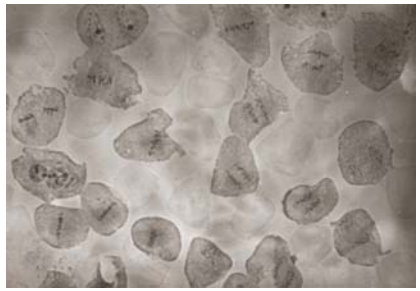
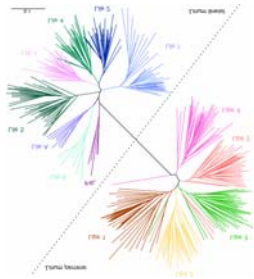




Progress Report: Genetic Considerations for Wildland Forb and Shrub Restoration Plantings

E. Durant McArthur

USDA-FS-RMRS-Shrub Sciences Laboratory

Are native or restored populations more variable?

Taxon	Populations		Polymorphic loci		Alleles/locus	
	N	R	N	R	N	R
Artemisia	3	2	43%	28%	1.53	1.43
Atriplex	9	3	55%	63%	1.59	1.57
Ericameria	6	2	56%	62%	1.63	1.63
Krascheninnikovia	2	1	44%	53%	1.53	1.67
Purshia	4	3	33%	40%	1.57	1.60

N = Native

R = Restored

No consistent pattern.

Genetics of Restored Populations of Intermountain Shrubs

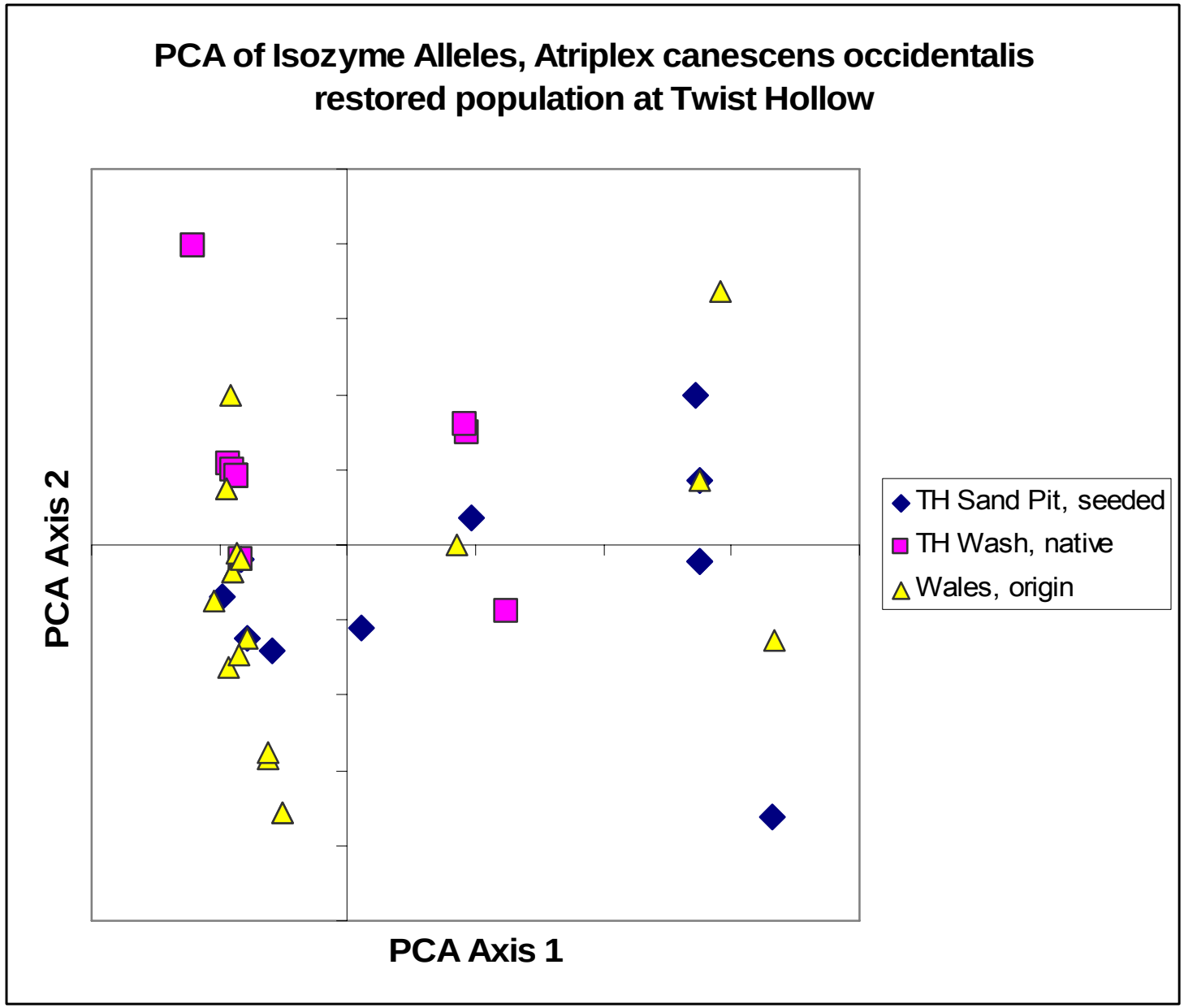
Results for complete sets:

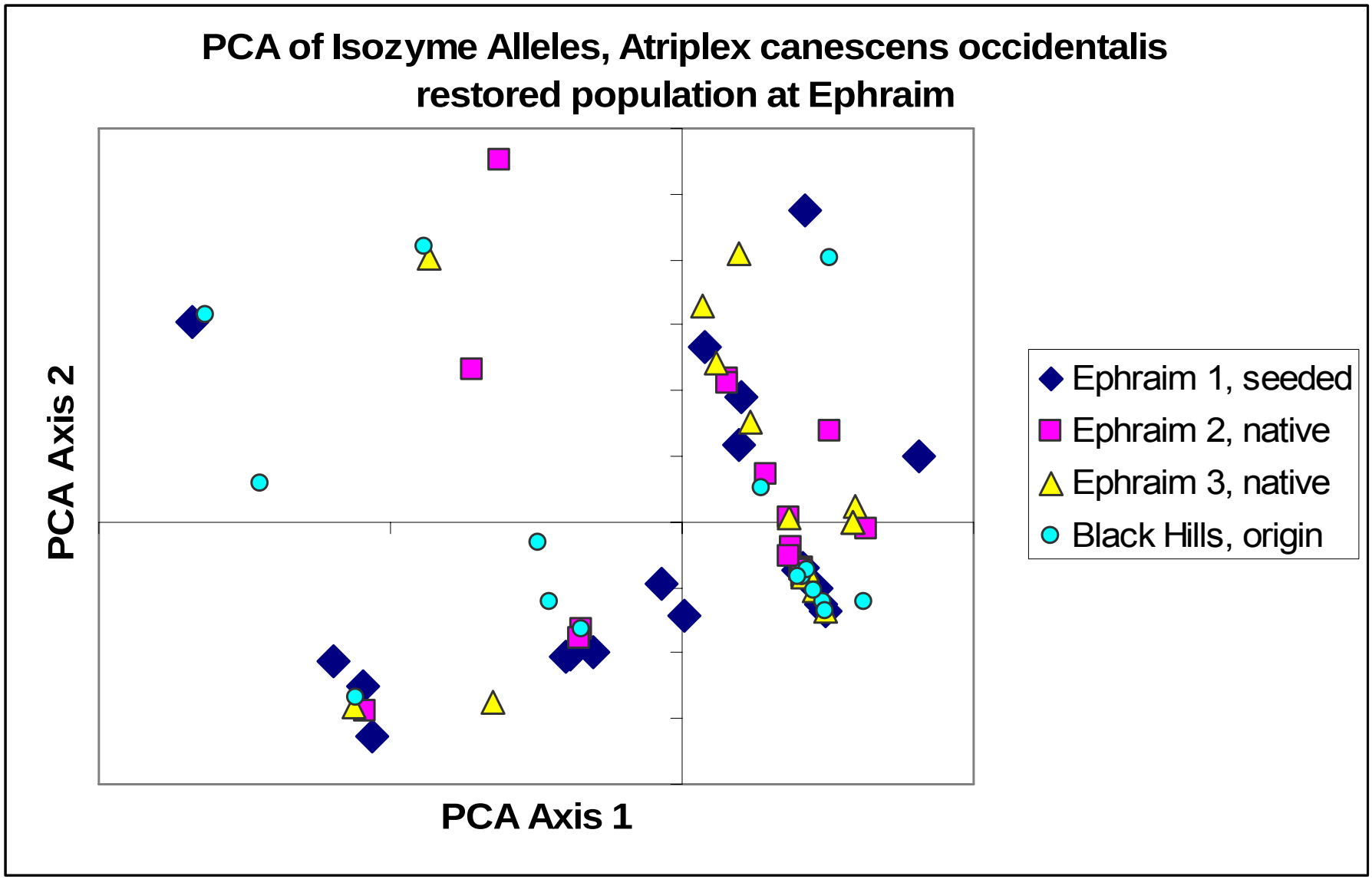
Usually seed source was

“genetically appropriate”

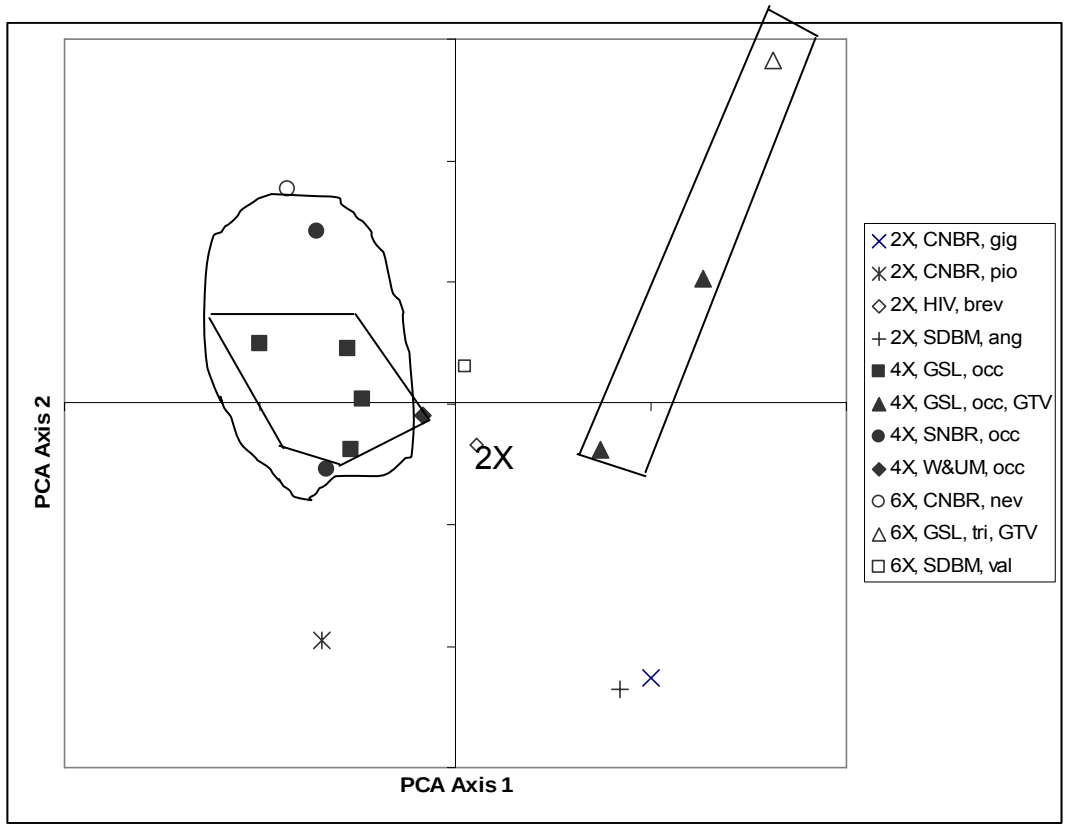
= similar to natives near restoration site

and the restored population was similar, too.


PCA of Isozyme Alleles, Atriplex canescens occidentalis restored population at Twist Hollow
PCA Axis 2
PCA Axis 1
TH Sand Pit, seeded
TH Wash, native
Wales, origin


PCA of Isozyme Alleles, Atriplex canescens occidentalis
restored population at Ephraim
PCA Axis 2
PCA Axis 1
Ephraim 1, seeded
Ephraim 2, native
Ephraim 3, native
Black Hills, origin

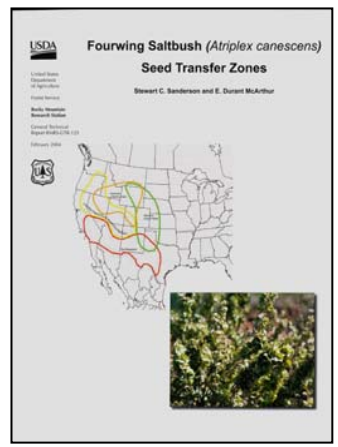
Principal Components Analysis of Genetic Distances Based on Isozymes of *Atriplex canescens* and *A. tridentata*



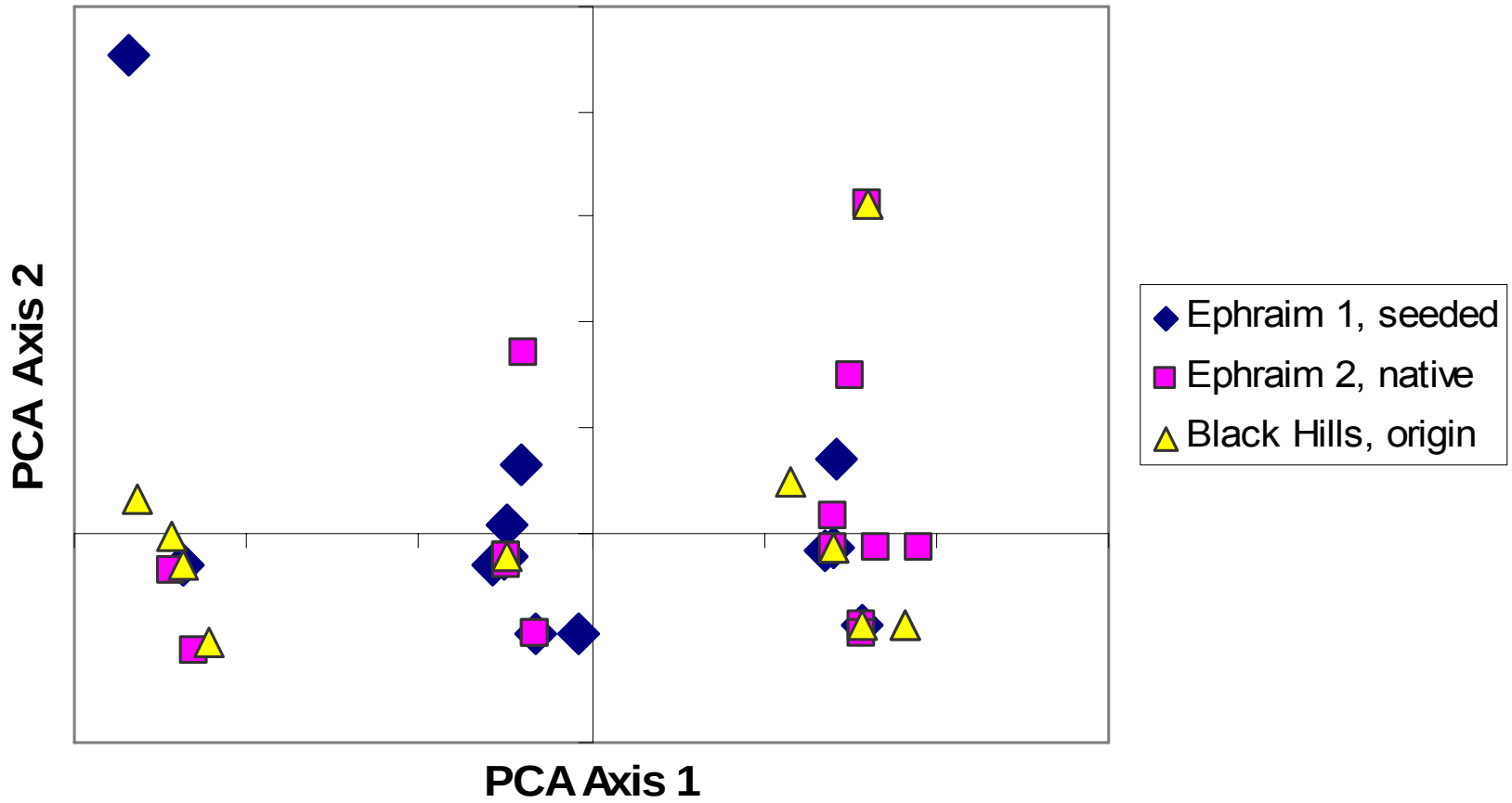
16 Populations
272 Individuals
12 Loci

Influences of PCs
Axis 1 = 57%
(Isoenzyme Frequency)
Axis 2 = 26%
(Ploidy)

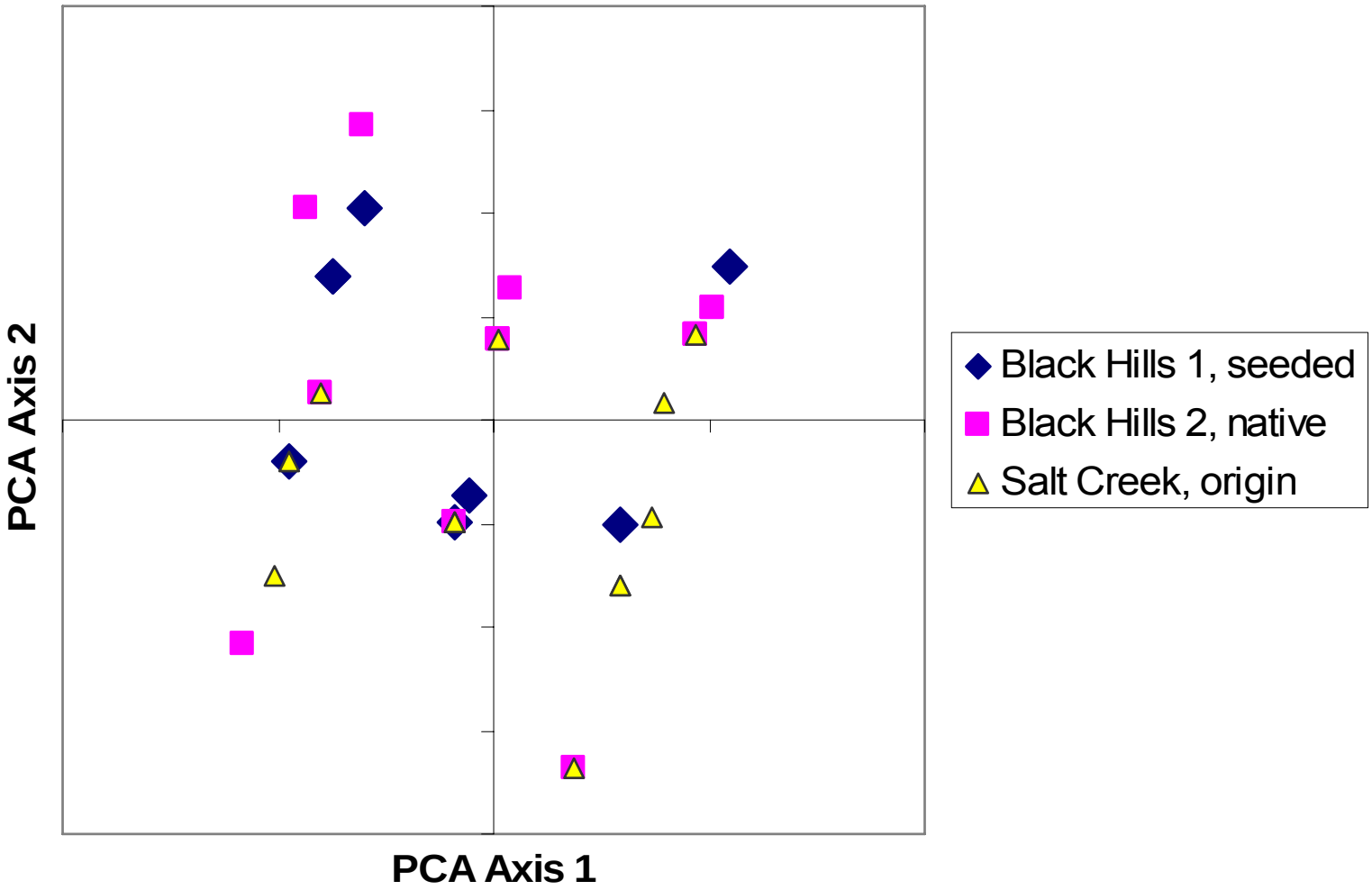
Supports Sanderson & McArthur (2004)



PCA of Genetic Distances amont individuals, Ceratoides lanata, restored population at Ephraim

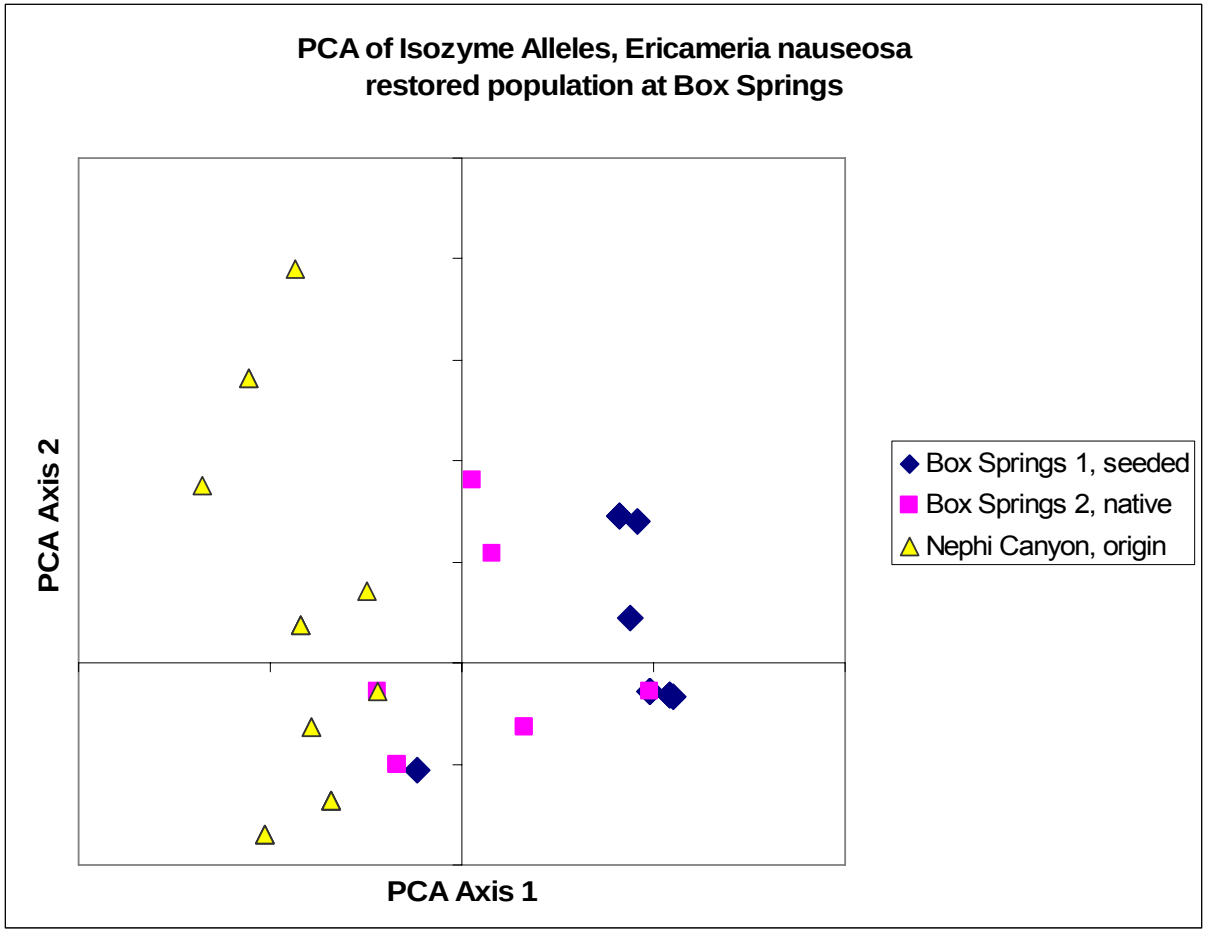


PCA of Isozyme Alleles, Ericameria nauseosa restored population at Black Hill



Genetics of Restored Populations of Intermountain Shrubs

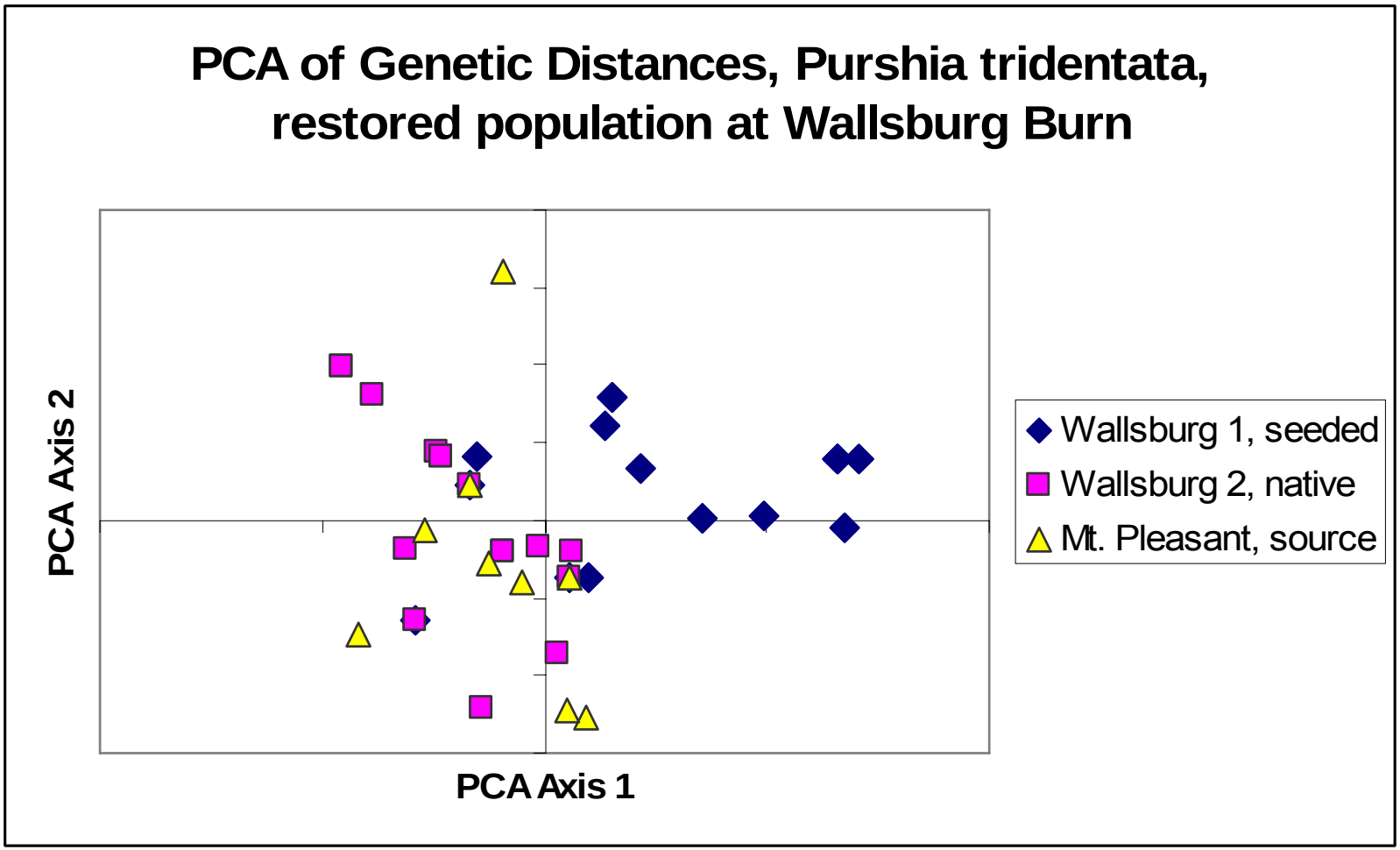
Sometimes results were unexpected.



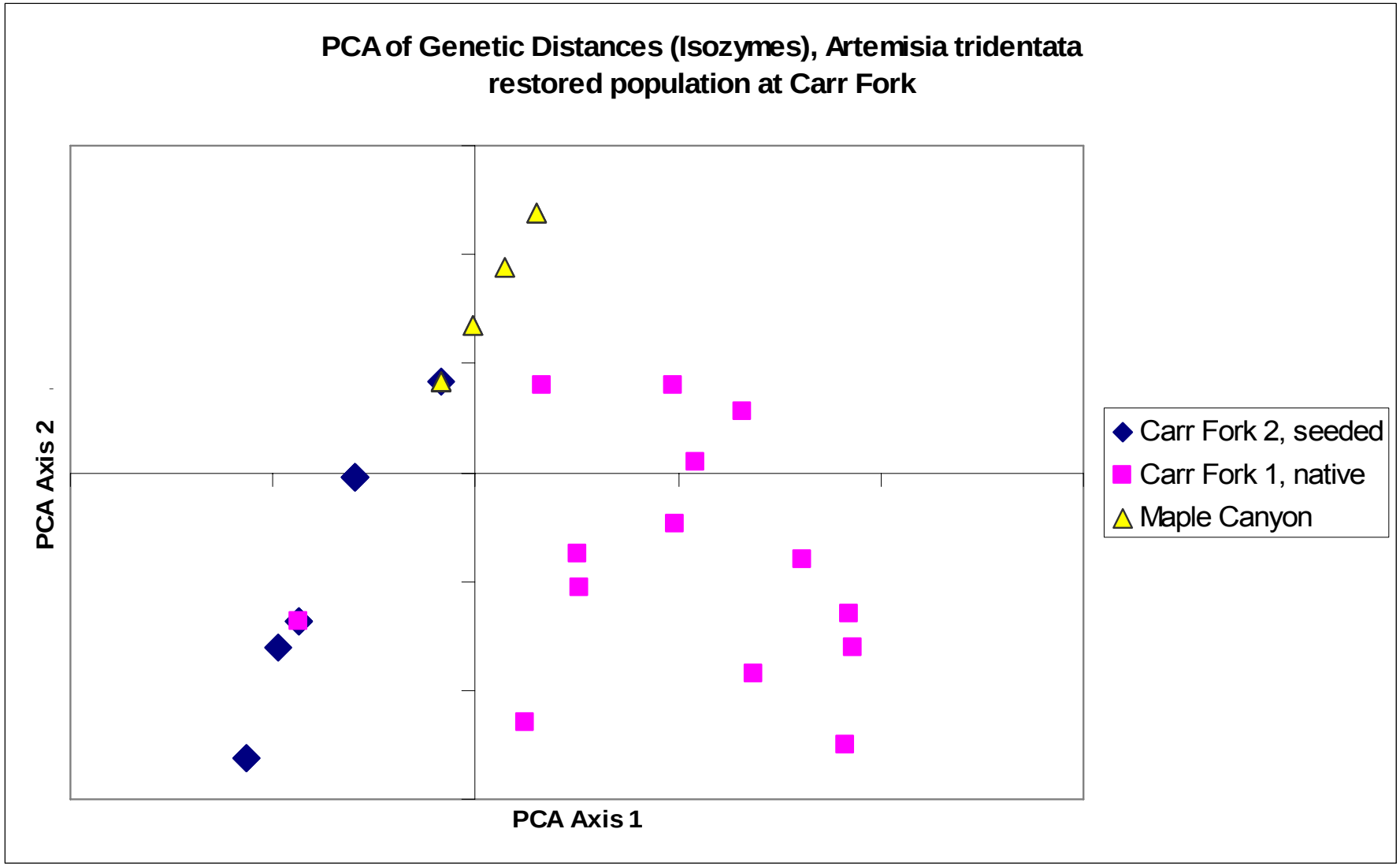
Did seeded population fail?

Was the area reseeded naturally from nearby populations?

Was the area reseeded from a soil seed bank? Most likely explanation.



Why the seeded population is so different, when the parents are similar, is unknown but it appears that that a mistake was made in the identity of the seeded population.



Both Carr Fork 2 and Maple Canyon are seriously lacking in genetic variation. Inappropriate transfer? More analysis is needed.

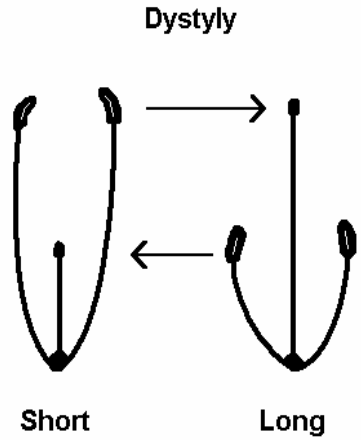
Do Ecoregions Explain Genetic Results?

Taxon	Set	Location	Ecoregion		MLRA	
"Genetically appropriate"			from	to	from	to
Artemisia tridentata	B	Carr Fork	19f	13c	GSL	GSL
Atriplex canescens	A	Twist Hollow	14a	14a	GSL	SNBR
Atriplex canescens	C	Ephraim	19d	19g	GSL	GSL
Ericameria nauseosa	B	Black Hills	19f	19g	GSL	GSL
Krascheninnikovia lanata	A	Ephraim	19d	19d	GSL	GSL
"Genetically appropriate," but outcome questionable						
Purshia tridentata	A	Wallsburg Burn	19g	19g	GSL	GSL
Genetically inappropriate						
Ericameria nauseosa	A	Box Springs	19f	19f	GSL	CP

Species	Populations	Isozymes	AFLPs	cpDNA	Form	Family
Astragalus utahensis	5	5	4	5	forb	Fabaceae
Balsamorhiza sagittata	4	4	*	0	forb	Asteraceae
Crepis acuminata	5	5	2	5	forb	Asteraceae
Crepis occidentalis	1	1	1	1	forb	Asteraceae
Erigeron pumilus	8	7	5	7**	forb	Asteraceae
Eriogonum umbellatum	7	4	4	7	forb	Polygonaceae
Eriogonum heracleoides	1	1	1	1	forb	Polygonaceae
Eriogonum ovalifolium	2	2	1	2	forb	Polygonaceae
Heliomeris multiflora	6	6	2	0	forb	Asteraceae
Lathyrus brachycalyx	2	2	2	2	forb	Fabaceae
Lomatium dissectum	3	3	*	*	forb	Apiaceae
Lomatium grayii	2	2	*	*	forb	Apiaceae
Lupinus argenteus/sericeus	8	8	4	8	forb	Fabaceae
Penstemon acuminatus	1	1	*	*	forb	Scrophulariaceae
Penstemon deustus	2	0	*	*	forb	Scrophulariaceae
Penstemon speciosus	2	2	*	*	forb	Scrophulariaceae
Phlox longifolia	3	3	*	*	forb	Polemoniaceae
Tragopogon dubius	3	3	*	*	forb	Asteraceae
Vicia americana	6	6	6	6	forb	Fabaceae

Long-styled ‘Appar”
Linum perenne

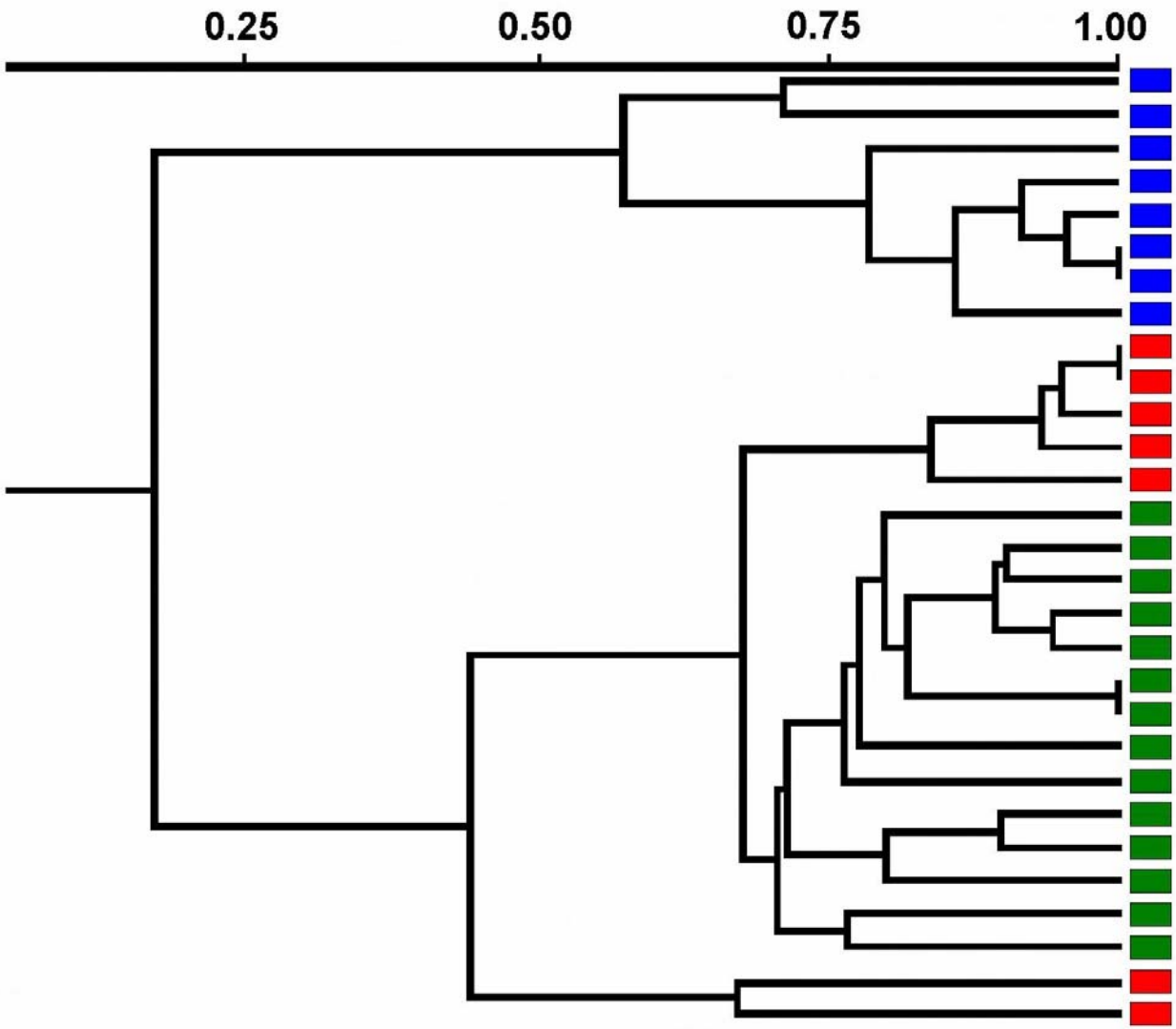
Short-styled ‘Appar”
Linum perenne



Long-styled Native
Linum lewisii

Perennial Blue Flax Flowers

Phenogram of Perennial Blue Flax Populations Based on Bulked RAPD Samples



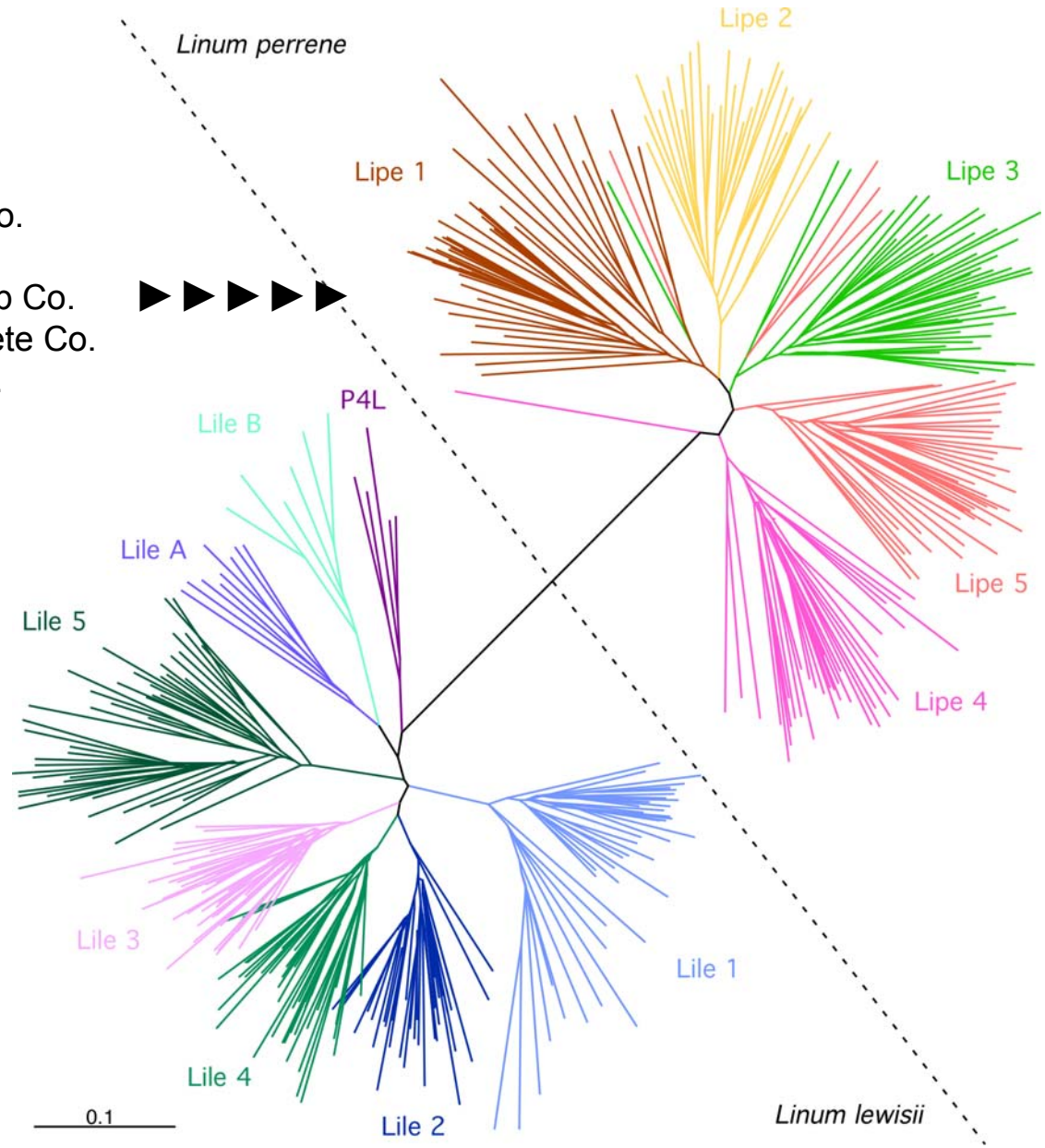
Population Key:

Blue = North American
Red = European
Green = ‘Appar’

Neighbor Joining Phenogram of Genetic Similarity Based on 470 Loci from 8 ISSR Primers

1 = Eagle Mountain, Utah Co.
2 = Holden, Millard Co.
3 = Salt Creek Canyon, Juab Co.
4 = Ephraim Canyon, Sanpete Co.
5 = Provo Canyon, Utah Co.

1= Eureka, Tooele Co.
2 = Holden, Millard Co.
3 = Cove Fort, Millard Co.
4 = Maple Grove, Millard Co.
5 = Ibapah, Tooele Co.
A = Pony Express, Tooele Co.
B = Richmond, Cache Co.
PL4 = Native in 'Appar' planting



Flax Seed

Character	n	North American accessions	n	European accessions	n	'Appar' accessions	Attained significance
Seed length (mm)	9	4.0 a	9	3.5 b	3	3.3 b	**0.010**
Seed width (mm)	9	2.1 a	9	2.0 a	3	1.9 a	0.128
Seed width/length ratio	9	0.52 a	9	0.58 b	3	0.57 ab	**0.011**
Weight of 25 seeds (mg)	9	49 a	9	42 ab	3	34 b	**0.047**

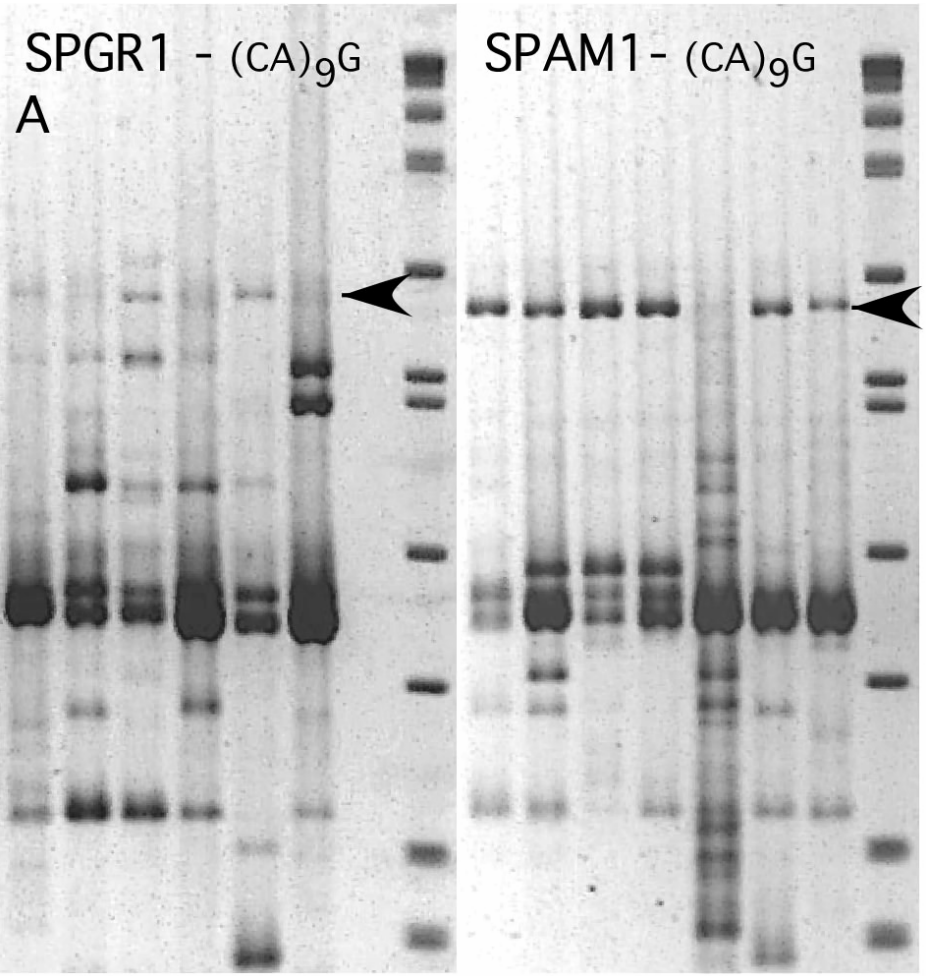
Means and attained significance values for 4 seed characters from 21 accessions of *Linum*. Significant model effects are in bold. Letters following means denote significant differences among source groups at $p = 0.05$.

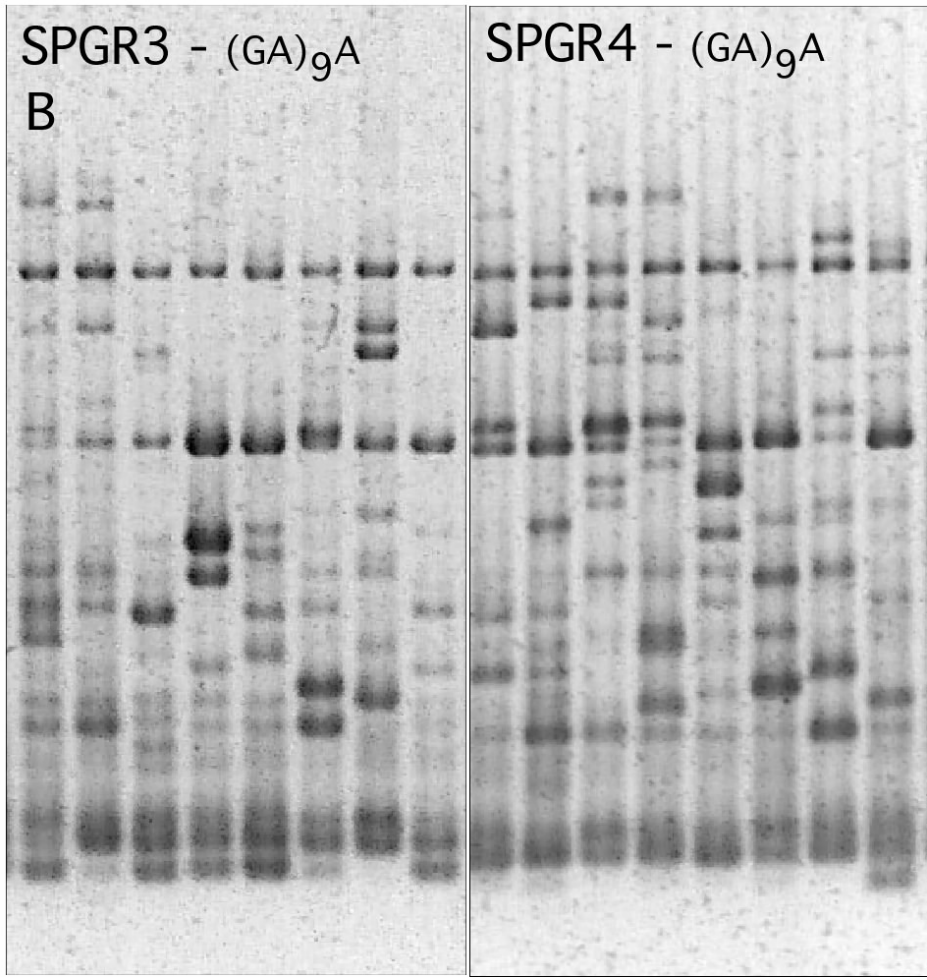
Means and attained significance values for 16 morphological characters from *Linum*.

Character	n	North American accessions	n	European accessions	n	'Appar' accessions	Attained significance
Plant height (cm)	81	47.7 a	87	43.5 a	30	39.2 b	< **0.0001**
Leaf angle (rank 1-5)	83	3.6 a	87	2.0 b	30	1.6 b	< **0.0001**
Leaf length (mm)	81	16.2 a	87	14.4 b	30	12.3 c	< **0.0001**
Leaf width (mm)	81	1.6 a	87	1.6 a	30	1.3 b	**0.0002**
Longest internode length (mm)	81	6.7 a	87	4.7 b	30	5.2 b	< **0.0001**
Number nodes per 3 cm	79	8.6 a	87	10.8 b	30	10.2 ab	**0.0005**
Basal stem color(y,g,r)	82	Green a	87	Green/Red b	30	Red c	**0.0052**
Stem diameter (mm)	79	1.5 a	87	1.3 b	30	1.1 c	< **0.0001**
Number flowering stems	79	11.2 a	87	17.6 b	30	16.7 b	< **0.0001**
Number of days to first flowering	77	23.6 a	87	24.1 a	30	23.6 a	0.6041
Flower diameter (mm)	77	29.6 ab	87	31.1 a	30	29.4 b	**0.0007**
Petal color(b,l,w)	76	Lavender a	87	Blue/Lavender b	30	Blue c	< **0.0001**
Pistil length of long-styled (mm)	76	10.9 a	40	8.3 b	16	7.5 b	**0.0029**
Stamen length of long-styled (mm)	76	7.1 a	40	4.7 b	16	4.5 b	< **0.0001**
Pistil length of short-styled (mm)	--	--	47	4.9 a	14	4.8 a	0.2531
Stamen length of short-styled (mm)	--	--	47	7.4 a	14	7.1 a	0.5054

Sphaeralcea appears to have high levels of genetic diversity in both seeded and native stands.

Sphaeralcea parvifolia
along Colorado River
In Utah

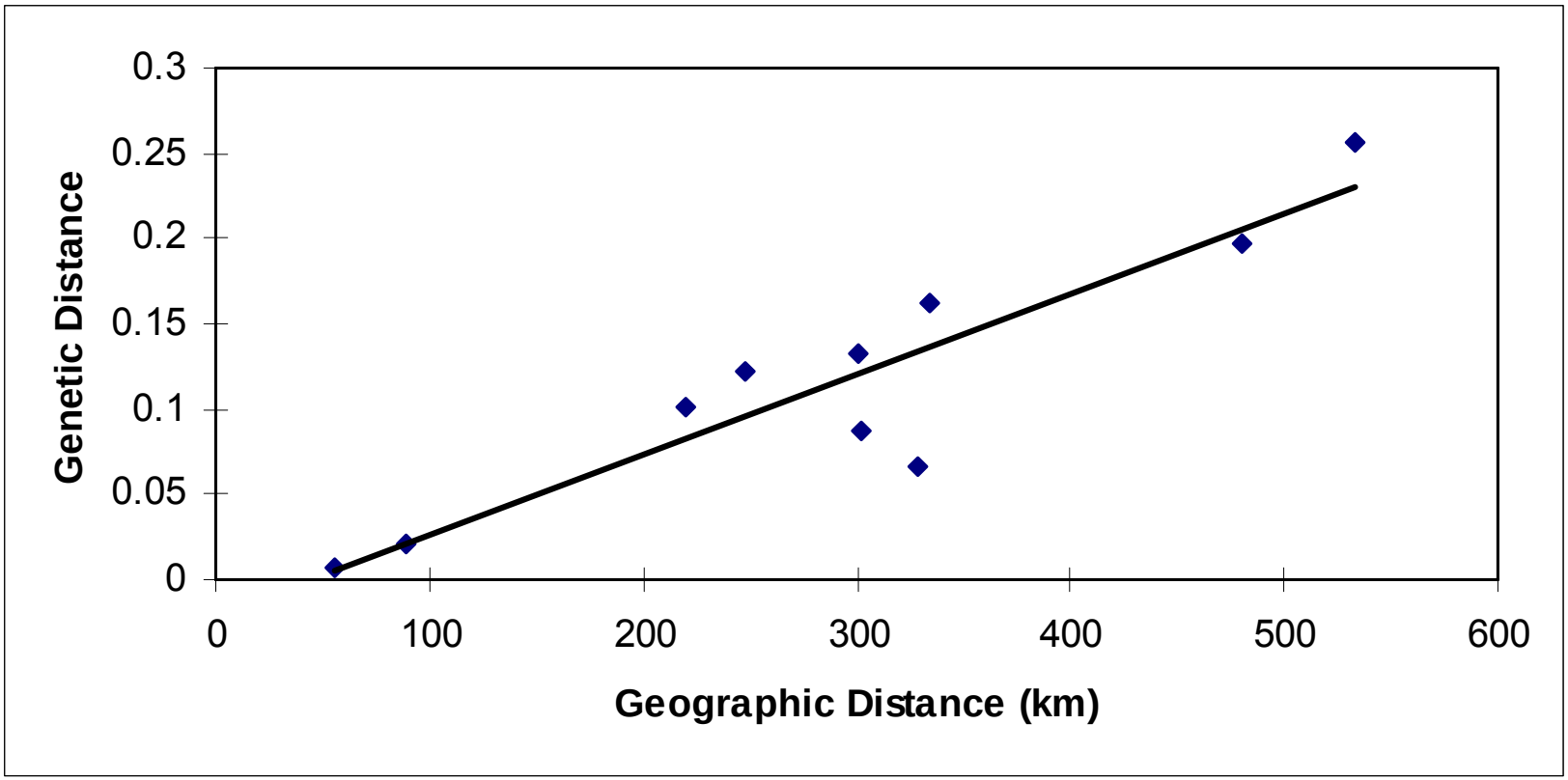

SPGR1 - (CA)9G
A
SPAM1- (CA)9G


SPGR3 - (GA)9A
B
SPGR4 - (GA)9A

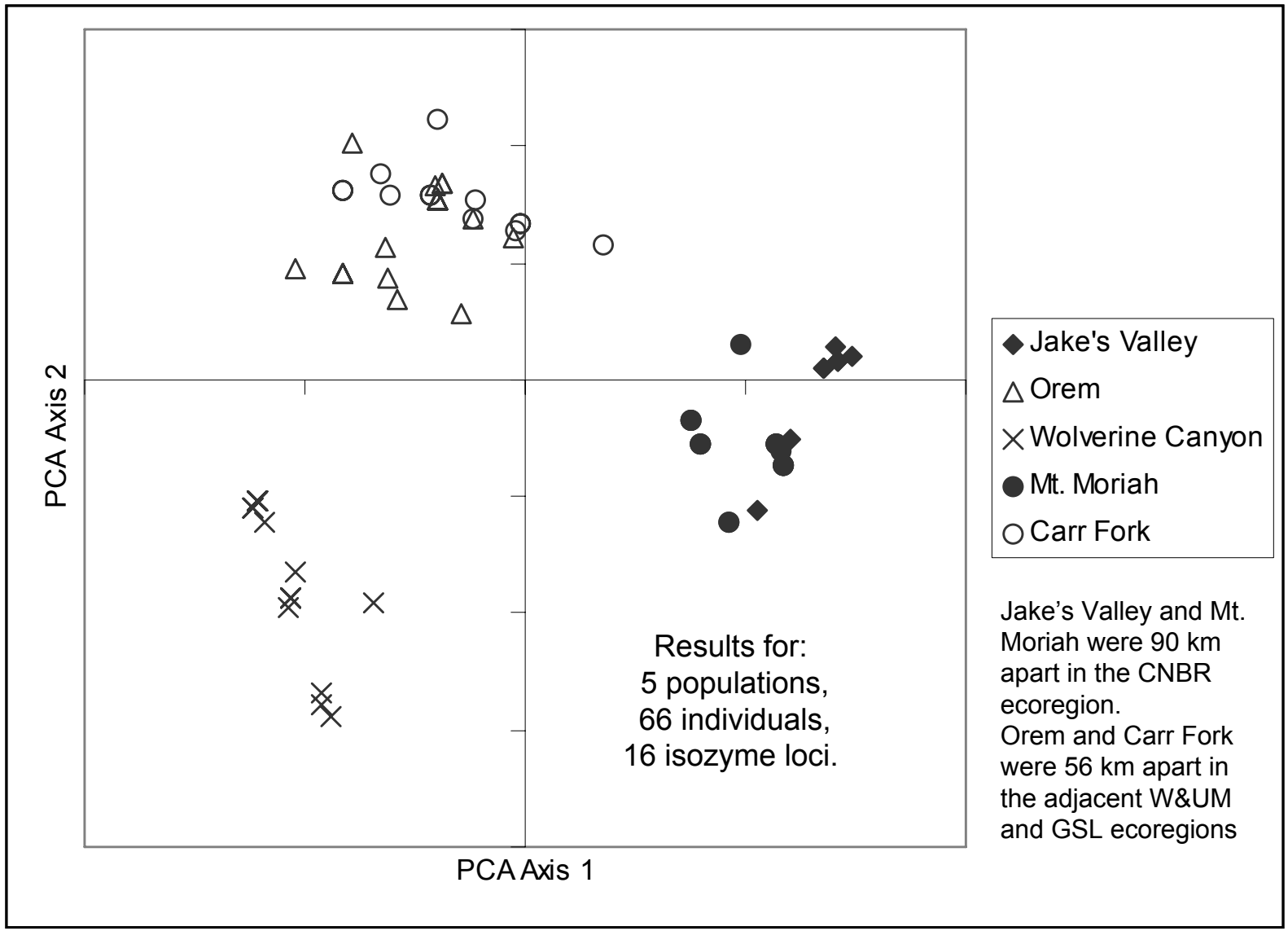
Penstemon specious

Penstemons have been used widely
In revegetation plantings; penstemons
are know to hybridize. Our studies with
Palmer's penstemon, however, showed
No introgression with sympatic
Indigenous penstemons.

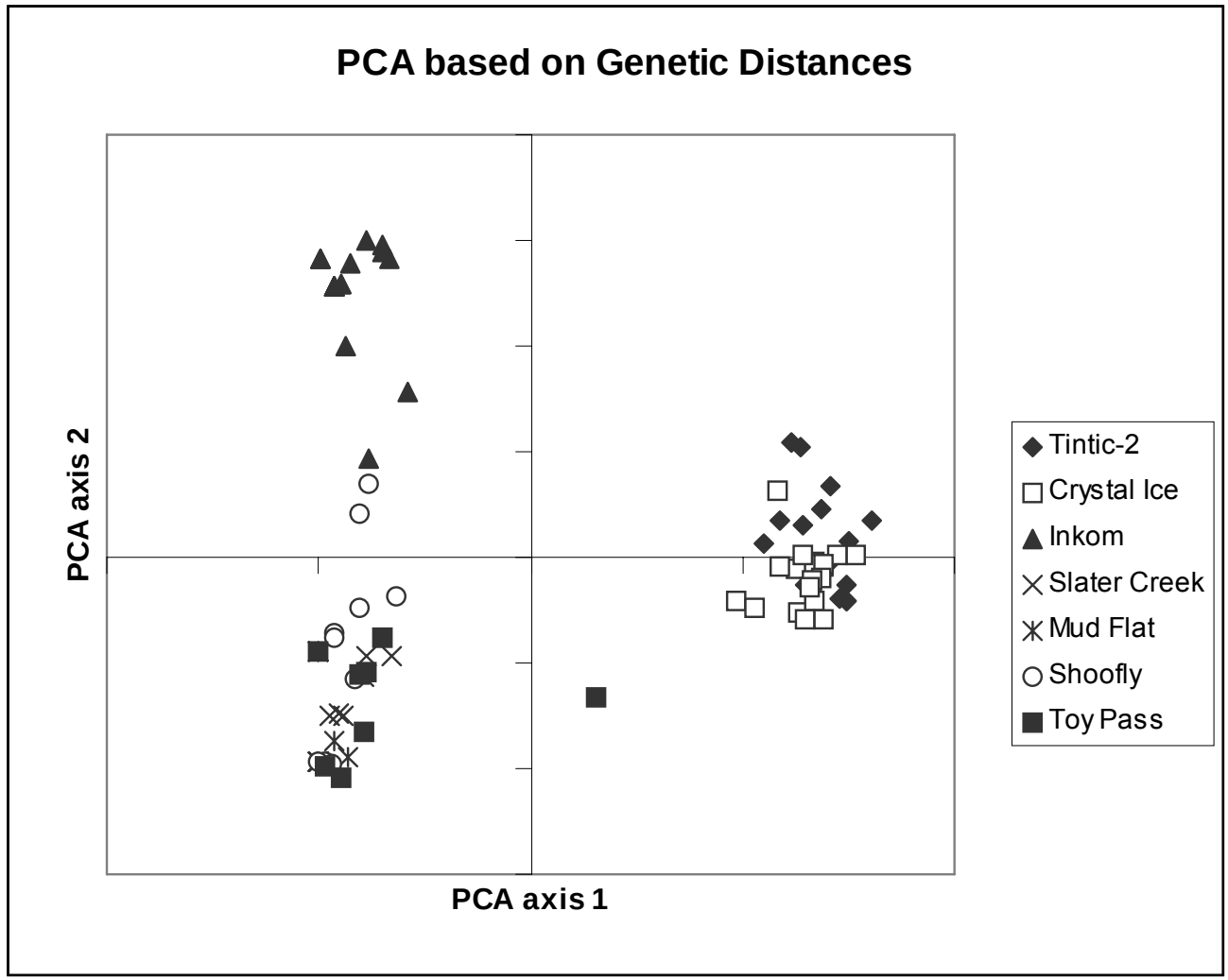
Genetic distance as a function of geographic distance, for *Astragalus utahensis*.

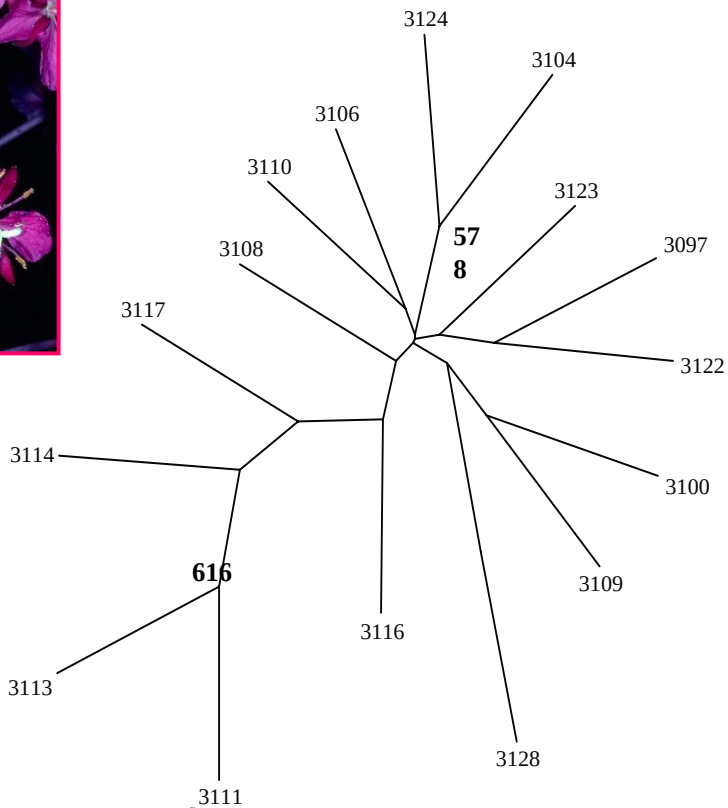


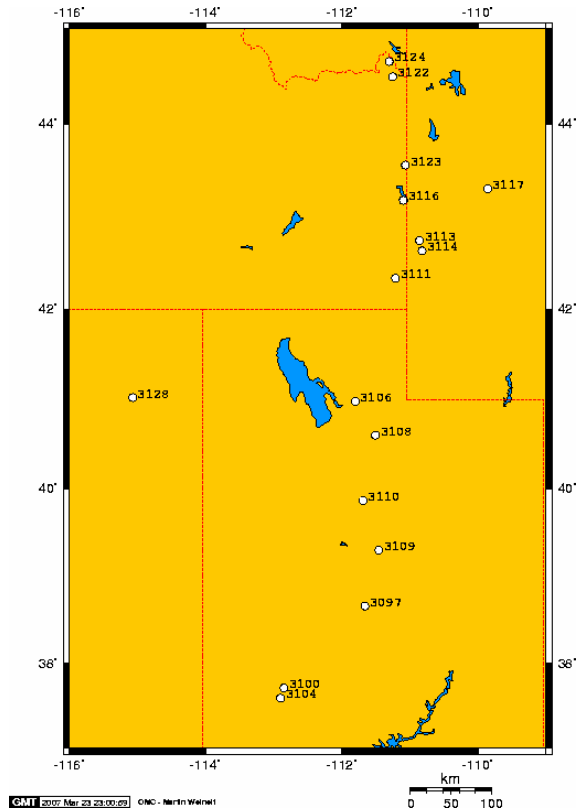
Principal Components Analysis of Genetic Distances Among Individuals of *Astragalus utahensis.*



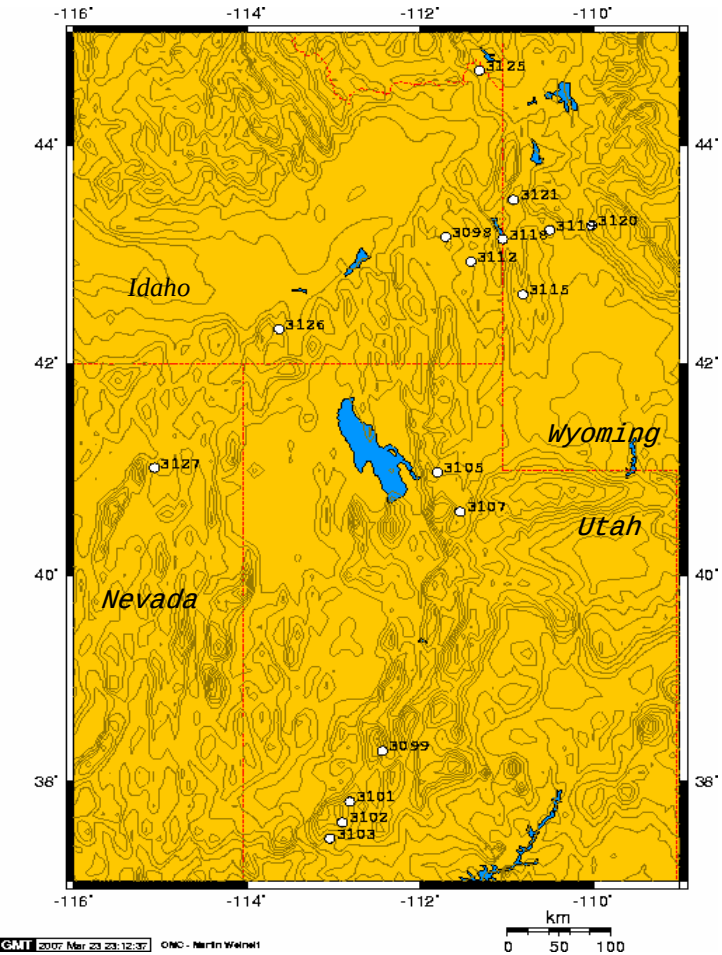
Principal Components Analysis Based on Genetic Distances Among 87 Individuals of *7 Eriogonum umbellatum* Populations, Generated Using Eight Loci



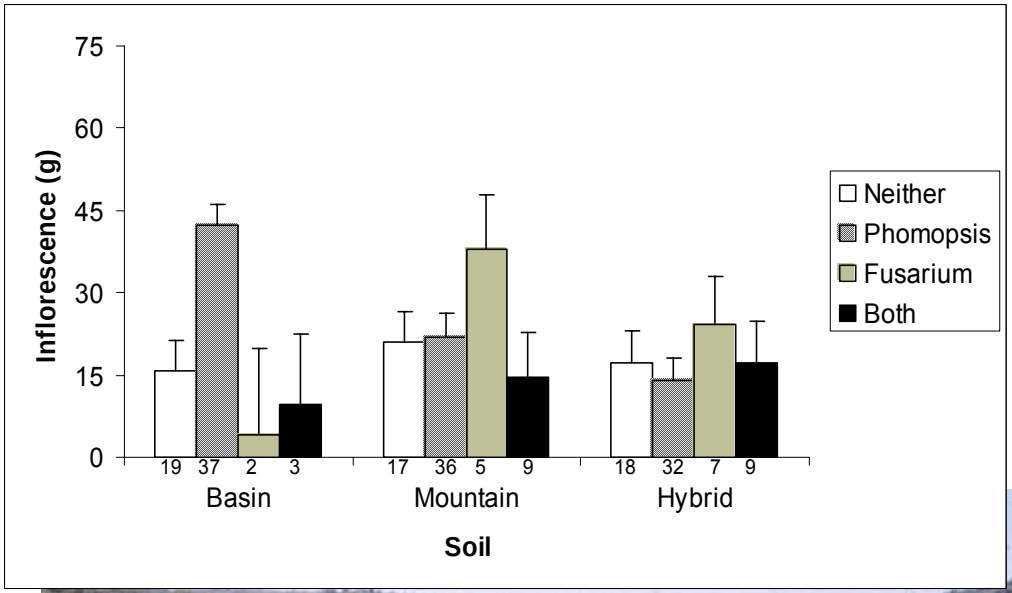




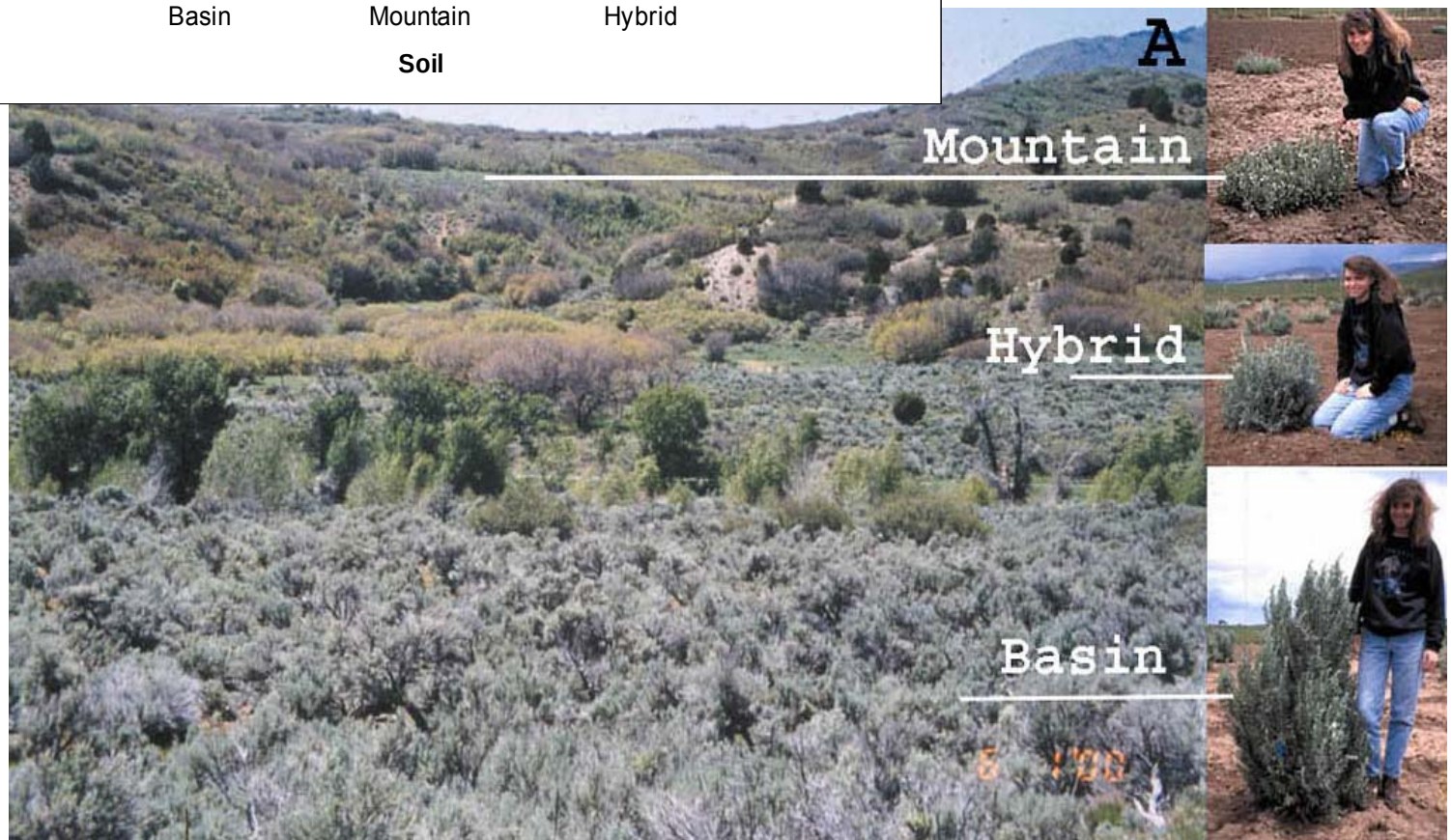
Significant allele frequency variation was observed among populations (θ = 0.184, 95% C.I. 0.125 to 0.251), but no evidence of isolation by distance was observed among all populations ($R2$ = 0.003, P = 0.56), indicating that differentiation is likely due to restricted gene flow even at small scales. Population assignment tests indicate a single population, EDM 3111, to be distinct from the other collections.



Populations were significantly differentiated (θ = 0.205, 95% C.I. 0.128 to 0.301), indicating that 20% of the observed variation is partitioned among populations. Pairwise measures of differentiation indicated most pairs of populations to be significantly differentiated, but no evidence was found for isolation by distance, indicating neighboring populations are no more likely to be genetically similar than geographically separated pairs. Bayesian clustering analyses indicate 7 genetic groups to be present in the combined data set, and individual assignment tests indicate these groups do not follow a geographic pattern.



Salt Creek Canyon
Big Sagebrush Hybrid Zone



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