



A Shcherbina

Climatic Refugia in a Warming World Illustrations from Great Basin

Ecosystems

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Science 2014

NEWSFOCUS



Welcome to Beringia

Quaternary Refugia

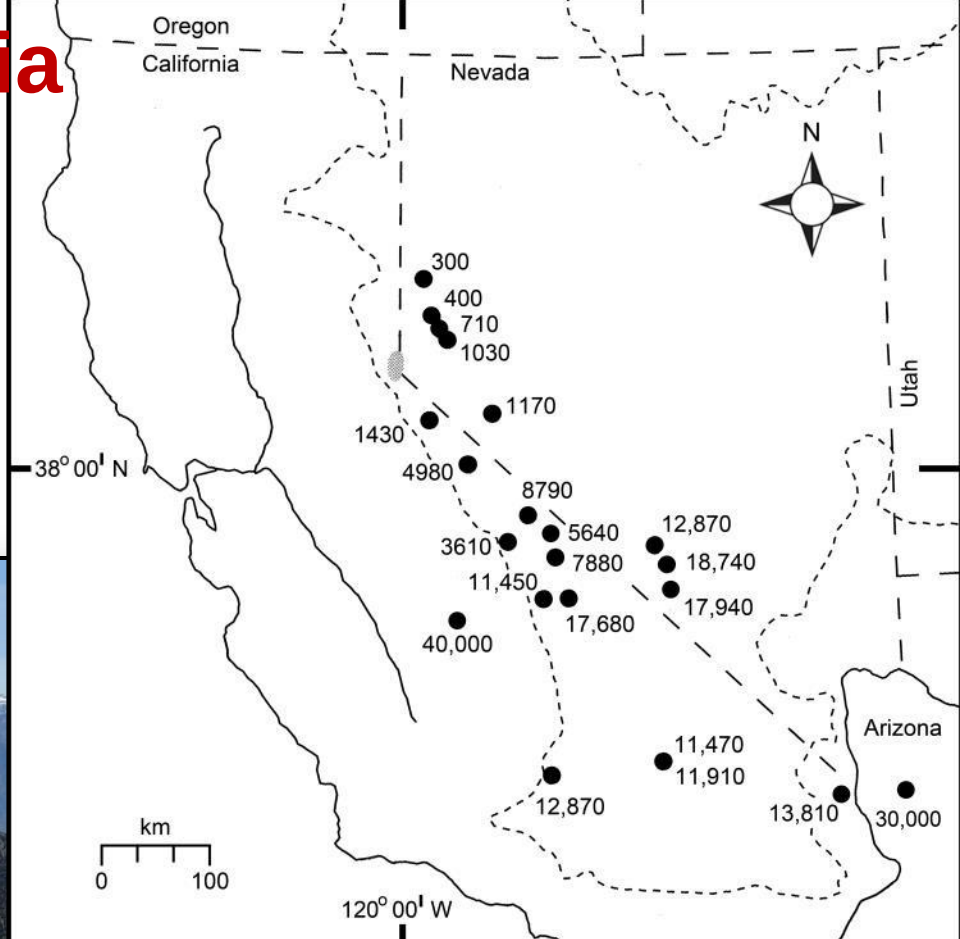
Isolated areas where climate was buffered against cold of glacial periods such that relict populations of warm-adapted species could persist until favorable climates returned
e.g., Hulten 1937

Safe Havens
and Sources for
Recolonization
e.g., Heusser 1955



Cryptic- and Micro-Refugia

Single-Needled Pinyon Pine:
Glacial refugia in the
southern Great Basin



(*Pinus monophylla*)

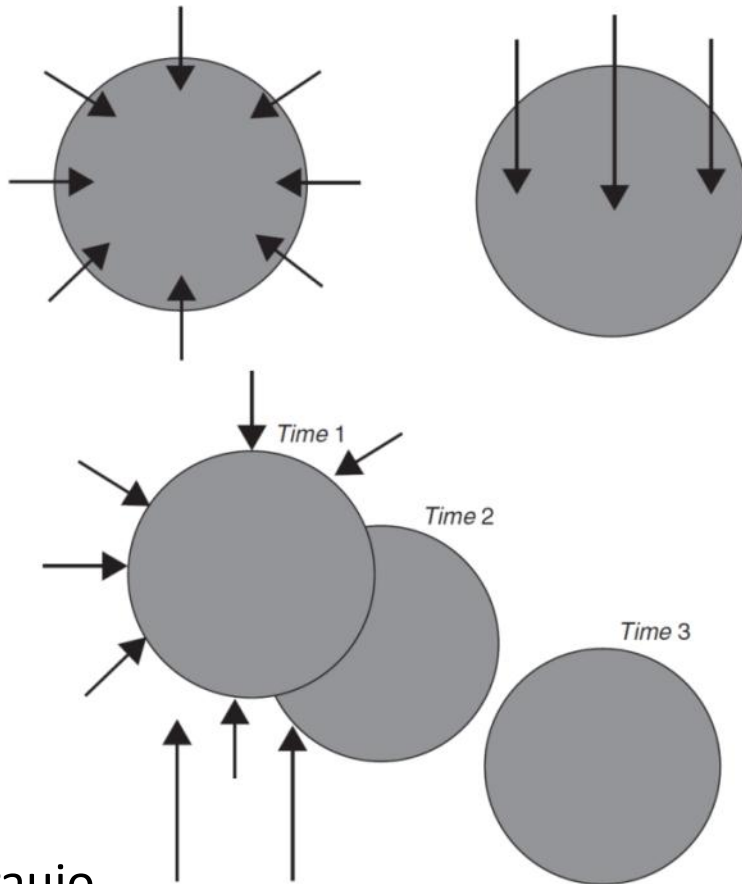


Mechanisms of Historical Refugia

- Range contraction
- Favorable, stable climate

...

- Source for dispersal & rapid recolonization
- Centers of evolutionary divergence



Central to the concept is eventual return to favorable climates

Refugia for Climate Adaptation:

“Areas that are relatively buffered from modern climate change so as to increase persistence of valued physical, ecological, and socio-cultural resources”

Climatic buffering can result from:

- Locally decoupled climatic processes
- Complex topography

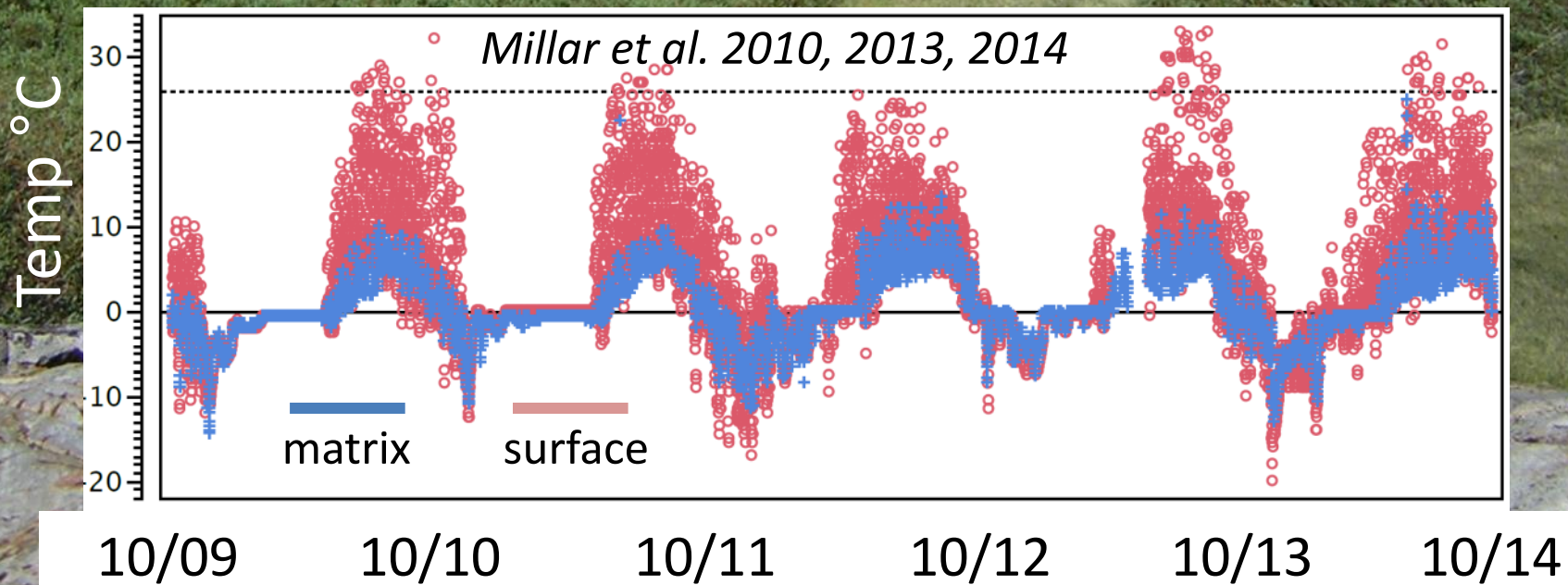
American Pika (*Ochotona princeps*)



American Pika (*Ochotona princeps*)



- Talus matrices thermally buffered: Summer cool, winter warm
- Thermal processes partially decoupled from free air
 - Matrix lapse rates $-3.2\text{ }^{\circ}\text{C}/\text{km}$ ($= \frac{1}{2}$ free air value)
 - Persistent springs support “stable” wetlands





J Spaedtke



A Smith



J Holmquist



Refugia Options for Pikas

1. Proactive: Delineate and Improve Areas with Good Habitat with Healthy Populations

Low-High Elevation Pairs for 6 Canyons, Sierra Nevada



Mono Basin pika range: 2190—3980 m; 1800 m elev span



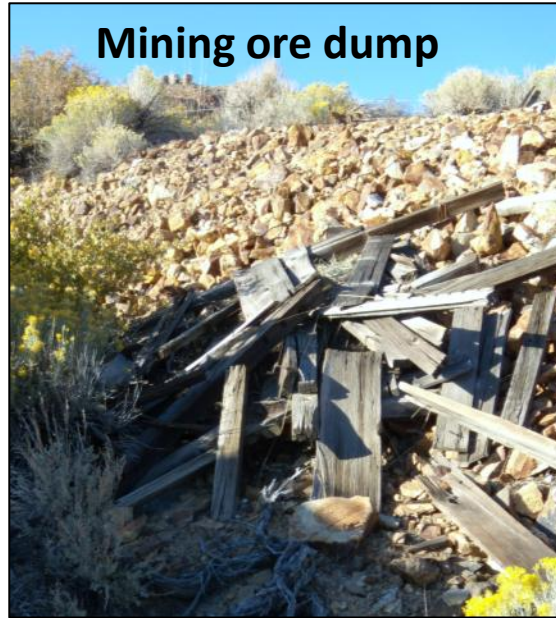
Abundant, high-quality habitat;
High connectivity;
Large elevation span;
Saturated pika populations

Expand dispersal opportunities

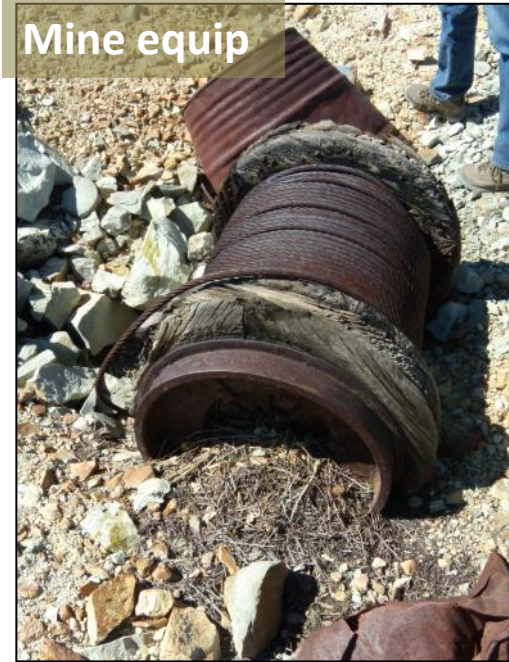
Trail wall



Mining ore dump



Mine equip



Building foundation

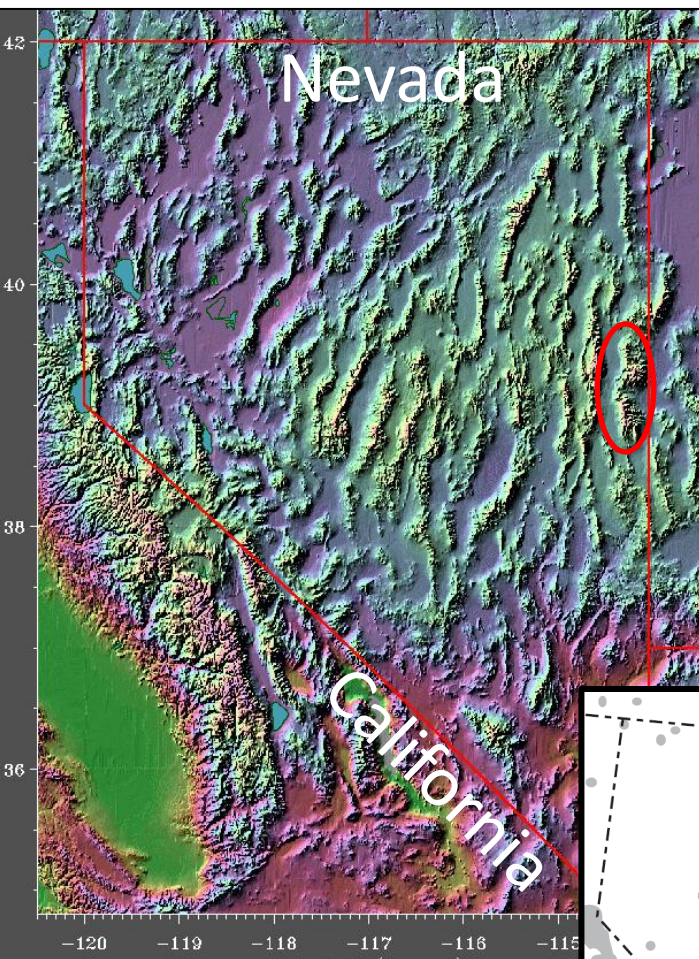


Highway rip-rap



Refugia Options for Pikas

2. Reactive: Realign declining populations



Combine Adaptation Tools: Assisted Migration with Refugia

Assess:

Site Selection: climate-resilient; elevation gradients; abundant, high quality habitat (seasonal); connectivity; predator/disease; historic habitat

Recipient Ecosystem: sensitive spp; community dynamics; predator-prey relations

Source population: viability, genetic diversity, demography, impacts to source ecosystem

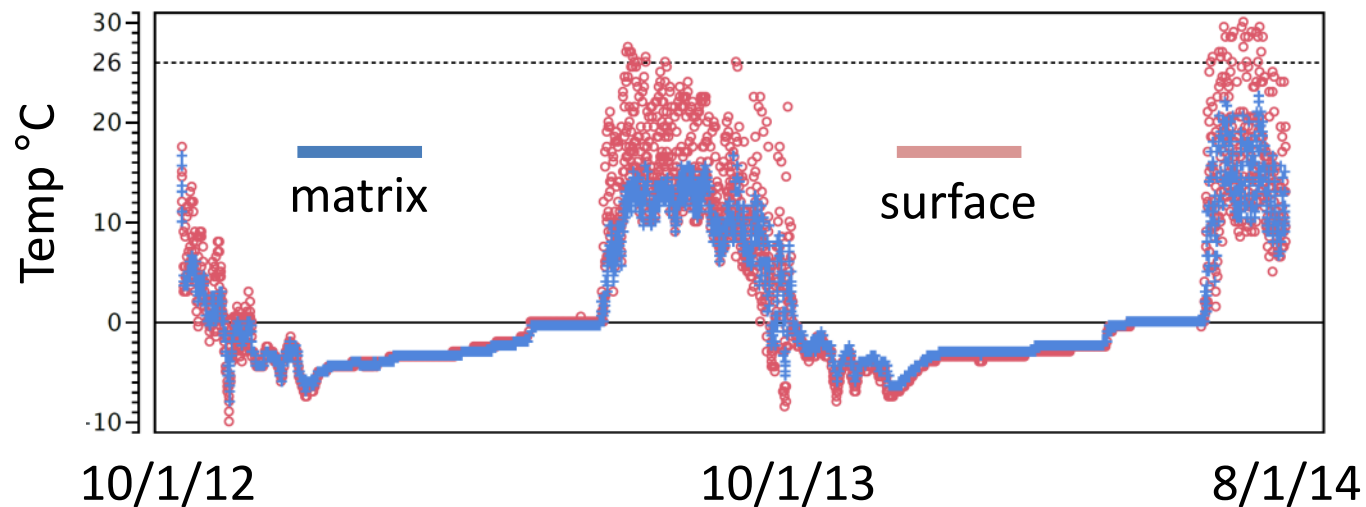


Millar and Grayson in prep

Potential Refugia/Re-introduction Location: Snake Range, NV



NB: I am not advocating this action. Many more assessments would be needed, even if reintroduction were deemed appropriate



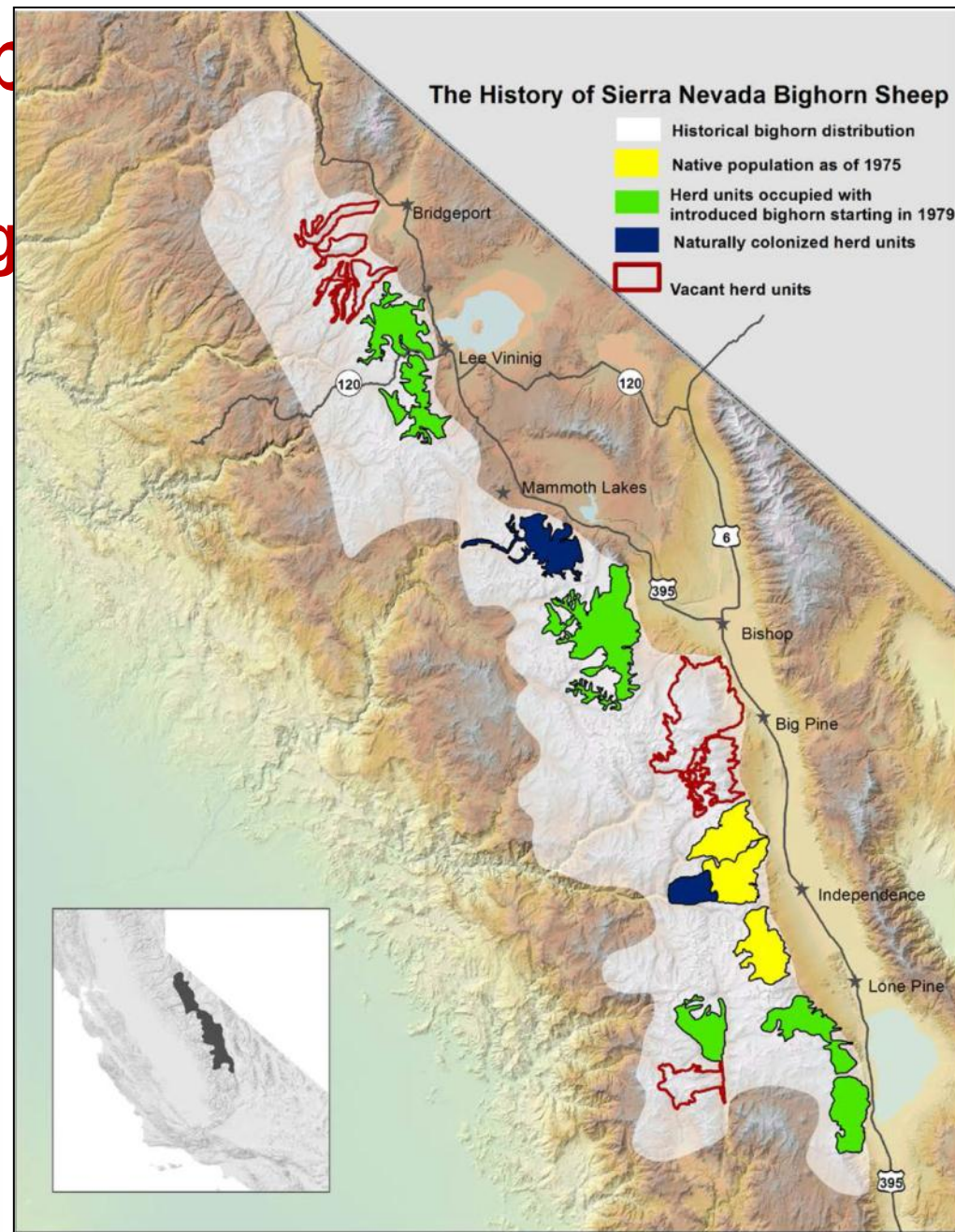
Sierra Bighorn Sheep

(*Ovis canadensis sierrae*)

De-Facto Refugia Strategy

ESA Listed, 2000

Recovery Plan, 2007



Few et al. 2015

Extensive Assessments

Risk Analysis:

- climate resilient
- source pop'n PVA
- sensitive species
- predation/disease
- recipient pop'n PVA

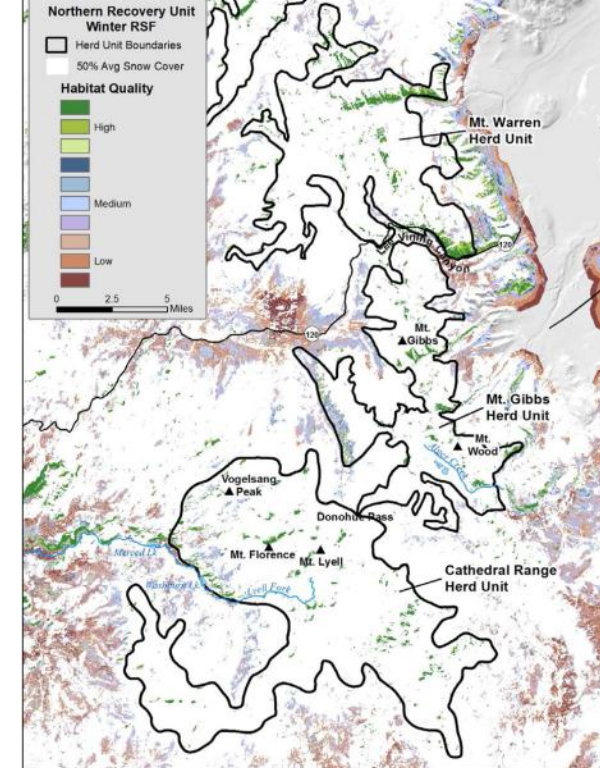
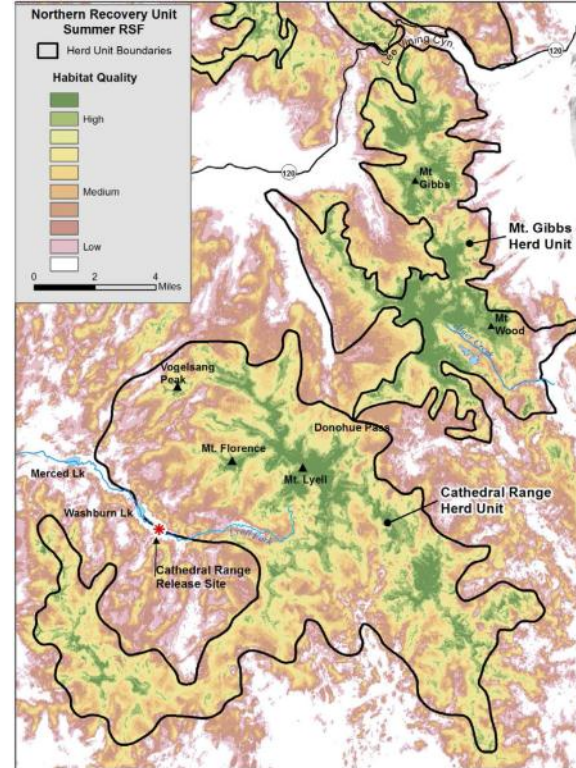


Table 4. Estimated probabilities of attaining various levels of females in reintroduced populations. Population projections are based on demographic data collected 1999-2011

Demographic Rates and Translocation Details	Yr	Pr (N<5)	Pr (N>15)	Pr(N>25)	Pr (N>25 for >7 consecutive yr)
Positive Growth ($\lambda = 1.018$)					
10 ewes start, no augmentation	5	0.025	0.461	0.034	NA
	10	0.055	0.617	0.289	0.004
	20	0.091	0.767	0.581	0.369
10 ewes start, +5 year 3	5	0.006	0.758	0.234	NA
	10	0.016	0.794	0.51	0.084
	20	0.027	0.866	0.713	0.589

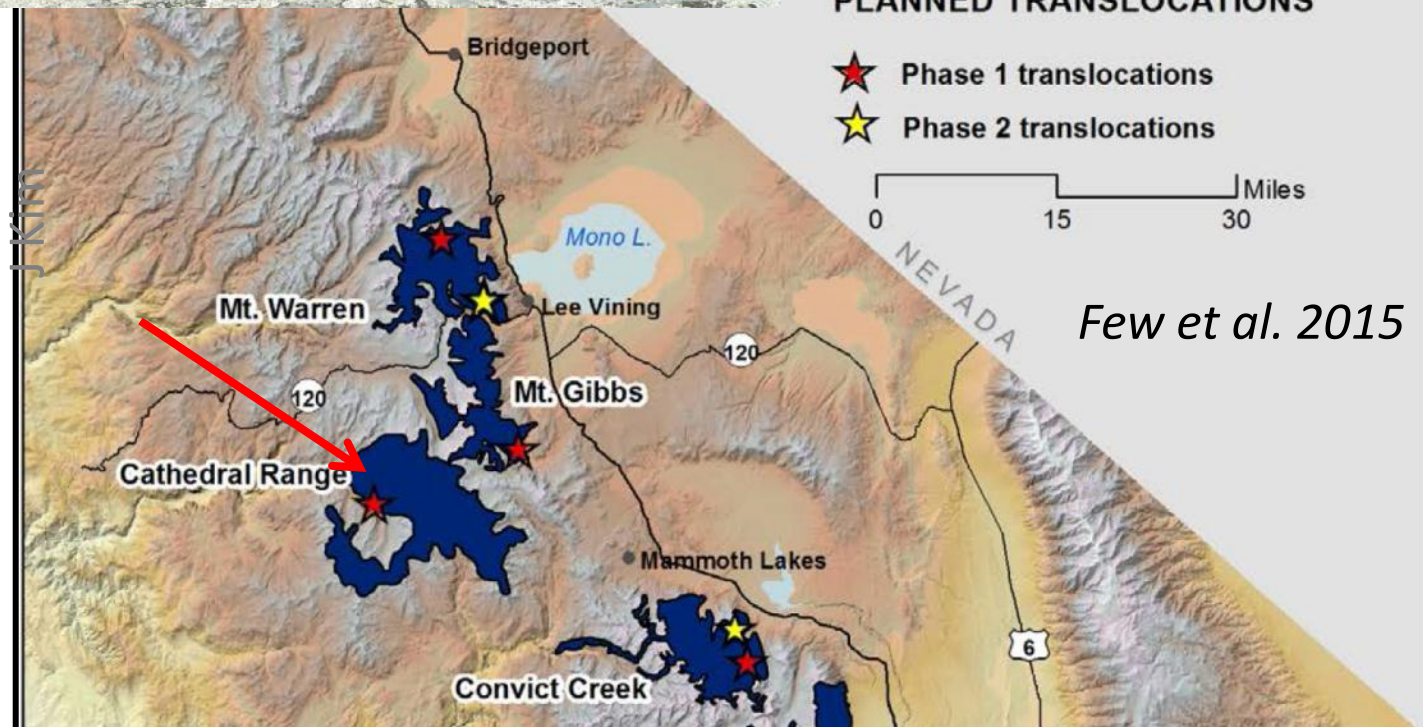
Cathedral Range: A New Herd Unit

“Refugium”,
Yosemite NP



S Bumgardner

Translocations
happened
last week!



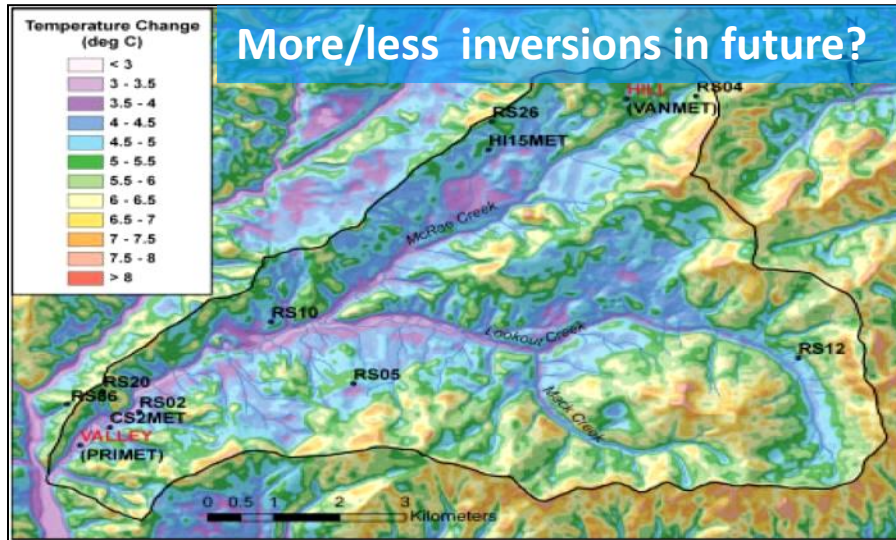
Adaptation Options in the Face of Ongoing Change

- Promote **Resistance** (short term)
- Increase **Resilience** (short term)
- Assist Ecosystems to **Respond**
- **Realign** Altered Ecosystems

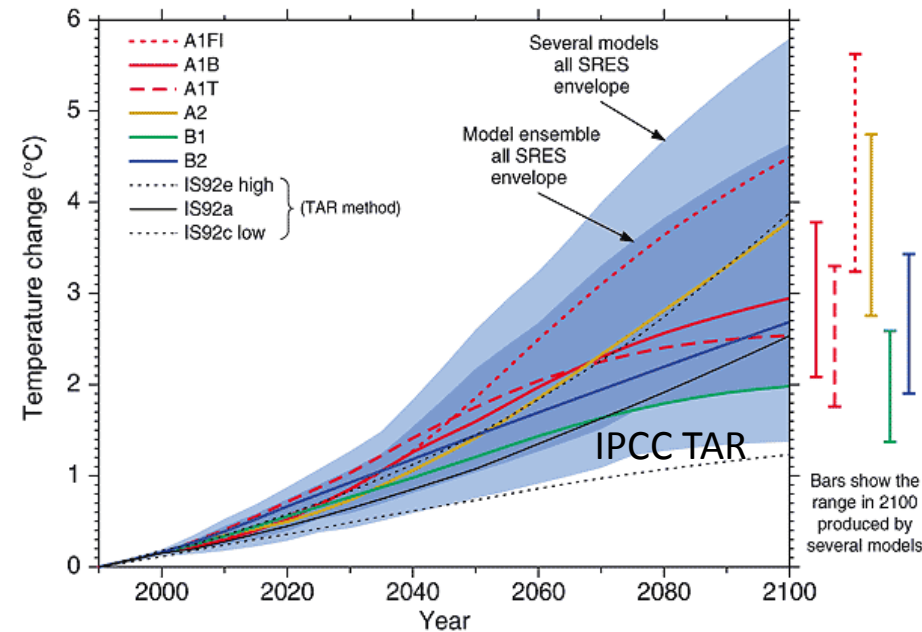
Millar et al. 2007

Challenges to Refugia as a Climate Adaptation Strategy

Stability of Refugia?



Directional Climate Change



Land Use & Disturbance?



**Refugia: At
Best A Short-
Term Strategy**