

# Introgression and the origin of maize in Mexico and the Southwest US

Jeffrey Ross-Ibarra

[@jrossibarra](https://twitter.com/jrossibarra) • [www.rilab.org](http://www.rilab.org)

Dept. Plant Sciences • Center for Population Biology • Genome Center  
University of California Davis

# acknowledgements



Rute Fonseca  
(Copenhagen)



Matt Hufford  
(Iowa State)



Joost van Heerwaarden  
(Wageningen)



Tom Gilbert (Copenhagen)



John Doebley (Wisconsin)



# maize origins

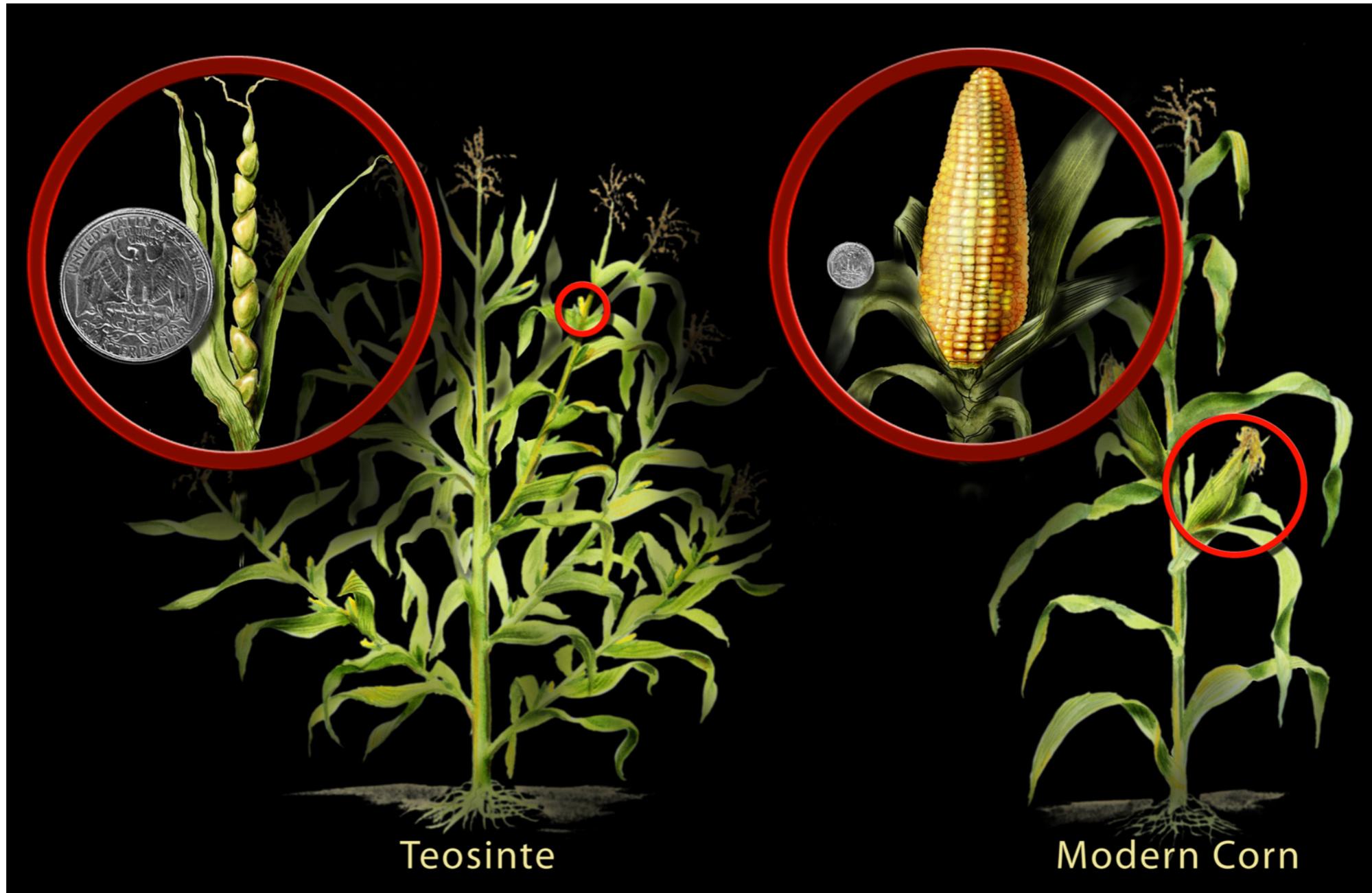


Modern Corn

# maize origins



# maize origins



# maize origins



Fig. 1A



Fig. 1B

Tripsacum

extinct maize

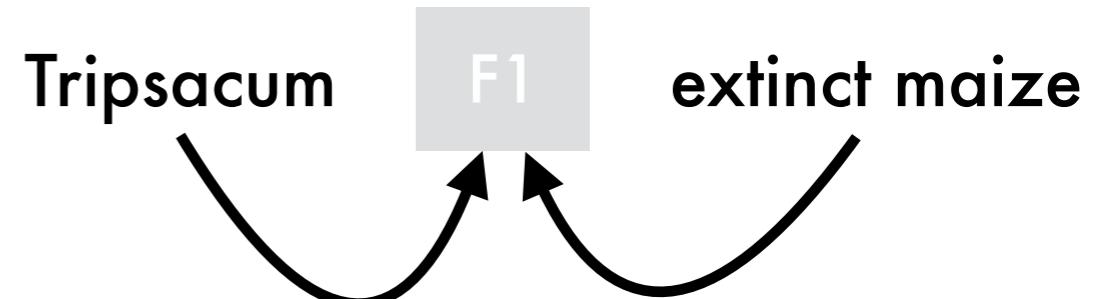
# maize origins



Fig. 1A

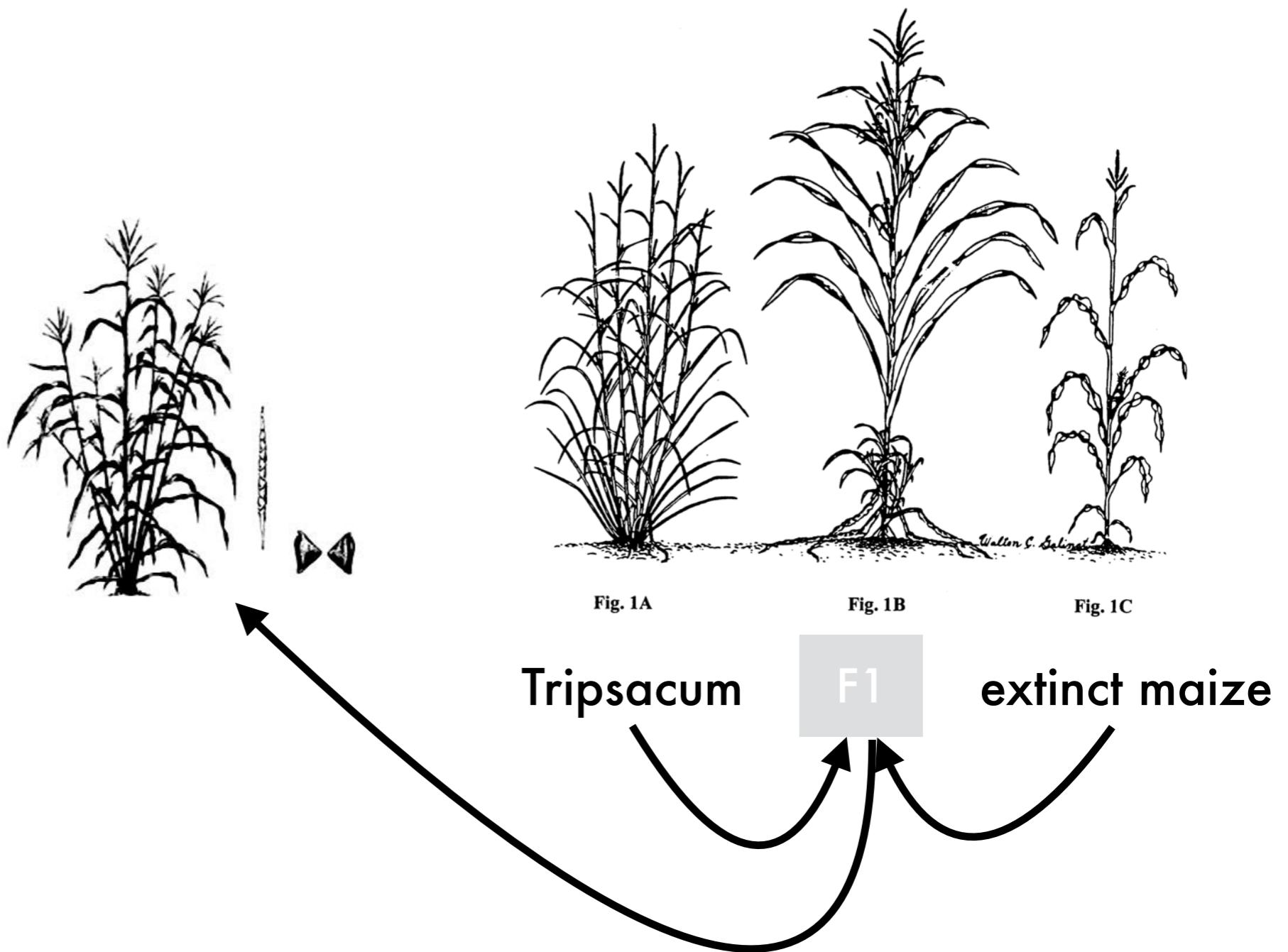
Fig. 1B

Fig. 1C



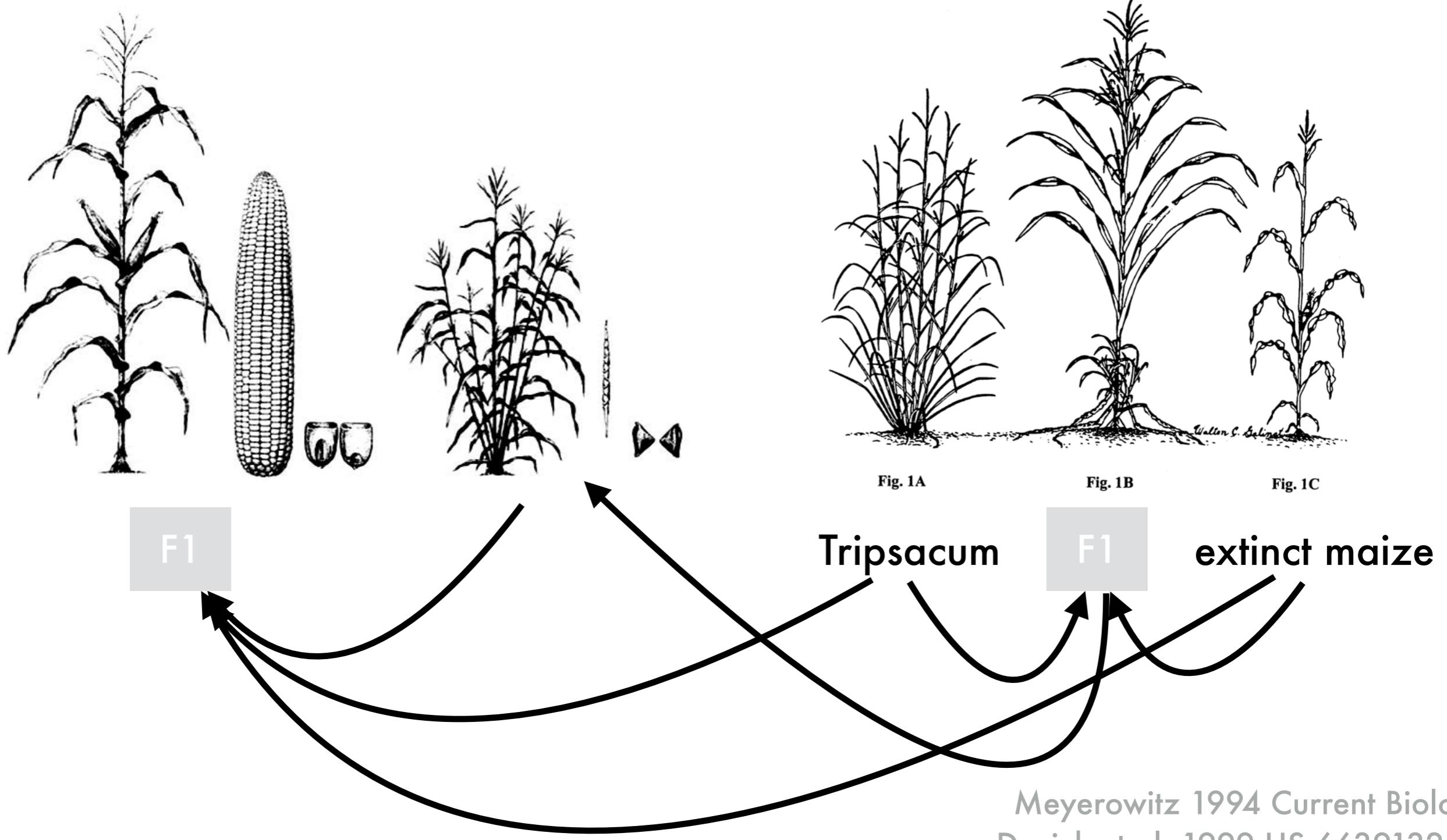
Meyerowitz 1994 Current Biology  
Duvick et al. 1999 US 6639132 B1

# maize origins

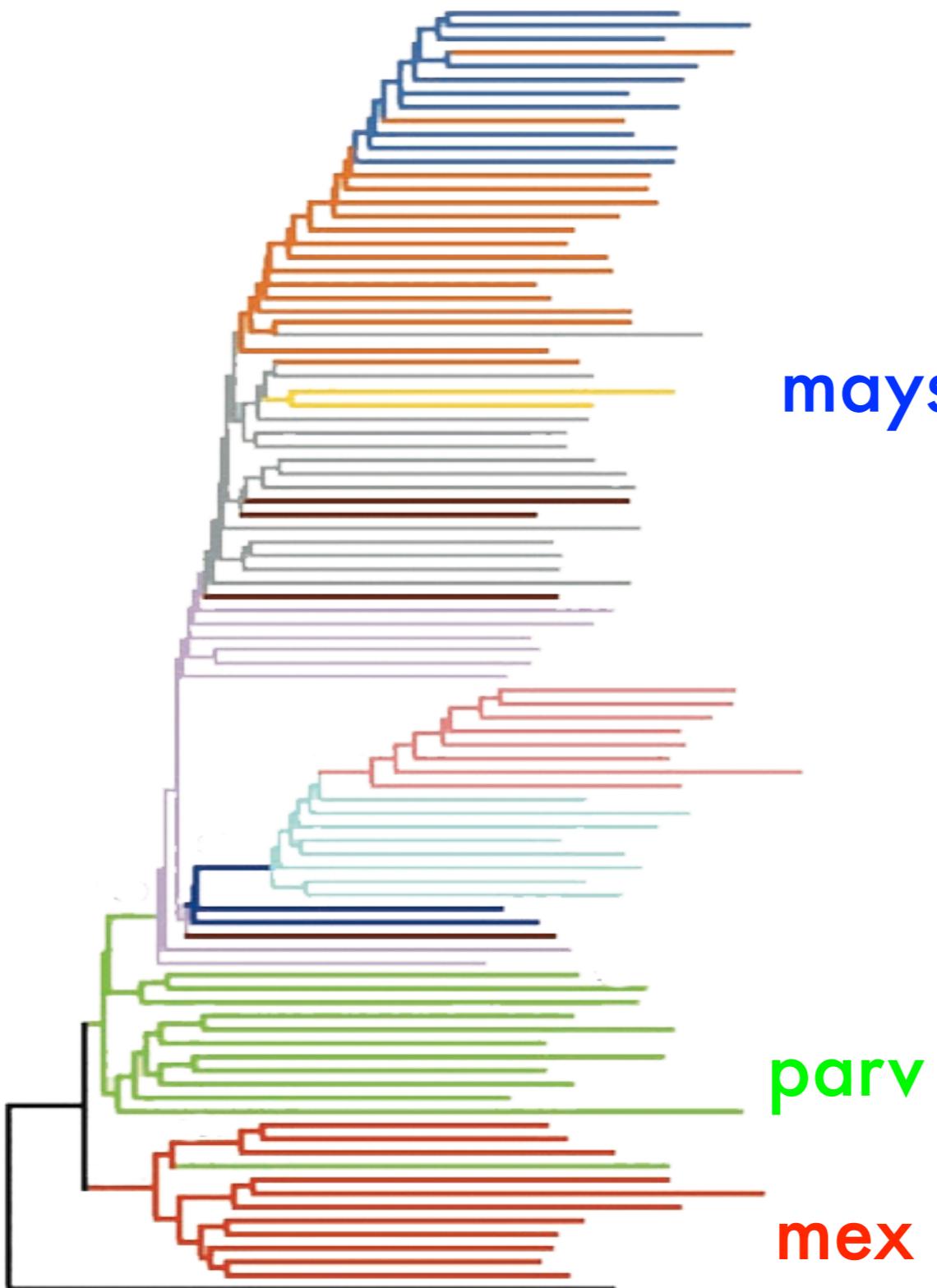


Meyerowitz 1994 Current Biology  
Duvick et al. 1999 US 6639132 B1

# maize origins

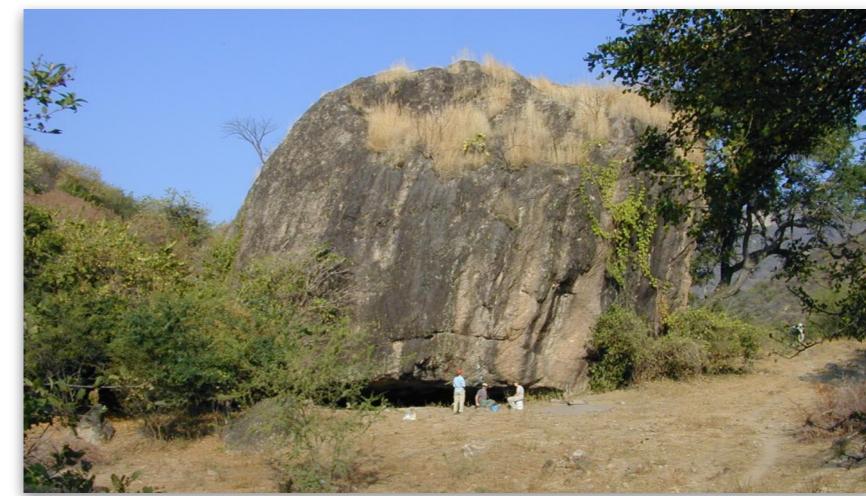
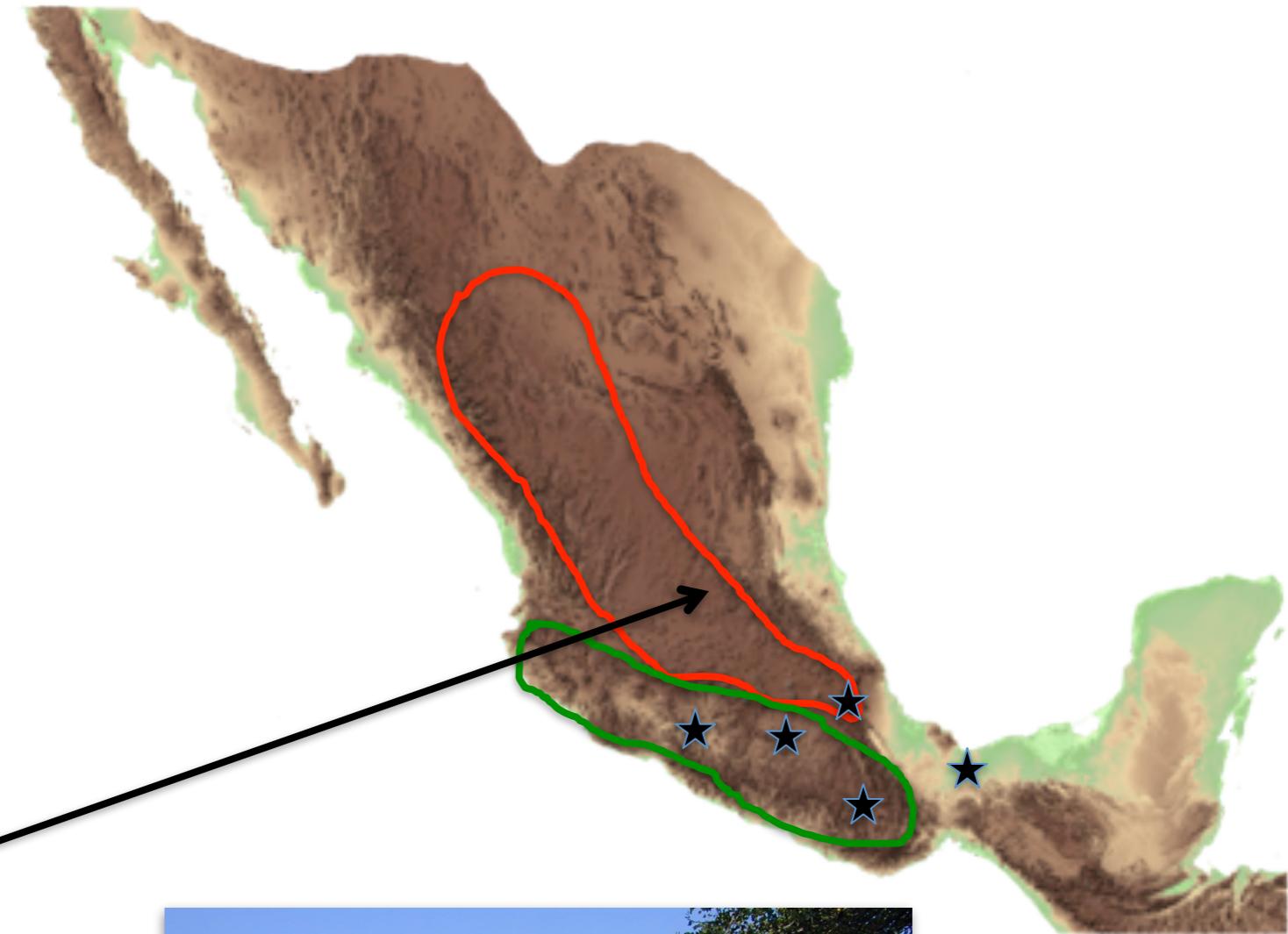
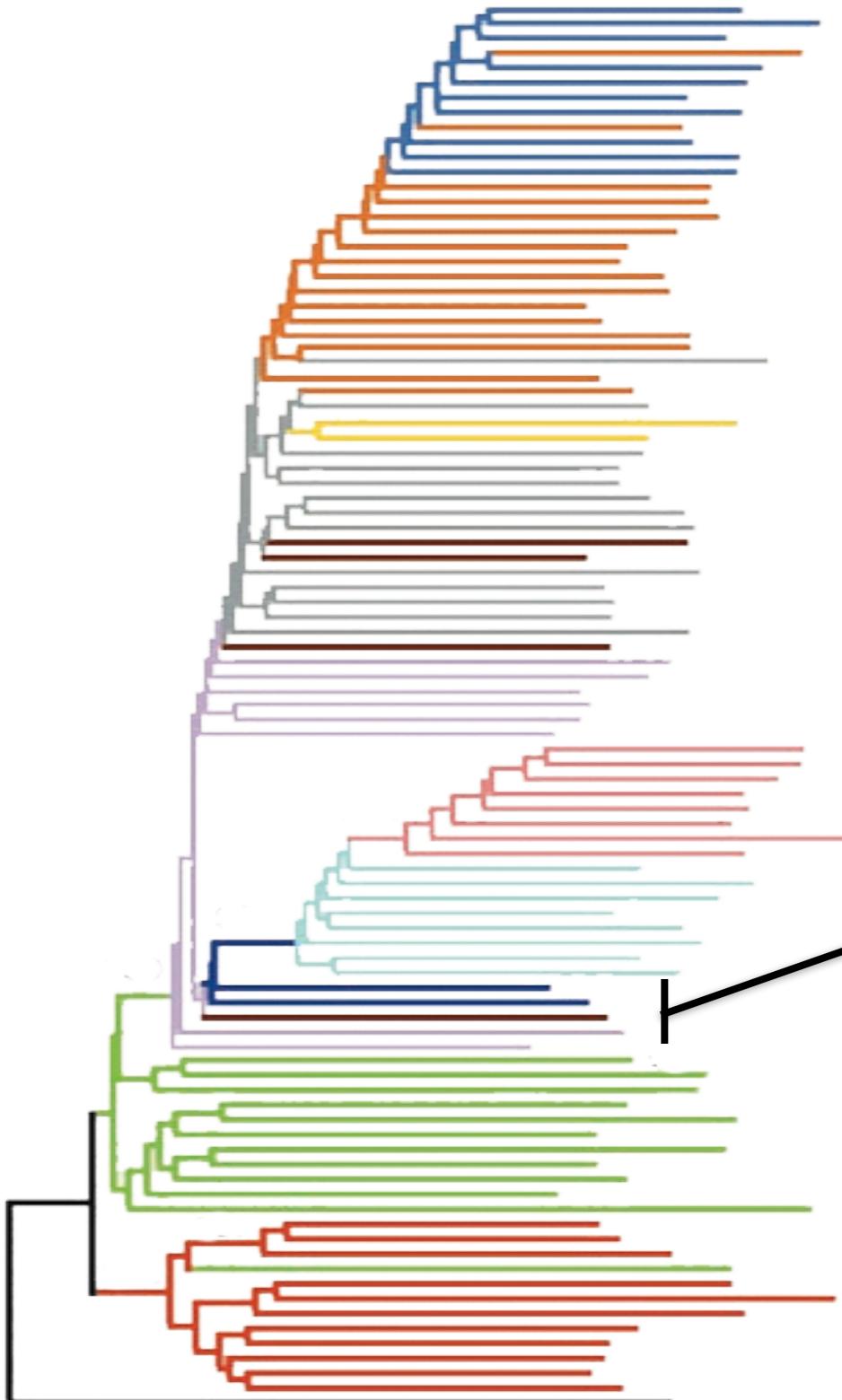


# single origin from teosinte



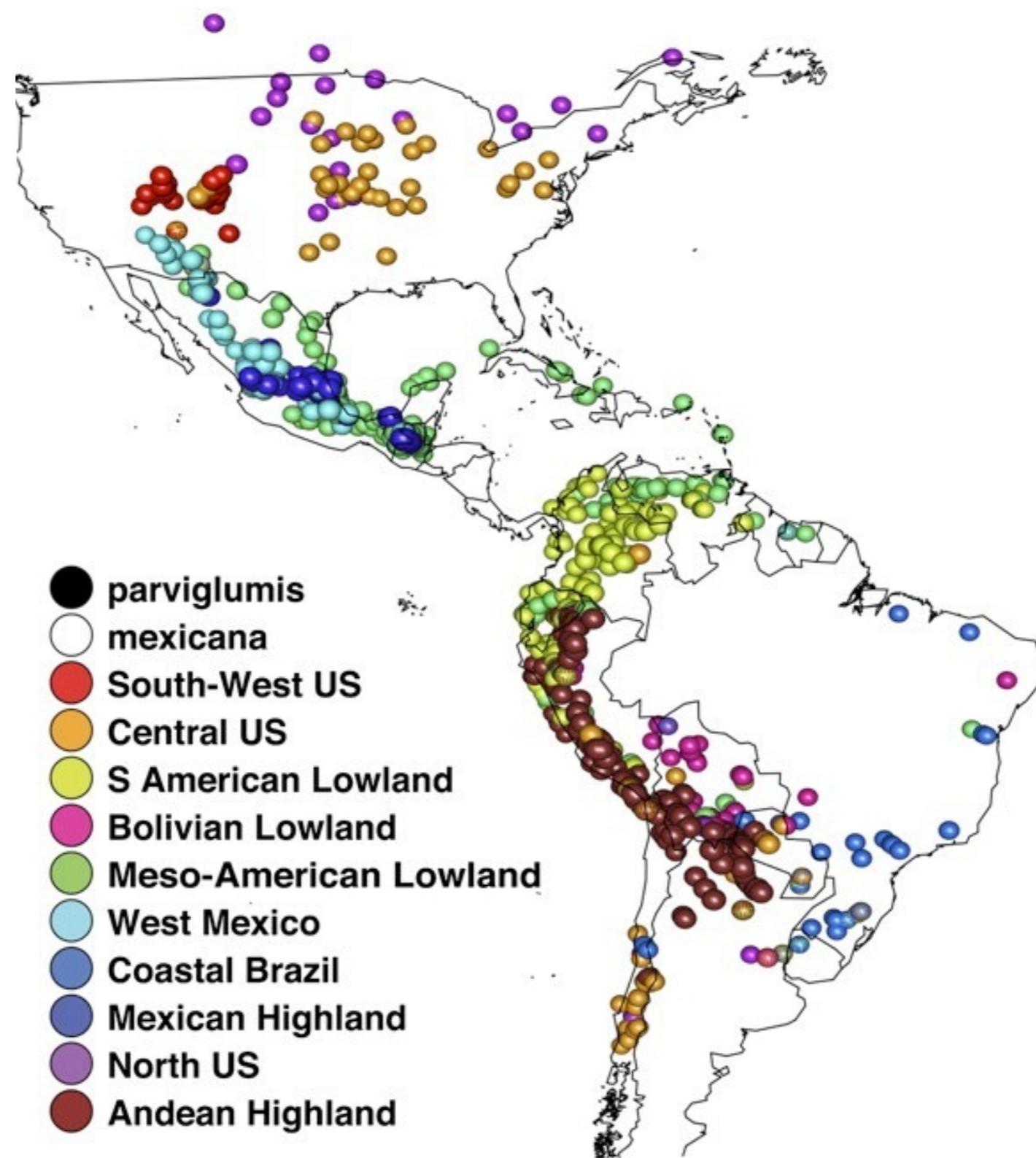
Matsuoka et al. 2002 PNAS  
Piperno et al. 2009 PNAS

# paradox of maize ancestry

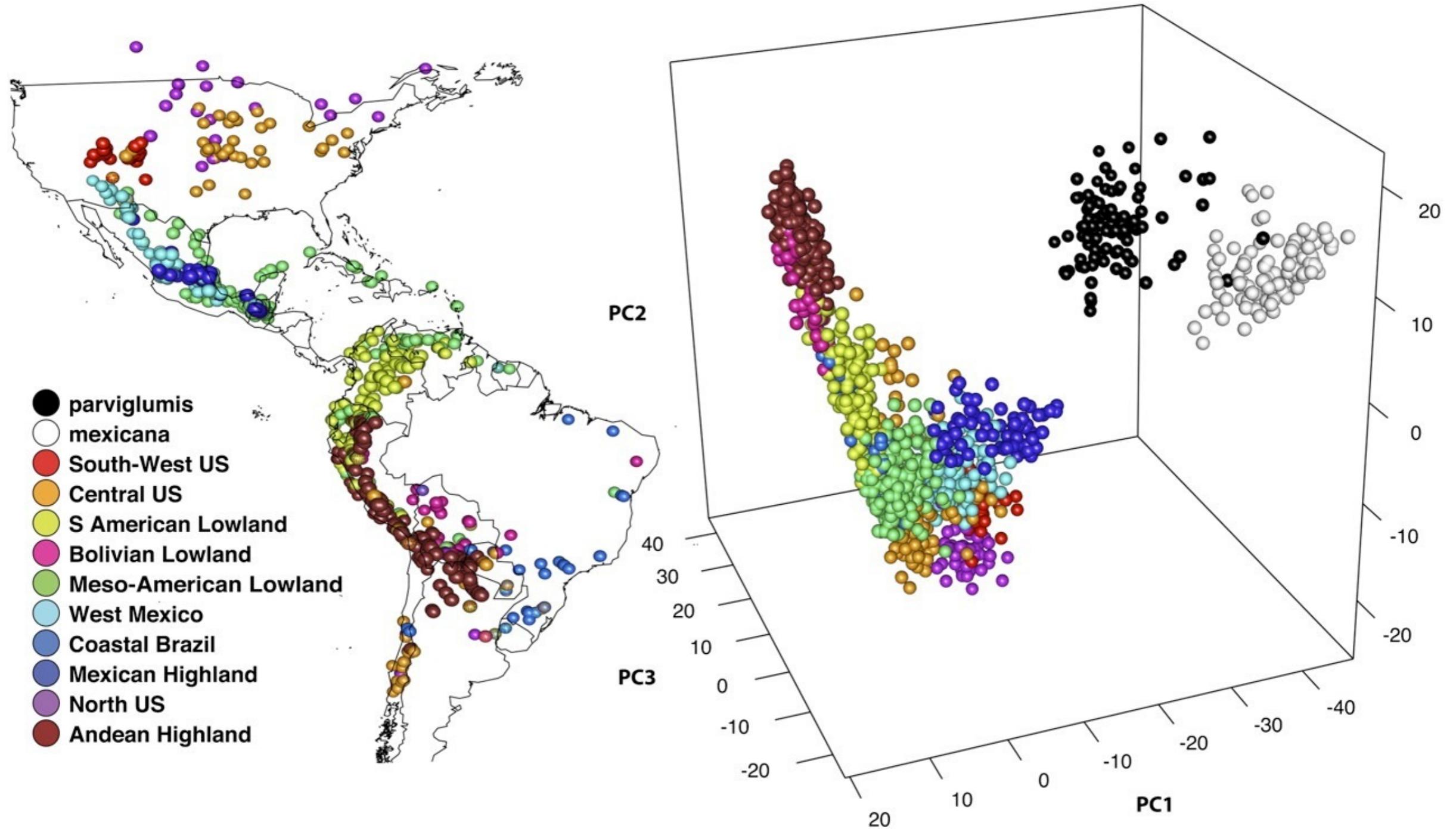


Matsuoka et al. 2002 PNAS  
Piperno et al. 2009 PNAS

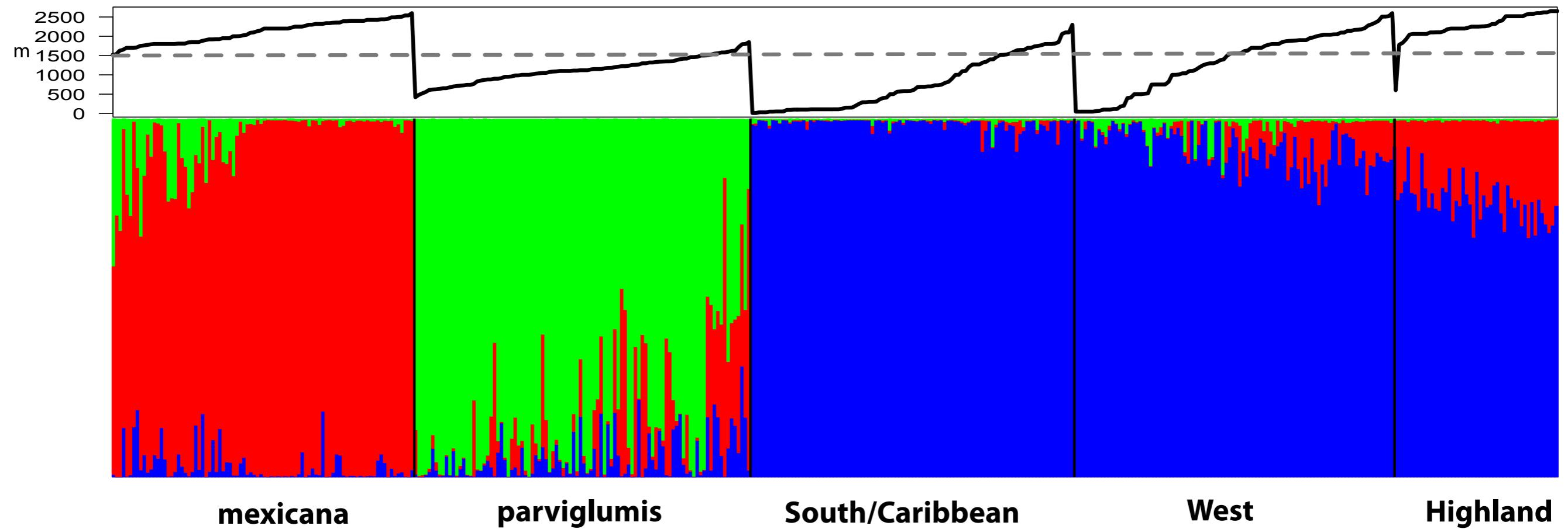
# landrace and teosinte sampling



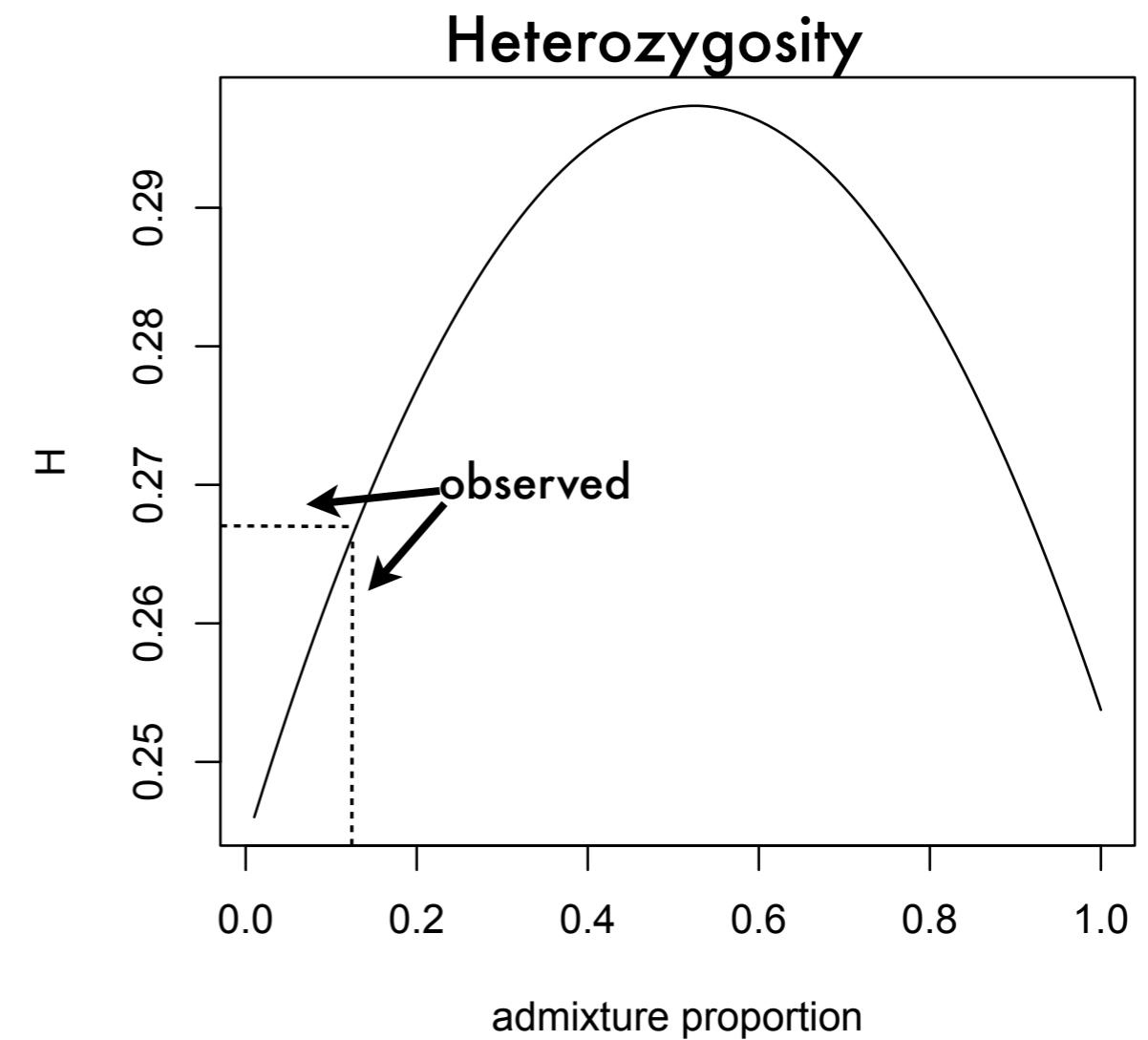
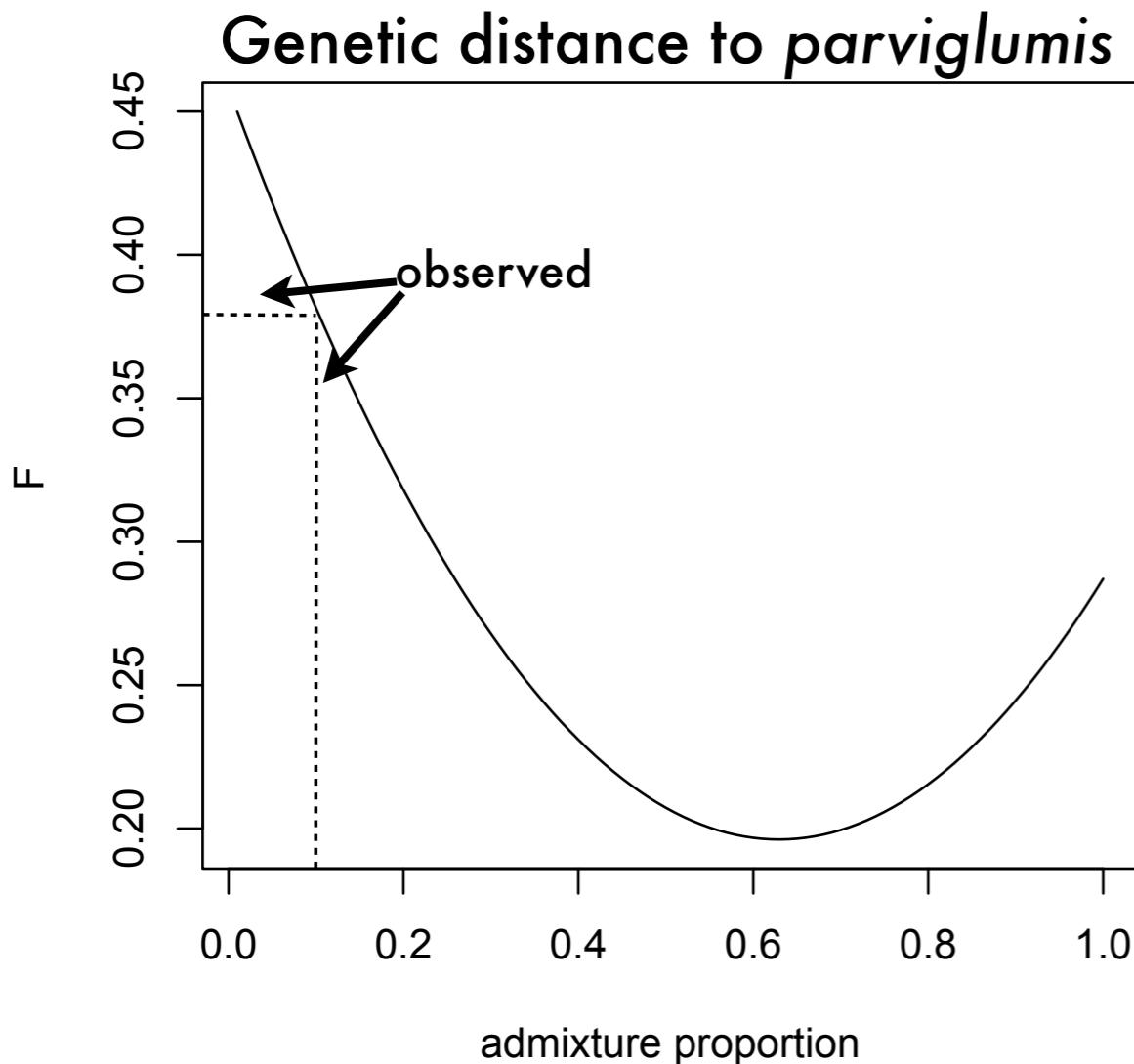
# SNPs show highland similarity to teosinte



# admixture explains patterns of diversity



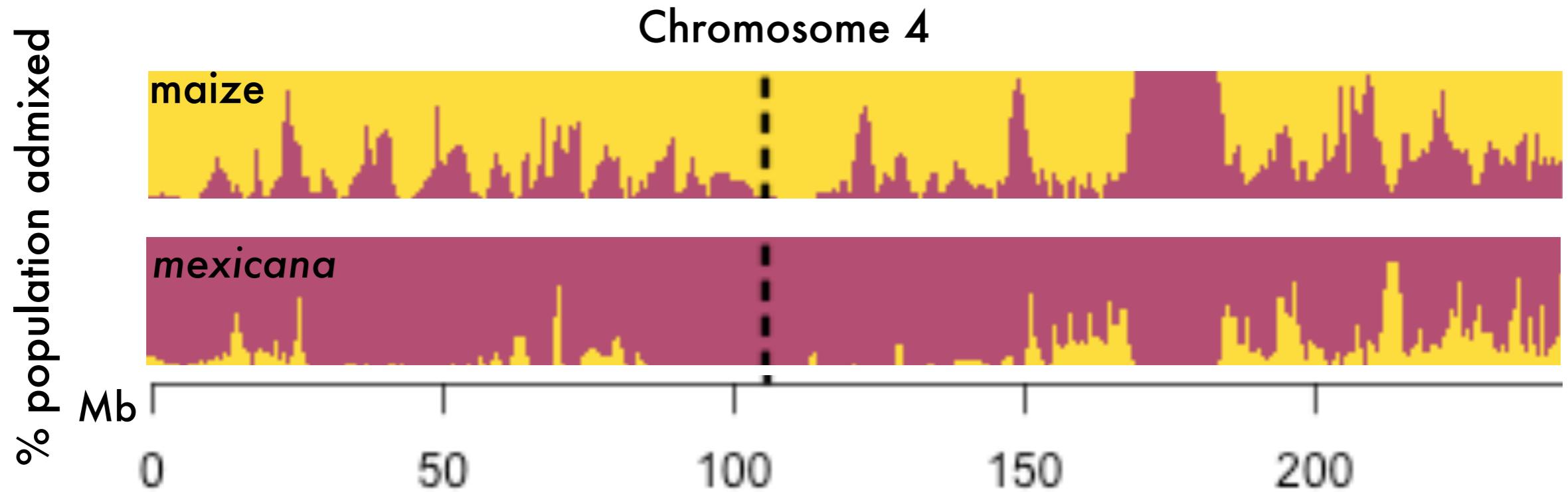
# admixture explains patterns of diversity



# hybrids commonly observed

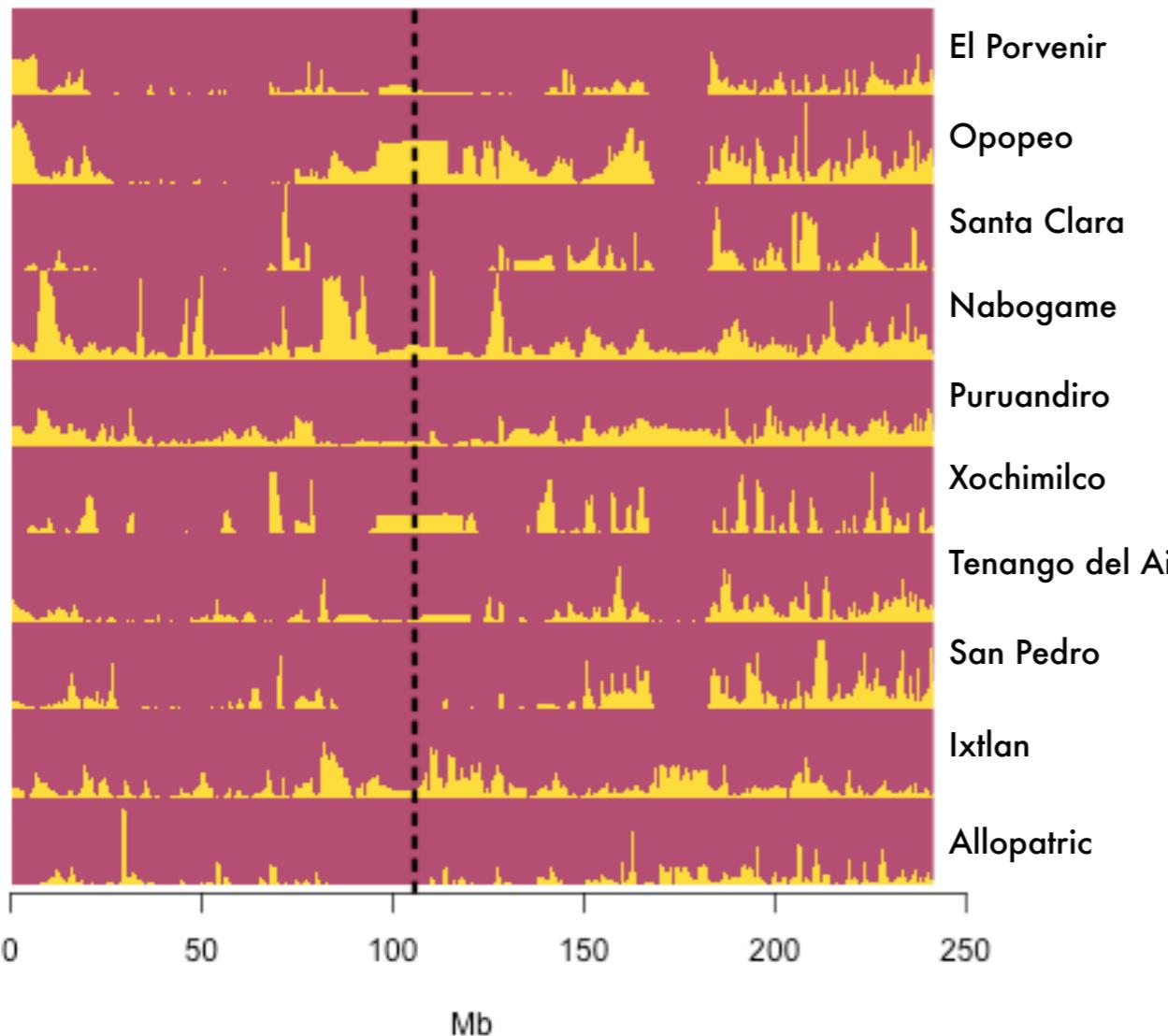


# admixture along the genome

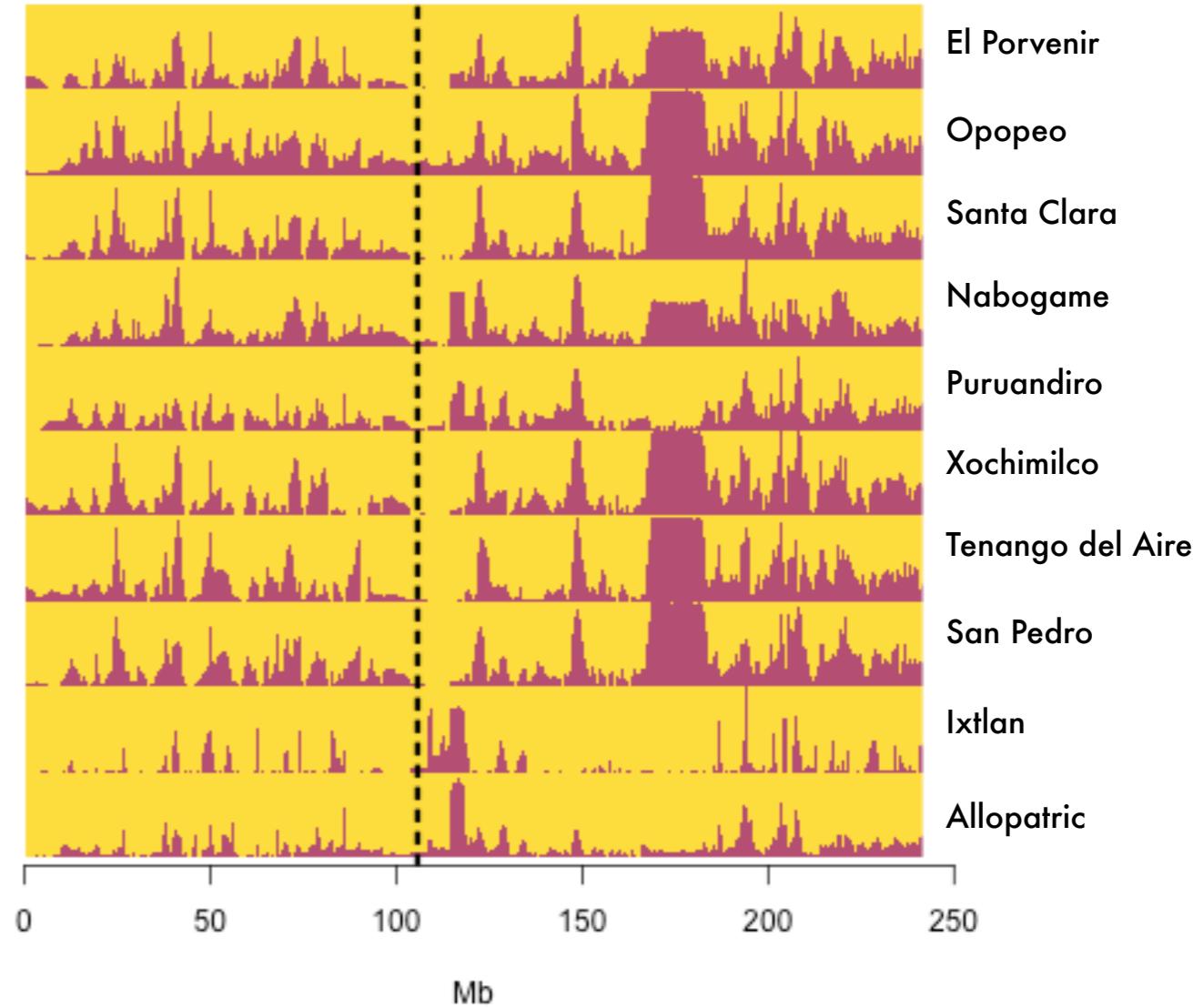


# admixture localized, asymmetric

Chromosome 4: Mexicana

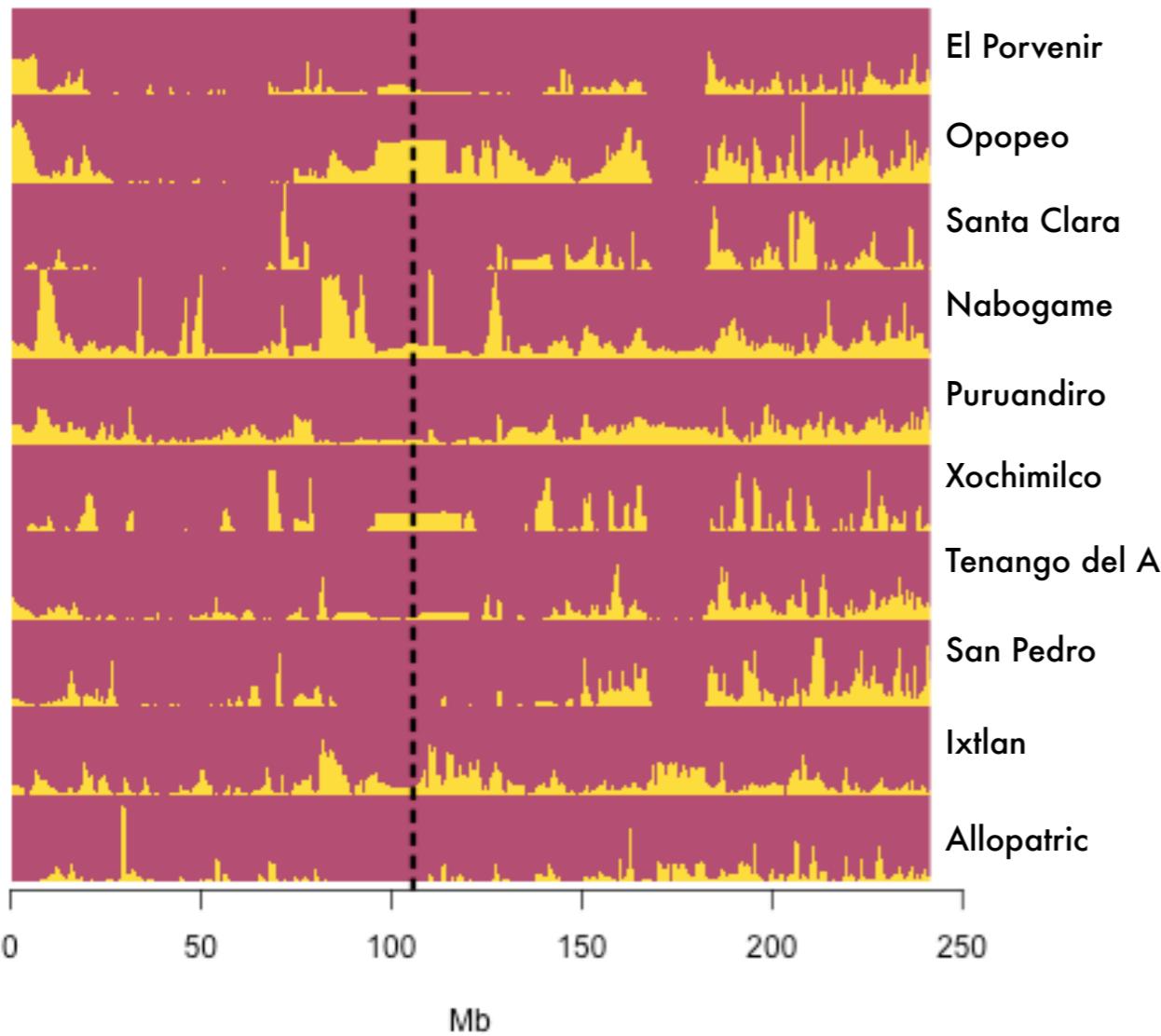


Chromosome 4: Maize

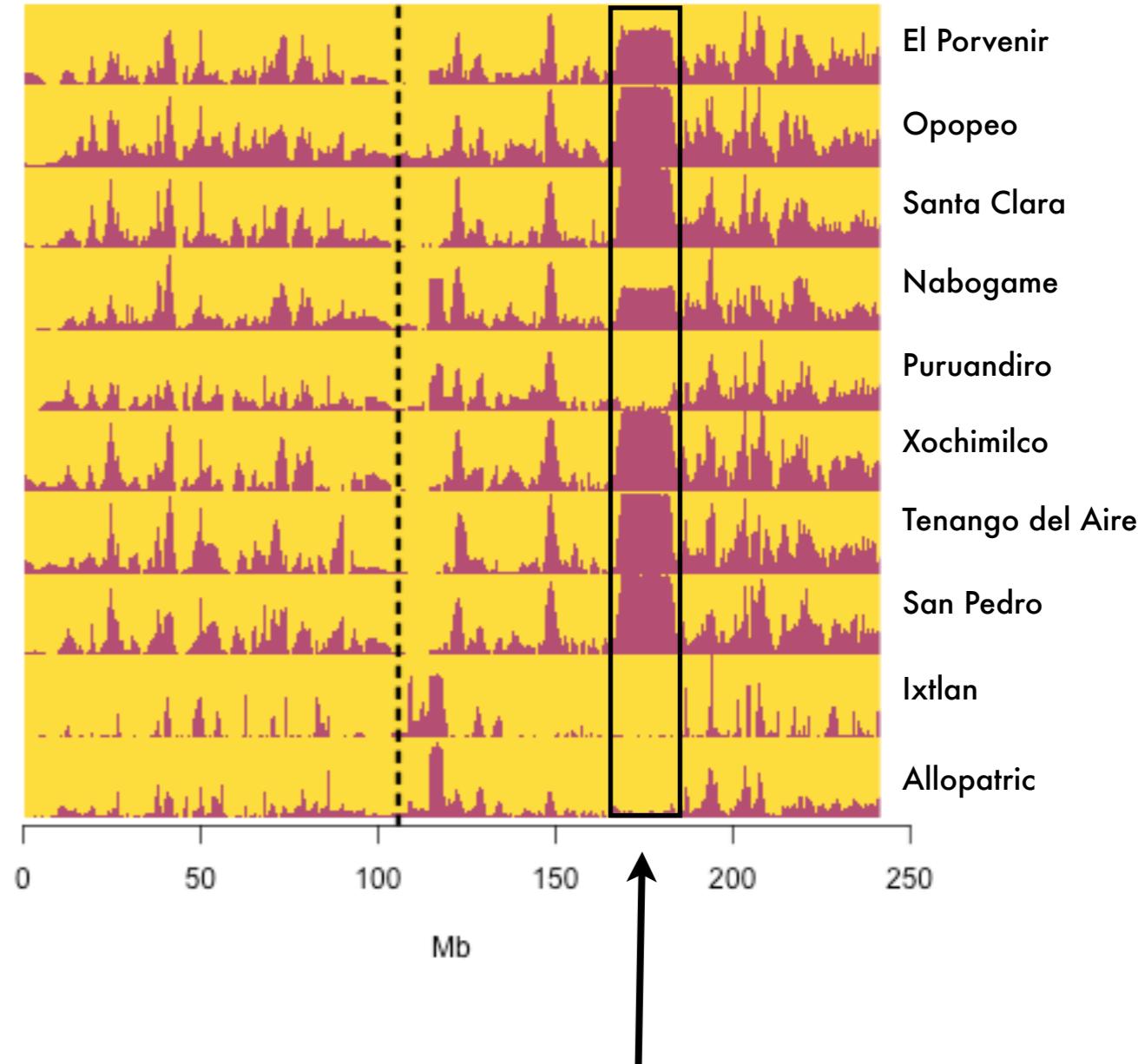


# admixture localized, asymmetric

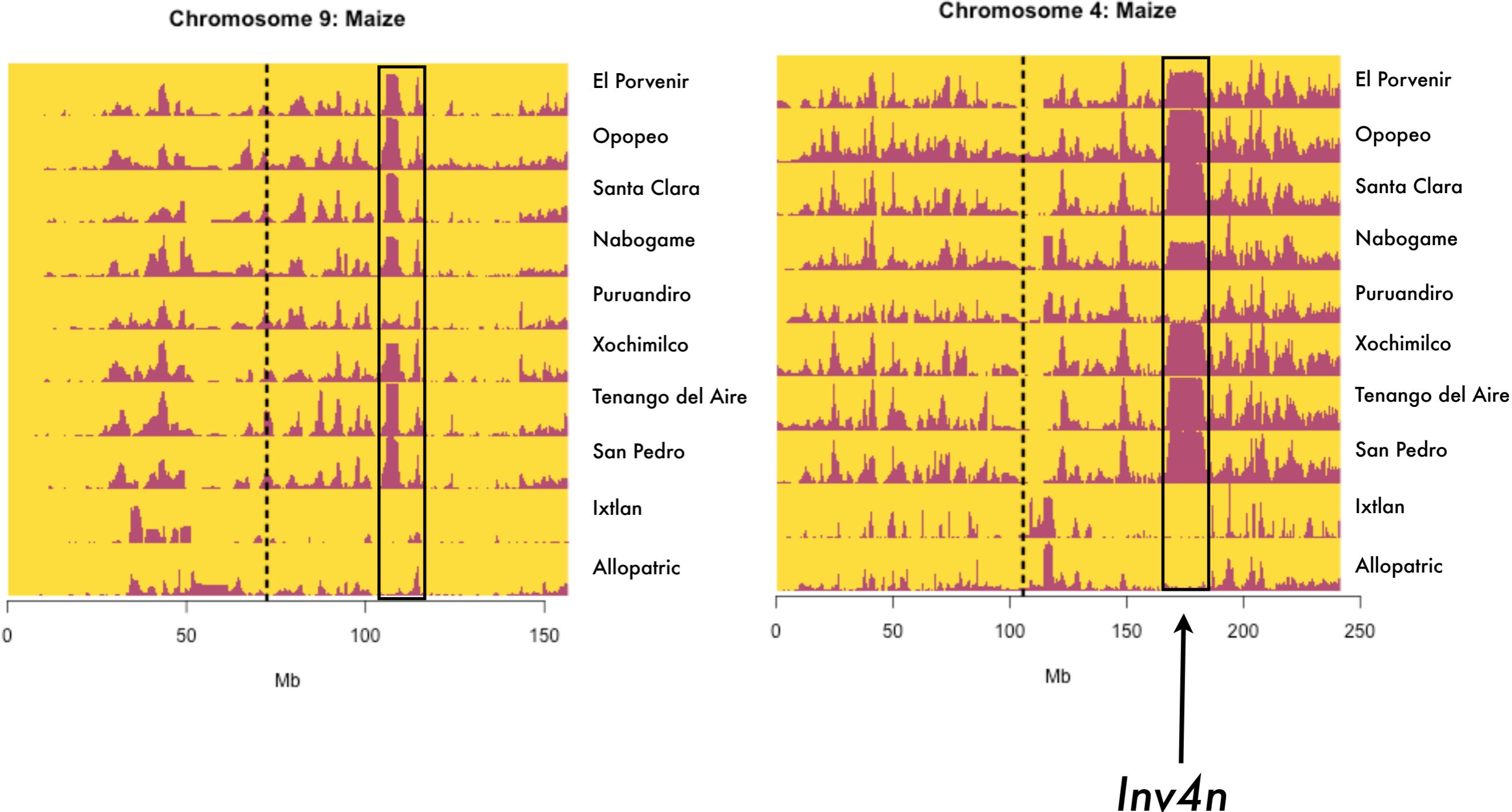
Chromosome 4: Mexicana



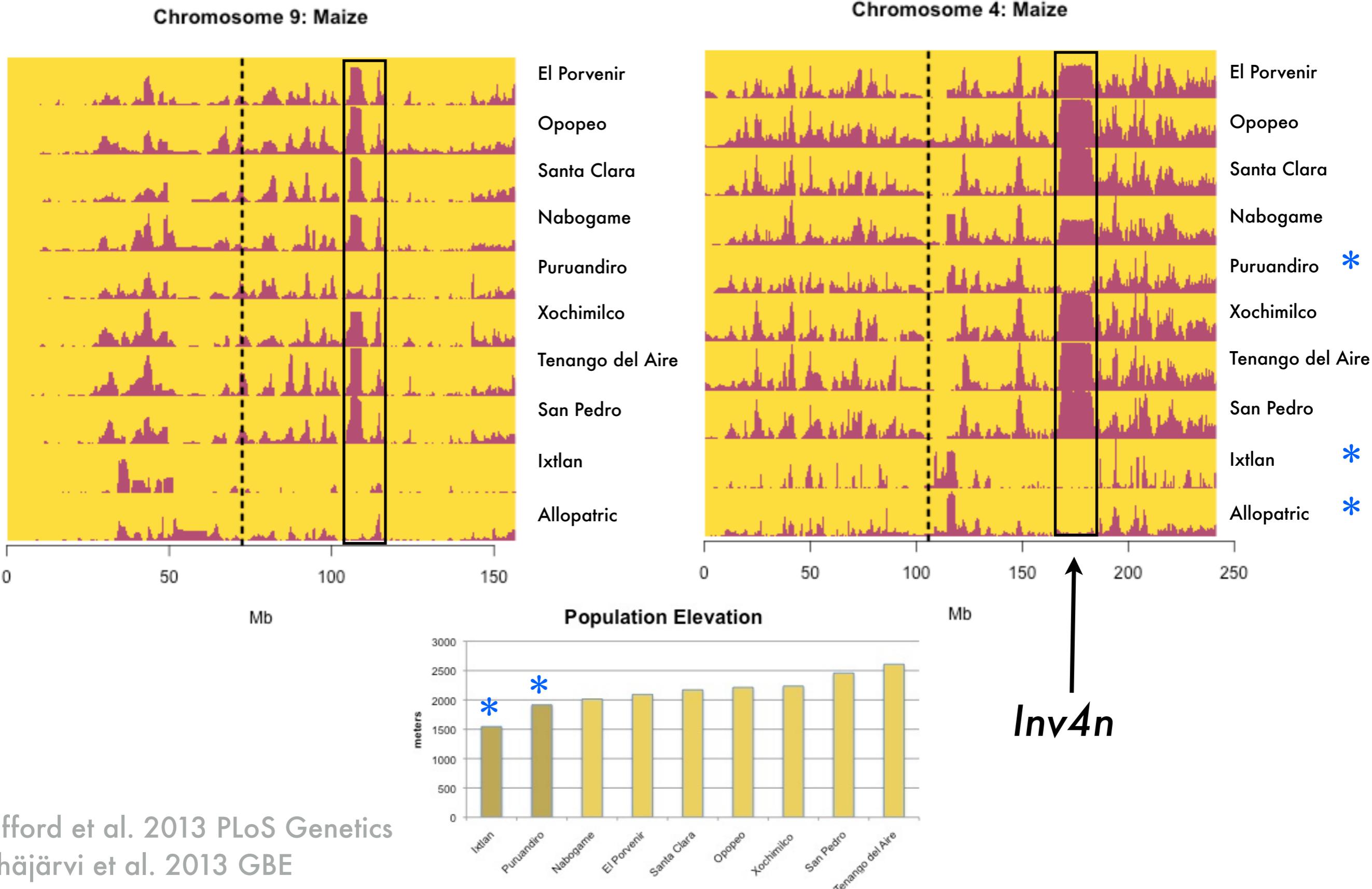
Chromosome 4: Maize



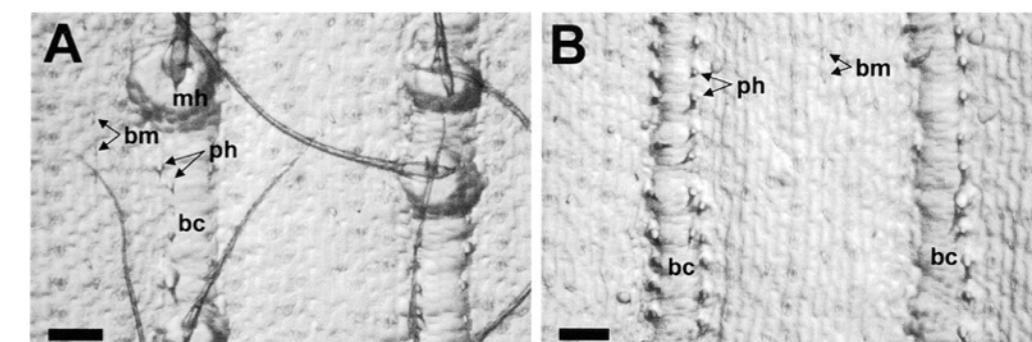
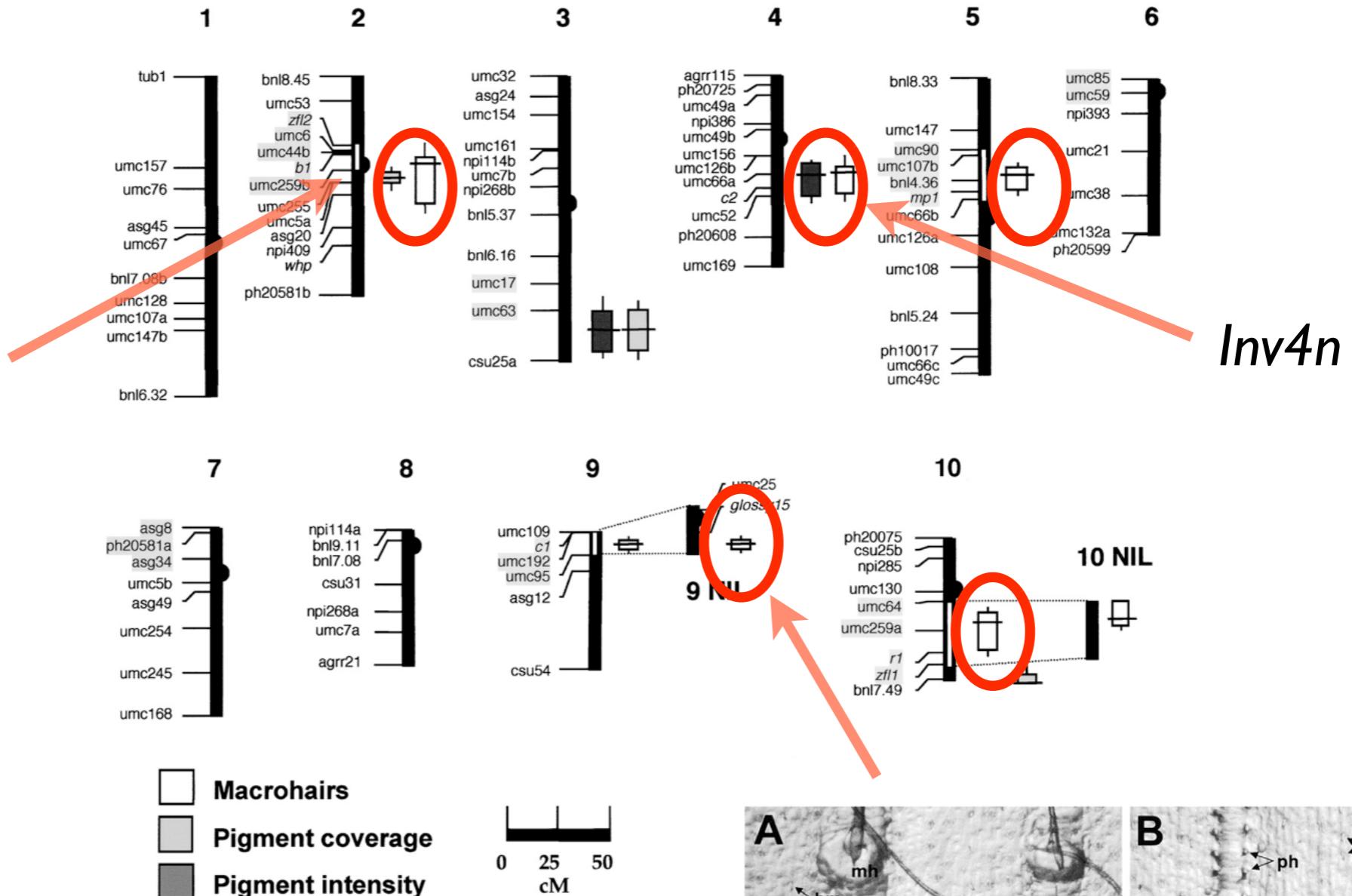
# admixture localized, asymmetric



# admixture localized, asymmetric

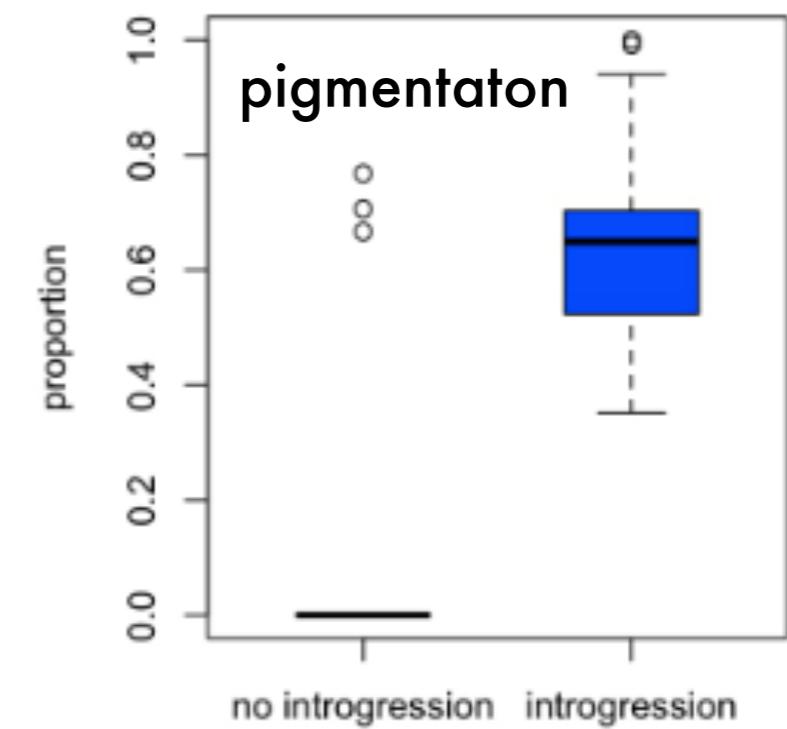
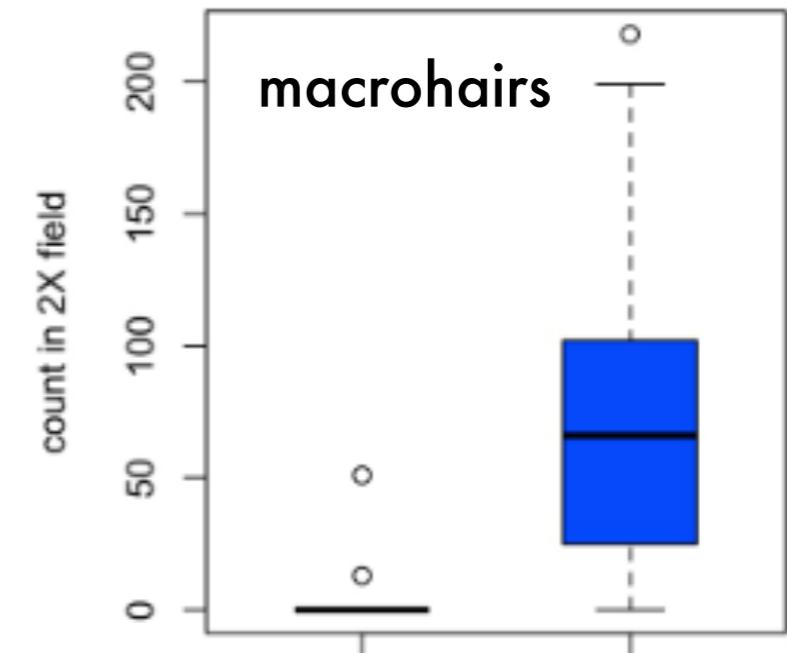
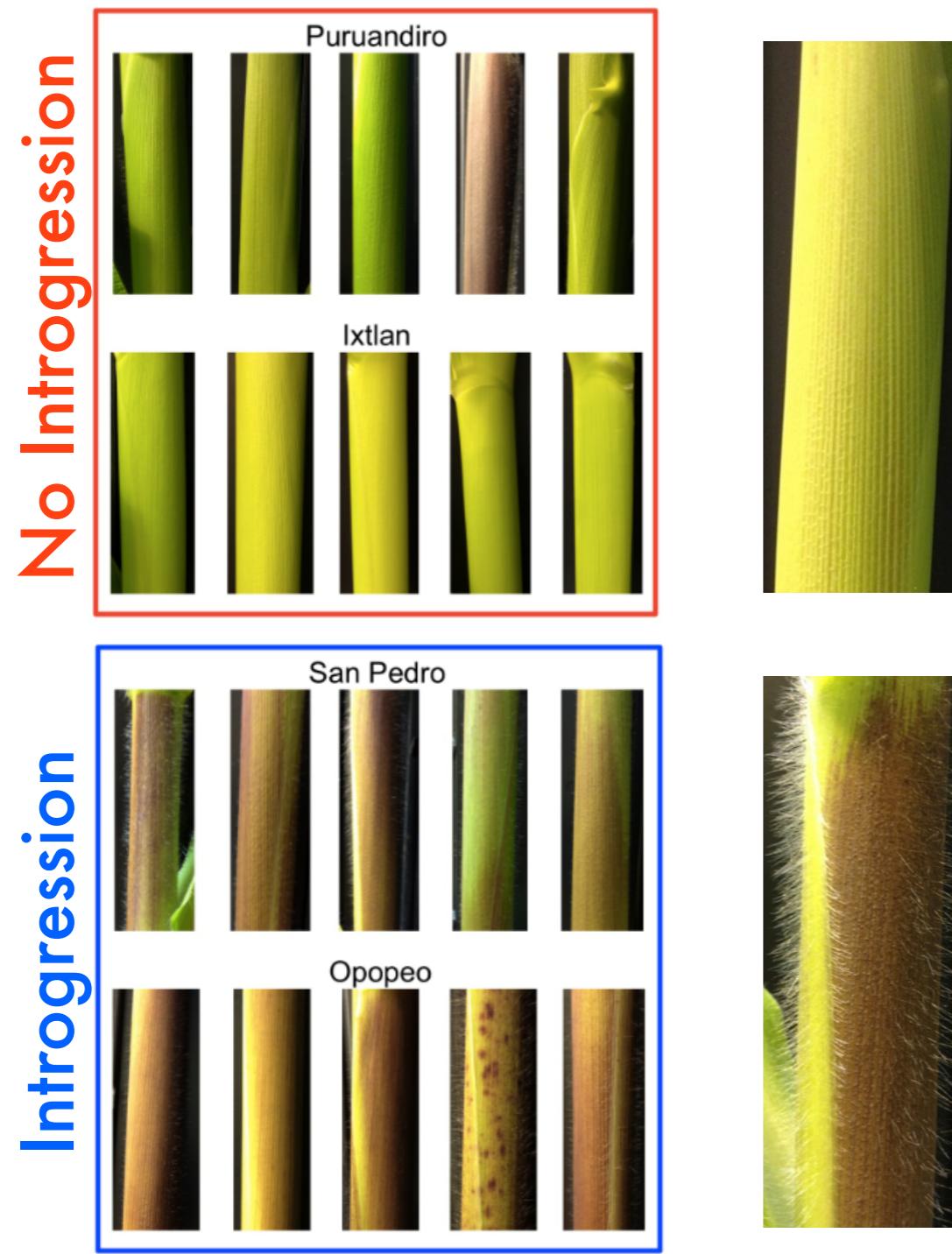


# introgressions overlap with mexicana QTL

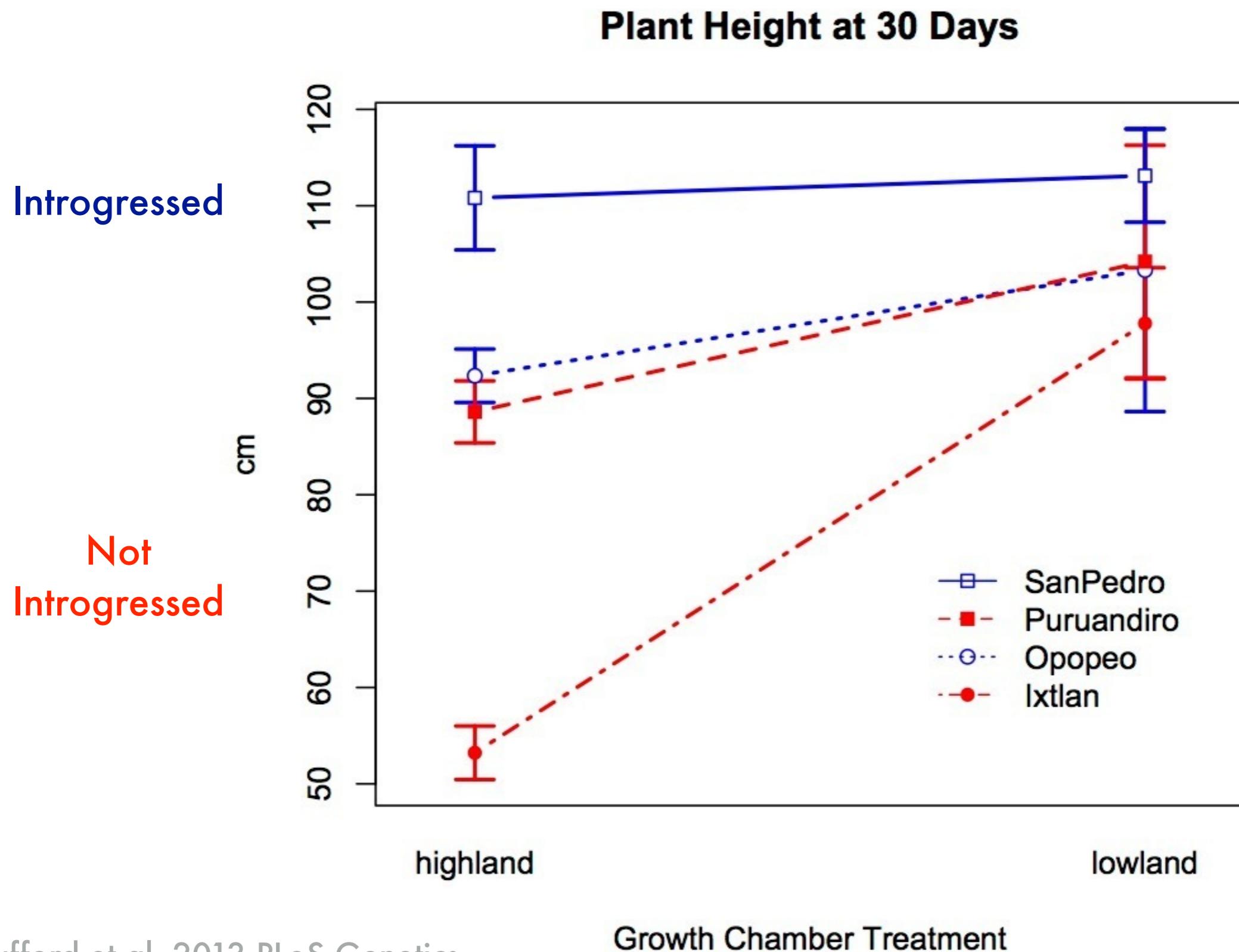


Lauter et al. 2004 Genetics  
Moose et al. 2004 Genetics

# introgressions show *mexicana* phenotypes

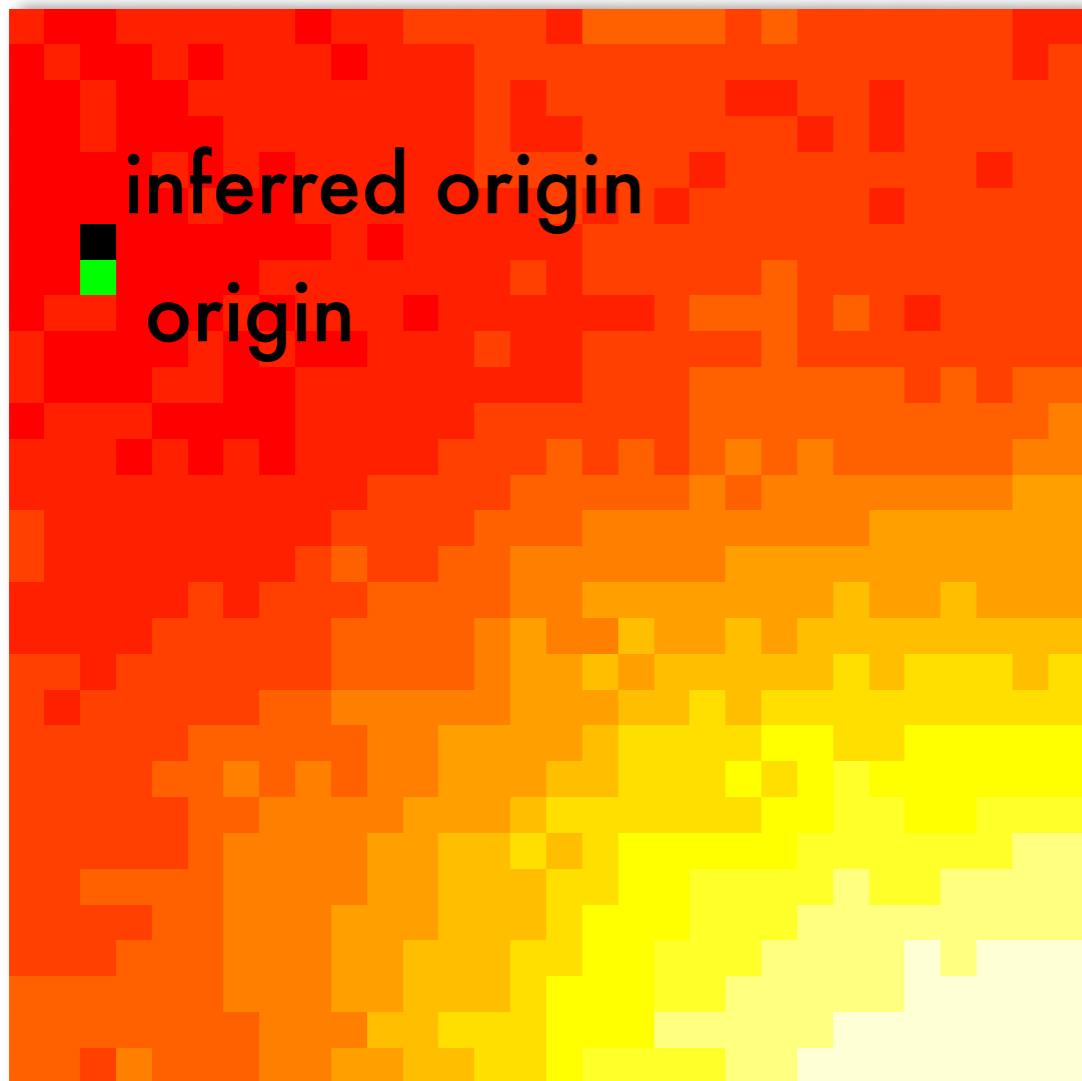


# introgressions grow faster at low temp

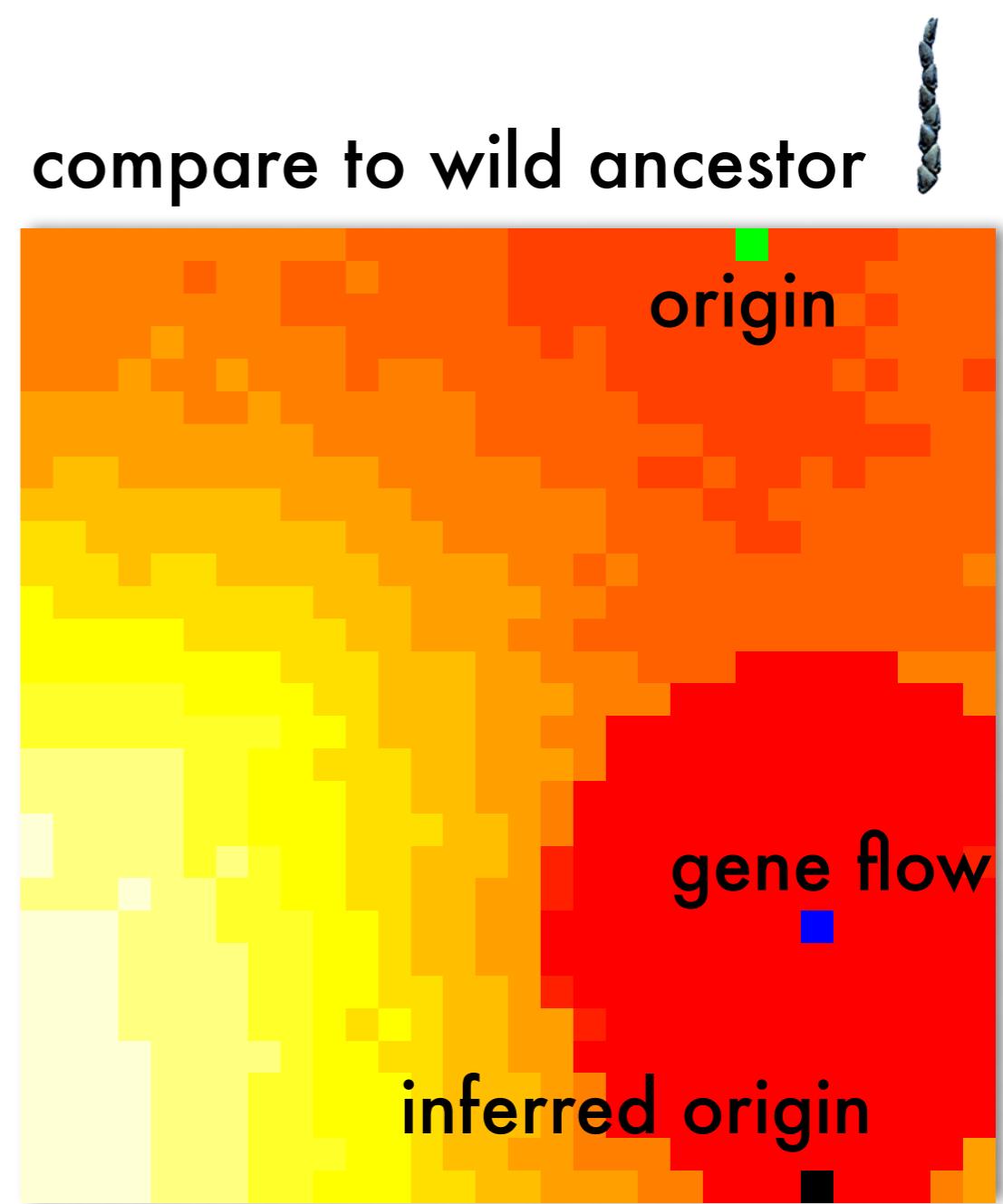
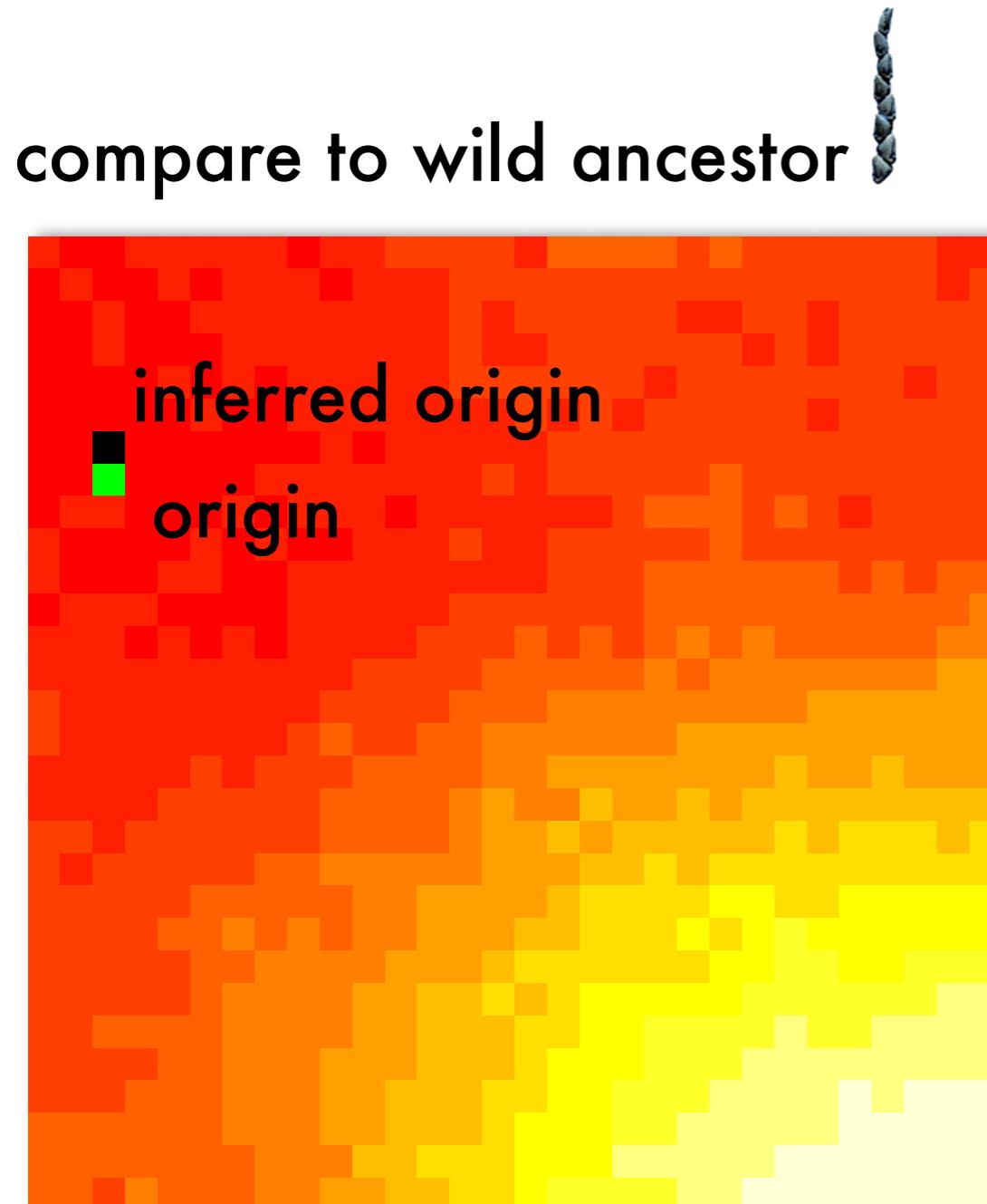


# admixture confounds ancestral inference

compare to wild ancestor

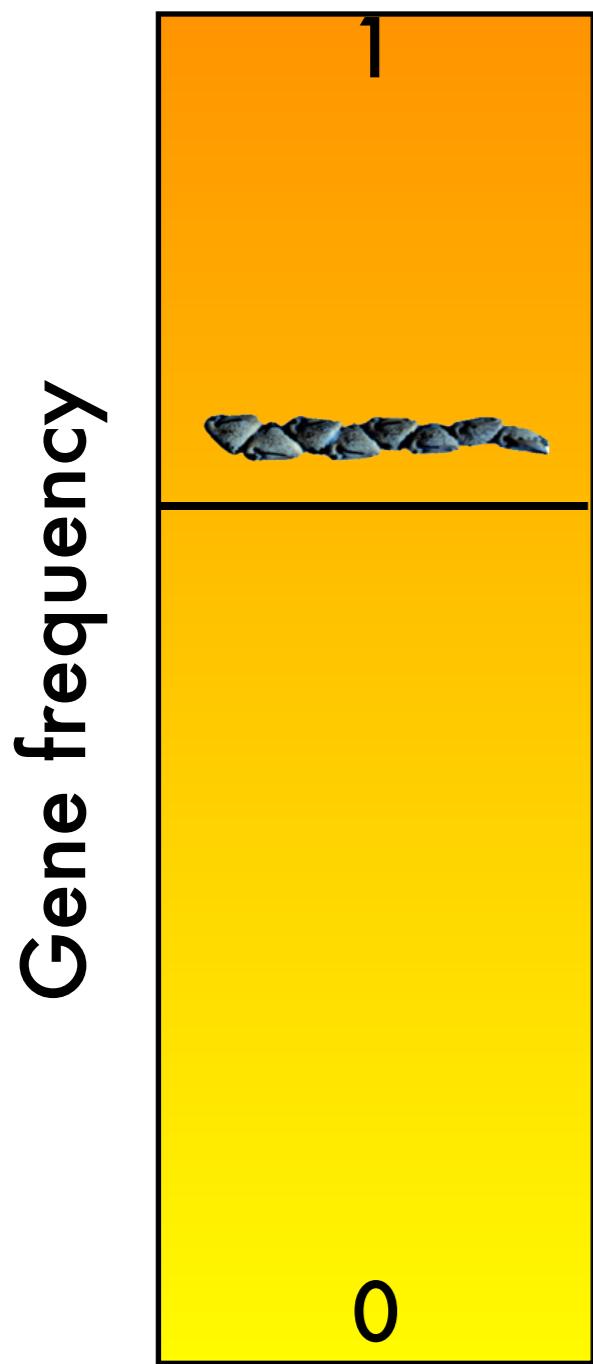


# admixture confounds ancestral inference



# a solution: ancestral reconstruction

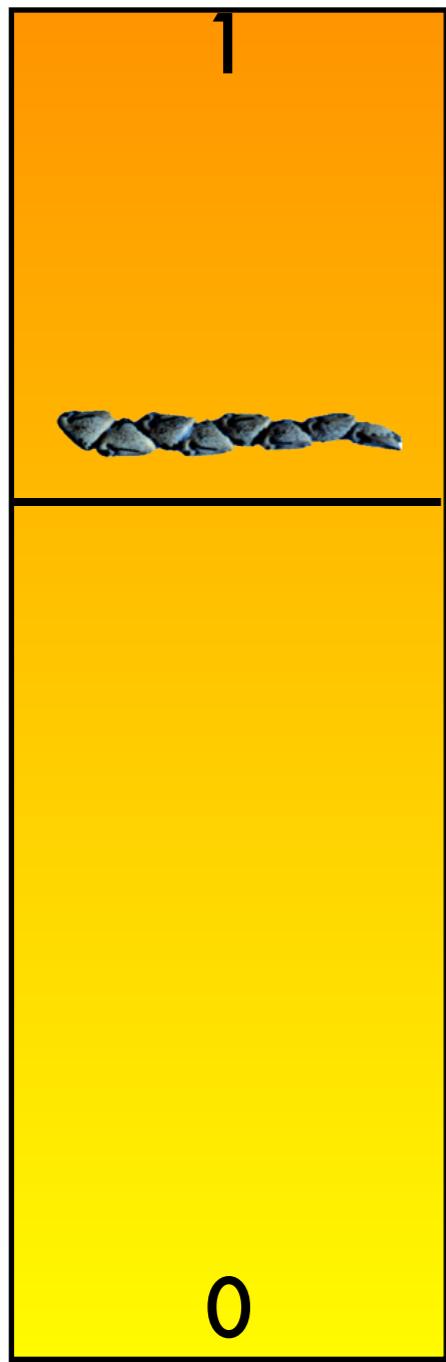
wild ancestor



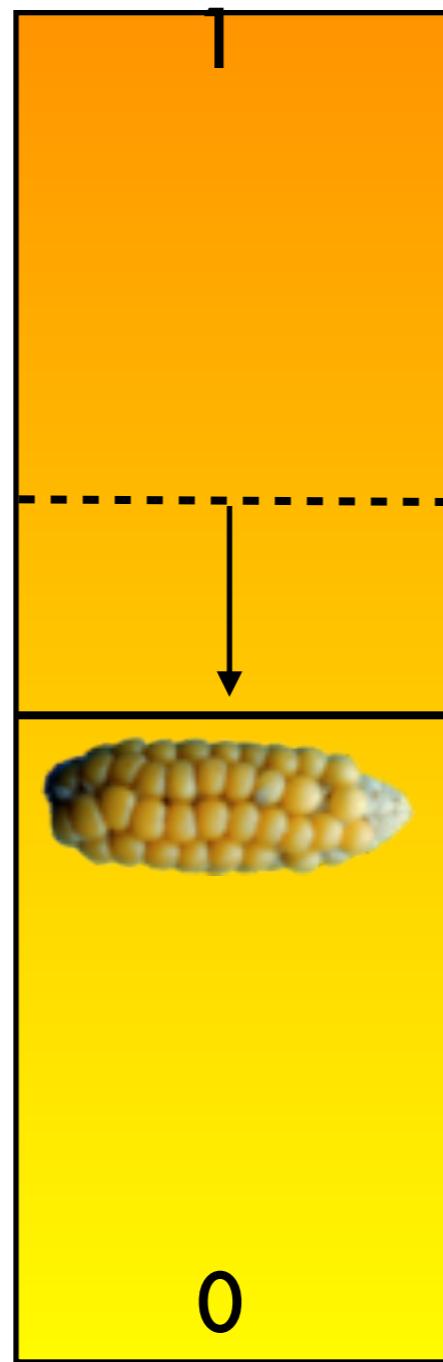
# a solution: ancestral reconstruction

wild ancestor

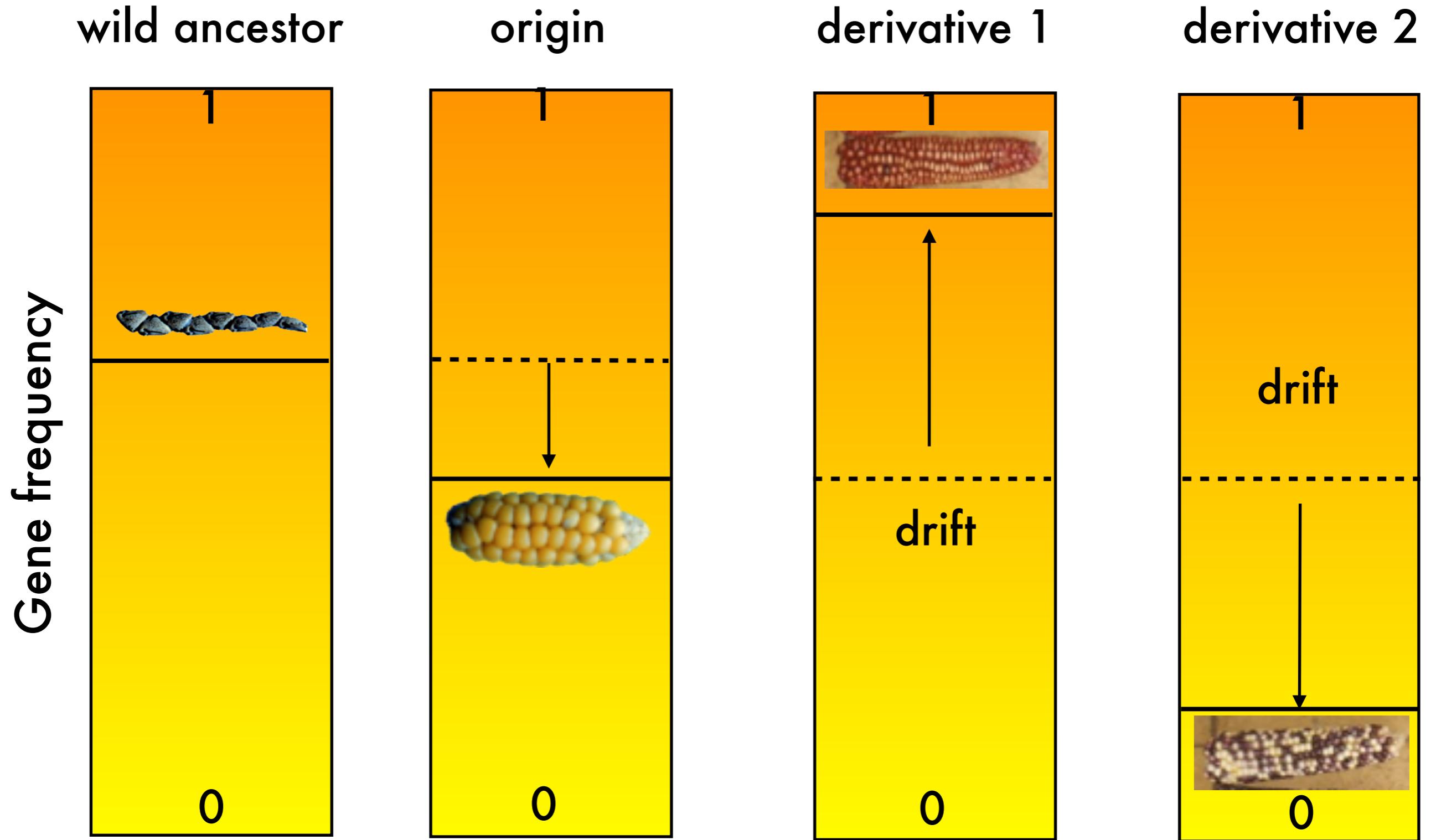
Gene frequency



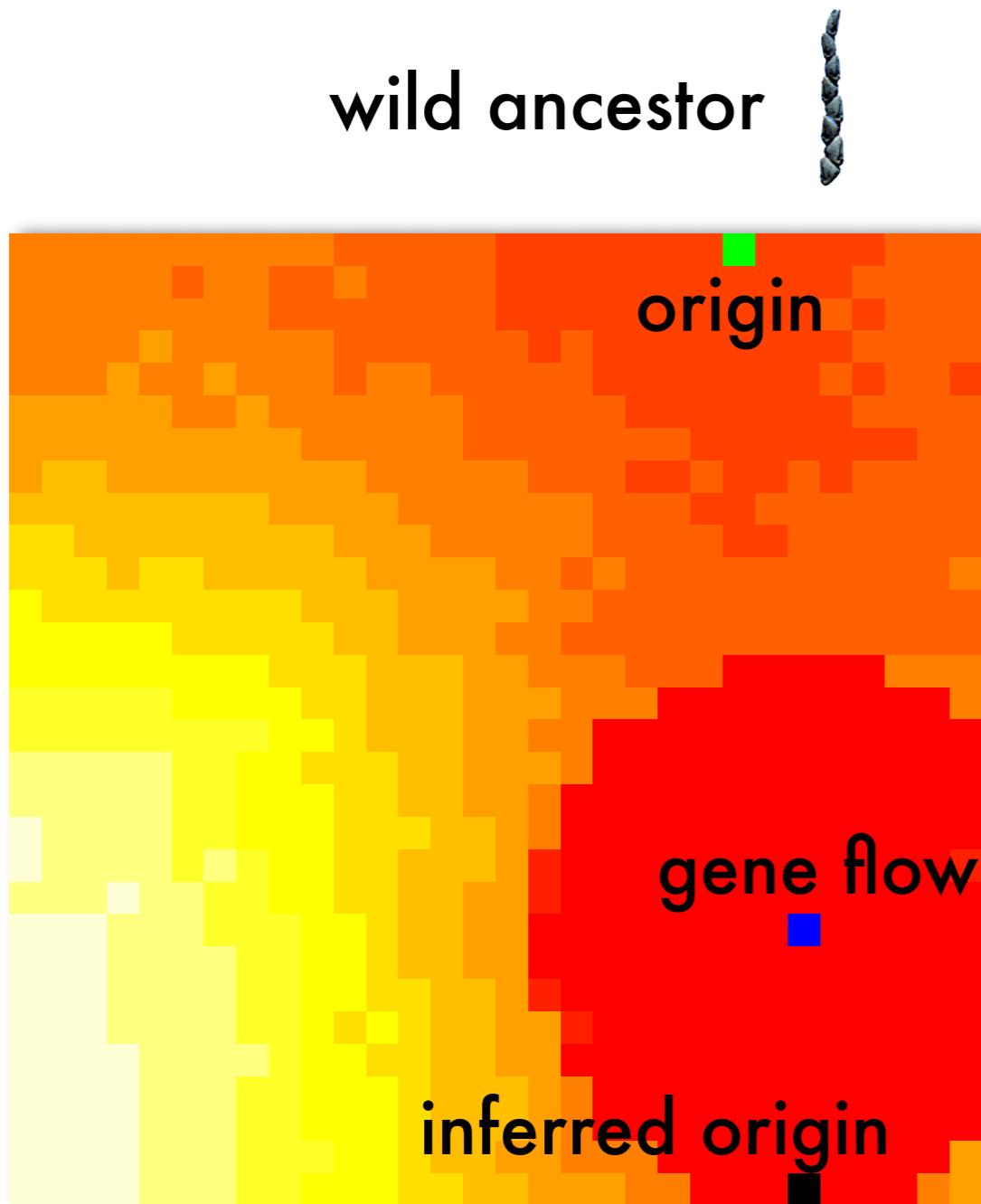
origin



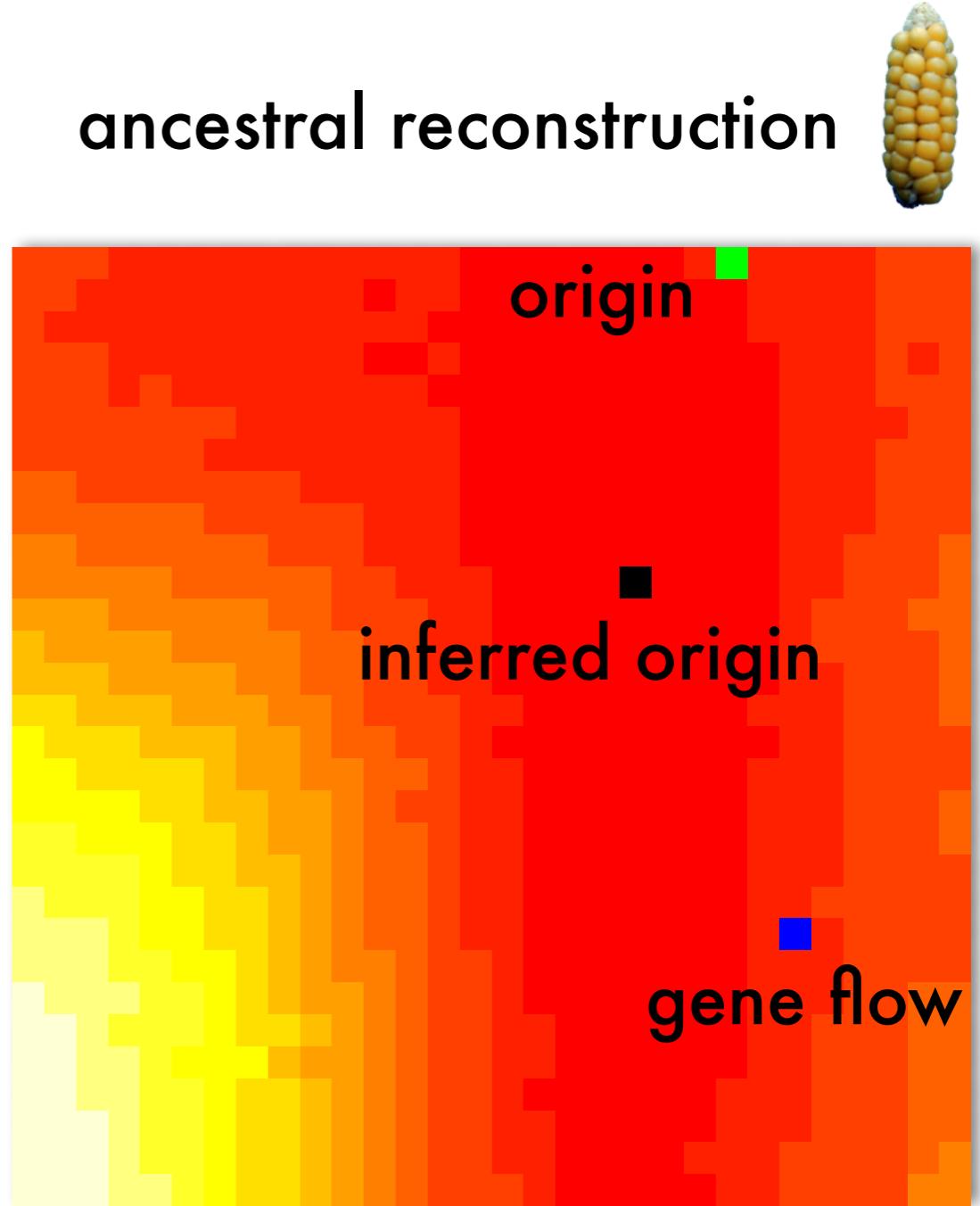
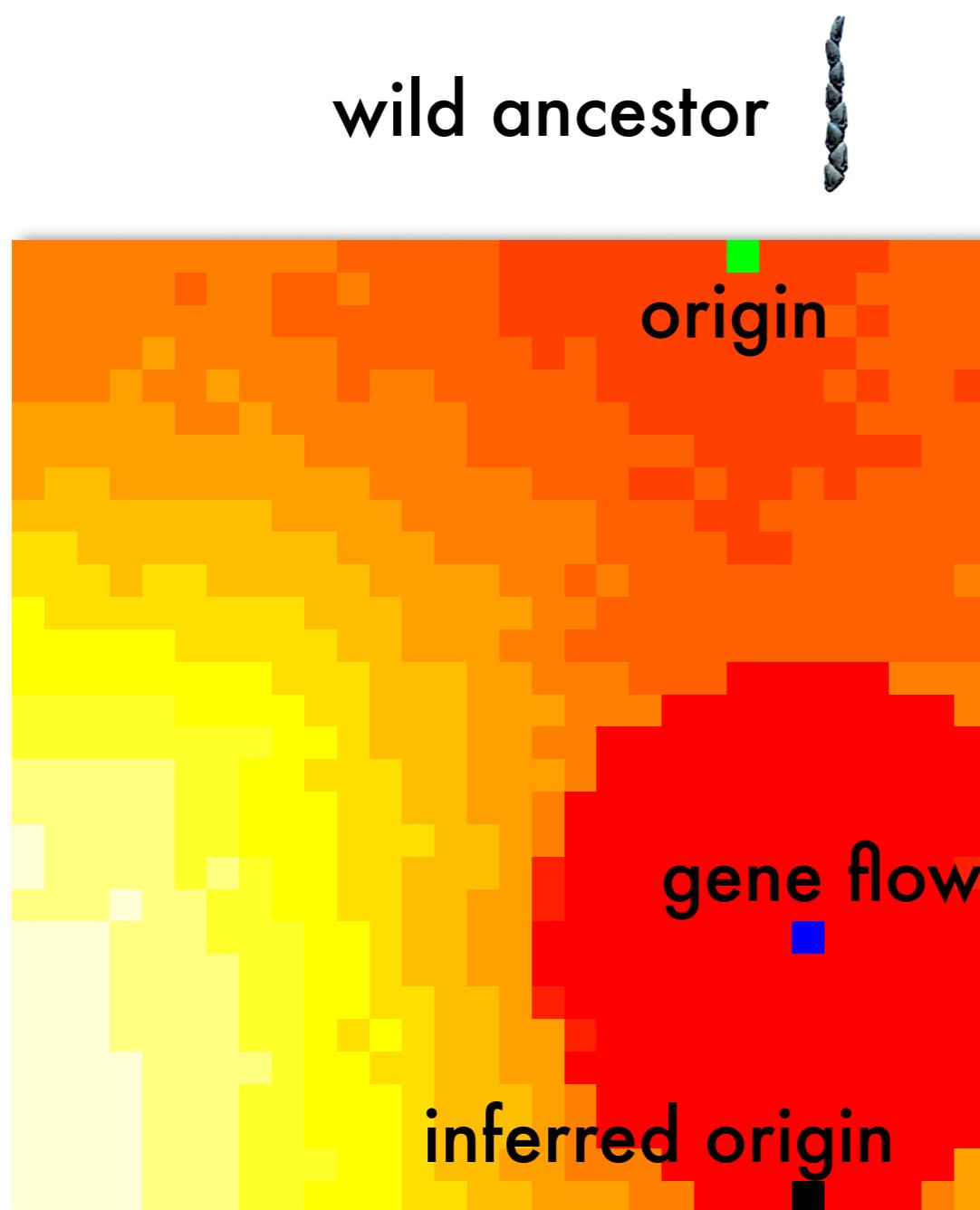
# a solution: ancestral reconstruction



# ancestral reconstruction resolves origins

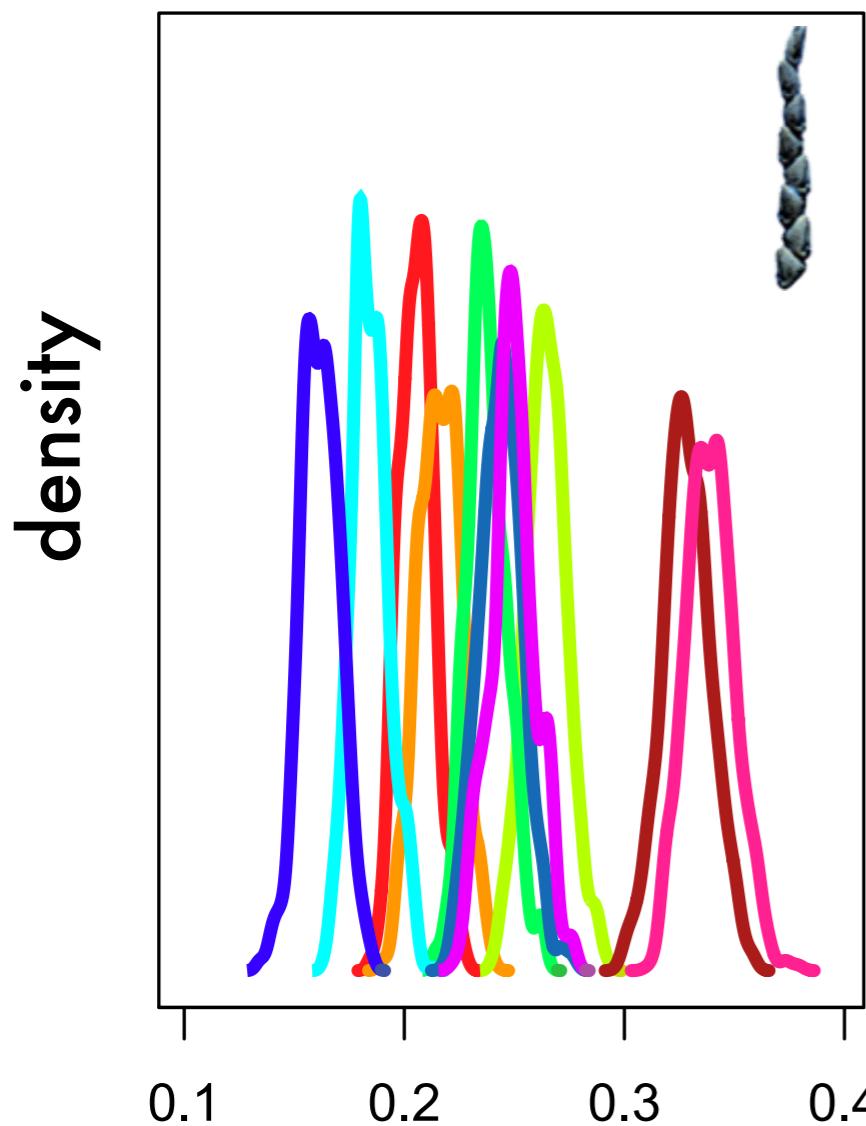


# ancestral reconstruction resolves origins

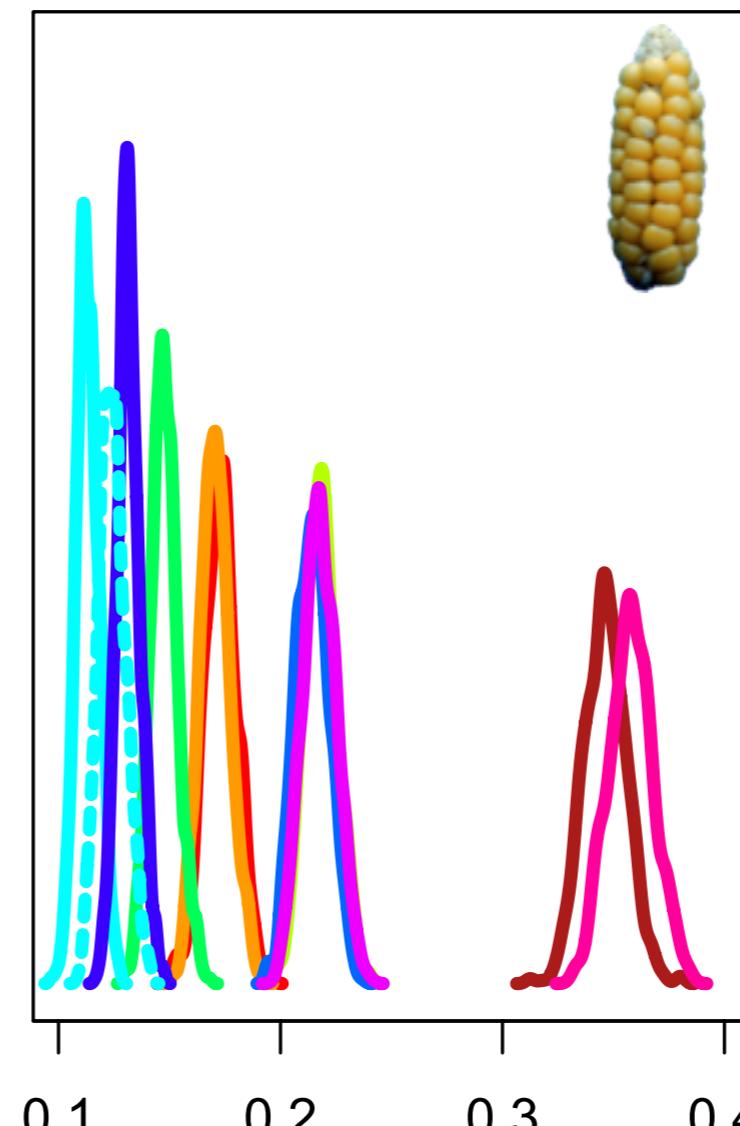


# maize origins in lowland west Mexico

Compared to wild teosinte



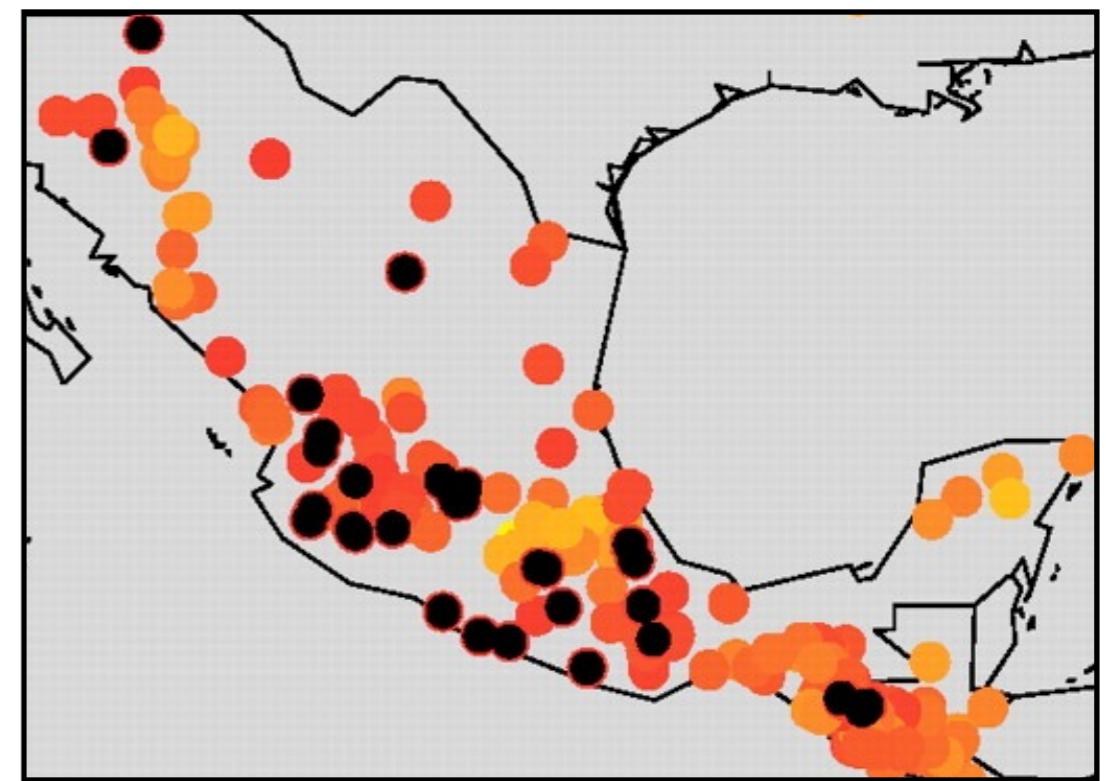
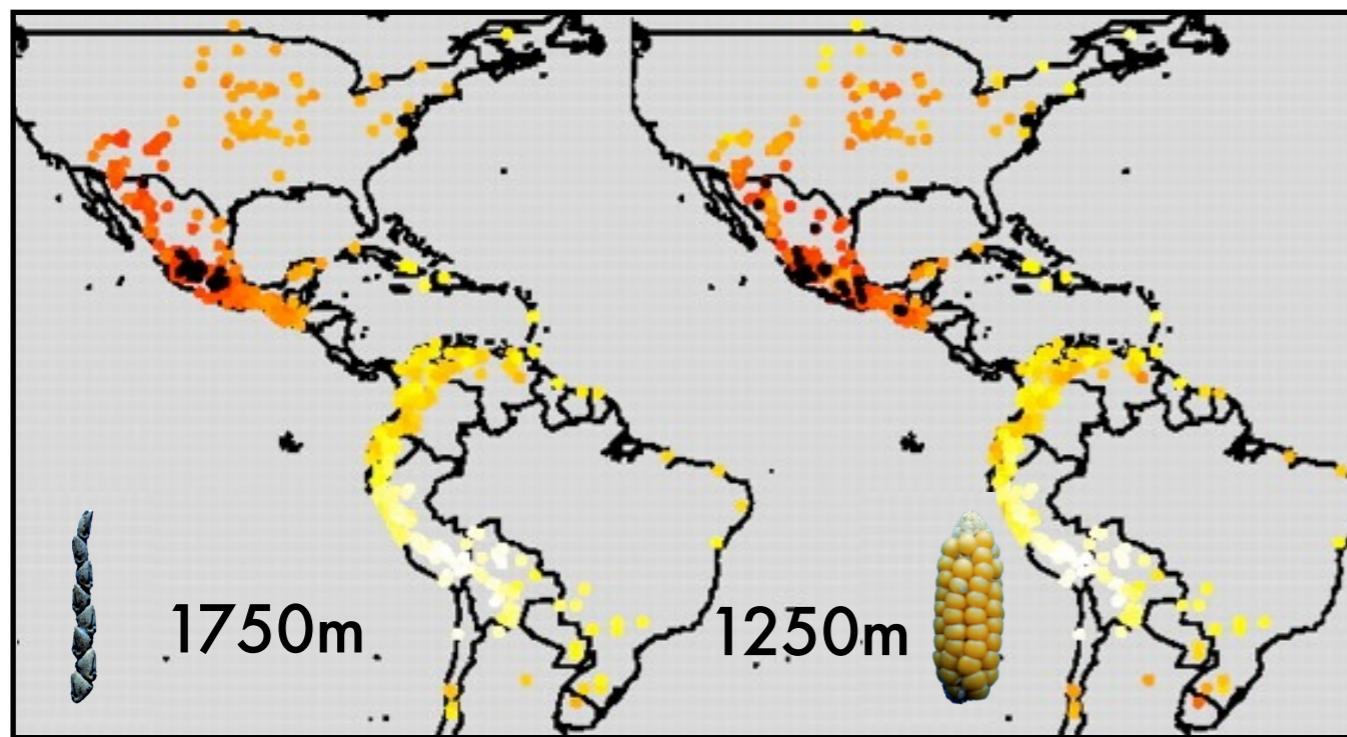
Compared to ancestral maize



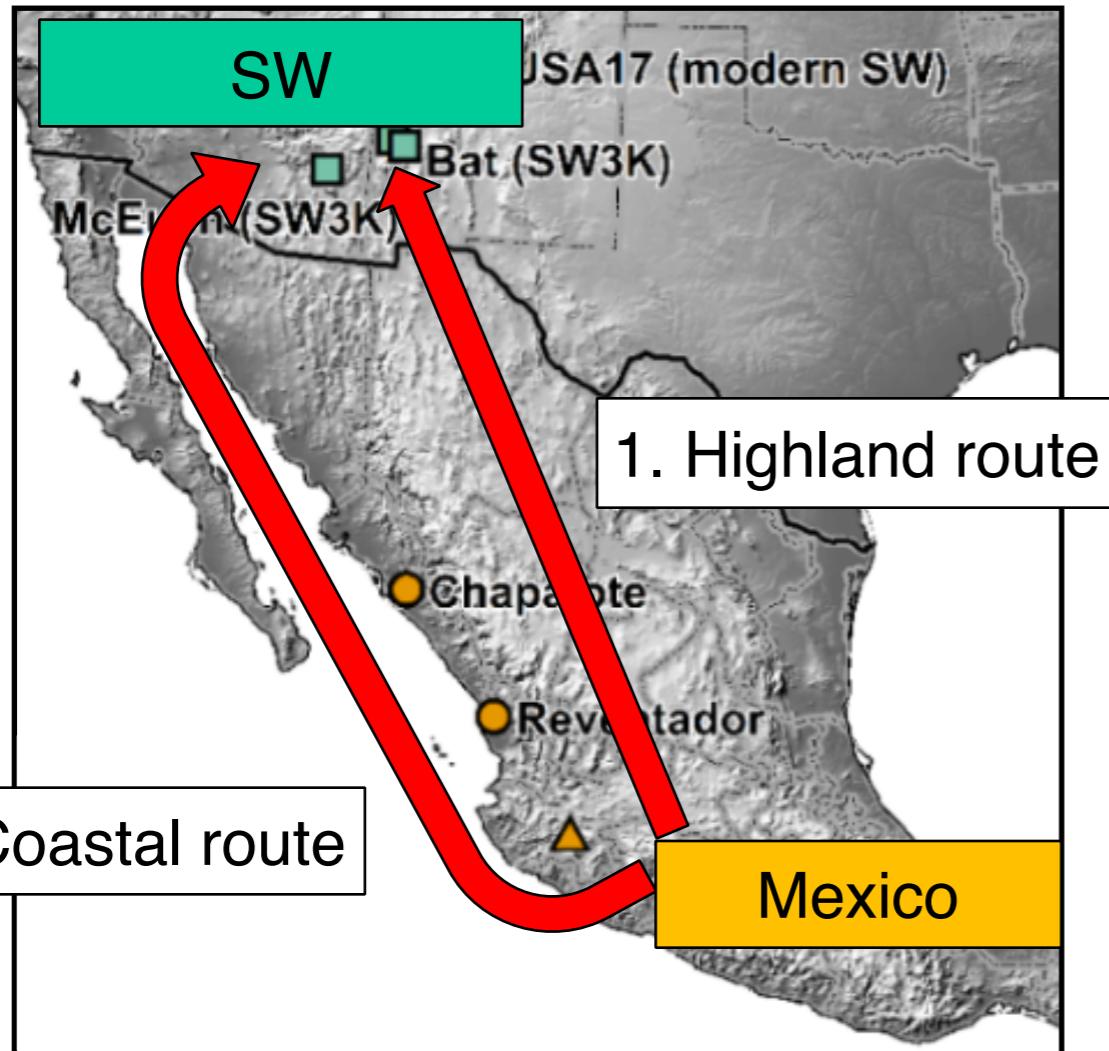
- South-West US
- Central US
- S American Lowland
- Andean Highland
- Tropical Lowland
- West Mexico
- Coastal Brazil
- Mexican Highland
- North US
- Bolivian Lowland

Genetic distance from ancestor

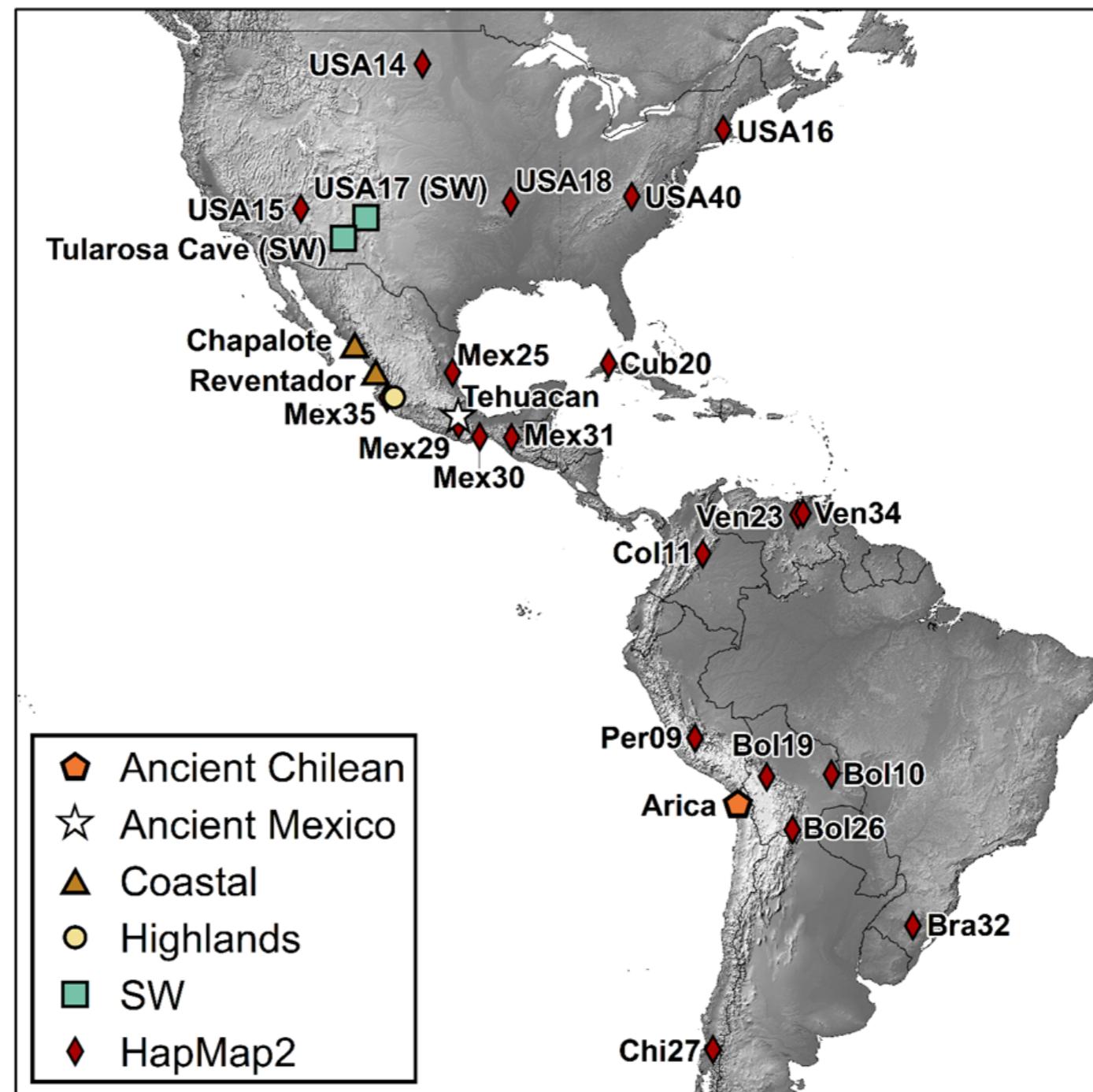
# maize origins in lowland west Mexico



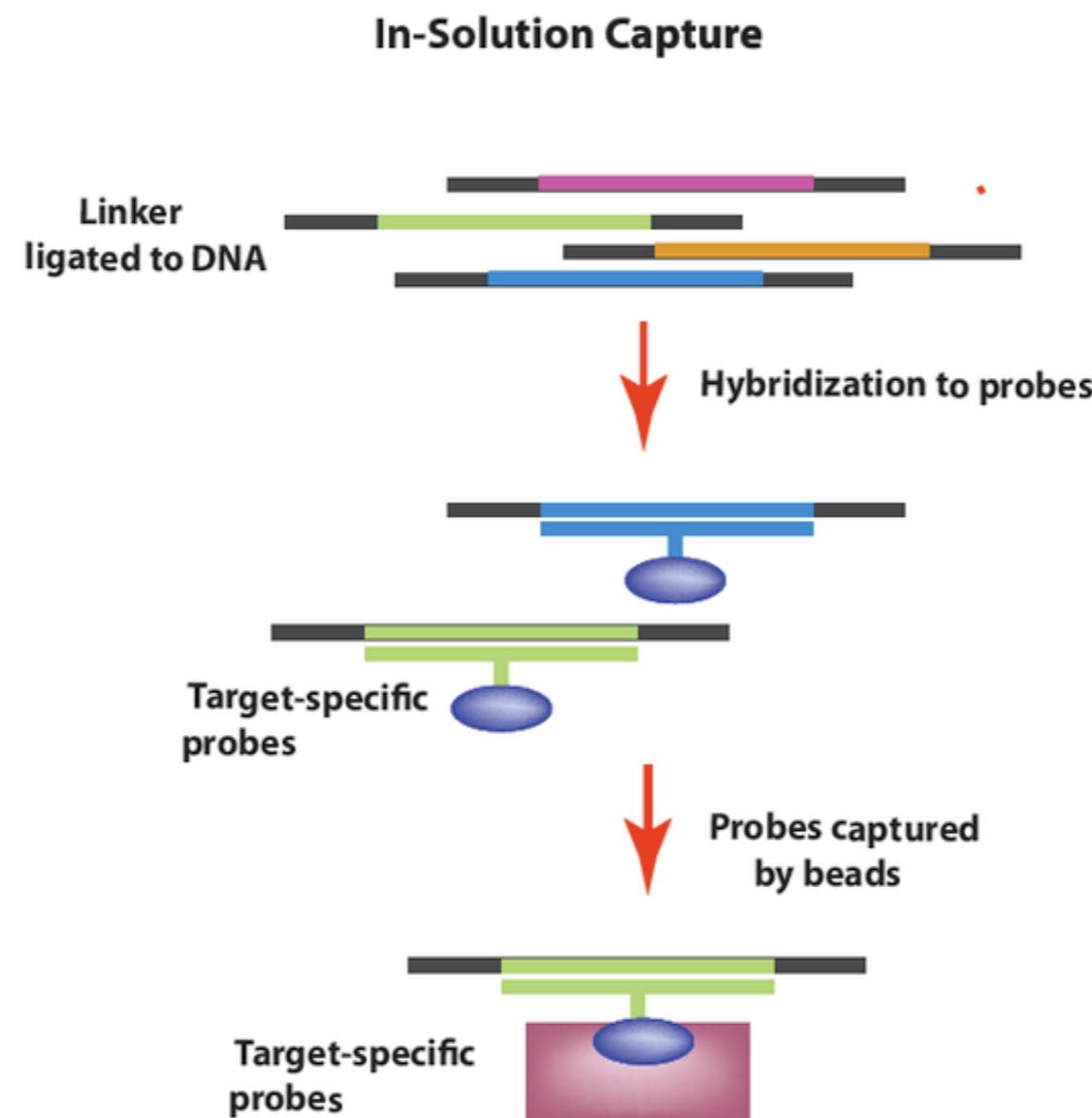
# how did maize arrive and adapt to SW US?



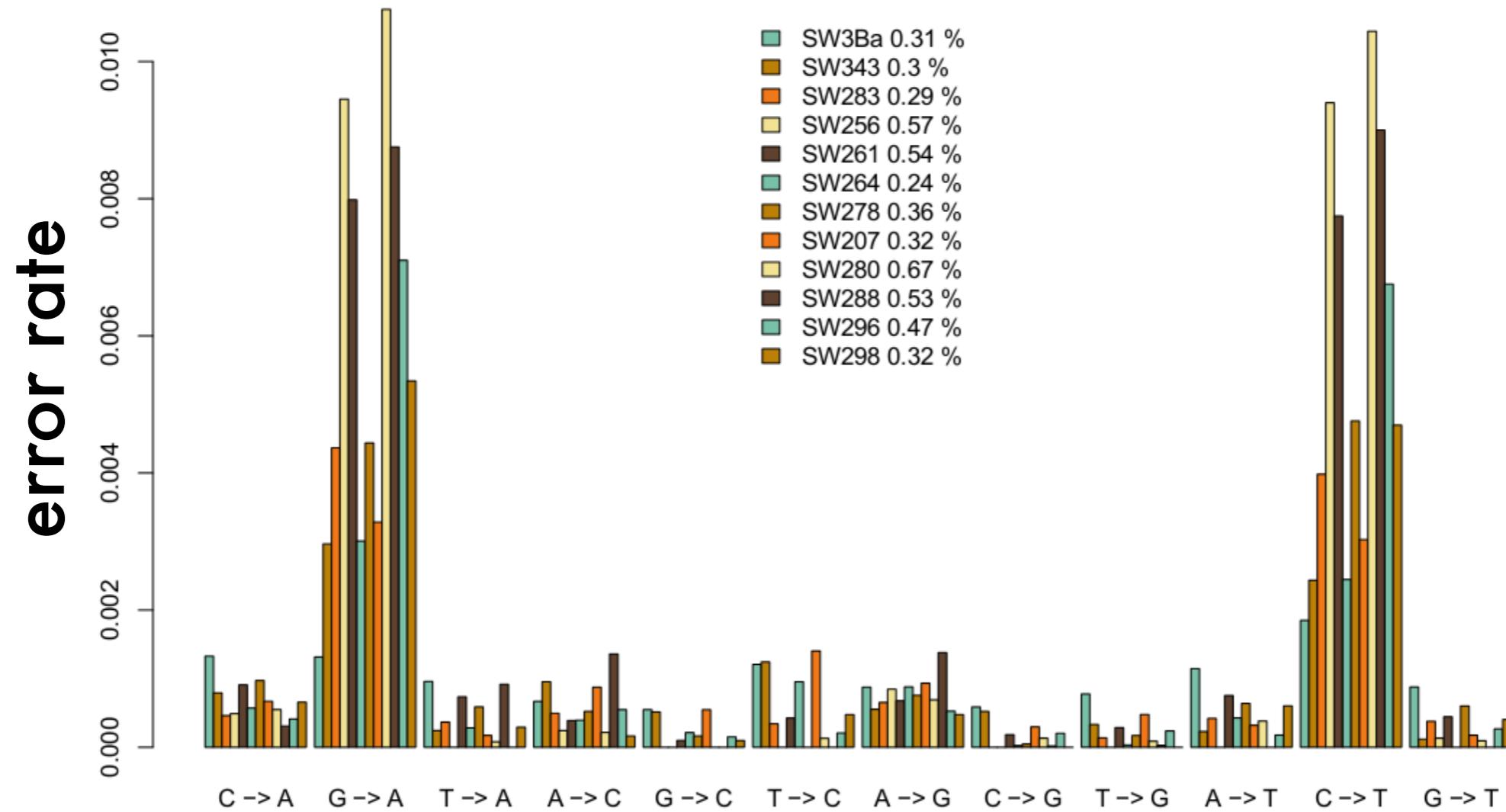
# ancient cobs to investigate chronology



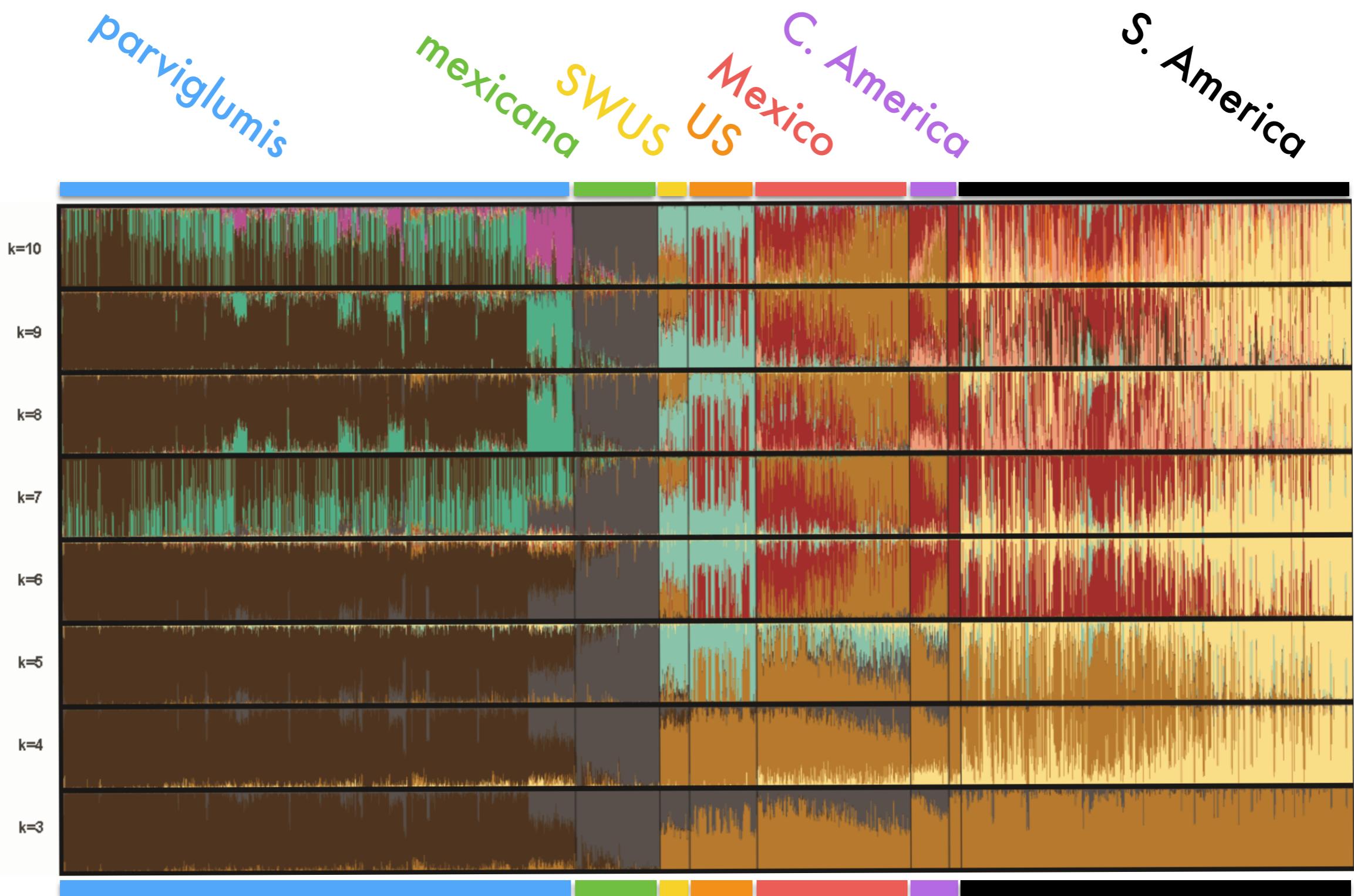
# DNA capture to enrich for subset of genome



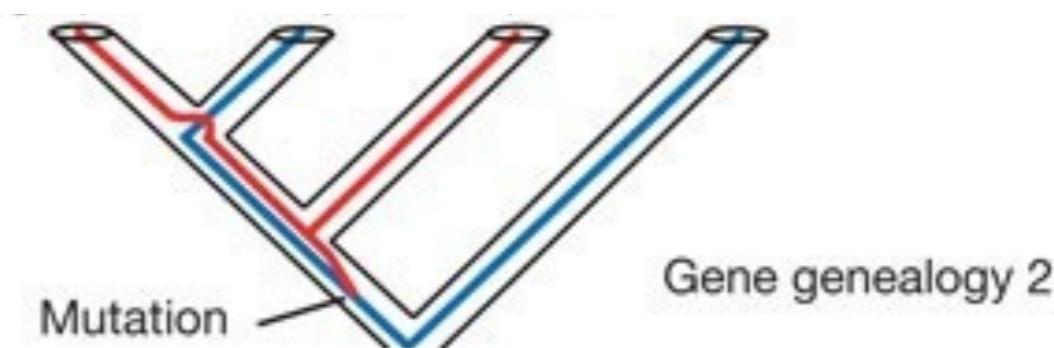
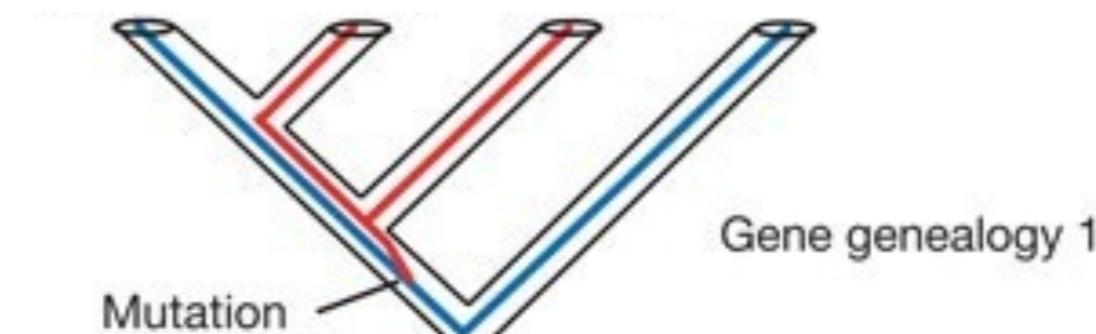
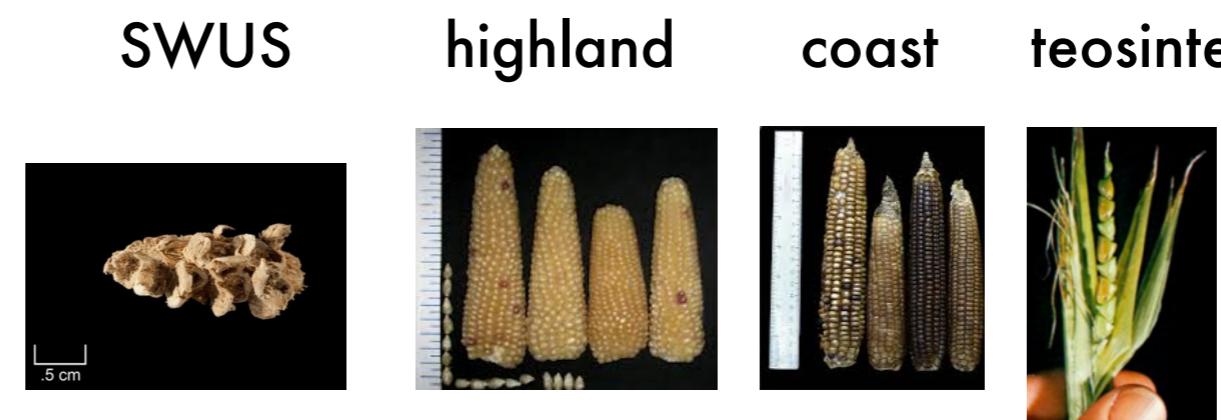
# ancient DNA data analysis: ANGSD



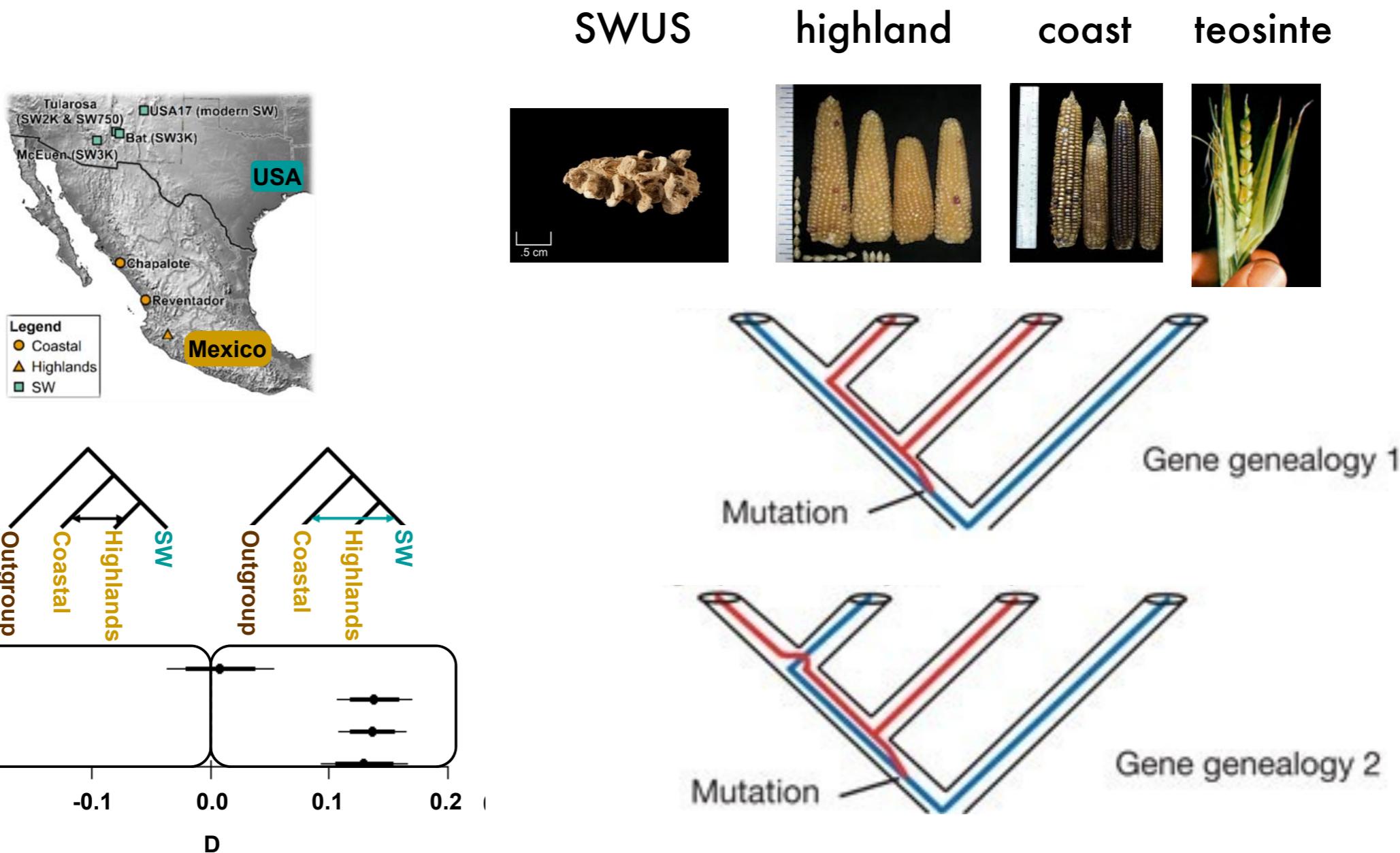
# SW shares ancestry with highland Mexico



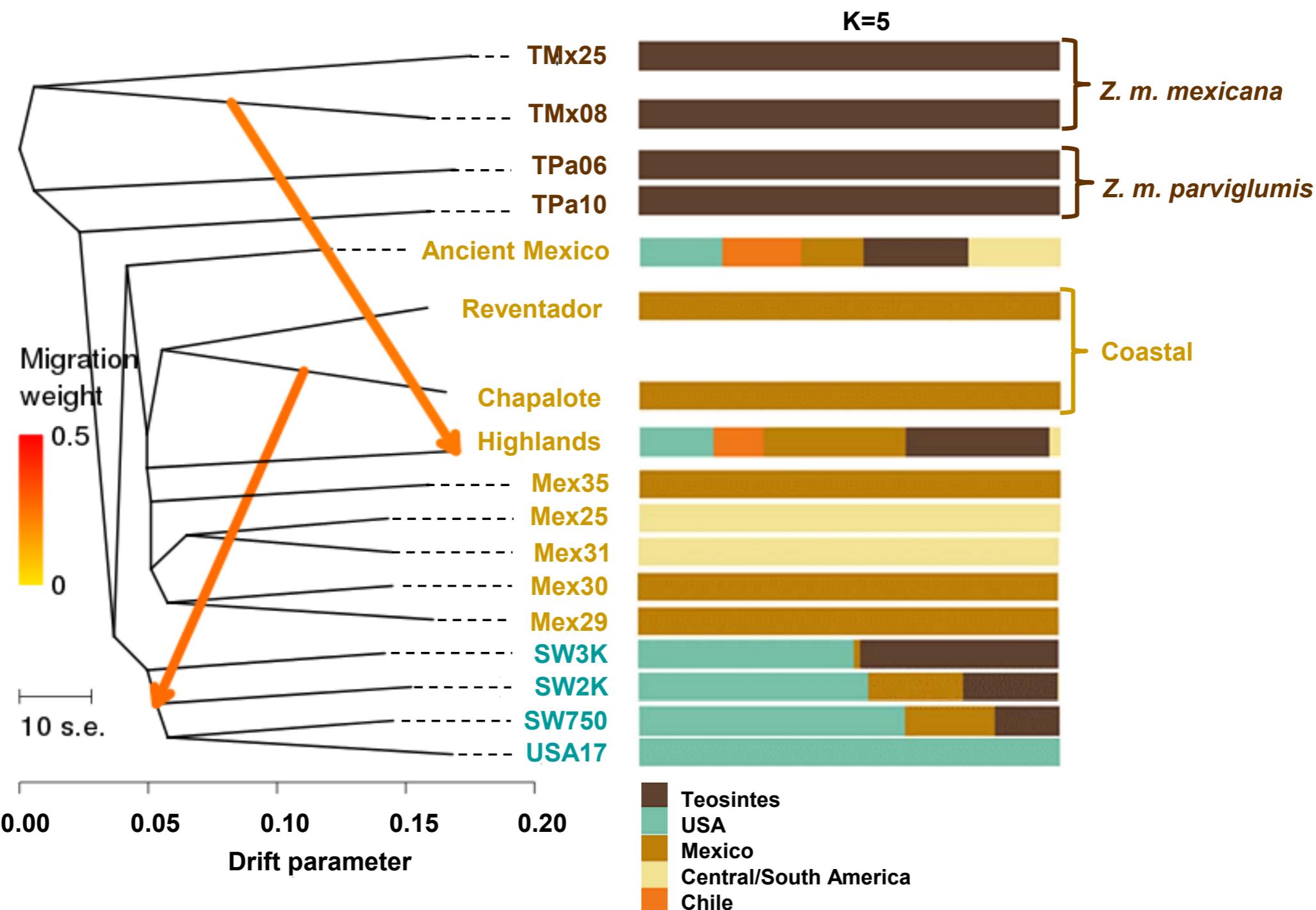
# allele counts support both hypotheses



# allele counts support both hypotheses



# tree, admixture analyses support results



# ancient population genomics



~2000 years b.p.



n=10



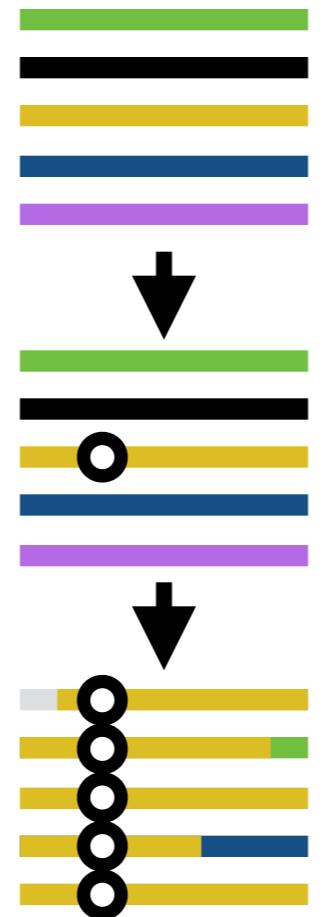
Changes in shape and size

~750 years b.p.

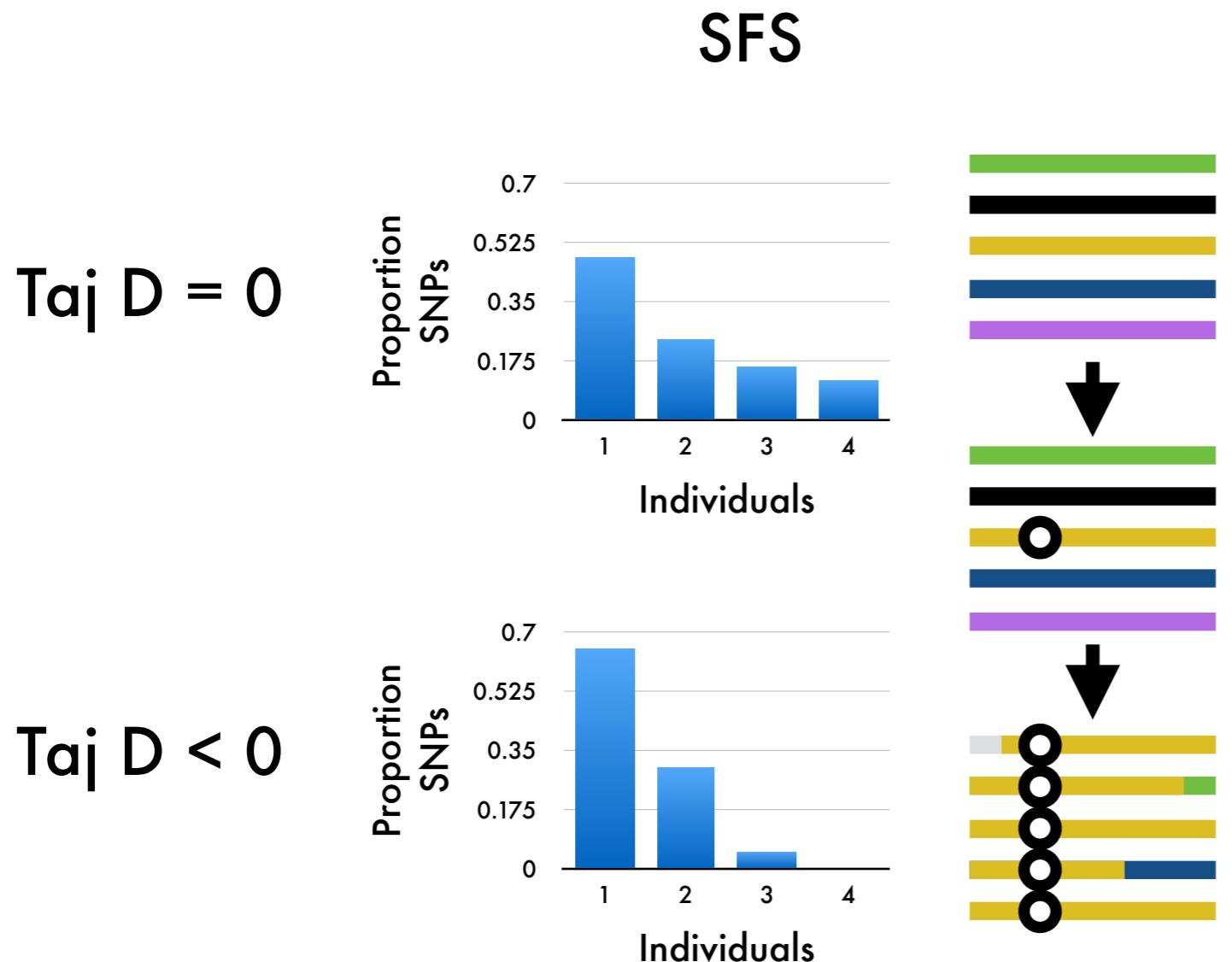


n=12

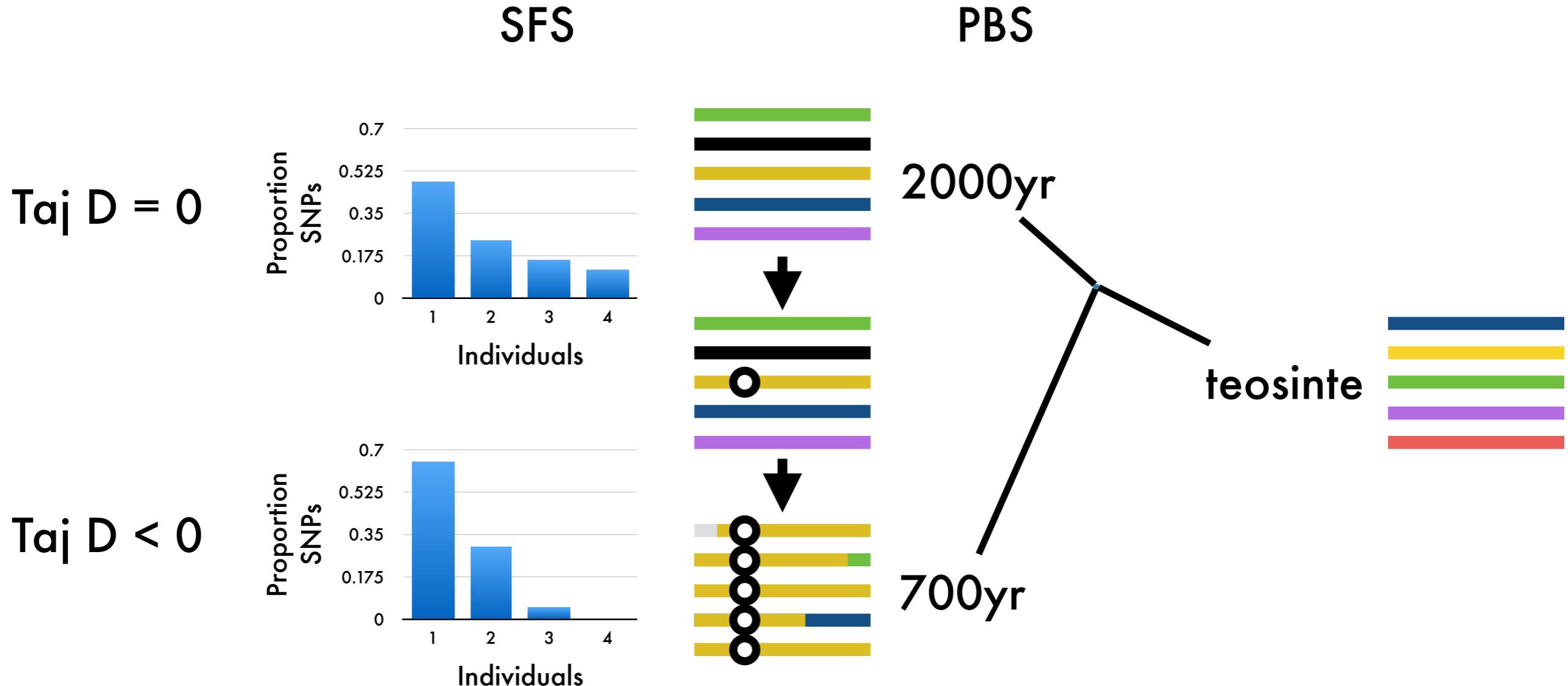
# selection affects patterns of diversity



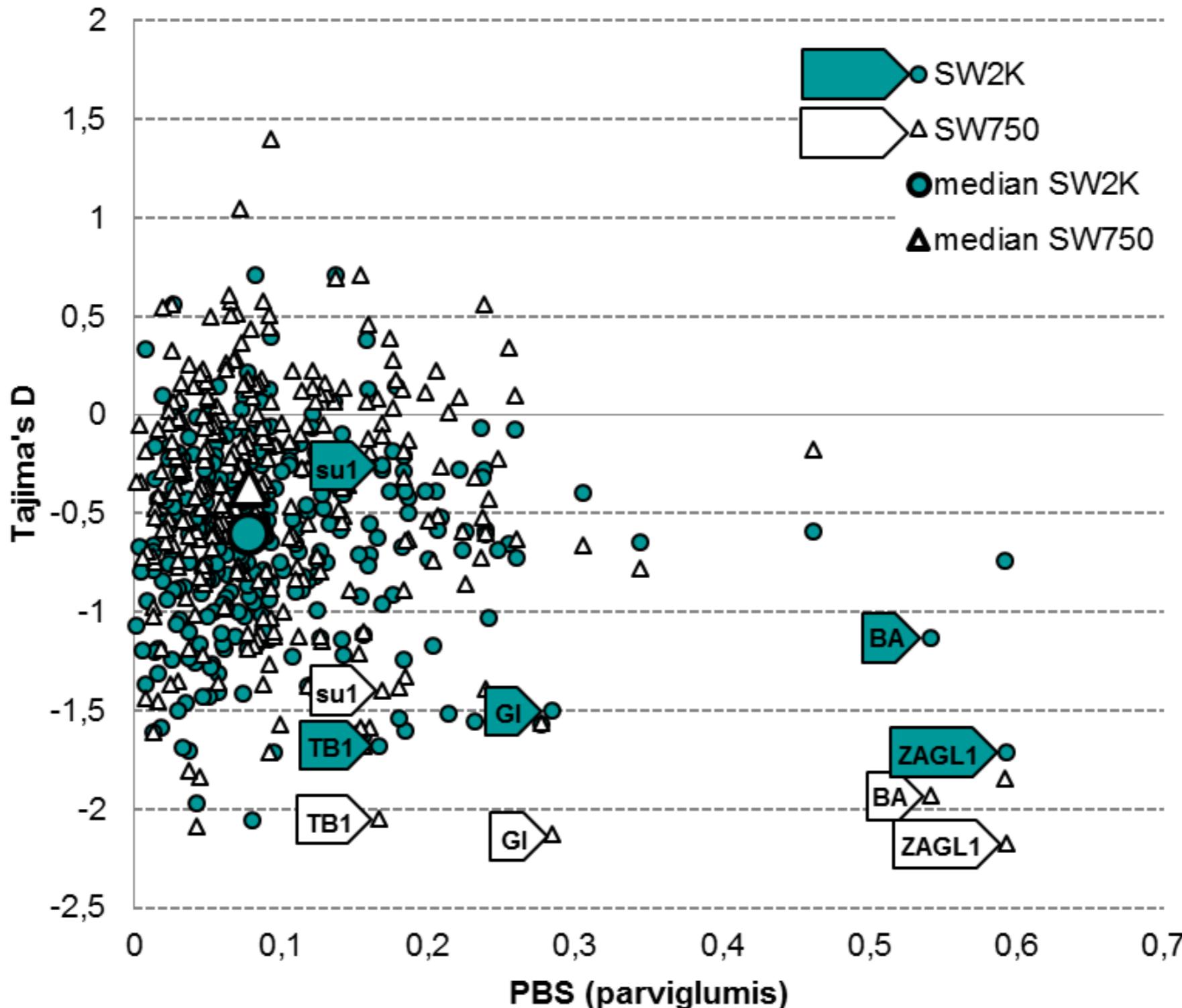
# selection affects patterns of diversity



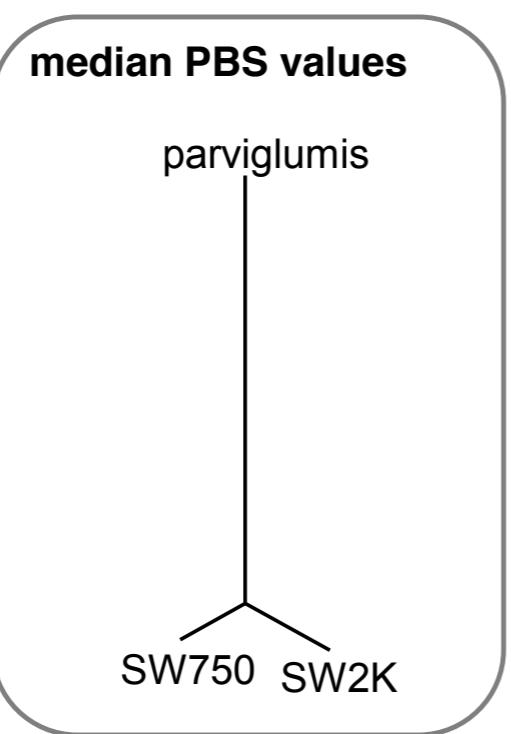
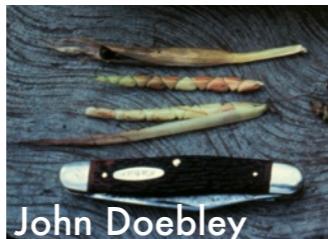
# selection affects patterns of diversity



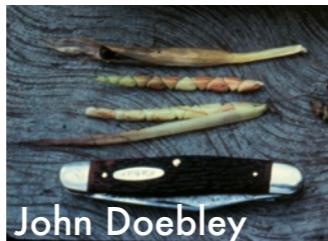
# methods identify known domestication loci



# domestication loci



# domestication loci



median PBS values

parviglumis

SW750 SW2K

*zagl1*

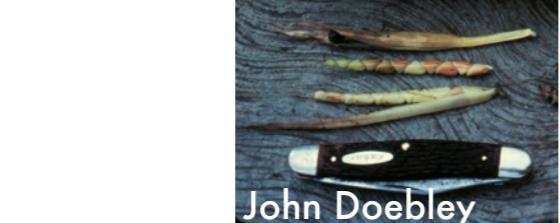
parviglumis

PBS(parviglumis)

SW750 SW2K



# adaptation loci



## median PBS values

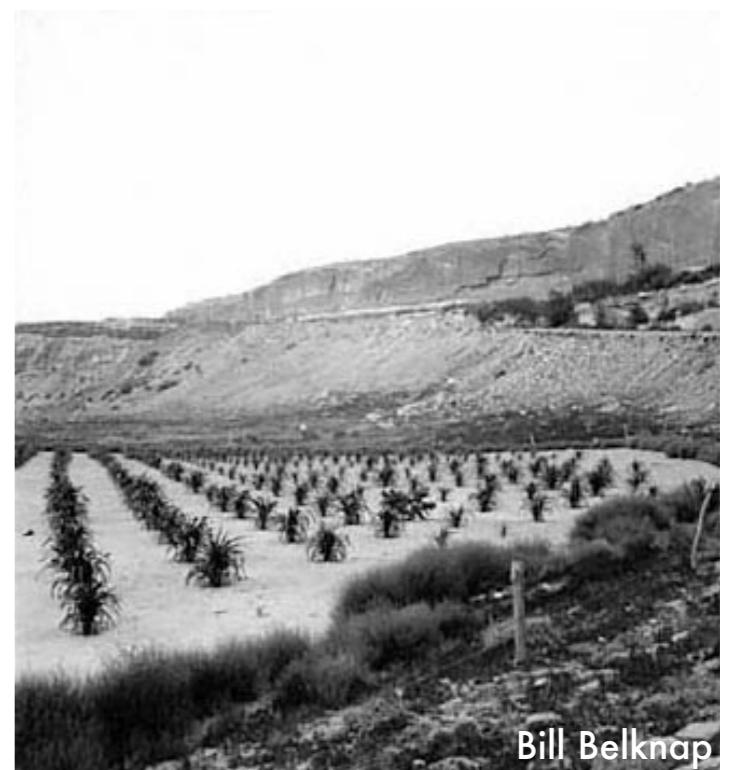
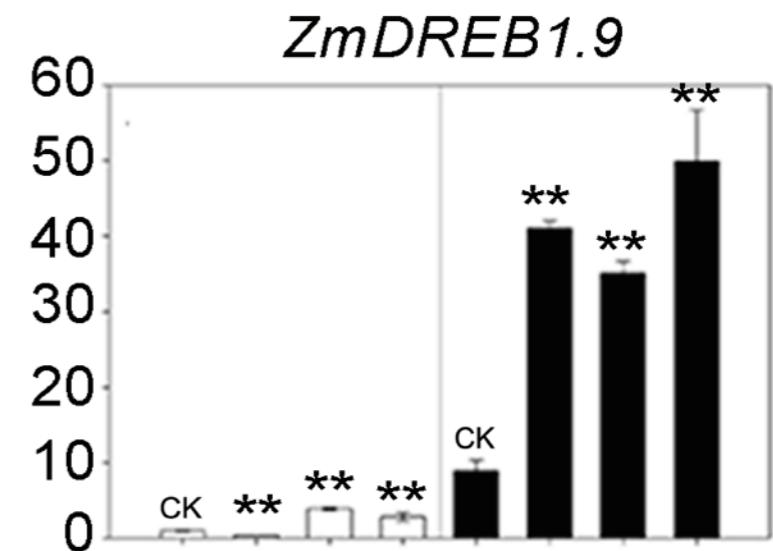
## parviglumis

SW750 SW2K

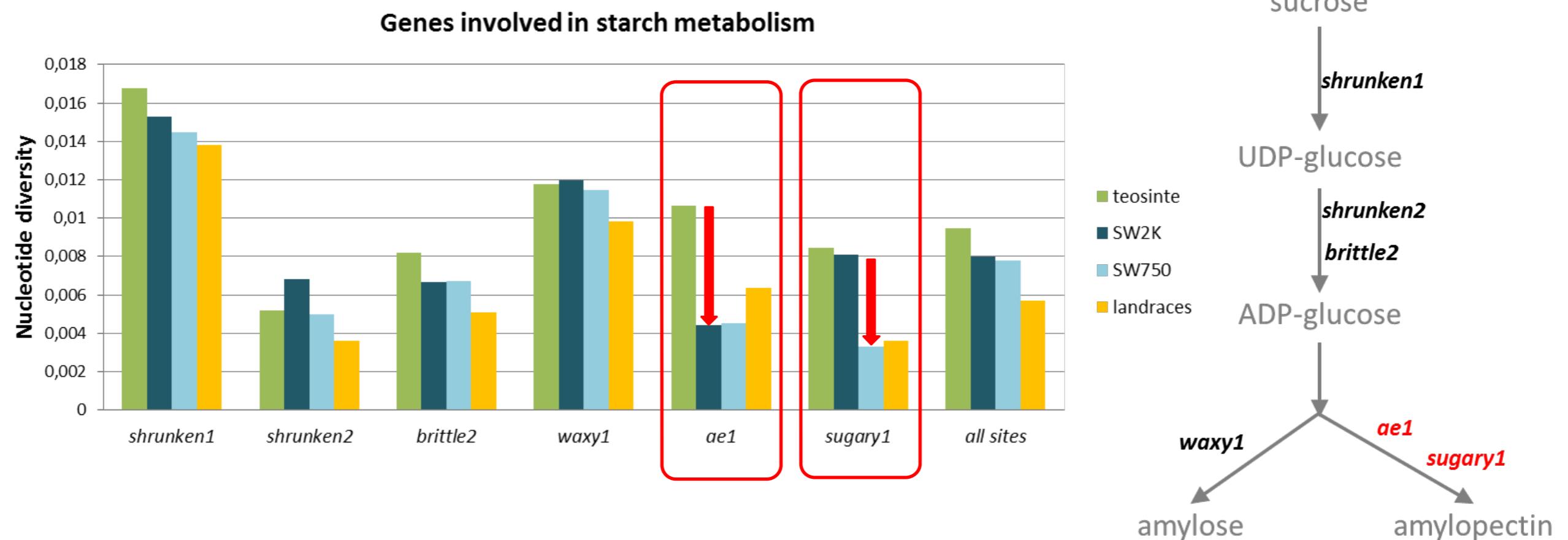
dehyd1A

parviglumis

SW2K



# chronology of selection on starch pathway



# concluding thoughts

- introgression confounds simple estimates of origin
- ancestral reconstruction provides resolution
- introgression adapted maize to highlands
- Southwest US maize originated in highlands with subsequent gene flow from Pacific Coast
- ancient DNA allows chronology of gene flow, adaptation