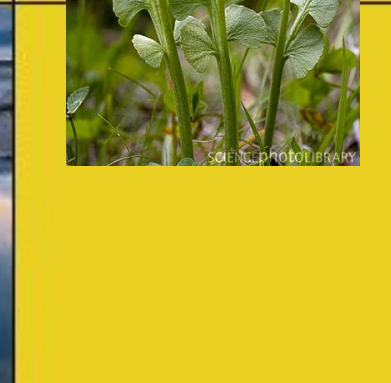
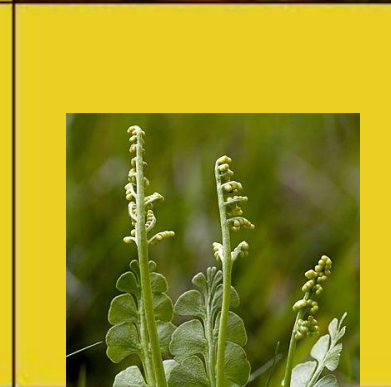
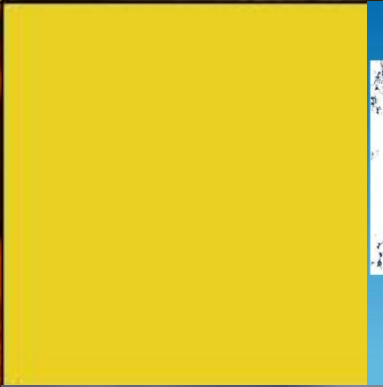


Climate Change Refugia

Sierra Nevada:

Challenges and Opportunities





Presenters and Conversations

Facilitator: Where are We?

Deanna Dulen, Superintendent, Devils Postpile National Monument

Cold-air Pooling in the Mountains—What do we need to know?

Dr. Michael Dettinger, Research Hydrologist, USGS,

Refugia for Climate Adaptation: Examples from Sierra Nevada Bighorn Sheep and American Pika

Dr. Connie Millar, , Senior Scientist, Forest Service, Pacific Southwest Research Station

Cold Air Drainages as Climate Refugia for plants (and other less motile organisms :

Dr. Alison Colwell, PhD, Botanist, Yosemite National Park

Soda Springs Meadow as a climate change refugium: management implications for visitor use and biological communities.

Monica Buhler, Natural Resource Program Manager, Devils Postpile National Monument

Compass Conversation: Where are we headed from here?

Climate Change is Happening Now!!! Rapidly driving the world to uncertain scenarios.



Warm winter forces Iditarod dog sled race to move north

By Jareen Imam, CNN

Updated 7:57 AM ET, Mon March 9, 2015



The start of the Iditarod was missing one key element 01:57

Story highlights

Alaska's famed Iditarod race starts Saturday

A lack of snow forces the starting point to move 225 miles north

Warm air from the Pacific has affected weather conditions in Alaska

It's the second time in the race's 43-year history that the starting point has moved from Willow to Fairbanks because of weather-related issues, an Iditarod spokesperson said. The first time was in 2003.

While cities across the northeastern United States have seen record snowfall this winter, Alaska received less snow than usual. Anchorage collected only 20 inches of snow this season, compared with a seasonal average of 80 inches.

Race organizers made the unanimous decision in February to move the race after determining that conditions were worse than last year in critical areas, and "therefore not safe enough for the upcoming race," Iditarod Chief Executive Stan Hooley said in a [press release](#).

While snow has fallen east of the Alaska Range over the past couple of weeks, other parts of the trail did not get much or any of it, Hooley told CNN affiliate KTVA-TV in February.

(CNN)—An unseasonably warm winter has left parts of Alaska's Iditarod trail without snow, exposing grass and gravel and forcing the famous dogsled race to move 225 miles north.

Opening ceremonies in the Iditarod Trail Sled Dog Race kick off Saturday in Anchorage. When the race begins Monday, mushers will cross the starting line in Fairbanks instead of Willow, the traditional starting point.

Extreme drought in California



Cyclone Pam: 24 confirmed dead as Vanuatu president blames climate change

16 Mar 2015 592



Cyclone Pam: Vanuatu president says climate change contributed to death and destruction

16 Mar 2015 88

We
rac

By Jareen
Update

More snow fell on Boston on Sunday, enough to make this the snowiest season ever on record there. The National Weather Service said 2.9 inches fell by 7 p.m., pushing total snowfall for the winter of 2014-2015 to **108.6 inches**. 6 days ago



6 days ago

Boston breaks seasonal snowfall record with 108.6 inches

www.usatoday.com/story/.../boston-snowfall-record/24822823/ USA Today ▾

Climate Shock &/or Future Scenario

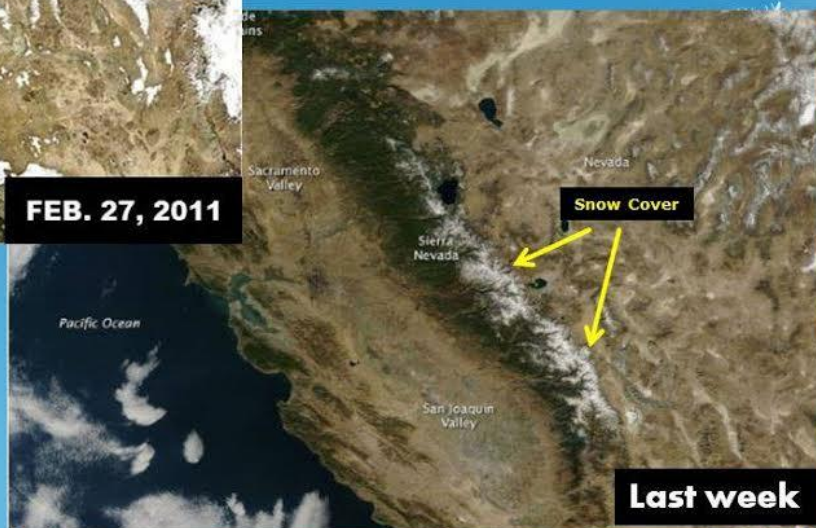
Yearly snowpack comparison in the southern Sierra Nevada



FEB. 27, 2011

% of normal to date

Current	21 %
2014	36 %
2013	77 %
2012	29 %
2011	125 %



Last week



CC Driver of Extinctions:

- The current rate of global species extinction is approximately 1,000 times higher than before the worldwide spread of humanity. Conservation efforts have lowered the rate by about a fifth, at least in vertebrates—the animals for which data are available. But the hemorrhaging continues and will almost certainly accelerate under existing conditions, and could become catastrophic within this century. Parks and other protected reserves are , the best way to protect biodiversity, but they remain far too small, covering a little over 10 percent of the land and 2 percent of the sea. E.O. Wilson.

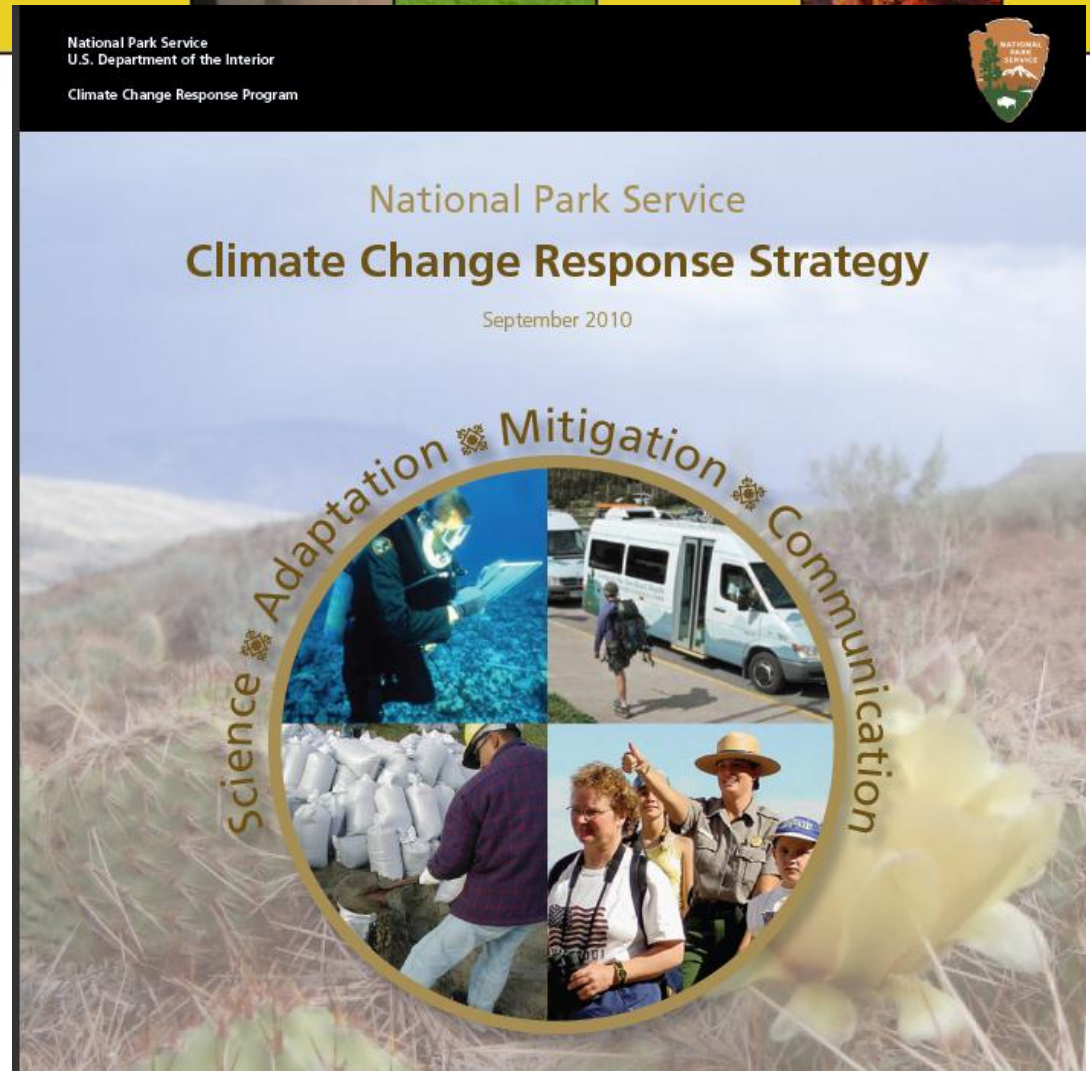
Protected Areas Provide Natural Solutions to Climate Change

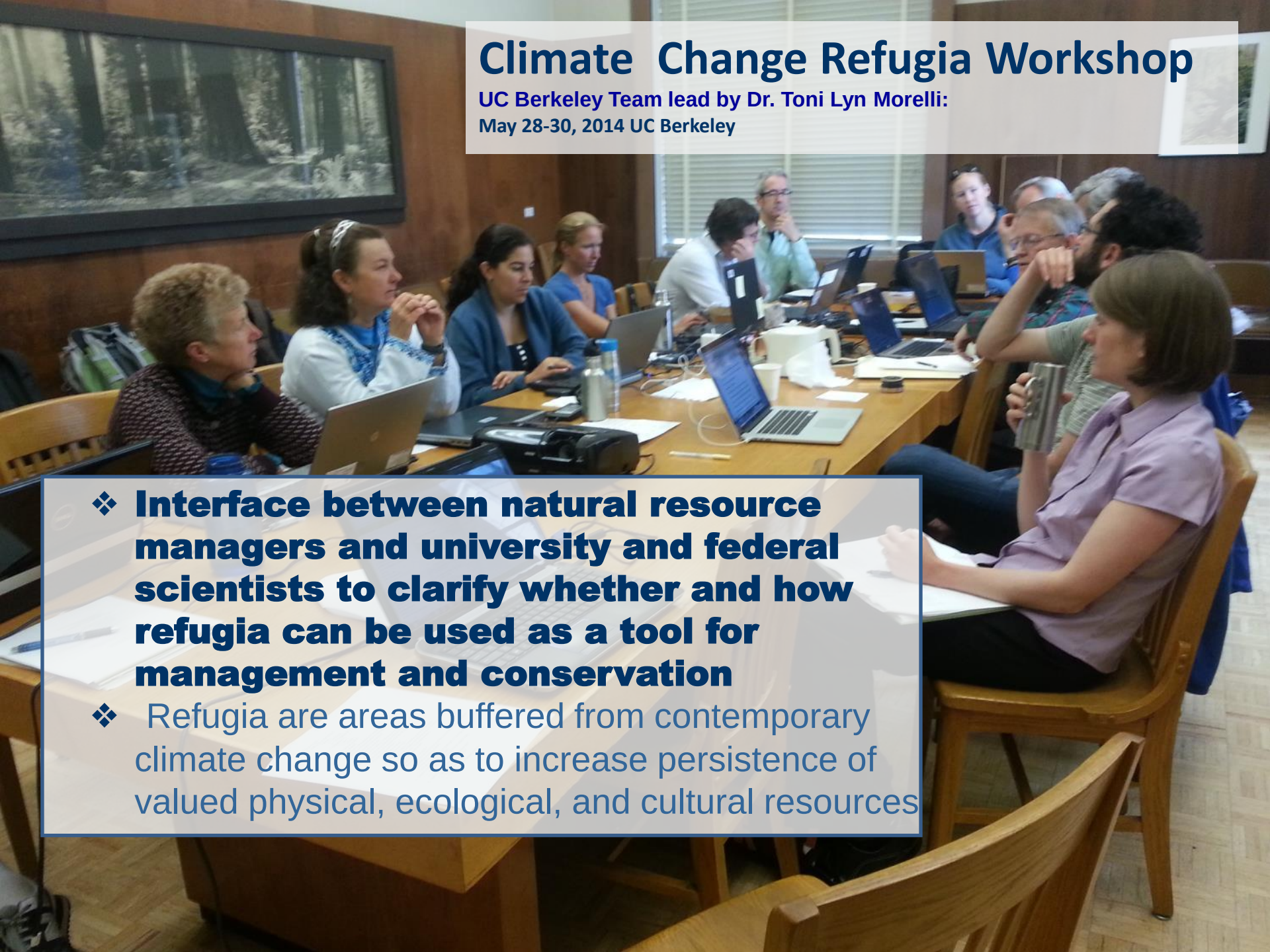
- What we can do in our sphere of influence:
- Identify Manage Refugia

Science

Science: Goal 3. 1

The U.S. Climate Change Science Program Synthesis and Assessment Product 4.4: recommends specific approaches for adaptation, such as *resilience*, *redundancy*, *connectivity*, **and protecting refugia (places that are relatively unaffected by climate change)**. The NPS needs to verify the scientific foundation of these concepts and identify criteria to evaluate their performance so that they may be applied appropriately in restoration and protection of park resources.



A group of people are seated around a long wooden table in a workshop setting. They are using laptops and looking at documents. The room has wood-paneled walls and a large framed picture of a forest on the left. A semi-transparent text box is overlaid on the top right of the image.

Climate Change Refugia Workshop

UC Berkeley Team lead by Dr. Toni Lyn Morelli:
May 28-30, 2014 UC Berkeley

- ❖ **Interface between natural resource managers and university and federal scientists to clarify whether and how refugia can be used as a tool for management and conservation**
- ❖ Refugia are areas buffered from contemporary climate change so as to increase persistence of valued physical, ecological, and cultural resources

Geographic locations likely to experience reduced warming



<u>Characteristics of Physical Locations</u>	<u>Physical Explanation and examples (with potential caveats)</u>	<u>Caveats resulting from unidirectional global warming</u>
Near/in a large body of water	Coastal areas will warm at a slower rate than inland areas due to the high heat capacity of water; Deep lakes will warm at a slower rate than shallower lakes.	Sea level rise may inundate some habitat.
Near a water source (riparian areas, wetlands, where groundwater rises near the surface)	Evaporation results in cooler temps. Many organisms can cool themselves (or survive warmer temperatures with access to water).	Some water sources, such as glaciers, may suddenly run out; Overall water availability in the future may change
Shaded (by overlying or equator-ward vegetation or surrounding topography)	As temperatures warm, both snowmelt and phenology are expected to shift earlier in the season, a time when the sun is lower in the sky, and the difference between shaded and sunny sides is greater (Lundquist and Flint 2006).	Warming forest cover emits more longwave radiation, and so some forested areas may actually experience greater rates of winter warming, accelerating snowmelt rates (Cristea et al. 2013). Areas in the shade without forest cover overhead will not experience this effect (Lawler and Link 2011), suggesting forest strips or gaps provide better refugia than uniform cover.



<u>Characteristics of Physical Locations</u>	<u>Physical Explanation and examples (with potential caveats)</u>	<u>Caveats</u>
Local areas within topographically complex terrain where changes in atmospheric circulation result in local changes that offset climate change.	Cold air pools exposed to increased frequency of high pressure systems (Pepin et al. 2011); Downwind slopes exposed to decreasing frequency and/or speeds of downslope winds (Lundquist and Cayan 2007)	Global climate models do not currently demonstrate high certainty in how such circulation patterns will change, making predictions difficult
Areas where snow tends to pile up (either locally or within the upslope water-contributing area)	Deep snow drifts provide insulation to the snow below and provide water later in the season. (So heterogenous snowcover is preferable to uniform snowcover). These drifts can occur in downwind topographic depressions, in granite fissures, or at the base on an avalanche shoot or a topographic slope too steep to accumulate snow	If all snow changes to rain, this won't help anymore.

Ecological factors:

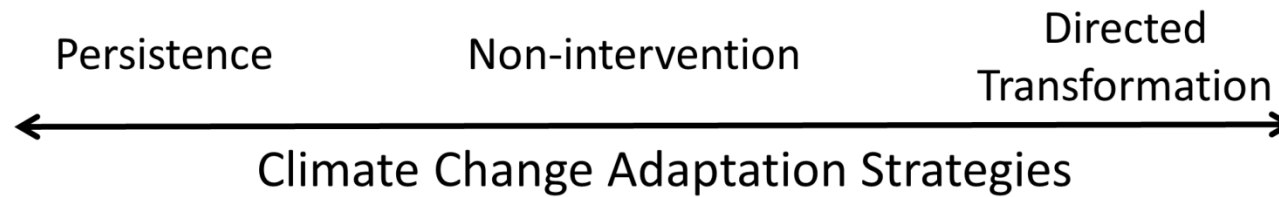


Connectivity across landscapes, bioregions, and elevations.

High biodiversity .

Multiple water sources where some organisms can cool themselves.

Social ecology: Public lands/protected areas across the landscape.



Resistance and Resilience Strategies

Study of baselines

Lack of capacity

Political sensitivity.

Realignment
with habitat
enhancement,
seedlings, watering
and /or assisted
migration.

Management strategies may integrate/fluctuate between strategies based on feedback loops

Recognize as
dynamic
waystations.



Identify and Manage Refugia to conserve species, populations, genetic diversity, and evolutionary potential.

Specifics: Species can retreat when needed, and dodge extinction.



In the future, where refugia can also also serve as waystations for migrating species, and/or sources for future regeneration.

In these presentations, we will explore how Scientists and Managers working together are developing the foundation of finding refugia and developing adaptation strategies.

Cold Air Pools

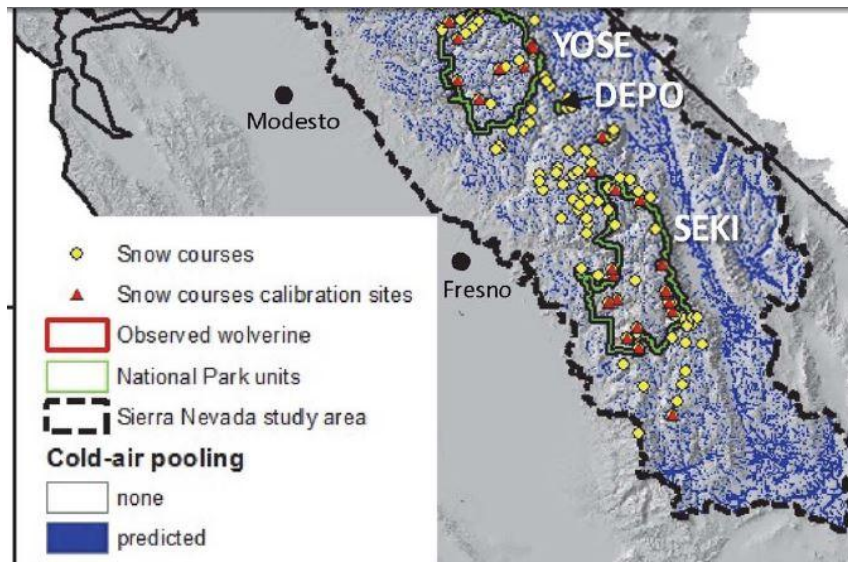


OPEN ACCESS Freely available online

PLOS ONE

Incorporating Cold-Air Pooling into Downscaled Climate Models Increases Potential Refugia for Snow-Dependent Species within the Sierra Nevada Ecoregion, CA

Jennifer A. Curtis^{1*}, Lorraine E. Flint², Alan L. Flint³, Jessica D. Lundquist⁴, Brian Hudgens⁵, Erin E. Boydston⁶, Julie K. Young⁷



Sierra Nevada CAPs with implications for other Mountainous Terrains

