California Landscape Conservation Cooperative Webinar Series

CaliforniaLCC.org

Today's guest presenters –
Toni Lyn Morelli and Sean P. Maher, Museum of Vertebrate Zoology, University of California Berkeley

Topic: "Determining Landscape Connectivity and Climate Change Refugia Across the Sierra Nevada"

For audio, please call: 866-737-4154 Passcode: 6437042#

Webinar will begin shortly. Please mute your phone.

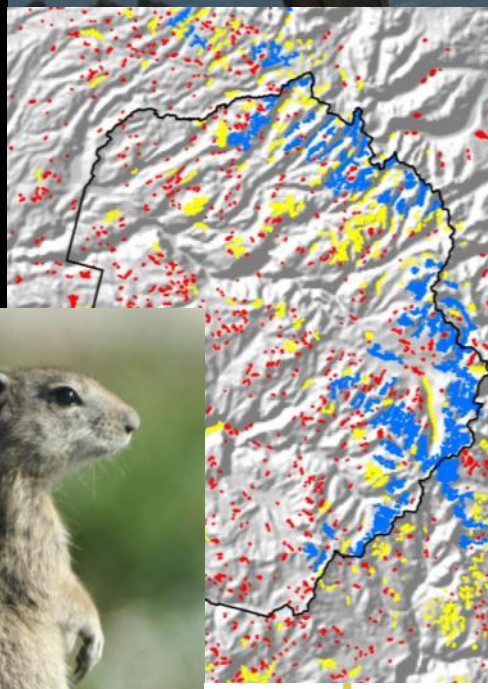
August 20, 2013

Determining Landscape Connectivity and Climate Change Refugia Across the Sierra Nevada

Toni Lyn Morelli[1,2] & Sean P. Maher[1,5]

with Craig Moritz[4], Steven R. Beissinger[5], Michelle Hershey[1], Marisa Lim[1], Christina Kastely[1], Lindsey Eastman[1], Alan L. Flint[3] & Lorraine E. Flint[3]

[1] MVZ, UC Berkeley
[2] Northeast Climate Science Center, UMass
[3] USGS, Sacramento CA
[4] RSB, ANU, Canberra
[5] ESPM, UC Berkeley



Outline

- Biological and Management Relevant Context
  - Climate Change Refugia
  - Metapopulation dynamics
  - California climate change trends
- Research Objectives
- Patterns of Connectivity in Meadows
  - How Sierra Nevada meadows have changed and will change
- Refugia Mapped
- Maps Tested – Montane Mammal Data
- Implications for Management

The Role of Climate Change Refugia

Biological Conservation 142 (2009) 3020–3029

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Biogeography and conservation of taxa from remote regions: An application ecological-niche based models and GIS to North-African Canids

José C. Brito [a,*], André L. Acosta [a], Francisco Álvares [a], Fabrice Cuzin [b]

Journal of Applied Ecology

Journal of Applied Ecology 2008, **45**, 1722–1731 doi: 10.1111/j.1365-2664.2008.01569.x

Adapting landscapes to climate change: examples of climate-proof ecosystem networks and priority adaptation zones

Claire C. Vos[1*], Pam Berry[2], Paul Opdam[1,3], Hans Baveco[1], Bianca Nijhof[1], Jesse O'Hanley[2]†,

The Role of Climate Change Refugia

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2012) **21**, 393–404

RESEARCH REVIEWS

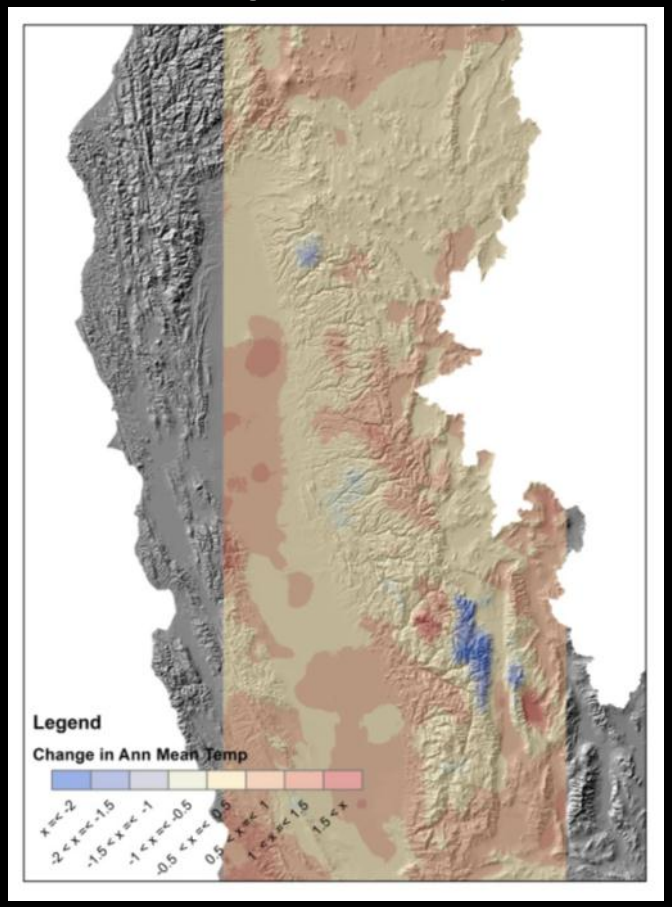
Refugia: identifying and understanding safe havens for biodiversity under climate change

Gunnar Keppel[1]*, Kimberly P. Van Niel[2], Grant W. Wardell-Johnson[1], Colin J. Yates[3], Margaret Byrne[3], Ladislav Mucina[1], Antonius G. T. Schut[1], Stephen D. Hopper[4] and Steven E. Franklin[5]

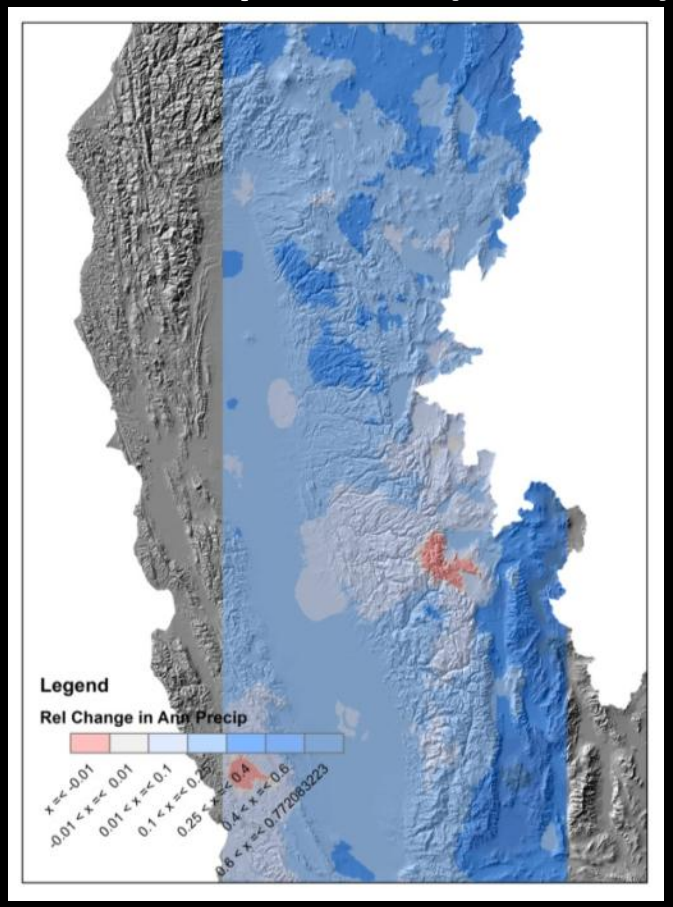
"Refugia are habitats that components of biodiversity retreat to, persist in and can potentially expand from under changing environmental conditions…applicable to biodiversity under potential future climates arising from the enhanced greenhouse effect."

Climate change in 20th Century

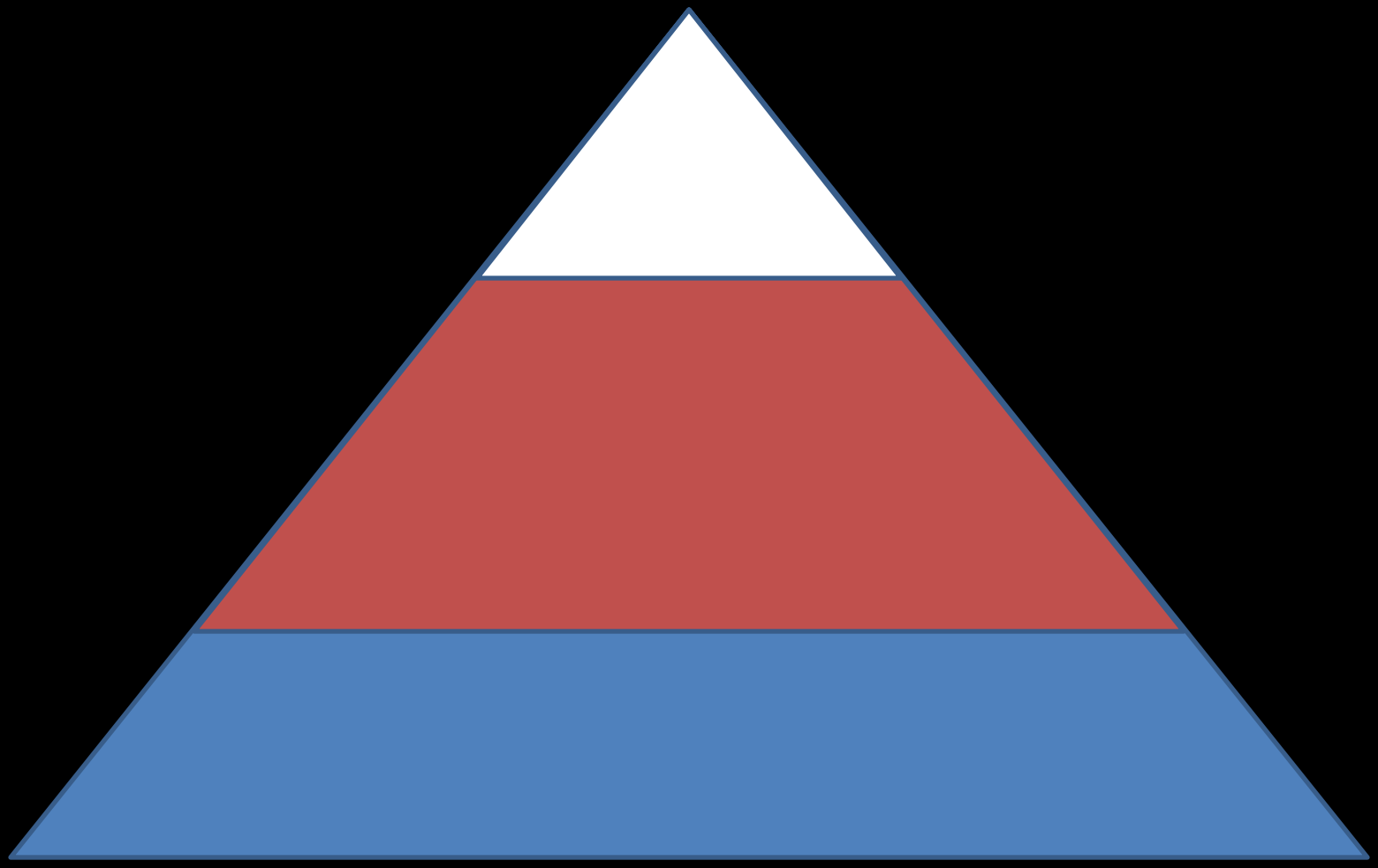
Annual Temperature (Actual)

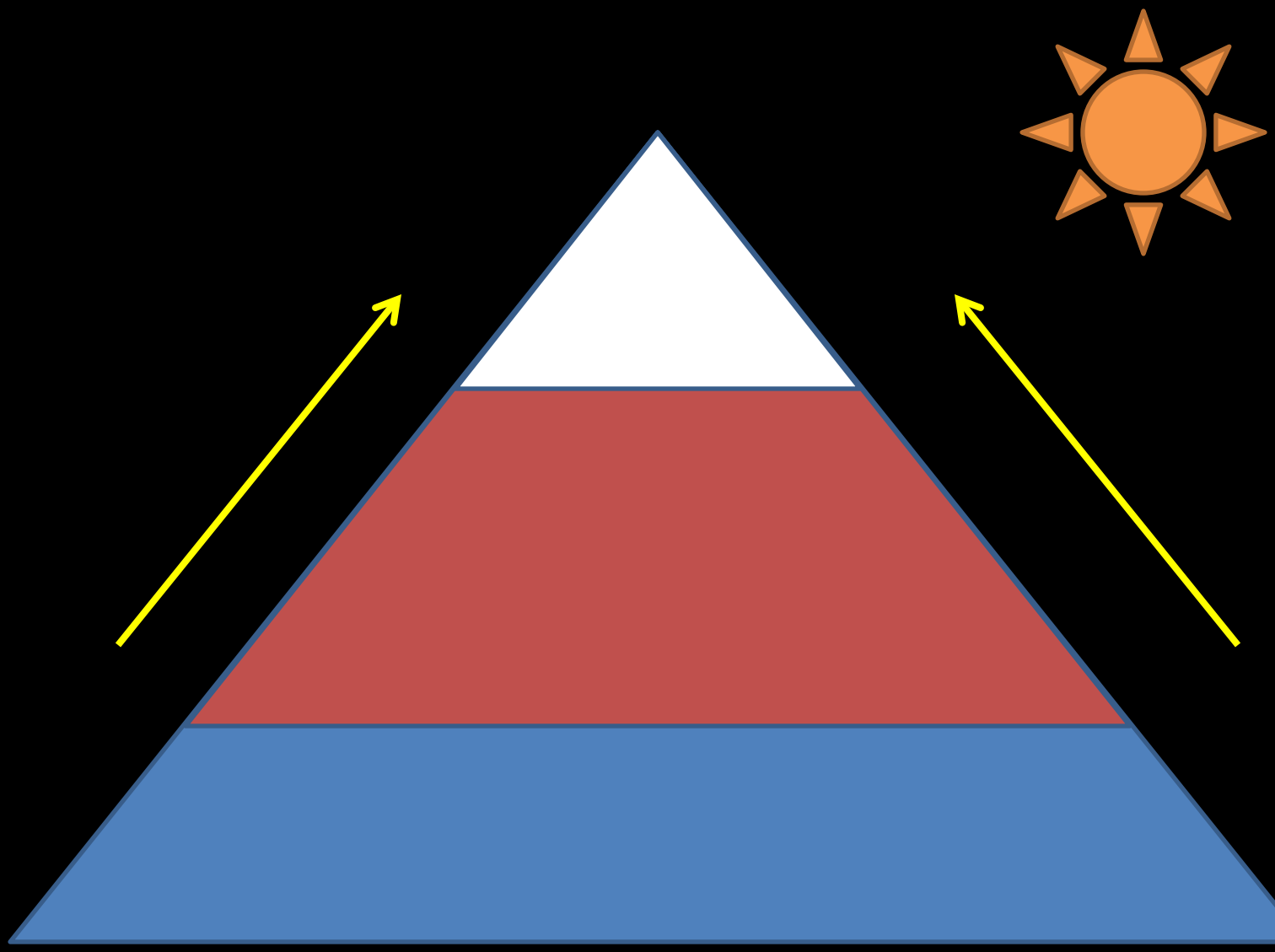


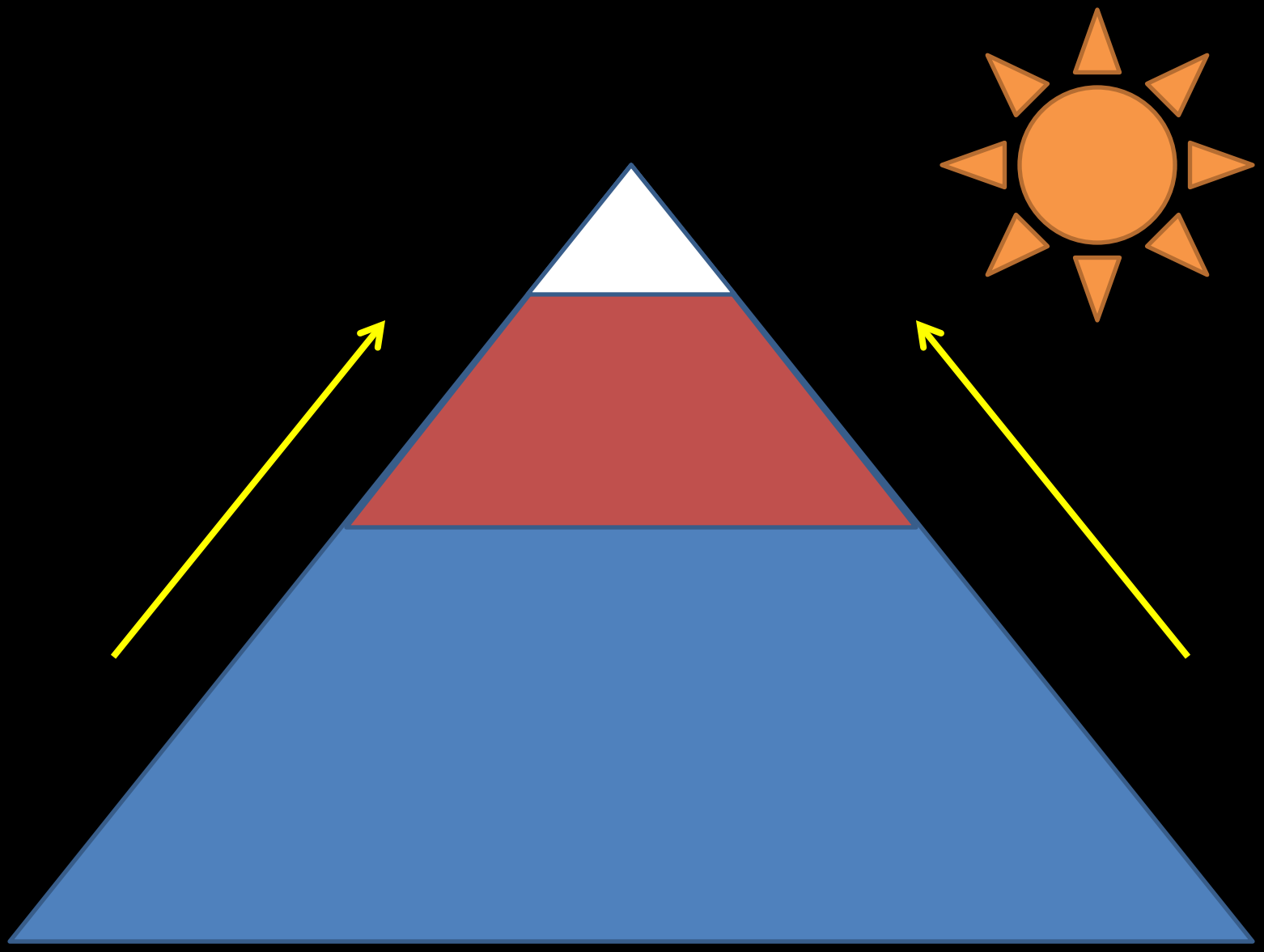
Annual Precipitation (Relative)



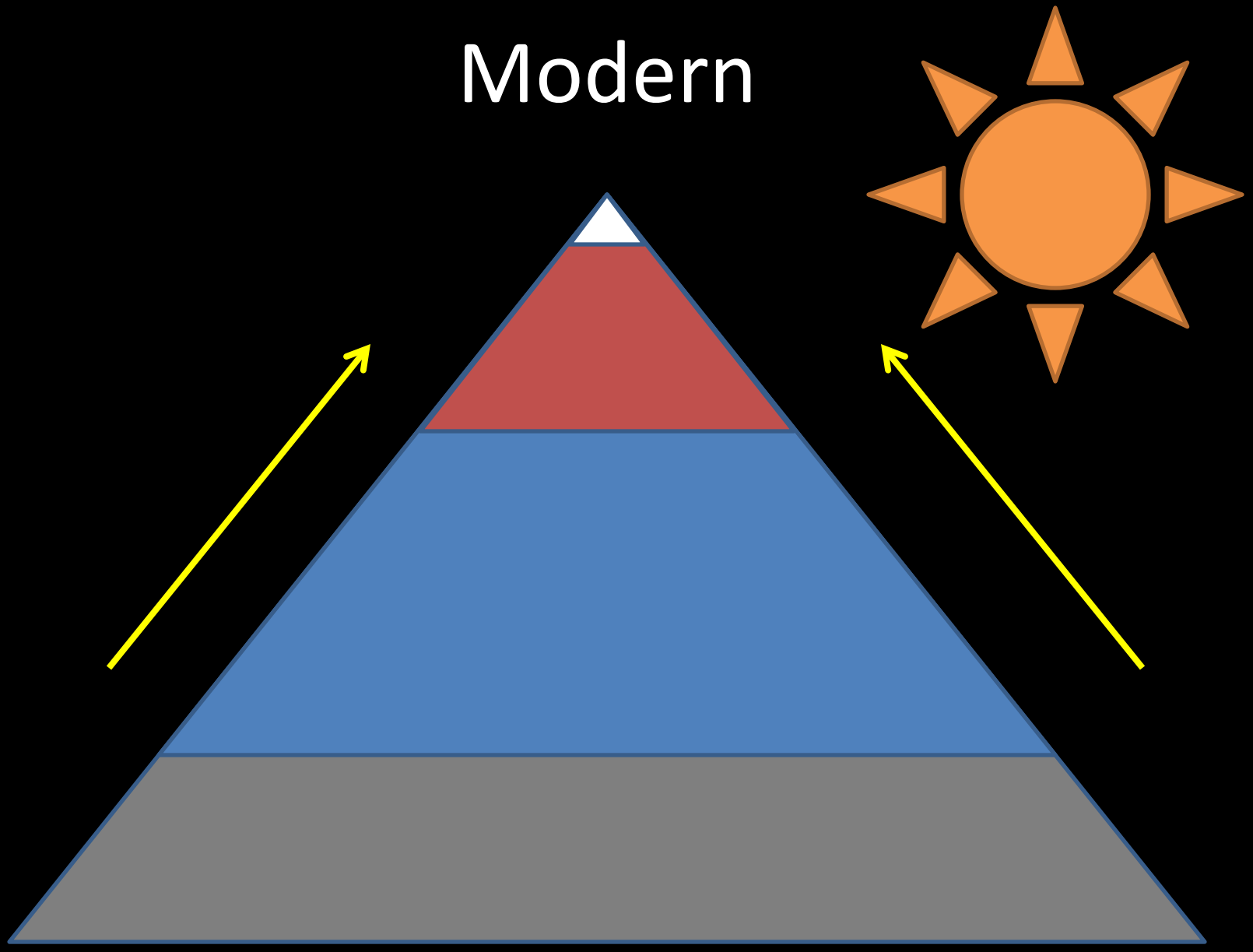
Historic





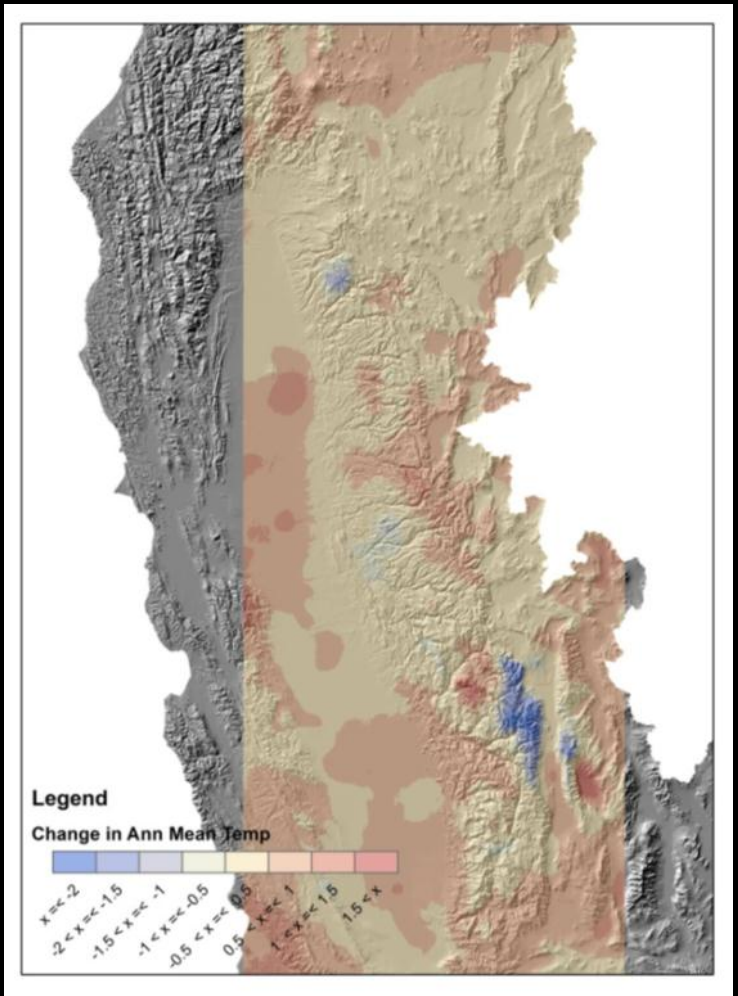


Modern

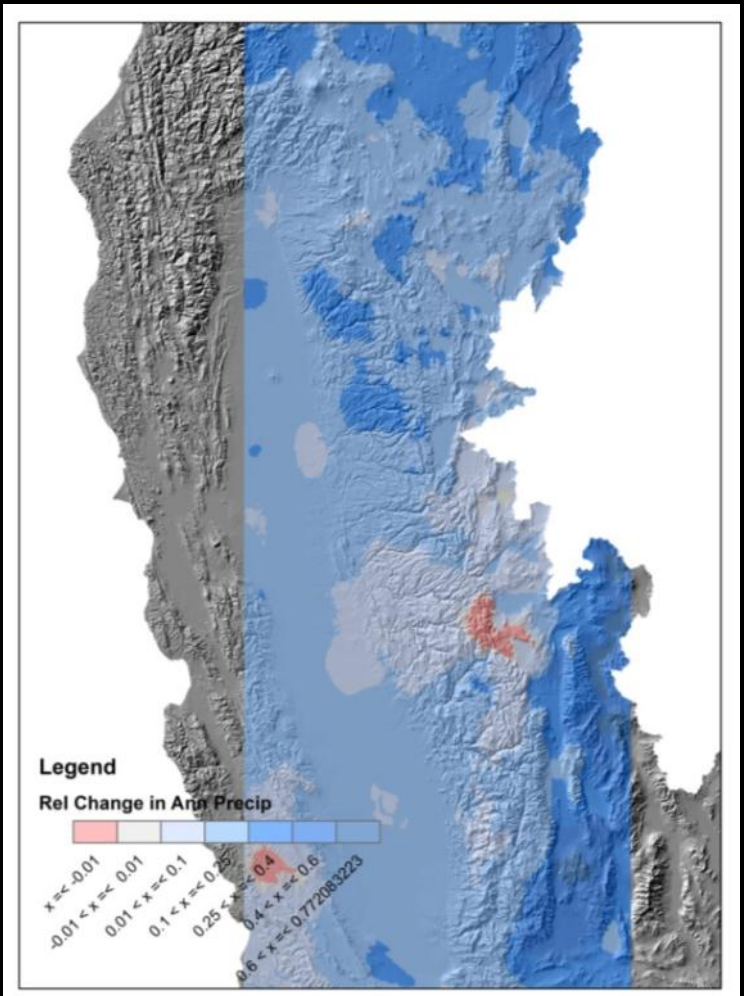


Climate change in 20th Century

Annual Temperature (Actual)

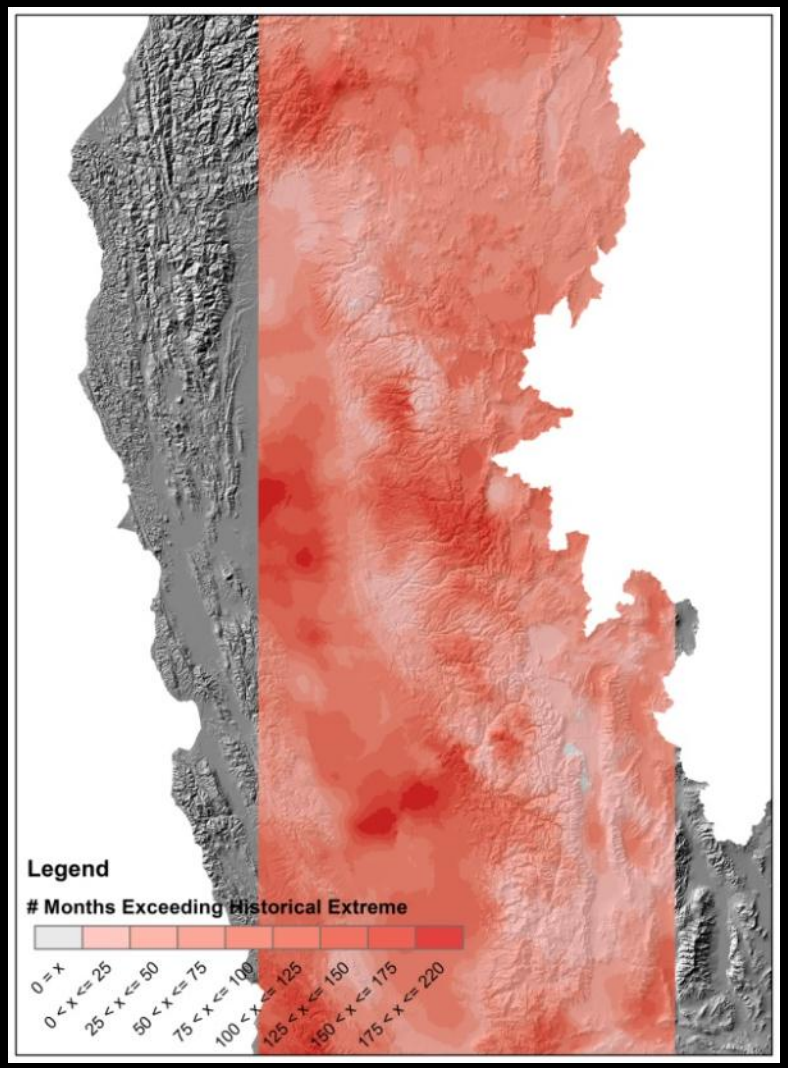


Annual Precipitation (Relative)

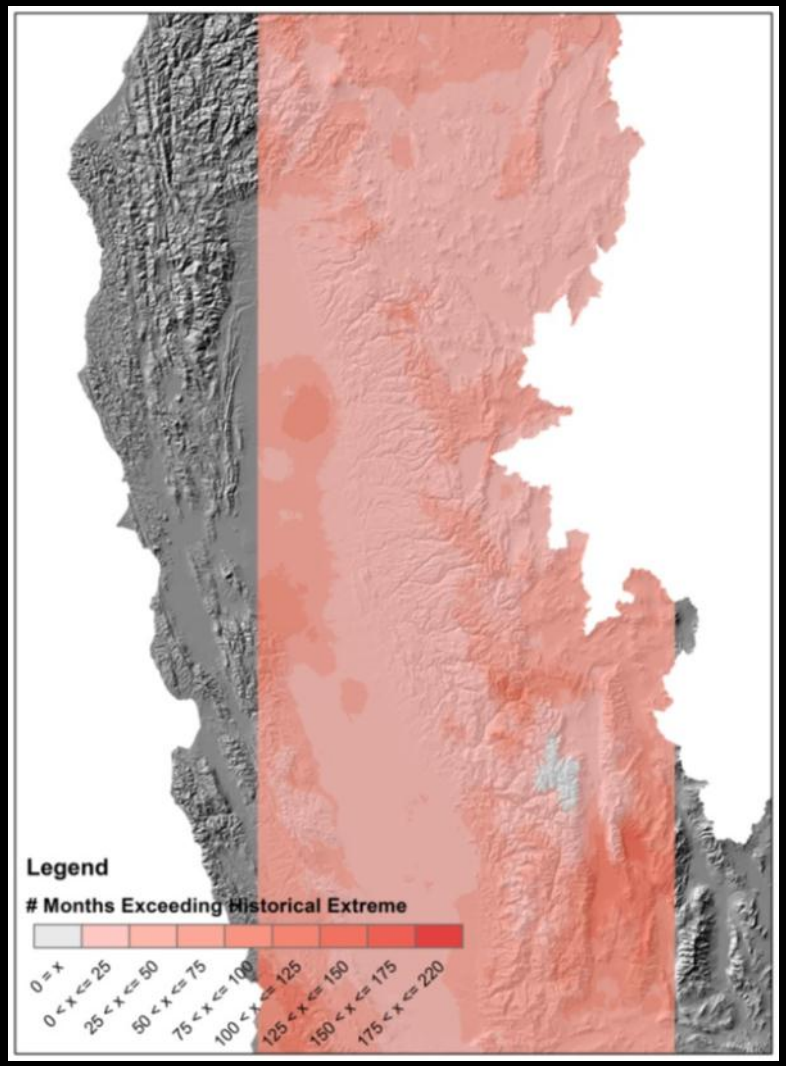


Do patterns differ between variables?

Minimum Temp

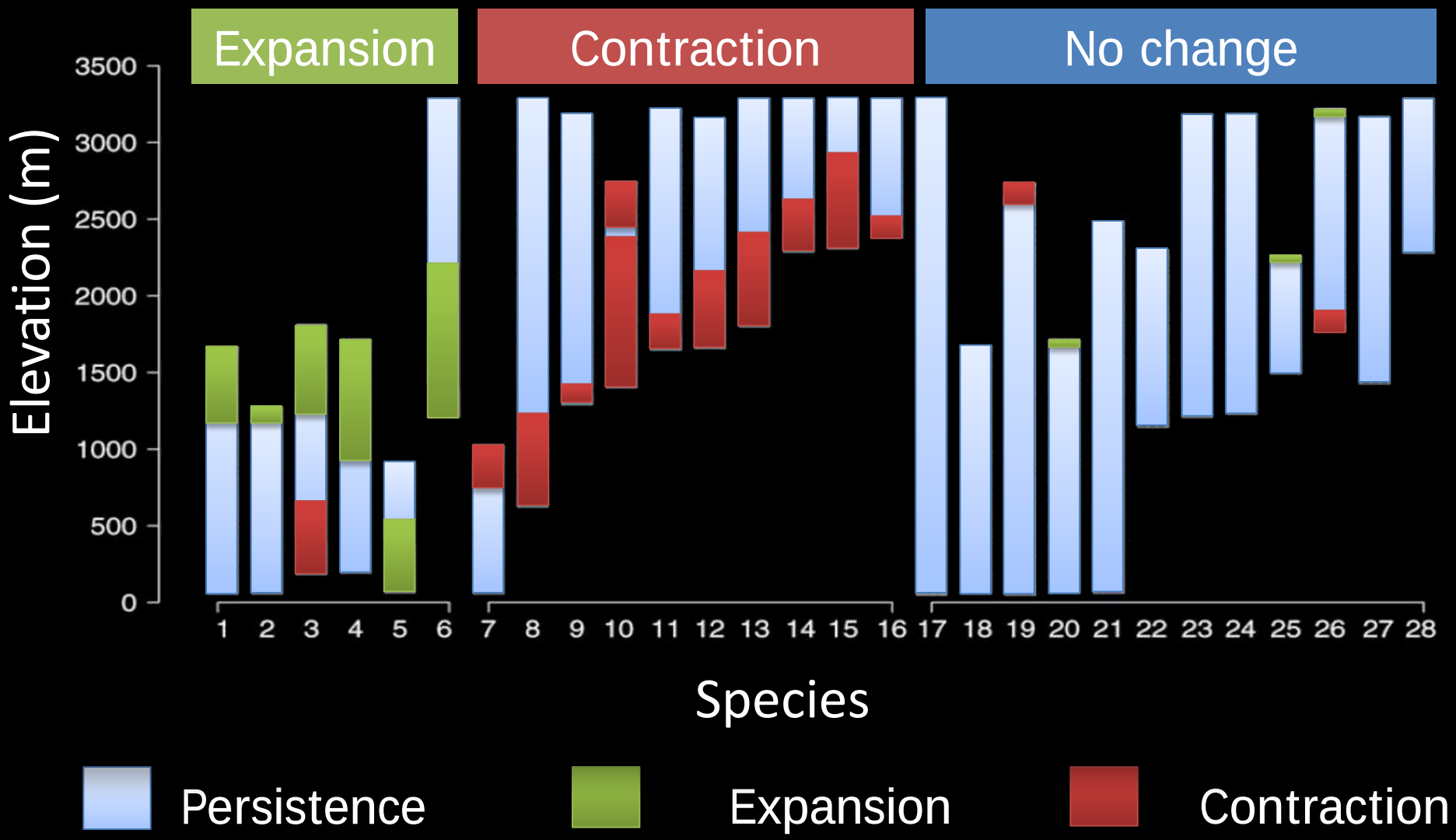


Maximum Temp

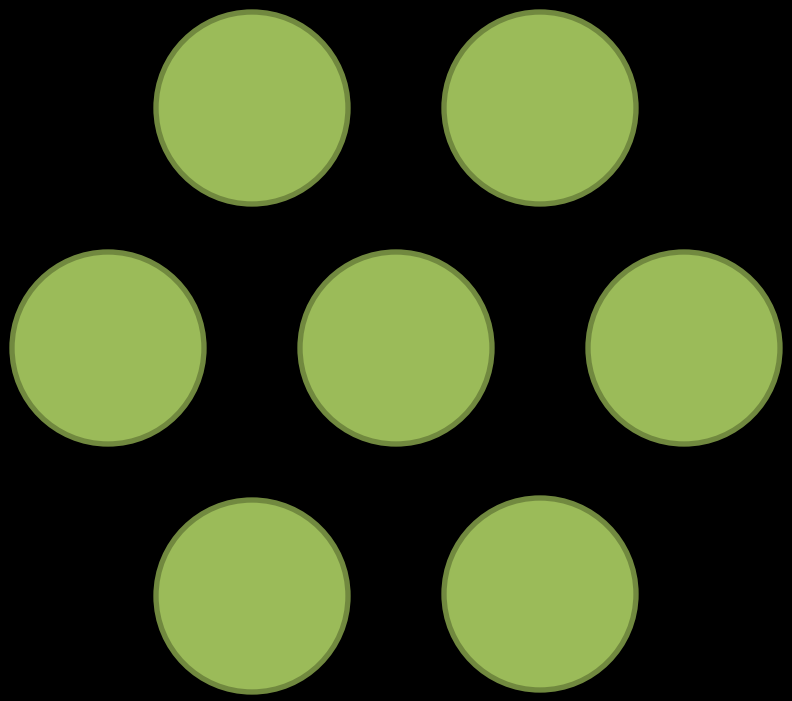


Moritz et al. 2008
Science

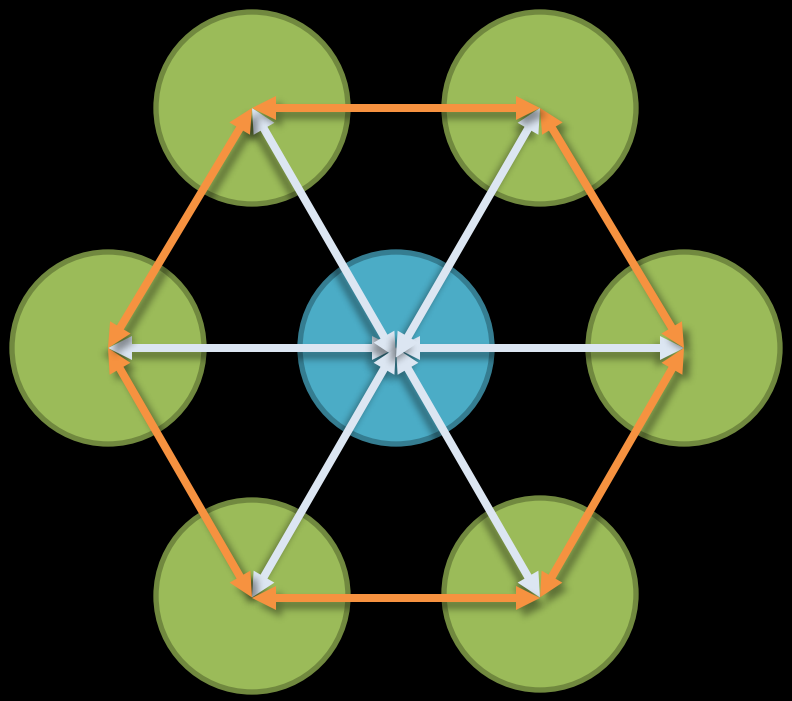
Grinnell Resurvey Project



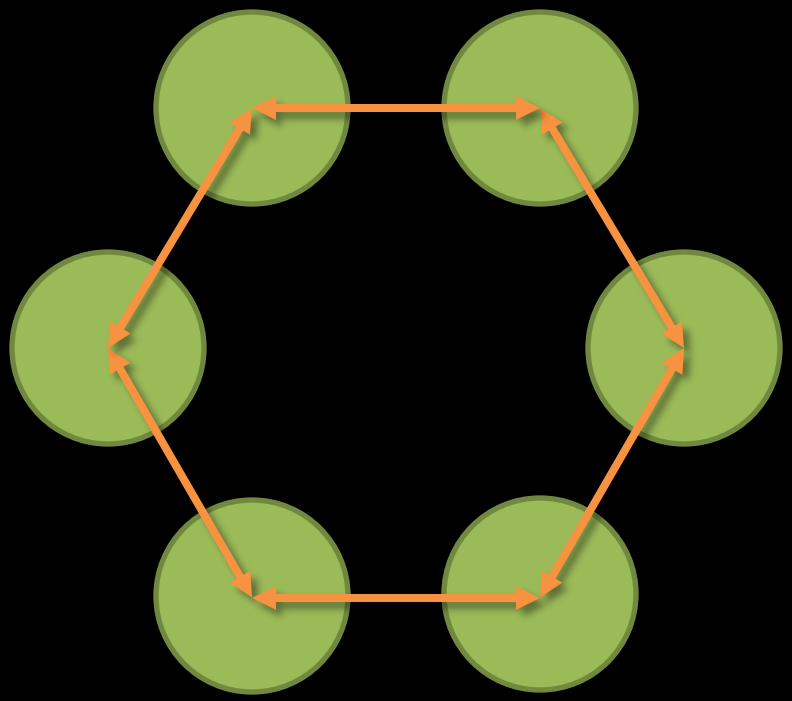
Metapopulations and connectivity



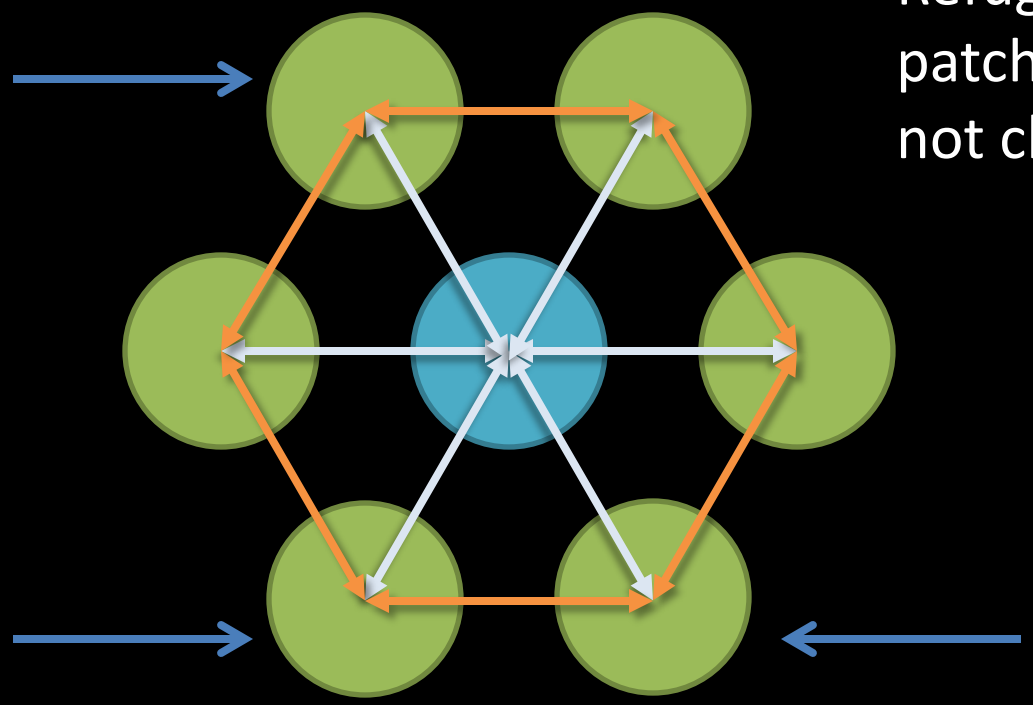
Metapopulations and connectivity



Metapopulations and connectivity

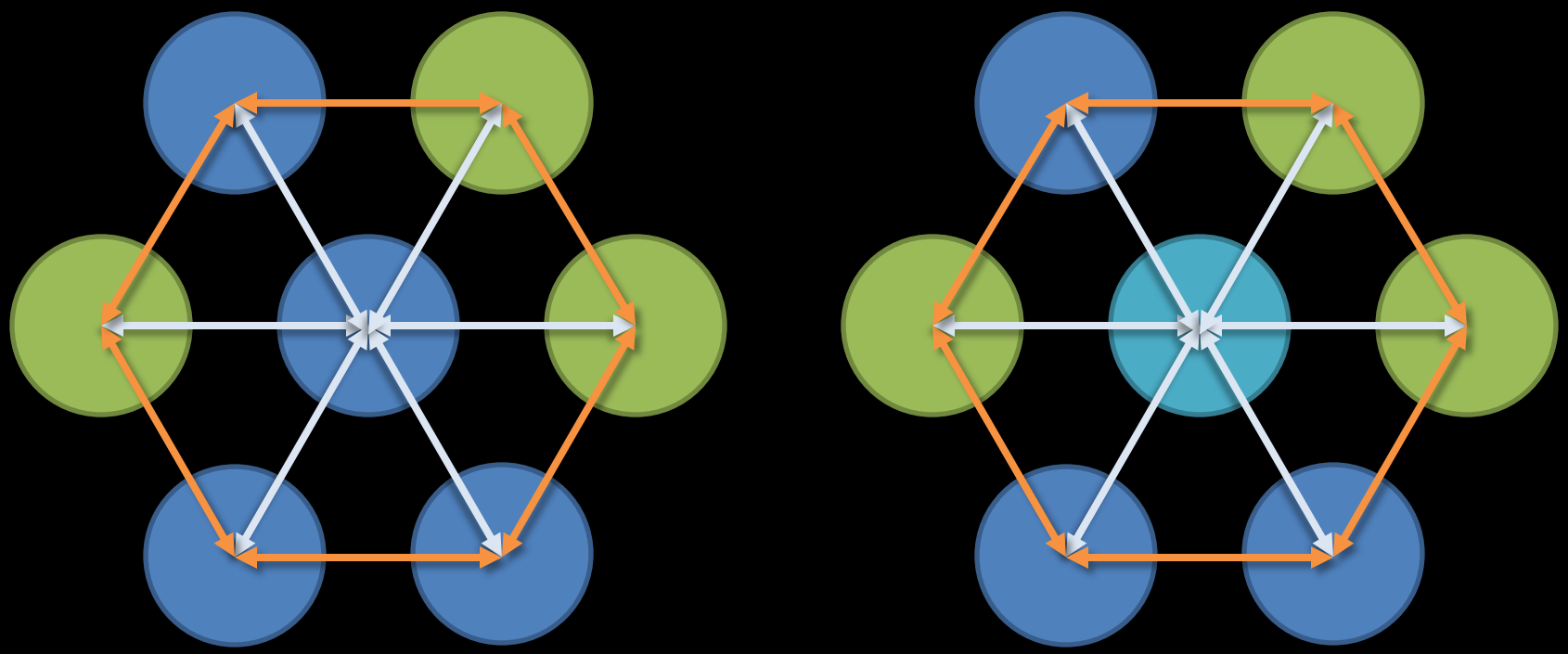


Refugia and connectivity

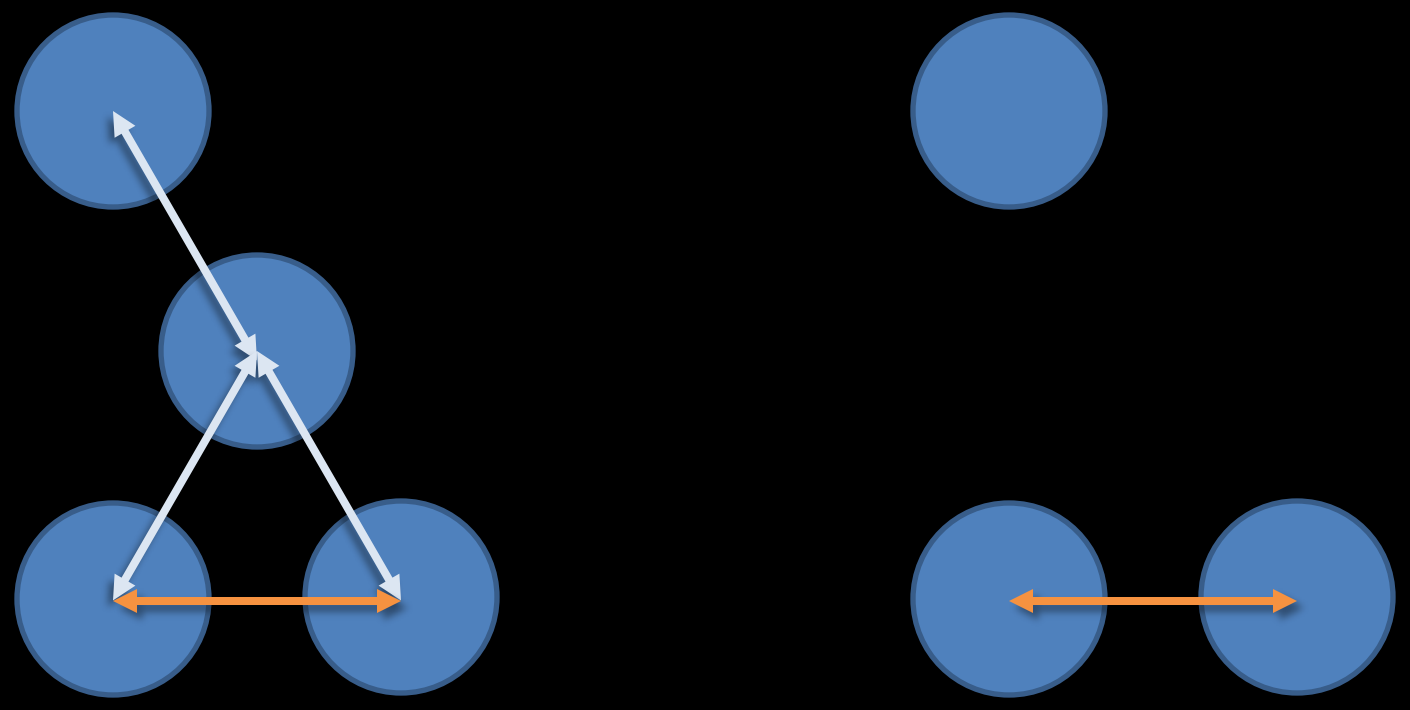


Refugia defined as patches that do not change (a lot)

Refugia and connectivity



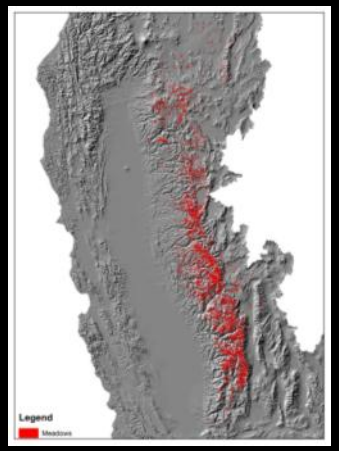
Refugia and connectivity

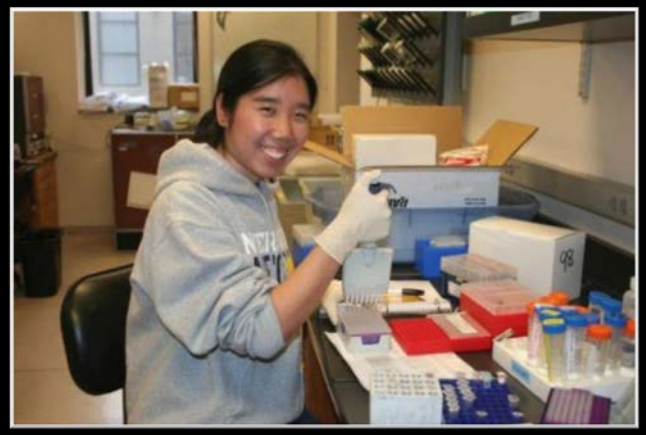


Well-connected refugial sites are likely to be important for occupancy of populations and gene flow

PROJECT OBJECTIVES

- Map hypothetical connectivity of meadows in the Sierra Nevada
- Map hypothetical climate change refugia in the Sierra Nevada
- TEST mapped connectivity and refugia using occupancy and genetic data





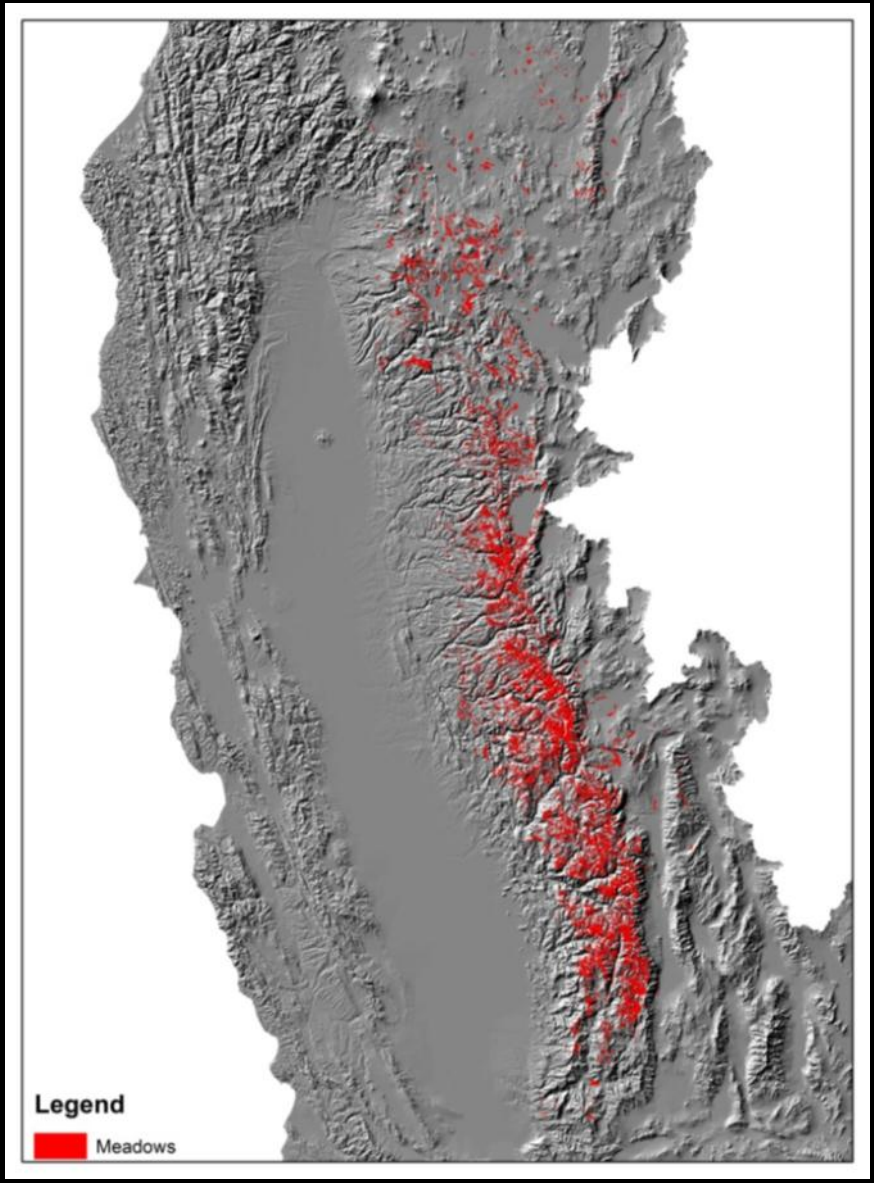
Hypotheses of connectivity to test

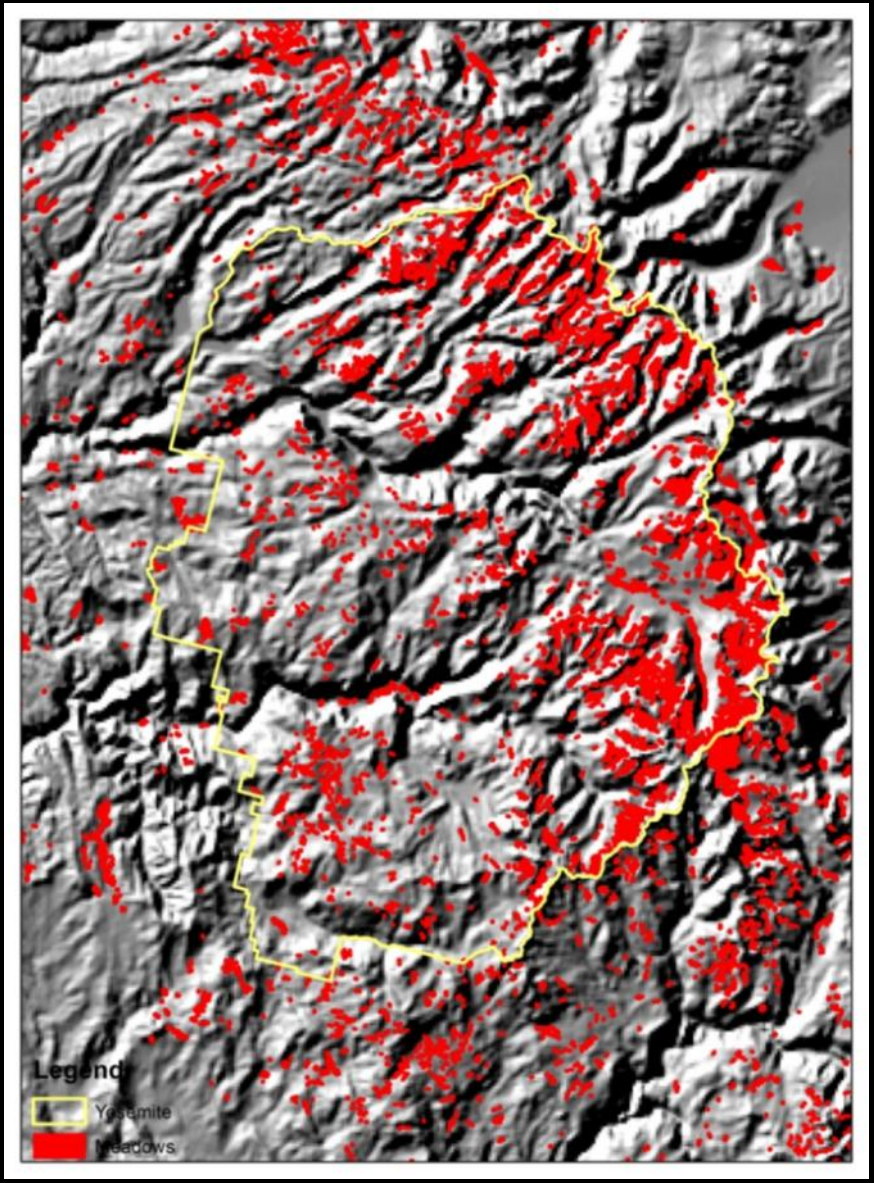
1. Isolation by **distance**
2. Isolation by **topography**
3. Isolation by **watercourses**
4. Isolation by **roads**
5. Isolation by **environmental heterogeneity**

How are meadows connected and how is their environment changing?

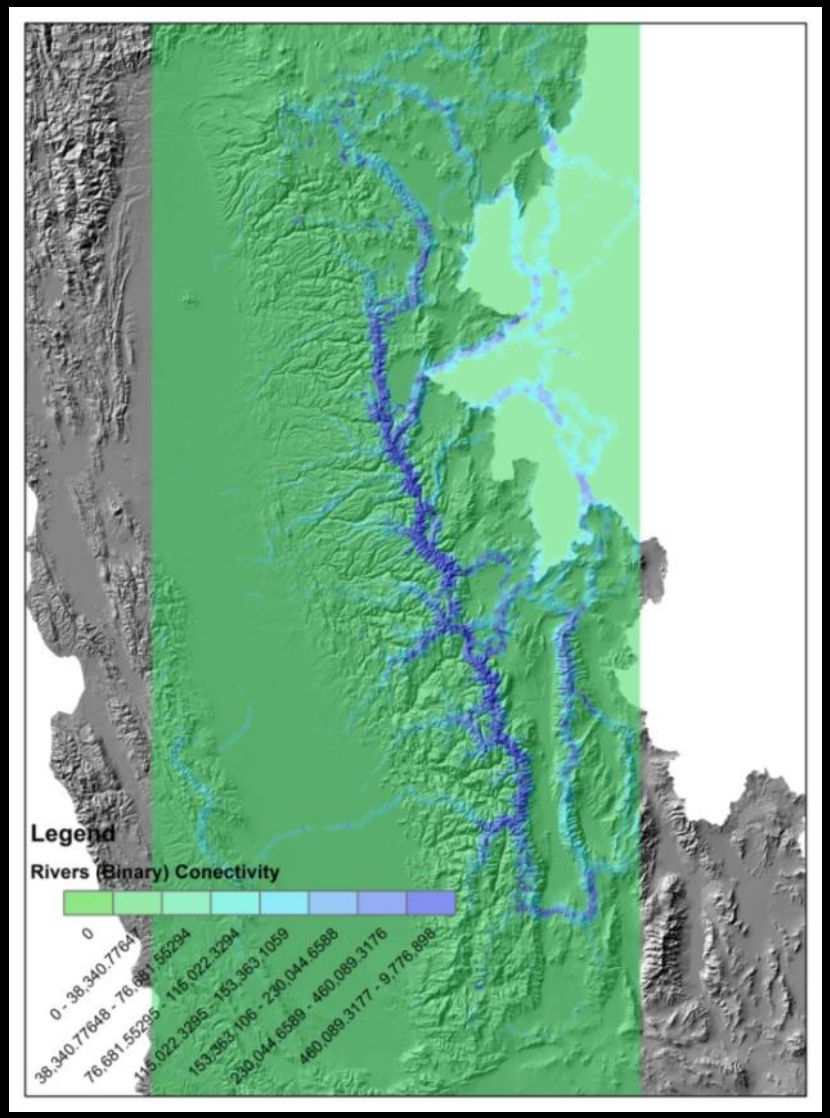
- Spatial layer of meadows – ICE at UC Davis
- Estimate the connectivity between them using Circuitscape based upon resistance and conductance surfaces
- Plotted forward in time to assess how meadows are expected to change

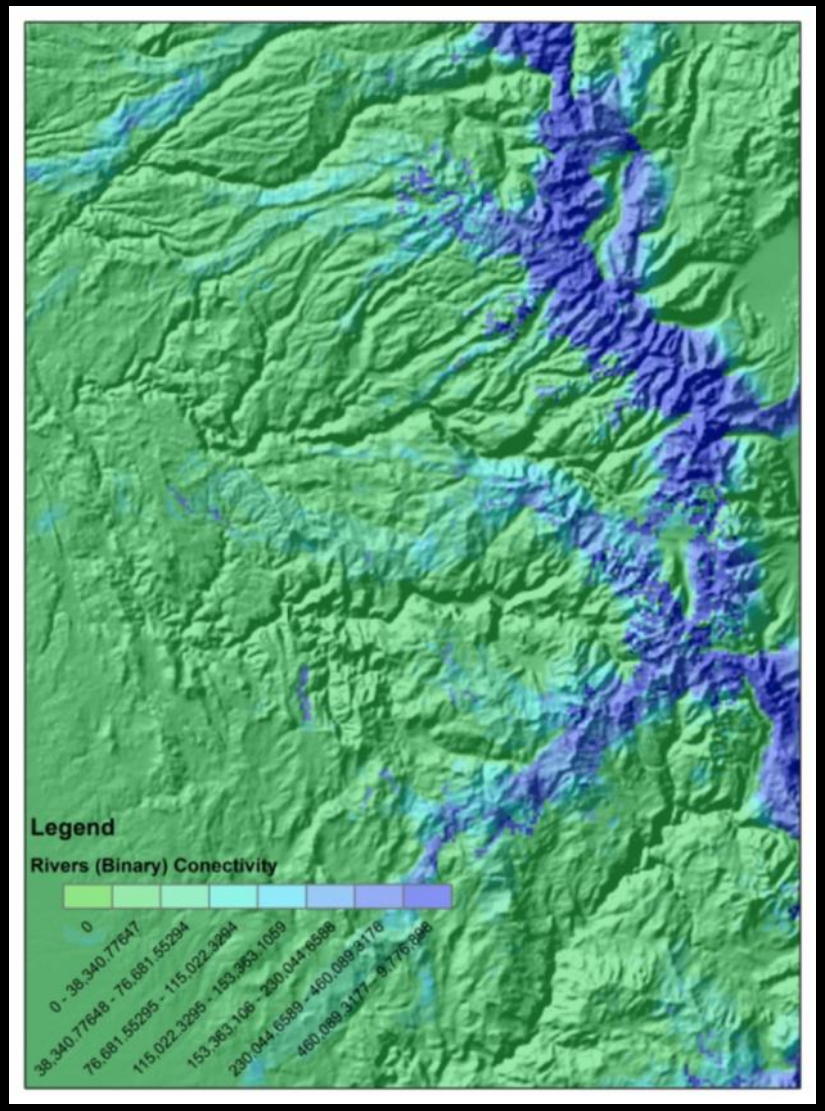
Meadows



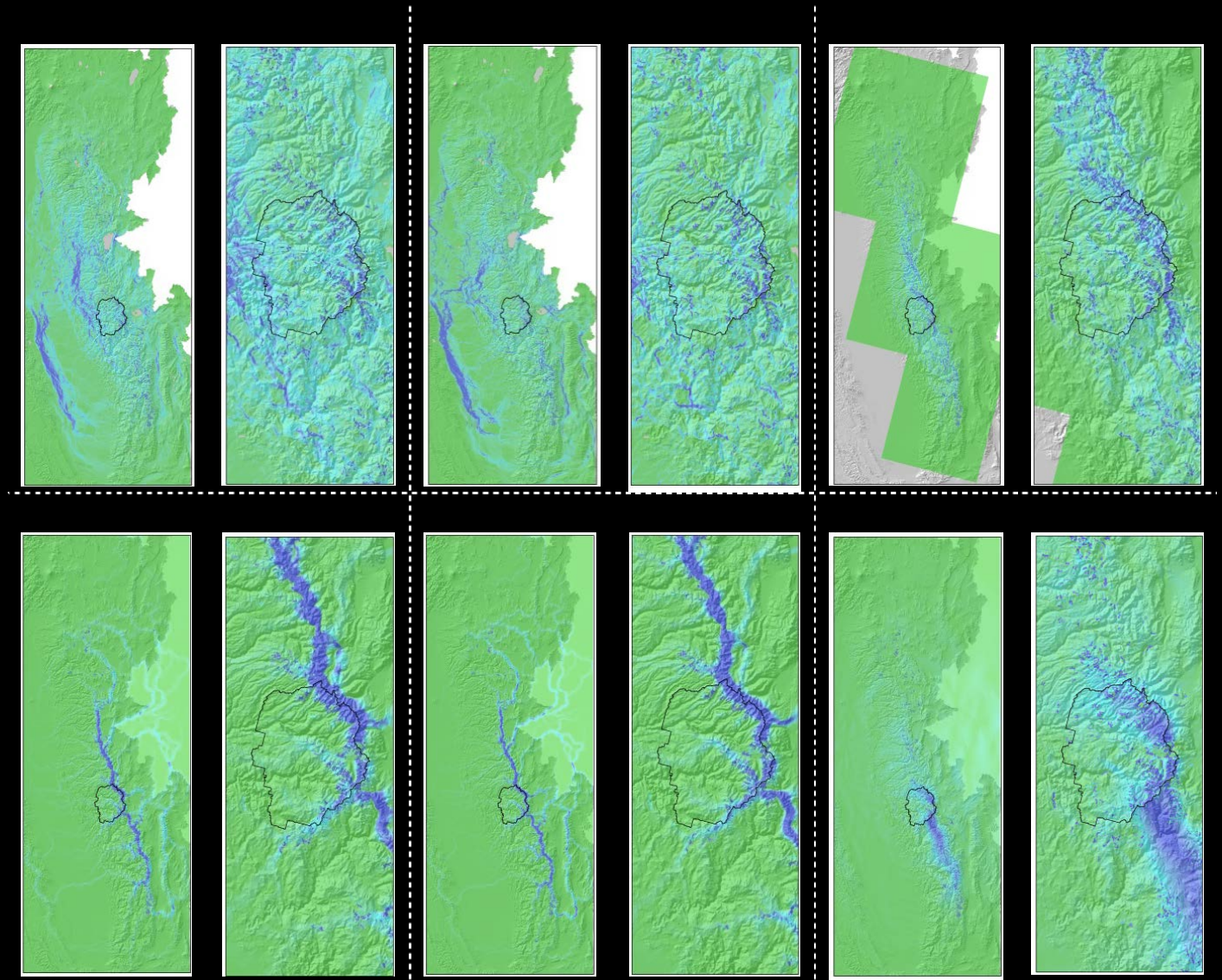


Connectivity based on presence or absence of watercourses (Hyp #3)

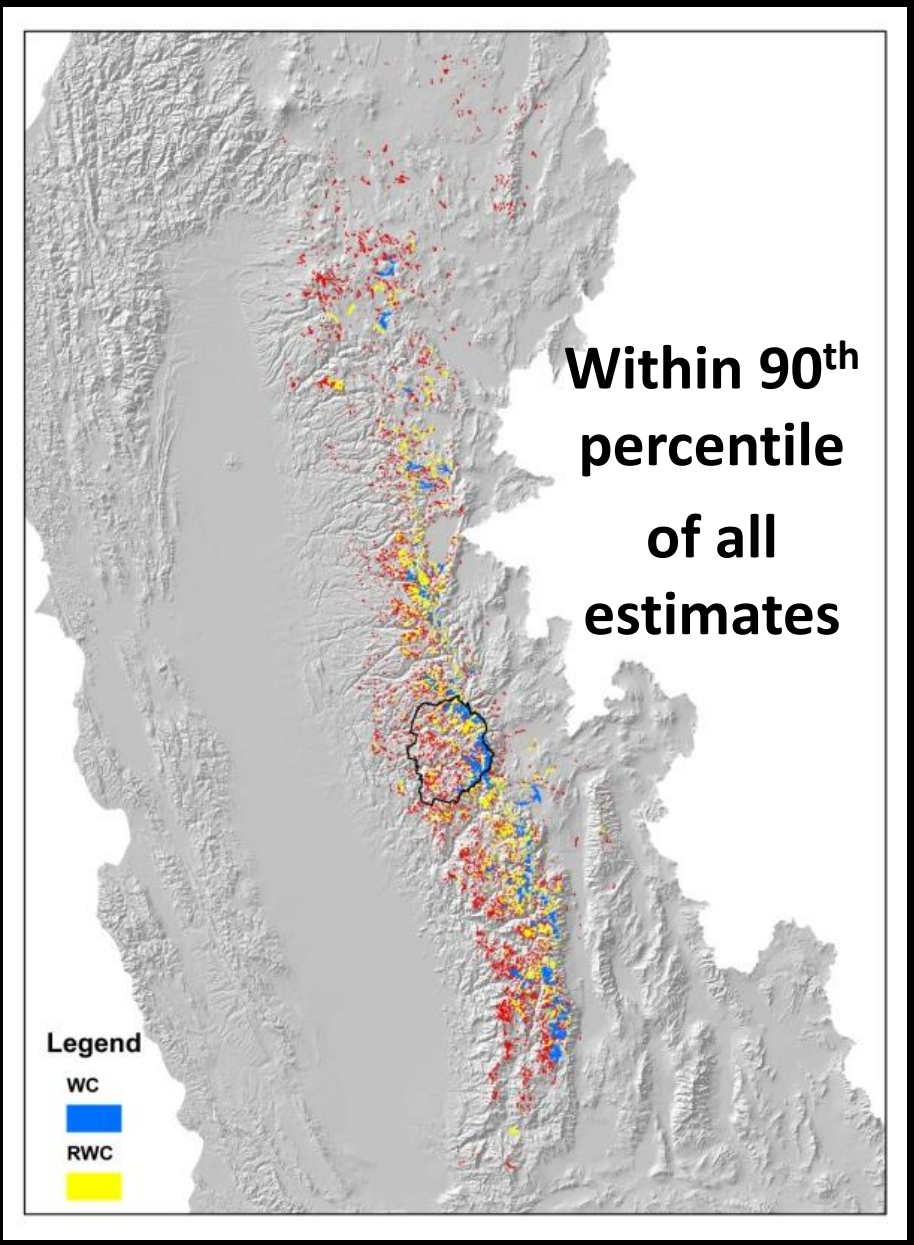


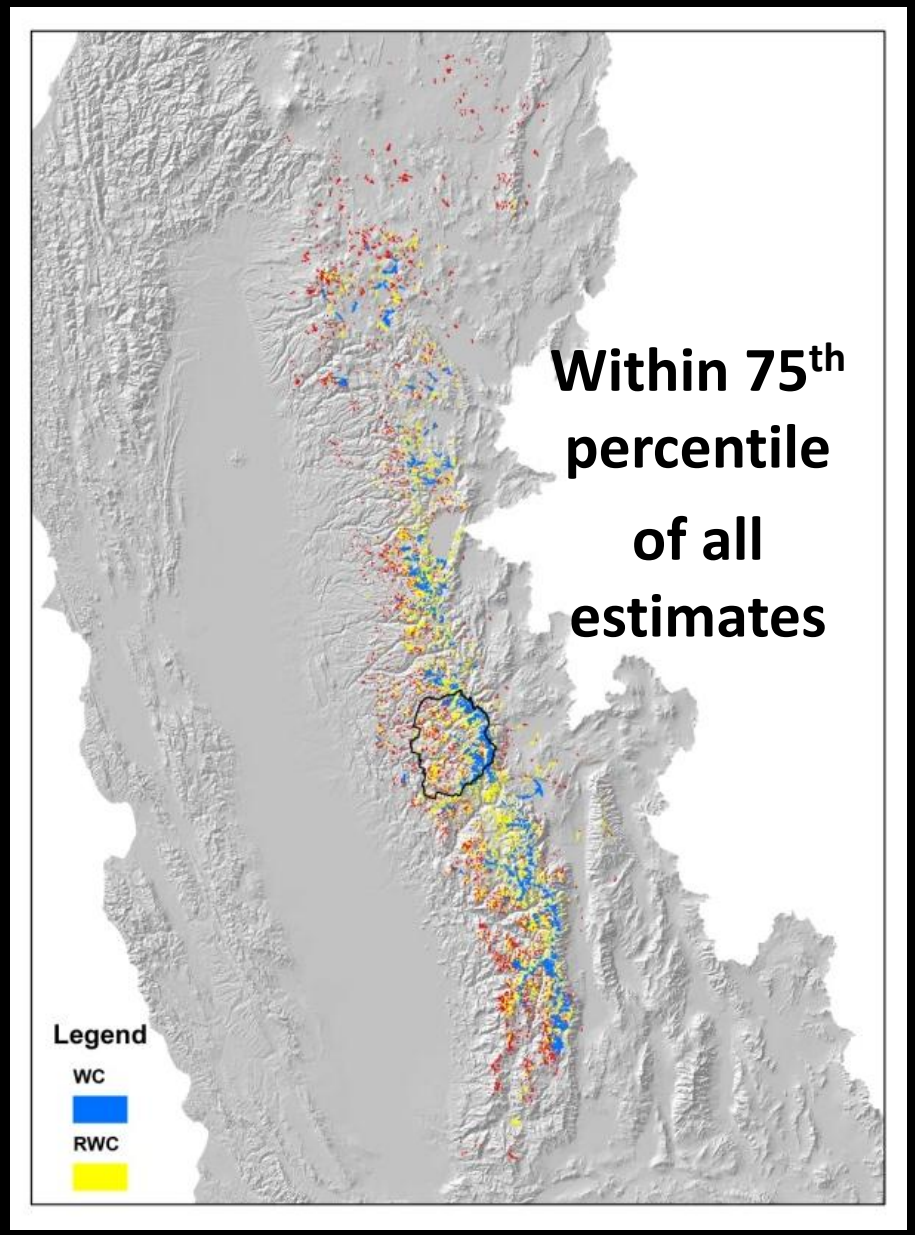


Overall patterns of connectivity depends on surface



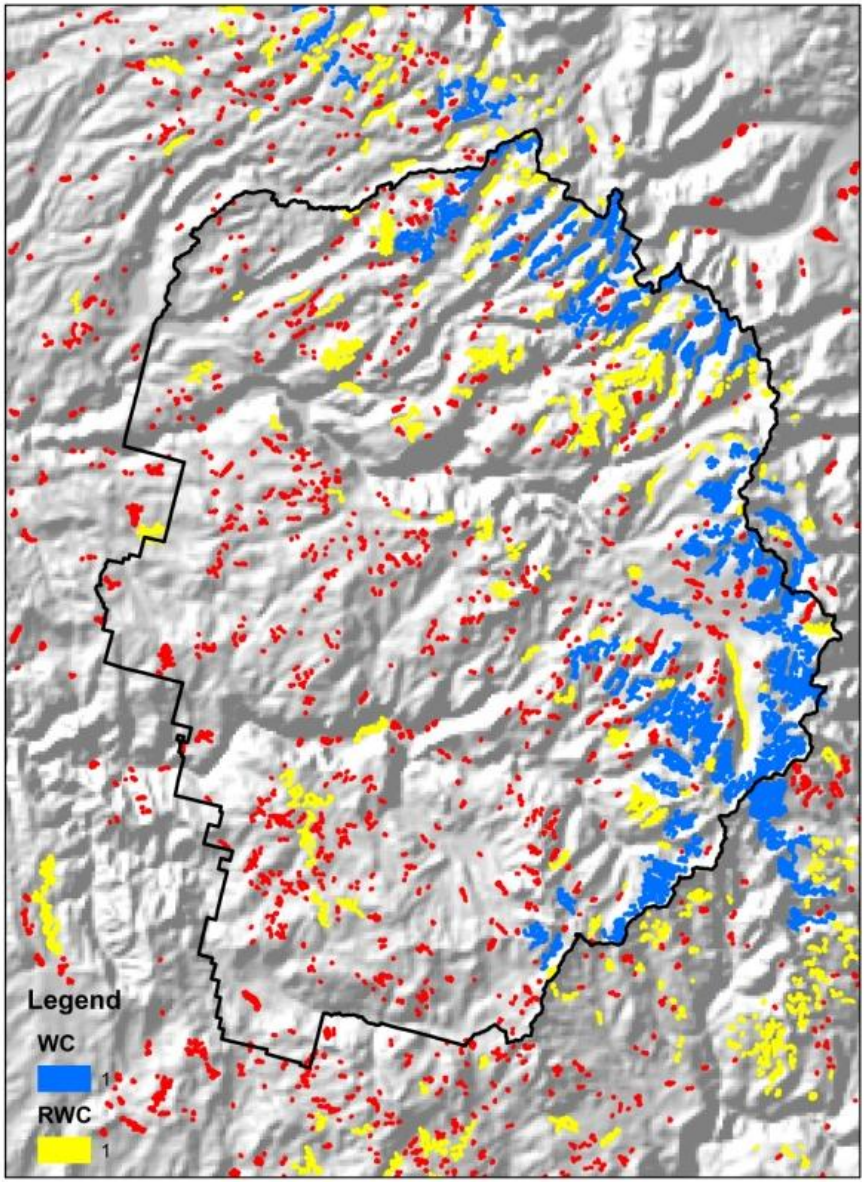
Where are the Well-Connected Meadows?



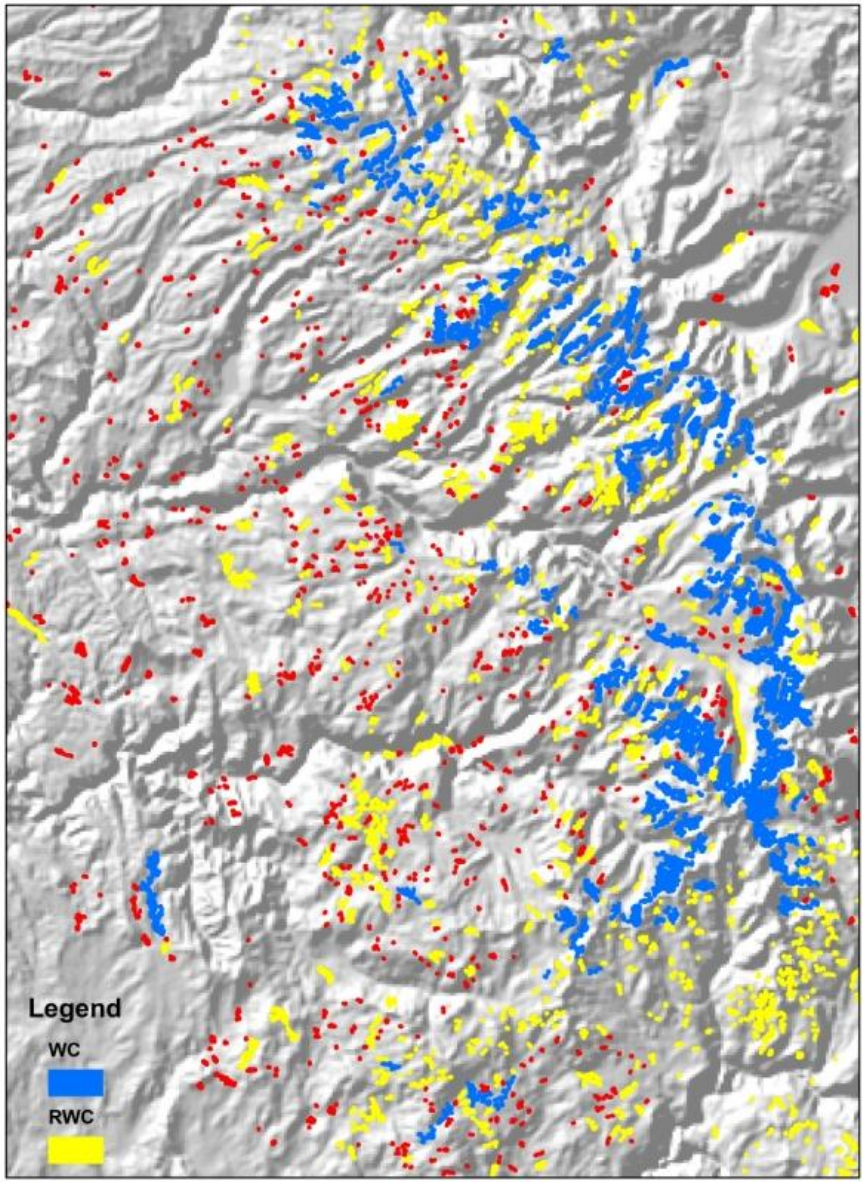


Where are the Well-Connected Meadows?

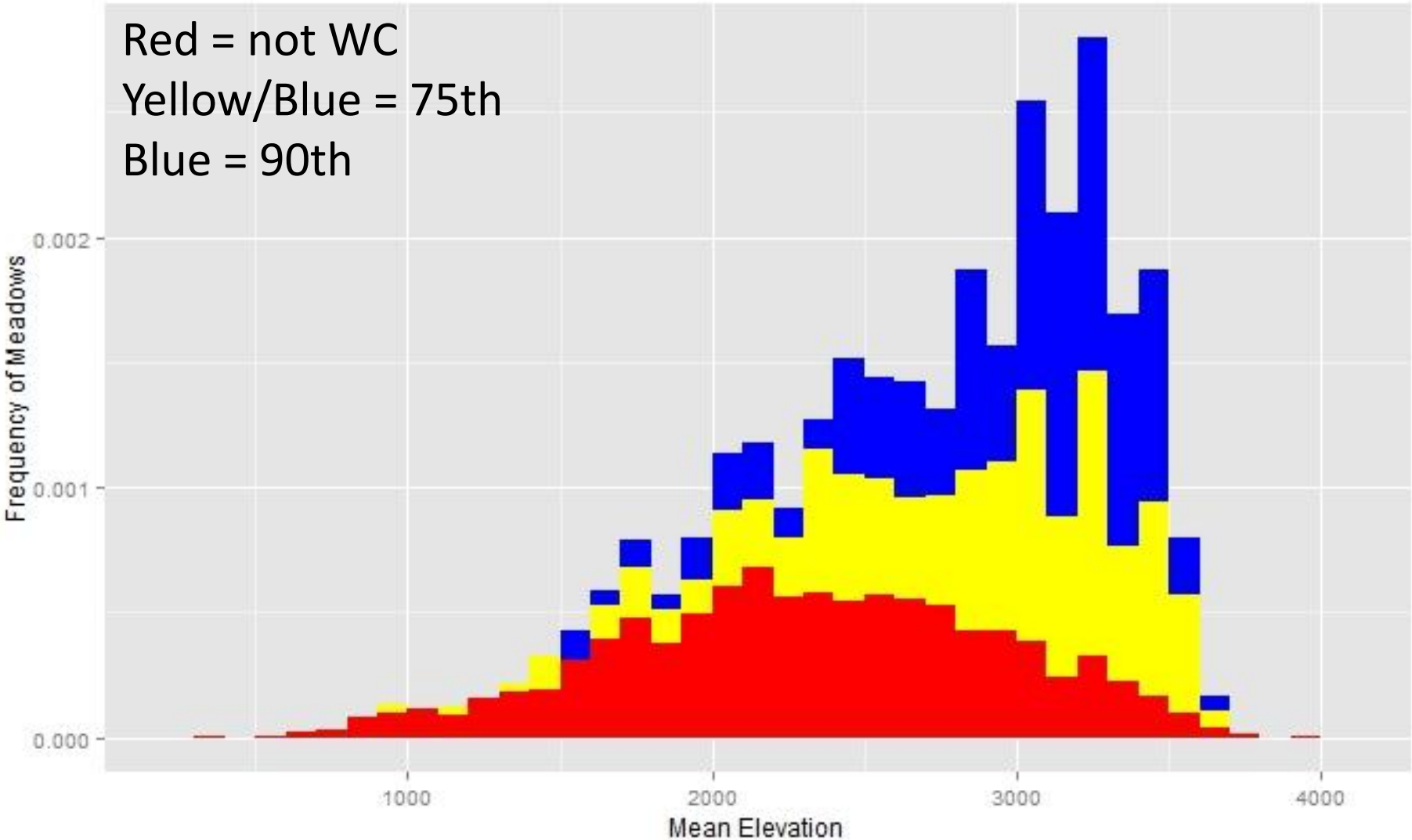
90th Percentile



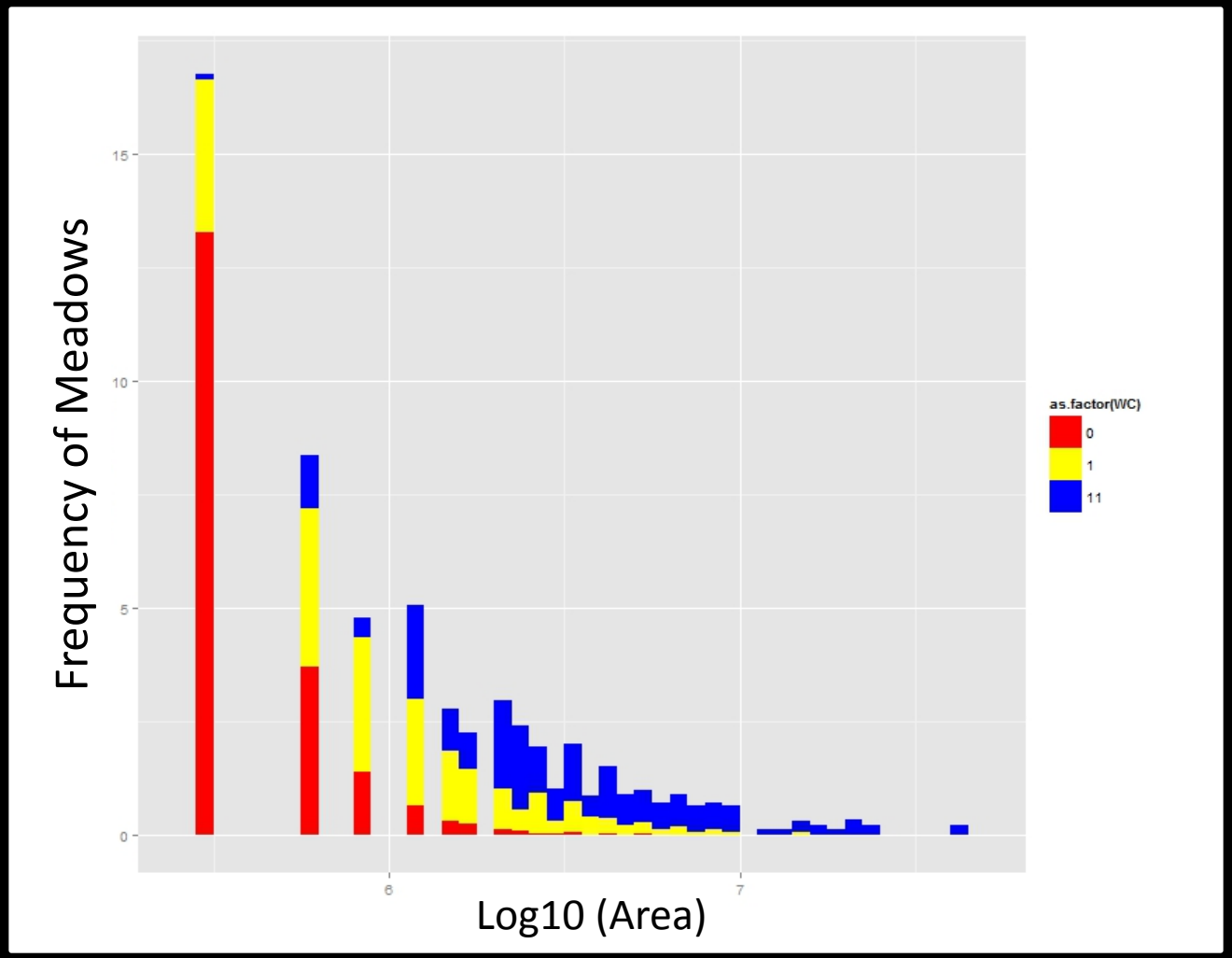
75th Percentile



Are Well-Connected Meadows at higher elevations?

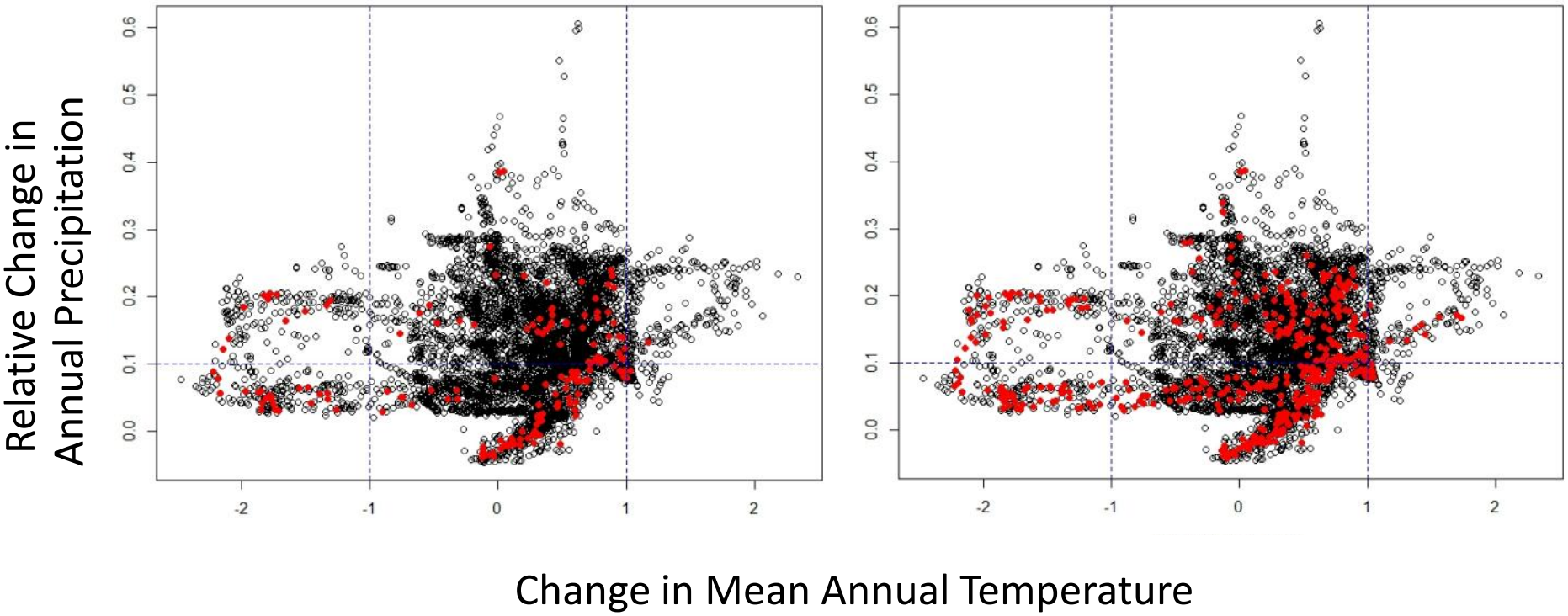


Are larger meadows more connected?



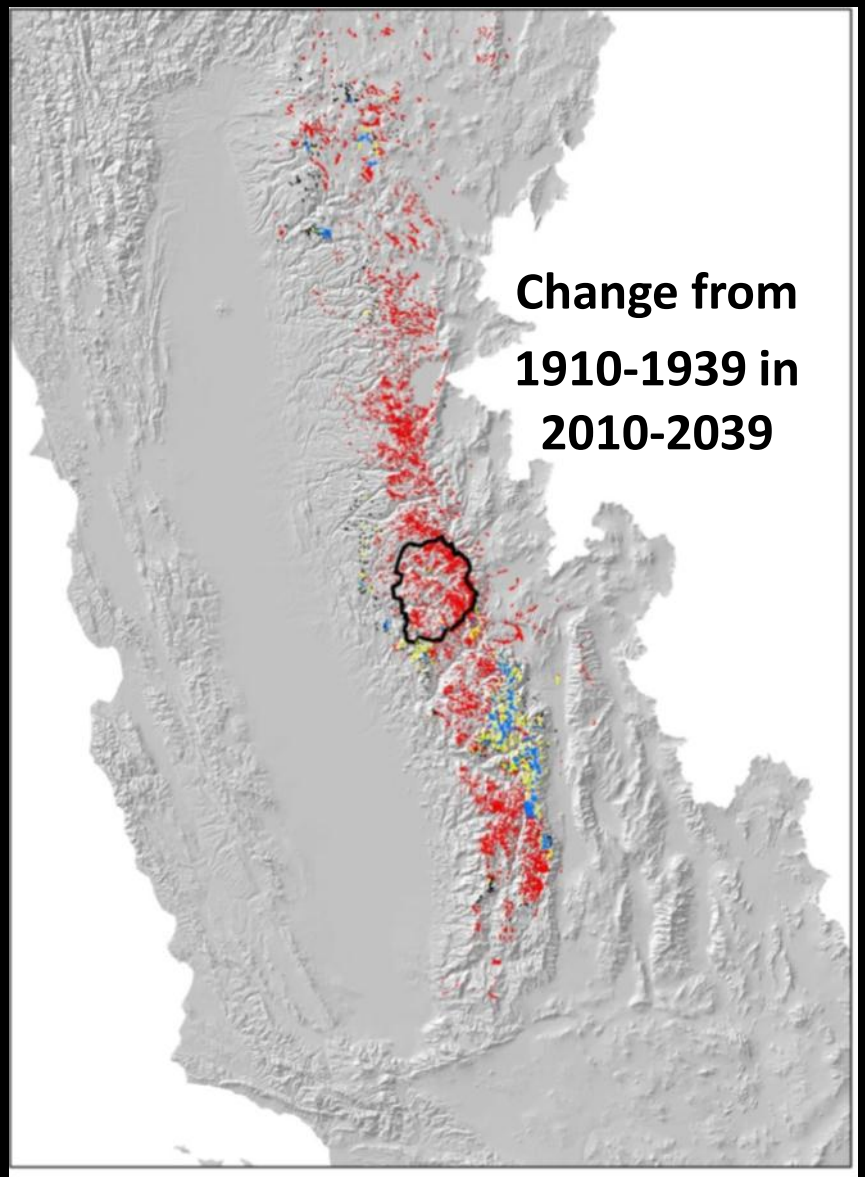
Change within meadows is variable

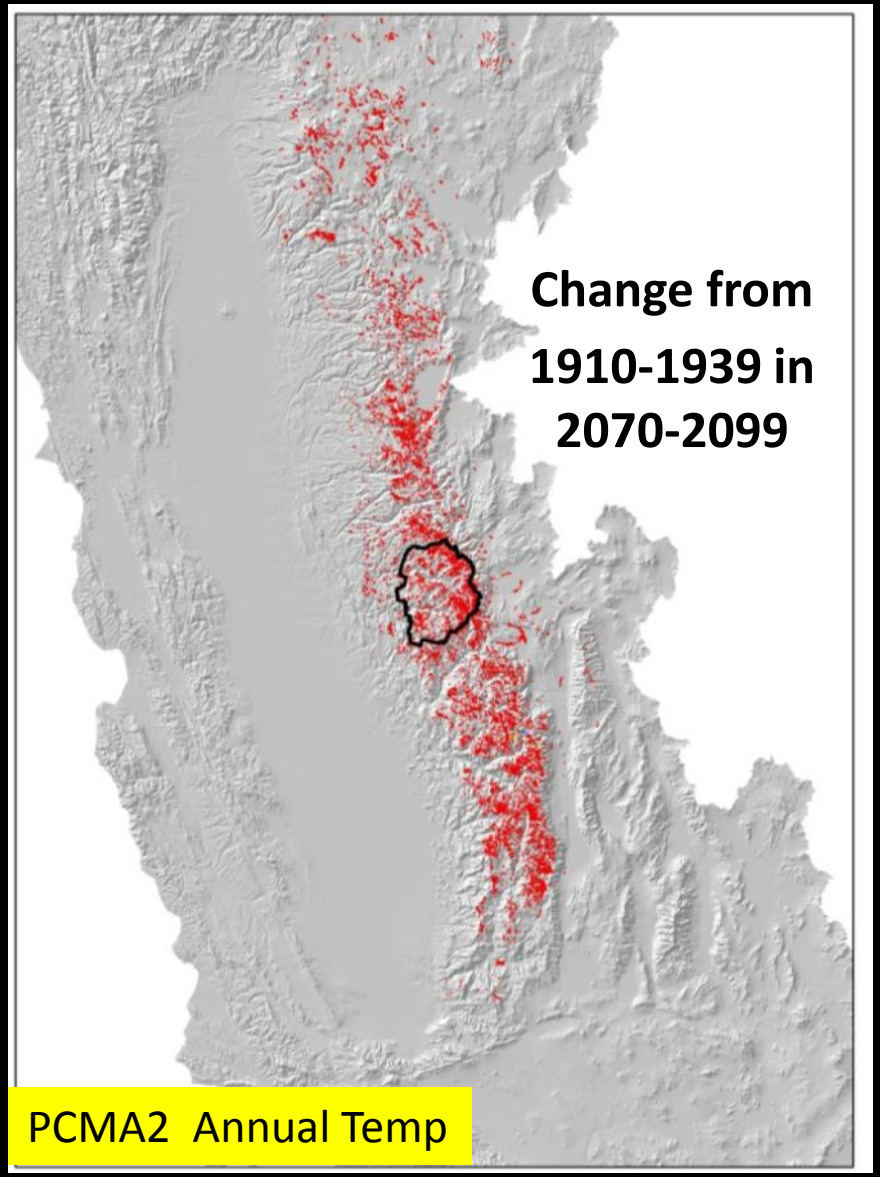
Within 90th Percentile **Within 75th Percentile**



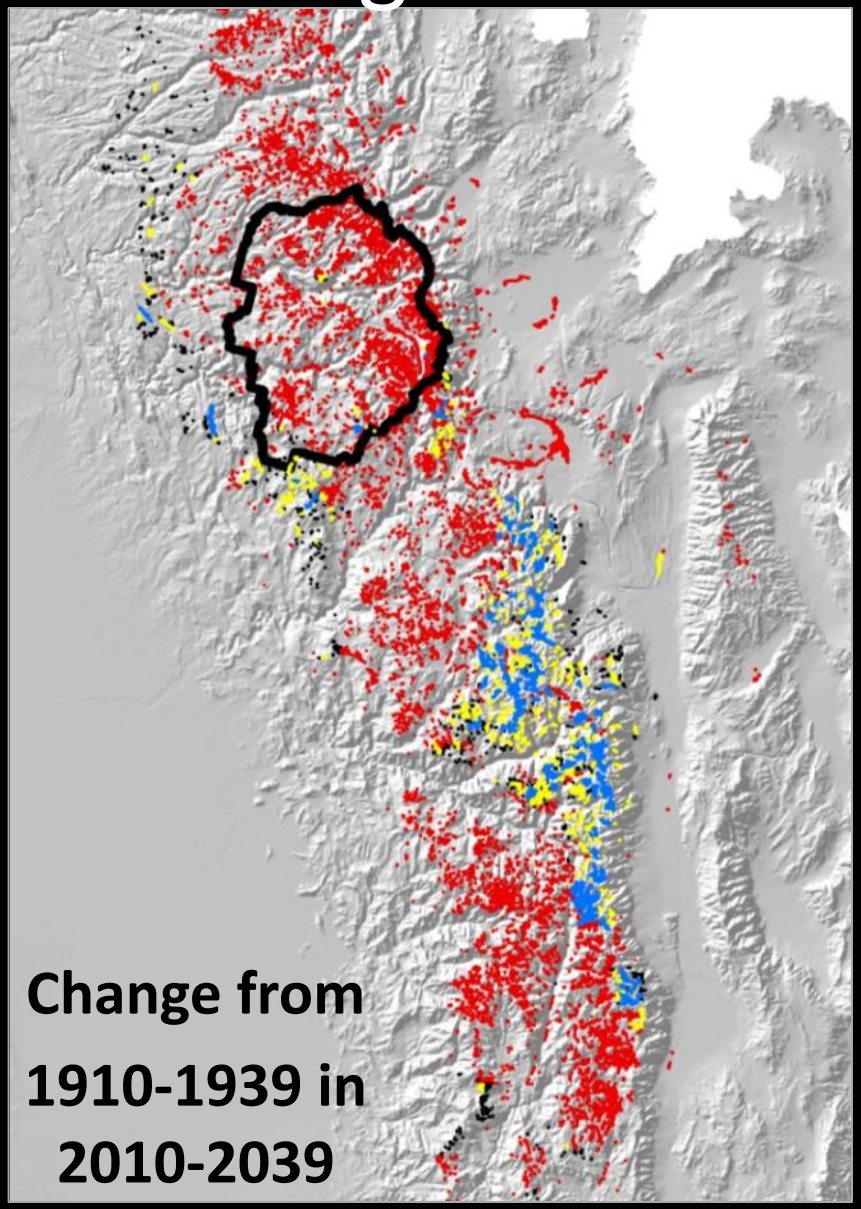
WC meadows are red points

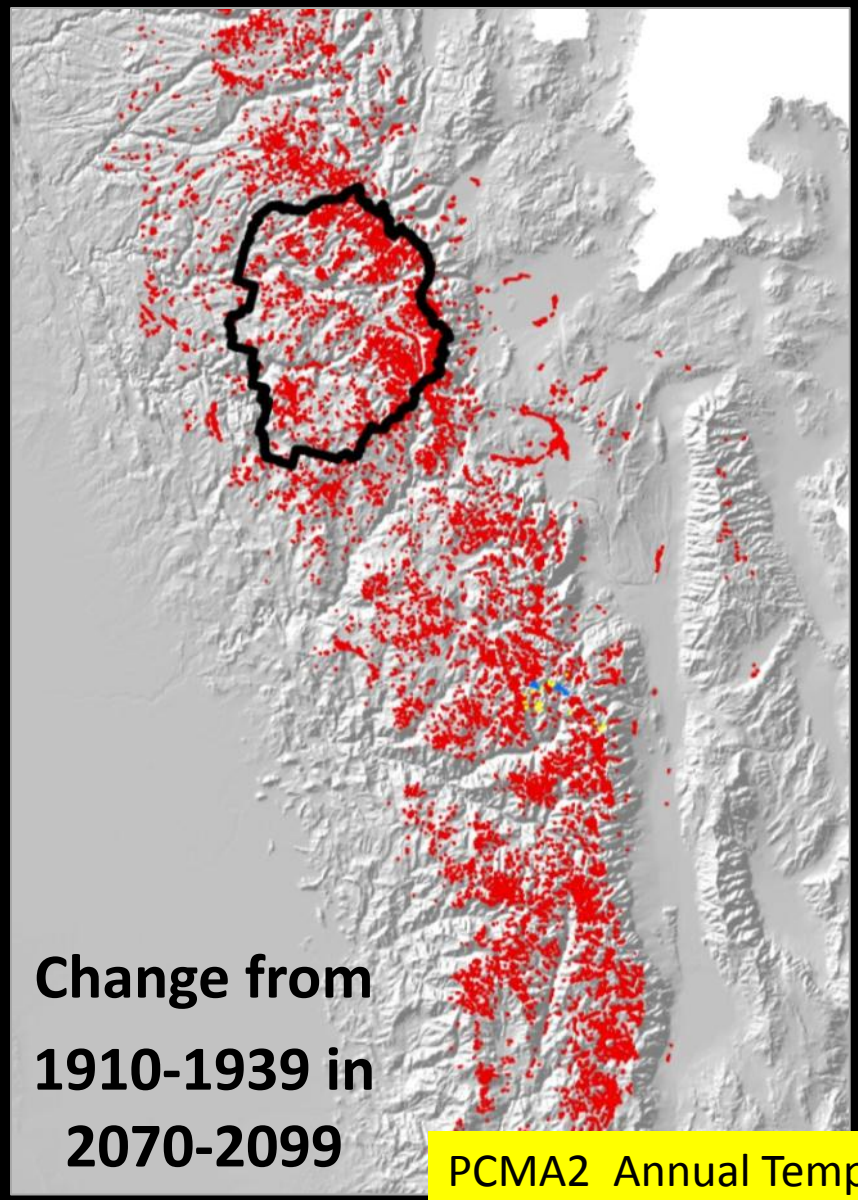
So how do we expect climate to change in well-connected meadows?





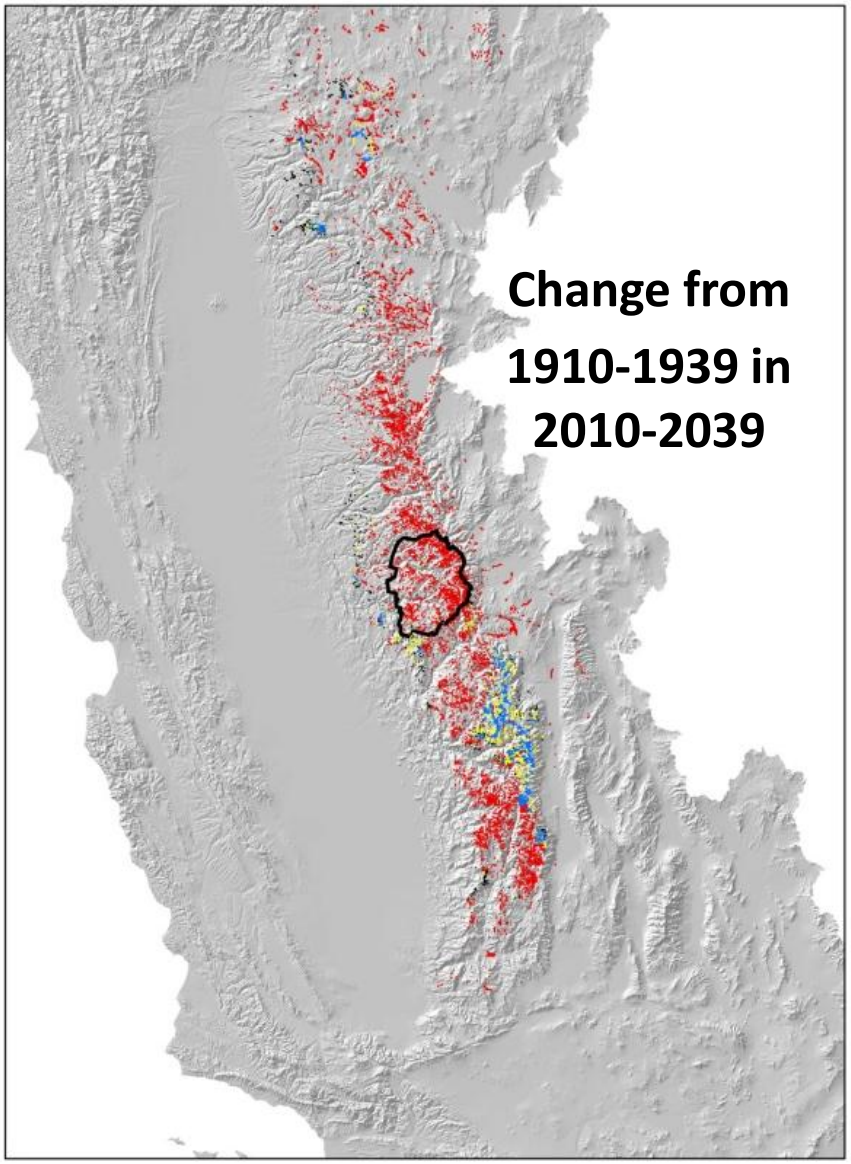
So how do we expect climate to change in well-connected meadows?

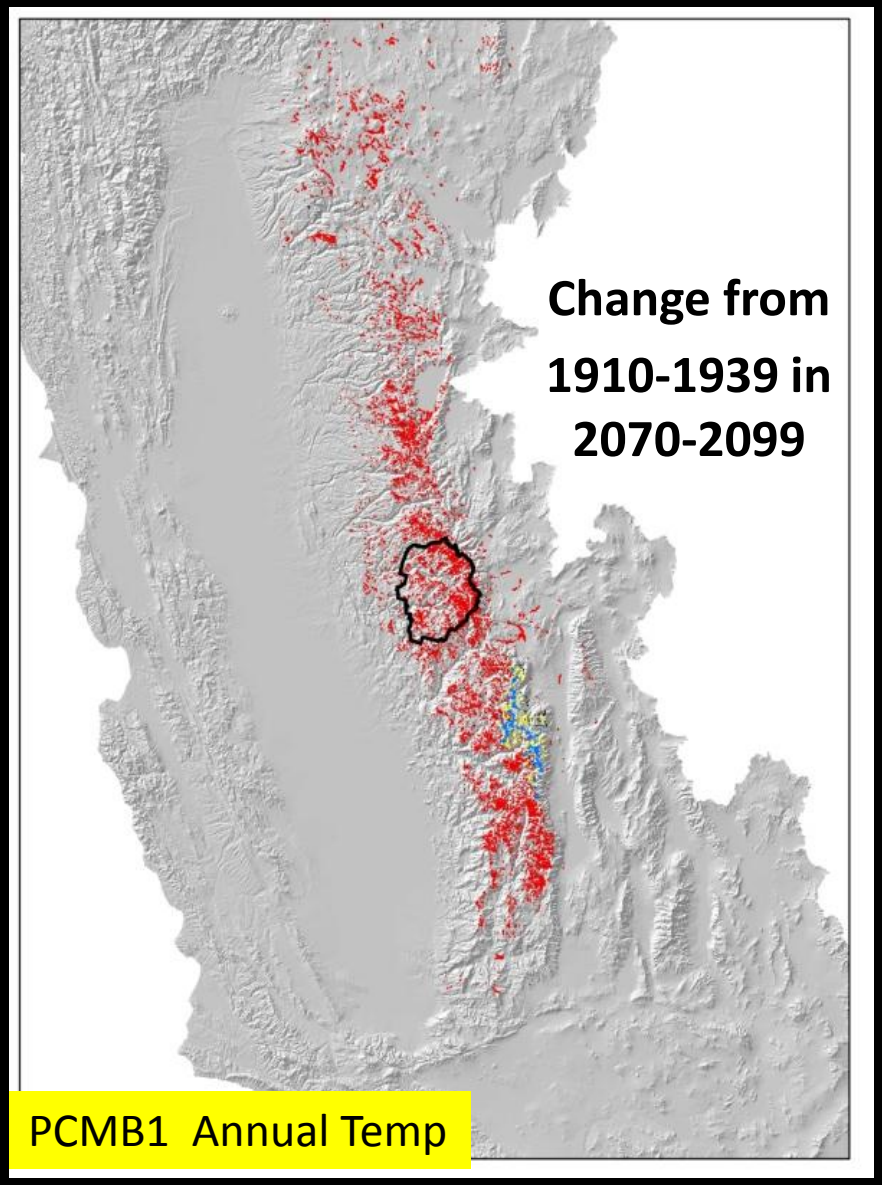




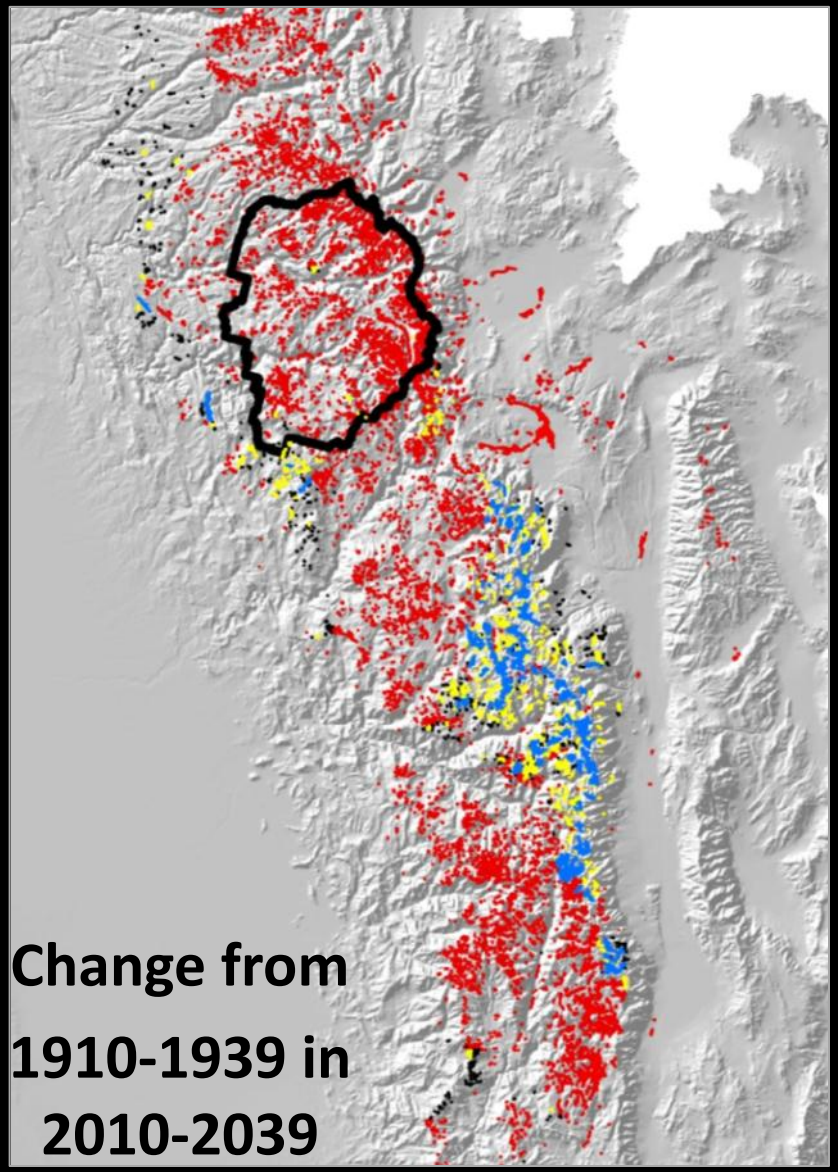
PCMA2 Annual Temp

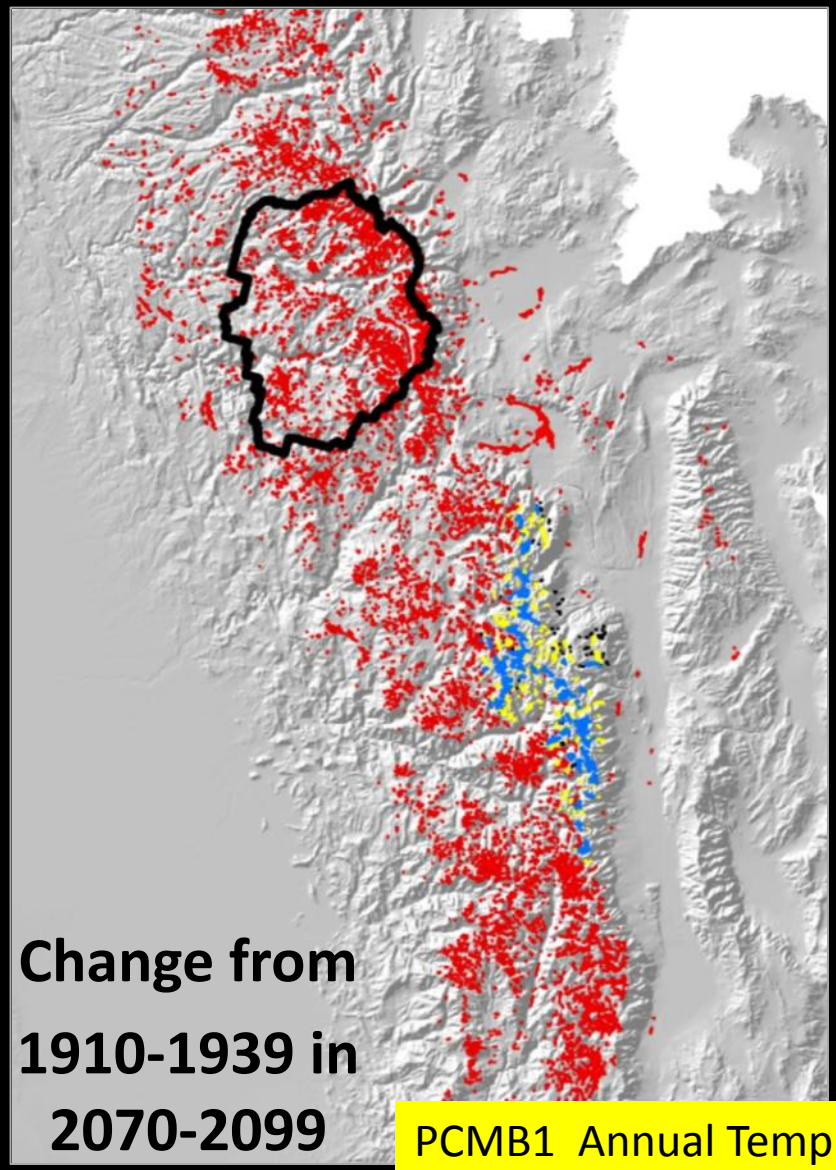
So how do we expect climate to change in well-connected meadows?





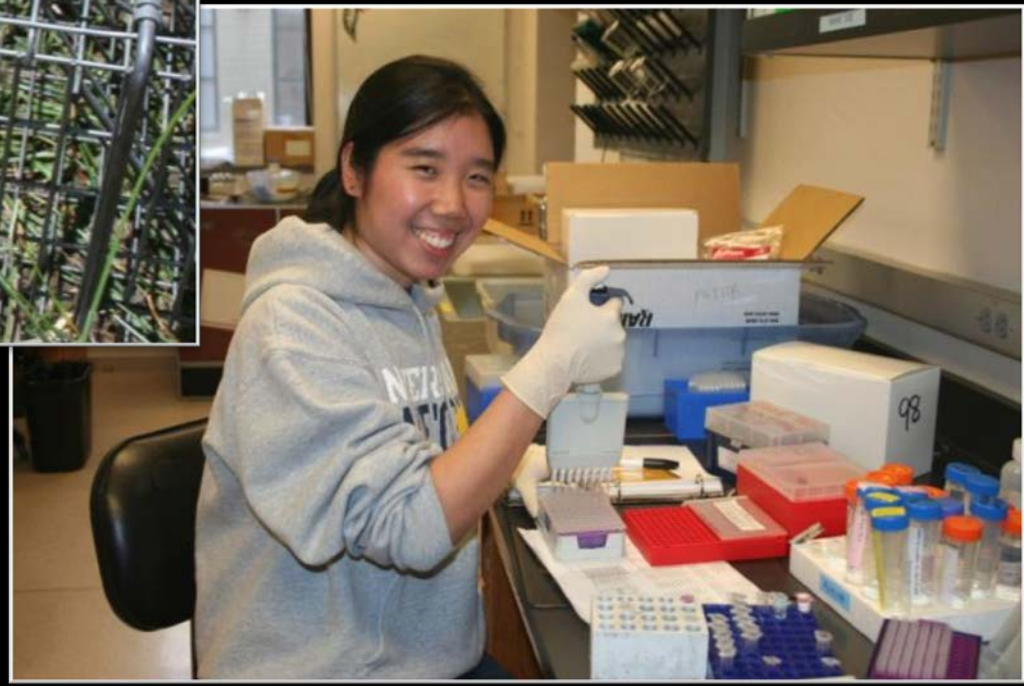
So how do we expect climate to change in well-connected meadows?





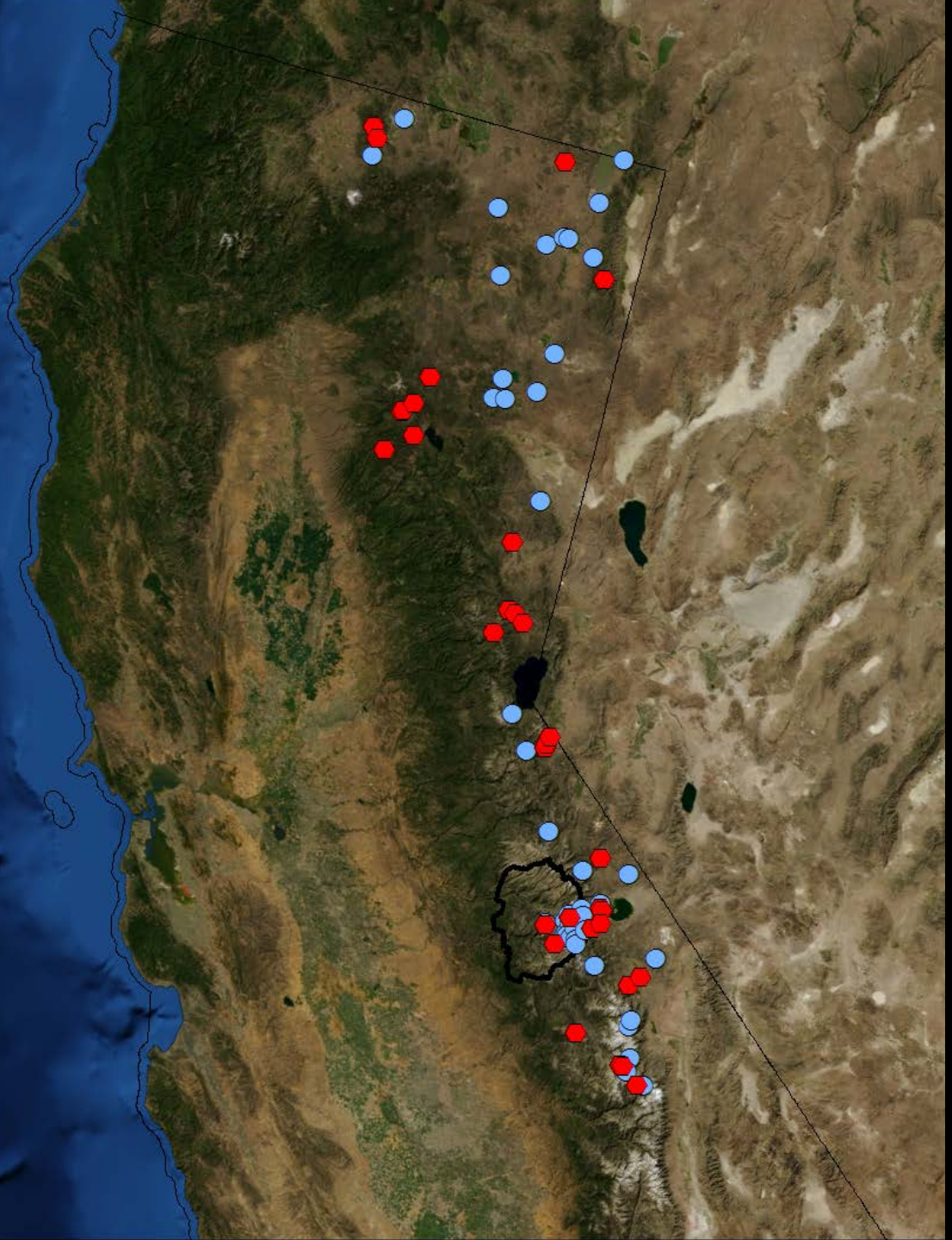
PCMB1 Annual Temp

Testing the Refugia and Connectivity Maps



Belding's Ground Squirrel (*Urocitellus beldingi*)

- Montane meadow specialist
- Highly detectable
- Group-living
- Habitat specialist

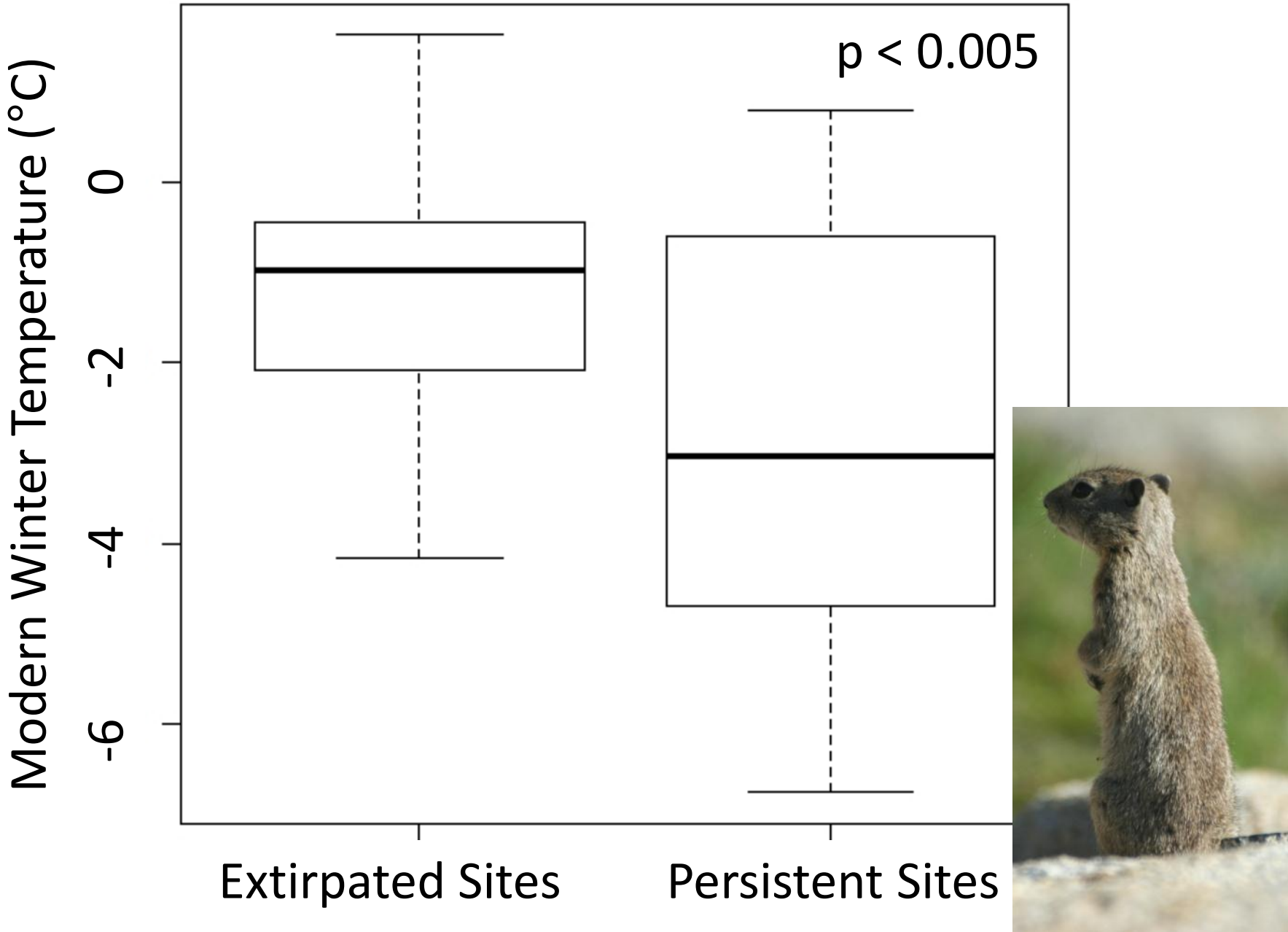


Site Extirpations (N=31)

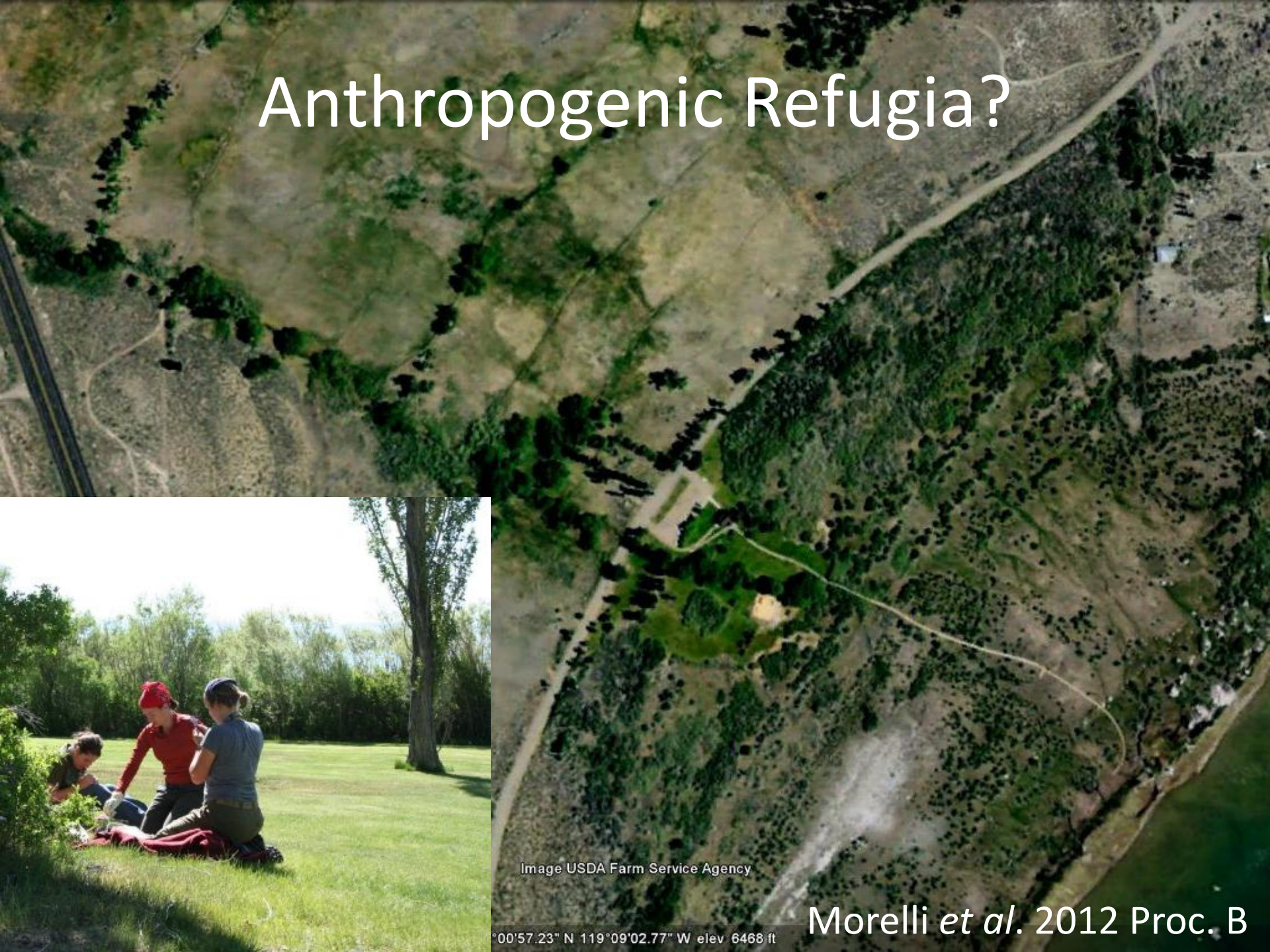
Site Persistence (N=43)

Morelli *et al*. 2012 Proc. B

Site Extinction at Hotter Sites



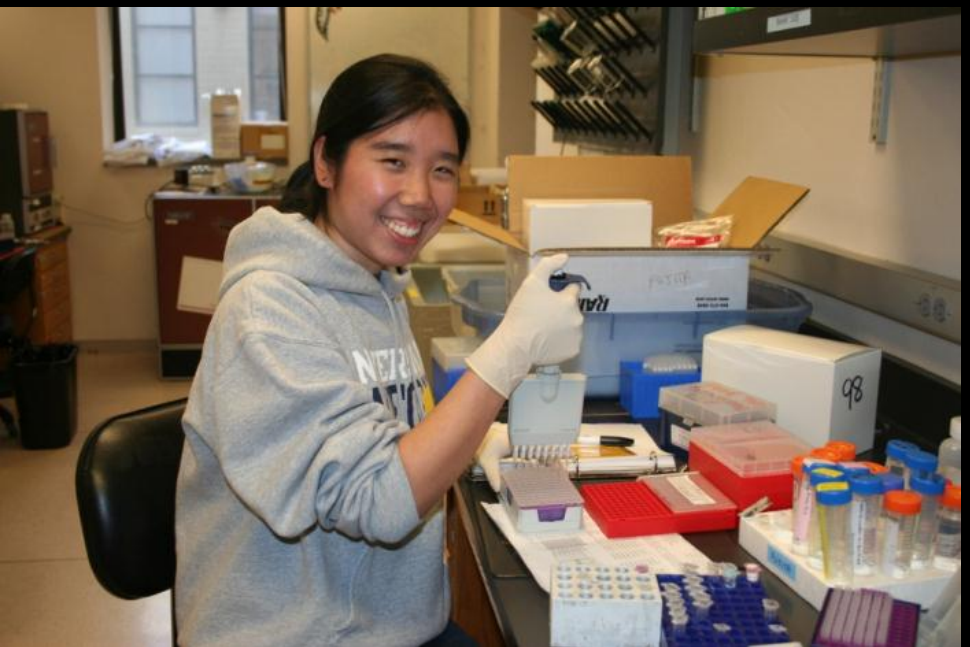
Anthropogenic Refugia?



Morelli *et al*. 2012 Proc. B

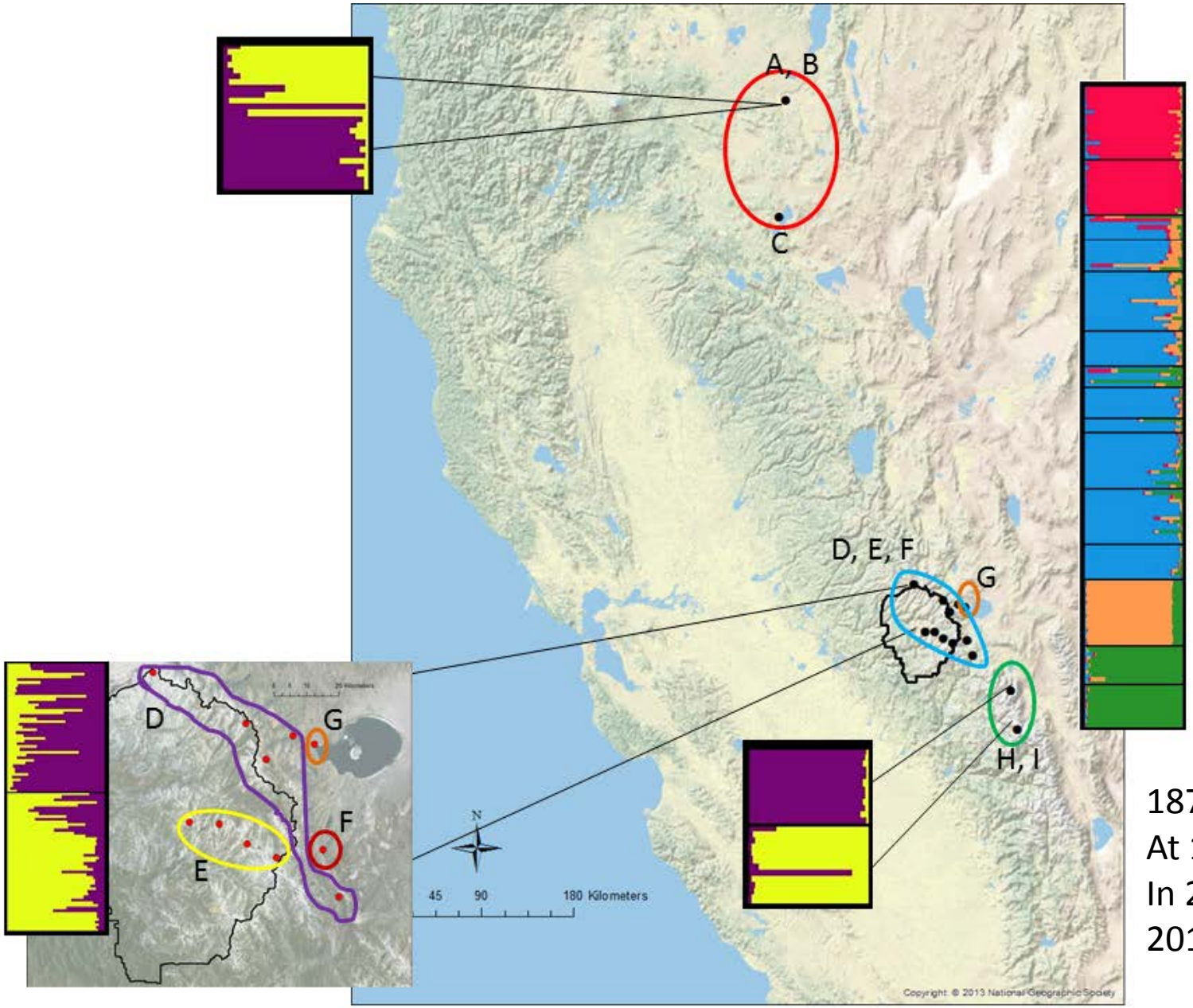
Genetic Analysis

- 187 tissue samples
- Qiagen extraction
- 12+ nuclear microsatellite loci



- Genepop
- FSTAT
- STRUCTURE
  - –Model-based clustering method
- BayesAss

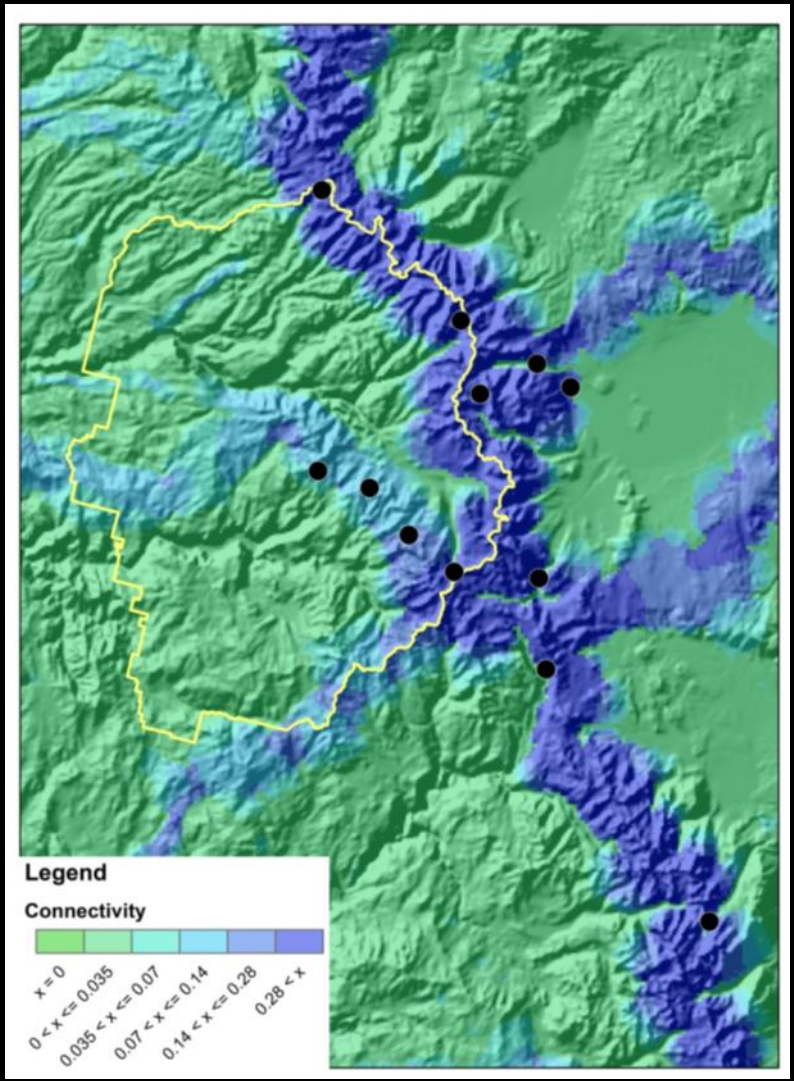
Genetic Structure Across CA



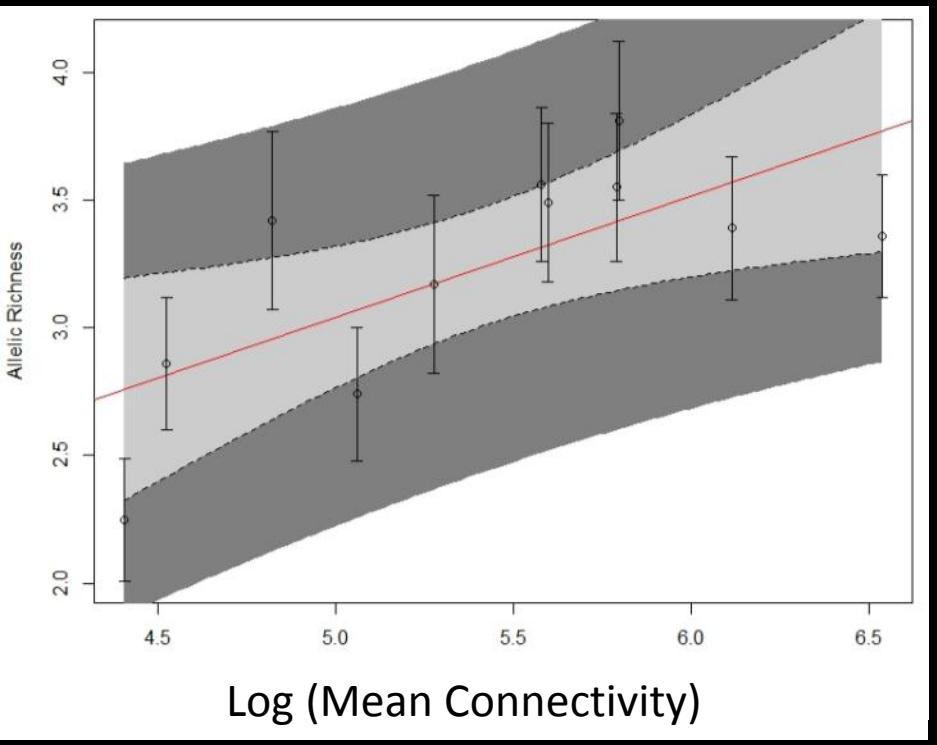
187 ad/subad sampled
At 15 sites
In 2003-2011 (most 2010-2011)

Is genetic distance related to isolation?

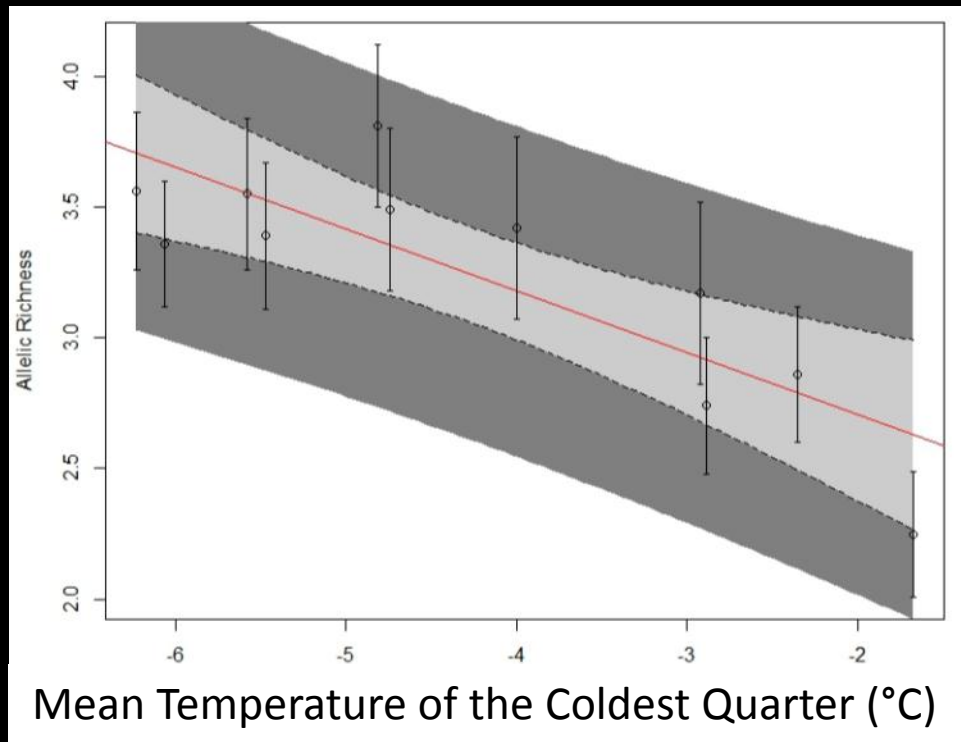
- Permutations to examine patterns of Fst
- Support for dispersal limitation by watercourses (Hyp 3)



Is allelic richness related to connectivity or climate?



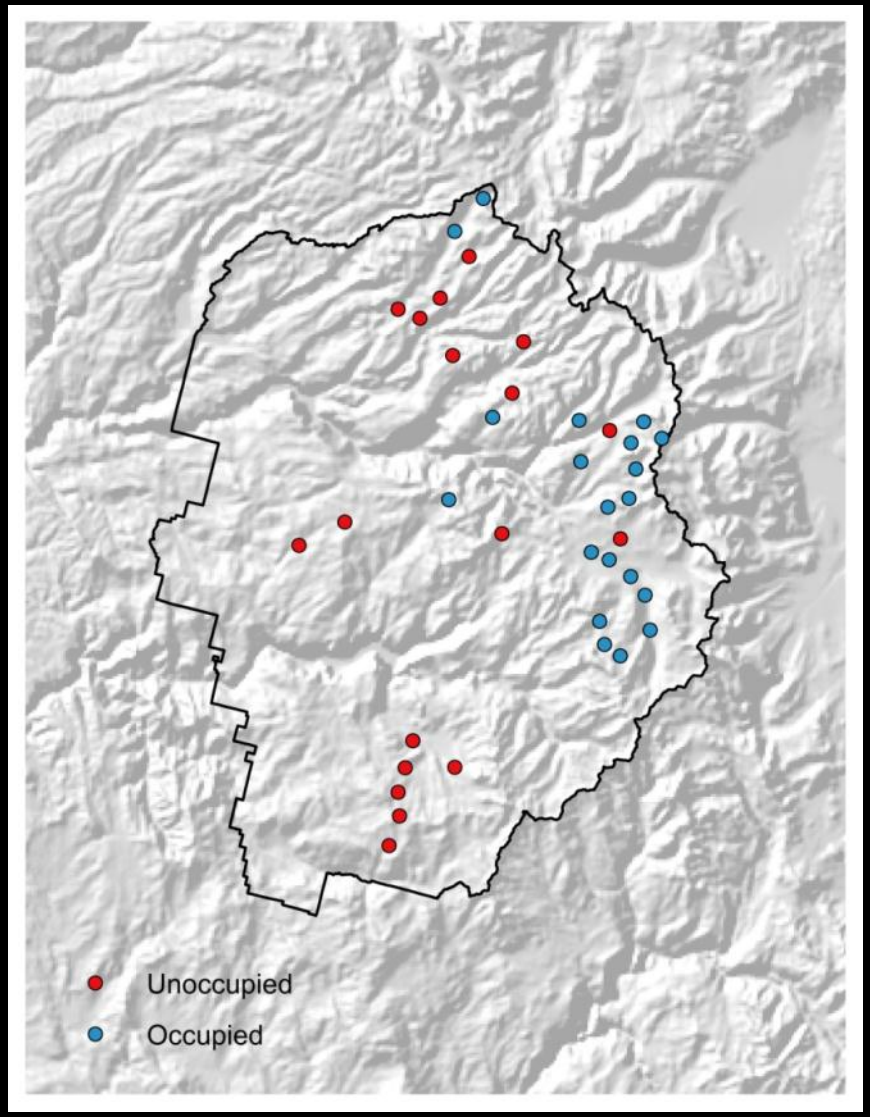
Positive relationship between AR and Connectivity – More alleles in well connected meadows



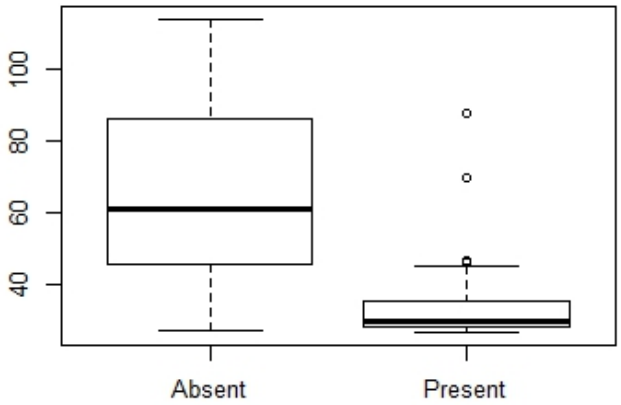
Negative relationship between AR and Temperature – Fewer alleles in warmer meadows

2011 Surveys for Belding's Ground Squirrel

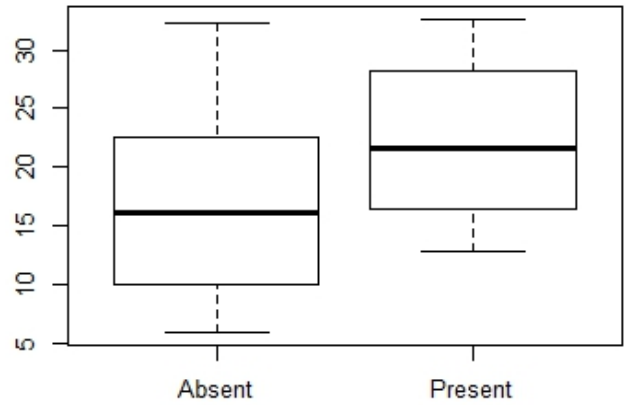
- Independent data set
- 38 sites, distributed throughout YNP
- 20 occupied, 18 unoccupied



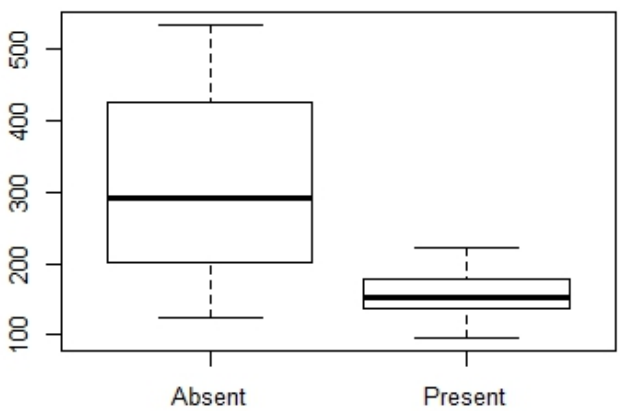
Are there potential refugial sites?



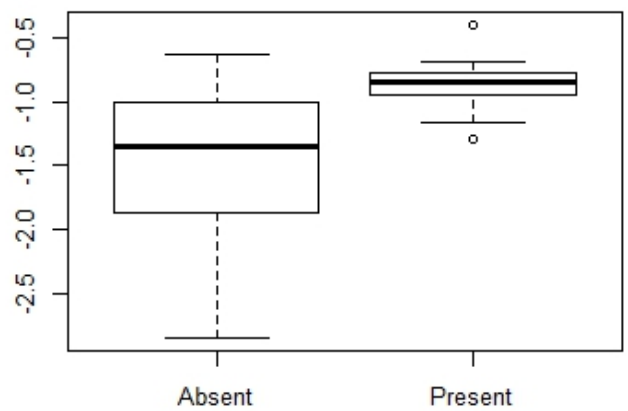
Months Tmin Warmer than Historic 95% Quantile



Months Tmax Warmer than Historic 95% Quantile

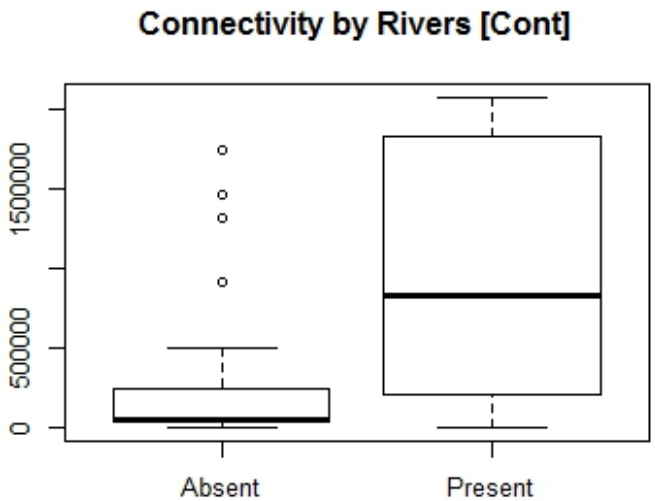


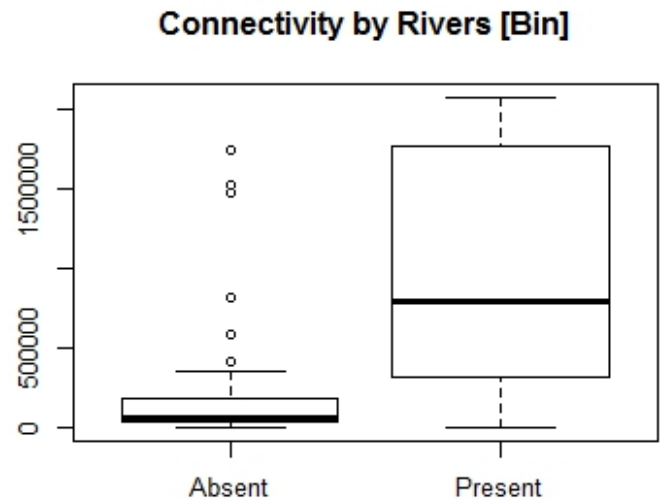
Mean CWD (1970-1999)

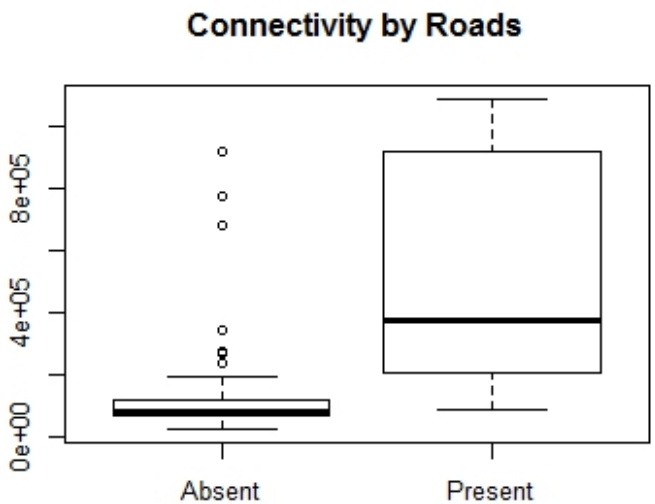


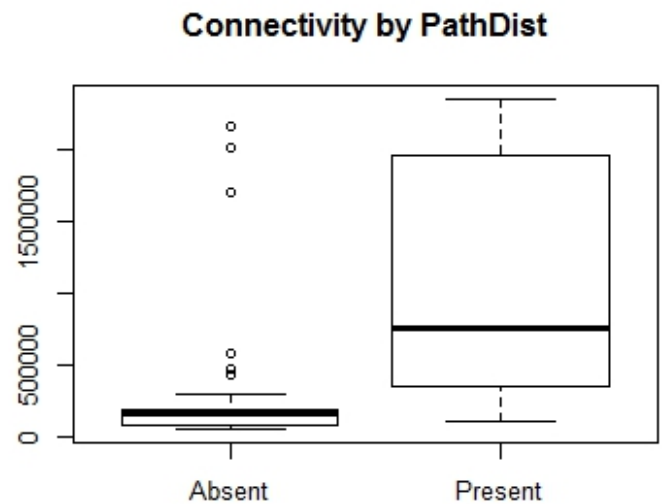
PC2 of Warming Tmin Months

Do these measures predict presence?









Conclusions and Implications

- Climate may be changing more rapidly than species can move or adapt
- Inclusion of connectivity within climate change research with empirical data is important
- Management strategies and challenges for Sierra Nevada meadows systems
- Opportunities for California managers to focus limited resources on critical areas?

Funding & Data Sources

CA LCC

NSF

UC Davis
Information Center for the Environment (ICE)

Comments & Assistance

- Michelle Koo
- Moritz Lab
- Beissinger Lab
- Ilaria Mastroserio, Jeni Chan, Matt Pfannenstiel, and other field assistants
- BIGCB working group
- Biotic Responses to Climate Change in California working group

Thanks!

CA LCC

California Landscape Conservation Cooperative

Webinar Series

CaliforniaLCC.org

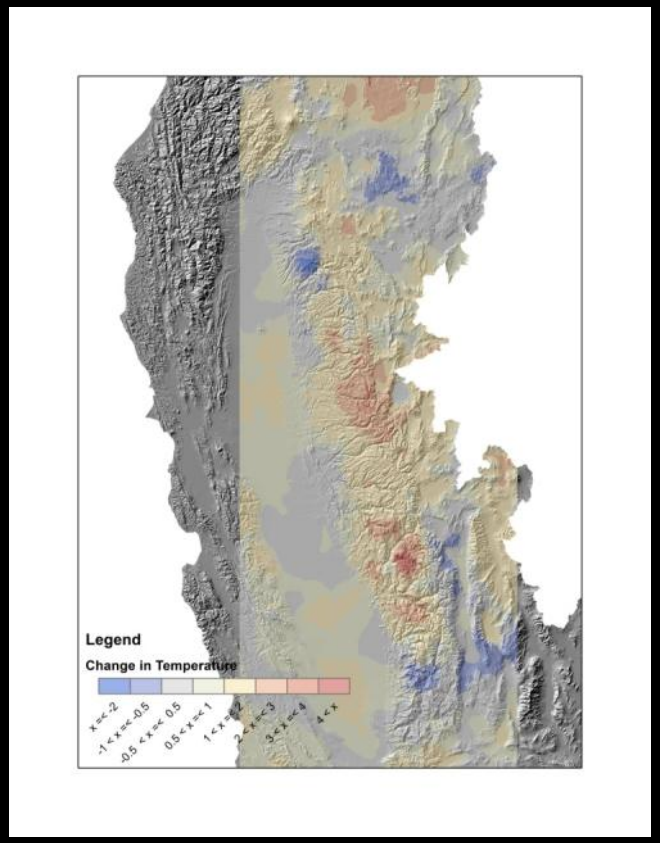
Thank you for joining us. A recorded version of this webinar will be available on our website in about a week.

If you have questions about the webinar, contact Rebecca Fris at 916-278-9415.

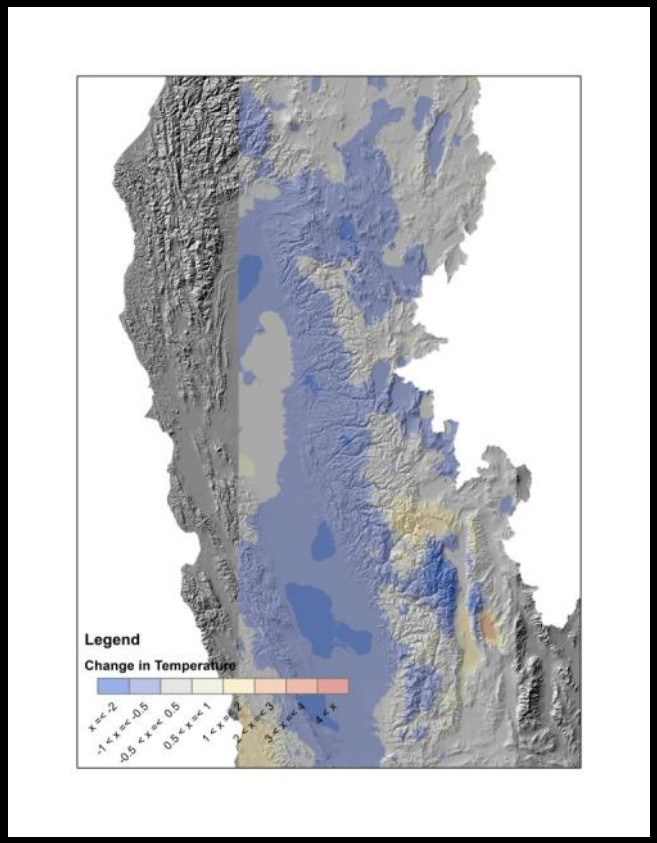
August 20, 2013

Min and Max Temp changes are seemingly independent

Minimum Temperature of Coldest Month

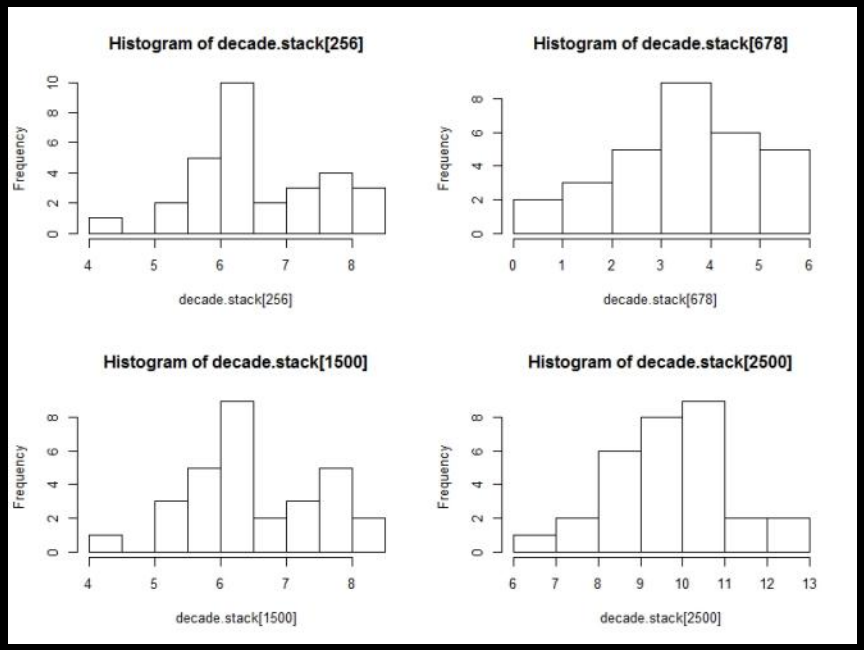


Maximum Temperature of the Warmest Month

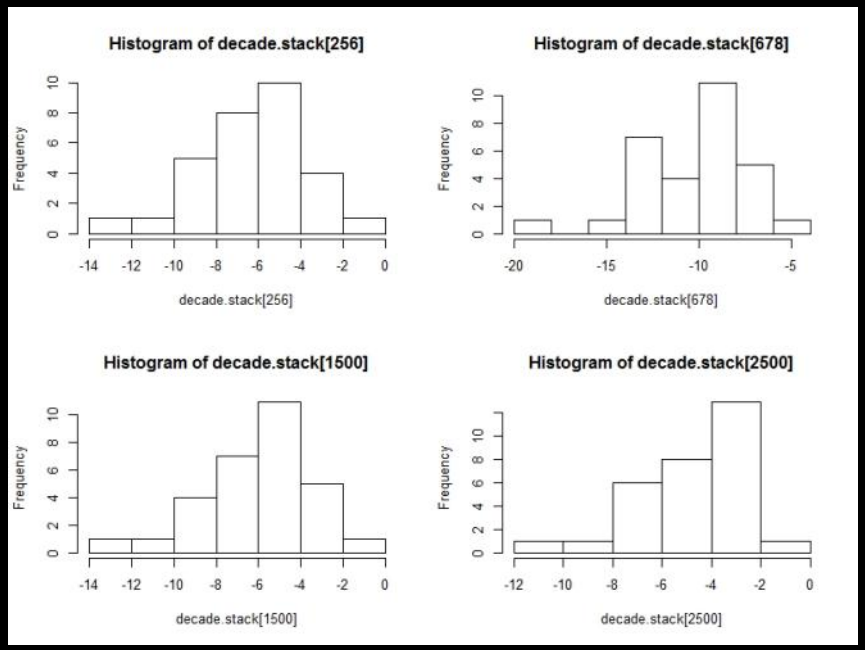


Per pixel variation in climate variables

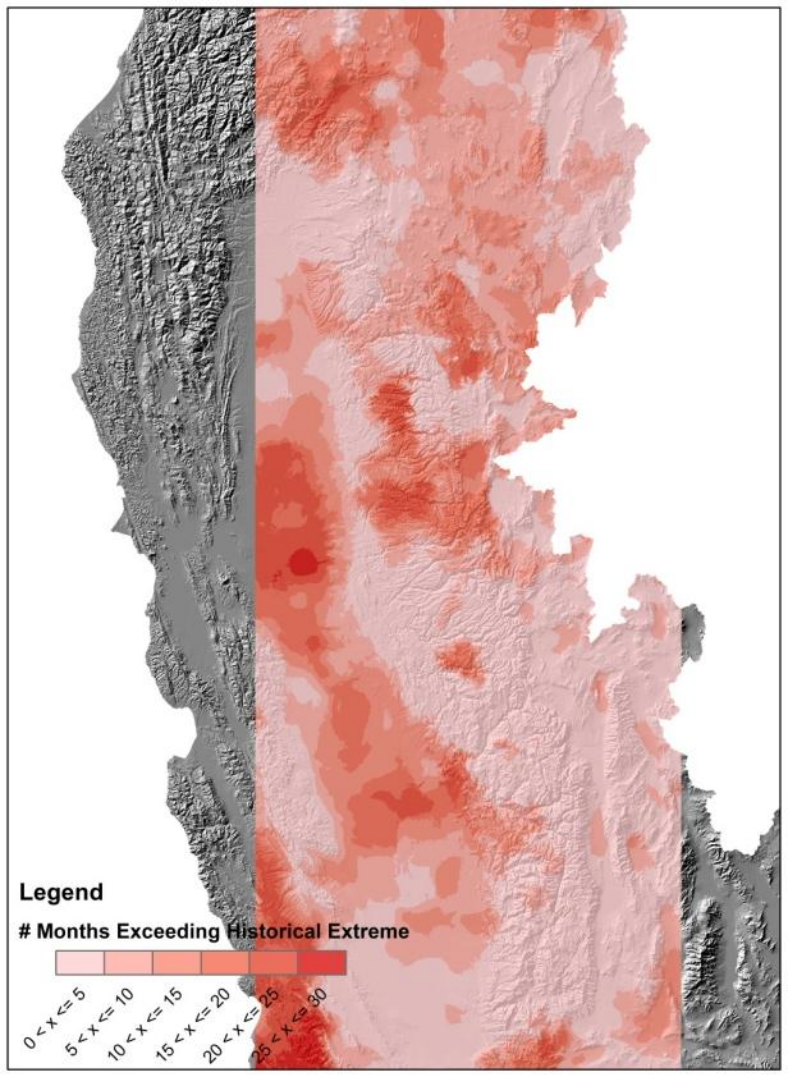
August Minimum Temp

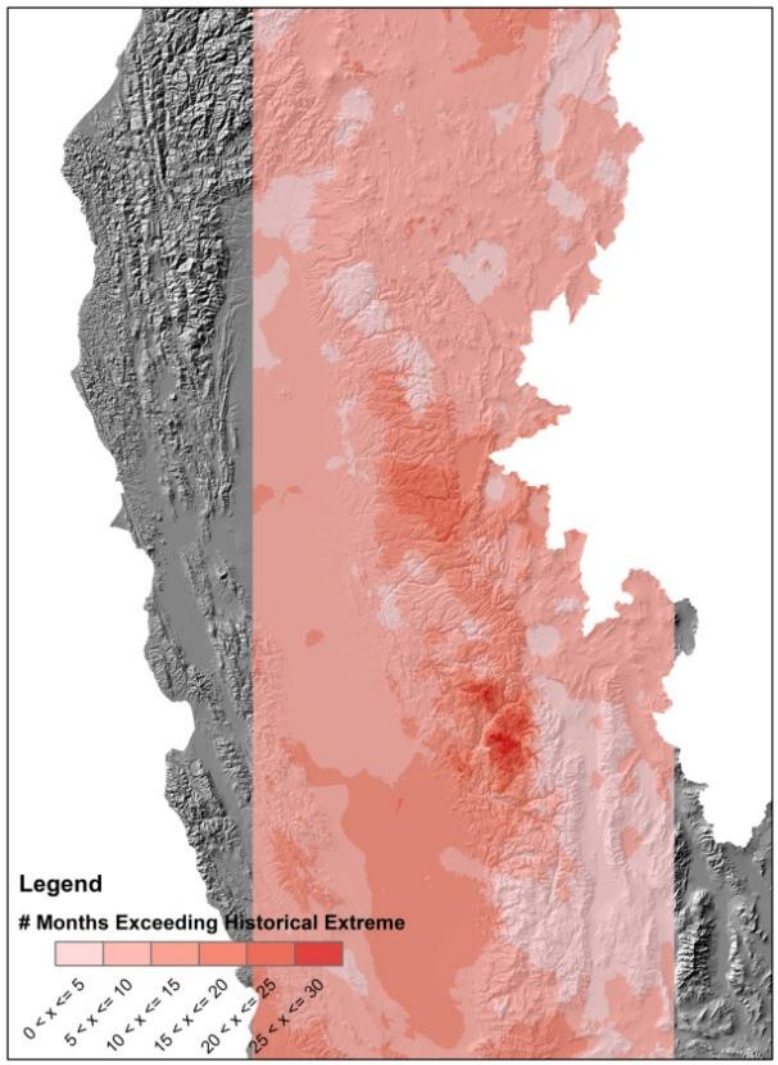


January Minimum Temp

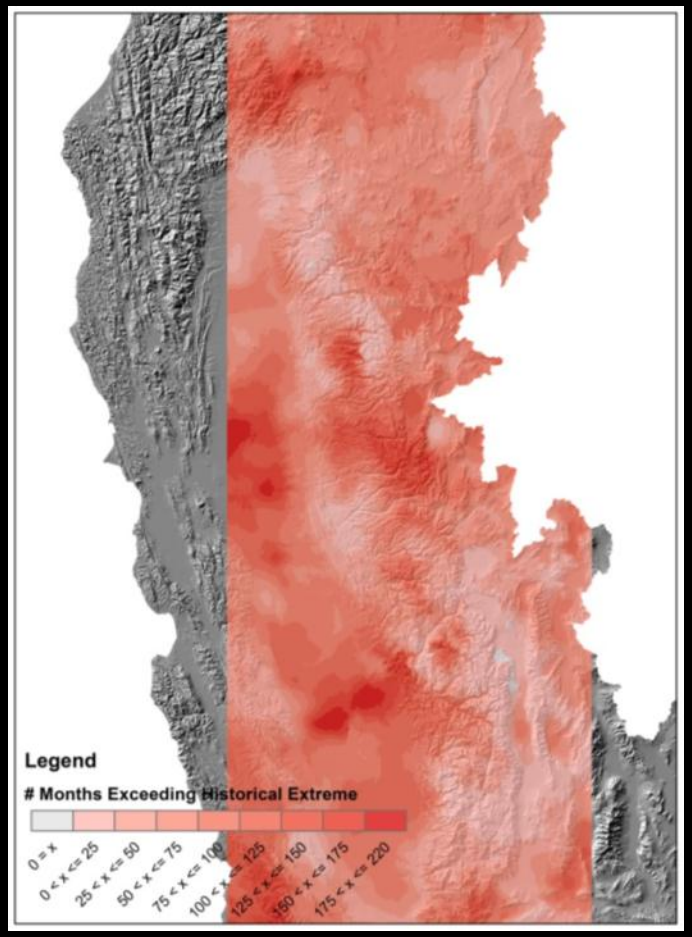


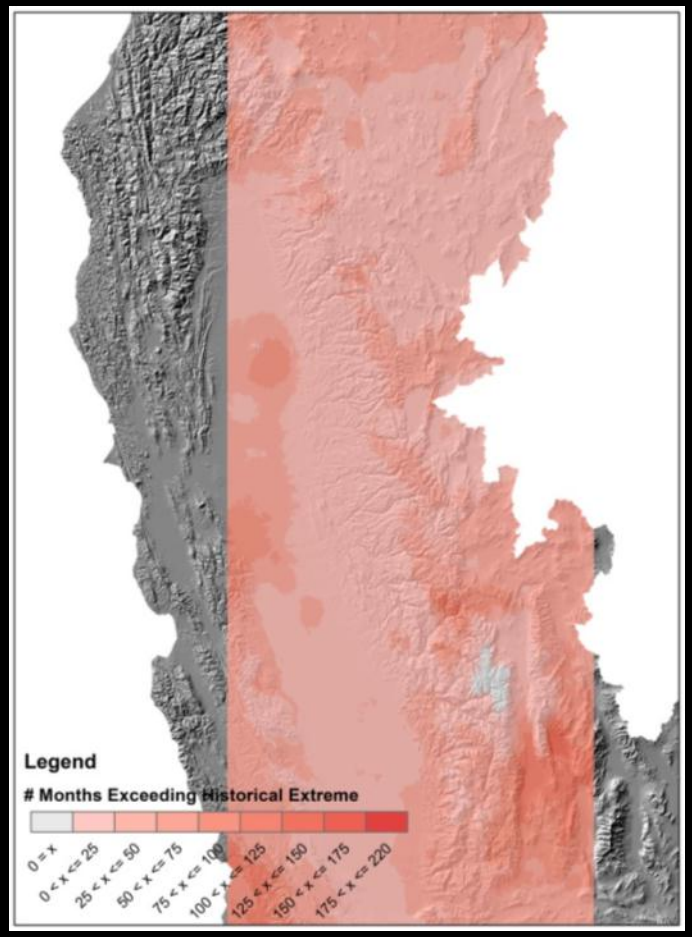
Are within month patterns similar?



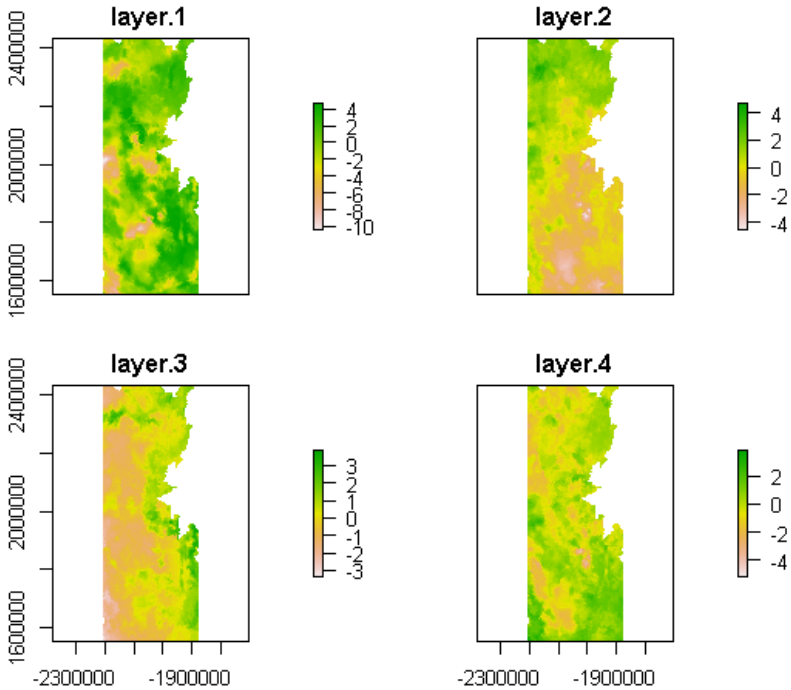


Do patterns differ between variables?





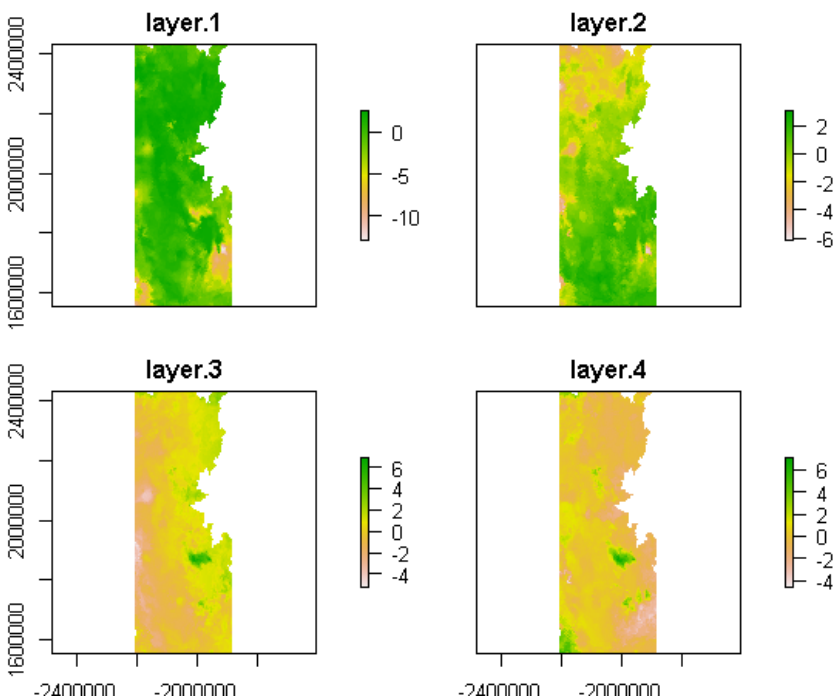
PCA to help disentangle patterns in Tmin



Comp1	Comp2	Comp3	Comp4
2.6186201	1.3439391	1.0197269	0.98377712
0.4897979	0.1290123	0.0742745	0.06912982
0.4897979	0.6188102	0.6930847	0.76221456

Variable	Loading 1	Loading2	Loading 3	Loading 4
Apr	-0.302	0.151	-0.139	0.18
Aug	-0.317	0.184	0.196	0.277
Dec	-0.289	-0.133	0.107	-0.306
Feb	-0.267	-0.249	-0.1	-0.304
Jan	-0.239	-0.267		-0.387
Jul	-0.303	0.229	0.107	0.278
Jun	-0.289	0.208	0.178	0.226
Mar	-0.237	0.128	-0.574	-0.196
May	-0.255	0.349	-0.208	-0.1
Nov	-0.282	-0.291	-0.198	
Oct	-0.319	-0.197	0.14	0.198
Sep	-0.304	-0.207		0.185
Eastings	0.161	-0.196	-0.638	0.44
Northings		0.595	-0.166	-0.33

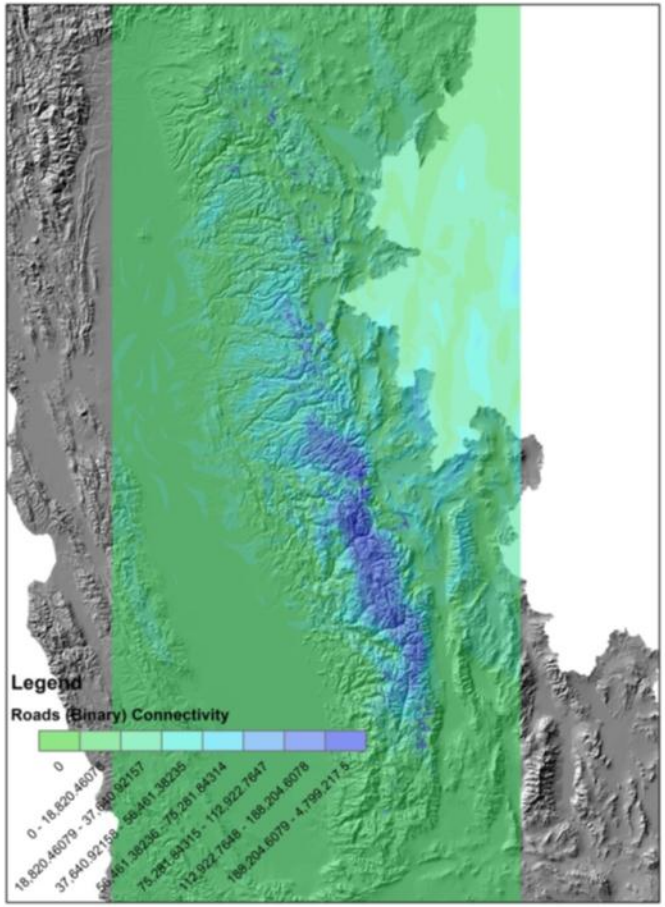
Tmax patterns are a little different

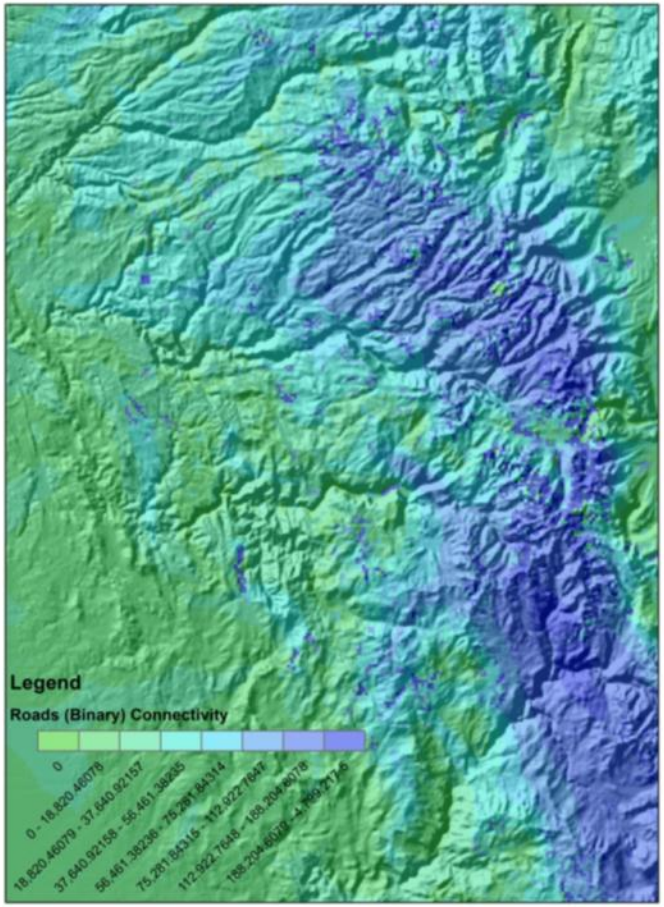


Comp.1	Comp.2	Comp.3	Comp.4
2.30336	1.547151	1.234438	1.111587
0.378962	0.170977	0.108846	0.088259
0.378962	0.549939	0.658784	0.747043

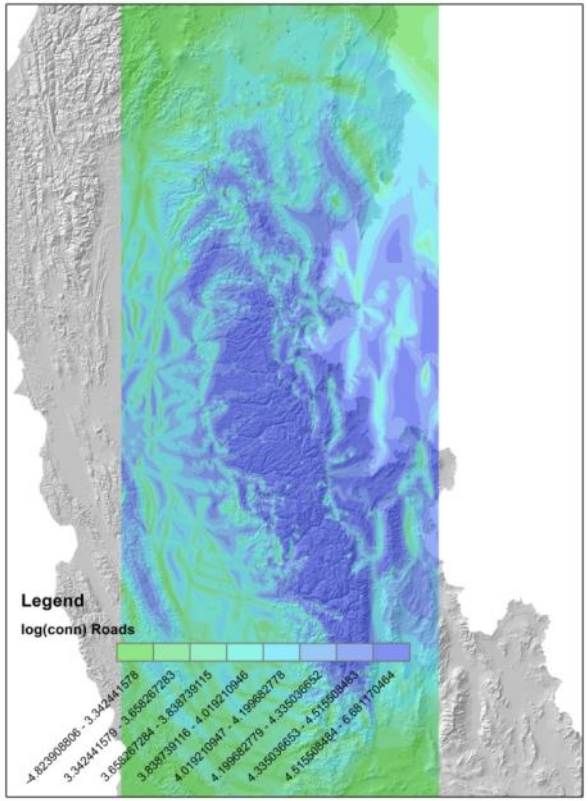
Variable	Loading 1	Loading2	Loading 3	Loading 4
Apr	-0.353	0.146		
Aug	-0.329		0.296	0.204
Dec	-0.142	-0.442	-0.241	-0.141
Feb		-0.559		-0.114
Jan	-0.229	-0.208	-0.198	-0.36
Jul	-0.28	-0.152	0.282	0.461
Jun	-0.335		0.225	0.208
Mar	-0.331	0.232		-0.168
May	-0.271	0.103	-0.45	0.188
Nov	-0.243		0.18	-0.507
Oct	-0.343		-0.26	-0.134
Sep	-0.301	-0.24	0.133	0.138
Eastings	-0.105	0.177	0.547	-0.424
Northings	0.205	-0.49	0.207	

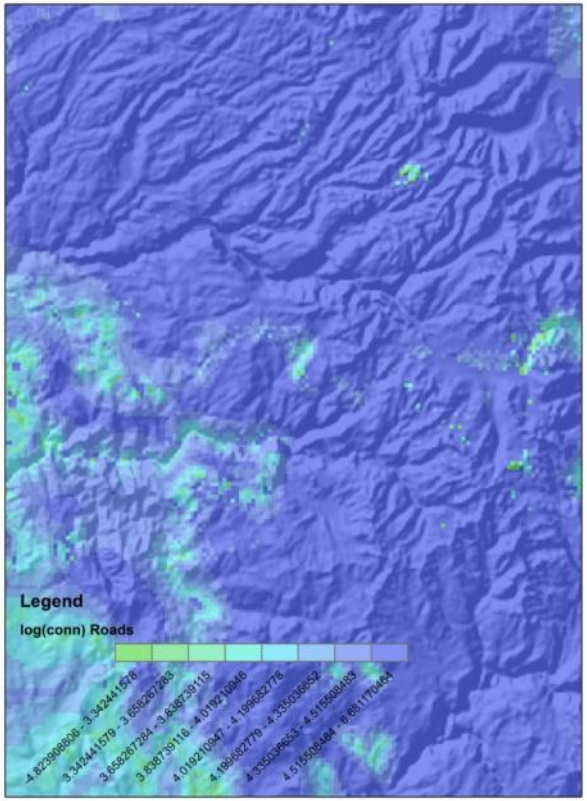
Connectivity based on distance from roads (Hyp #4)



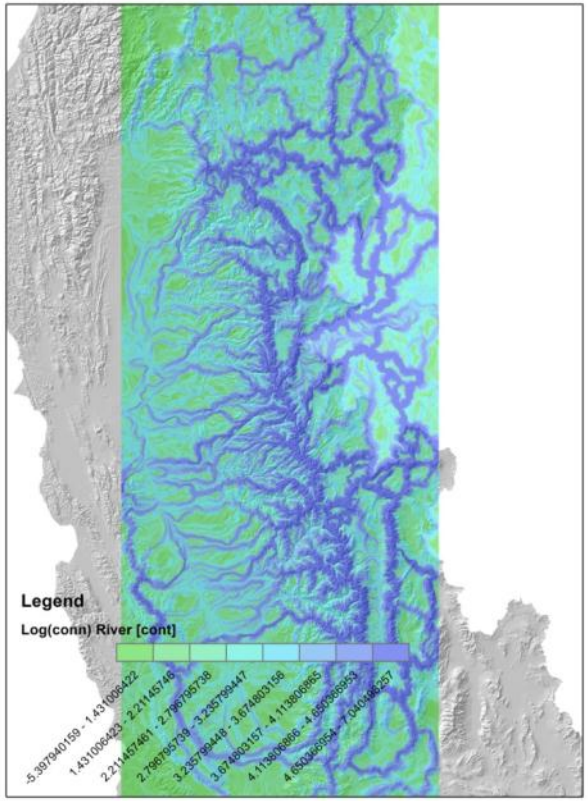


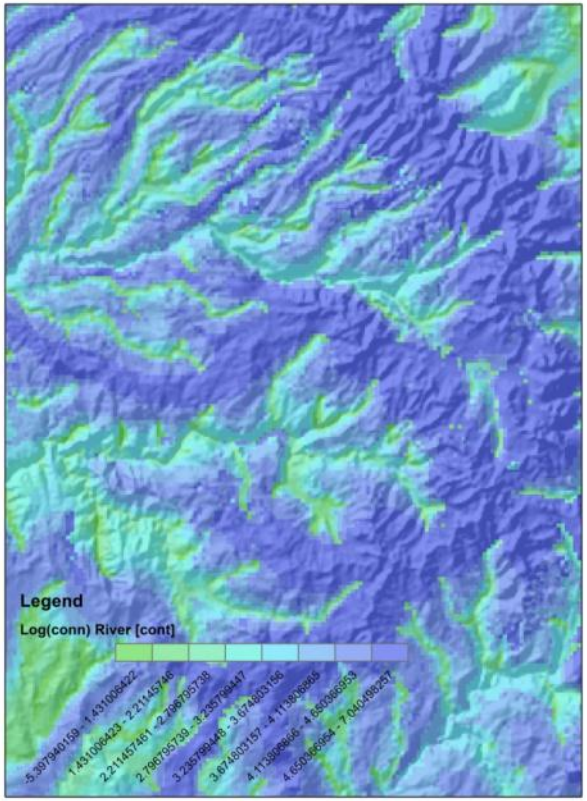
Connectivity based on conductance as distance from roads





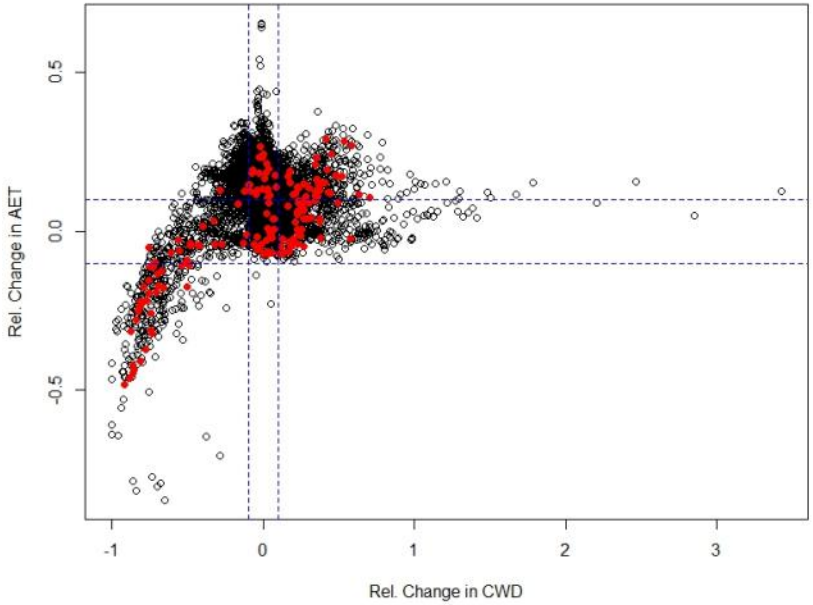
Connectivity based on conductance as distance from rivers



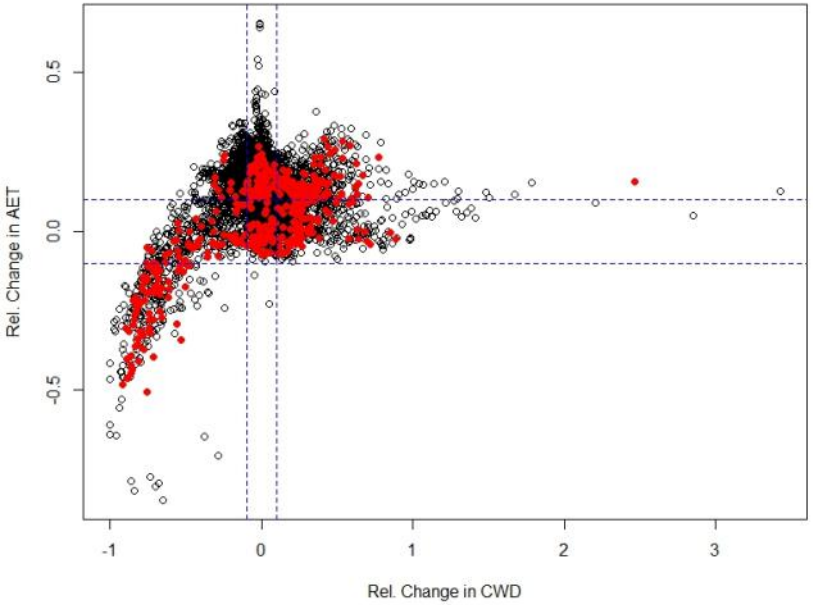


Vegetation likely already affected

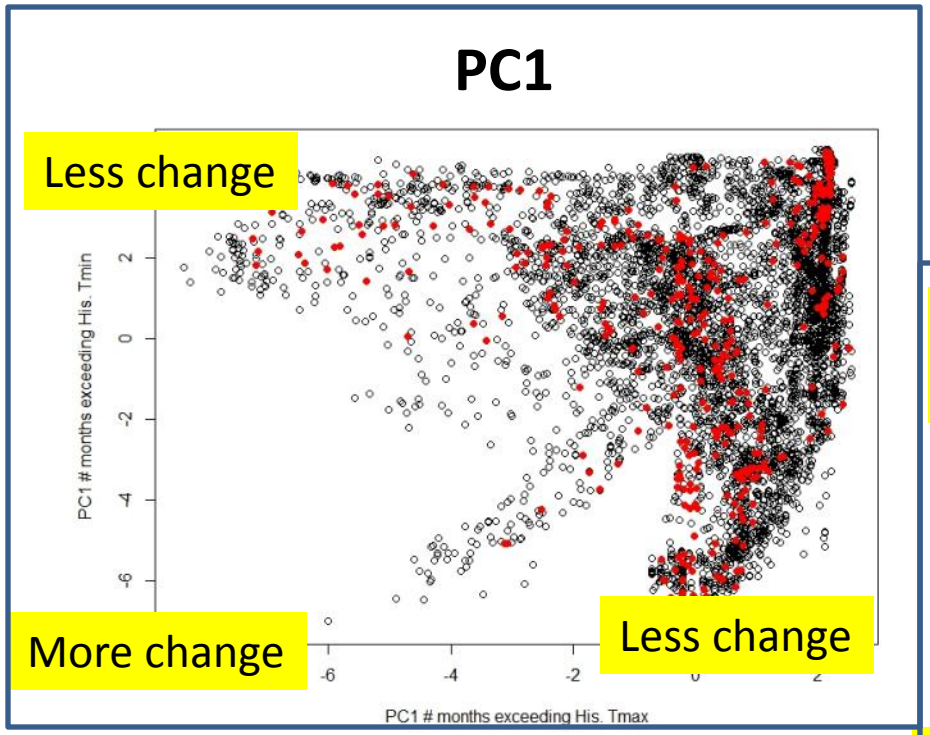
Applying 90th Percentile

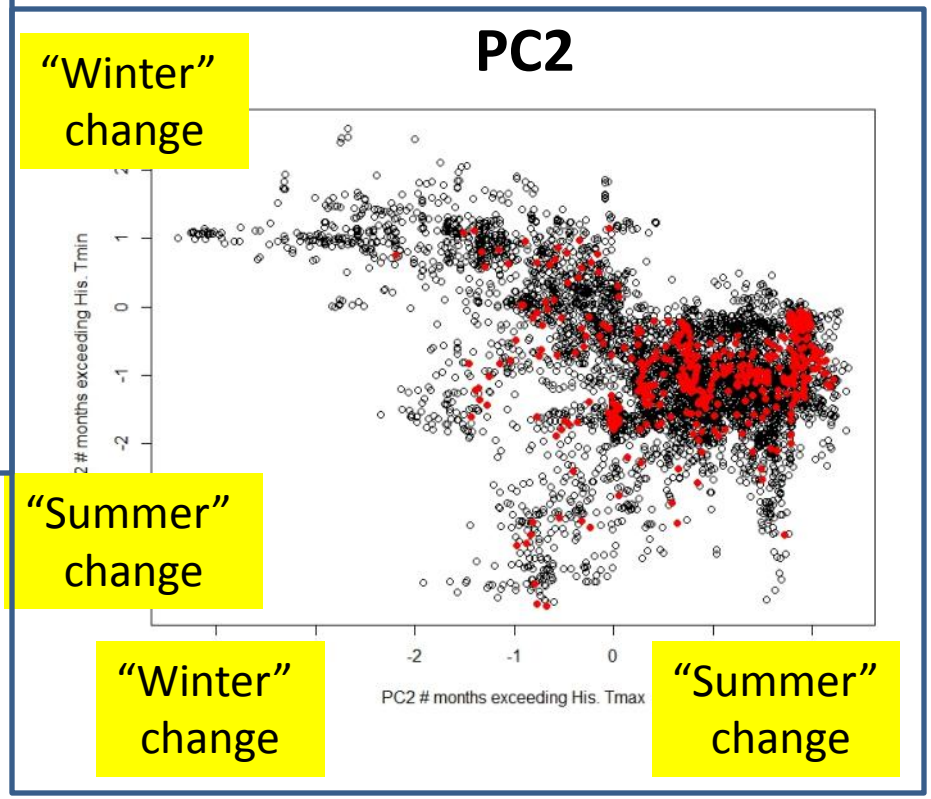


Applying 75th Percentile

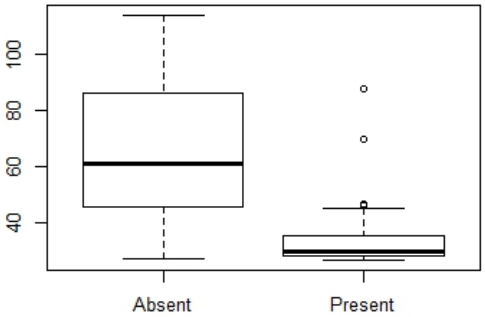


Timing of change differs between Tmin and Tmax along the Sierra Nevada

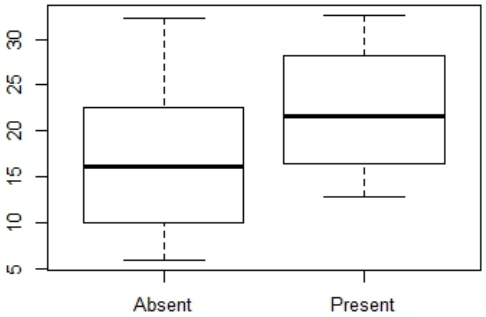




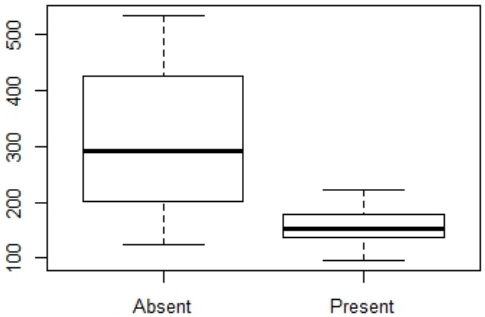
Are there potential refugial sites?



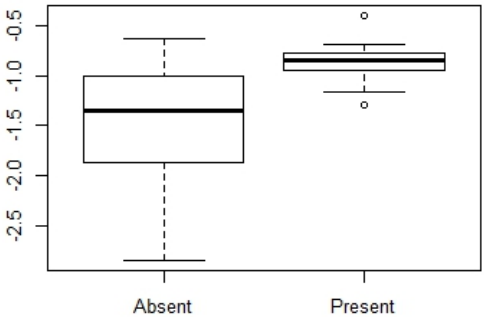
Months Tmin Warmer than Historic 95% Quantile



Months Tmax Warmer than Historic 95% Quantile



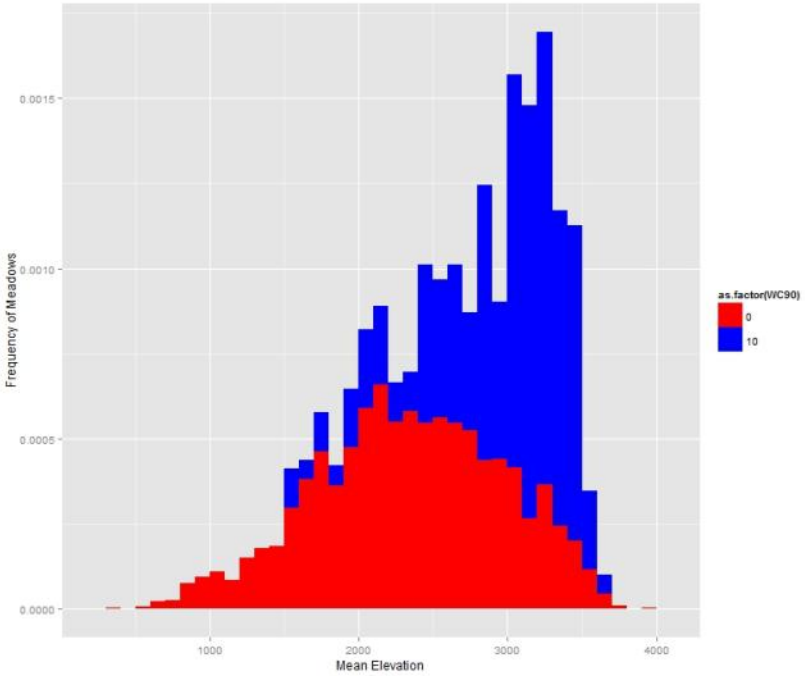
Mean CWD (1970-1999)



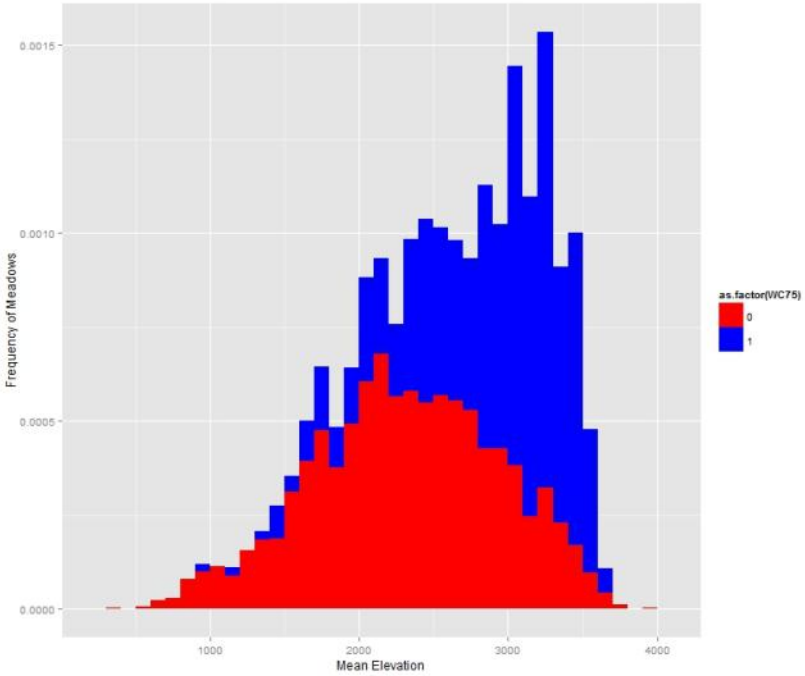
PC2 of Warming Tmin Months

Are Well-Connected Meadows at higher elevations?

Applying the 90th Percentile



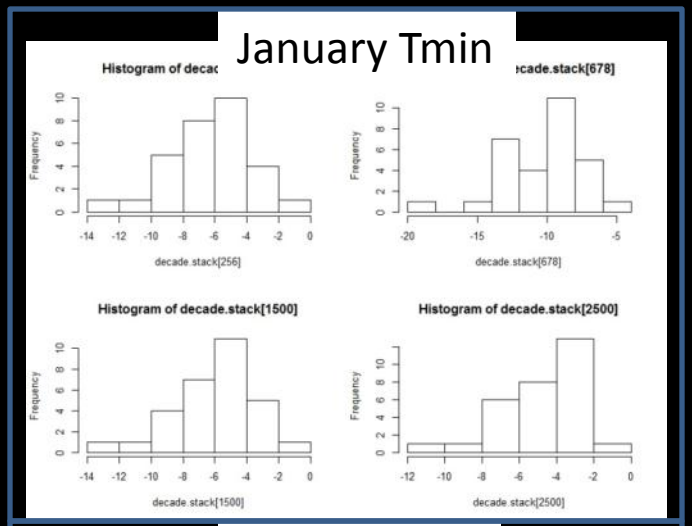
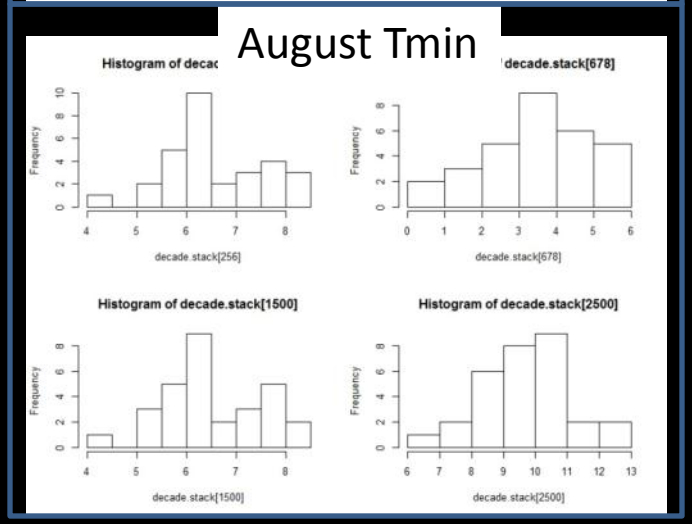
Applying the 75th Percentile



Why assess connectivity of meadows in the Sierra Nevada?

- Discrete habitat units
- Islands within a mixture of forests
- Draw for visitors and hikers

- Heterogeneous change in within SN, both recent and predicted in the future
- Can species move through the matrix?
- Identify well-connected “refugia”
- Preservation and management decisions (????)

Understanding extreme changes by month

- Generate quantile maps per month per variable for the historic era
- Count the number of months in the modern era that exceed that value
- Sum the monthly maps
- PCA with monthly maps