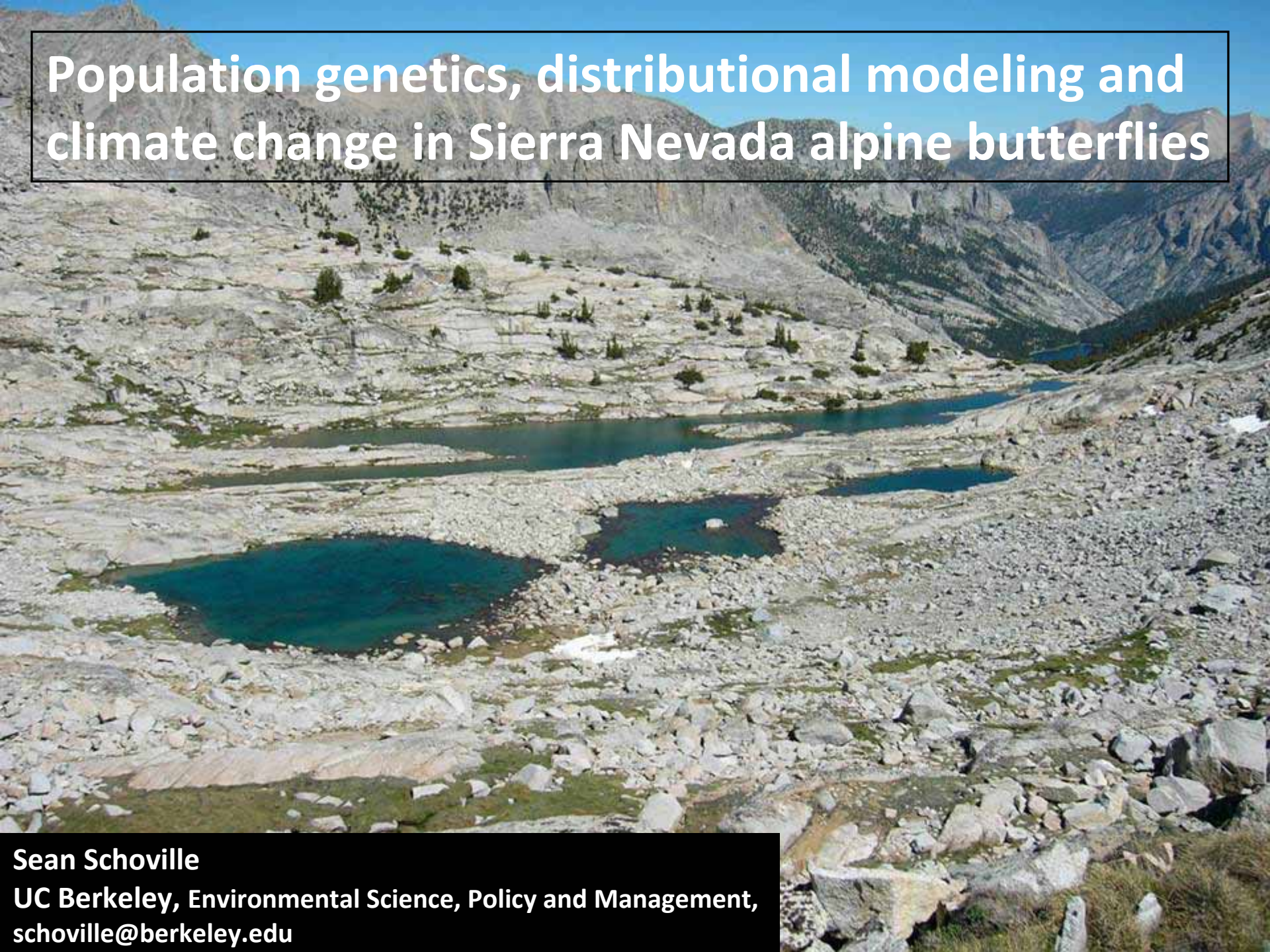


# Population genetics, distributional modeling and climate change in Sierra Nevada alpine butterflies

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Sierra Nevada Parnassian (*Parnassius behrii*)



Sierra Green Sulphur (*Colias behrii*)



Rockslide Checkerspot (*Chlosyne whitneyi*)



Greenish Blue (*Plebejus saepiolus*)



Lustrous Copper (*Lycaena cupreus*)

# How does climate change effect alpine butterflies over evolutionary timescales?



Sandhill Skipper (*Polites sabuleti*)

Where do alpine butterflies come from?

How have glaciations influenced alpine butterfly populations?

Do all species share the same history?

# What are the effects of centennial climate change on the spatial distribution of alpine butterflies?

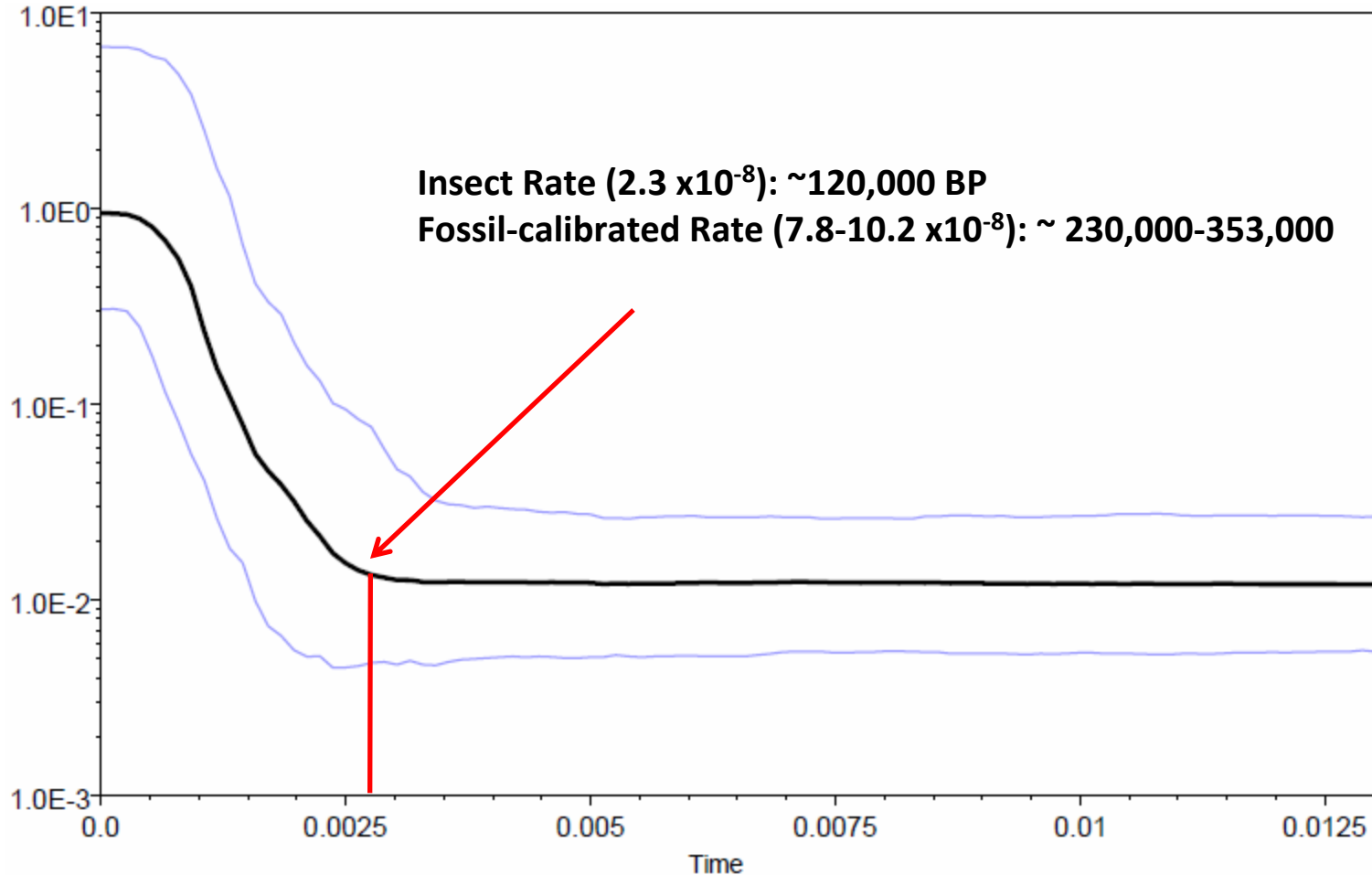
Are there observable changes in alpine butterflies and where are changes occurring?

What are the long-term evolutionary consequences of continued climate change?



# Effective Population Size over Time

## Bayesian Skyline Plot of COI mtDNA data, *P. smintheus* complex



## Other alpine butterflies



Photo: Adam Winer

**Ivalda Arctic (*Oeneis chryxus*):**

**Sierra Nevada populations are genetically identical to populations in Wyoming.**

**(Nice and Shapiro, 2001)**

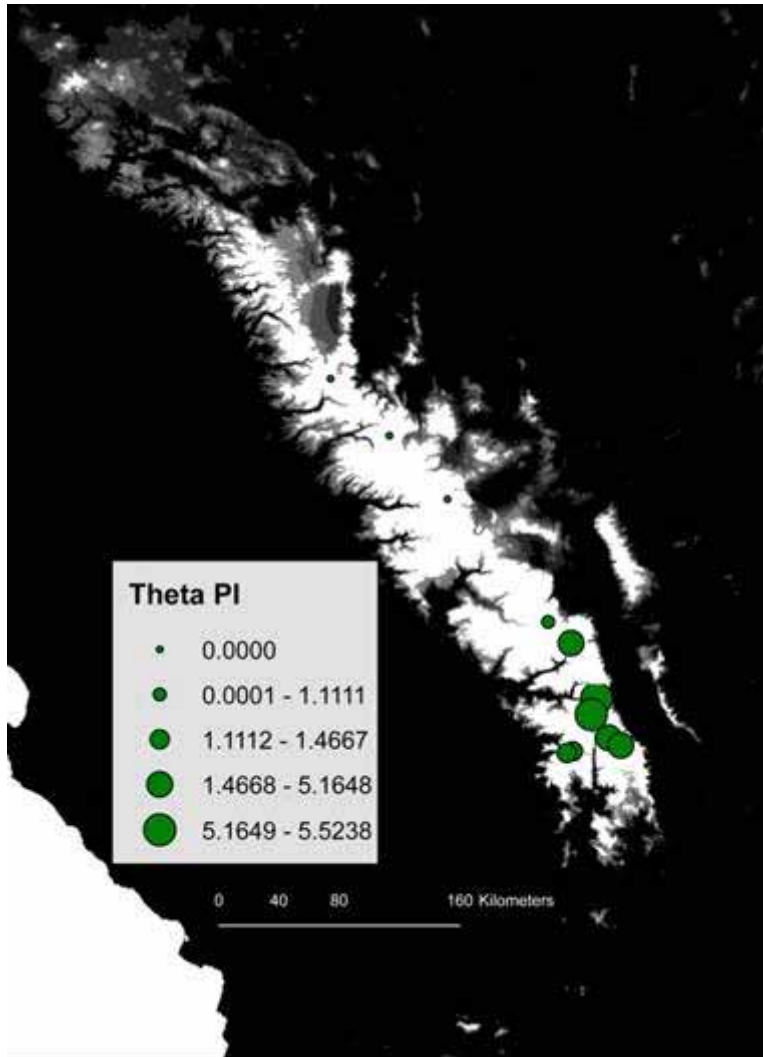


**Sierra Green Sulphur (*Colias behrii*):**

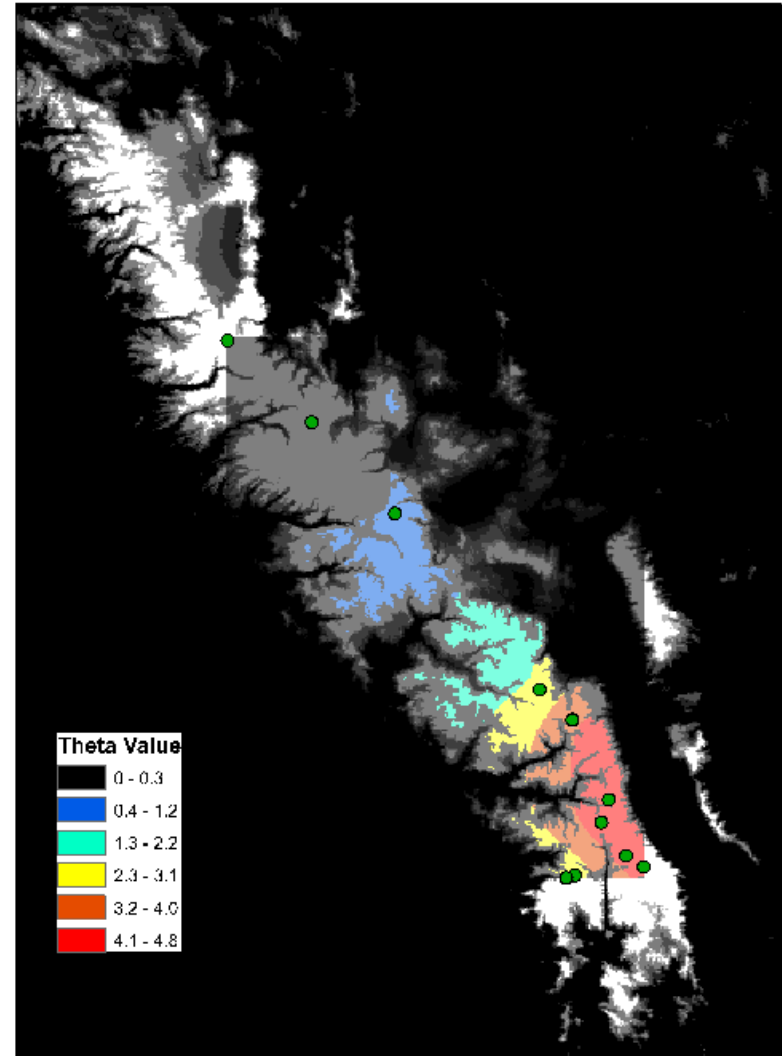
**Closely related to Rocky Mountain *Colias* and also a Star-Shaped gene tree.**

Photo: Stephanie Skophammer

# *Parnassius behrii*

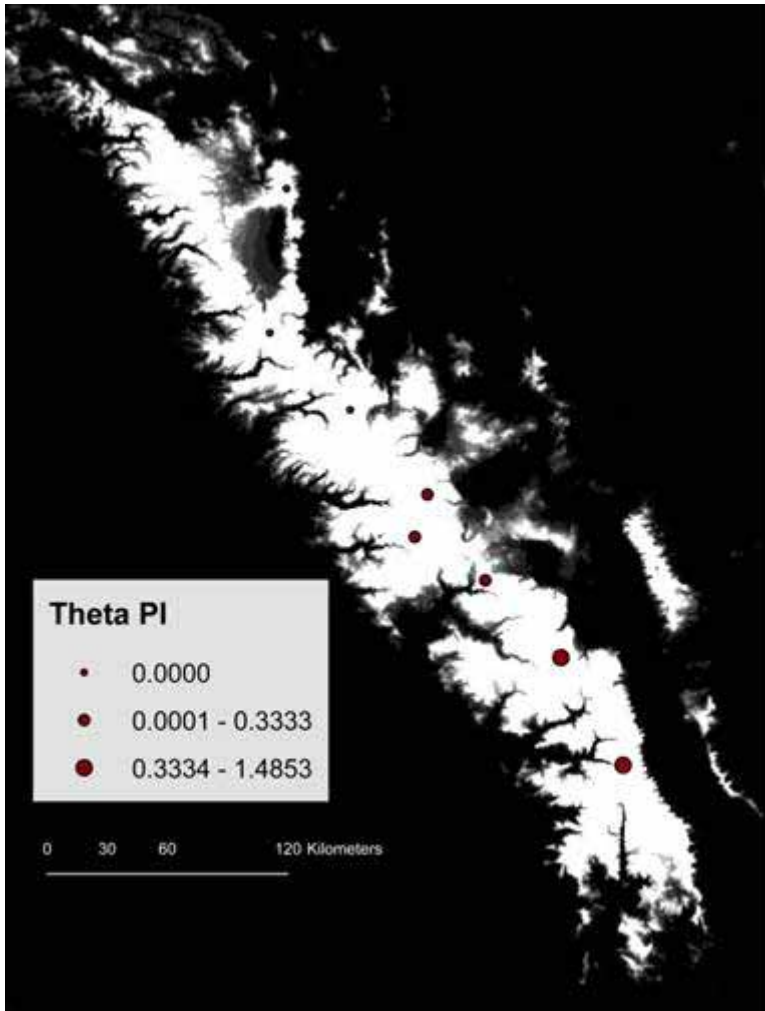


Sampling points. Size proportional to genetic diversity values.

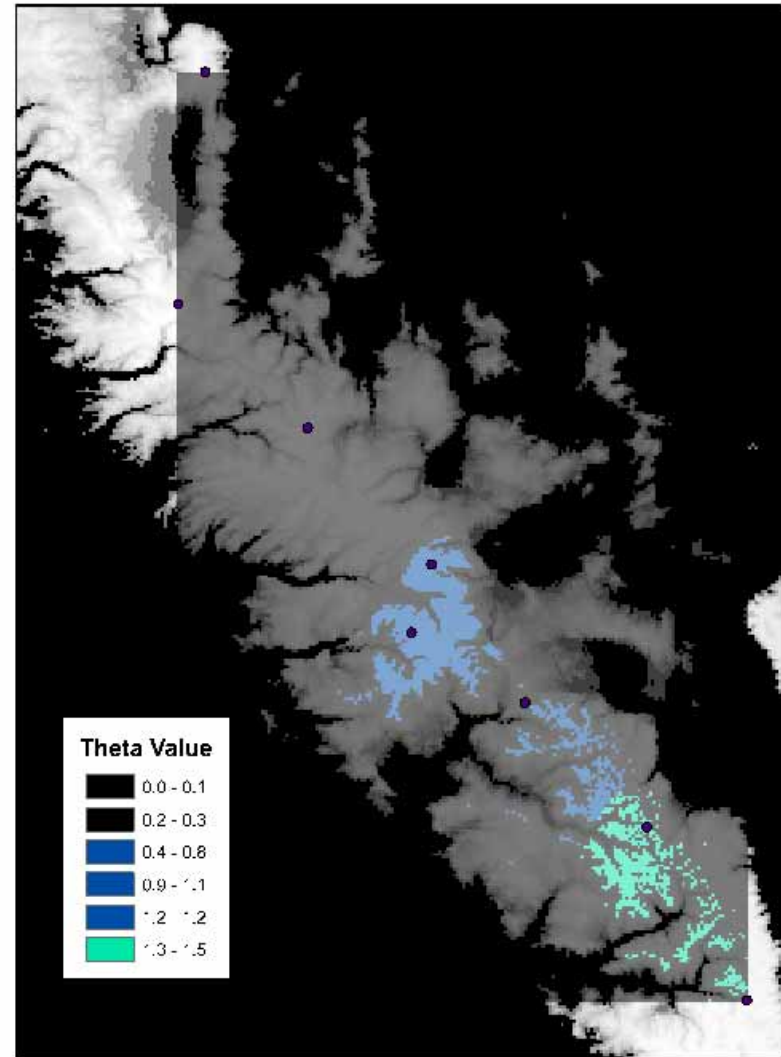


IDW-kriged genetic diversity surface

## *Oeneis chryxus*

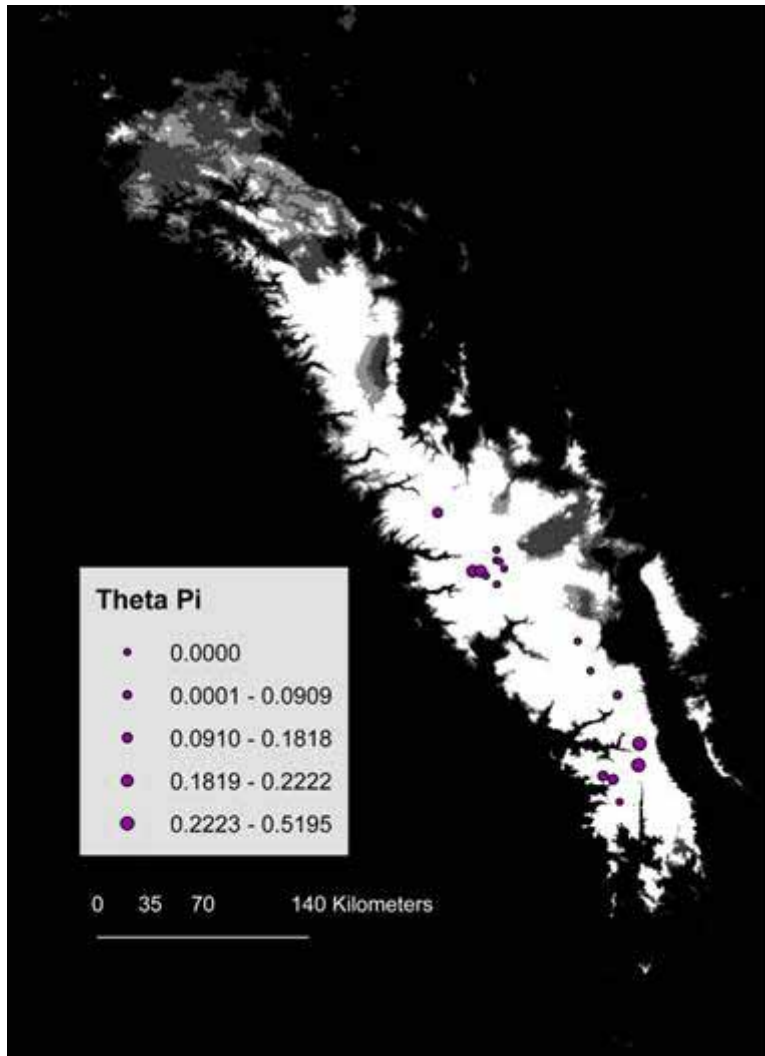


Sampling points. Size proportional to genetic diversity values.

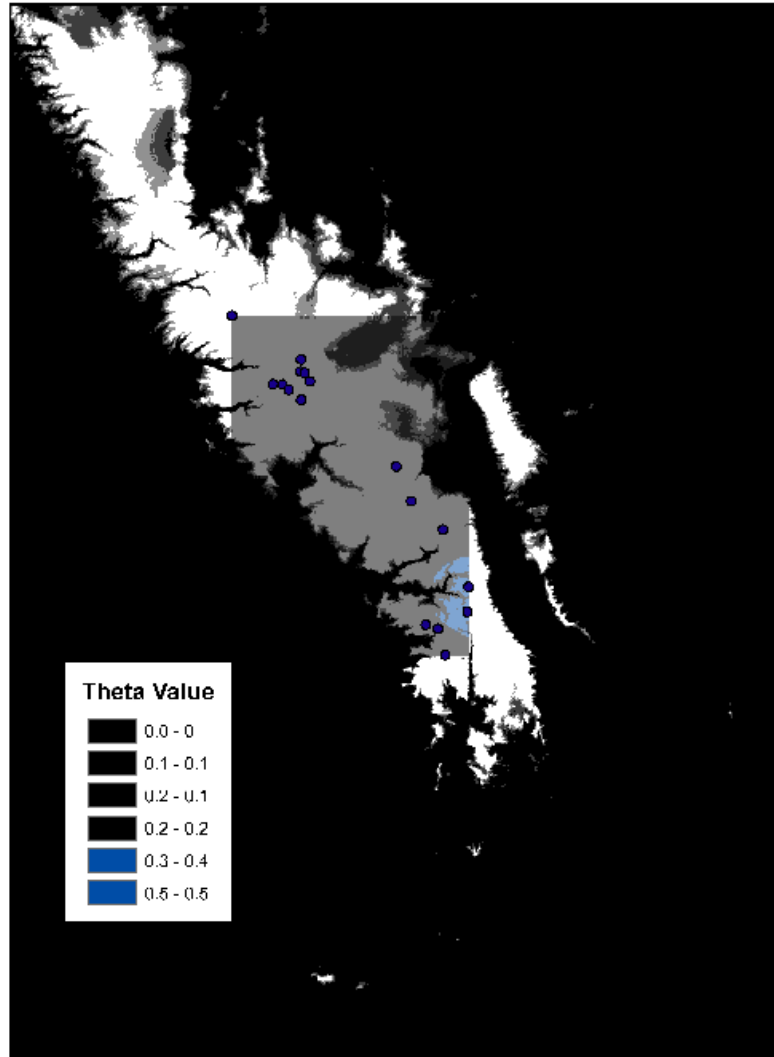


IDW-kriged genetic diversity surface

## *Colias behrii*



Sampling points. Size proportional to genetic diversity values.



IDW-kriged genetic diversity surface

# Centennial Climate Change



# Species Distribution Modeling

Utilizing presence-only data, we can predict a species spatial distribution based on environmental correlates.

Maximum Entropy: algorithm maximizing the probability of species occurrence in a landscape, given observational data and constraints imposed by environmental features.



Occurrence  
Data

+



Climatic  
Data

=



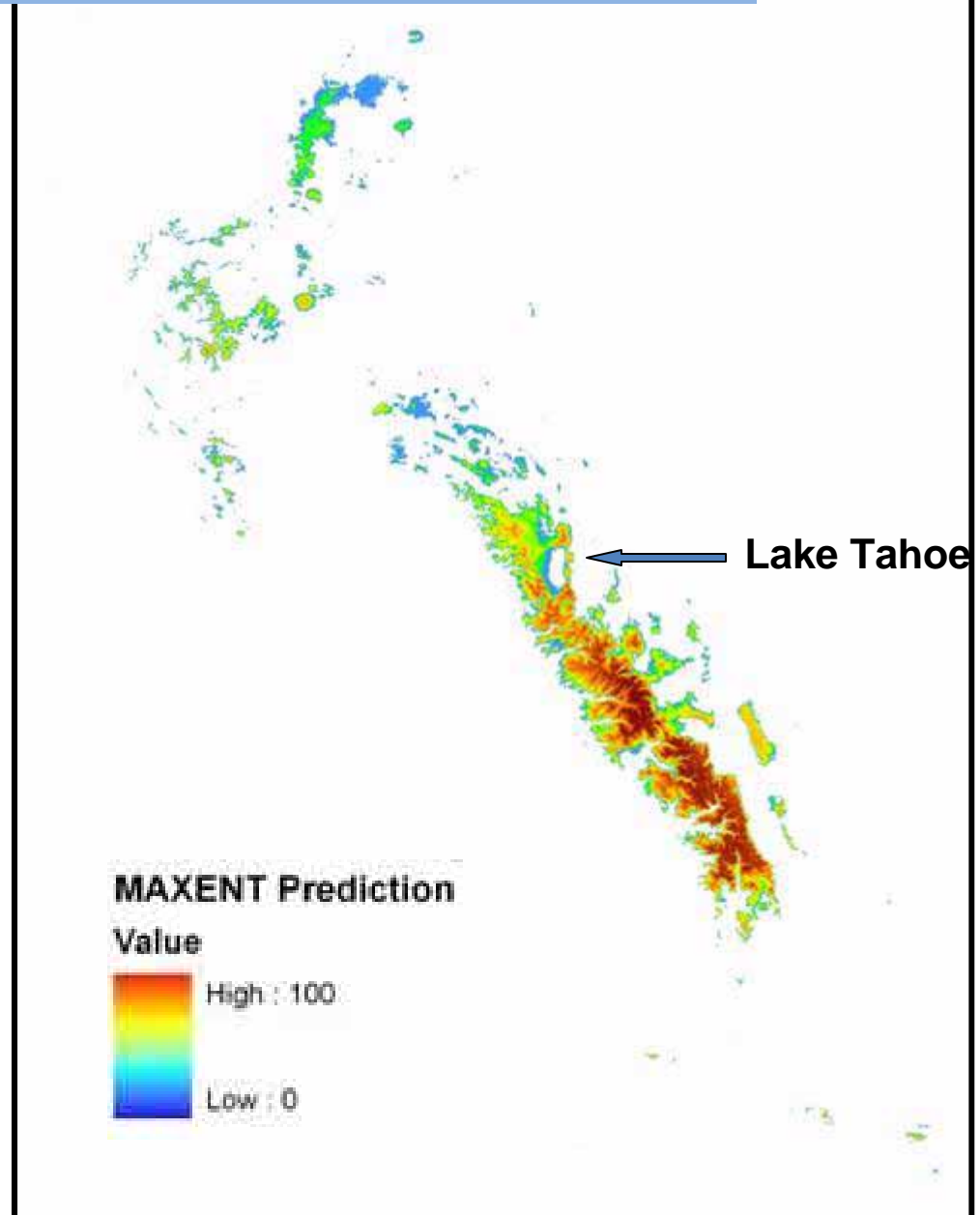
Predicted  
Distribution

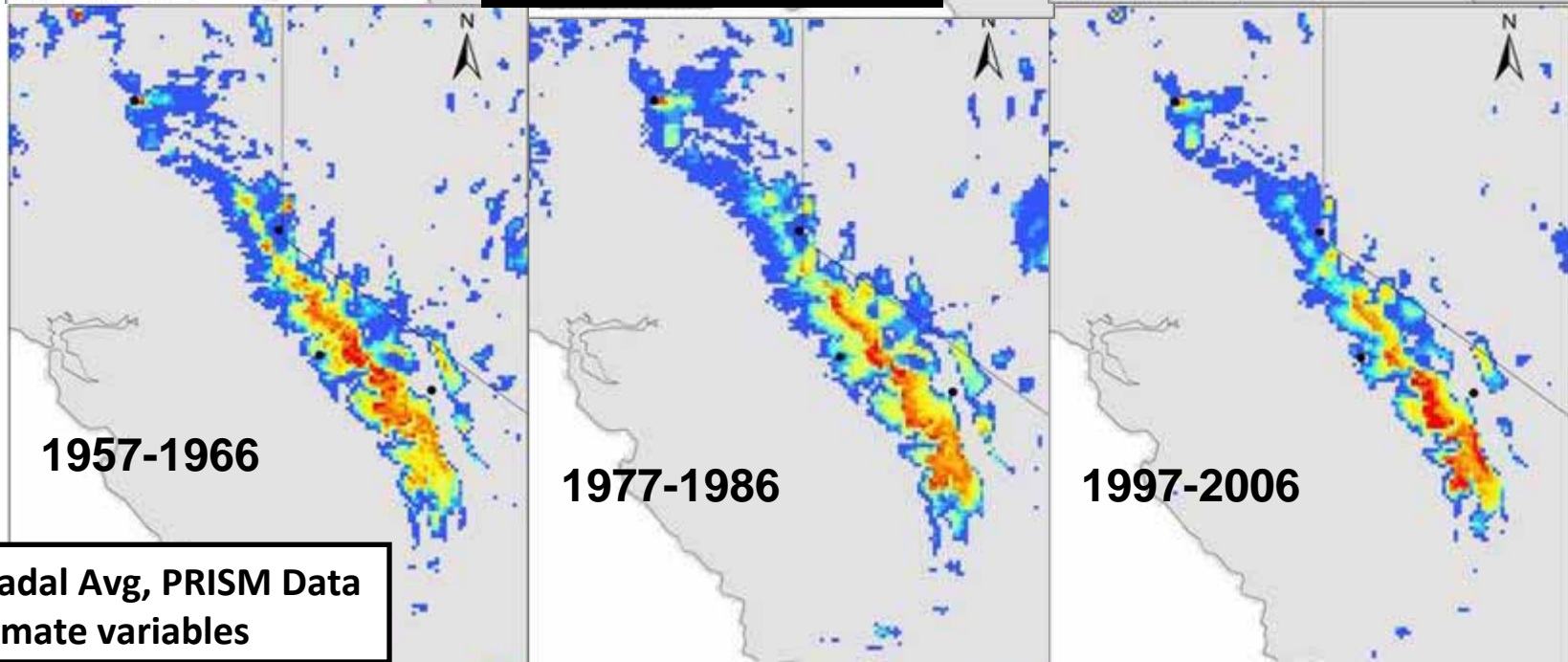
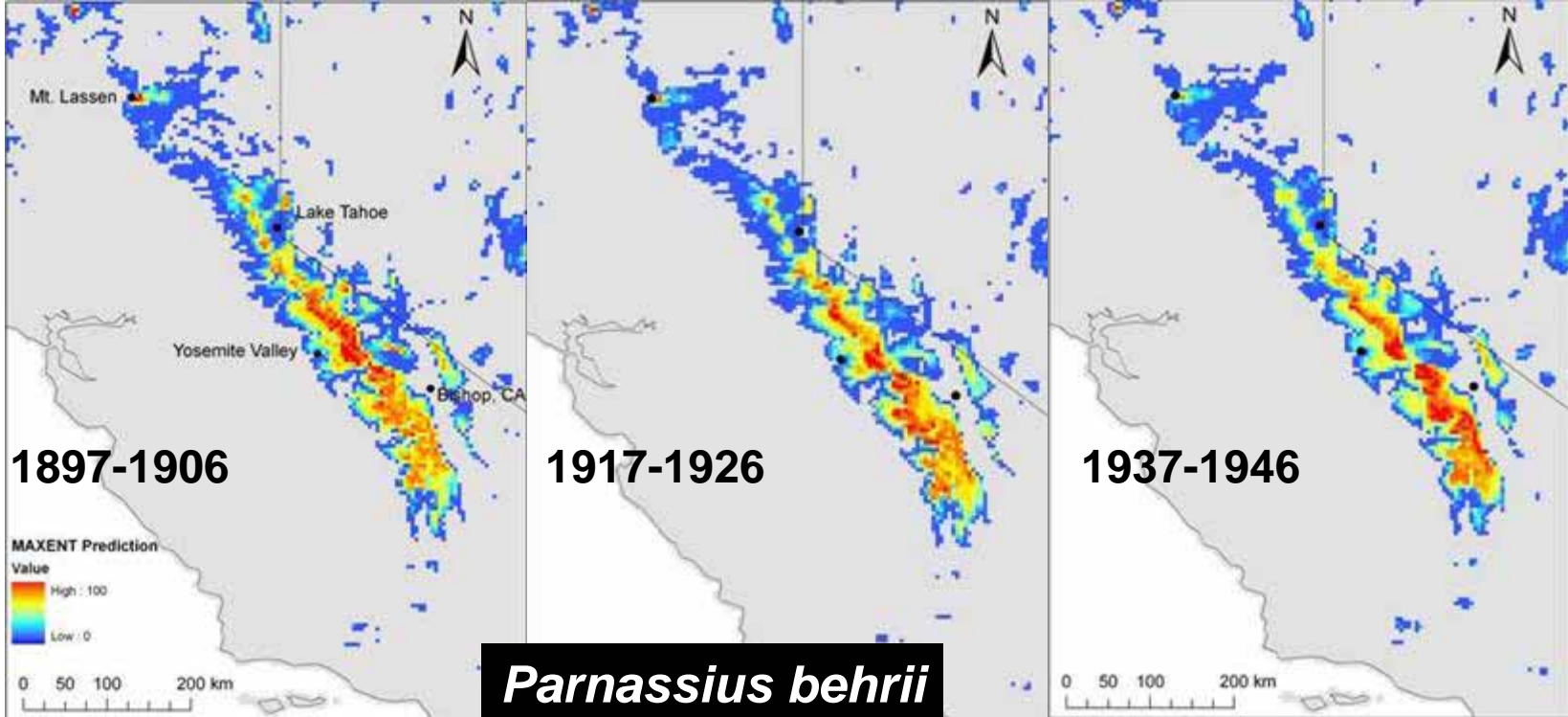
# Suitable Habitat for Multiple Alpine Butterfly species

**High spatial concordance  
in suitable habitat,  
primarily in the central  
and southern Sierra.**

## Modeling Conditions

- 50yr avg Weather Data (WorldClim)
- 19 climate variables
- hostplant distribution if available





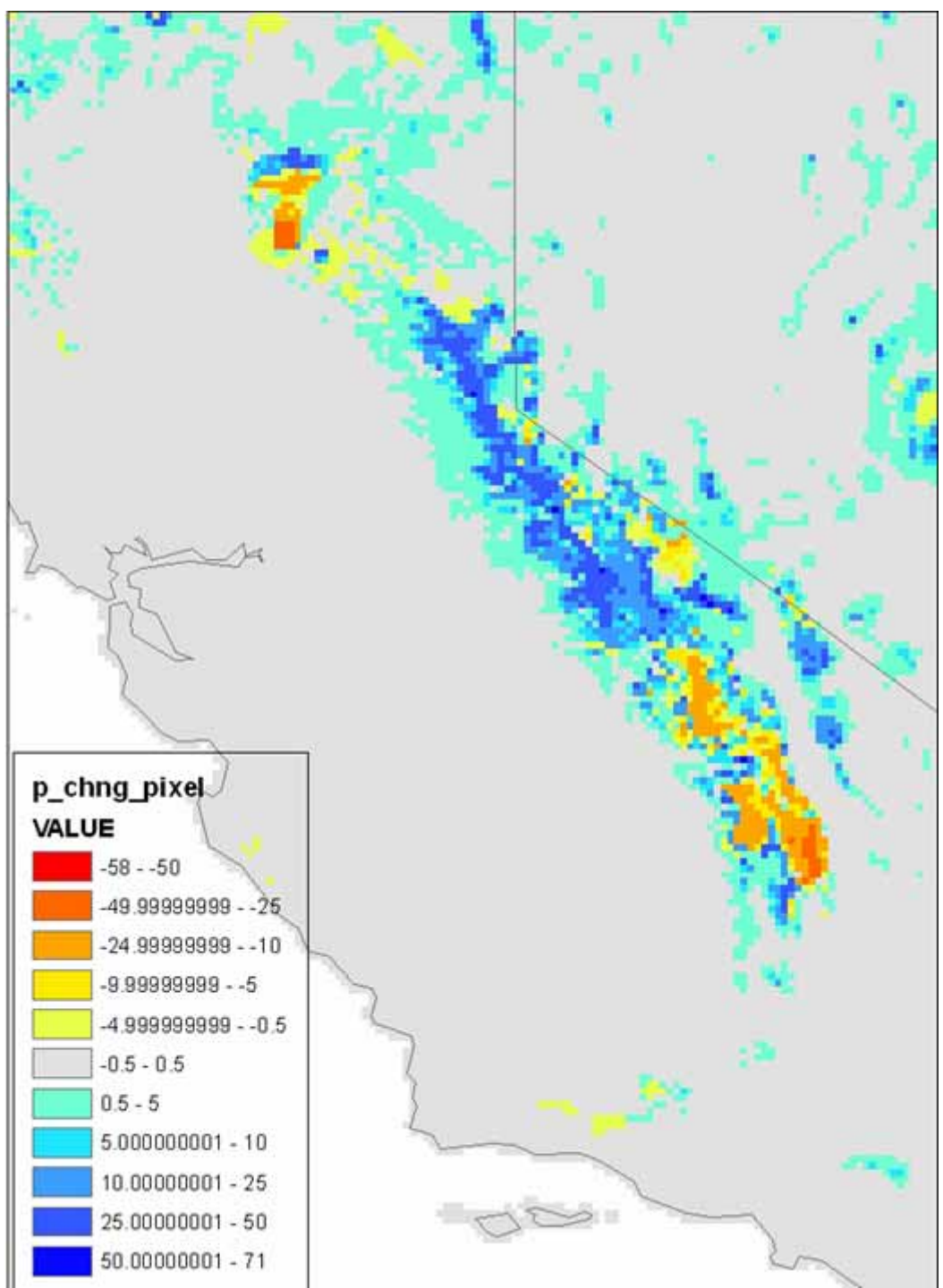
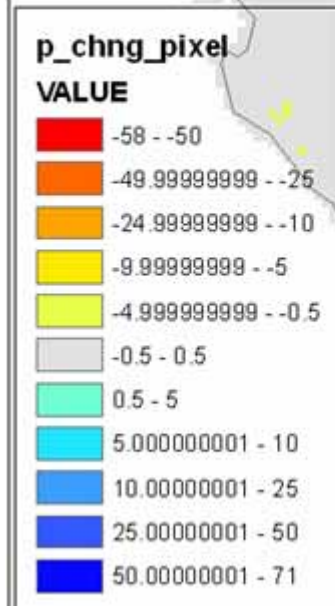
-Decadal Avg, PRISM Data  
-5 climate variables

# Accumulated Change in Habitat Suitability over 100 years

*Parnassius behrii*

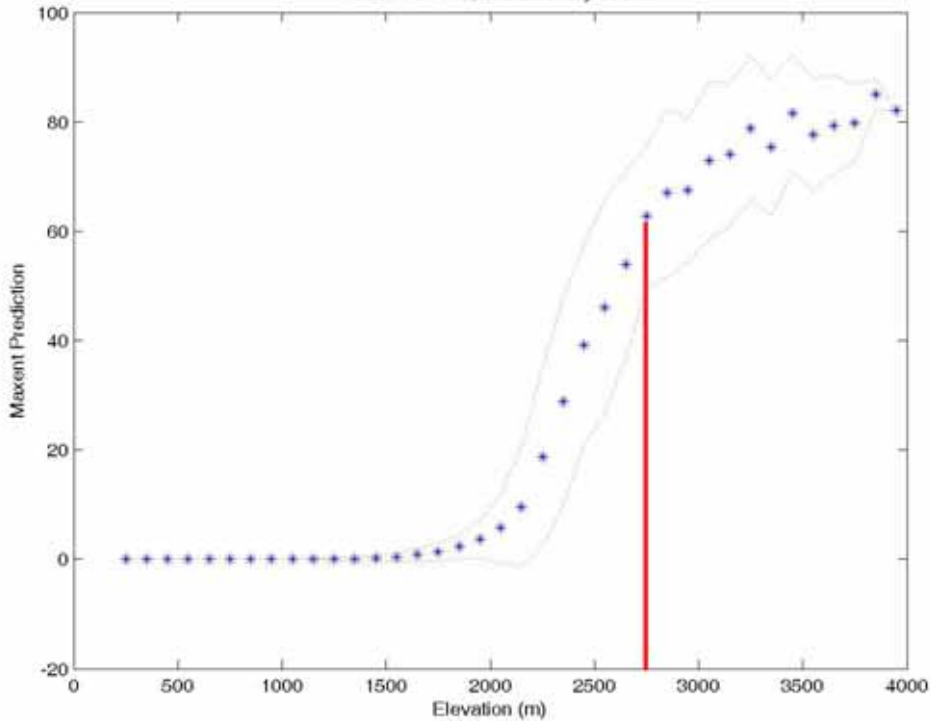
Increasing suitability →

Decreasing suitability →

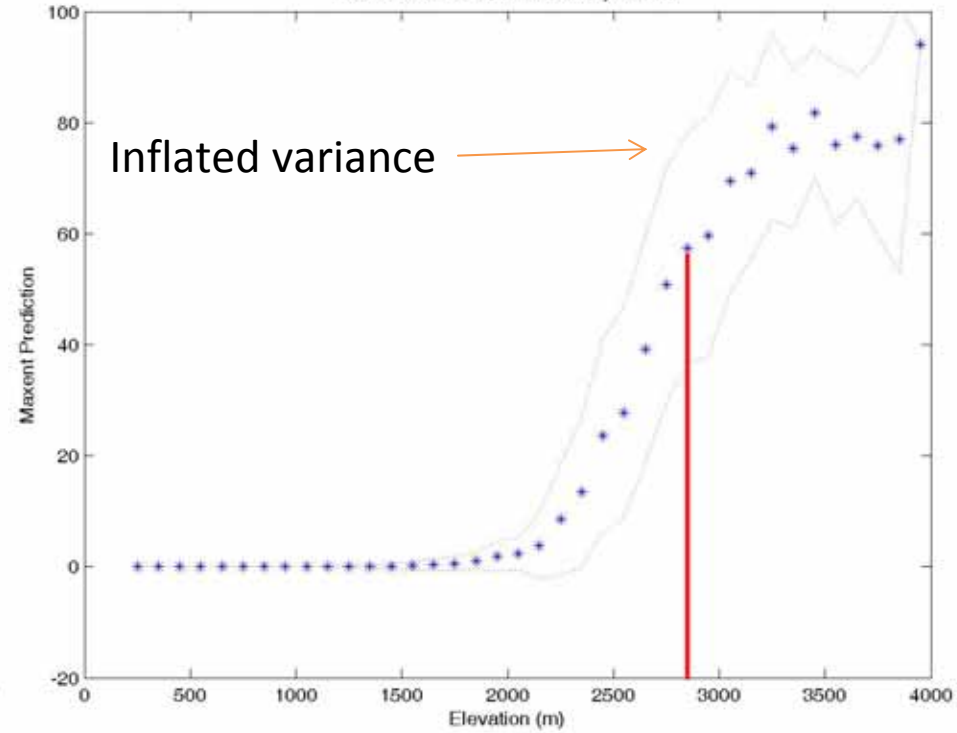


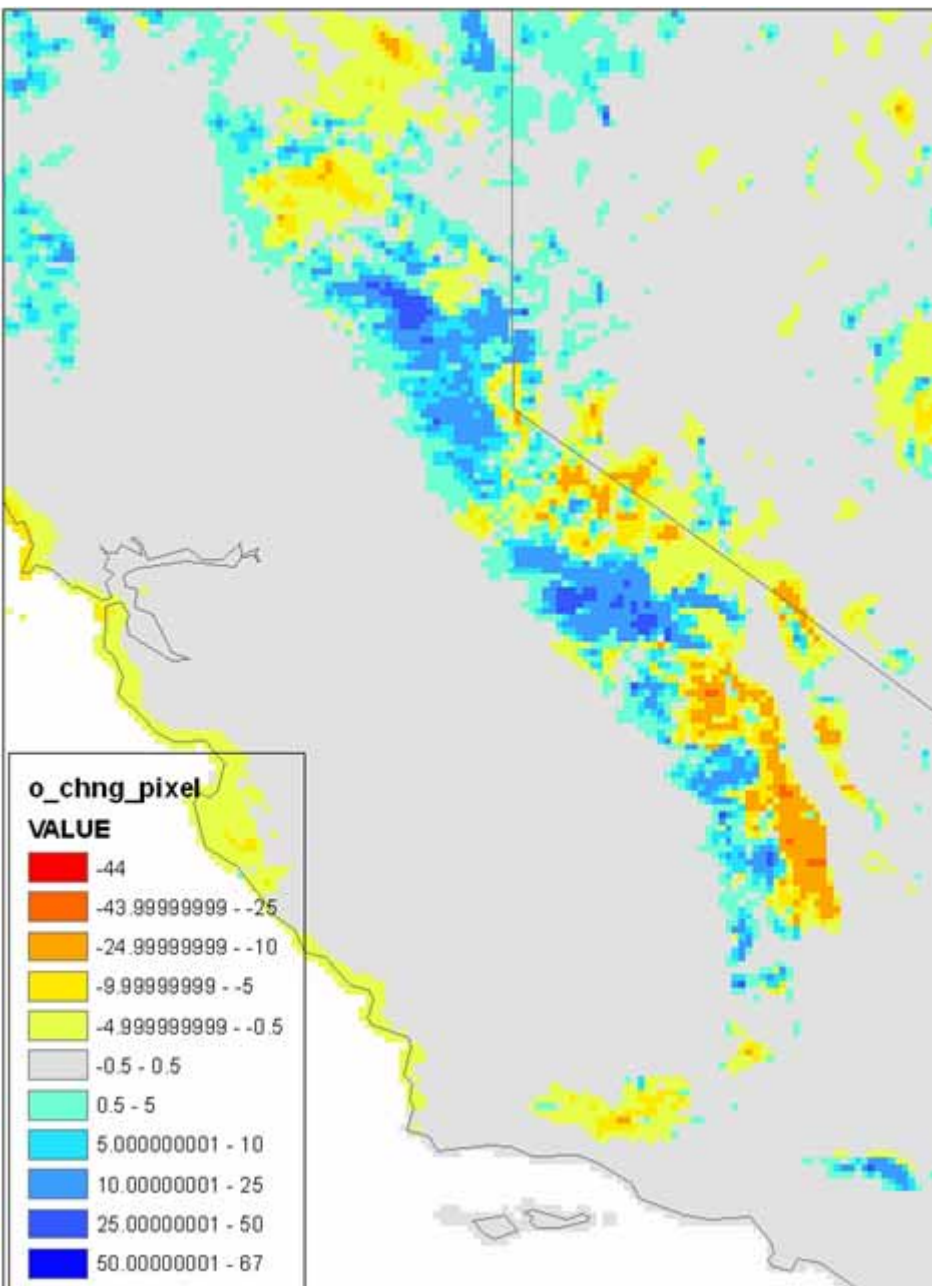
# Suitable habitat on average increases in elevation

Parnassius 1917, binned every 100 m

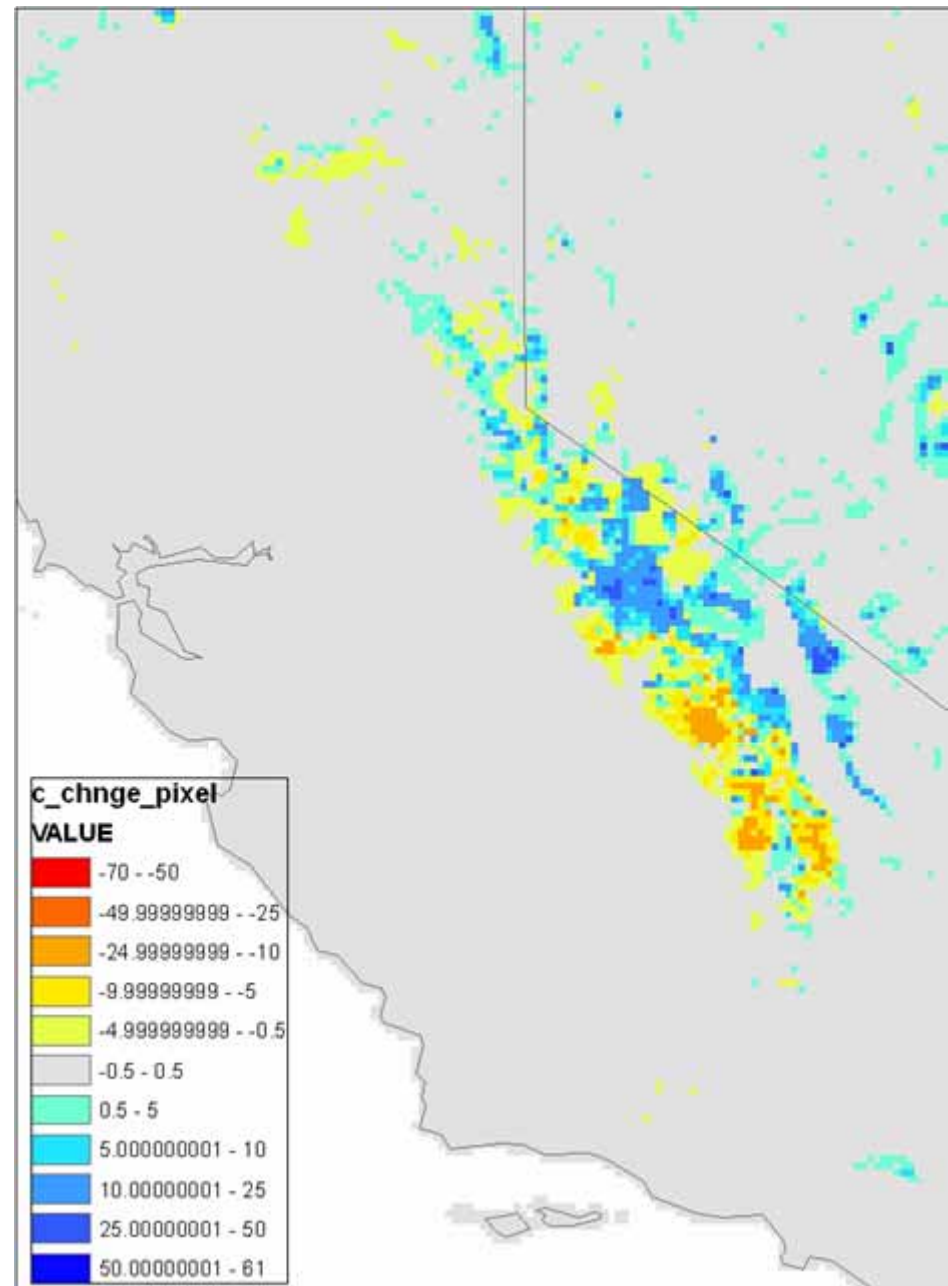


Parnassius 1997, binned every 100 m





*Oeneis chryxus*



*Colias behrii*

# On-going Research

## Yosemite Butterfly Surveys:

Garth and Tilden: 1933-1963

Resurvey Period: 2006-2008

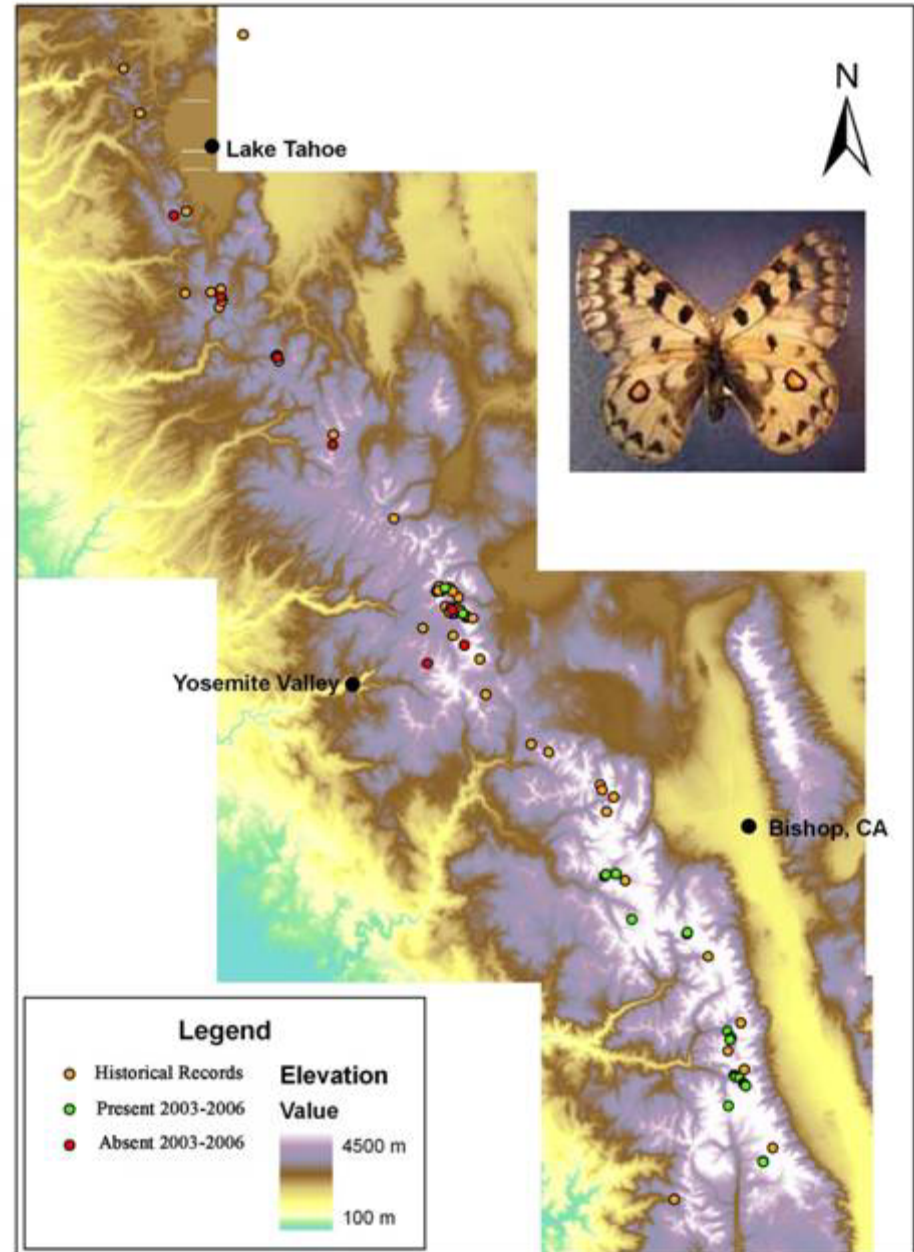
## Occupancy Modeling

-are there historical changes  
in occurrence?

## Line-transect abundance data

-baseline data for future modeling  
and survey efforts

Figure I: *Parnassius behrii* Occurrence Records



# Acknowledgements- Many thanks!

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- **Butterfly catchers: Sean Rovito, Tina Cheng, Becky Chong, Vance Vredenburg, Dave Daversa, Tate Tunstall, Stephanie Schoville, Matt Medeiros**

**View from Milly's Footpass**



My favorite...

# The Far Side®

