

Climate Change Refugia Conservation



Toni Lyn Morelli - Northeast CASC, USGS
Rebecca Quinones & Brian Hawthorne – MA DFW



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The Northeast Climate Adaptation Science Center works with natural and cultural resource managers in the Northeast and Midwest regions to apply future climate scenarios to decision making and co-produce information, and tools for climate change adaptation.

2015 Fellows Retreat

The 2015 NE CSC Fellows Retreat was held September 22-25 in Suring, Wisconsin. Twenty Graduate and Postdoctoral Fellows gathered to share their research, develop collaborations, and learn from stakeholders and scientists who have established strong working relationships.



Photo: Thomas Borriot, NE CSC Graduate Fellow

[Read more](#)



NE CSC News



New Publication: Multi-Species Occupancy Models
Tuesday, February 25, 2020

Over the past decade, recent technologies such as drones and trail cameras have revolutionized wildlife monitoring, particularly by facilitating multi-species community studies. While this work has great potential to inform conservation planning, a new paper analyzing 92 such projects suggests that their reliability may be

NE CSC e-Newsletters

- Jan 23 2020 news and events
- Nov 25 2019 news and events
- Oct 31 2019 news and events

[more newsletters](#)

Next NE CSC Webinar

Mar 25 2020 - 12:00pm
When Lake Superior Turns Green
Robert Sterner

[more upcoming](#)



Recent Videos



Stakeholder guidance helps to identify major misconception regarding dam removals

[more videos](#)



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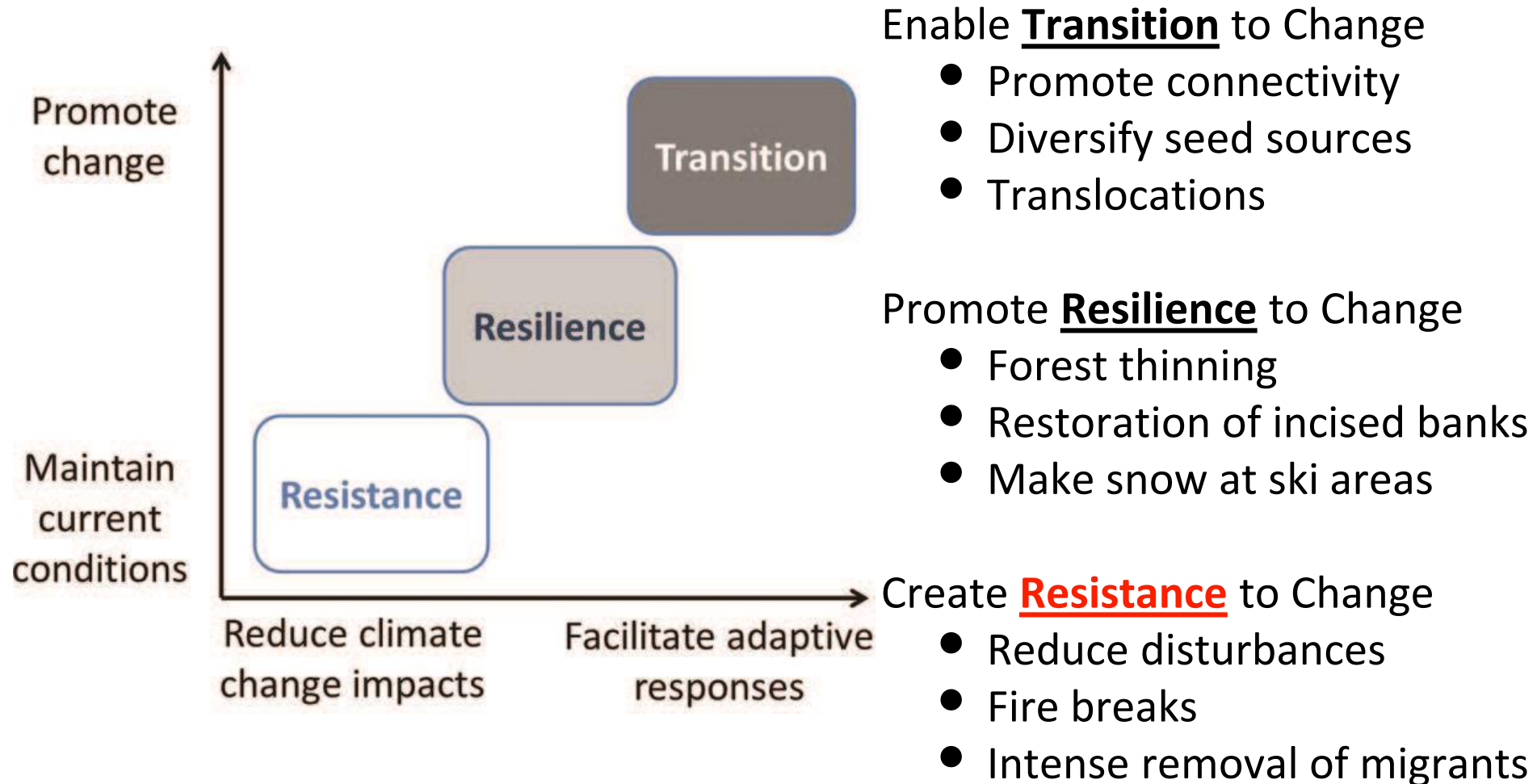
Signup here to receive our e-newsletter listing climate-related news and events throughout the Northeast!

Search

New resources

- Analysis of Resource

Climate Change Adaptation Options



Climate Change Refugia

Journal of Biogeography (*J. Biogeogr.*) (2014) **41**, 837–841

GUEST
EDITORIAL

The ecological and evolutionary implications of microrefugia

Jonathan A. Mee^{1*} and Jean-Sébastien Moore²



New
Phytologist

Review



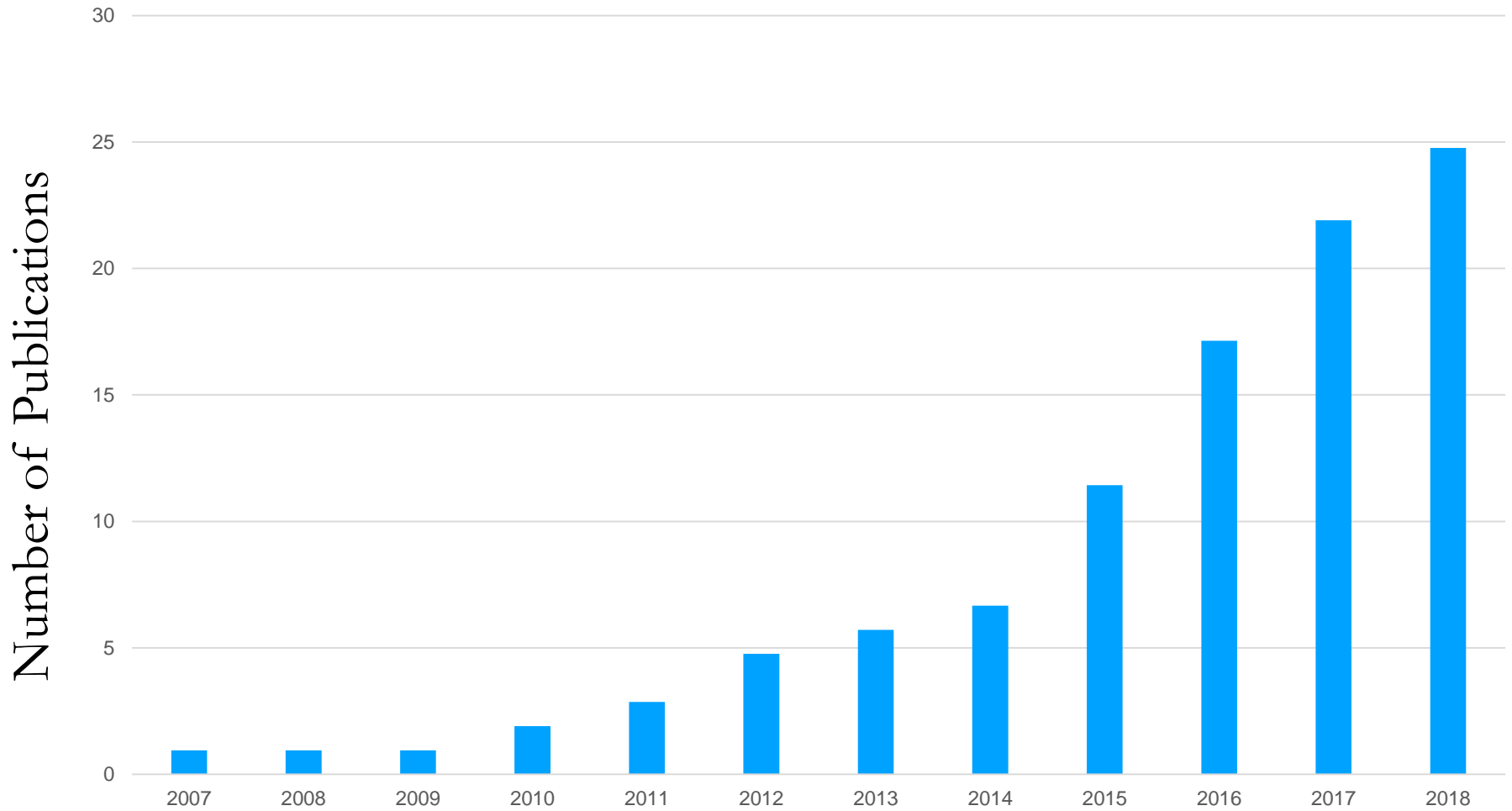
Tansley review

Climate refugia: joint inference from fossil records, species distribution models and phylogeography

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Tel: +1 541 3465787
Email: dgavin@uoregon.edu

Received: 4 February 2014
Accepted: 6 June 2014

Daniel G. Gavin¹, Matthew C. Fitzpatrick², Paul F. Gugger³, Katy D. Heath⁴, Francisco Rodríguez-Sánchez⁵, Solomon Z. Dobrowski⁶, Arndt Hampe^{7,8}, Feng Sheng Hu⁴, Michael B. Ashcroft⁹, Patrick J. Bartlein¹, Jessica L. Blois¹⁰, Bryan C. Carstens¹¹, Edward B. Davis¹², Guillaume de Lafontaine¹³, Mary E. Edwards¹⁴, Matias Fernandez⁴, Paul D. Henne¹⁵, Erin M. Herring¹,



WOK: “climate refugia” or
“climate change refugia”

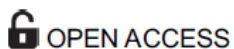


COLLECTION REVIEW

Managing Climate Change Refugia for Climate Adaptation

Toni Lyn Morelli^{1,2,3*}, Christopher Daly⁴, Solomon Z. Dobrowski⁵, Deanna M. Dulen⁶, Joseph L. Ebersole⁷, Stephen T. Jackson^{8,9}, Jessica D. Lundquist¹⁰, Constance I. Millar¹¹, Sean P. Maher^{2,3,12}, William B. Monahan¹³, Koren R. Nydick¹⁴, Kelly T. Redmond¹⁵, Sarah C. Sawyer¹⁶, Sarah Stock¹⁷, Steven R. Beissinger^{2,3}

1 U.S. Geological Survey, DOI Northeast Climate Science Center, Amherst, MA, United States of America, 2 Department of Environmental Science, Policy and Management, University of California, Berkeley, CA, United States of America, 3 Museum of Vertebrate Zoology, University of California, Berkeley, CA, United States of America, 4 College of Engineering, Oregon State University, Corvallis, OR, United States of America, 5 College of Forestry and Conservation, University of Montana, Missoula, MT, United States of America, 6 U.S. National Park Service, Devils Postpile National Monument, Mammoth Lakes, CA, United States of America, 7 U.S. Environmental Protection Agency, Western Ecological Division, Corvallis, OR, United States of America, 8 U.S. Geological Survey, DOI Southwest Climate Science Center, Tucson, AZ, United States of America, 9 Department of Geosciences and School of Natural Resources and Environment, University of Arizona, Tucson, AZ, United States of America, 10 Department of Civil and Environmental Engineering, University of Washington, Seattle, WA, United States of America, 11 USDA Forest Service, Pacific Southwest Research Station, Albany, CA, United States of America, 12 Department of Biology, Missouri State University, Springfield, MO, United States of America, 13 USDA Forest Service, Forest Health Technology Enterprise Team, Fort Collins, CO, United States of America, 14 U.S. National Park Service, Sequoia & Kings Canyon National Parks, Three Rivers, CA, United States of America, 15 Western Regional Climate Center, Desert Research Institute, Reno, NV, United States of America, 16 USDA Forest Service, Pacific Southwest Region, Vallejo, CA, United States of America, 17 U.S. National Park Service, Yosemite National Park, El Portal, CA, United States of America



Areas relatively buffered from contemporary climate change that enable persistence of valued physical, ecological, and socio-cultural resources

Climate Change Refugia

Topographically complex terrain creates varied microclimates and increases the likelihood that current climates will continue to exist nearby.

Deep snow drifts provide insulation to the surface below and provide water later in the season.

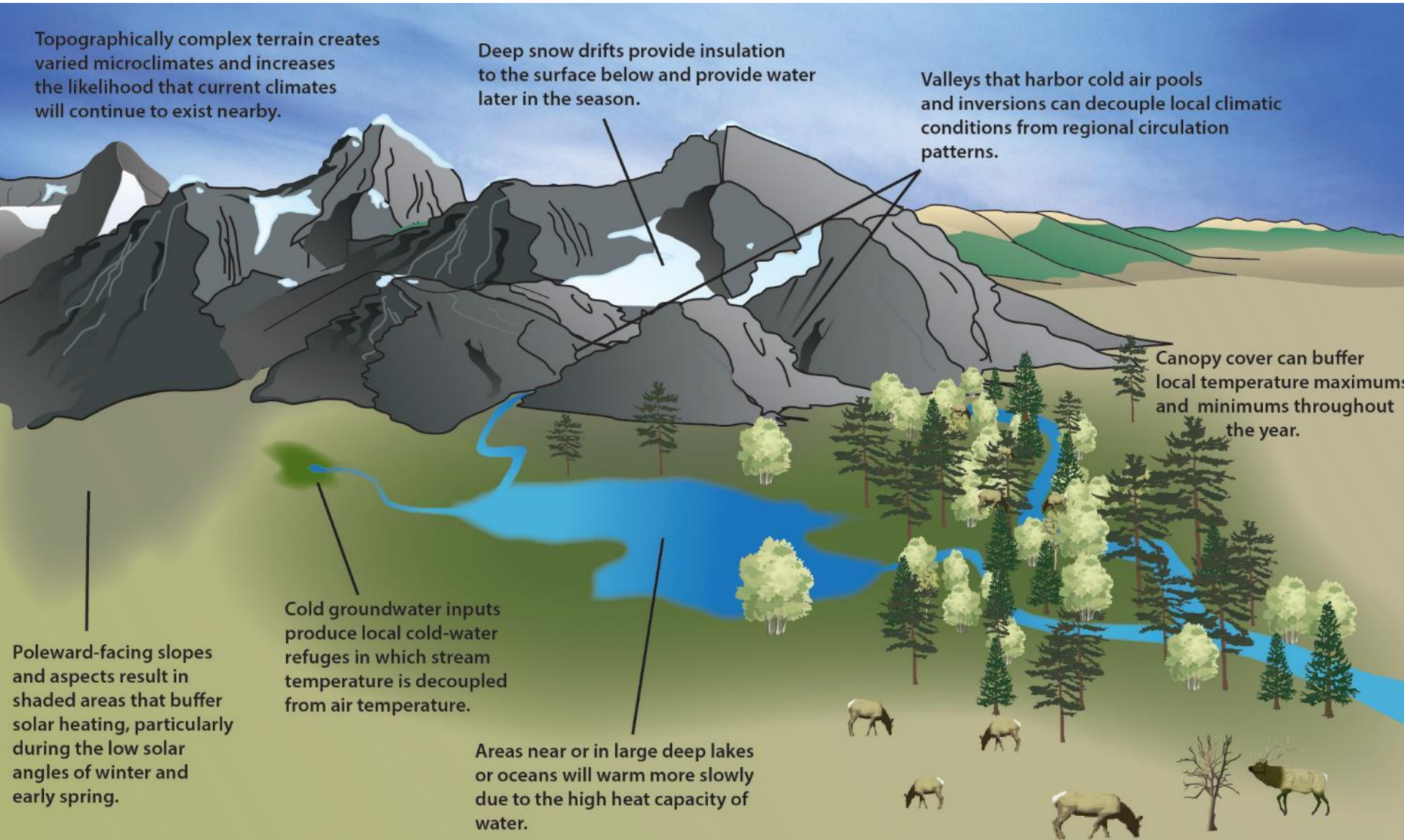
Valleys that harbor cold air pools and inversions can decouple local climatic conditions from regional circulation patterns.

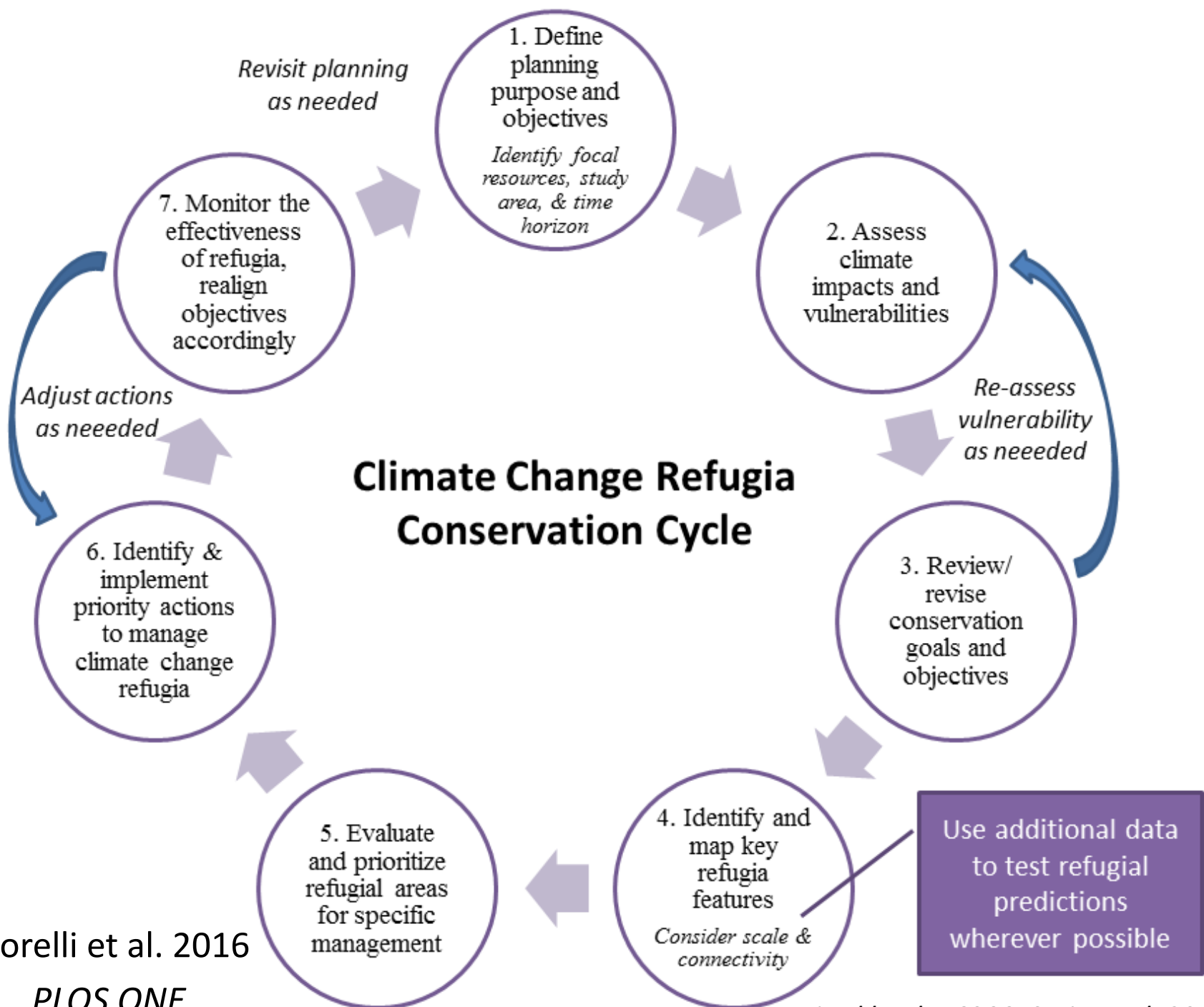
Canopy cover can buffer local temperature maximums and minimums throughout the year.

Cold groundwater inputs produce local cold-water refuges in which stream temperature is decoupled from air temperature.

Areas near or in large deep lakes or oceans will warm more slowly due to the high heat capacity of water.

Poleward-facing slopes and aspects result in shaded areas that buffer solar heating, particularly during the low solar angles of winter and early spring.





Morelli et al. 2016

PLOS ONE

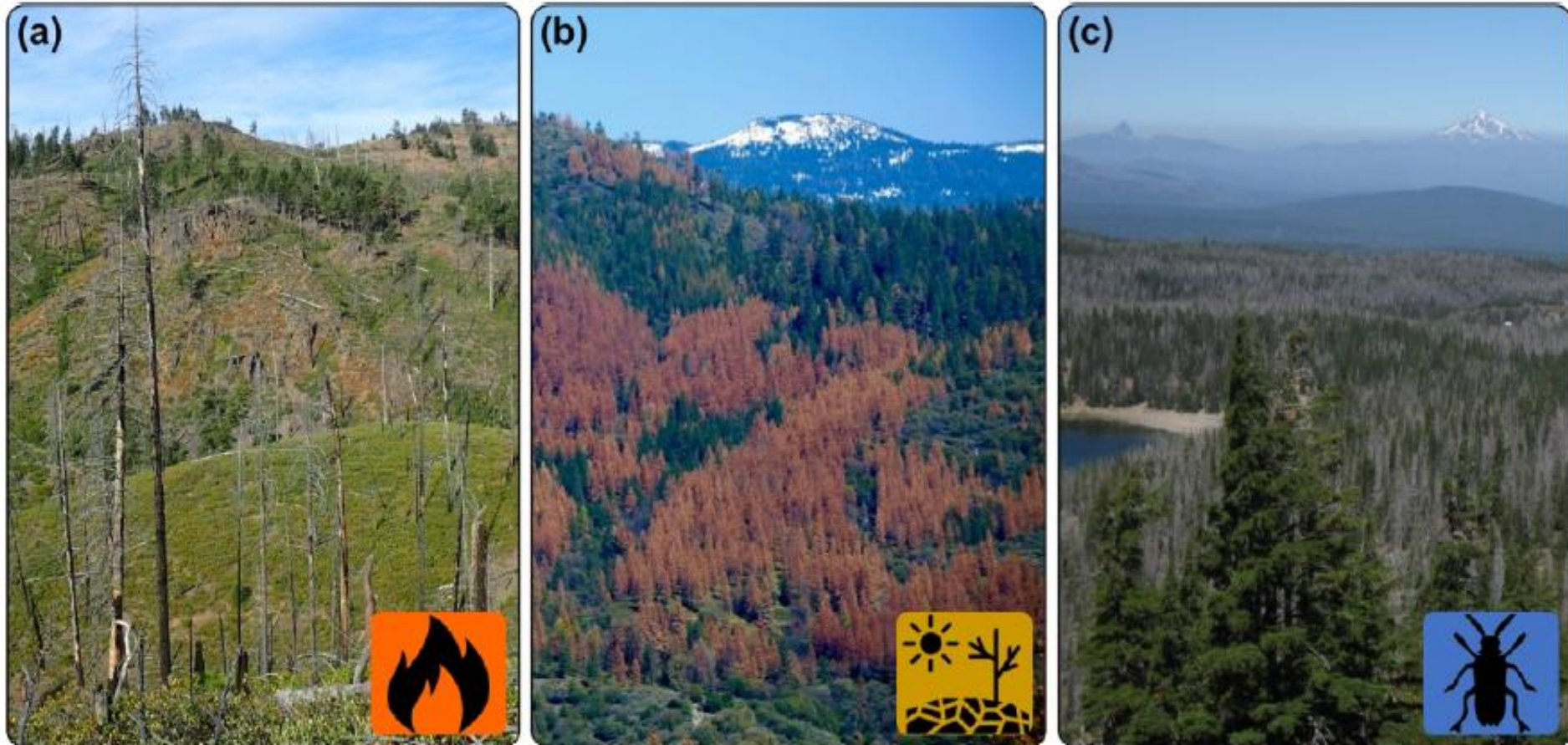
Inspired by the CSCC, Stein et al. 2014

Hydrological Refugia

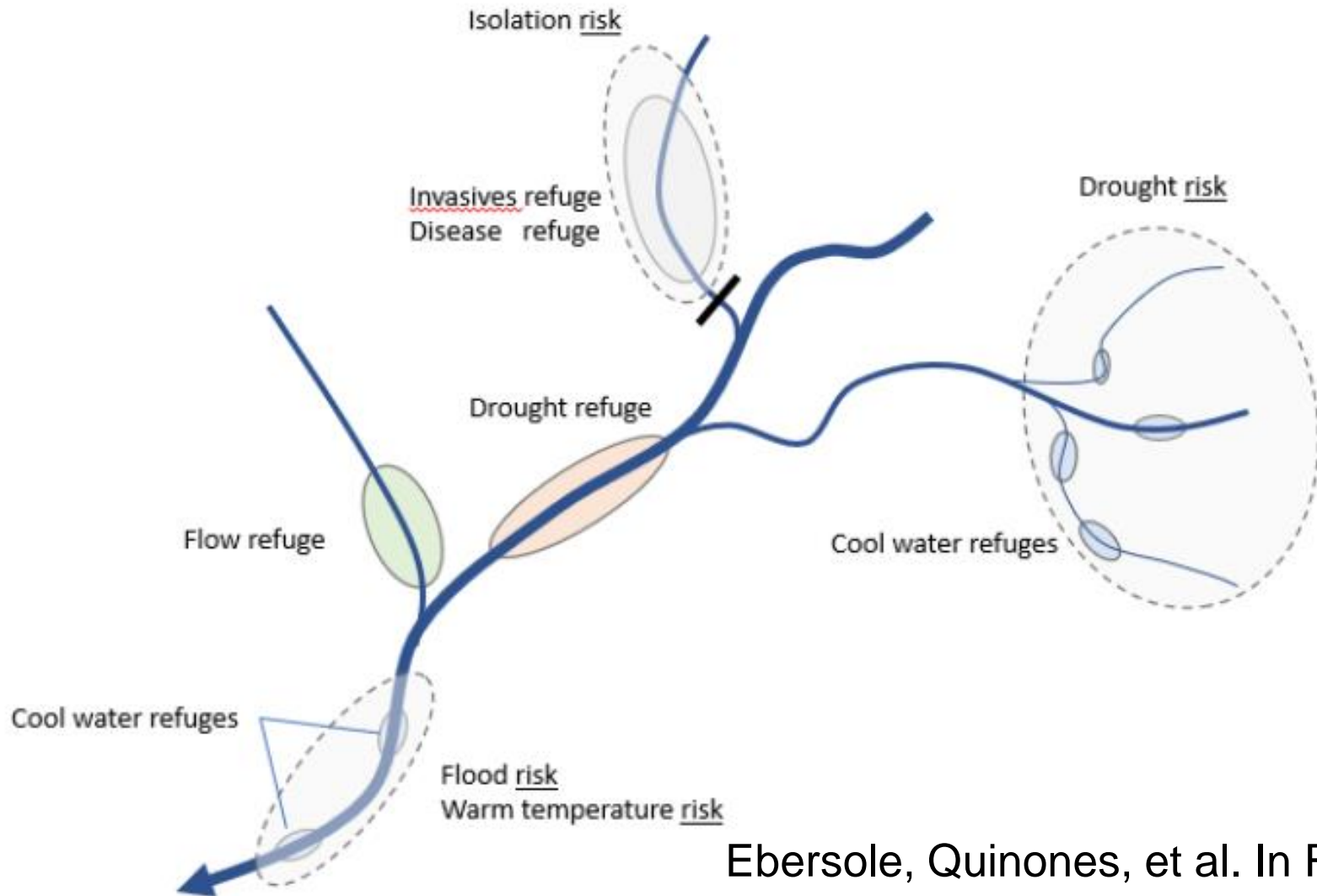


Cartwright et al
Frontiers In Review

Disturbance Refugia



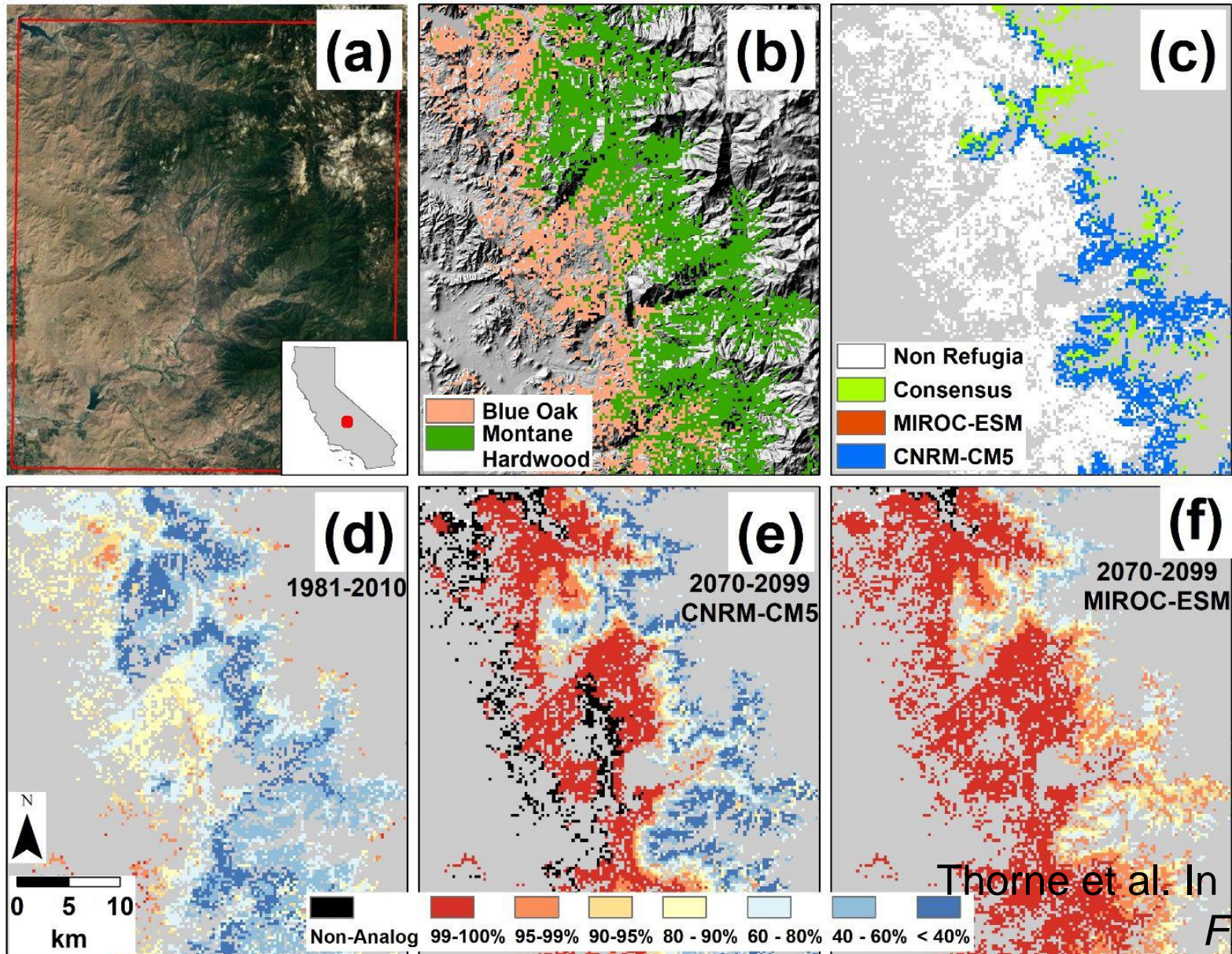
Coldwater Refugia

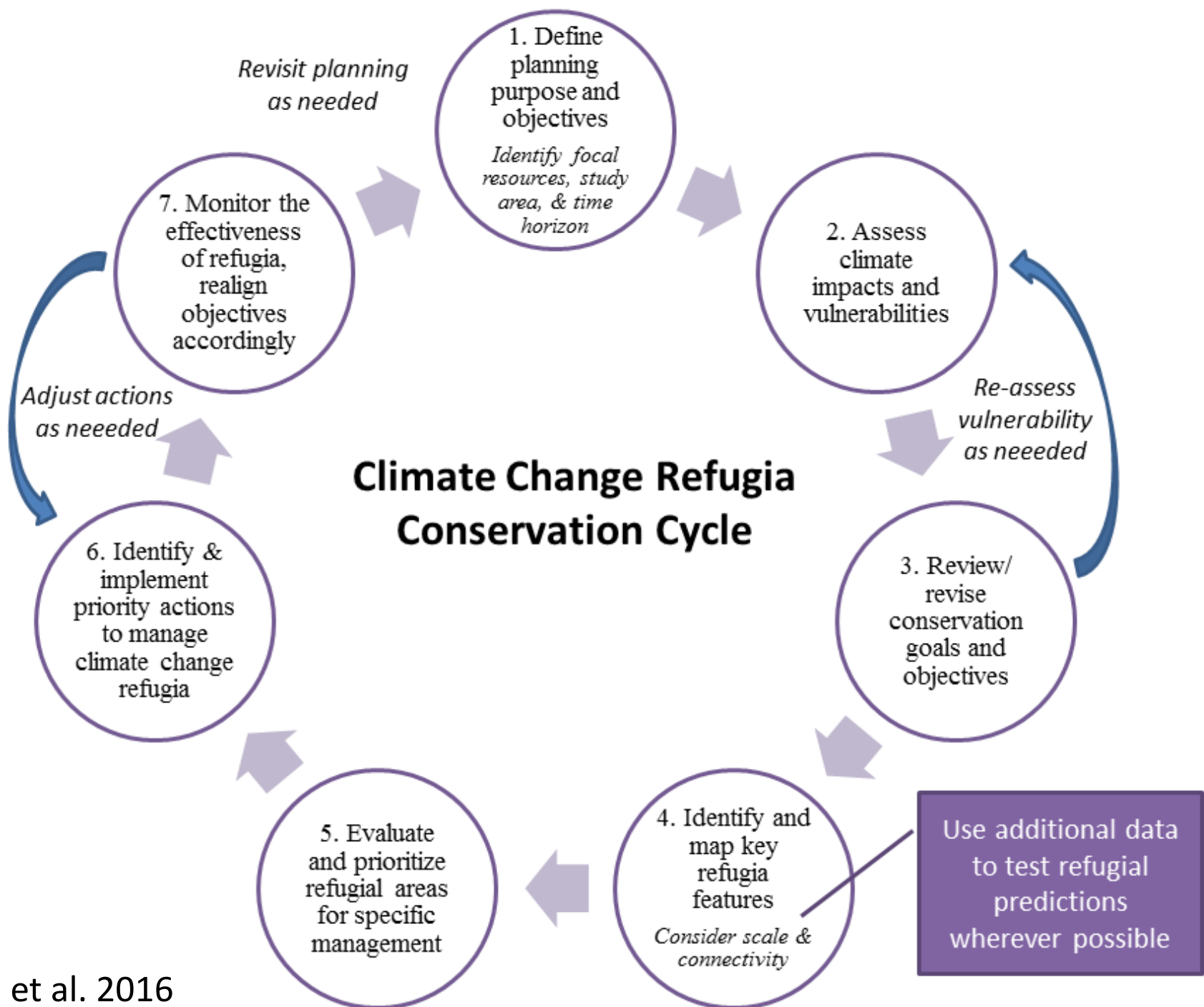


Ebersole, Quinones, et al. In Review

Frontiers

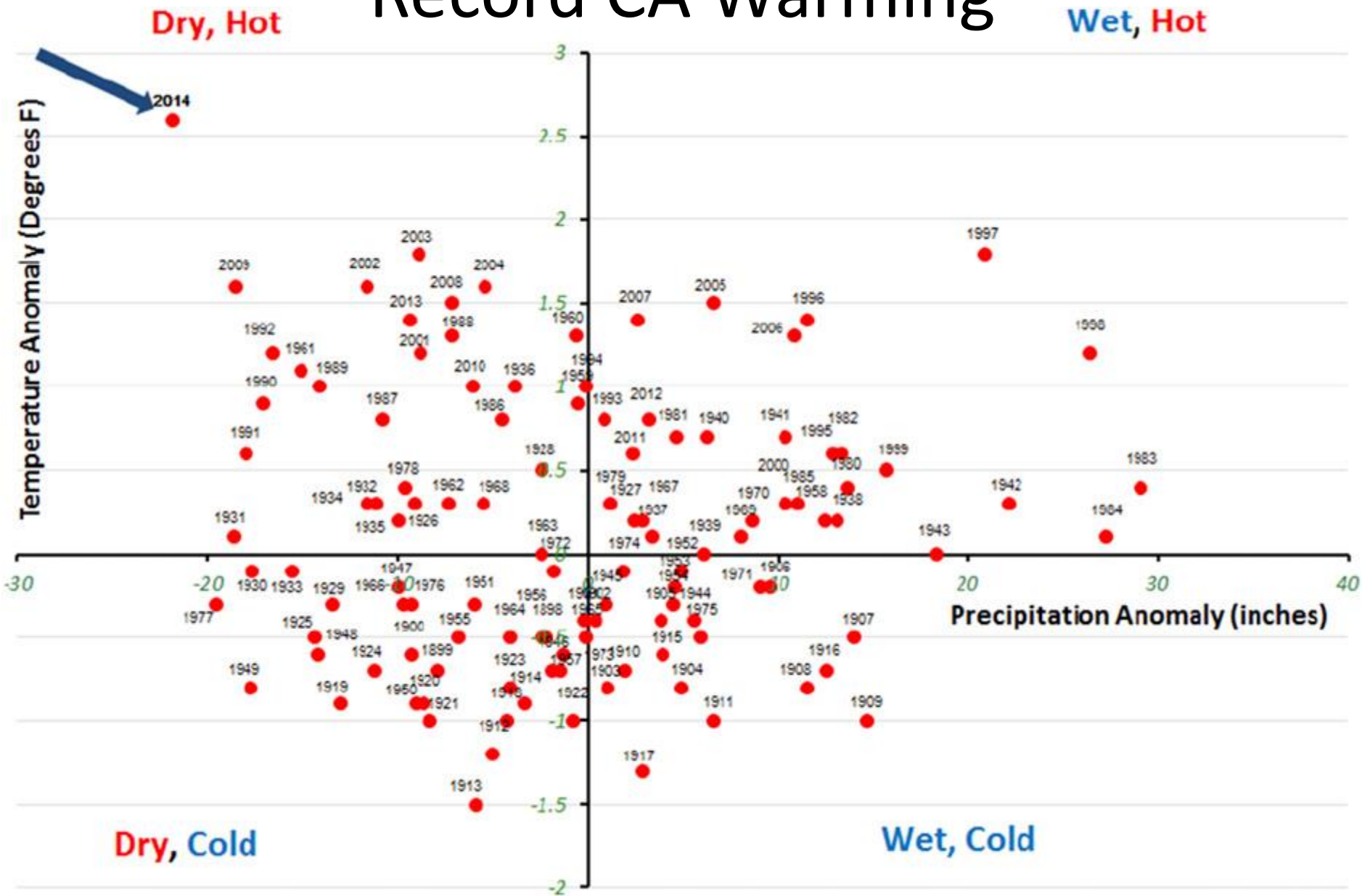
Vegetative Climate Refugia

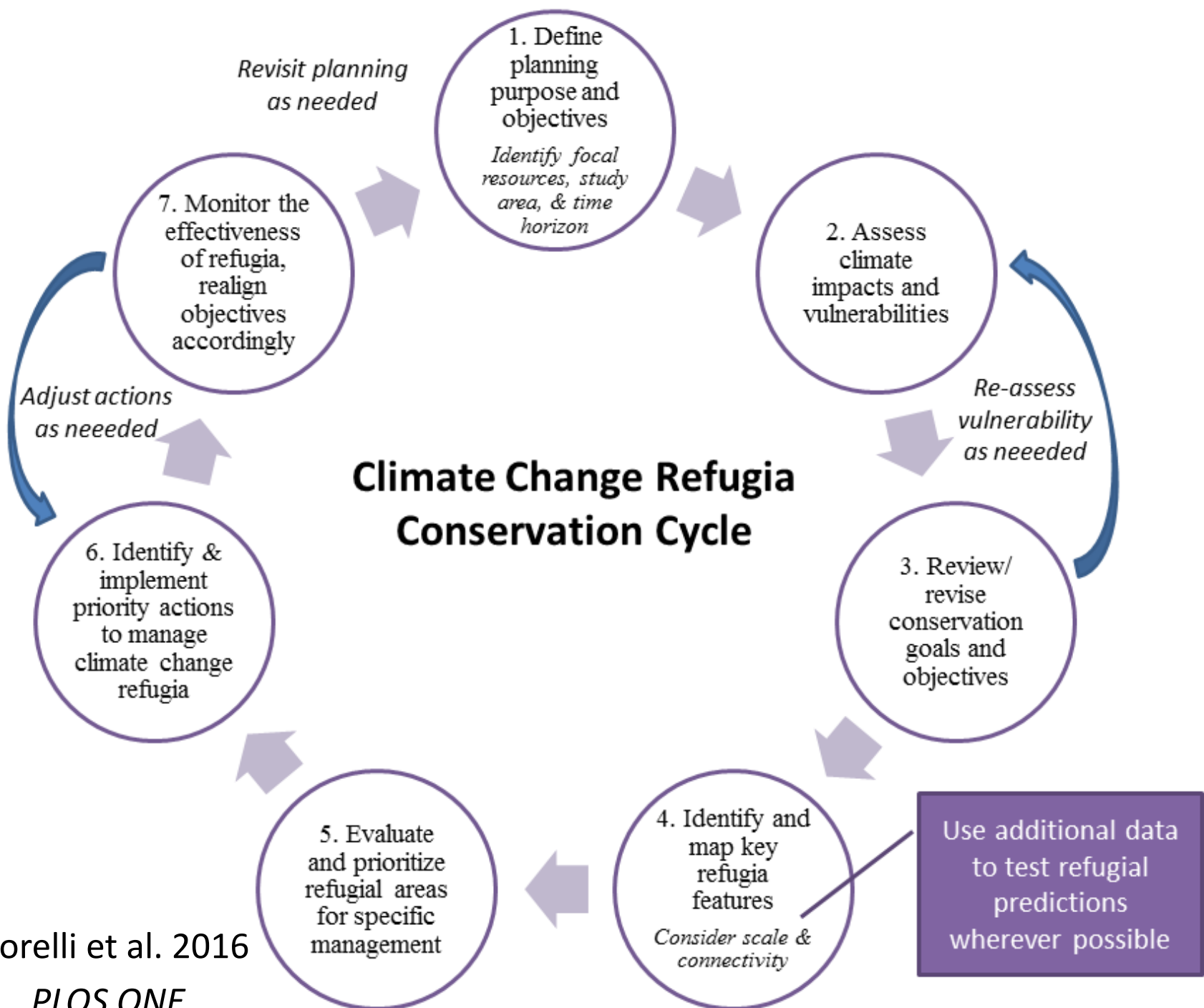






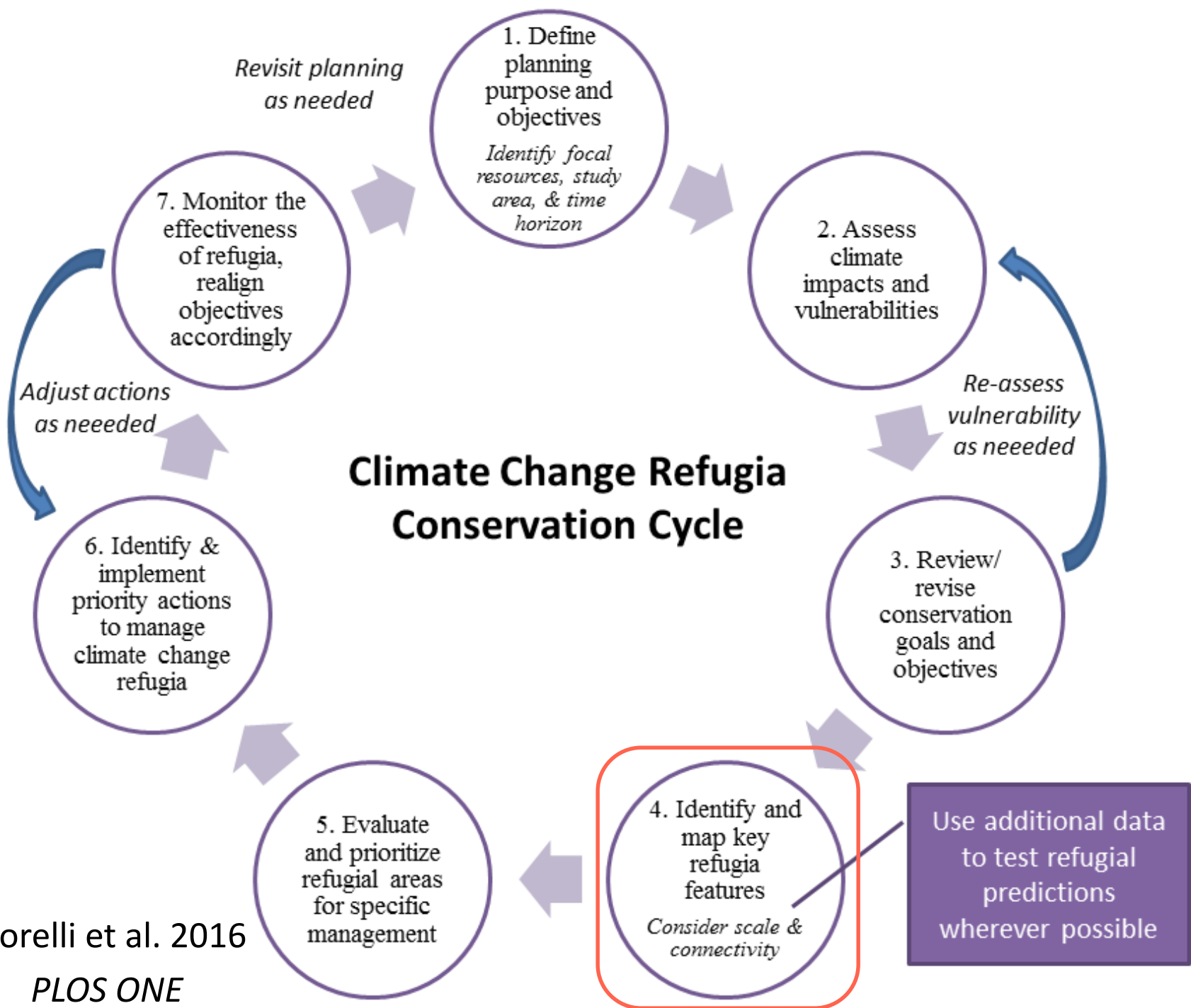
Record CA Warming

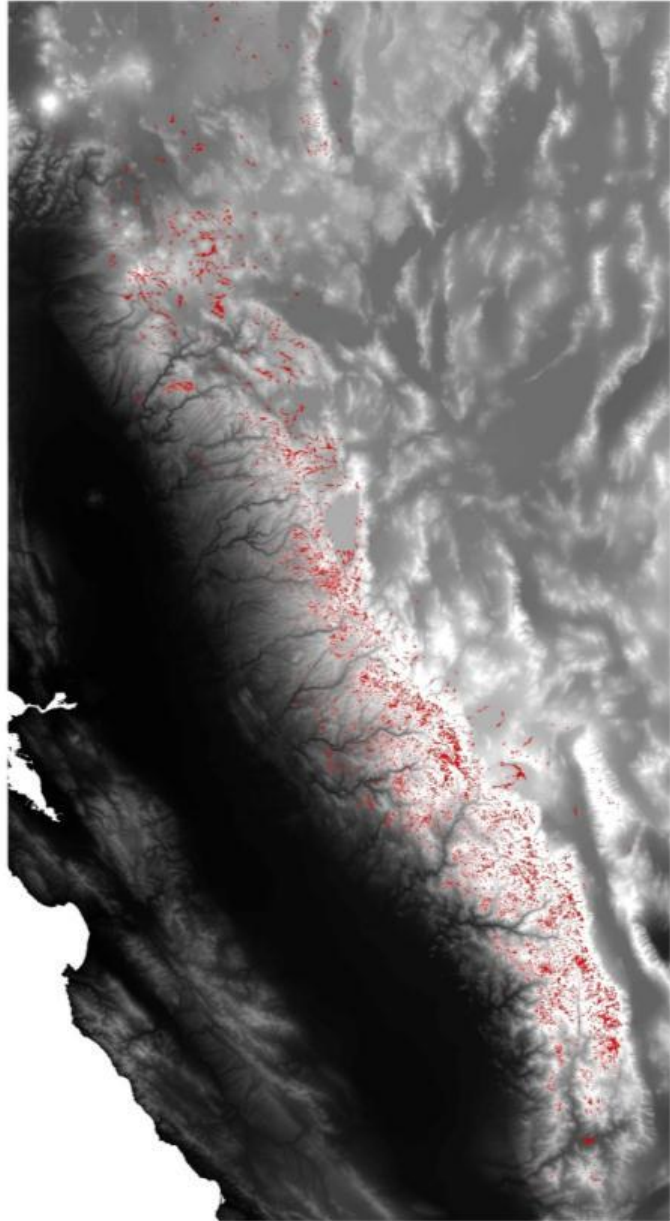




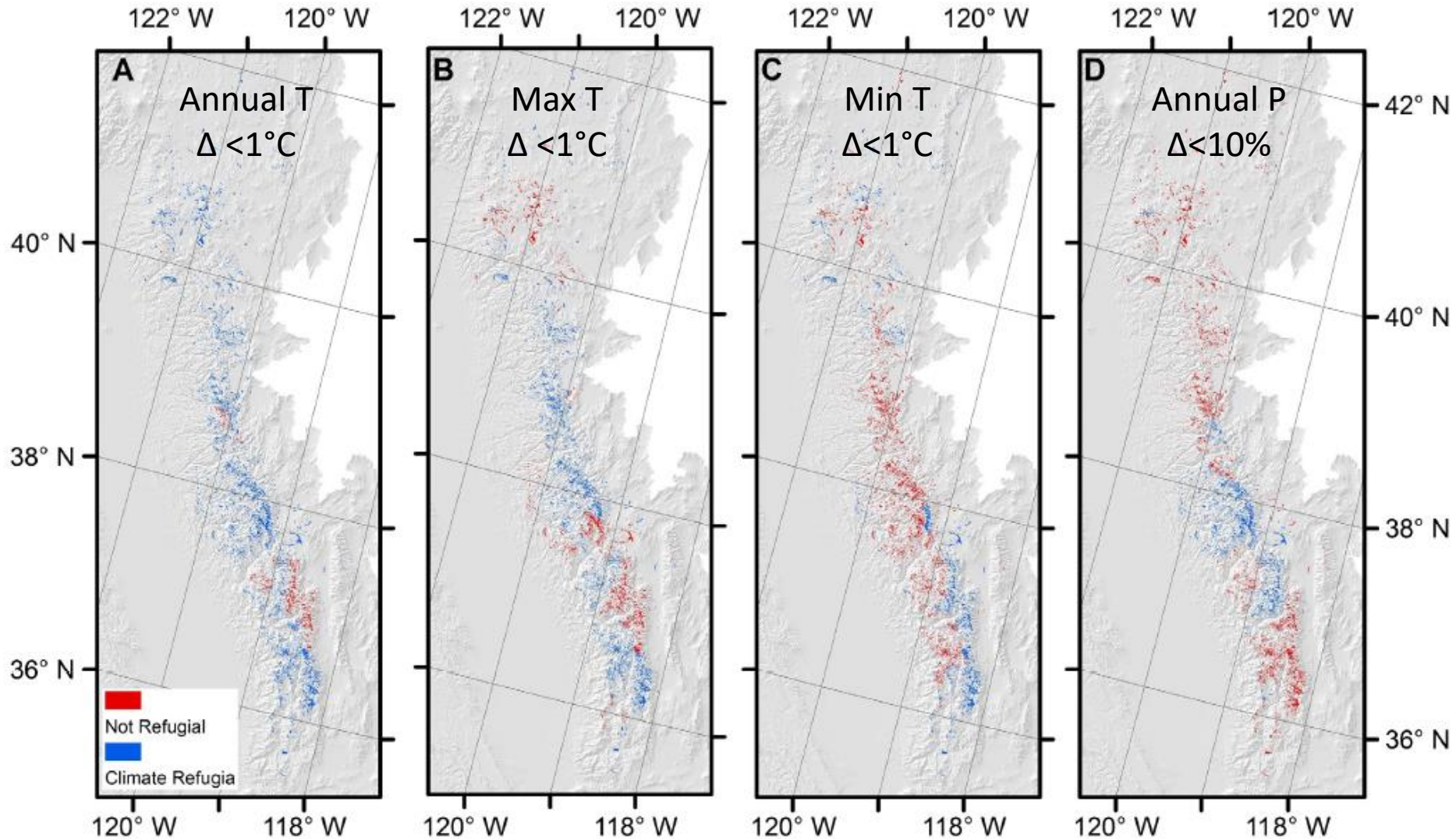
Montane Meadows





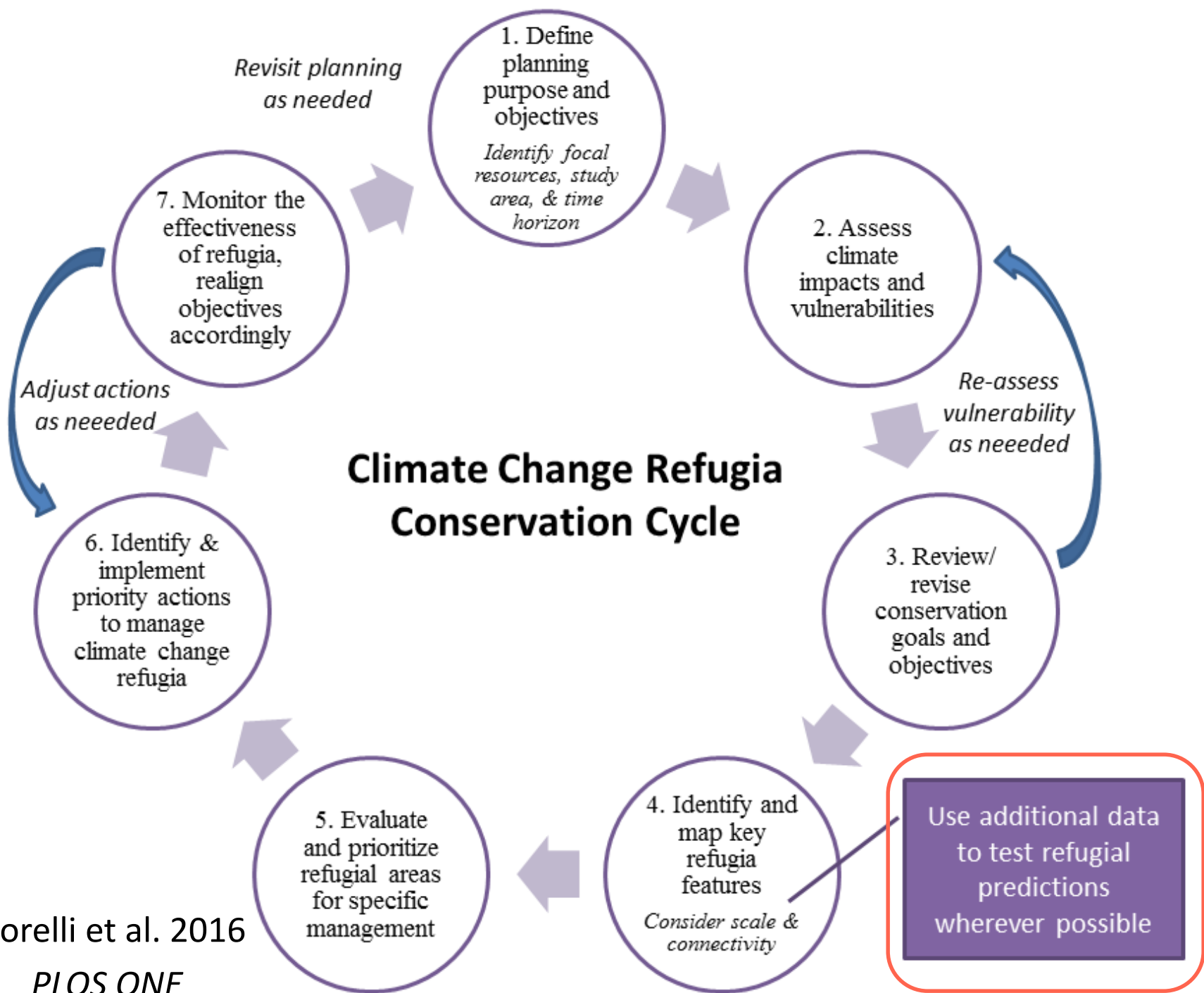


Mapping Climate Change Refugia



1970-1999 - 1910-1939

Maher, Morelli et al. 2017
Ecosphere



Morelli et al. 2016

PLOS ONE

Belding's Ground Squirrel (*Urocitellus beldingi*)



Grinnell - 1911

May 25 Yosemite

Besides the ever-present ground squirrels, *Citellus*
beecheyi (observed up to 6000 ft.) the only other mammal
we have seen was a Gray Squirrel at the village,
mashing across the road with a mouthful of forage.
Tobacco fumigations show a greater abundance





74 Historical Presences

Original Surveys: 1902-1966
Resurveys: 2003-2011
Detectability (p) > 0.995 for
2+ visits



Persistent Sites = 43

Extirpated Sites = 31

Original Surveys: 1902-1966

Resurveys: 2003-2011

Detectability (p) > 0.995 for
2+ visits

Site Extirpations (N=31)

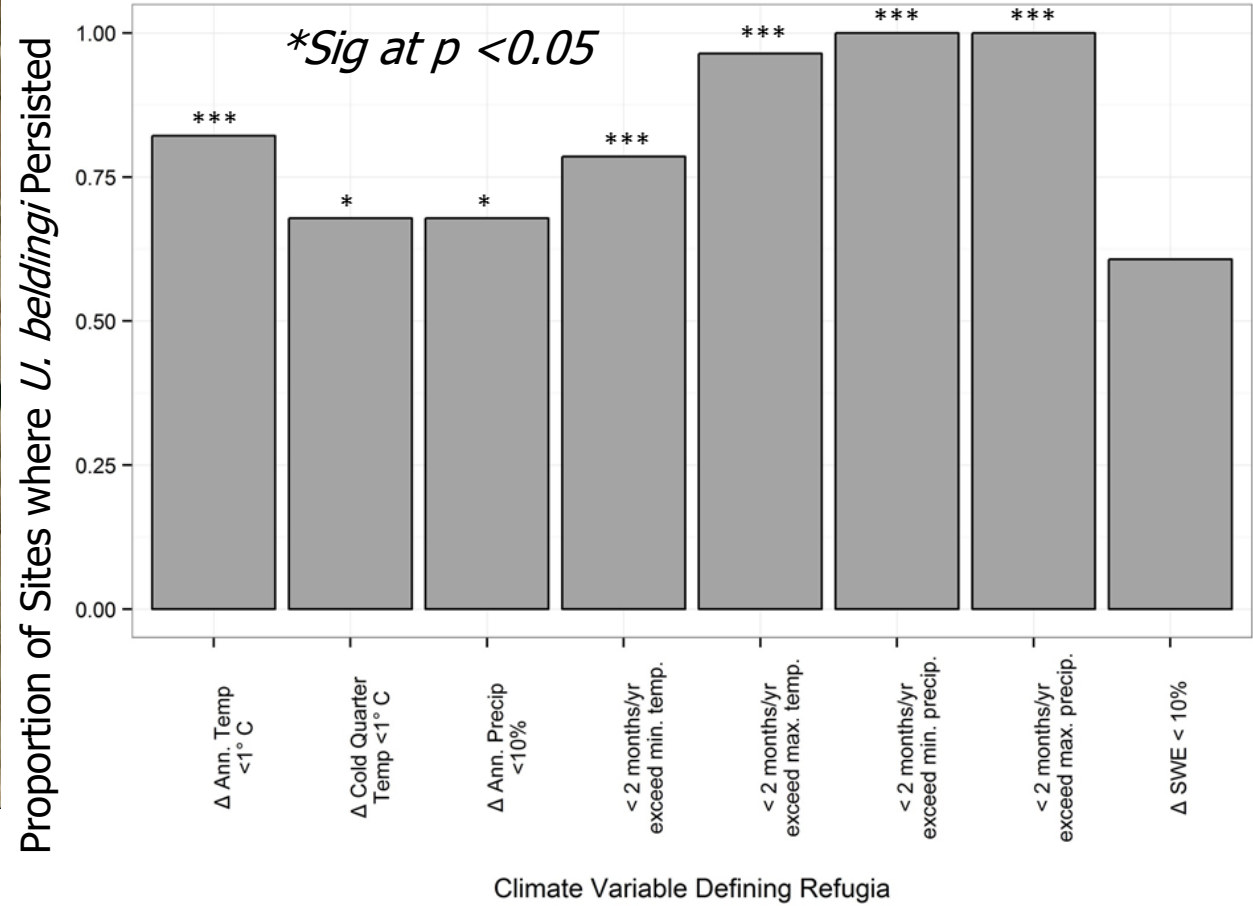
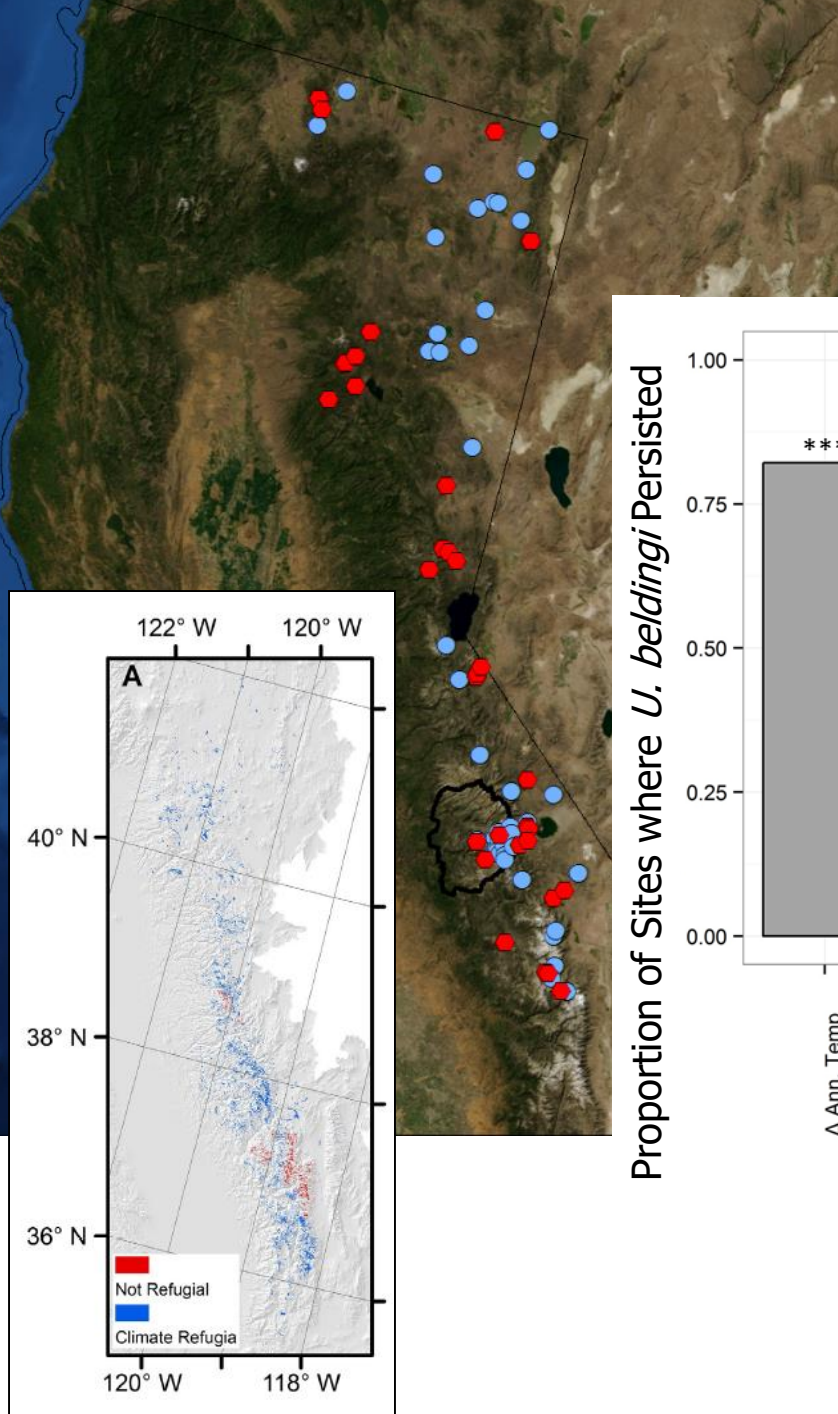


Site Persistence (N=43)



42% Rate of Site Extirpations Across CA

Climate Change Refugia Predict Persistence



Morelli et al. 2018

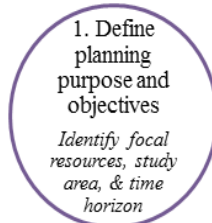
Climate Change Responses

Maintain montane meadow habitats in the Sierra Nevada, w/a 15-20 year planning cycle; consider 50-100 year climate projections

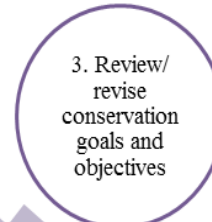
Monitor: meadow wetness via remote sensing and field measurements; indicator species; downstream watershed variables (streamflow, sediment load, etc)

Reduced moisture availability and precipitation; disruption of species synchronicity; vegetation shifts; increased recreation impacts from more visitors and longer seasons

Revisit planning as needed



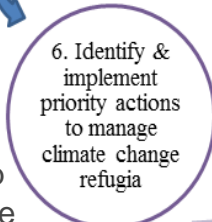
Re-assess vulnerability as needed



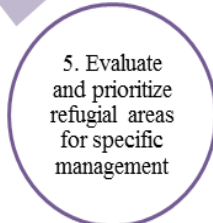
Maintain sufficient montane meadow habitats to protect critical ecosystem services in prioritized watersheds

Climate Change Refugia Conservation Cycle

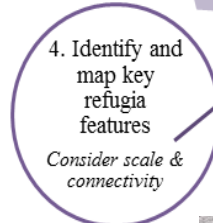
Adjust actions as needed



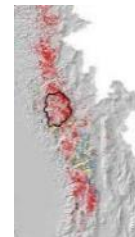
Minimize overgrazing; remove encroaching conifers & invasive species; mitigate road & trail impacts; assist migration of lower elev species; snow fencing to trap snow in desired locations; manage recreation & development; increase connectivity



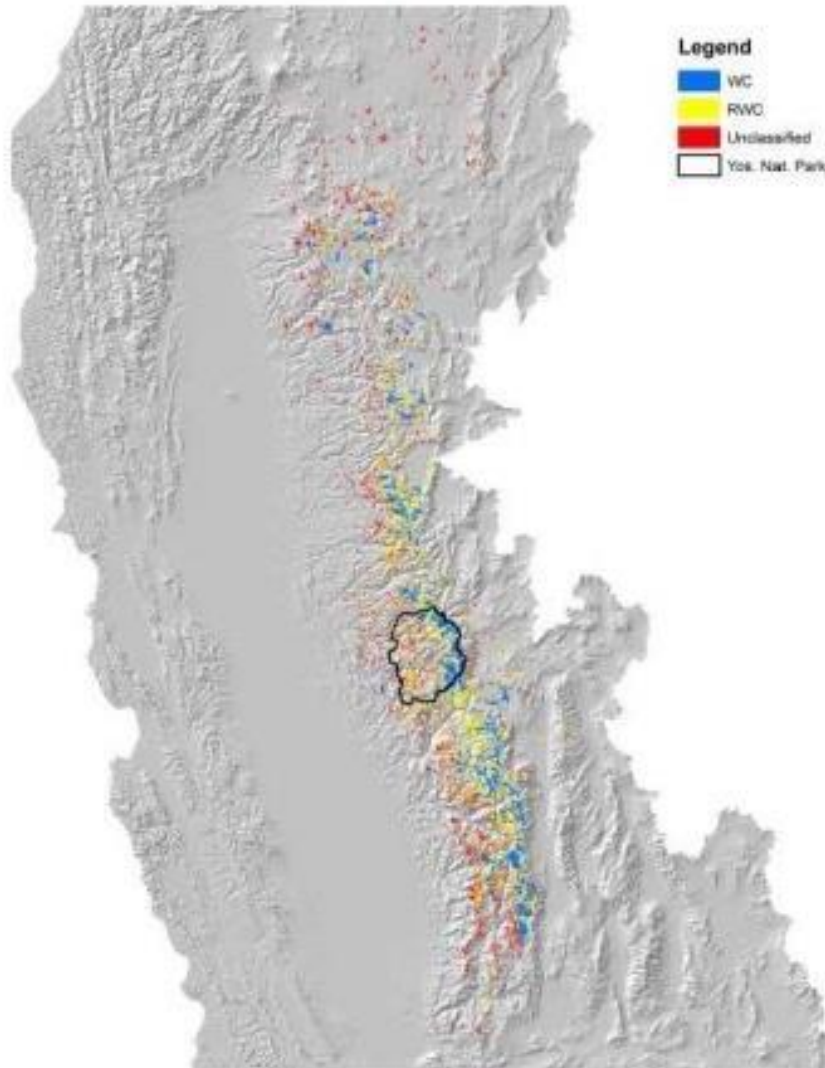
Medium or large meadows that are highly connected; areas of high biodiversity; meadows where species of management concern exist or might exist in the future; areas of high recreational value (if uses are compatible)



Use additional data to test refugial predictions wherever possible



On-the-Ground Refugia Conservation



Increase Connectivity

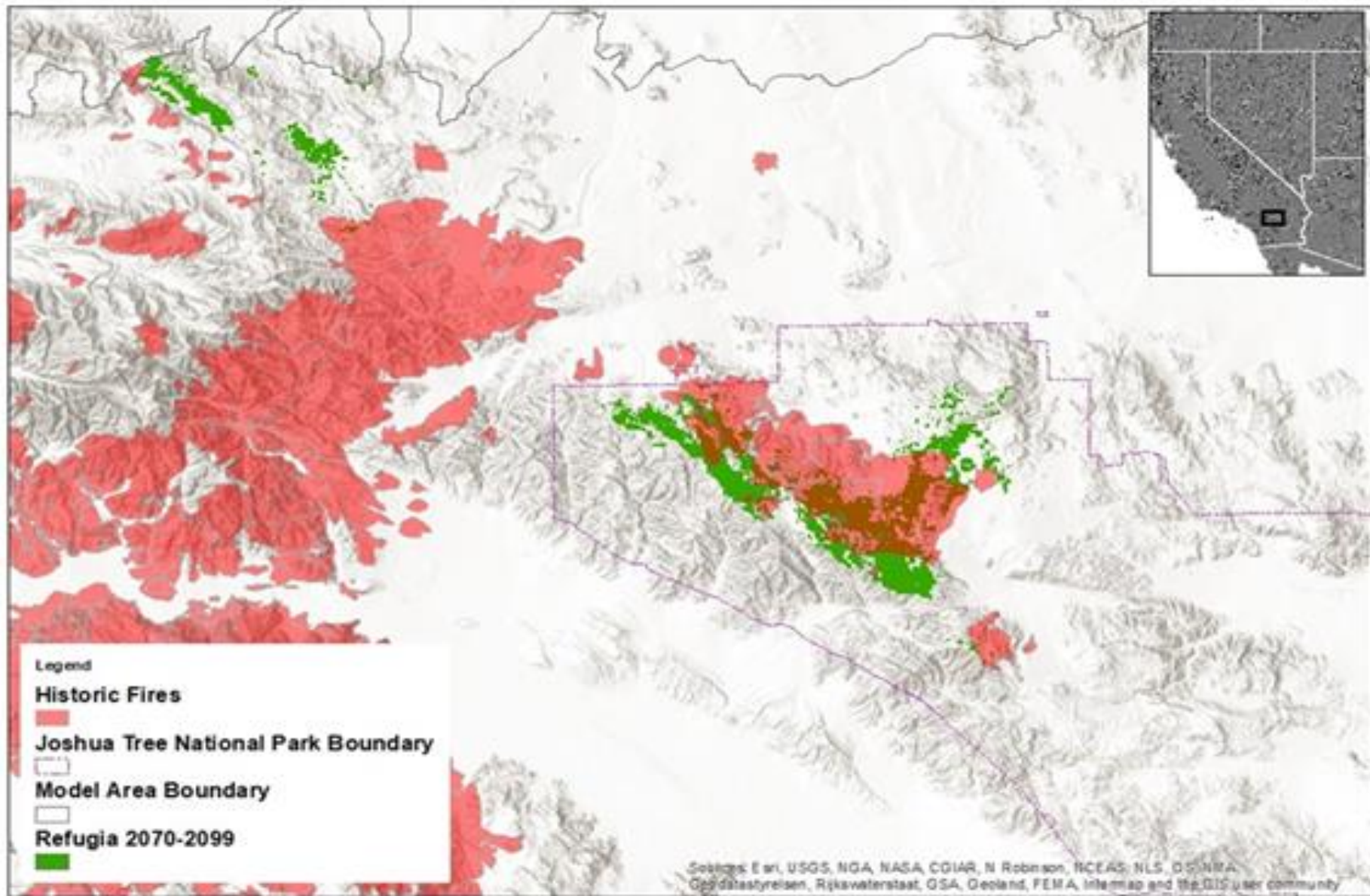
Improved culvert design

Road crossings

Reroute trails

Assisted migration?







Partners include:

- Cal-Trout
- US Forest Service
- National Park Service
- CA County Depts

Impacts of Climate Change and Invasive Plants in Sierra Meadows: Overview and Recommendations

California Invasive Plant Council, December 2015. info@cal-ipc.org



Cal-IPC



*The Sierra Nevada region is treasured for its natural beauty as well as its importance to California's water supply.
Photo by Bob Case.*

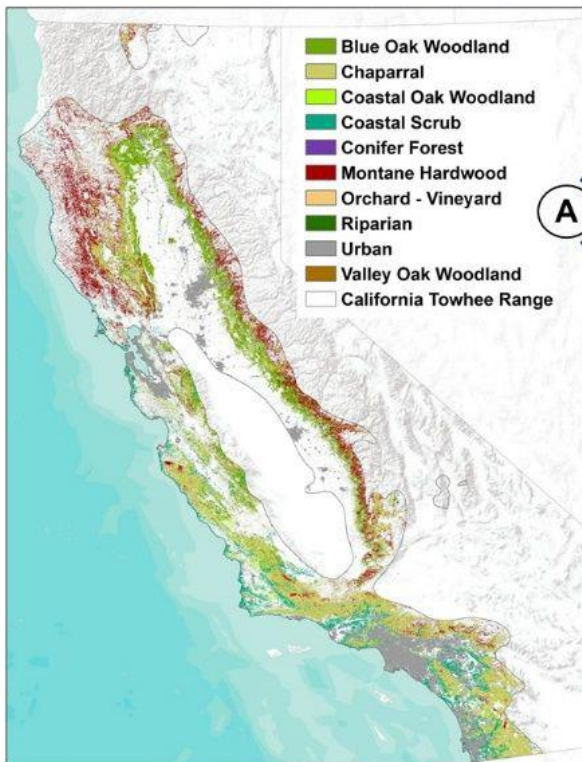
[The value of Sierra meadows](#)

Plan identifies both climate change and invasive plants as top threats to wildlife in the Sierra Nevada (CDFW 2015).

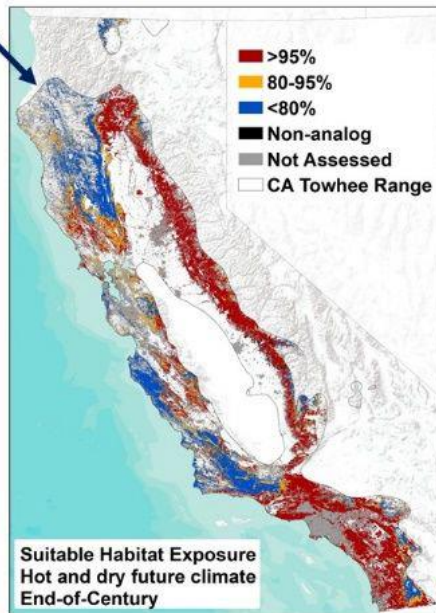
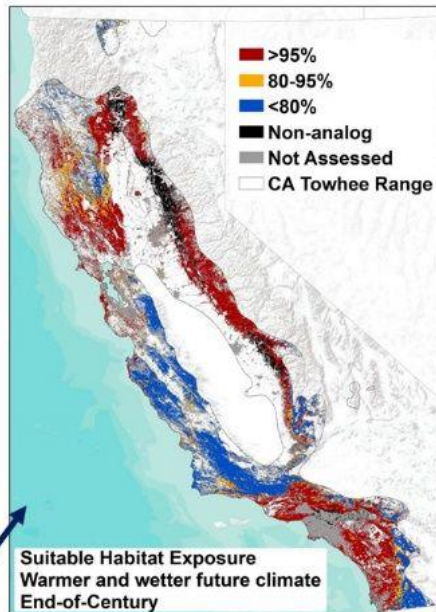
Sierra Nevada meadow complexes are wetland habitats with great ecological importance despite their limited extent (Manley et al. 2009). They are biological hotspots for birds and amphibians, providing habitat for species that include the federally-endangered willow flycatcher, federally-endangered great gray owl, and federal candidate Yosemite toad, as well as nine species of trout and salmon (Ratcliff 1985, NFWF 2010). Meadows promote lower stream temperatures, higher plant productivity, and increased insect prey availability (NFWF 2010). During summer months, montane meadows are considered the single most important habitat in the Sierra Nevada for birds (NFWF 2010).

How climate change affects the weather in the Sierra Nevada will be result of several processes

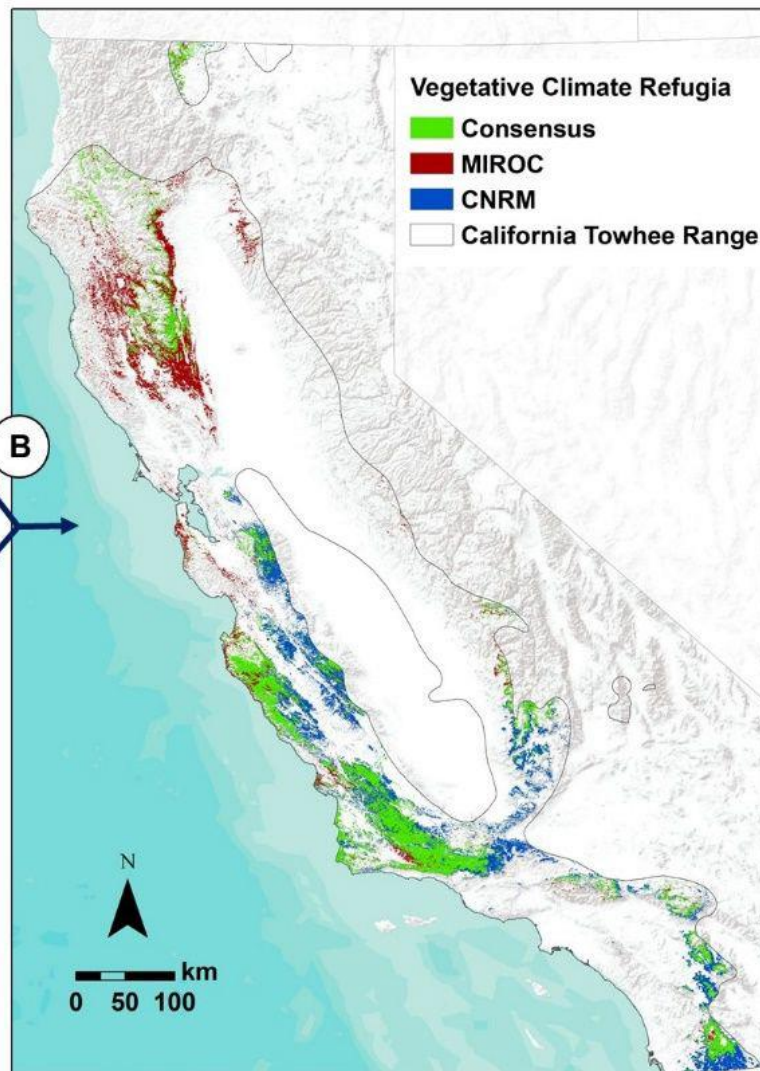
Developing a vulnerability index for Sierra meadows and BMP; includes climate refugia maps



1. Current extent of California Towhee suitable habitat in California.



2. Predicted vegetative climate exposure to California Towhee suitable habitat.



3. Vegetation climate refugia in California Towhee suitable habitat.

SOUTHWEST COLORADO SOCIAL-ECOLOGICAL CLIMATE RESILIENCE

Identify and protect refugia

- Protect ranches and manage development
- Identify soil attributes that favor sagebrush
- Maintain diversity of structural stages, canopy cover classes
- Restore post-disturbance forests
- Protect healthy trees in larger stands affected by insects, disease, fire
- Conserve refugia that contribute to watershed flows
- Conserve persistent wetlands that remain wet during severe droughts, especially within special management areas
- Conserve refugia and habitat connectivity for pinyon-juniper obligates
- Manage for highest at-risk values (e.g., property, certain trees)



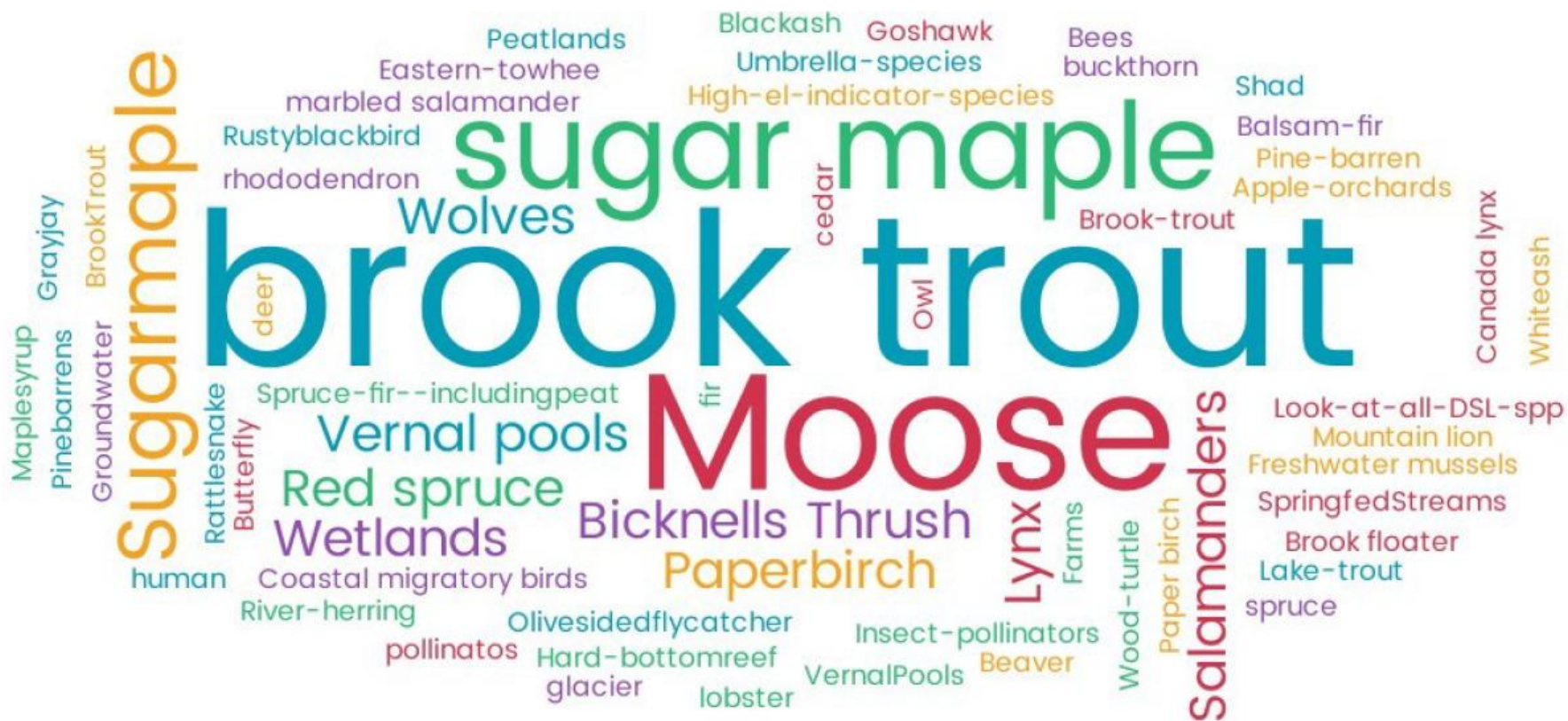
Conserving Conifer Strongholds



STORIES IN MINNESOTA

Saving Minnesota's Iconic Conifers





Incorporating climate change refugia into climate adaptation in the Acadia National Park region

- About the project
- Methods
- Results
- Who we are
- Citations



About the project

Climate change is predicted to have significant impacts on New England's biodiversity. If emissions continue unabated, mean global temperature is predicted to rise by 3-5 °C by the end of the century, and well beyond the range of natural variability.¹ Changes are already evident in Acadia National Park (ACAD). Between 1895 and 2010, annual precipitation significantly increased in ACAD by 16% and temperatures by 0.8 °C; the rate of temperature increase in the park is expected to be 3-6 times greater by 2100, particularly in inland portions.²

Identifying climate change refugia for representative species can provide valuable information for adapting to climate change.³ Climate change refugia are areas relatively buffered from contemporary climate change over time that enable persistence of valued physical, ecological, and socio-cultural resources.⁴ Many of the physical characteristics and microclimatic gradients that can create climate change refugia - such as high spatial heterogeneity in topography and habitat, proximity to large water bodies, and regular inland diffusion of coastal fog^{5 6} - are present in ACAD (Fig. 1).

This project seeks to identify and map climate change refugia for a suite of species in the Acadia National Park Region, and to work with managers to use these data products in strategically guiding on-the-ground management and conservation actions.



Work by Jenny Smetzer in collaboration with Acadia NPS and Schoodic Institute

<http://rpubs.com/jsmetzer/496972>

Results

Below are interactive maps of putative climate change refugia for species, generated through the SCS Project, DSL Project, and based on the tree data of Duveneck and Thompson (2017). There are also static maps showing current and future probability of occupancy as predicted by the SCS species distribution models across much of Maine.

Please note: Although the interactive maps are restricted to the Downeast Maine coastal area, data layers for **all of Maine** are available upon request [data link coming soon]. More information about the DSL project, and climate change refugia data for these, and additional species can be accessed [here](#).

- [About the project](#)
- [Methods](#)
- [Results](#)
- [Who we are](#)
- [Citations](#)

Interactive SCS Refugia Maps	Interactive Tree Refugia Maps	Interactive DSL Refugia Maps	Static maps
			
Black Crowberry	Labrador Tea	Three-toothed cinquefoil	
			
American Bittern	Black-throated Green Warbler	Chestnut-sided Warbler	
			
Magnolia Warbler	Olive-sided Flycatcher	Northern Flying Squirrel	

Who we are

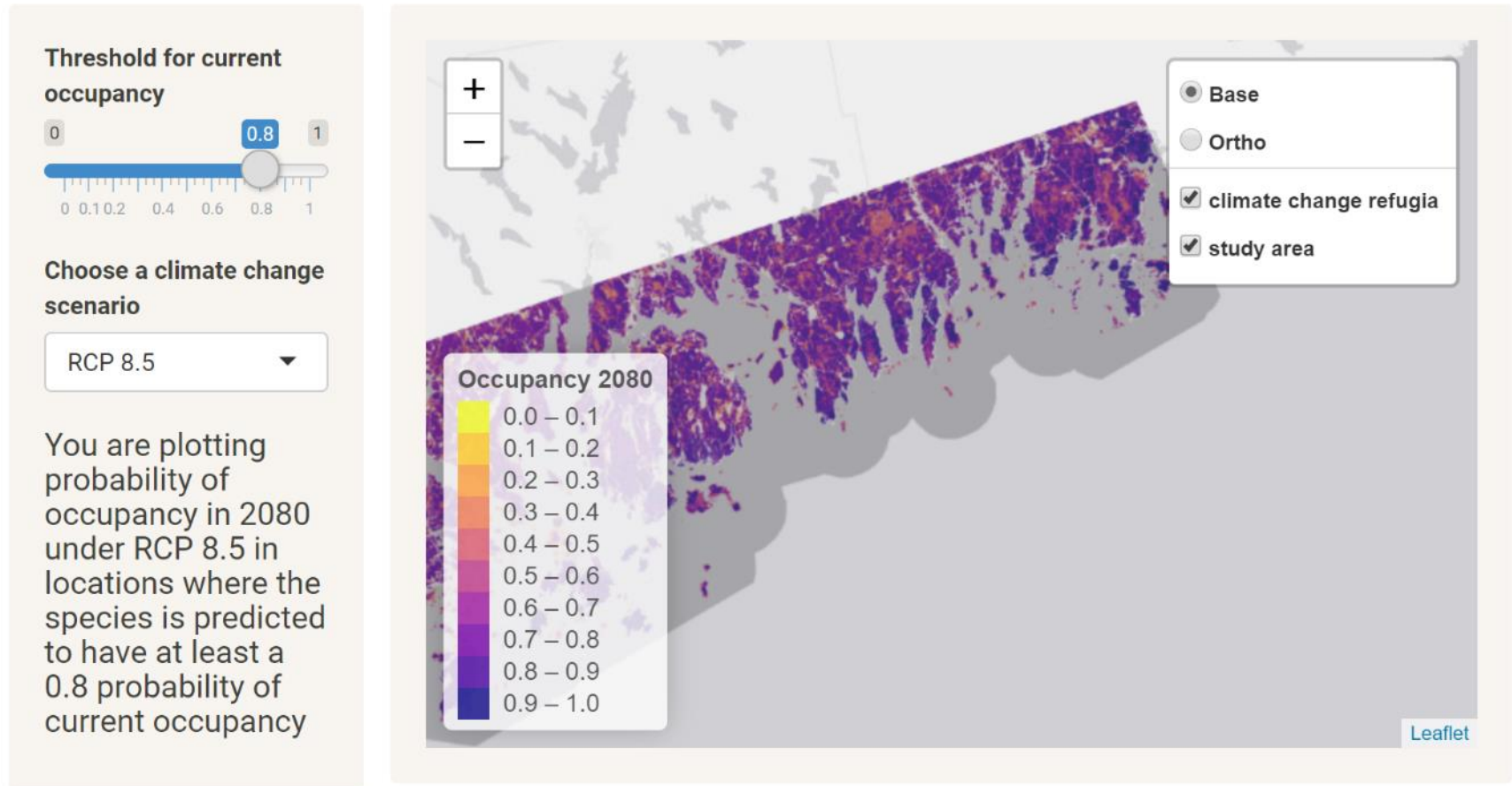
This project is funded through the [Second Century Stewardship](#) research fellowship, and the U.S. [Geological Survey](#). The work is a collaboration between [Jennifer Smetzer](#), Second Century Stewardship Fellow, and [Toni Lyn Morelli](#), Research Ecologist with the Northeast Climate Adaptation Science Center and USGS.

Work by Jenny Smetzer in collaboration with Acadia NPS and Schoodic Institute

<http://rpubs.com/jsmetzer/496972>

Black-throated Green Warbler (*Setophaga virens*)

Please be patient: data loads slowly!

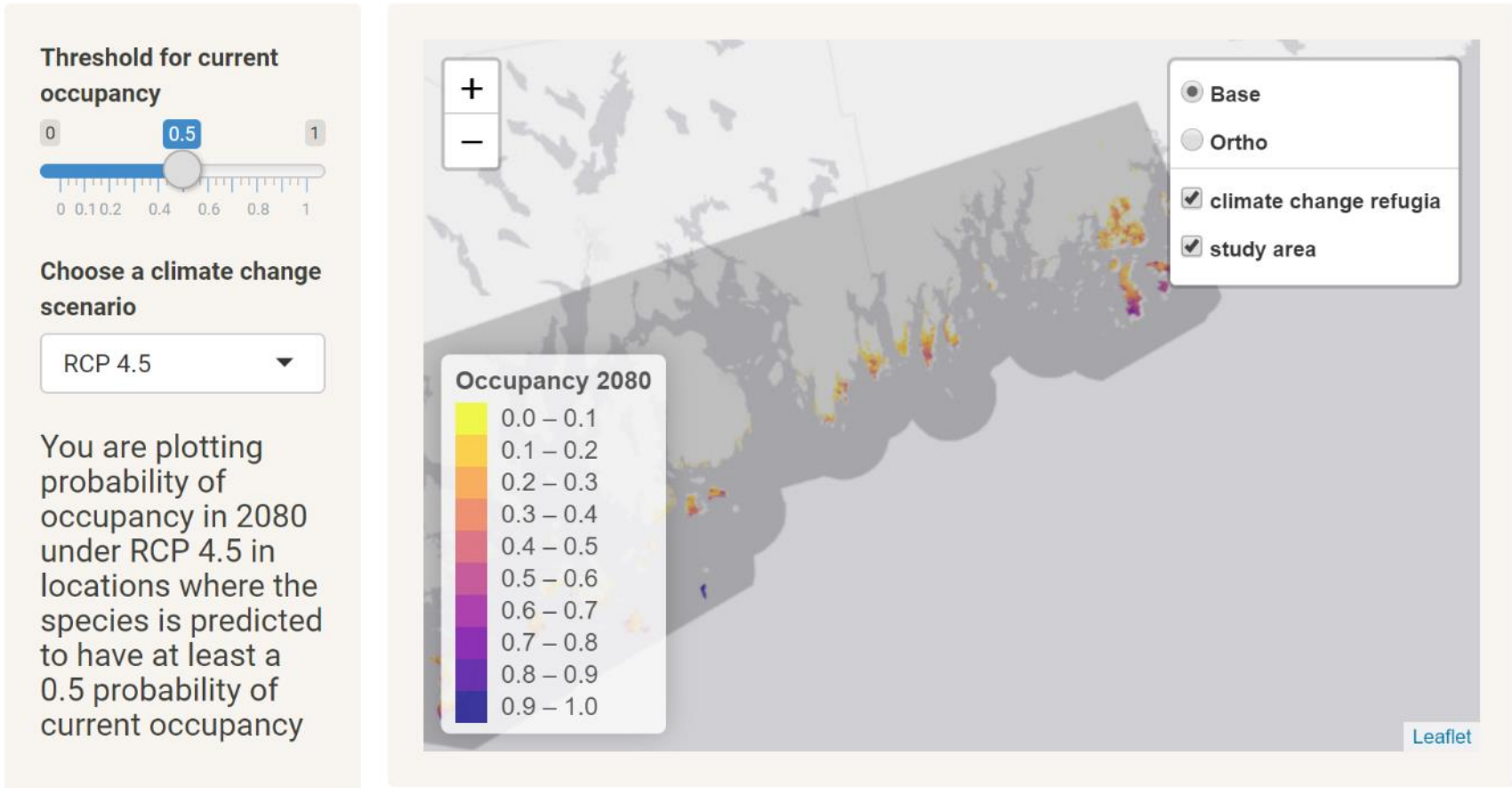


Work by Jenny Smetzer in collaboration with Acadia NPS and Schoodic Institute

<http://rpubs.com/jsmetzer/496972>

Black Crowberry (*Empetrum nigrum*)

Please be patient: data loads slowly!

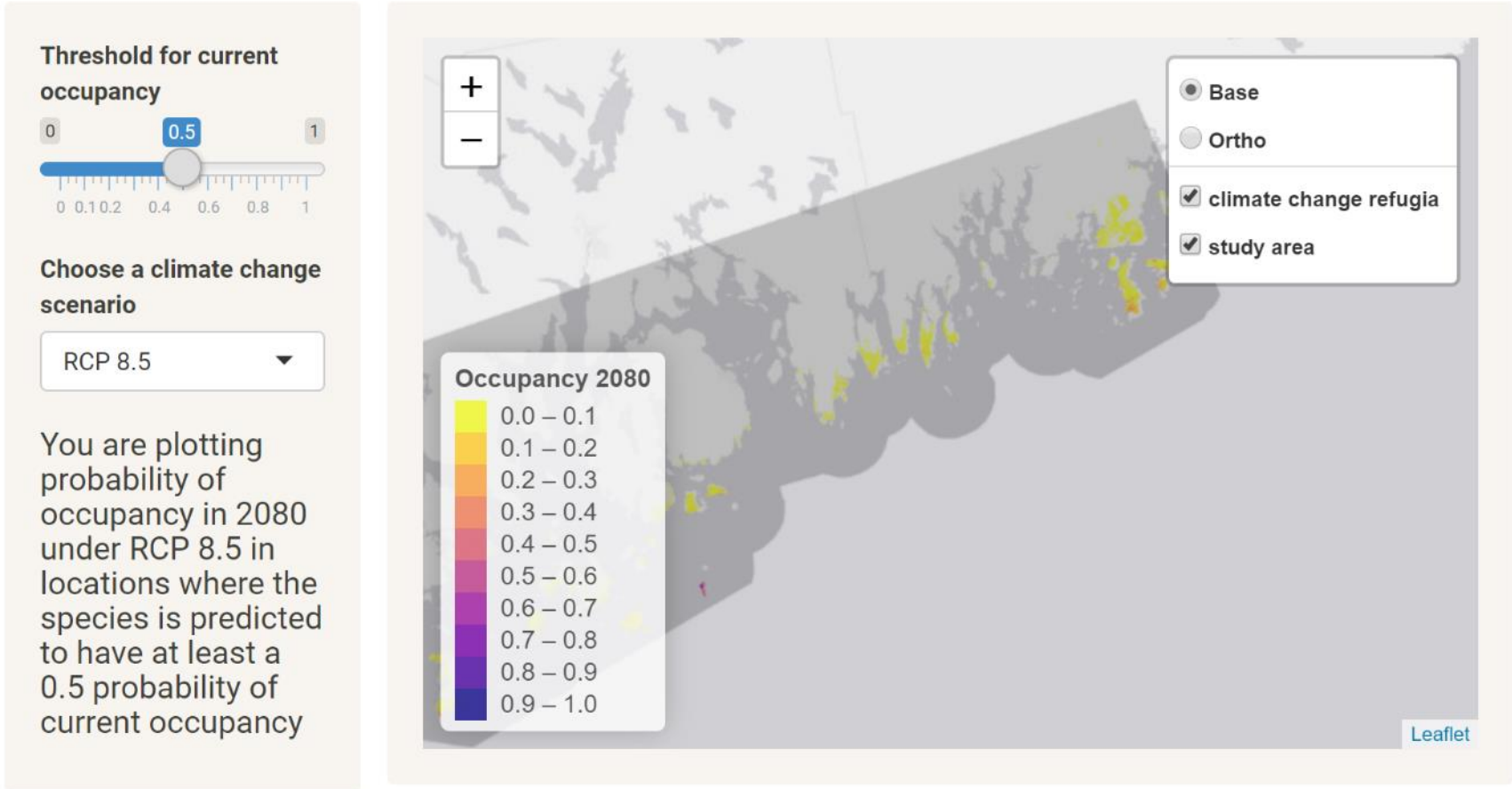


Work by Jenny Smetzer in collaboration with Acadia NPS and Schoodic Institute

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Black Crowberry (*Empetrum nigrum*)

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<http://rpubs.com/jsmetzer/496972>



Dedicated to accelerating the science and management of climate change refugia.

NORTHWEST NORTHEAST BOREAL



REFUGIA RESEARCH COALITION

— RRC —

connecting science to actions

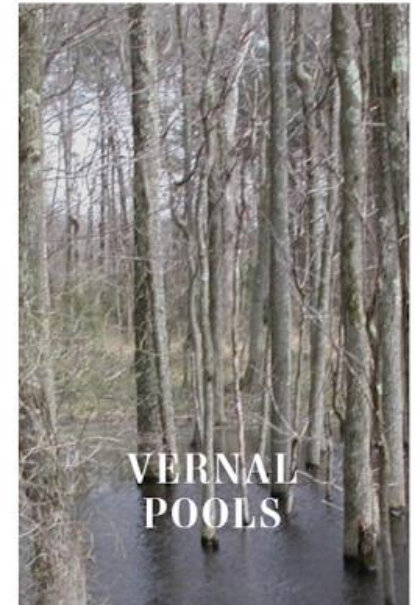
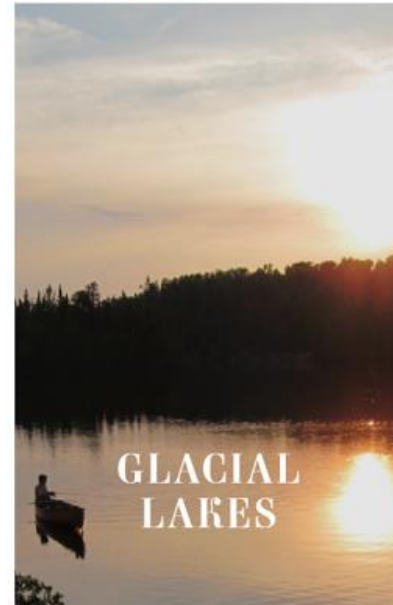
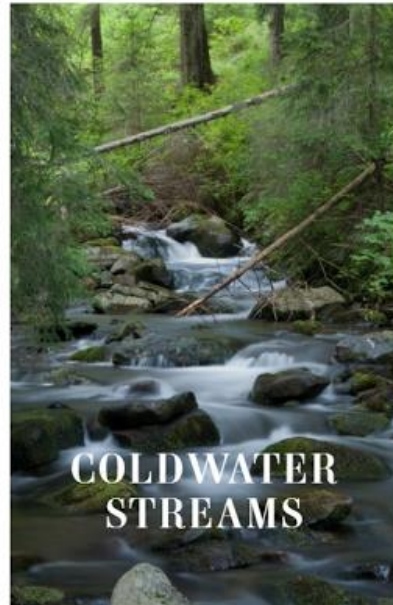
Climaterefugia.org



— ECOSYSTEMS IN THE NORTHEAST —

The goal of the NE RRC is to bring together natural resource managers and scientists from across the region who are interested in using (or just learning more about) climate change refugia management as a tactic for conserving species in the face of climate change.

One of the first steps, which we conducted at our kickoff workshop at the NE CSC's Regional Science Meeting in May 2017, was to develop a preliminary short list of species and ecosystems to focus northeast refugia management and mapping on. Through a process of real-time voting and discussion we settled on a short list of ecosystems and species to focus on.





THE ECOLOGICAL SOCIETY OF AMERICA

Frontiers in Ecology and the Environment

Special Issue
Climate Change Refugia

Just pretend –
Expected June 2020

NATIONAL PARK SERVICE PROJECTS

The goal of the SW RRC is to bring together natural resource managers and scientists from across the region who are interested in managing climate change refugia as a tactic for conserving species and other resources in the face of climate change.




Photo by : Mark Urban

Workshop on Climate Change Refugia Conservation
for NPS Lands and Landscape

March 16 and 19

Remote Options Available

Climaterefugia.org/events

A scenic view of a mountain range at sunset or sunrise. The sky is filled with soft, orange and pink clouds. The mountains are rugged and rocky, with some peaks covered in snow. A waterfall is visible on the right side of the image. The overall atmosphere is peaceful and majestic.

Thanks!

[Climaterefugia.org](https://climaterefugia.org)
tmorelli@usgs.gov