

# Welcome to the Conservation Lecture Series



<https://www.wildlife.ca.gov/Conservation/Lectures>

Questions? Contact [Margaret.Mantor@wildlife.ca.gov](mailto:Margaret.Mantor@wildlife.ca.gov)

# Predicting current and future distributions of rare plants: *Lessons From the Intersections of Science, Policy, and Management*

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**Patrick McIntyre**

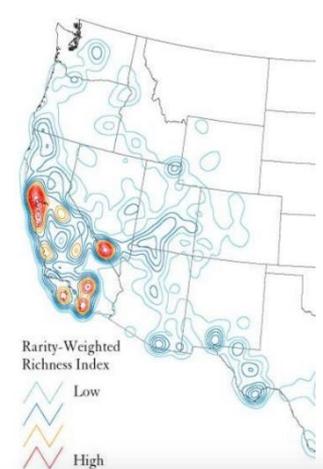
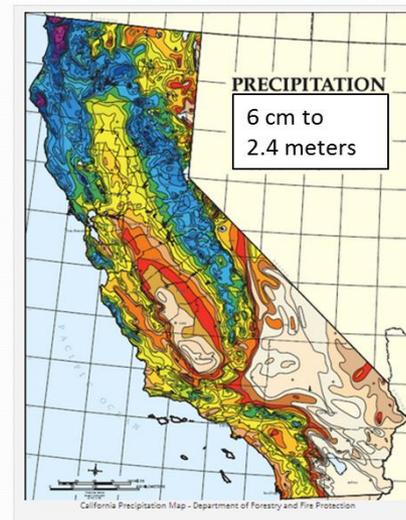
Patrick.McIntyre@Wildlife.CA.Gov



Biogeographic Data Branch

# Rare plants in California

- **Biodiversity hotspot**
- **> 6,500 plants (~30% found only in CA)**
- **>1,600 considered rare (CNPS Inventory)**



## Today: Distribution modeling & rare plants

### I. Present (basic modeling)

Introduction to methods  
Issues to watch for

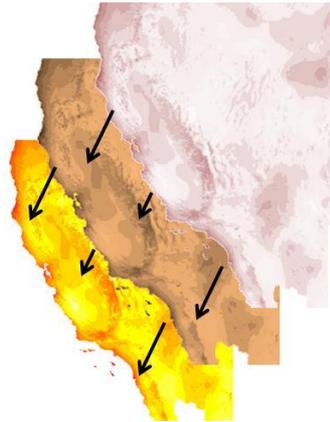
### II. Future (specific examples)

Scenarios of climate change  
Rare plant biology

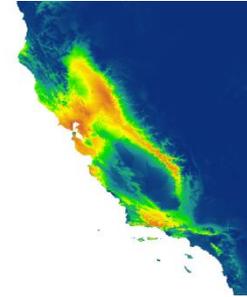
# Species distribution modeling



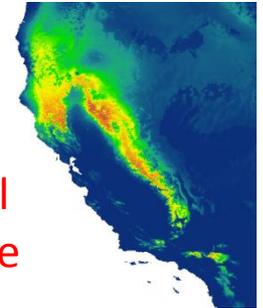
+



→  
statistical  
model



→  
global  
change



## Species locations (and absences)

- Museum specimens
- Focused surveys
- Citizen science

## Predictor variables

- Temperature
- Precipitation
- Elevation

## Estimated distribution

## Future (or past) distribution

# Species distribution modeling

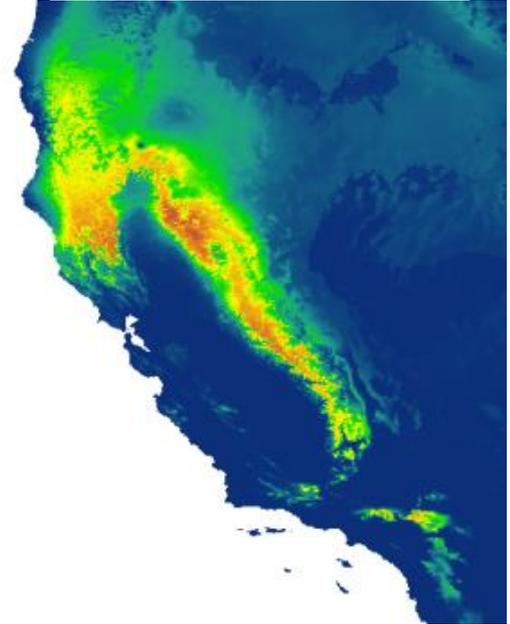
**Complex methods with simple output:**

**Thousands of scientific papers in last 15 years**

## Areas of application

- **Global health**
- **Agriculture**
- **Biological Conservation and Management**
  - Predict current habitat
  - Assess climate change

$$Q(y = 1|z) = \frac{e^H q_z(x(z))}{1 + e^H q_z(x(z))}$$

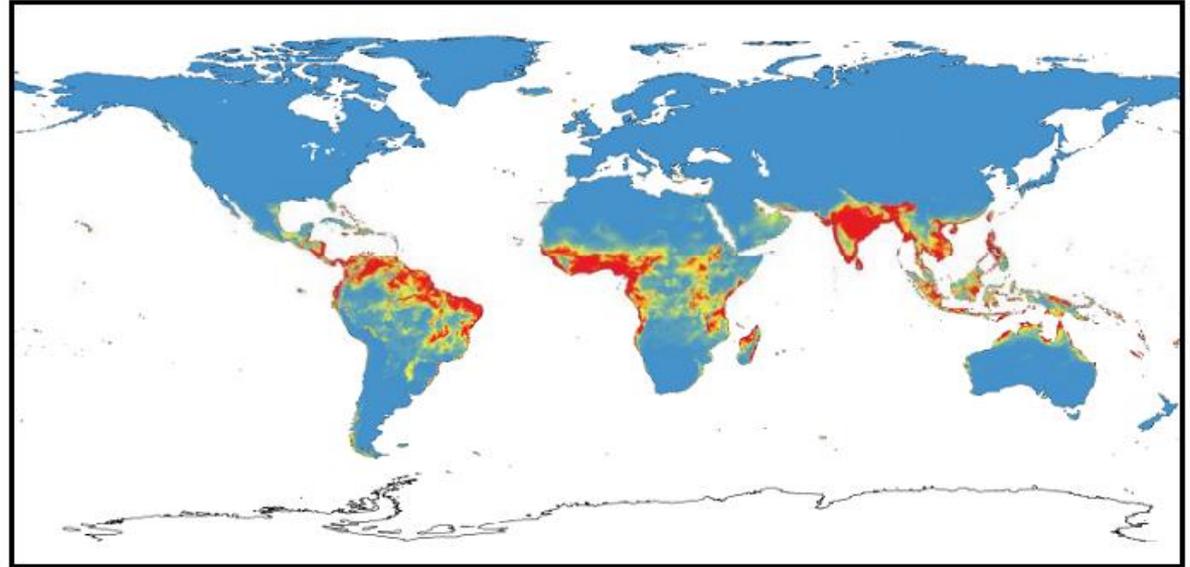


# Vector born diseases

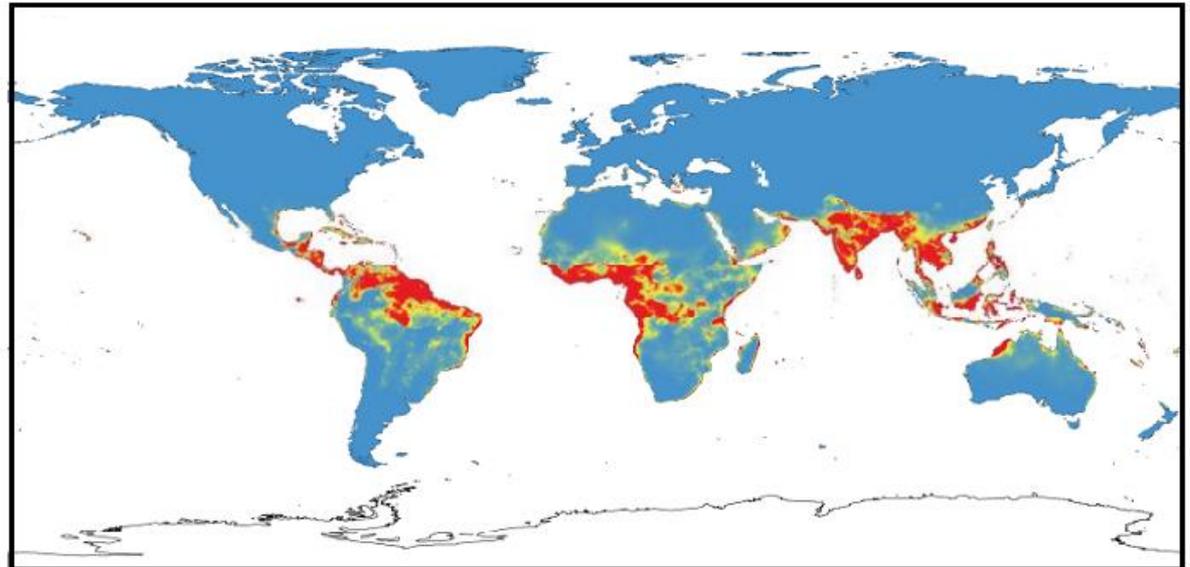
## Zika virus & vector



2016



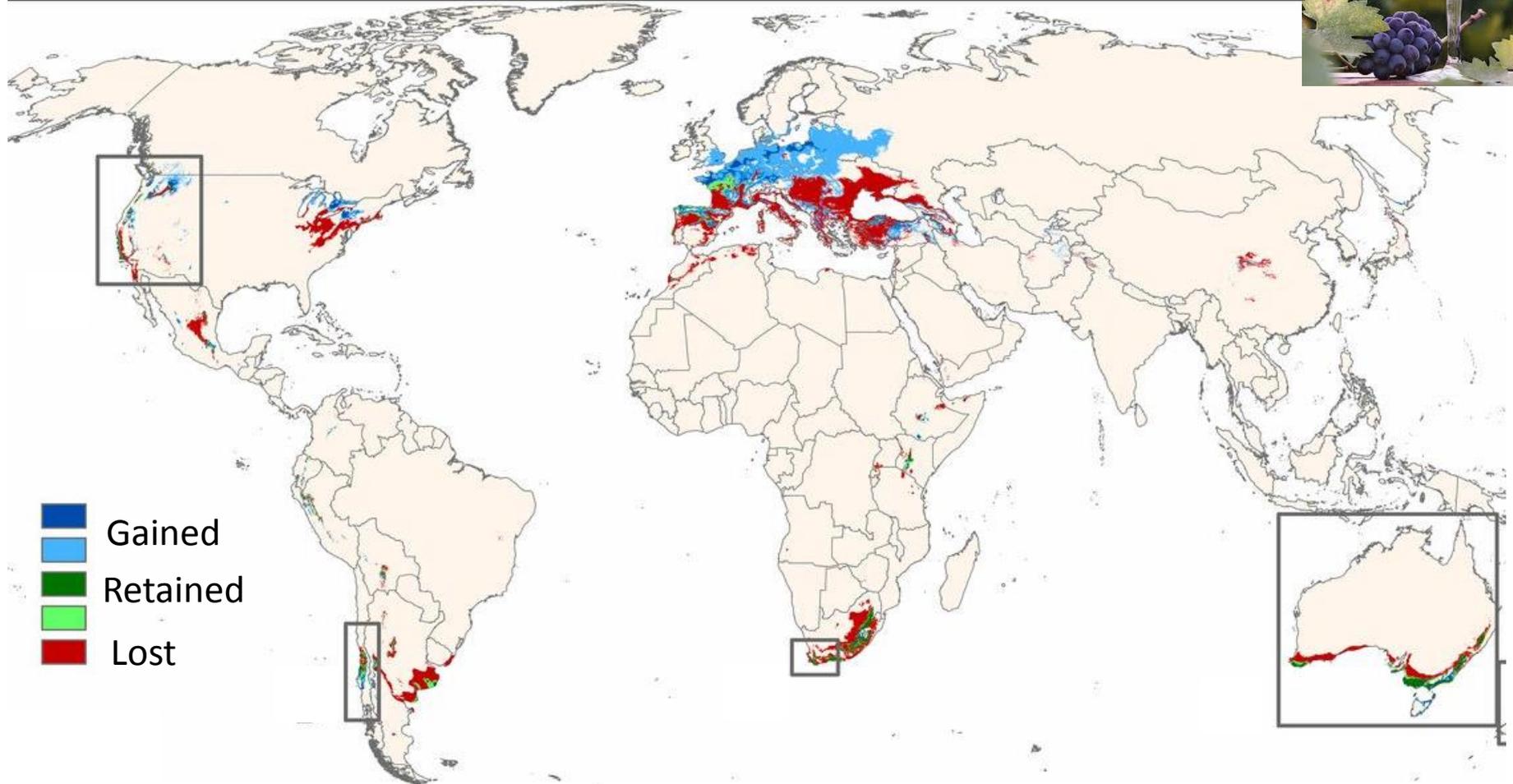
2050



# Climatic suitability for wine production in 2050

Up to 70% losses in key regions

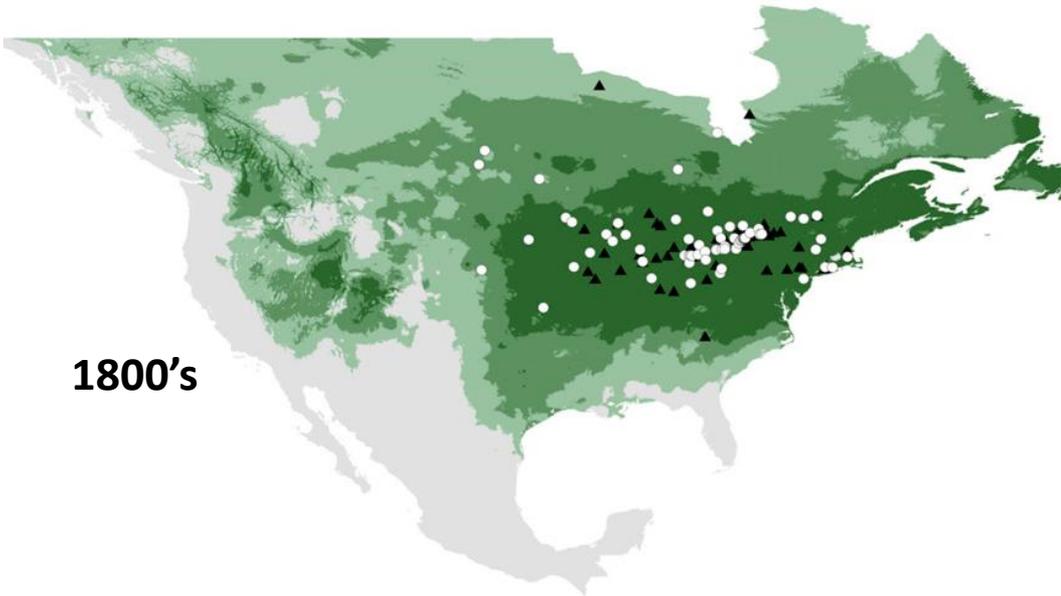
\$300 billion industry



# Projecting into the past to understand extinction



Passenger pigeon



1800's

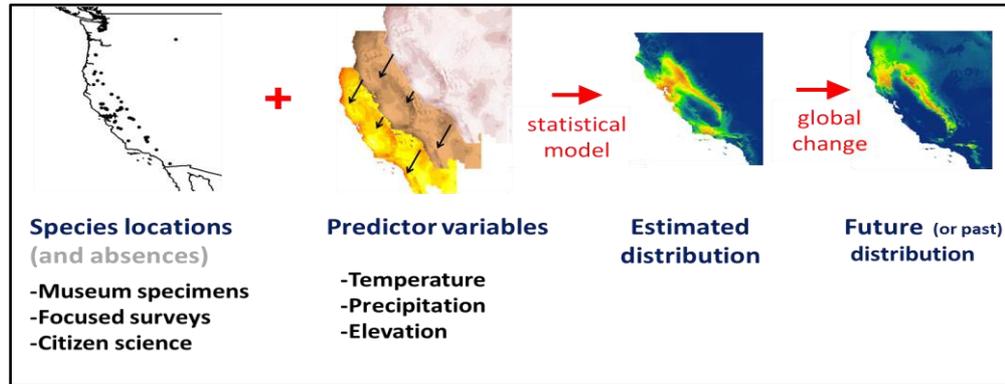


Last glacial maximum

Source: Hung et al. 2014, PNAS

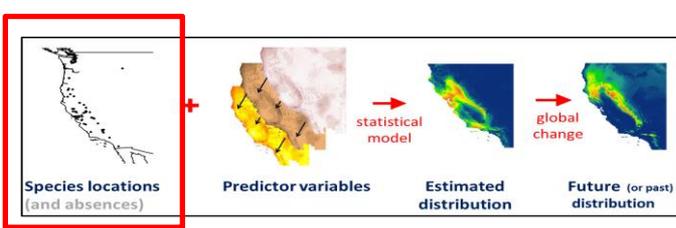


# Species distribution modeling: Rare Plants



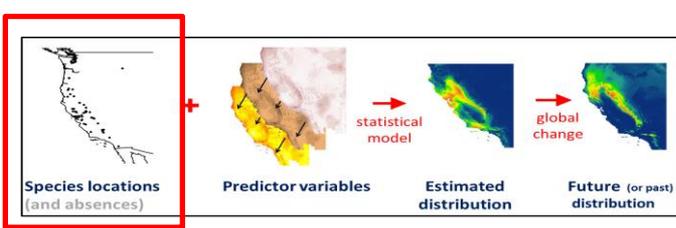
- Find unknown populations
- Understand biology
- Range maps
- Climate change vulnerability
- Regulatory guidance: survey areas
- Hard-line maps: development zones

# What to watch out for?

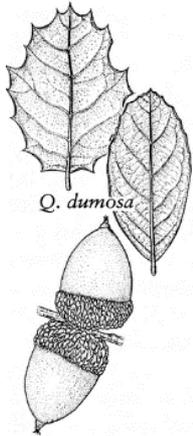


## Example 1: Challenges with biodiversity data

# What to watch out for?



## Example 1: Challenges with biodiversity data

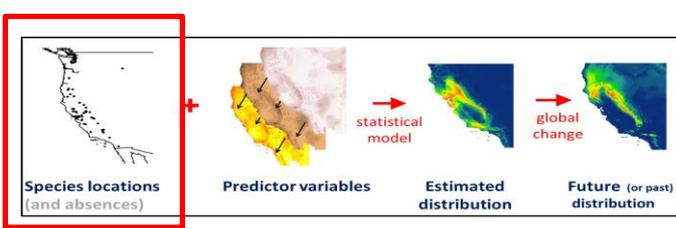


Flora of North America  
Range Map

Nuttall's scrub oak (*Quercus dumosa*)

**California Rare Plant Rank 1B.1**

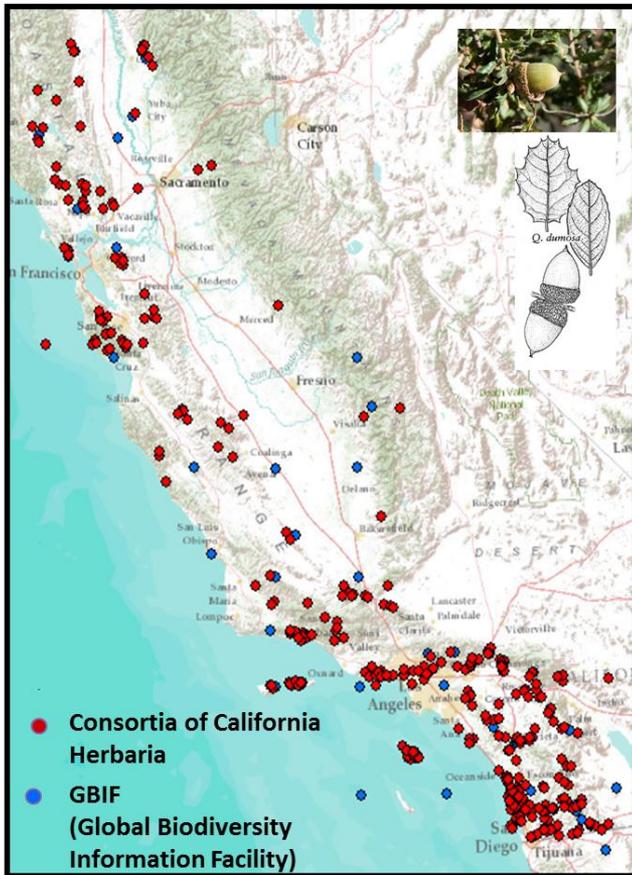
**(Rare or endangered in CA with serious threats)**



# Example 1: Challenges with biodiversity data

Nuttall's scrub oak- *Quercus dumosa*

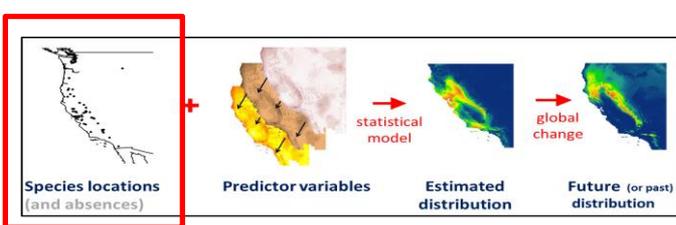
## Basic search results



Flora of North America  
Range Map

### Herbarium records



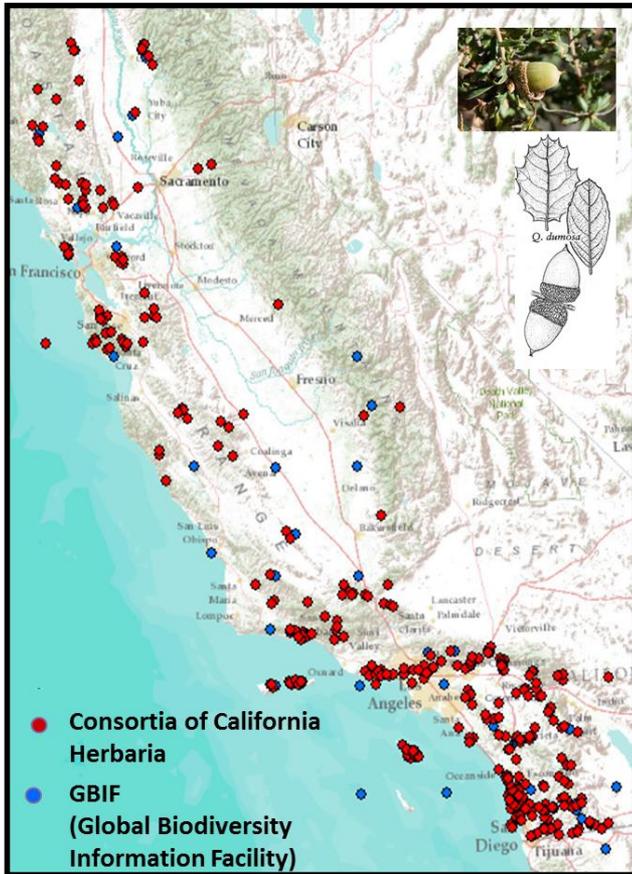


# Example 1: Challenges with biodiversity data

Nuttall's scrub oak - *Quercus dumosa*

## Basic search results

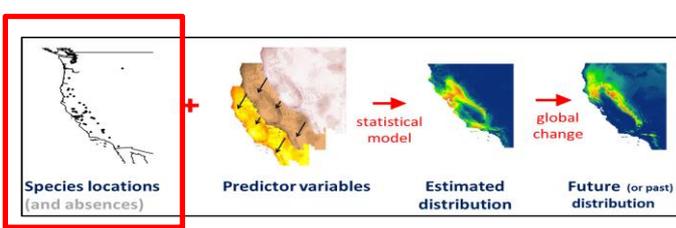
## Quality-checked dataset



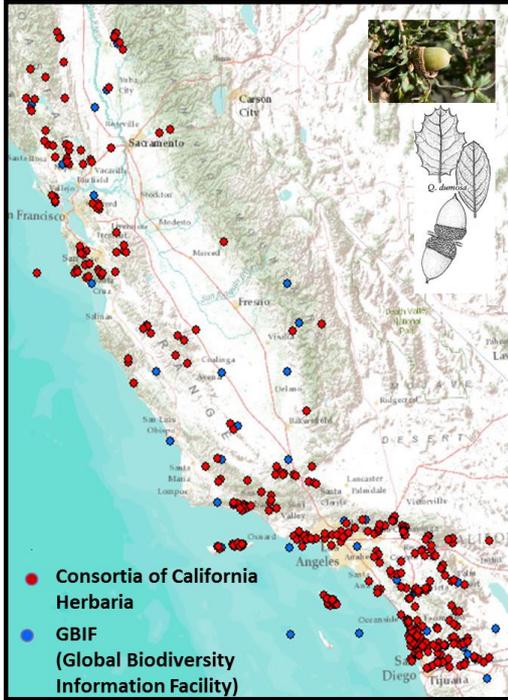
Herbarium records



California Natural Diversity Database



# Example 1: Challenges with biodiversity data



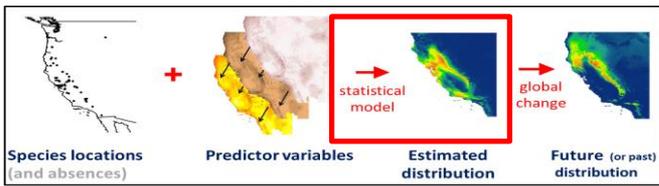
## Taxonomy has changed

**1842:** *Quercus dumosa*  
name for all CA scrub oaks

**Today:** Over 10 different species  
names for scrub oaks

**CNDDDB-** reviewed in 2011

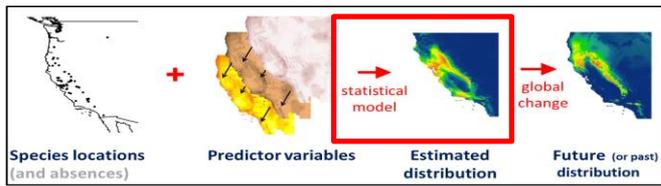
Biodiversity data is widely available but error prone



# What to watch out for?

Example 2: Model accuracy can be misleading

## Example 2: Model accuracy can be misleading



### Mojave monkeyflower (*Mimulus mohavensis*)

- CA Endemic
- Rare Plant Rank 1B.2
- Annual

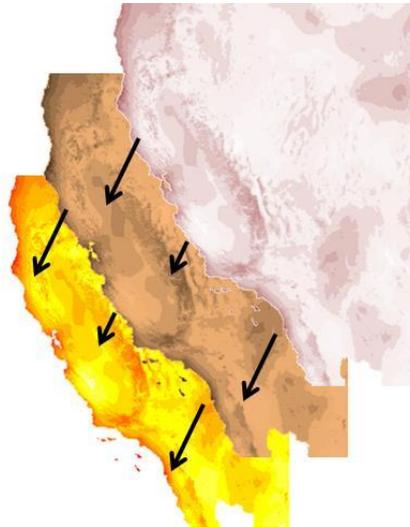


○ Known occurrences



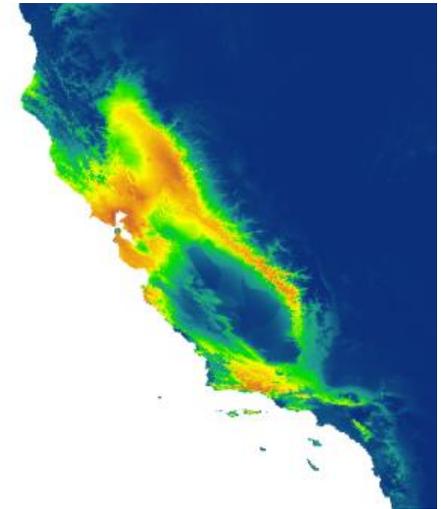
Species locations:

CNDDDB Records



Predictor variables:

Bioclimatic Variables

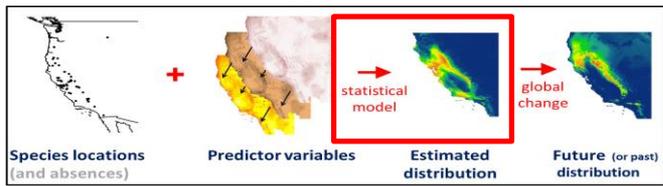


Statistical method:

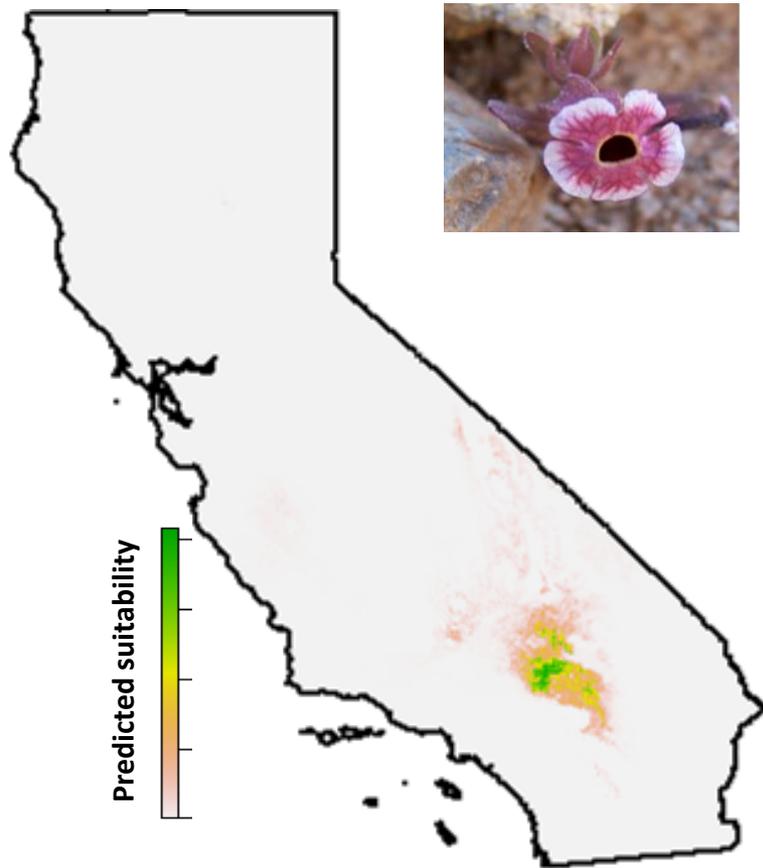
Maxent  
(Presence only)



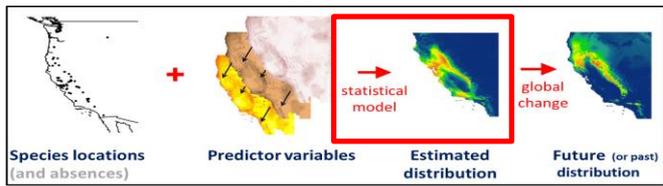
## Example 2: Model accuracy can be misleading



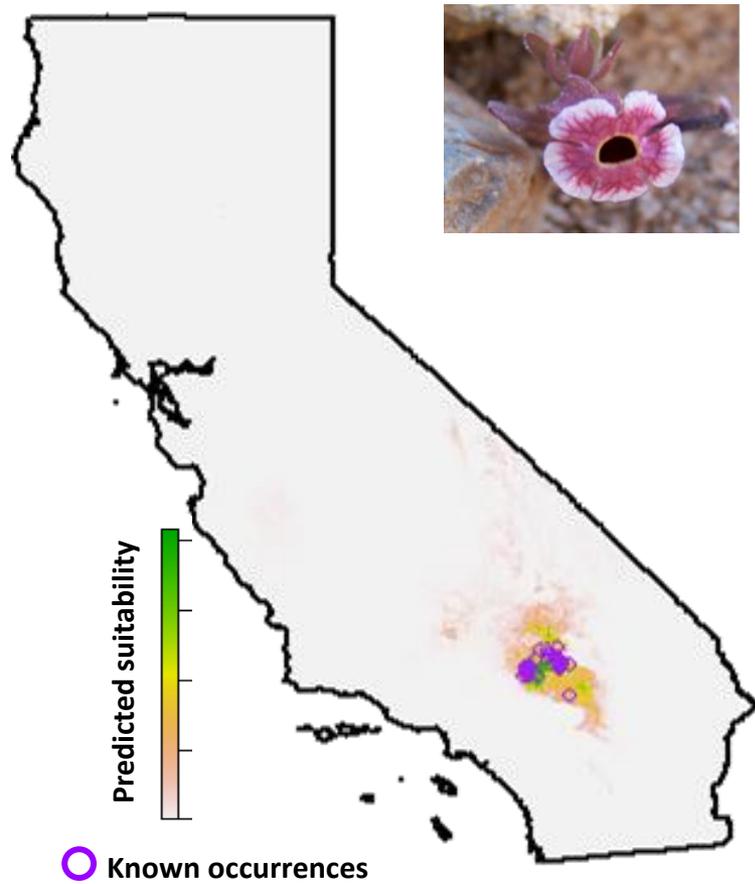
### Predicted model for Mojave monkeyflower:



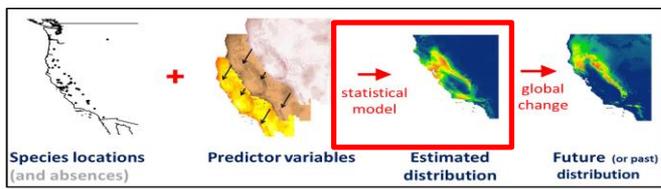
## Example 2: Model accuracy can be misleading



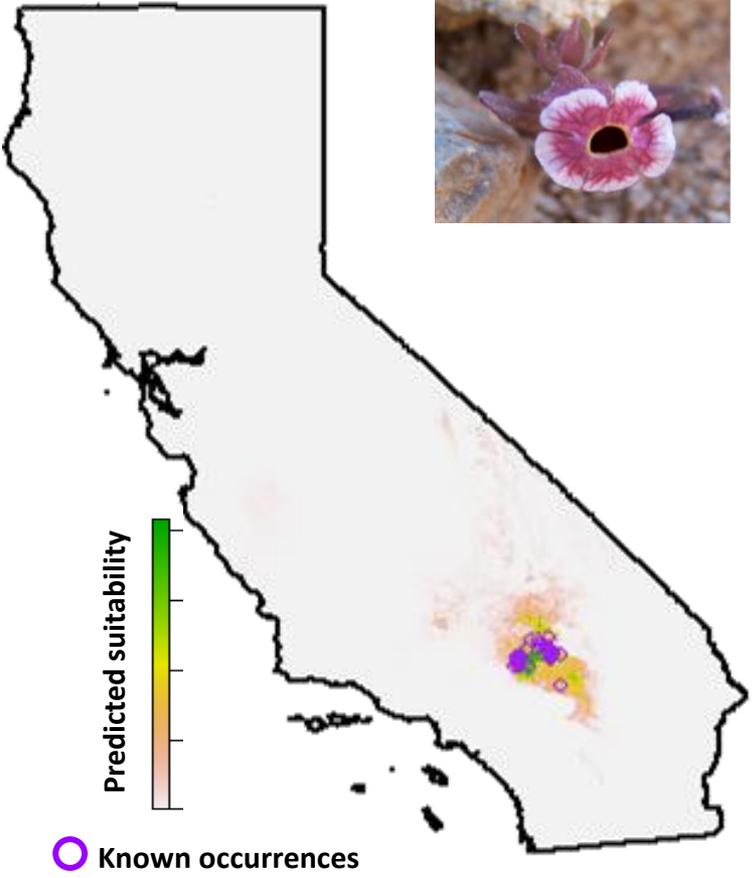
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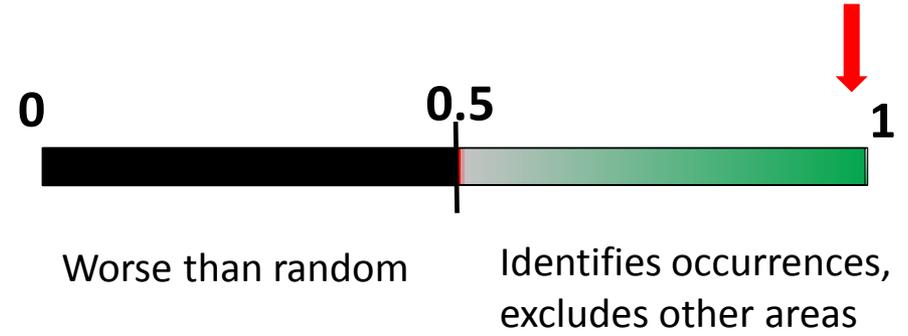
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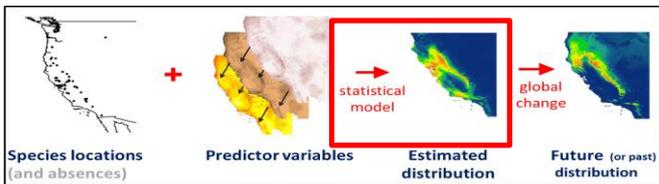


### Predicted model for Mojave monkeyflower:



Model score (AUC): 0.993



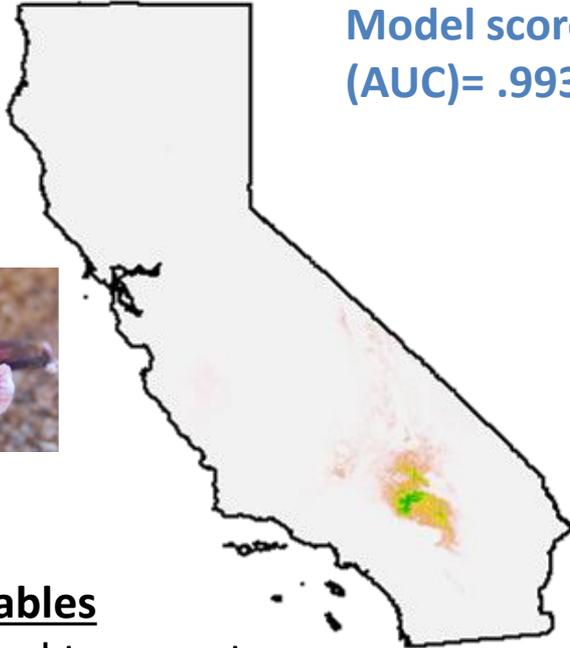


## Example 2: Model accuracy can be misleading

### Comparing models

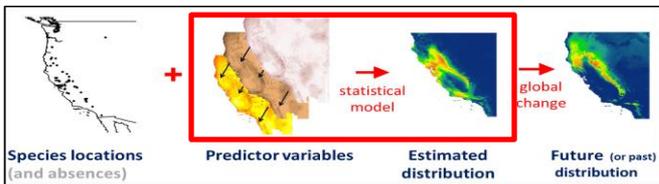
### Climatic model

Model score  
(AUC)= .993



### Variables

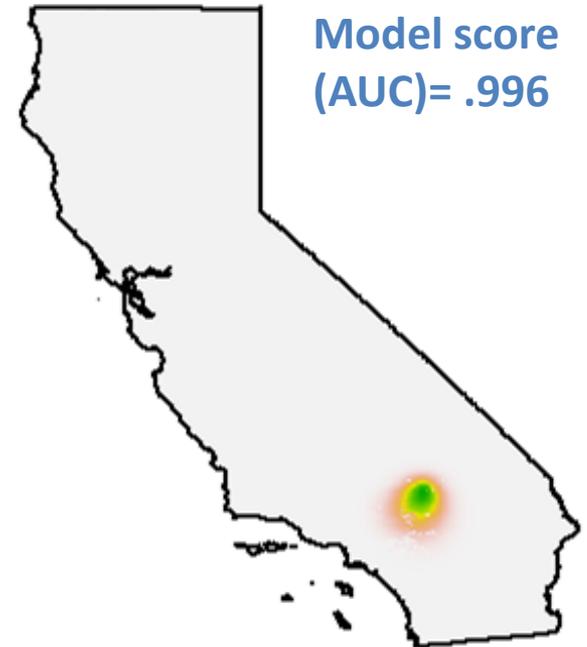
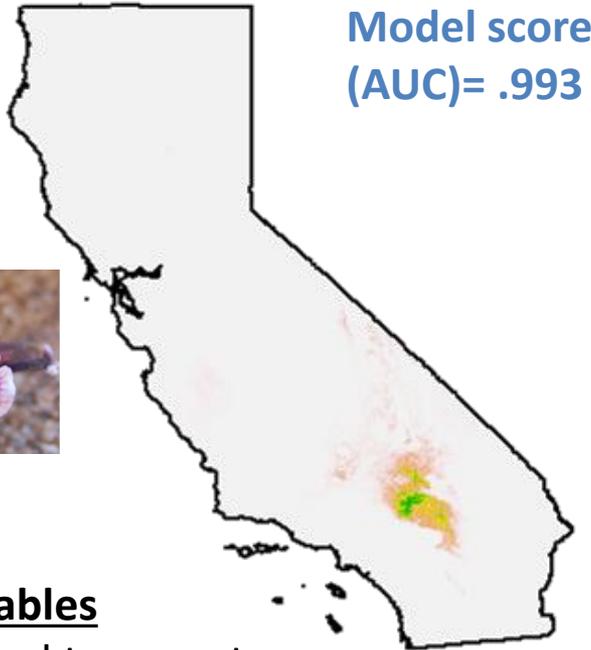
- Annual temperature
- Annual rainfall
- Summer max temp
- Winter min temp
- Seasonality
- + 10 other Bioclimatic variables



## Example 2: Model accuracy can be misleading

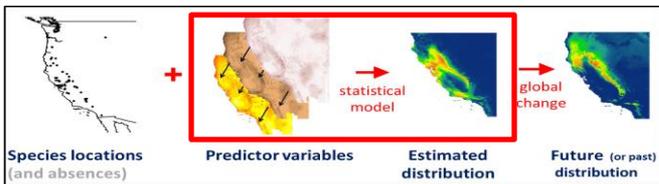
### Comparing models

#### Climatic model



#### Variables

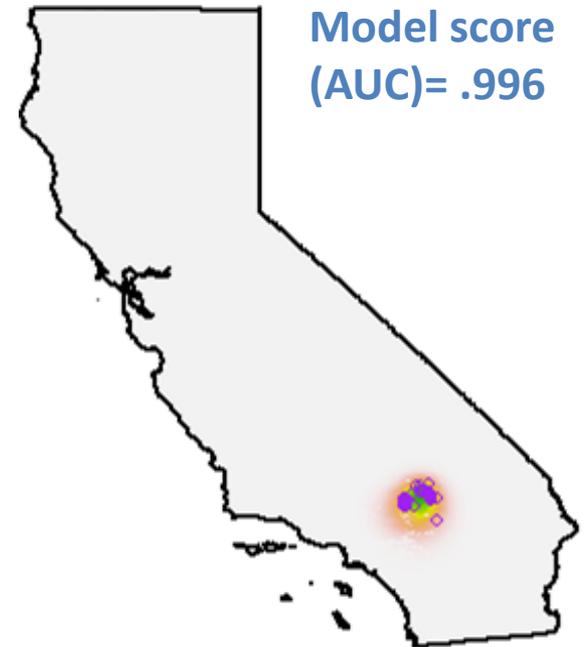
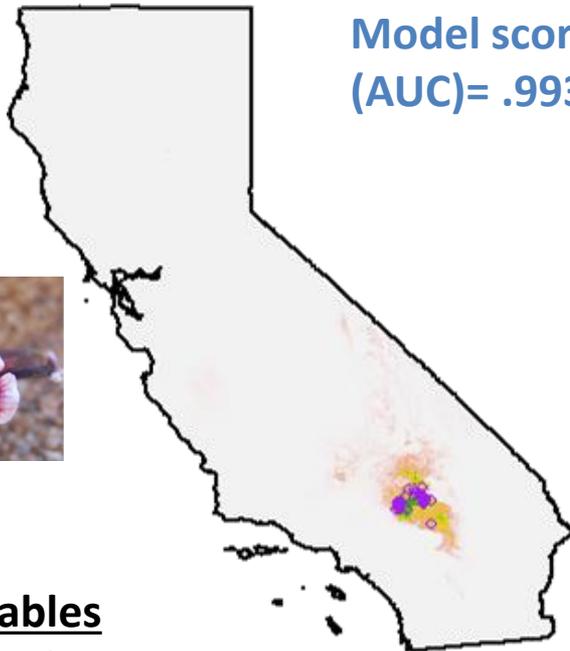
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## Example 2: Model accuracy can be misleading

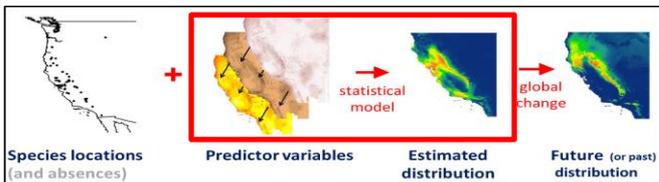
### Comparing models

#### Climatic model



#### Variables

Annual temperature  
 Annual rainfall  
 Summer max temp  
 Winter min temp  
 Seasonality  
 + 10 other Bioclimatic variables

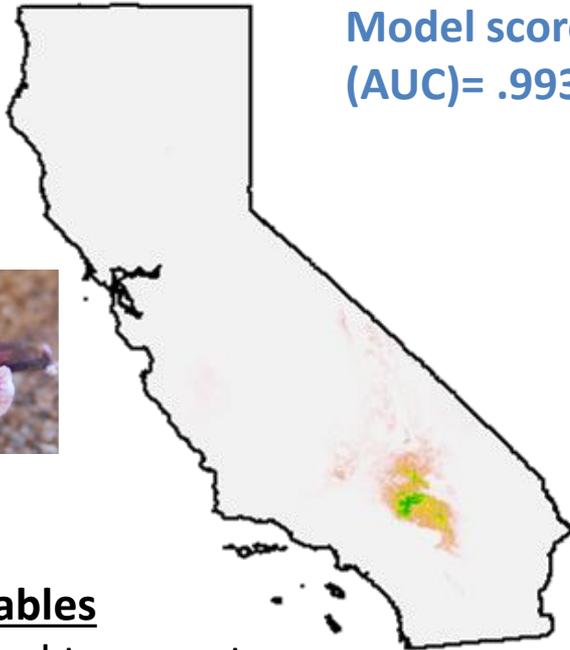


## Example 2: Model accuracy can be misleading

### Comparing models

#### Climatic model

Model score  
(AUC)= .993

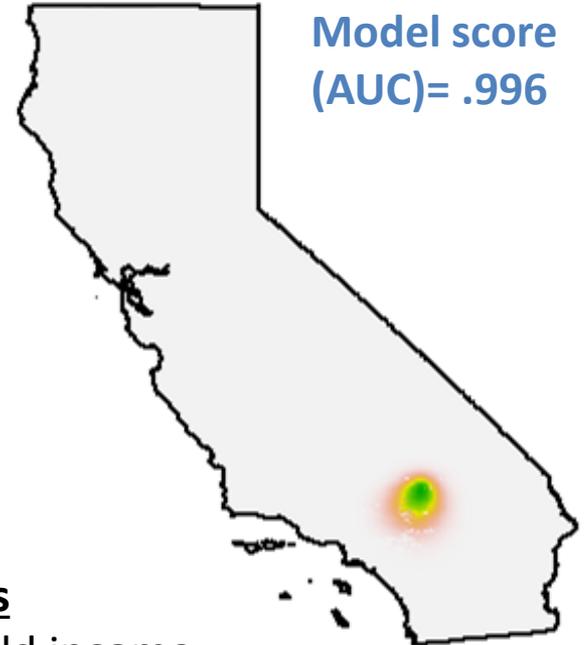


#### Variables

Annual temperature  
Annual rainfall  
Summer max temp  
Winter min temp  
Seasonality  
+ 10 other Bioclimatic variables

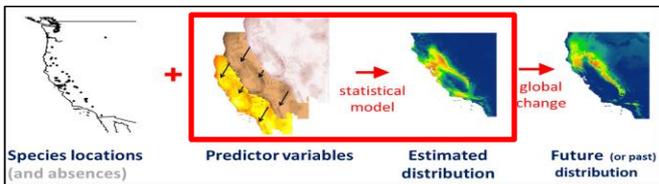
#### “Census and City” Model

Model score  
(AUC)= .996



#### Variables

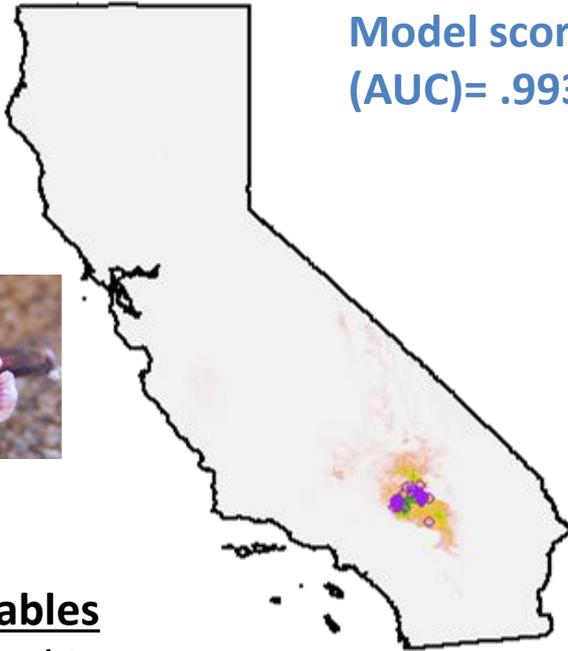
Household income  
Education level  
Property values  
Distance from Los Angeles  
Distance from Barstow  
Distance from Sacramento



## Example 2: Model accuracy can be misleading

### Climatic model

Model score  
(AUC)= .993

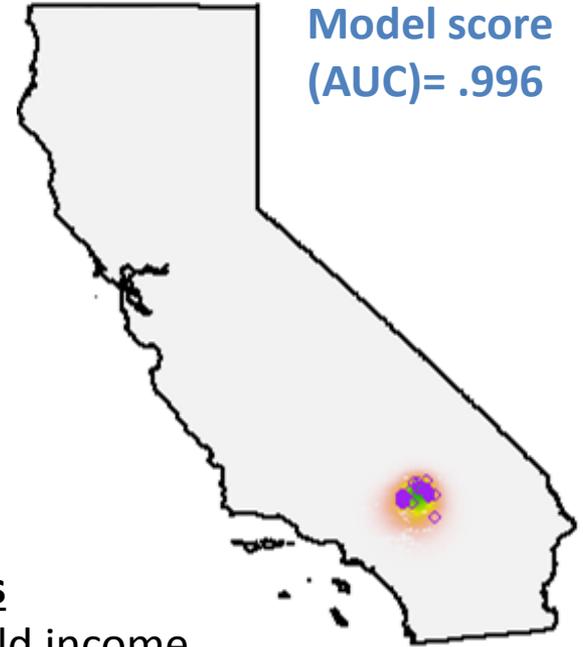


#### Variables

Annual temperature  
Annual rainfall  
Summer max temp  
Winter min temp  
Seasonality  
+ 10 other Bioclimatic variables

### “Census and City” Model

Model score  
(AUC)= .996

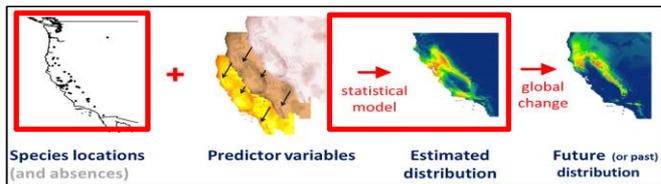


#### Variables

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Education level  
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Distance from Barstow  
Distance from Sacramento



## Example 2: Model accuracy can be misleading



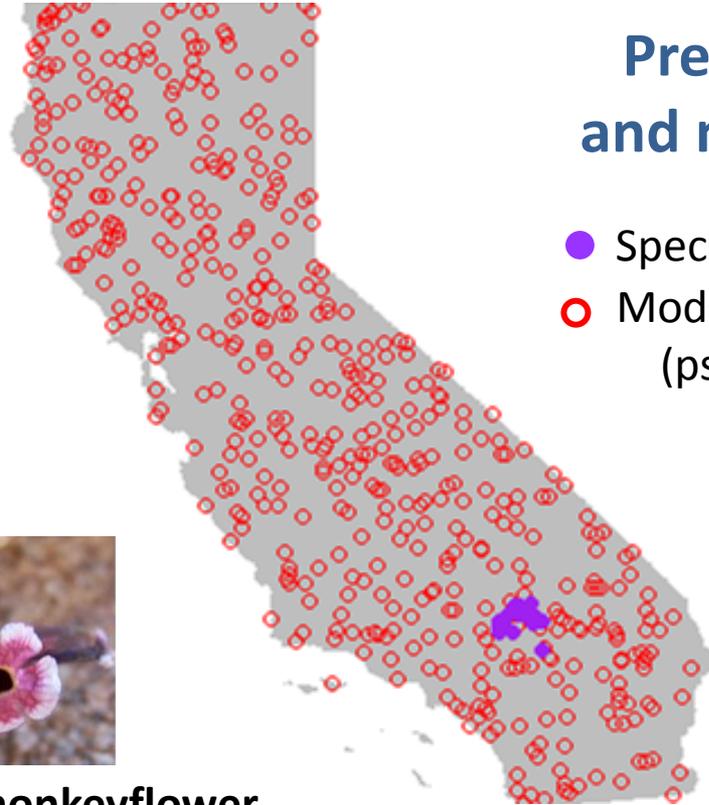
## What the is the modeling asking?

**Predict purple  
and minimize red**

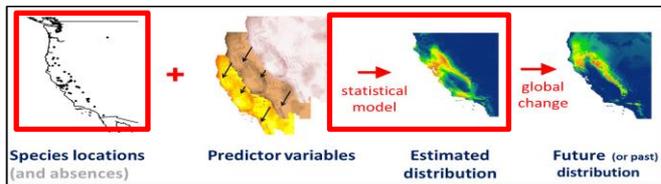
- Species presence points
- Model background points (pseudoabsences)



**Mojave monkeyflower**

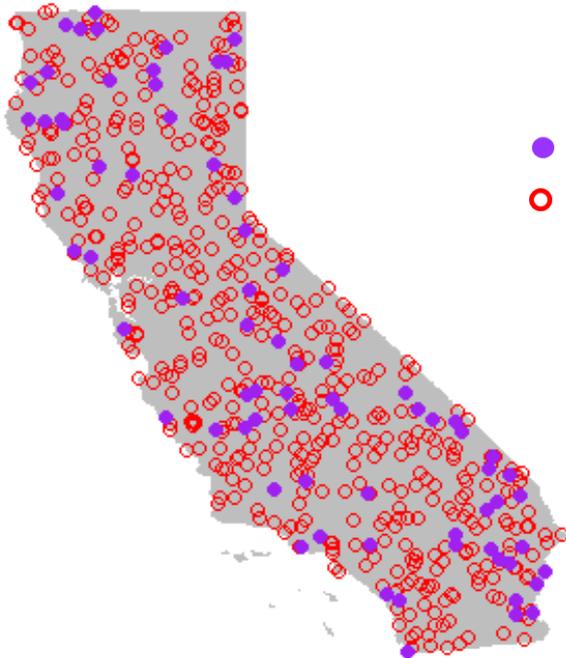


## Example 2: Model accuracy can be misleading



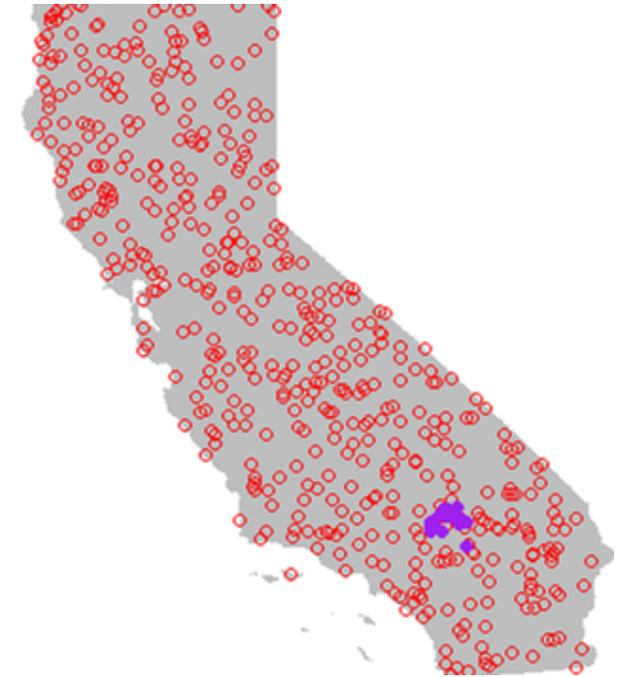
## Narrow distributions can lead to false confidence

### Evenly dispersed



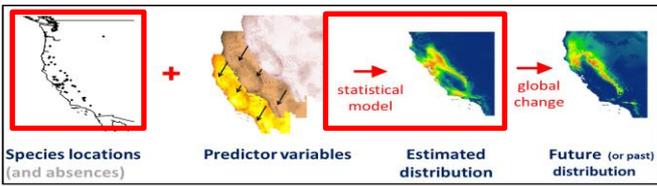
Common & widespread plants

### Clustered



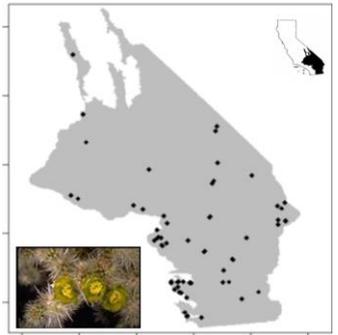
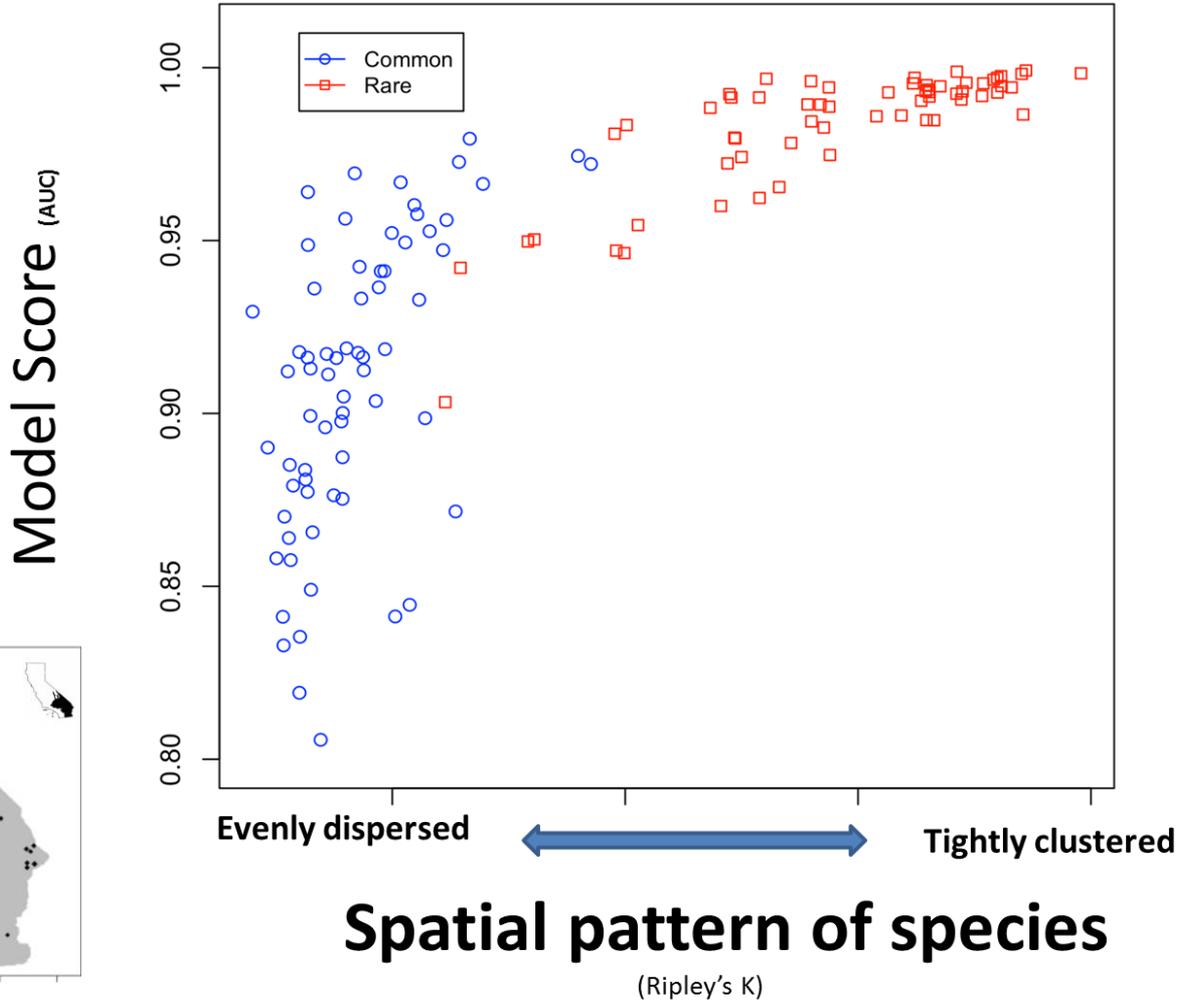
Rare and restricted plants

- Species presence points
- Model background points (pseudoabsences)

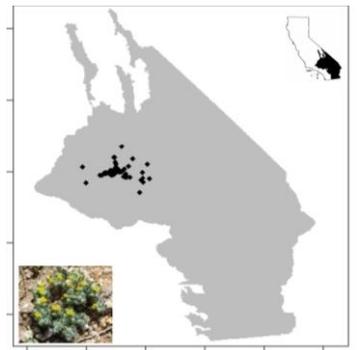


# Example 2: Model accuracy can be misleading

## Common vs. rare desert plants

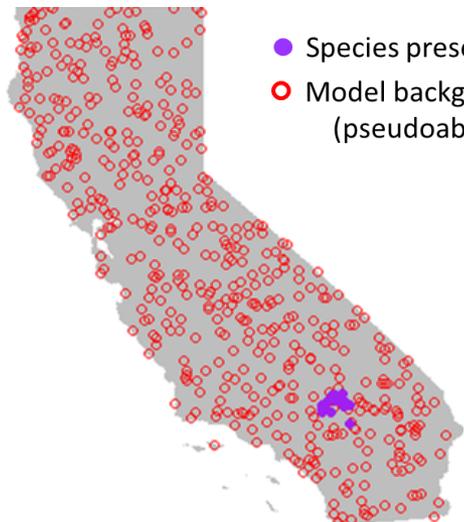
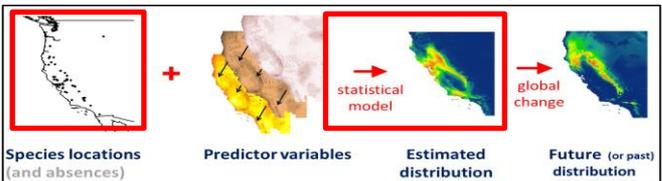


Silver cholla  
(*Cylindropuntia echinocarpa*)



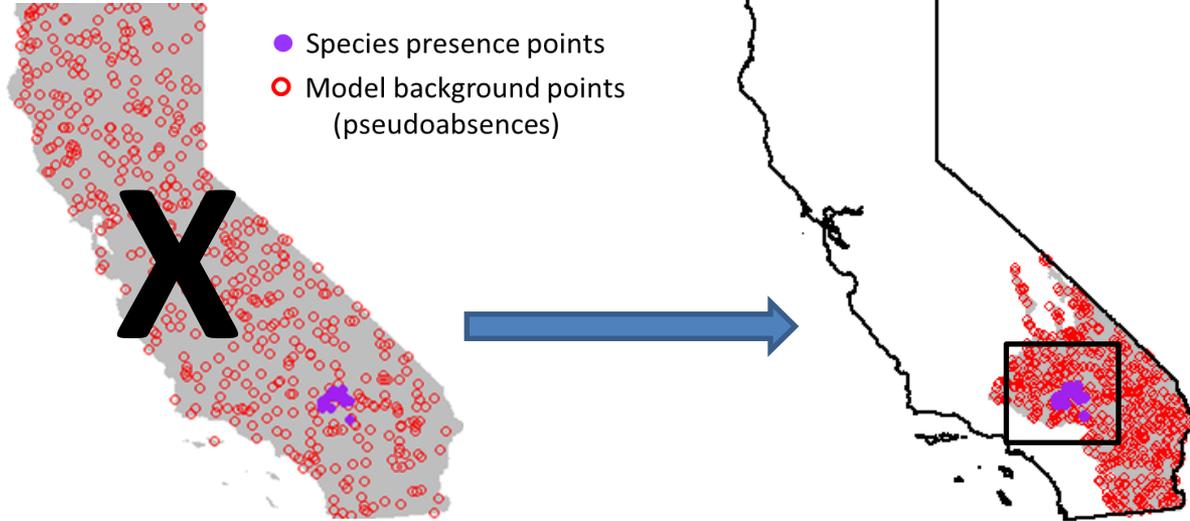
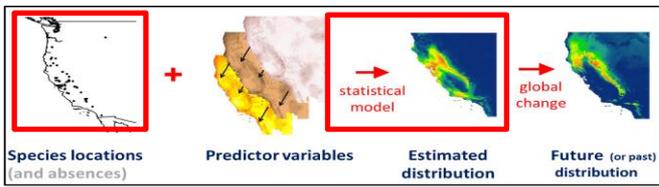
Barstow woolly sunflower  
(*Eriophyllum mohavense*)

## Example 3: Solutions can generate new issues

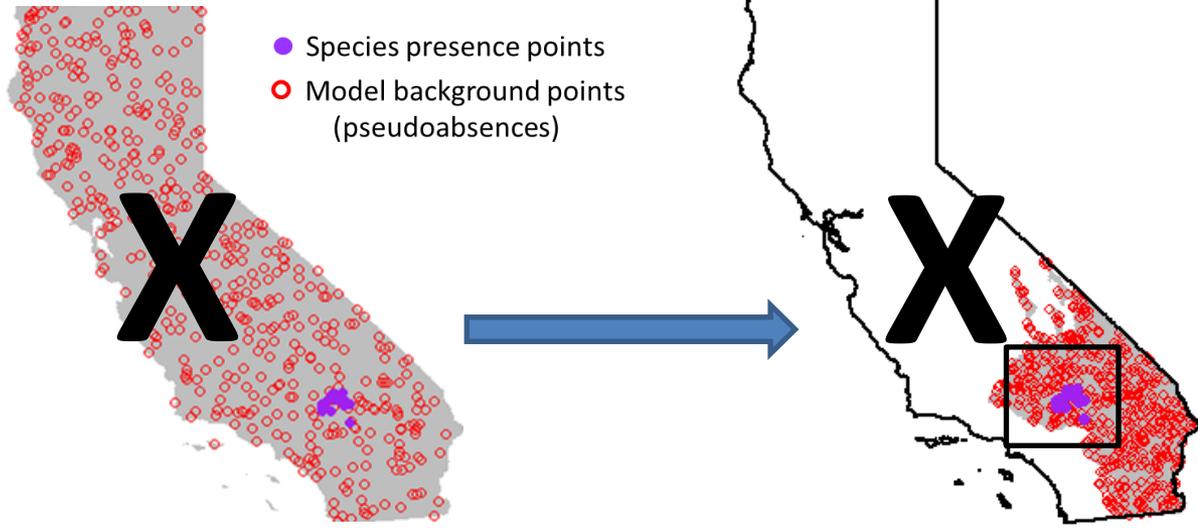
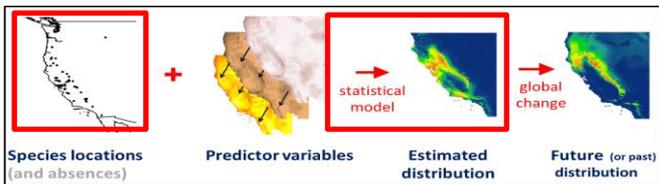


- Species presence points
- Model background points (pseudoabsences)

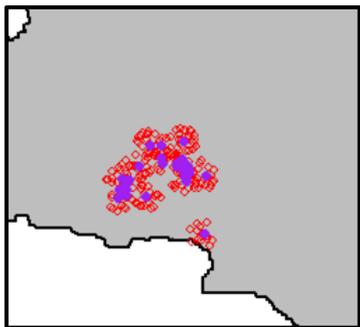
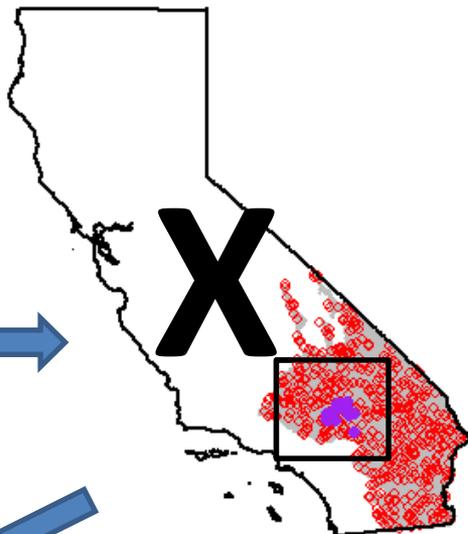
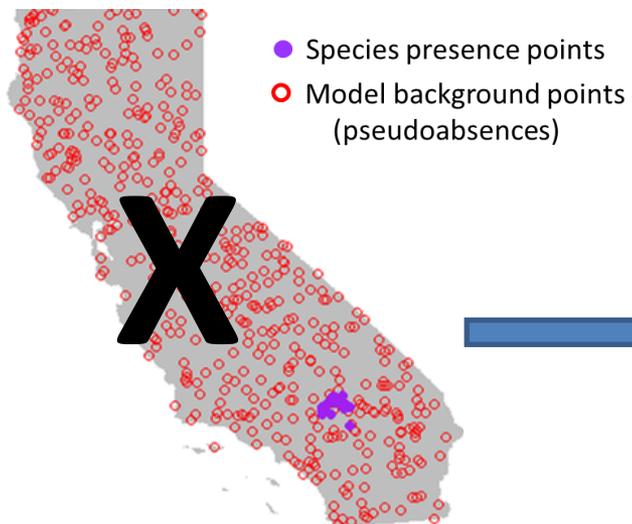
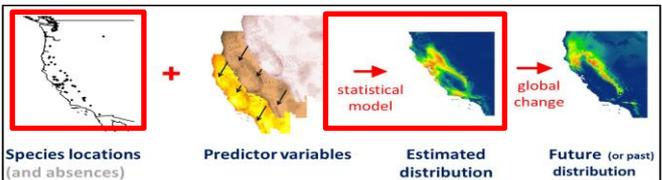
### Example 3: Solutions can generate new issues



### Example 3: Solutions can generate new issues

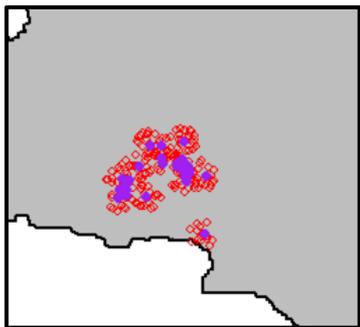
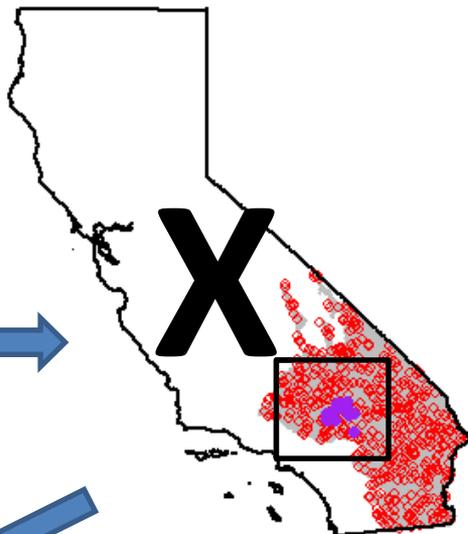
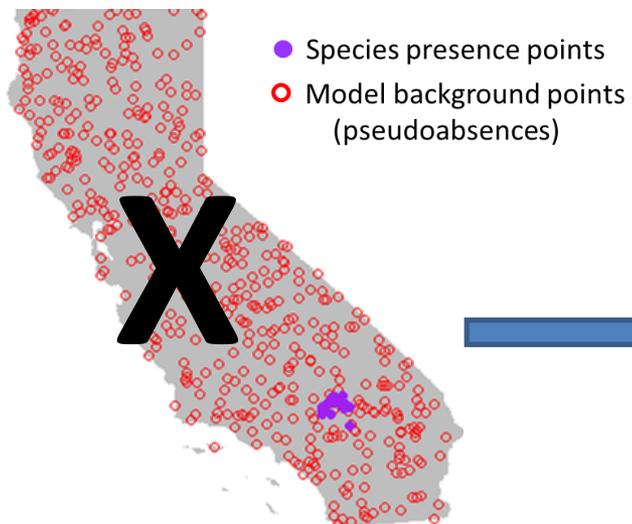
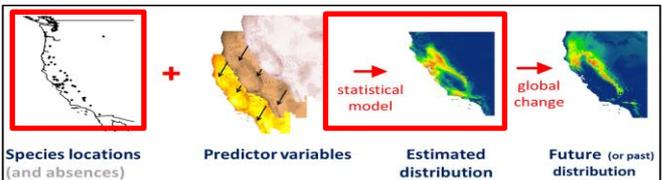


### Example 3: Solutions can generate new issues

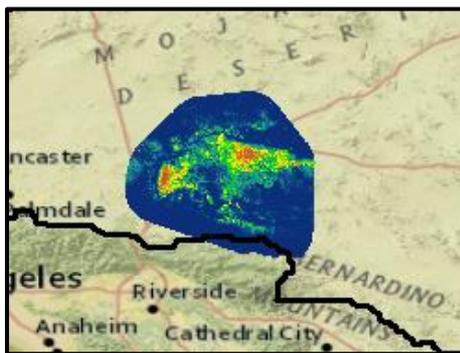


Model within 'dispersal distance'

### Example 3: Solutions can generate new issues



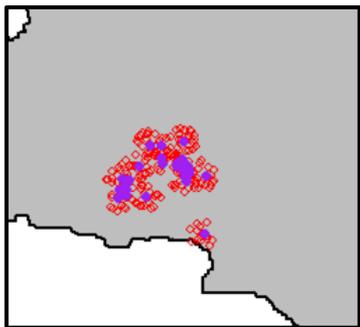
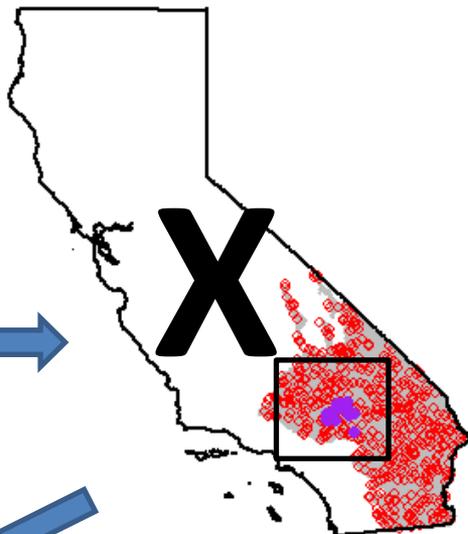
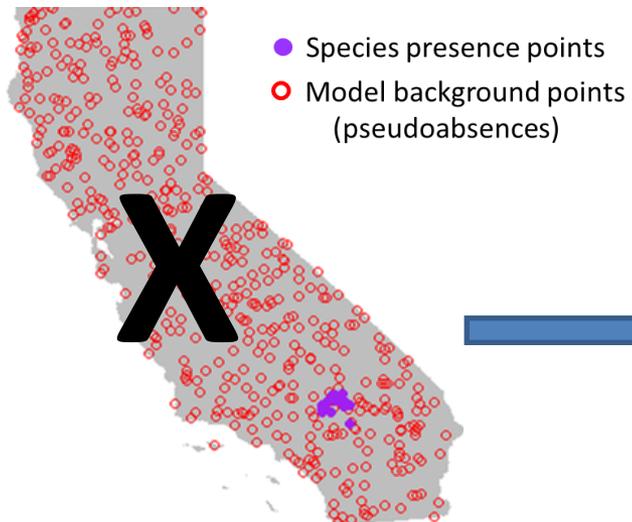
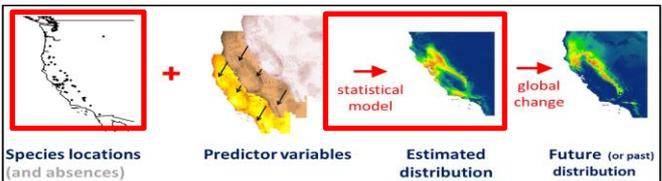
Model within 'dispersal distance'



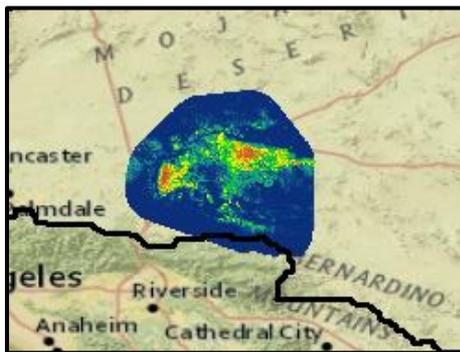
Model applies to small area



### Example 3: Solutions can generate new issues



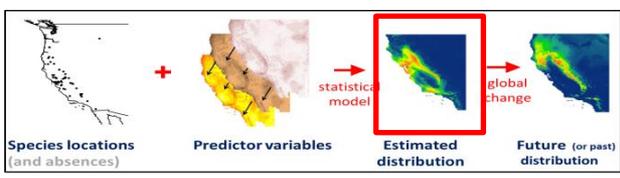
Model within 'dispersal distance'



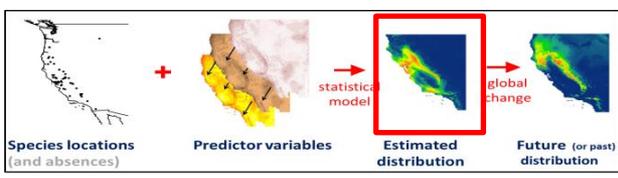
Model applies to small area



Predict beyond the model conditions

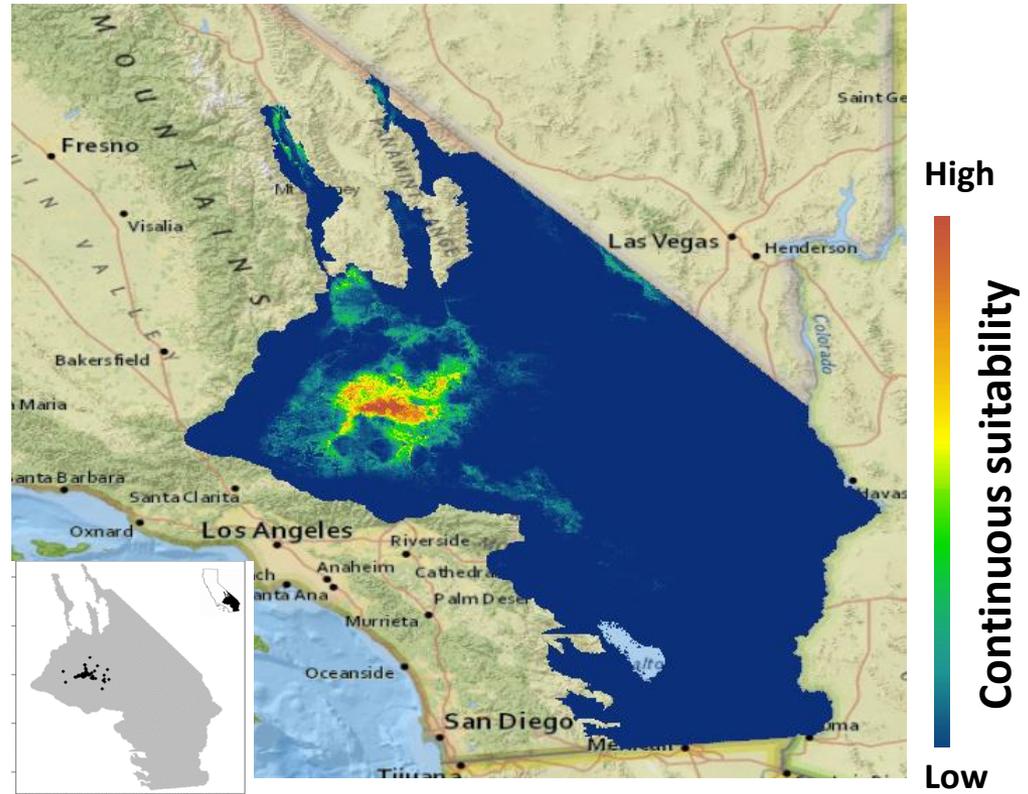


## Example 4: One model, multiple predictions

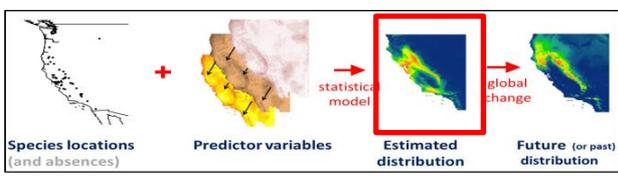


# Example 4: One model, multiple predictions

**Barstow woolly sunflower**  
*(Eriophyllum mohavense)*  
 CNPS 1B



**Regulatory need:**  
 predicted habitat- yes or no?

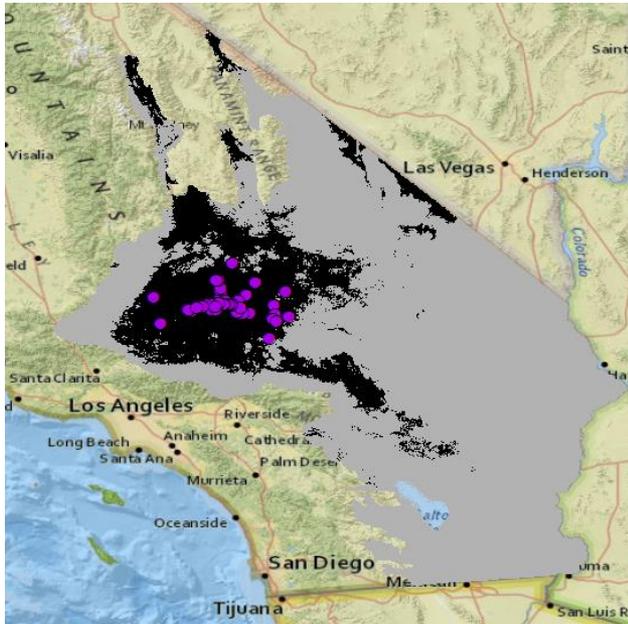


# Example 4: One model, multiple predictions

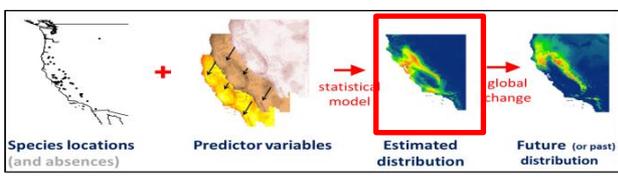


**Threshold 1:**

**Capture all known occurrences**



**15,000 Km<sup>2</sup> predicted habitat**

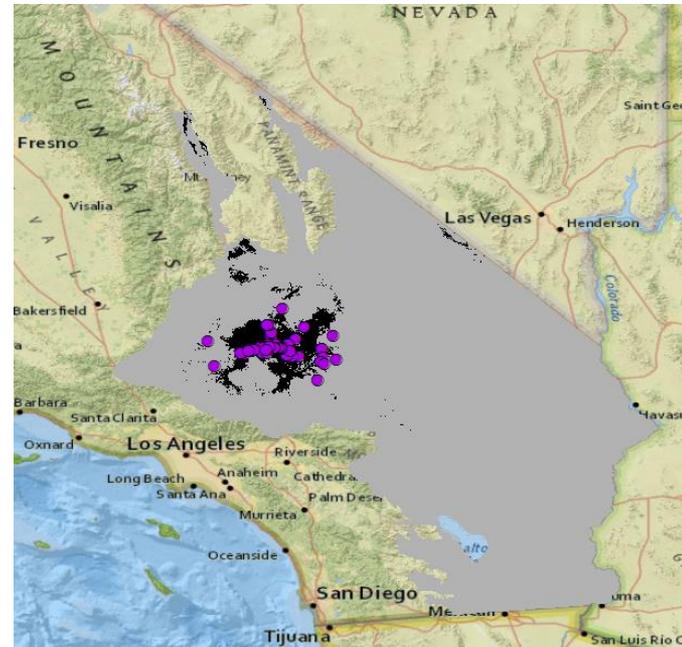
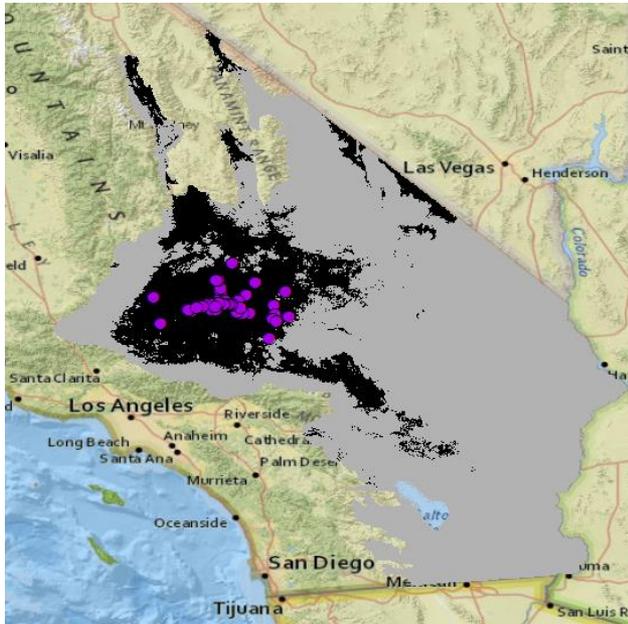


# Example 4: One model, multiple predictions



**Threshold 1:**  
Capture all known occurrences

**Threshold 2:**  
Balance identifying occurrences & excluding background

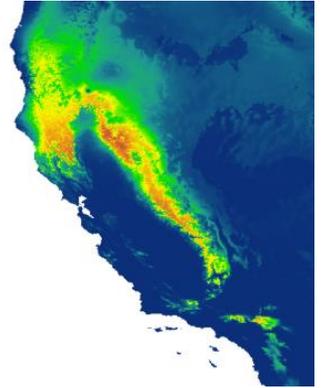


15,000 Km<sup>2</sup> predicted habitat

3,100 Km<sup>2</sup> predicted habitat  
Excludes 15/62 (24%) of occurrences

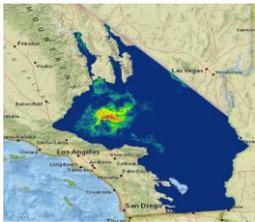
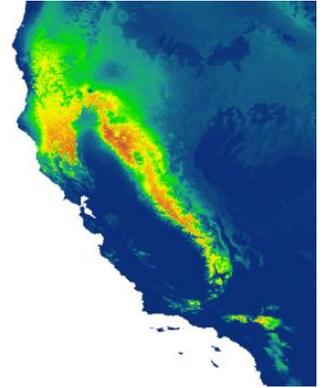
# Assessing distribution models in conservation & management

- Quality occurrence data?
- Spatial distribution addressed?
- Meaningful variables?
- Uncertainty acknowledged?
- How important are the specific predictions?



# Assessing distribution models in conservation & management

- Quality occurrence data?
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Find unknown populations



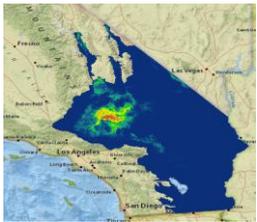
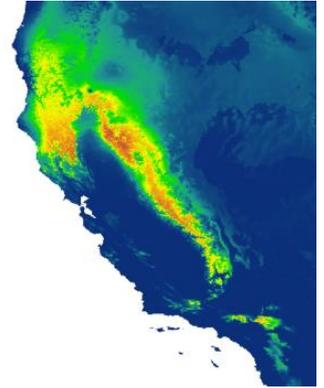
Hard line regulatory maps



Level of scrutiny

# Assessing distribution models in conservation & management

- Quality occurrence data?
- Spatial distribution addressed?
- Meaningful variables?
- Uncertainty acknowledged?
- How important are the specific predictions?



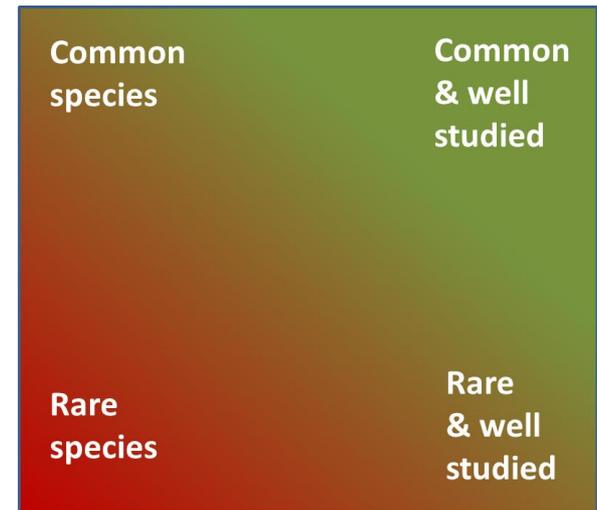
Find unknown populations



Hard line regulatory maps

Level of scrutiny

# of independent occurrences



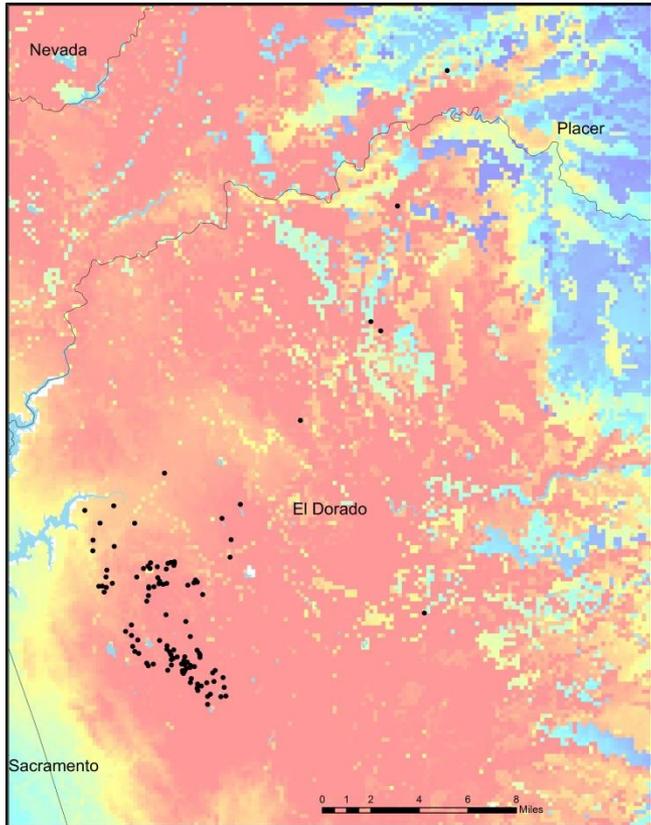
Knowledge of biology of species



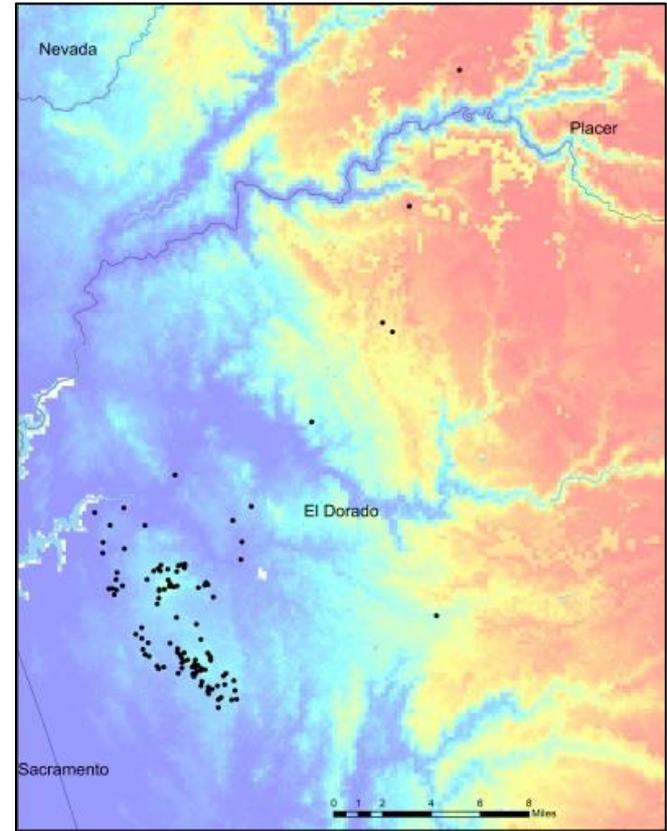
# Part 2: Future distributions

# Climate Envelope Models

**2010**

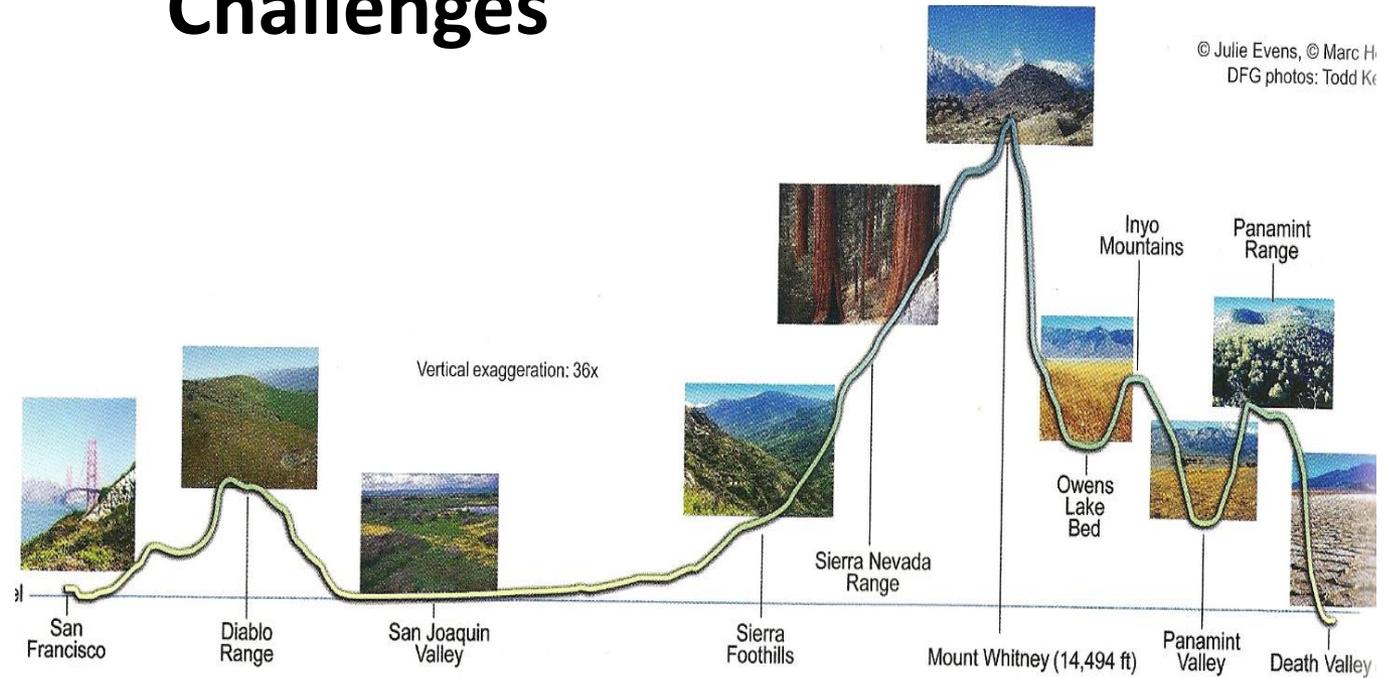


**2100**



- 1. Assess range of variables (max temp, precip, etc.) where species currently occurs**
- 2. Assess where this same range of variables will occur in the future**

# Challenges



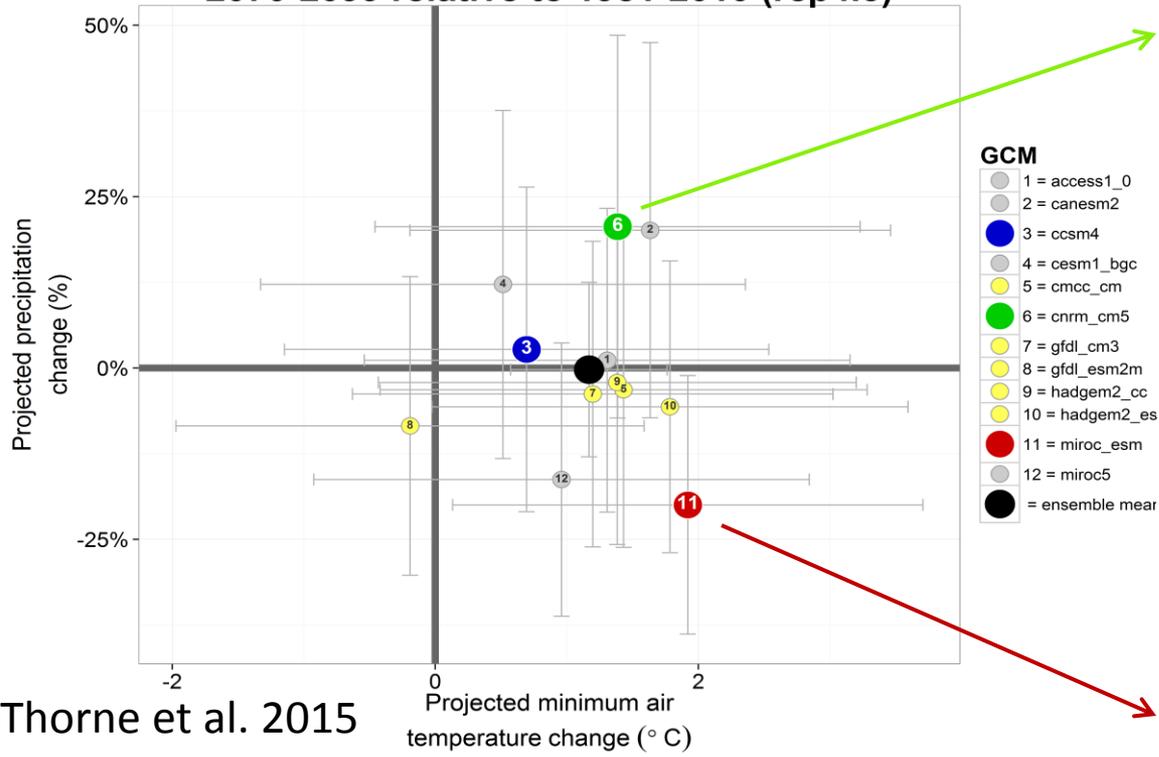
- Complex landscape
- Uncertainty



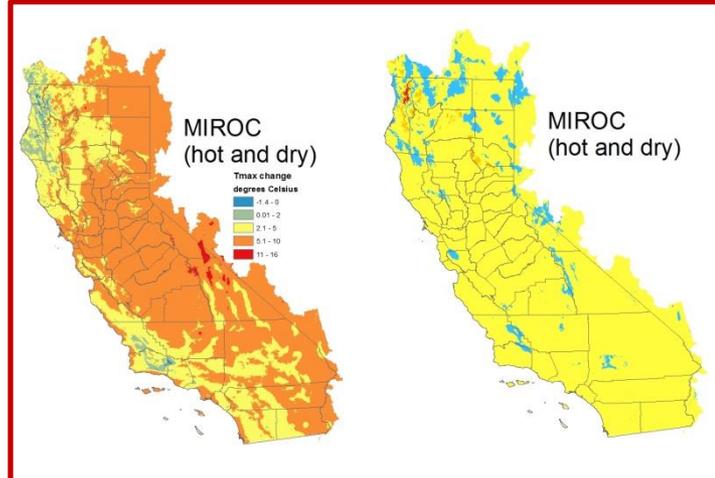
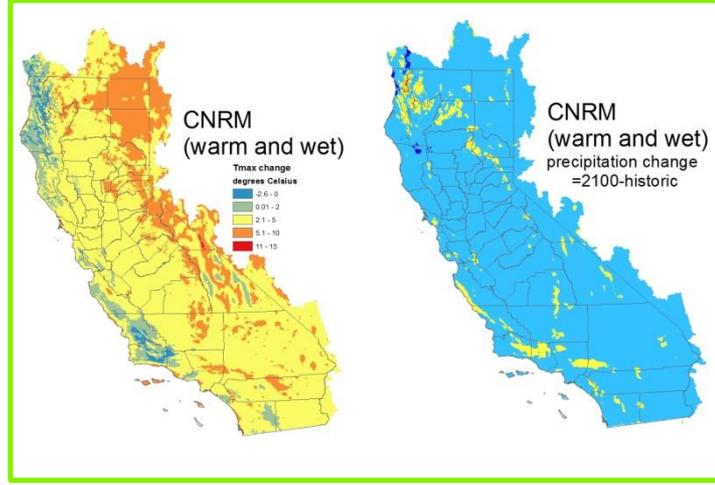
"It is far better to foresee even without certainty than not to foresee at all."  
 --Henri Poincare

# Uncertainty

**Climate Change Projections for California 2070-2099 relative to 1981-2010 (rcp4.5)**



Thorne et al. 2015



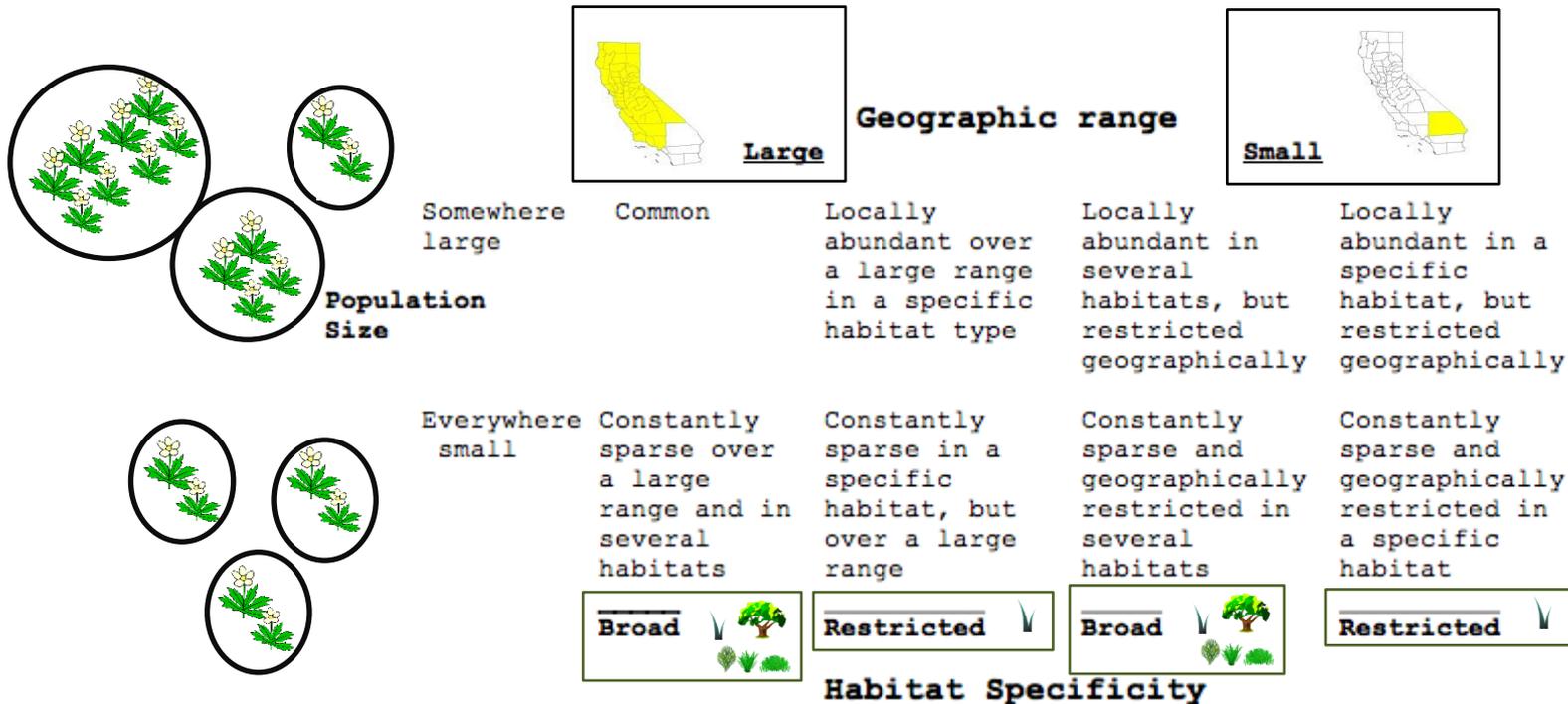
# Climate Vulnerability Assessment for CA Rare Plants

Brian Anacker, Melanie Gogol-Prokurat, Krystal Leidholm, Steve Schoenig



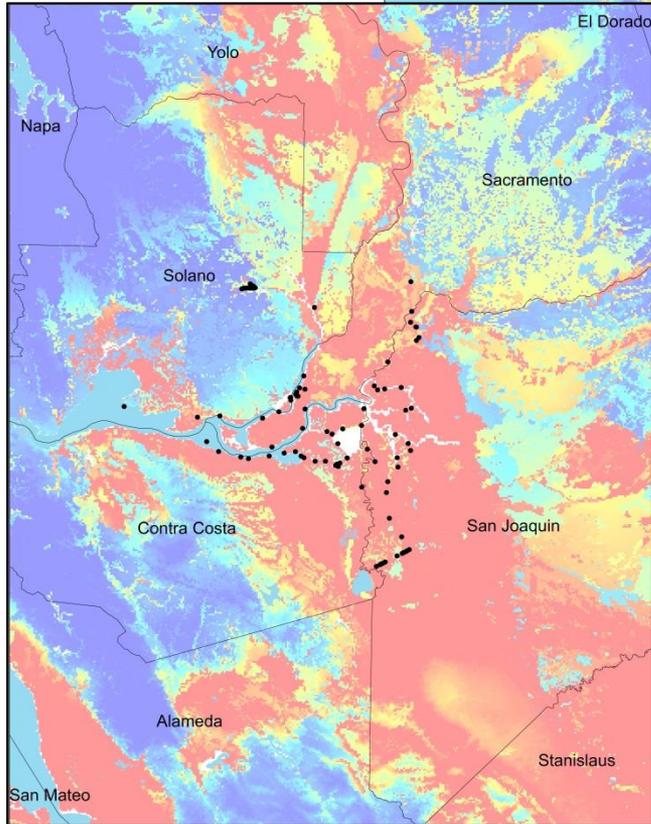
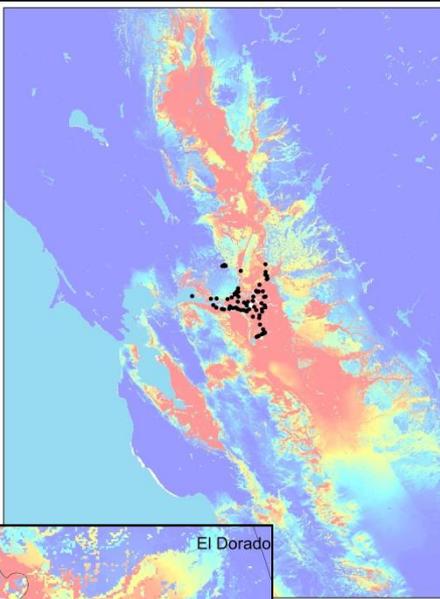
Algodones Dunes Sunflower  
(*Helianthus niveus* ssp. *tephrodes*)

“The patina of monolithic rarity may have hindered our understanding of an exceedingly heterogeneous assemblage of organisms.” –*Rabinowitz 1981*

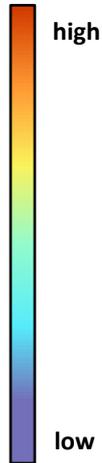


## 7 Forms of rarity

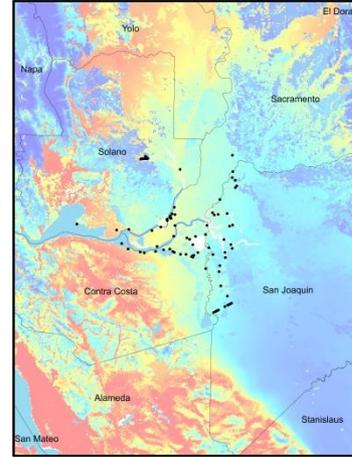
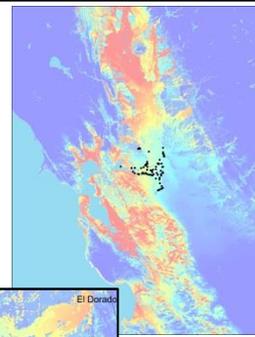
*Limosella australis*  
Delta mudwort



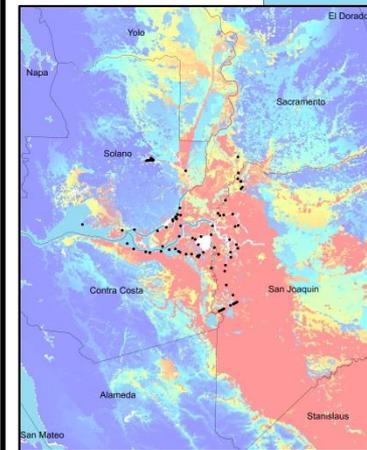
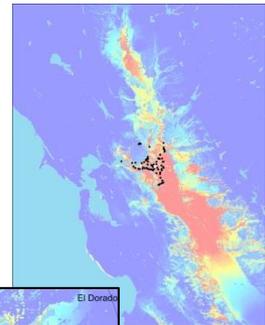
Habitat suitability



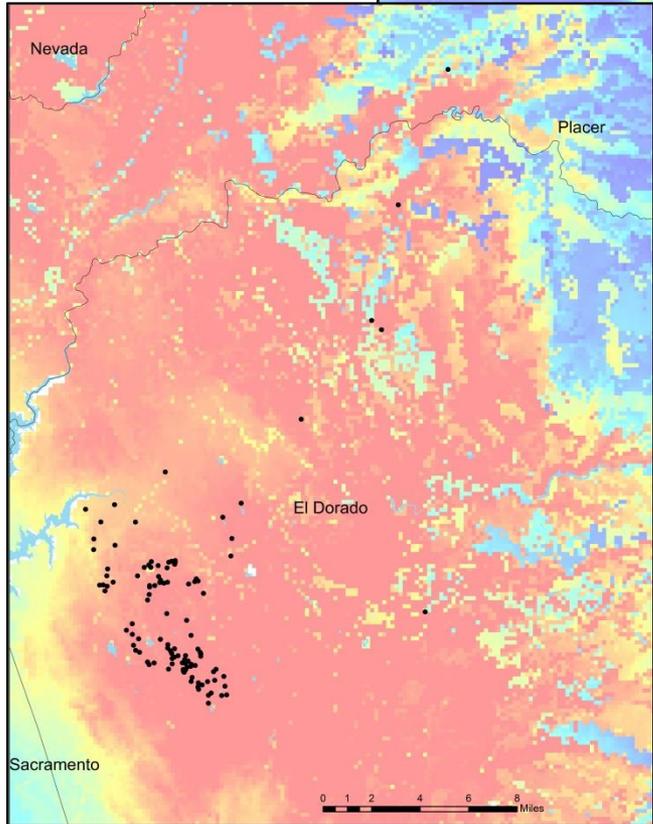
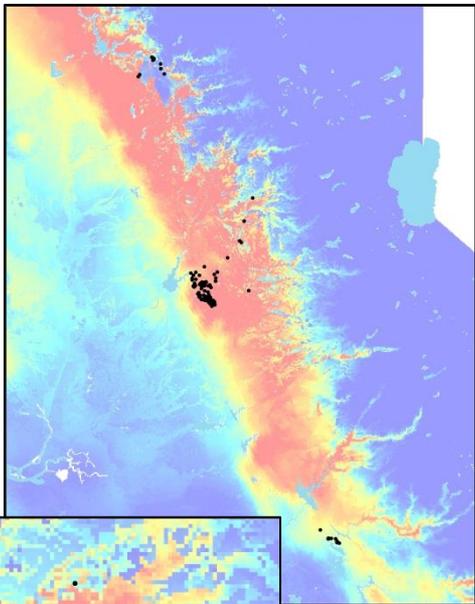
Hot +  
Dry



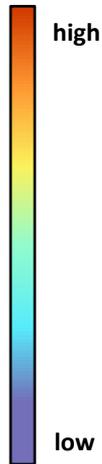
Warm  
+ Wet



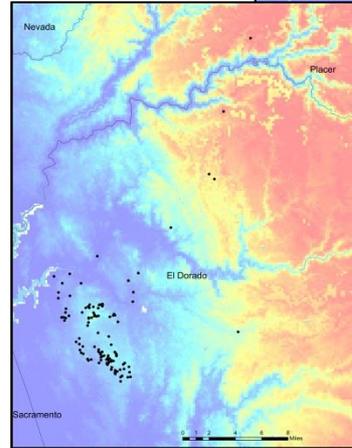
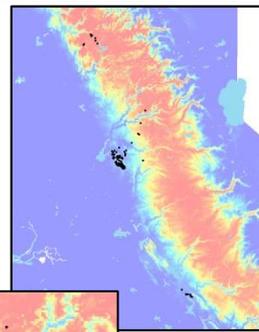
*Packera layneae*  
Layne's ragwort



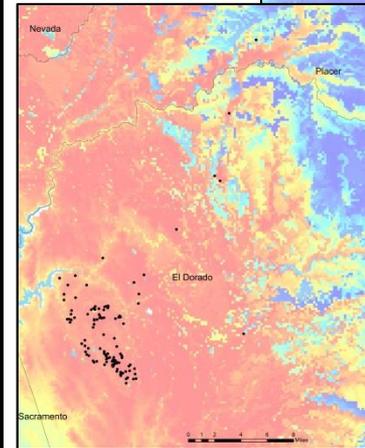
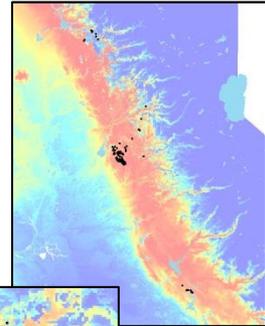
Habitat suitability

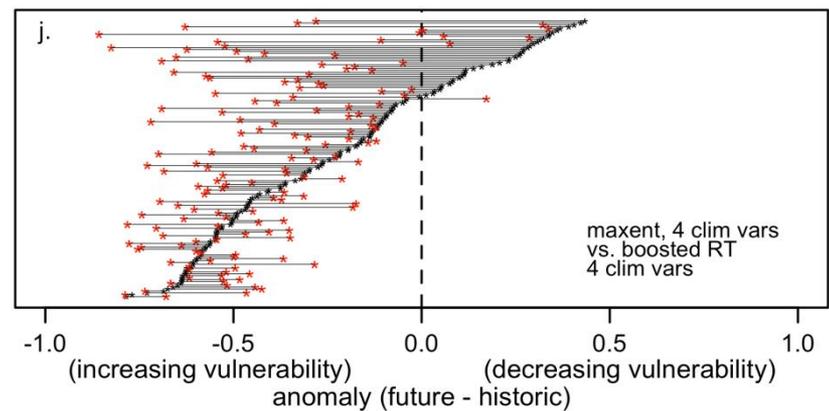
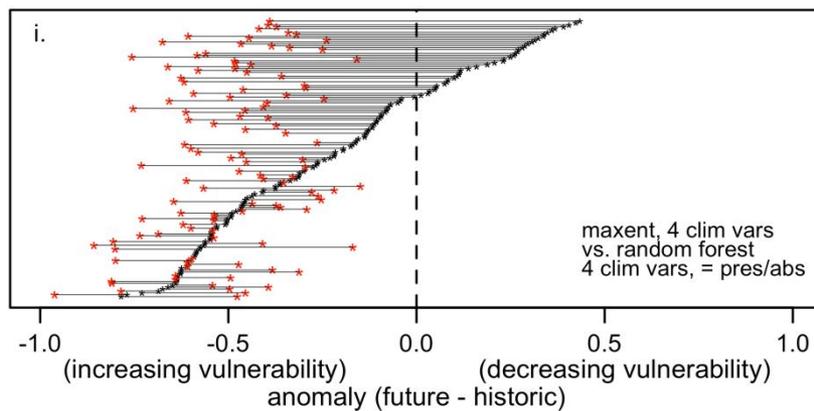
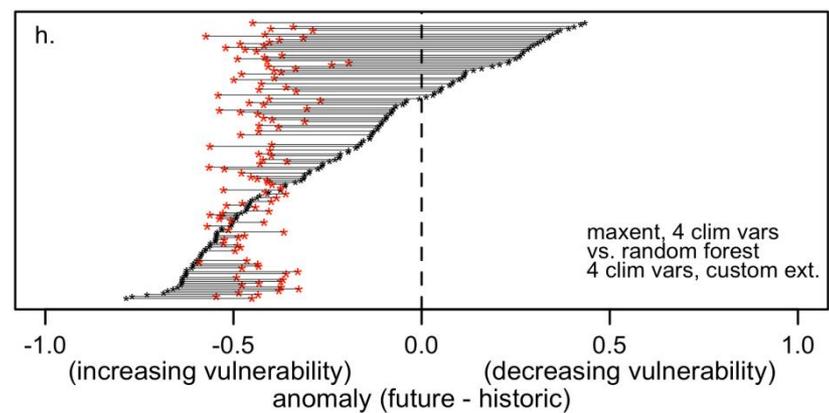
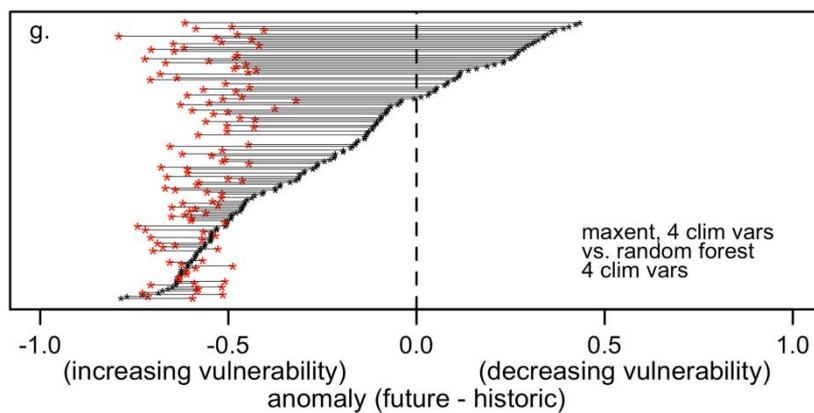
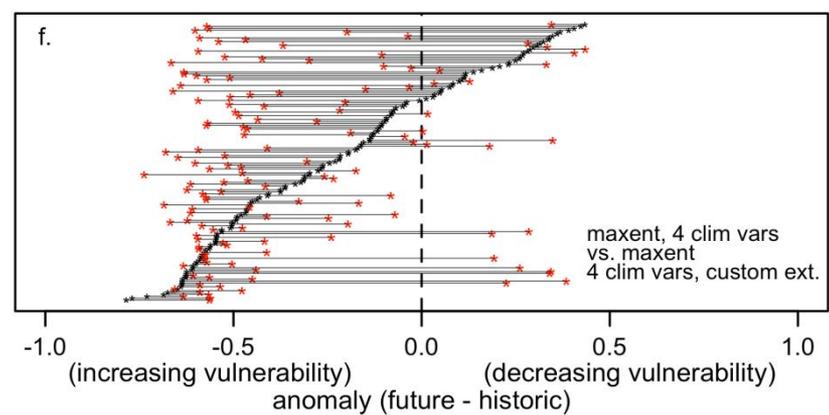
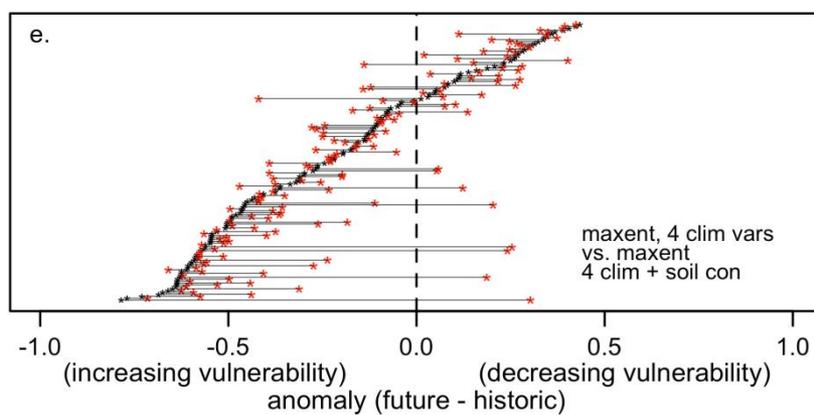


Hot +  
Dry



Warm  
+ Wet

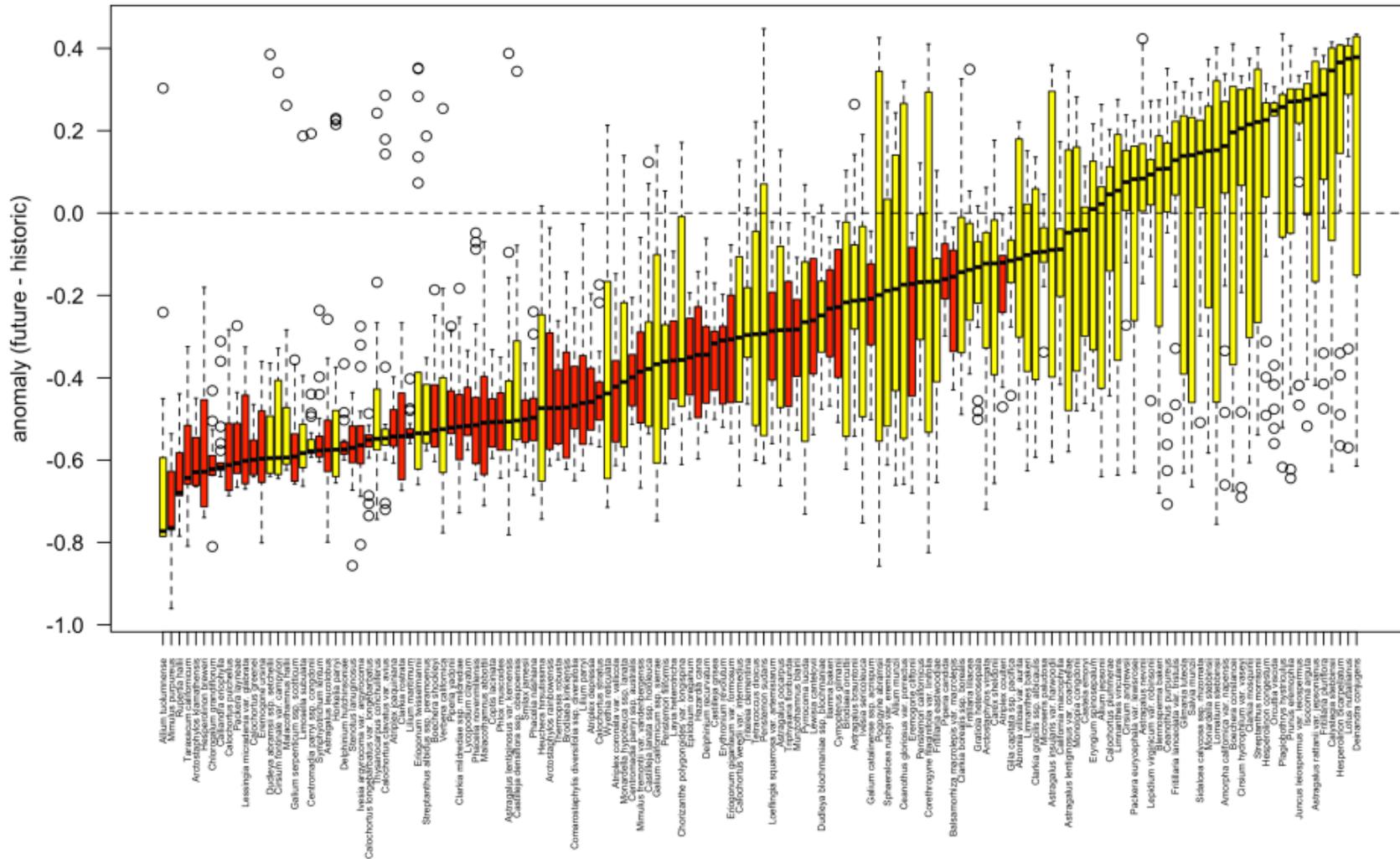






# Anomaly score

## 156 rare plant taxa



# CCVI Results

Extremely Vuln,  $n=2$

Highly Vuln,  $n=40$

Moderately Vuln,  $n=57$

Presumed Stable,  $n=32$

Increase Likely,  $n=16$

Insufficient Info,  $n=9$

Many unknowns

No short-cuts

Strongly driven by SDM results

Other important factors

Anthropogenic barriers

Topographic complexity

Human response to climate change

Historical thermal niche



*Mimulus purpureus*

Grank: 2  
Srank: 2  
CRPR: 1B.2  
Fed List: None



*Piperia yadonii*



Grank: 2  
Srank: 2  
CRPR: 1B.1  
Fed List: End

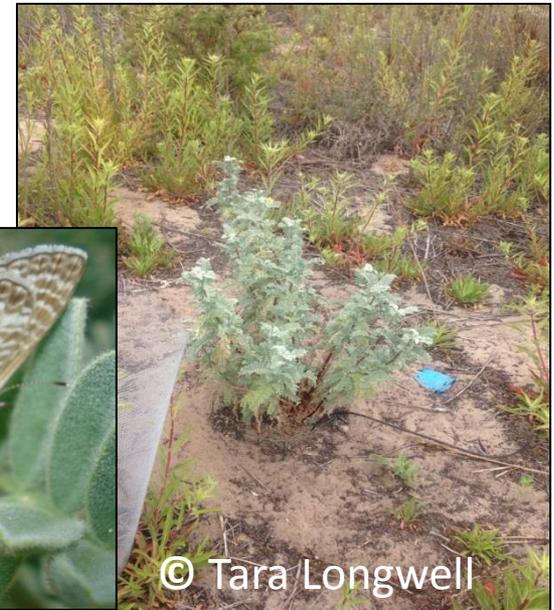
# Uses

- Assess species vulnerability
- Identify monitoring priorities
- Planning for climate resiliency
- Inform translocation/new populations



## Ventura marsh milk-vetch

*Astragalus pycnostachyus*  
var. *lanosissimus*



© Tara Longwell

Challenges: long time horizon, uncertainty

“a slow-moving emergency”

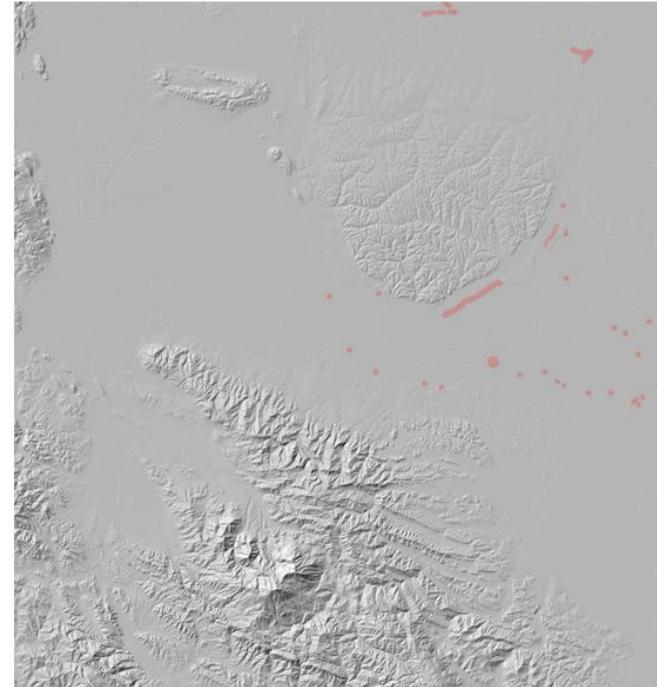
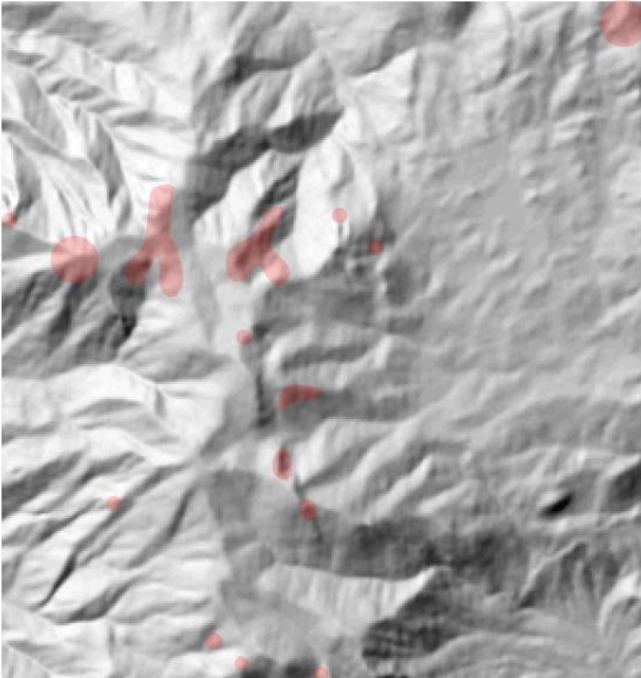
# Topographic complexity



*Eriogonum twisselmannii*



*Limosella australis*



# Soil endemism



*Wyethia reticulata*



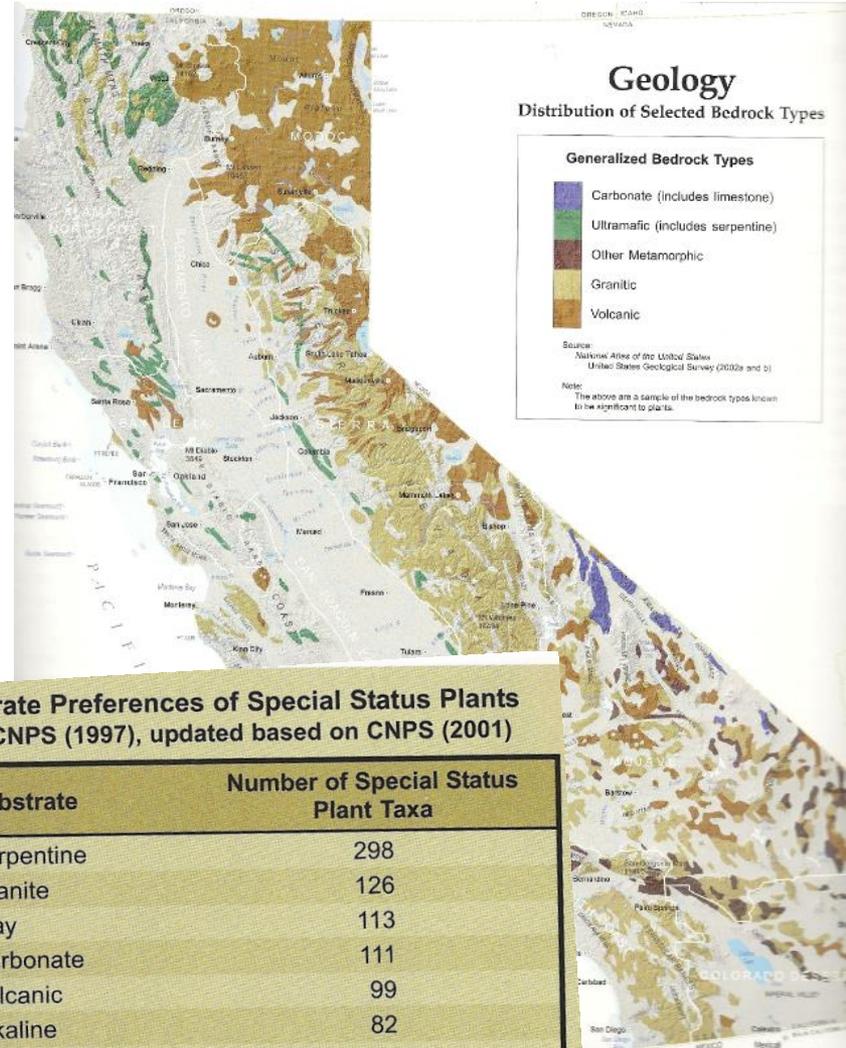
*Calystegia stebbinsii*



*Packera layneae*



*Ceanothus roderickii*



**Substrate Preferences of Special Status Plants After CNPS (1997), updated based on CNPS (2001)**

Substrate	Number of Special Status Plant Taxa
Serpentine	298
Granite	126
Clay	113
Carbonate	111
Volcanic	99
Alkaline	82
Gabbro	20
Sandstone	19
Shale	10
Gypsum	1

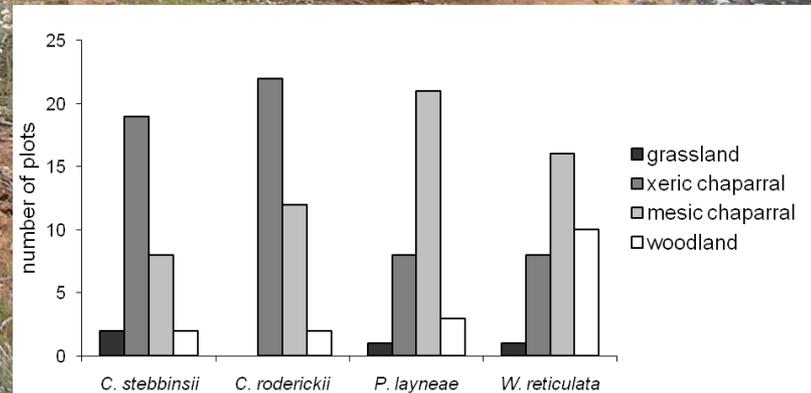
# Comparing field data with SDMs

Grassland

Chaparral

Xeric Mesic

Woodland.



# Land Cover



Layne's ragwort (*Packera layneae*)

Occurs in white-leaved manzanita (*Arctostaphylos viscida*) chaparral



 *Packera layneae*

Meters  
0 62.5125 250 375 500

## Vegetation type

### NVCS NAME

-  *Arctostaphylos viscida*
-  Built-up and Urban Disturbance
-  California Annual and Perennial Grassland
-  *Pinus sabiniana*
-  *Quercus douglasii*
-  *Quercus kelloggii*
-  *Quercus wislizeni*

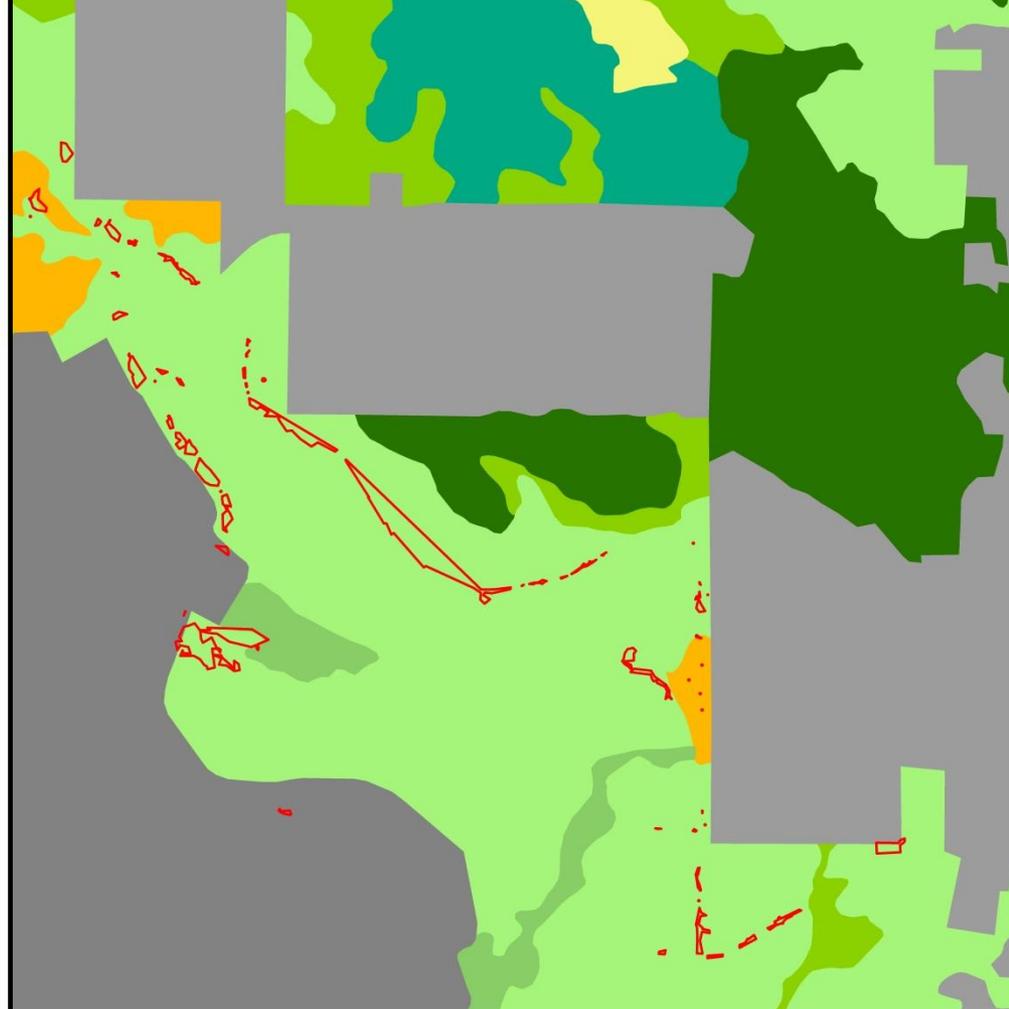
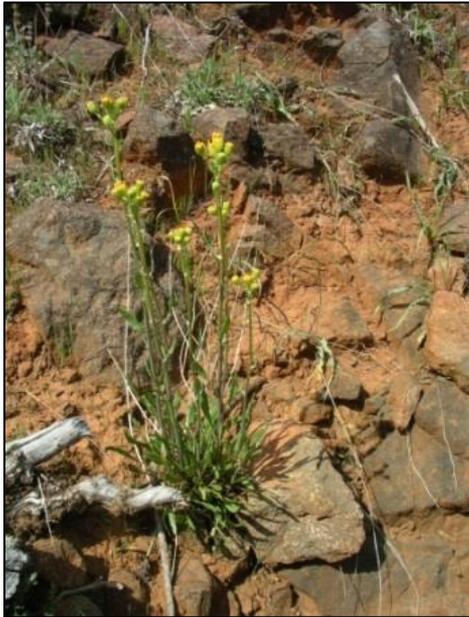


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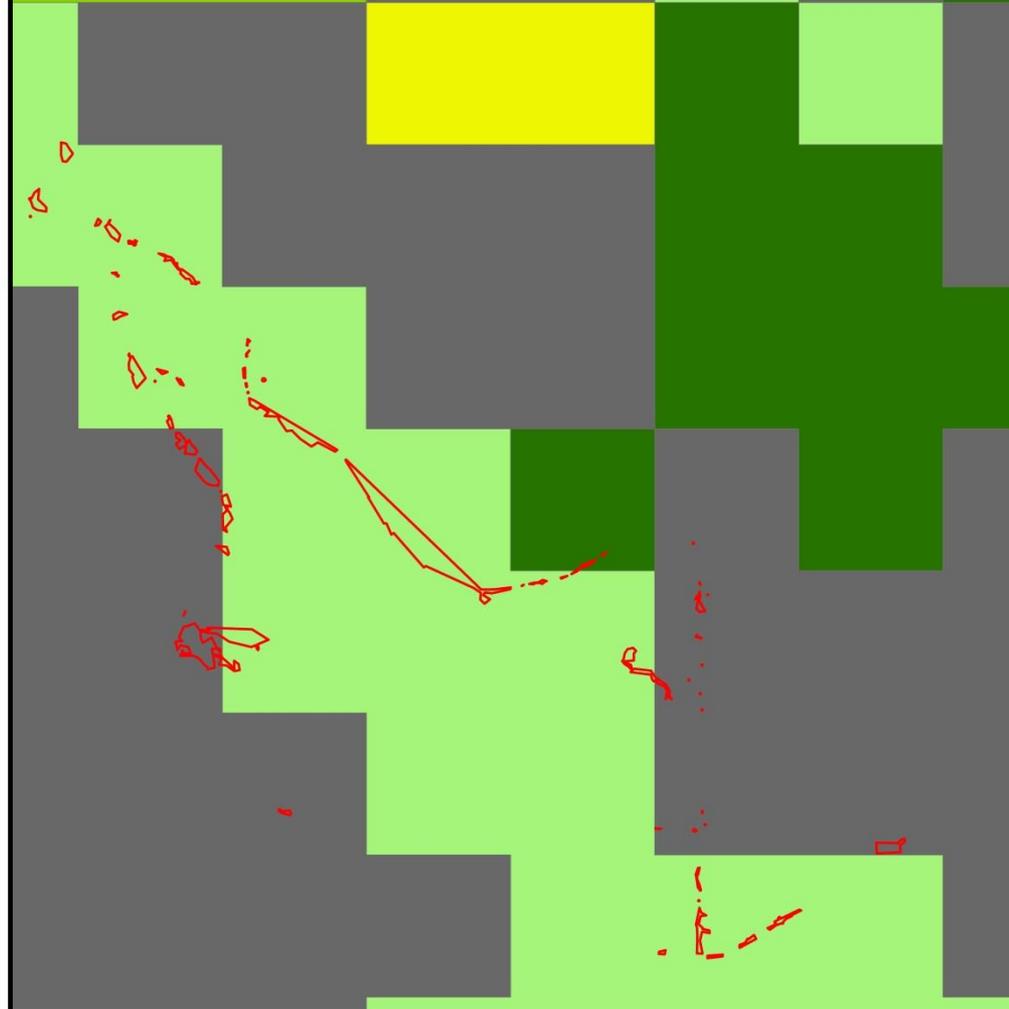


# Land Cover



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 *Packera layneae*

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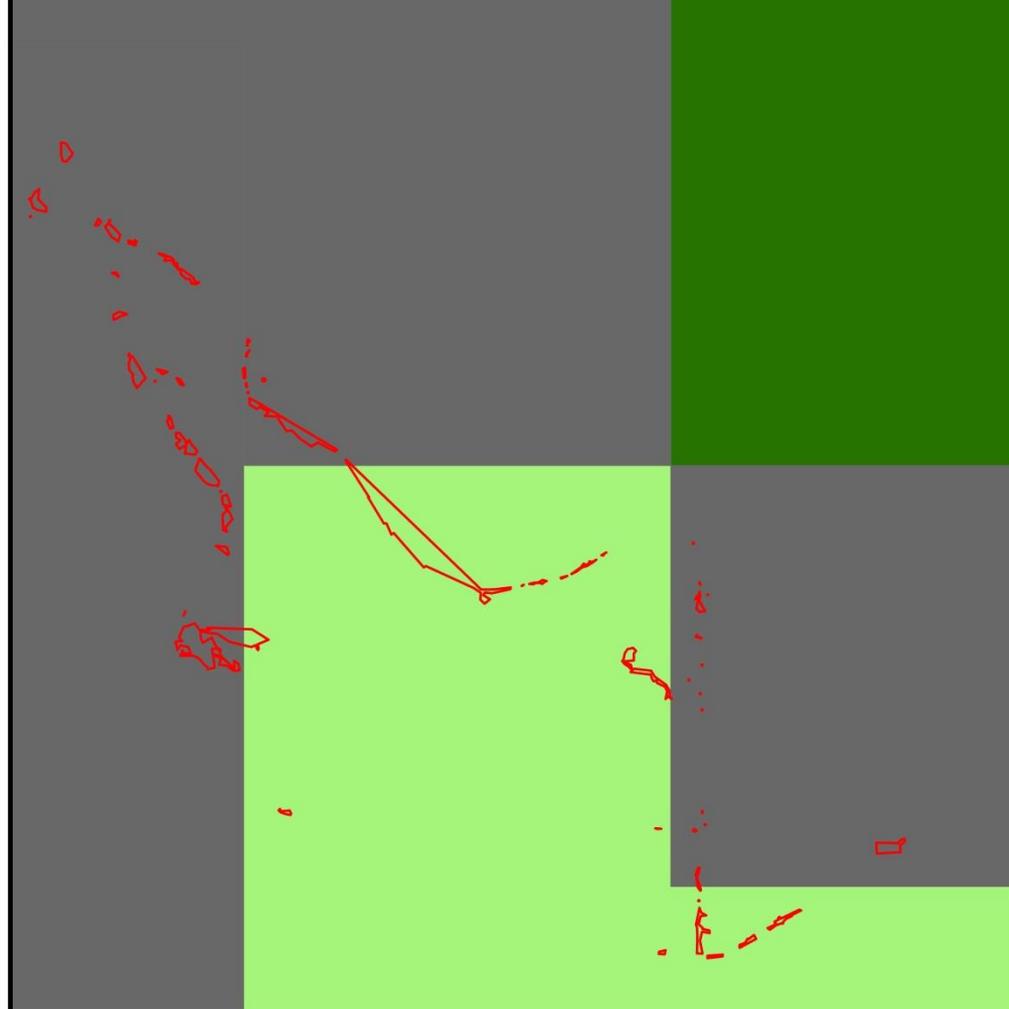
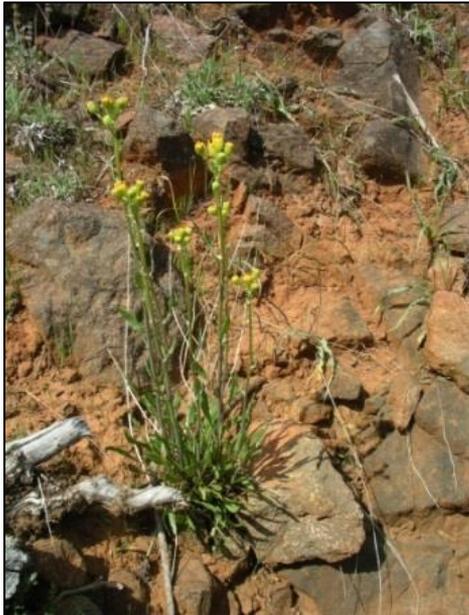


# Land Cover



Layne's ragwort (*Packera layneae*)

Occurs in white-leaved manzanita (*Arctostaphylos viscida*) chaparral



 *Packera layneae*

Meters  
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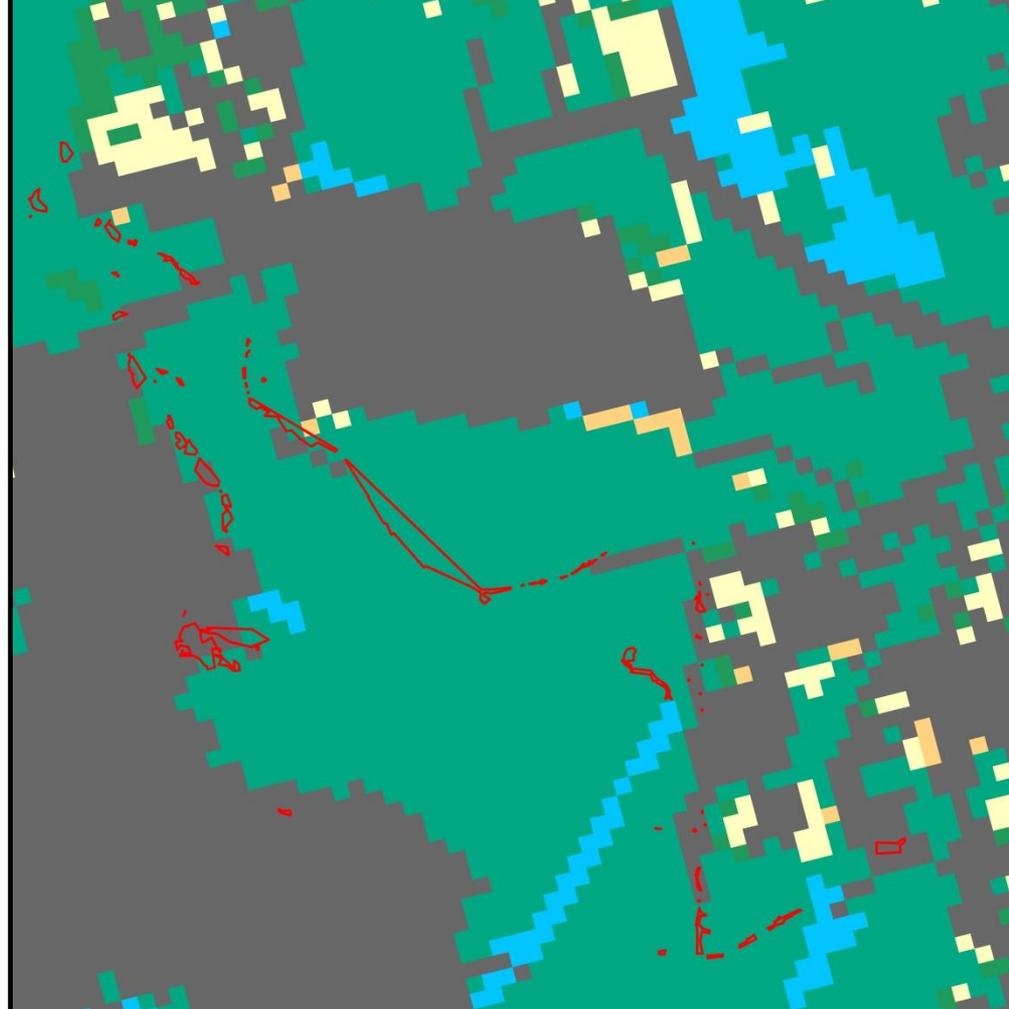


# Land Cover



Layne's ragwort (*Packera layneae*)

Occurs in white-leaved manzanita (*Arctostaphylos viscida*) chaparral



 *Packera layneae*

Meters  
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-  *Quercus douglasii*
-  *Quercus kelloggii*
-  *Quercus wislizeni*



# Other important variables



- **Litter cover**
- **Gravel cover**



- Patch size
- Distance to other patches



**Science**

**+**

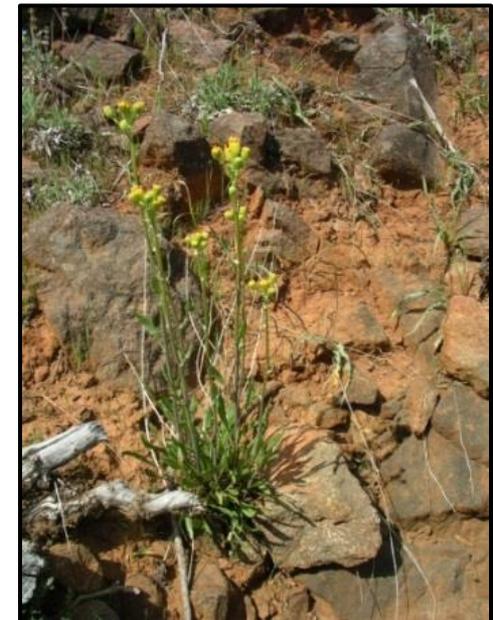
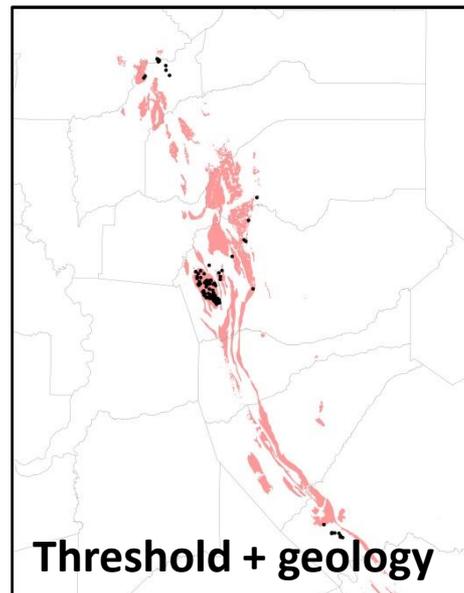
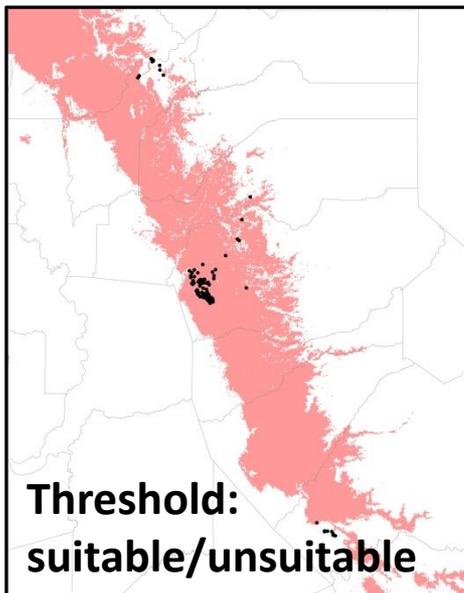
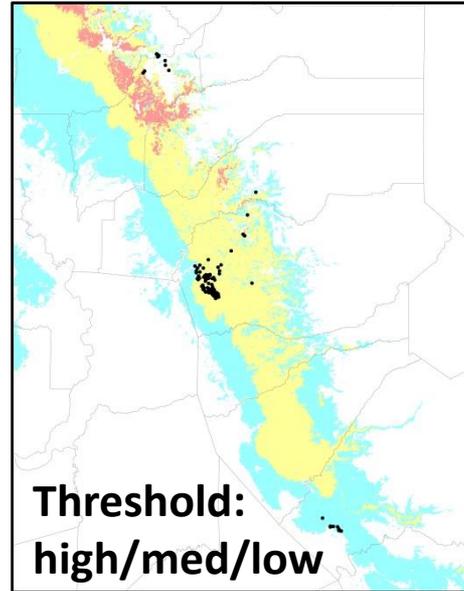
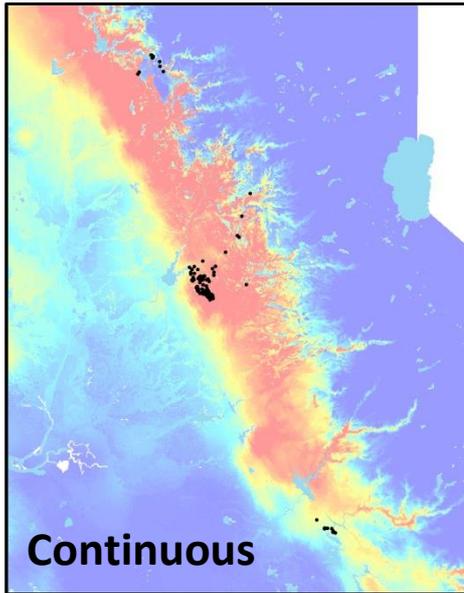
**Art**



# Science

+

# Art



# Closing thoughts

Find unknown populations

Understand biology

Assess climate change impacts

Identify areas where surveys are required

Conservation planning

Importance of precision

