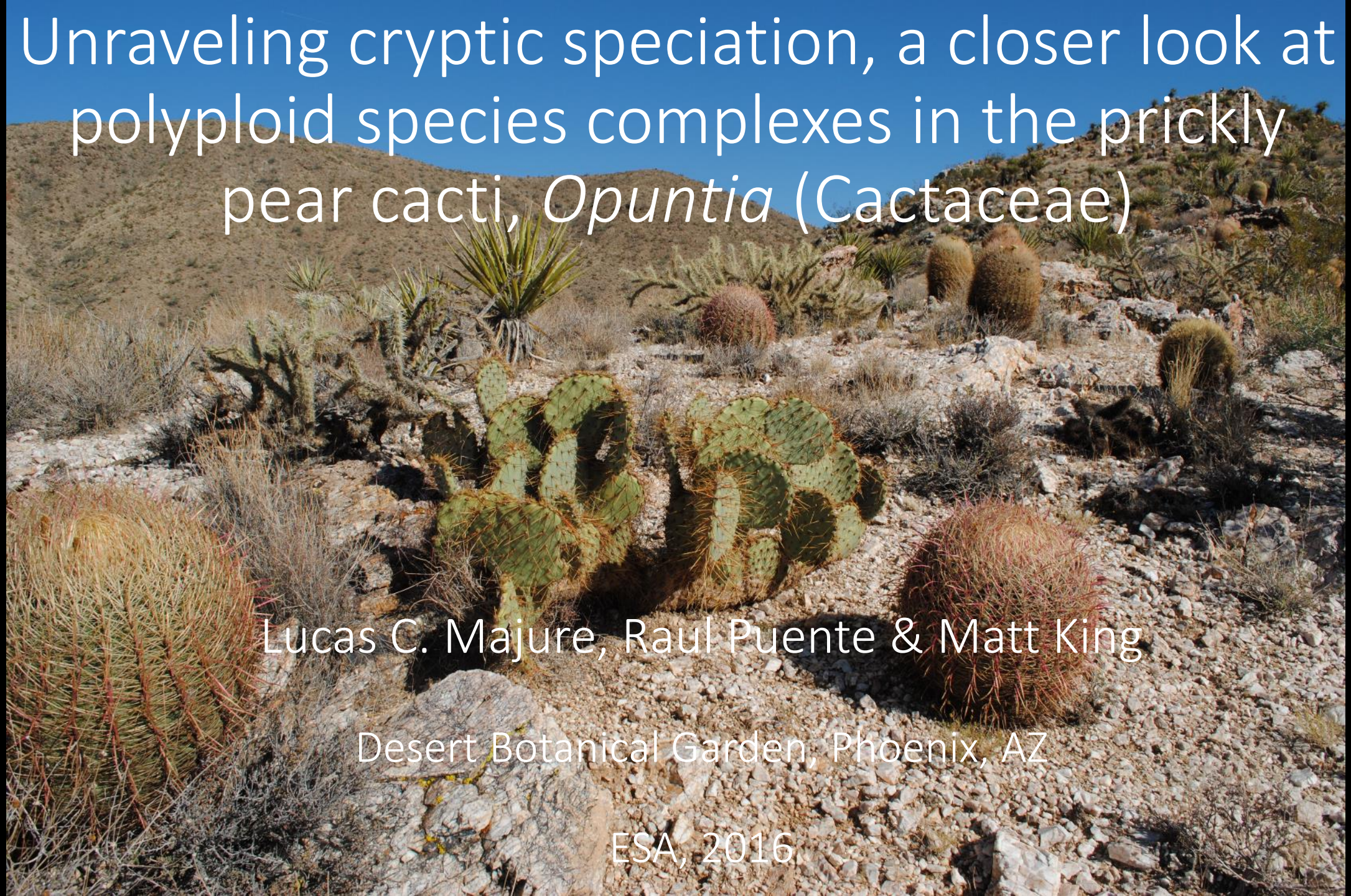
Unraveling cryptic speciation, a closer look at polyploid species complexes in the prickly pear cacti, *Opuntia* (Cactaceae)

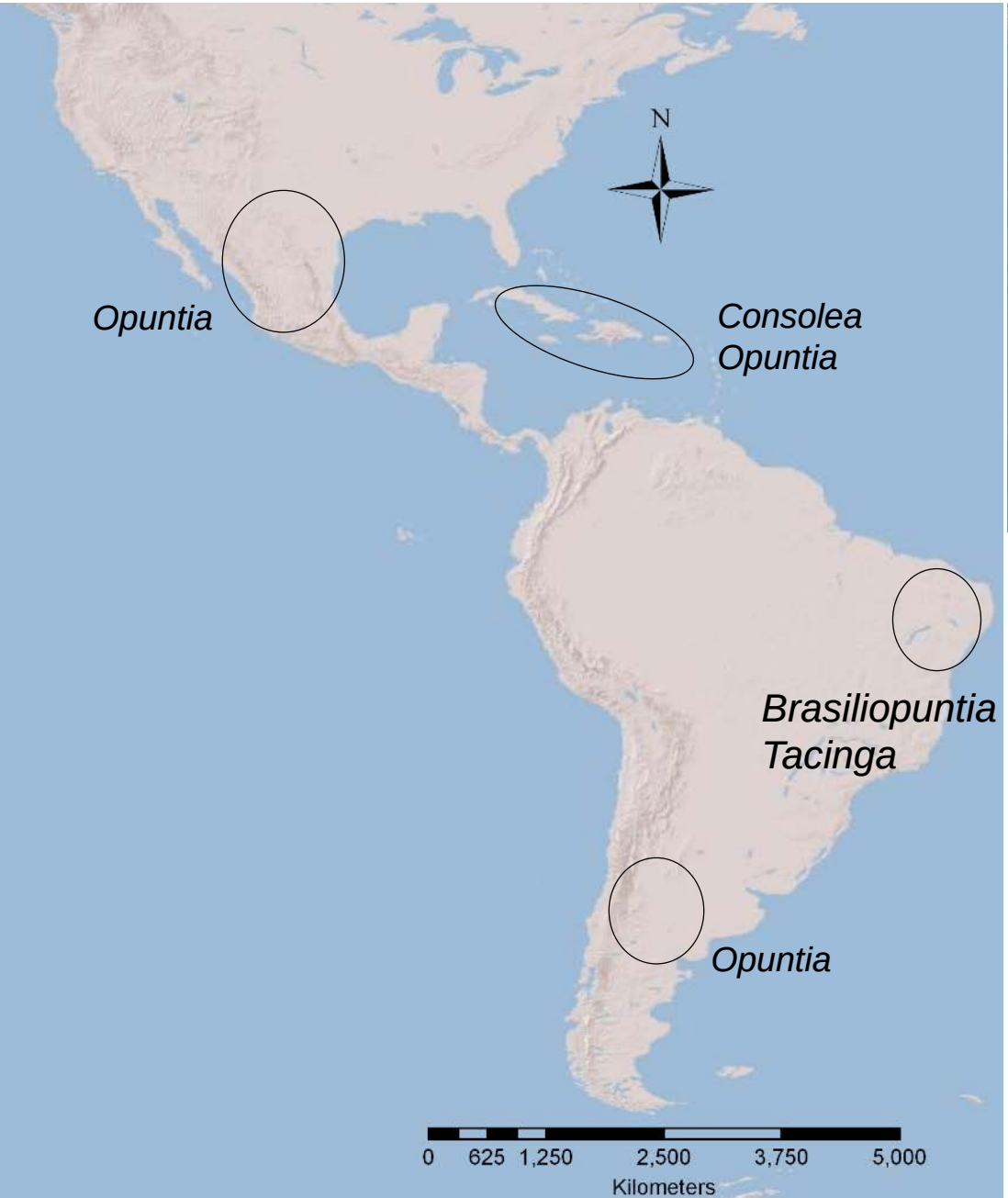


Lucas C. Majure, Raul Puente & Matt King

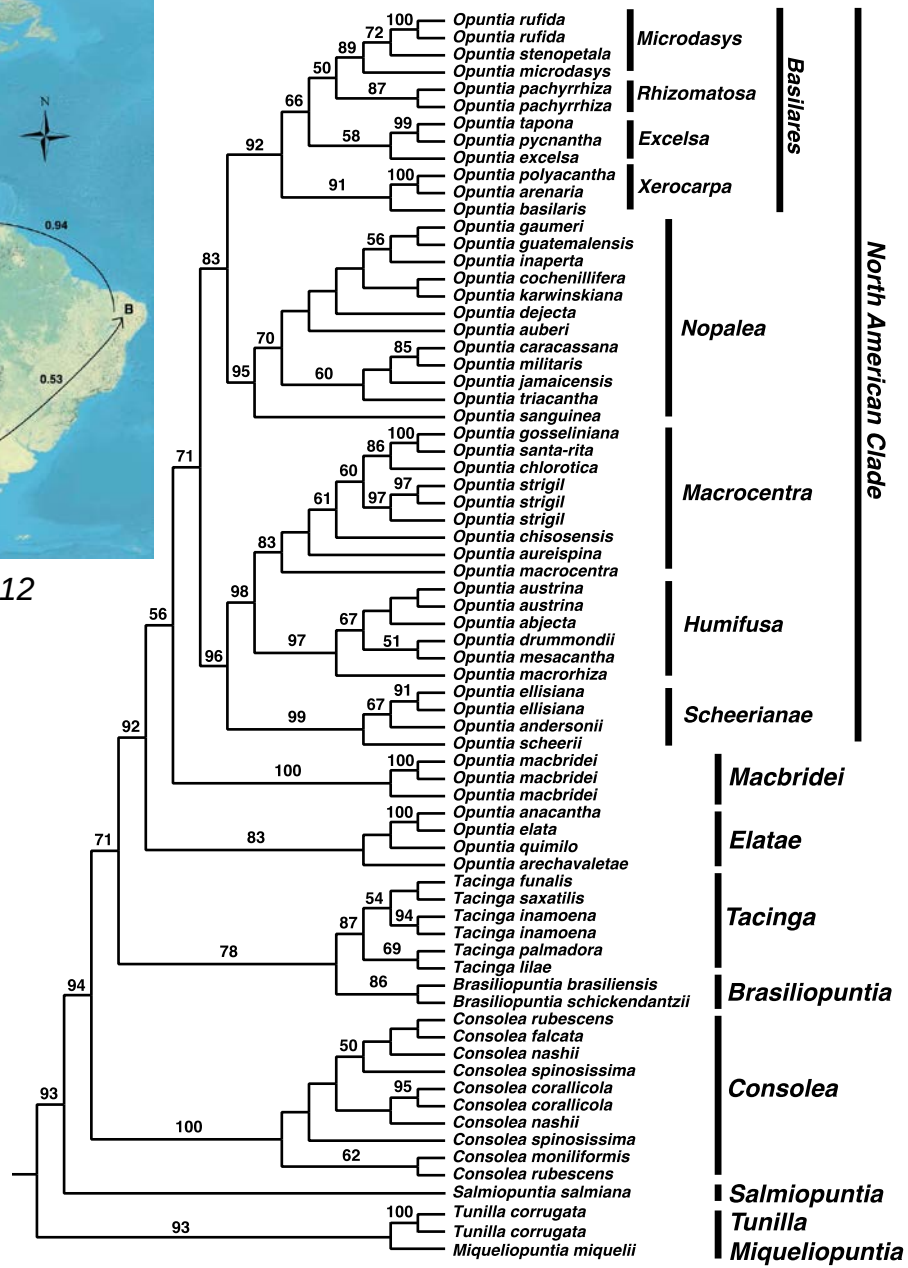
Desert Botanical Garden, Phoenix, AZ

ESA, 2016

Distribution & Phylogeny (Tribe Opuntieae)



Majure et al. 2012



Majure & Puente

Polyploidy & Reticulate Evolution

O. abjecta-2x

+

O. dillenii-6x

=

O. ochrocentra-5x

O. rufida-2x

+

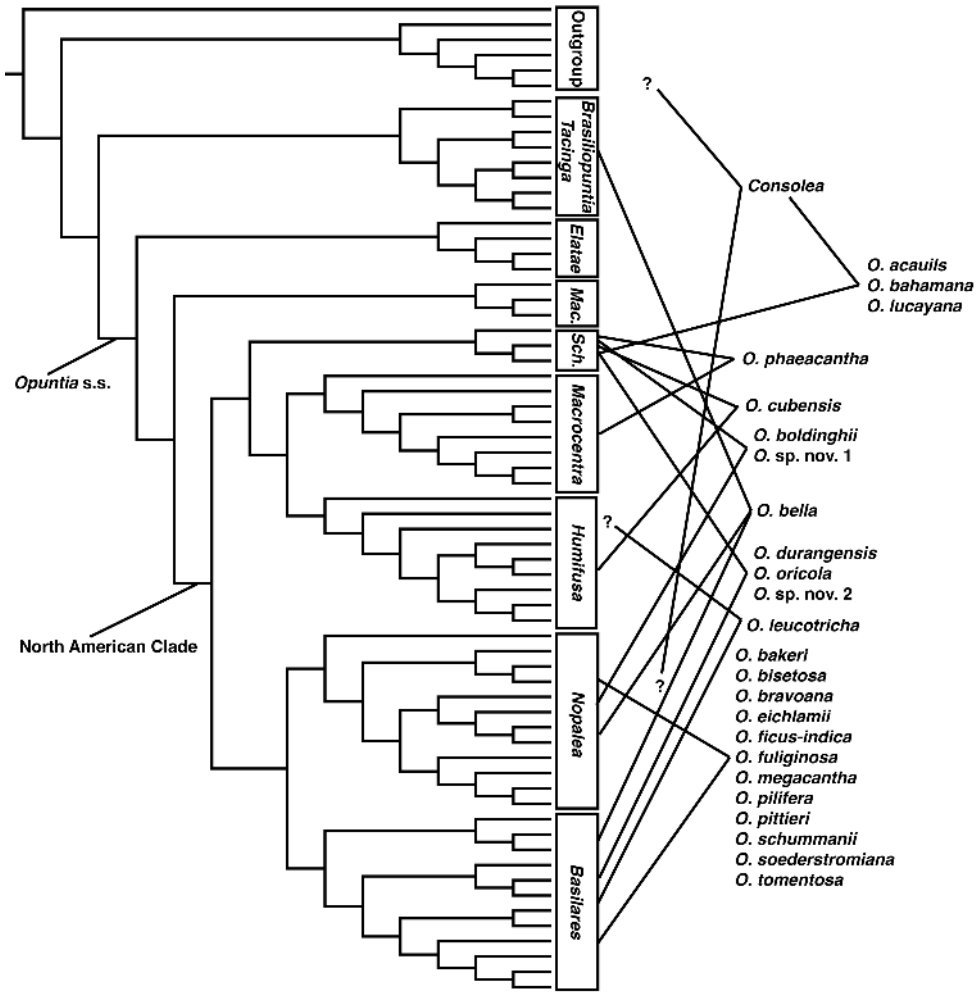
O. azurea=2x

=

O. rufida x *O. azurea-2x*

Polyploidy & Reticulate Evolution

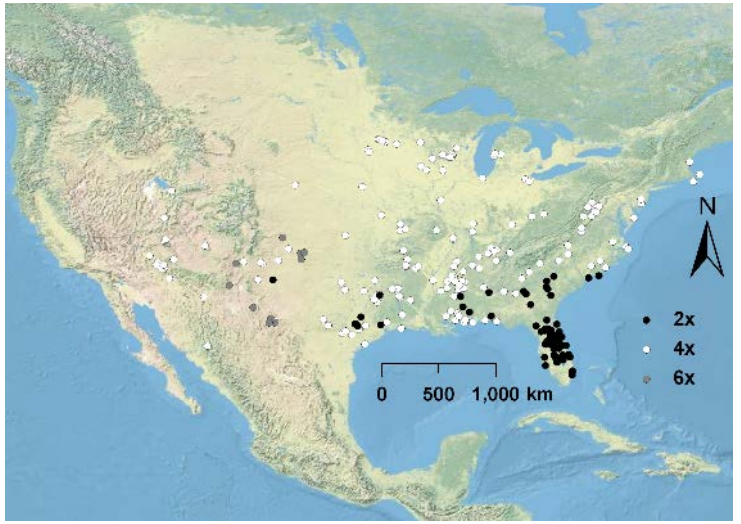
- Chromosome numbers well documented.
- Polyploidy very common in tribe Opuntieae!
- Out of 164 taxa with counts, 26.2% diploid, 13.4% both diploid and polyploid, 60.4% polyploid (Majure et al. 2012)

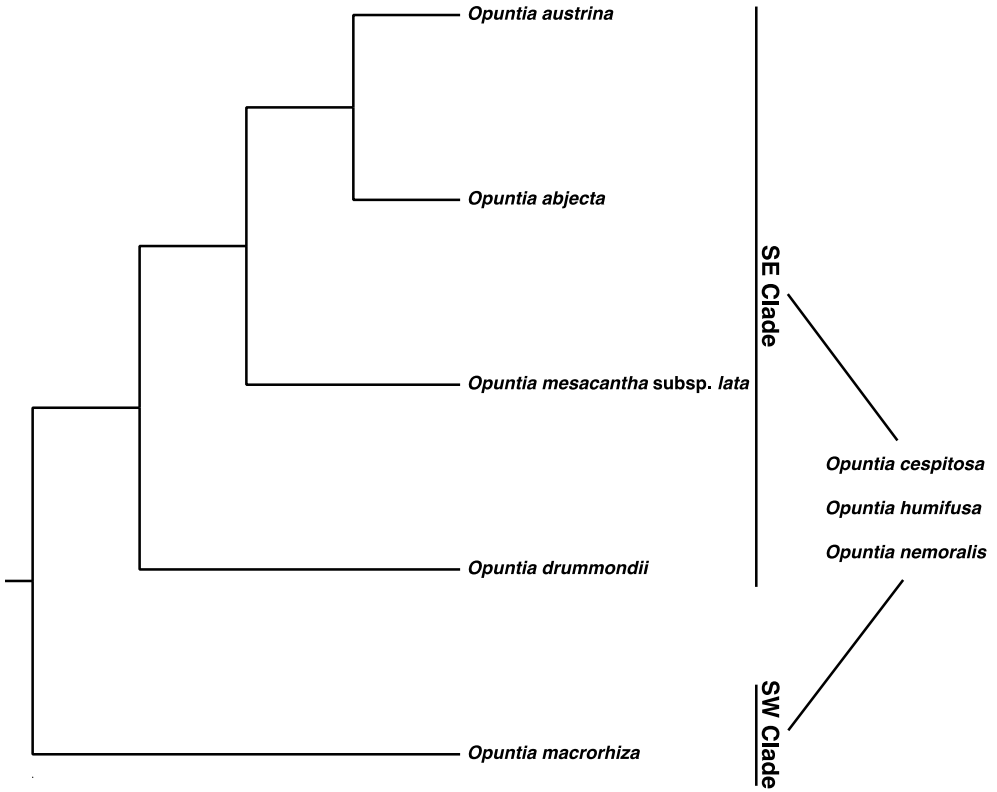


Majure et al. 2012

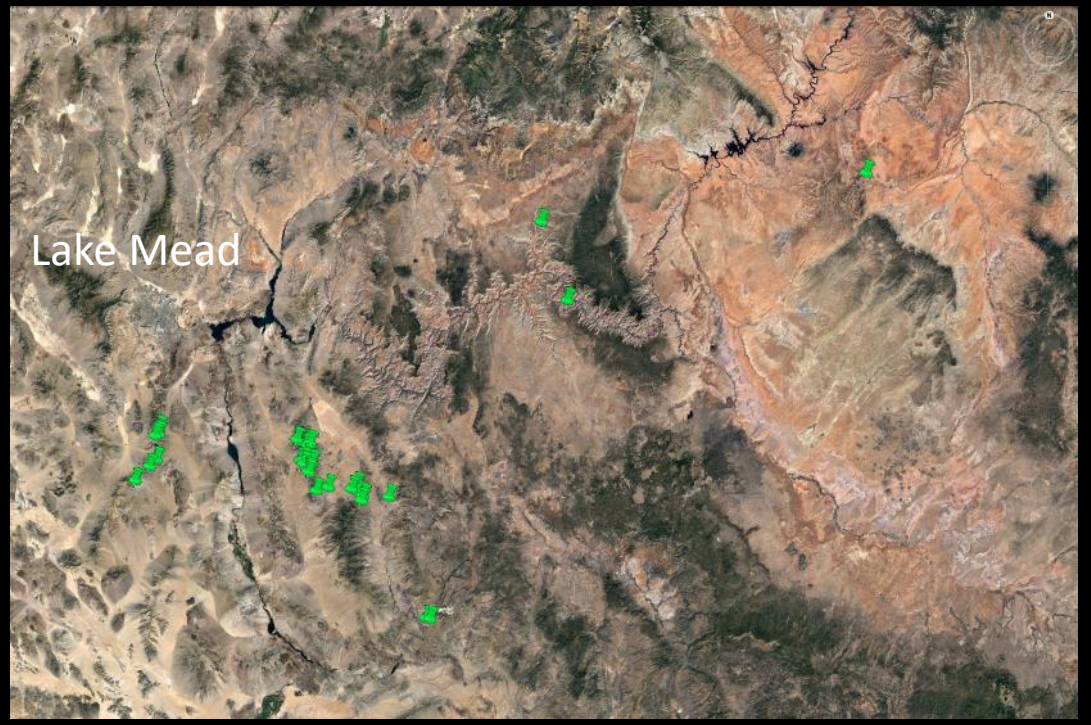
Species Complexes

Opuntia humifusa species complex
(Majure et al. 2012)



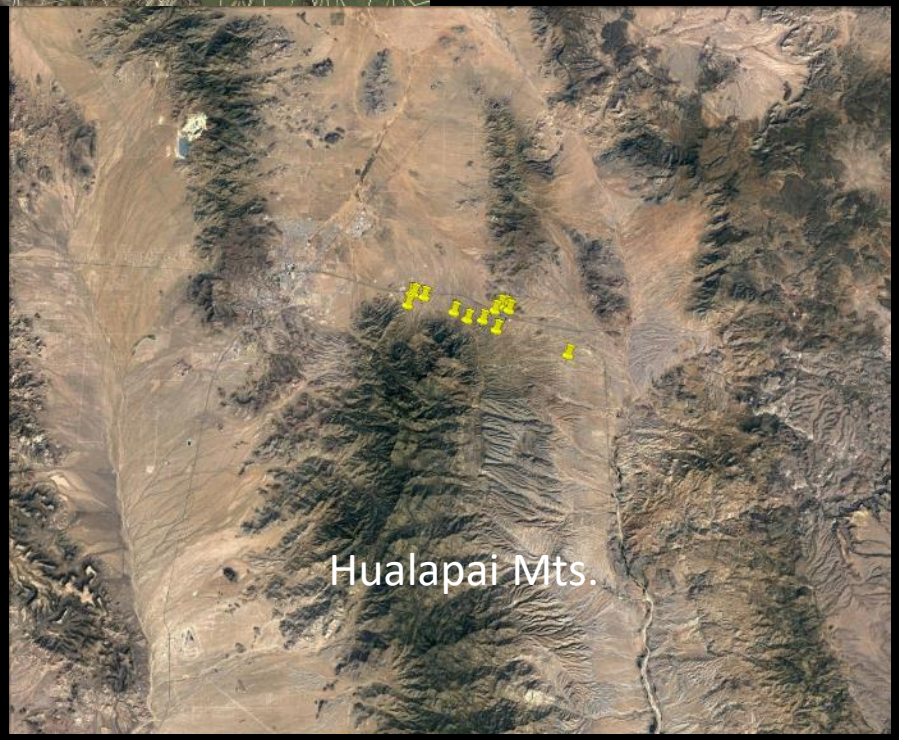


Opuntia curvispina (2*n*=44)



Distribution

Opuntia martiniana (2*n*=44)

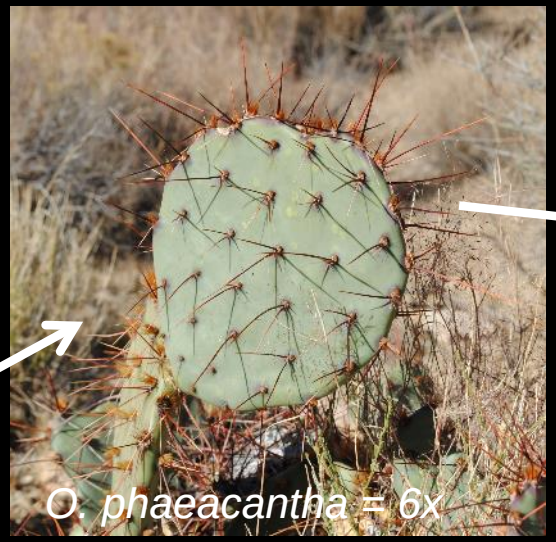


Distribution

Opuntia curvispina vs. *O. martiniana*

Putative parents ??

x



=

Parfitt 1980

x

=

Opuntia curvispina vs. *O. martiniana*

O. curvispina* = *O. martiniana

(Pinkava 2003)

Methods

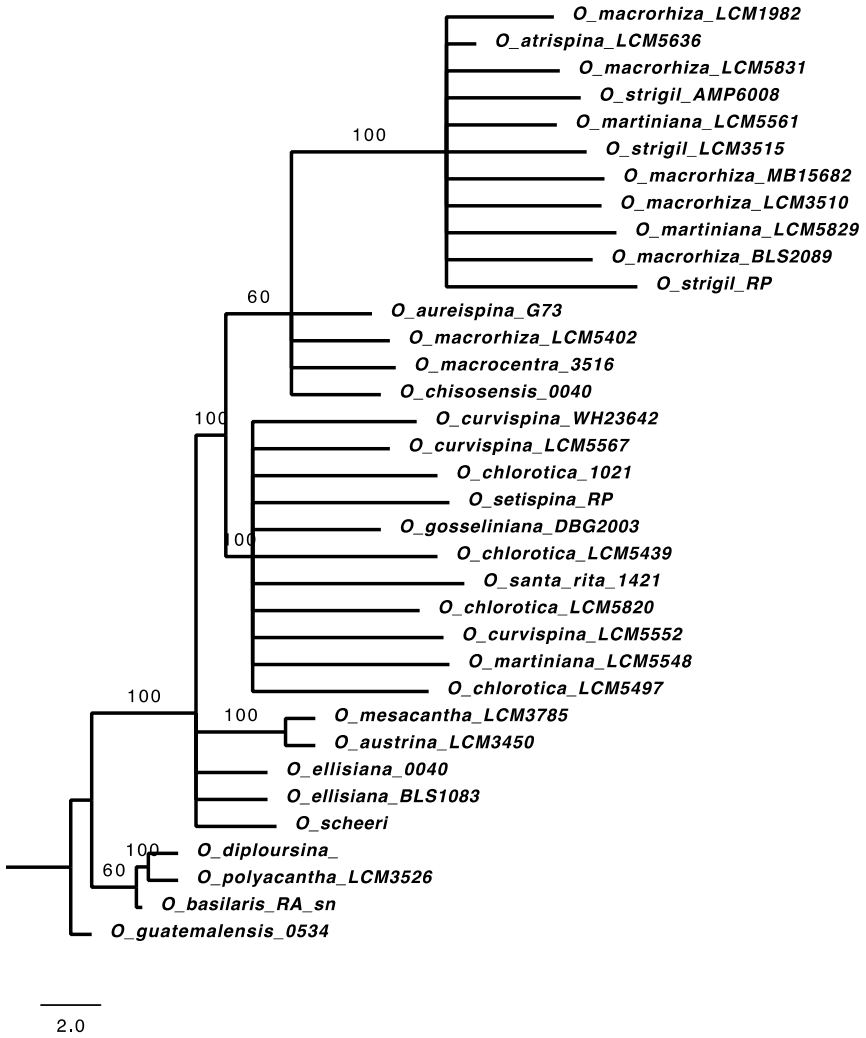
- Phylogeny
  - ITS vs. Plastid phylogeny (*atpB-rbcL, matK, ycf1*)
    - Included *O. curvispina, O. martiniana* from across ranges

- Niche Modeling
  - Georeferenced points from SEINet portal & fieldwork
    - *O. chlorotica, O. curvispina, O. engelmannii, O. macrorhiza, O. martiniana, O. phaeacantha*
    - Herbarium records vetted for accuracy (i.e., species id) – mostly ASU, DES herbaria
  - DEM cropped to focal area (Hualapai Mts.) (90 m resolution SRTM elevation model) (Jarvis et al. 2008)
    - Lat, long, elev. extracted from each cell and downscaled for annual and season climatic variables (Climate NA dataset-Wang et al. 2016)- for *O. martiniana*
  - Other taxa – defined 20km buffer around points, randomly sampled 10000 background points; background + reference pts overlaid on 90m SRTM to extract elevations, then downscaled for ClimateNA data
  - 27 Bioclimate layers (ClimateNA) in Maxent

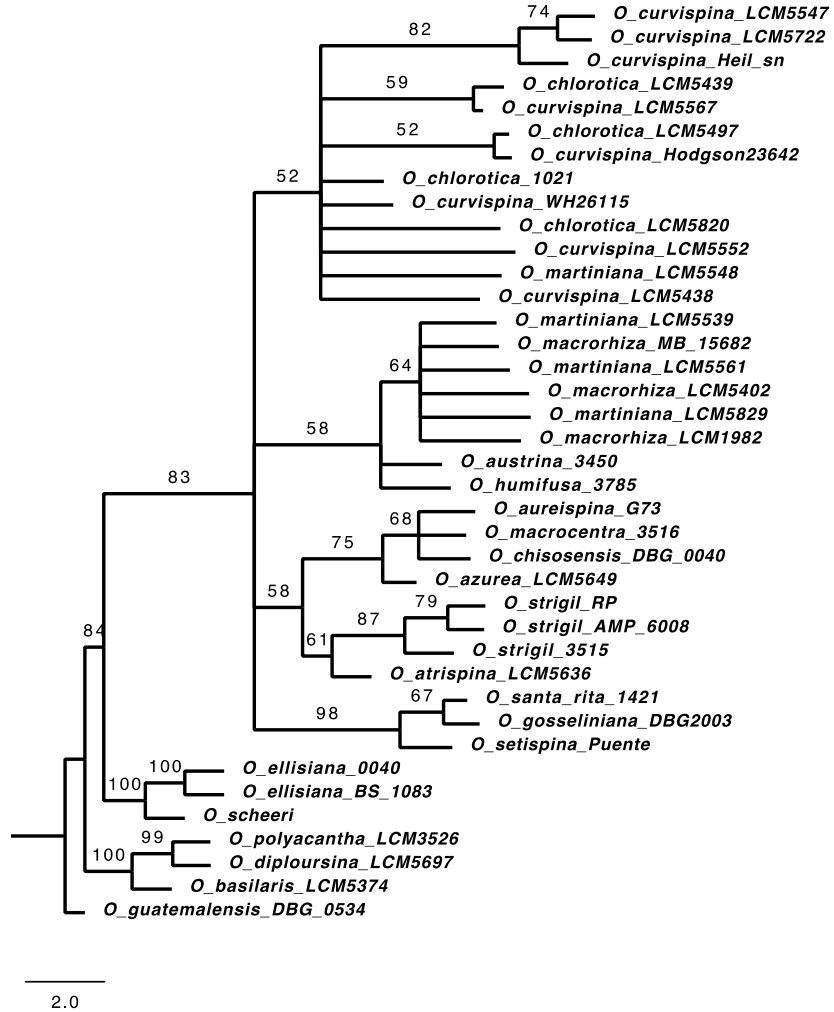
Phylogenetic relationships

- ITS vs. Plastid phylogeny

ITS



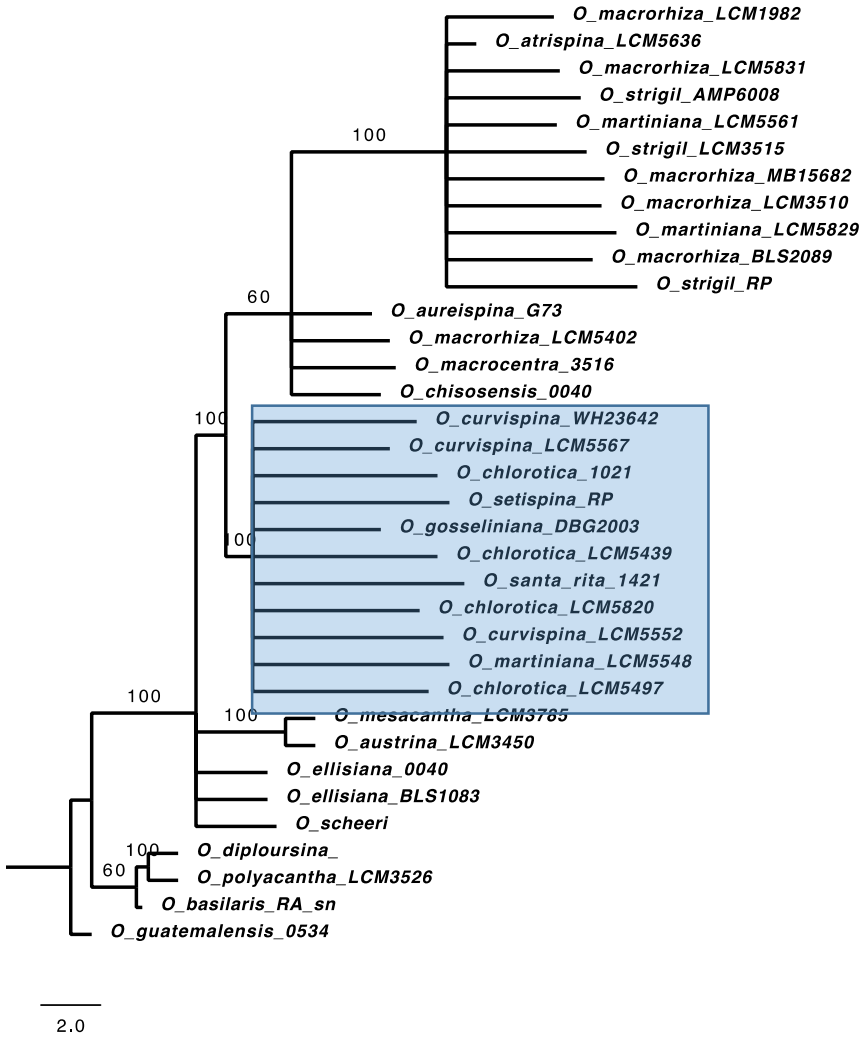
Plastid



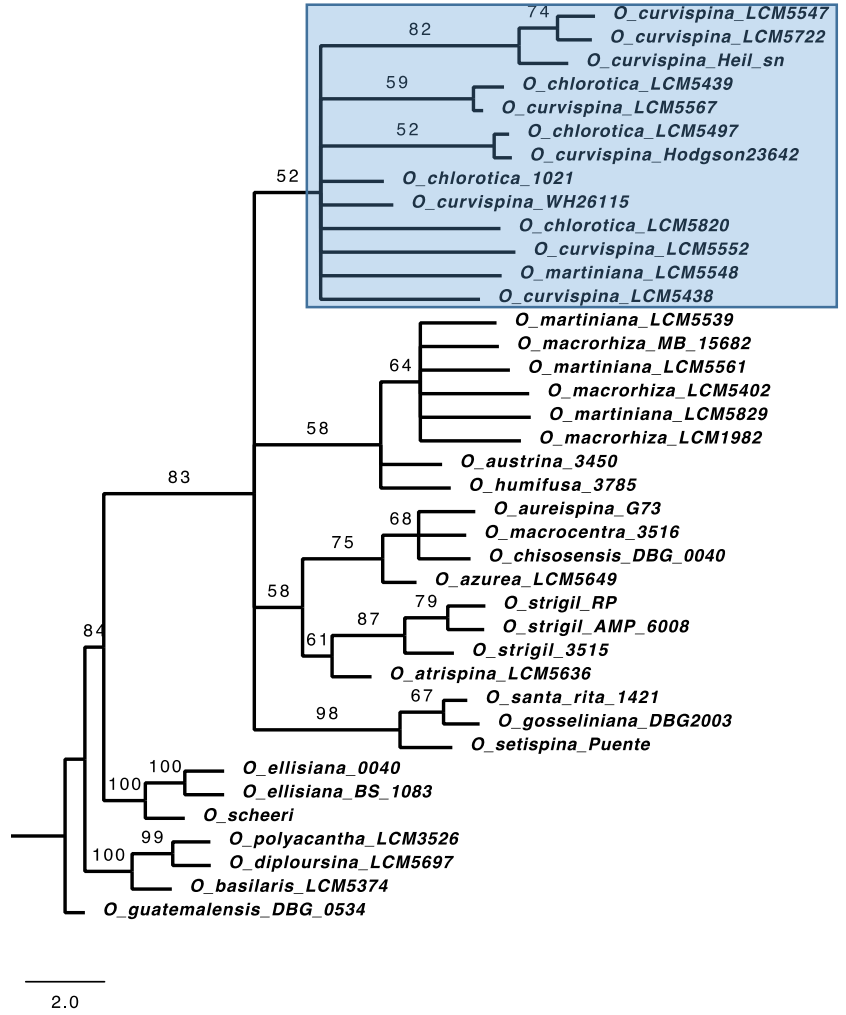
Phylogenetic relationships (*O. curvispina*)

- ITS vs. Plastid phylogeny

ITS



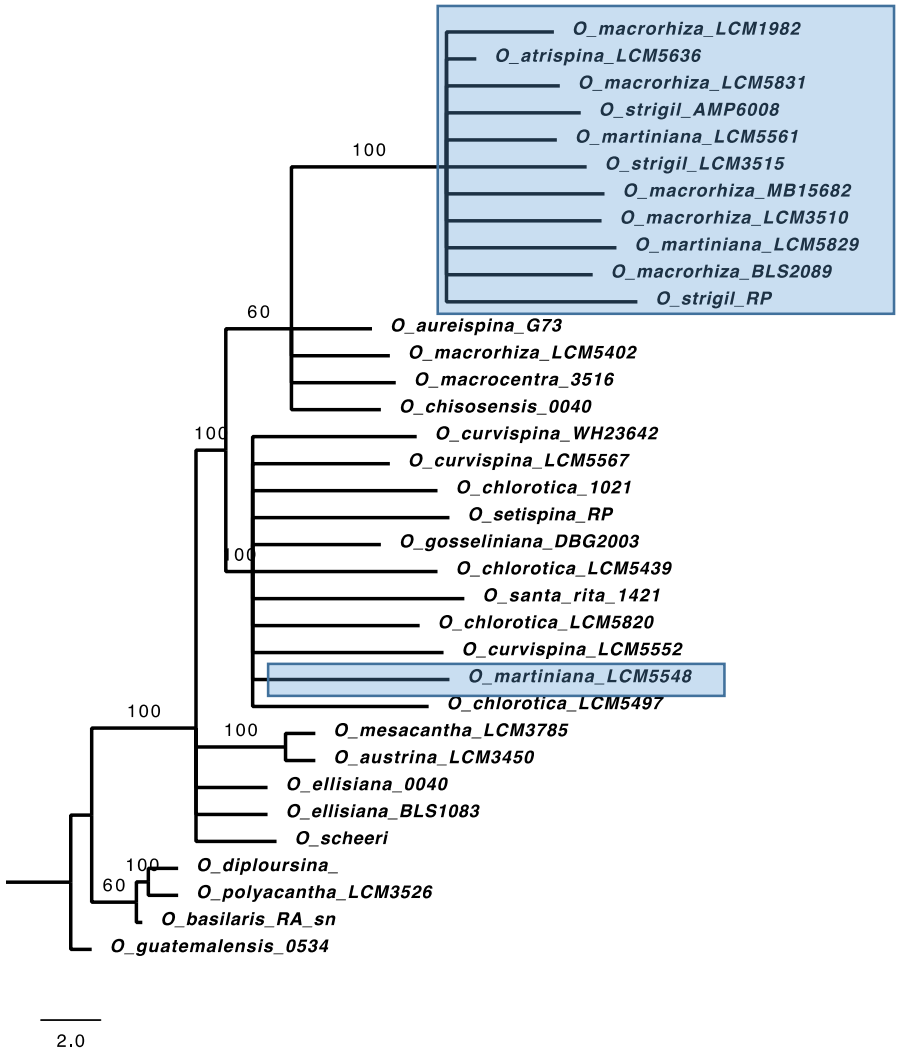
Plastid



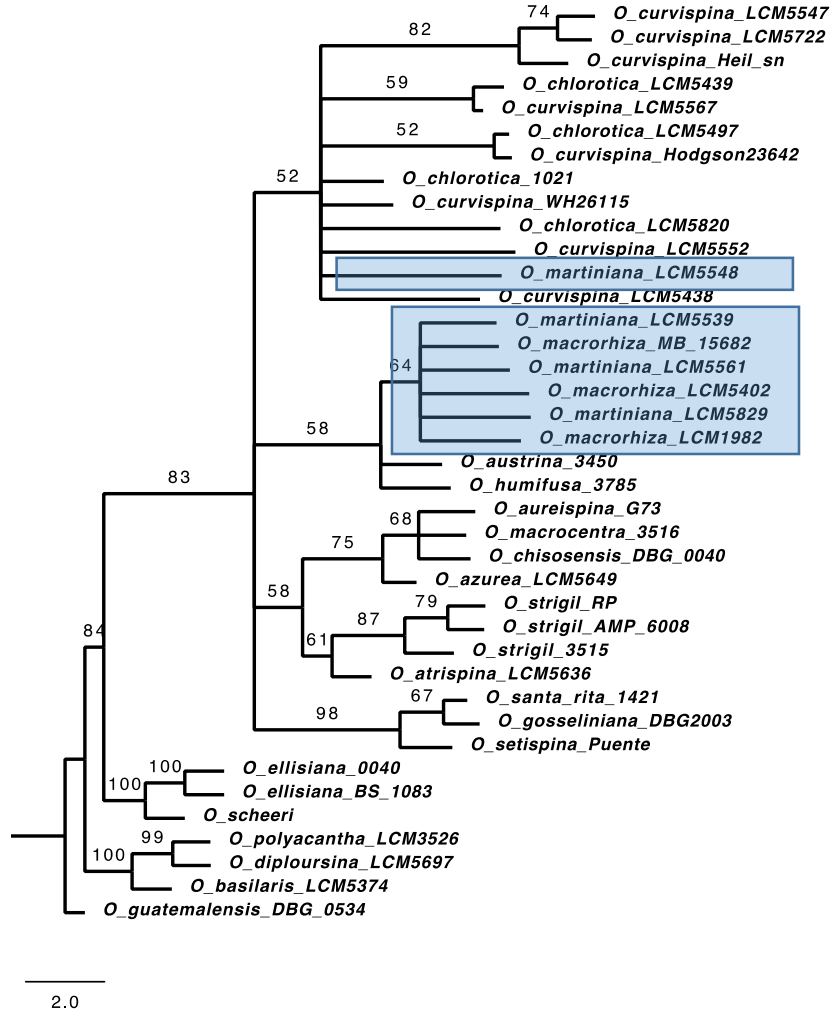
Phylogenetic relationships (*O. martiniana*)

- ITS vs. Plastid phylogeny

ITS



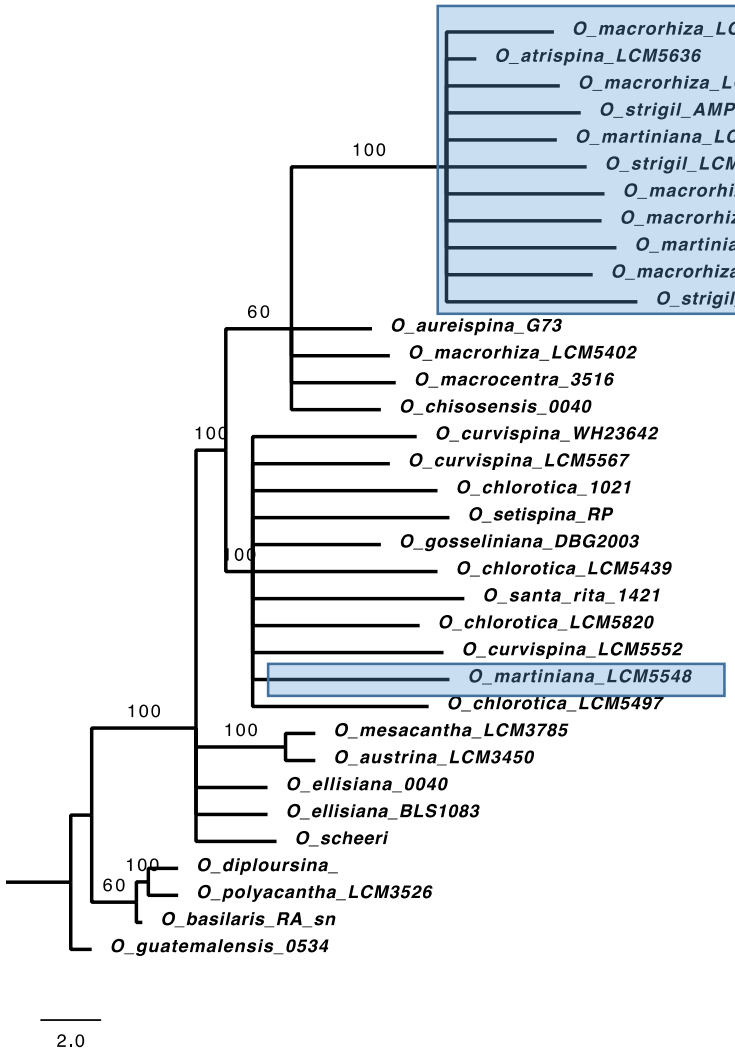
Plastid



Phylogenetic relationships (*O. martiniana*)

- ITS vs. Plastid phylogeny

ITS

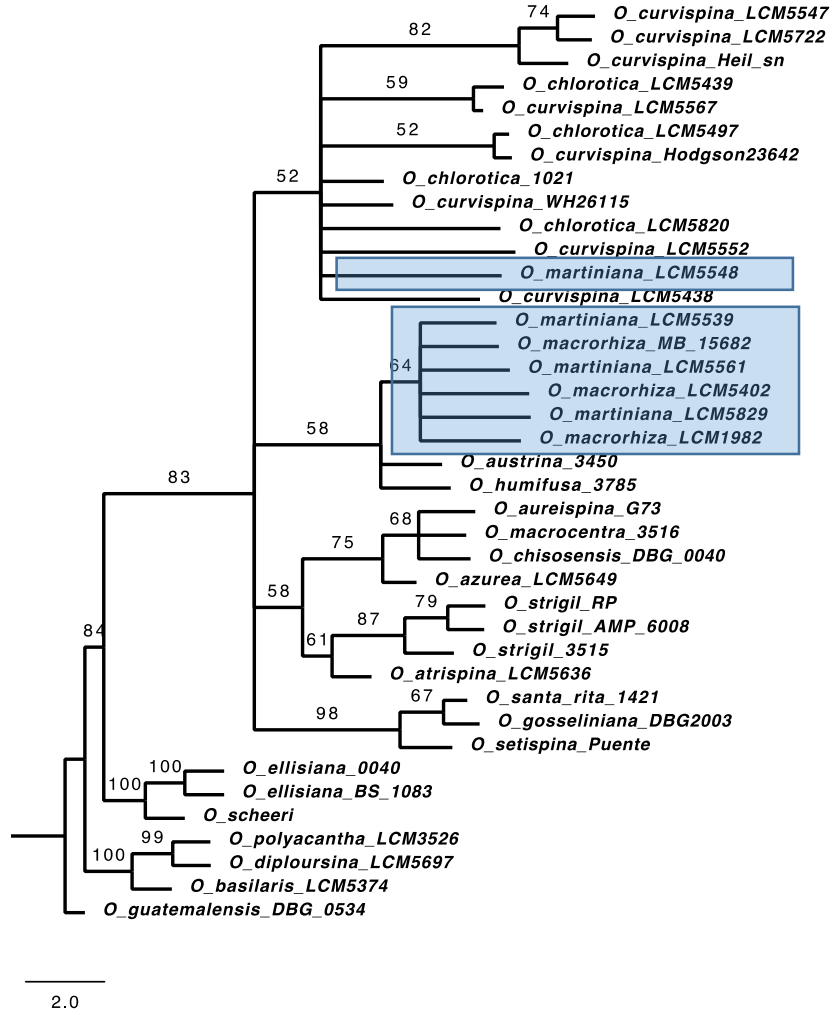


Parent A x parent B

II

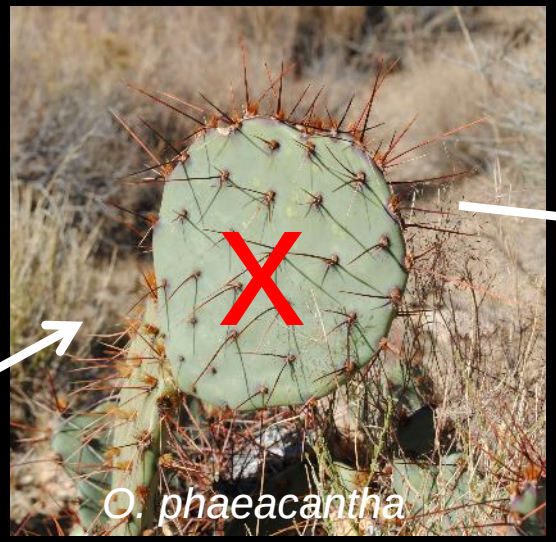
O. martiniana

Plastid



Opuntia curvispina vs. *O. martiniana*

Putative parents ??



=

Parfitt 1980

=

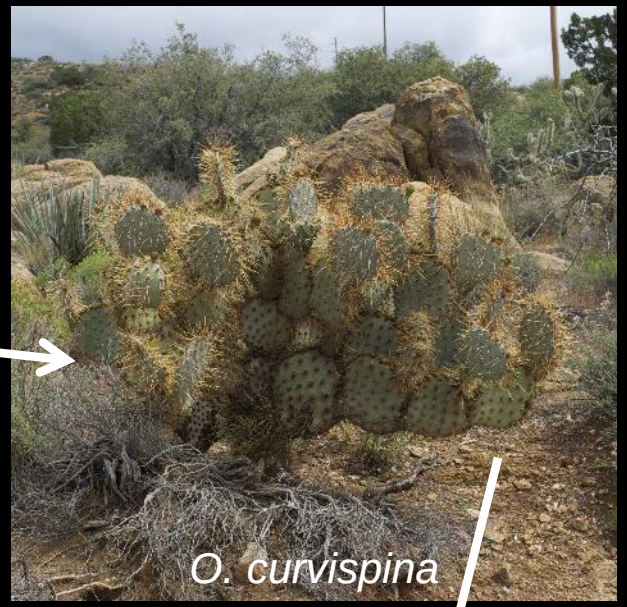
Opuntia curvispina vs. *O. martiniana*

Putative parents ??


O. chlorotica

auto?

=

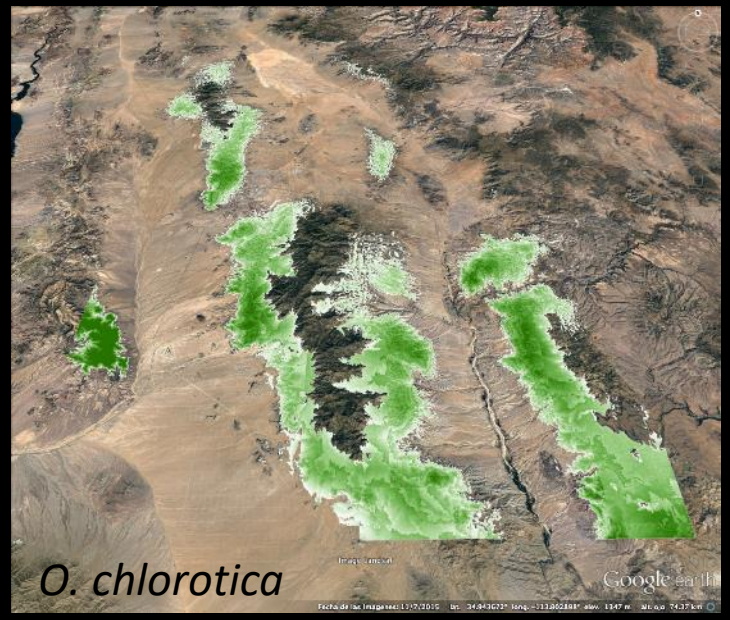

O. curvispina

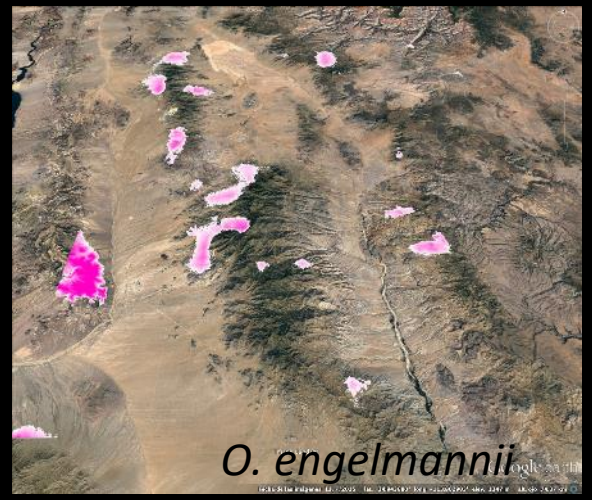

O. macrorhiza

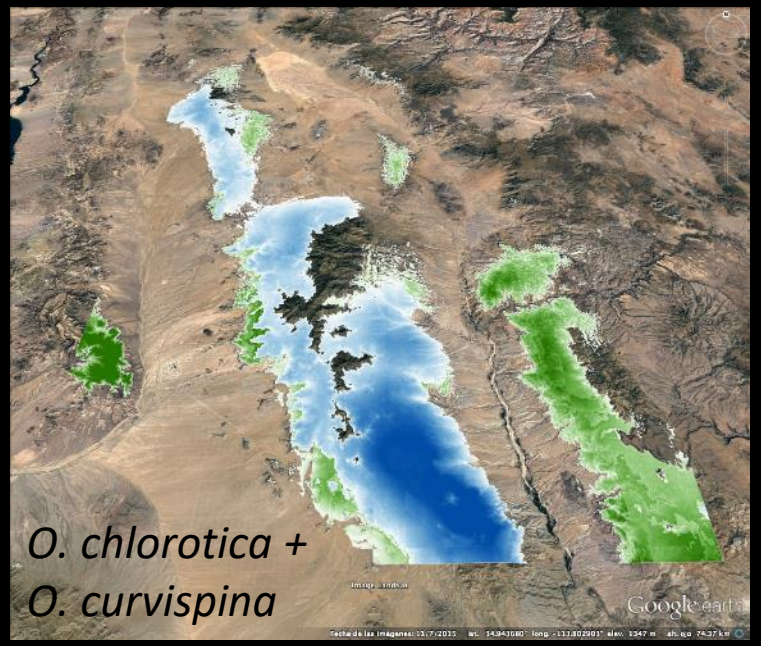
=


O. martiniana

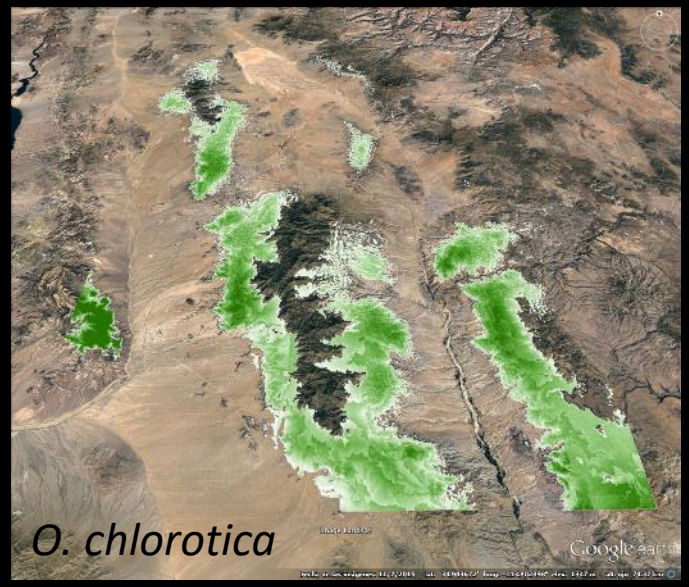
Niche modeling







Niche modeling



O. macrorhiza + O. martiniana + O. curvispina

Niche modeling

O. chlorotica

Extreme minimum temps., summer heat moisture index, RH

O. curvispina

° days <0°C, RH, Summer precip., Summer heat moisture index

O. macrorhiza

Winter precip., mean coldest month temp., ° days <18°C

O. martiniana

° days > 18°C, summer precip

General habitat characters

O. chlorotica

Elev. 705-1649m

Granitic, volcanic soils

Mohave, Sonoran

O. curvispina

Elev. 846-1638m

Granitic, volcanic or limestone soils

Mohave

O. macrorhiza

Elev. 1200 + m

Limestone, granitic soils

Everywhere

O. martiniana

Elev. 1162-1392m

Granitic soils

Mohave

Conclusions

- *Opuntia curvispina* and *O. martiniana* derived separately (= not synonymous!!)

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- *O. curvispina* parental taxa *O. chlorotica* and ?? (putative autopolyploid?)
- *O. martiniana* parental taxa most likely *O. curvispina* and *O. macrorhiza* s.l.

Conclusions

- *Opuntia curvispina* and *O. martiniana* derived separately (= not synonymous!!)
- *O. curvispina* parental taxa *O. chlorotica* and ?? (putative autopolyploid?)
- *O. martiniana* parental taxa most likely *O. curvispina* and *O. macrorhiza* s.l.
- *O. martiniana* shows a distribution at the boundaries of both *O. curvispina* and *O. macrorhiza*

Further work

- Incorporate more DNA data for exploring parental species (low copy nuclear loci)
- Ground truthing models
- Expanding model area to AZ, CA, NV, as well as edaphic data

Acknowledgments

Desert Botanical Garden

Mojave National Preserve

BLM (AZ, CA, NV)

IDigBio

Joe McAuliffe