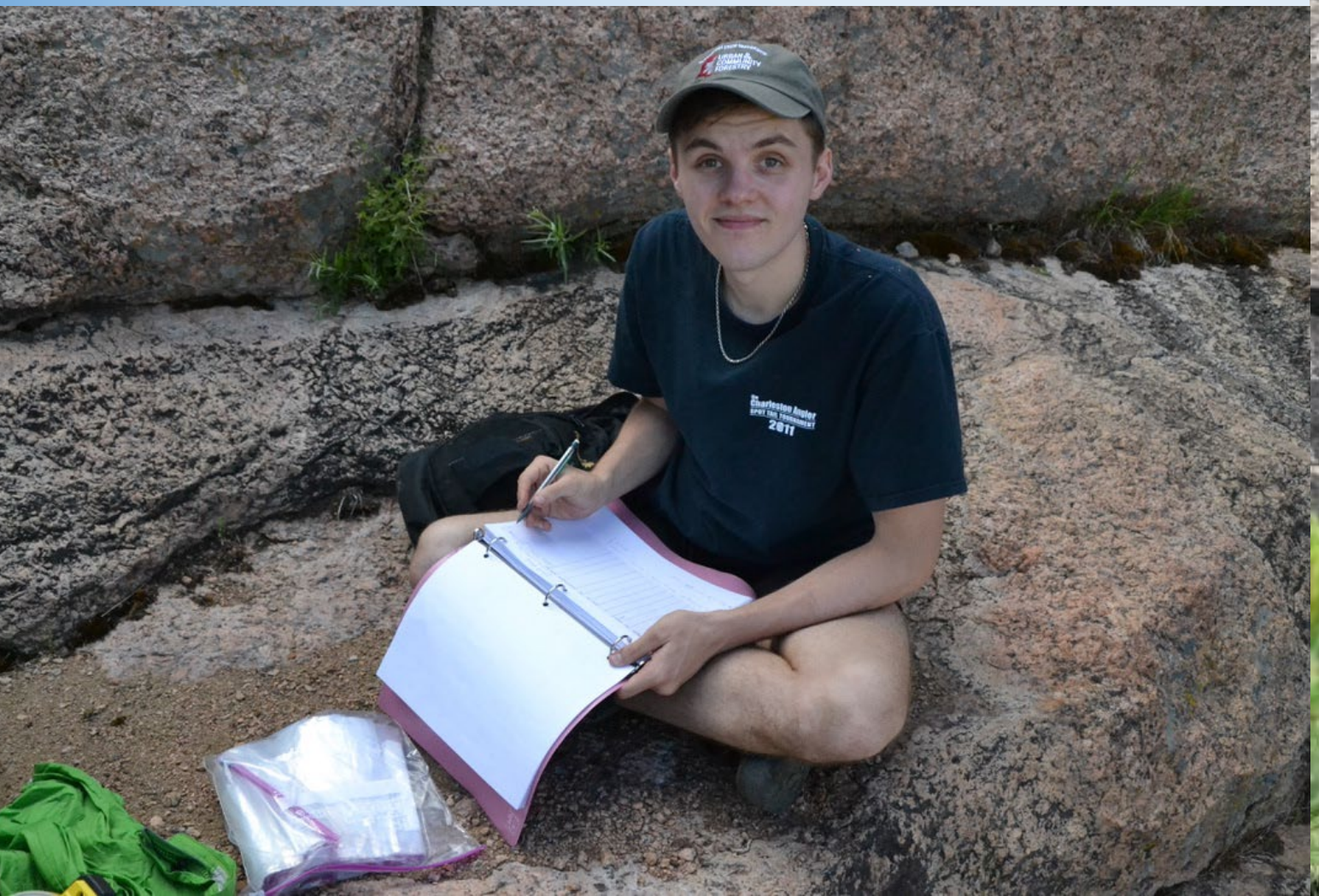
Genetic Updates for *Mimulus gemmiparus, Penstemon acaulis,* and *P. yampaensis*

Mit McGlaughlin

University of Northern Colorado

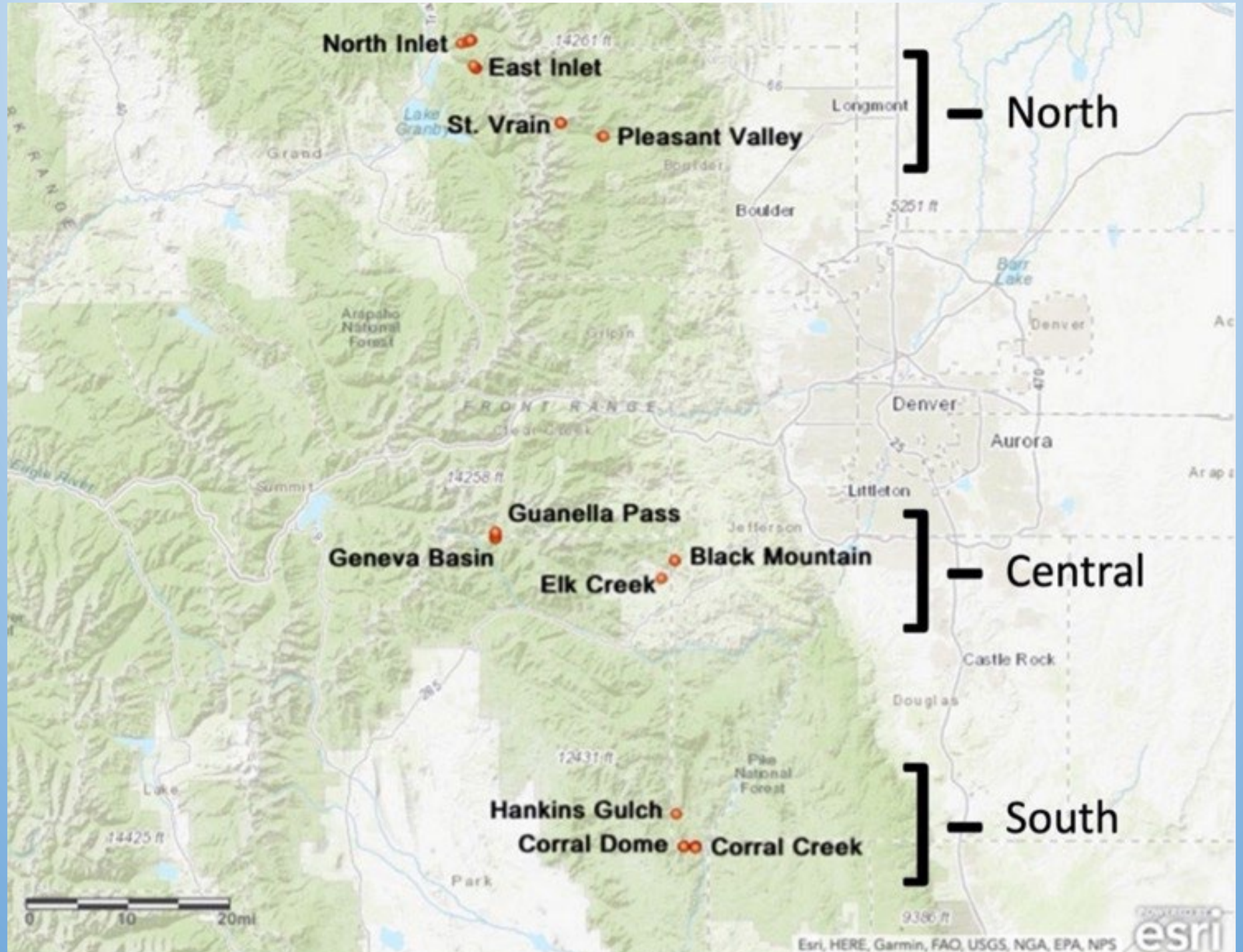
Genetic analysis of the rare, Colorado endemic *Mimulus gemmiparus* (Rocky Mountain Monkey Flower)

Branson Wetzstein



Mimulus gemmiparus - Rocky Mountain Monkey Flower

- Formally treated as *Erythranthe gemmipara* (W.A. Weber) G.L. Nesom & N.S. Fraga (Phrymaceae)
- Colorado endemic plant which possesses a limited range, strict habitat requirement, and unique life history
- 11 known natural populations


North Inlet
East Inlet
St. Vrain
Pleasant Valley
Longmont
North
Boulder
Denver
Aurora
Littleton
Guanella Pass
Geneva Basin
Black Mountain
Elk Creek
Central
Castle Rock
Hankins Gulch
Corral Dome
Corral Creek
South
0
10
20mi
Esri, HERE, Garmin, FAO, USGS, NGA, EPA, NPS

Brood Bulbil

- Asexually produced plantlet -> clonal spread
- Acts similarly to a seed – can over-winter and grow into a new plant
- New plant will be genetically identical to the plant it formed on
- New sites could be founded with a single bulbil
- Concerns about genetic bottlenecks and lack of adaptation

Study Aims

Q1. Does *M. gemmiparus* exhibit clonal spread?

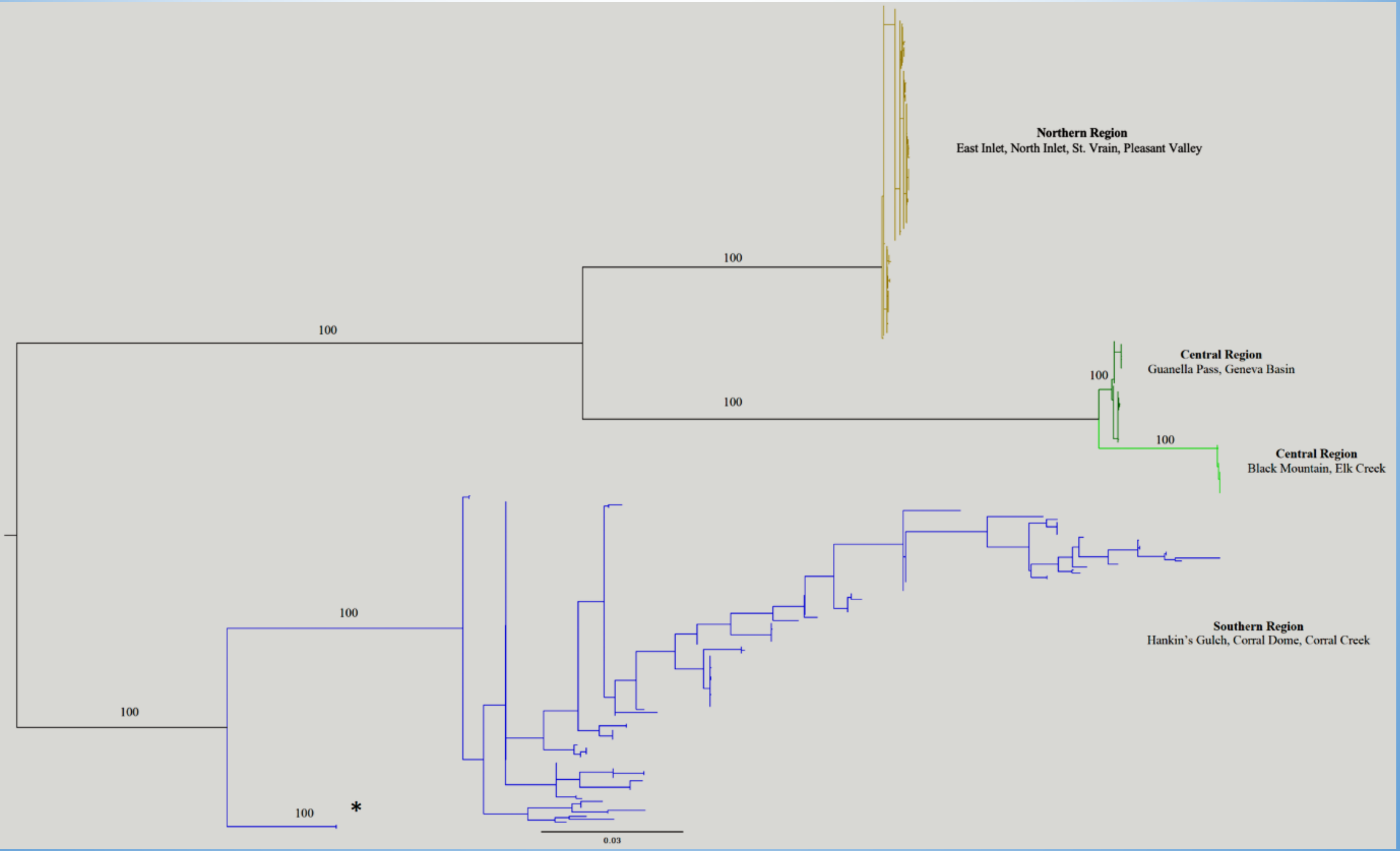
Q2. Is there evidence of inbreeding within populations and patches?

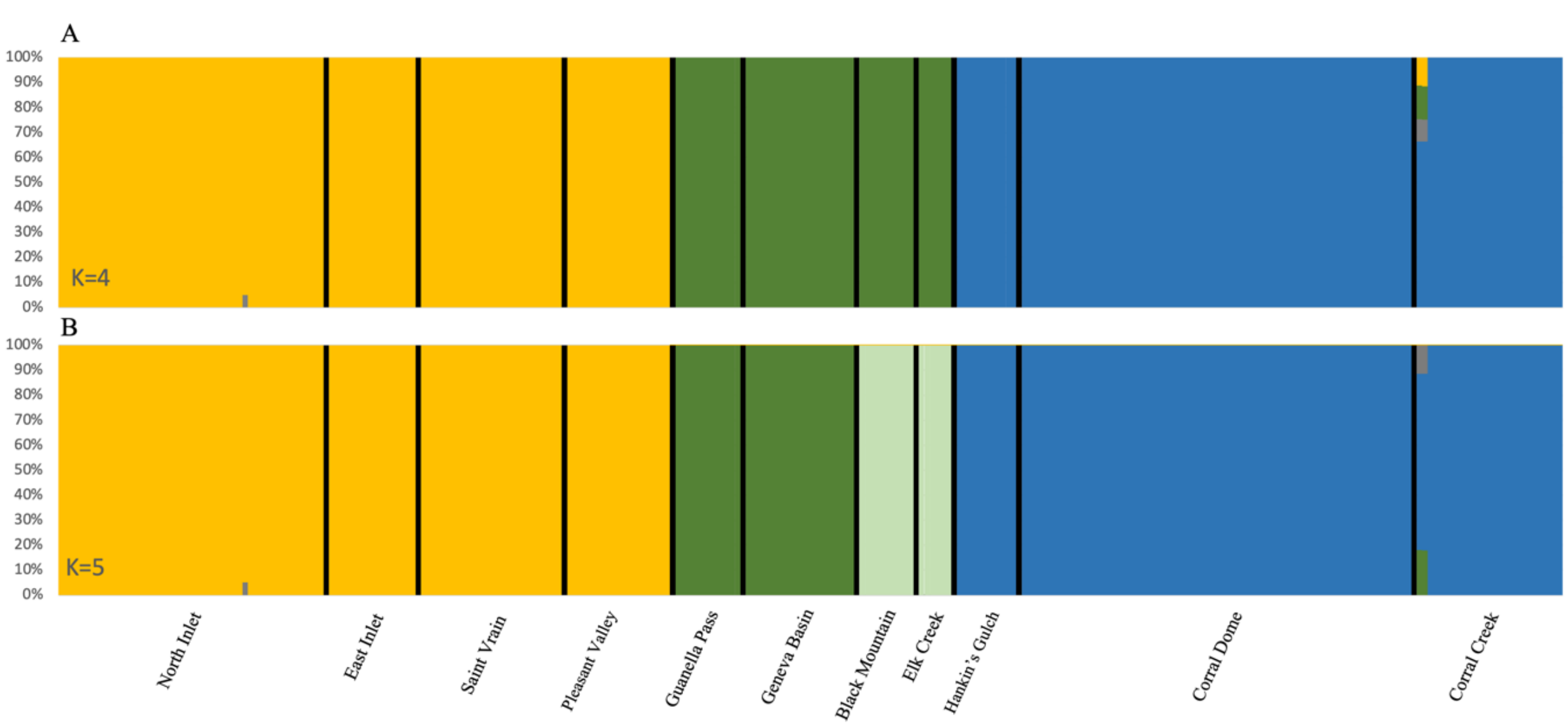
Q3. What is the level of genetic diversity contained within patches and populations composed of multiple patches?

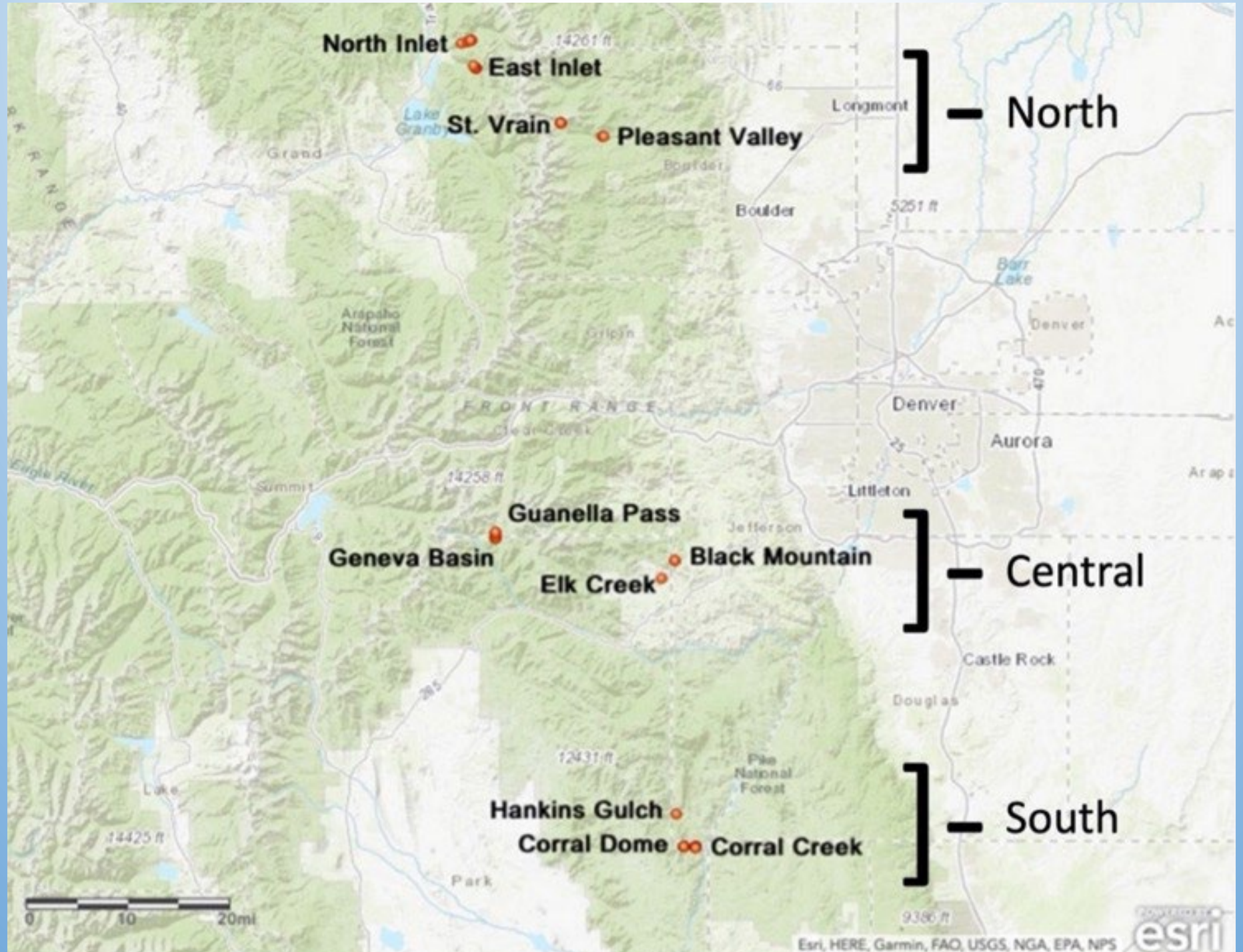
Q4. How is genetic diversity partitioned across the range of *M. gemmiparus* and should different regions be treated as separate management units?

Population	N[1]	# of Clones	Clone ID[2]	$E_{genotypes}$[3]	H_N[4]	H_S[5]
North Inlet	51	2	1, 2	1.040	0.039	0.069
East Inlet	16	1	1	1	0	0
Saint Vrain	27	1	1	1	0	0
Pleasant Valley	19	1	1	1	0	0
Guanella Pass	13	1	3	1	0	0
Geneva Basin	22	1	3	1	0	0
Black Mountain	12	1	4	1	0	0
Elk Creek	5	1	4	1	0	0
Hankin's Gulch	12	1	28	1	0	0
Corral Dome	74	26	6 - 25, 28 - 33	9.219	0.904	1.327
Corral Creek	27	4	5, 26, 27, 28	1.602	0.390	0.380
Total	278	33	Average	1.806	0.121	0.161

1 – N, total number of samples; 2 - Clone ID, specific clone found; 3 - $E_{genotypes}$, effective number of genotypes; 4 - H_N, Nei's corrected genetic diversity, and 5 - H_S, Shannon index corrected for sample size


Northern Region
East Inlet, North Inlet, St. Vrain, Pleasant Valley
Central Region
Guanella Pass, Geneva Basin
Central Region
Black Mountain, Elk Creek
Southern Region
Hankin's Gulch, Corral Dome, Corral Creek
100
100
100
100
100
100
100
100
*
0.03


A
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
K=4
B
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
K=5
North Inlet
East Inlet
Saint Vrain
Pleasant Valley
Guanella Pass
Geneva Basin
Black Mountain
Elk Creek
Hankin's Gulch
Corral Dome
Corral Creek


North Inlet
East Inlet
St. Vrain
Pleasant Valley
Longmont
North
Boulder
Denver
Aurora
Littleton
Guanella Pass
Geneva Basin
Black Mountain
Elk Creek
Central
Castle Rock
Hankins Gulch
Corral Dome
Corral Creek
South
0
10
20mi
Esri, HERE, Garmin, FAO, USGS, NGA, EPA, NPS

Conclusions

Q1. Does *M. gemmiparus* exhibit clonal spread?

- Strict clonal spread was observed

- No evidence of sexual reproduction

Q2. Is there evidence of inbreeding within populations and patches?

- No evidence of inbreeding because there is no sexual reproduction

Conclusions

Q3. What is the level of genetic diversity contained within patches and populations composed of multiple patches?

- Most populations are composed of a single clone (8) or each patch is a distinct clone (1)
- Only Corral Dome had multiple clones within patches (all)
- Genetic diversity is distributed very unevenly, with only the South having measurable amounts of genetic diversity

Conclusions

Q4. How is genetic diversity partitioned across the range of *M. gemmiparus* and should different regions be treated as separate management units?

- Strong regional structure
    - North – 4 populations, 2 observed clones, 1 clone rare
    - Central – 4 populations, 2 observed clones in 2 regions
    - South – 3 populations, 29 observed clones

Management Units

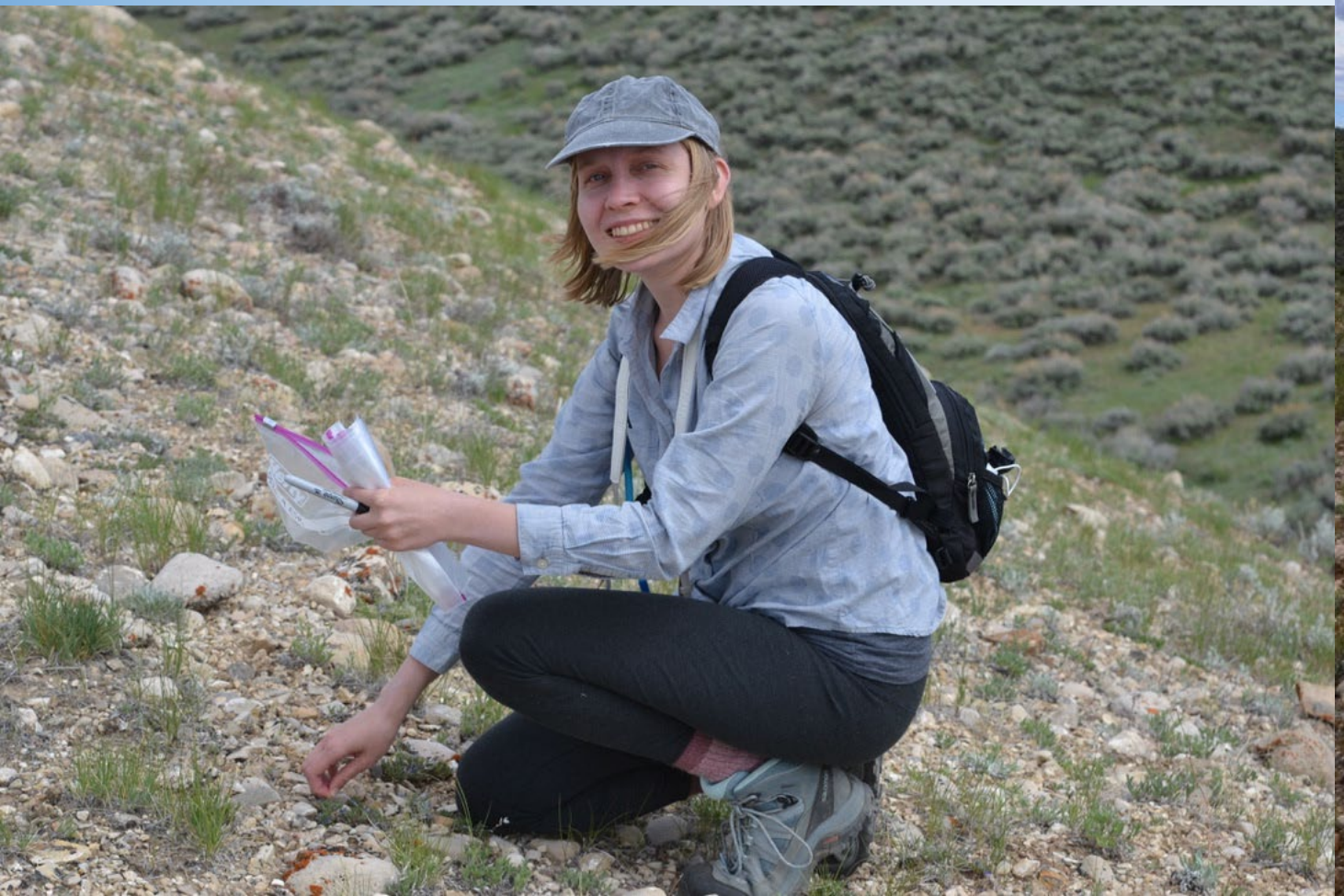
Population	Region	Manager
North Inlet	North	Rocky Mountain National Park
East Inlet		
Saint Vrain		Arapahoe-Roosevelt National Forest
Pleasant Valley		
Guanella Pass	Central[1]	Pike-San Isabel National Forest
Geneva Basin		
Black Mountain	Central[2]	Staunton State Park
Elk Creek		
Hankin's Gulch	South	Pike-San Isabel National Forest
Corral Dome		
Corral Creek		

Conservation Recommendations

- *Mimulus gemmiparus* should be reconsidered for listing under the ESA –> previous determination relied heavily on number of stems
- The entire species is composed of ~33 genetic individuals
- Lack of diversity = lack of adaptability
- Substantial disturbance at a single site, Corral Dome, could lead to the loss of 79% of all known diversity
- Within regions, there is limited concern about moving plants from one site to another – e.g. all north is effectively identical
- All genetic diversity could be easily captured in cultivation

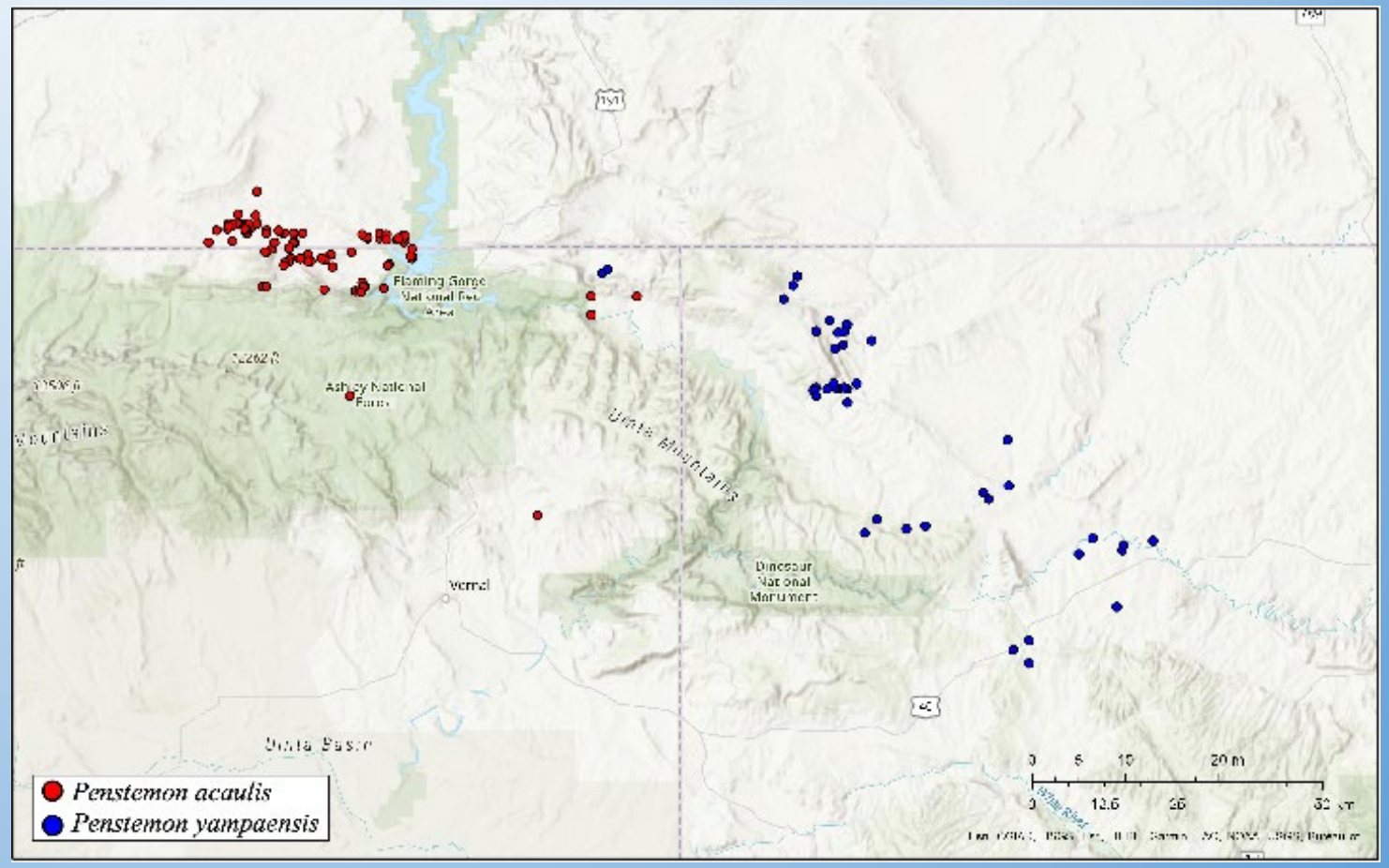
Understanding Species Boundaries Between *Penstemon acaulis* and *Penstemon yampaensis:* Implications for Conservation and Management

Juliet Simpson



Penstemon acaulis and *P. yampaensis*

- *P. acaulis* – endemic to NE Utah and SW Wyoming
- *P. yampaensis* - NW Colorado (Moffat County)
- Disagreements on which species to recognize and the specific distribution
- *P. acaulis* was a candidate for ESA listing (1990's)



P. acaulis

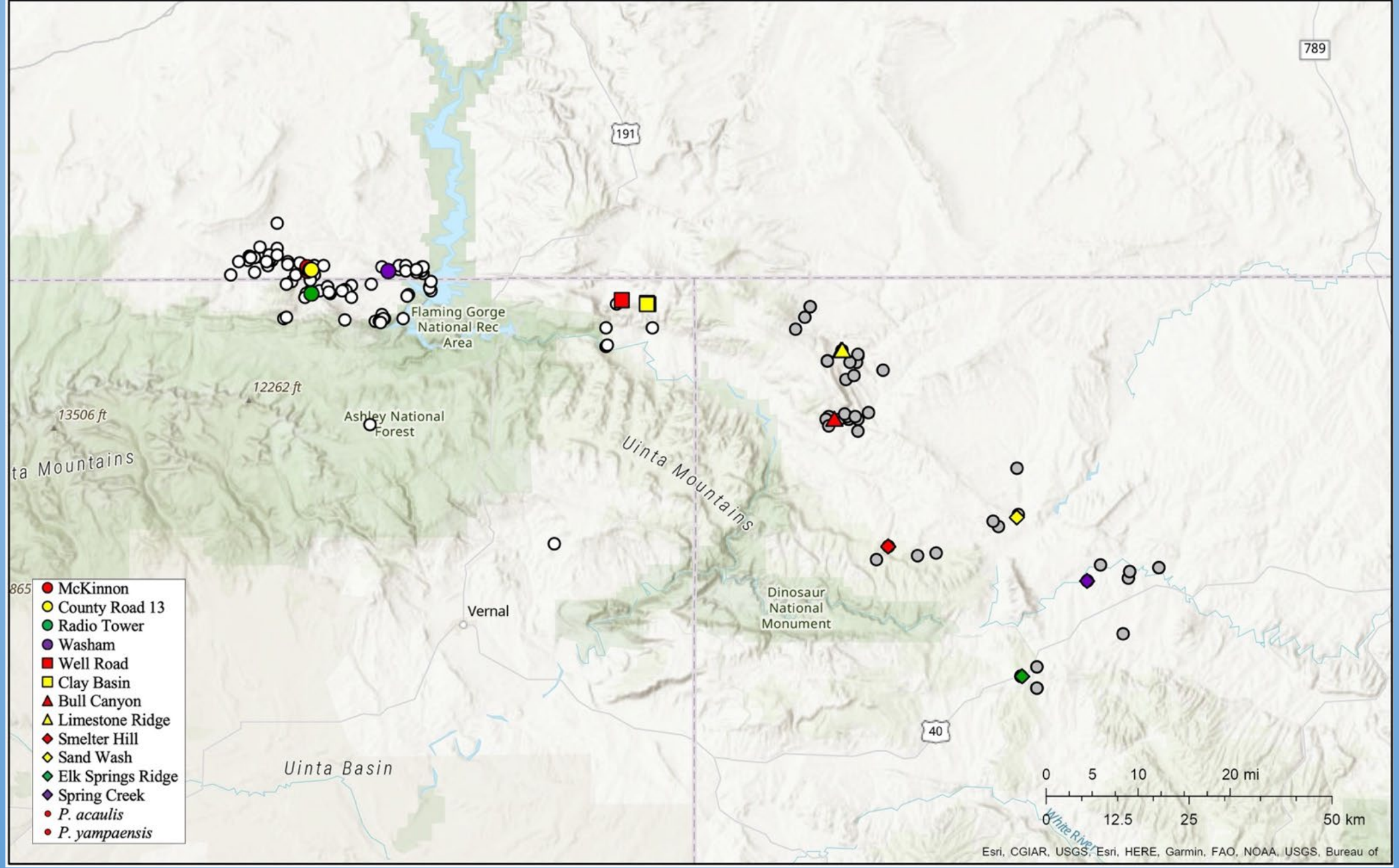
P. yampaensis

Study Aims

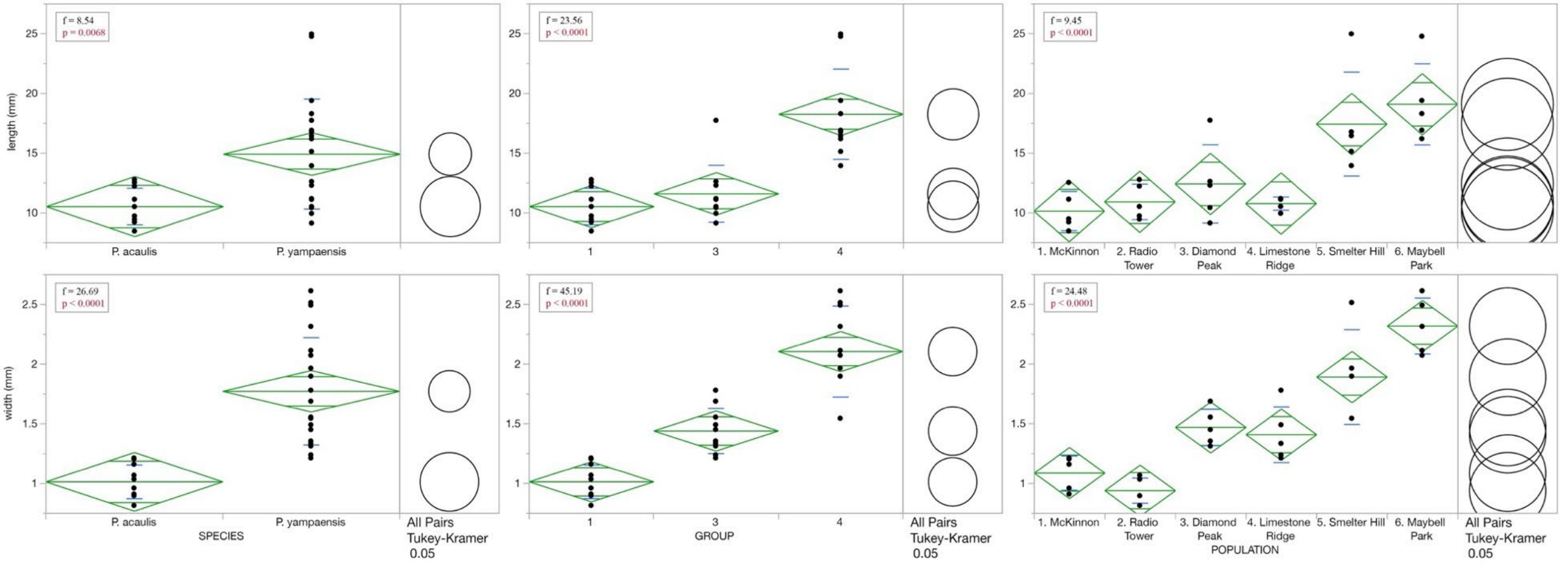
Q1. What is the genetic taxonomic placement of *P. yampaensis* and should it be recognized at the level of species distinct from *P. acaulis*?

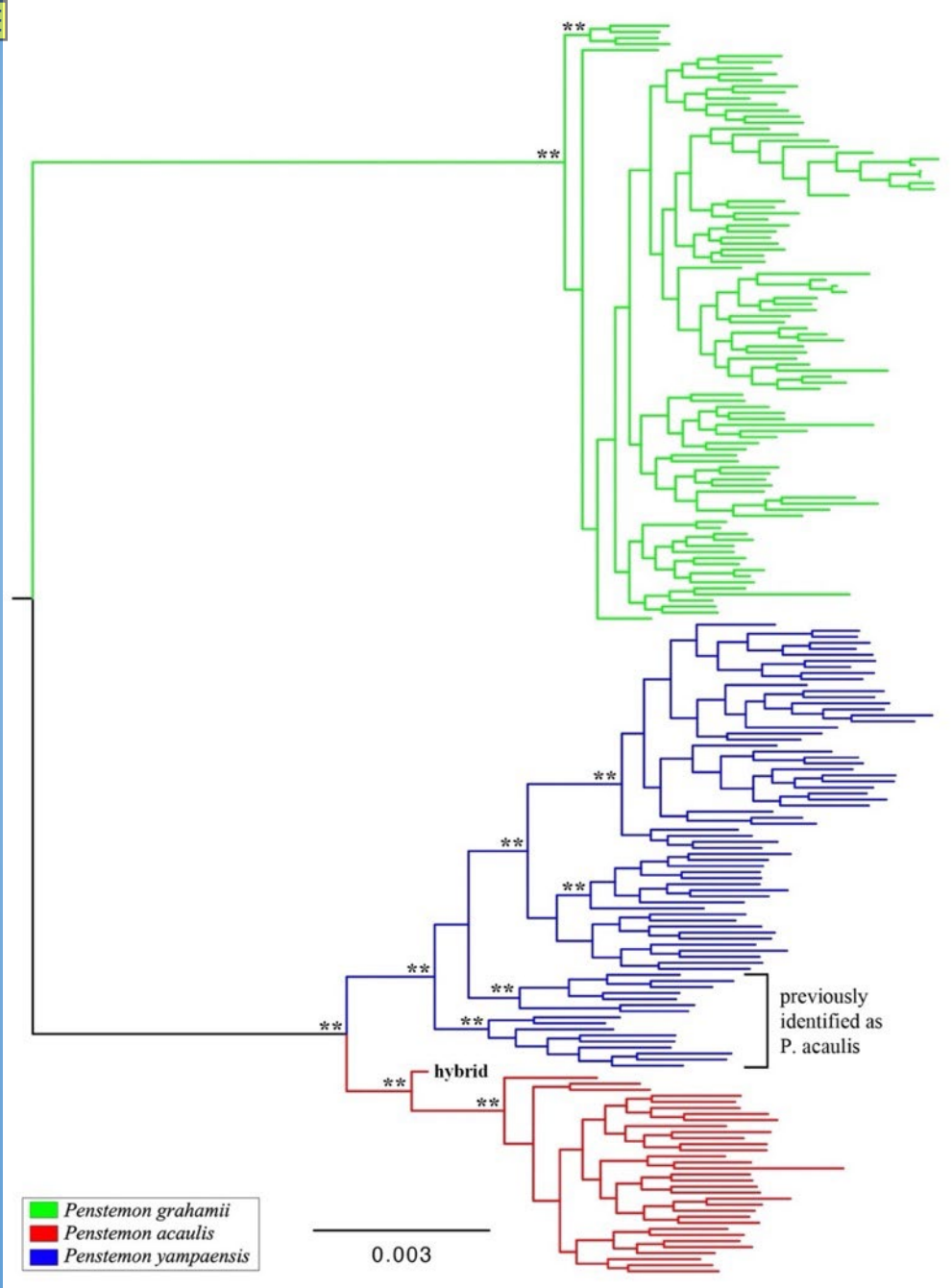
Q2. Is there evidence of hybridization among *P. yampaensis* and *P. acaulis*?

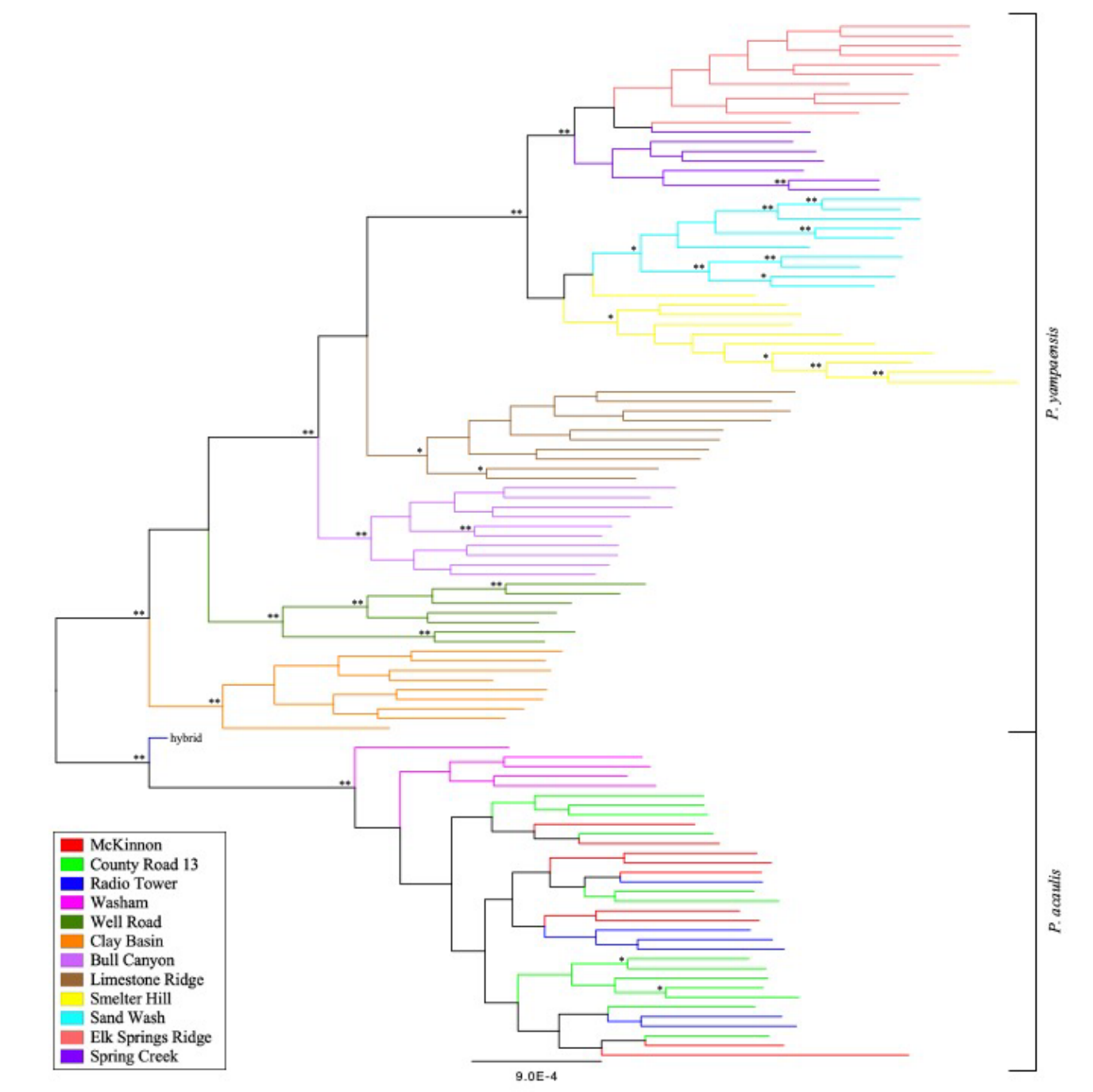
Q3. What is the genetic connectivity among populations within and among drainages?

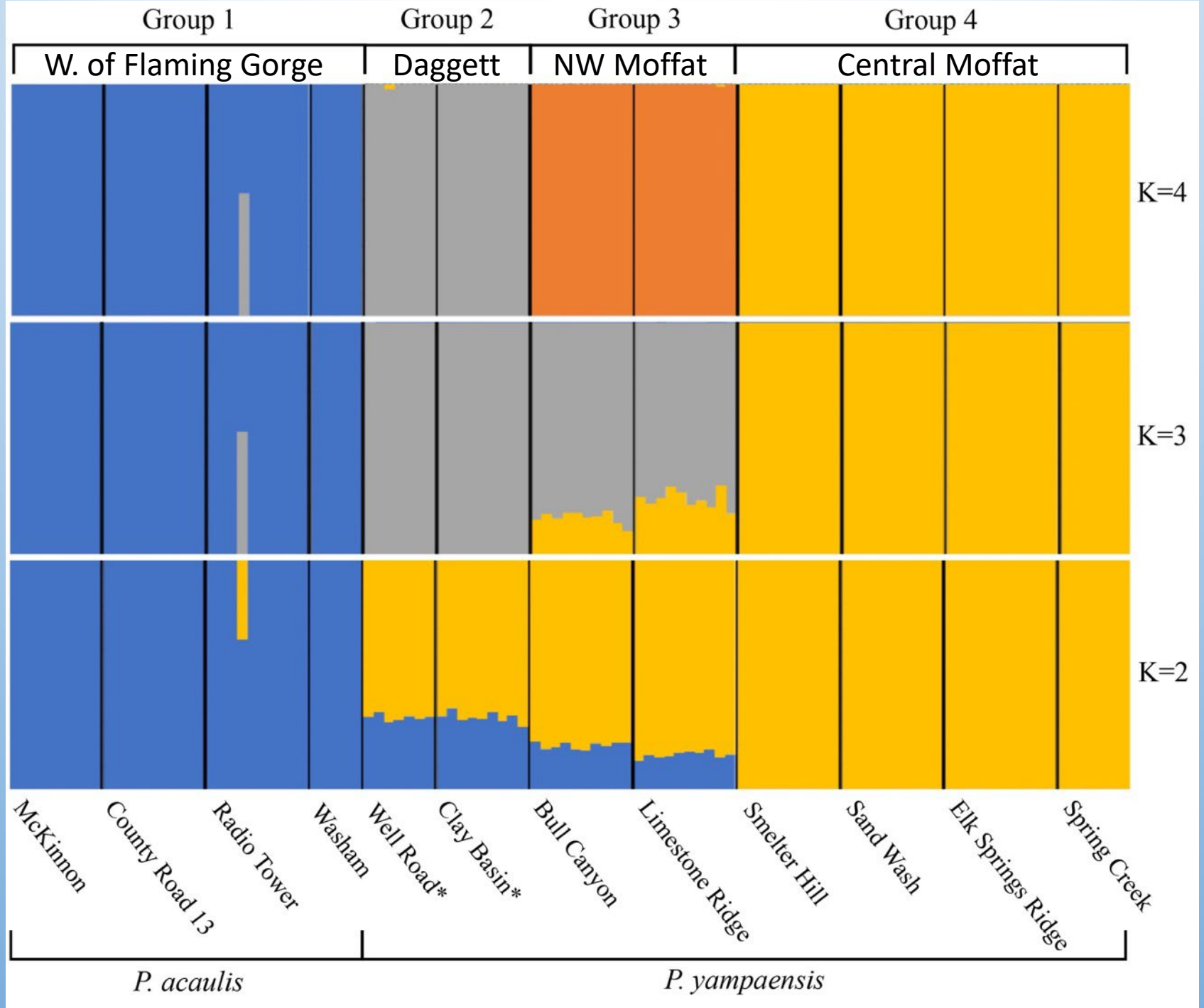

789
191
Flaming Gorge National Rec Area
12262 ft
13506 ft
Ashley National Forest
ta Mountains
Uinta Mountains
Vernal
Dinosaur National Monument
40
Uinta Basin
White River
McKinnon
County Road 13
Radio Tower
Washam
Well Road
Clay Basin
Bull Canyon
Limestone Ridge
Smelter Hill
Sand Wash
Elk Springs Ridge
Spring Creek
P. acaulis
P. yampaensis
0 5 10 20 mi
0 12.5 25 50 km
Esri, CGIAR, USGS, Esri, HERE, Garmin, FAO, NOAA, USGS, Bureau of

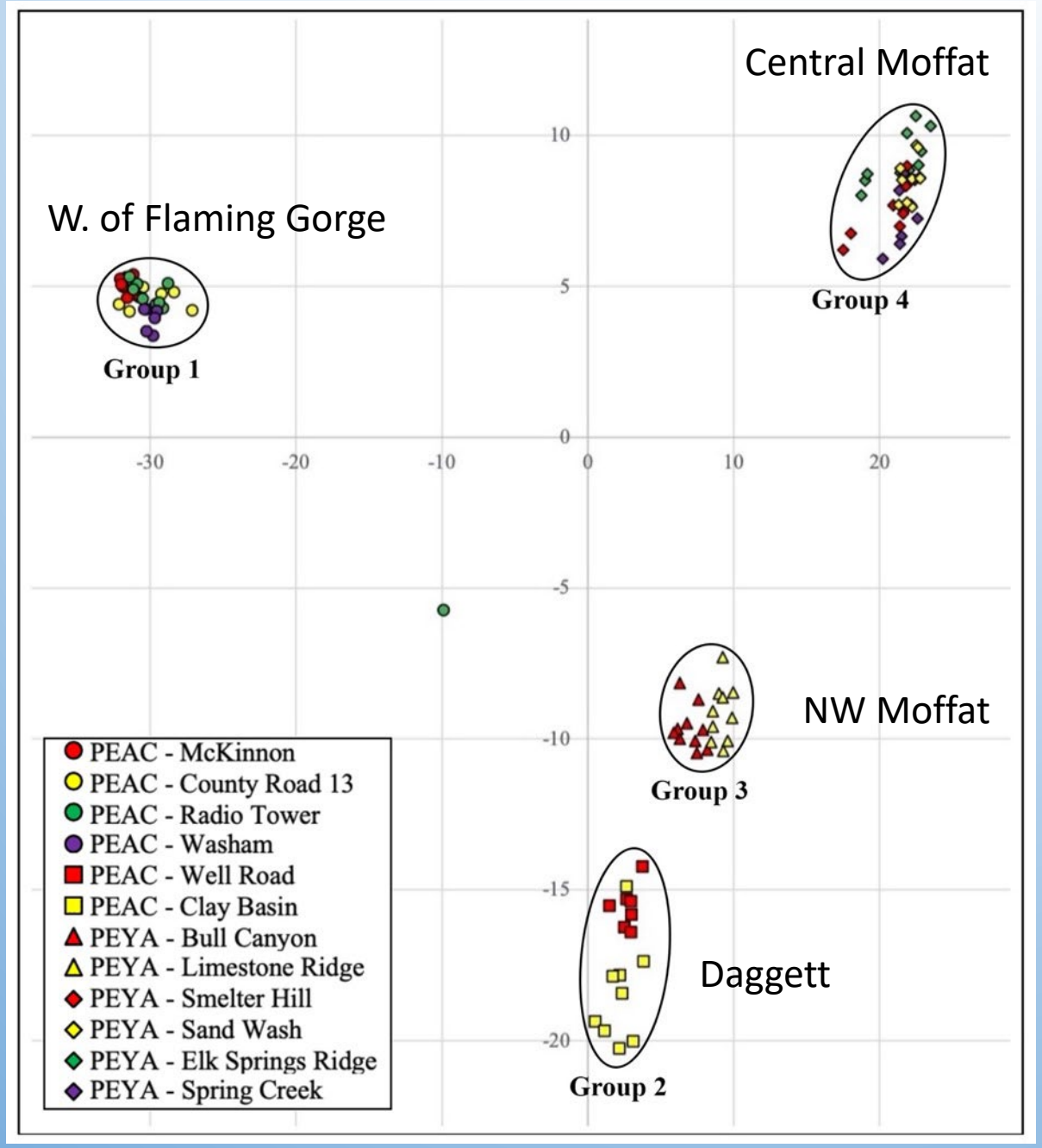
Comparisons of Leaf Length and Width



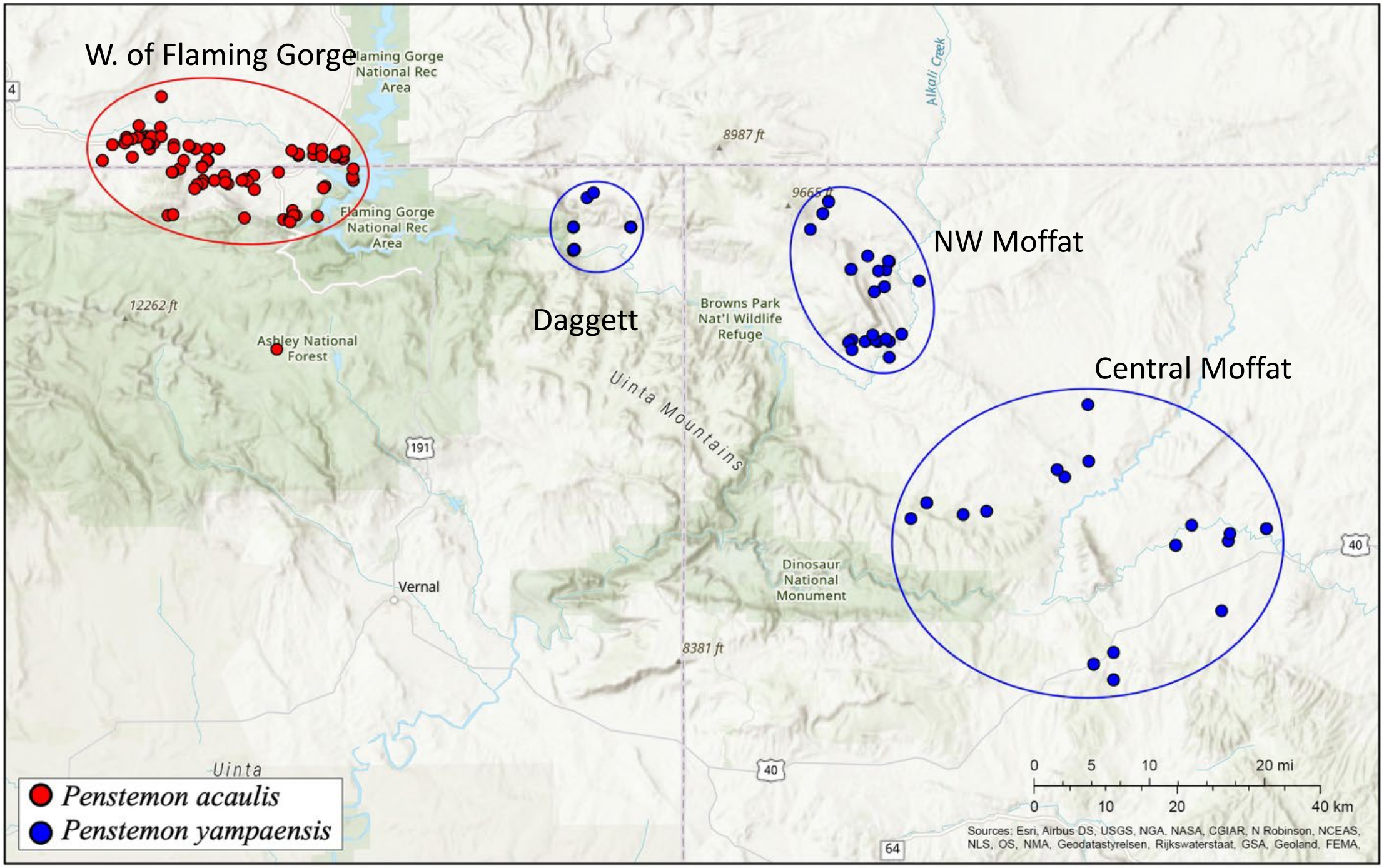

hybrid
previously identified as P. acaulis
Penstemon grahamii
Penstemon acaulis
Penstemon yampaensis
0.003


hybrid
McKinnon
County Road 13
Radio Tower
Washam
Well Road
Clay Basin
Bull Canyon
Limestone Ridge
Smelter Hill
Sand Wash
Elk Springs Ridge
Spring Creek
9.0E-4
P. yampaensis
P. acaulis


Group 1
Group 2
Group 3
Group 4
W. of Flaming Gorge
Daggett
NW Moffat
Central Moffat
K=4
K=3
K=2
McKinnon
County Road 13
Radio Tower
Washam
Well Road*
Clay Basin*
Bull Canyon
Limestone Ridge
Smelter Hill
Sand Wash
Elk Springs Ridge
Spring Creek
P. acaulis
P. yampaensis



Note. 24.09% of genetic variation is explained by axis 1 (X-axis) and 4.80% is explained by axis 2 (Y-axis).


W. of Flaming Gorge
Flaming Gorge National Rec Area
Flaming Gorge National Rec Area
Alkali Creek
8987 ft
9665 ft
NW Moffat
Daggett
Browns Park Nat'l Wildlife Refuge
12262 ft
Ashley National Forest
Central Moffat
Uinta Mountains
191
Vernal
Dinosaur National Monument
8381 ft
40
Uinta
64
Penstemon acaulis
Penstemon yampaensis
0 5 10 20 mi
0 10 20 40 km
Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA,

Results

Q1. What is the genetic taxonomic placement of P. yampaensis and should it be recognized at the level of species distinct from P. acaulis?

- Two evolutionary distinct species, species boundary does not follow state line

Q2. Is there evidence of hybridization among P. yampaensis and P. acaulis?

- Yes. 1 hybrid found. Is of recent origin because it is a 50/50 split.

Q3. What is the genetic connectivity among populations within and among drainages?

- Each geographic area/drainage is genetically distinct, indicating that among area gene flow is not common.

Conservation Recommendations

- *P. acaulis* (PEAC) and *P. yampaensis* (PEYA) are separate species
  - PEAC – UT/WY west of Flaming Gorge
  - PEYA – UT/CO east of Flaming Gorge -> NE UT pops not previously treated as this species
- 4 total management units – 1 PEAC, 3 PEYA
- Plants should not be moved among management units
- PEAC should be reconsidered for ESA listing -> new circumscription reduces range by ~55% (~900 sq/km total)
- Hybridization can occur so management should limit the potential to move seeds among species

Funding and Collaborators

Mimulus gemmiparus

Penstemon acaulis and
Penstemon yampaensis

Sami Naibauer –
'doer of all things'