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\textsuperscript{1,2} & Sean P. Maher\textsuperscript{1,5}

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

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[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
We argue for the utility of a proactive approach in conservation that is focused on identifying and protecting genetic hotspots and climate refugia with viable populations and low vulnerability.
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
Climate change in 20th Century

Annual Temperature (Actual)

Annual Precipitation (Relative)
Do patterns differ between variables?

Minimum Temp

Maximum Temp
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
Connectivity based on presence or absence of watercourses (Hyp #3)
Overall patterns of connectivity depends on surface
Where are the Well-Connected Meadows?

Within 90th percentile of all estimates

Within 75th percentile of all estimates
Where are the Well-Connected Meadows?

90th Percentile

75th Percentile
Are Well-Connected Meadows at higher elevations?

Red = not WC
Yellow/Blue = 75th
Blue = 90th
Are larger meadows more connected?

![Histogram showing the frequency of meadows at different log10 areas, with different colors indicating different factors.](image)
Change within meadows is variable

Within 90th Percentile

Within 75th Percentile

Relative Change in Annual Precipitation

Change in Mean Annual Temperature

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

Change from 1910-1939 in 2010-2039

Change from 1910-1939 in 2070-2099
Testing the Refugia and Connectivity Maps
Belding’s Ground Squirrel
(Urocitellus beldingi)

- Montane meadow specialist
- Highly detectable
- Group-living
- Habitat specialist
Site Extinction at Hotter Sites

Modern Winter Temperature (°C)

Extirpated Sites

Persistent Sites

-6 -4 -2 0 2 4

p < 0.005
Anthropogenic Refugia?
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**
  - Absent
  - Present

- **Months Tmax Warmer than Historic 95% Quantile**
  - Absent
  - Present

- **Mean CWD (1970-1999)**
  - Absent
  - Present

- **PC2 of Warming Tmin Months**
  - Absent
  - Present
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

- CALCC
- 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!
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.
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

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Tmax patterns are a little different

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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

PC1

Less change

More change

Less change

PC2

“Winter” change

“Summer” change

“Winter” change

“Summer” change
Are there potential refugial sites?
Are Well-Connected Meadows at higher elevations?

Applying the $90^{th}$ Percentile  
Applying the $75^{th}$ 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