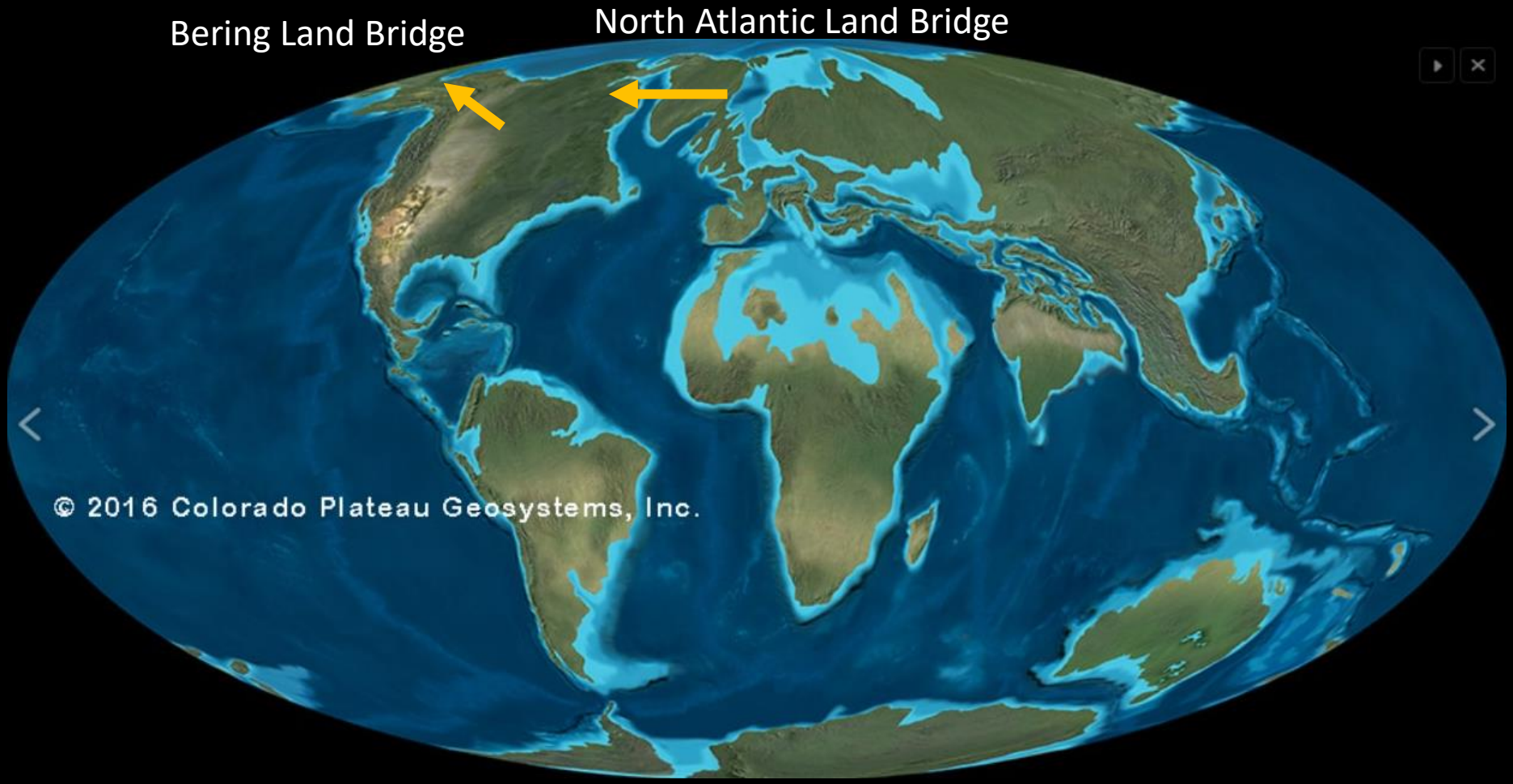
Data and images courtesy of Burke Museum (Univ. Washington), Yale Peabody Museum, Bouchal et al. (2014), Jaynes (1975)

Hypothesized origin of *Castanea* in eastern Asia

Ref: Jaynes (1975) *Advances in Fruit Breeding*



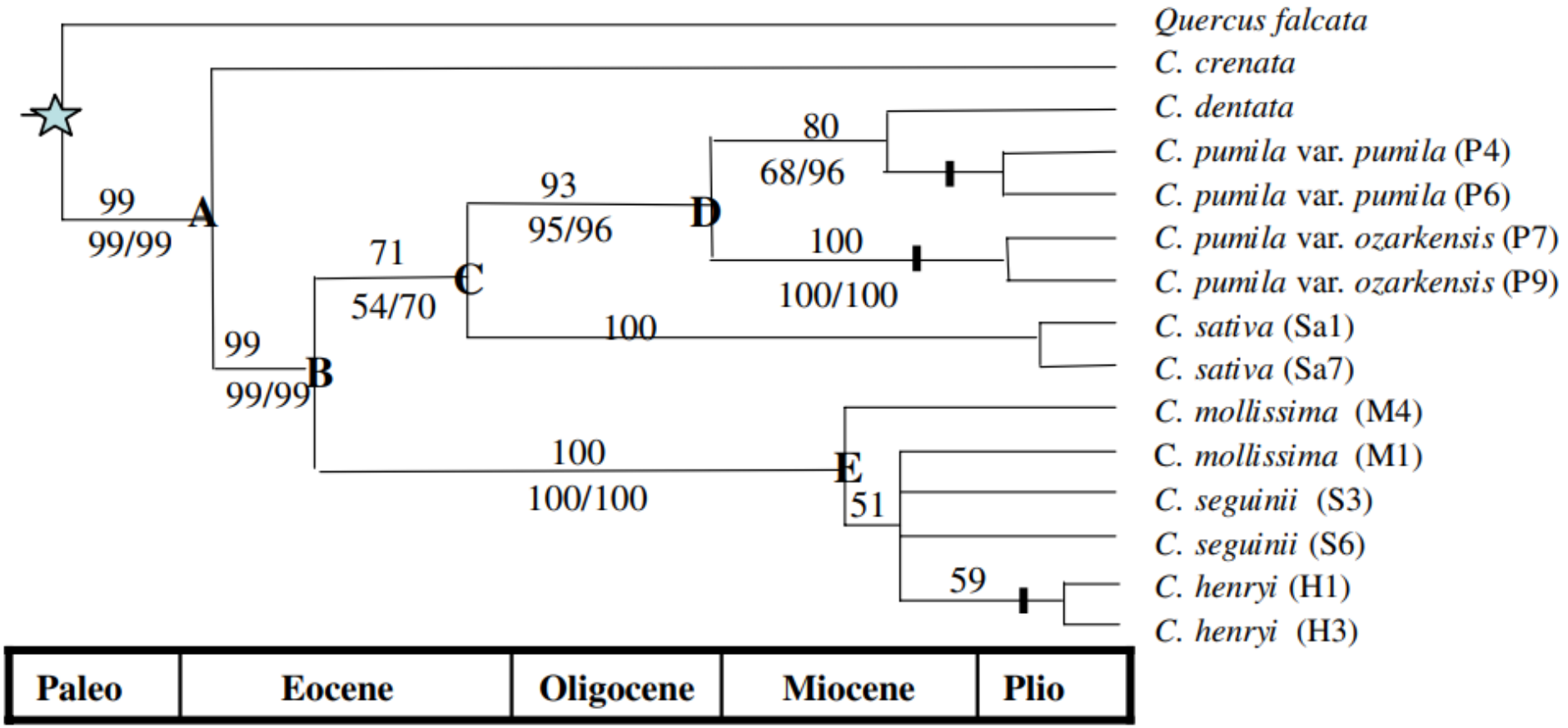
“Land bridges” have allowed migration of species across the globe



~40 million years ago, map by RC Blakey (NAU)

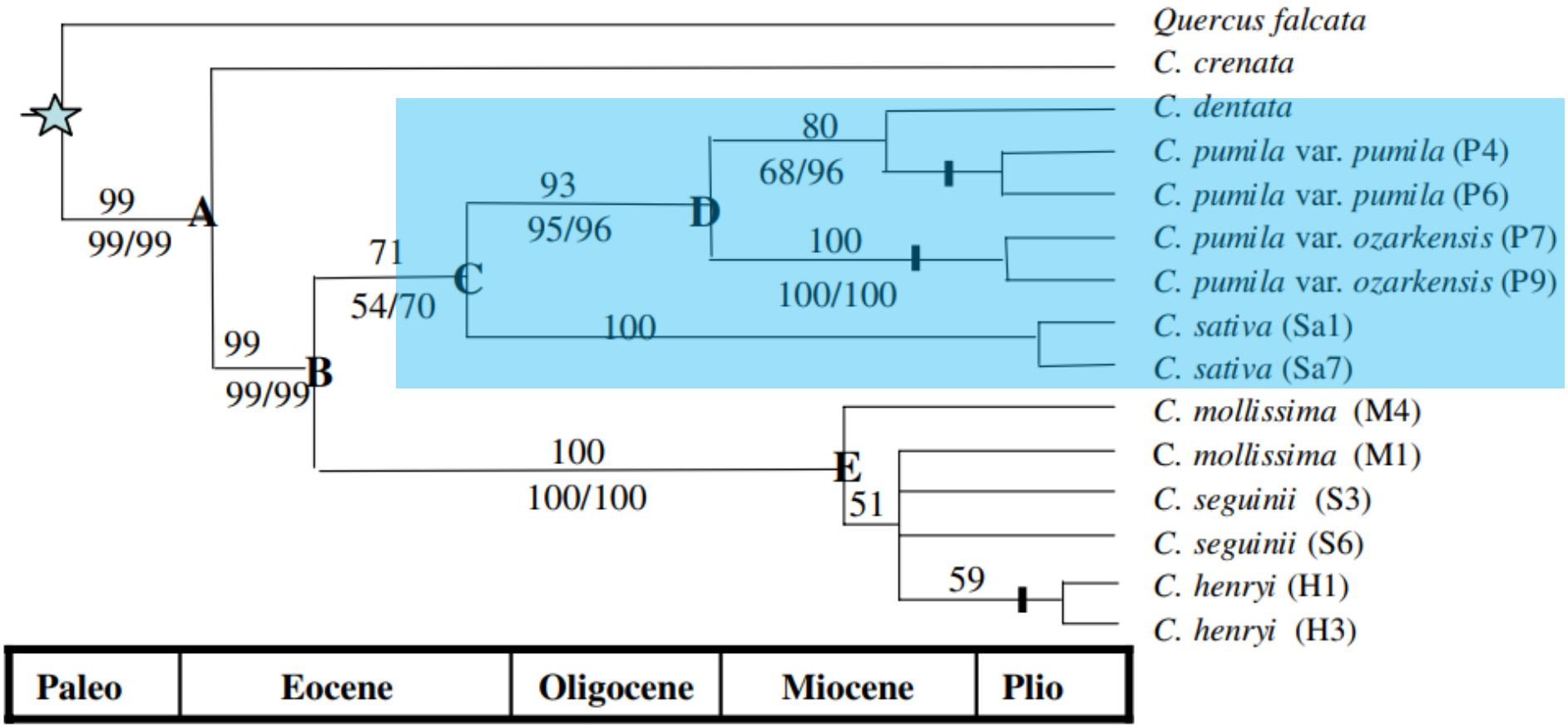
Castanea evolutionary tree inferred from chloroplast DNA

Ref: Lang, Dane, Kubisiak, Huang (2007) Mol. Phylogenet. Evol. 43:49-59

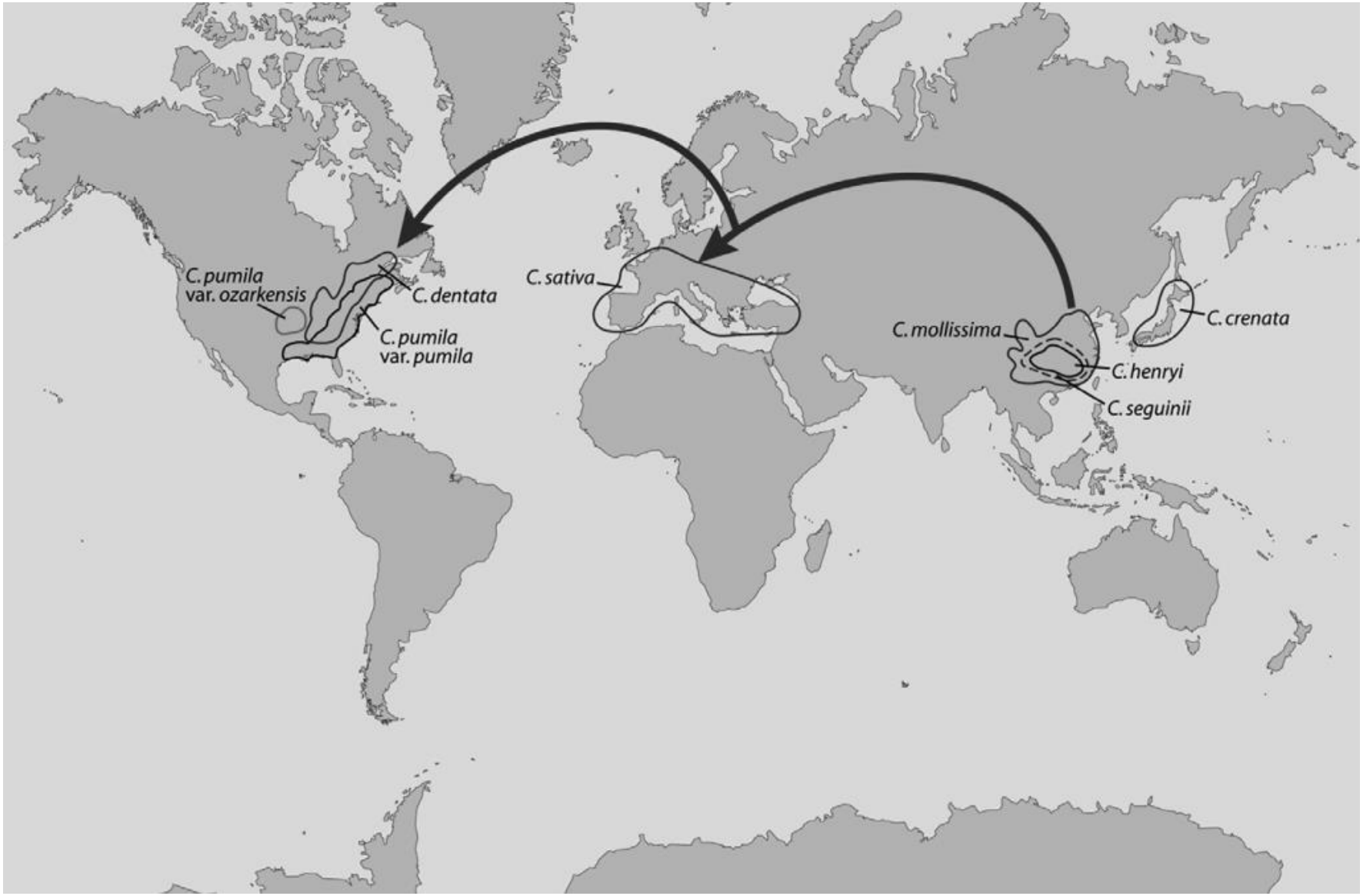


C. sativa is more closely related to N. American *Castanea*

Ref: Lang, Dane, Kubisiak, Huang (2007) Mol. Phylogenet. Evol. 43:49-59

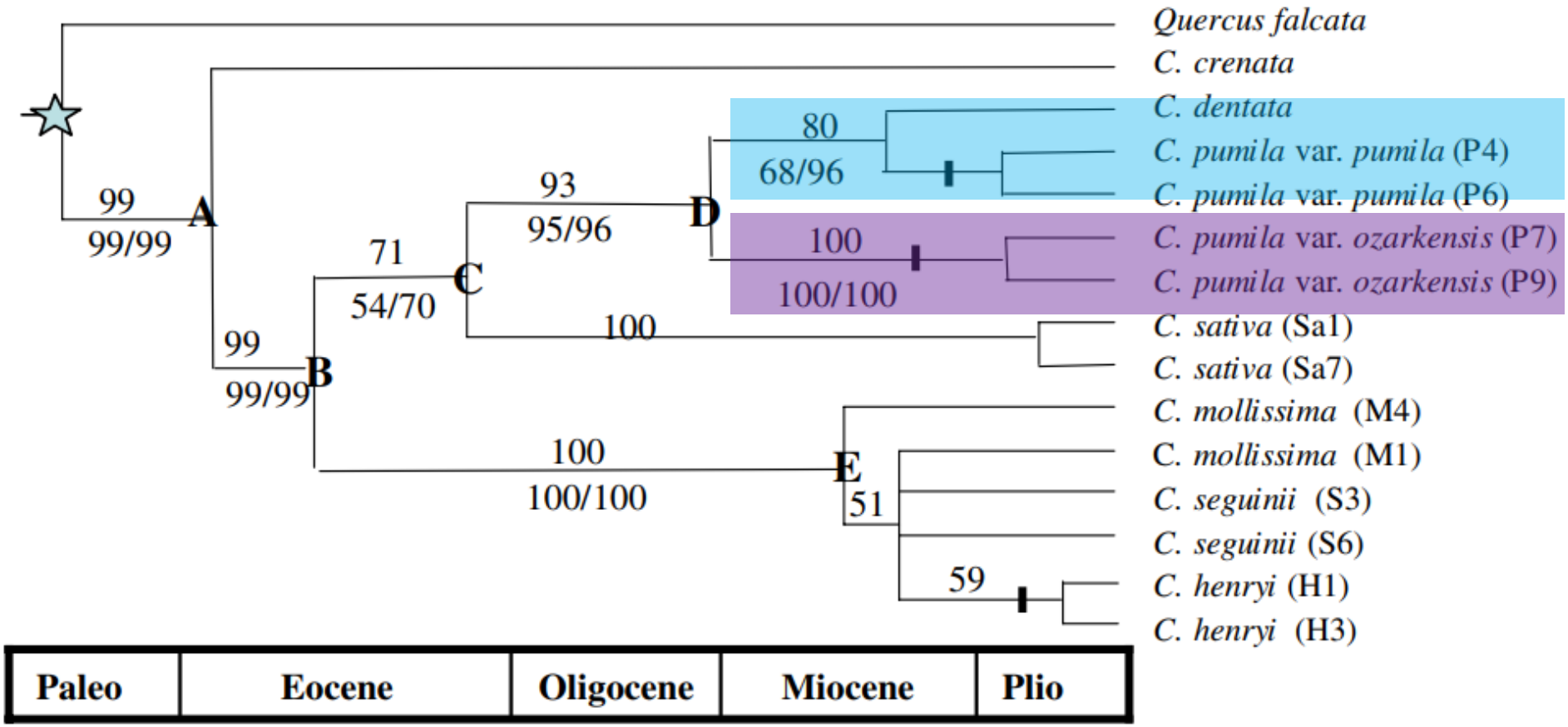


Lang et al. (2007): a hypothesized westward migration of *Castanea* from eastern Asia

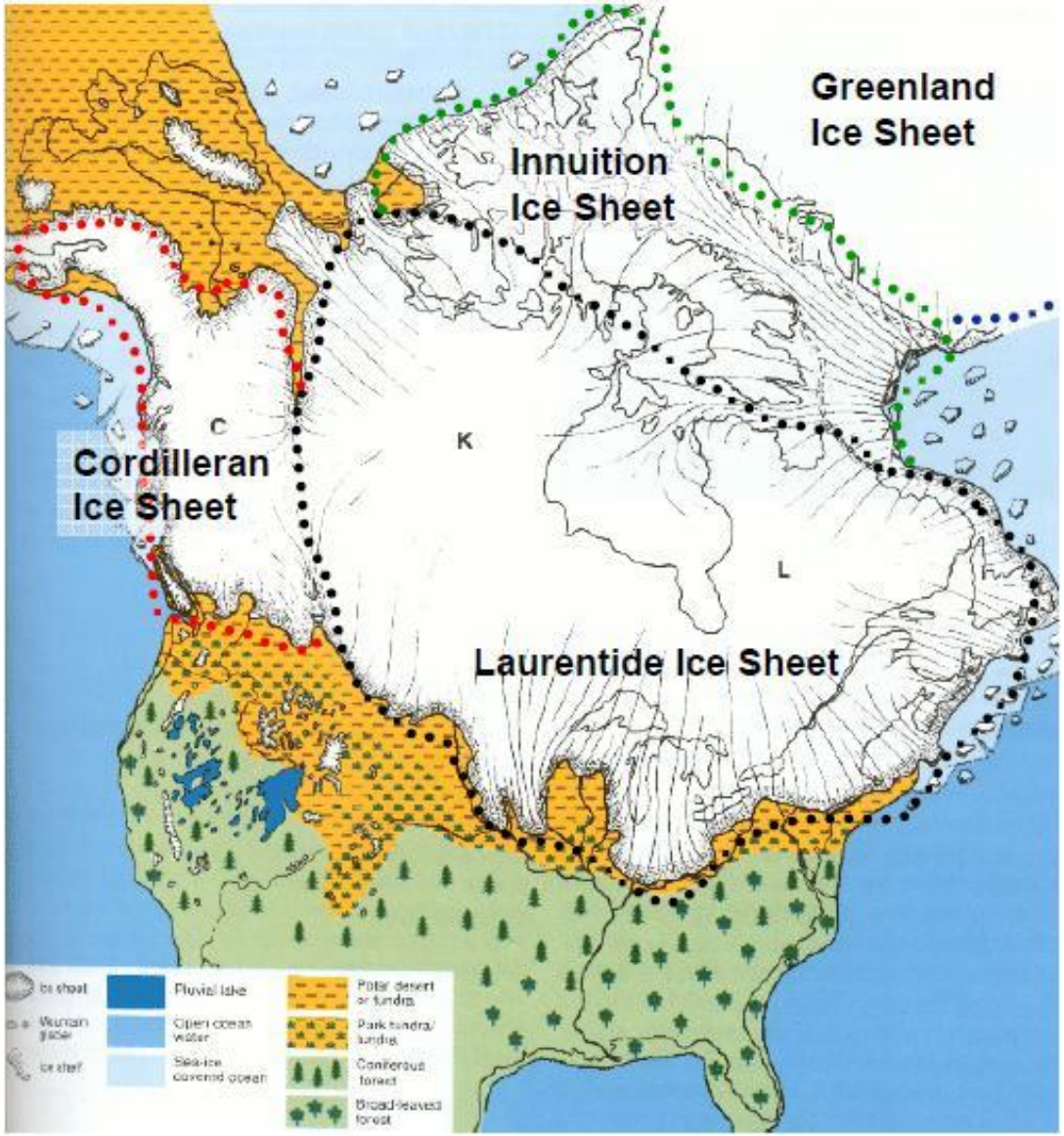


Castanea evolutionary tree inferred from chloroplast DNA

Ref: Lang, Dane, Kubisiak, Huang (2007) Mol. Phylogenet. Evol. 43:49-59

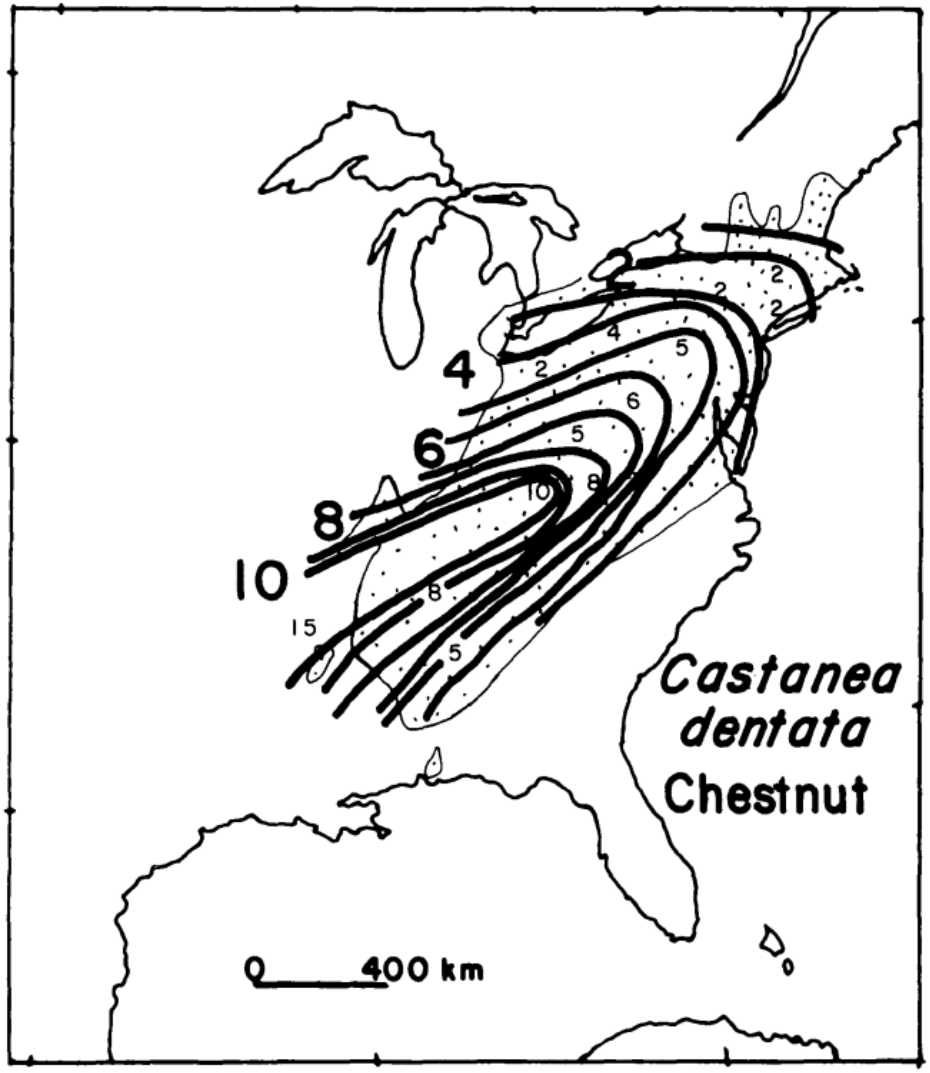


Pleistocene glaciation cycles from ~2.5 mya – 11,700 ya



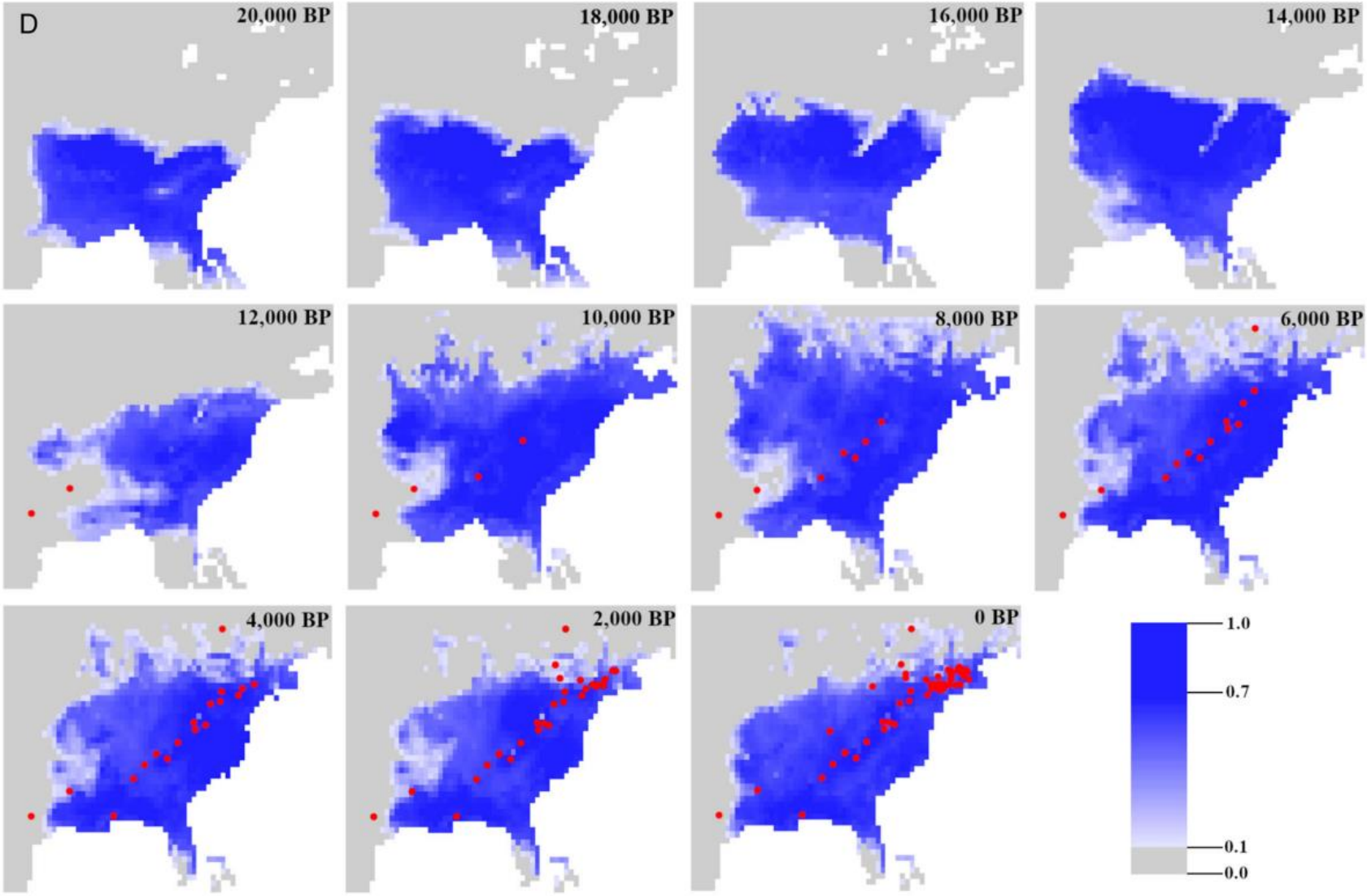
Extent of ice at the last glacial maximum, ~20,000 ya

Migration of *Castanea* after last ice age inferred from the pollen record



Davis (1983) *Ann. Mo. Bot. Gard.* 70:550-563

…but new studies may add detail to the story



Species distribution modelling predictions (blue) and pollen records (red dots) from Spriggs and Fertakos (2021) Am J. Bot.

Hybridization between *Castanea* species in the wild

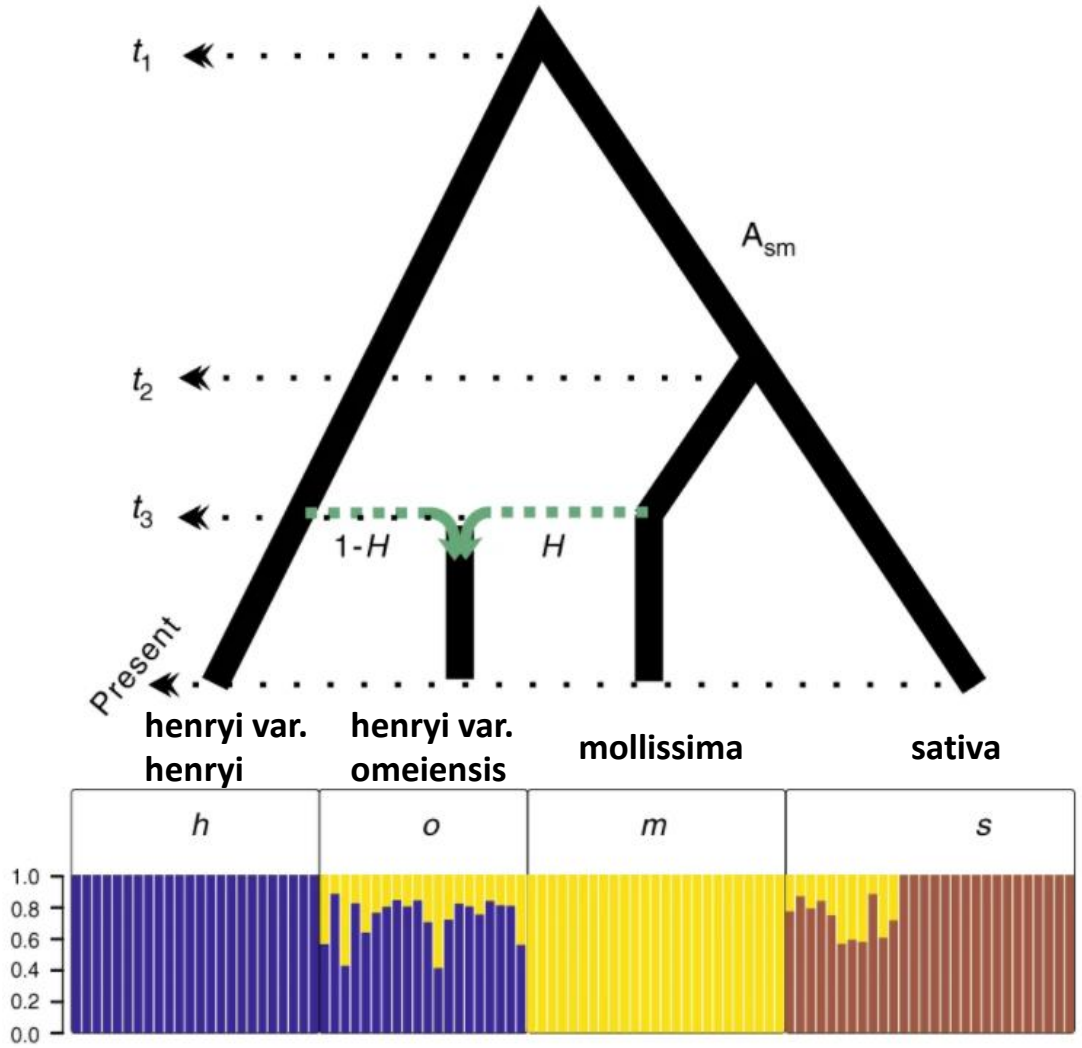
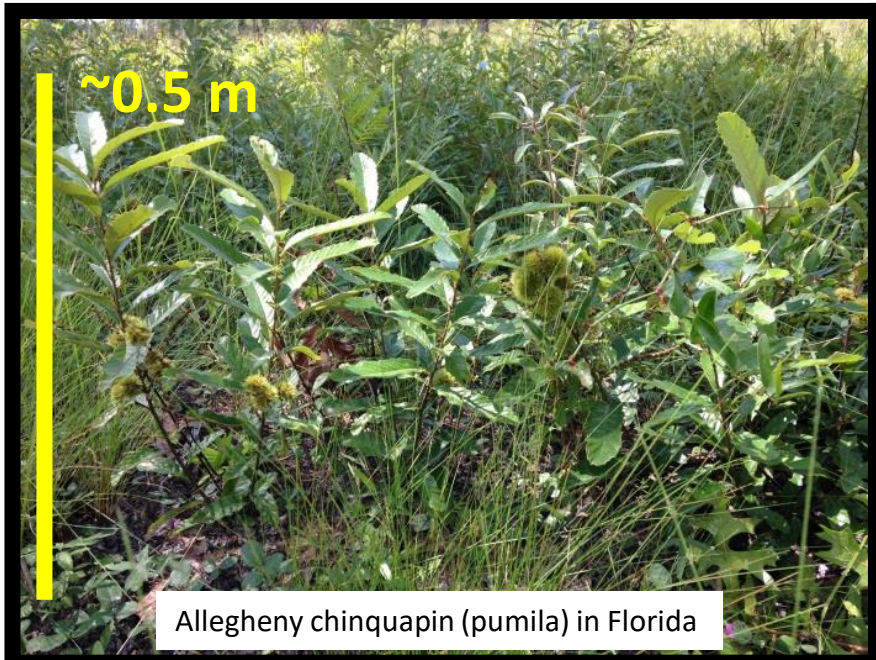


Fig. adapted from Sun et al. (2020) "Genomic basis of homoploid hybrid speciation in chestnut trees" *Nature Comm.*

North American *Castanea* species



Allegheny chinquapin (pumila) in Florida

Allegheny chinquapin (pumila) from Georgia


Ozark chinquapin (ozarkensis) in Arkansas

American chestnut in Tenn.

C. alabamensis snag

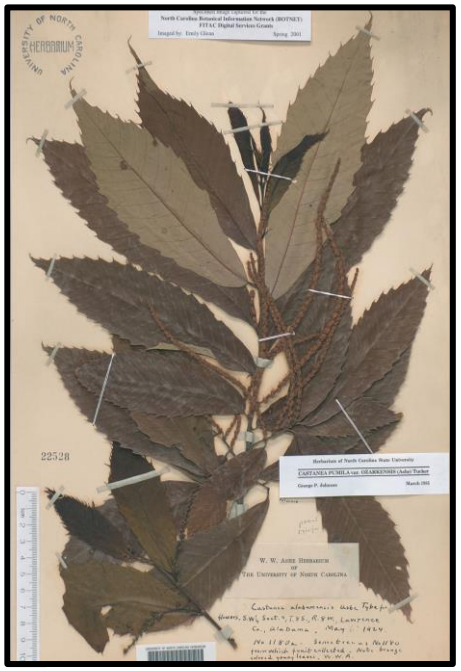
Has hybridization contributed to morphological variation? (the case of *Castanea alabamensis*)

Allegheny chinquapin (pumila)

×

American chestnut (dentata)

=

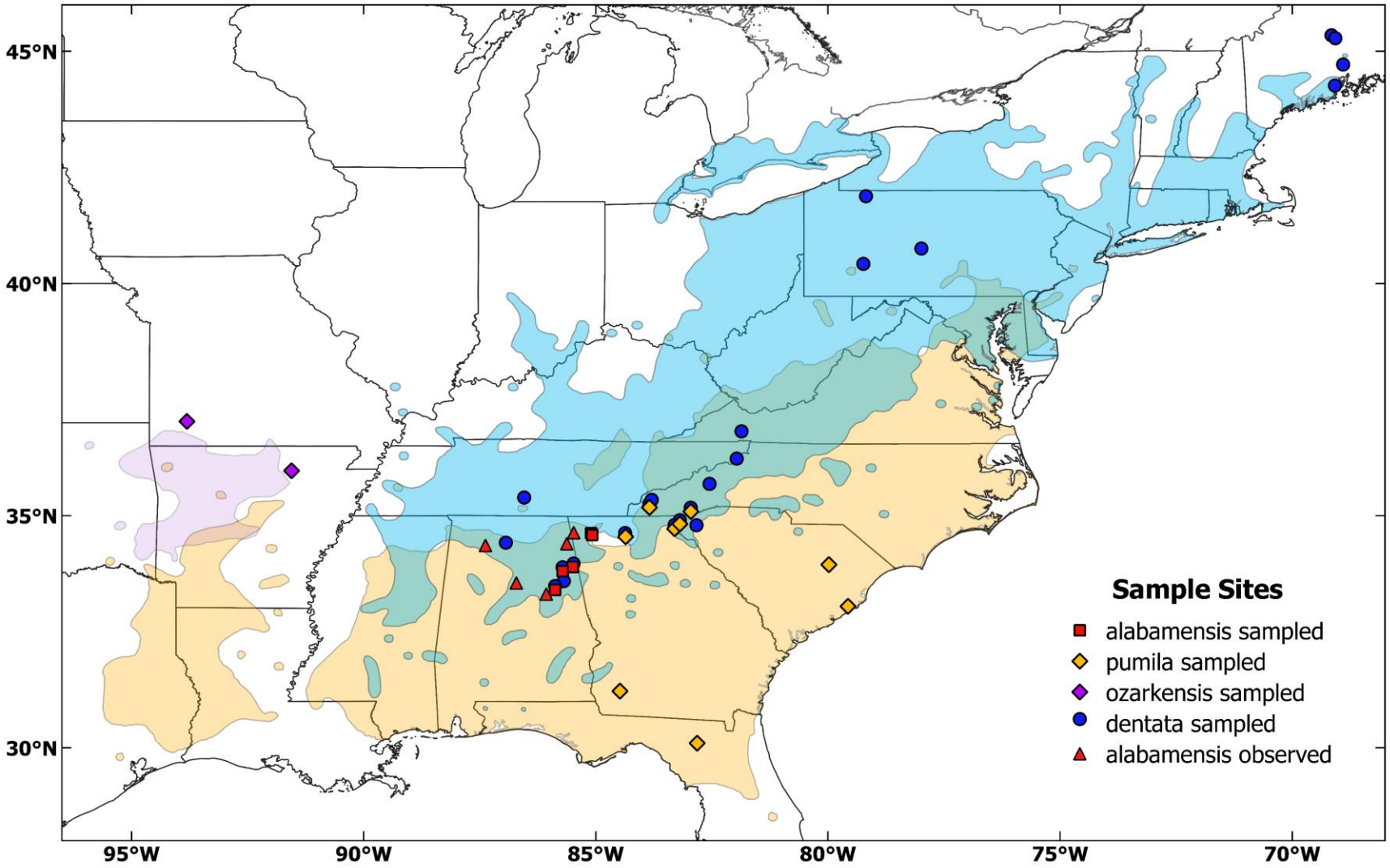


Castanea alabamensis

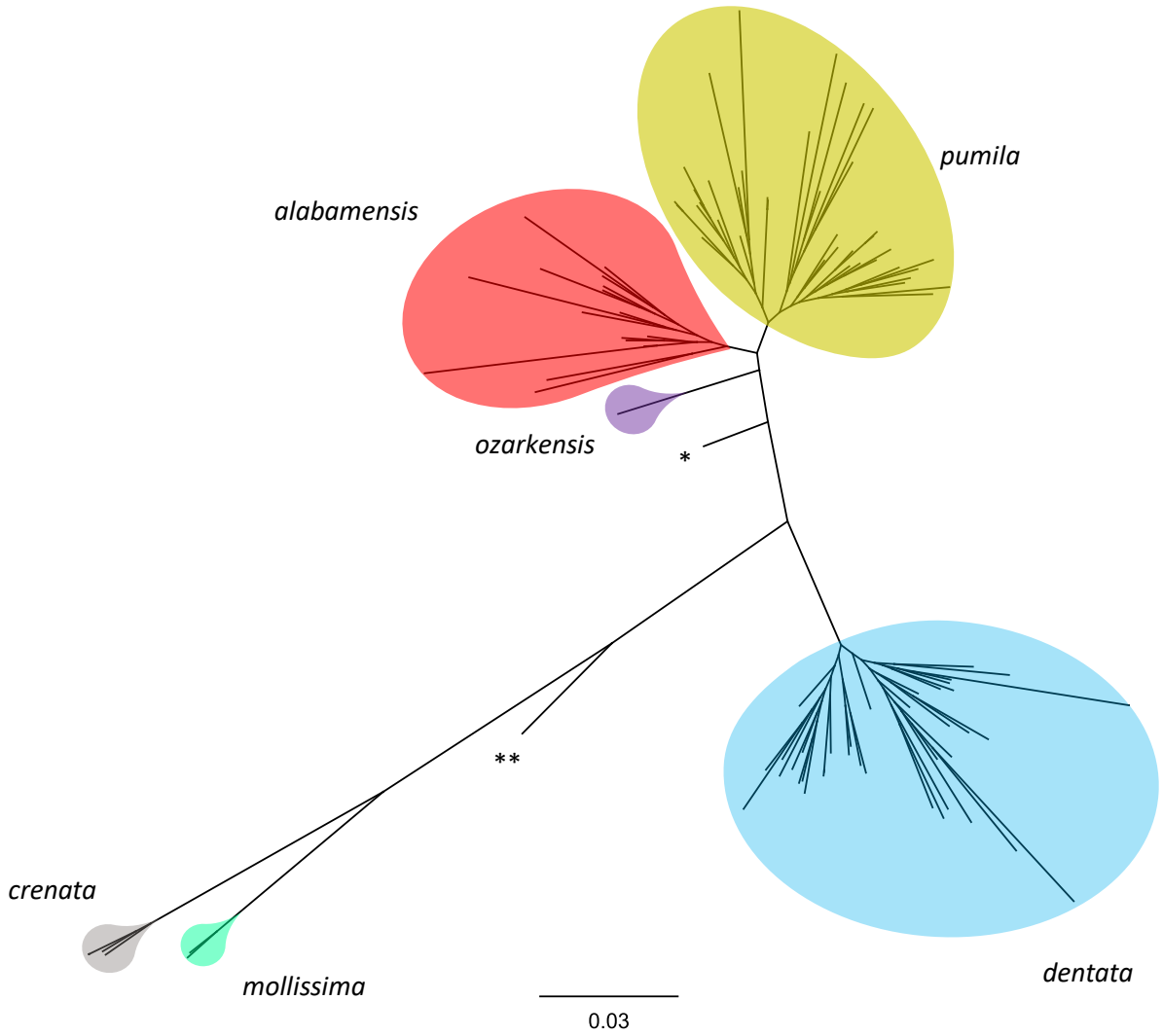
?

Perkins, Zhebentyayeva, Sisco, Craddock (2021) *Systematic Botany* 46:973-984

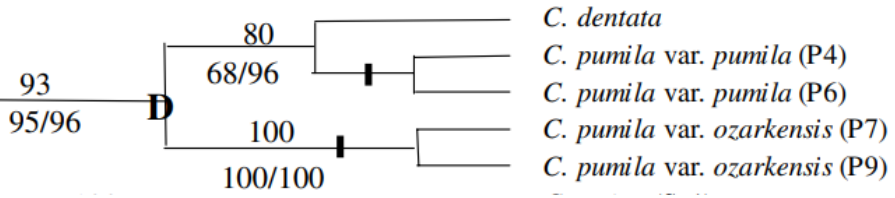
Samples sites: 2006-2008, 2015-2017



Castanea alabamensis is a distinct chinquapin clade

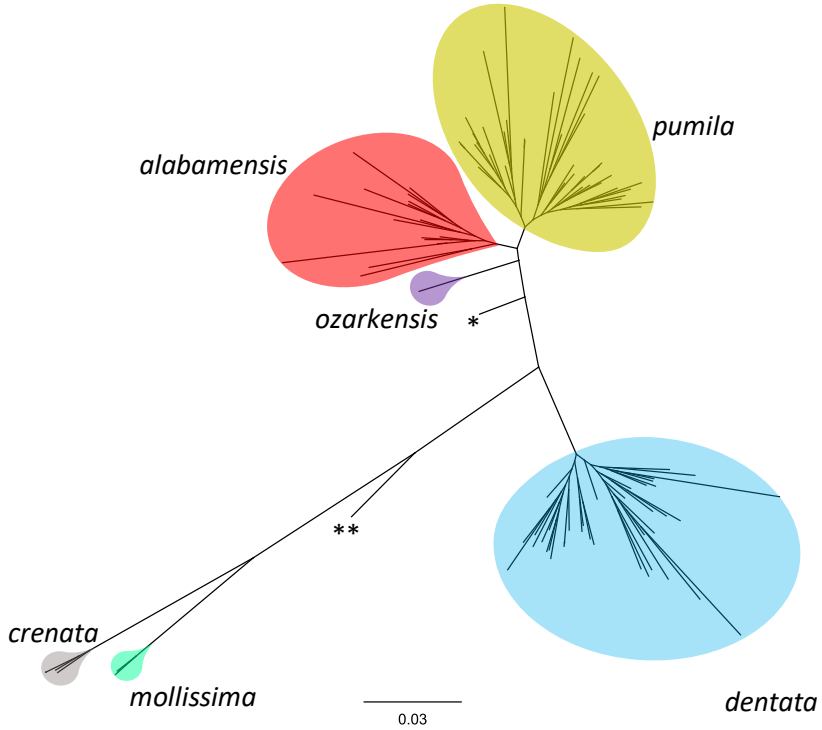


Allegheny chinquapin is more closely related to Ozark chinquapin than to American chestnut



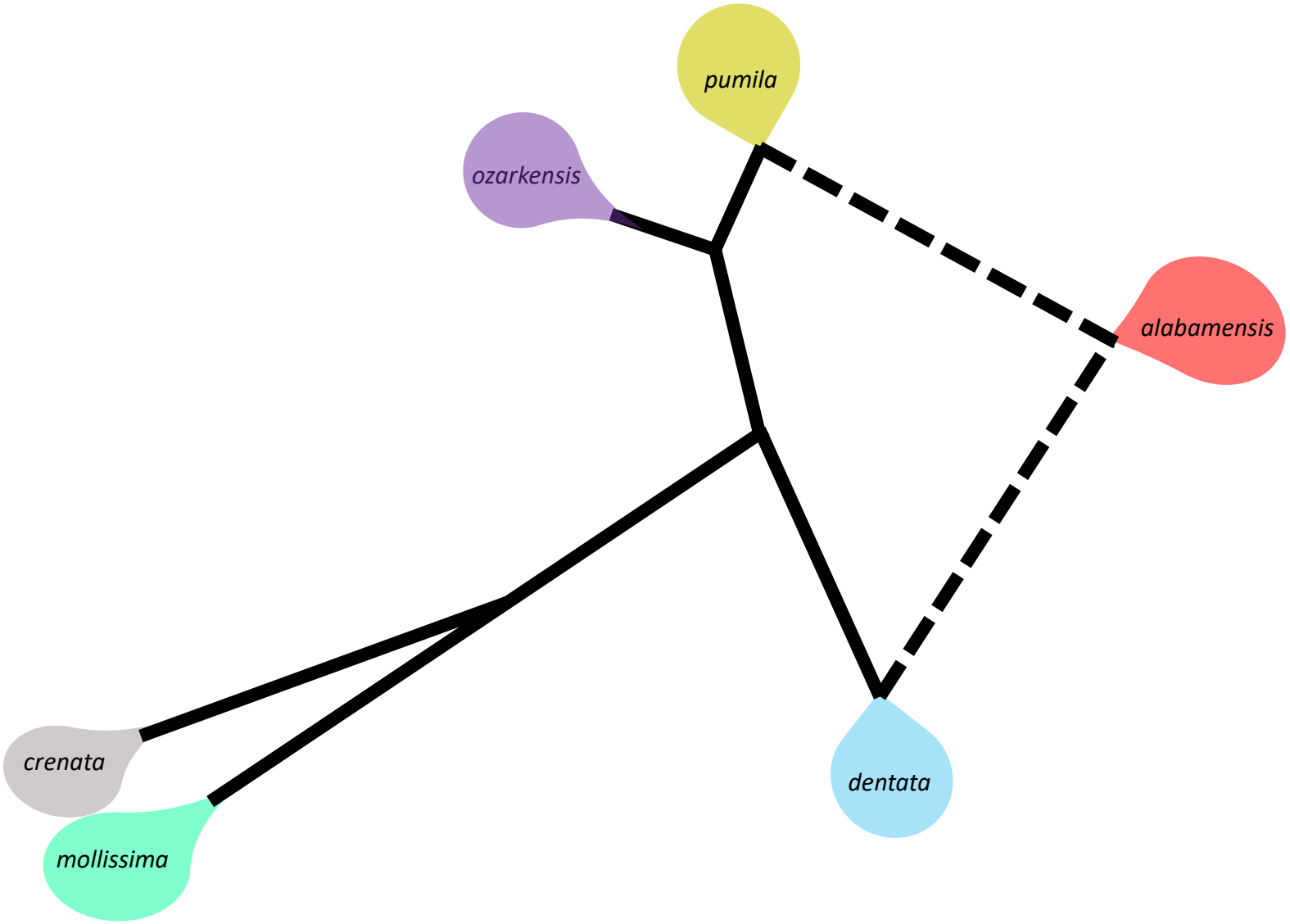
Evolutionary relationships inferred from chloroplast DNA
From Lang et al. (2007)

vs.

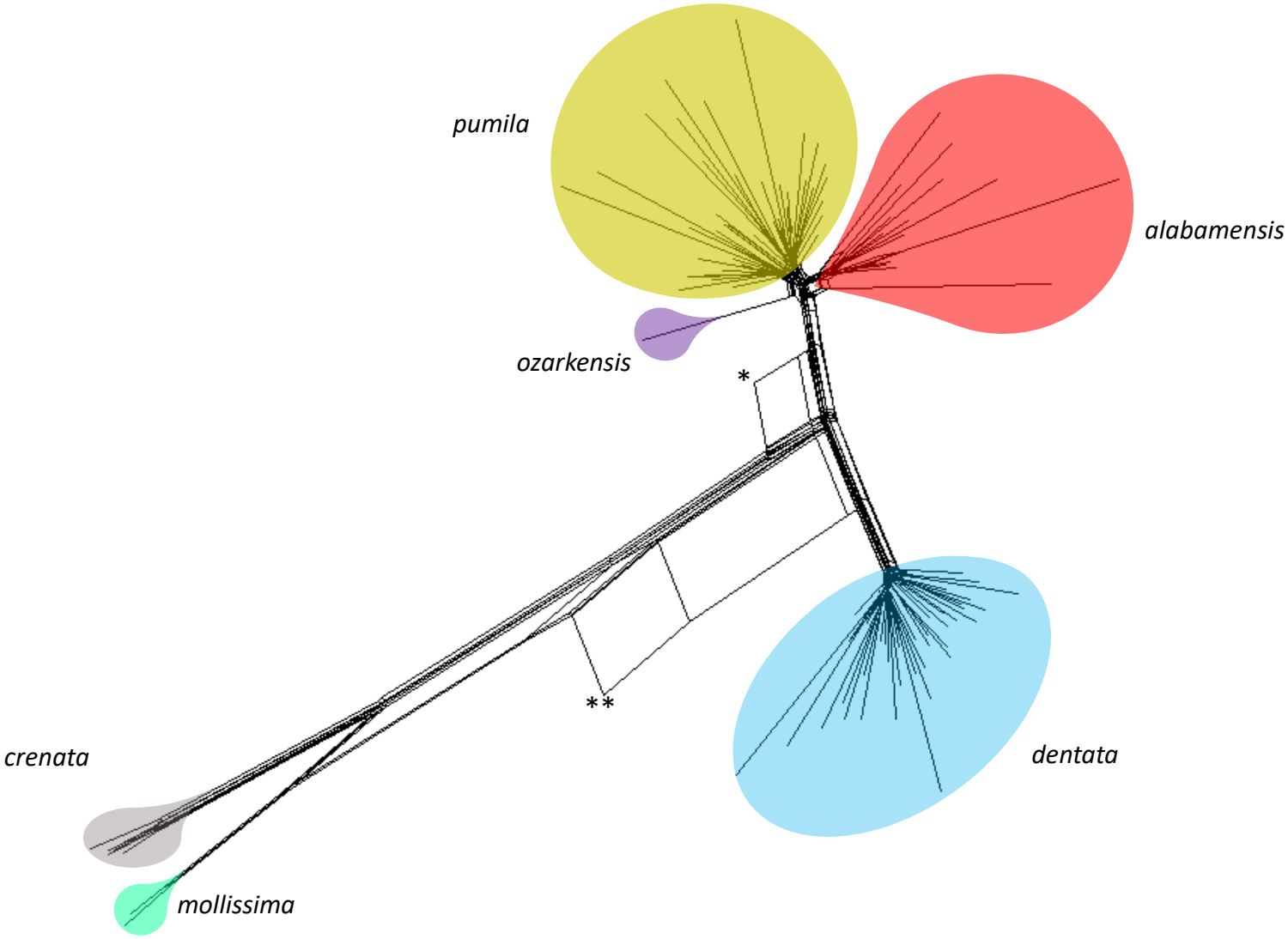


Evolutionary relationships inferred from nuclear DNA

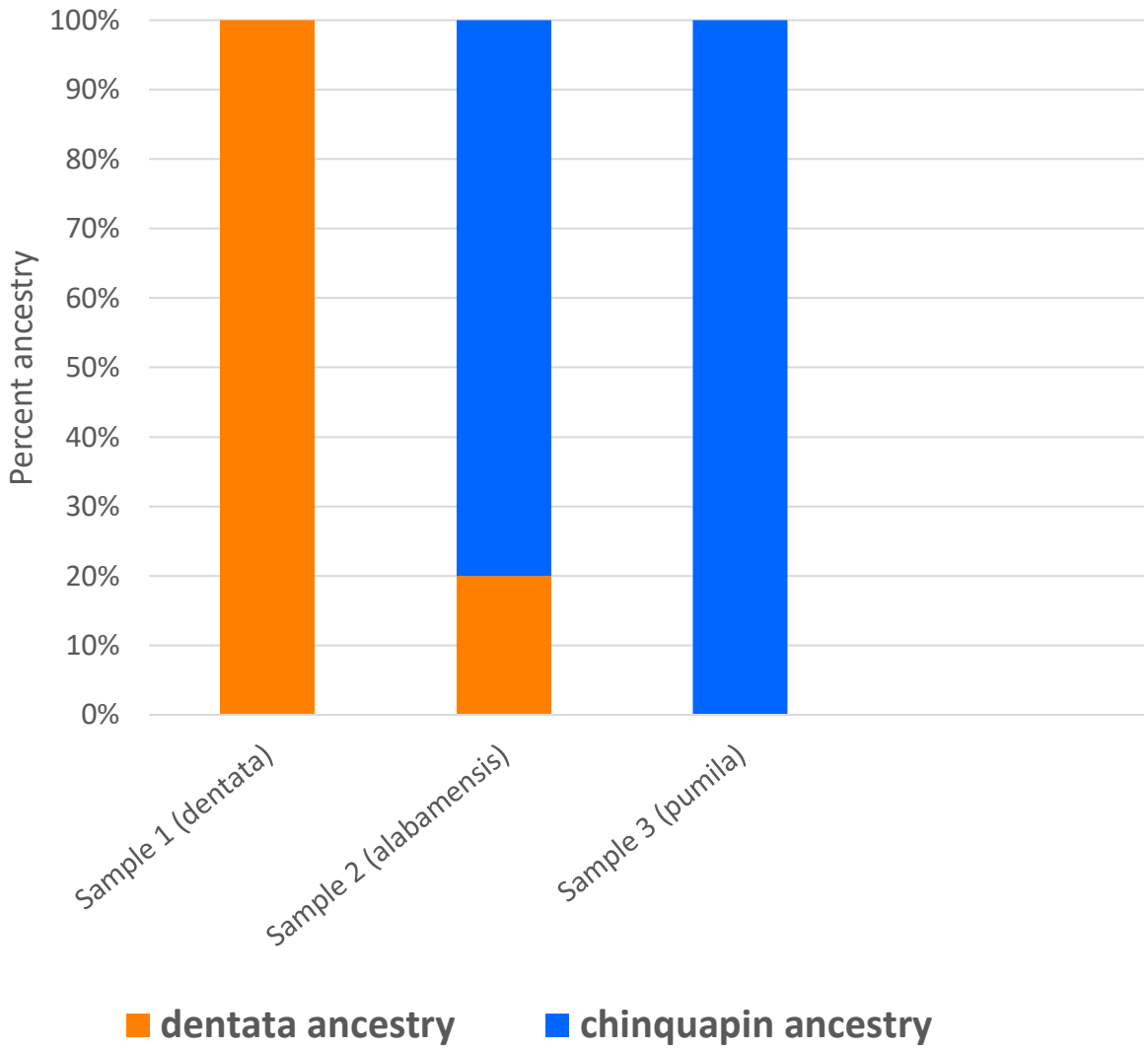
Prediction: C. alabamensis will have a **reticulate** pattern of descent in network analysis



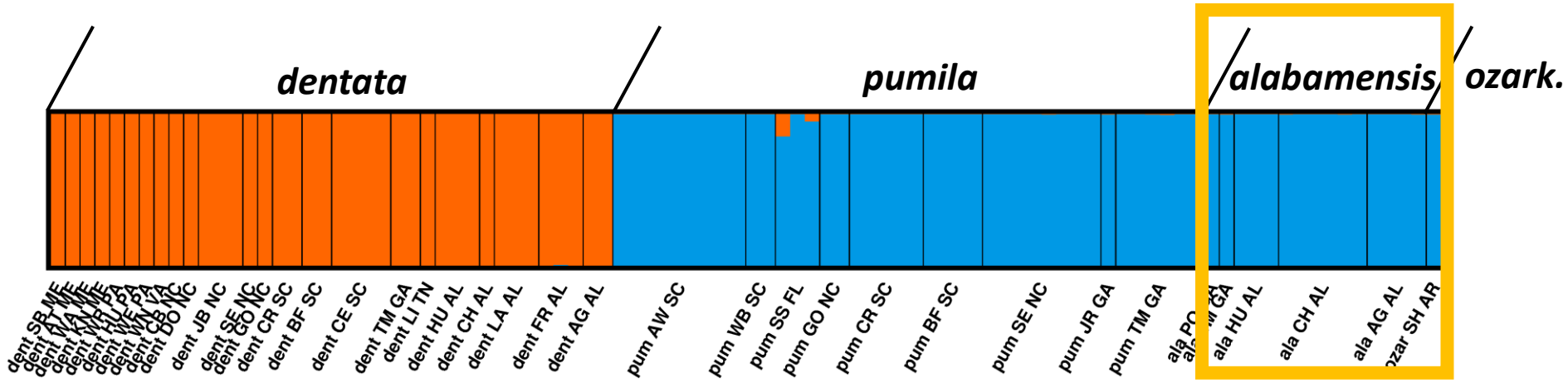
Result: C. alabamensis pattern of descent is **not** reticulate



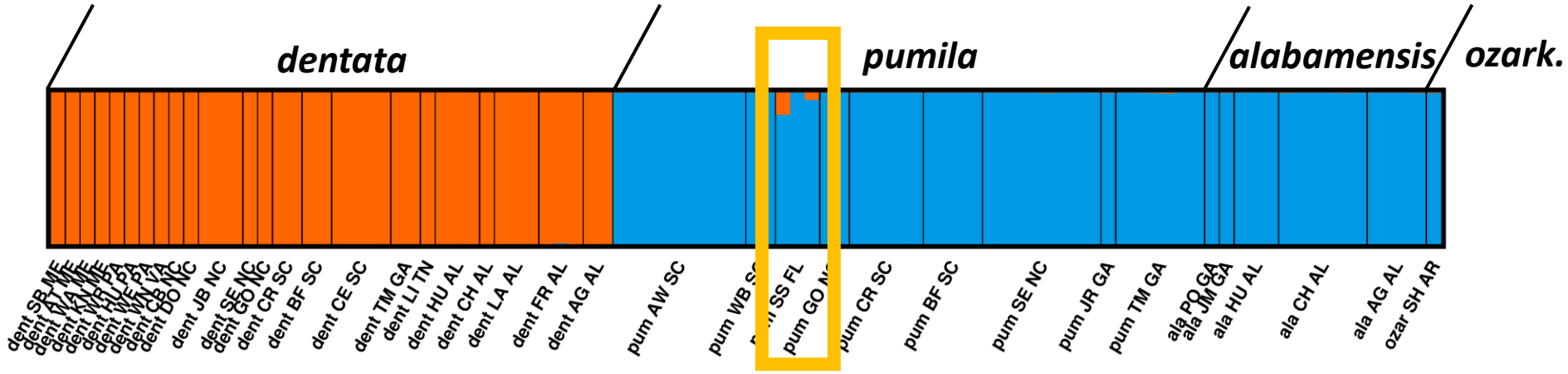
Prediction: STRUCTURE will identify low levels of *C. dentata* ancestry in *C. alabamensis*



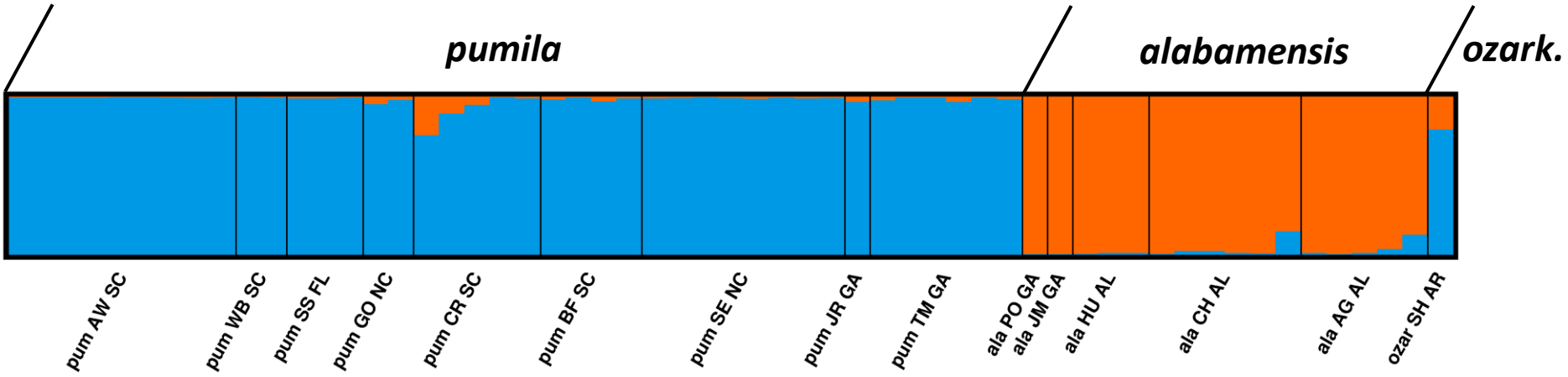
Result: no evidence of C. dentata ancestry in C. alabamensis



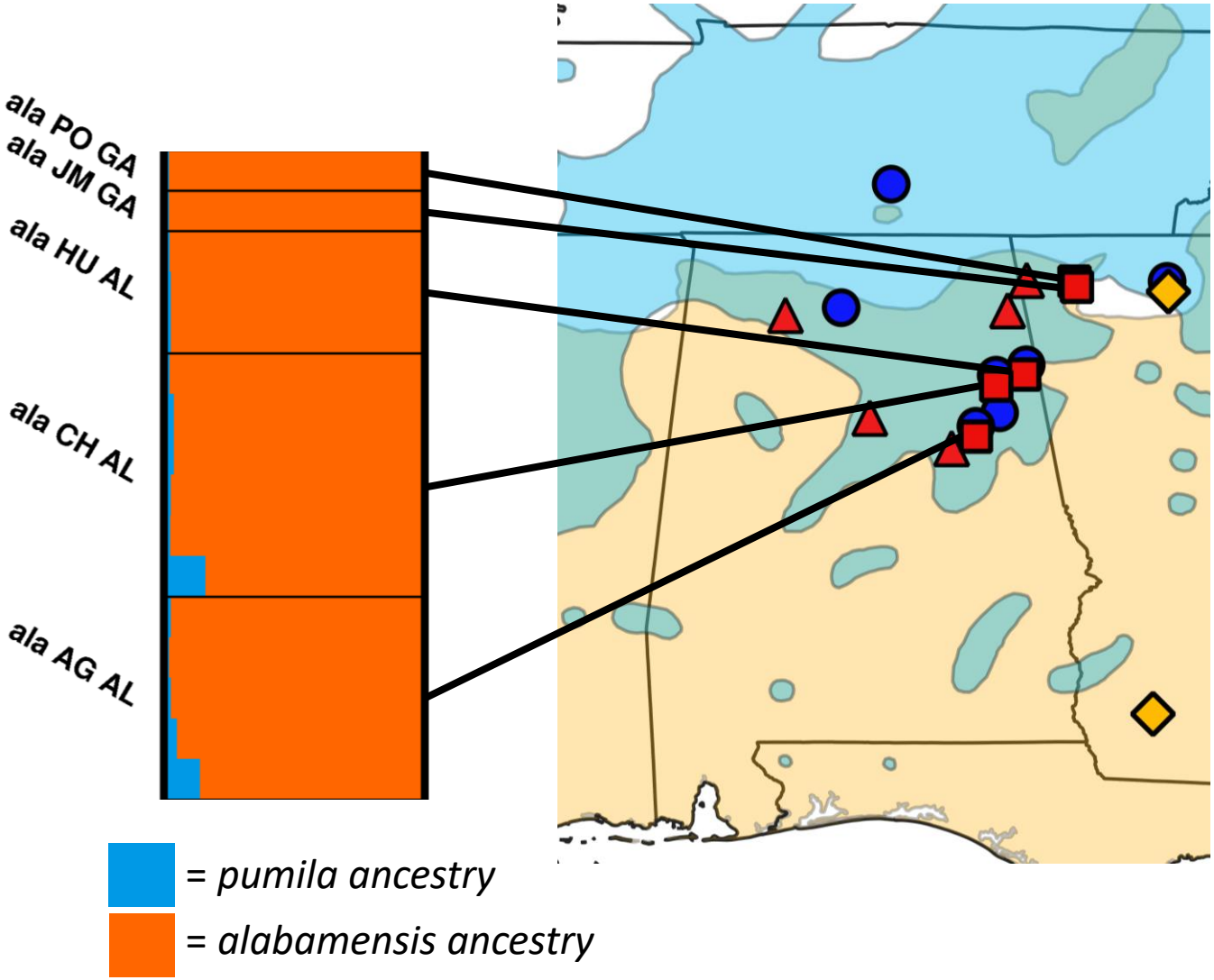
STRUCTURE identifies potential *C. dentata* ancestry in population of *C. pumila* in Florida



Admixture between different chinquapin taxa may be common



Admixture between different chinquapin taxa may be common



Has hybridization contributed to this diversity?

In the case of *C. alabamensis*…

Systematic Botany (2021), 46(4): pp. 973–984

DOI 10.1600/036364421X16370109698524
Date of publication December 21, 2021

Genome-Wide Sequence-Based Genotyping Supports a Nonhybrid Origin of *Castanea alabamensis*

M. Taylor Perkins,[1,2] Tetyana Zhebentyayeva,[3] Paul H. Sisco,[4] and J. Hill Craddock[1,5]

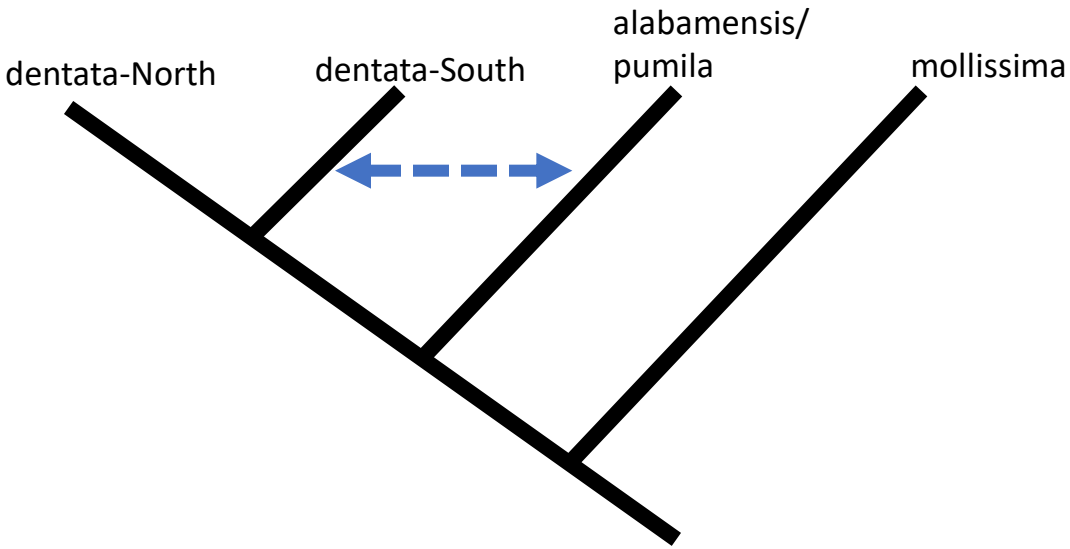
Current research: whole genome re-sequencing of North American *Castanea* species

- Alex Sandercock, Jason Holliday (VA Tech)
- Jared Westbrook, Paul Sisco (TACF)
- Fred Paillet (U of Arkansas)
- Hill Craddock, Paola Zannini (UT-Chattanooga)
- Tatyana Zhebentyayeva (Penn State)

Whole genome sequences available
American chestnut 388 plants
Allegheny chinquapin 15 plants
Ozark chinquapin 10 plants
C. alabamensis 5 plants

We're adding 228 samples
American chestnut 27 plants (from 13 sites)
Allegheny chinquapin 80 plants
Ozark chinquapin 61 plants
C. alabamensis 60 plants

Testing for gene flow between southern C. dentata and sympatric chinquapins: ABBA-BABA test



Future research questions:

1) Has chinquapin contributed to genetic diversity in American chestnut? Was there any adaptive significance?

2) When did American chestnut diverge from chinquapins?

3) What was the westernmost extent of *C. dentata* just before *Phytophthora* and *Cryphonectria* arrived?

4) Is the hypothesized westward migration of *Castanea* supported by genome sequencing data? Or was migration into North America more complex?

Questions?
(you can also email me at: tperkins2588@gmail.com)