Evolutionary Hotspots and Climate Change in California

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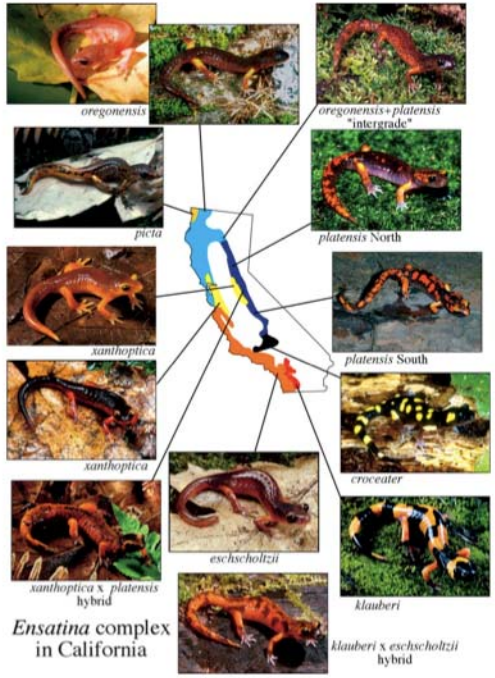
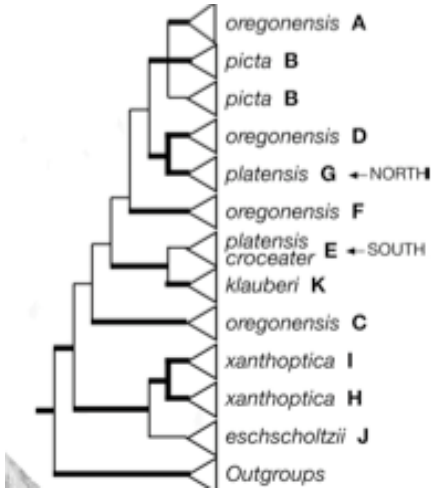
Evolutionary hotspots and climate change in California

- What landscapes engender diversity?
- Where will these hotspots persist with climate change?
- What land protection strategy will maximize protection of California's unique diversity into the future?

California is a natural laboratory for the study of evolution



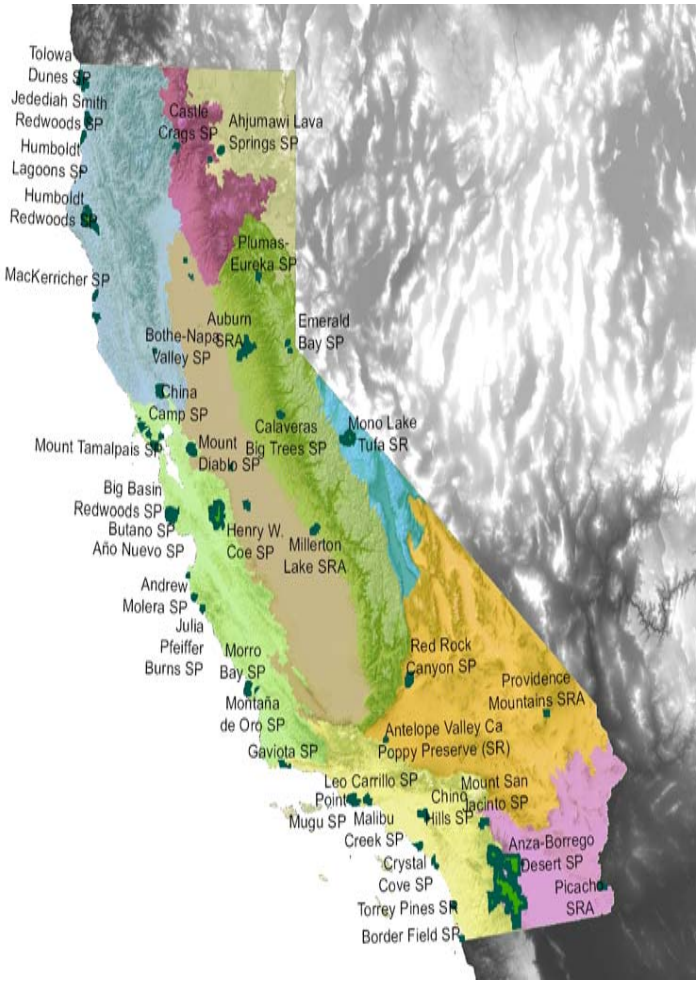


A policy-driven challenge to evolutionary biologists

Active process of land acquisition for conservation in CA:

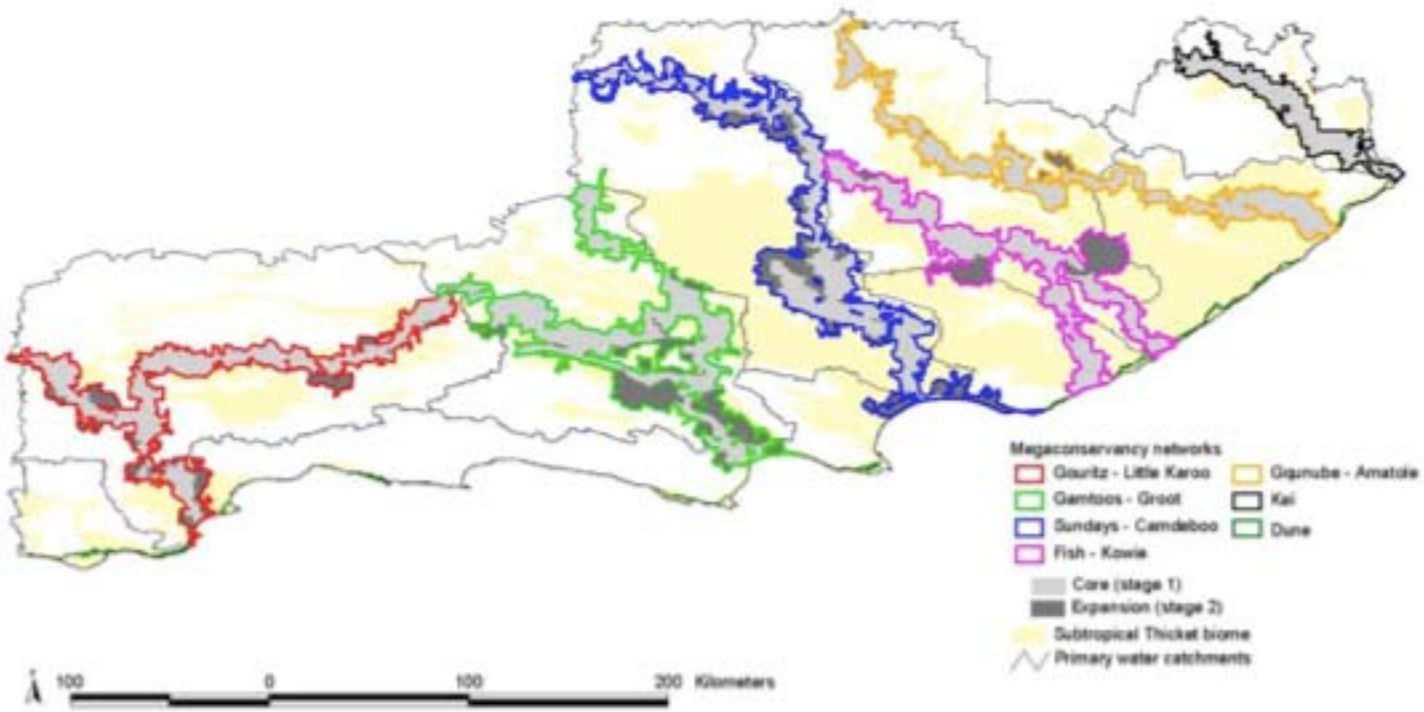
CSP, TNC & others:

- $0.5B last 5 yrs for purchase
- Prop 84: $6B 2007-2013
- Get it right, make it count..
- Include **Evolutionary Processes** as a factor in planning to assist resilience



Where are the areas of active diversification: <u>Evolutionary hotspots</u>?

Environmental surrogates for evolutionary processes: South Africa (Cowling et al.)



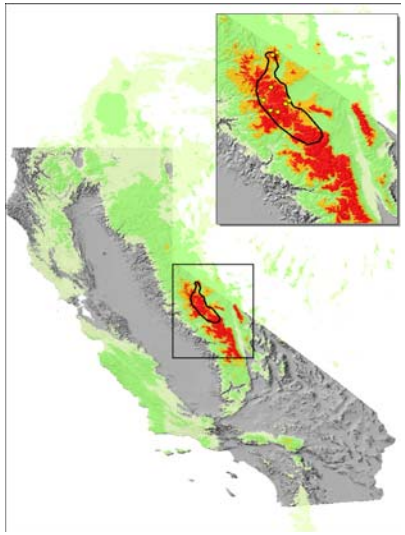
Diversification across lowland-upland gradients, edaphic gradients, macroclimatic gradients

Phase I: Mammals

Select (near) endemic taxa
(>75% range in CA)

130 subspecies

26 species



Estimate ranges @ 1km resolution

(MVZ points -> range-map-clipped MaxENT models)

Richness maps

Endemism-richness = ∑(1/area) per cell

mtDNA distance to sister species (GenBANK, unpubl)

Neo-endemism

= ∑(1/distance) per cell

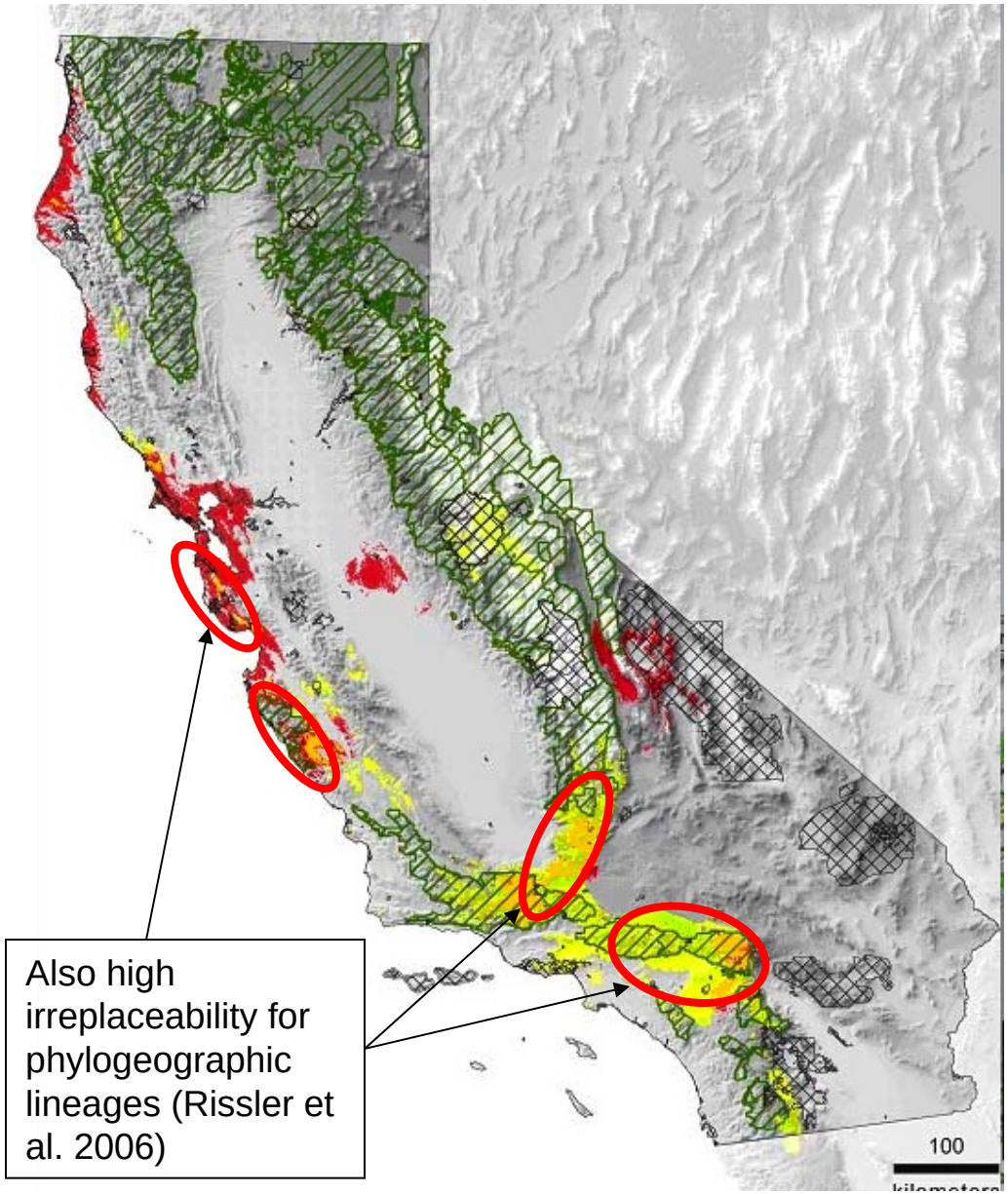
Neo- and subspecies endemism (top 10%) & comparison with CA/Fed Protected Areas

Species & subspecies neo-endemism areas overlap in Tehachapi, Sth Coast and Peninsular Ranges

Environmental correlates: coastal gradients, biogeographic overlap areas (gradients)

Good potential for integrated reserve design in most areas, esp Tehachapis (Tejon)

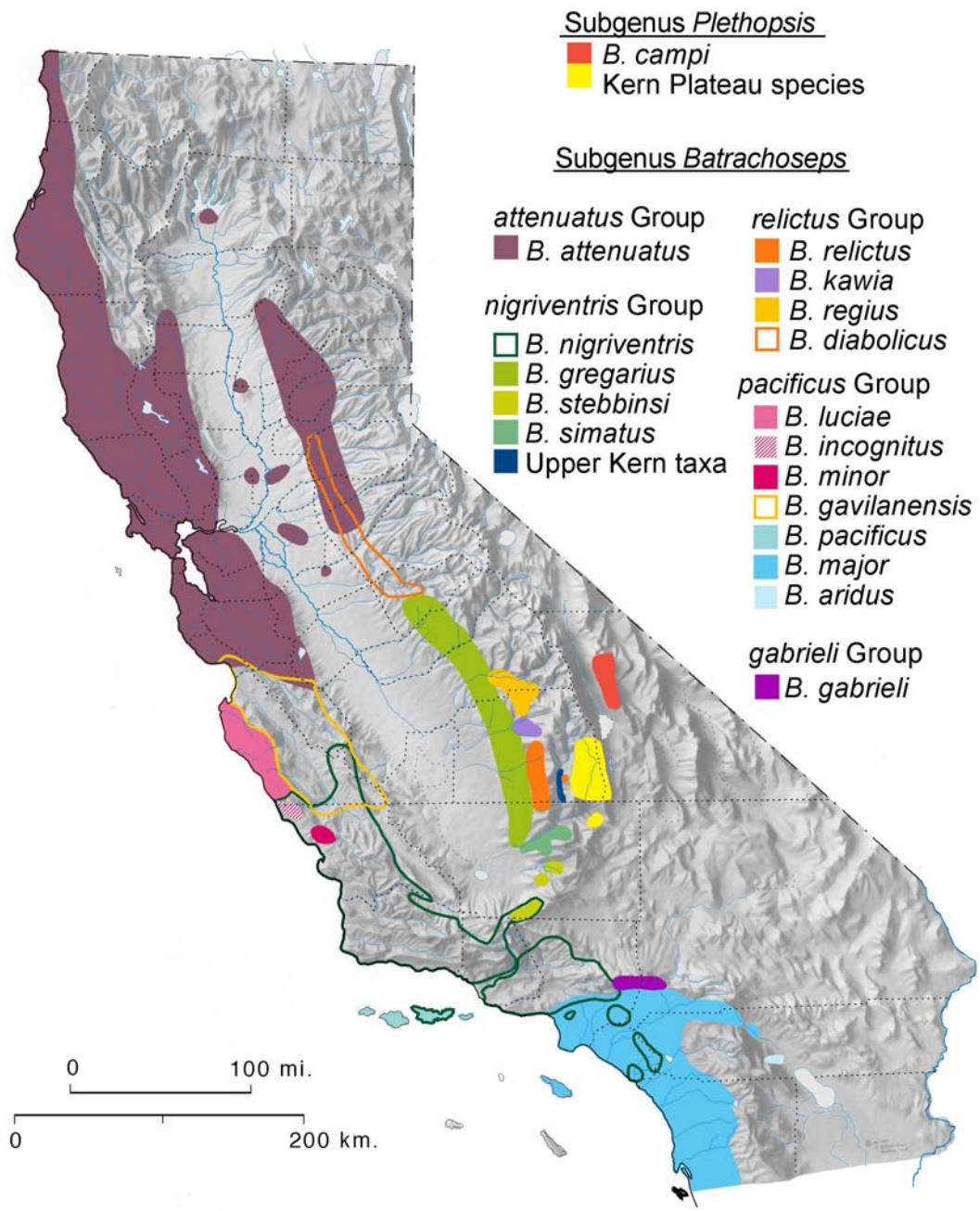
Note - other <u>taxa</u> & <u>approaches</u> needed (eg. Sork, Vandergast/Bohonak etc.)



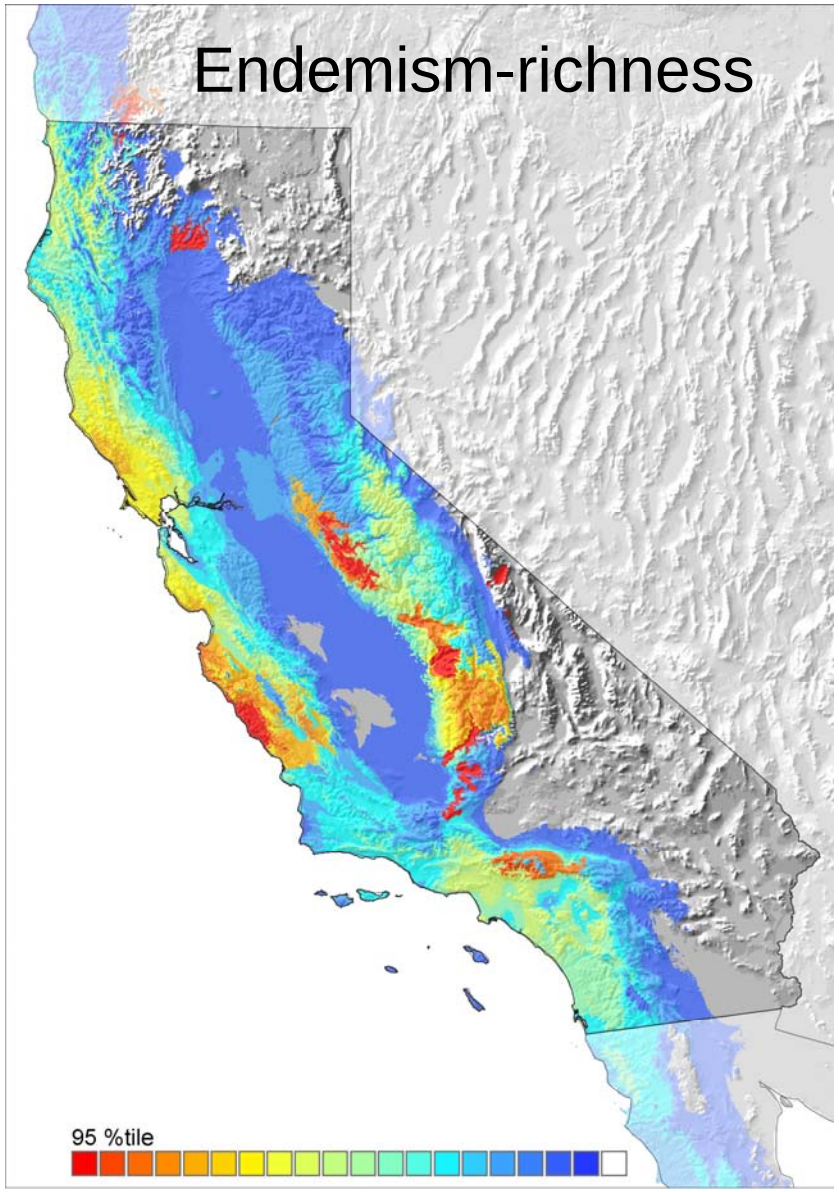
Also high irreplaceability for phylogeographic lineages (Rissler et al. 2006)

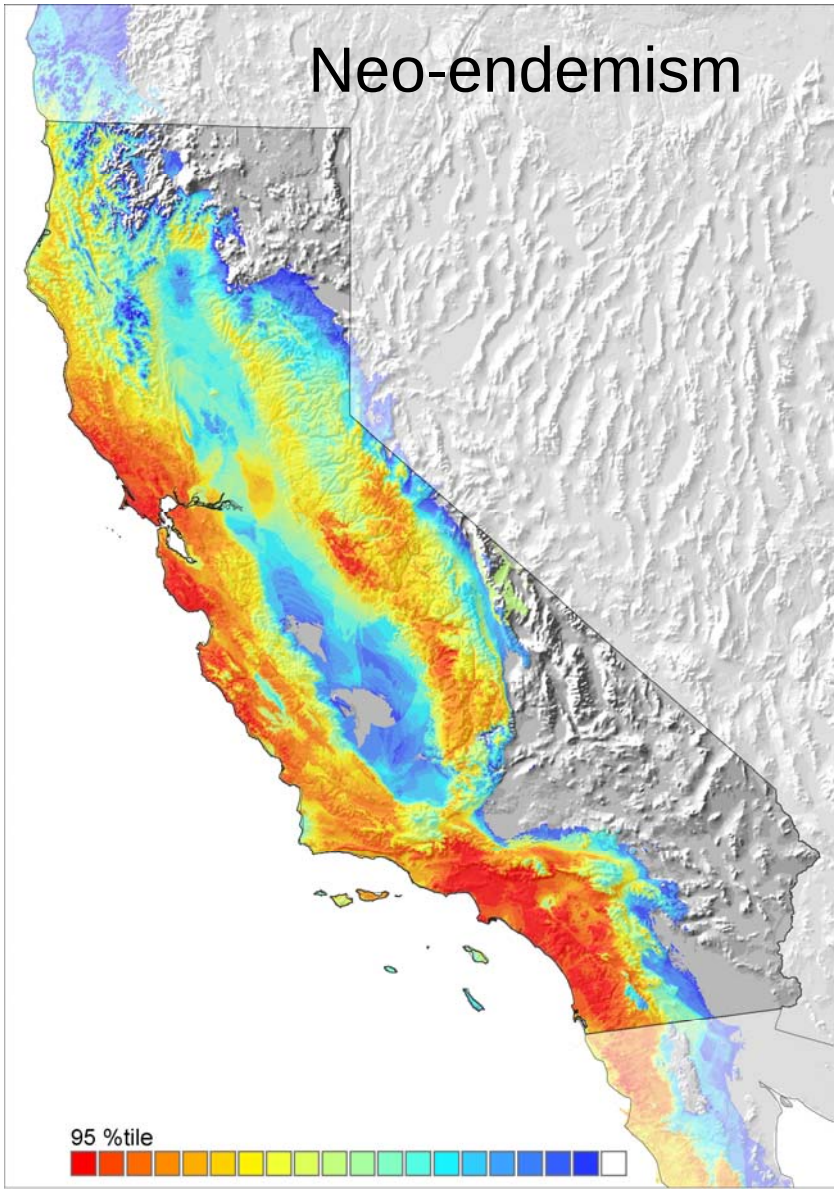
Amphibian diversity in California: 40 “endemic” species (& counting…)

About 50% of these are slender salamanders!

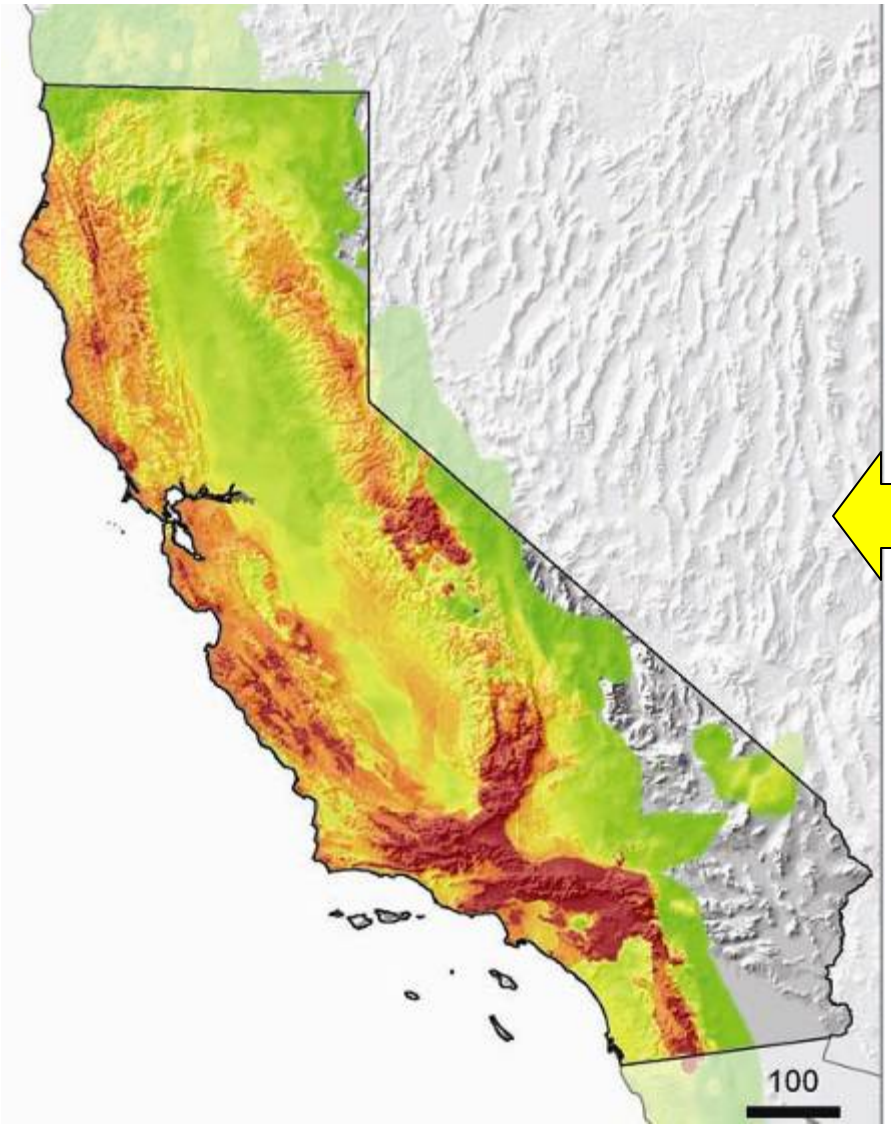


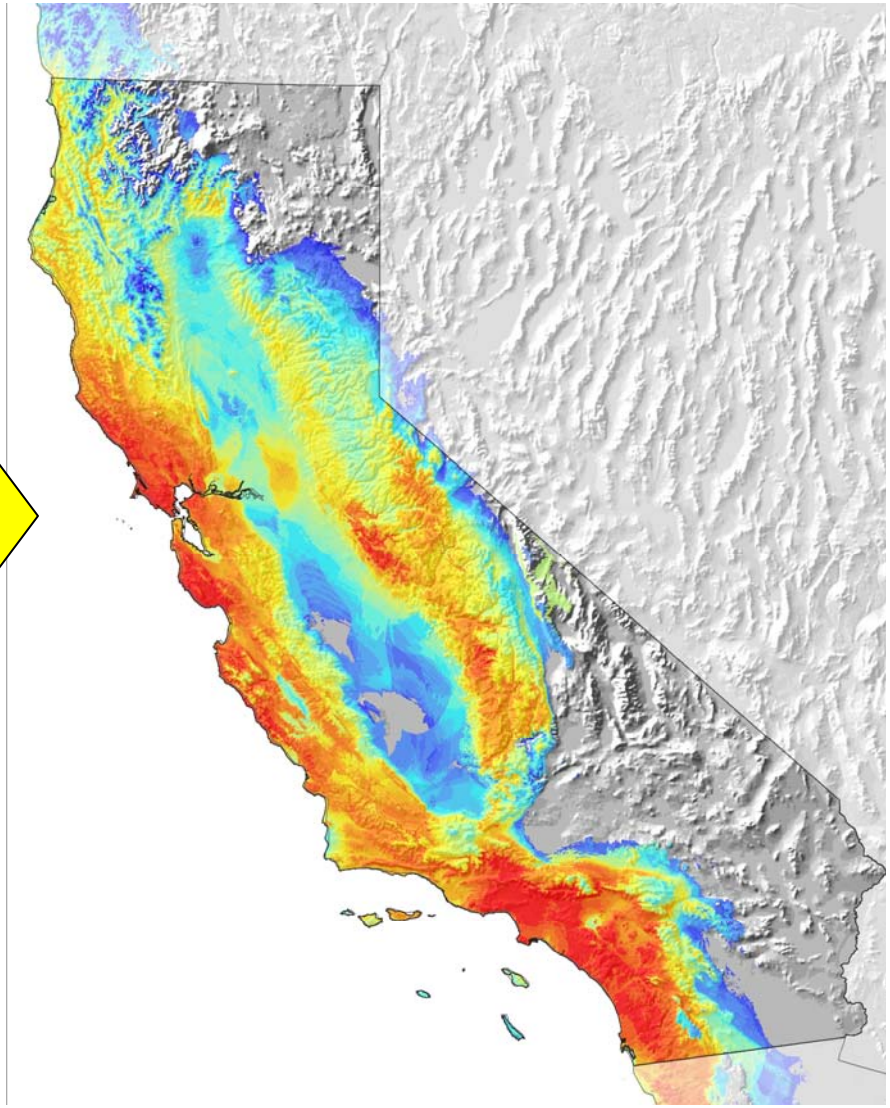
Amphibian hotspots (40 CA endemics)





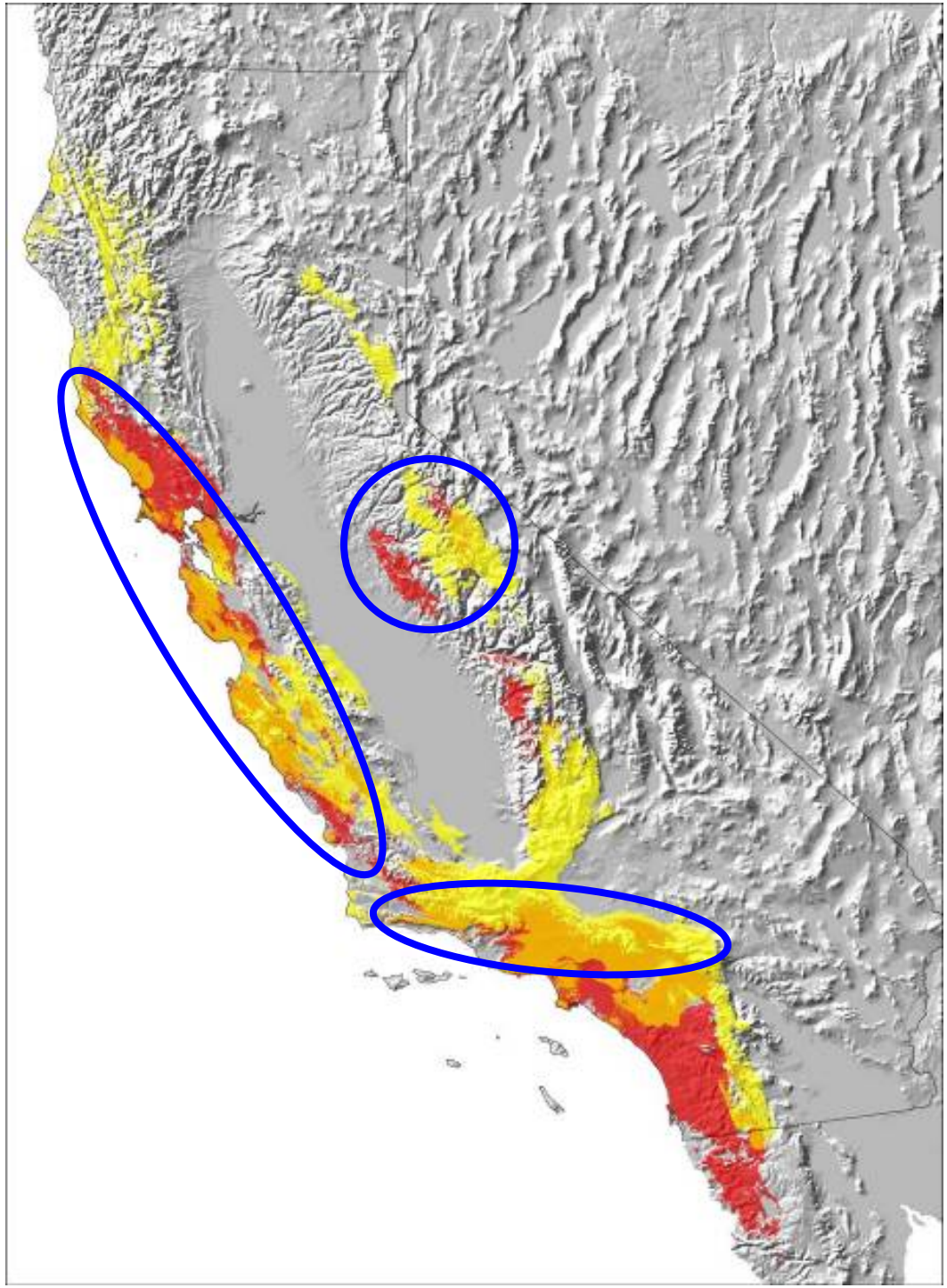
Mammal/Amphibian Neo-endemism Comparison





Mammalian & Amphibian Evol Hotspots coincide in several areas

- Central coast
- Central Sierra
- Transverse Ranges



Neo-endemism of CA plants

(polyploid derivatives) Stebbins & Major 1965

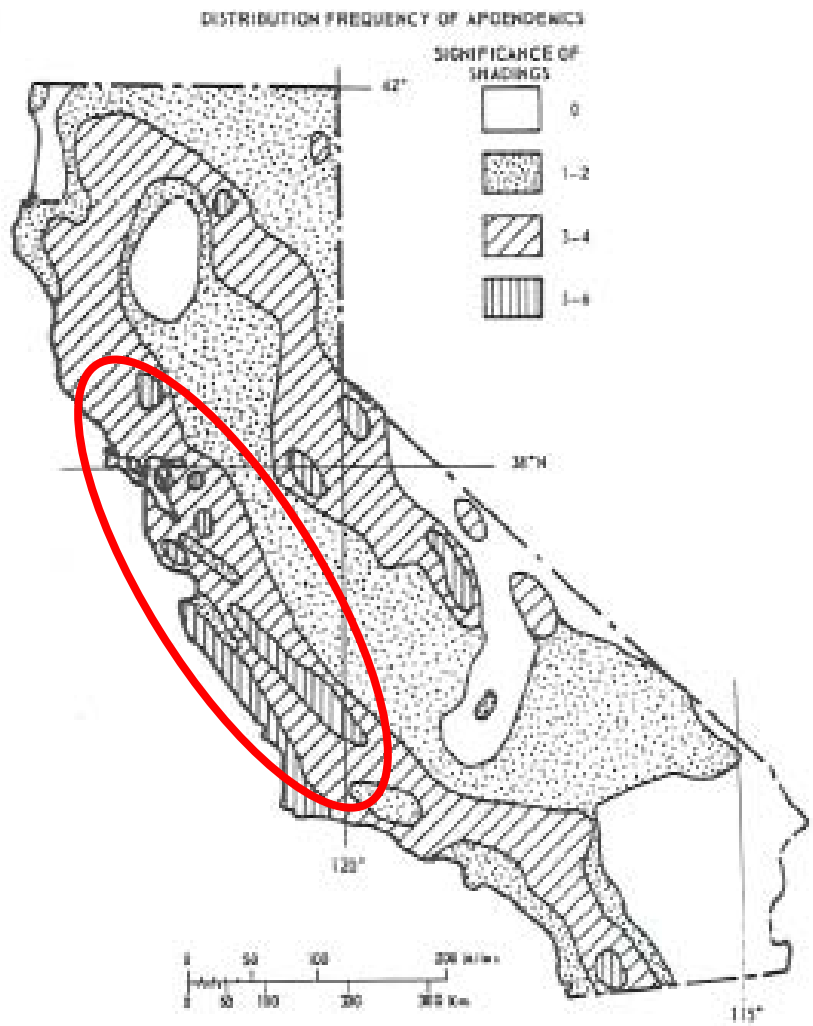


FIG. 4. Map of the distribution frequency of apoendemics in California. See Table 11.

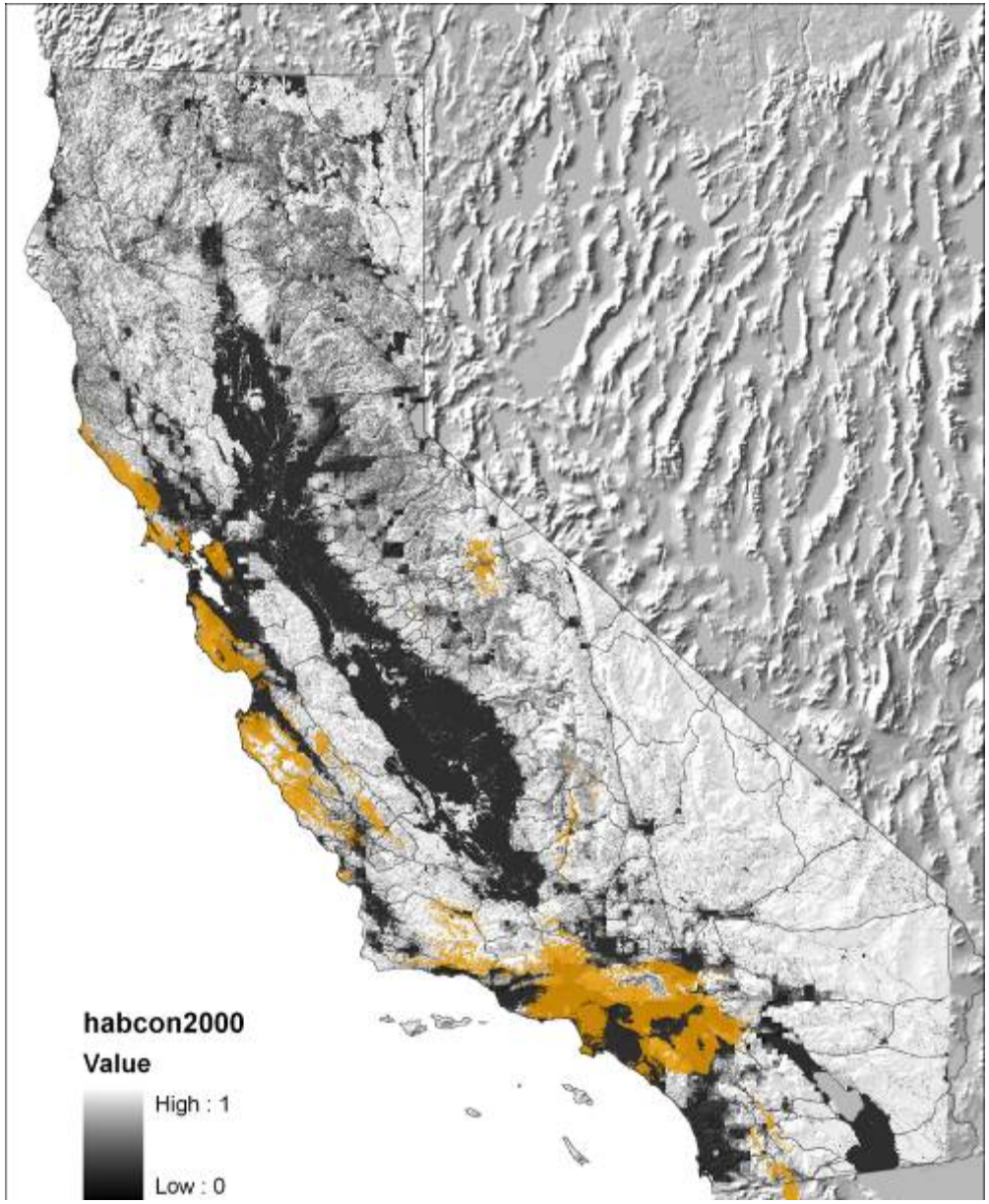
<u>Hypothesis</u>:

Elevated neo-endemism in regions with recent (Plio-Pleistocene) development of full Mediterranean climate AND not subject to recent glaciation

(also Raven & Axelrod 1978)

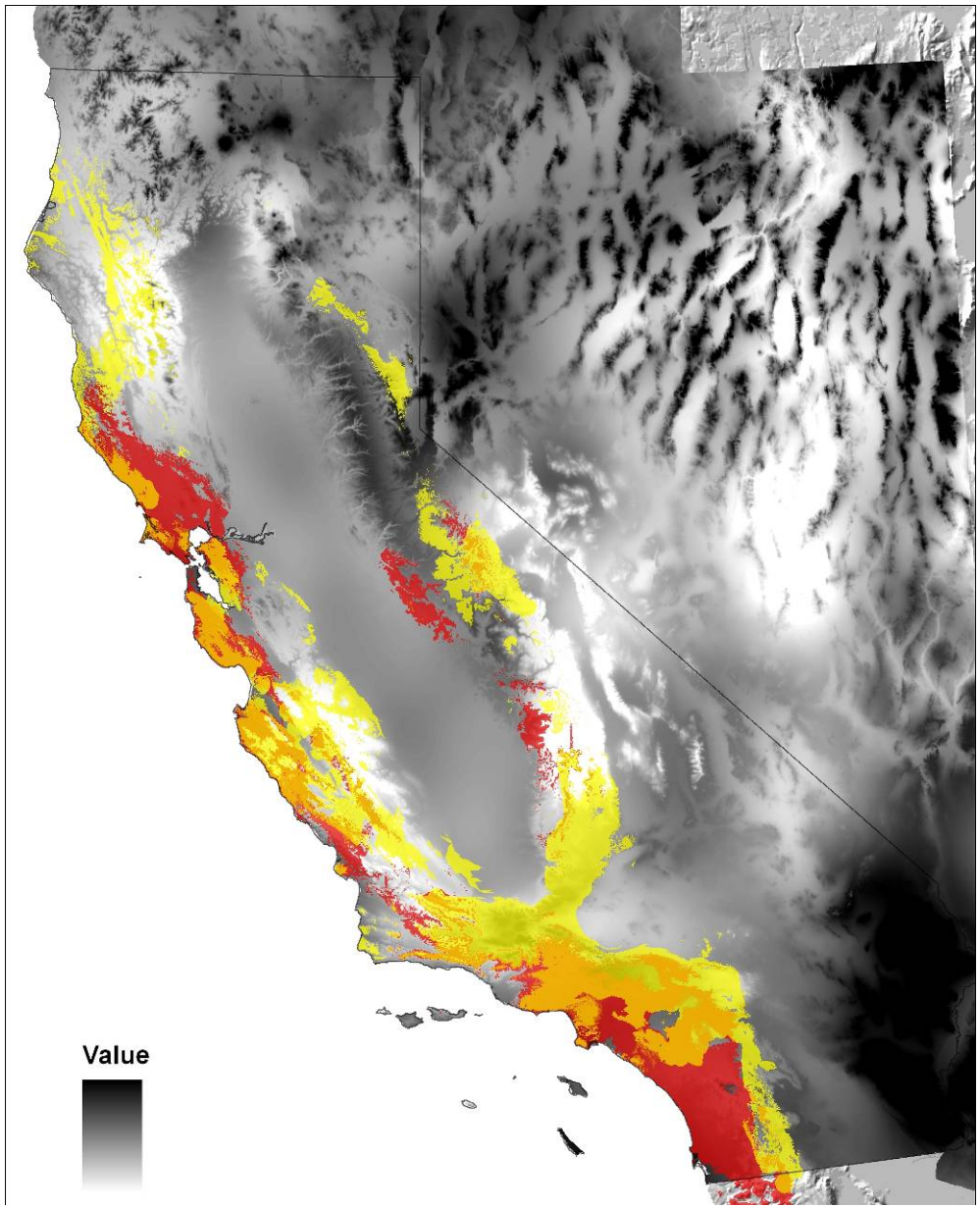
Several Evolutionary Hotspots occur in areas with high ecological integrity

Ecological integrity map: Davis et al 2003, NCEAS Report)



- How will landscapes promoting diversity shift with climate change?

- Temperature change in minimum temp. of Jan. in last century

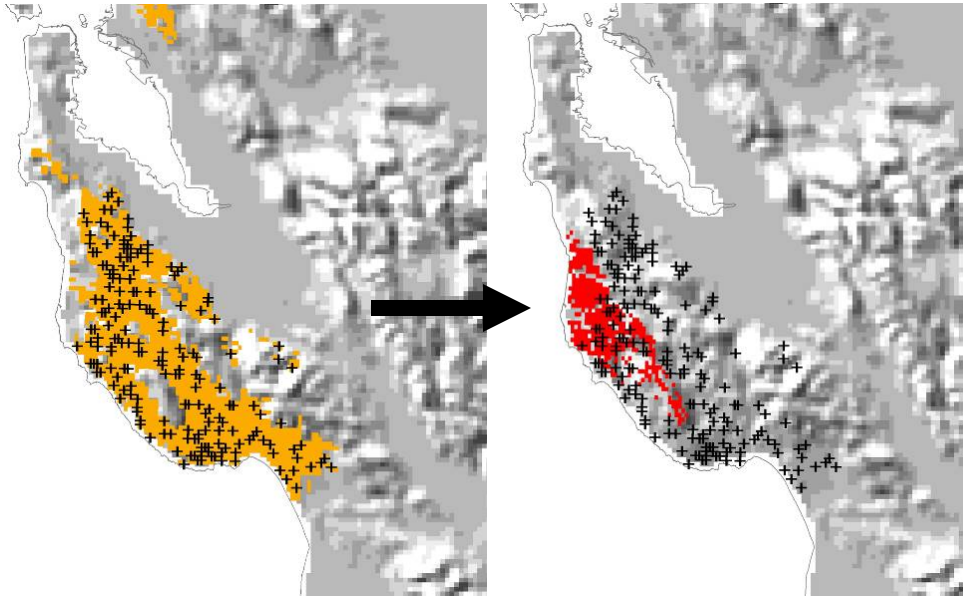


<u>Preliminary</u> modeling of evolutionary hotspots (with 2x [CO_2])

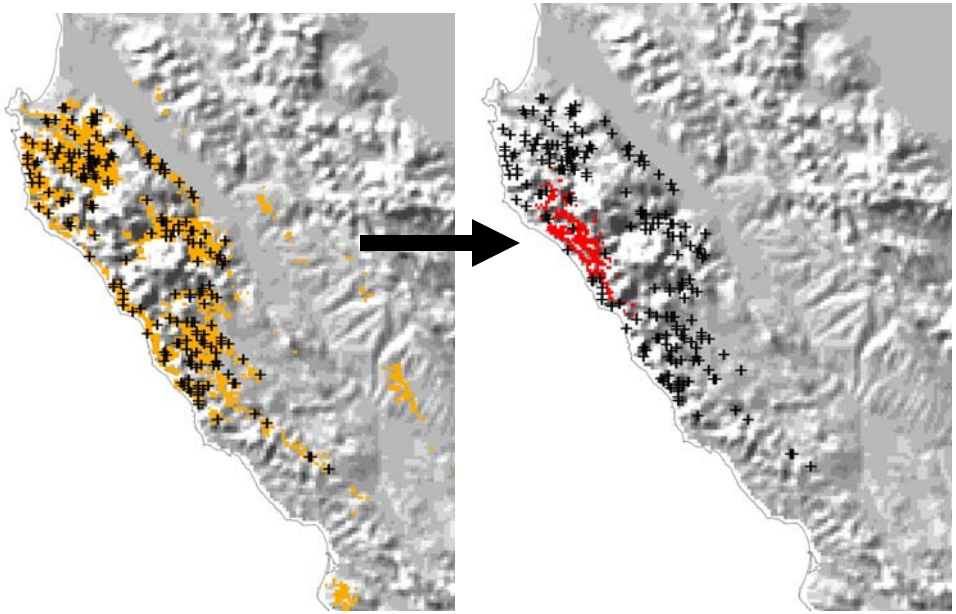
⇒Landscapes that sustain diversification may contract (eg. towards coast)

Is there evidence for responses to past climate change?

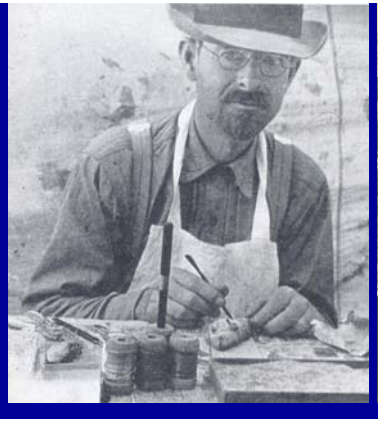
Santa Cruz Range

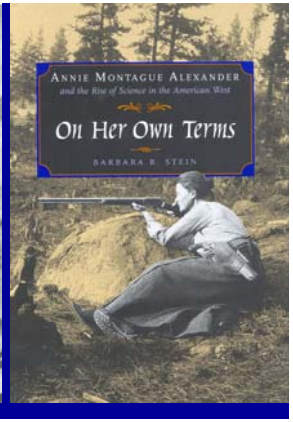


Santa Lucia Range

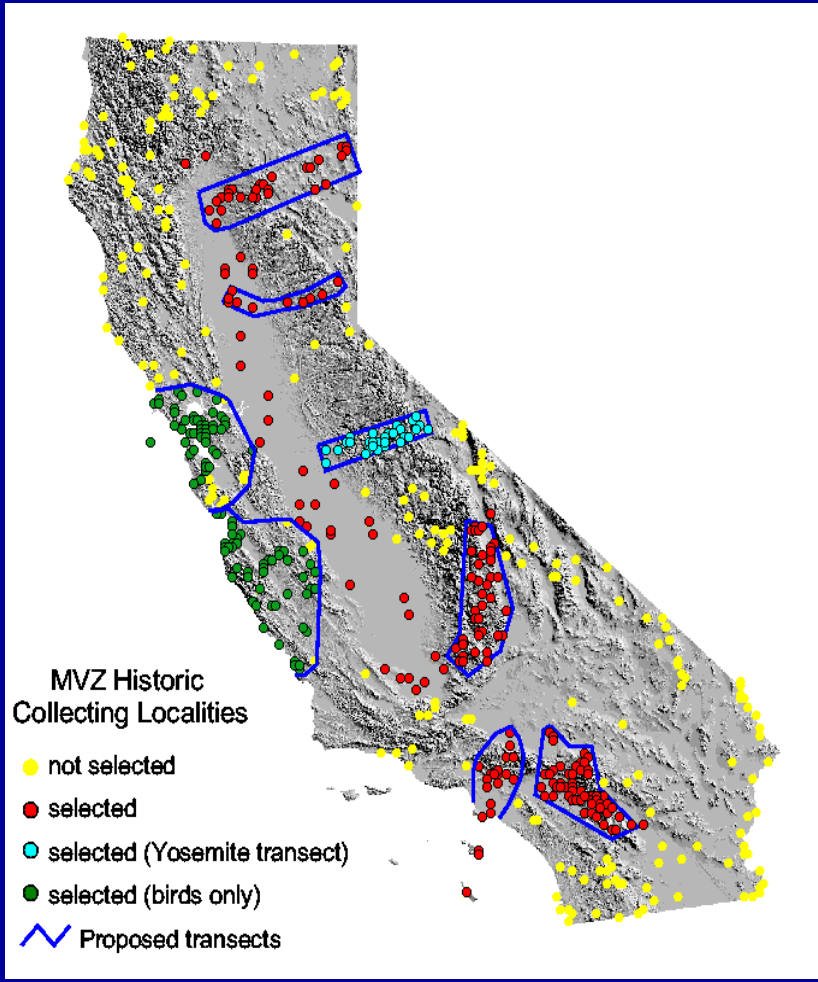


The Grinnell Project





"At this point I wish to emphasise what I believe will ultimately prove to be the greatest purpose of our museum. This value will not, however, be realized until the lapse of many years, *possibly a century*, assuming that our material is safely preserved. And this is that the student of the future will have access to the original record of faunal conditions in California and the west, whereever we now work" (Grinnell, 1910)



MVZ - specimen archival record

Museum of Vertebrate Zoology Data Access

This form accesses **216,050 mammal** records from the Museum of Vertebrate Zoology, University of California, Berkeley, updated last on 24 Sep 2005.

Search | Clear Form

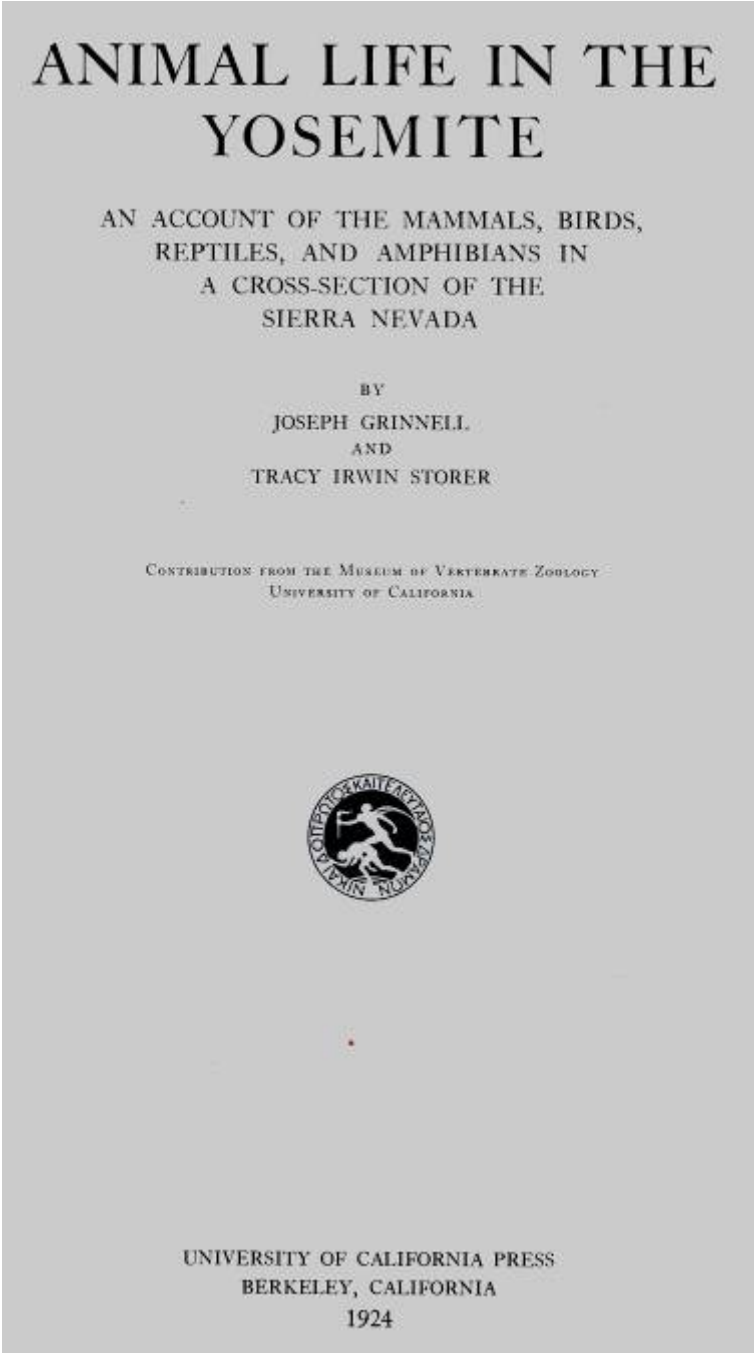
View: All specimens | Species counts only

Sort by Higher taxonomy | Display 30 records per page.

Taxon name	Enter any part of the scientific name (genus, sp., ssp.) Examples: Myotis velifer, Lynx	County	U.S. Only. Example: Calaveras
		State/Province	Example: California, Río Negro
Family		Country	Brazil
Year between	and (inclusive)	Continent/Ocean	any
MVZ Cat. No.		Island	
Accn. No.		Island Group	any
Collector		Locality	Examples: Ithaca, Los Baños

Partial words will match. If more than one field is completed, they will be AND'ed together. Case is not important, but searches are diacritical sensitive.

Go to MVZ query home page | questions and comments



ANIMAL LIFE IN THE YOSEMITE

AN ACCOUNT OF THE MAMMALS, BIRDS, REPTILES, AND AMPHIBIANS IN A CROSS-SECTION OF THE SIERRA NEVADA

BY

JOSEPH GRINNELL

AND

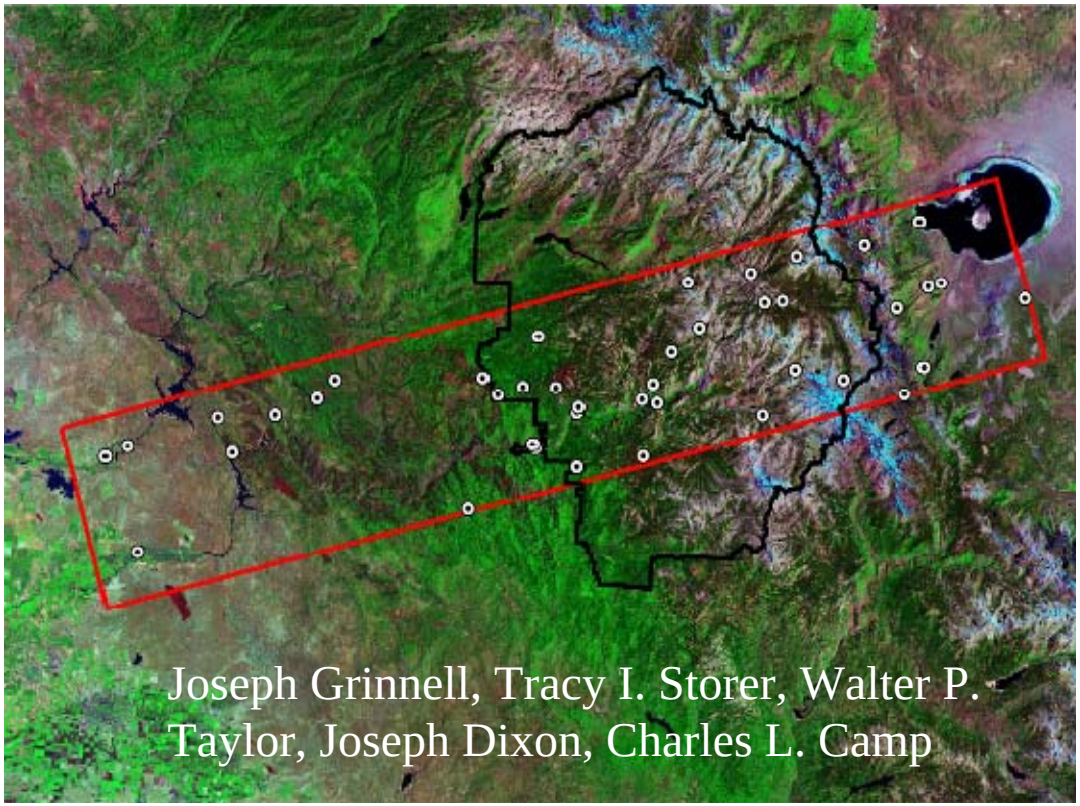
TRACY IRWIN STORER

CONTRIBUTION FROM THE MUSEUM OF VERTEBRATE ZOOLOGY
UNIVERSITY OF CALIFORNIA

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY, CALIFORNIA
1924

Yosemite transect

41 sites, elevational range 300 - 12,000 ft



fieldwork began on 19 Nov. 1914 and ended on 11 Aug. 1920

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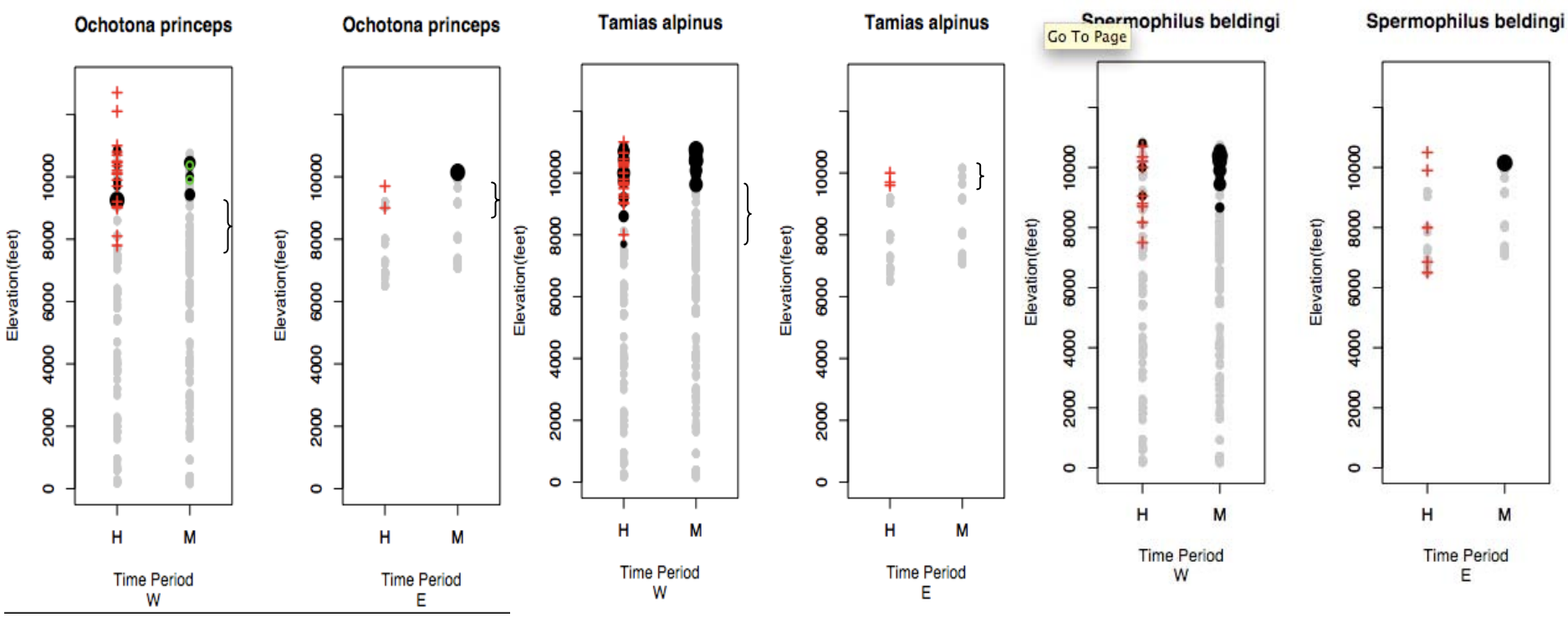
957 “man-days” in the field
~3,000 pages of field notes
4354 specimens obtained
~700 photographs

Upwards retraction of high elevation species

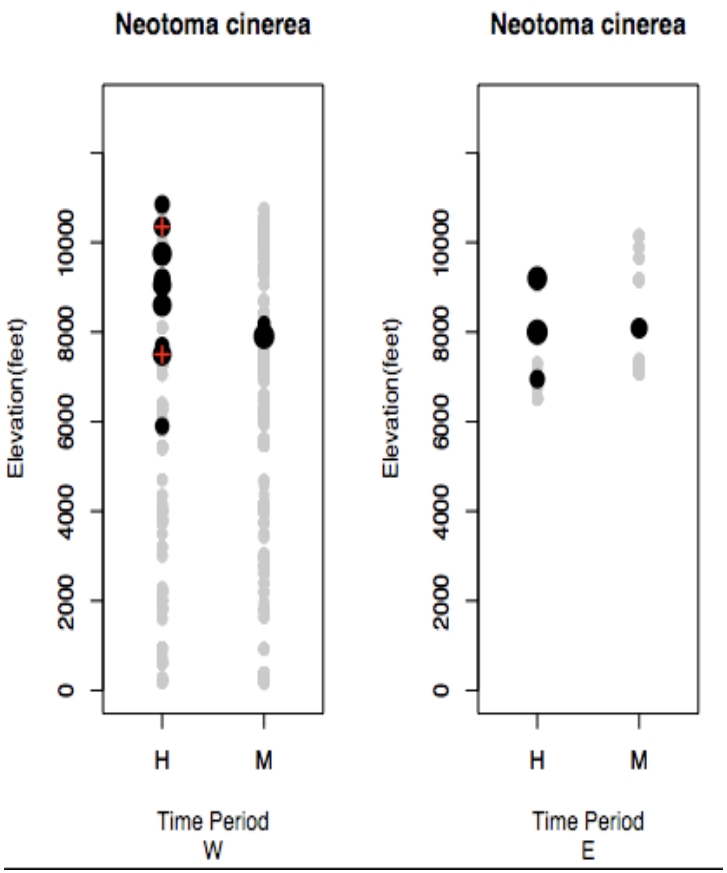
also Spermopholis lateralis (+ 244m), Phenacomys intermedius (+185m?)

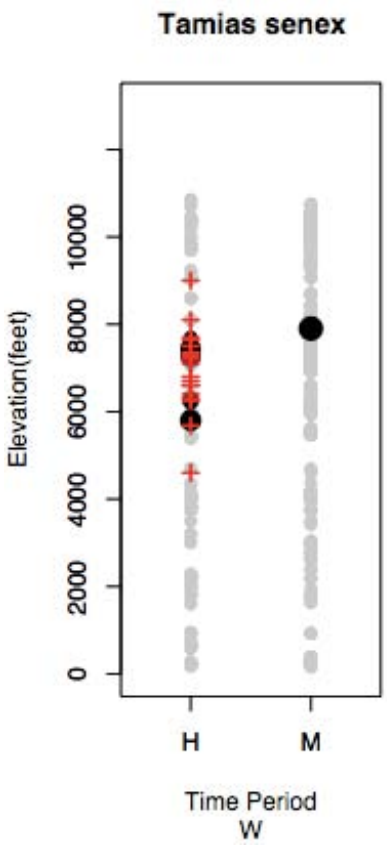


+ 497m + 350m + 589m absent + 355m + 939m

Range collapse of mid-high elevation species

Absent - Gulo luscus, Erithizon dorsatum, Lepus townsendii





-791m

+604m

-339m

+347m

-334m

+1007m

No change:

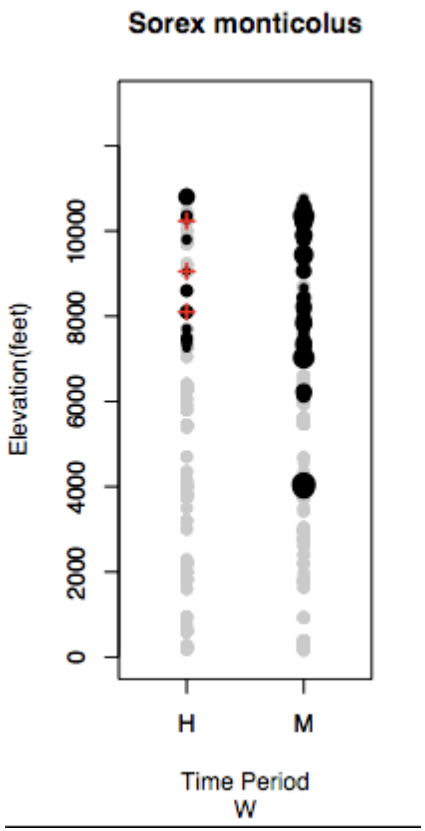
Thomomys monticola

Marmota flaviventris

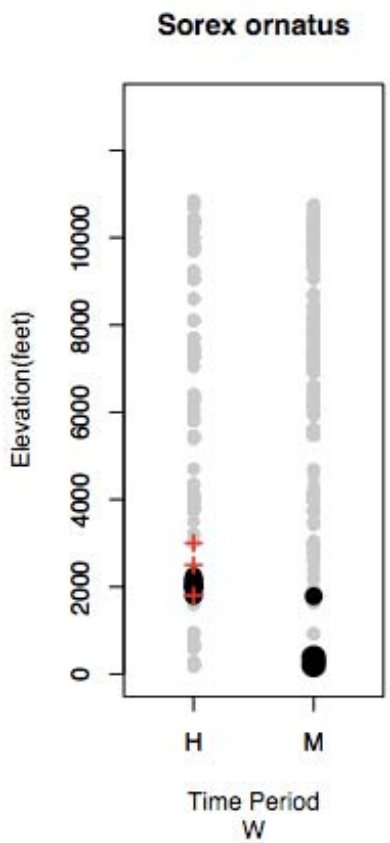
Tamias speciosus

Sorex lyelli?

Downwards expansion of mid-high elevation species



-1000m



-370m (ns)

-484m (p = 0.04)

Overall:

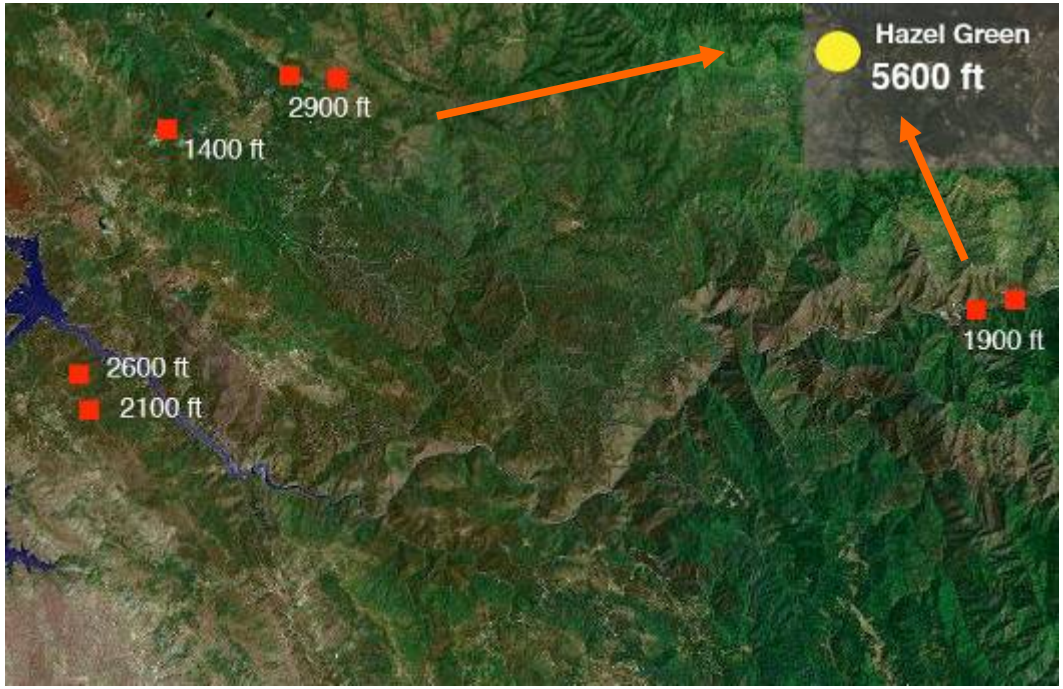
41 species, 35 reliable

Min elev: **+17** (434m); -2 (512m)

Max elev: +8 (457m); -6 (415m)

California pocket mouse (*Chaetodipus californicus*)

elevational increase of a low elevation species



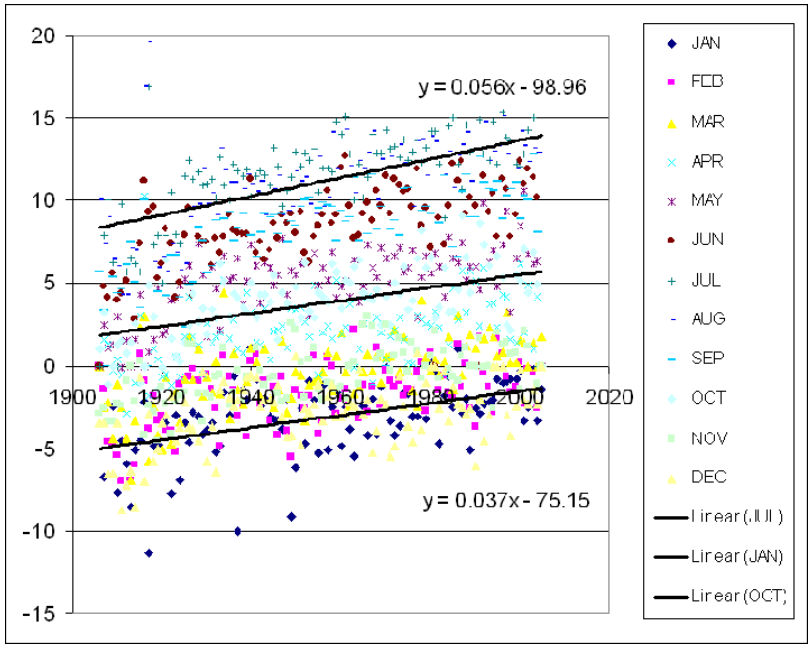
Piñon mouse
Peromyscus truei

habitat expansion associated with elevational increase in distribution

lodgepole - whitebark pine, upper Lyell Canyon, 10, 200 ft

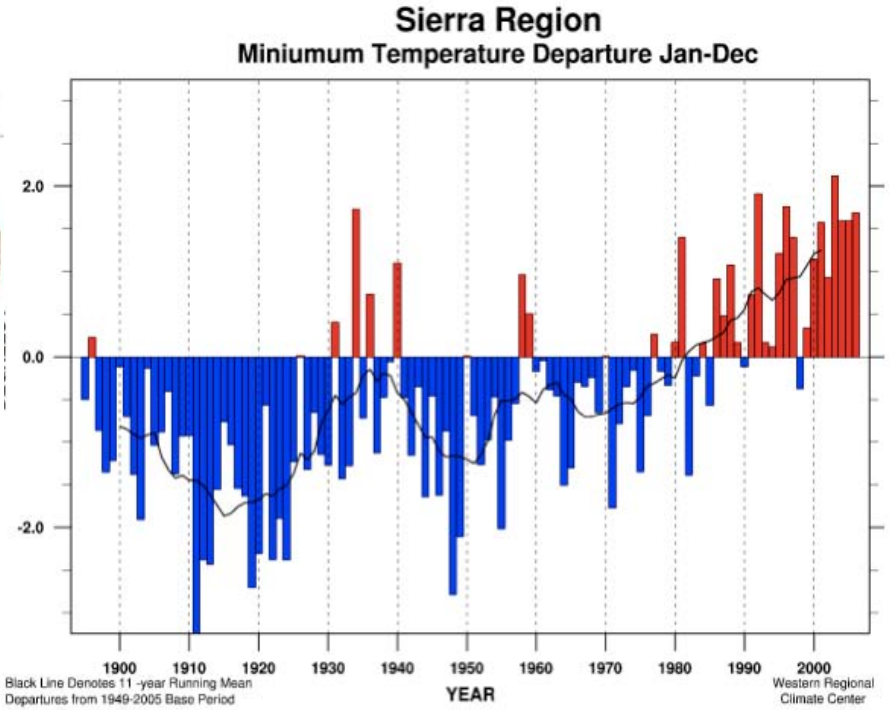
piñon - juniper woodland, sage and rabbitbrush understory, east slope Sierra Nevada, 8000 ft

Multiple lines of evidence for substantial (+2-3 C) warming in the Sierra Nevada



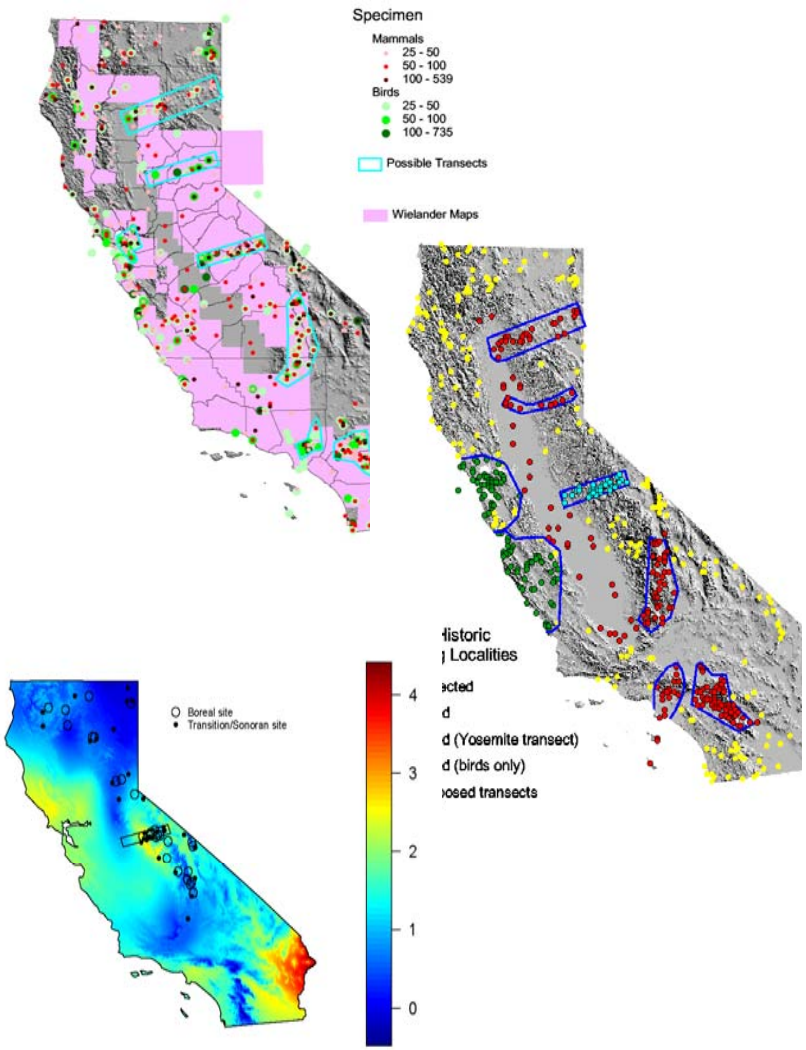
Lyell glacier 1903 - 2003

Veg change
- Millar et al.



An emerging research priority

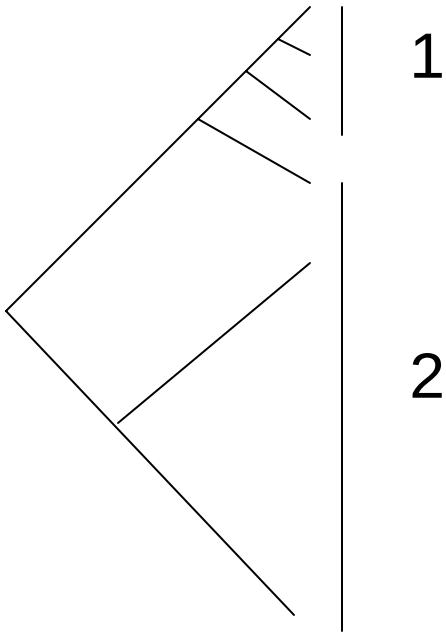
- Obtain and integrate information on century-scale response to past climate & land cover change
  - identify resilient vs sensitive species
  - improve prediction of future responses
  - Historical climate surfaces
  - Historical vegetation (Wieslander)
  - Plant and animal distributions (museums)
  - Long term ecological dynamics - UC NRS partnership



Management & policy implications

- Rates of diversification are not randomly distributed - cold & hotspots
- Common environmental theme is gradients/ecotones, geological complexity
- Location & extent of hotspots likely to shift with climate
- Protection of EHs requires <u>large-scale</u> and <u>coordinated</u> planning to protect connectivity across gradients, and large, heterogeneous areas
- Protected areas are not immune from effects of climate change, but offer the greatest potential for resilience

Two ways of thinking about phylogenies in conservation



Cradle: DP 1 > 2

DP = Diversity potential

Ark: PD 2 > 1

With apologies to Erwin!

Mapping processes: surrogates?

Generative processes

Opportunity

Adaptive diversification

Abiotic: Steep environmental gradients (climate, soils etc)

Biotic interactions: Holocene expansion zones (coevol hotpots)

Non-adaptive diversification

Habitat Isolates

Niche space

Novel environments (eg. geology, neohabitats

Genetic isolation

Spatial complexity, fragmentation of habitats

Stability

Quaternary refugia from paleomodels