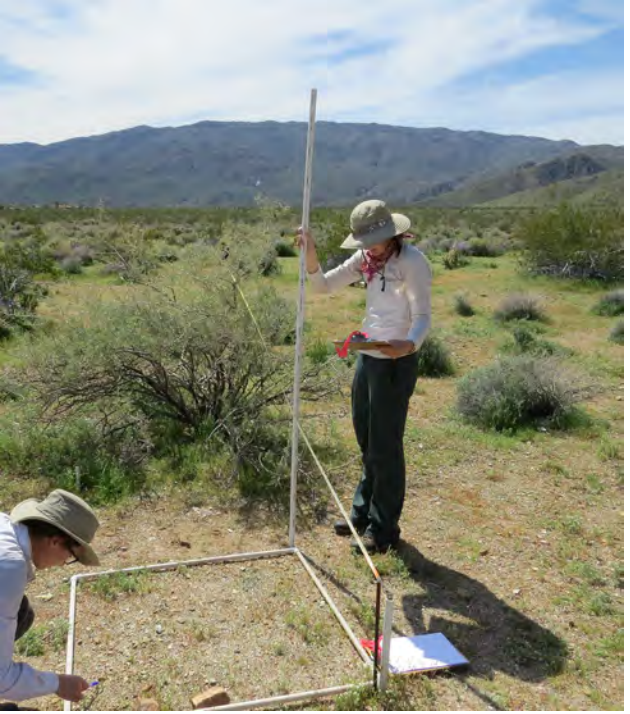
Resistance

This year's theme: ***Beyond Eradication: Resistance, Resilience, and Recovery***.

Sarah Kimball
UC Irvine

Equity in Field Safety Discussion: Friday, 10:45 – 11:45am, Zuma Room



UCI Environmental Collaboratory

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Community Partners

The Nature Conservancy
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Natural Communities Coalition
restoration | management | partnership

Laguna Canyon Foundation

Irvine Ranch Conservancy

Sea & Sage Audubon

Newport Bay Conservancy

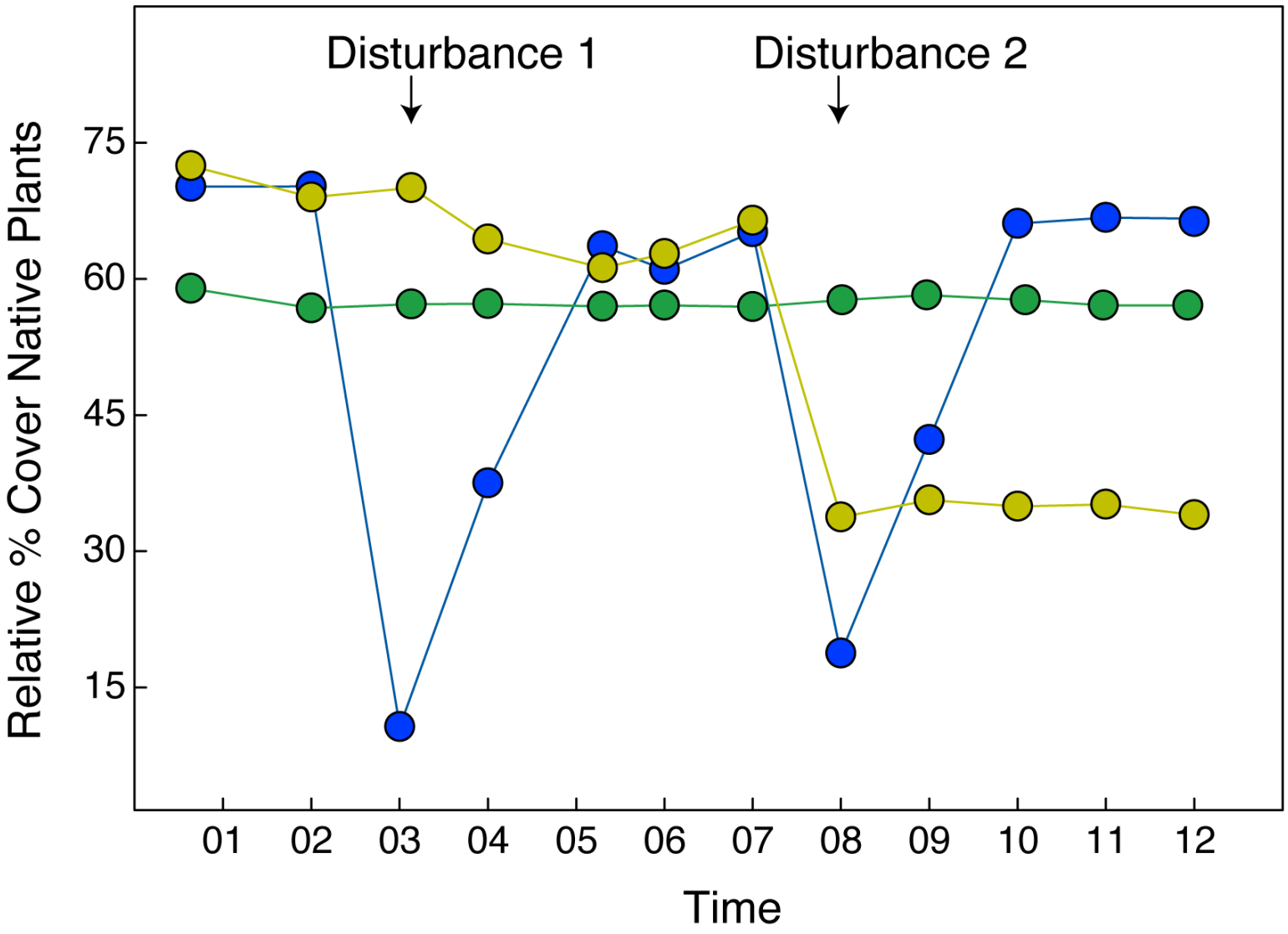
NOAA
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

H2OC Stormwater Program

Irvine Ranch Water District

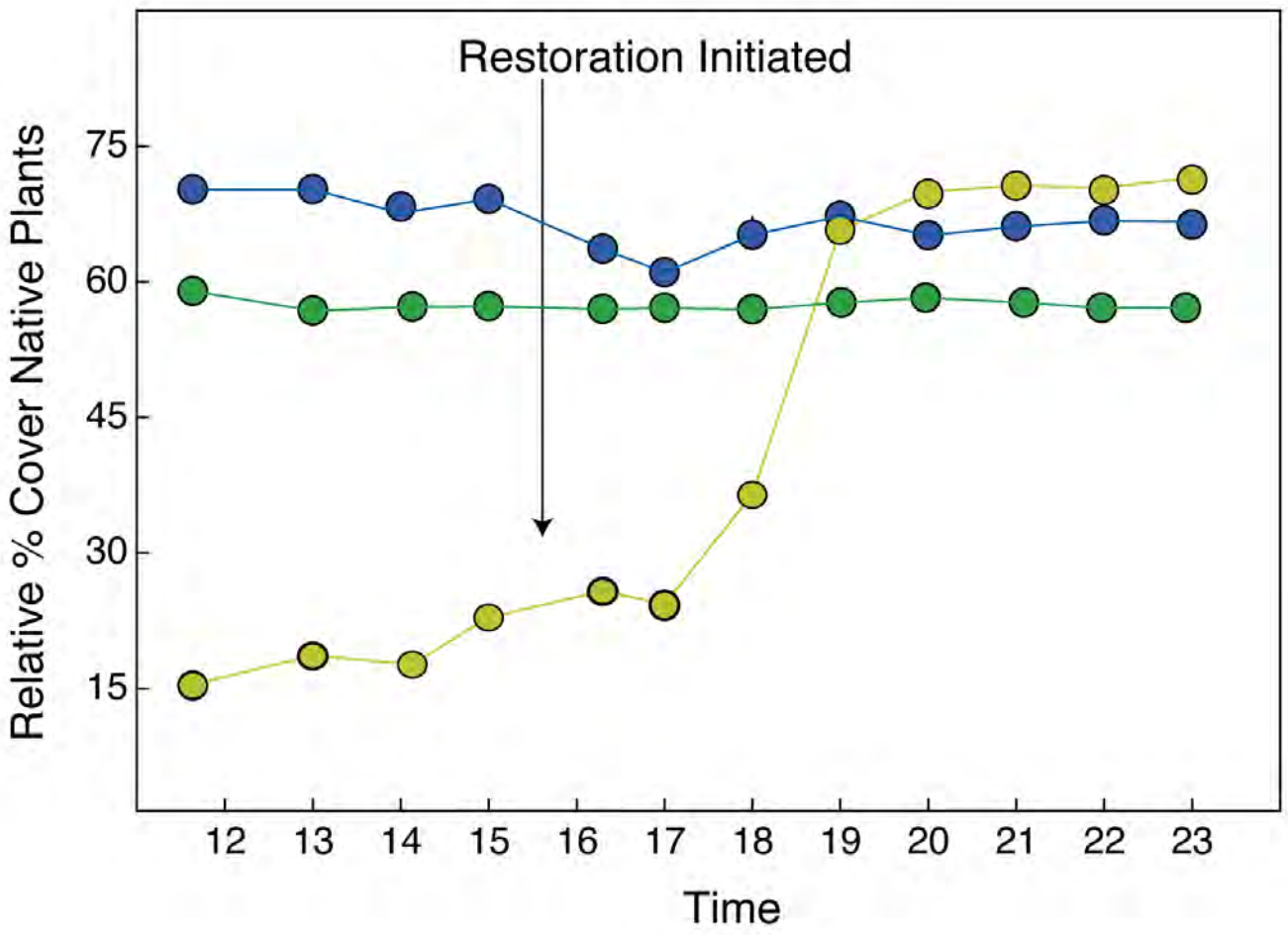
Natural Reserve System
University of California

Resistance & Resilience



- Green is resistant to disturbance.
- Blue is resilient to disturbance.
- Yellow is resistant to first disturbance but not resistant or resilient to second disturbance.

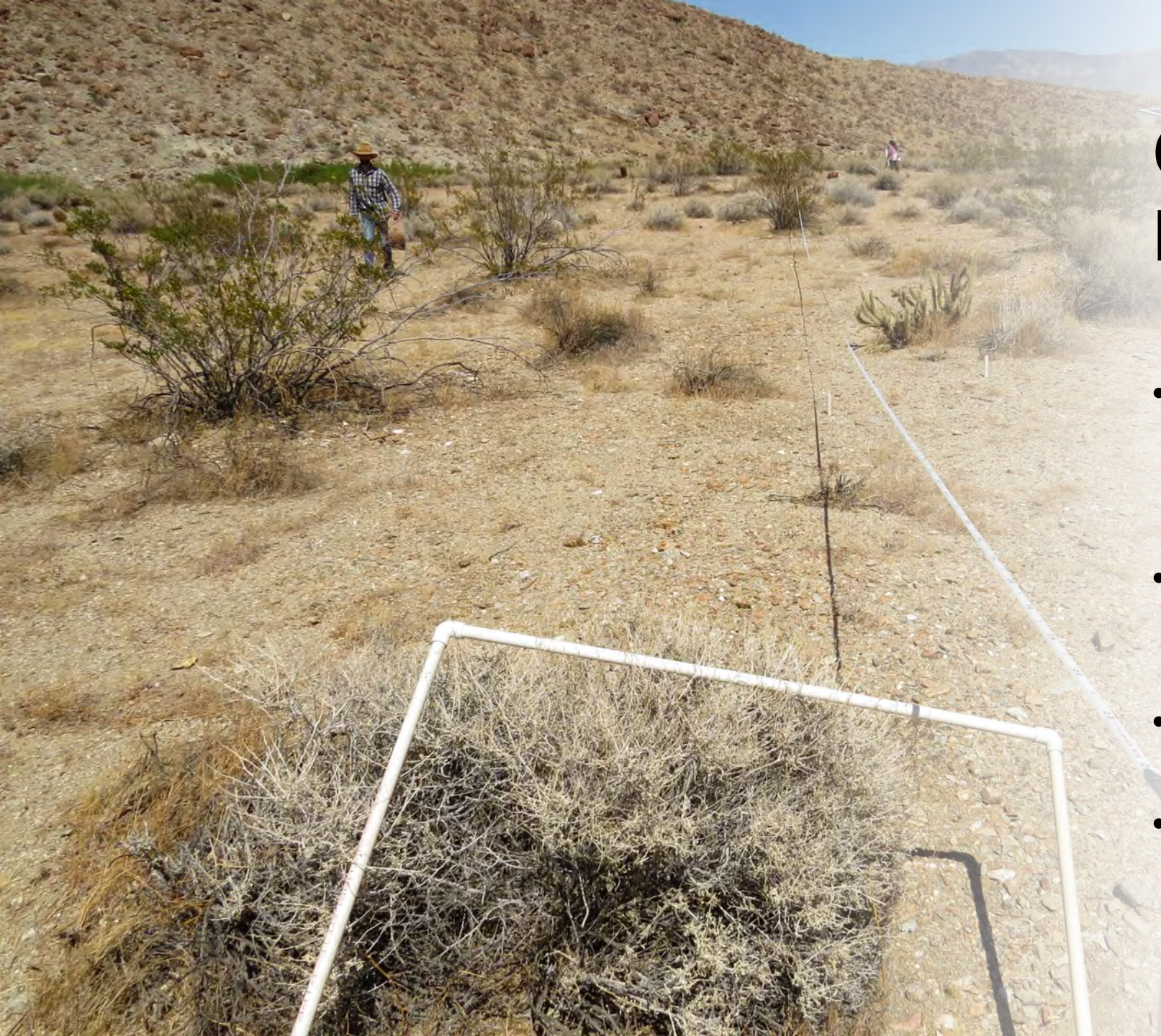
Recovery



- Yellow community recovers after restoration
- Restoration practitioners aim to restore resistant & resilient communities

Different Types of Disturbances Can Interact

How can we restore resistant communities?



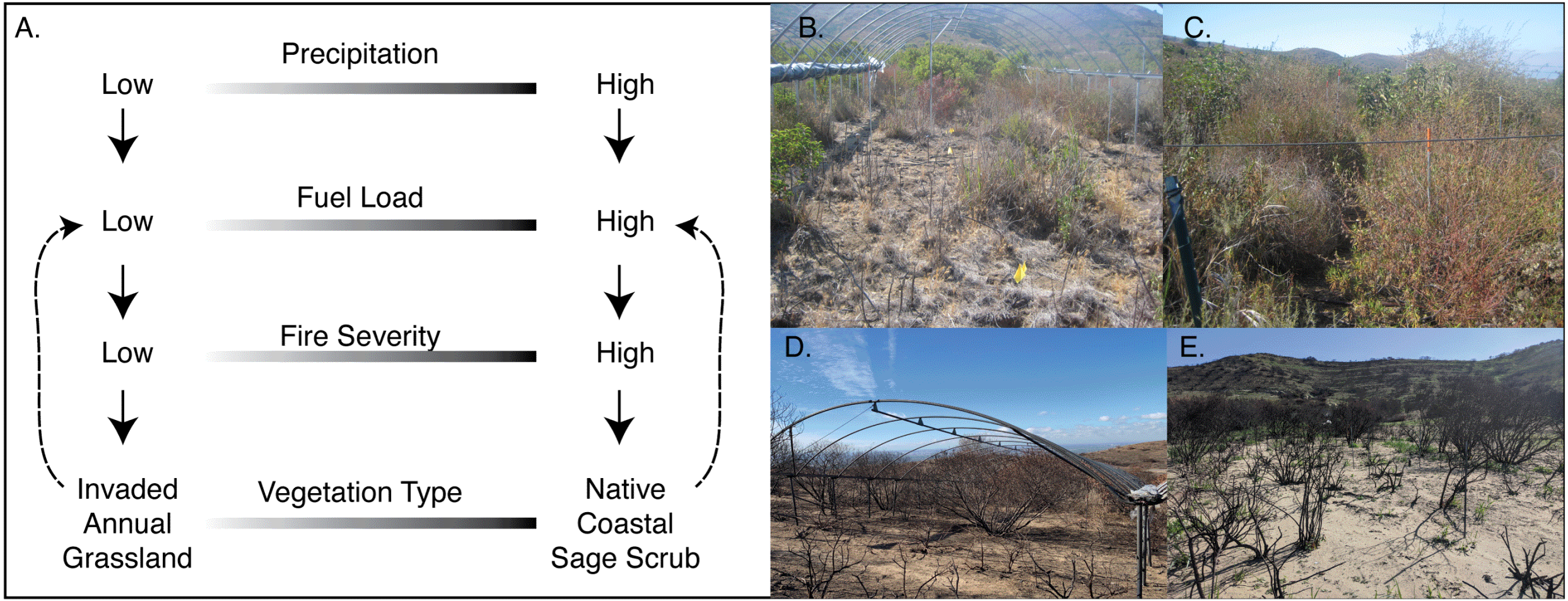
Climate and Resistance

- Climate change is a continuous disturbance, but challenging to manipulate in experimental context
- Conduct identical actions in spaces with different abiotic conditions (slope aspect)
- Conduct identical actions in years with different weather
- Rainfall manipulation exclosures

Loma Ridge Global Change Experiment (LRGCE)

Kimball et al. 2024, *Ecology*; Nguyen et al. 2016, *Journal of Ecology*; Kimball et al. 2014, *Ecological Applications*

Long-term drought promoted invasive species by reducing wildfire severity



Kimball, S., J. Rath, J.E. Coffey, M.R. Perea-Vega, M. Walsh, N. M. Fiore, P. M. Ta, K. T. Schmidt, M. L. Goulden, S. D. Allison. 2024. Long-term drought promotes invasive species by reducing wildfire severity. *Ecology*.

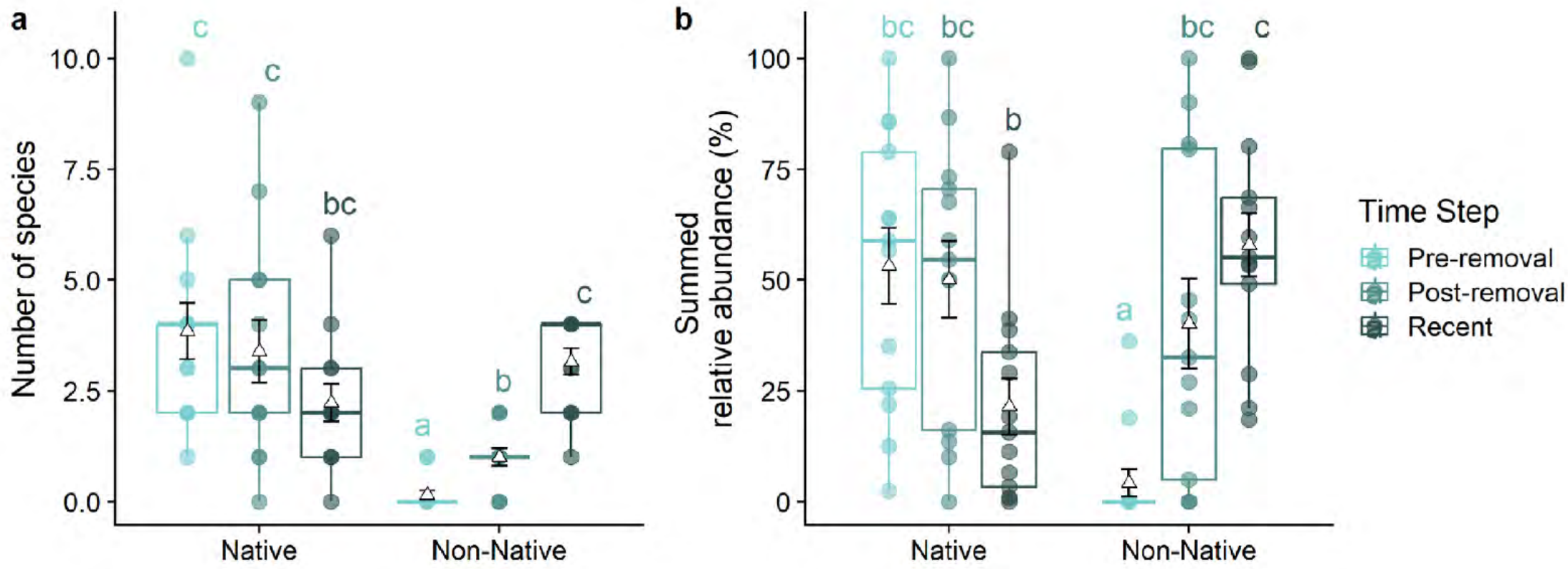
Bee Canyon Burned Restoration (BCBR)

Resistance to Wildfire

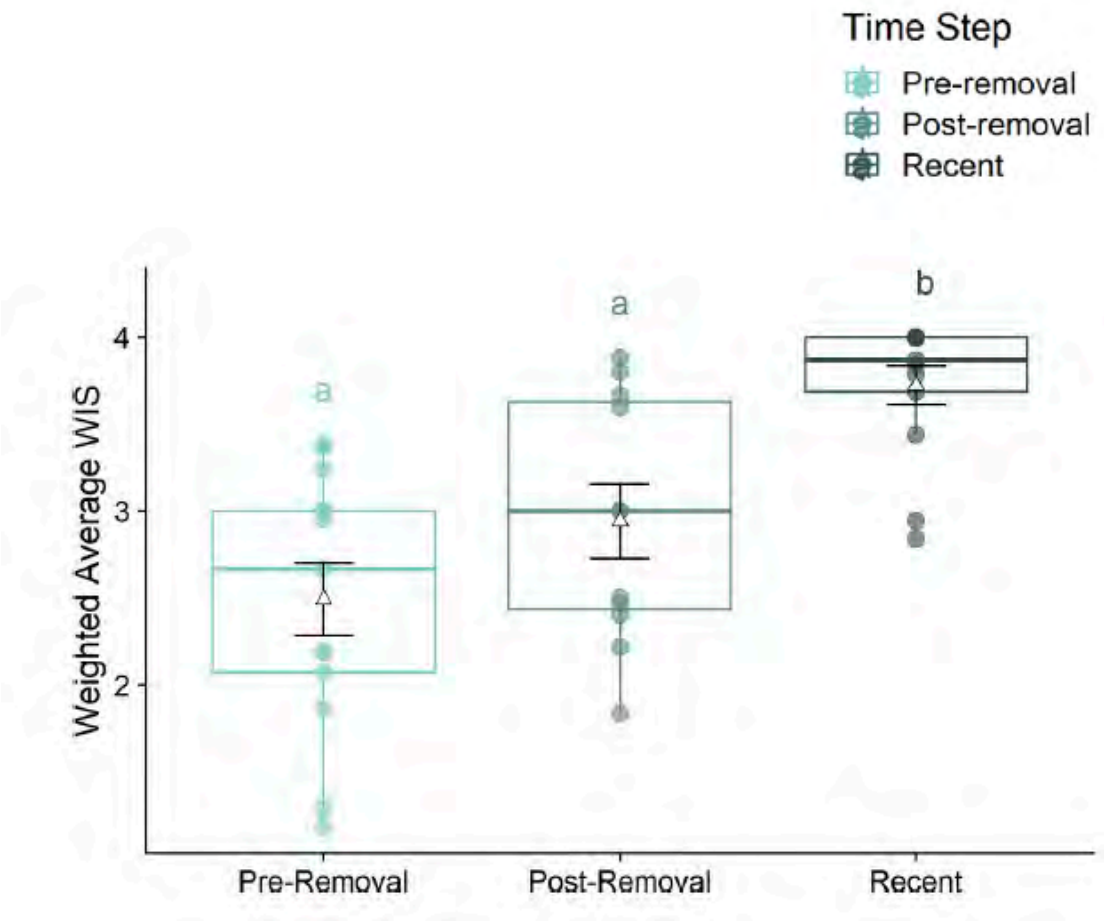
Sentenac Cienega Restoration Study (SCRS)

Brigham, L.M., Coffey, J., Lulow, M. E., Ta, P., Kimball, S. 2024. Persistent invasion by non-native species and transition to an upland community after removal of invasive *Tamarix* in a Californian Cienega. *Journal of Arid Environments* 224.

After *Tamarix* removal, *Bassia hyssopifolia* & other non-native species invaded



Removal of invasive *Tamarix* was followed by a shift from wetland to upland plant communities

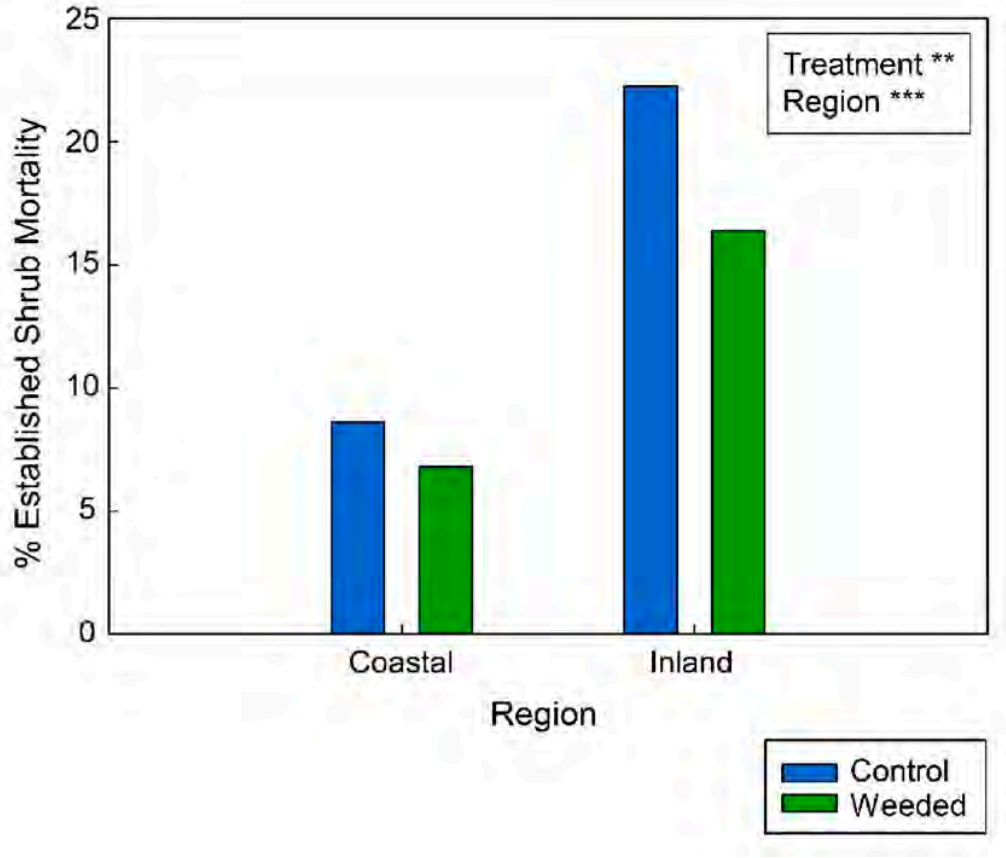


Brigham, L.M., Coffey, J., Lulow, M. E., Ta, P., Kimball, S. 2024. Persistent invasion by non-native species and transition to an upland community after removal of invasive *Tamarix* in a Californian Cienega. *Journal of Arid Environments* 224.

Passive Restoration Experiment (PRE)

Ta, et al. 2024. Effects of Non-Native Annual Plant Removal on Native Species in Mediterranean-Climate Shrub Communities. *Diversity* 16 (2), 115.

Removal of invasive annuals reduced native shrub mortality during drought

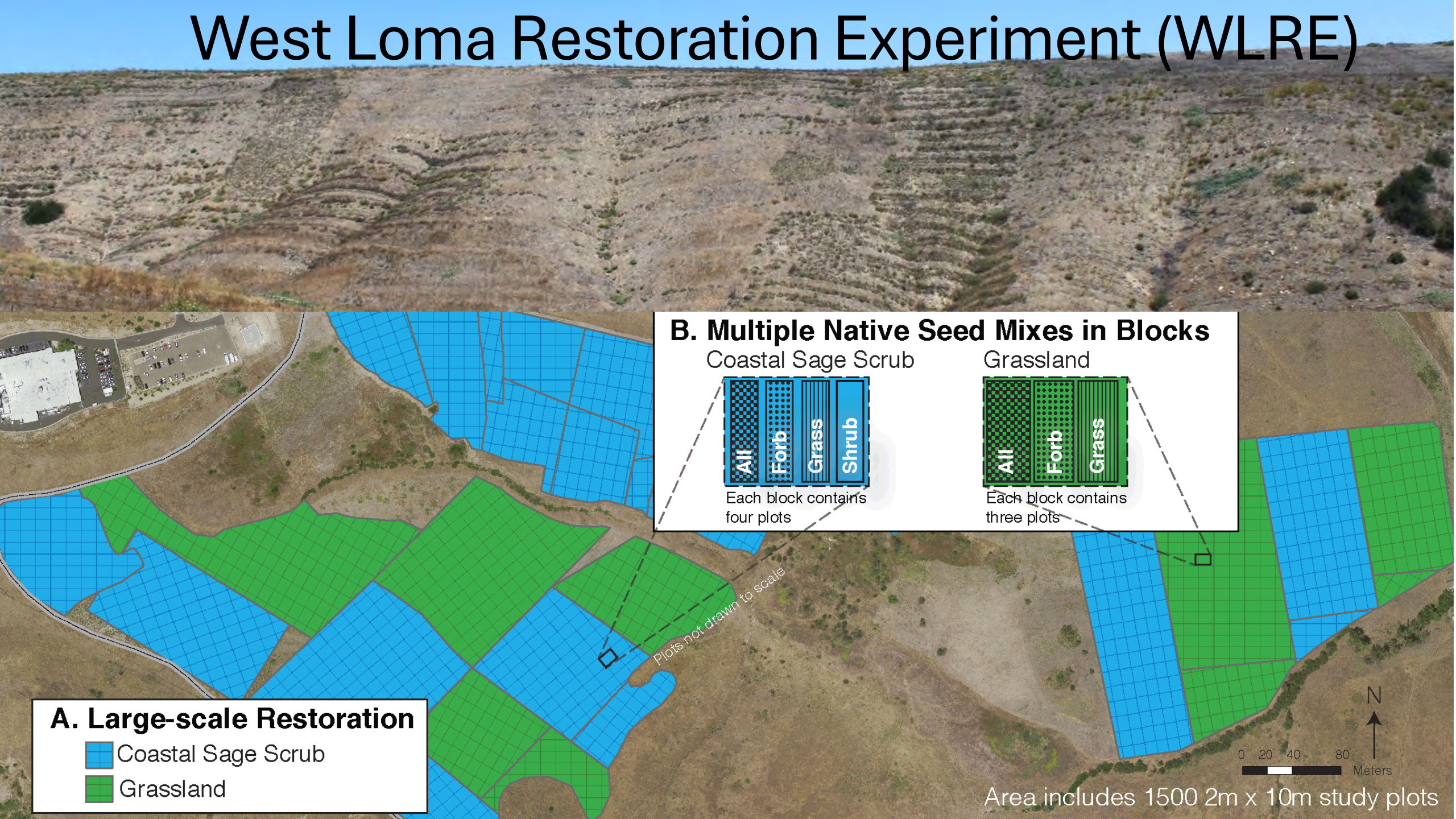


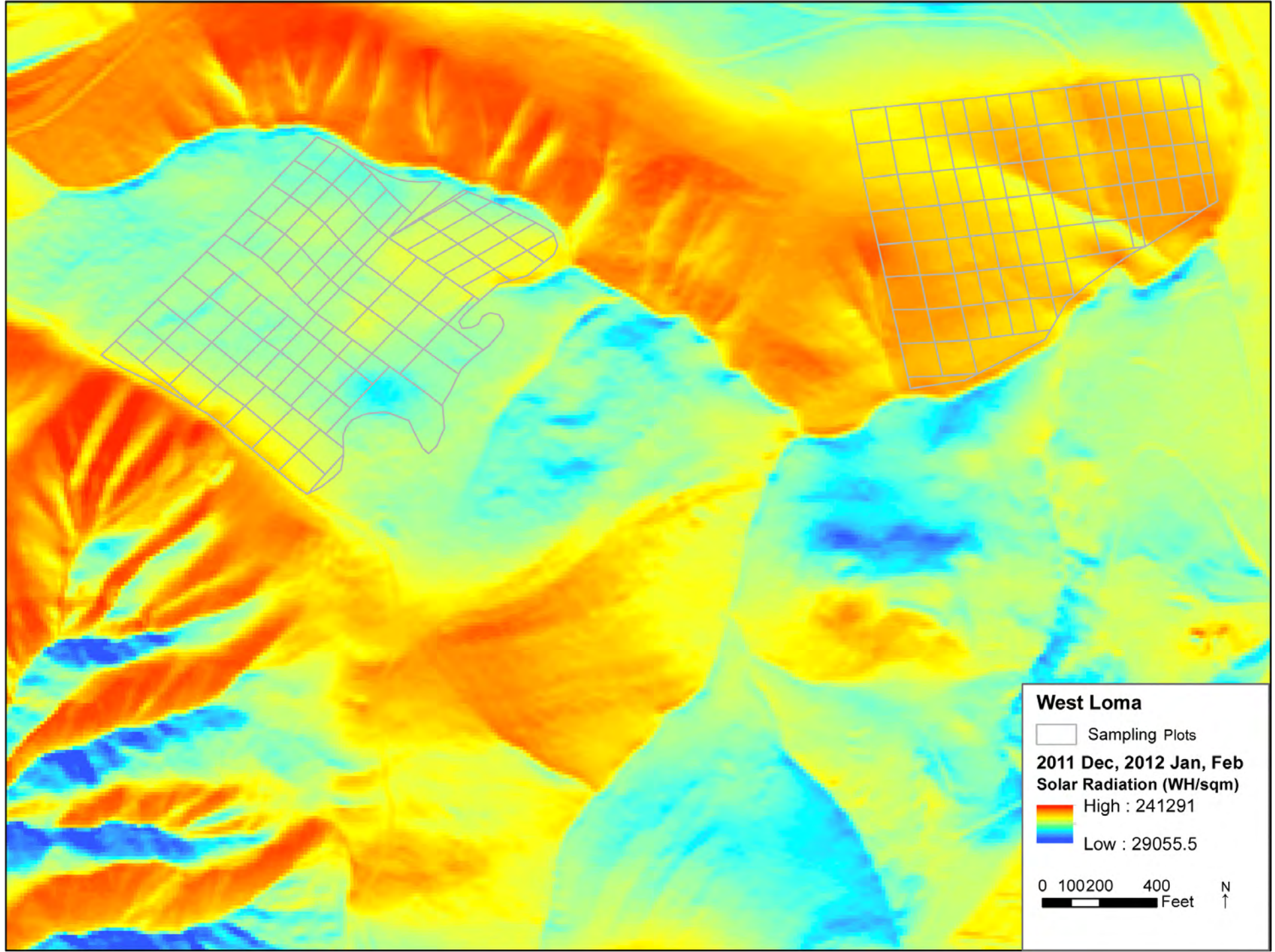
Ta, et al. 2024. Effects of Non-Native Annual Plant Removal on Native Species in Mediterranean-Climate Shrub Communities. *Diversity* 16 (2), 115.

West Loma Restoration Experiment (WLRE)

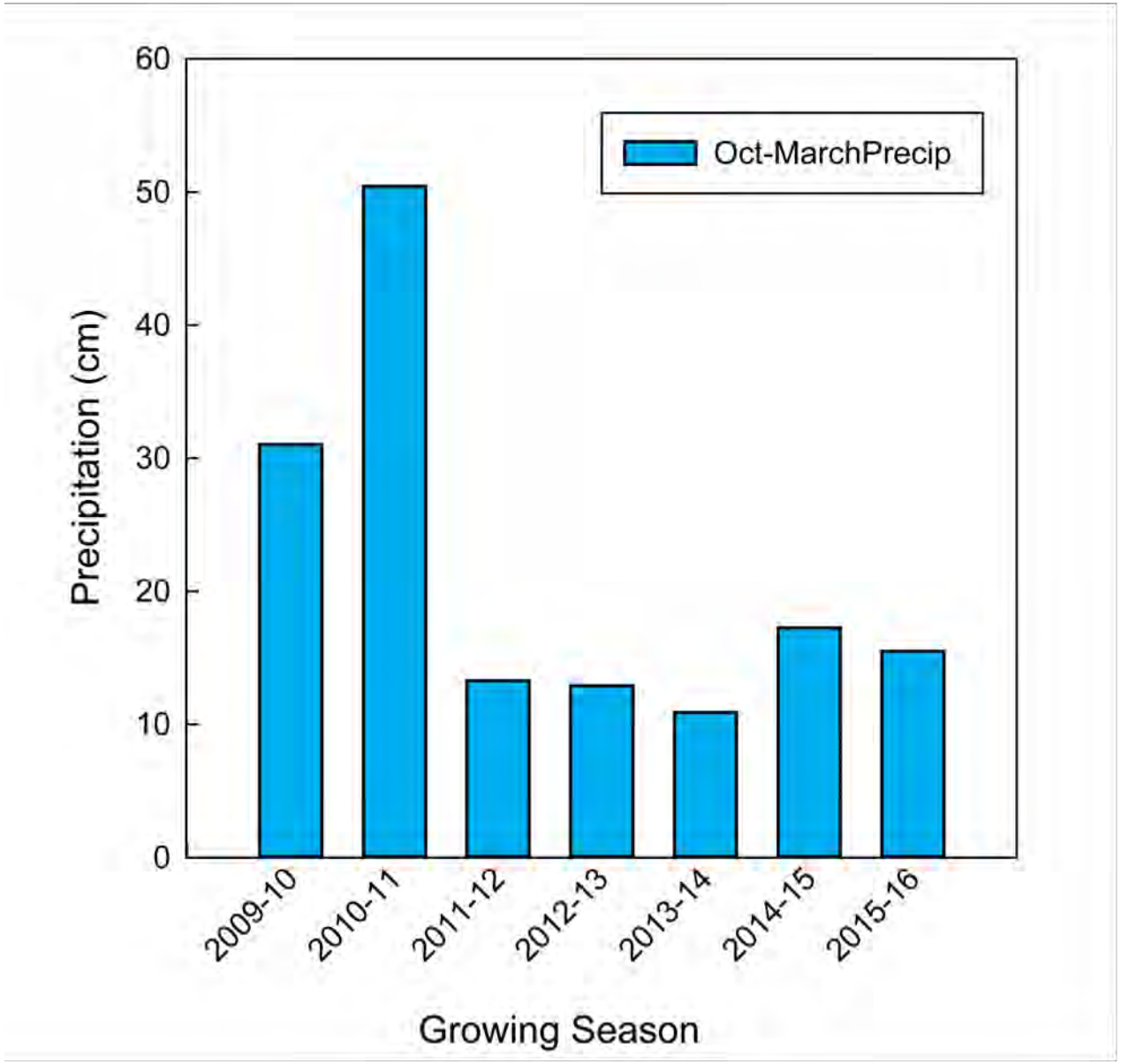
Funk et al. 2023, *Ecological Applications*; Kimball et al., 2017, *Ecology and Evolution*; Kimball et al., 2015,. *Restoration Ecology*.

West Loma Restoration Experiment (WLRE)



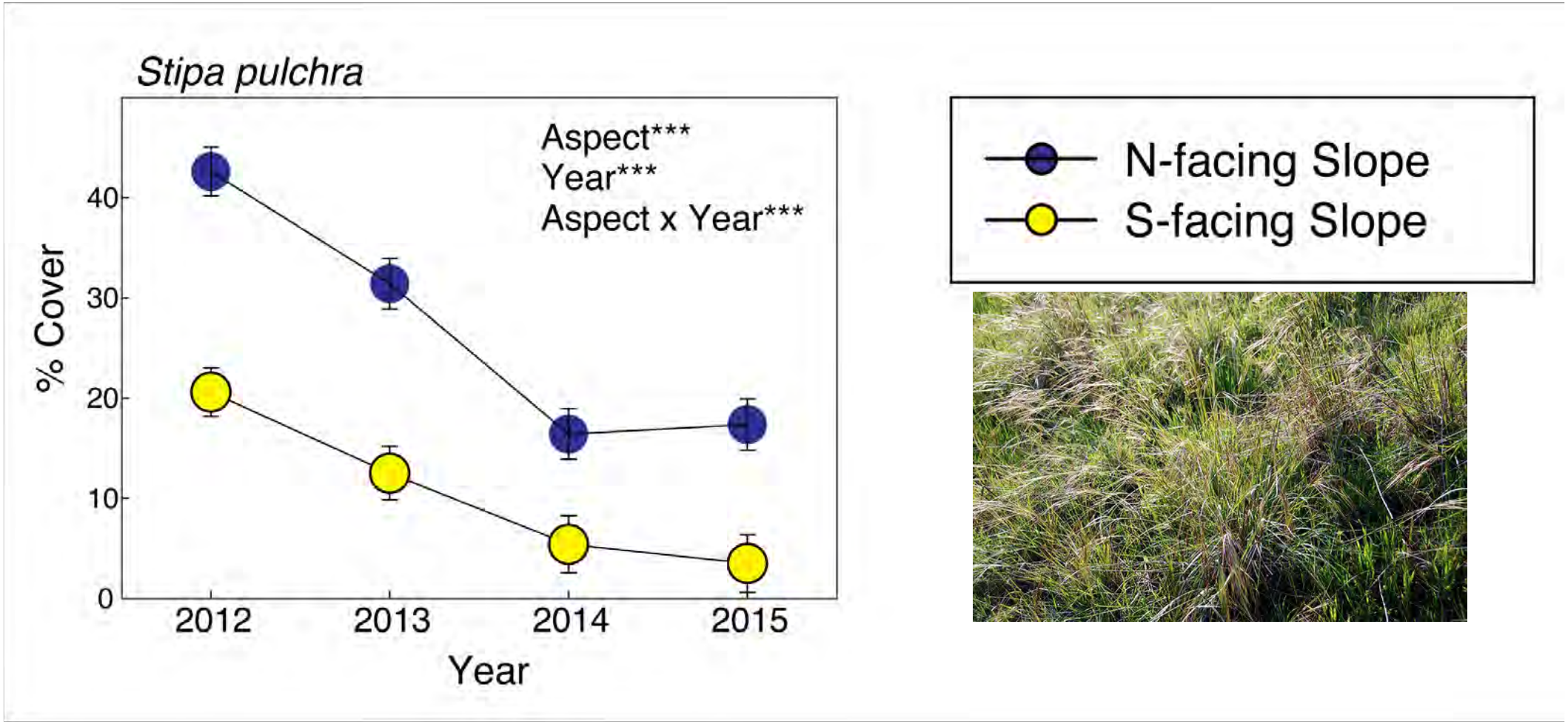

West Loma
Sampling Plots
2011 Dec, 2012 Jan, Feb
Solar Radiation (WH/sqm)
High : 241291
Low : 29055.5
0 100200 400
Feet
N

Post-Restoration Drought

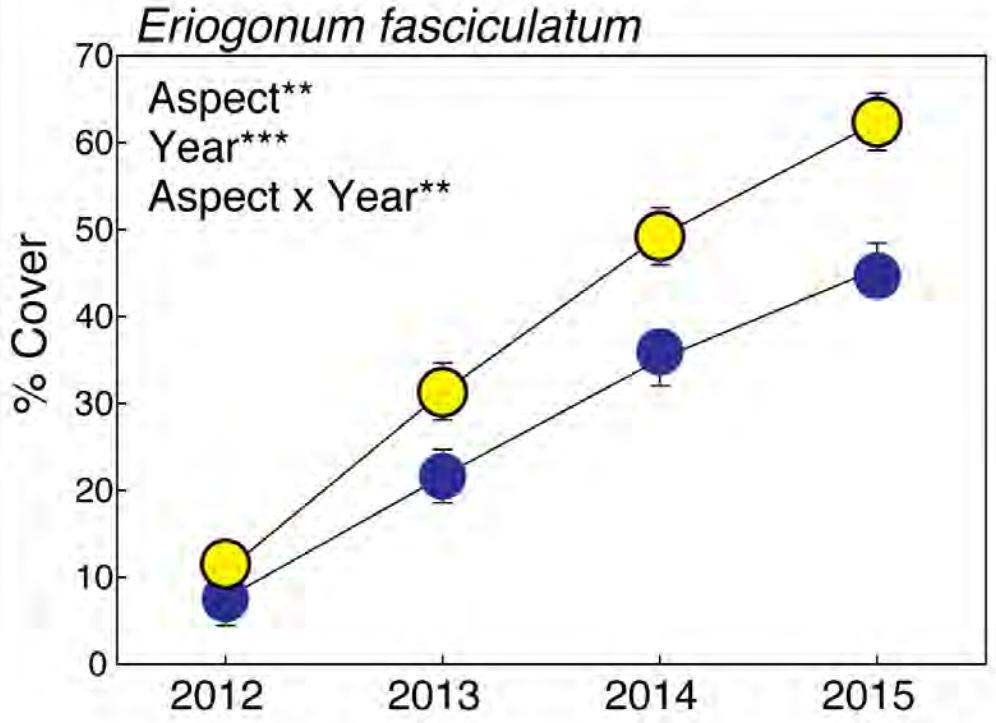


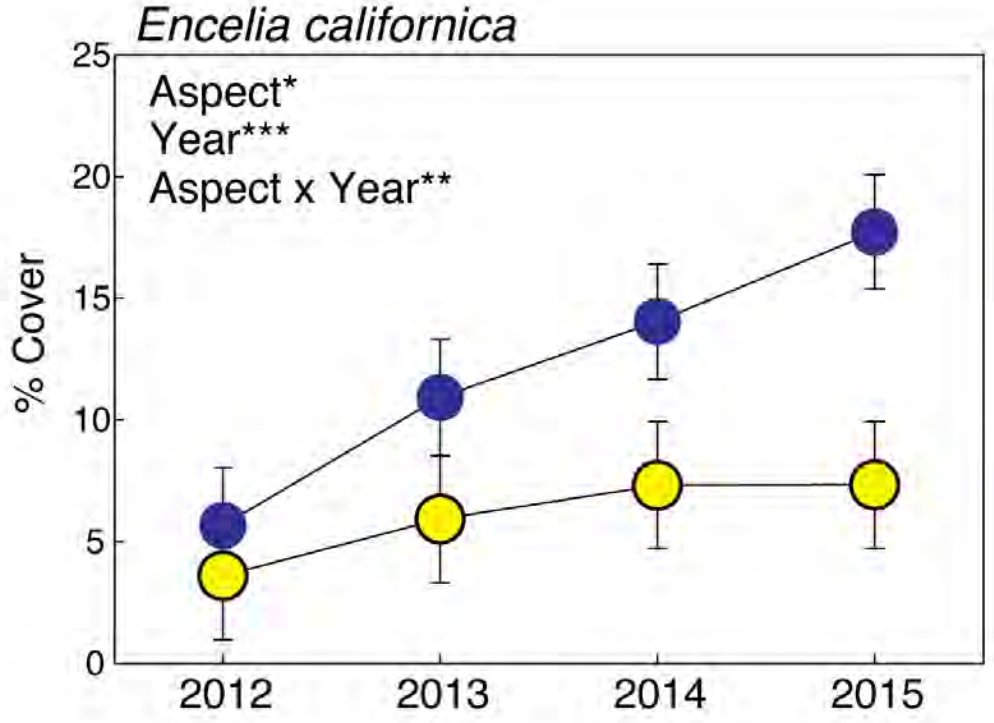
Increasing Native Cover During Restoration Fills Vacant Space and Helps Prevent Future Invasions

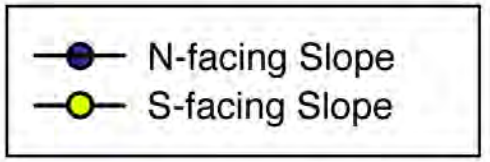
Cover of key species through time on N- and S-facing slopes

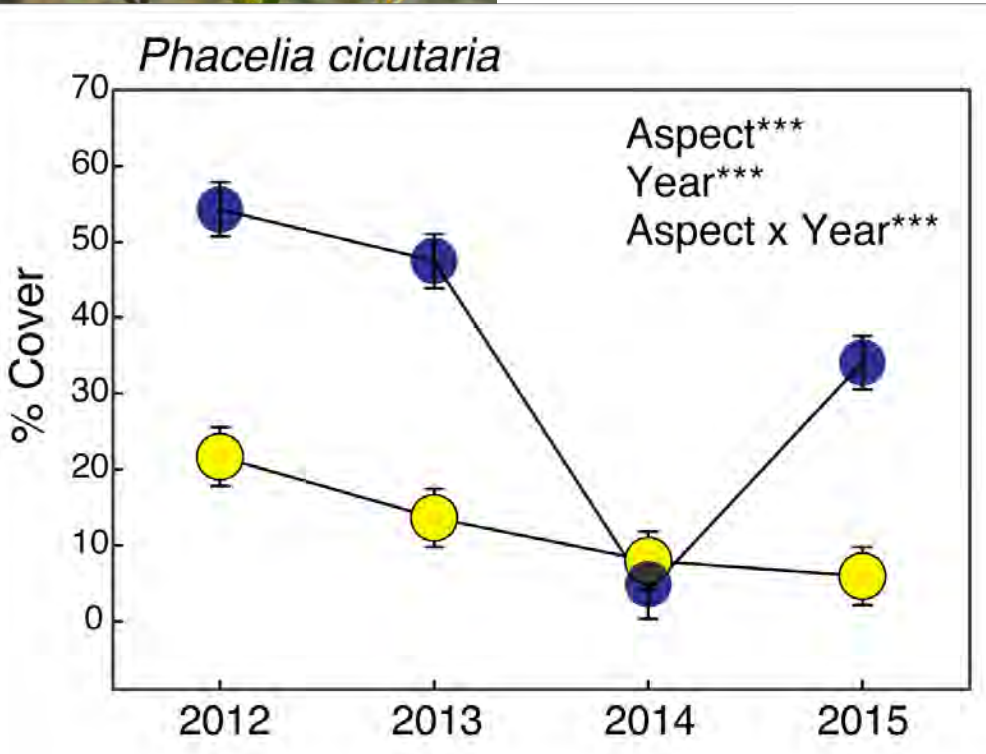


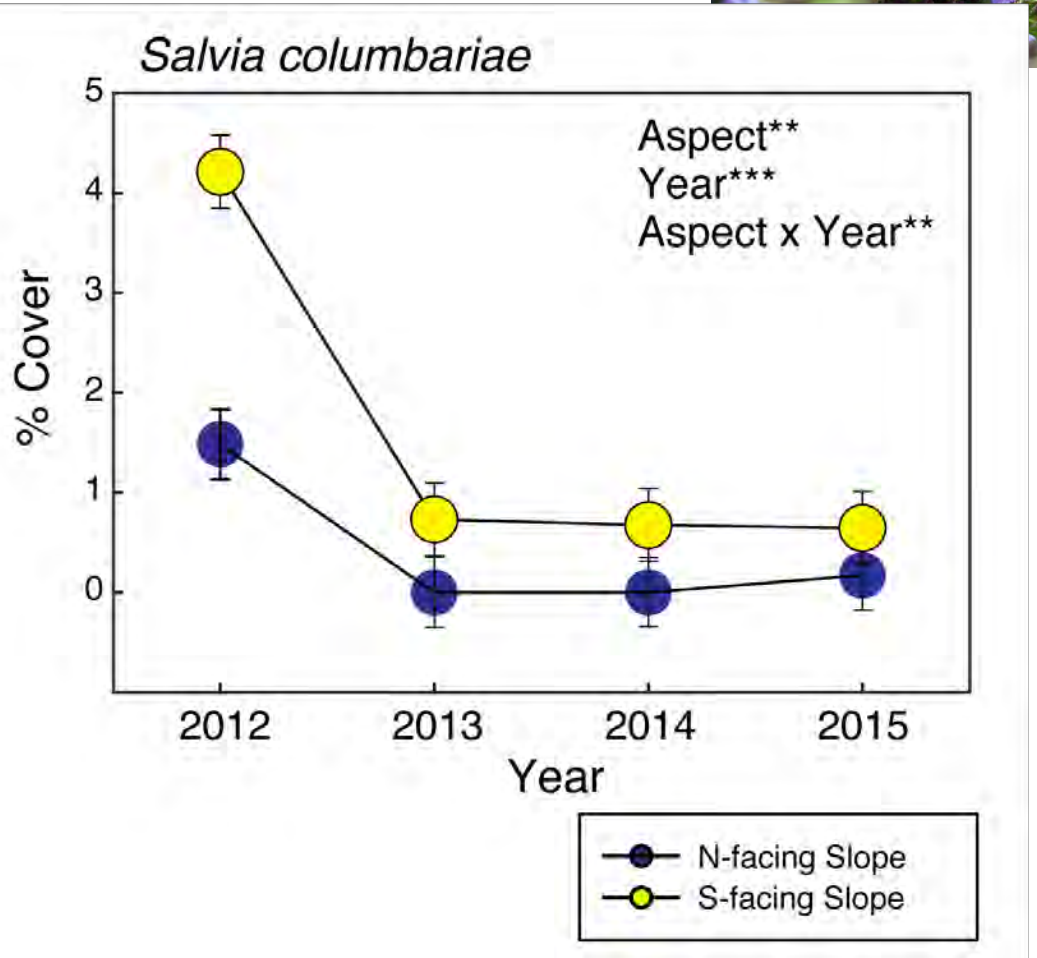
Cover Through Time on N- and S-facing Slopes



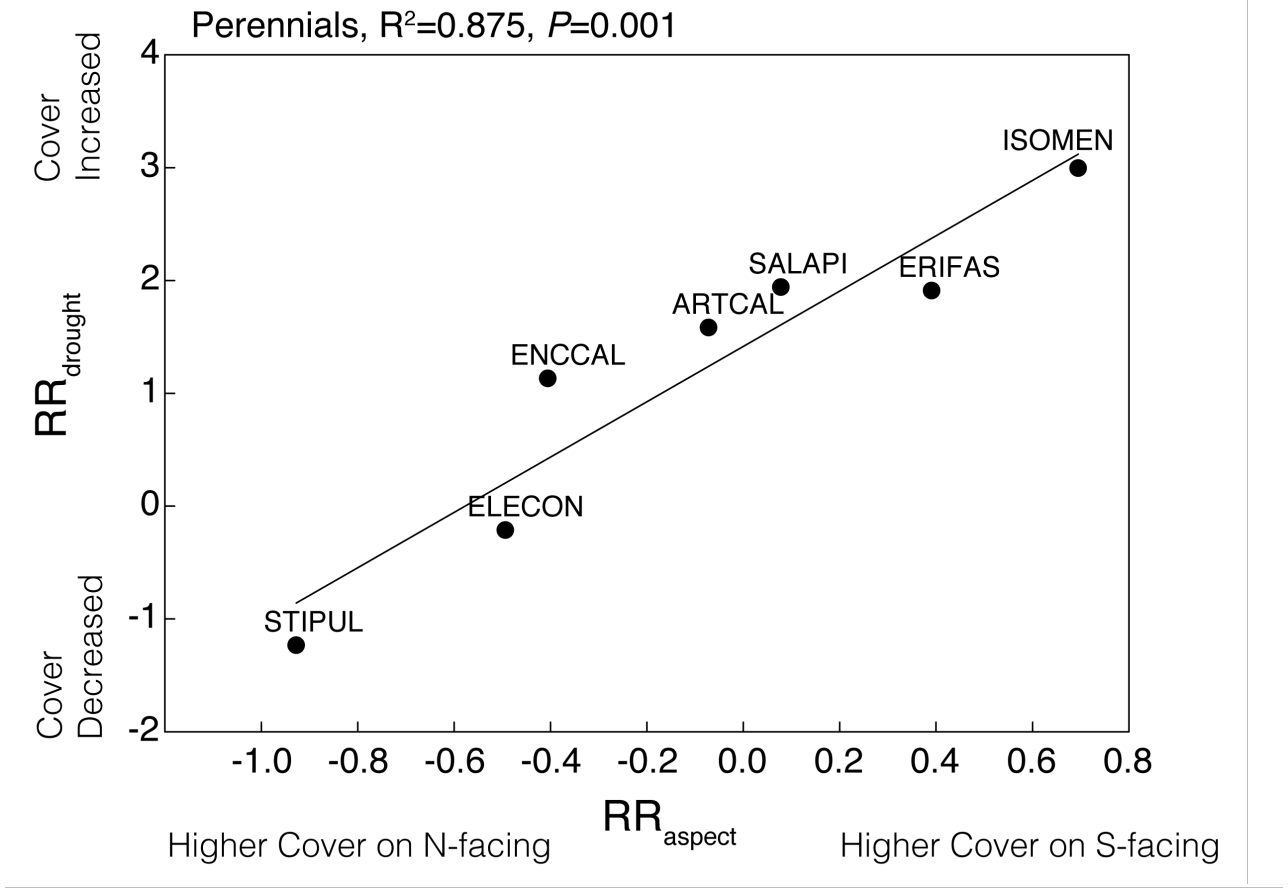


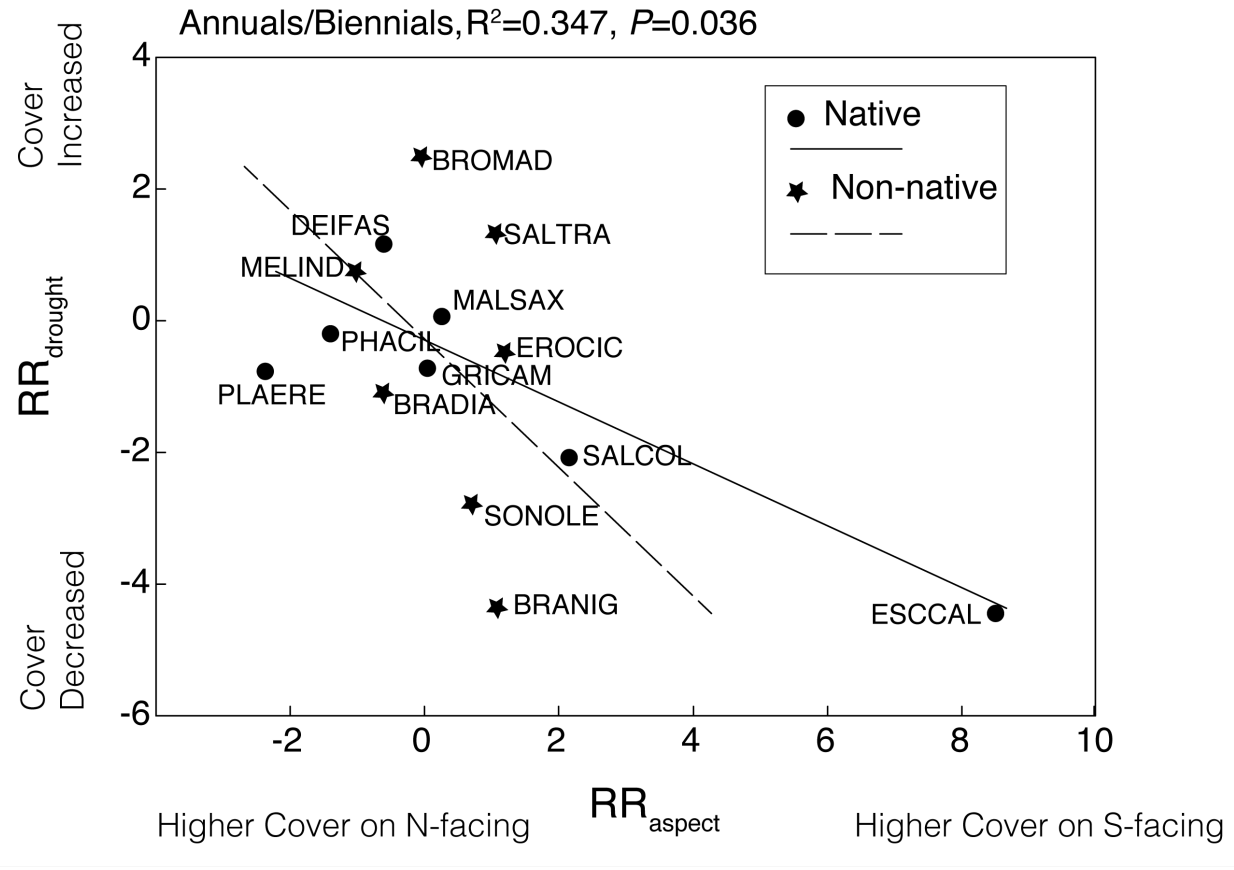



Phacelia cicutaria
Aspect***
Year***
Aspect x Year***
% Cover
70
60
50
40
30
20
10
0
2012
2013
2014
2015


Salvia columbariae
Aspect**
Year***
Aspect x Year**
% Cover
5
4
3
2
1
0
2012
2013
2014
2015
Year
N-facing Slope
S-facing Slope

Relationship Between Slope Aspect Preference and Response to Drought Varied Depending on Lifespan

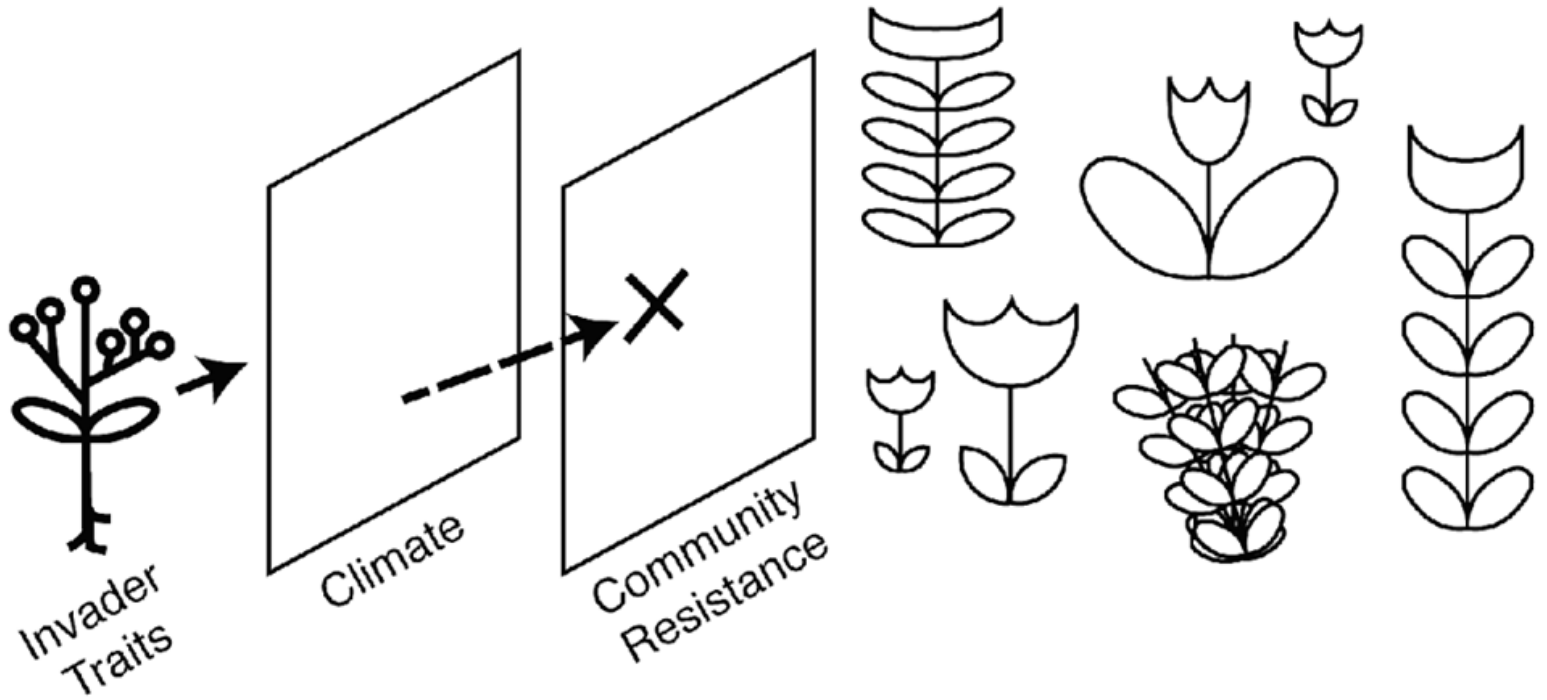




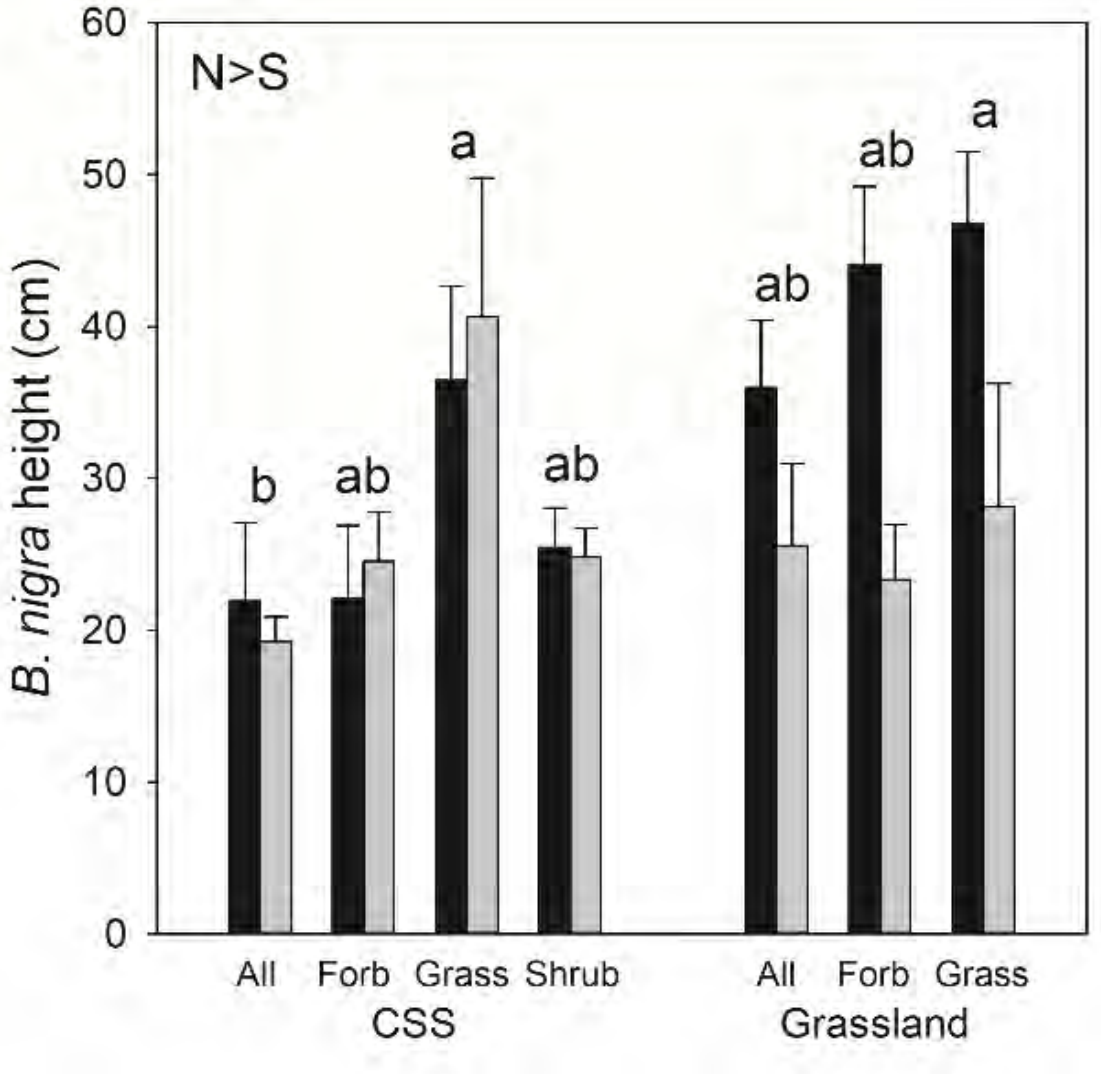
Implications for Restoring Resistant Communities

- Shrubs like *Eriogonum* that survive drought well are also good species to plant on south-facing slopes
- Grasslands may establish better on north-facing slopes than south-facing due to higher *Stipa* success

Functional traits and resistance



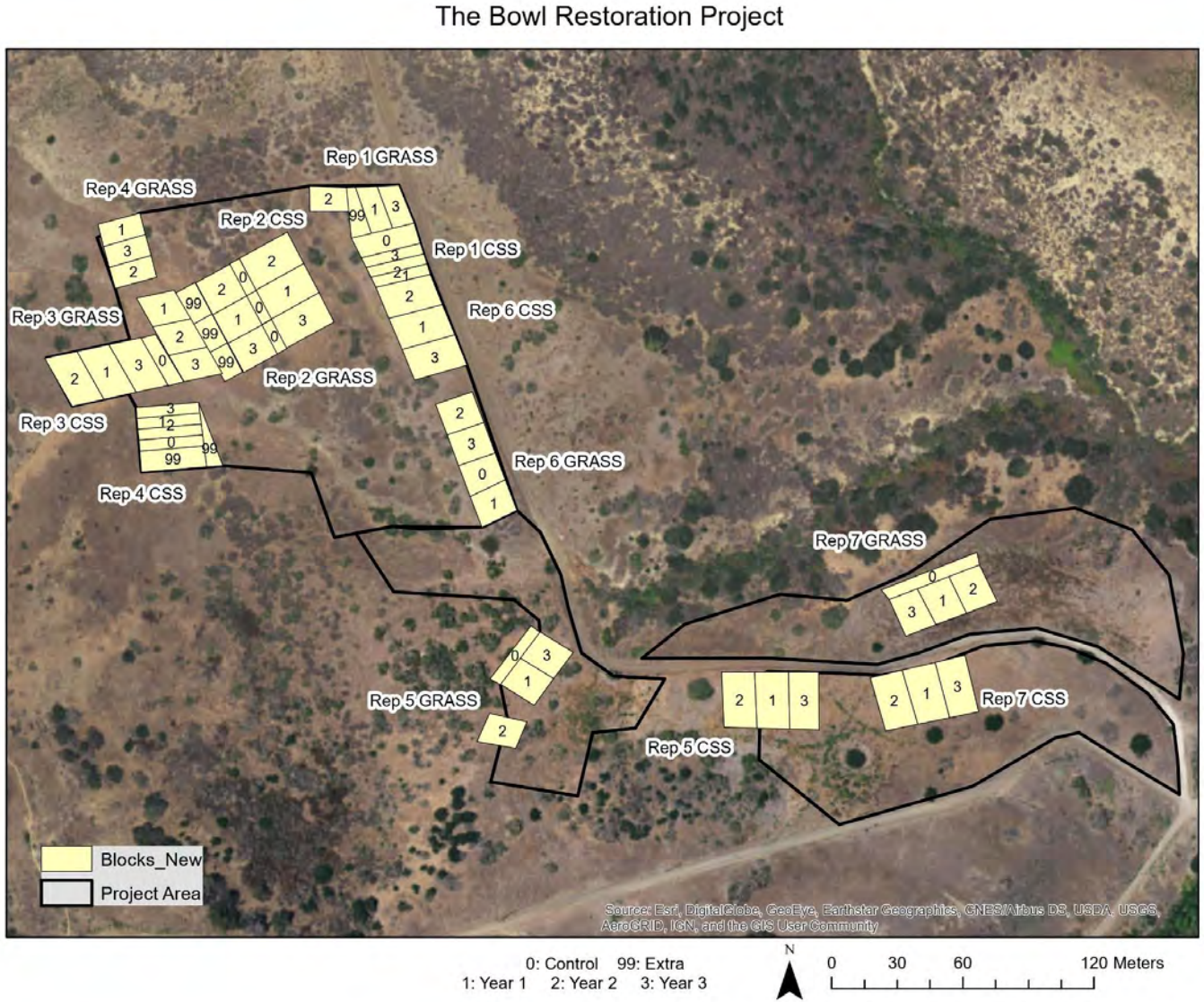
Invasive *Brassica nigra* was taller on N-facing slopes planted with native grasses

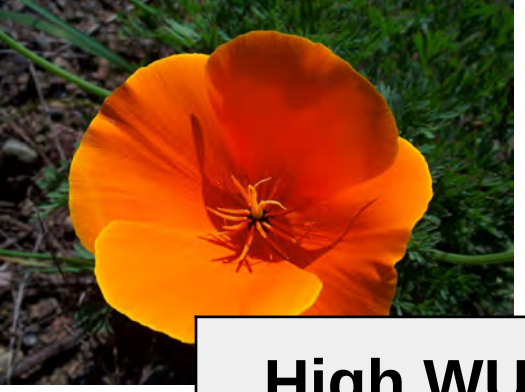


Effect of CWM traits on *Brassica nigra* height

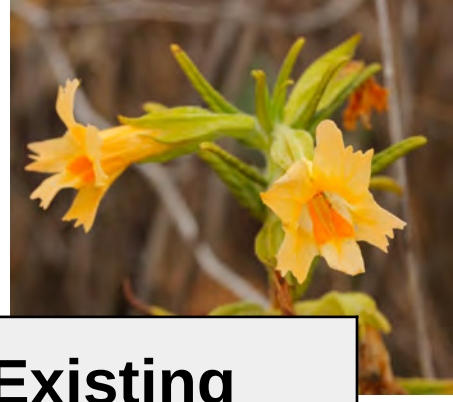
“The Bowl” at Crystal Cove State Park

Experimental Design – Identical Restoration Methods Initiated in Replicate Years



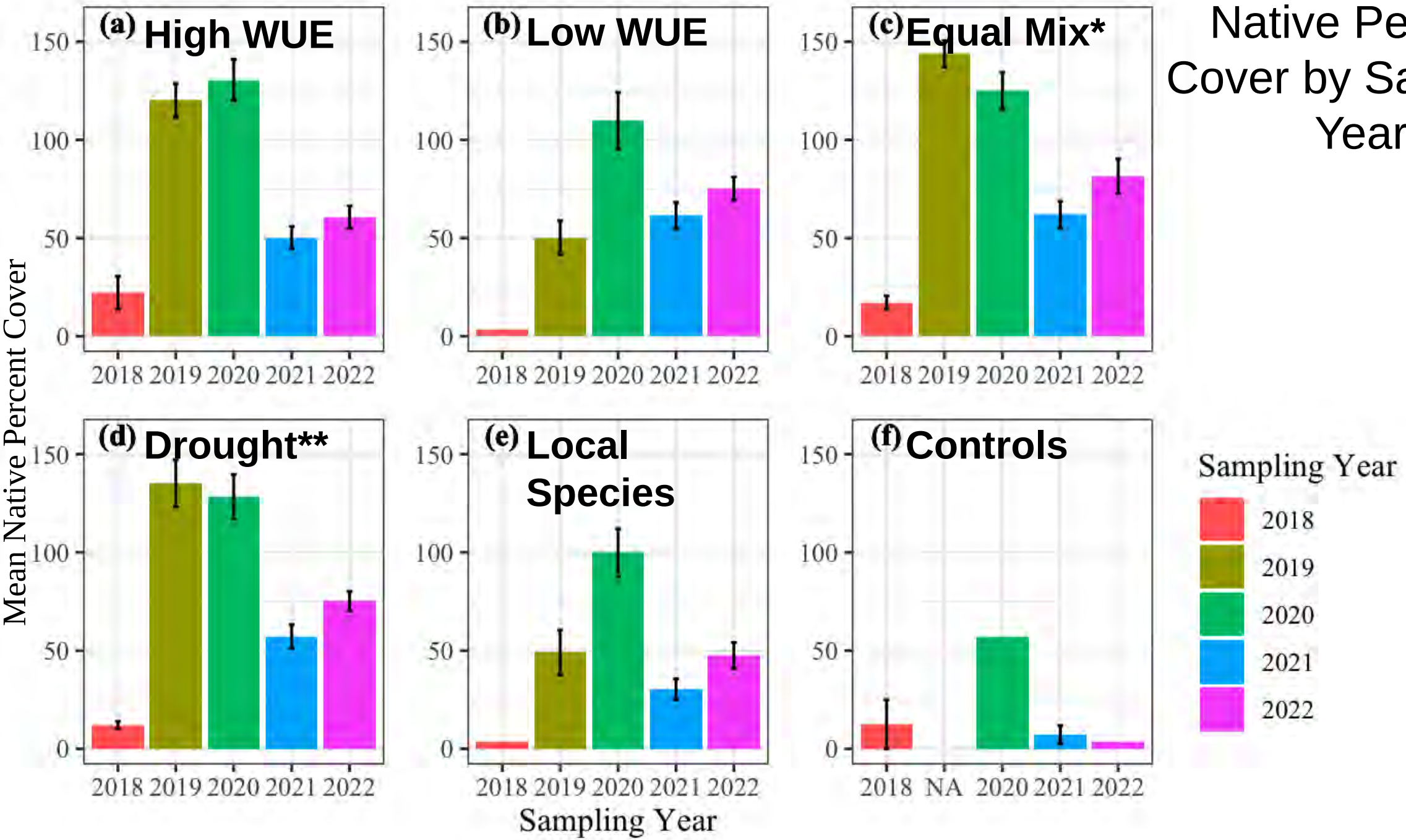


Native Seed Mixtures



High WUE (A)	Low WUE (B)	Equal Mix (C)	Drought Survival (D)	Existing Species (E)
Encelia californica	*Artemisia californica*	*Diplacus aurantiacus*	*Encelia californica*	*Peritoma arborea*
Deinandra fasciculata	*Salvia mellifera*	*Encelia californica*	*Deinandra fasciculata*	*Phacelia parryi*
Eschscholzia californica	*Phacelia cicutaria var. hispida*	*Salvia mellifera*	*Artemisia californica*	*Emmenanthe penduliflora*

Native Percent Cover by Sampling Year

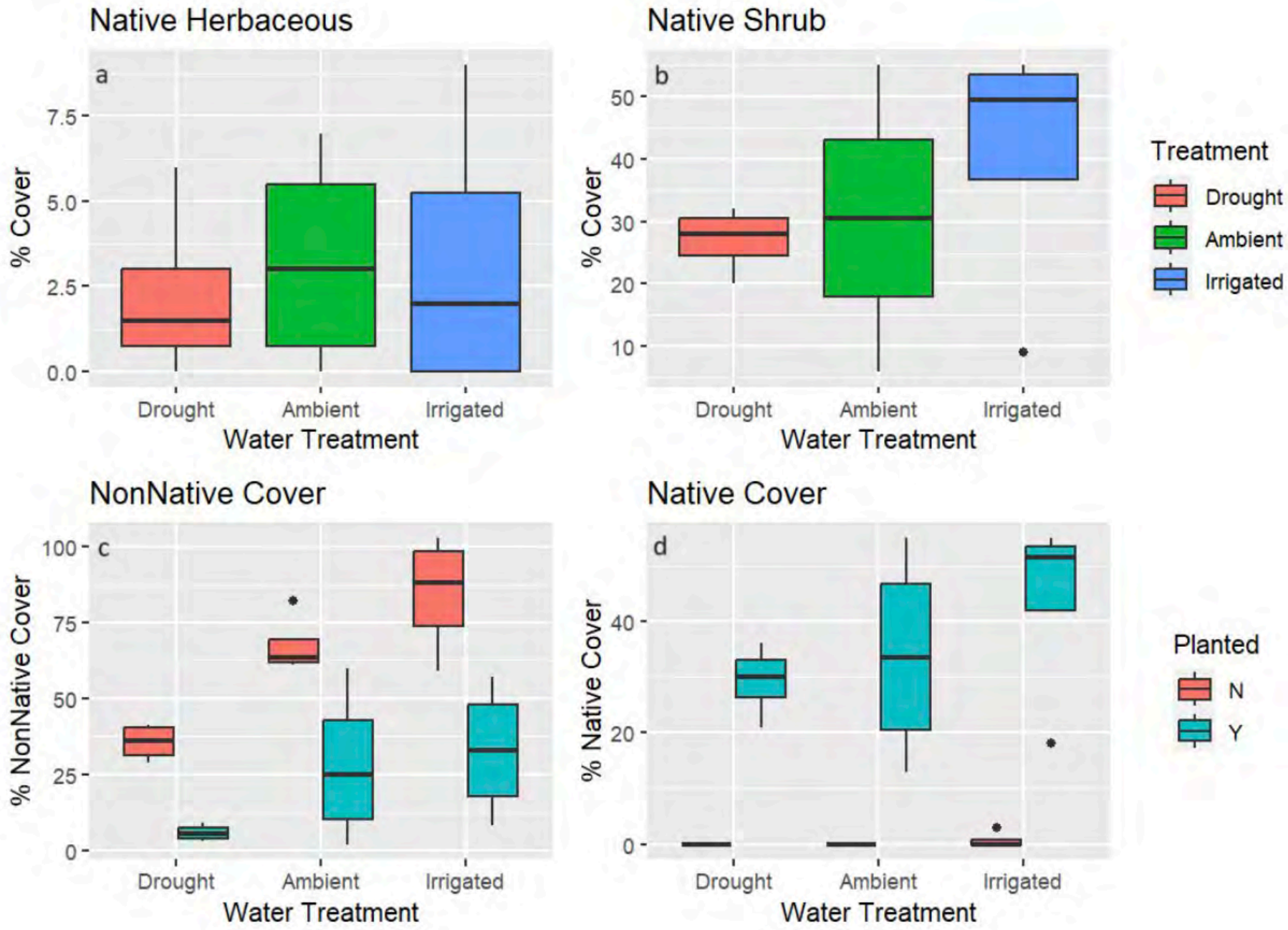


Implications for Restoring Resistant Communities

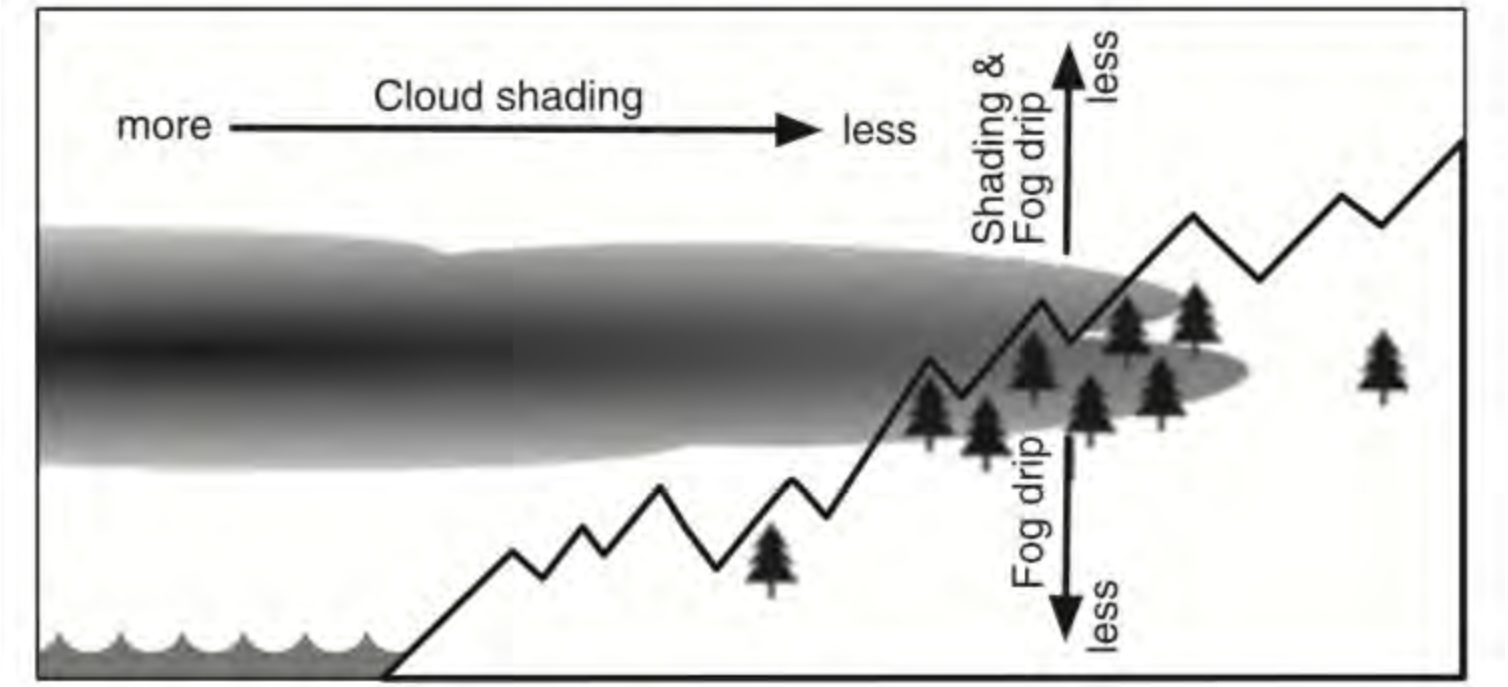
- Most species performed best when planted in a wet year
- Natives with the highest water-use-efficiency values established best when planted during a dry year
- Planting in more than one year with a diverse seed mix may result in the greatest success over time

UCI Drought Net Experiment
Rainfall Manipulation - UCI Ecological Preserve

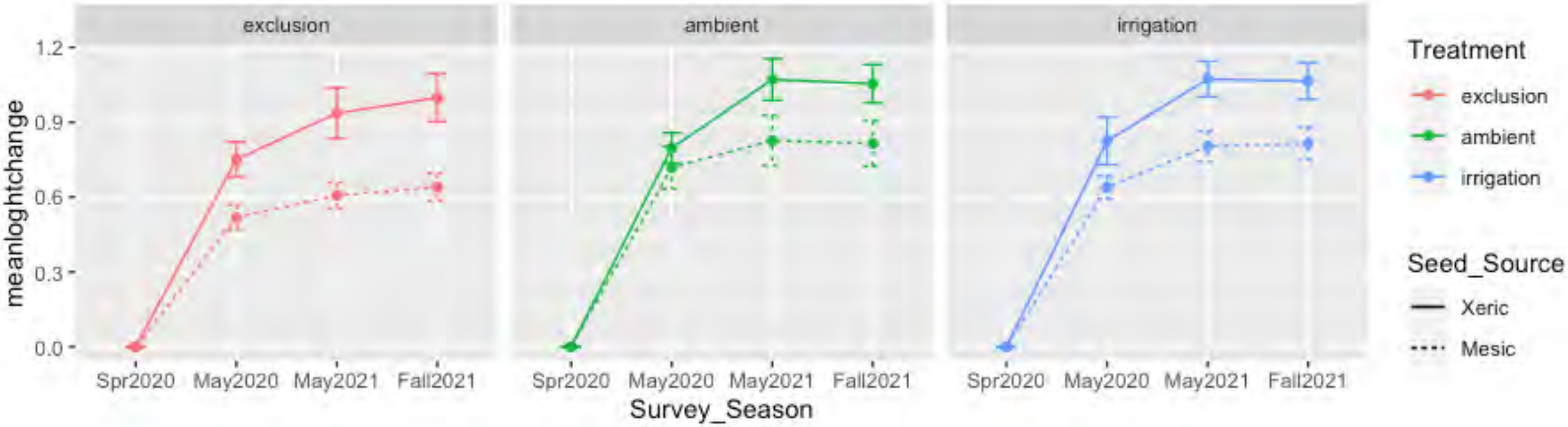
How can we restore resistant communities?


Native Herbaceous
a
% Cover
7.5
5.0
2.5
0.0
Drought
Ambient
Irrigated
Water Treatment
Native Shrub
b
% Cover
50
40
30
20
10
Drought
Ambient
Irrigated
Water Treatment
Treatment
Drought
Ambient
Irrigated
NonNative Cover
c
% NonNative Cover
100
75
50
25
0
Drought
Ambient
Irrigated
Water Treatment
Native Cover
d
% Native Cover
40
20
0
Drought
Ambient
Irrigated
Water Treatment
Planted
N
Y

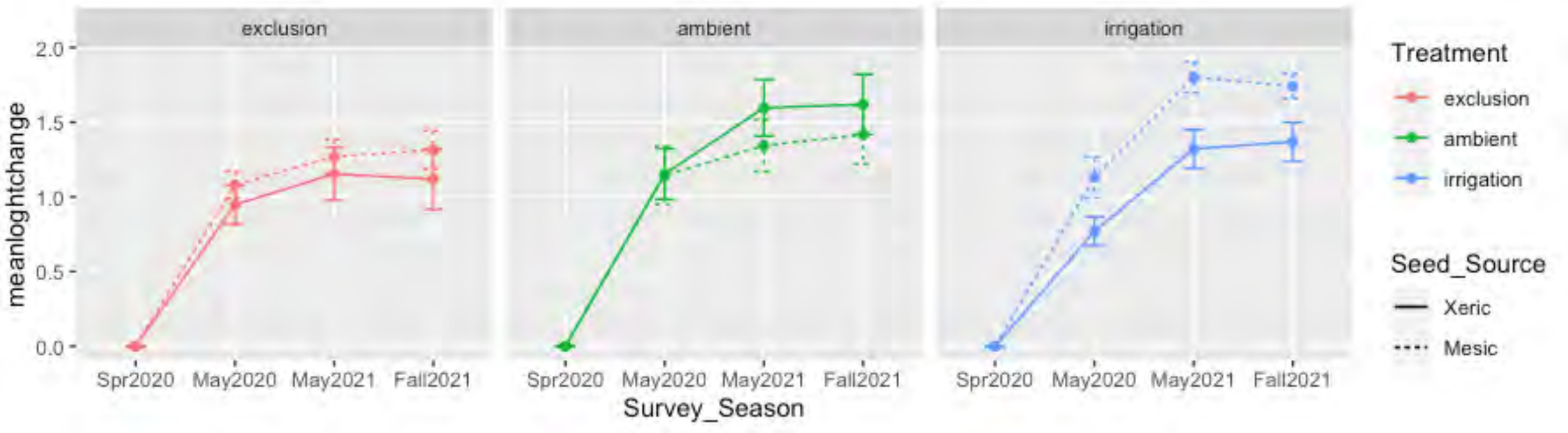
Local Adaptation Along Environmental Gradient



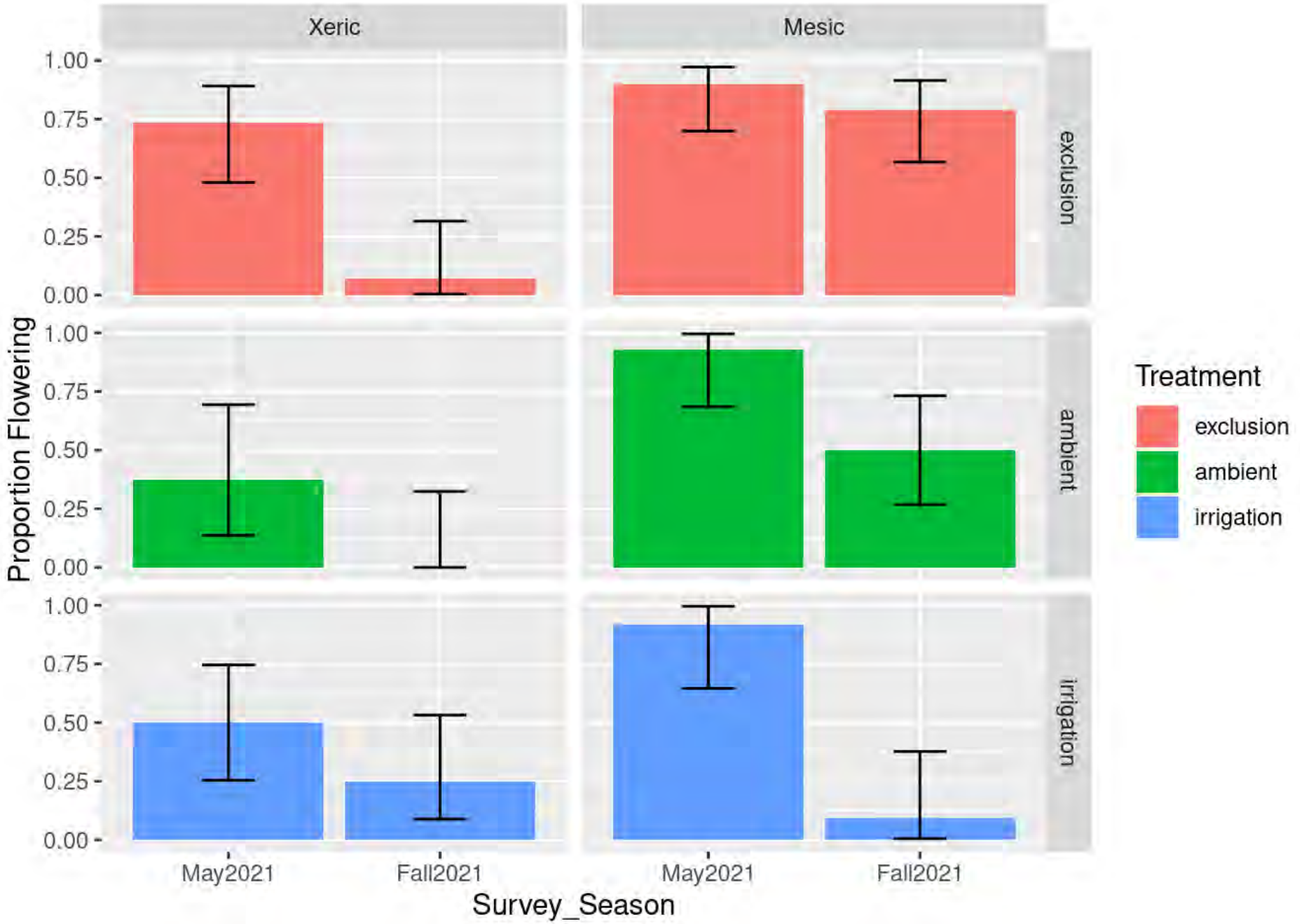
Inland-sourced *Artemisia californica* grew more than coastal-sourced populations ($p<0.01$)



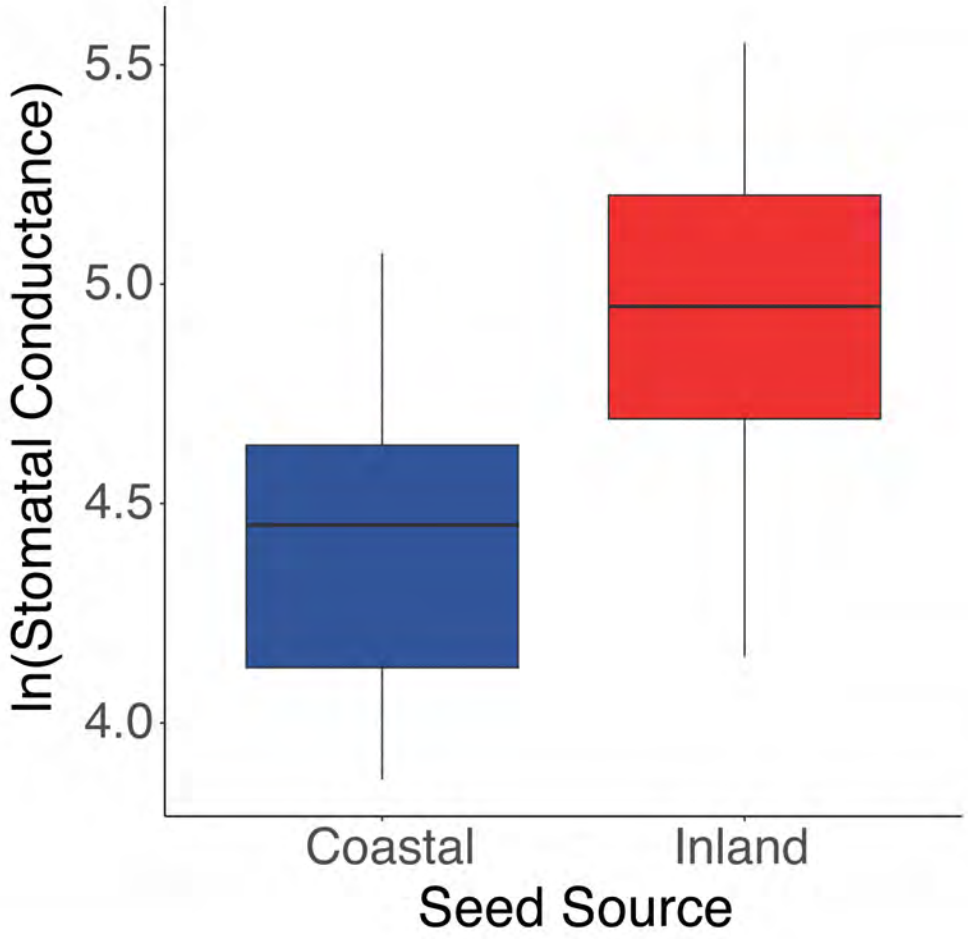
Inland-sourced *Salvia mellifera* grew more than coastal-sourced populations in ambient, but not in other water treatments (Significant interaction)



Coastal-sourced populations of *Eriogonum fasciculatum* had more flowering plants than inland-sourced populations



Stomatal conductance values were higher for inland-sourced populations of *Eriogonum fasciculatum* compared to coastal-sourced populations



Implications for Restoring Resistant Communities

- Locally sourced populations are not always best
- Different species have different traits that enable them to respond to variation in rainfall
- There’s a complexity of responses, so adding diverse genotypes likely improves restoration success

Goal: Restore Resistant and Resilient Systems

Resistant Communities: Wildfire

- LRGCE – Drought interacts with wildfire to reduce resilience of native systems
- BCBR – Restoration including diverse functional groups resistant to wildfire

Resistant Communities: Drought

- SCRS – Removing invasives + drought = disturbance, shifts in dominant invasive and community type
- PRE – Removing invasives during drought can improve resistance of native shrubs
- WLRE – Drought-tolerant native perennials increased cover and resisted invasion on S-facing slopes & during drought, while native annuals with traits closest to invasives resisted invasion on N-facing slopes and in wet years

Resistant Communities: Competition

- WLRE – Trait-based approaches can help prevent invasion by planting fast-growing annuals in high-resource environments and stress-tolerant perennials in low-resource environments

Resistant Communities: Fitness

- Bowl – Seeding in multiple years promotes diverse & resistant communities
- DN – Sourcing plants from wider geographic areas can improve restoration outcomes

Manipulating Community Assembly Filters & Plant Traits Can Improve the Ability to Restore Resistant Communities