

Sharing new conservation genetics data for *Sclerocactus mesae-verdae*, *S. cloverae*, and *S. parviflorus*



UNIVERSITY OF  
**NORTHERN**  
**COLORADO**

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# Why Genetics?

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- Traditionally, species have been recognized based on morphology, ecology, and/or geography
- Genetic data is increasingly being used to identify and describe distinctive entities -> debate on what is a species persists

Phenotype = Genotype + Environment

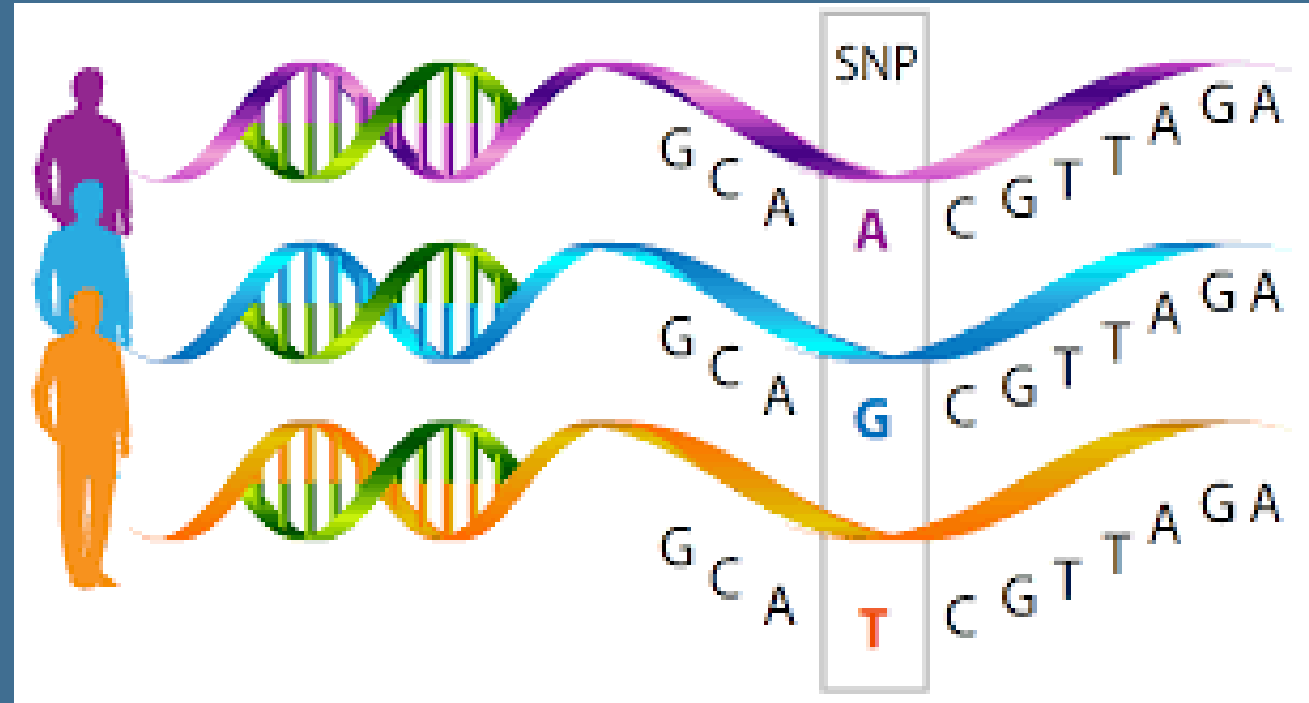
# When Genetics?

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- Groups with taxonomic confusion
- Groups with limited 'morphological' characters
- Groups with significant morphological variability  
-> Phenotypic Plasticity
- Groups experiencing considerable population loss
- Geographic regions where land managers want to define primary areas for conservation

# Genetic Methods - RADseq

- ddRAD – whole genome Next Generation sequencing technique
- 1000's of unique genetic regions
- Single Nucleotide Polymorphisms (SNP's)
- Fine- scale observations between:
  - Individuals
  - Populations
  - Closely related species
- Relatively inexpensive
- No prior genetic information required



# Previous *Sclerocactus* Genetics



## *Sclerocactus glaucus* (K. Schum.) L.D. Benson

- Endemic to western Colorado, USA
- ESA Threatened -> recommended to delist in 2023
- Previous genetic work (microsatellites) determined limited hybridization and that central spine morphology was plastic

## *Sclerocactus wetlandicus* Hochstätter and *Sclerocactus brevispinus* K.D. Heil and J.M. Porter

- Endemic to Uinta Basin, Utah, USA
- ESA Threatened -> significant oil and gas development
- Distinguished based on size and central spine morphology



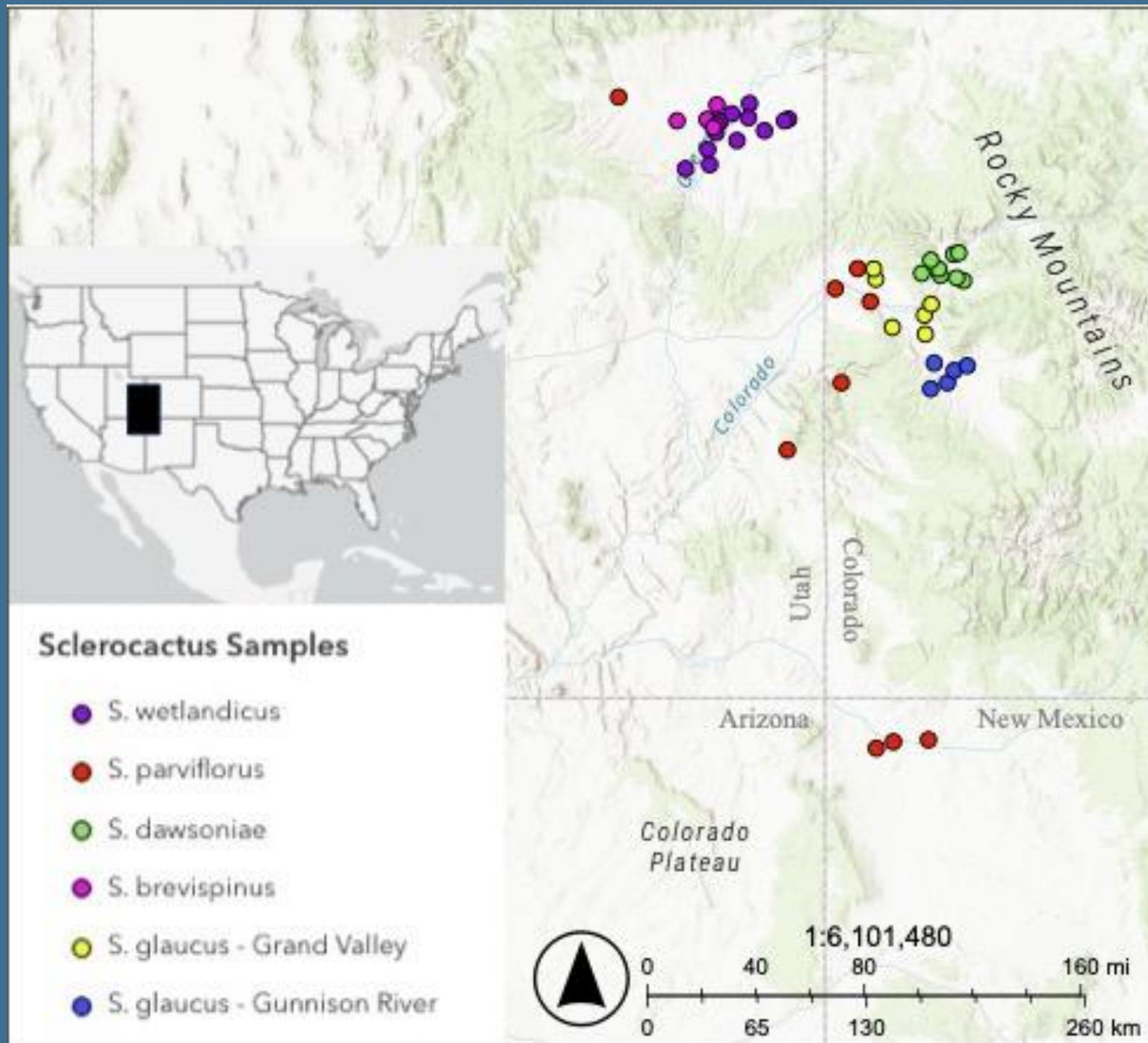
*S.*  
*glaucus*  
ESA  
Threatened



*S.*  
*brevispinus*  
ESA  
Threatened



*S.*  
*wetlandicus*  
ESA  
Threatened



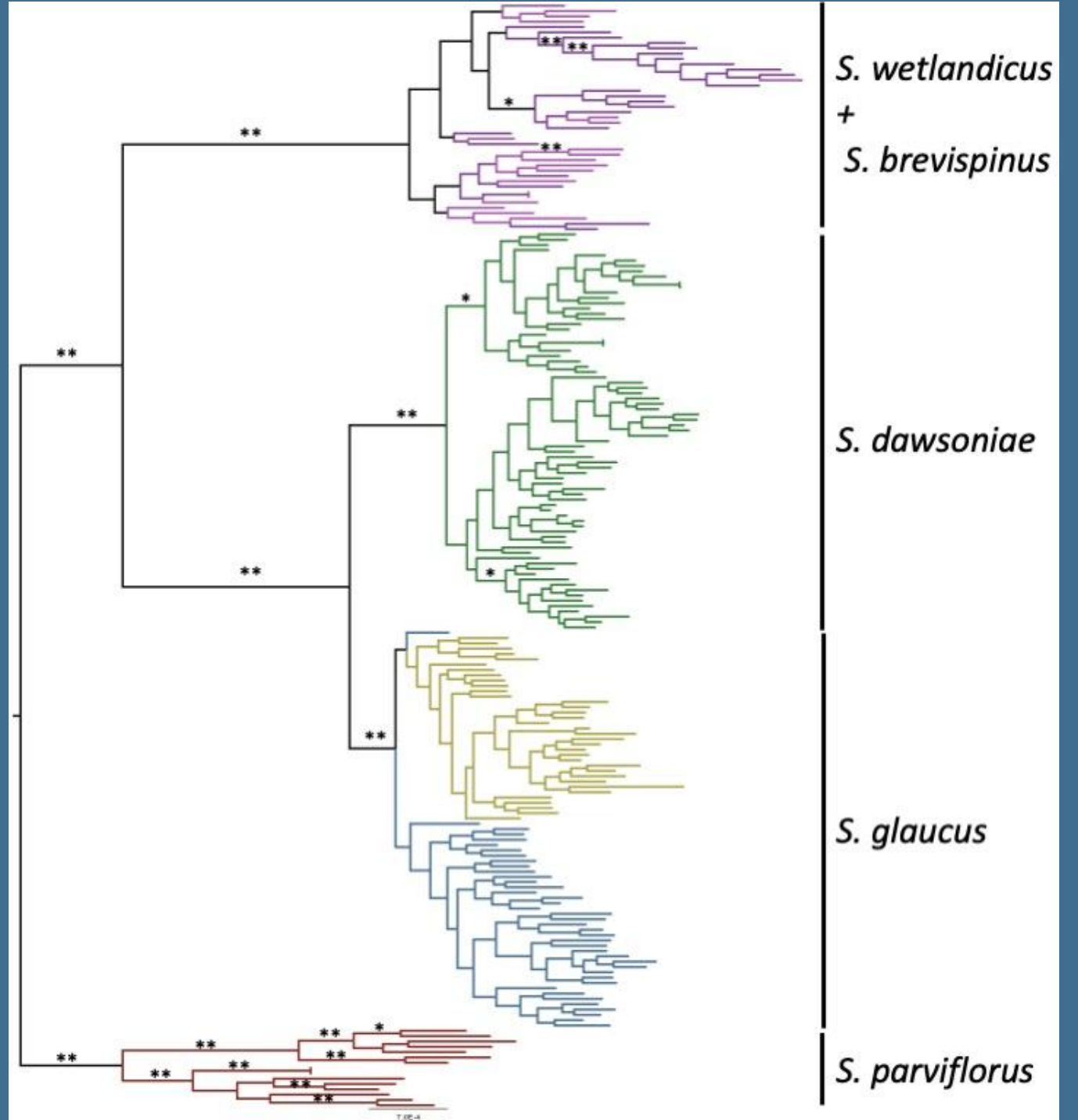
*Sclerocactus wetlandicus* and *Sclerocactus brevispinus* are not distinct species

- Slight east/west geographic structure that does not follow taxonomy
- *S. wetlandicus* – has priority

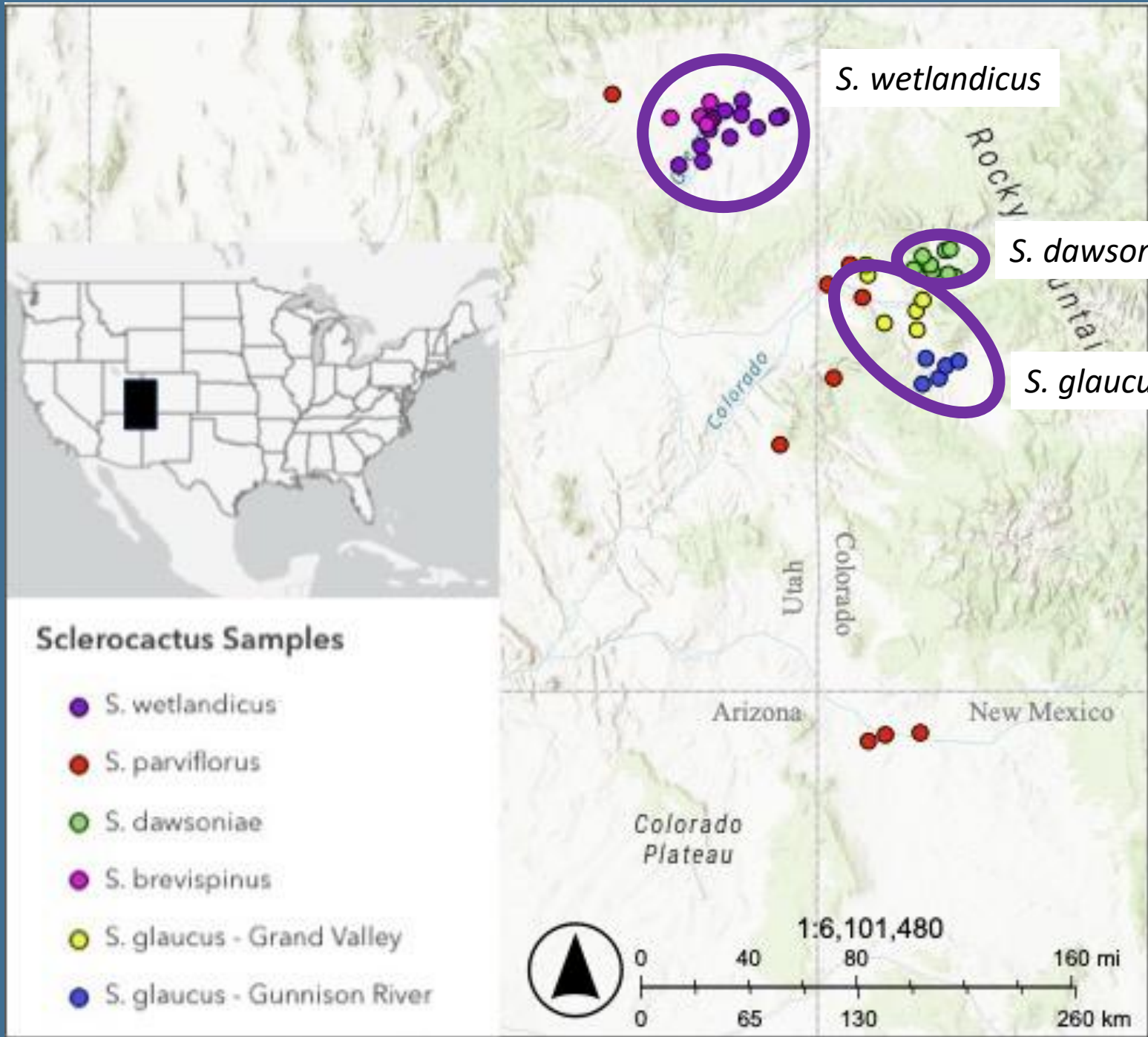
*Sclerocactus glaucus* contains two genetic groups

- *S. glaucus*
- *S. dawsoniae* M.E. McGlaughlin and S. Naibauer – new 2024

Taxonomic rearrangement combines two rare taxa and recognizes one new rare species





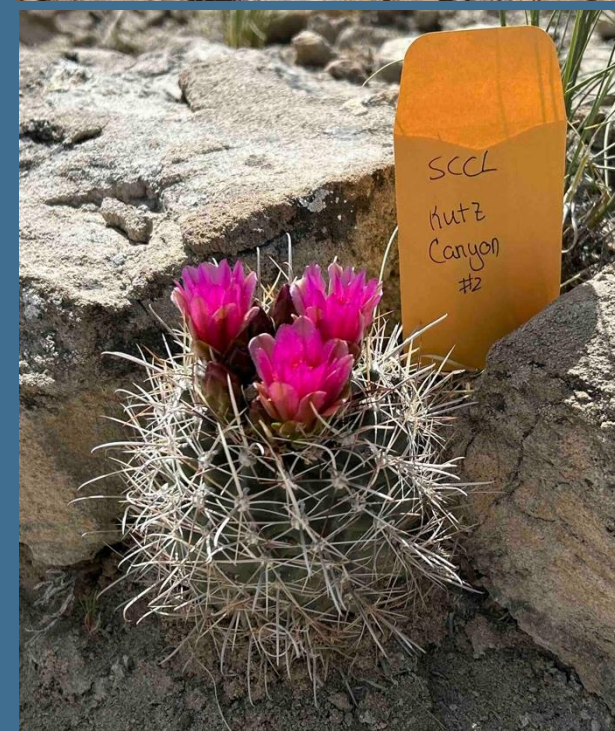


# New Mexico *Sclerocactus*



## *Sclerocactus cloverae* K.D. Heil & J.M. Porter

- Endemic to north western New Mexico, Nacimiento Formation
- Under review for ESA listing
- Previous genetic work determined that *ssp. brackii* is not a distinctive entity
- Distinguished from *S. parviflorus* based on smaller flower size and more dense spines
- Significant oil and gas development impacts



# New Mexico *Sclerocactus*



## *Sclerocactus parviflorus* Clover and Jotter

- Widespread distribution centered on the Colorado Plateau (AZ, CO, NM, UT)
- Considerable morphological variability  
→ size, spine, flower color
- Multiple named varieties
- Distinguished based on large pink/purple flowers, overall size

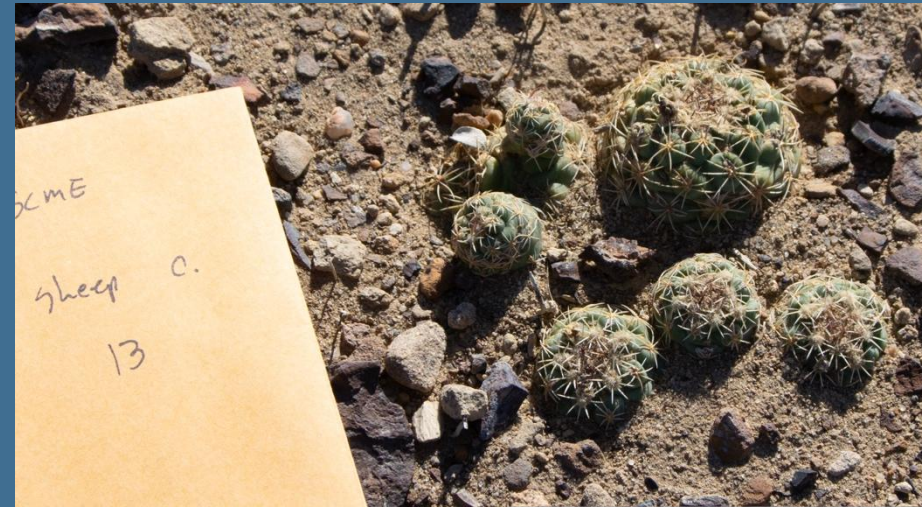


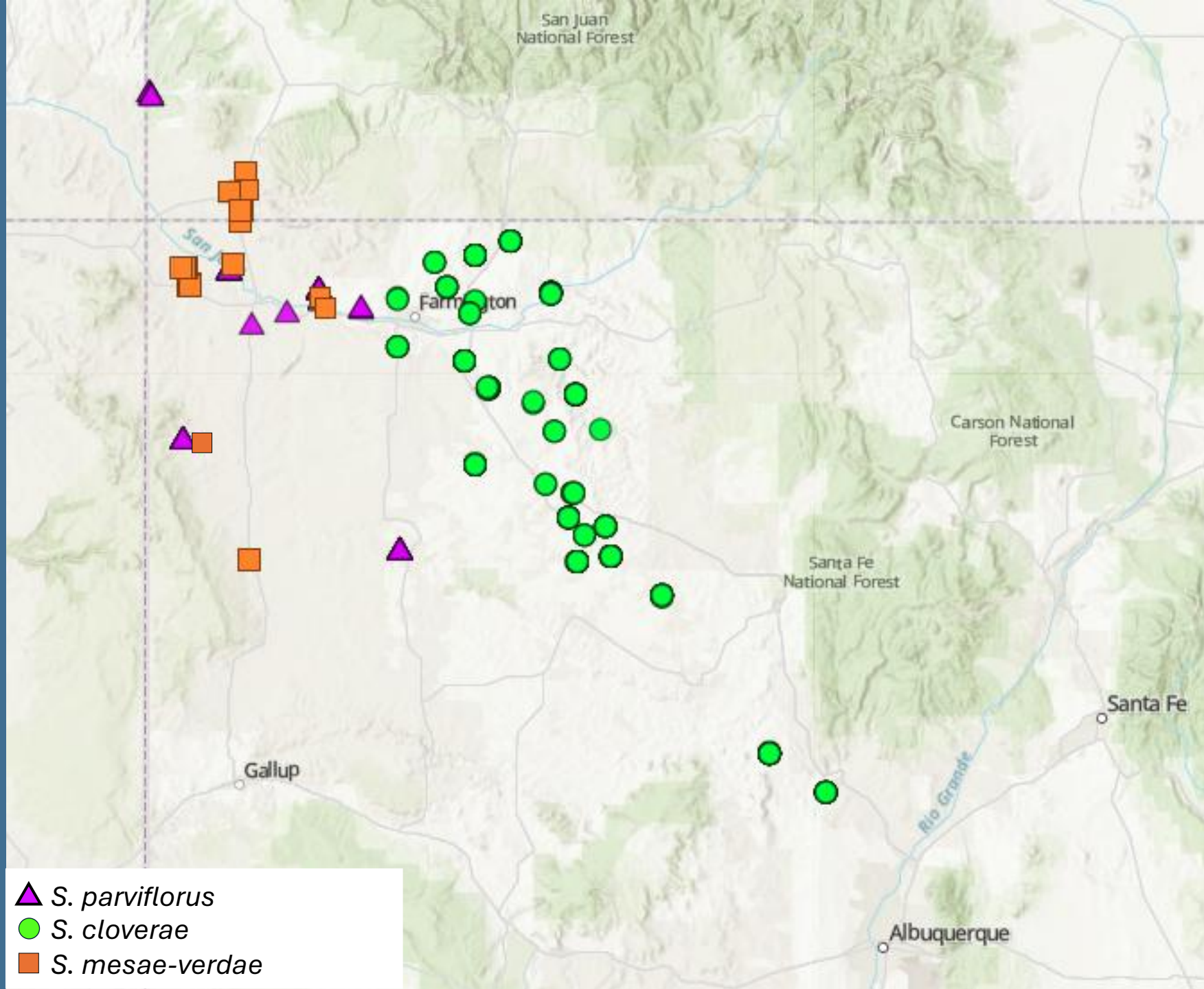
# New Mexico *Sclerocactus*



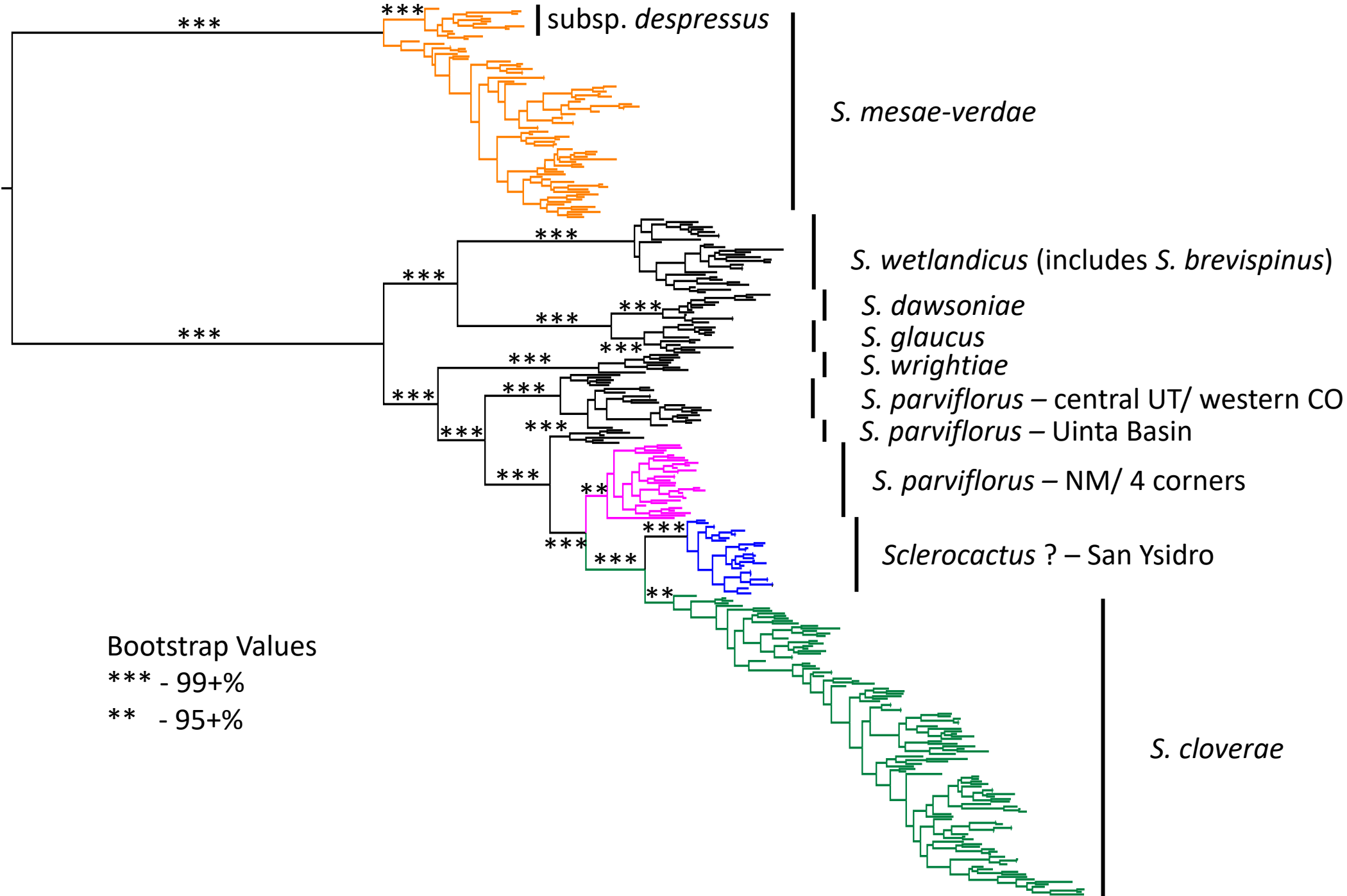
## *Sclerocactus mesae-verdae* (Boissevain ex Hill & Salisbury) L. Benson

- Endemic to north western New Mexico
- ESA Threatened
- subsp. *depressus* O’Kane, K.D. Heil, & A. Clifford – described in 2022, disjunct southern portion of the range
- Oil and gas, drought, insects, and invasive species impacts









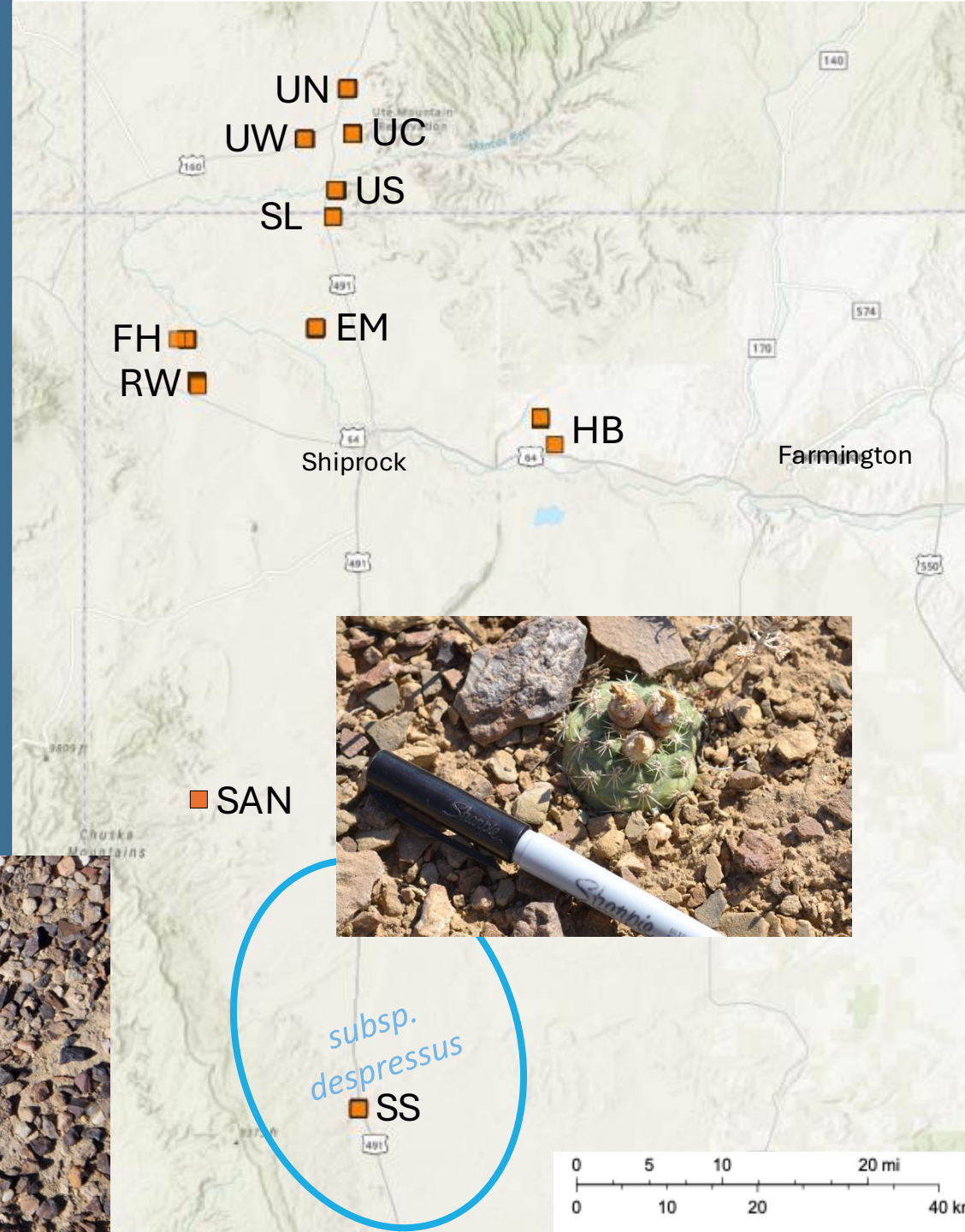
Bootstrap Values

\*\*\* - 99+%

\*\* - 95+%

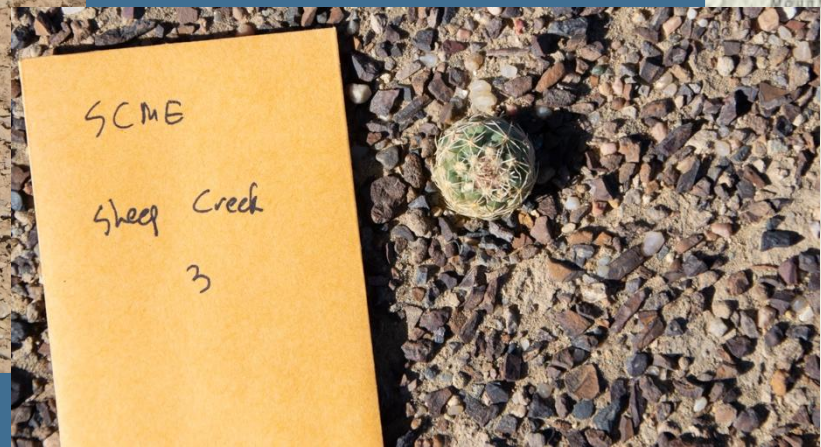
# *Sclerocactus mesae-verdae*

- 9 sampled populations, 10-20 plants per population
- SS – subsp. *despressus*
- SAN – uncertain taxonomy



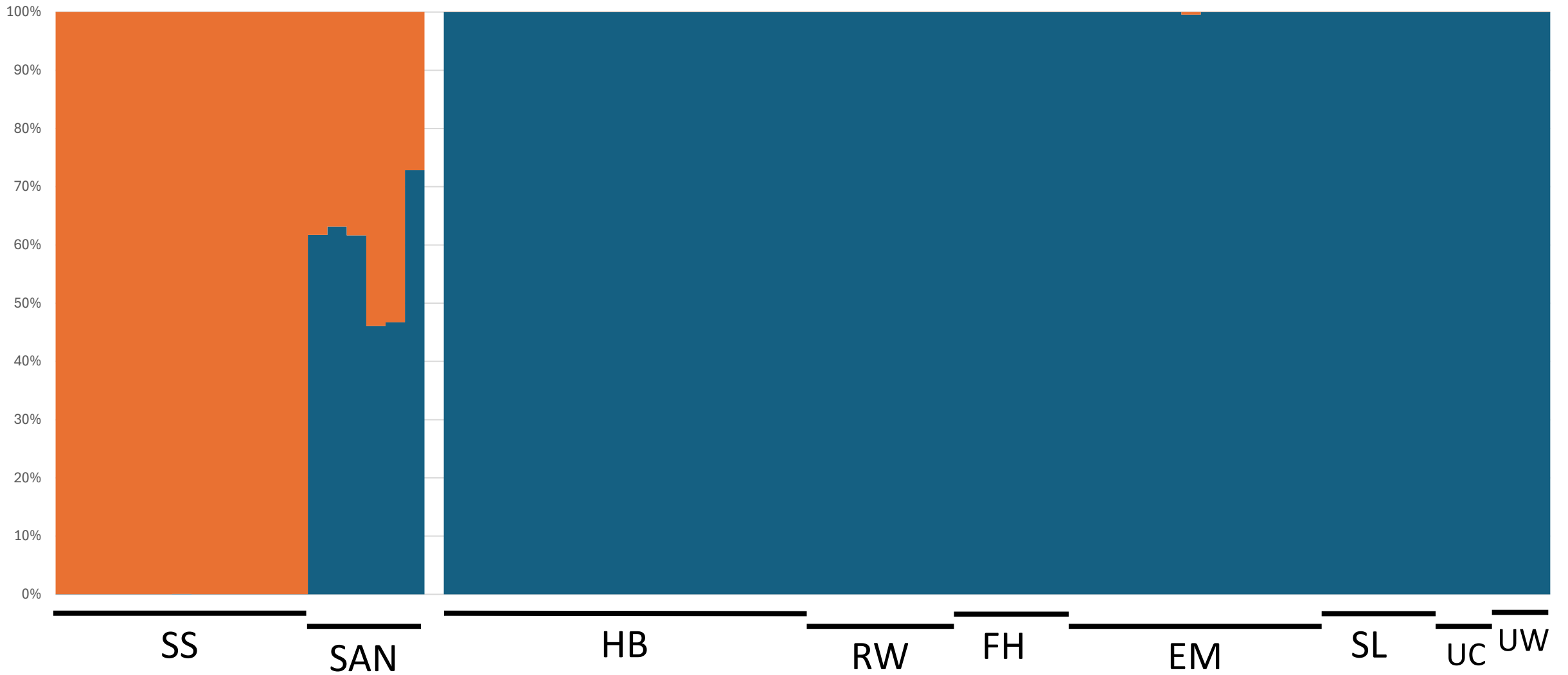
■ SAN

subsp.  
*despressus*  
■ SS





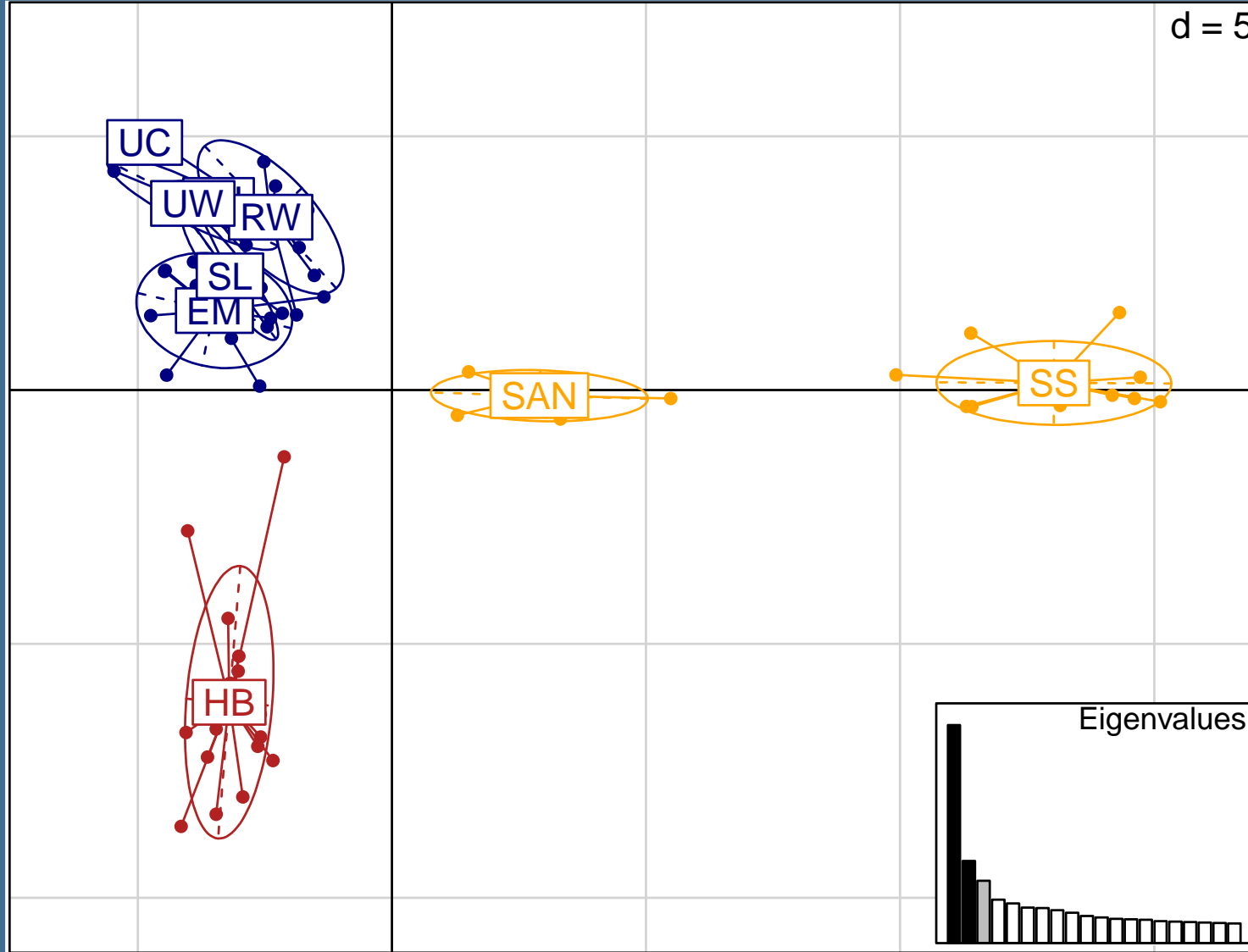
# STRUCTURE ANALYSIS (K=2)



## Principle Coordinate Analysis

## Genetic Diversity

Axis 2 – 5.3%



d = 5

Pop	N	Ho	He	Fis
SS	13	0.226	0.242	0.07
SAN	6	0.309	0.342	0.10
HB	18	0.199	0.216	0.08
RW	9	0.253	0.268	0.06
FH	5	0.349	0.348	0.00
EM	12	0.199	0.220	0.10
SL	7	0.289	0.303	0.05
UC	3	0.446	0.456	0.02
UW	3	0.473	0.484	0.02

## Genetic Distance Among Populations

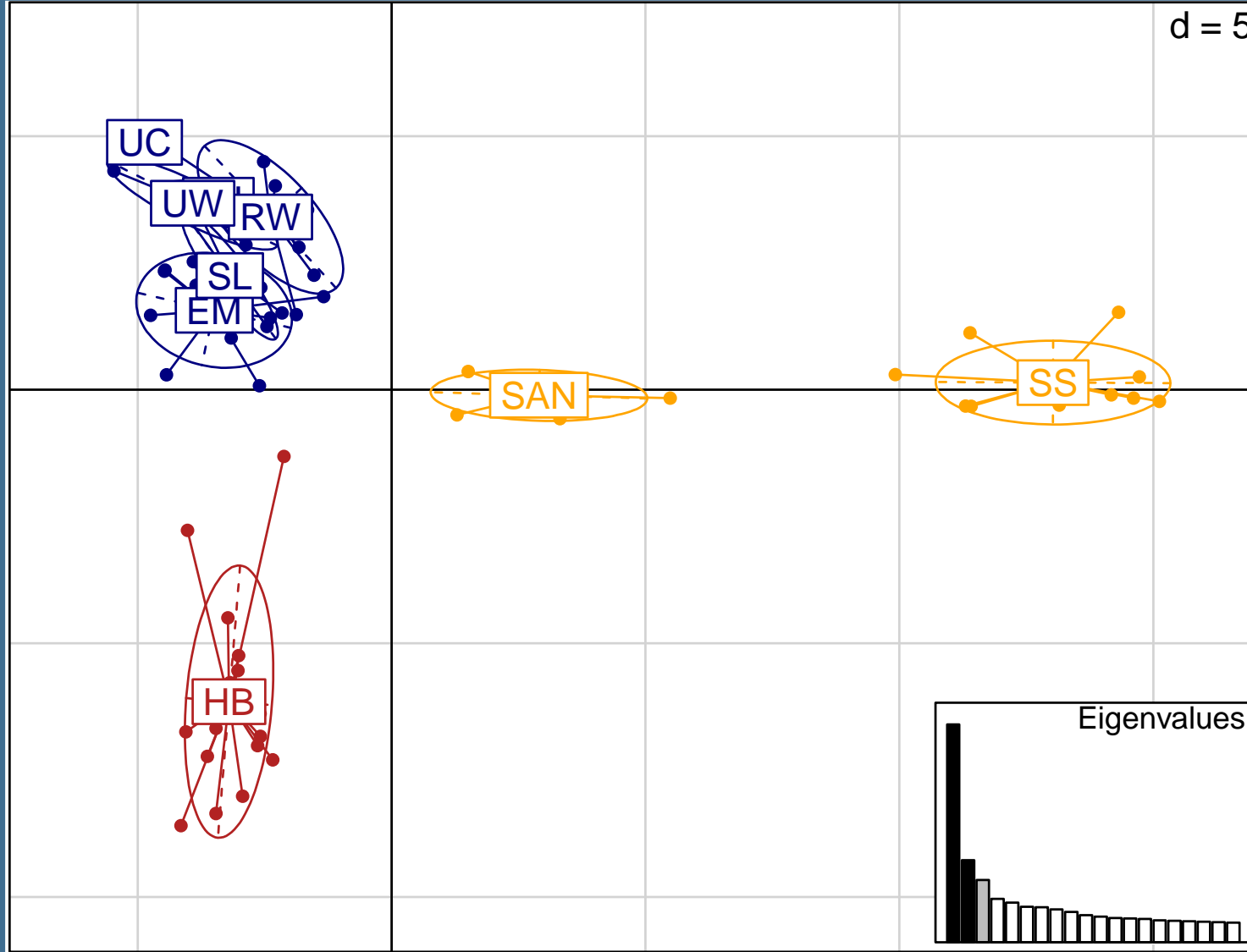
	SS	SAN	HB	RW	FH	EM	SL
SS	0.00						
SAN	0.18	0.00					
HB	0.32	0.13	0.00				
RW	0.31	0.15	0.12	0.00			
FH	0.35	0.15	0.16	0.06	0.00		
EM	0.29	0.10	0.08	0.07	0.10	0.00	
SL	0.29	0.20	0.07	0.14	0.09	-0.01	0.00

Axis 1 – 14.2%

## Principle Coordinate Analysis

## Genetic Diversity

Axis 2 – 5.3%



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Pop	N	Ho	He	Fis
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Axis 1 – 14.2%

## Principle Coordinate Analysis

## Genetic Diversity

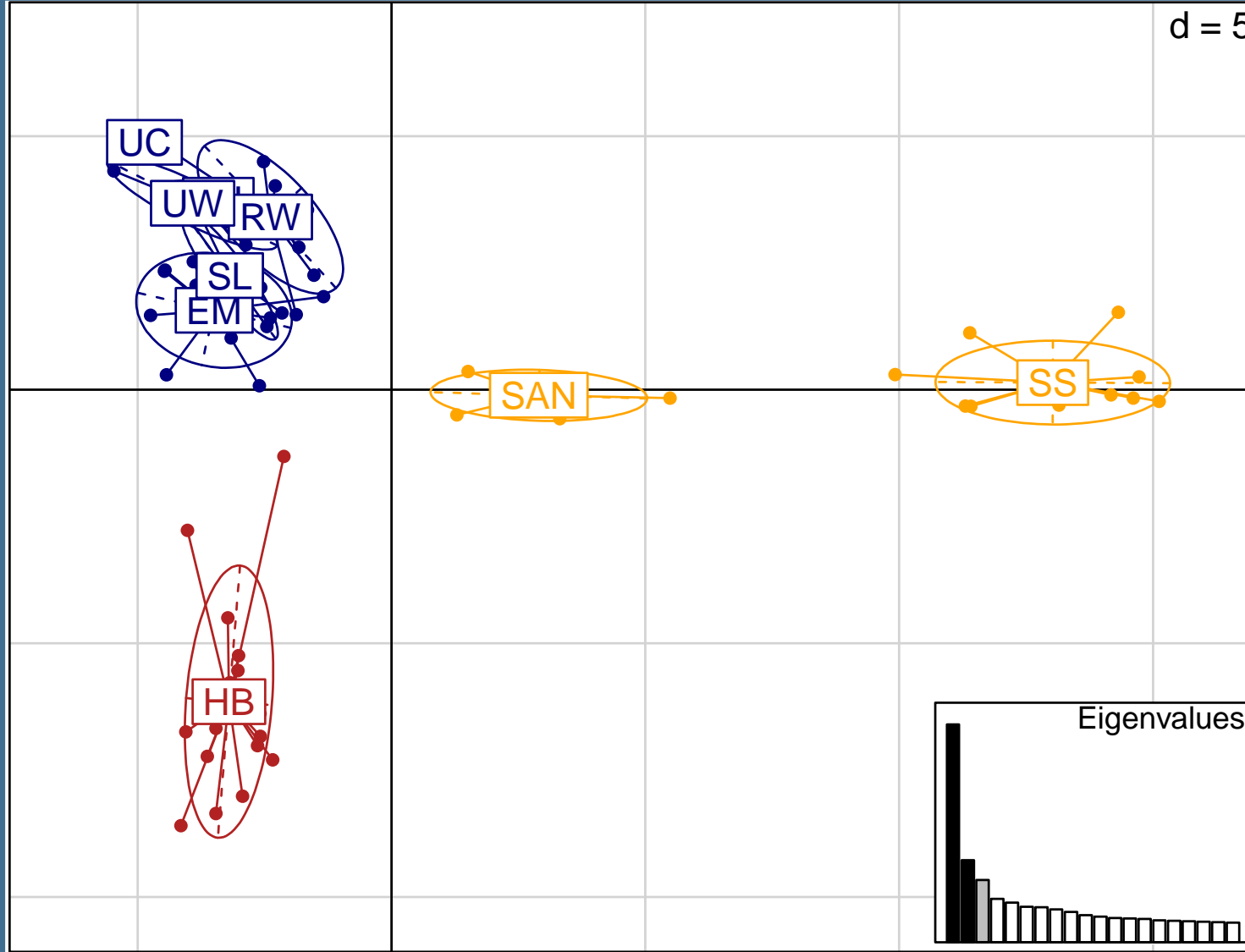
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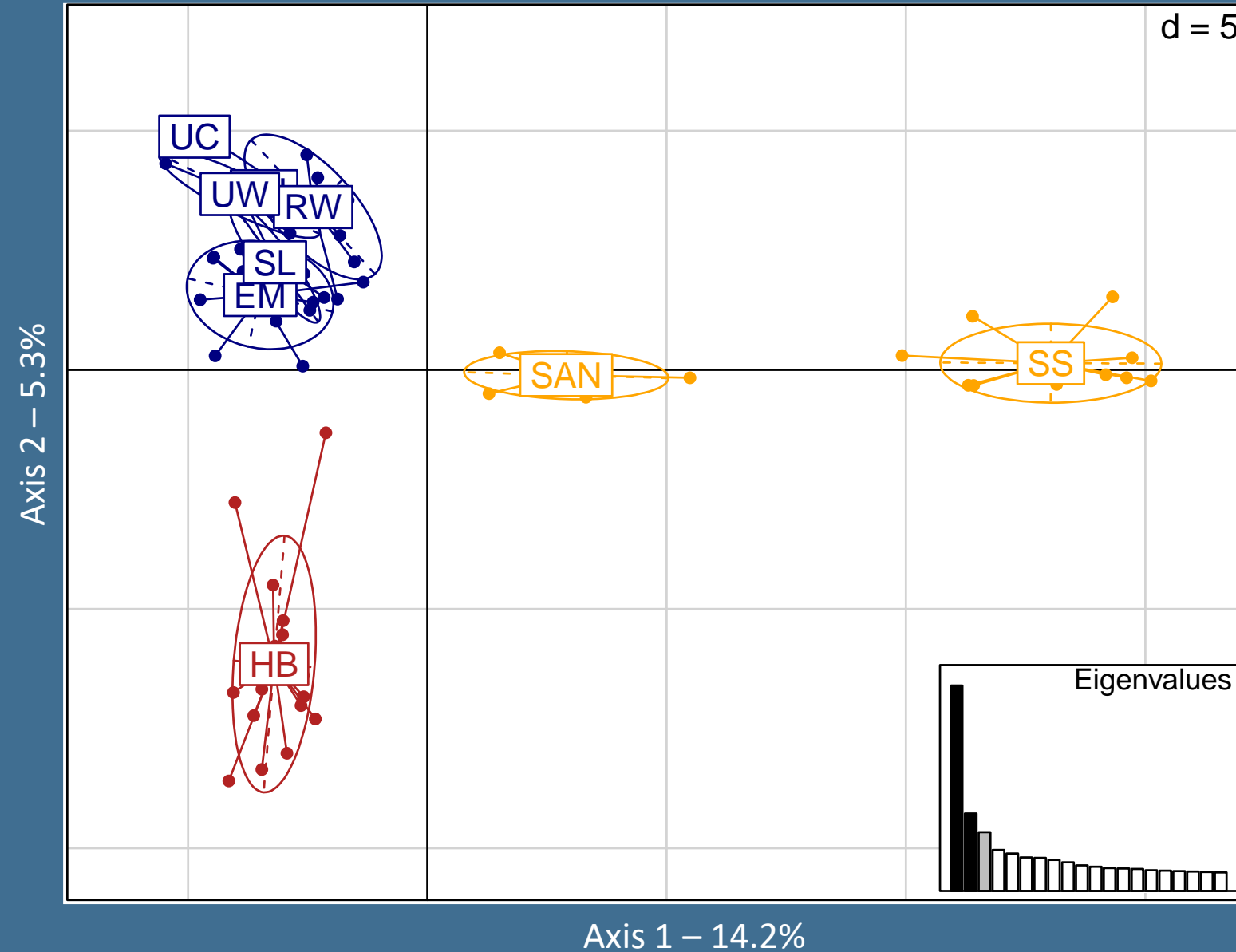
d = 5

Axis 2 – 5.3%



Axis 1 – 14.2%

## Principle Coordinate Analysis



## Genetic Diversity

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SAN	6	0.309	0.342	0.10
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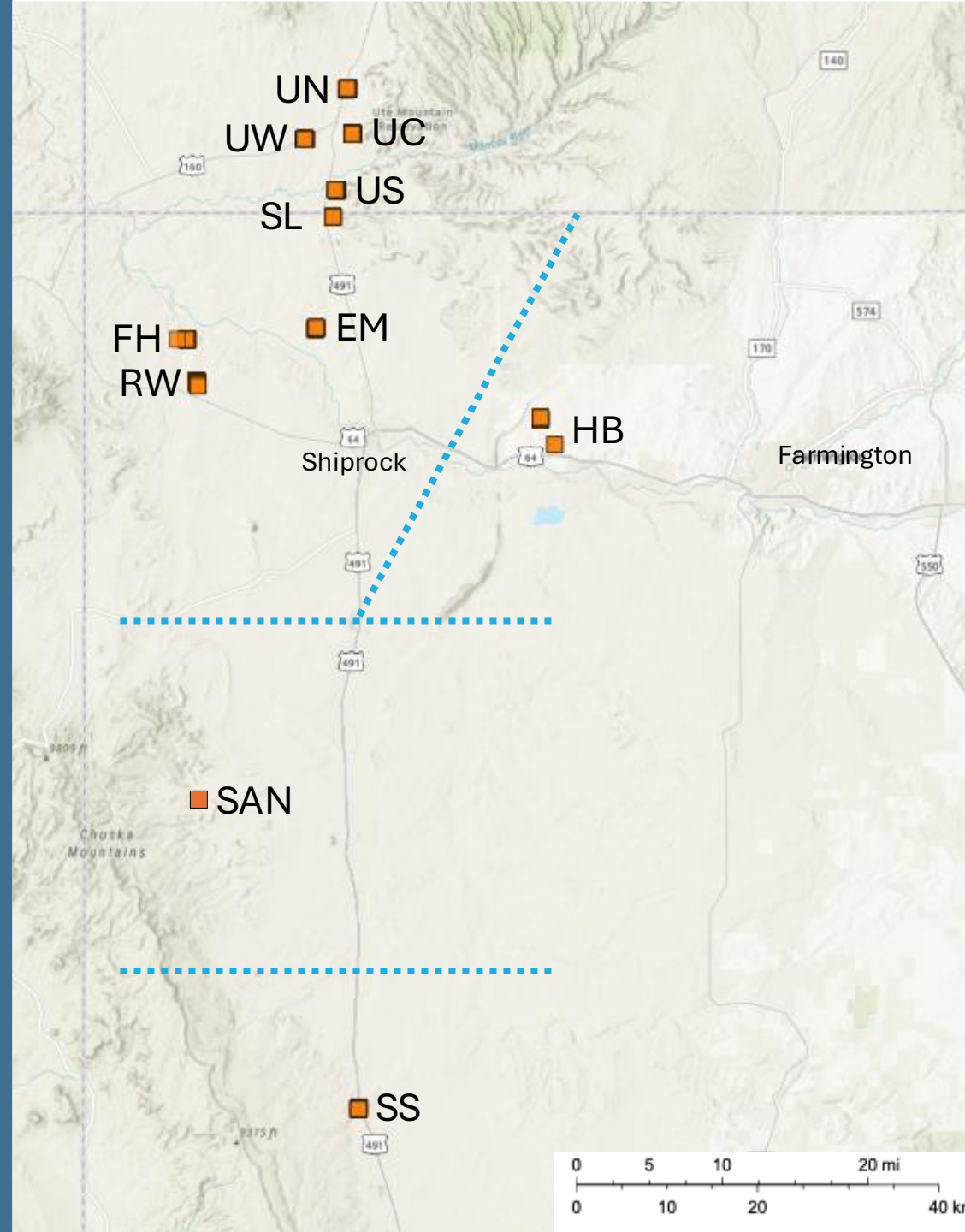
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Fst > 0.25 among species for *Sclerocactus*

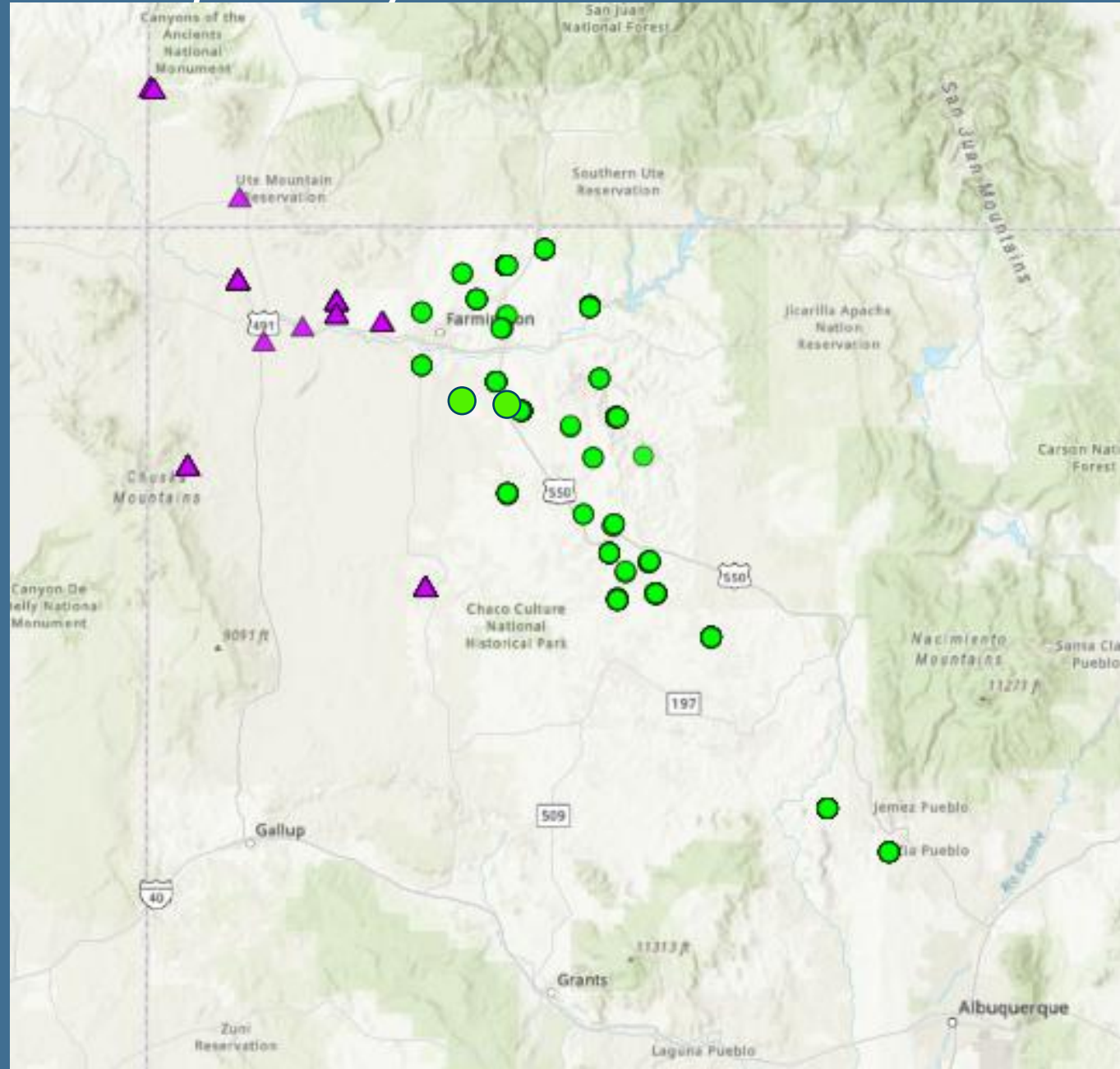
# *Sclerocactus mesae-verdae*

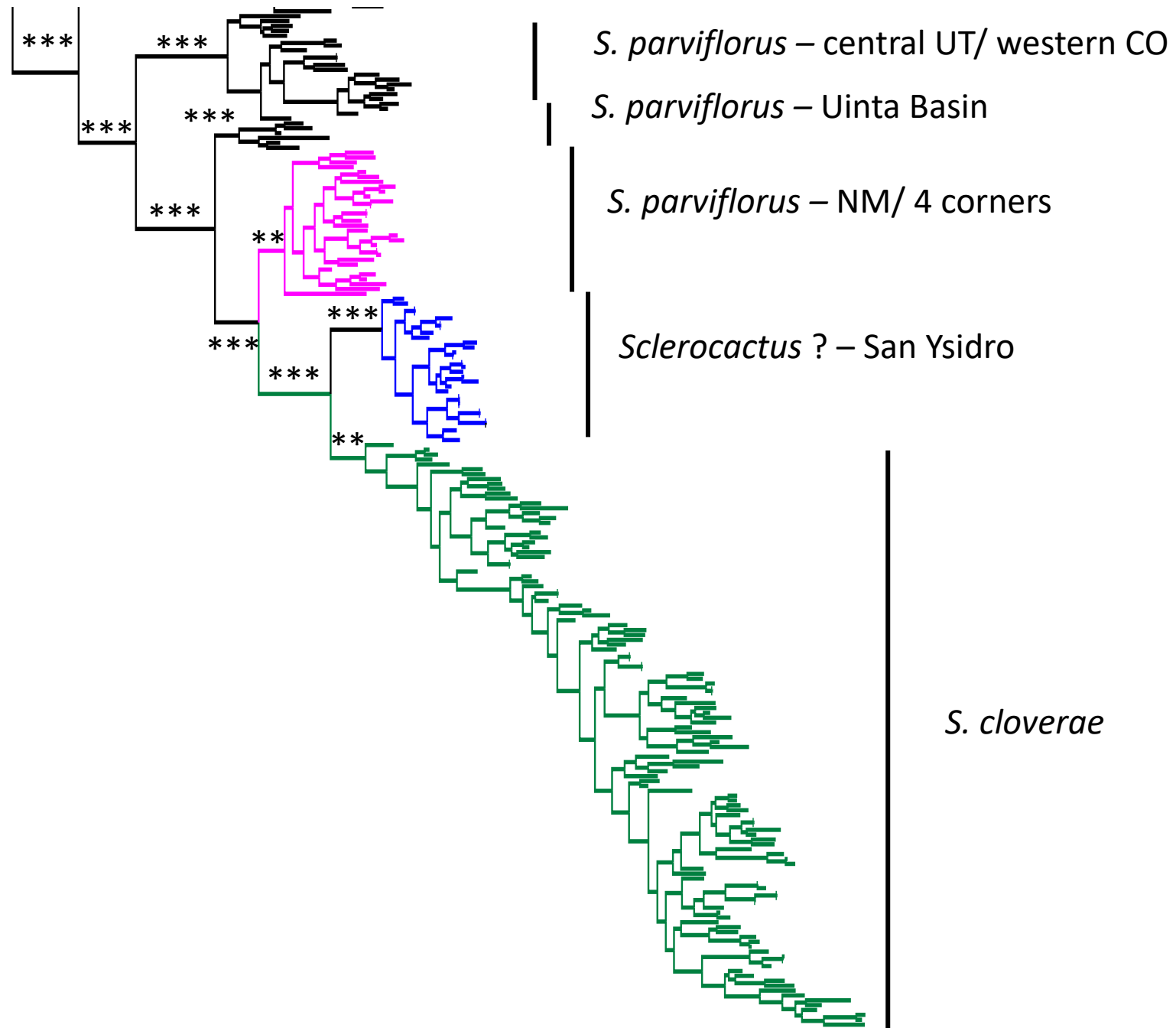
- 2-4 genetic groups
  - South – subsp. *despressus*
  - East – Hogback area
  - North – All sites north and west of Shiprock
- SAN populations are intermediate between North/South groups
- Genetic Diversity is moderate
- No sign of significant inbreeding
- Additional study of Chuska Mountains



# *Sclerocactus cloverae* and *S. parviflorus*

- *S. cloverae* – 22 populations
- *S. parviflorus* – 12 populations
- Uncertain assignment of southern *S. cloverae* populations (San Ysidro)
- Uncertain assignment of western *S. cloverae* populations (Hogback)





Bootstrap Values

\*\*\* - 99+%

\*\* - 95+%

9.0E-4



# STRUCTURE ANALYSIS (K=3)



*Sclerocatus?*  
San Ysidro

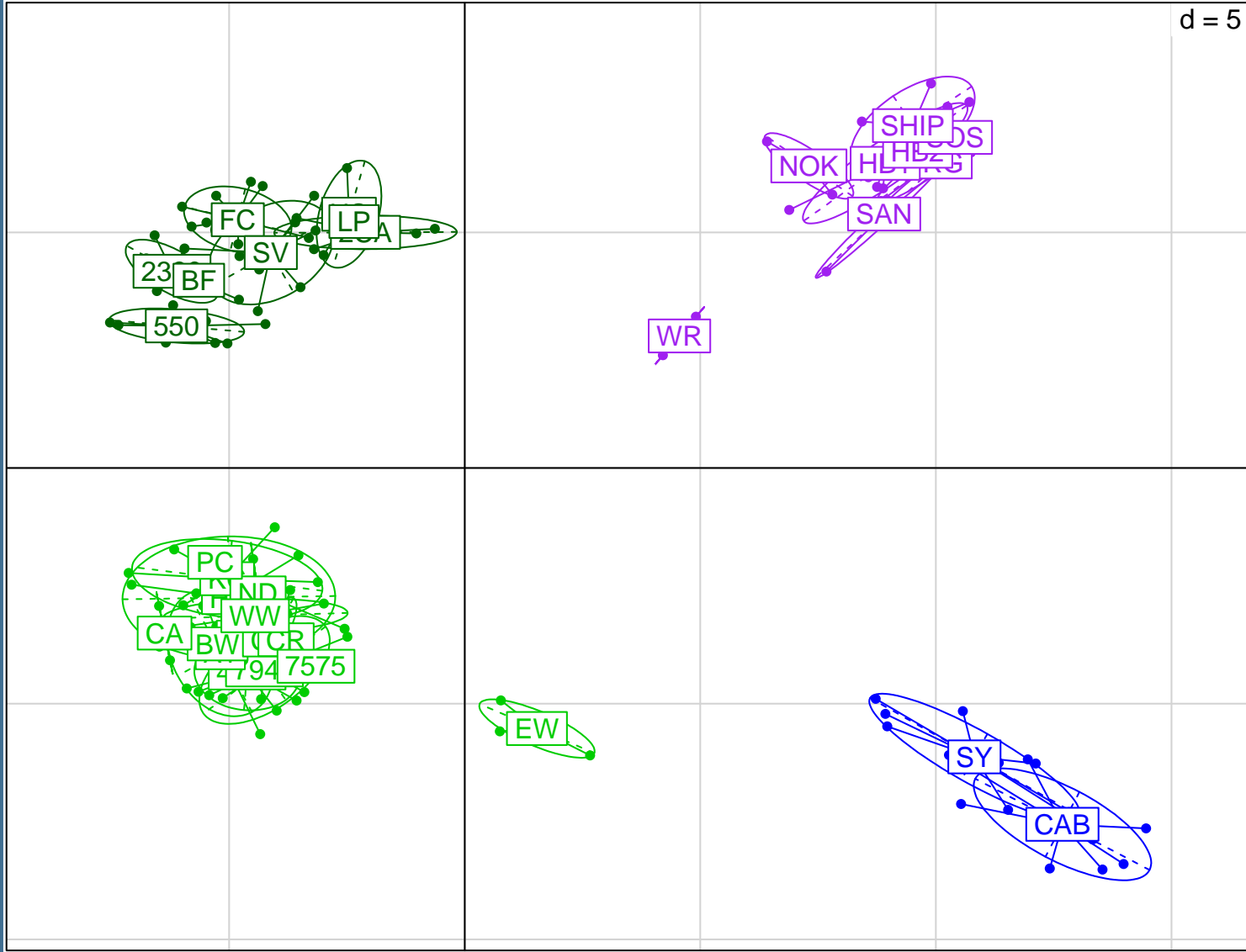
*S. cloverae*  
South -> North -> West

*S. parviflorus*  
East -> West

# Principle Coordinate Analysis

d = 5

Axis 2 – 7.0%



Axis 1 – 13.1%

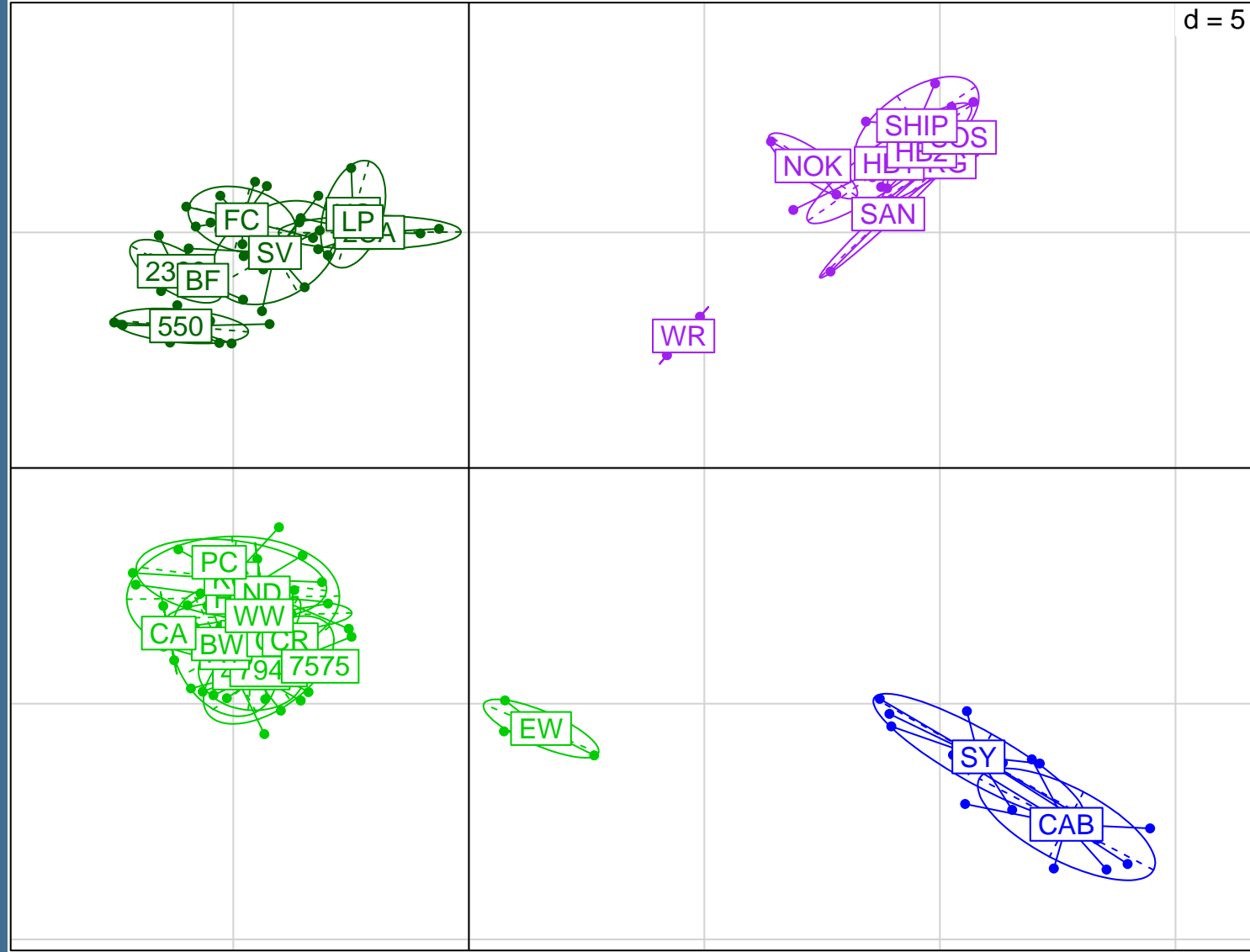
## Genetic Distance Among Populations

	San Ysidro	SCCL South	SCCL North	SCPA
San Ysidro	0.09			
SCCL South	0.41	0.08		
SCCL North	0.45	0.21	0.14	
SCPA	0.38	0.32	0.31	0.07

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d = 5

Axis 2 – 7.0%



Axis 1 – 13.1%

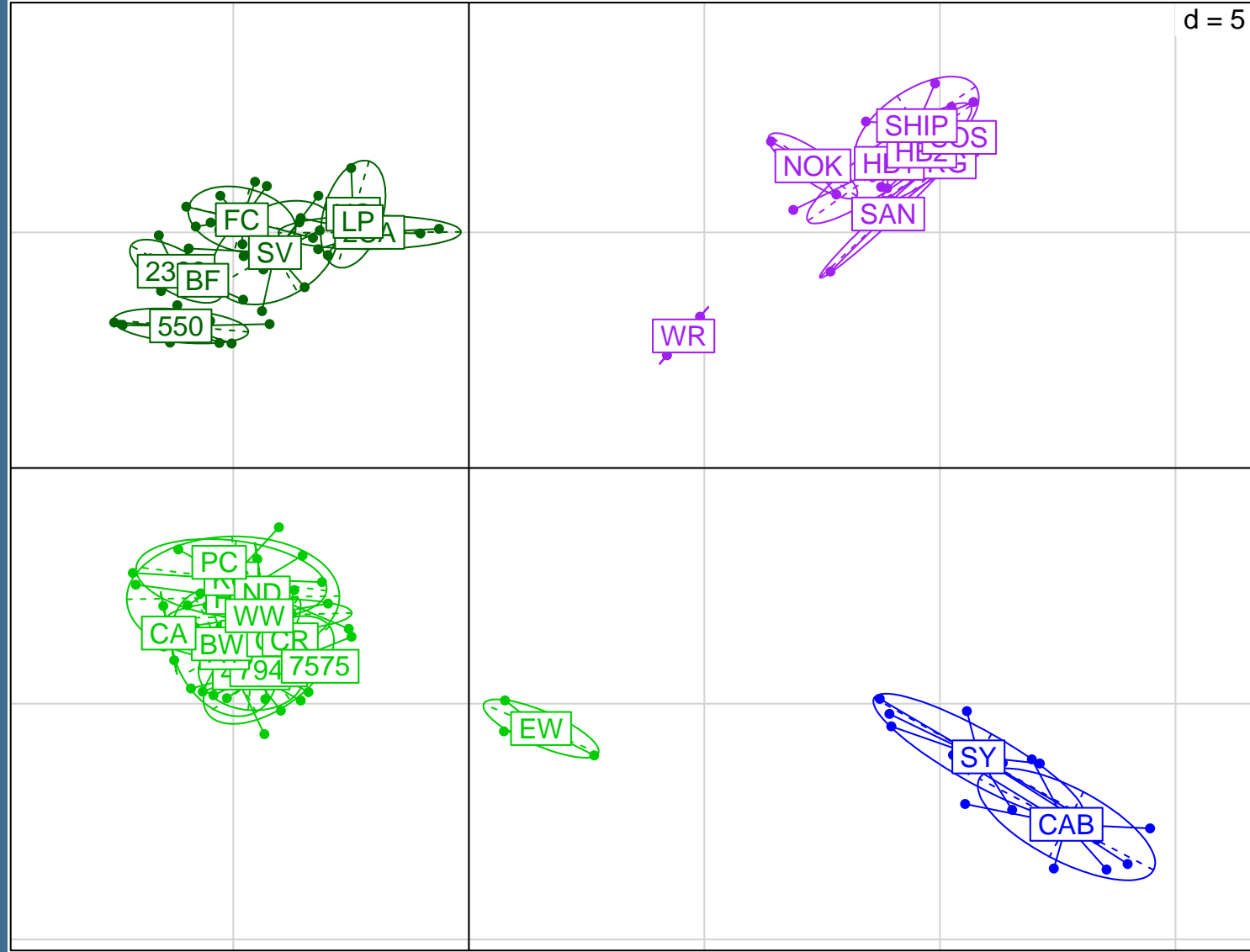
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# Principle Coordinate Analysis

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Axis 2 – 7.0%



Axis 1 – 13.1%

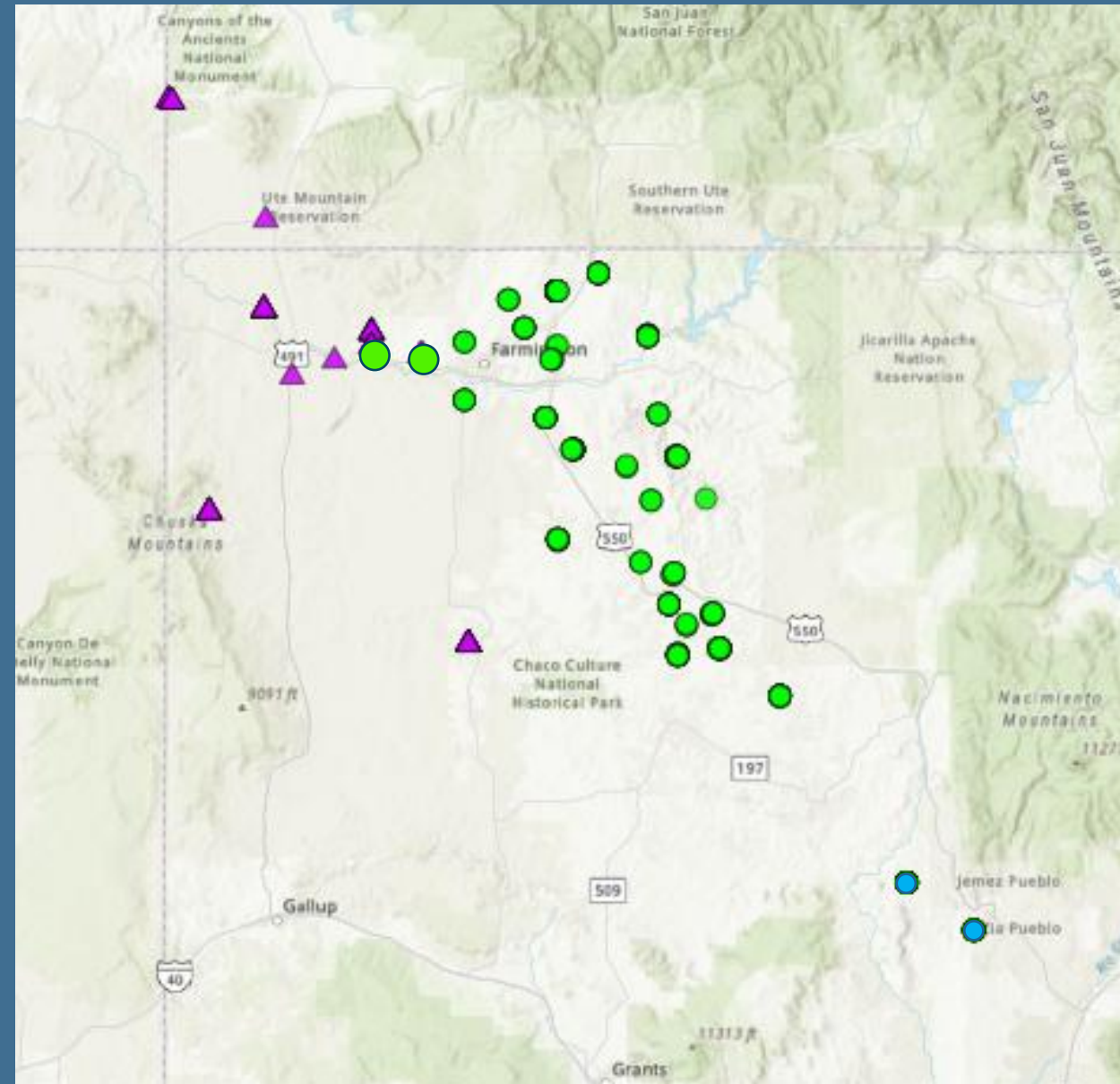
## Genetic Distance Among Populations

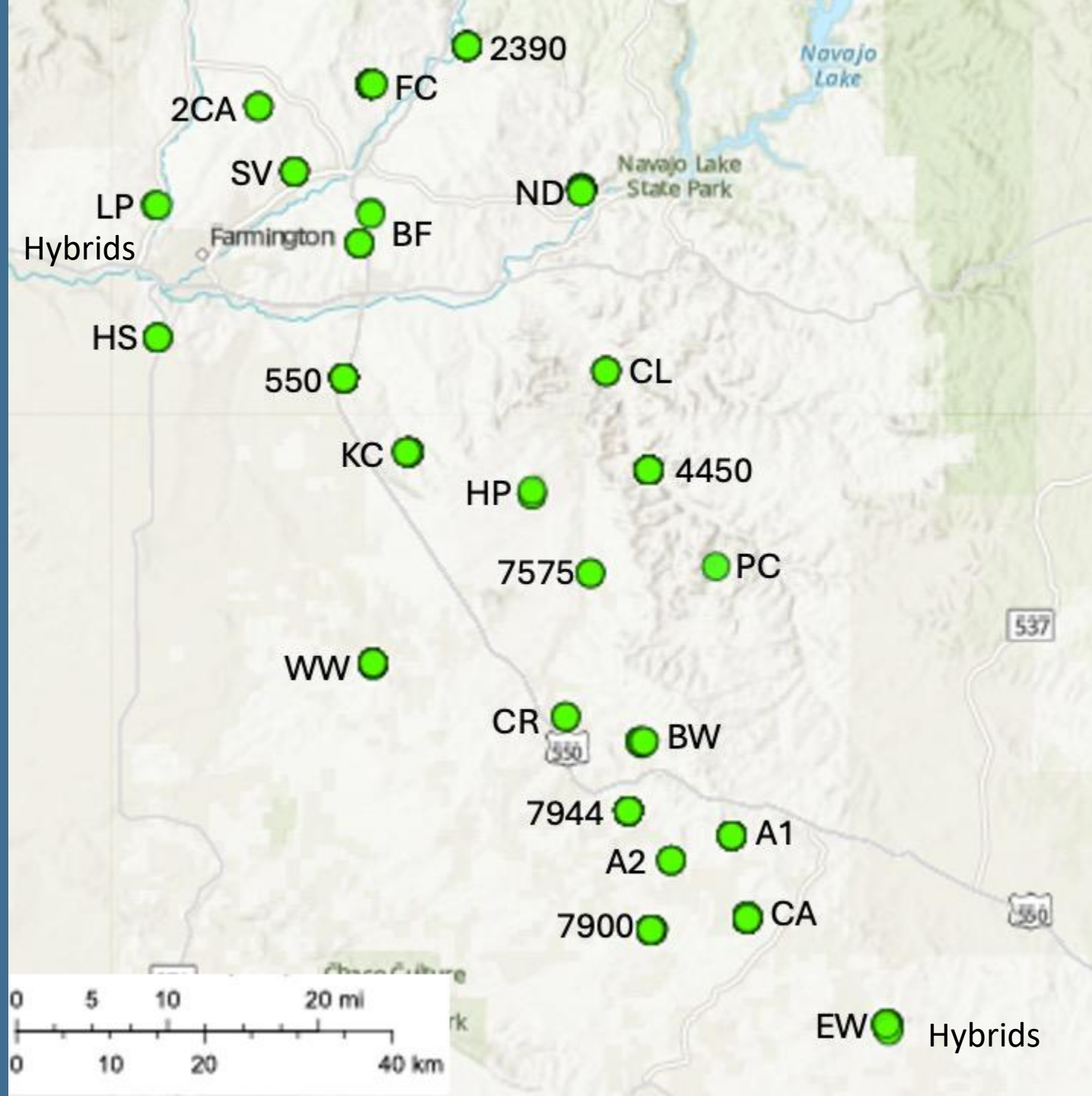
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Fst > 0.25 among species for *Sclerocactus*

# *Sclerocactus cloverae* and *S. parviflorus*

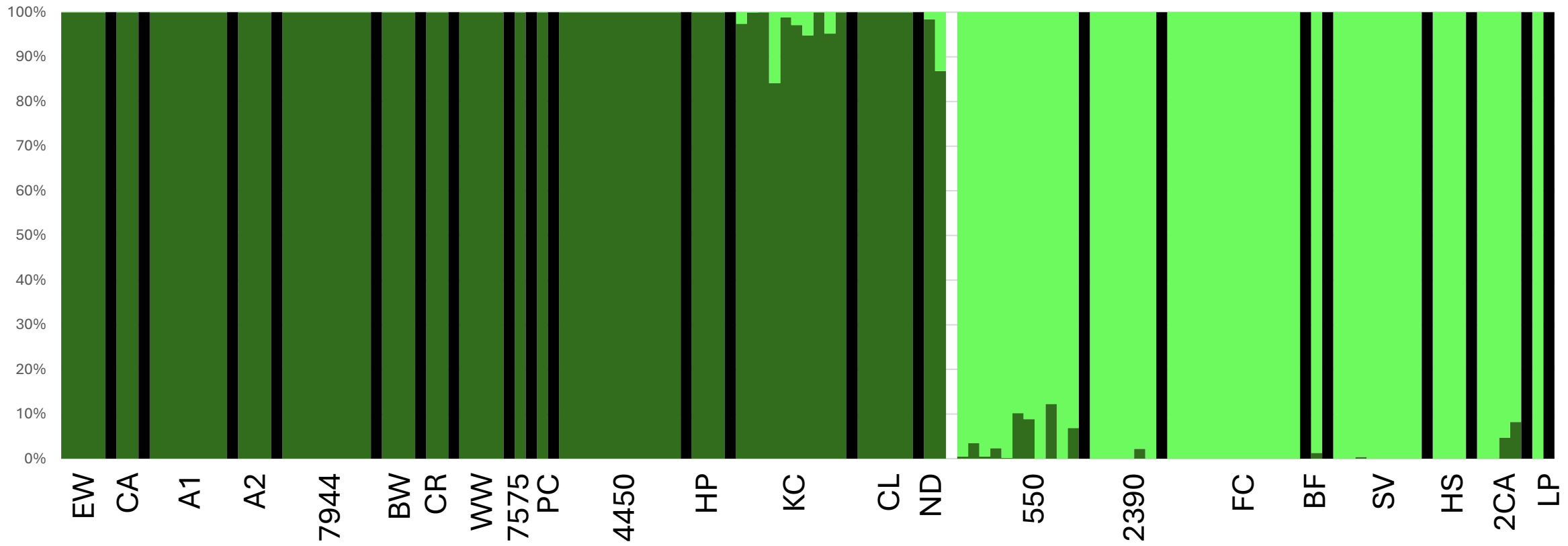
- *S. cloverae* – 22 populations
- *S. parviflorus* – 10 populations
- *Sclerocactus* ? / San Ysidro – 2 populations



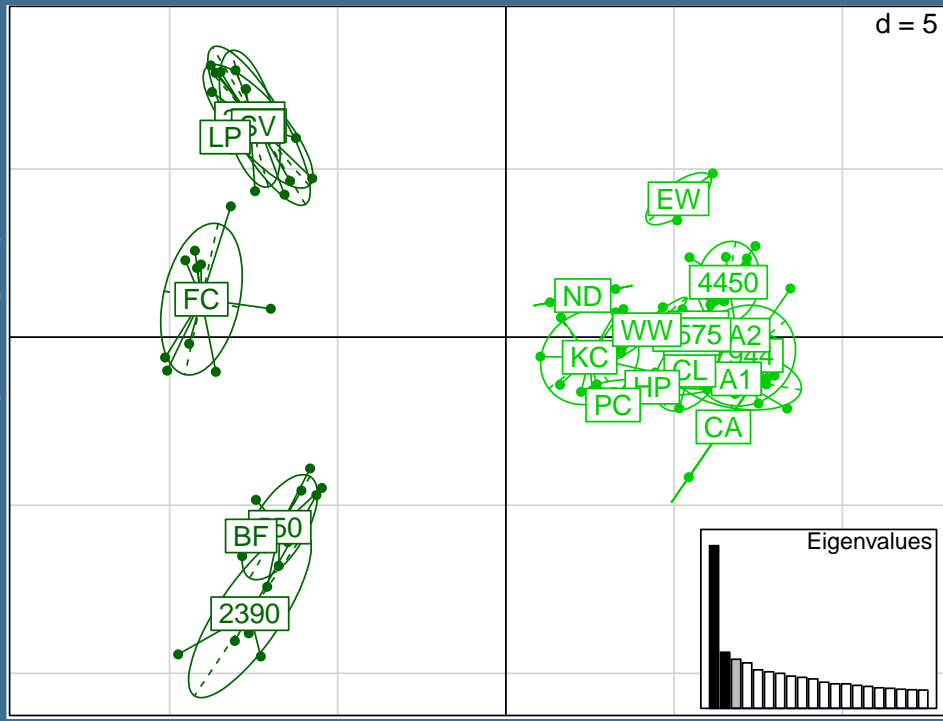
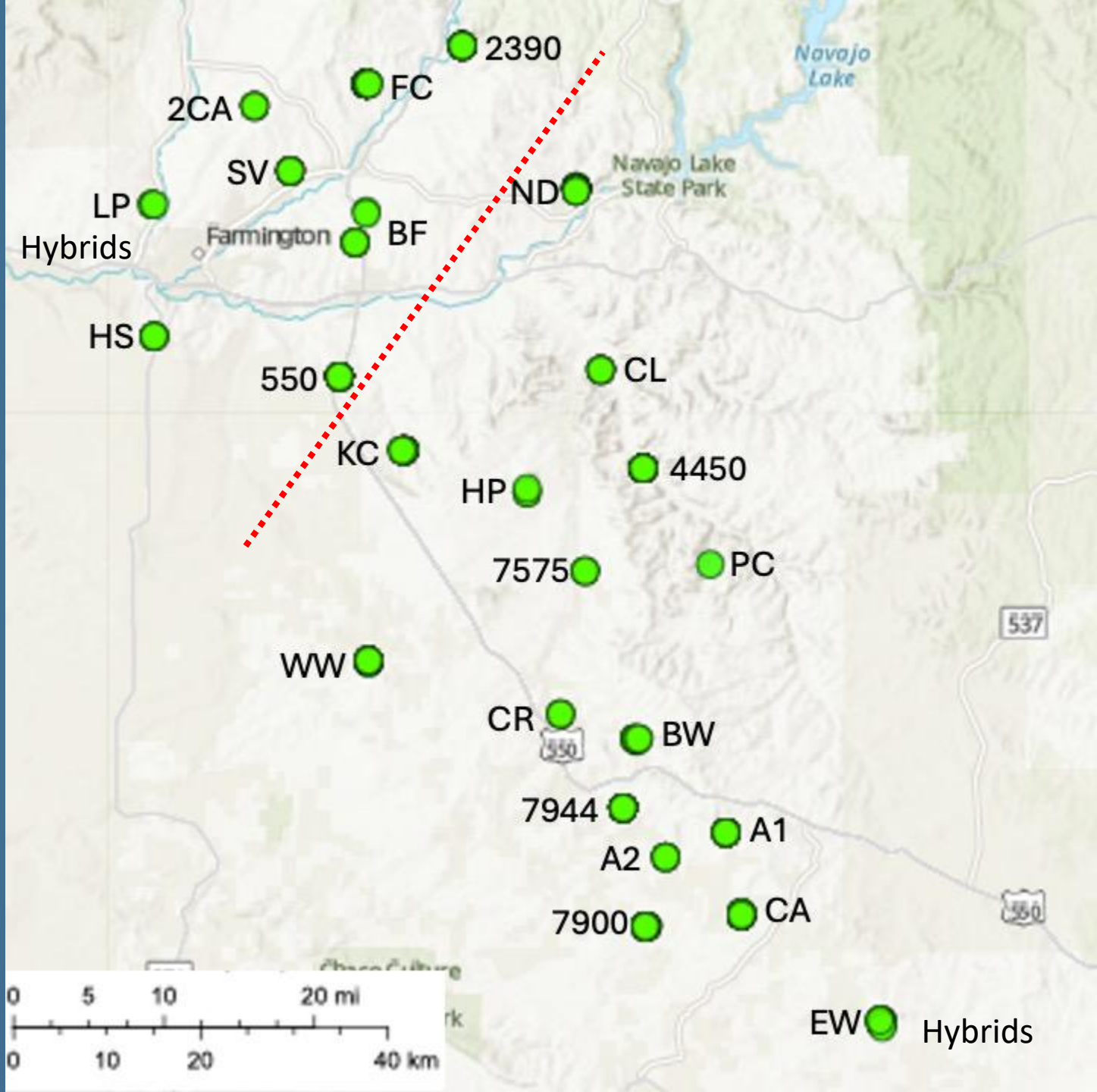


South

North



Pop	N	Ho	He	Fis
A1	7	0.363	0.371	0.02
7944	8	0.343	0.356	0.04
4450	11	0.284	0.29	0.02
KC	10	0.263	0.283	0.07
CL	5	0.367	0.377	0.03
550	11	0.241	0.258	0.07
2390	6	0.354	0.365	0.03
FC	12	0.25	0.265	0.06
SV	8	0.356	0.36	0.01



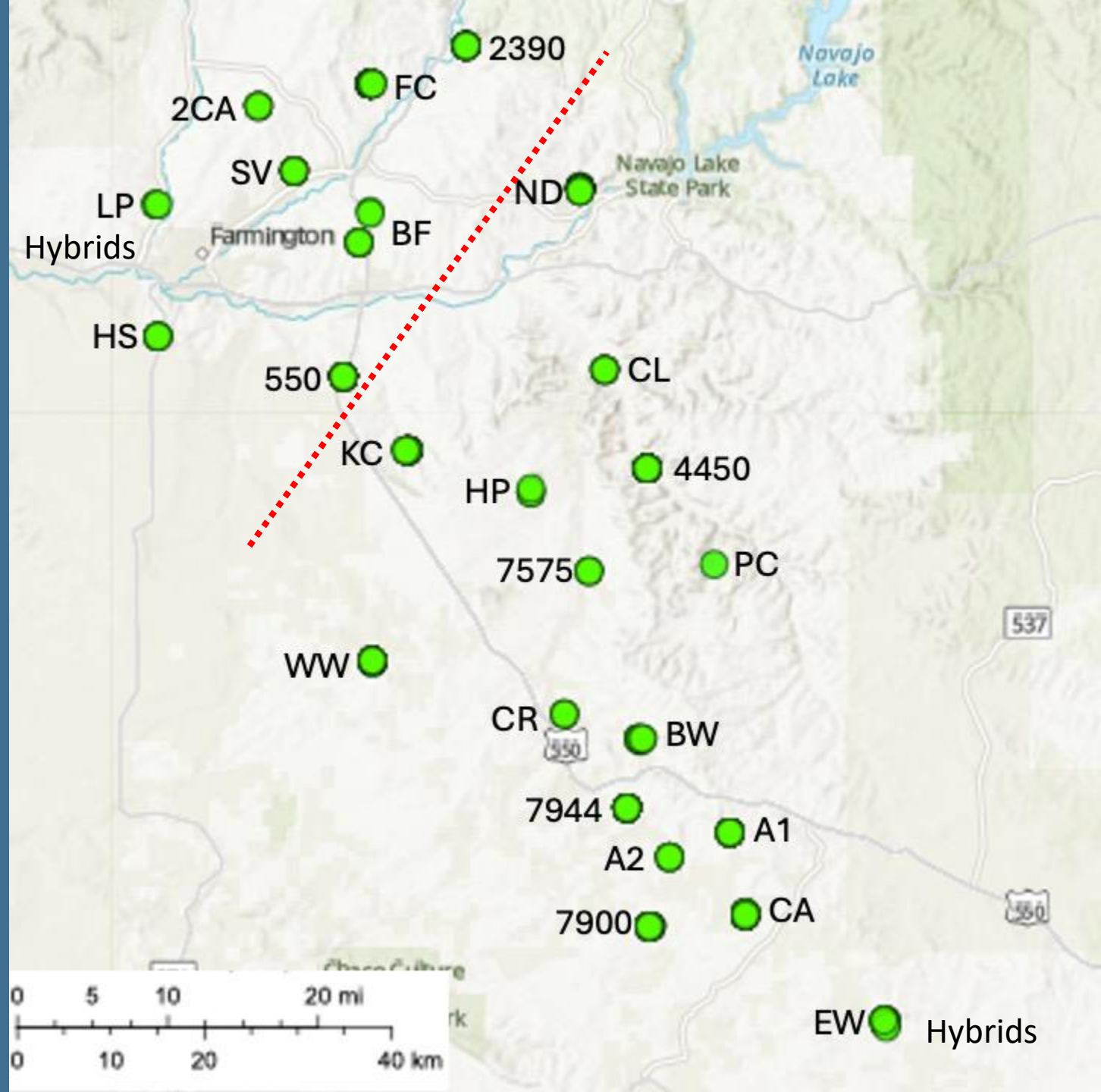
Axis 1 – 9.5%

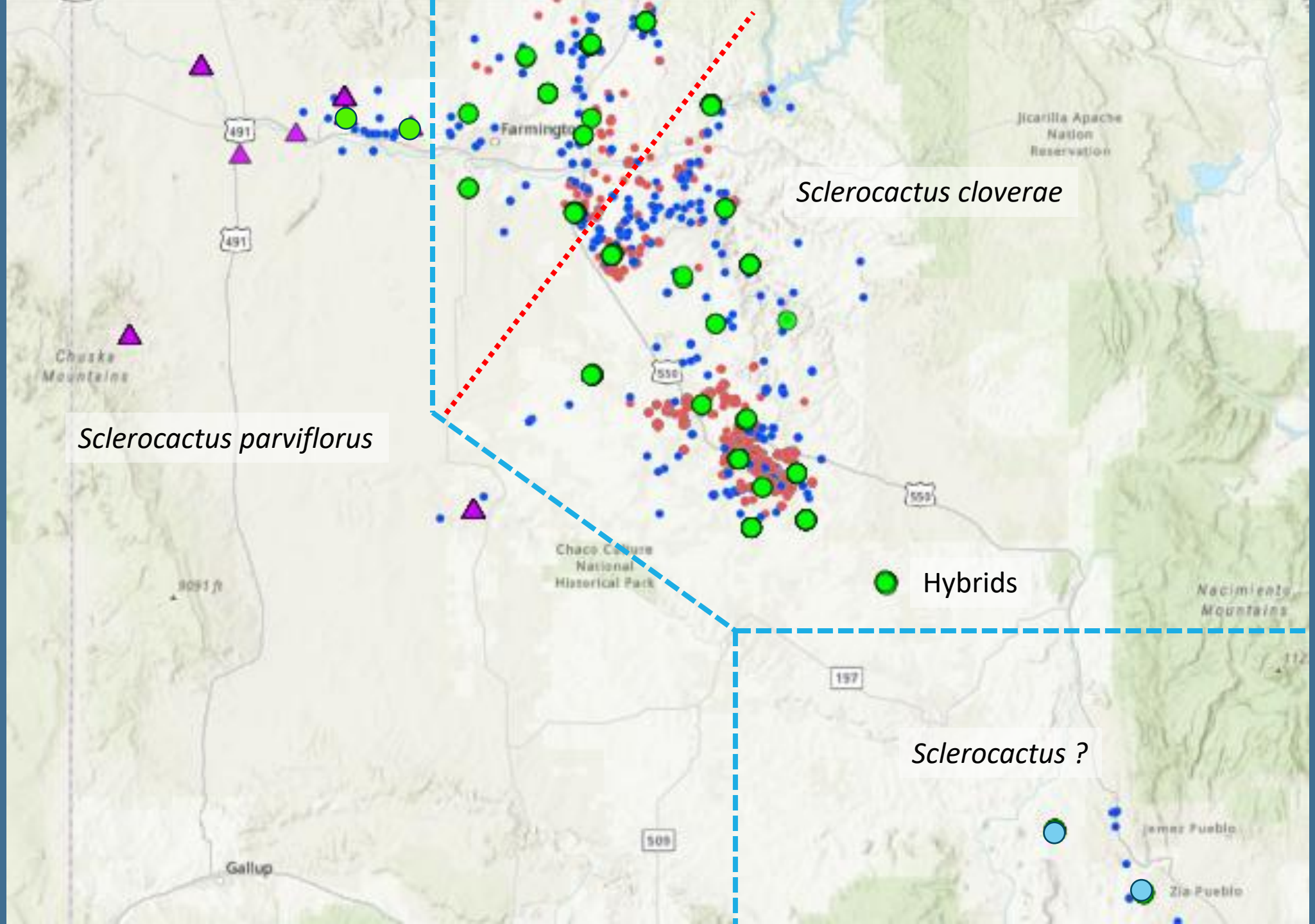
Axis 2 – 3.2%



# *Sclerocactus cloverae*

- 2 genetic groups
  - North
  - South
- Limited mixing between groups
- Genetic Diversity is moderate
- No sign of significant inbreeding
- Additional samples being added to the dataset – 7900, CA, ND, BF





*Sclerocactus parviflorus*

*Sclerocactus cloverae*

● Hybrids

*Sclerocactus ?*

# Conclusions

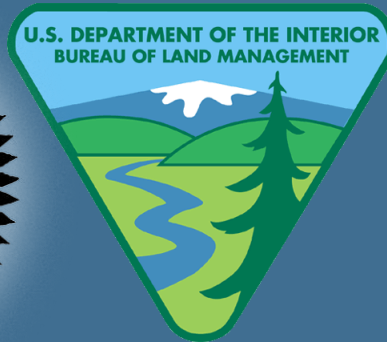
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- Genetic data is useful in determining species boundaries within *Sclerocactus*
- Some of the previously describe morphological variability within species is due to differences among groups
- Genetic health within populations is good
- Managers should maintain the genetic groups as management units

# Funding



# Permits and Localities



# Questions?

