Modeling climate change impacts on habitat suitability to inform restoration of southern California shrublands

Erin C. Riordan, Arlee M. Montalvo & Jan L. Beyers

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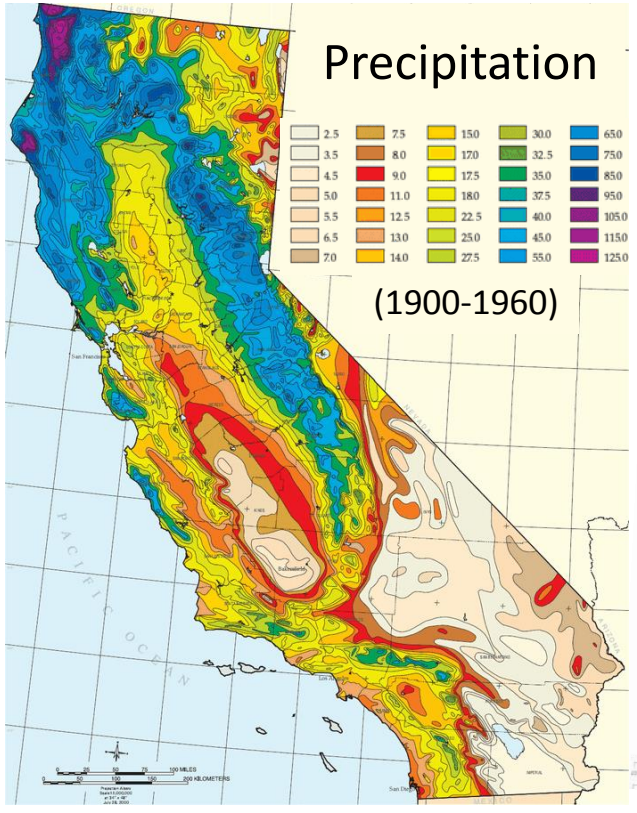
eriordan@ucla.edu

UCLA RCRCD RIVERSIDE-CORONA RESOURCE CONSERVATION DISTRICT USDA FOREST SERVICE US DEPARTMENT OF AGRICULTURE

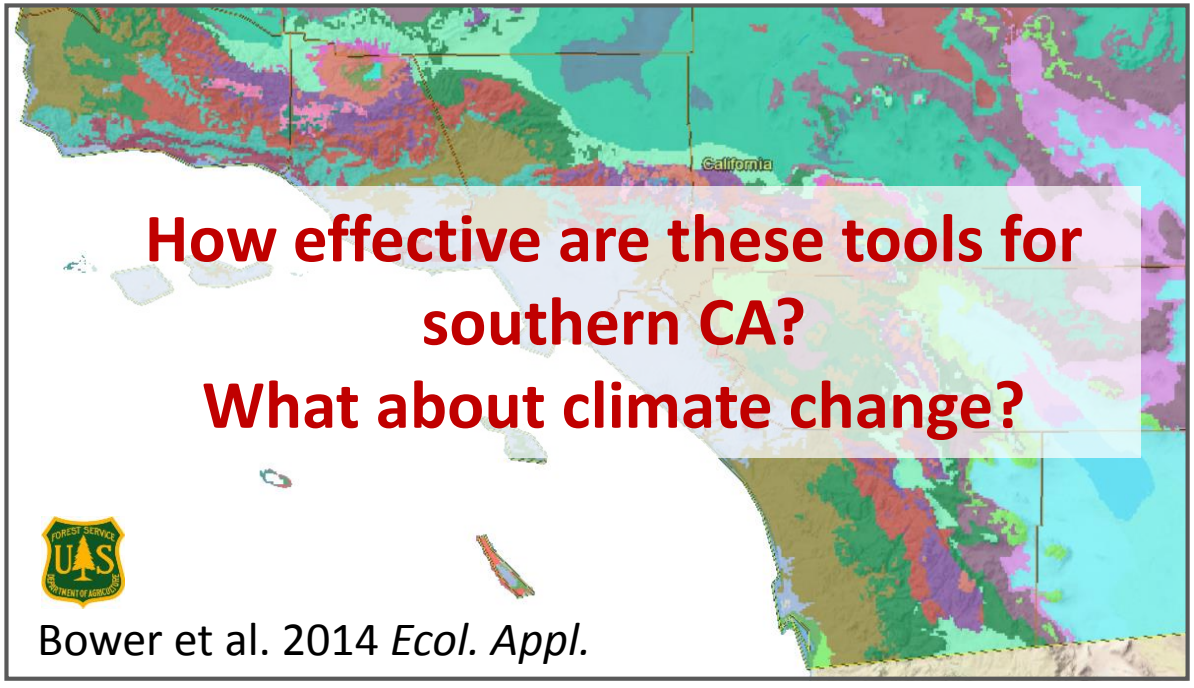
Ecological restoration in southern California

How do we responsibly source appropriate plant materials for restoration?

Environmental heterogeneity of California

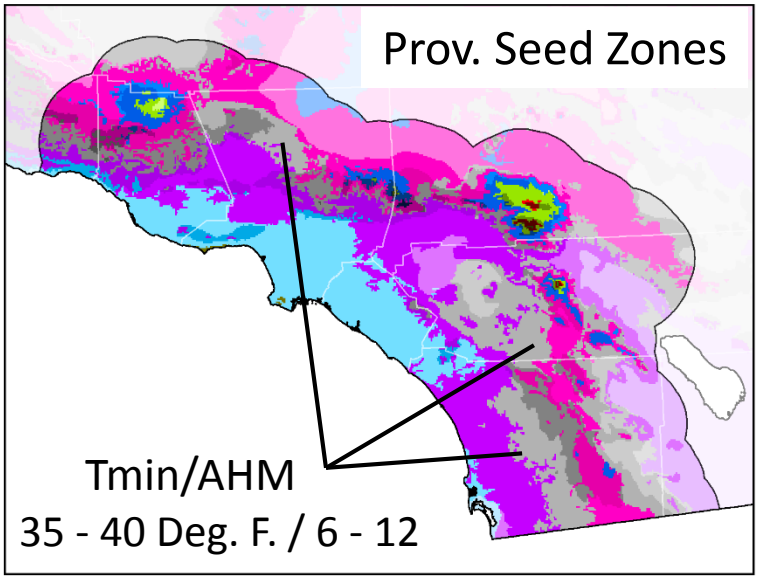


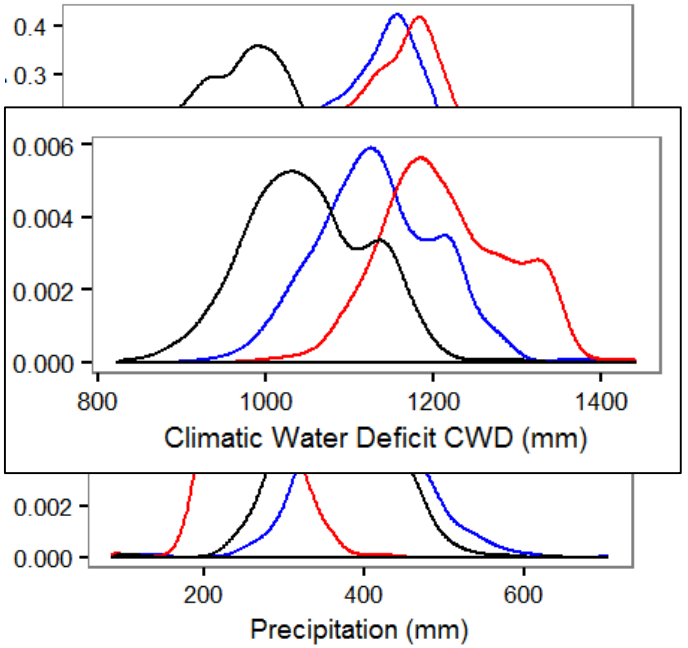
Provisional Seed Zones



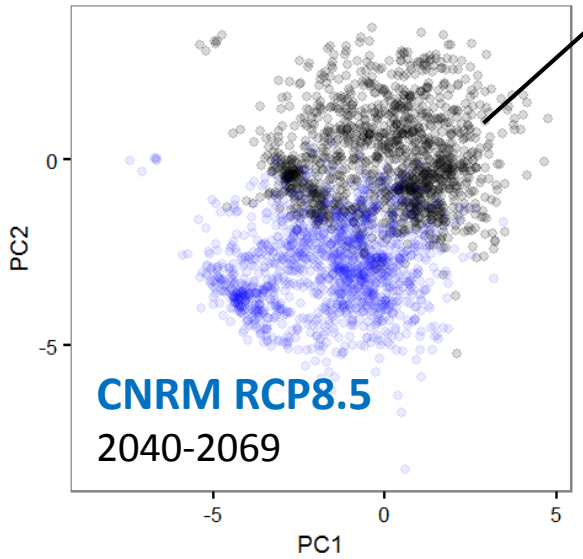
http://www.fs.fed.us/wwetac/threat_map/SeedZones_Intro.html

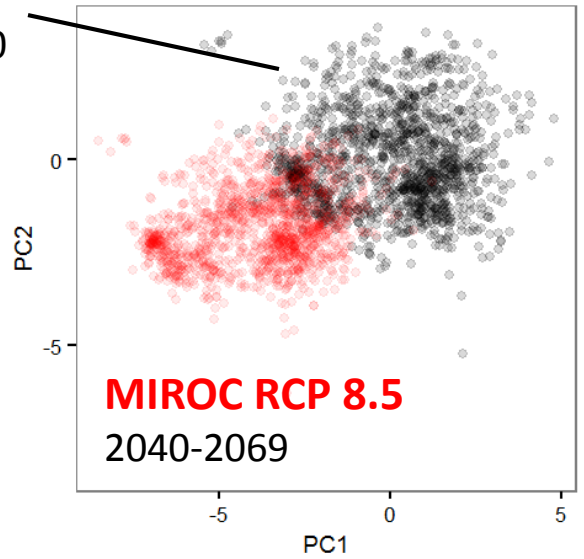
Rate of climate change may exceed species' capacity to respond





Baseline
1951-1980





Can species distribution models inform ecological restoration?

Species occurrences
(Herbarium records)

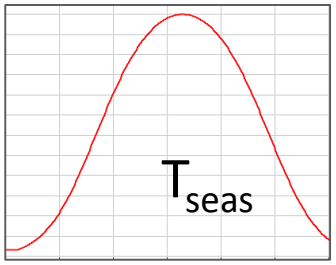
+

Baseline conditions
(1951–1980)

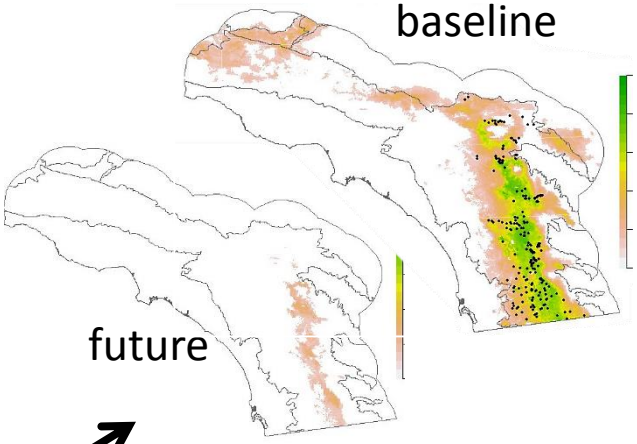
Future conditions
(2040–2069)

MAXENT

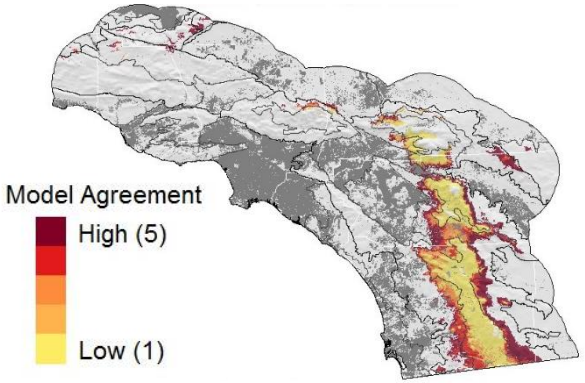
Species Distribution
Model (SDM) algorithm

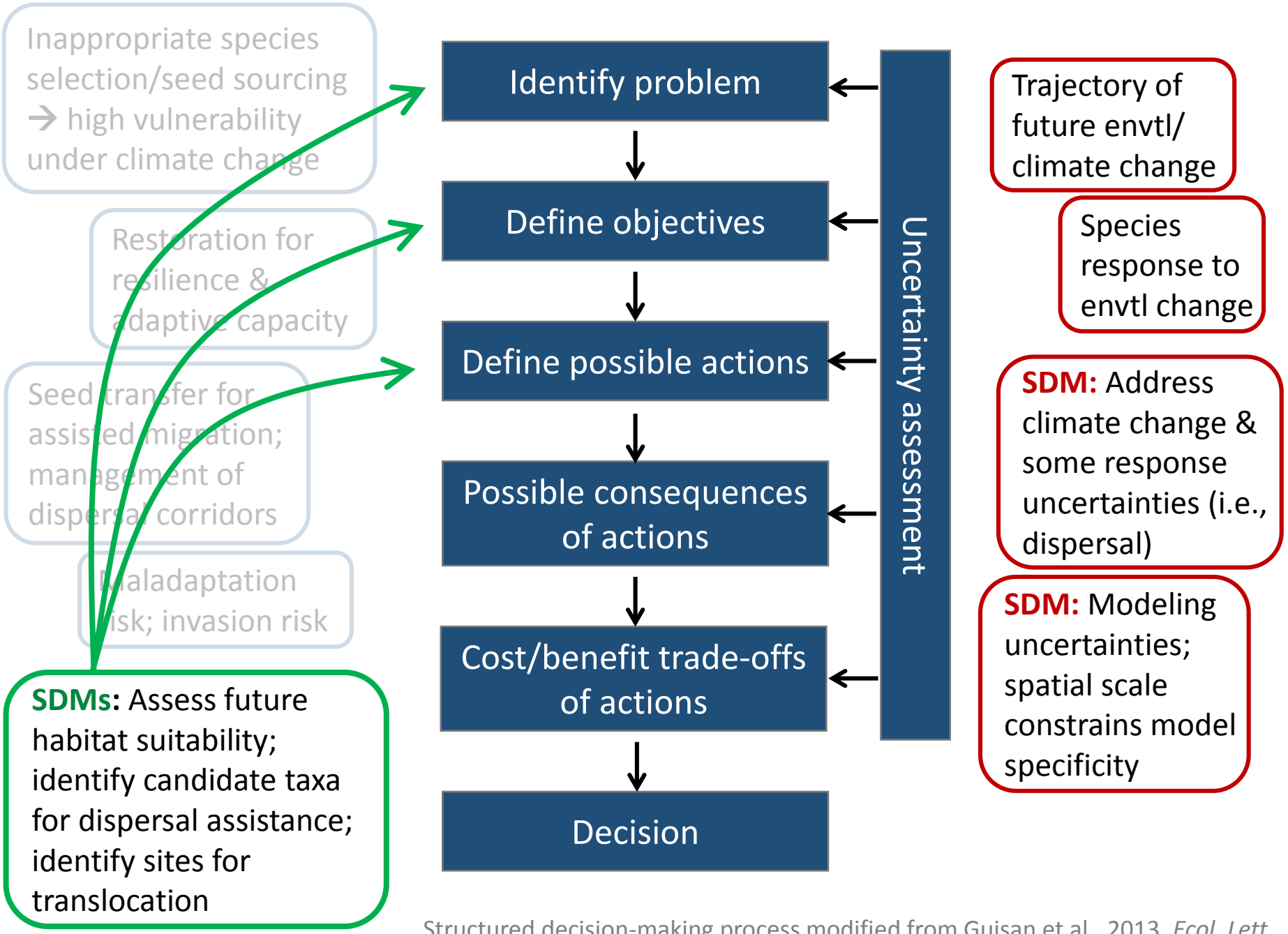


Habitat suitability



Planning Tools

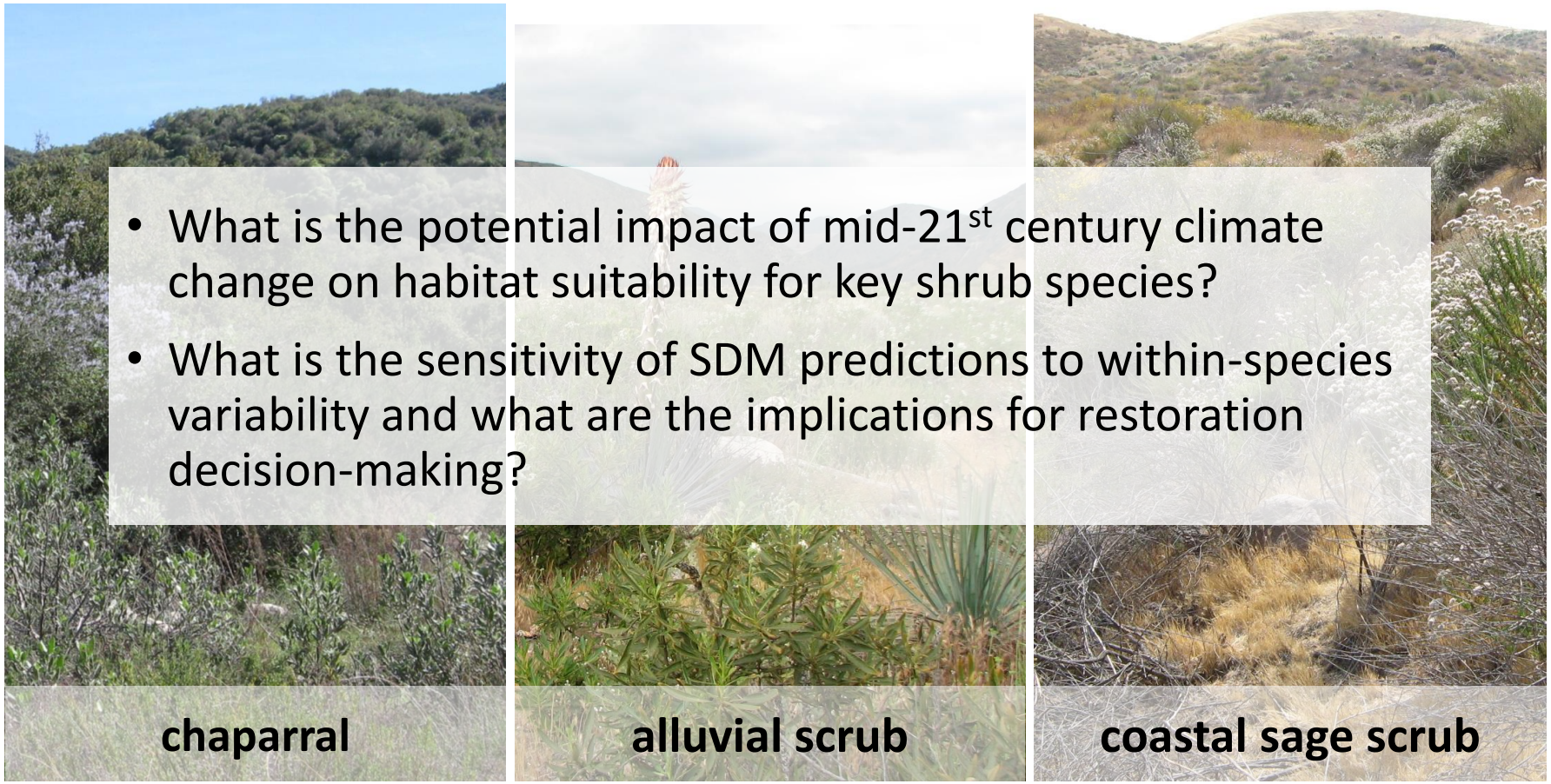




Structured decision-making process modified from Guisan et al., 2013. *Ecol. Lett.*

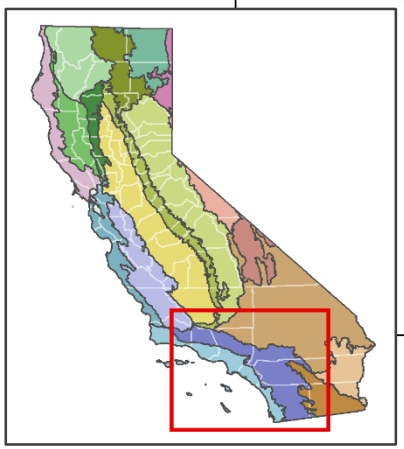
Project Objectives

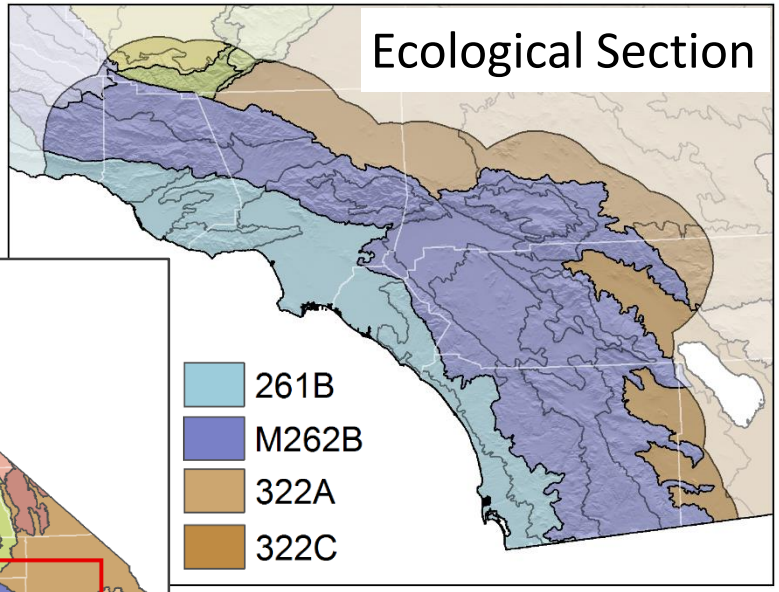
Examine the usefulness of species distribution models (SDMs) to inform plant material sourcing for ecological restoration in southern CA shrublands

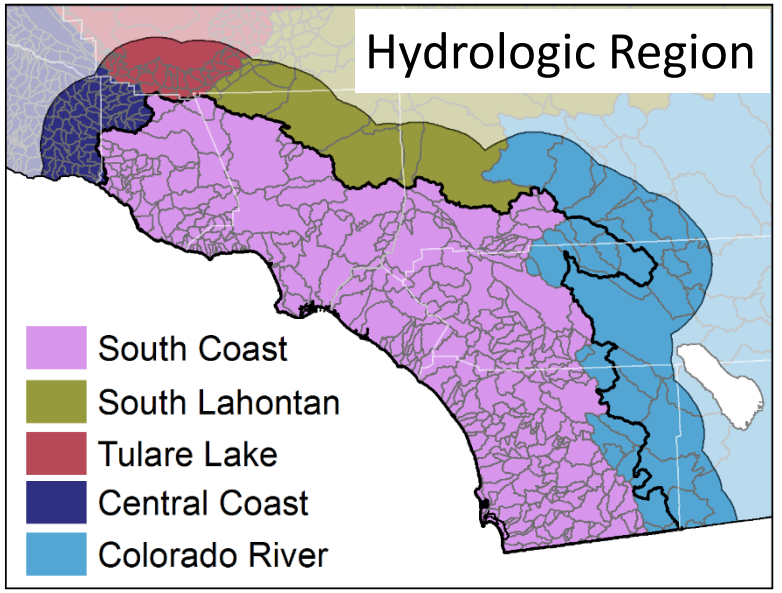


- What is the potential impact of mid-21st century climate change on habitat suitability for key shrub species?
- What is the sensitivity of SDM predictions to within-species variability and what are the implications for restoration decision-making?

chaparral **alluvial scrub** **coastal sage scrub**





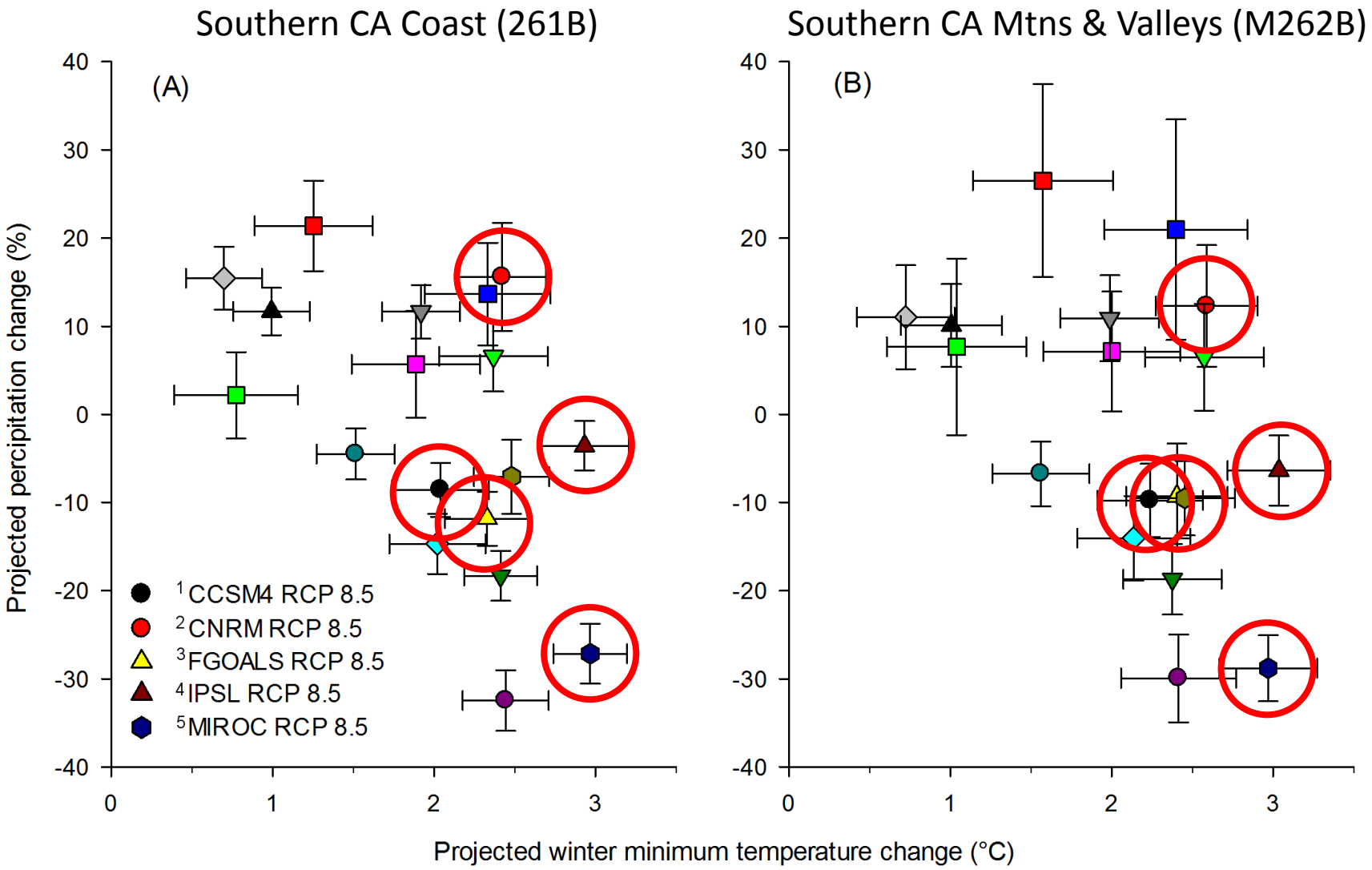


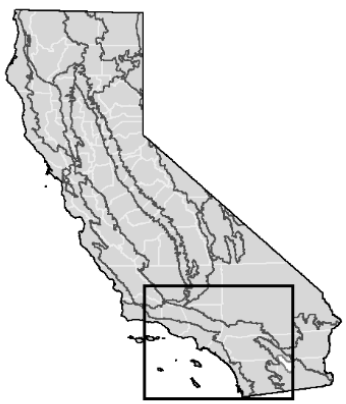
Native plant taxa for modeling

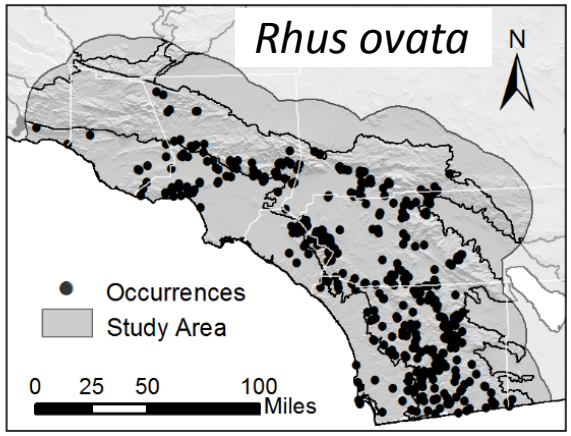
- 44 common taxa (shrubs, herbs, grasses)
- 36 shrubs & subshrubs (CSS & low-elevation chaparral)
  - Effect of infraspecies variation (12 infraspecies-species comparisons)
  - Effect of regional variation (30 regional-full range comparisons)

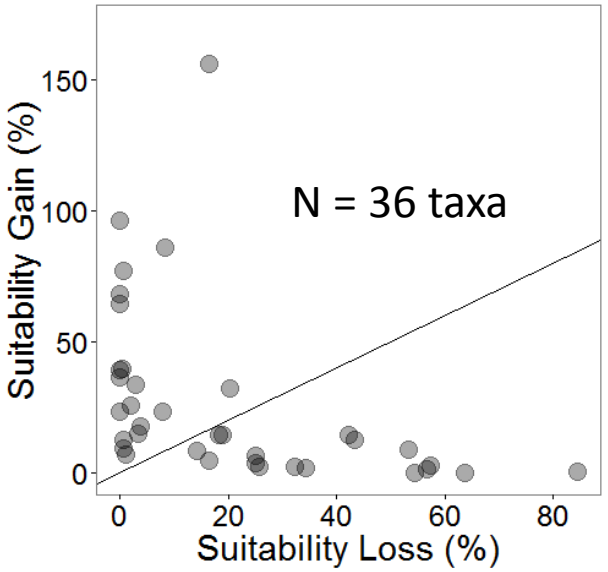
Projected change in southern California climate

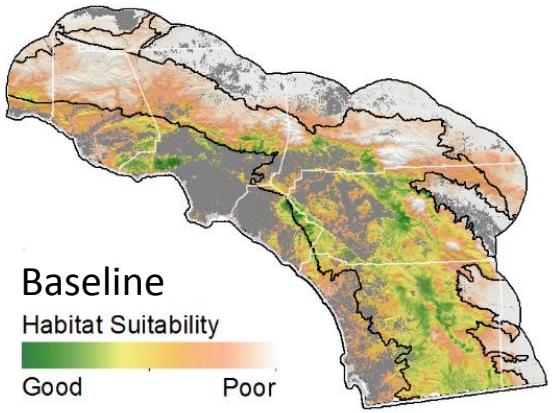
2040–2069 relative to 1951–1980

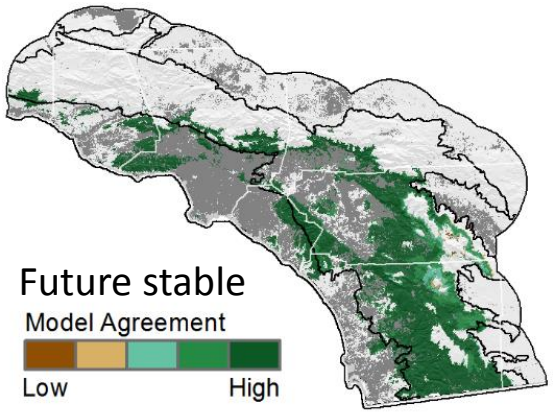


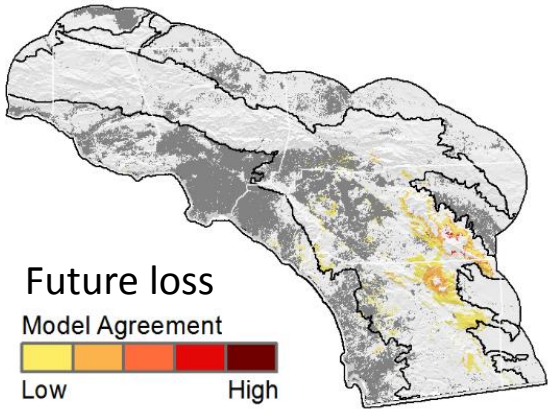


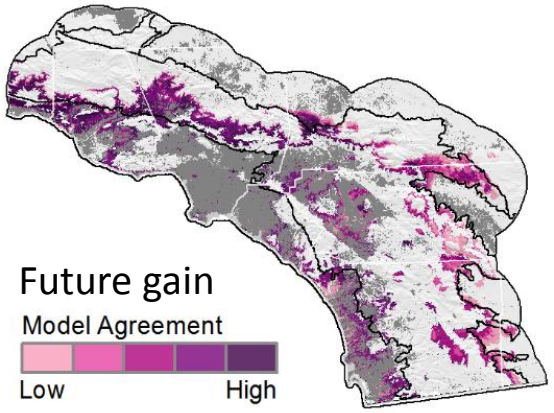

Rhus ovata
N
Occurrences
Study Area
0 25 50 100
Miles

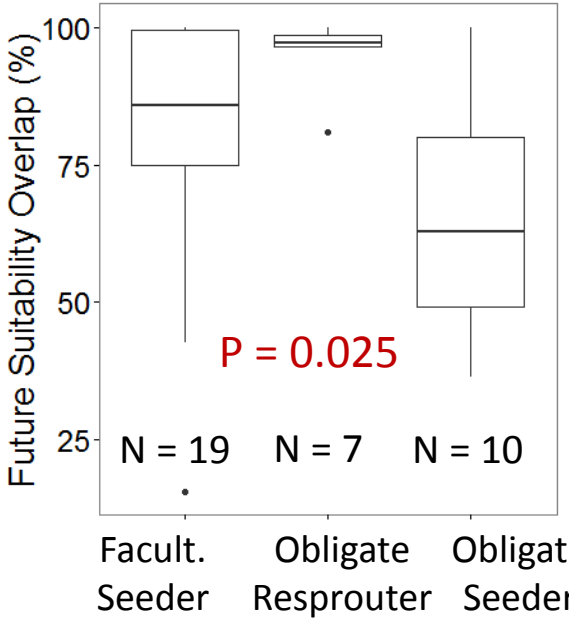

Suitability Gain (%)
150
100
50
0
N = 36 taxa
0 20 40 60 80
Suitability Loss (%)


Baseline
Habitat Suitability
Good
Poor

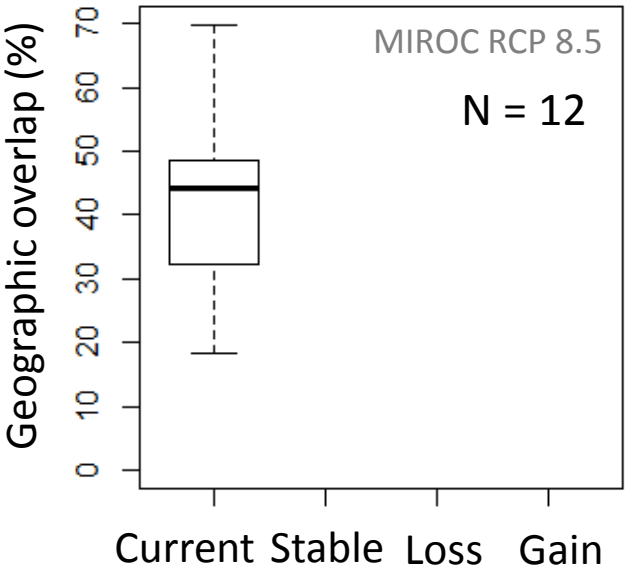

Future stable
Model Agreement
Low
High


Future loss
Model Agreement
Low
High

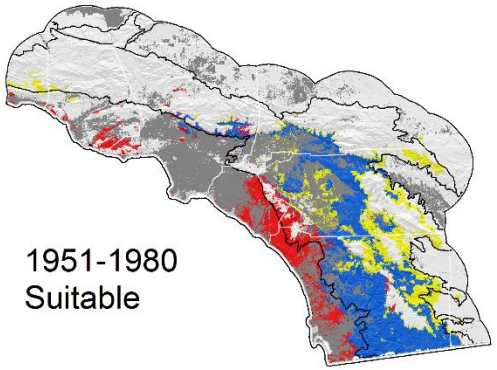

Future gain
Model Agreement
Low
High


Future Suitability Overlap (%)
100
75
50
25
P = 0.025
N = 19
N = 7
N = 10
Facult. Seeder
Obligate Resprouter
Obligate Seeder

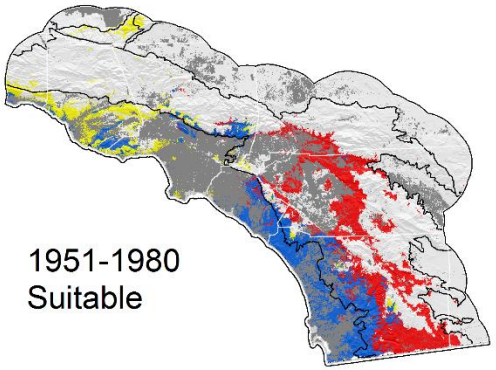
Species vs. Infraspecies

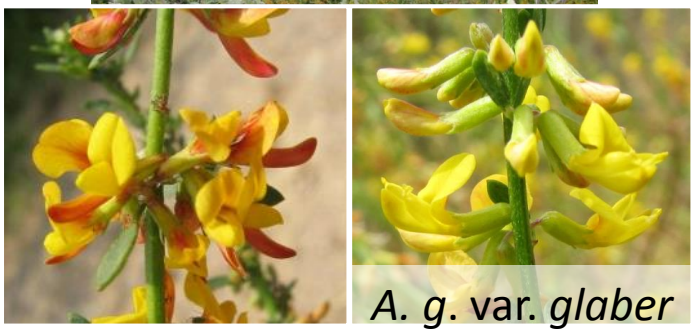


Acmispon glaber var. *brevialatus*



Acmispon glaber var. *glaber*

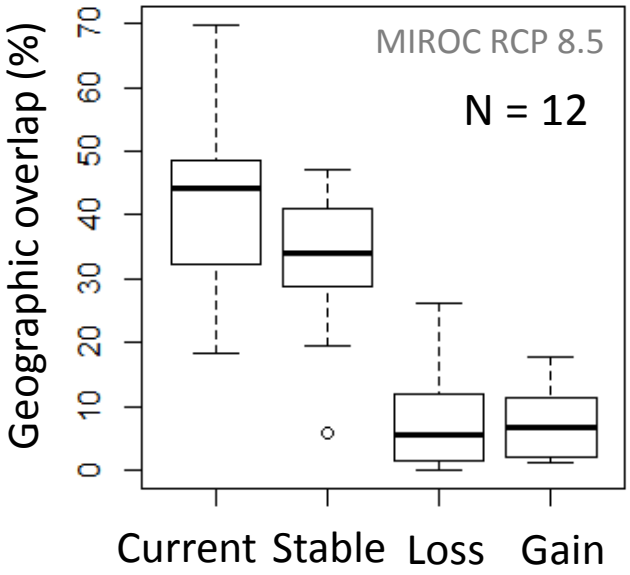




Species
Infrasp.
Both
Developed

MIROC RCP 8.5

Species vs. Infraspecies

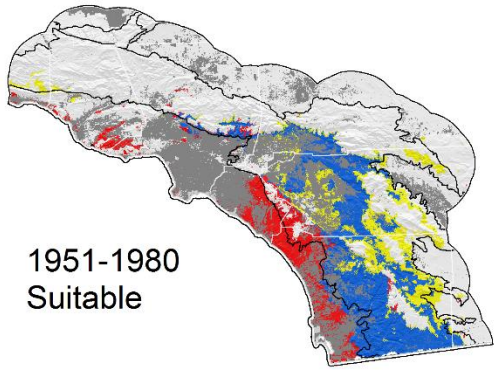


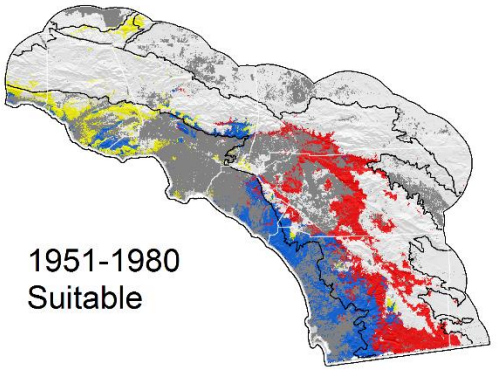
A. g. var. *brevialatus*

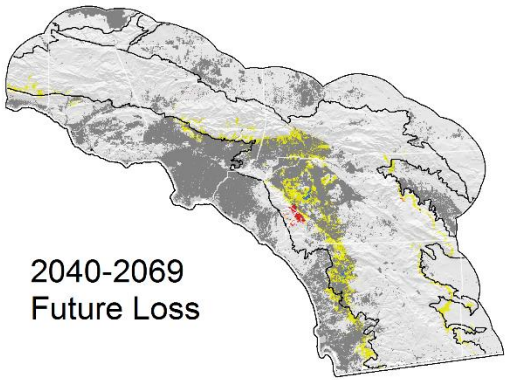
A. g. var. *glaber*

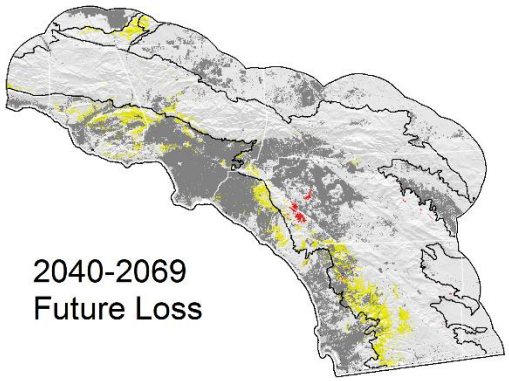
Acmispon glaber var. *brevialatus*

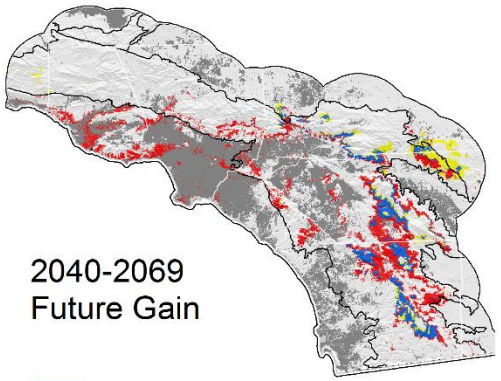
Acmispon glaber var. *glaber*

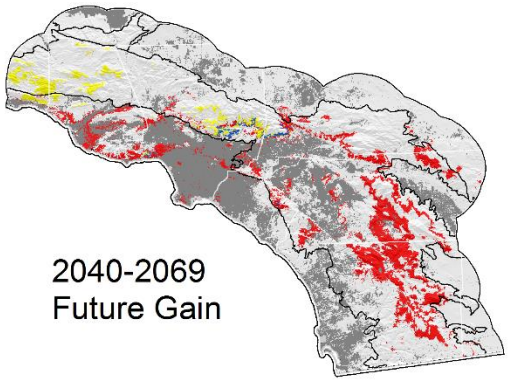






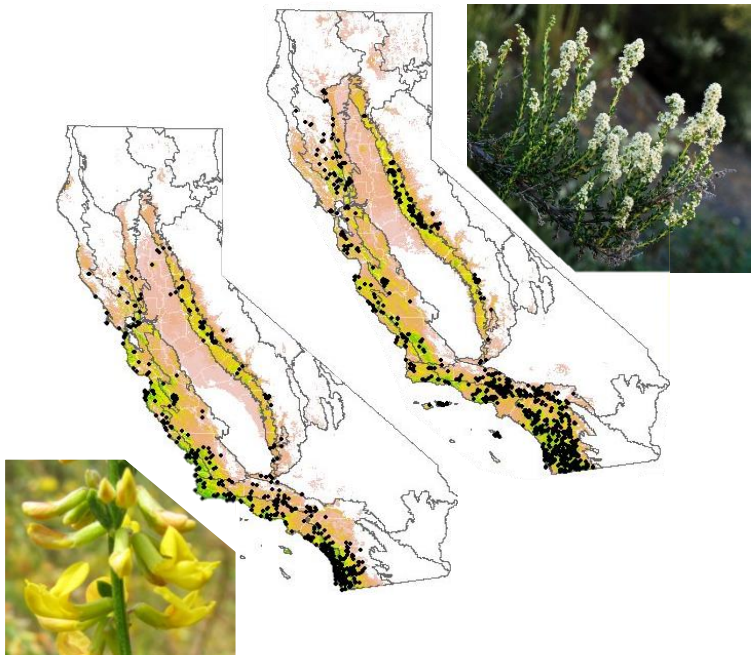




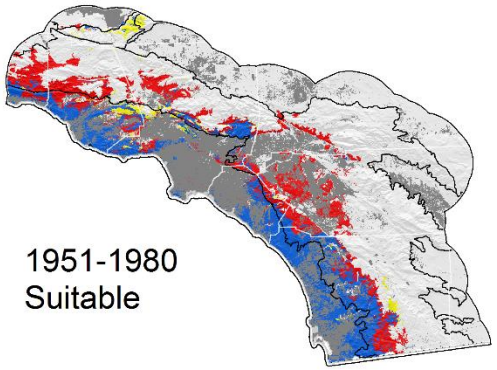


Species Infrasp. Both Developed

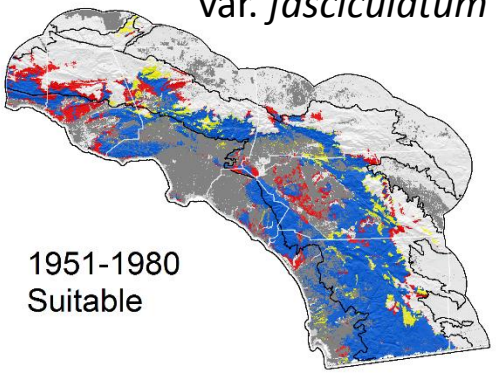
MIROC RCP 8.5

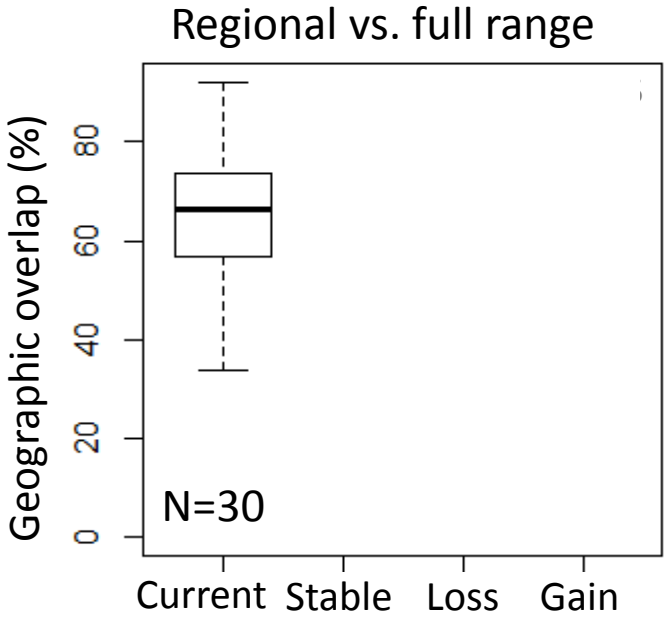


Acmispon glaber var. glaber



Adenostoma fasciculatum var. *fasciculatum*





Full Range Regional Both Developed

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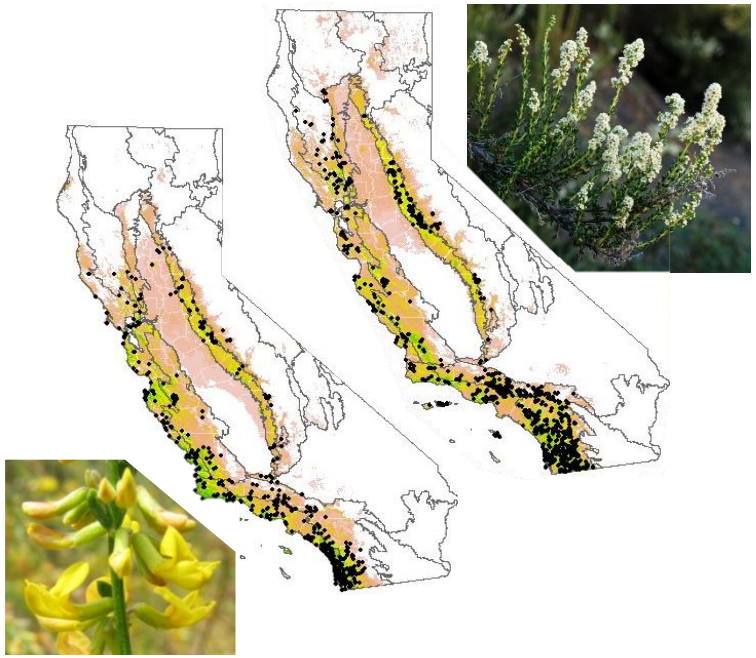
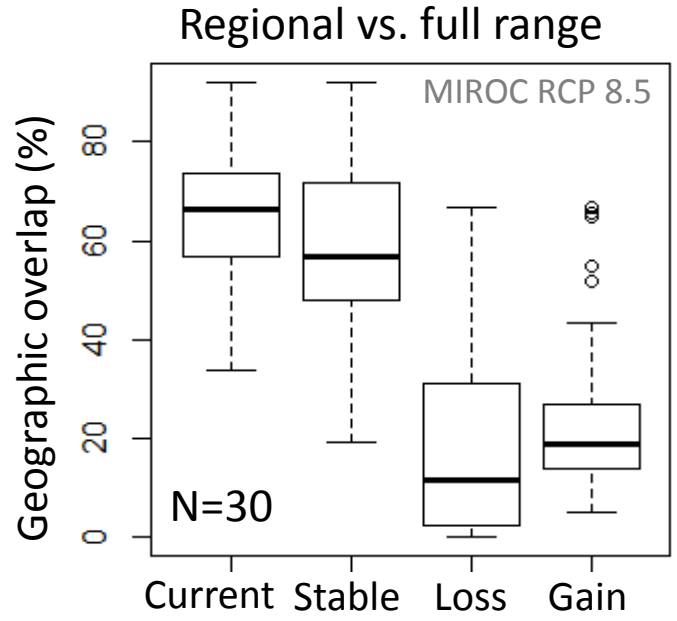
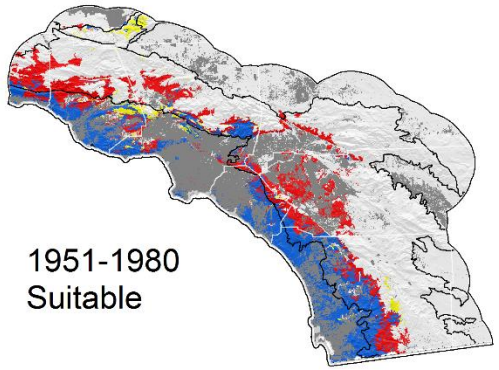
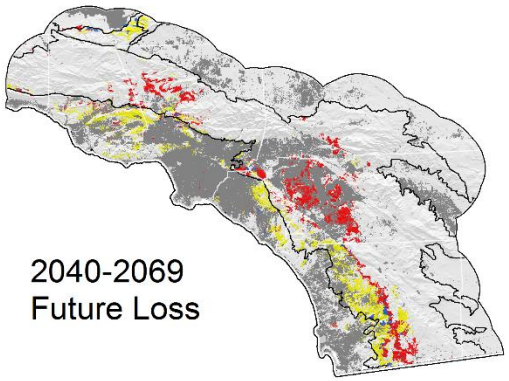
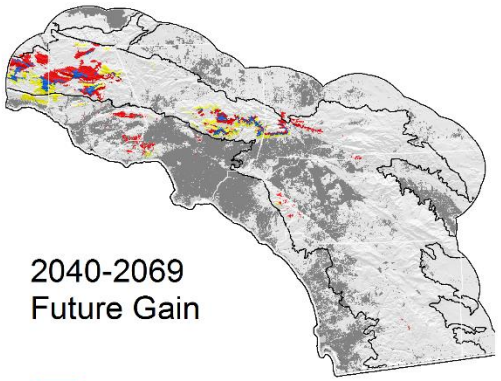




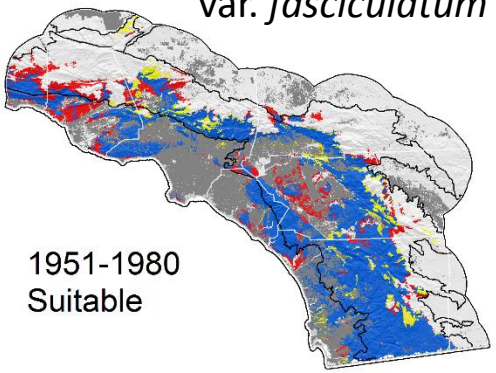
Acmispon glaber var. glaber

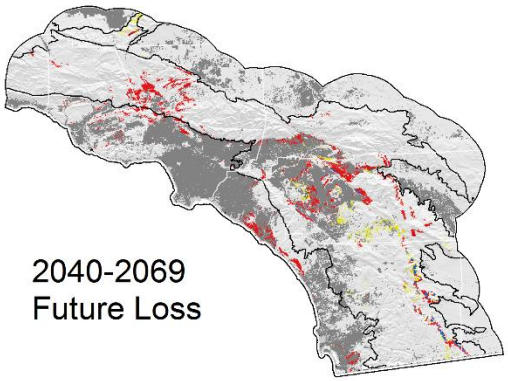


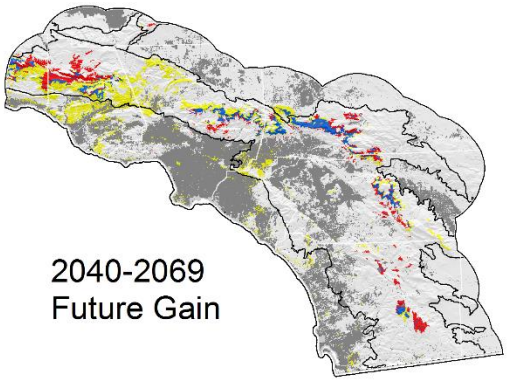




Adenostoma fasciculatum var. *fasciculatum*



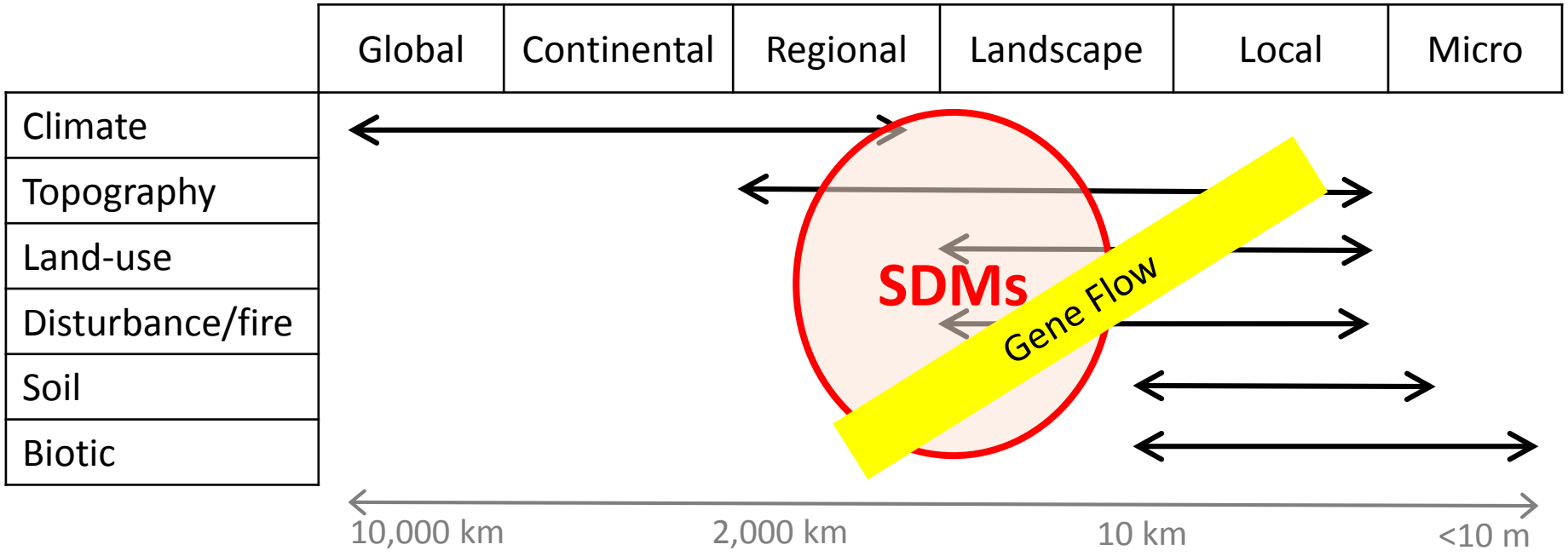




Full Range Regional Both Developed

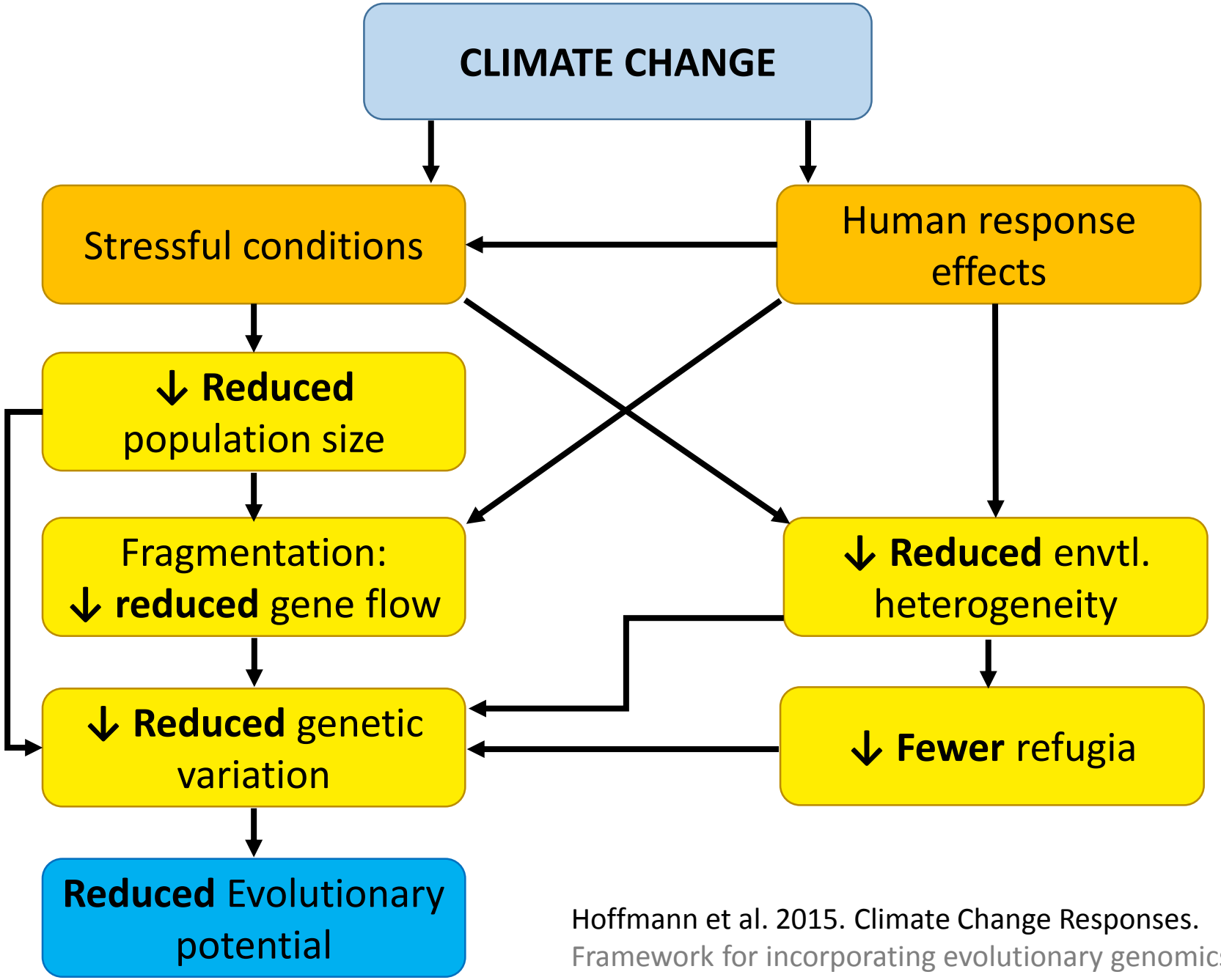
MIROC RCP 8.5

Scale and within-species variation matter



- Regional variation and infraspecies-level structure affect current model predictions and forecasts
- **Expert knowledge** about the species' physiology, ecology, demographics, life history traits, and population genetics, informs interpretation and practical applications of model results

Modified from: Pearson & Dawson 2003 *GEB*



Hoffmann et al. 2015. Climate Change Responses.
Framework for incorporating evolutionary genomics into biodiversity conservation management.

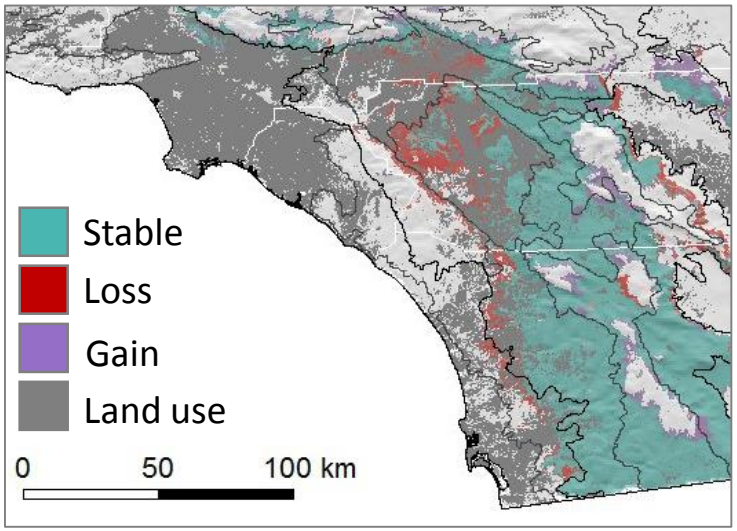
Applications for restoration

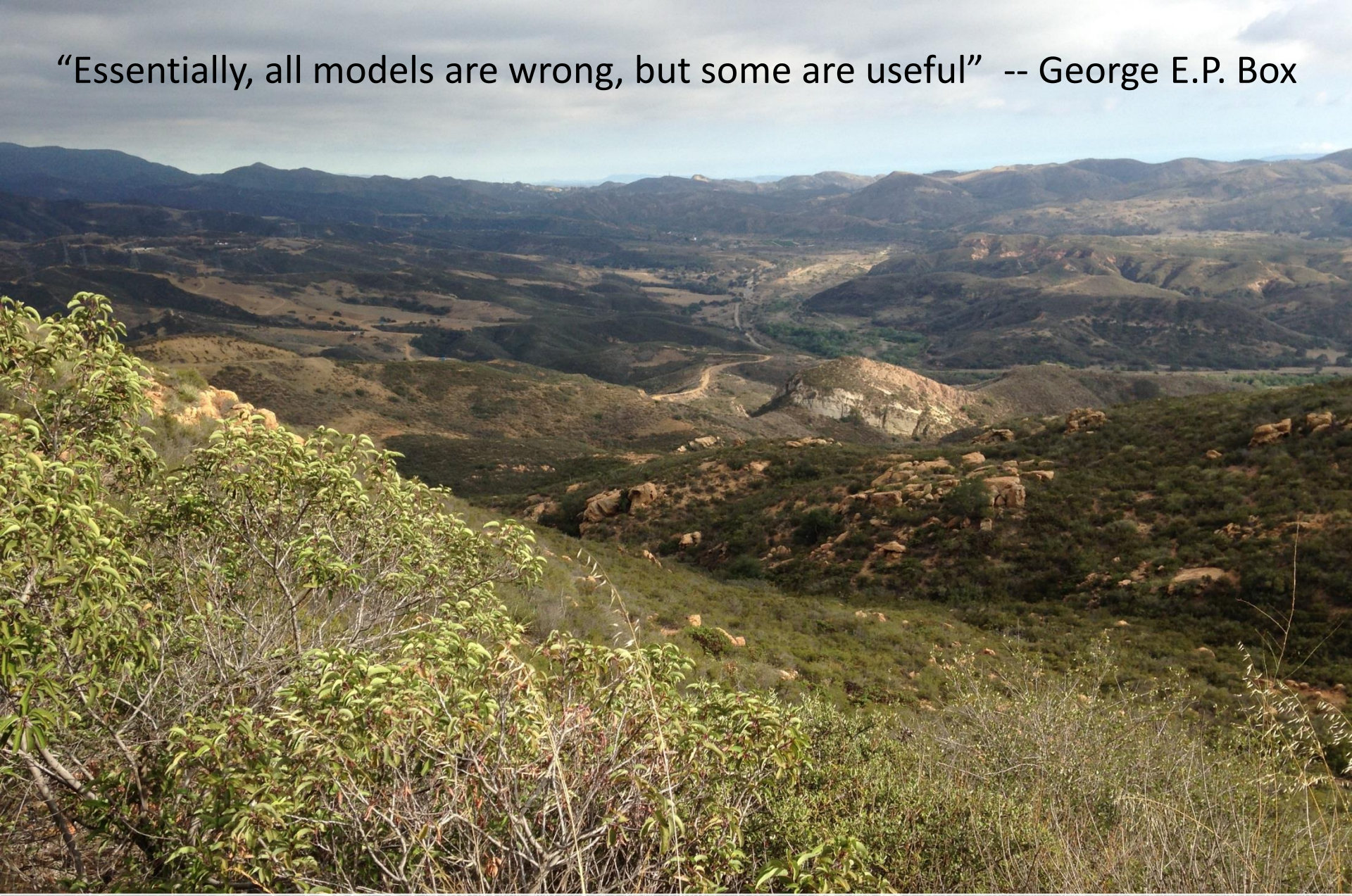
Species selection: Avoid highly vulnerable taxa and range extensions

- Degree of projected future climate exposure (habitat suitability loss)?
- Overlap in future and contemporary habitat suitability?
- Are species traits suggestive of high vulnerability under climate change and/or other threats (land use; altered fire regimes)?

Seed sourcing: Inform scale of seed transfer

- Weigh potential climate stress, species gene flow, evolutionary potential
- Candidates for assisted migration: high climate exposure, low gene flow/adaptive capacity, or highly compromised dispersal capacity
- **Balance risk of creating maladapted populations with the risk of local extinction (extirpation)**




“Essentially, all models are wrong, but some are useful” -- George E.P. Box

Questions?