Soil effects on an endemic vernal pool annual plant, *Limnanthes douglasii spp. rosea* (Meadowfoam)

Daniel J. Toews
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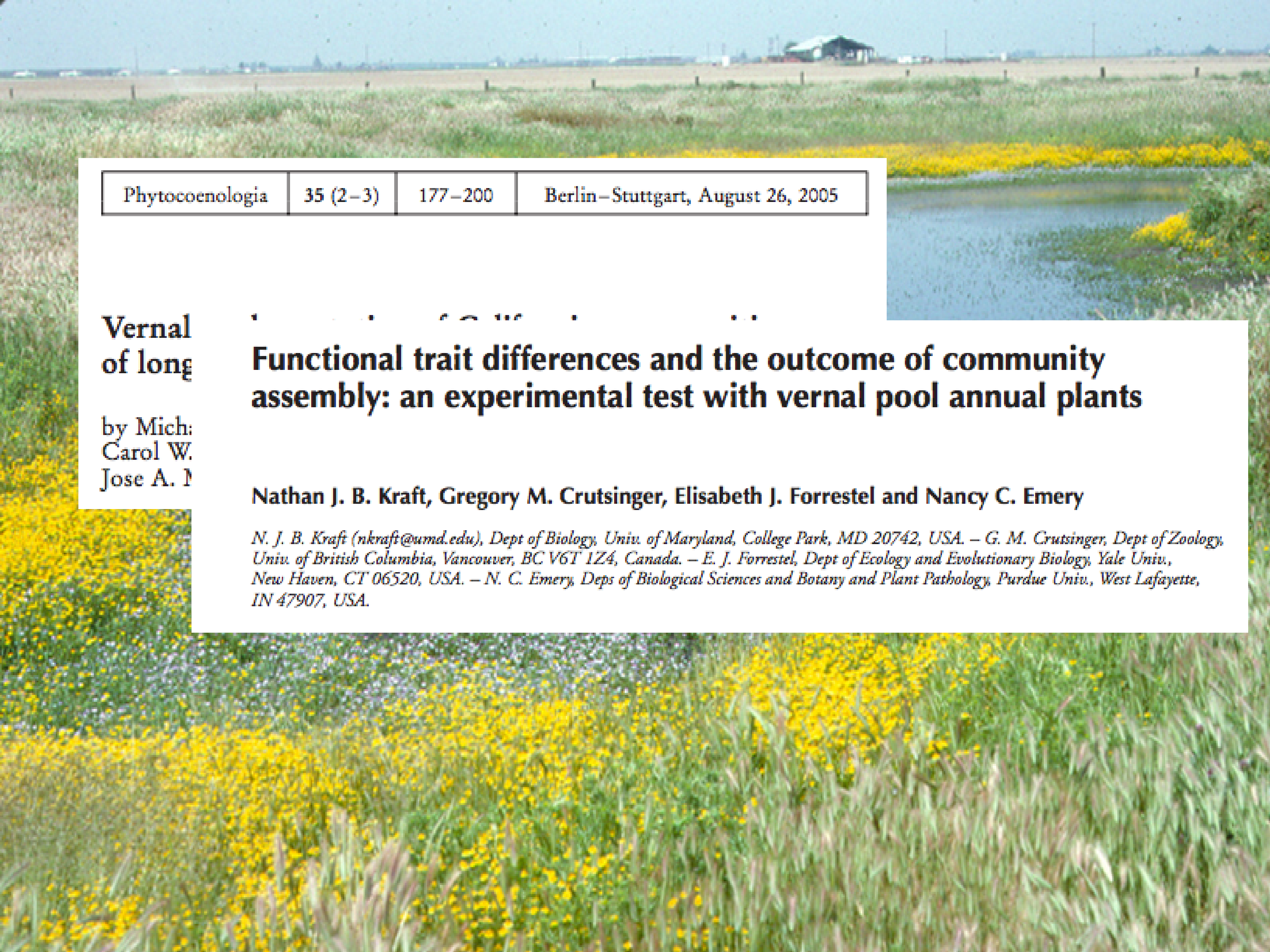
University of California, Merced

AquAlliance, 2018

Phytocoenologia | 35 (2–3) | 177–200 | Berlin–Stuttgart, August 26, 2005

Vernal pool vegetation of California: communities of long-inundated deep habitats

by Michael G. Barbour, Ayzik I. Solomeshch, Robert F. Holland, Carol W. Witham, Roderick L. Macdonald, Sarel S. Cilliers, Jose A. Molina, Jennifer J. Buck, and Janell M. Hillman, Davis, USA



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Vernal
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Jose A. N

Functional trait differences and the outcome of community assembly: an experimental test with vernal pool annual plants

Nathan J. B. Kraft, Gregory M. Crutsinger, Elisabeth J. Forrestel and Nancy C. Emery

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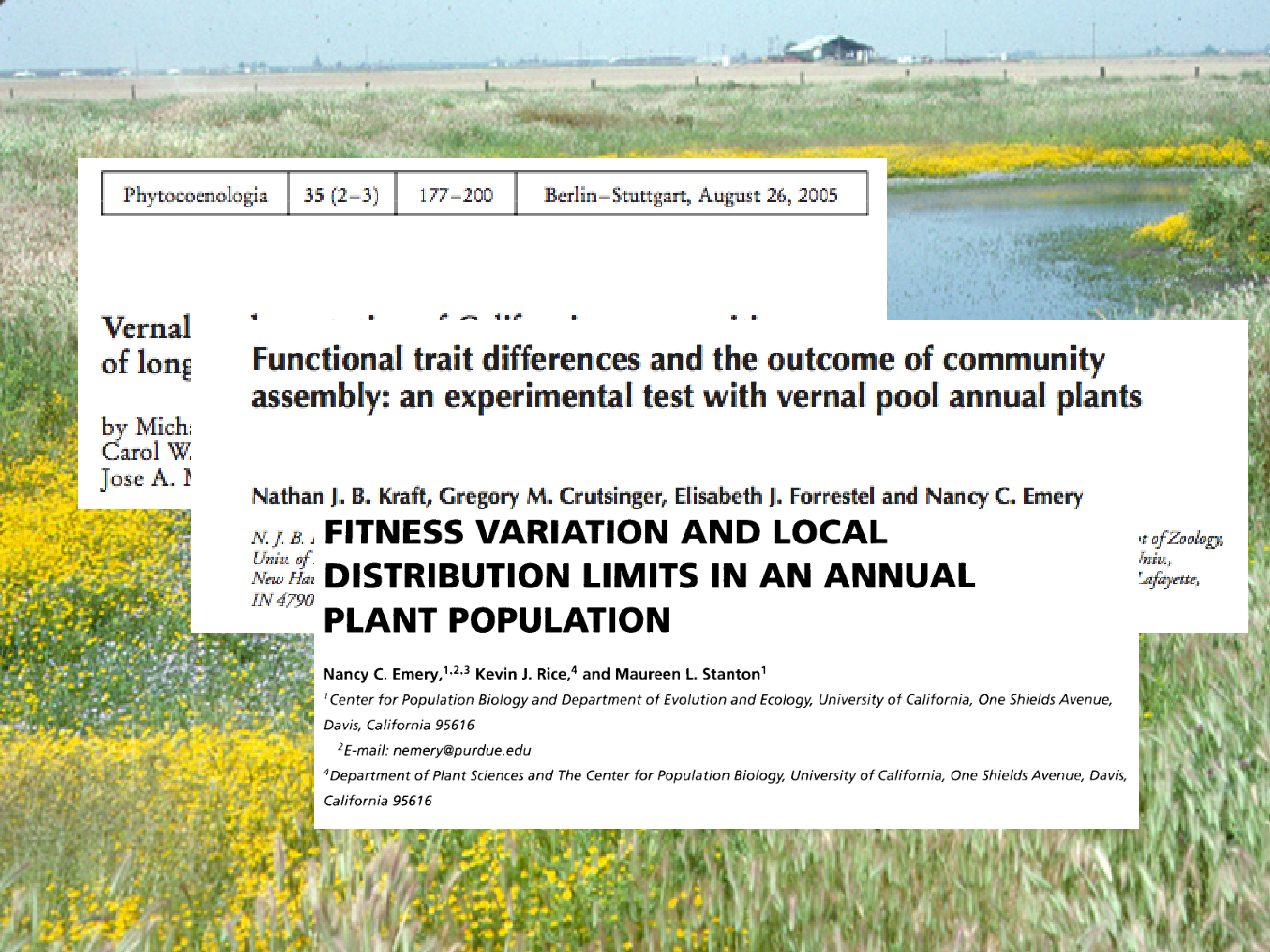

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FITNESS VARIATION AND LOCAL DISTRIBUTION LIMITS IN AN ANNUAL PLANT POPULATION

Nancy C. Emery,[1,2,3] Kevin J. Rice,[4] and Maureen L. Stanton[1]

[1]Center for Population Biology and Department of Evolution and Ecology, University of California, One Shields Avenue, Davis, California 95616

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[4]Department of Plant Sciences and The Center for Population Biology, University of California, One Shields Avenue, Davis, California 95616

Extant Vernal Pool Distribution: California's Great Valley, 2012 [ds1070]

Uploaded by Dustin Pearce

Jul 27, 2015

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Open in Map

Description:

This mapping documents the changes in extent and condition of vernal pool habitat in the Great Valley between 2005 and 2012. "Vernal pool habitat" is defined as vernal pools and the surrounding upland (typically grassland) habitat matrix. The 2005 basemap was created by using double-blind mapping protocol and included 21.4 million acres in and surrounding the Sacramento and San Joaquin valleys (Witham et al 2013). The area included in the 2012 remapping effort focused on the 807,820 acres identified in the 2005 map and areas immediately surrounding the previously mapped polygons. Special attention was paid to areas where habitat was being created through mitigation banking. The result of the 2012 remapping shows 764,868 acres of extant habitat. This is down from 2005, a net reduction of 42,952 acres. Habitat actually was eliminated from 47,306 acres, but these losses were partially off-set by 1,679 acres of mitigation banks built since 2005, and by 2,675 acres that we

~90 - 95% destroyed, altered or degraded

Vernal Pool Regions
Carrizo
Central Coast
Lake-Napa
Livermore
Mendocino
Modoc Plateau
Northeastern Sacramento Valley
Northwestern Sacramento Valley
San Diego
San Joaquin Valley
Santa Barbara
Santa Rosa
Sierra Valley
Solano-Colusa
Southeastern Sacramento Valley
Southern Sierra Foothills
Western Riverside County
Modoc Plateau
Northeastern Sacramento Valley
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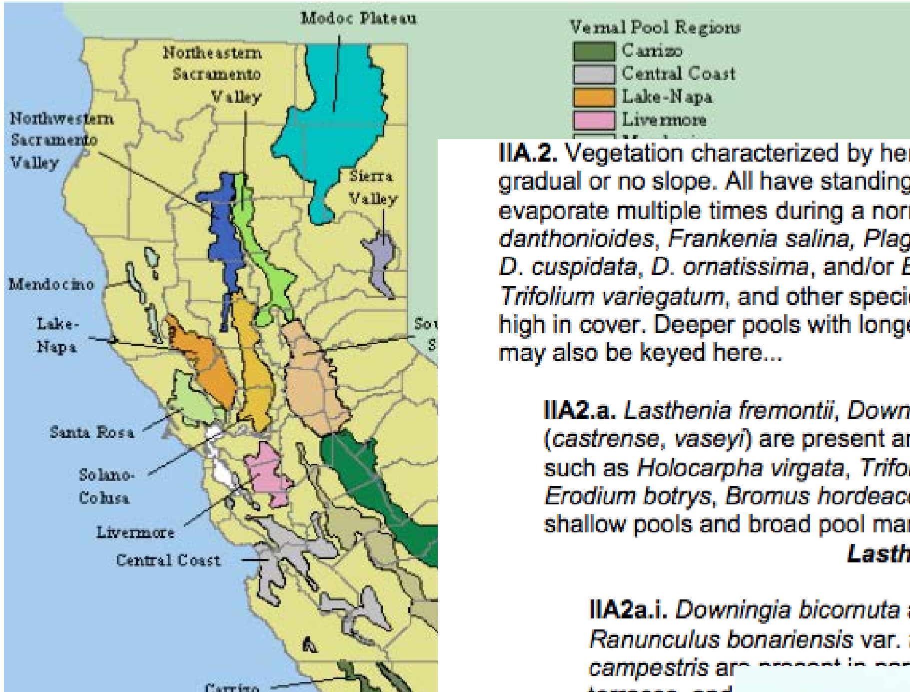
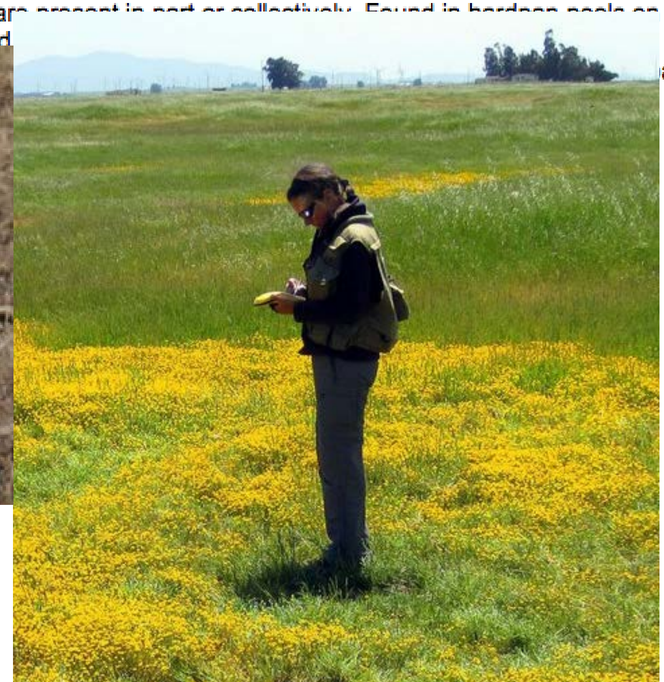


IIA.2. Vegetation characterized by herbs of ephemeral wetlands in swales and vernal pools with very gradual or no slope. All have standing water during the winter and early spring, which may fill and evaporate multiple times during a normal rainy season ("flashy" hydrology). *Deschampsia danthonioides*, *Frankenia salina*, *Plagiobothrys stipitatus*, *Lasthenia fremontii*, *Downingia bicornuta*, *D. cuspidata*, *D. ornatissima*, and/or *Eryngium castrense* may be characteristic. *Layia fremontii*, *Trifolium variegatum*, and other species of moist stands described above typically are absent or not high in cover. Deeper pools with longer inundation periods and *Eleocharis* spp. diagnostically present may also be keyed here...

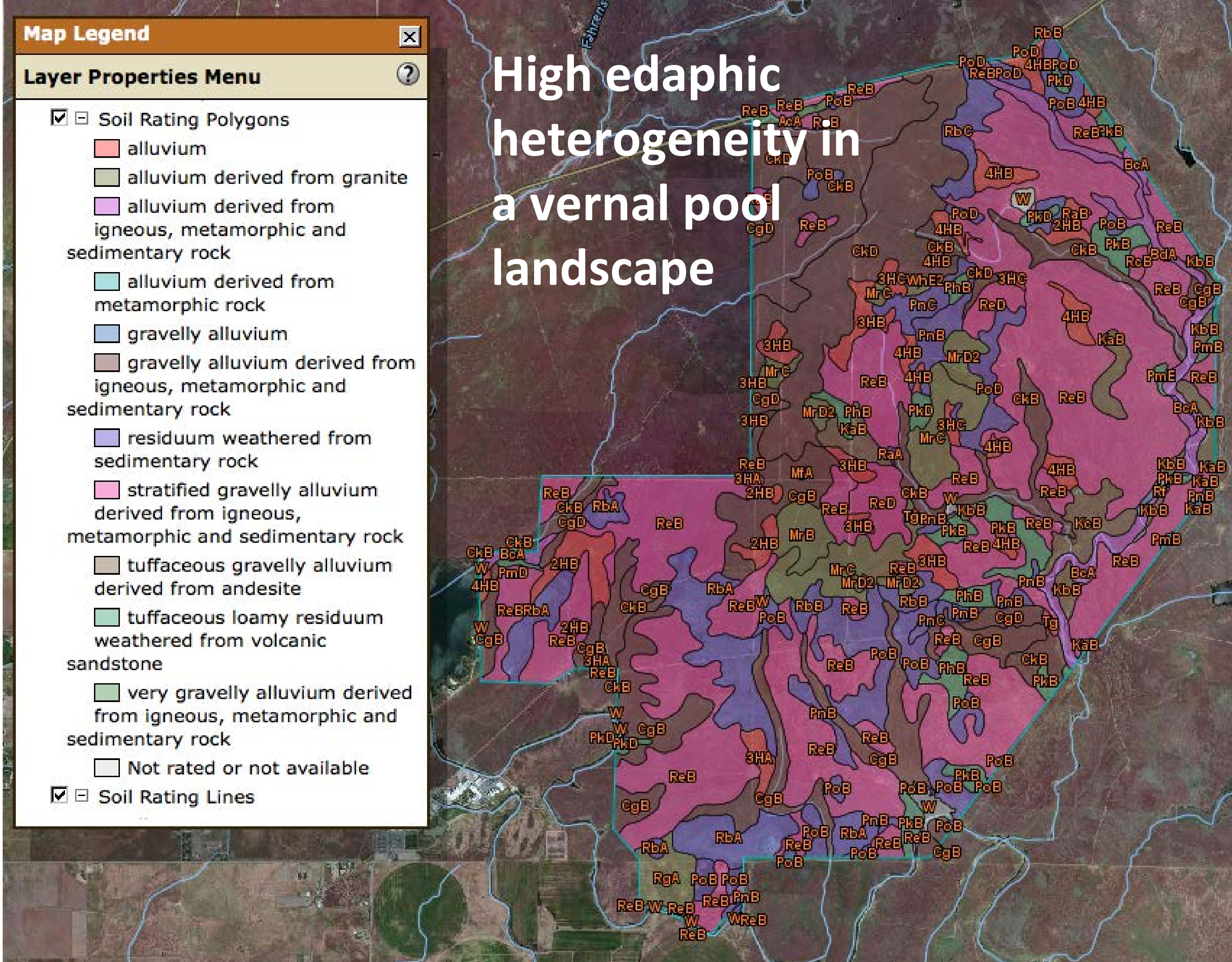
IIA2.a. *Lasthenia fremontii*, *Downingia* spp., *Navarretia leucocephala*, and/or *Eryngium* (*castrense*, *vaseyi*) are present and *Deschampsia danthonioides* is characteristic. Upland species such as *Holocarpha virgata*, *Trifolium variegatum*, *Trifolium depauperatum*, *Hypochaeris glabra*, *Erodium botrys*, *Bromus hordeaceus*, and *Vulpia bromoides* are typically absent. Found in shallow pools and broad pool margins throughout the region…
***Lasthenia fremontii* – *Downingia* (*bicornuta*) Herbaceous Alliance**

IIA2a.i. *Downingia bicornuta* and *Lasthenia fremontii* are conspicuous in the herb layer, while *Ranunculus bonariensis* var. *trisepalus*, *Gratiola ebracteata*, and *Castilleja campestris* subsp. *campestris* ar… low terraces, high terraces, and…

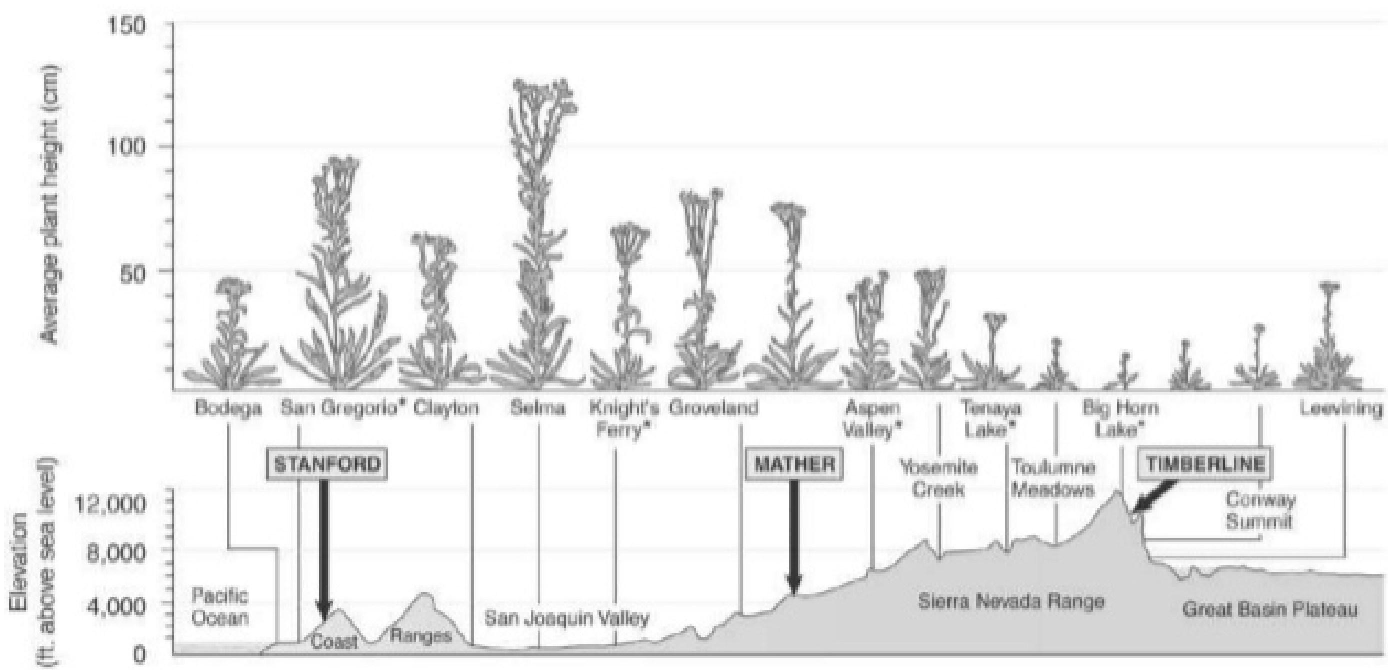
…aceous Association



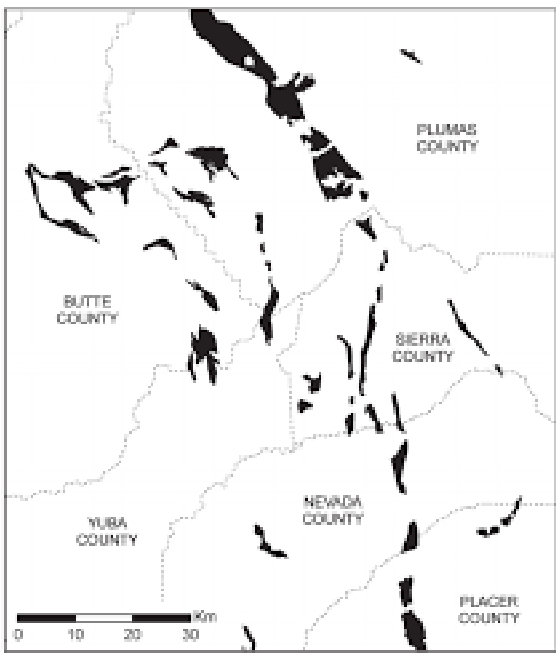
High edaphic heterogeneity in a vernal pool landscape

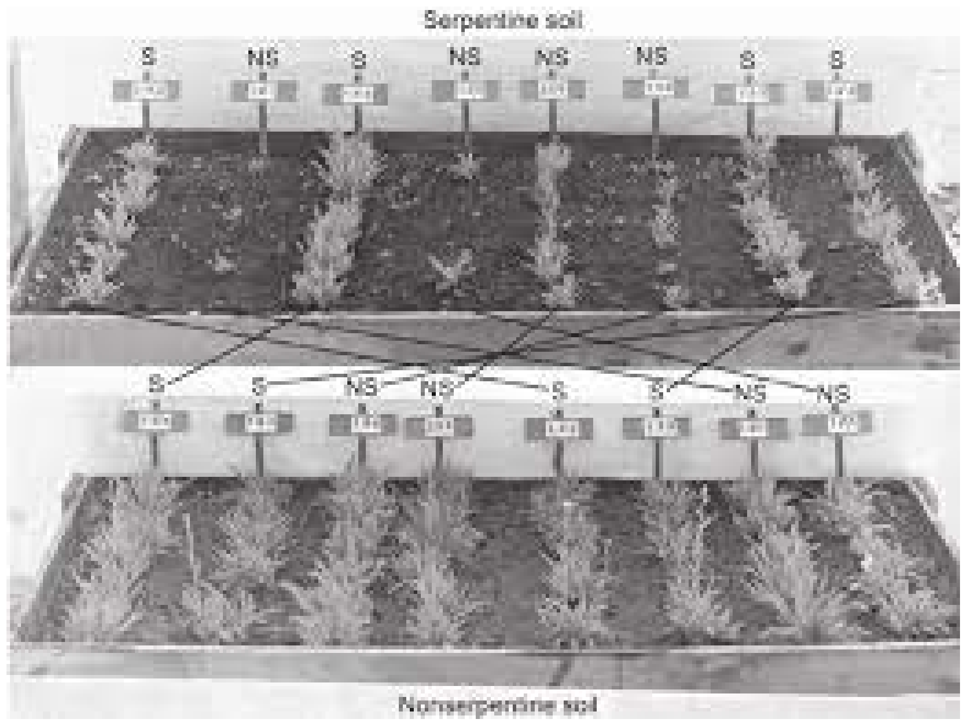


- Phenotypic and genetic differences within populations have been documented across large and small-scale environmental gradients
  - 1930’s Clausen, Keck and Hiesey study is a classic example.



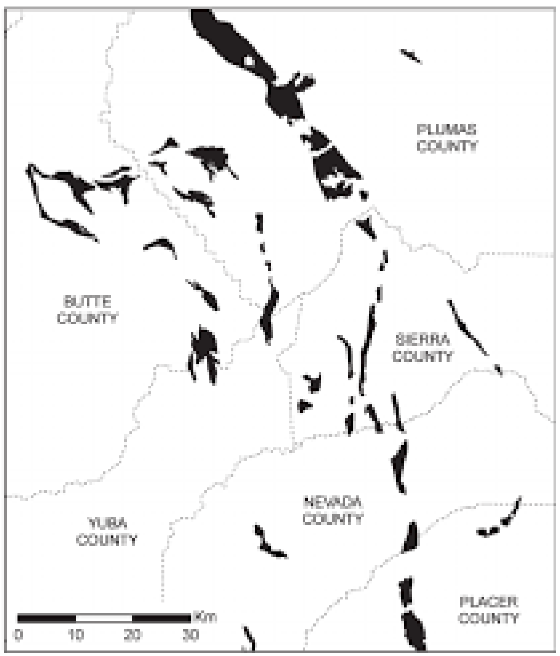
- Locally adapted populations have been documented among many plant species across large and small-scale environmental gradients,

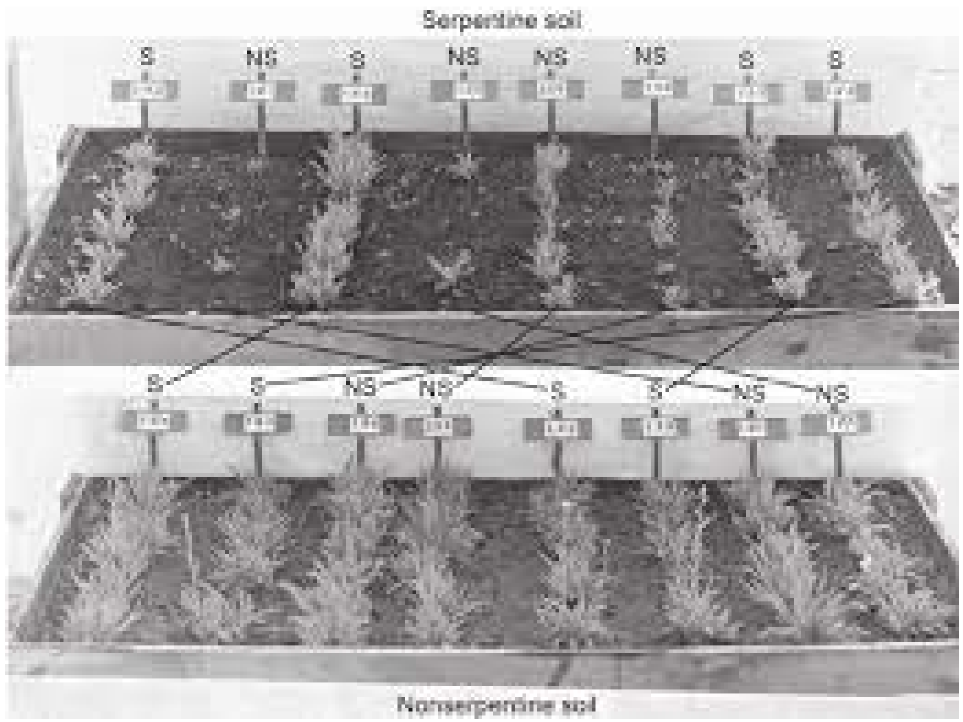




Smith et al., 2011; Waser and Price, 1985;https://www.fs.fed.us/psw/topics/forest_genetics/cons_biol_wright.shtml; Elam, 1998

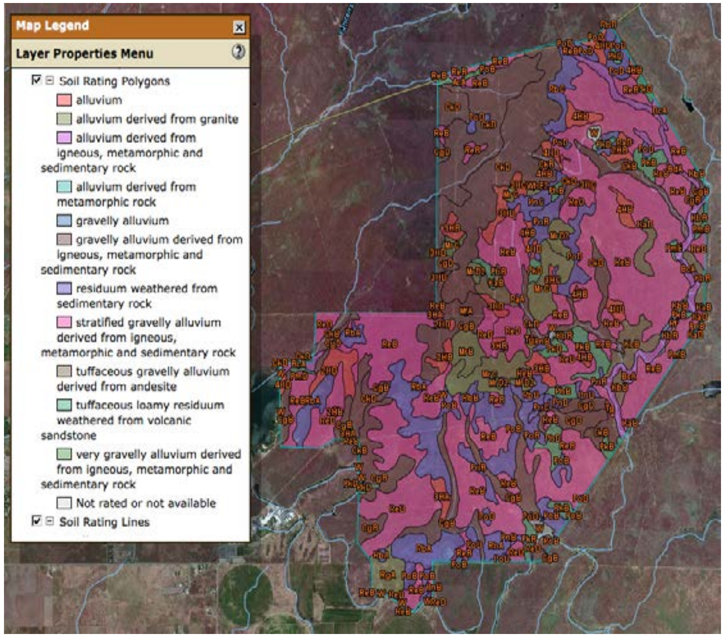
- Locally adapted populations have been documented among many plant species across large and small-scale environmental gradients,
- it is unknown if vernal pool plant species have this scale of soil adaptation.



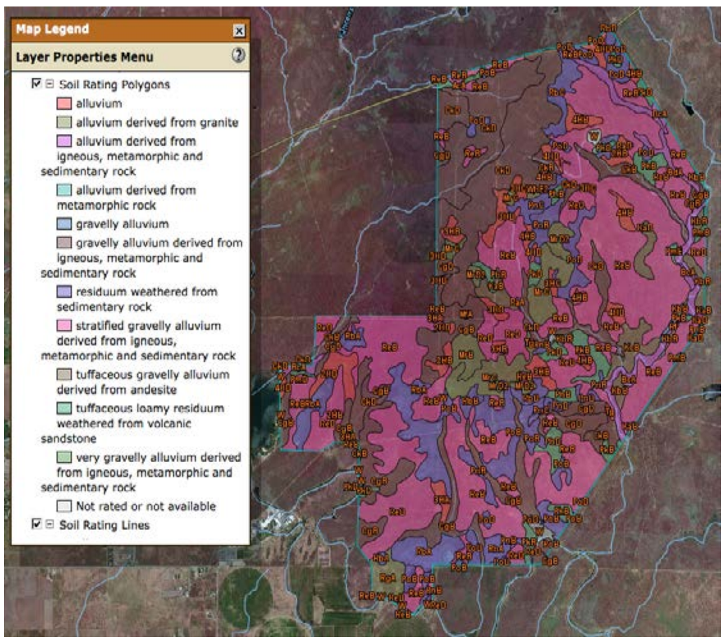


Smith et al., 2011; Waser and Price, 1985;https://www.fs.fed.us/psw/topics/forest_genetics/cons_biol_wright.shtml; Elam, 1998

Does soil type matter to vernal pool plant species?



Does soil type matter to vernal pool plant species?



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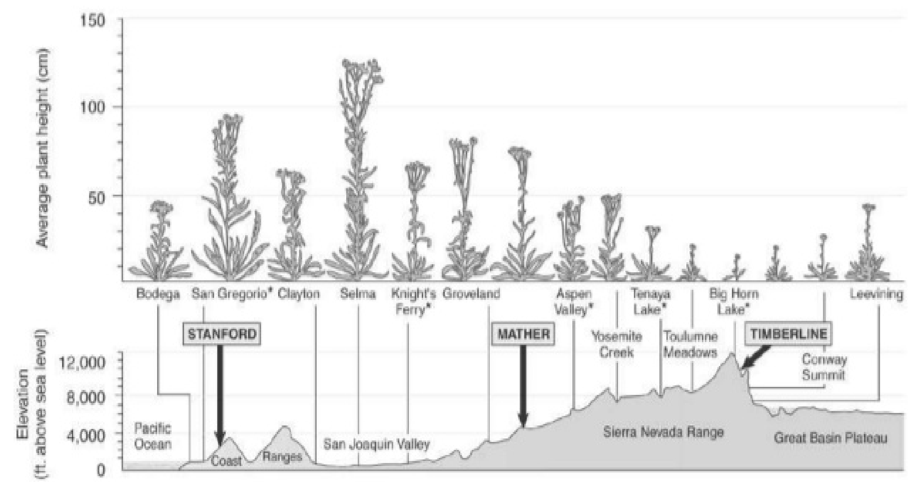
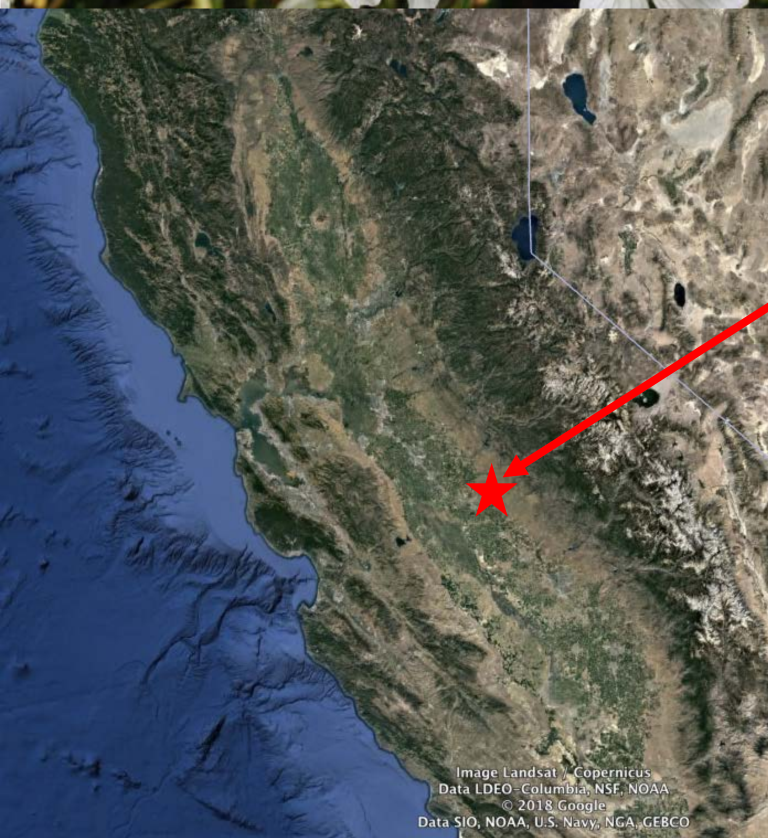
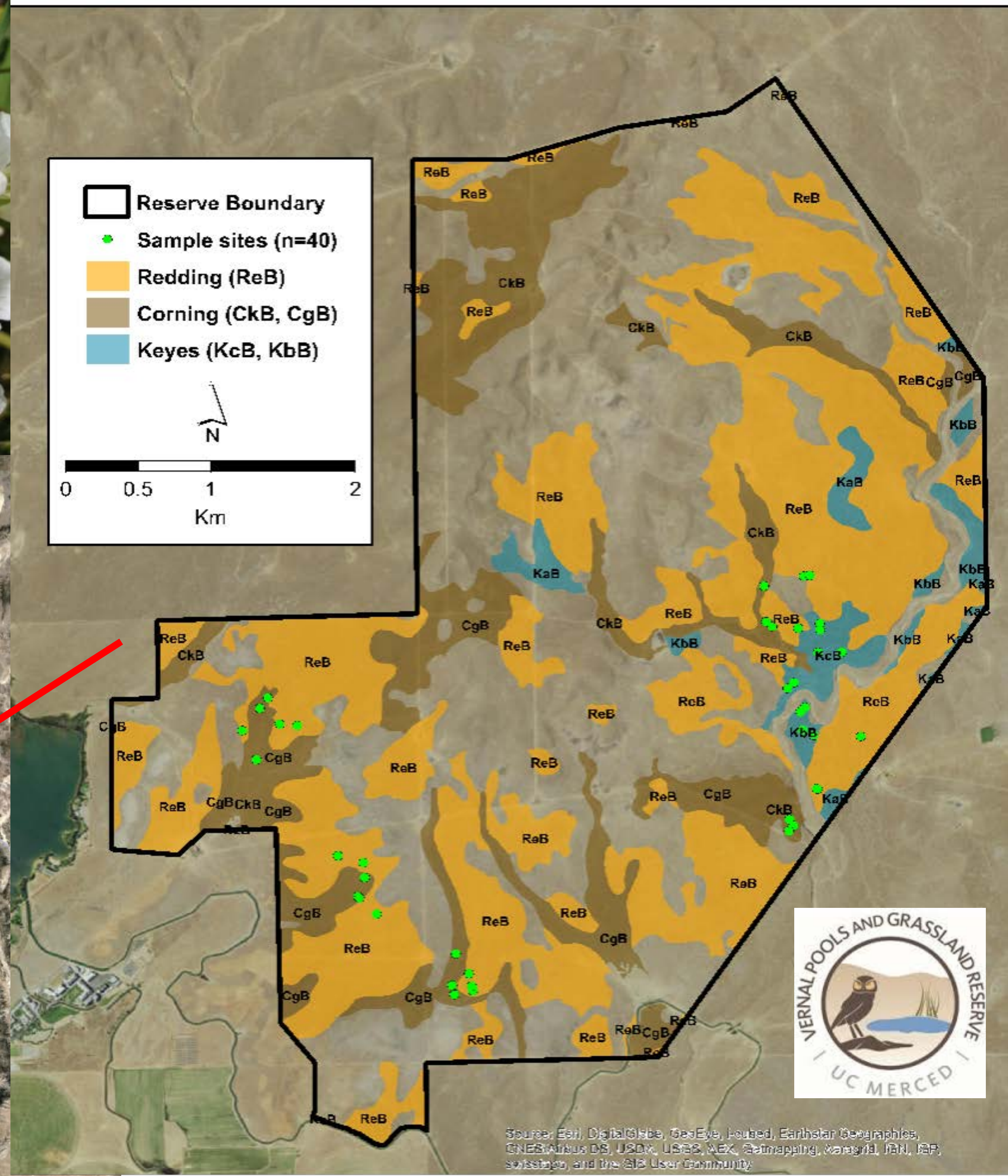


Common garden greenhouse experiment

My question: Is plant growth and performance of an endemic vernal pool plant species affected by soil type?

Merced Vernal Pools and Grasslands Reserve



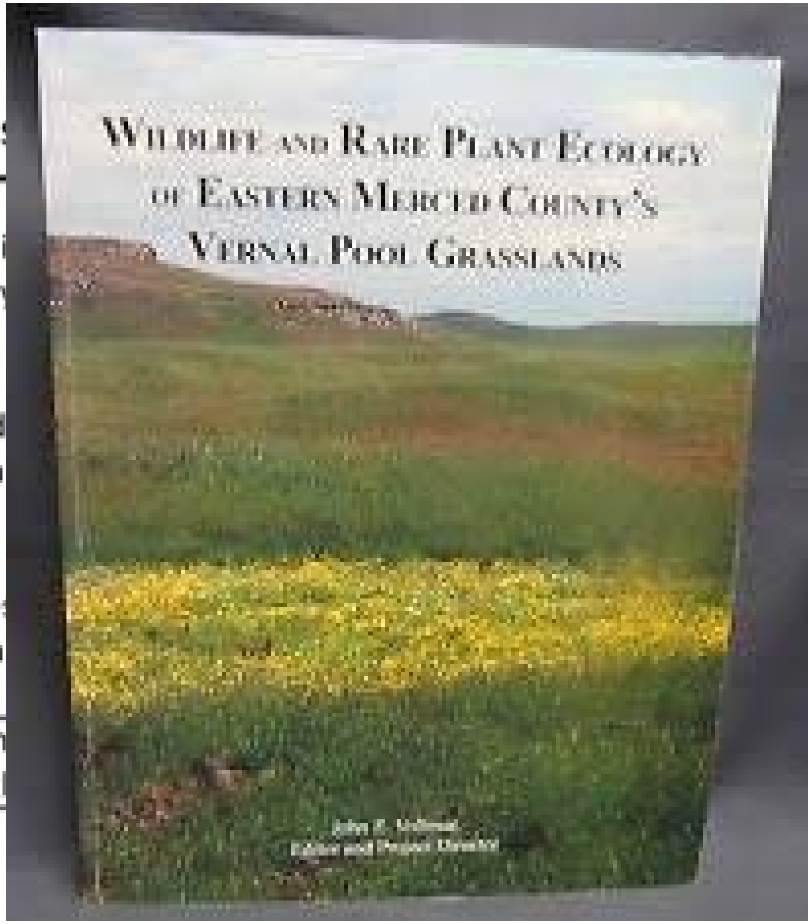


Study soils

Soil type	Parent material	pH	Available H2O	Organic Matter	Sand %	Silt %	Clay %
Corning gravelly sandy loam	Part of the Upper Laguna formation deposited as gravelly alluvium derived from igneous, metamorphic and sedimentary rock during the Late Pliocene 3-12 my.	5.9	0.08	0.38	41.4	33	25.6
Redding gravelly loam	Stratified gravelly alluvium derived from igneous, metamorphic and sedimentary rock deposited in the North Merced Gravels formation 1-3 my.	5.8	0.06	1.02	38.1	36.8	25
Keyes gravelly laom	Tuffaceous gravelly alluvium derived from andesite as part of the Upper Riverbank formation deposited in the Pleistocence ocene 0.1 my.	7.2	0.05	0.38	55	31.6	13.4

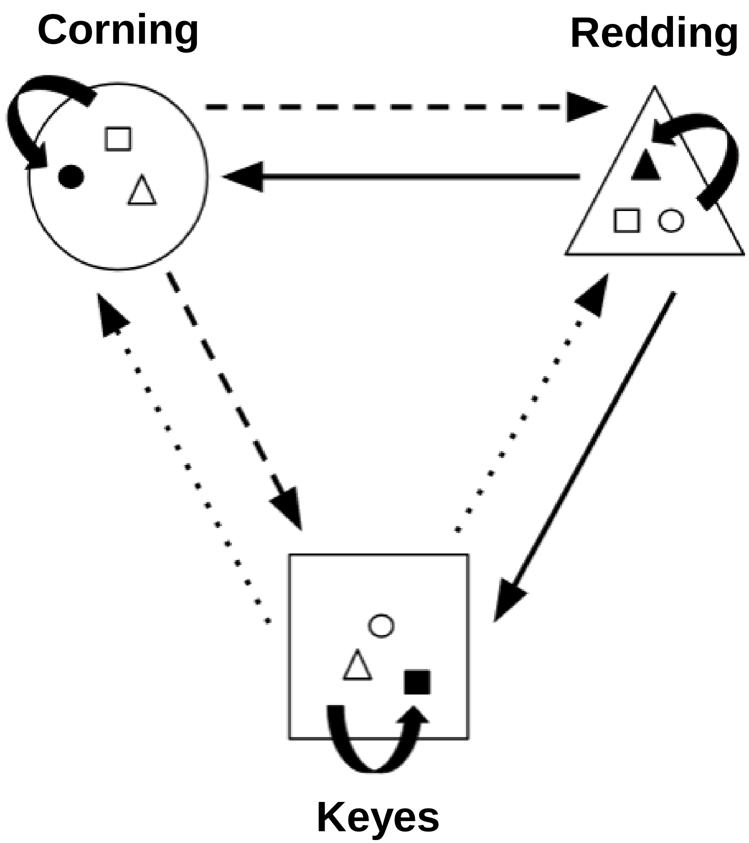
*Although these formations have their genesis at vastly different time scales, the ensuing pedogenesis represents a conglomerate of locally derived and deposited materials from their associated formations.

Study soils



- Arkley, 1962
- Marchand, 1976
- Allwardt, 1981
- Vollmar, Holland and others

Methods: Reciprocal randomized block design



- 9 vernal pools
- 3 soil types
- 4000+ seeds used
- 855 seedlings transplanted for this experiment

Methods: Germination and planting

- 4000+ seeds to germinate
  - <26% germination in pilot trial
  - 1401 seeds germinated for experiment
- 855 seedlings transplanted

Methods: Germination and planting

Fitness measures

Phenotypic trait measurements indicative of plant fitness:

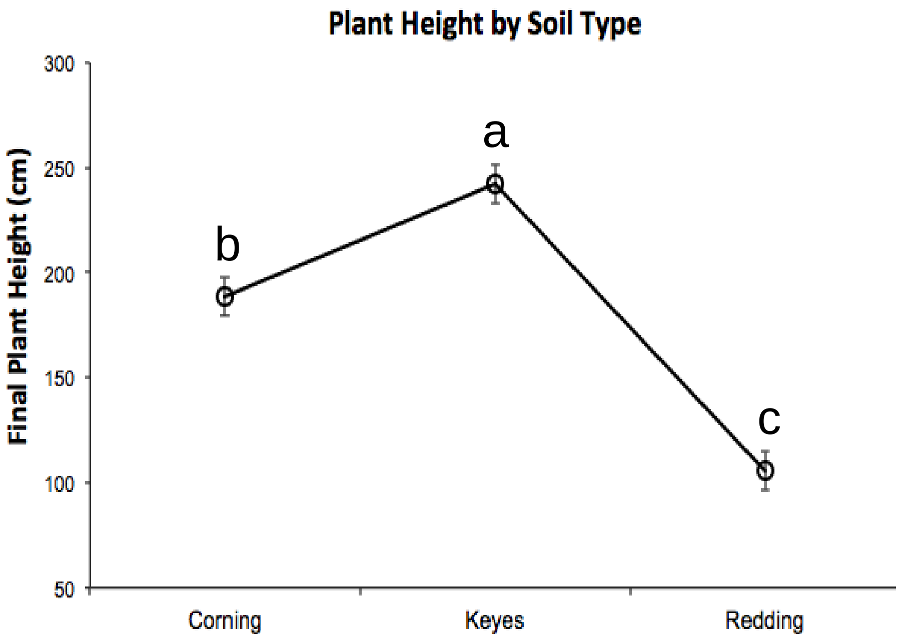
- Survival
- Final plant height
- Final root length
- Plant biomass
- Total number of flowers
- Final reproductive output = (total buds + total flowers)
- Reproductive success (fruits per flower)

Results

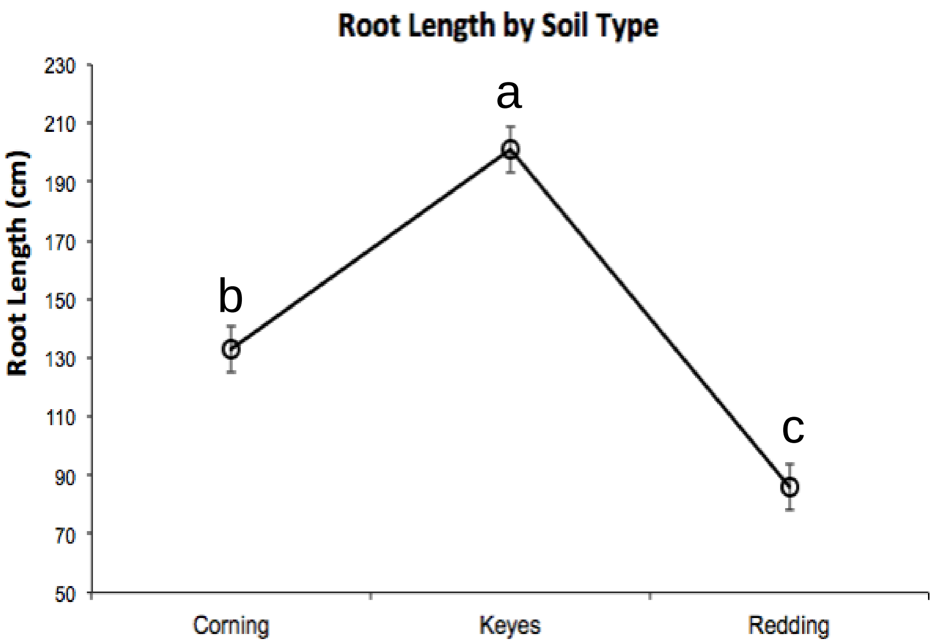
Table 1. Standard least squares model results for phenotypic traits. Values in bold were significant for a=0.05.

Response variable	df	L-R ChiSquare	P-value	Response variable	df	F Ratio	Prob > F
Survival				**Total reproductive success**			
Soil Treatment	2	10.7303287	**0.0047***	Soil origin	2	2.7255	0.0664
Soil Origin	2	4.68006569	0.0963	Soil Treatment	2	12.6814	**<.0001**
Soil Origin*Soil Treatment	4	1.79402518	0.7736	Block	6	14.1184	**<.0001**
Seed mass (g)	1	13.2041216	**0.0003***	Seed mass (g)	1	6.3852	**0.0118**
Block	6	140.100631	**<.0001***	Soil origin*Soil Treatment	4	1.3355	0.2555
Final plant height (cm)	**df**	**F Ratio**	**P-value**	**Fruits/flower**			
Soil origin	2	2.7707	0.0635				
Soil Treatment	2	26.1967	**<.0001**	Site soil type	2	4.638	**0.0102**
Block	6	37.3361	**<.0001**	Block soil type	2	5.881	**0.003**
Seed mass (g)	1	13.1892	**0.0003**	Block	6	3.4025	**0.0028**
Soil origin*Soil Treatment	4	0.7209	0.5779	Site soil type*Block soil typ	4	1.1237	0.3448
Root length (cm)				**Reproductive output**			
Soil origin	2	2.44	0.0881	Soil origin	2	1.4068	0.2458
Soil Treatment	2	48.1093	**<.0001**	Soil Treatment	2	12.413	**<.0001**
Block	6	54.0523	**<.0001**	Block	6	31.891	**<.0001**
Seed mass (g)	1	7.9808	**0.0049**	Seed mass (g)	1	19.3546	**<.0001**
Soil origin*Soil Treatment	4	0.9643	0.4266	Soil origin*Soil Treatment	4	2.049	0.0862
Biomass (g)				**Final number flowers**			
Soil origin	2	2.9298	**0.0542**	Soil origin	2	1.0425	0.3532
Soil Treatment	2	6.4092	**0.0018**	Soil Treatment	2	11.1863	**<.0001**
Block	6	18.6334	**<.0001**	Block	6	26.0428	**<.0001**
Seed mass (g)	1	4.6241	**0.032**	Seed mass (g)	1	15.1595	**0.0001**
Soil origin*Soil Treatment	4	0.3298	0.858	Soil origin*Soil Treatment	4	1.5082	0.1983

Plant growth and performance



p<0.0001*



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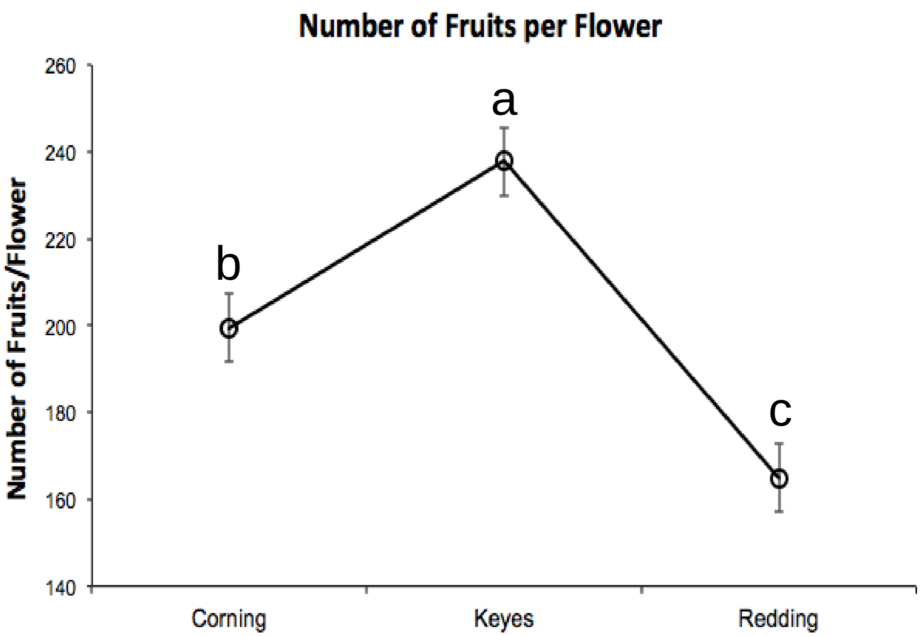

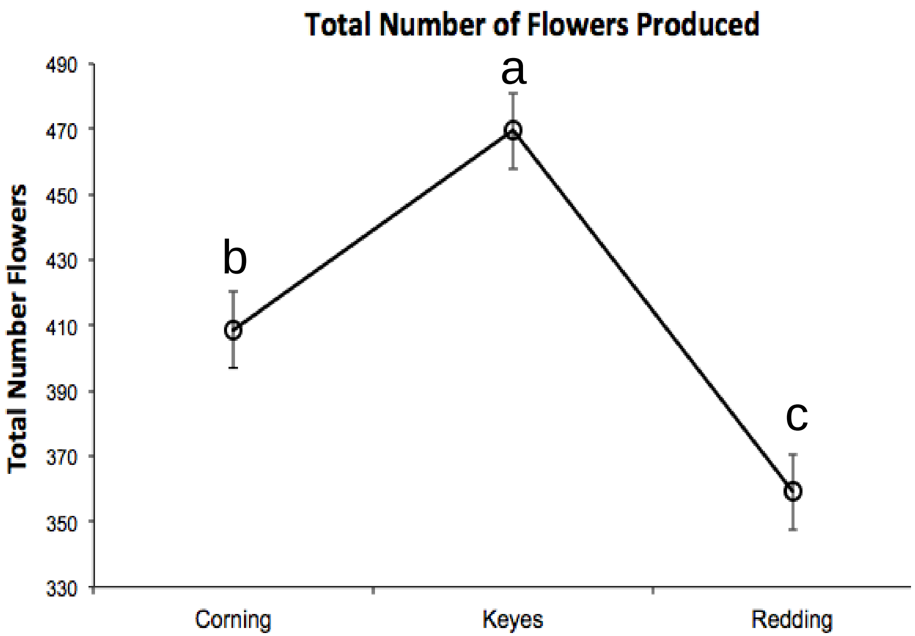

p<0.0001*

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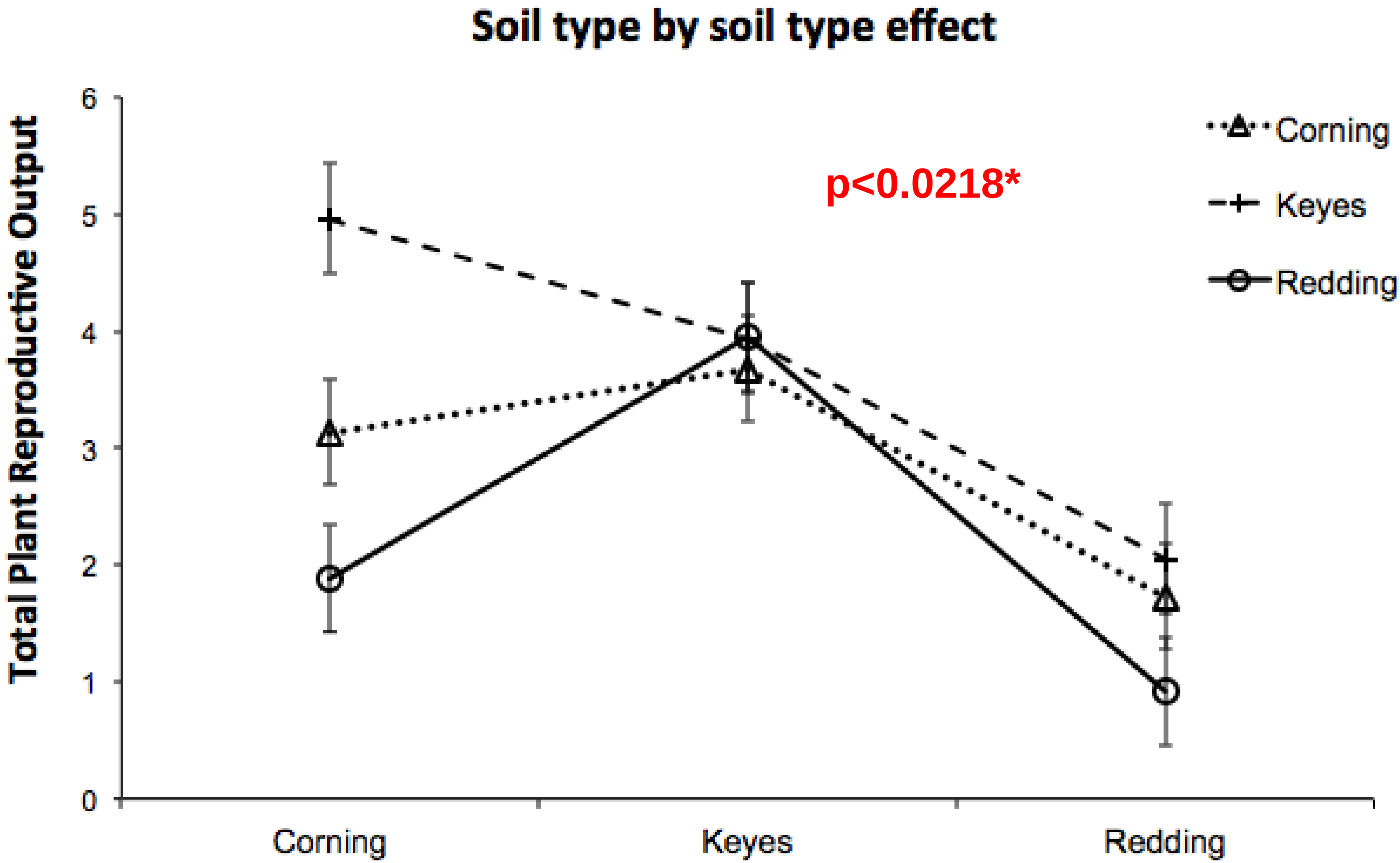
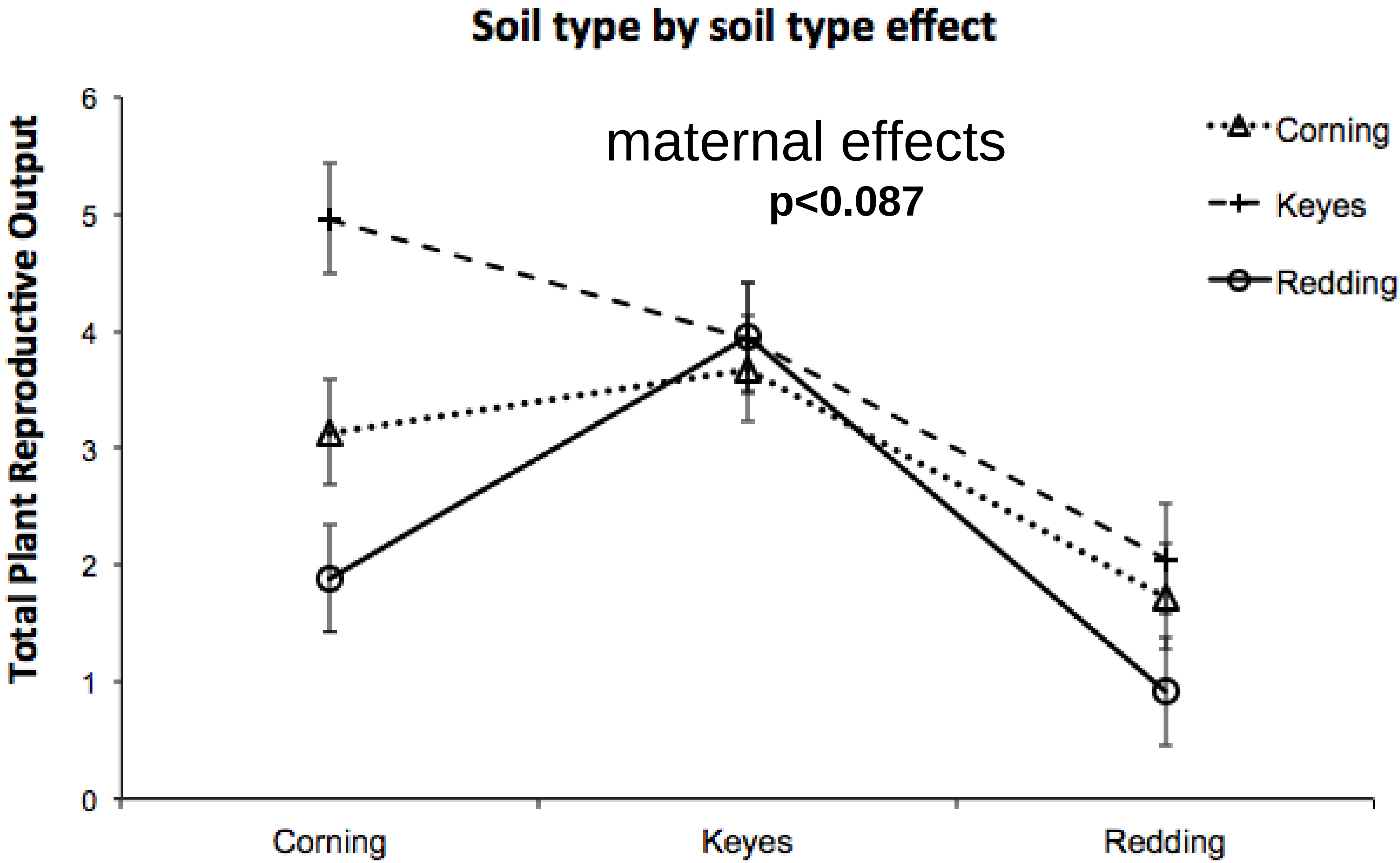
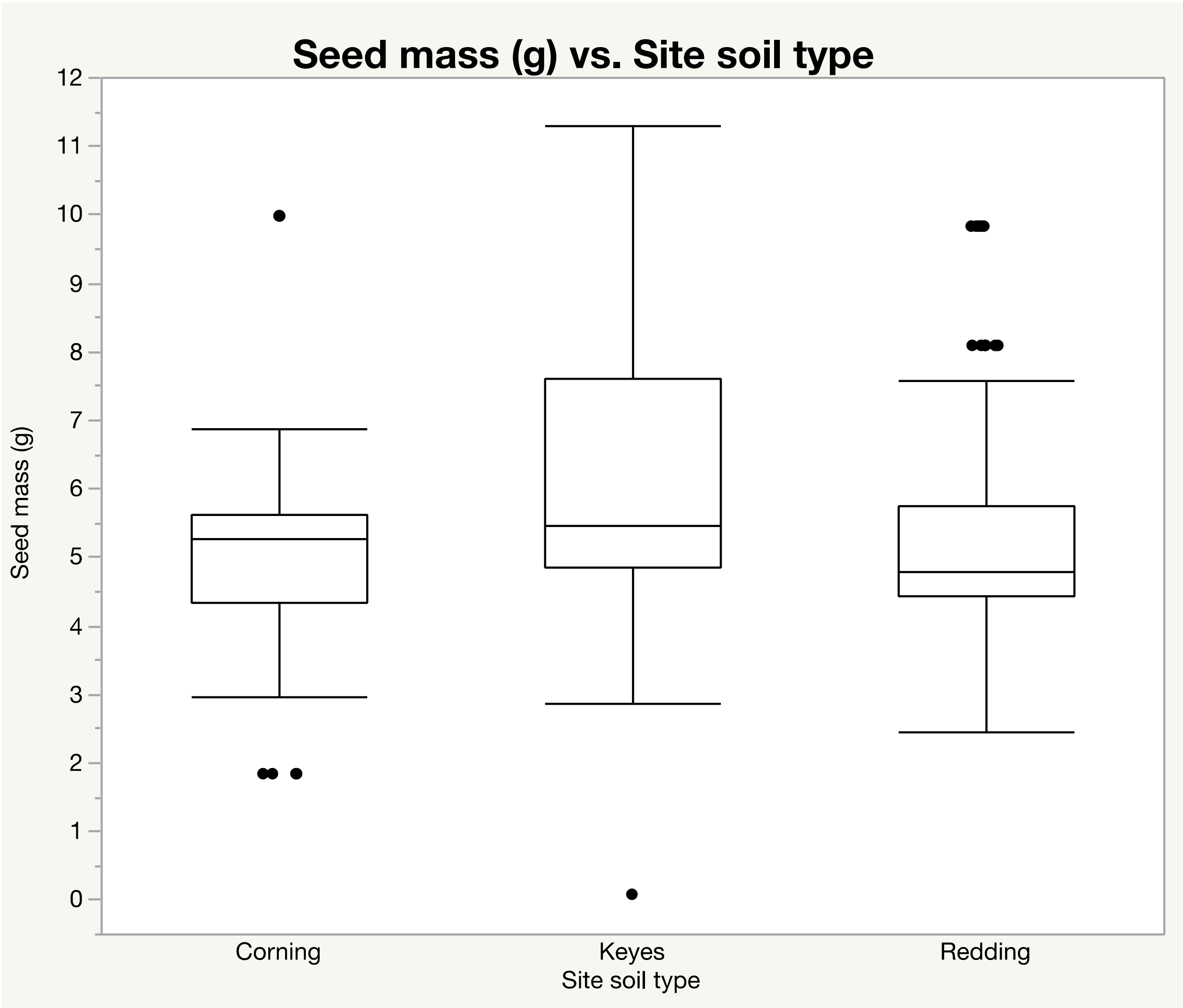
Significant home soil type effects



Significant home soil type effects?



Maternal effects



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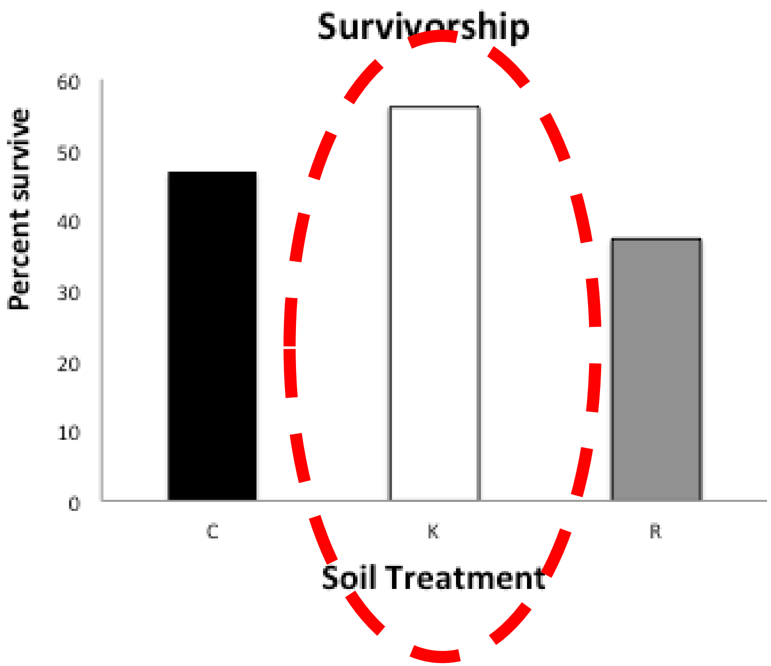
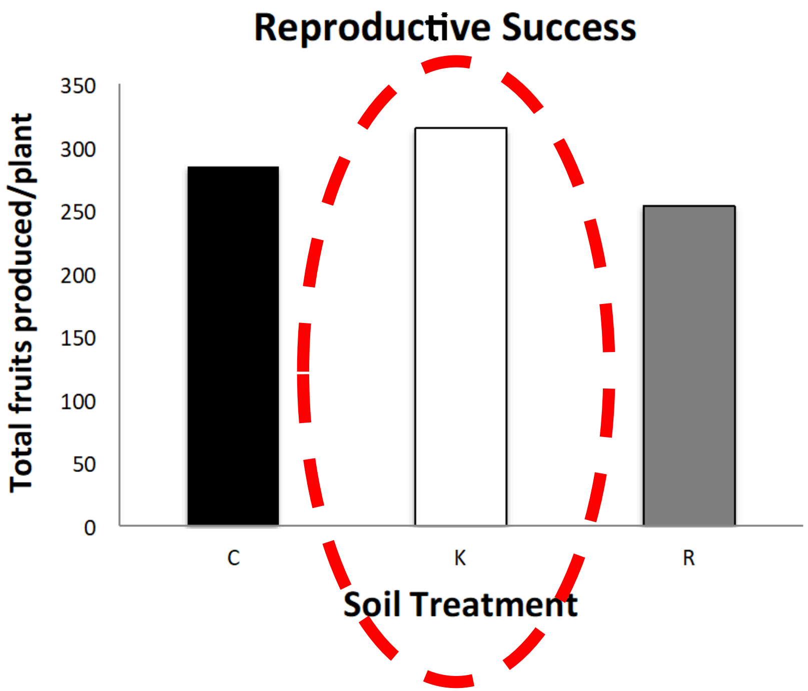
Significant soil type effects





Conclusions

Does soil type matter to vernal pool plant species?

YES!

Conclusions

Does soil type matter to vernal pool plant species?

YES!

Plant growth and performance was significantly affected by soil type

Conclusions

1. Plant performance was affected by soil type.

2. There are multigenerational effects, whereas plants from pools on Keyes soil type produce larger seeds.

3. This maternal effect is correlated with better fitness.

Thank you

VERNAL POOLS AND GRASSLAND RESERVE
UC MERCED

UCMERCED
GRADUATE DIVISION
Environmental Systems

Natural Reserve System
UNIVERSITY OF CALIFORNIA

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SIERRA NEVADA RESEARCH INSTITUTE

Results: It’s HOT in here!!!

- Only 46.6% of plants survived to the end of experiment. Massive die off in first week of April (Hot! ~ 110F in greenhouse).

Results: It’s HOT in here!!!

Preliminary data

Table 2. One-way ANOVA results and standard deviations for percent clay, cation exchange capacity (CEC), sodium adsortion ratio (SAR), Ca:Mg ratio and pH for two vernal pool soil types. * illustrates P-values of statistical significance.

Soil Type	% Clay	CEC (cmolc/kg)	SAR	Ca:Mg	pH
Keyes	11.9	5.81 ± 0.40	0.05 ± 0.01	4.47 ± 0.53	6.11 ± 0.07
Corning	16.1	7.80 ± 0.58	0.06 ± 0.01	2.64 ± 0.61	5.38 ± 0.38
P-value ($p<0.05$)		*** p = 0.012**	p = 0.20	*** p =0.017**	*** p = 0.031**

Preliminary data