

Evidence for recent effects of climate on the rapidly shrinking distribution of the American pika

Chris Ray, CU-Boulder
Erik Beever, USGS
Philip Mote, OCCRI
Nifer Wilkening, CU-Boulder
Peter Brussard, UNR





Pikas are...
related to rabbits
as big as your fist
habitat specialists
non-hibernating

...and...
herbivorous
hay-stackers
highly territorial
and vocal



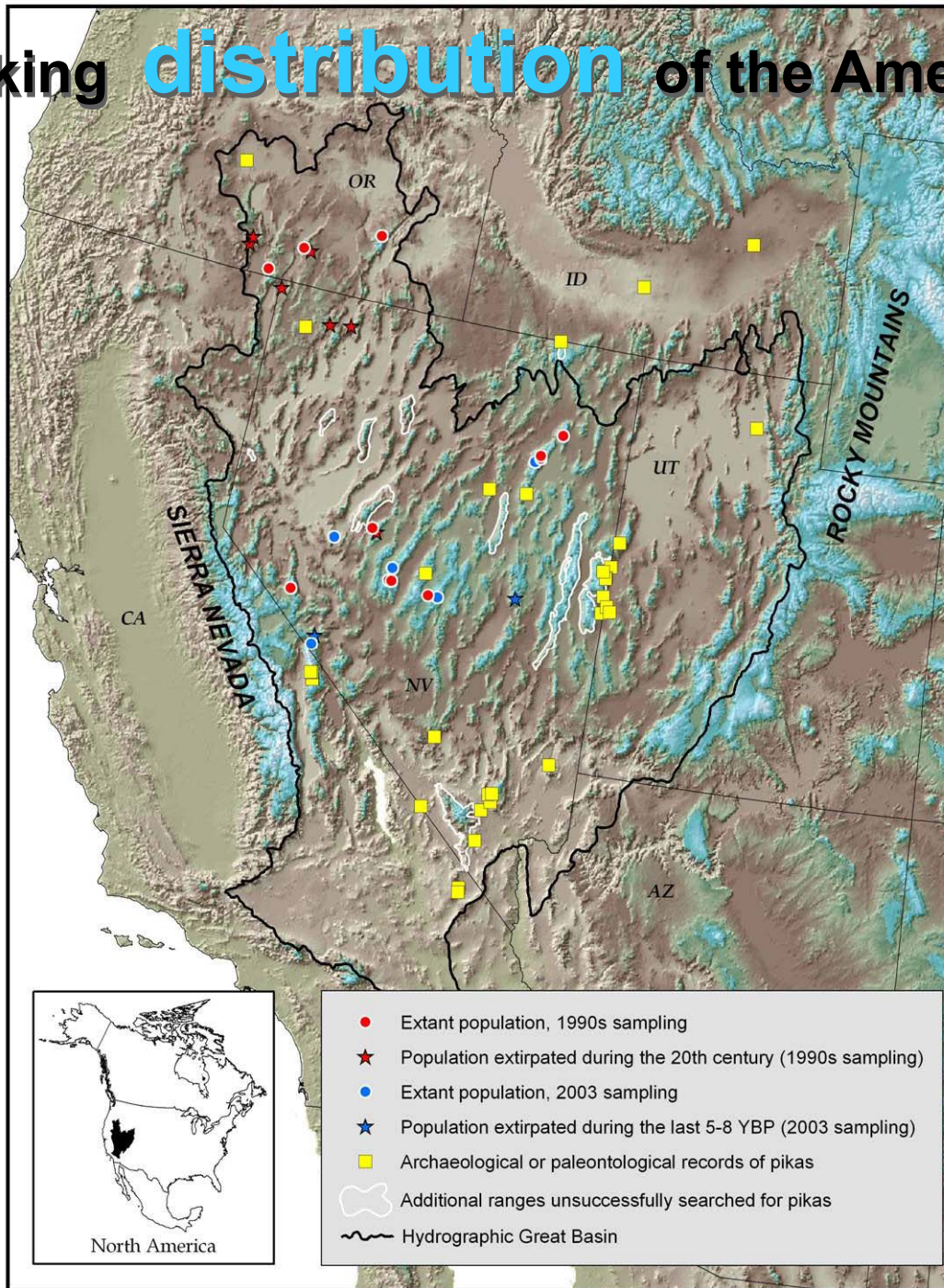


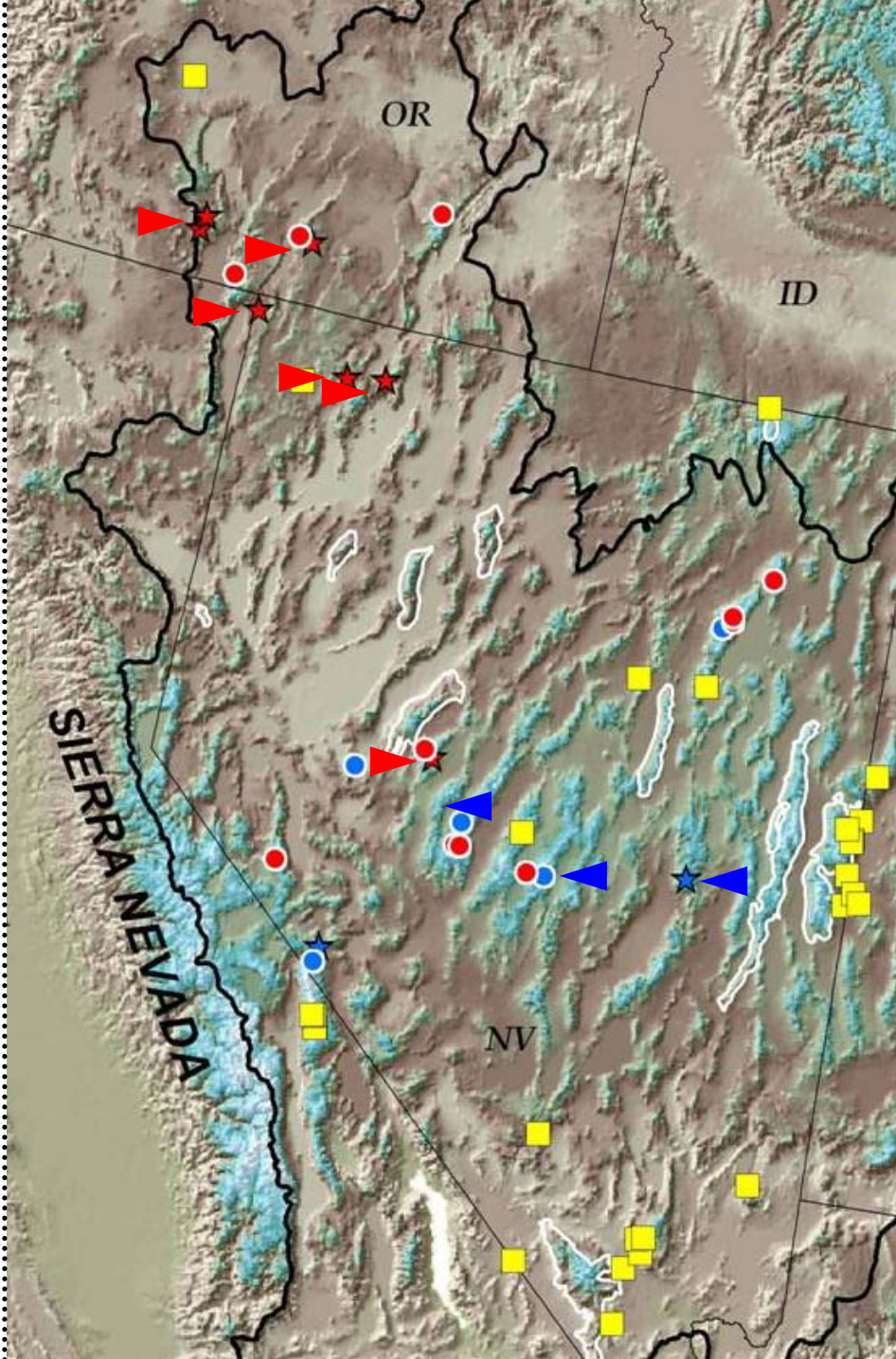
Outline

Evidence for decline

Potential drivers

Shrinking **distribution** of the American pika





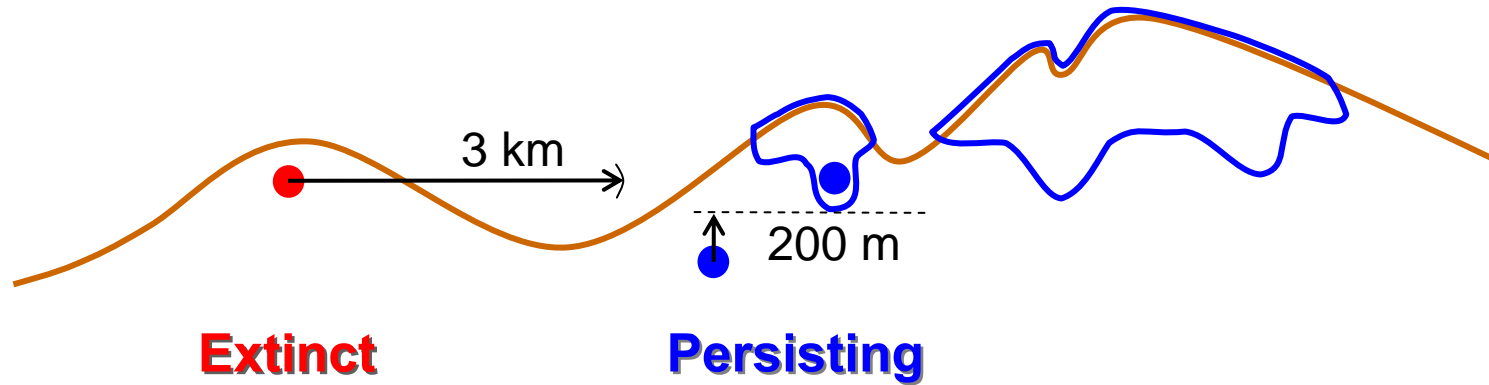
**25 historical populations
recorded 1898-1990
(average date = 1933)**

**6 extinct by 1999 (▶)
9 by 2007 (◀)**

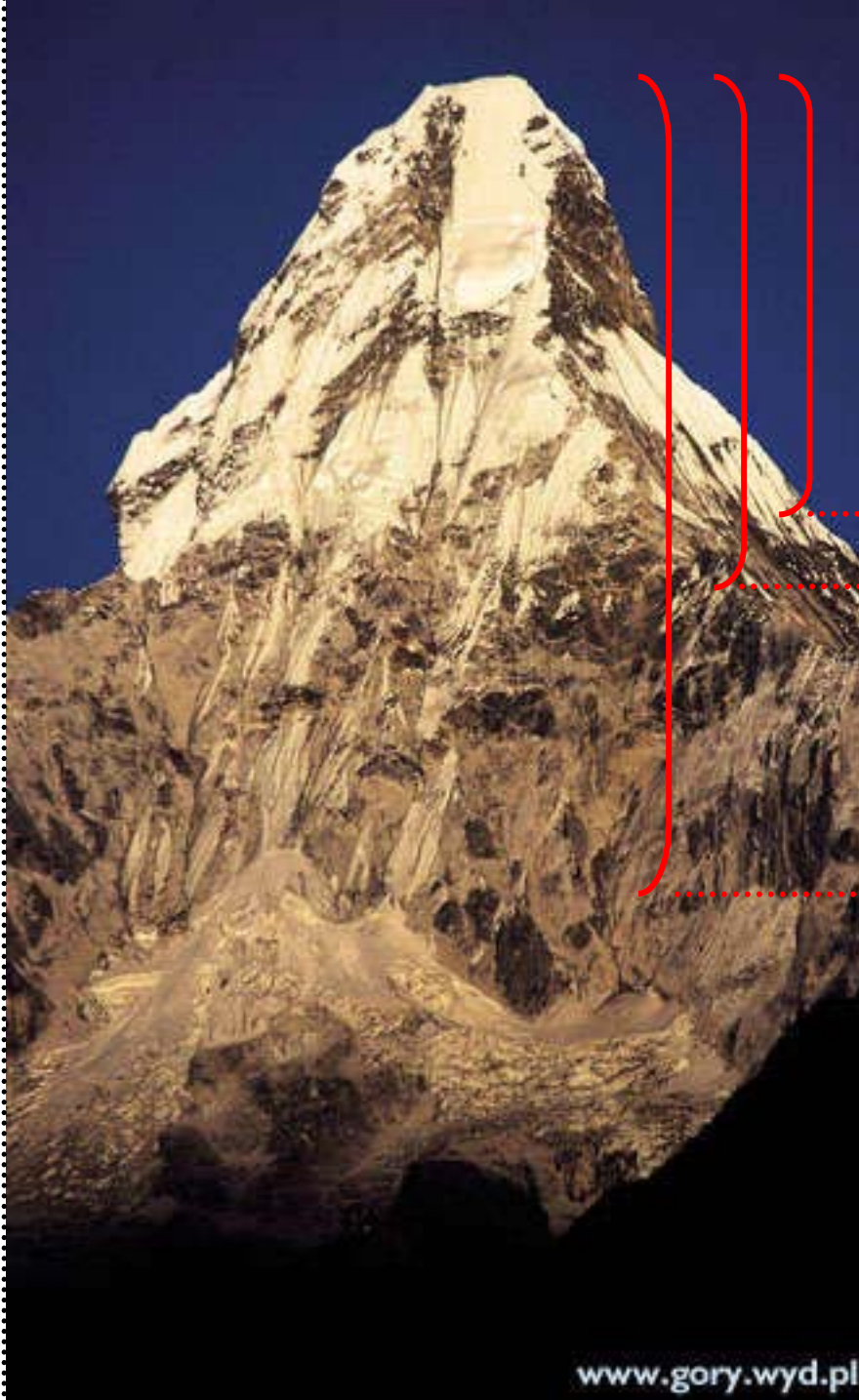
Extinction rate is rising

**Opportunity for modeling
and model updating**

Defining local extinction



Rising mean minimum elevation of 25 historical pika populations in the Great Basin



..... 2008: 2,535 m

..... 1999: 2,500 m

..... 1933: 2,275 m

} 4.0 m/yr

} 3.5 m/yr

Similar patterns in the Sierra Nevada
(Moritz 2007)



Outline

Evidence for decline

Potential drivers

What predicts extinction?

A small, brown mouse with large ears is perched on a dark, jagged rock. The background is a dark, shadowed rocky crevice, suggesting a high-altitude or volcanic environment. The mouse is facing left, and its body is illuminated by a light source from the upper left.

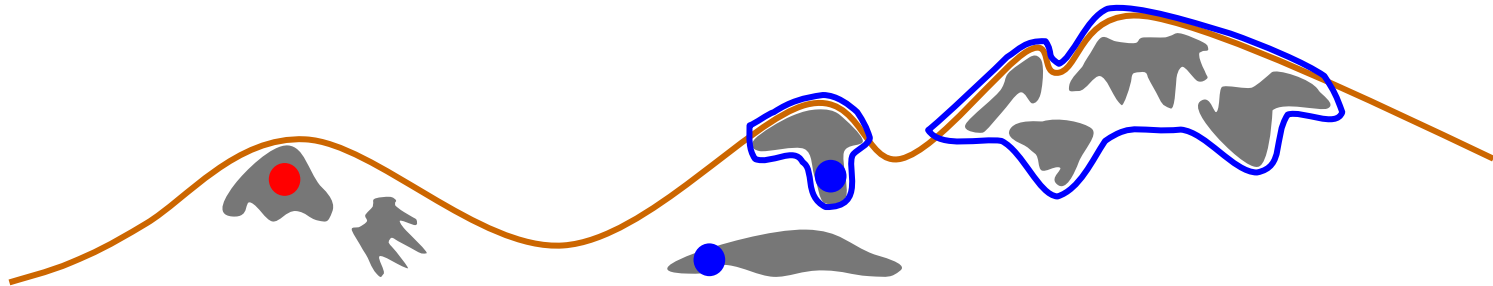
Habitat size/structure

Human impacts

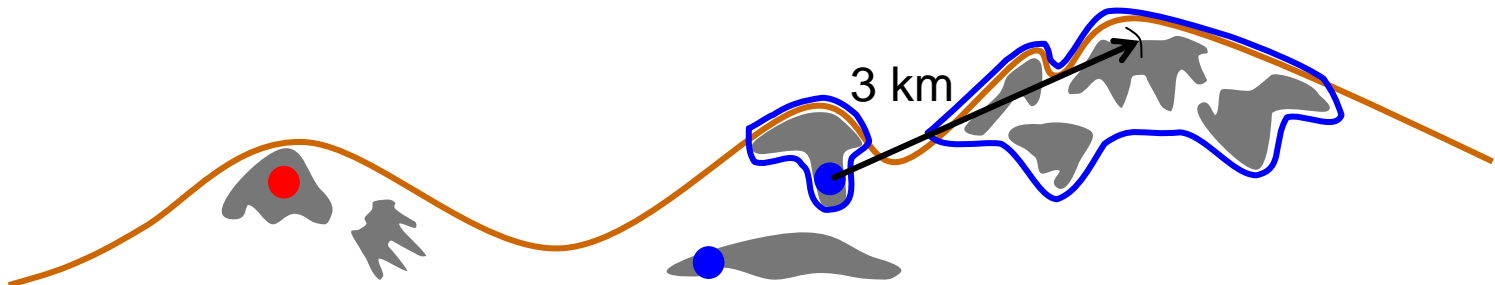
Species interactions

Thermal stress

Likely predictors

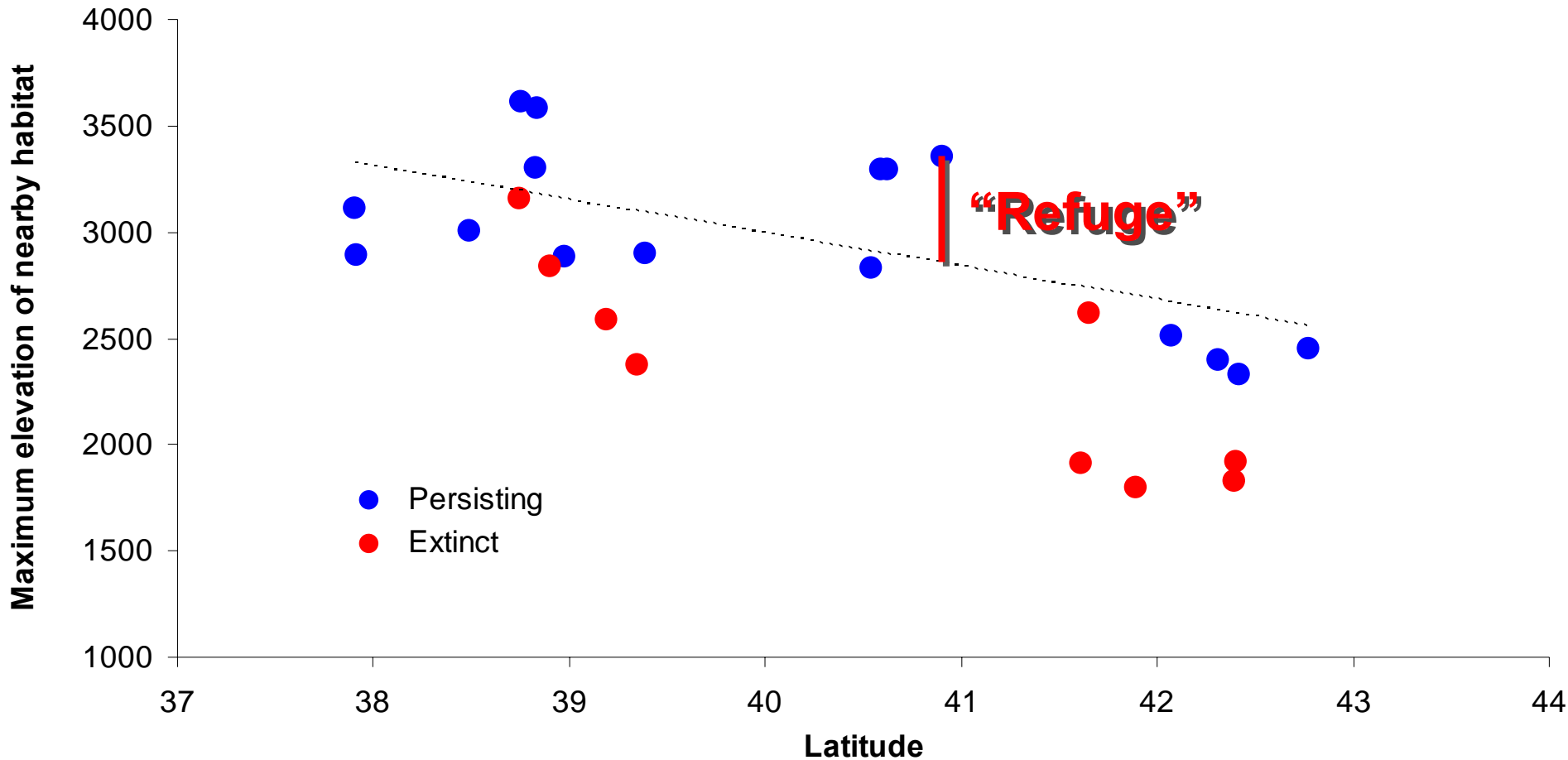


“Habitat” – amount within mountain range

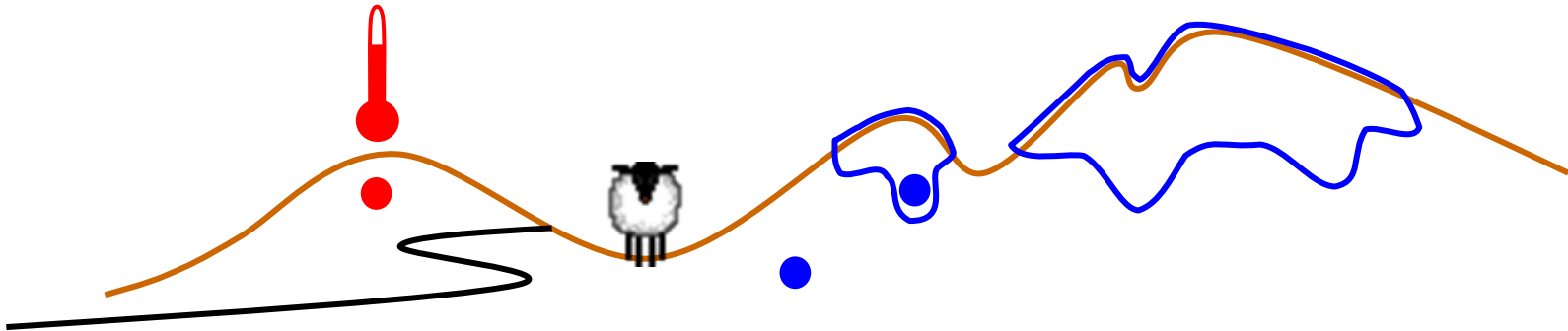


“Refuge” – highest habitat within 3 km

Relationship between extinction and the proximity of a high-elevation habitat refuge



Likely predictors, continued



“Access” – distance to nearest non-4WD track

“Grazing” – long-term use of the site by livestock

“Heat” – mean daily max T in August (PRISM 1971-2000)



shanaweber@mac.com

Summer heat stress

Grinnell 1917

MacArthur & Wang 1973

Smith 1974

Hafner 1993

Hafner & Sullivan 1995

Verts & Carraway 1998

Li et al. 2001

Simpson 2001

Beever 2002



Winter exposure

Tapper 1973

Smith 1978

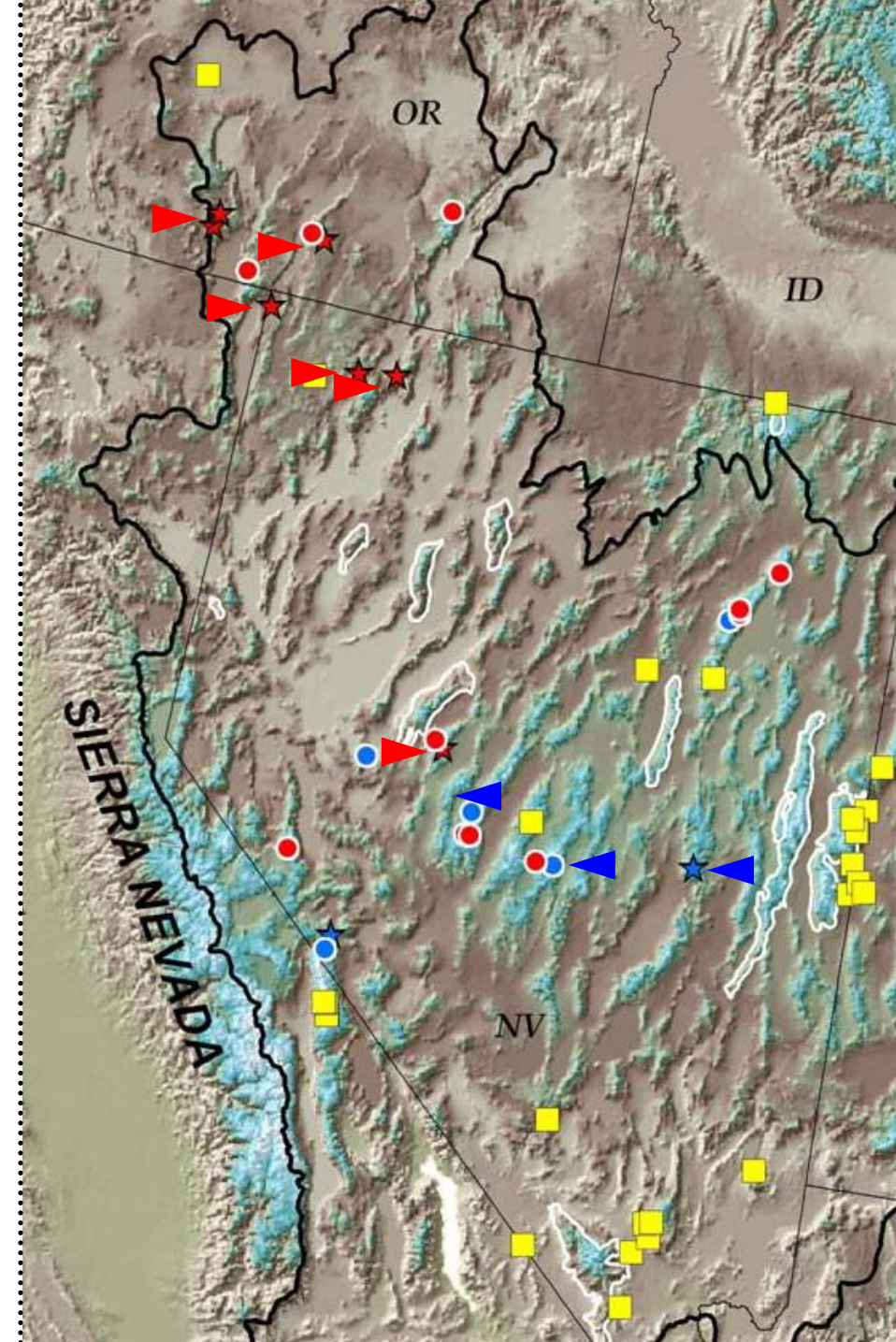
chris.ray@colorado.edu

What predicts extinction?

Habitat size/structure
Human impacts
Species interactions
Thermal stress

1999:
Habitat
Refuge
Access
Grazing
Heat

chris.ray@colorado.edu



What predicts extinction? (Model updating, part 1)

Rank	1999	2007a
1*	Habitat, -	Habitat, -
2	Refuge, -	Refuge, -
3	Access, +	Grazing, +
4	Grazing, +	Access, +
5	Heat, +	Heat +

**Ranked using AIC*

Evidence Ratio (w_0/w_i)

Rank	1999	2007a
1	1.0	1.0
2	1.1	1.5
3	1.8	2.1
4	2.4	4.4
5	3.0	4.7

What predicts extinction?

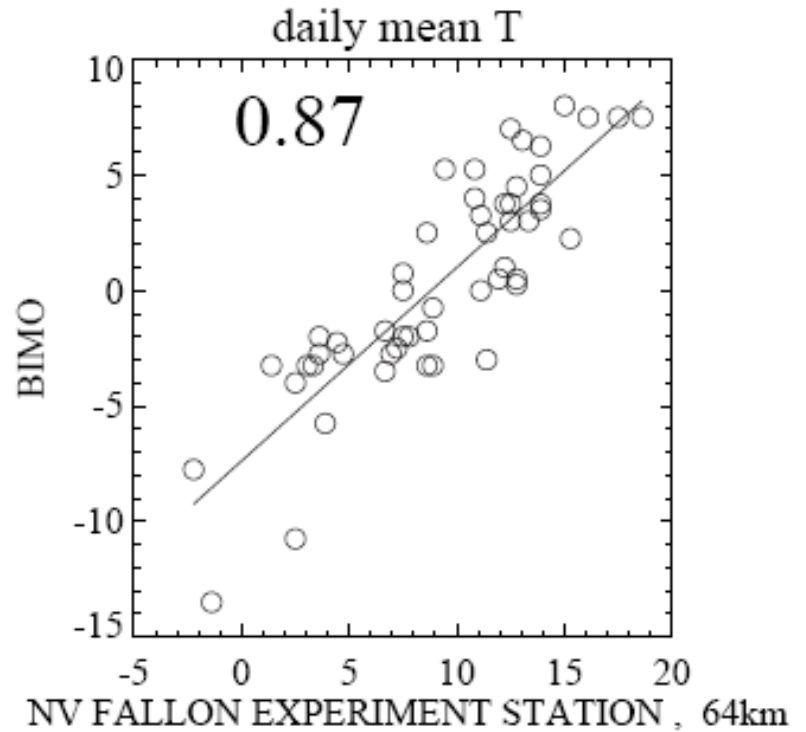
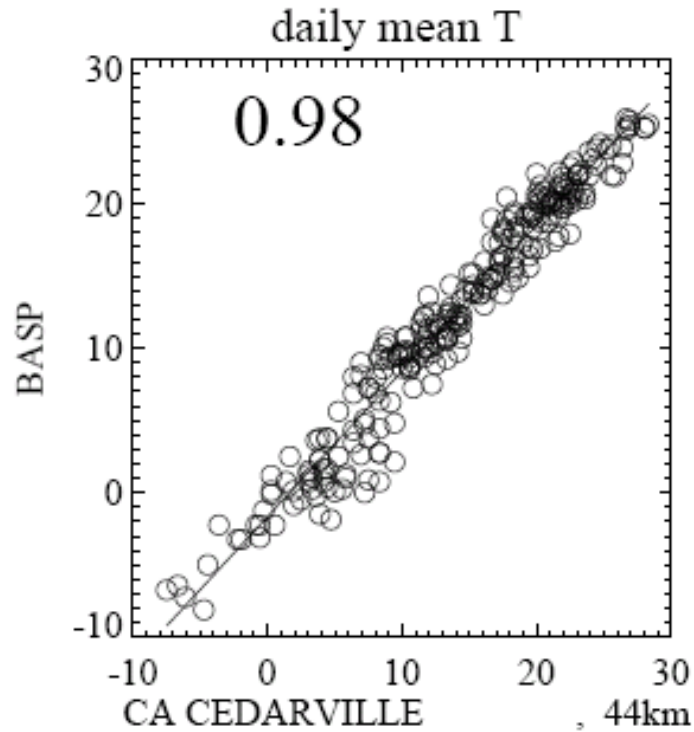
Habitat size/structure
Human impacts
Species interactions
Thermal stress

2007b:
Acute heat-stress
Chronic heat-stress
Acute cold-stress

chris.ray@colorado.edu

Talus vs. ambient temperatures

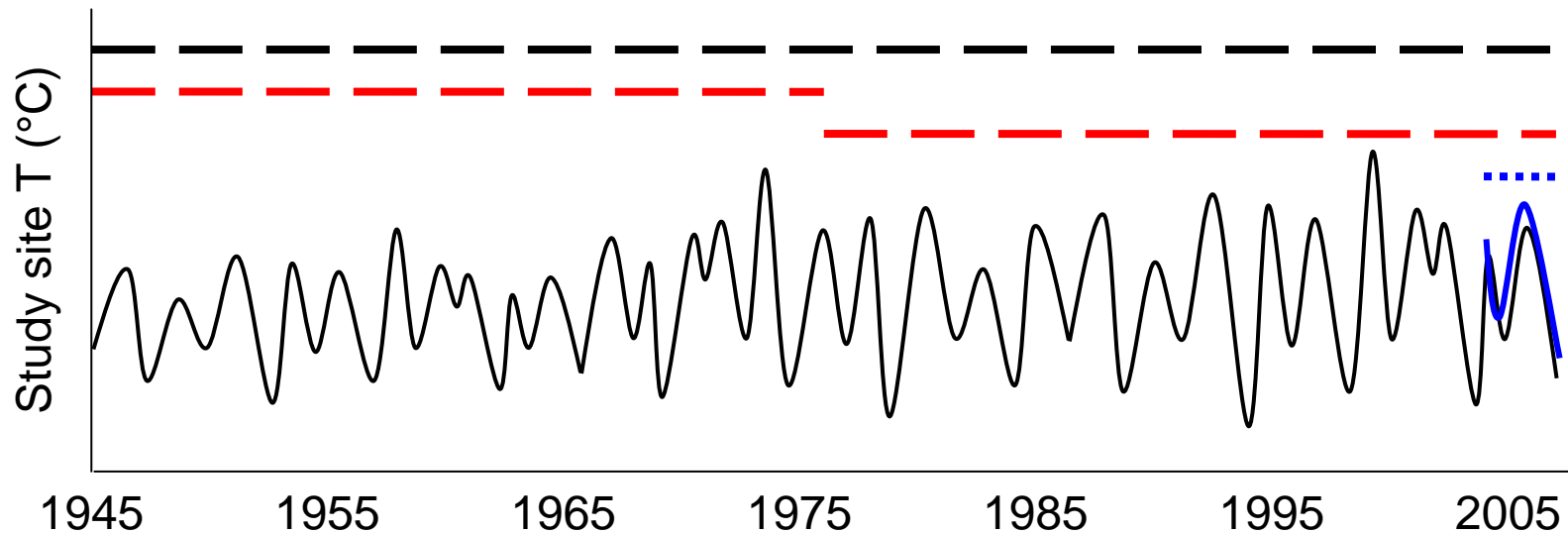
2005-2006 study site T (°C)



2005-2006 HCN* station T (°C)
*Historical Climatology Network

Hindcasting metrics of stress

3 data sets: LT = long-term, Δ = climate change, R = recent



3 stress metrics

Acute heat-stress

Chronic heat-stress

Acute cold-stress

Data used

days > 28 °C

Summer mean T

days < -10* °C

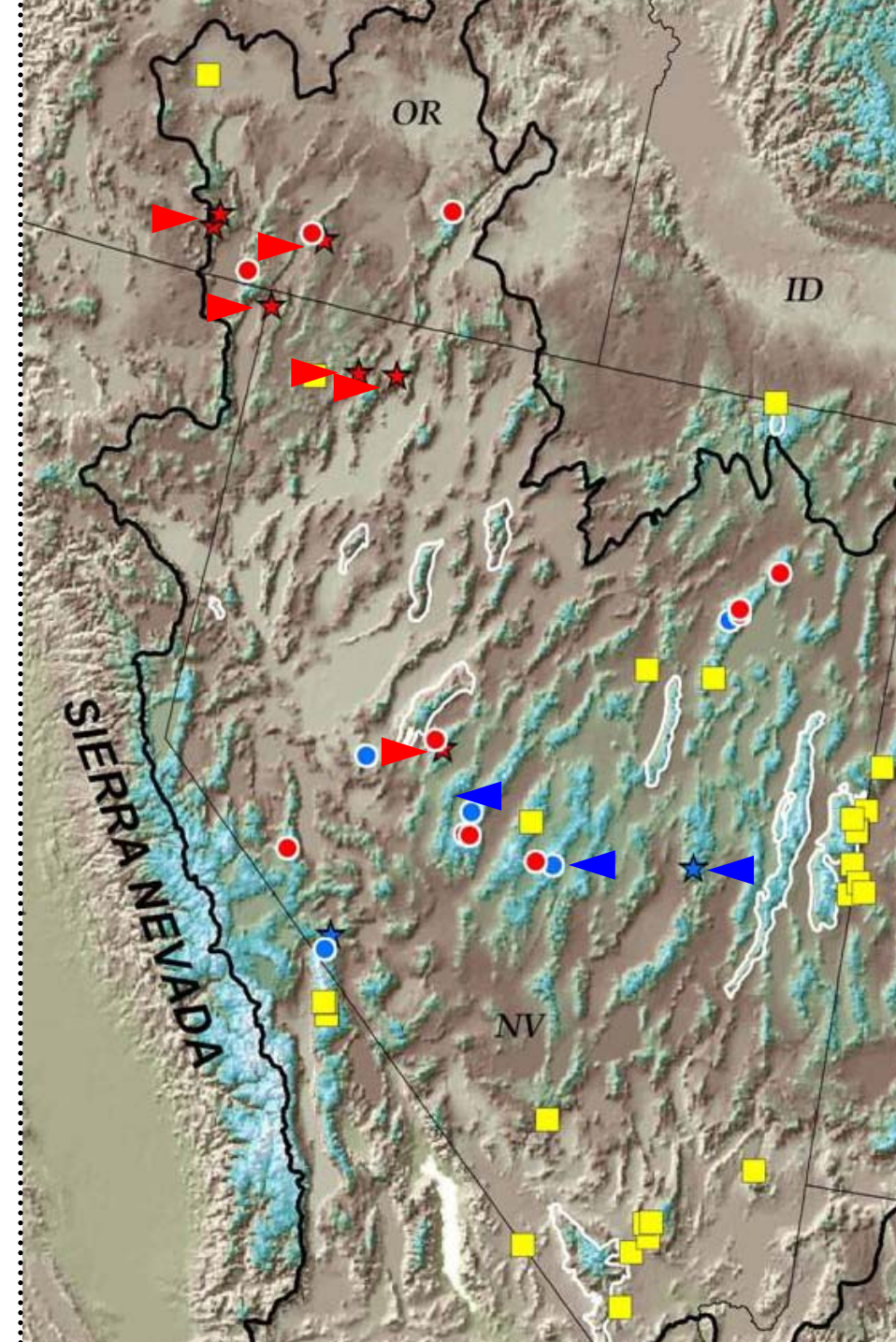
**post-hoc predictor*

Hindcasts





LT_{>28}, $\Delta_{>28}$, R_{>28}

LT _{μ S}, $\Delta_{\mu S}$, R _{μ S}

LT_{<-10}, $\Delta_{<-10}$, R_{<-10}

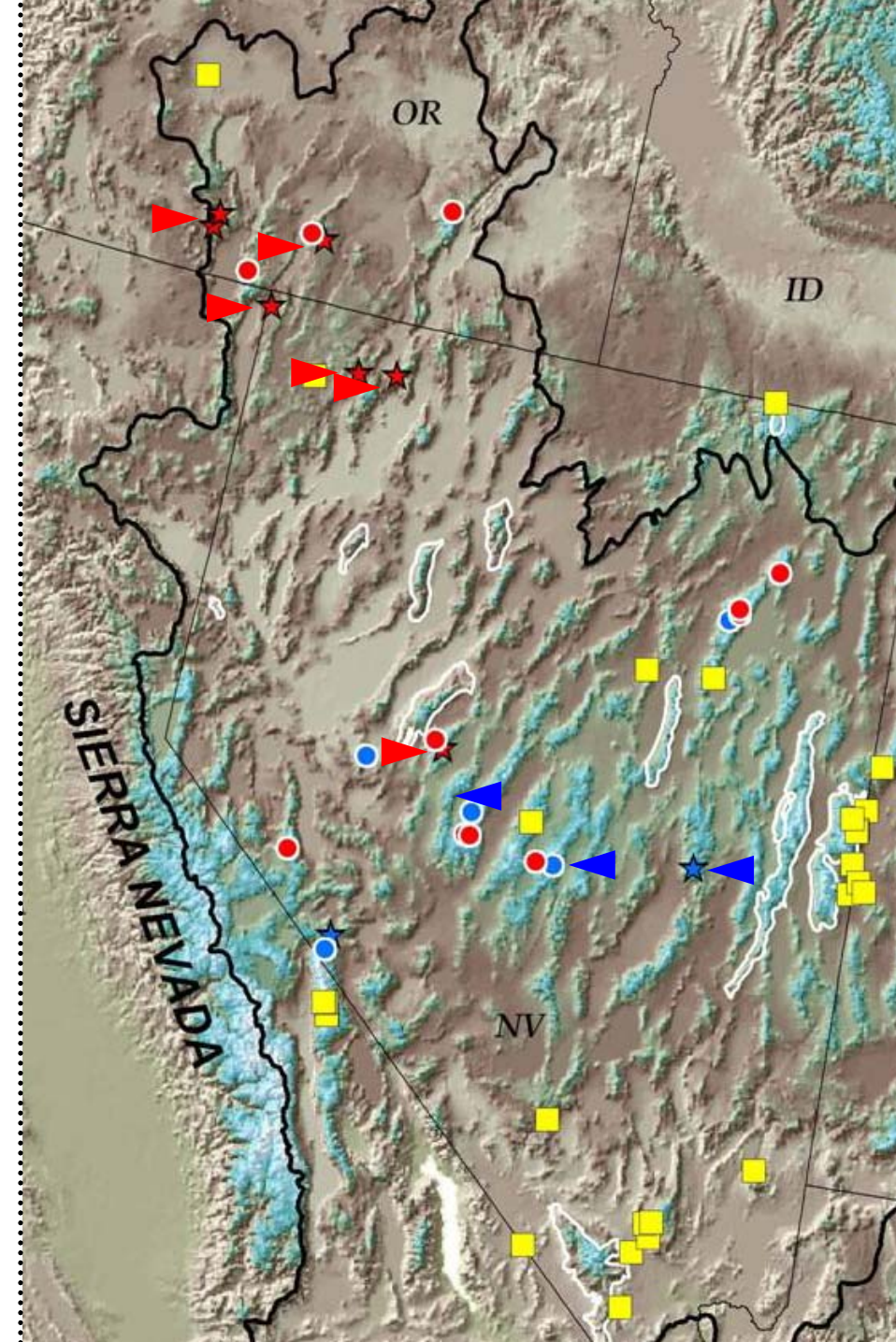


What predicts extinction? (Model updating, part 2)

Rank	 +  2007b	 +  2007c
1	LT _{<-10} , +	Habitat, -
2	R _{μS} , +	LT _{<-10} , +
3		Refuge, -
4		R _{μS} , +
5		Precip, -
6		Grazing, +

Evidence Ratio (w_0 / w_i)

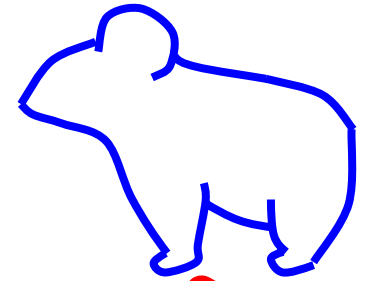
Rank	2007b	2007c
1	1.0*	1.0
2	1.0	1.1
3		1.4
4		1.8
5		3.0
6		3.4



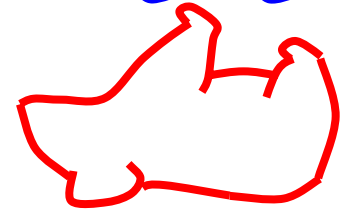
25 historical populations
 6 extinct by 1999 (▶)
 9 by 2007 (◀)

What predicts persistence?

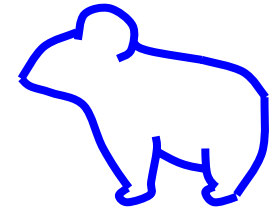
Amount of
 habitat



Acute
 cold stress
 (past 60 yrs)



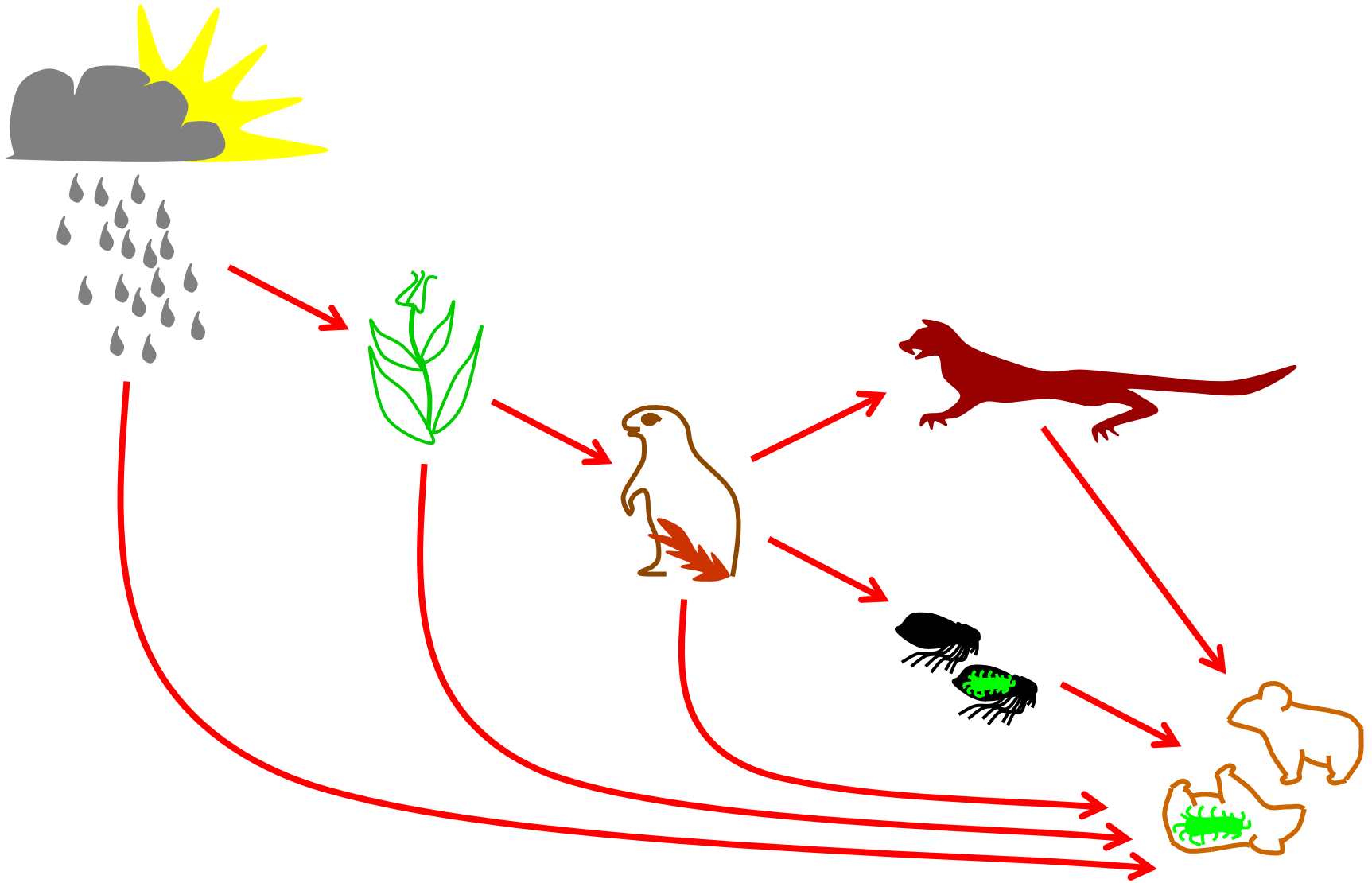
Elevational
 refuge



Chronic
 heat stress
 (recent)



How might climate cause extinction?



The end

chris.ray@colorado.edu