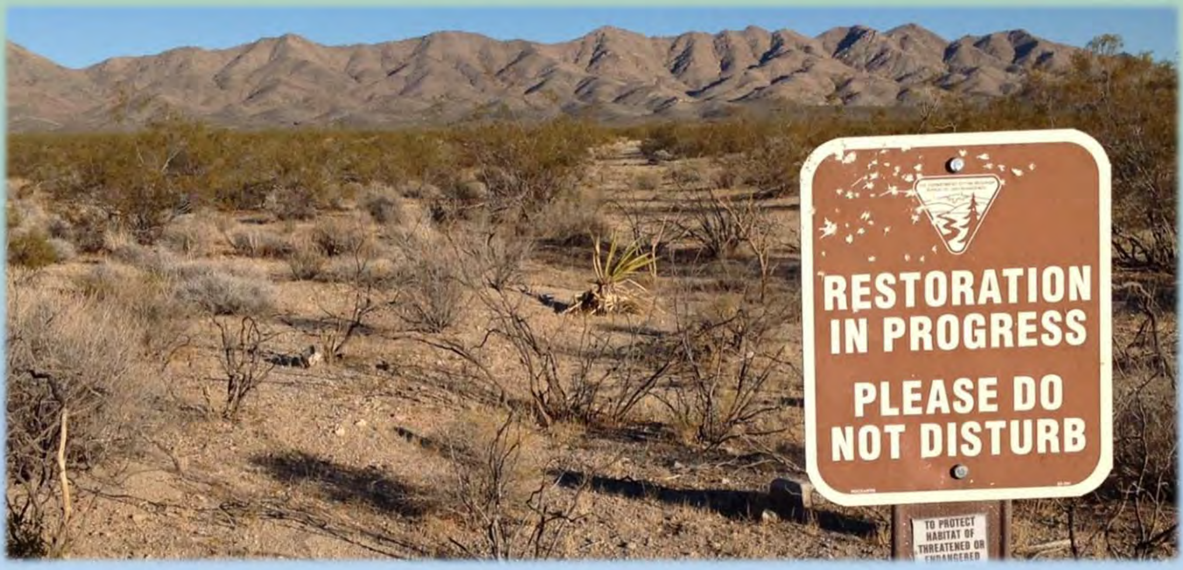
An Integrated Approach for Repairing Degraded Mojave Desert Shrublands



Lesley A. DeFalco,

USGS, Western Ecological Research Center

November 10th , 2016

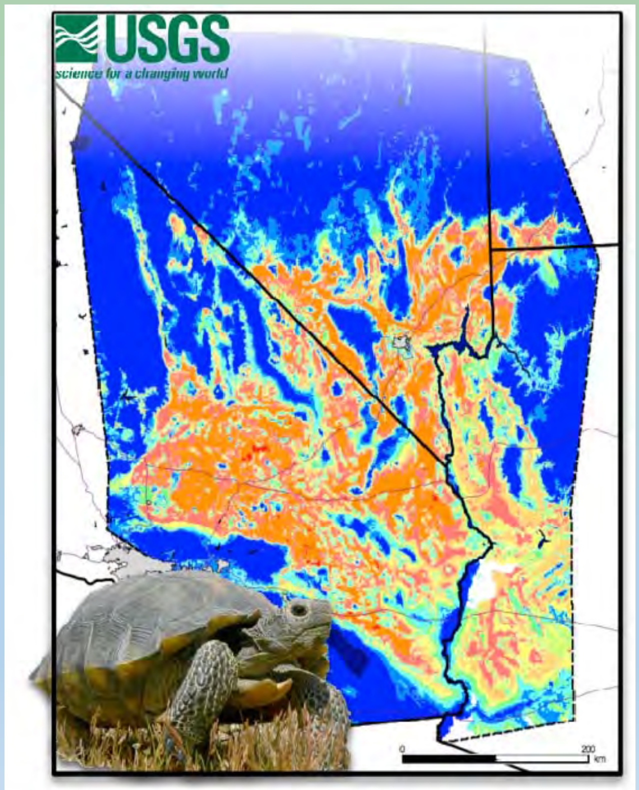
Society for Ecological Restoration, Southwest Chapter

Las Vegas, Nevada

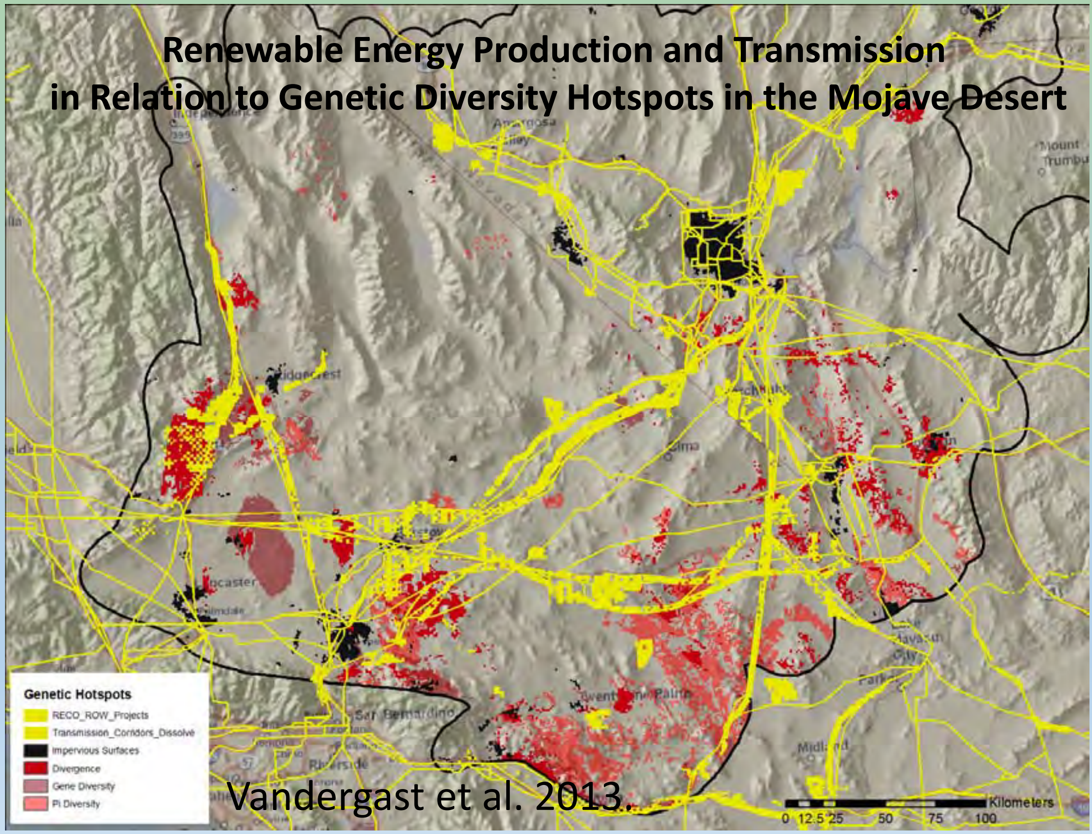
Mojave Desert is Symbolic of Major Ecological Restoration Challenges

Photos: T. Esque

Mojave Desert is Symbolic of Major Ecological Restoration Challenges



Adapted from Nussear et al. 2009



Vandergast et al. 2013

Wildfire: A Novel Disturbance Transforming Mojave Desert Shrublands

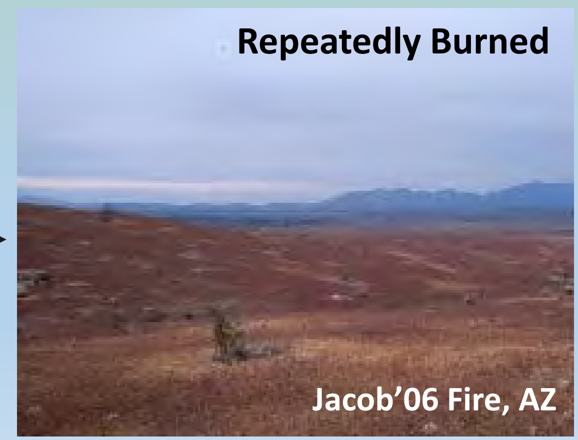
Gass Peak Fire, Nevada 2006

- ❖ Fires are carried by non-native annual grasses
- ❖ >1 million acres burned or re-burned in 2005/2006
- ❖ ~5% of federally-designated critical habitat

Dry Middle Fire, Nevada

Mt. Potosi, Nevada

Cascading Degradation of Habitat with Repeated Burning

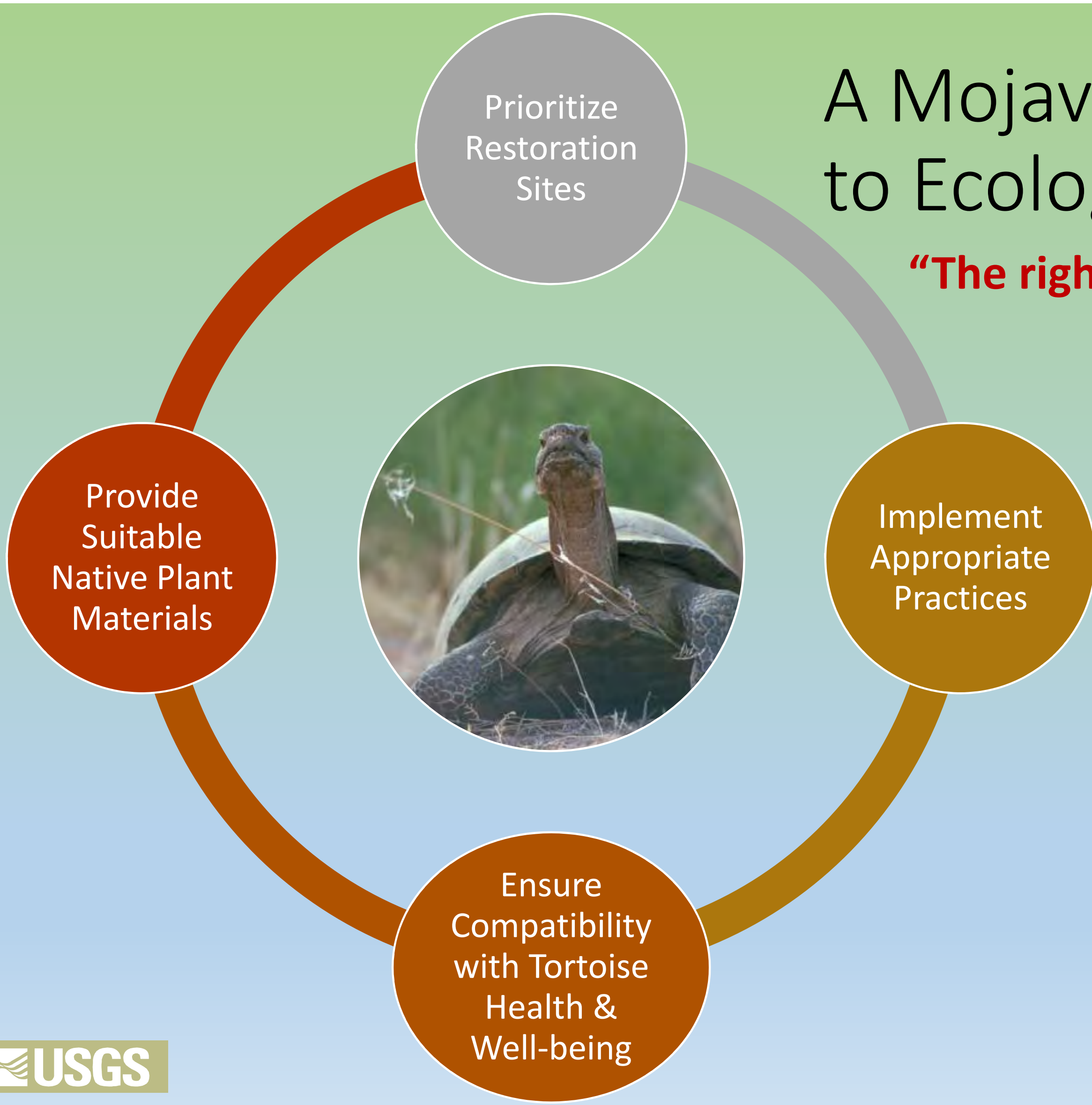


Partnerships and Collaborations are Essential!

Great Basin Institute
U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT
U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR
UTAH DNR WILDLIFE RESOURCES
RANCHO SANTA ANA BOTANIC GARDEN
USGS science for a changing world
NATIONAL PARK SERVICE
U.S. DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION
CLARK COUNTY NEVADA
TEXAS STATE UNIVERSITY 1899
University of Colorado Boulder
UNIVERSITY OF NEVADA LAS VEGAS
NTC NATIONAL TRAINING CENTER
sca
SAN DIEGO STATE UNIVERSITY 1897
CSN COLLEGE OF SOUTHERN NEVADA
NEVADA DIVISION OF FORESTRY
SEEDS OF SUCCESS
Nevada Conservation Corps
CHICAGO BOTANIC GARDEN

A Mojave Ecoregional Approach to Ecological Restoration

“The right seed at the right site at the right time”



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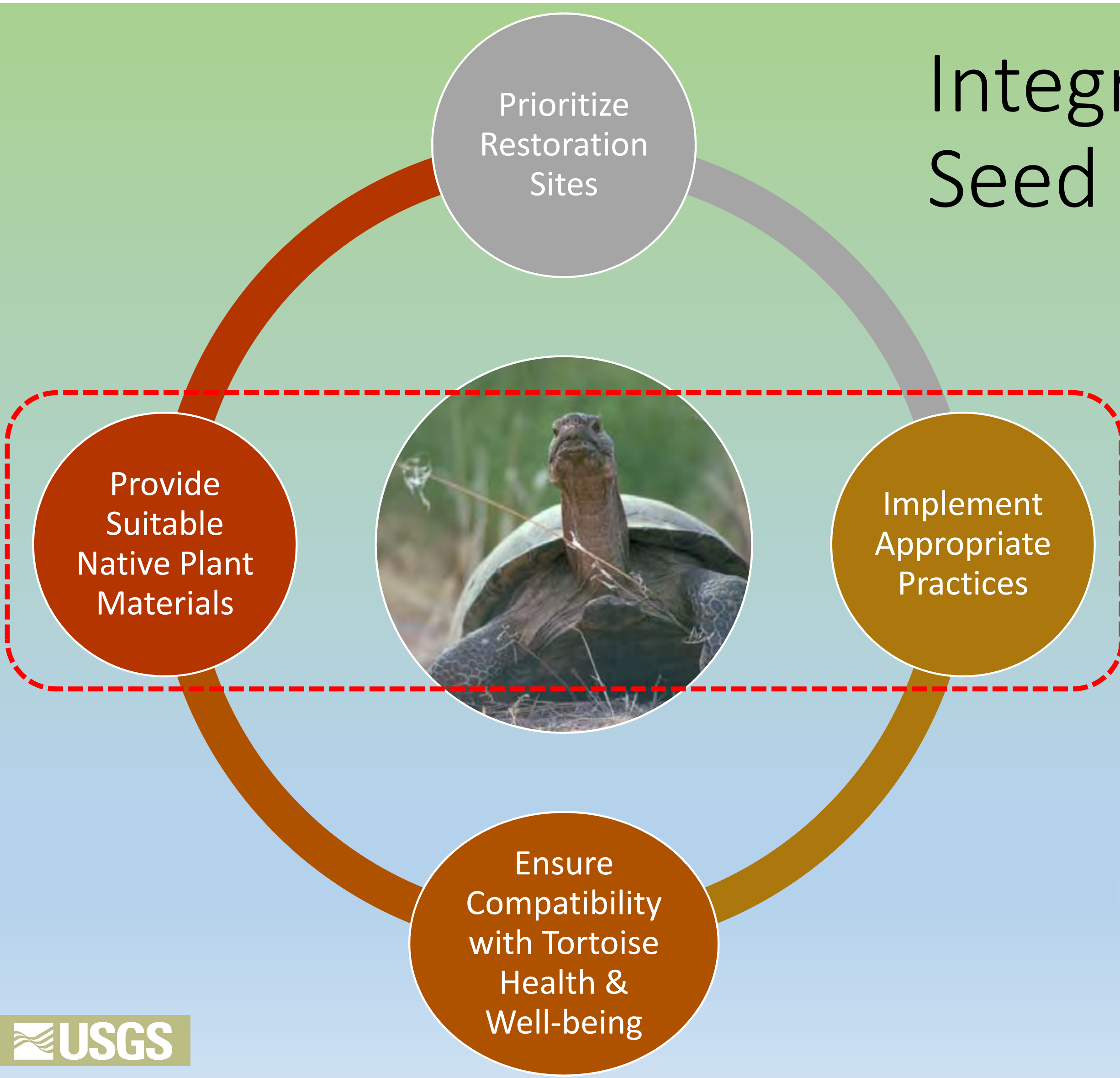
Integration with National Seed Strategy



Selecting Native Plant Materials: Finding "The Right Seed…"

Provide Suitable Native Plant Materials

- Priority Species List
  - Tortoise food and cover plants
  - Availability for immediate use
  - Potential for commercial collection vs. production
- Landscape Genetics
- Multiple Common Gardens

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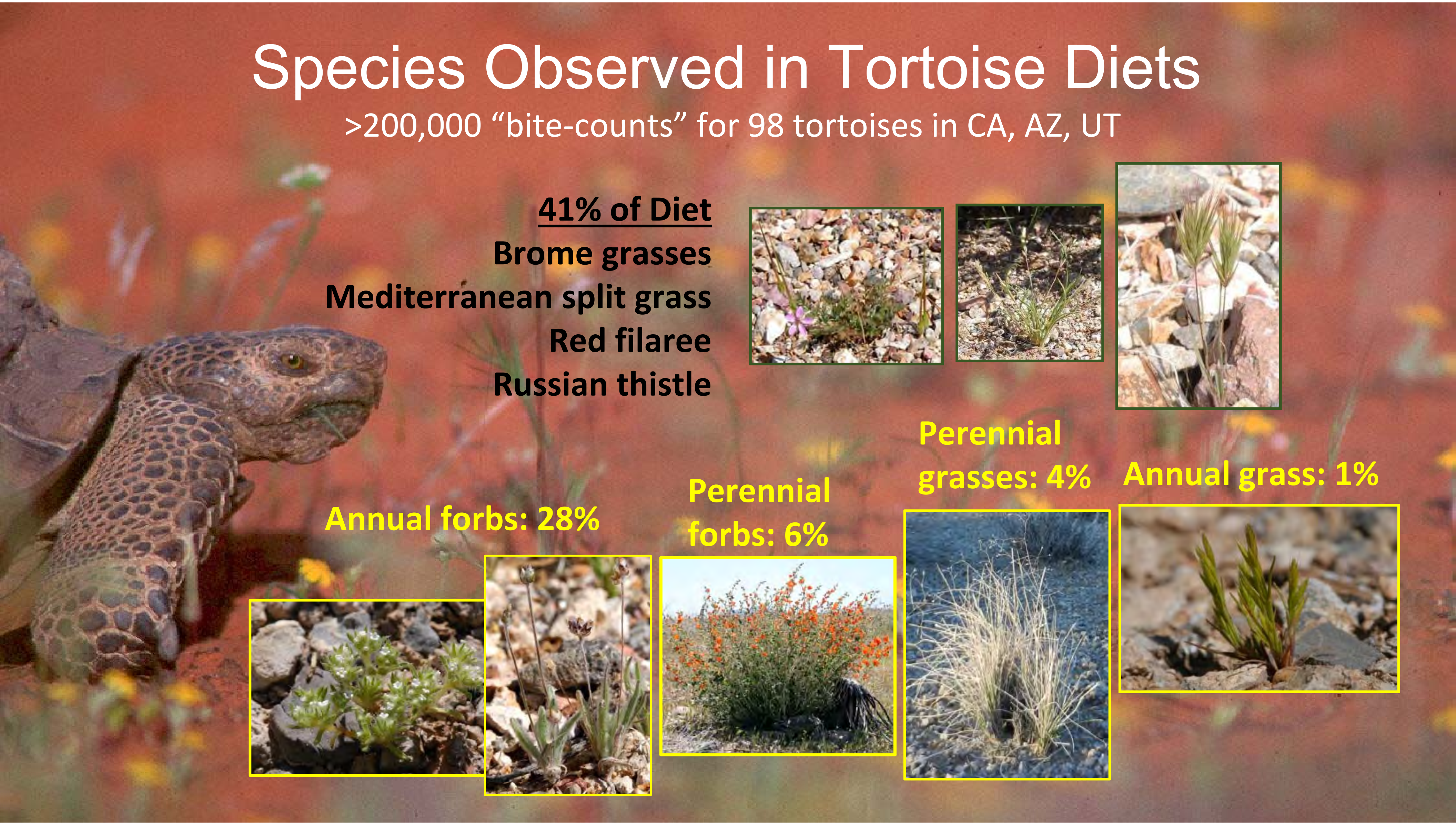
Species Observed in Tortoise Diets
>200,000 “bite-counts” for 98 tortoises in CA, AZ, UT
41% of Diet
Brome grasses
Mediterranean split grass
Red filaree
Russian thistle
Annual forbs: 28%
Perennial forbs: 6%
Perennial grasses: 4%
Annual grass: 1%

Diversity of Pollinators Also Supported

National Strategy to Promote the Health of Honey Bees and Other Pollinators

USGS

Long-lived, Shrubs Provide Majority of Cover for Tortoises

Species	#Obs	% Use[a]	# Sites	Habit / Recovery[b]
Creosotebush, *Larrea tridentata*	1659	43.08	8	Shrub / -
White bursage, *Ambrosia dumosa*	889	23.08	8	Shrub / -
Utah yucca, *Yucca schidigera*	185	4.80	6	Shrub / -
Wolfberrry, *Lycium andersonii*	173	4.49	8	Shrub / -
Cheesebush, *Hymenoclea salsola*	138	3.58	5	Shrub / +
Nevada jointfir, *Ephedra nevadensis*	132	3.43	6	Shrub / -
Desert globemallow, *Sphaeralcea ambigua*	123	3.19	6	Per Forb/ +
Joshua tree, *Yucca brevifolia*	120	3.12	4	Shrub / -
Desert holly, *Atriplex hymenolytra*	53	1.38	2	Shrub / -
Range ratany, *Krameria grayi*	53	1.38	5	Shrub / -
Jointfir, *Ephedra sp.*	44	1.14	1	Shrub / -

[a]Based on 3,800 observations across 8 monitoring sites in CA and NV

[b]Based on short- and long-term recovery (Shryock et al. 2014)

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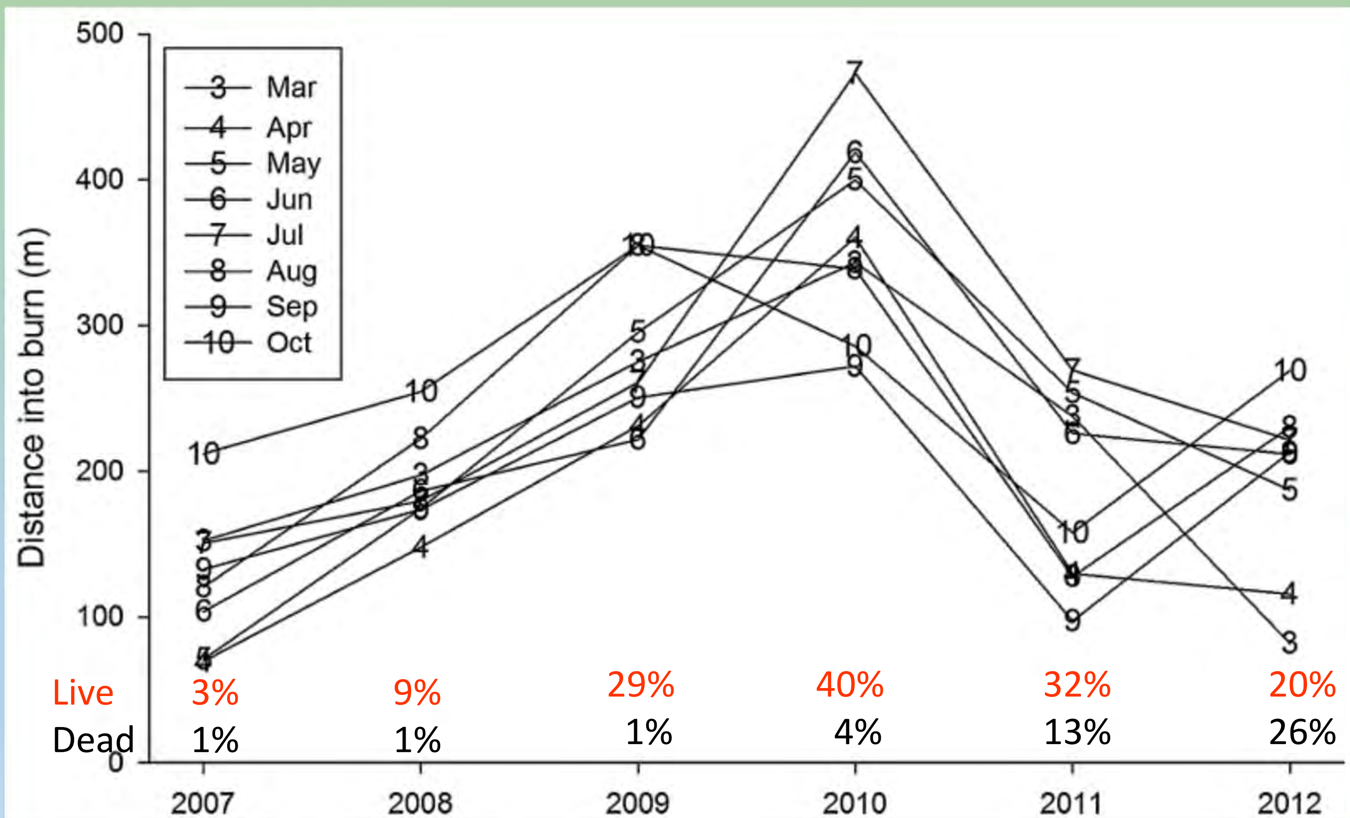
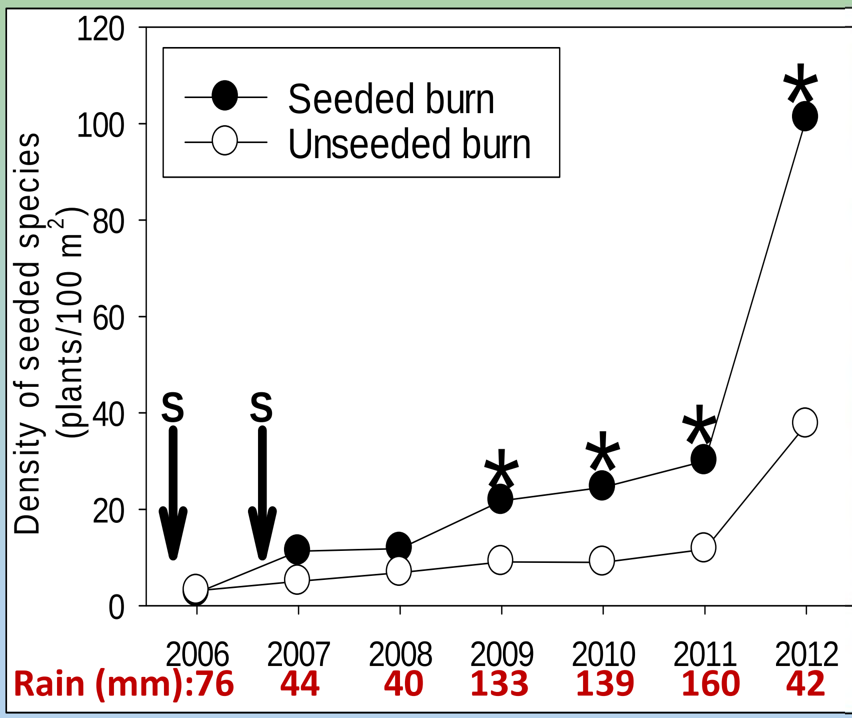
Esque *et al., unpubl. data*

Early-Colonizing Forbs Can Provide Short-Term Thermal Cover for Tortoises



Drake *et al.* 2015

Seeding Promotes Recruitment of Short-lived Perennial Forbs

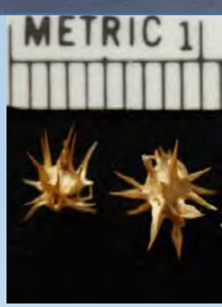


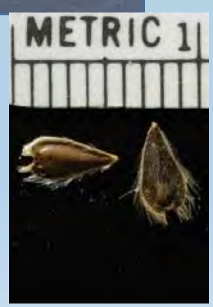
Seed Costs For Native Shrubs are Prohibitive

< 5% for Bonnie Springs, NV 2005 (22 seeds/m^2 *H. salsola*)

5% for Coyote Springs, NV in 2005 (17 seeds/m^2 *A. dumosa, A. canescens*)

4% for Coyote Springs, NV in 2006 (29 seeds/m^2 *L. tridentata, A. dumosa, H. salsola*)





Species	Relative Cost
Sand dropseed, *Sporobolus cryptandrus*	1.0
Sideoats grama, *Bouteloua curtipendula*	6.0
Indian ricegrass (Rimrock), Achnatherum hymenoides	7.6
Palmer's penstemon, Penstemon palmeri	31.1
White evening primrose, Oenothera dentata	40.3
Cheesebush, Hymenoclea salsola	44.3
Desert marigold, Baileya multiradiata	69.2
Indian ricegrass (Paloma), A. hymenoides	80.0
Creosotebush, Larrea tridentata	96.2
Nevada Ephedra, Ephedra nevadensis	905.1

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High Priority Species(2016-2017)

Work Done, or in Progress:

- Desert Globemallow (*Sphaeralcea ambigua*)
- Nevada Jointfir (*Ephedra nevadensis*)
- Burrobrush (*Ambrosia dumosa*)
- Desert Indianwheat (*Plantago ovata*)
- Creosote (*Larrea tridentata*)
- Indian Ricegrass (*Stipa hymenoides*)
- Big Galleta (*Pleuraphis rigida*)

High Future Priority:

- Bush Muhly (*Muhlenbergia porteri*)
- Yellow Cups (*Chylismia brevipes*)
- Lanceleaf Browneyes (*Chylismia claviformis*)
- Sixweeks Fescue (*Vulpia octoflora*)
- Needle Grama (*Bouteloua aristidoides*)
- Sixweeks Grama (*Bouteloua barbata*)
- Smooth Desert Dandelion (*Malacothrix glabrata*)
- Chia (*Salvia columbariae*)
- Cheesebush (*Ambrosia salsola*)
- Pincushion Flower (*Chaenactis salsola*)
- Anderson Wolfberry (*Lycium andersonii*)
- White Ratany (*Krameria bicolor*)
- Littleleaf Ratany (*Krameria erecta*)

Slide courtesy J. Perkins

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- Priority Species List
- **Landscape Genetics**
- Multiple Common Gardens

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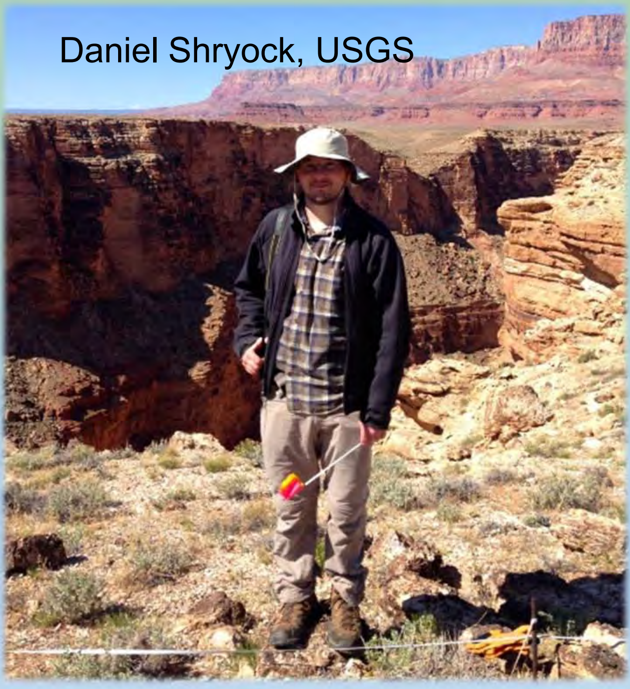
Article

Landscape genetic approaches to guide native plant restoration in the Mojave Desert

Daniel F. Shryock, Caroline A. Havrilla, Lesley A. DeFalco, Todd C. Esque, Nathan A. Custer, Troy E. Wood

Accepted manuscript online: 5 October 2016 Full publication history

DOI: 10.1002/eap.1447 View/save citation



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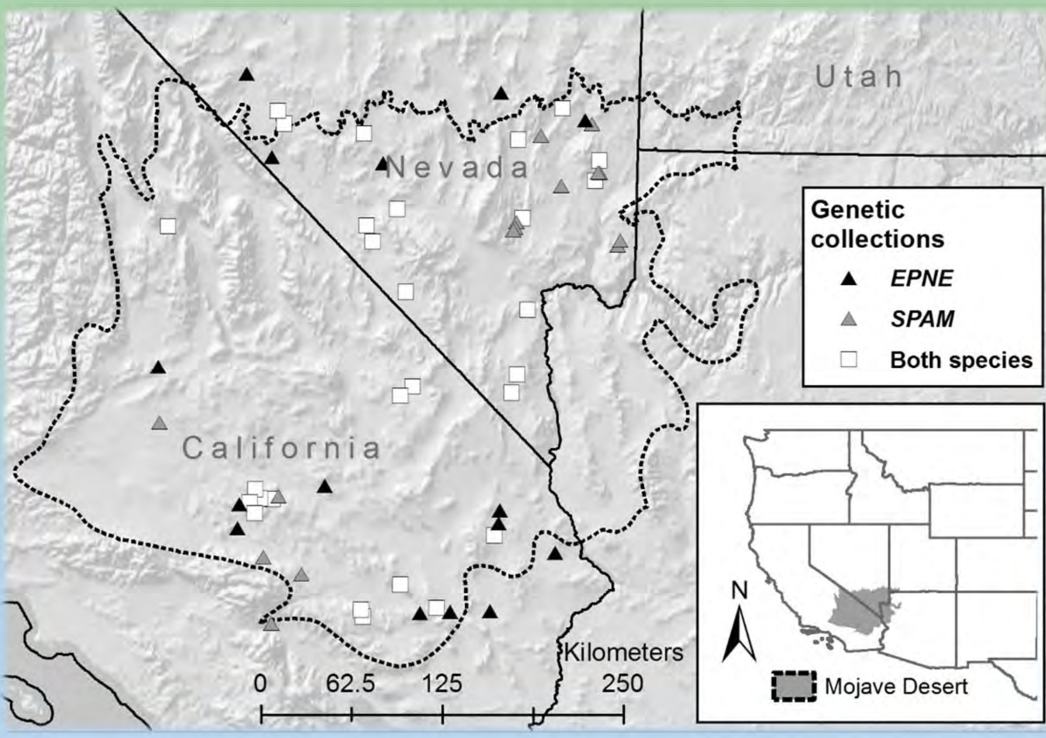
Detecting Genetic Signal of Adaptation



Ephedra nevadensis

Long-lived
Evergreen
Wind-pollinated
- 43 popns, 403 indiv
- 404 loci

Sphaeralcea ambigua

Short-lived
Drought deciduous
Insect-pollinated
- 47 popns, 446 indiv
- 153 loci

Shryock *et al.* 2016 *Ecological Applications*

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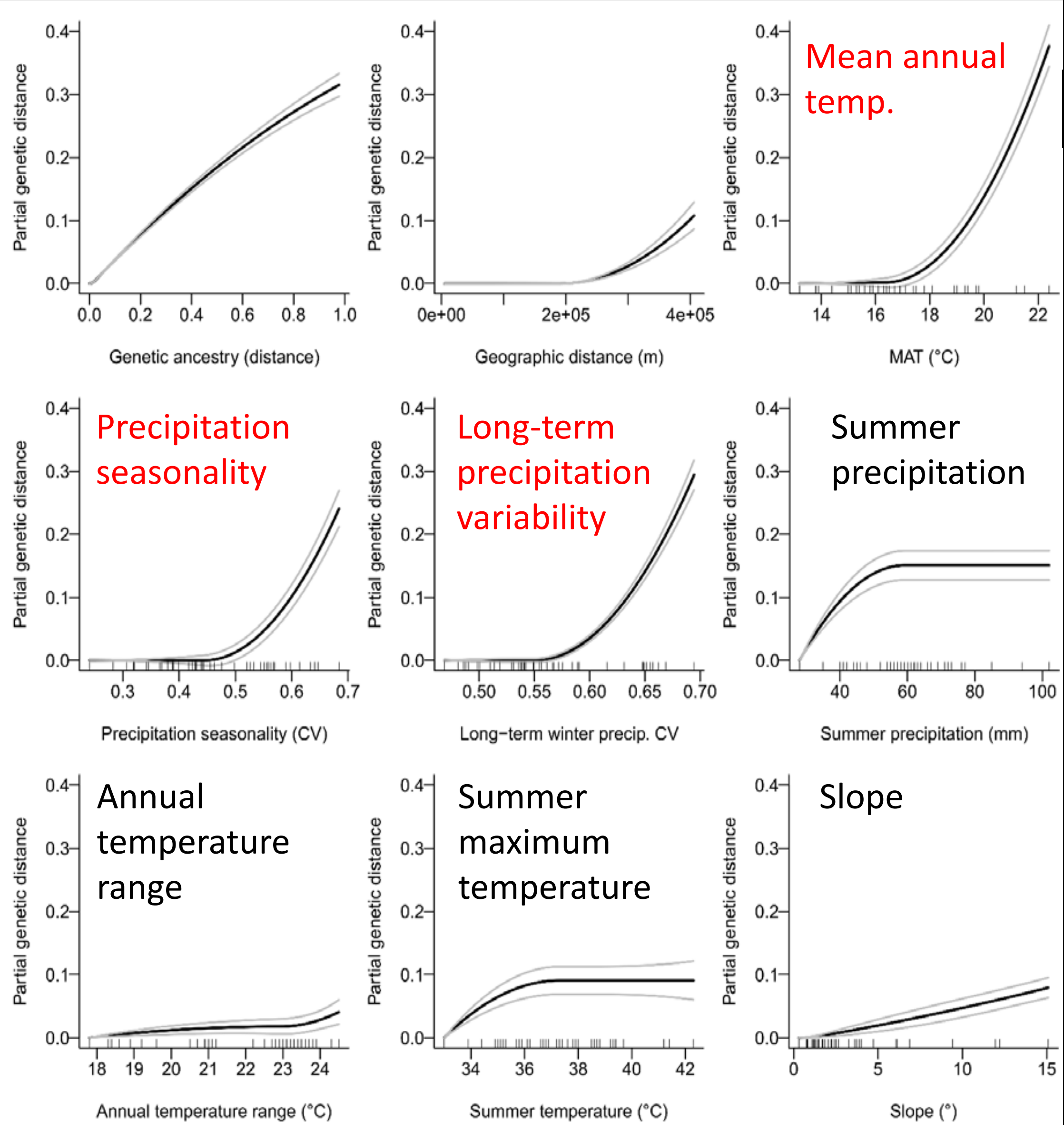
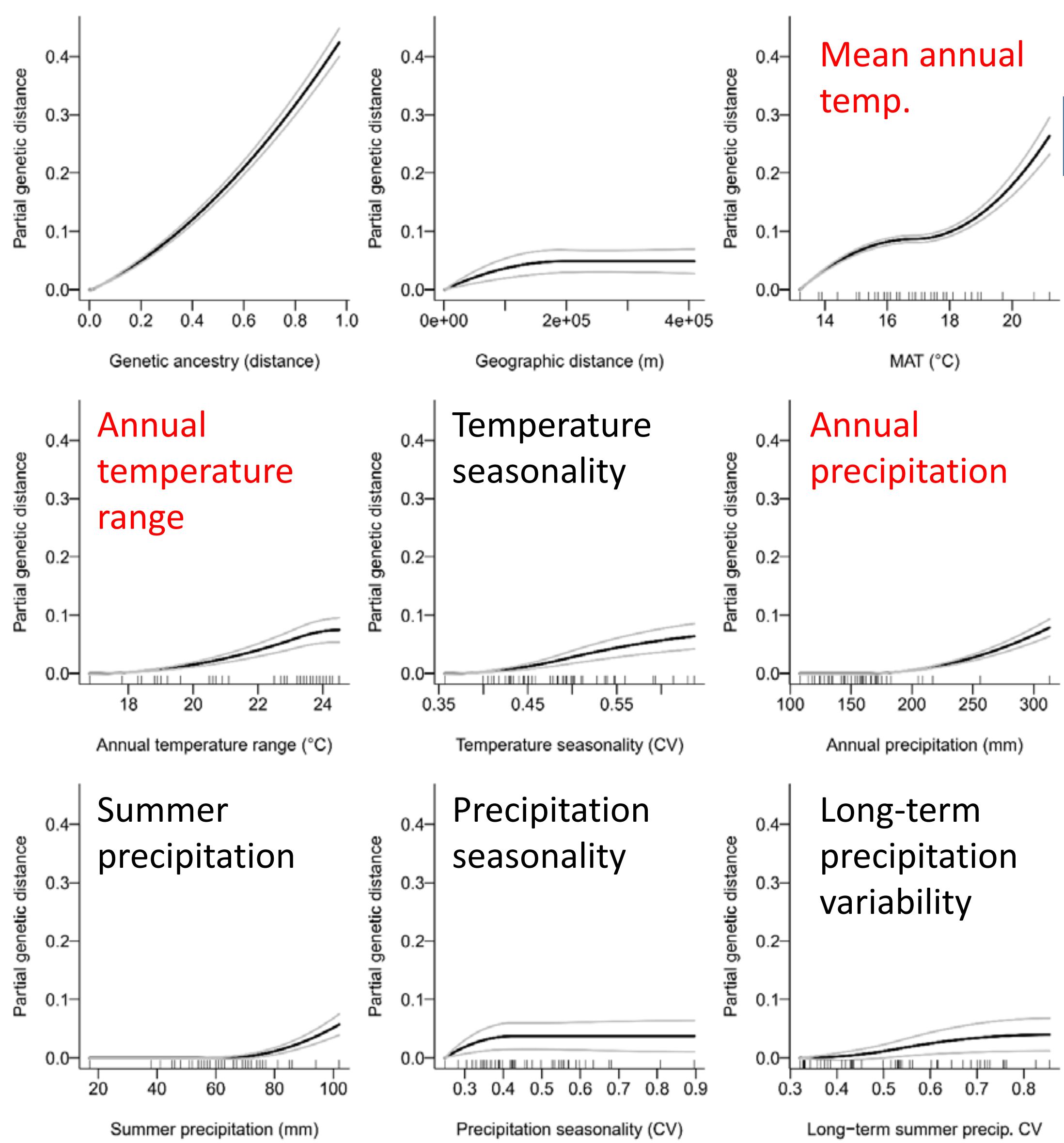


Ephedra nevadensis

Strongest predictors:

- **Mean annual temperature**
- **Precipitation variability**

Shryock *et al.* 2016 *Ecological Applications*



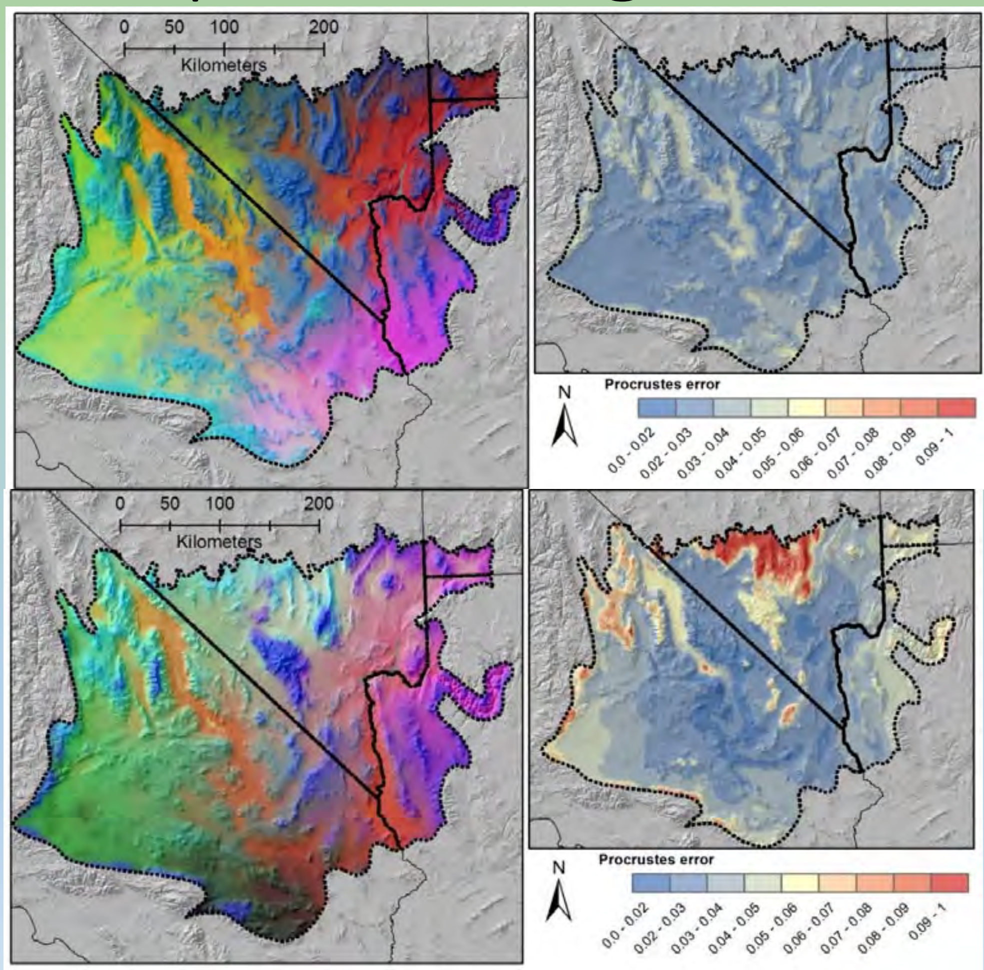
Sphaeralcea ambigua

Strongest predictors:

- **Mean annual temperature**
- **Temperature variability**
- **Precipitation totals**

Shryock *et al.* 2016 *Ecological Applications*

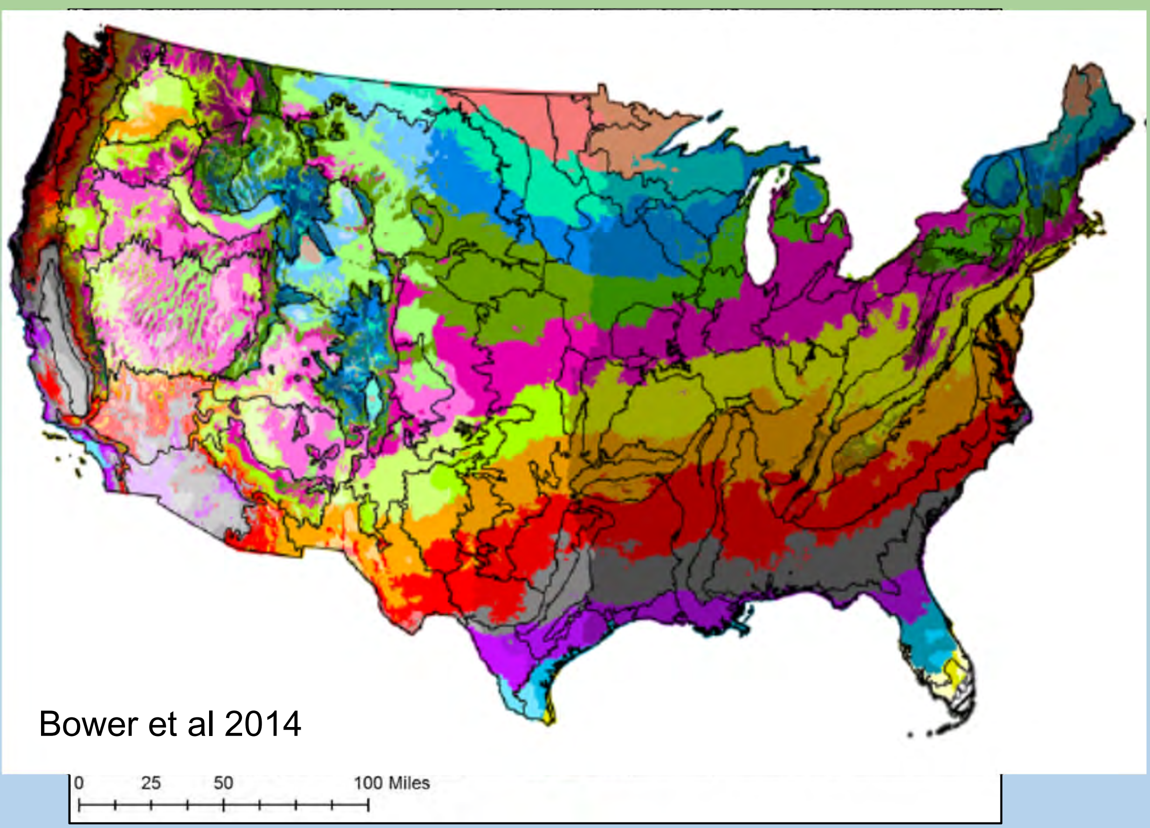
Spatial Interpolations of Between-Population Adaptive Divergence

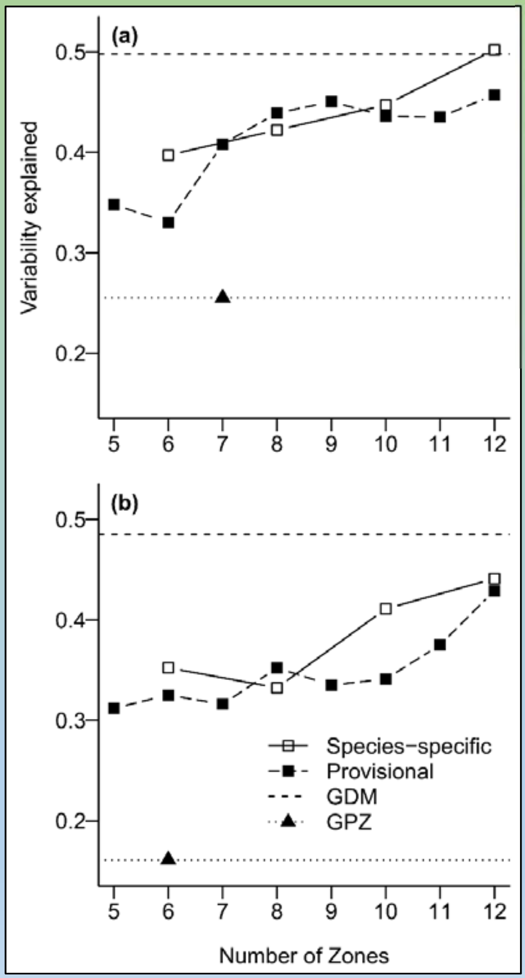


Ephedra nevadensis

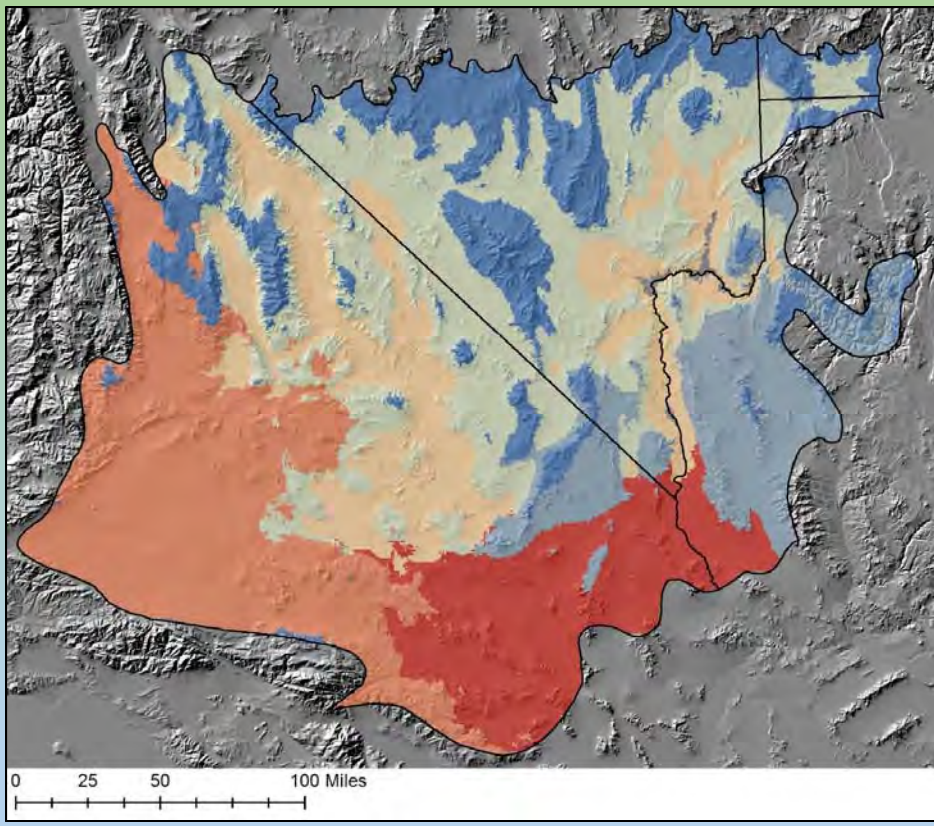
Sphaeralcea ambigua

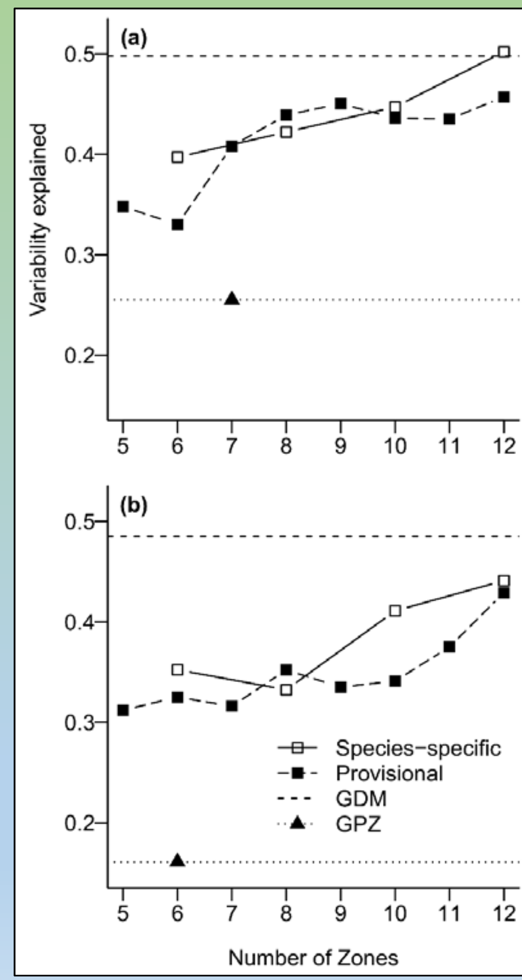
Shryock *et al.* 2016 *Ecological Applications*





Shryock *et al.* 2016 *Ecological Applications*

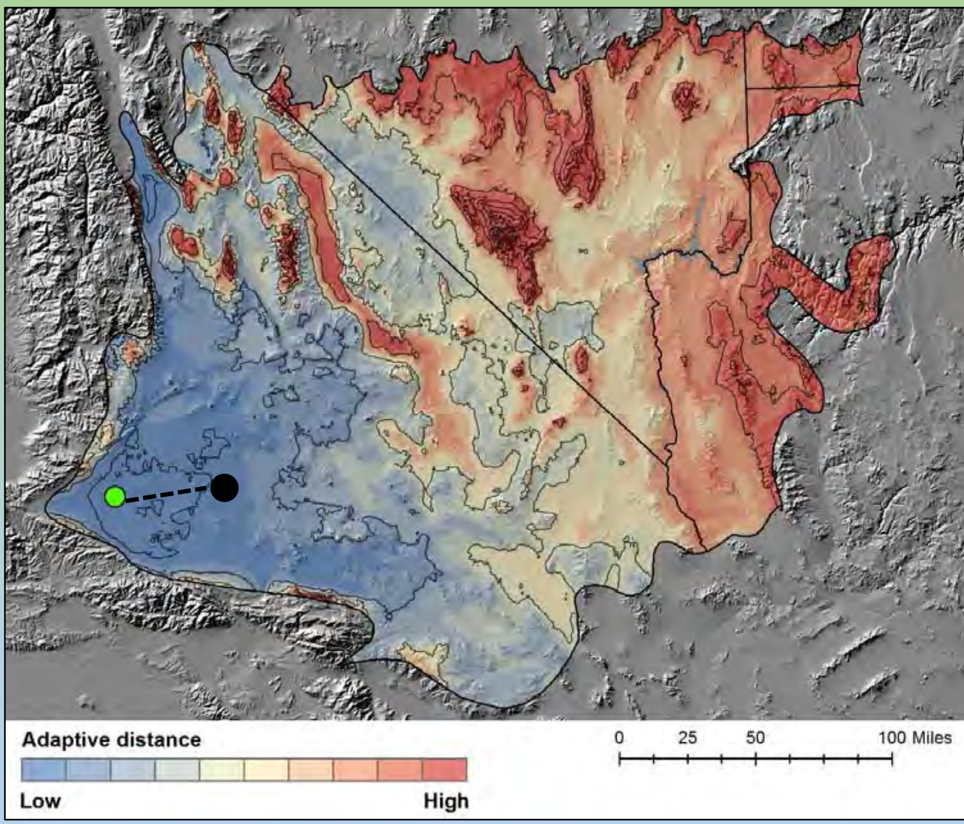


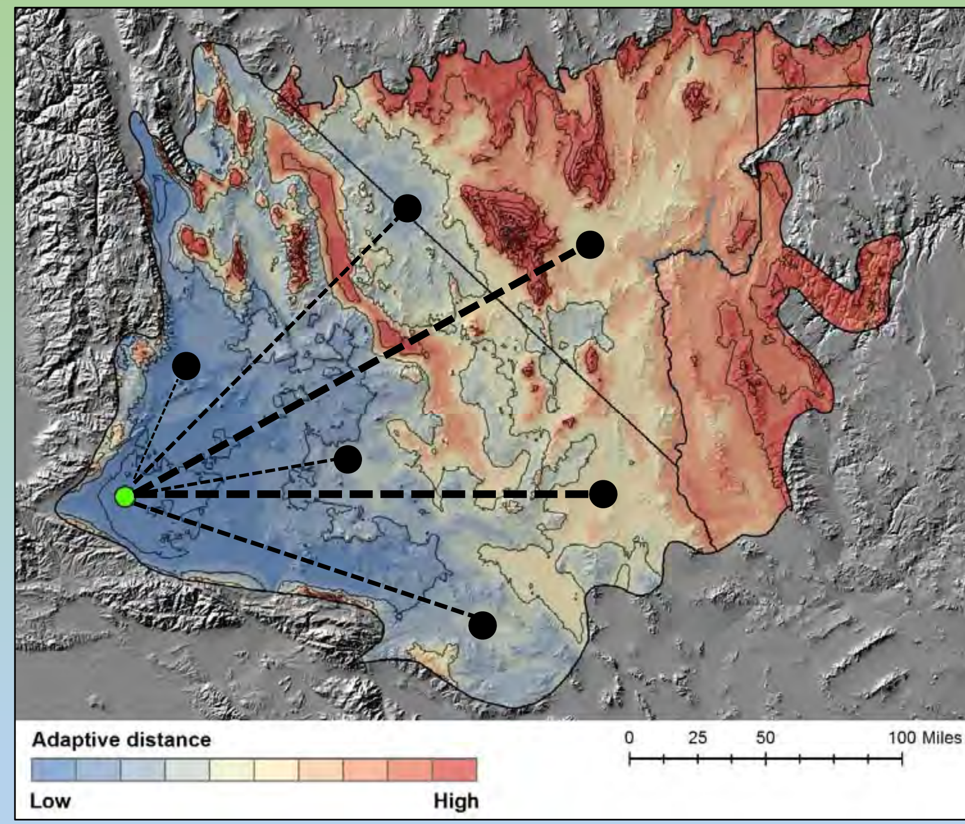


- **Incorporates 9 environmental variables**
- **Effective across plant functional types**

Local Provenancing

Admixture Provenancing





- **Local** (Home-site advantage approach)
  - Pros: Locally-adapted, native genotype
  - Cons: Low diversity / inbreeding depression

- **Admixture** (Genetic diversity approach)
  - Pros: Promote adaptive potential, resilience
  - Cons: Outbreeding depression/genetic swamping

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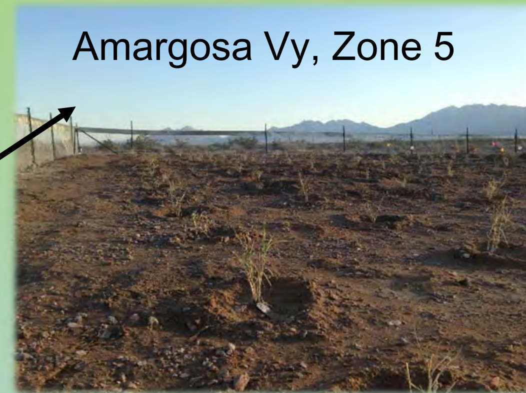
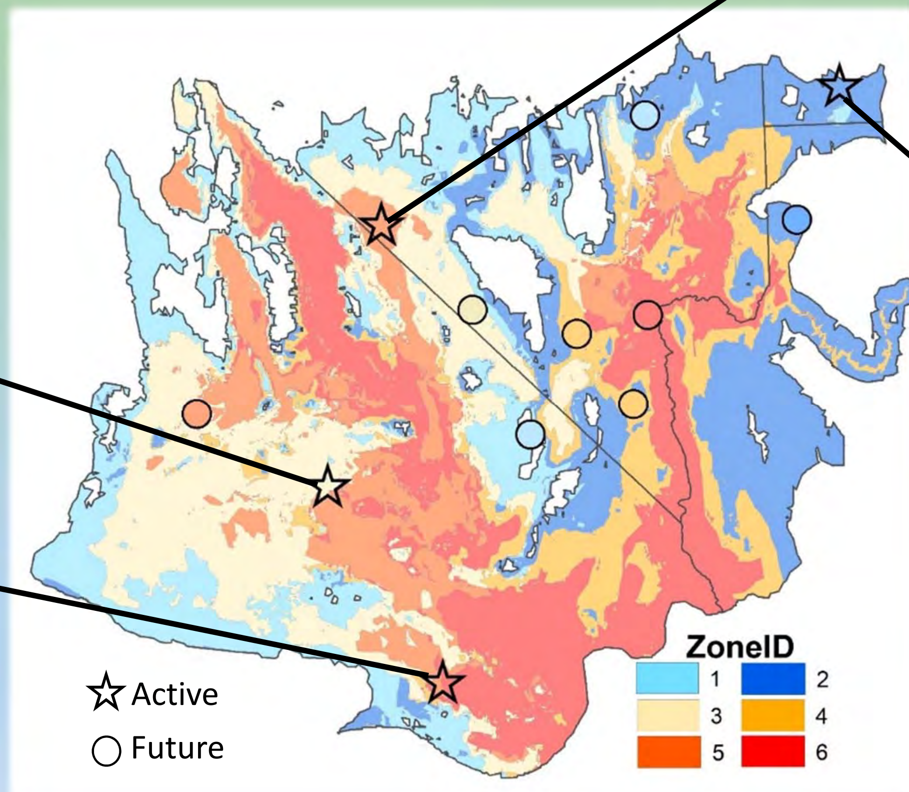
Models from D. Shryock, USGS

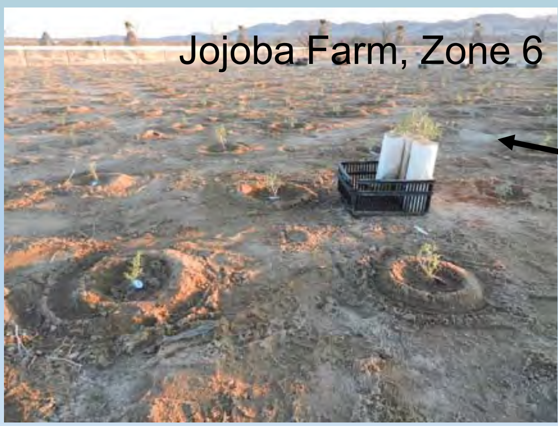
Predictive Provenancing

- Pros: Promote resilience to climate change
- Cons: Uncertainty, need fitness data





USGS Provisional Seed Transfer Zones



Selecting Native Plant Materials: "The Right Seed…"

Provide Suitable Native Plant Materials

- Priority Species List
- Landscape Genetics
- **Multiple Common Gardens**

Sphaeralcea ambigua

Ambrosia dumosa

Larrea tridentata

USGS

Multiple Common Gardens

- **Identify quantitative fitness traits**
- **Understand fitness risk of seed transfer**

Physiology

A_{max}, gs_{max}, leaf N, ψ

Morphology

Stem diam, canopy, leaf shape, stem water isotope

Phenology

Leaf formation/senescence, flowering/fruiting

Nathan Custer, Susan Schwinning
Texas State University – San Marcos

USGS

Assessing Appropriate Restoration Practices: "…the Right Place at the Right Time"

- Substrate preparation
  - Decompact, surface roughening
- Broadcast seeding
  - Timing, seed rates, encapsulation
- Container stock planting
  - Moisture amendments
- Herbicides
  - Pre- and post-emergent
- Seed encapsulation
  - Clay balls, sand wafers

USGS

Neighborhood Approach to Understanding Recruitment of Woody Species

- Many desert studies measure nurse and seedling pairs in undisturbed habitats (McAuliffe 1988, Cody 1993, Walker *et al.* 2015)
- Seedlings likely influenced by multispecies "neighborhoods"

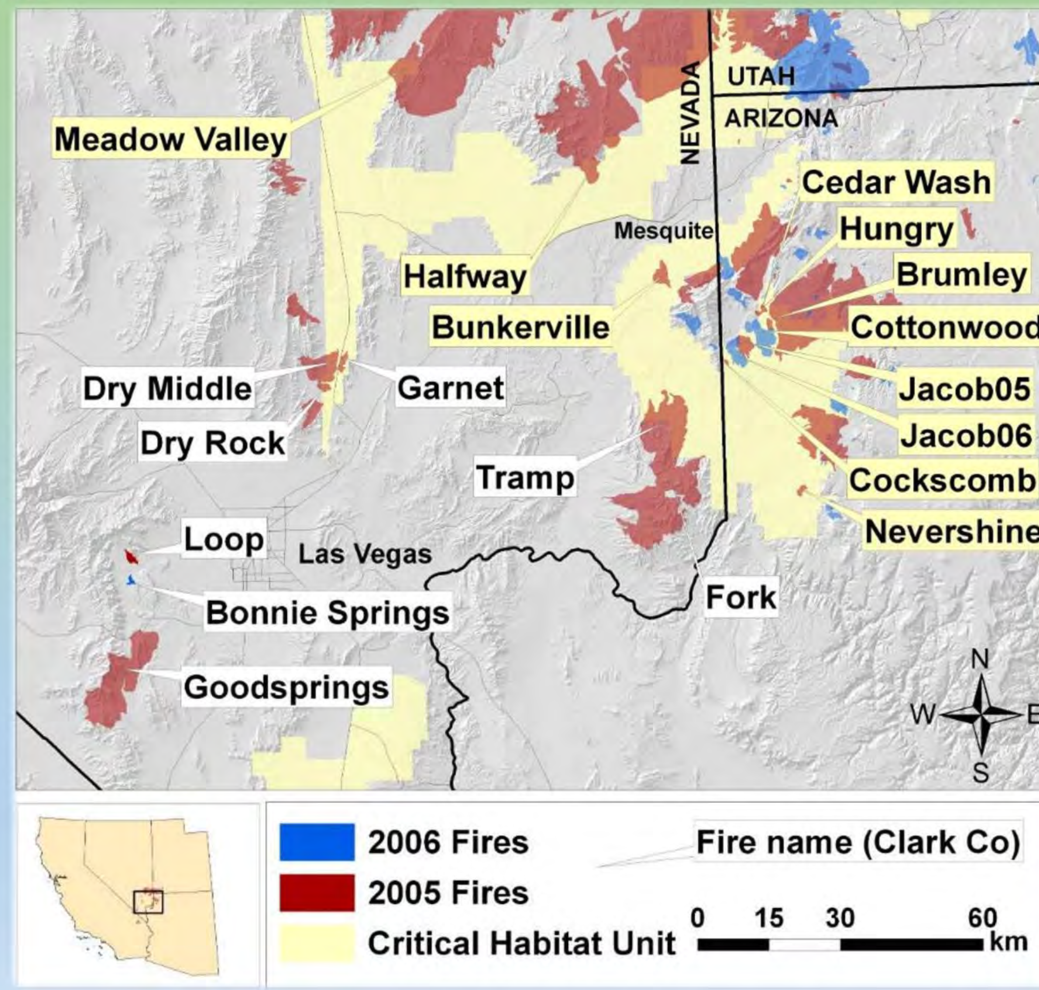
Forbs, Grasses ⟷ Shrubs

Competitor ⟷ Facilitator

Opportunistic ⟷ Conservative

(Butterfield & Briggs 2011)

Mojave Network of Long-term Monitoring Sites



- ❖ <u>Implementation</u>
  - ❖ 17 fire locations/7 fires
  - ❖ Burn-unseeded, Burn-seeded, unburned
- ❖ <u>Monitoring:</u> 150 m x 2 m belts

Seedling Neighborhoods

- Seedlings counted in each 2 m x 2 m quadrat (brittlebush, cresotebush, bursage)

- Neighboring species counted and classified:
  - Cactus
  - Forb
  - Perennial grass
  - Shrubs* (Shryock et al. 2014)

- Ordination of neighborhood

Forbs, Grasses

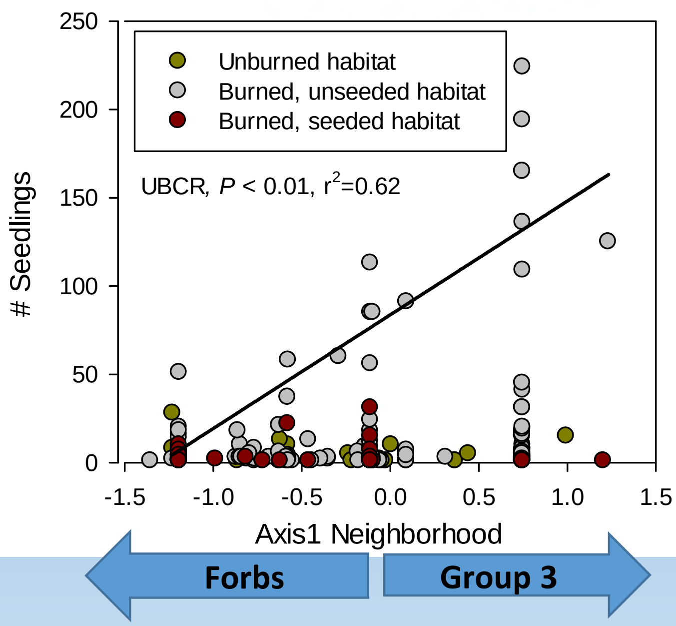
*Group 1, 2, 3

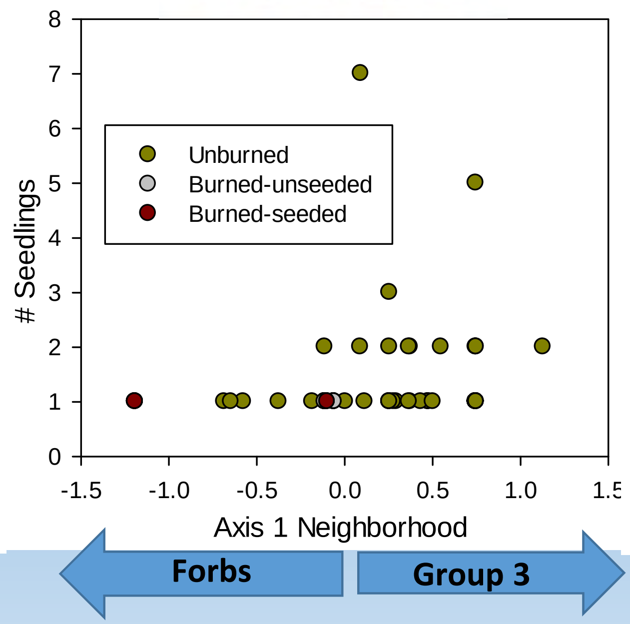
Competitor ⟷ Facilitator

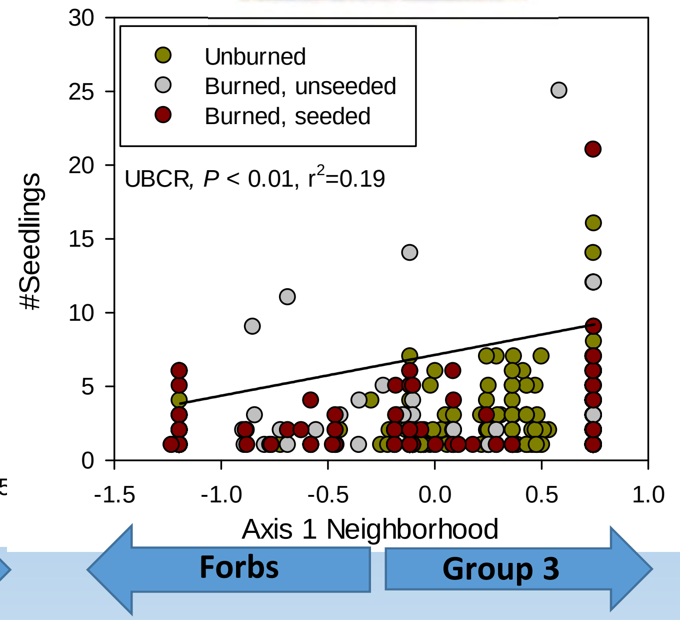
Opportunistic

Conservative

Neighborhood Influence on Recruitment







Soil Seed Bank 5 Years After Seeding

	Unseeded Burn (#/m²)		Seeded Burn (#/m²)	
	Lsmean	95% CI	Lsmean	95% CI
Seeded perennial forbs	11 a	5--26	66 b	41--106
Other perennial forbs	23	13--41	18	10--34
Seeded shrub	22 a	11--45	3 b	1--10
Perennial grass	4	1--13	3	1--11

USGS

Implications

❖ Lack of shrubs that provide the regeneration niche for seedlings limits the effectiveness of broadcast seeding

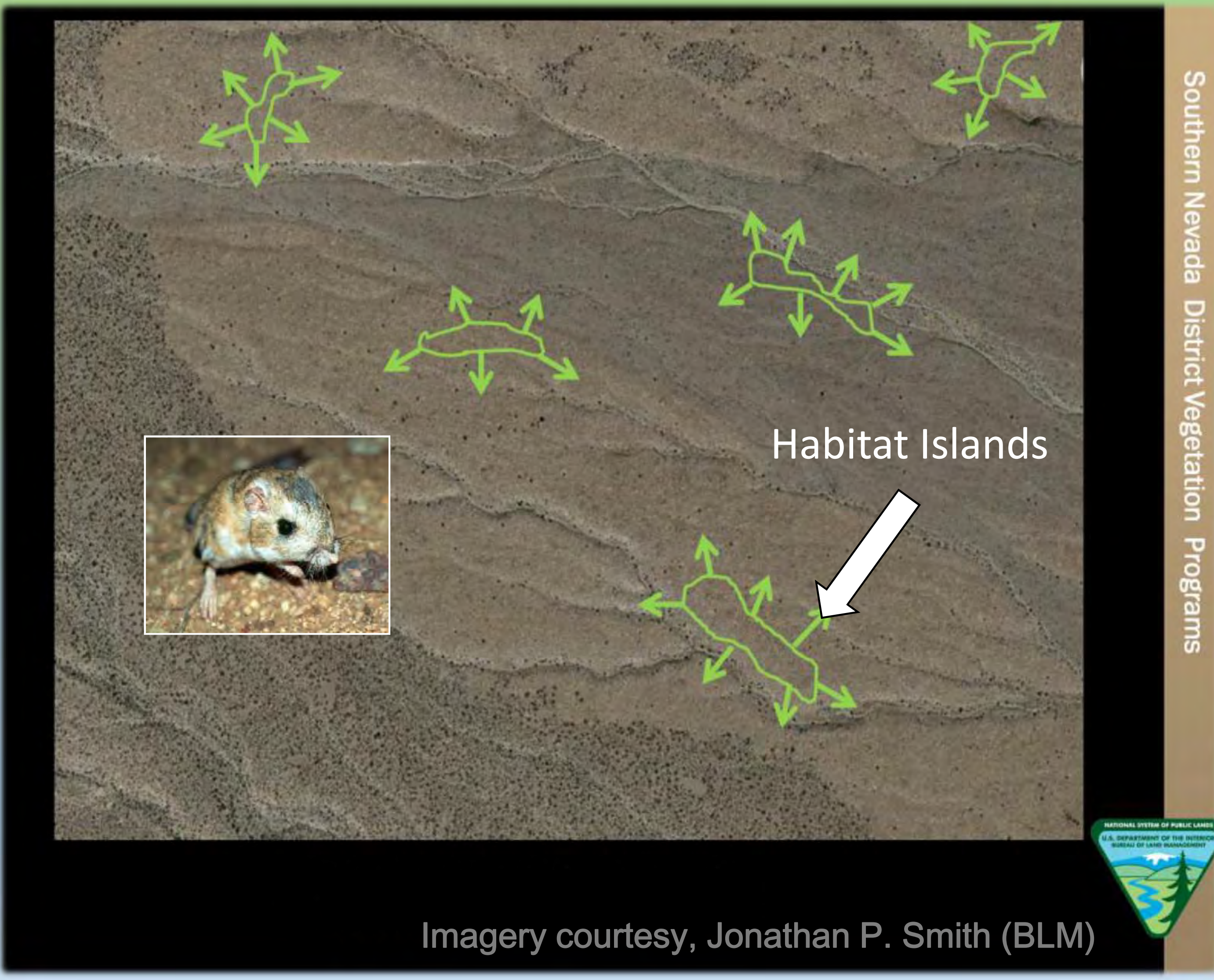
❖ Alternative practices for reinstating nurse plants are needed (container stock, artificial structure)

❖ Seeding rate is important to minimize increase in granivore pressure

Dry Middle Fire

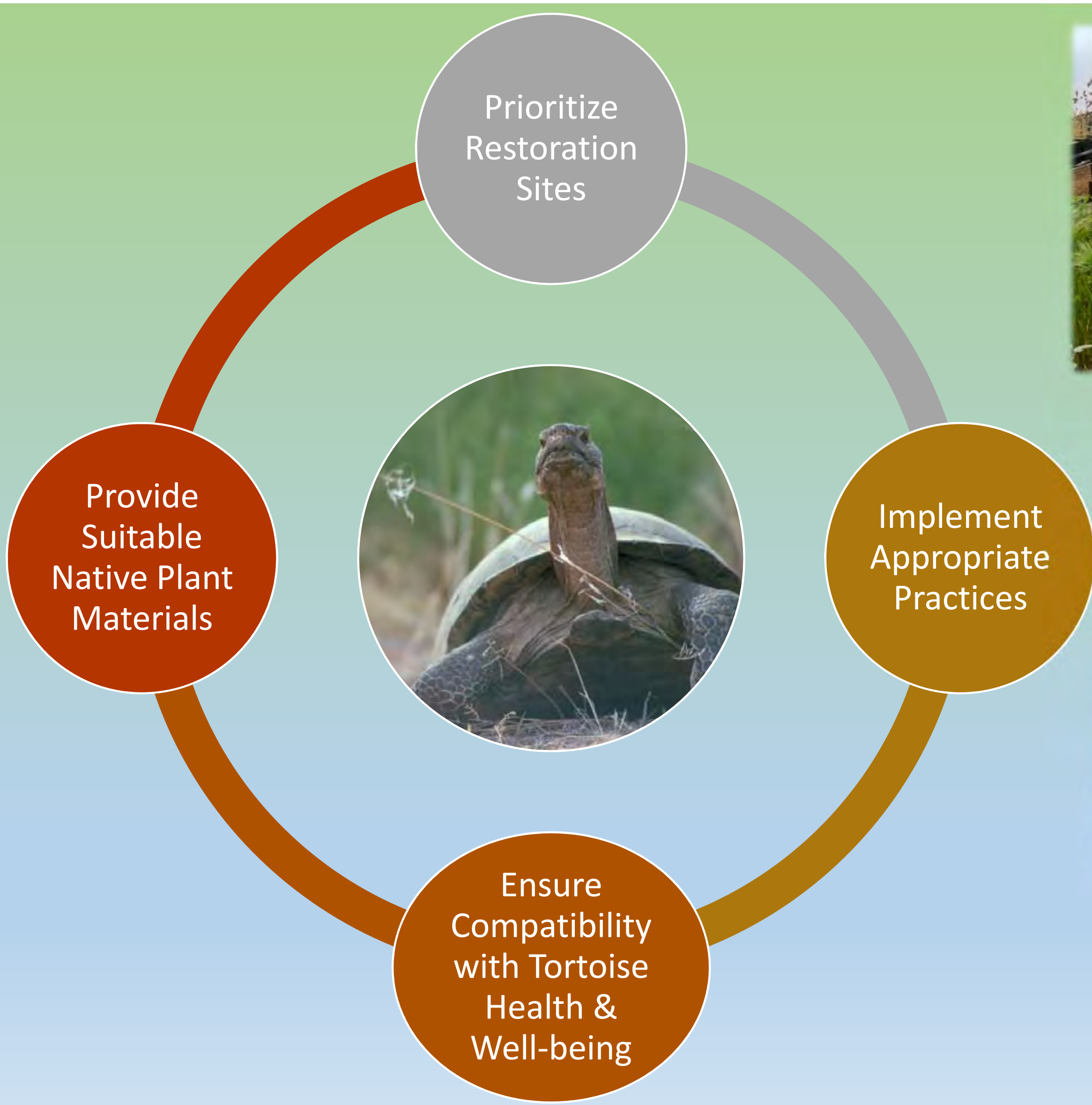
Jacob '06 Fire

USGS



Establishment of long-lived shrubs

- ❖ Hand-sowing of seeds
- ❖ Diversionary seeding
- ❖ Outplanting seedlings (90,000 over 3 years)


Prioritize Restoration Sites
Implement Appropriate Practices
Ensure Compatibility with Tortoise Health & Well-being
Provide Suitable Native Plant Materials


Kristina Drake, USGS
K. Drake