

A wide-angle photograph of a desert landscape. In the foreground, a cholla cactus with yellow flowers is prominent on the left, and a spiky yucca plant is in the lower center. The middle ground shows rolling hills and a vast valley. In the background, a range of mountains stretches across the horizon under a clear blue sky.

# Examining patterns of genetic diversity in rare cacti of the desert southwest to inform conservation

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# Research questions

- How do species form?
- What are the key factors shaping patterns of genetic variation across populations and species?
  - Evolutionary history, geography, biotic and abiotic interactions
- What are the relationships between genotype, phenotype, and evolutionary history?

Genus *Echinocereus*  
Cactaceae



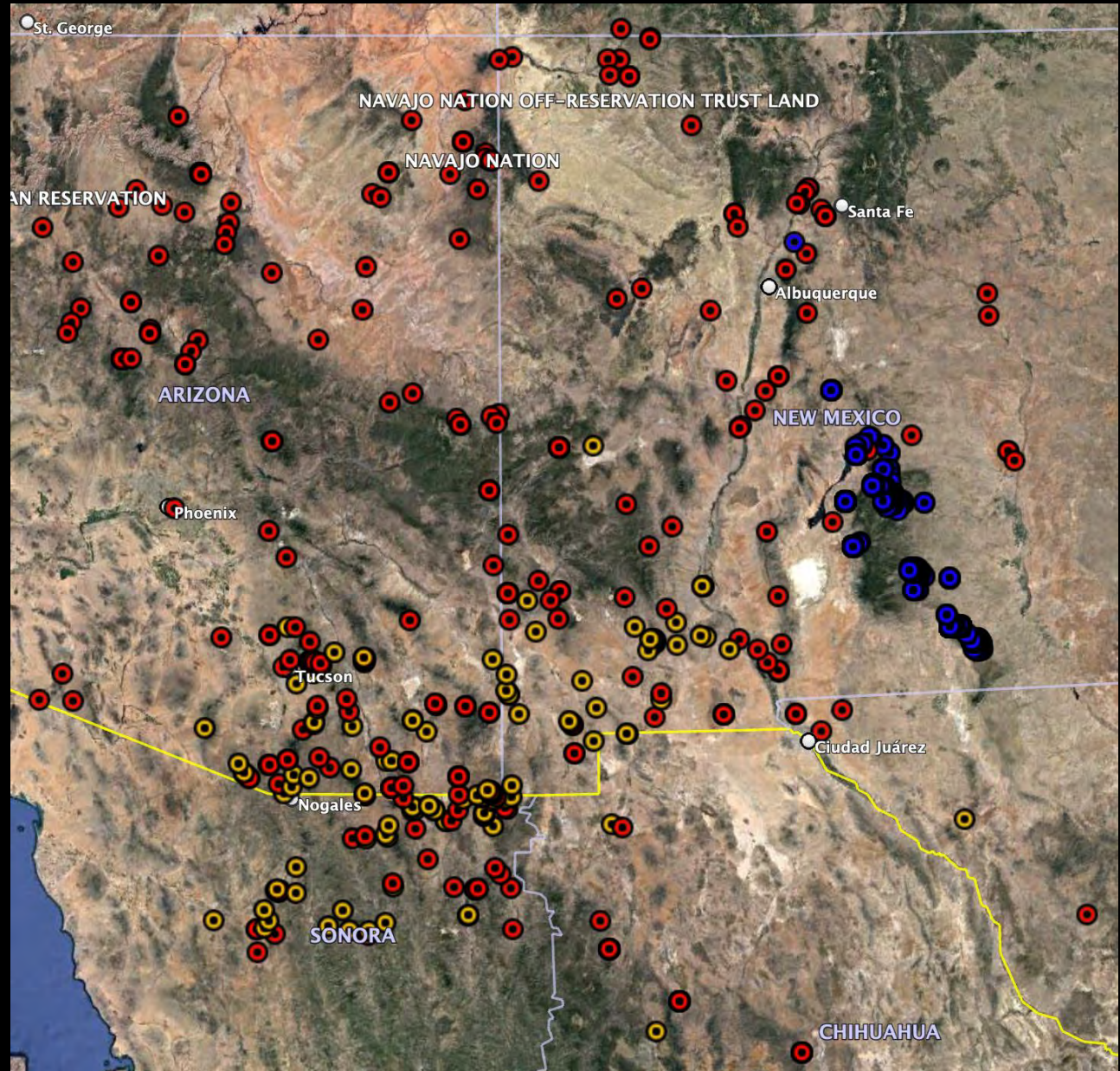
# Key Processes

- Drivers of speciation in rapidly diverging taxa
- Phenotypic variation – plasticity variable environment
- Alignment between phenotype and genotype

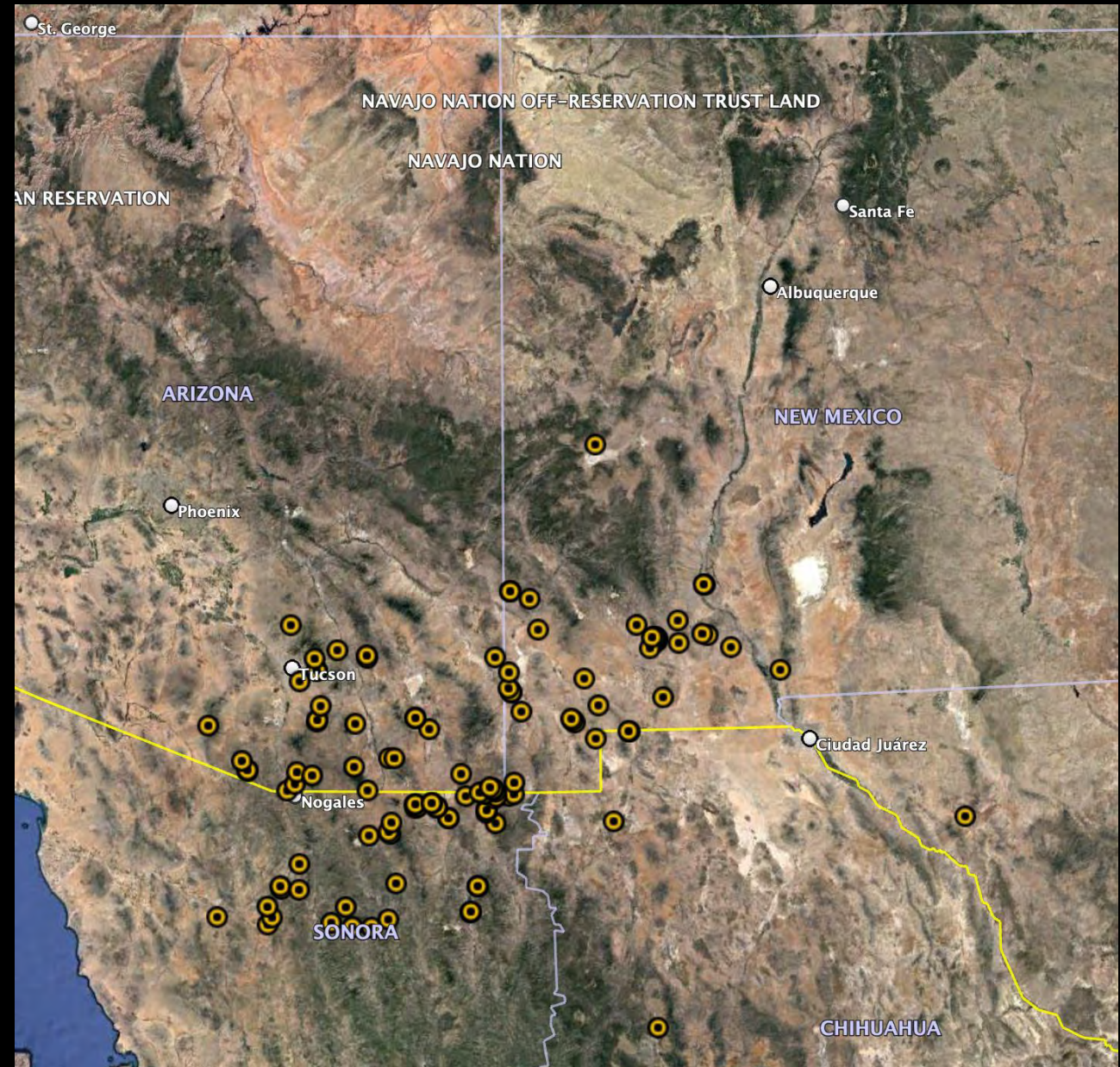
# *Echinocereus fendleri*



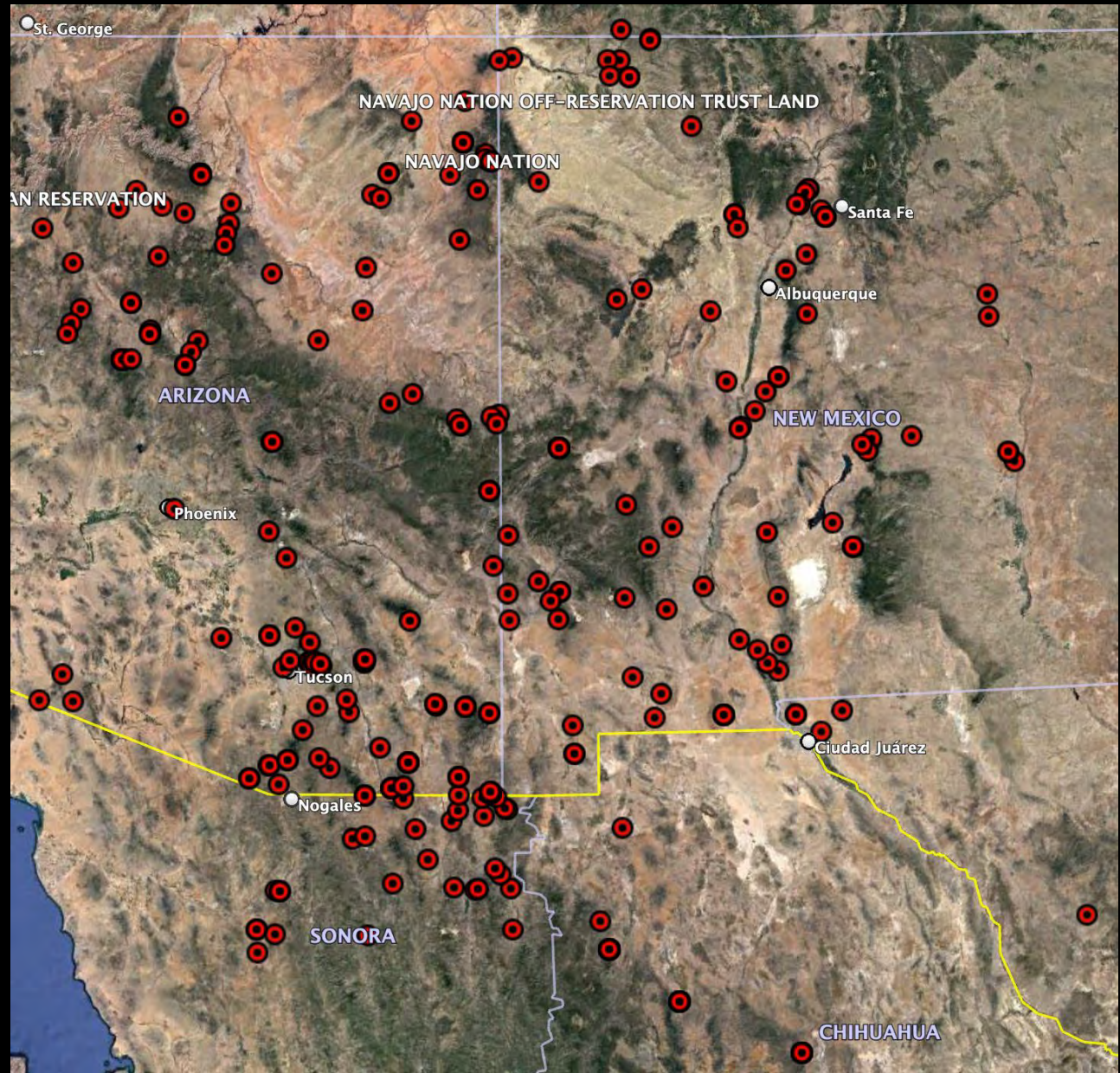
Photo by P. Alexander, 2010



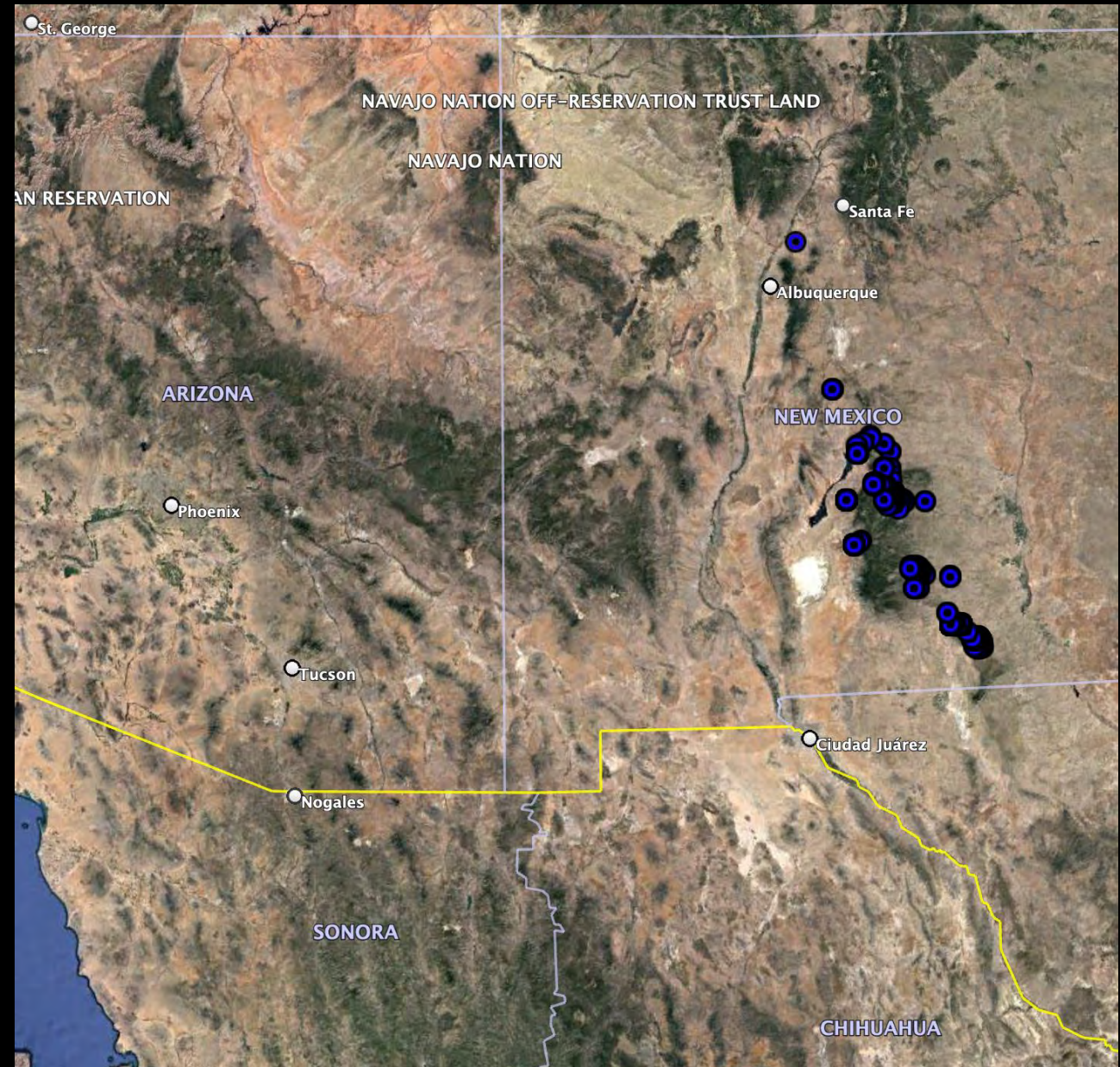
*Echinocereus  
fendleri  
var. rectispinus*



*Echinocereus fendleri*  
*var. fendleri*



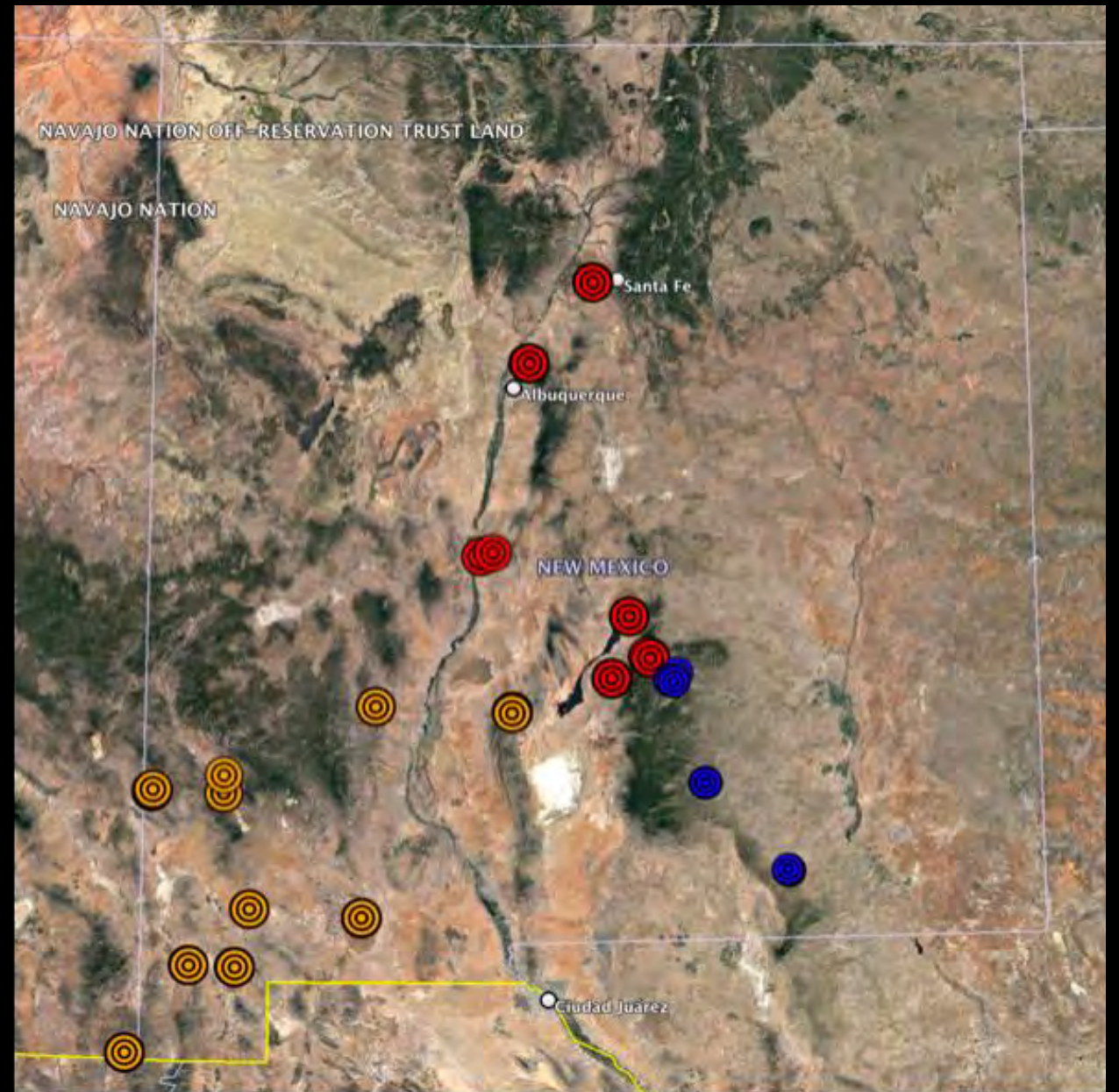
*Echinocereus  
fendleri  
var. kuenzleri*



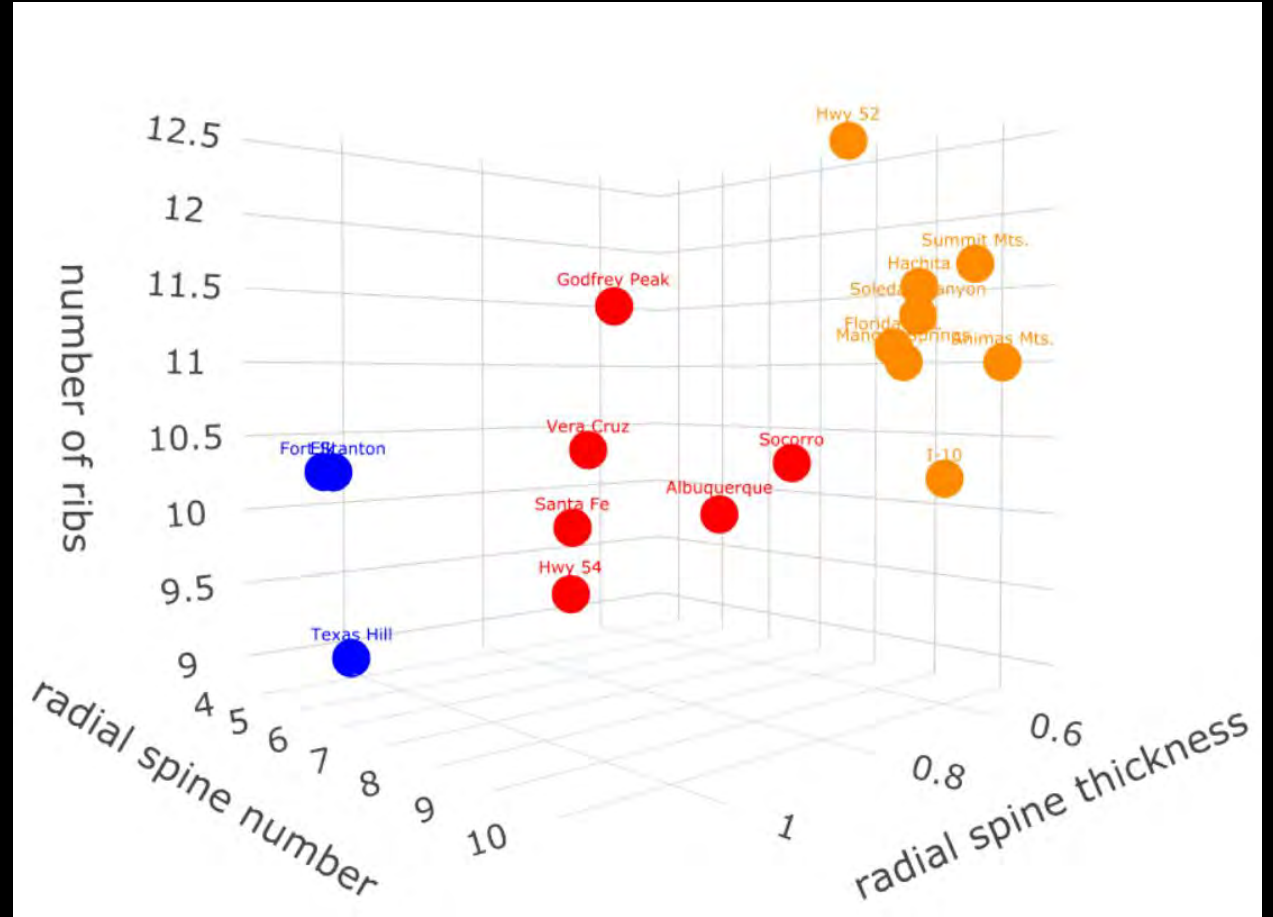


# Field Collections

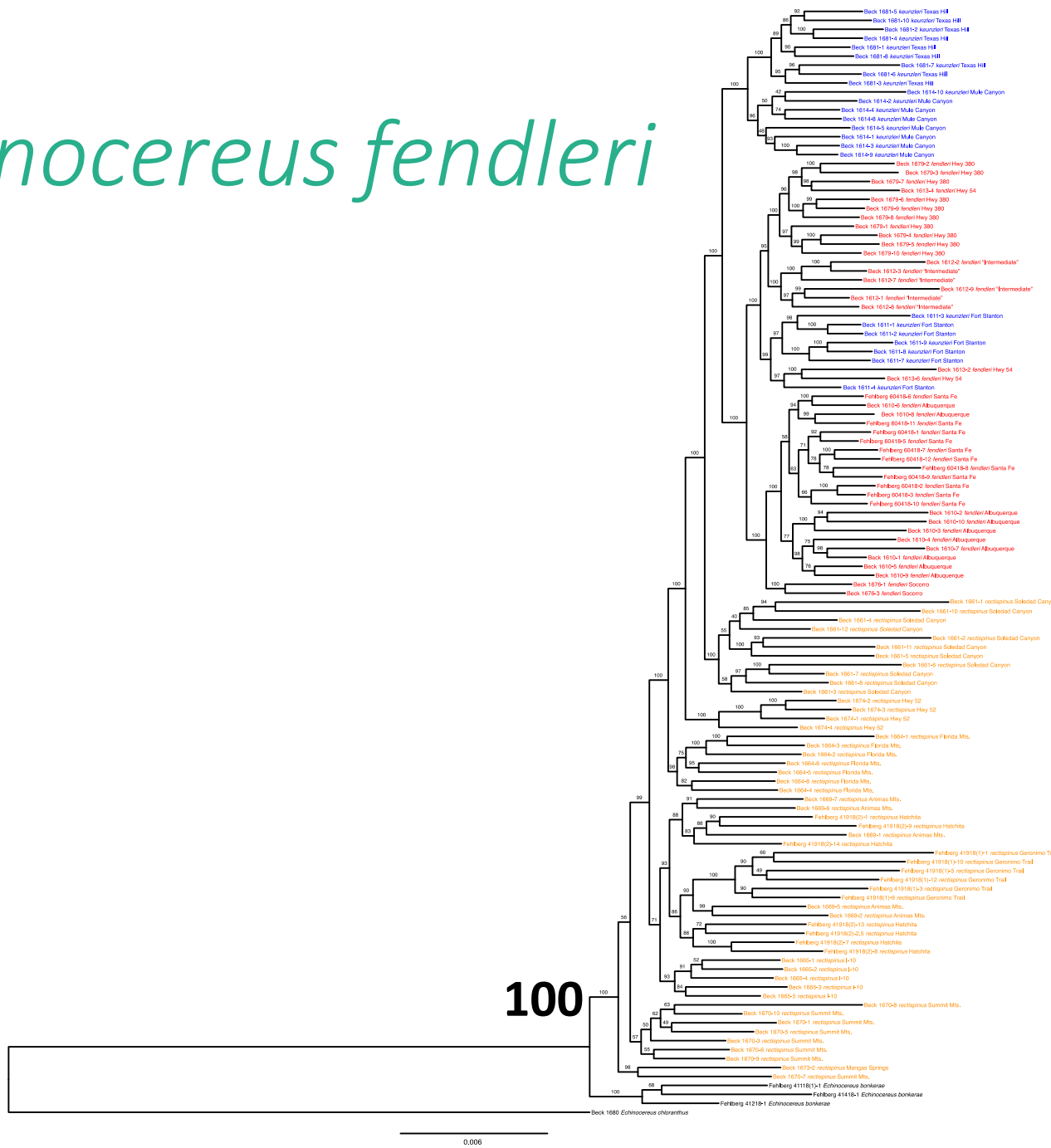
- Ingroup
  - Range of *E. fendleri* var. *kuenzleri*
  - Intermediate populations
  - 34 populations
  - 180 samples
- Outgroup
  - 18 populations
  - 75 samples



# Stem characters



# Echinocereus fendleri



*E. fendleri* var.  
*kuenzleri*

*E. fendleri* var.  
*fendleri*

*E. fendleri* var.  
*rectispinus*

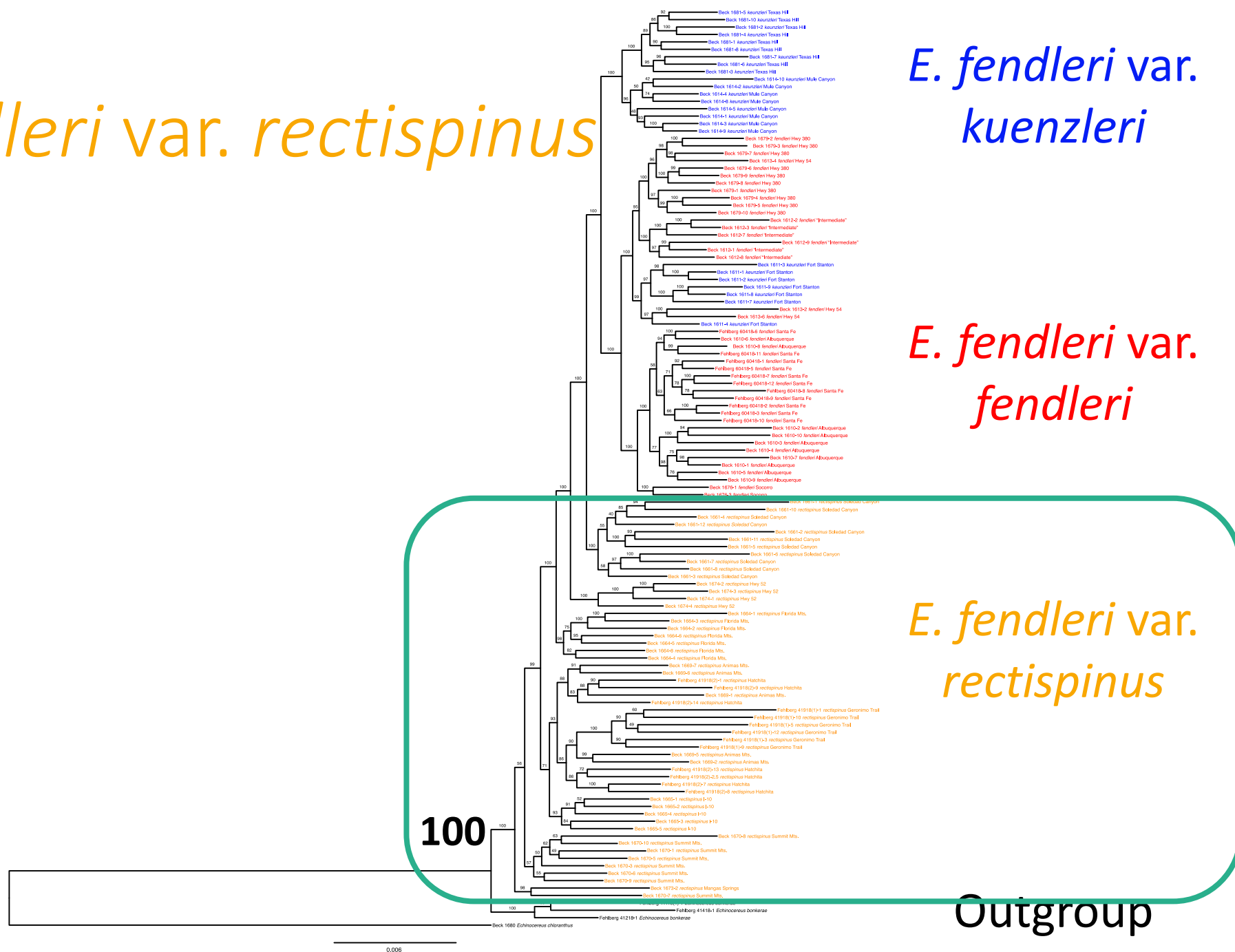
Outgroup

# *E. fendleri* var. *rectispinus*

*E. fendleri* var.  
*kuenzleri*

*E. fendleri* var.  
*fendleri*

*E. fendleri* var.  
*rectispinus*

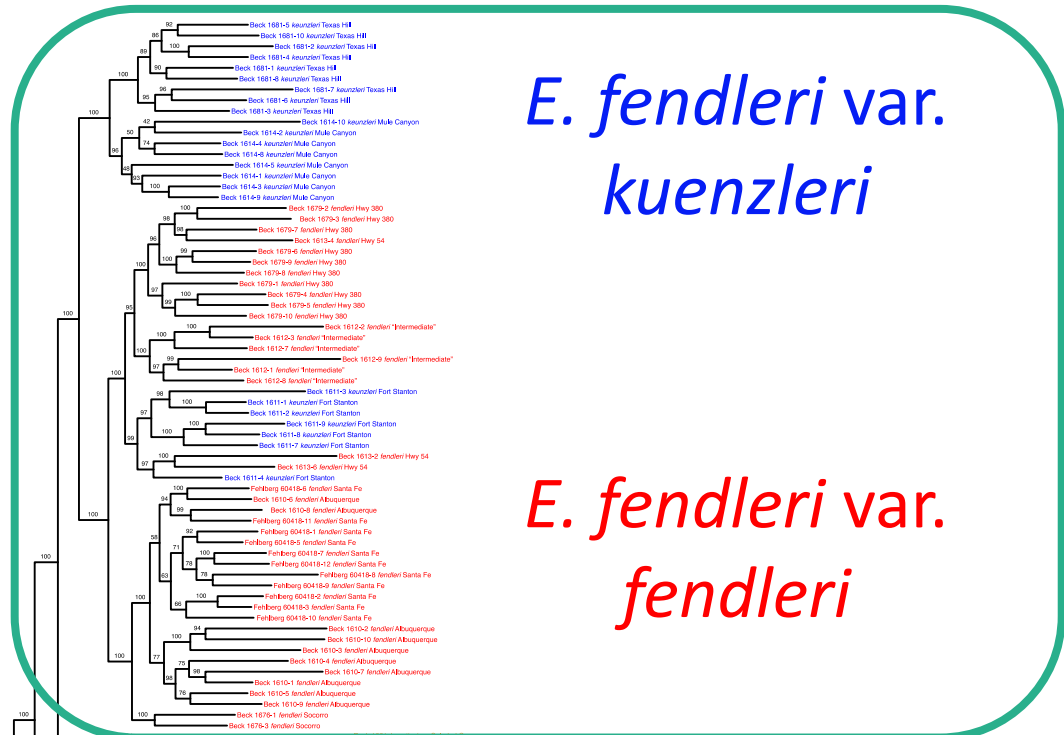


Outgroup

*E. fendleri* var. *kuenzleri*

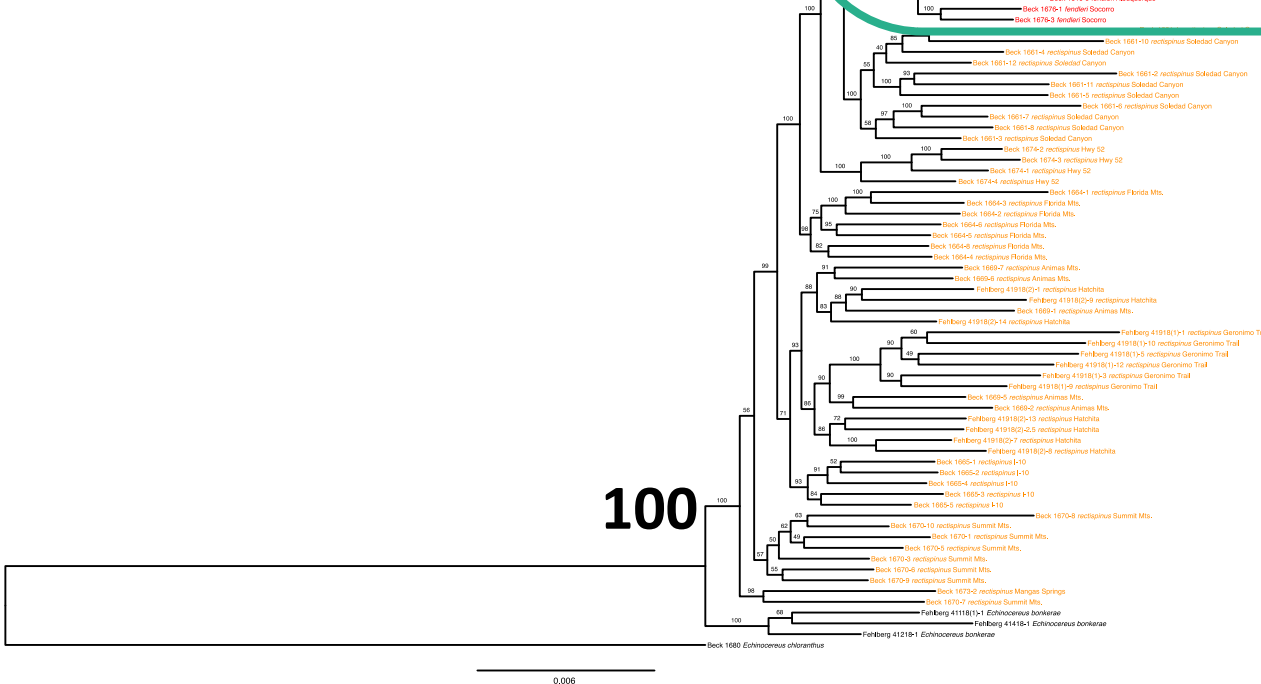
+

*E. fendleri* var. *fendleri*



*E. fendleri* var. *kuenzleri*

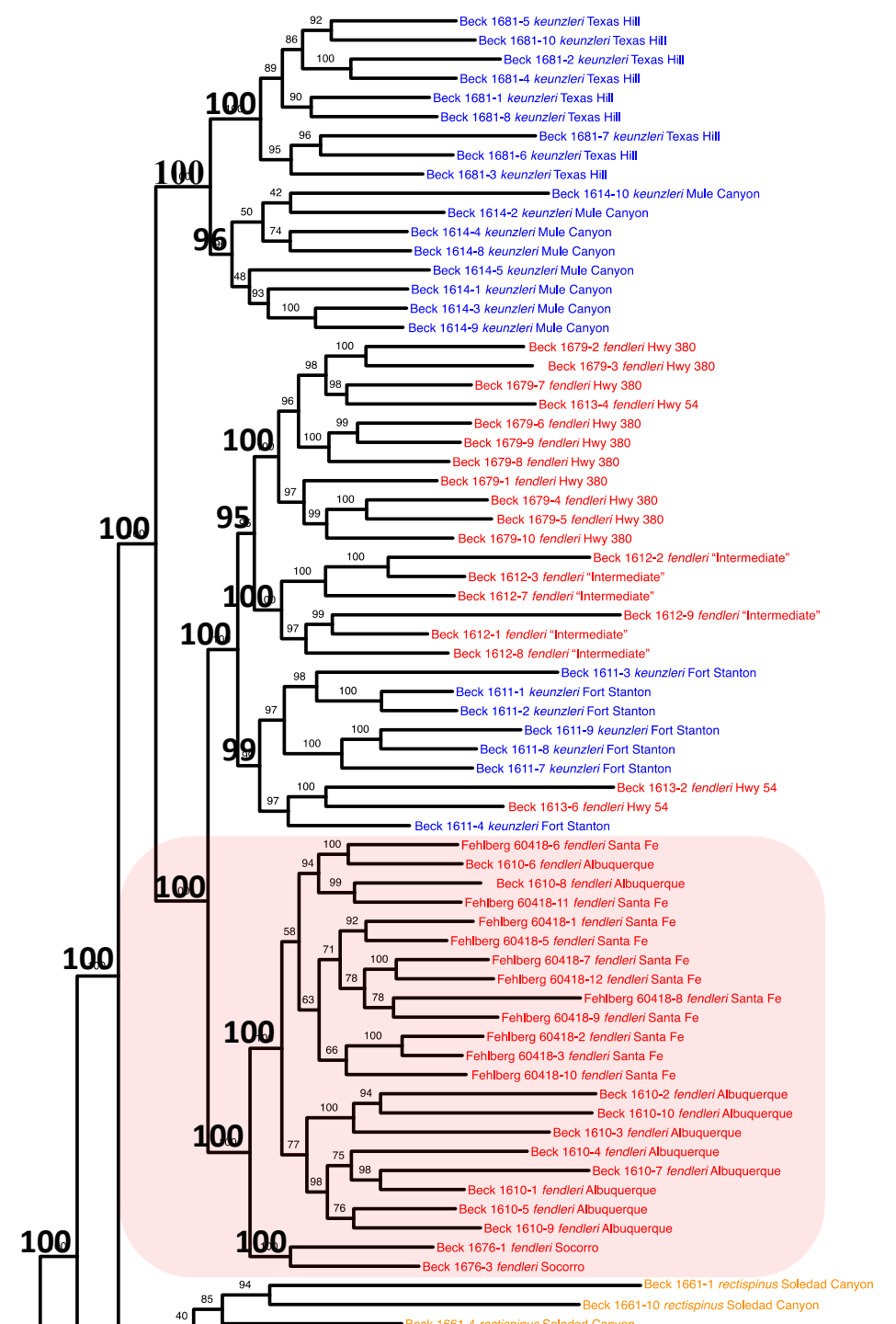
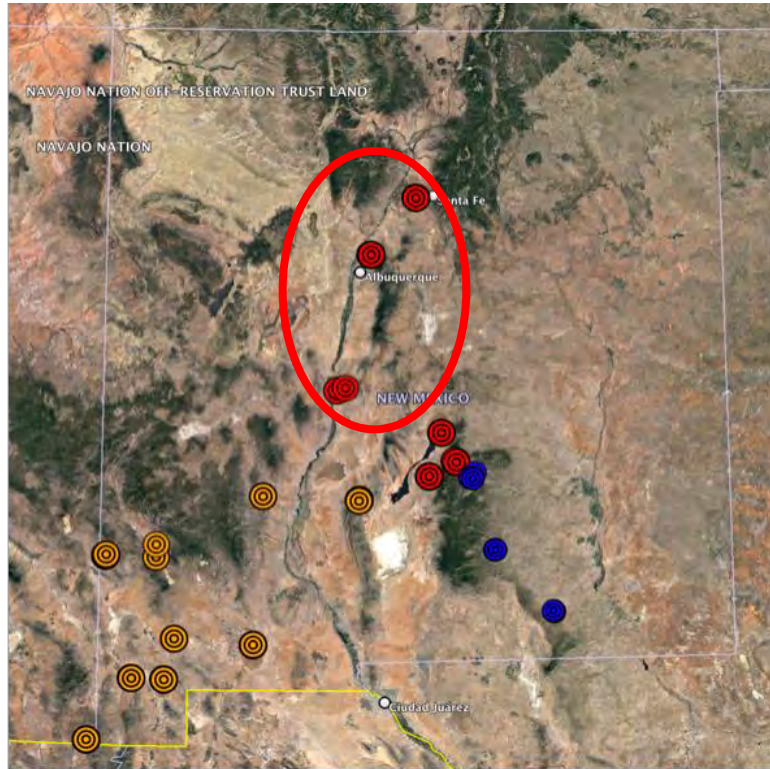
*E. fendleri* var. *fendleri*



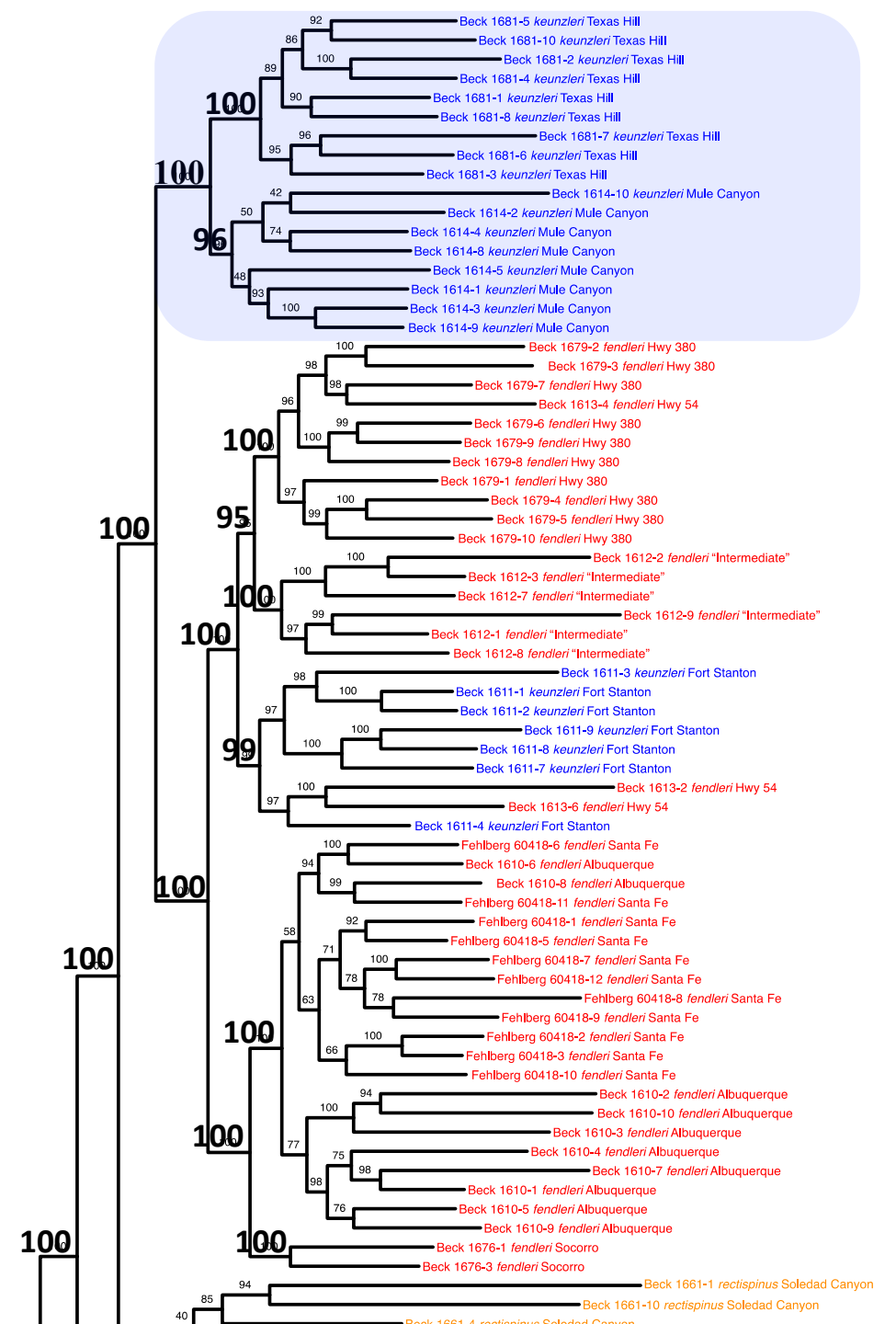
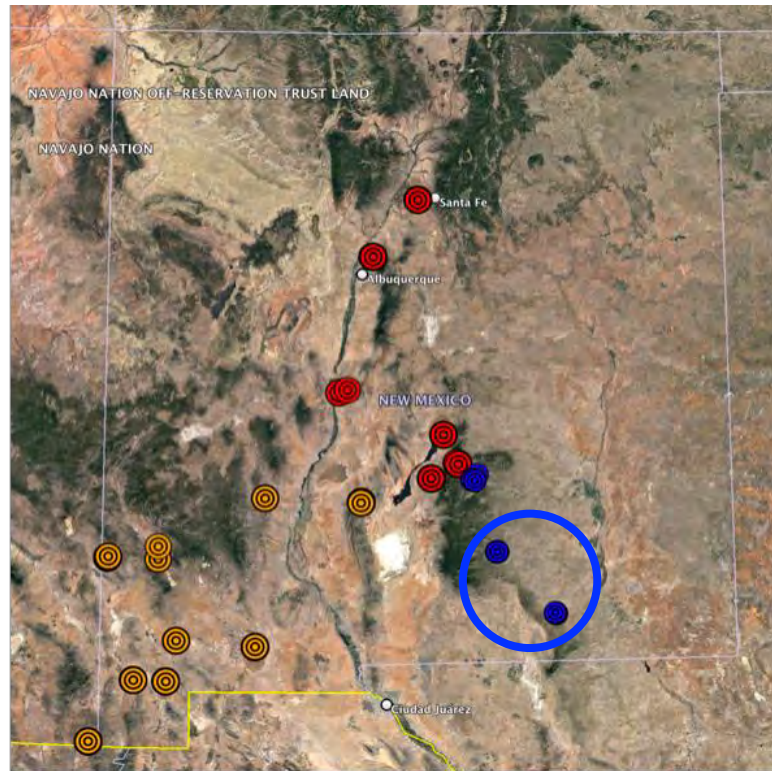
*E. fendleri* var. *rectispinus*

Outgroup

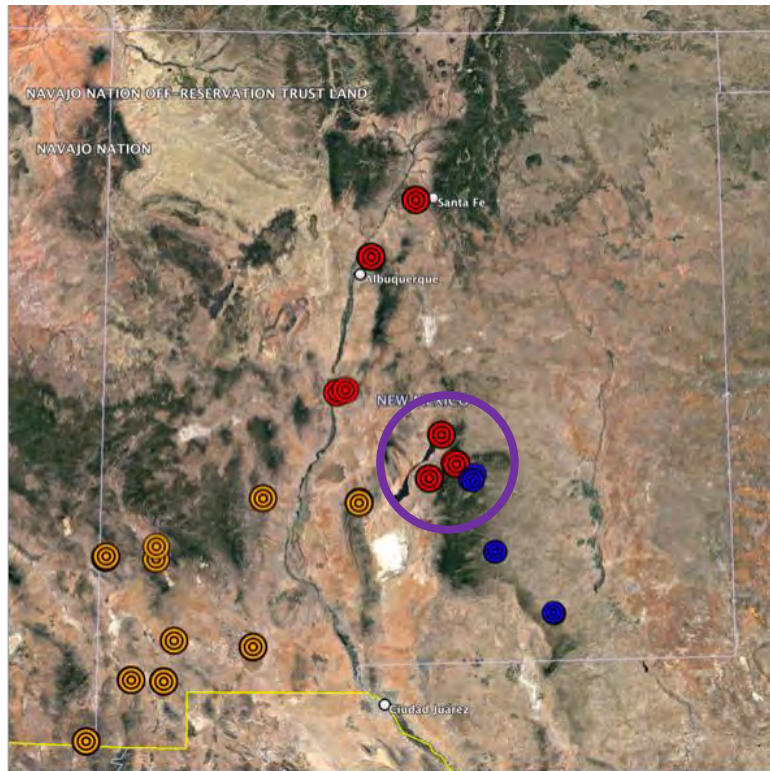
# *E. fendleri* var. *fendleri*



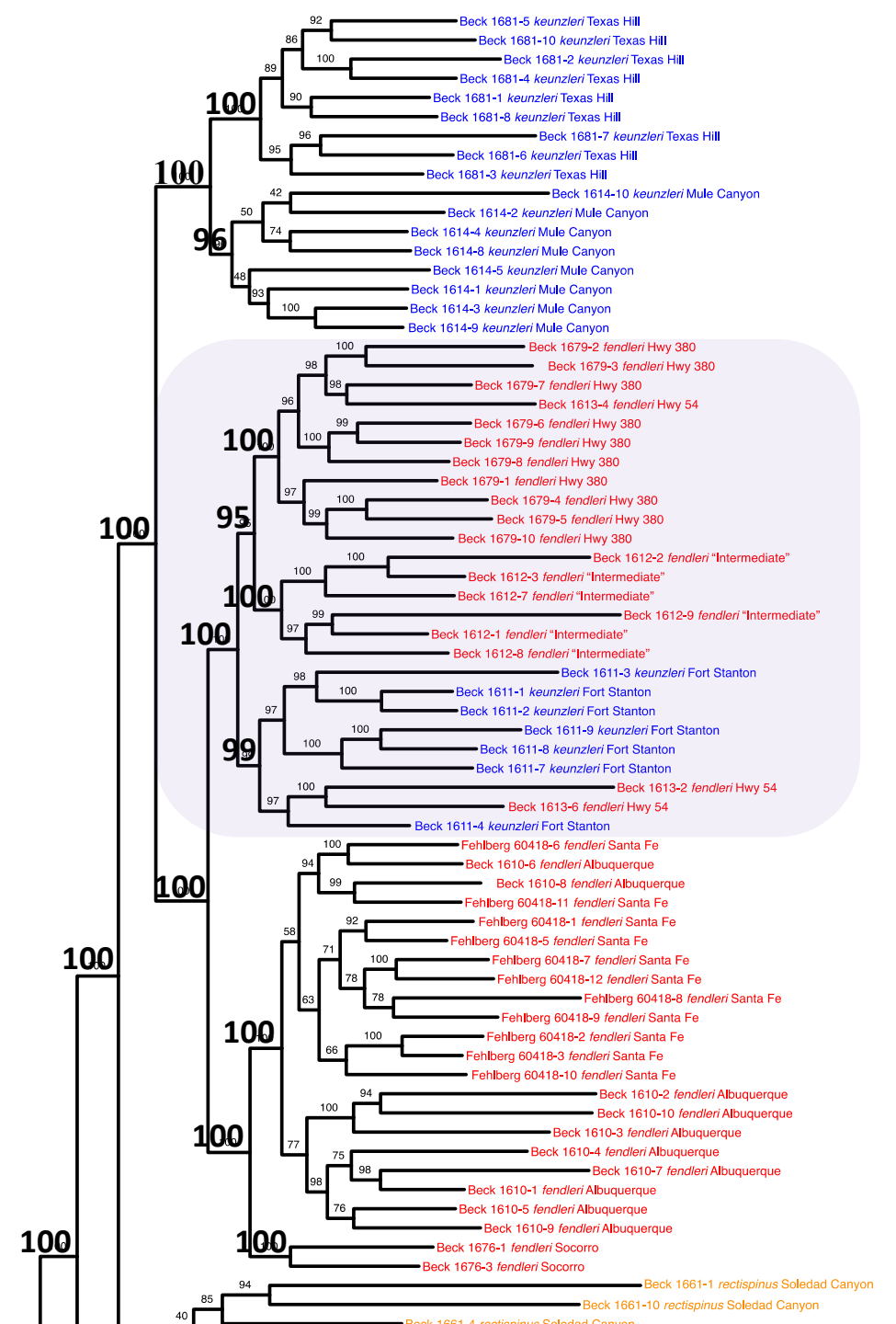
# *E. fendleri* var. *kuenzleri*



# *E. fendleri* var. *fendleri*

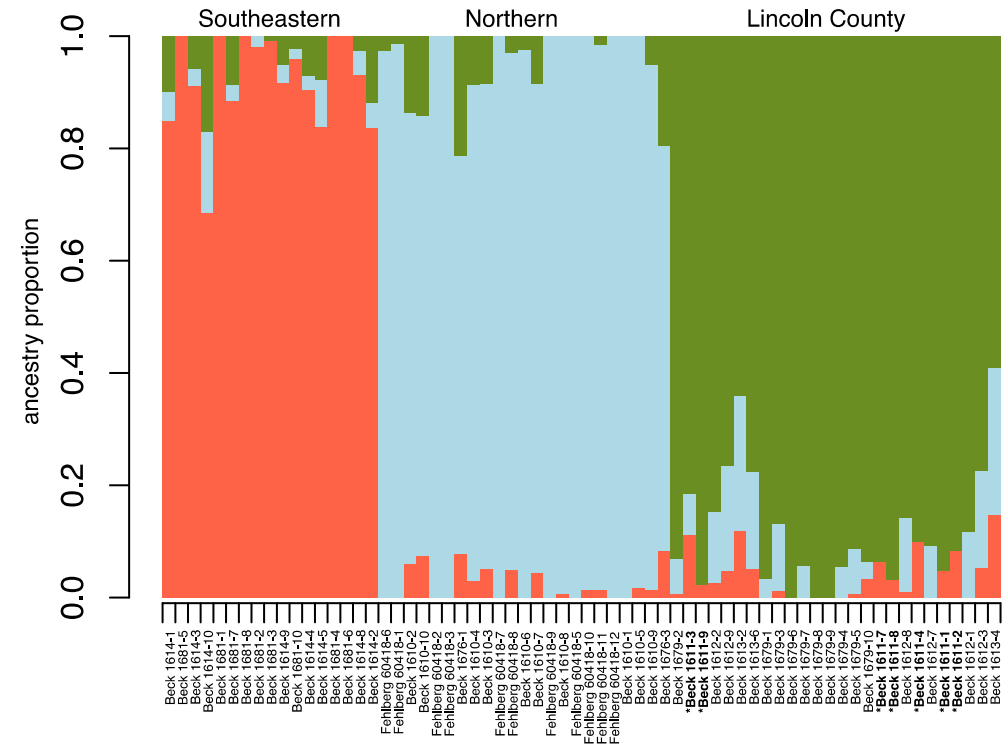
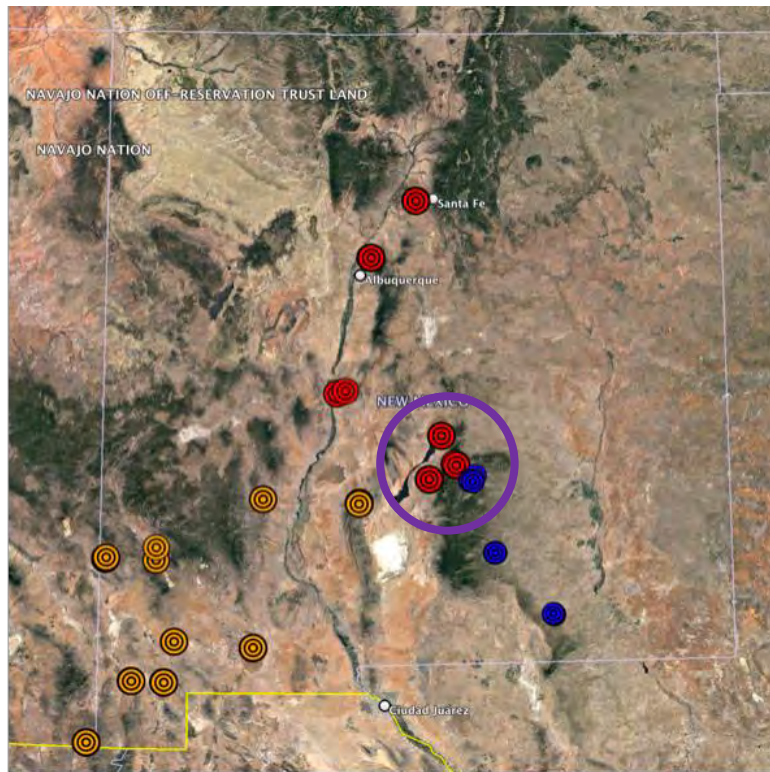


# *E. fendleri* var. *kuenzleri*



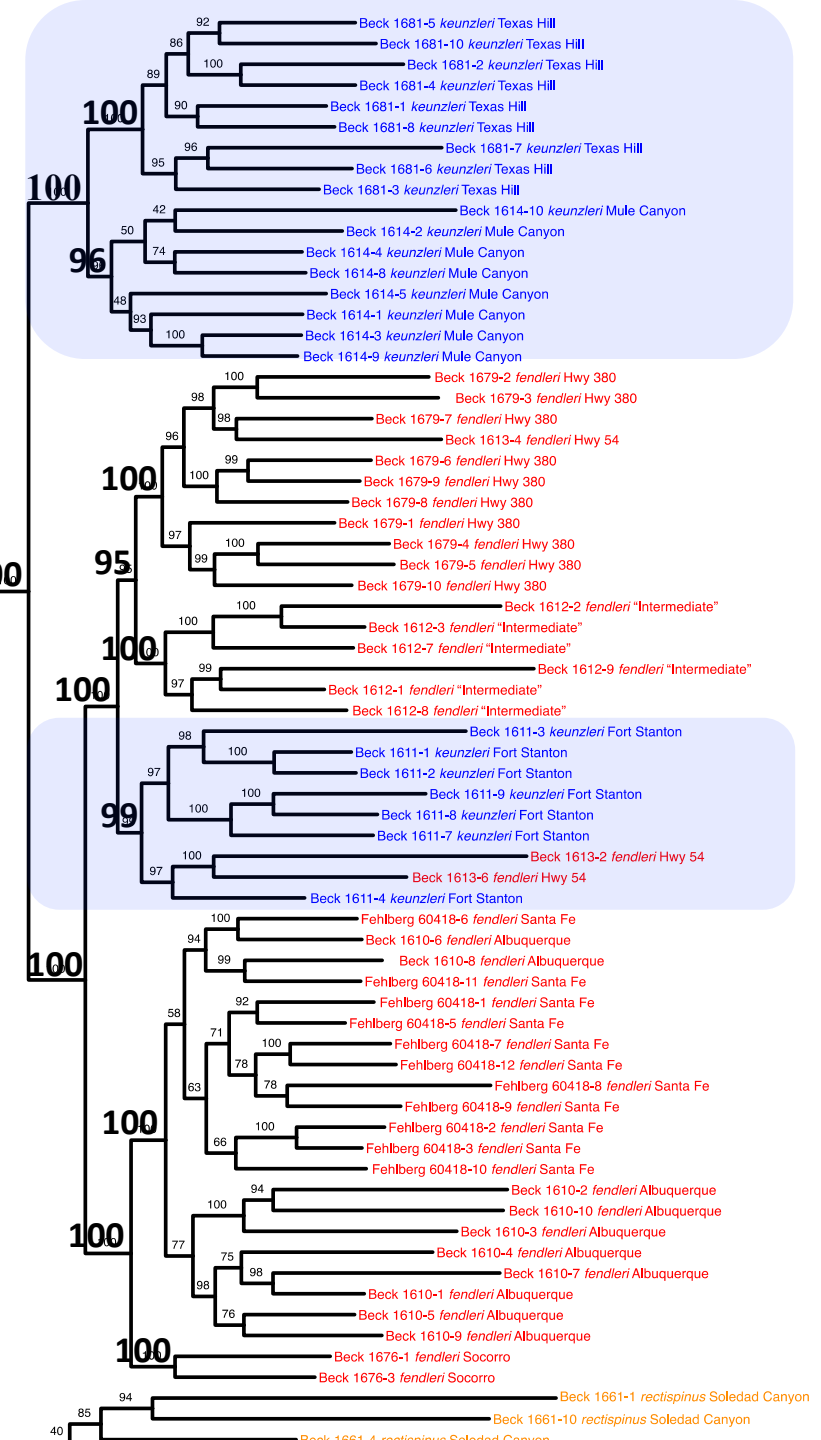
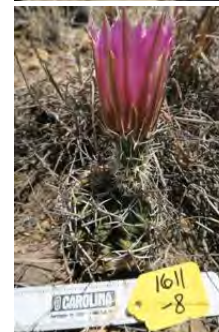
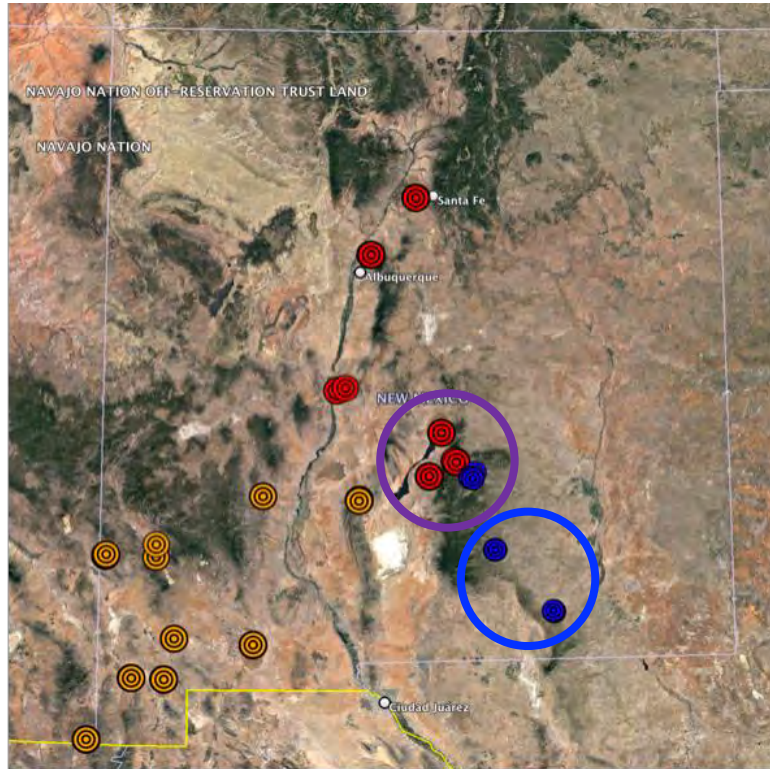


# *E. fendleri* var. *fendleri*



# *E. fendleri* var. *kuenzleri*

# *E. fendleri* var. *kuenzleri*



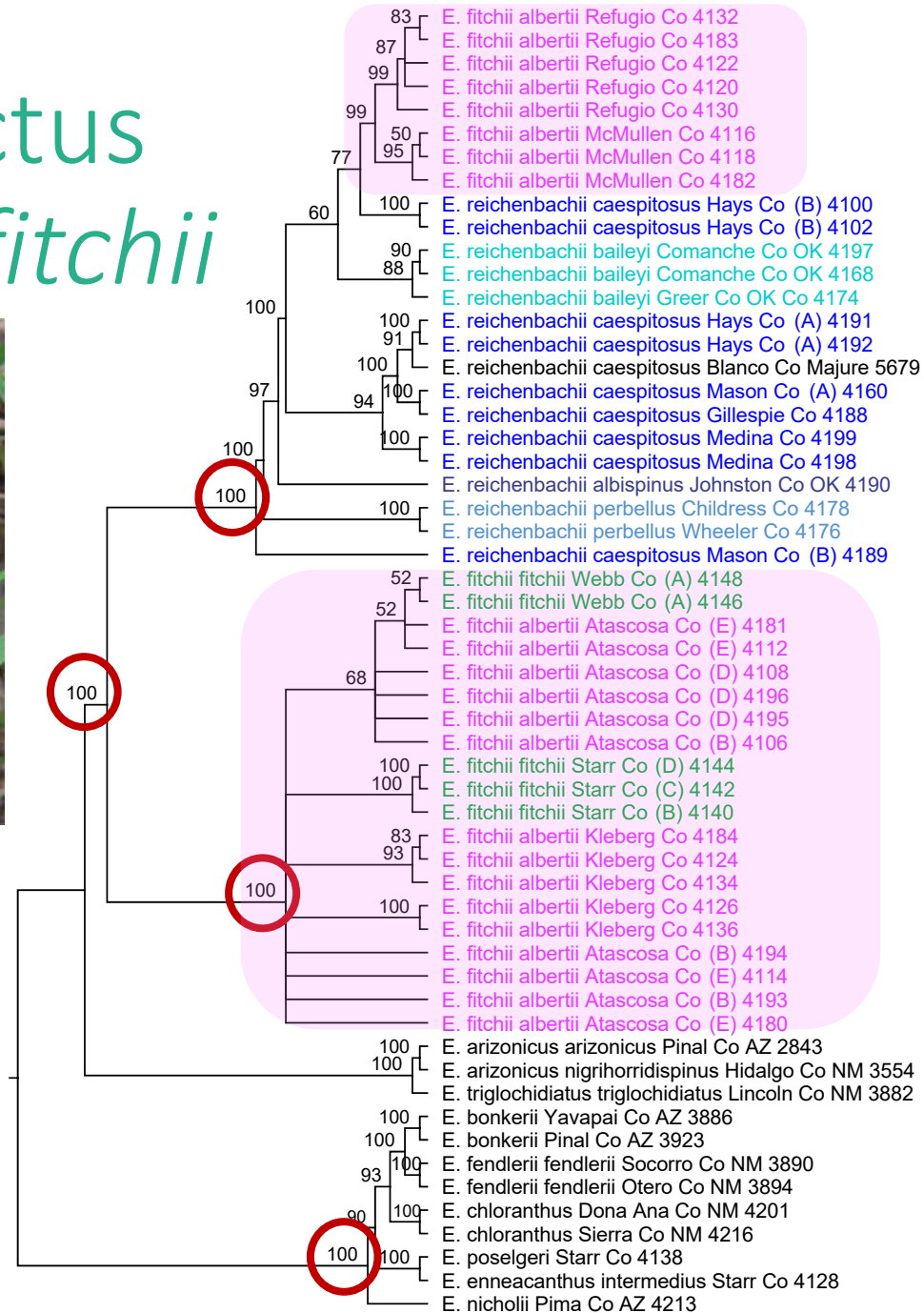
# Conclusions

- The federally endangered *E. fendleri* var. *kuenzleri* as currently recognized is not a single evolutionary lineage.
- Based on current sampling, *E. fendleri* var. *fendleri* and *E. fendleri* var. *rectispinus* are also not independent evolutionary lineages.
- The best current evidence is that *E. fendleri* is one widespread, morphologically variable lineage.
- Within this *E. fendleri*, there are two evolutionary lineages corresponding to the *E. fendleri* var. *kuenzleri* morphology.
- Additional sampling of *E. fendleri* var. *kuenzleri* and *E. fendleri* var. *fendleri* will be completed in the near future.

# Black Lace Cactus *Echinocereus fitchii*



Photo by D. Koehler, 2016



*E. fitchii* subsp.  
*albertii*

*E. reichenbachii*

*E. fitchii* subsp.  
*fitchii*

*E. fitchii* subsp.  
*albertii*

Outgroup



**Arizona Hedgehog Cactus**  
***Echinocereus arizonicus* subsp. *arizonicus***

# Chloroplast genome sequences ~111,000 base pairs

## Legend

*Echinocereus arizonicus* subsp. *arizonicus*

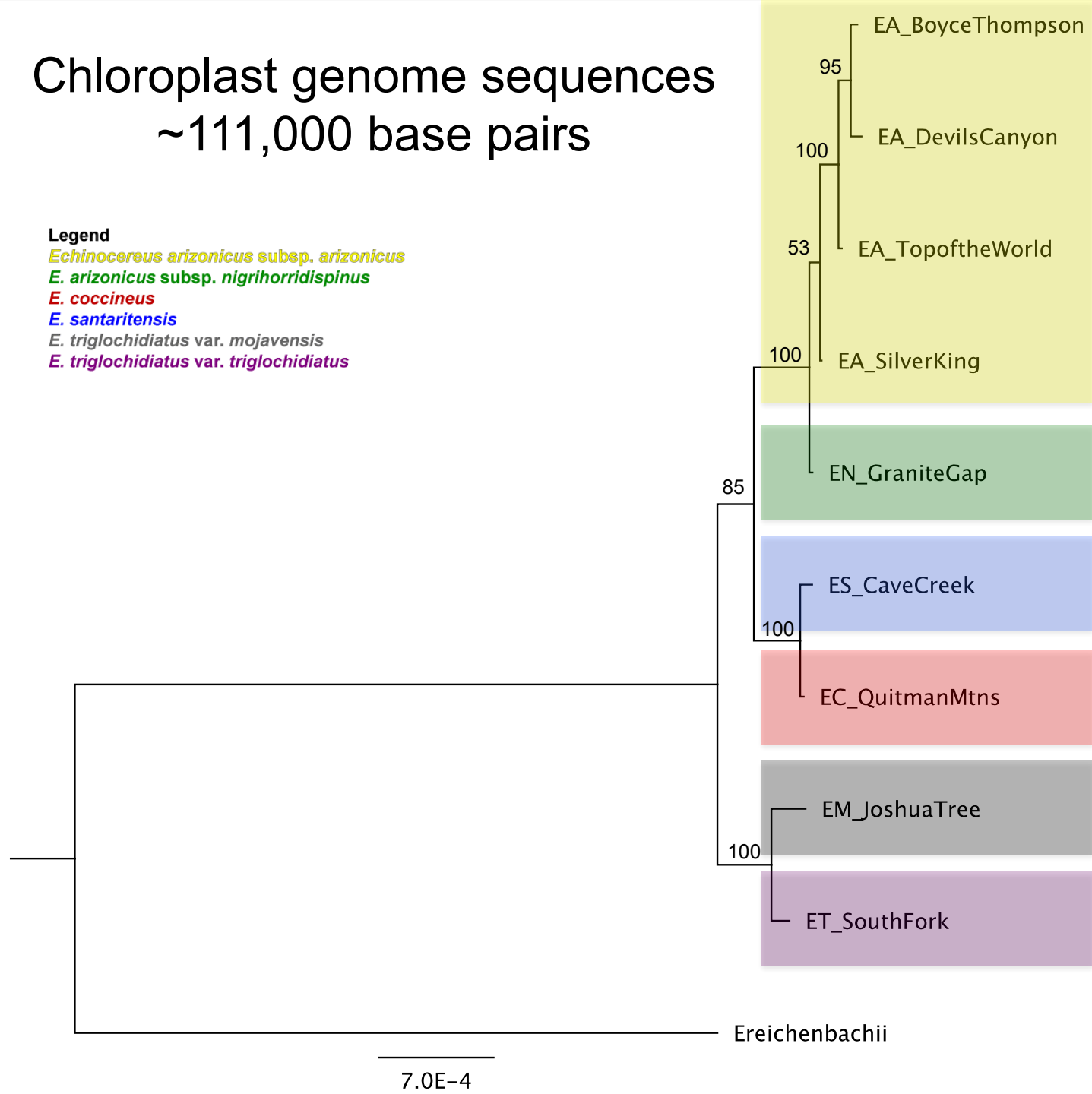
*E. arizonicus* subsp. *nigrihorridispinus*

*E. coccineus*

*E. santaritensis*

*E. triglochidiatus* var. *mojavensis*

*E. triglochidiatus* var. *triglochidiatus*





**Acuña Cactus**

***Echinomastus erectocentrus* var. *acunensis***



*E. erectocentrus* var. *acunensis*



*E. erectocentrus* var. *erectocentrus*



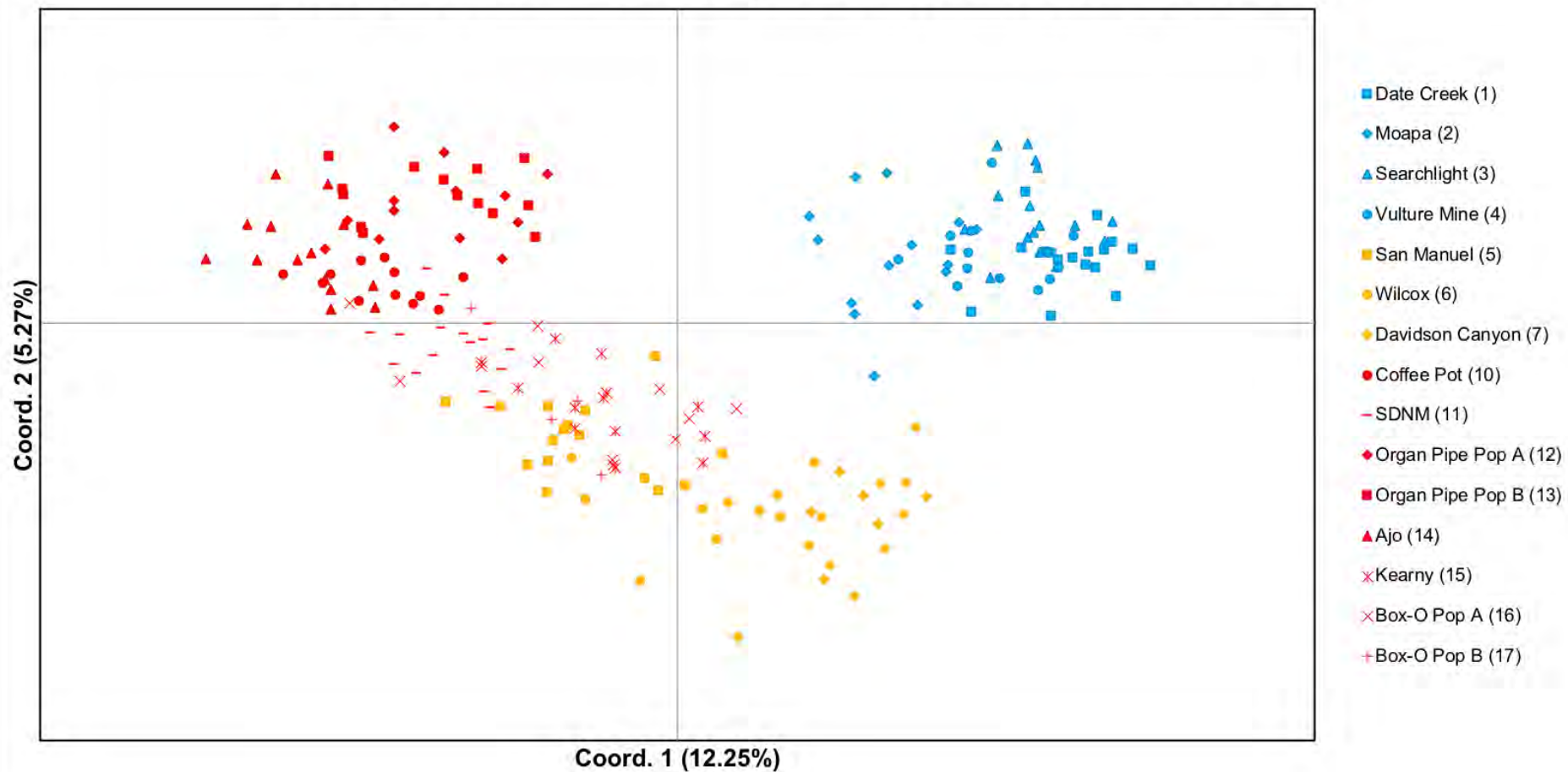
*E. johnsonii*



*E. intertextus*



## Principal Coordinates Analysis- Individual Genetic Distance



# Acknowledgements

- National Science Foundation
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- U.S. Bureau of Land Management
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