

# Climate Change Refugia as a Tool for Climate Adaptation

Toni Lyn Morelli, Northeast Climate Science Center, University of Massachusetts; [morelli@umass.edu](mailto:morelli@umass.edu)

Sean P. Maher, Department of Biology, Missouri State University, Springfield, MO

Craig Moritz, Research School of Biology, Australian National University, Acton, ACT, Australia

Steven R. Beissinger, Department of Environmental Science, Policy & Management & the Museum of Vertebrate Zoology, University of California, Berkeley



## Objectives

Natural resource managers need to develop climate change adaptation strategies to address the responses of species to overall warming trends and shifting precipitation regimes. Climate change refugia, areas that are relatively buffered from climate change so as to increase persistence of valued physical, ecological, and social resources, are of increasing interest but few studies have provided spatially explicit hypotheses of these refugia and even fewer have tested for them.

In this California Landscape Conservation Cooperative funded project, we identified climate change refugia and connectivity among meadows across the Sierra Nevada and used data on persistence, stability, and genetic diversity of mammal populations to validate these hypotheses.



## Background

The Belding's ground squirrel, *Urocitellus beldingi*, is found primarily in mid- to high-elevations from Oregon to Nevada. It is easily observed, readily sampled, and depends on ecologically important montane meadow habitats.

In a previous study, we found that *U. beldingi* has severely contracted its range over the last century, with extirpations more likely to occur in sites that had experienced more climate change; the effect was apparently mitigated by human influence at "anthropogenic refugia" (Morelli et al. 2012 *Proc B*).



UC Davis  
Information Center for  
the Environment (ICE)



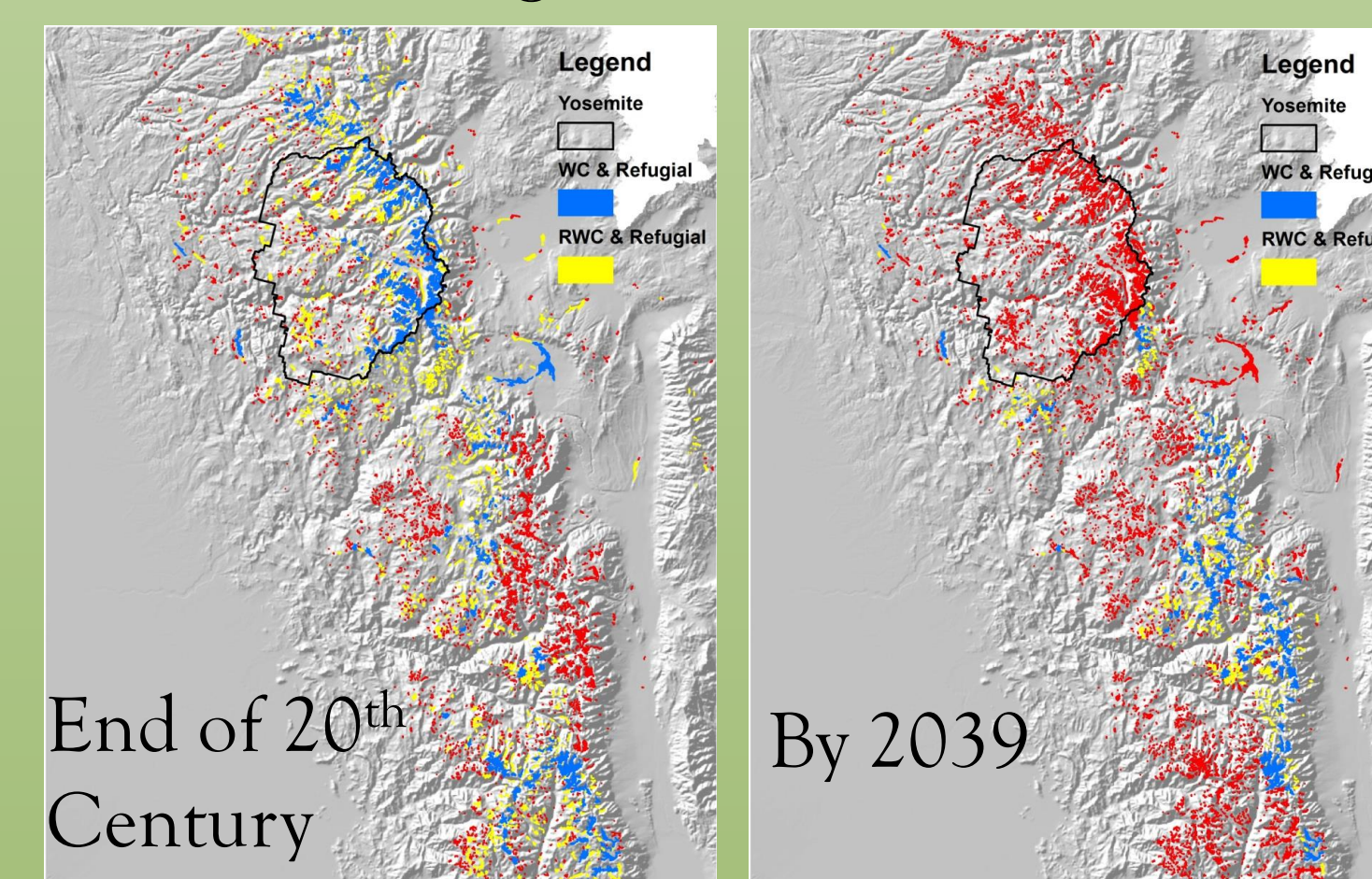
Are there places that buffer species from climate change?  
If so, where are they, and can species get there?

Sorry that I can't make the poster session but you can come see me at my talk tomorrow. -Toni Lyn

## Refugia Map

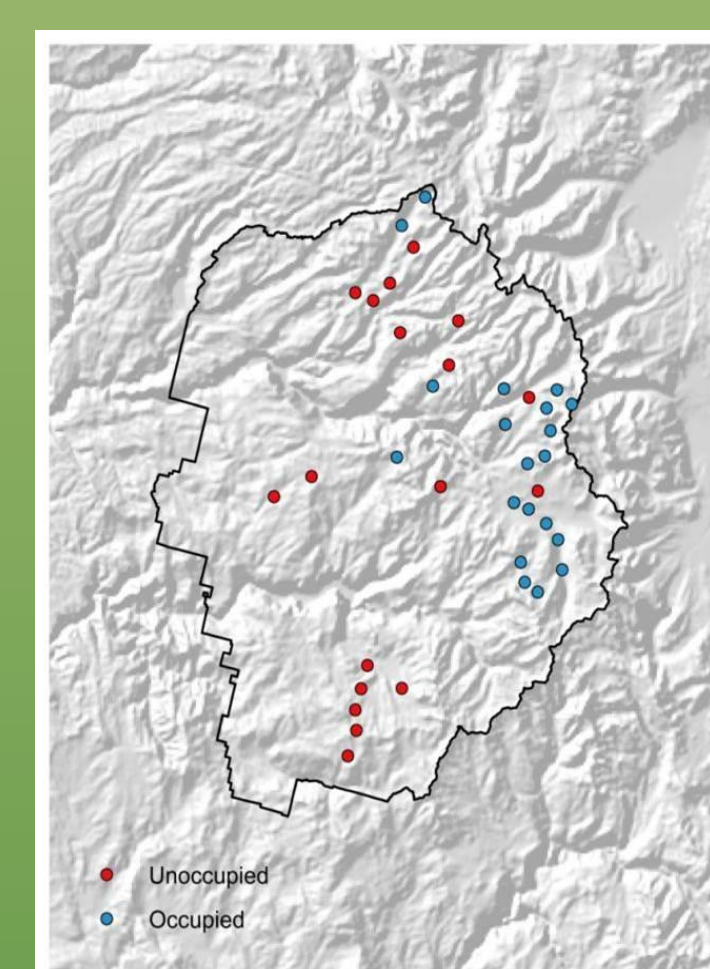
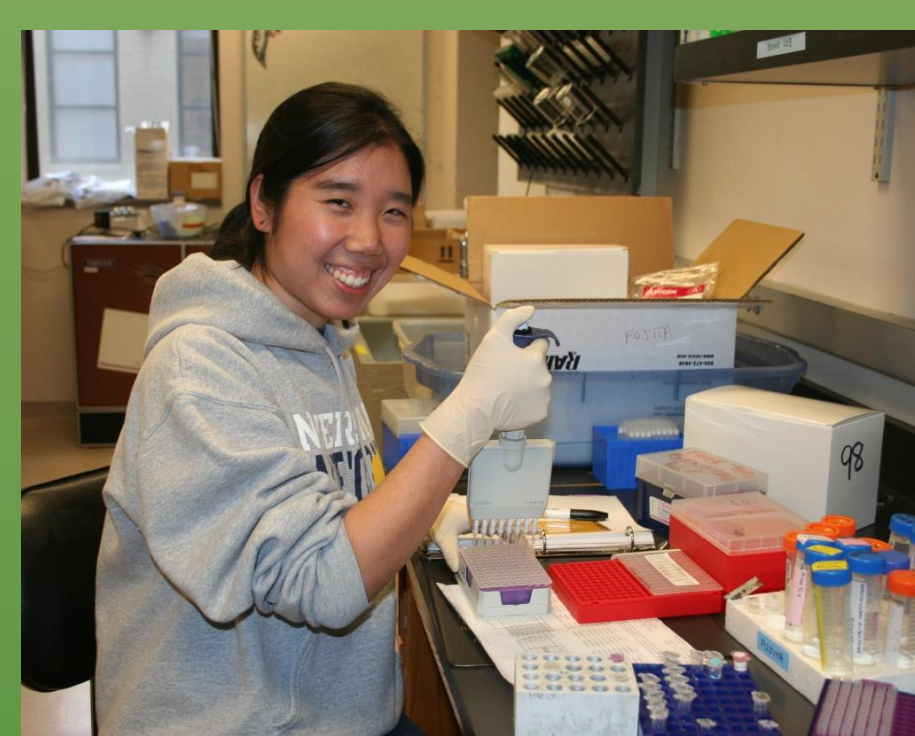
At the beginning of (and throughout) the project, we met with natural resource managers and scientists from the U.S. Forest Service, National Park Service, U.S. Geological Survey, and California Department of Fish and Wildlife. Through these discussions we determined that the best focus would be montane meadows and their associated wildlife.

The first step then was to map connectivity among the meadows of the Sierra Nevada and adjacent areas. We identified well-connected meadows, based on environmental heterogeneity, topographically weighted distance, rivers, and roads. Well-connected meadows that act as refugia (remain within 1°C of the mean annual temperature from 1910-1939) are shown in blue; refugial meadows that are not as connected are shown in yellow. The map on the left is based on observed trends in climate, whereas the map on the right represents estimates based on the GFDL circulation model, A2 climate scenario. The outline is Yosemite National Park.



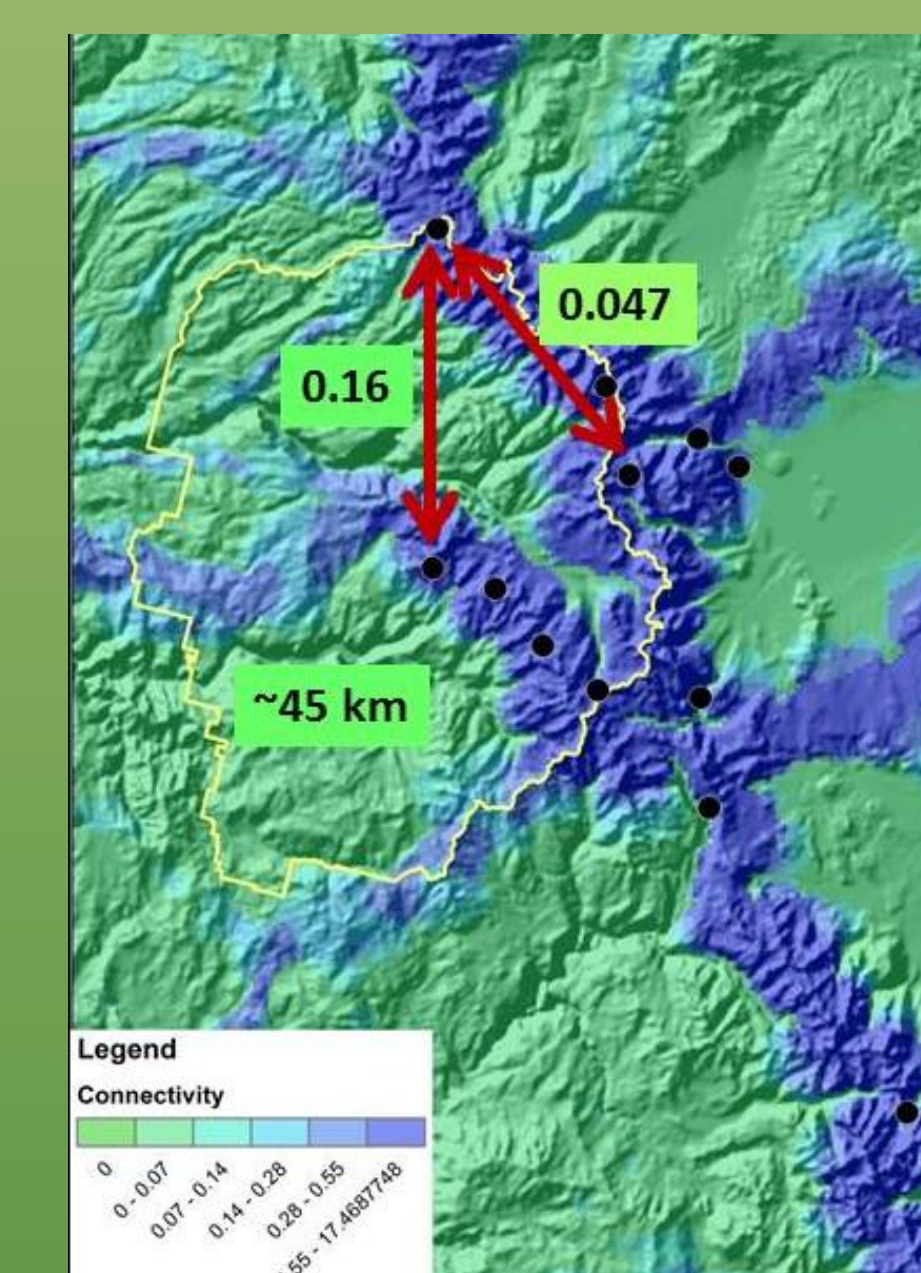
## Testing Refugia and Connectivity

Tissues samples from 170 adult Belding's ground squirrel from across California were analyzed by UC Berkeley undergraduates, resulting in nine subpopulations.



We also surveyed Yosemite National Park meadows to determine which were occupied by Belding's ground squirrels.

We found that genetic diversity (mean allelic richness) was higher in the hypothesized refugia as well as in meadows with higher connectivity. In addition, Yosemite NP meadows that were occupied by *U. beldingi* had a smaller change in minimum temperature across the last century and reduced climate water deficit during the end of last century.



Genetic distance was correlated with hypothesized connectivity (indicated in blue).

## Management Implications and Adaptation Options

This project's results teach us the following:

- Climate may be changing more rapidly than species can move or adapt
- Consideration of connectivity within climate change research is important
- Although no panacea, climate change refugia maps could be important tools for prioritizing habitats for management intervention in order to conserve populations

Climate adaptation options differ from agency to agency but possible actions to capitalize on this knowledge include:

- Reducing non-climate stressors in well-connected, refugial meadows to optimize biodiversity conservation
- Creating connections between large, isolated refugial meadows
- Understanding and encouraging the mechanisms that create refugia
- Considering more intrusive approaches in extraordinary cases such as taking action to maintain or even create refugia or assisting migration into them.

For more information, please see these resources:

<http://climate.calcommons.org/article/connectivity-and-refugia-sierra-nevada>

Morelli et al. 2012 Anthropogenic refugia ameliorate the severe climate-related decline of a montane mammal along its trailing edge *Proc B*