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science for a changing world

Understanding how ecological disturbance influences biological diversity: the rules aren’t what they used to be!

Erik A. Beever
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U.S. Department of the Interior
U.S. Geological Survey

Challenges and benefits of broad-scale management and conservation: lessons learned from programs across 50 years and 3 continents

Conservation Biology

Conservation Practice and Policy

Successes and Challenges from Formation to Implementation of Eleven Broad-Extent Conservation Programs

ERIK A. BEEVER,* BRADY J. MATTSSON,† †† MATTHEW J. GERMINO,‡
MAX POST VAN DER BURG,§ JOHN B. BRADFORD,¶ AND MARK W. BRUNSON**

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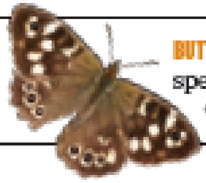
THIS WEEK

EDITORIALS

WORLD VIEW Not so fast, science is far from saved p.133



BUTTERFLIES British species flutter by earlier each year p.134

BARRIER GRIEF Australian floods could bring surge in coral-eating starfish p.136

Think big

The best way to manage national parks in the face of the effects of climate change is not to manage at the park level, but to work with landscapes. A new US initiative shows the way.

In 1882, the US conservationist George Bird Grinnell wrote about humans invading natural habitats as "the tide of immigration" that was then sweeping across the American West. "There is one spot left, a single rock about which this tide will break, and past which it will sweep, leaving it undefiled by the unsightly traces of civilization." That rock was Yellowstone National Park, then just ten years old.

Thanks in large part to the success of Yellowstone, this rocks-in-the-tide or 'protected area' model has been adopted worldwide. Yellowstone remains the archetype for the park as an island in space and time, walled-off from changes to the land around it. But any park scientist or manager will tell you that to freeze a park in time is an unattainable ideal. And for better or worse, parks cannot be completely isolated in space either. Yellowstone is surrounded by national forests, ranches, game refuges and other natural lands that are ten times the size of the park itself, as well as by the spawning tendrils of residential development. European spotted knapweed gets in and grizzly bears get out.

As the effects of global climate change begin to unspool, park managers at Yellowstone and around the world are deciding how to proceed, torn between their impulse to fight to keep ecosystems the way they are and a reluctance to fiddle with nature too much (see page 150).

Perhaps the best approach is for them to ponder instead the larger landscape in which their parks sit. Scaling up is reassuring. At the park level, climate change may extirpate a species. At the landscape level, climate change merely moves it. And scaling up is more effective. Ecologists and conservation biologists have known for decades that small isolated parks leak species. Smaller populations have smaller

all the different lands that the American antelope crosses on its way between summer and winter ranges in Wyoming. As the pronghorns make their way back and forth, the ungulates traipse across national forests, Bureau of Land Management gas fields, private cattle ranches and state-owned roads, where the department of transportation is this winter installing pronghorn-friendly underpasses. Coordinating all of those players is a massive job, one that was tackled in this case by the Wildlife Conservation Society, based in New York. But there is not the money to do for the whole of Earth what the society was able to do in Wyoming.

> *"It would be unforgivable to lose honeyeaters, antelopes, grizzlies and orchids."*

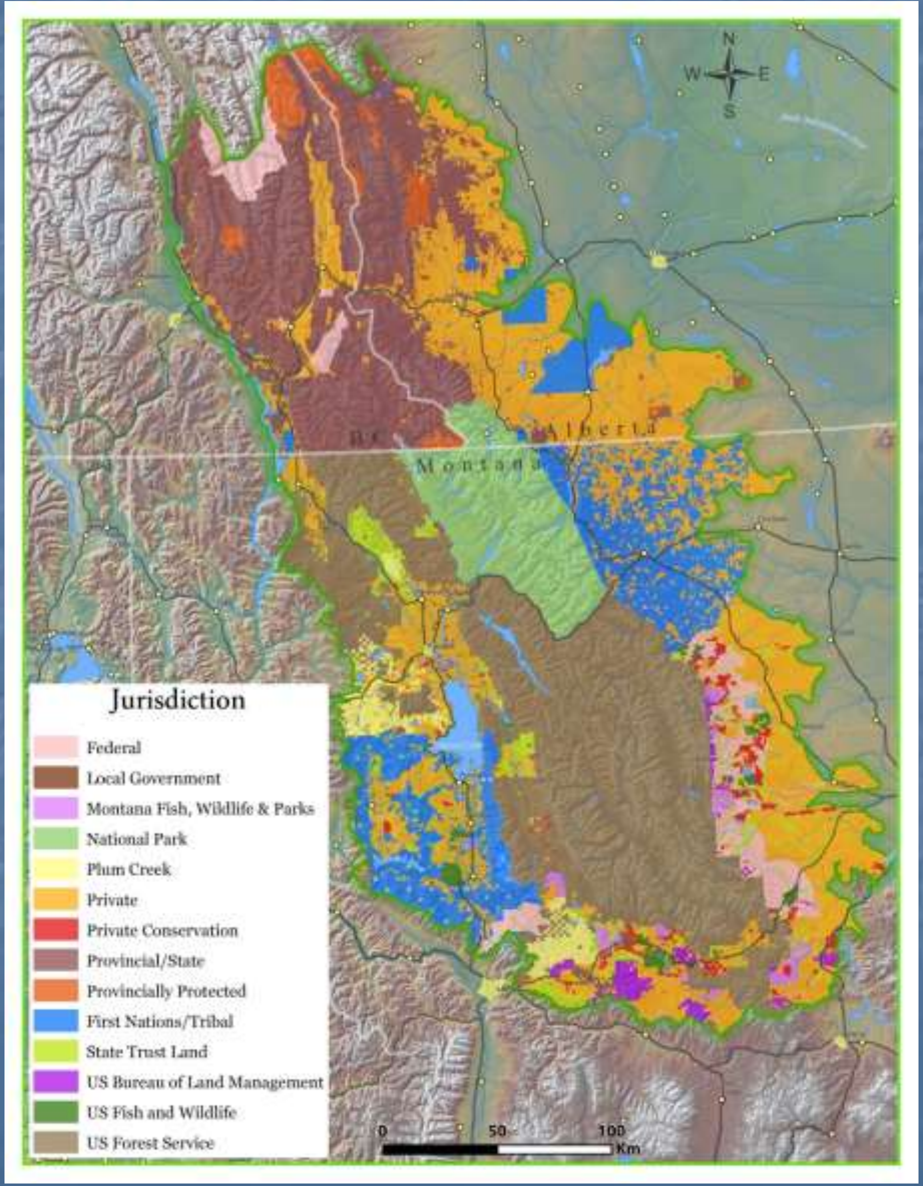
In February 2010, the US Department of Interior ordered all the land-management agencies it oversees to join with other federal, state and private land managers in 'landscape conservation cooperatives' to help to understand and respond to the effects of climate change. At a recent scientific meeting in Yellowstone, many scientists groaned at the prospect of yet another entity in the already crowded and confusing realm of conservation planning. But if these cooperatives are widely embraced, they could be a way to move beyond the truism that landscape-level conservation is needed, and start to do it.

It would be unforgivable to lose honeyeaters, antelopes, grizzlies and orchids, not because scientists didn't know how to save them, but because they were mired in bureaucratic mud. ■

***Nature*, editorial (2011)**

Why think BIG (broad-scale)?

- **Context is *everything***



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Why think BIG (broad-scale)?

- Context is *everything*

- **Threats are far-reaching, widespread**
  - **Desertification, invasive spp., airborne contaminants**

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Why think BIG (broad-scale)?

- Context is *everything*
- **Threats are far-reaching, widespread**
  - **Desertification, invasive spp., airborne contaminants**
- **Migratory & large-area spp., riparian areas**

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Why think BIG (broad-scale)?

- Ecosystems & services best conserved by broad-scale I&M, mgmt.

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Why think BIG (broad-scale)?

- Ecosystems & services best conserved by broad-scale I&M, mgmt
- **Species' ranges shifting**

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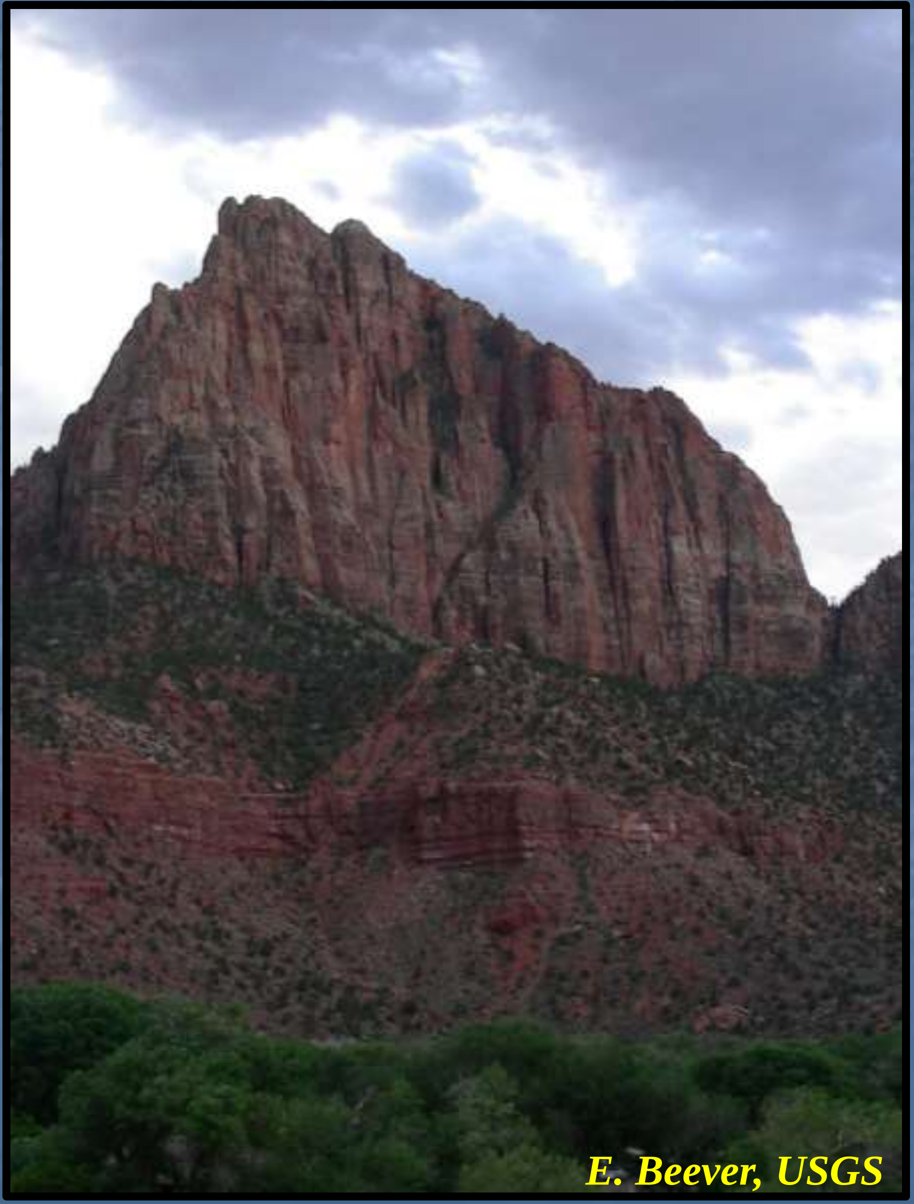
Why think BIG (broad-scale)?

- Ecosystems & services best conserved by broad-scale I&M, mgmt
- Species' ranges shifting
- Given limited resources and complex problems, effectiveness requires cost-sharing, leveraging, and collaboration



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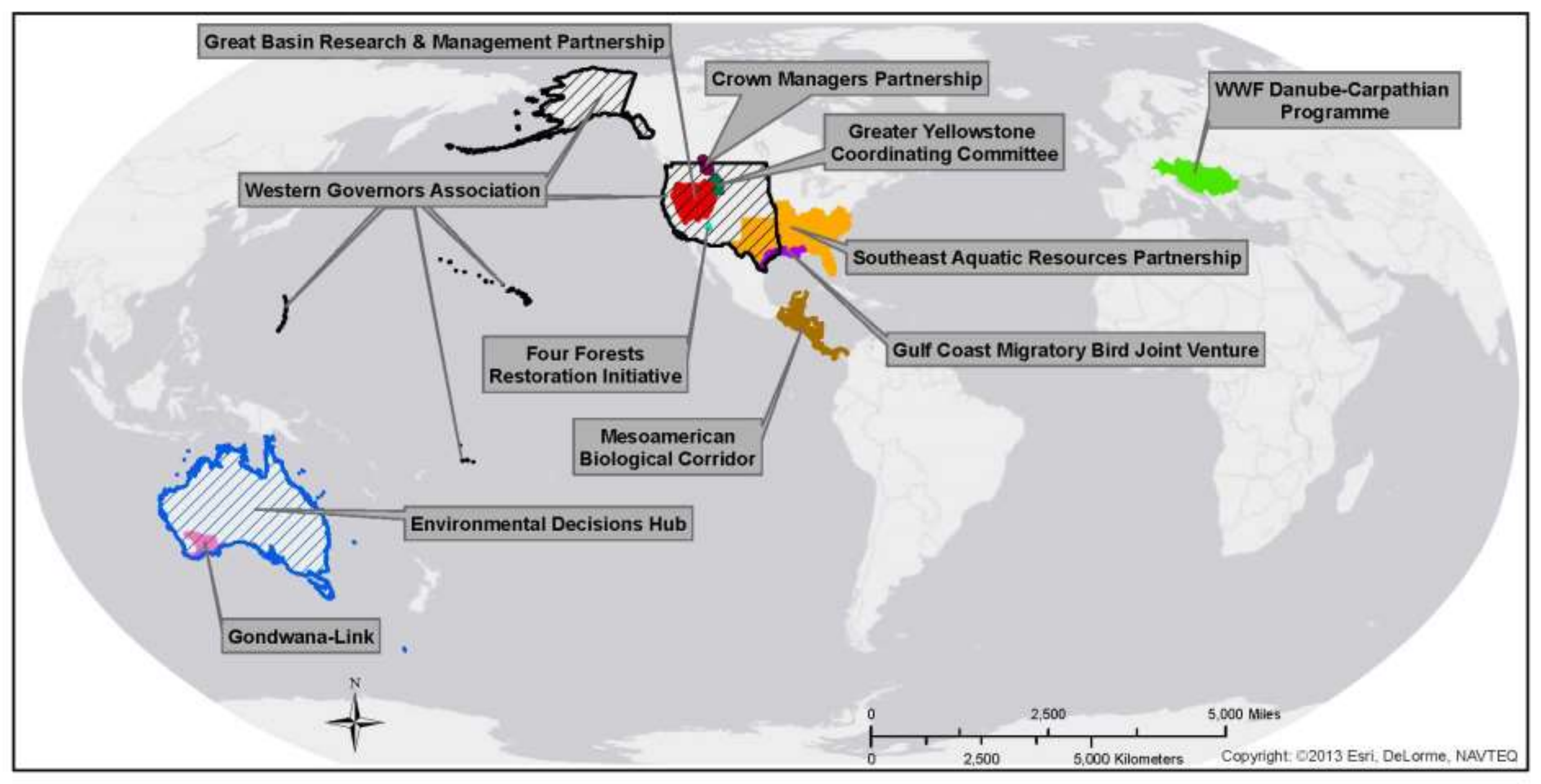
Criteria for program inclusion:

- **Conservation of multiple spp. or whole ecosystems**
- **Explicitly consider human benefits and reflect principles of ecosystem management**
- **Have systems with common dynamics, due to shared resources, drivers, phenomena ($\leq$ continent)**
- **Ties to land-mgmt decisions, cons. practitioners, both**

Criteria for program inclusion:

- Span jurisdictional, political, & watershed boundaries



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Attributes of 11 focal programs

- 29 countries, on 3 continents
- 9,712 – 7,692,024 km^2 in extent
- Coordinated by heads of state; First Nations; federal, state, & provincial agencies; univ.'s; private landowners

Attributes of 11 focal programs

- 29 countries, on 3 continents
- 9,712 – 7,692,024 km^2 in extent
- Coordinated by heads of state; First Nations; federal, state, & provincial agencies; univ.'s; private landowners
- **Started 1964-2011; MBC ended 2006, rest continue to Pres.**
- **Annual budget $27K - $16M; 0 to >100 of staff/program**
- **Diverse: education, policy components; objectives; stakeholders; trigger/funding; 1º decision-makers**

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Questionnaire (*n* = 17 Qs)

<u>Overarching Q</u>: What are the challenges and successes of broad-scale conservation partnerships?

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6 steps in broad-scale cons. partnerships

- **launching and maintaining the partnership**

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6 steps in broad-scale cons. partnerships

- launching and maintaining the partnership
- **developing management objectives**

6 steps in broad-scale cons. partnerships

- launching and maintaining the partnership
- developing management objectives
- **identifying management actions**

6 steps in broad-scale cons. partnerships

- launching and maintaining the partnership
- developing management objectives
- identifying management actions
- deciding which actions to take to accomplish objectives

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6 steps in broad-scale cons. partnerships

- .
- .
- .
- .
- **implementing actions**

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6 steps in broad-scale cons. partnerships

- launching and maintaining the partnership
- developing management objectives
- identifying management actions
- deciding which actions to take to accomplish objectives
- implementing actions
- **learning, adaptive mgmt, and filling information gaps**

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Relative costs of broad-scale approaches

- More expensive, tougher logistics
- Common elements are fewer, more generic
- Require more compromises to achieve agreement
- Less experimental control
  - Greater natural variability
  - Distributional controls may vary across the domain

Reported *challenges* of broad-scale cons.

- **Identifying focal areas of emphasis**

n = 41 different ones identified

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Reported *challenges* of broad-scale cons.

- Identifying focal areas of emphasis

n = 41 different ones identified

- **Differing data-storage platforms & methods; proprietary**

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n = 41 different ones identified

- Identifying focal areas of emphasis
- Differing data-storage platforms & methods; proprietary
- **Biggest drivers of outcomes are not controllable by cons.**

Reported *challenges* of broad-scale cons.

n = 41 different ones identified

- Identifying focal areas of emphasis
- Differing data-storage platforms & methods; proprietary
- Biggest drivers of outcomes are not controllable by cons.
- **Challenging to id. which activities best done regionally vs. locally**

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Reported *challenges* of broad-scale cons.

n = 41 different ones identified

- Identifying focal areas of emphasis
- Differing data-storage platforms & methods; proprietary
- Biggest drivers of outcomes are not controllable by cons.
- Challenging to id. which activities best done regionally vs. locally
- **Challenge of integrating regulatory mechanisms**

Reported *challenges* of broad-scale cons.

n = 41 different ones identified

ethods; proprietary

ntrollable by cons.

t done regionally vs.

echanisms

- **The sheer # of contemporary efforts is overwhelming**

Reported *challenges* of broad-scale cons.[2]

- **Disbelief that this 'fad' will last**

n = 41 different ones identified

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Reported *challenges* of broad-scale cons.[2]

n = 41 different ones identified

- Disbelief that this 'fad' will last
- **Trust is difficult to establish & keep**

Reported *challenges* of broad-scale cons.[2]

n = 41 different ones identified

- Disbelief that this 'fad' will last
- Trust is difficult to establish & keep
- **Difficult to find objectives that link to partner actions**

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Reported *challenges* of broad-scale cons.[2]

n = 41 different ones identified

- Disbelief that this ‘fad’ will last
- Trust is difficult to establish & keep
- Difficult to find objectives that link to partner actions
- **Hard to define and say how it’s additive to local efforts**

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Reported *challenges* of broad-scale cons.[2]

n = 41 different ones identified

- Disbelief that this 'fad' will last
- Trust is difficult to establish & keep
- Difficult to find objectives that link to partner actions
- Hard to define and say how it's additive to local efforts
- **Different: communication lexicons, data storage, regulatory mechanisms, planning schedules, laws, constituencies**

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Reported *challenges* of broad-scale cons.[2]

n = 41 different ones identified

...o partner actions

...tive to local efforts

...ta storage, regulatory
...vs, constituencies

- How do we <u>monitor</u> effectiveness of lg.-scale actions?

Reported *benefits* of broad-scale cons.

n = 26 different ones identified

- Generates revenue, political will
- Provides richer context for finer-scaled efforts
- Has achieved policy shifts, positive legislation, commitments
- Advanced the science of corridor dynamics, implement'n
- Focuses attn. on highest-priority issues, locations; no pets
- Provides leveraging of expertise, resources; established structure, networks facilitate rapid dissemination

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Reported *benefits* of broad-scale cons. [2]

- **Increases likelihood of sustainability**

n = 26 different ones identified


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Reported *benefits* of broad-scale cons. [2]

n = 26 different ones identified

- Increases likelihood of sustainability
- **Beginning to build portfolio of successful projects**

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Reported *benefits* of broad-scale cons. [2]

n = 26 different ones identified

- Increases likelihood of sustainability
- Beginning to build portfolio of successful projects
- **Greater efficiencies and cost-effectiveness**

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Reported *benefits* of broad-scale cons. [2]


E. Beever, USGS

n = 26 different ones identified

- I [illegible] ity
- I [illegible] cessful projects
- C [illegible] tiveness
- **Awareness of broad contexts informs local decisions**

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Reported *benefits* of broad-scale cons. [2]

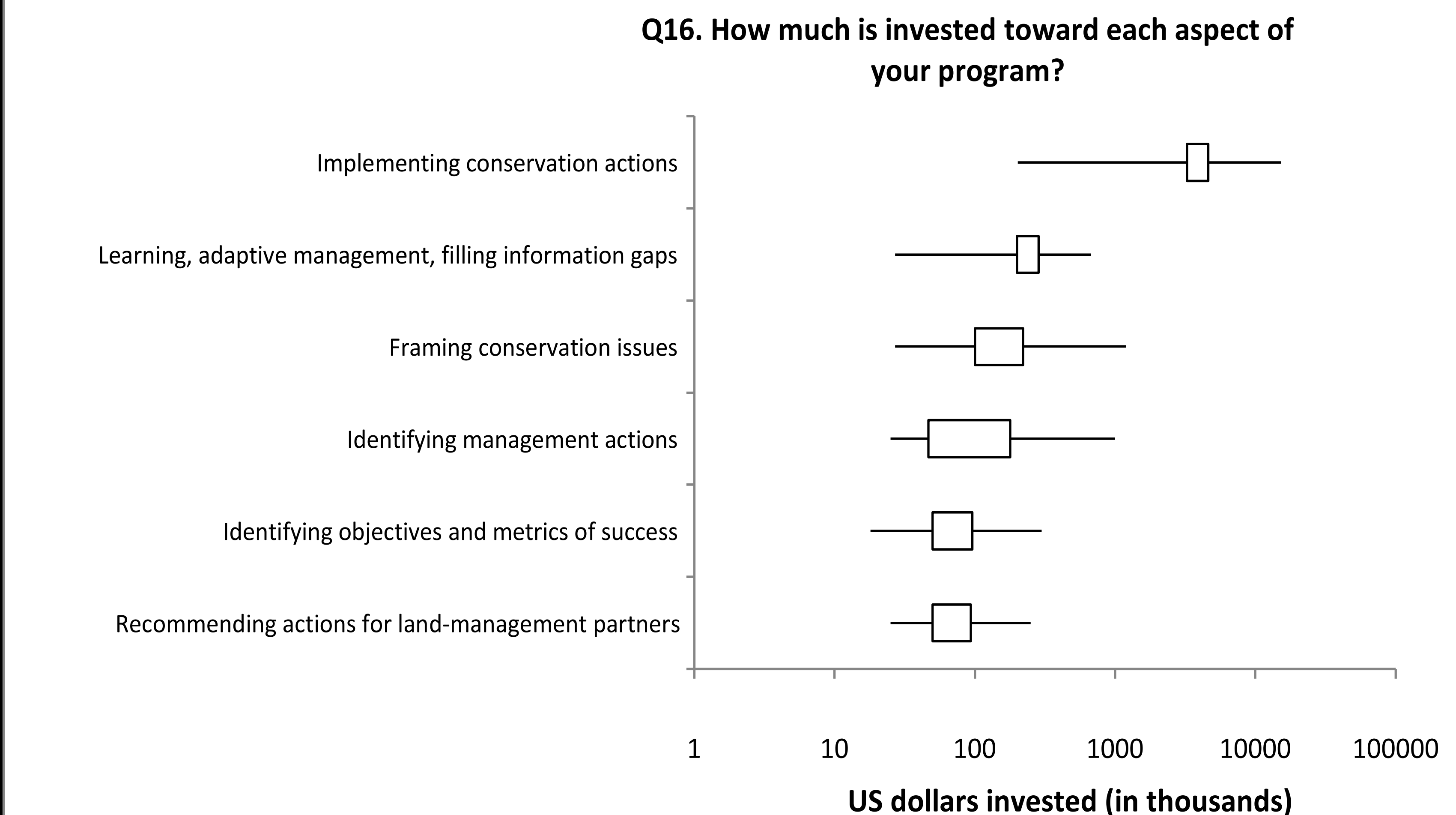

E. Beever, USGS

n = 26 different ones identified

- stainability
- lio of successful projects
- ost-effectiveness
- xts informs local decisions
- **It's possible to leave 'hats' at door to achieve consensus**

Results from particular questions

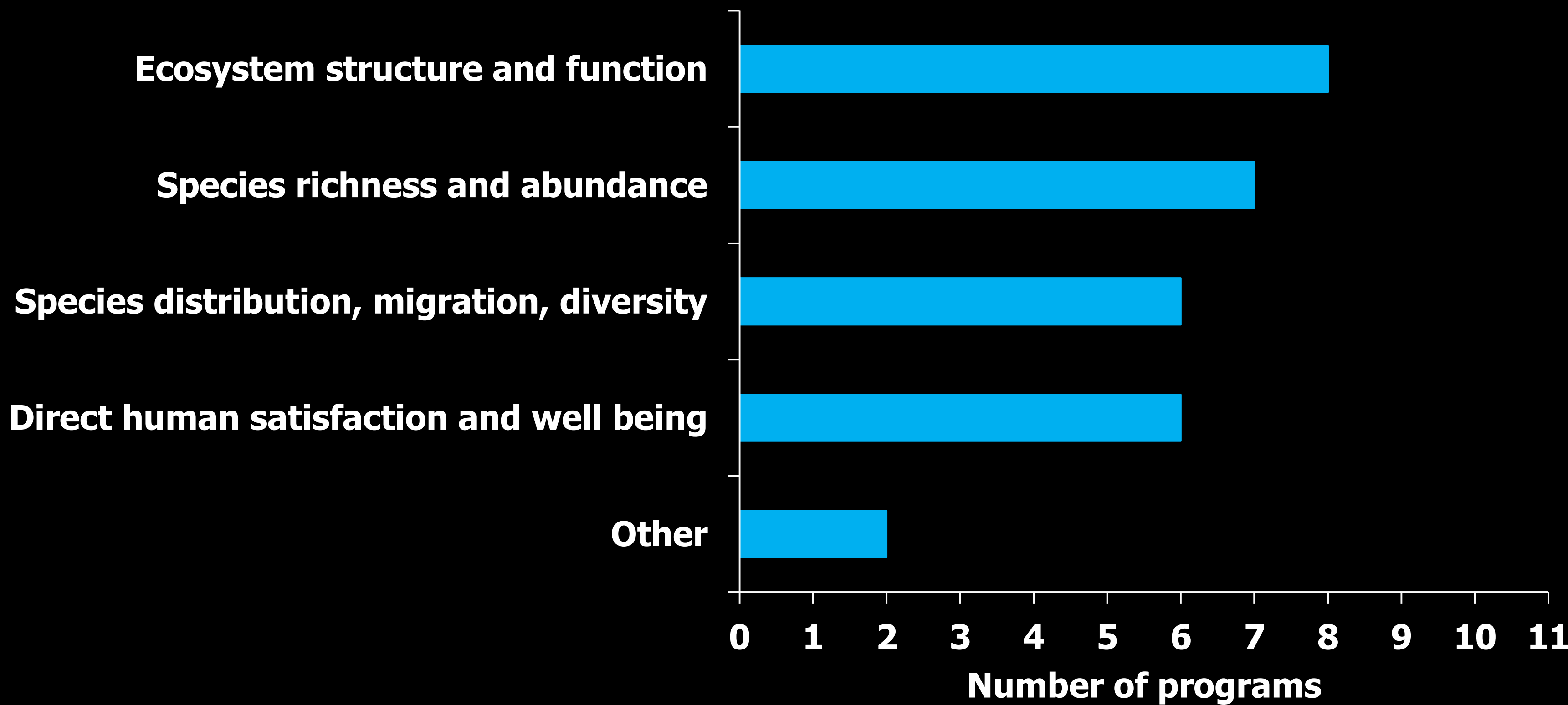
from Beever et al. 2014



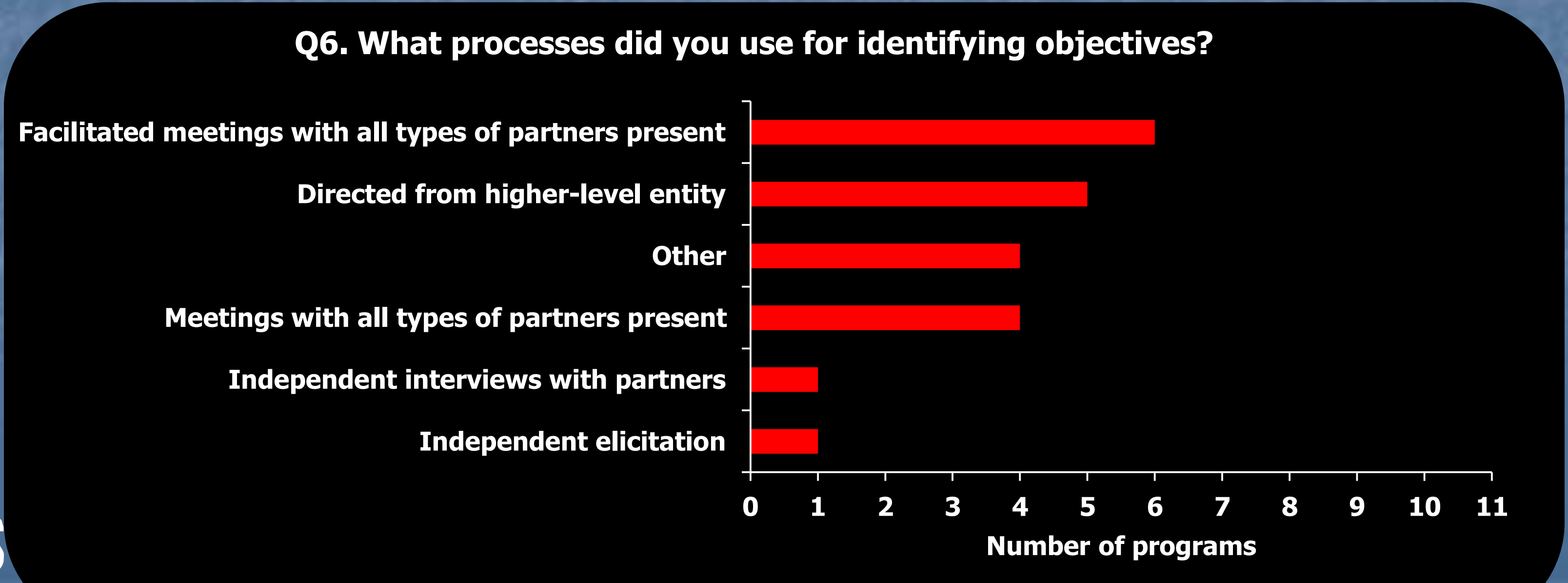
Results from particular questions

from Beever et al. 2014

Q3. What are the main components of the management objectives?



Results from particular questions



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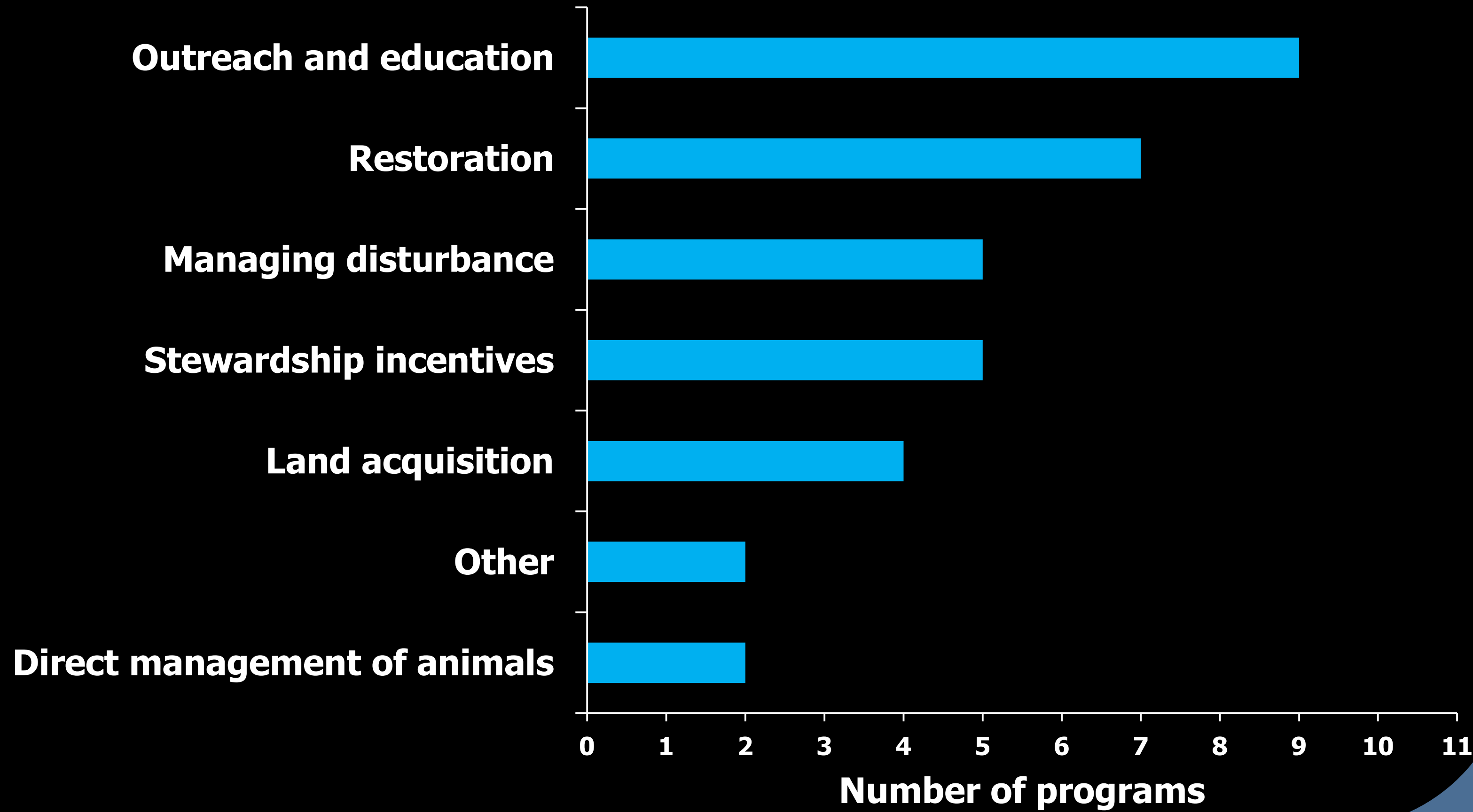
Results from particular questions

from Beever et al. 2014

Q8. Which on-the-ground actions are used to attain objectives?



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Results from particular questions

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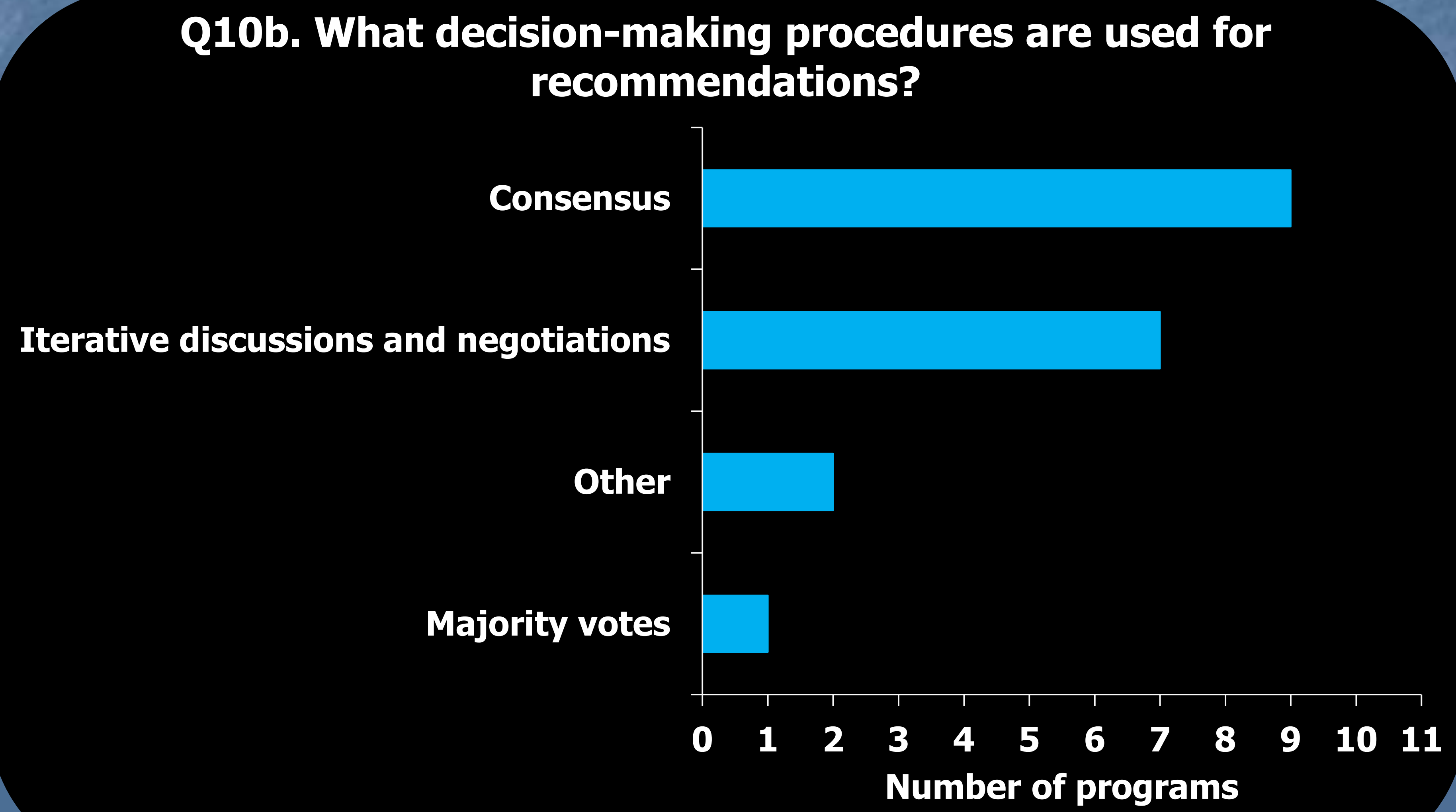

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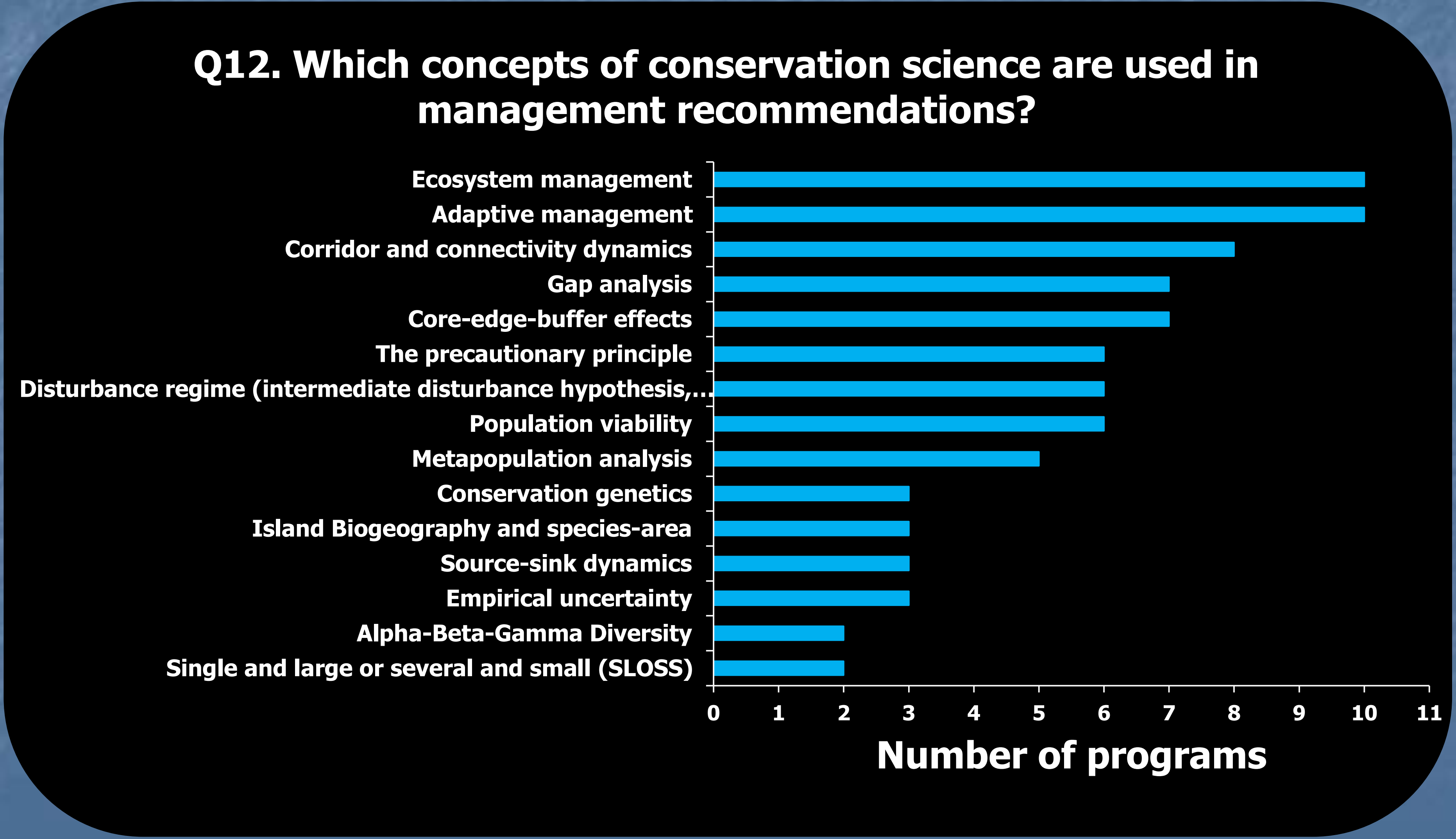

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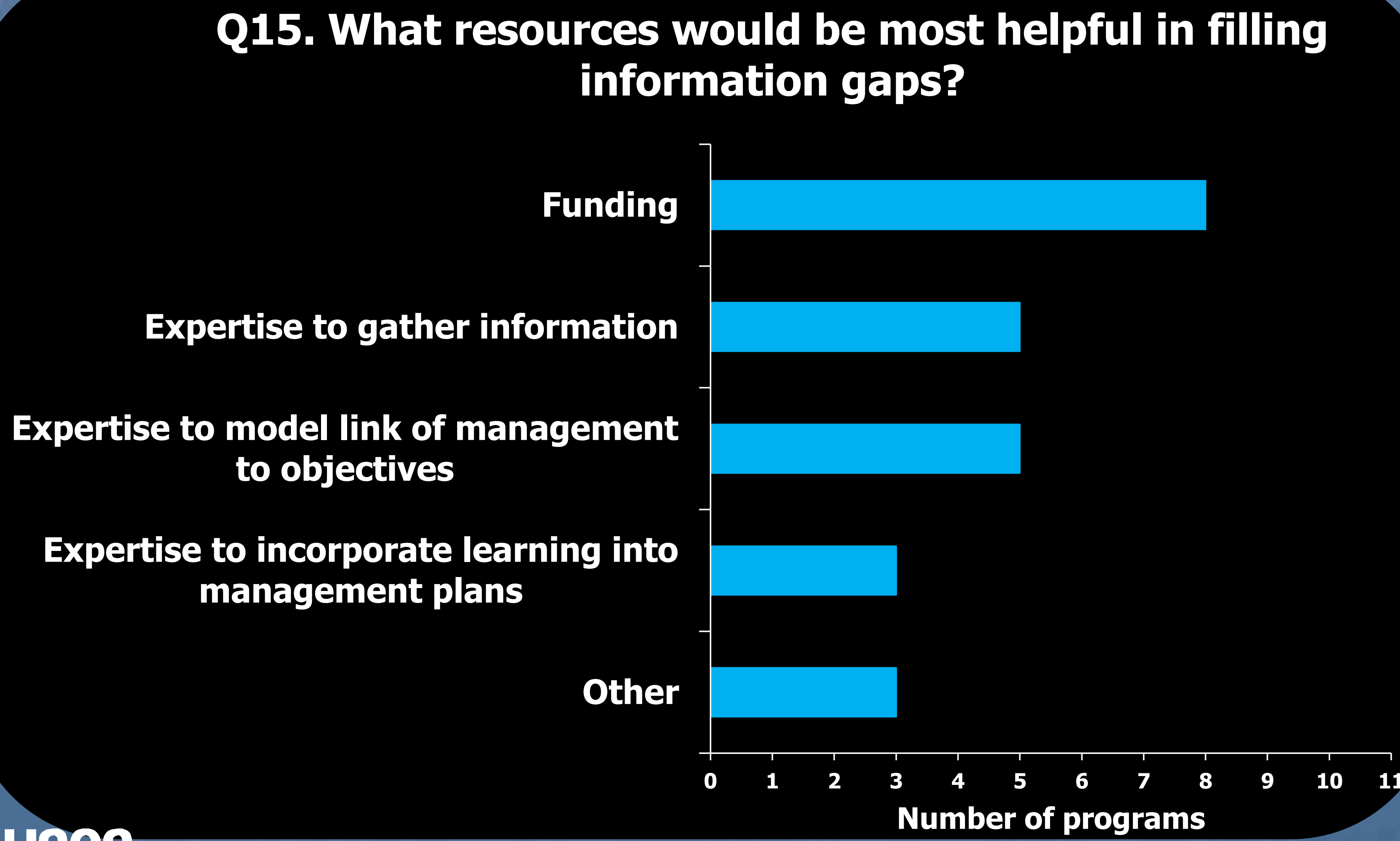

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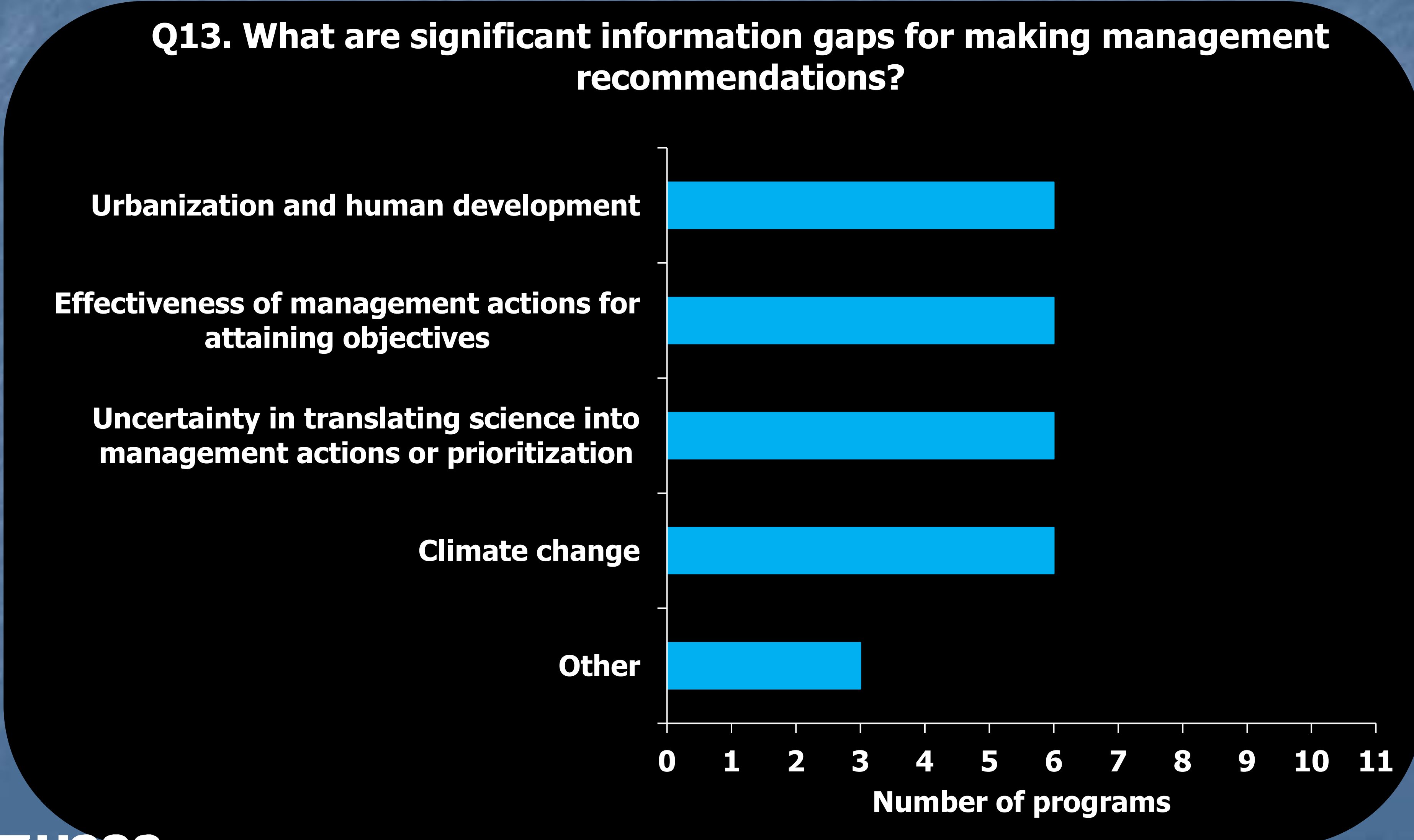

The broader view: take-home messages

- Broad-scale efforts face numerous, diverse challenges, but successes have been diverse, too
- Inverse relationship between areal extent, costs
- Differences in U.S. vs. other, developed vs. developing nations, terrestrial vs. aquatic programs
- Local-scale efforts both affect, and are affected by, broader-scale dynamics
- Success required diverse expertise: economics, sociology, policy, ecologies, mgmt, research

An old story: climate shapes mammal distribution

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PROCEEDINGS OF THE ROYAL SOCIETY B

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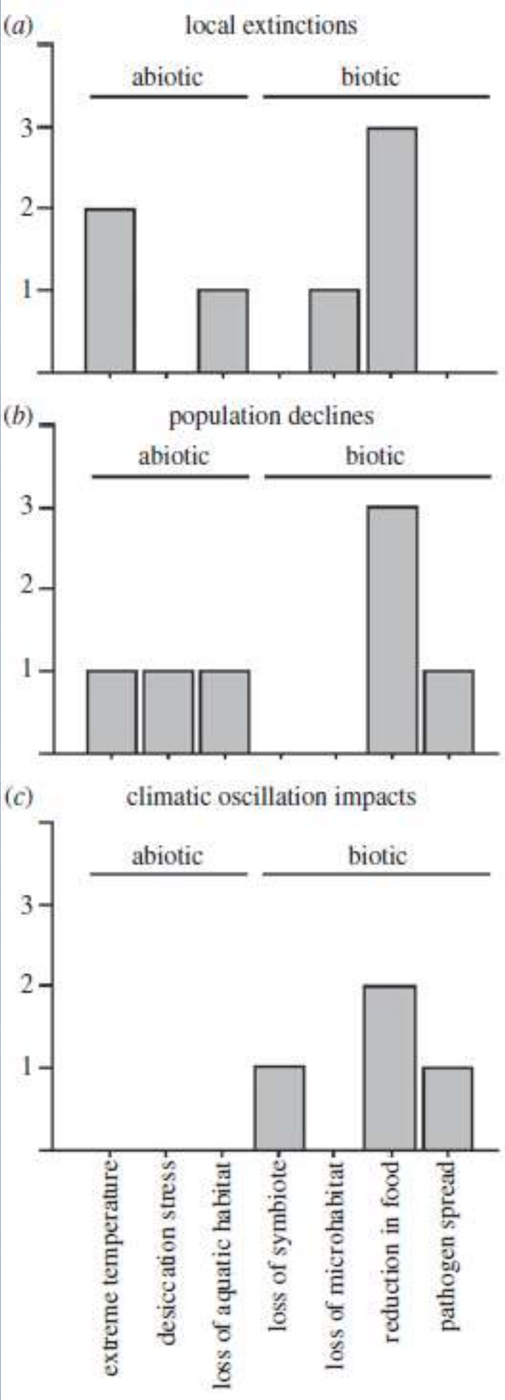
How does climate change cause extinction?

Abigail E. Cahill[†], Matthew E. Aiello-Lammens[†], M. Caitlin Fisher-Reid, Xia Hua, Caitlin J. Karanewsky, Hae Yeong Ryu, Gena C. Sbeglia, Fabrizio Spagnolo, John B. Waldron, Omar Warsi and John J. Wiens

- Extinctions and declines rarely effected through direct stress



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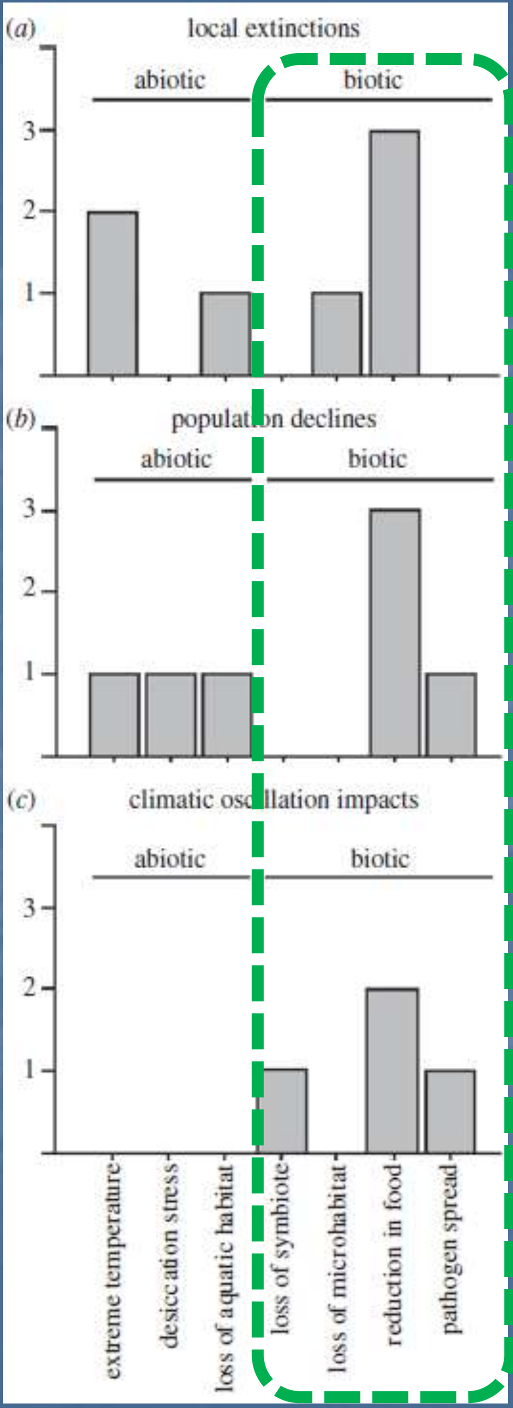
- Extinctions and declines rarely effected through direct stress
- Instead, *indirectly*, via species interactions, food supplies, habitat loss, pathogens



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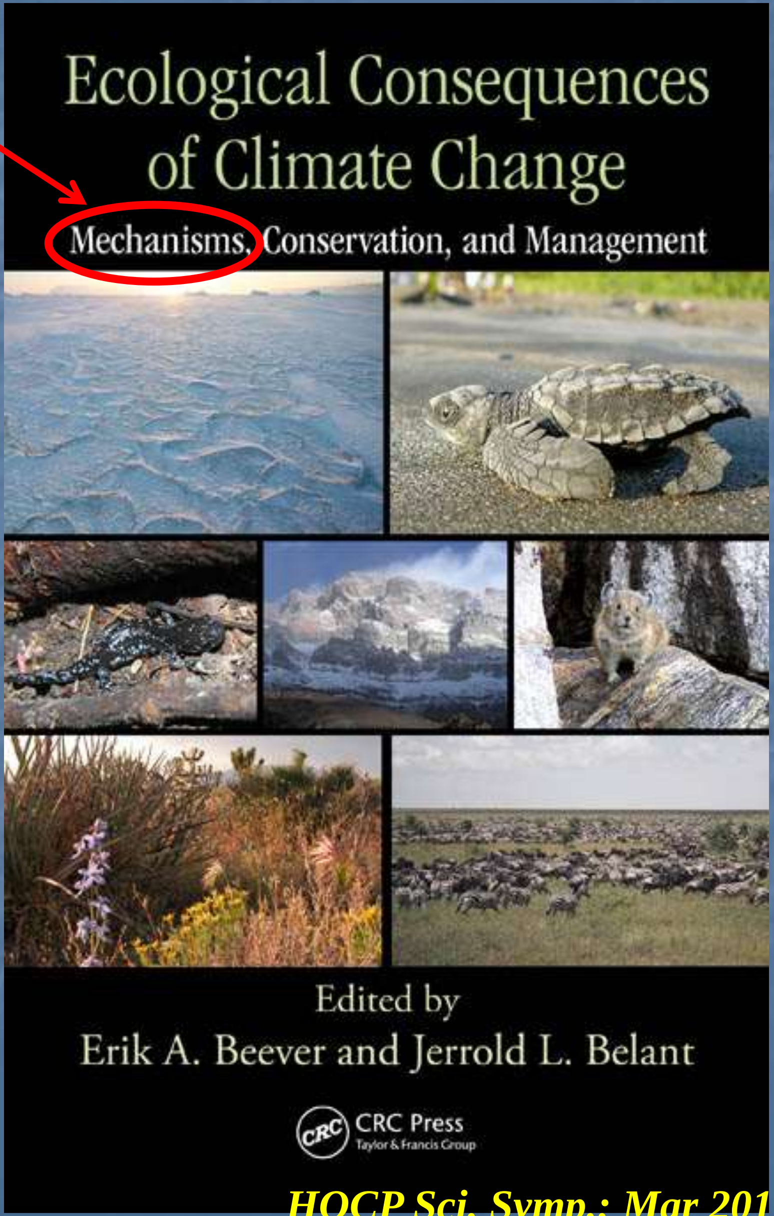
Mechanisms are *very* important !

Why and *how* …

- **Essential for adaptation, mitigation, management, and conservation strategies**



Potential mechanisms of CC on montane spp.

- Food abundance or quality
- Habitat fragmentation
- Disease, pests, parasites
- Competitors, predators
- Physical conditions (snow cover, streamflow, RH, precip)
- Exceeding (narrow) physiological tolerances

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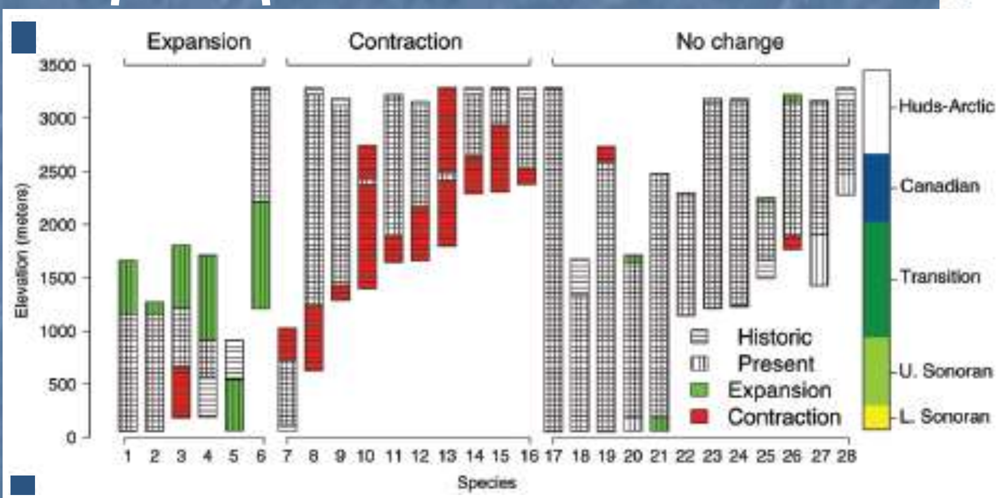
Species shift differently

- **Grinnell re-survey, YOSE**

Moritz et al. 2008



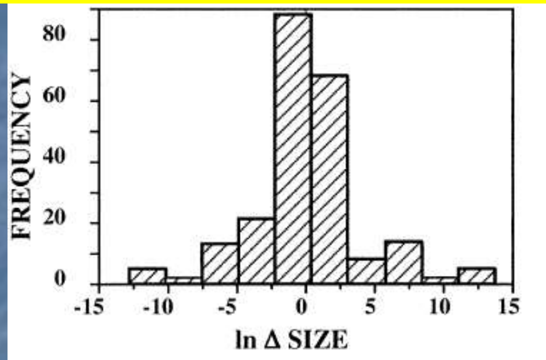
No.	Species	P(G)	P(C)	Original elevation range (m)	Range limit change (m)	
					Range expansions	
1	*Microtus californicus*	0.81	0.58	57–1160	+505 U	Elev
2	*Reithrodontomys megalotis*	0.99	0.87	57–1160	+112 U	Elev
3	*Peromyscus truei**	0.99	0.93	183–1220	**+589 U, +468 L**	Era*
4	*Chaetodippus californicus*	0.28	0.19	193–914	**+800 U**	Era*
5	*Sorex ornatus*	0.32	0.93	549–914	**−485 L**	Era
6	*Sorex monticolus*	0.99	0.97	2212–3287	**−1003 L**	Era
					Range contractions	
7	*Dipodomys heermanni*	0.16	0.98	57–1025	+63 L, **−293 U**	Era*
8	*Microtus longicaudus*	0.99	0.98	623–3287	**+614 L**	Era
9	*Zapus princeps*	0.98	0.90	1291–3185	+159 L, −64 U	Era
10	*Tamias senex*	0.95	0.71	1402–2743	+1007 L, −334 U	Elev
11	*Spermophilus lateralis*	0.70	0.89	1646–3200	**+244 L**	Era*
12	*Sorex palustris*	0.39	0.23	1658–3155	**+512 L**	Era
	*Neotoma cinerea**	0.90	0.71	1798–3287	**+609 L, −719 U**	Era*
	*Spermophilus beldingi**	0.98	0.98	2286–3287	+355 L	Elev
	Tamias alpinus	0.92	0.95	2307–3353	**+629 L**	Era
	Ochotona princeps[†]	NA	NA	2377–3871	+153 L	NA
					No change	
	*Peromyscus maniculatus**	0.99	0.99	57–3287	No change	Era*
	Thomomys bottae[†]	NA	NA	57–1676	No change	NA
	Spermophilus beecheyi	0.50	0.82	61–2734	−250 U	Era*
	Neotoma macrotis	0.90	0.91	183–1646	+67 U	Elev
	Peromyscus boylii	0.98	0.97	183–2469	−122 L	Elev
	Sorex trowbridgii	0.71	0.88	1160–2286	No change	Elev
	*Microtus montanus**	0.81	0.98	1217–3155	No change	Elev
	*Tamiasciurus douglasi**[†]	NA	NA	1229–3185	No change	NA
25	*Tamias quadrimaculatus*	0.95	0.85	1494–2210	+50 U	Era*
26	*Tamias speciosus**	1.00	1.00	1768–3155	+128 L, +65 U	Era*
27	*Thomomys monticola*[†]	NA	NA	1905–3155	No change	NA
28	*Marmota flaviventris*[†]	NA	NA	2469–3353	No change	NA

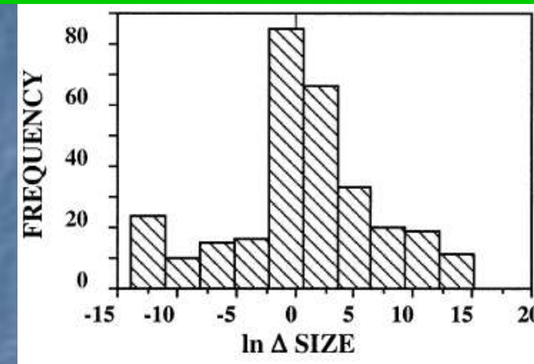
Species have shifted differently …

Lyons 2003, *J. Mammal.*

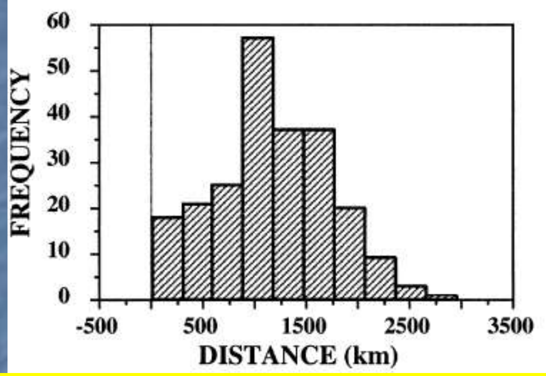
- **During paleo times, too … wildlife also shifted, diversely**

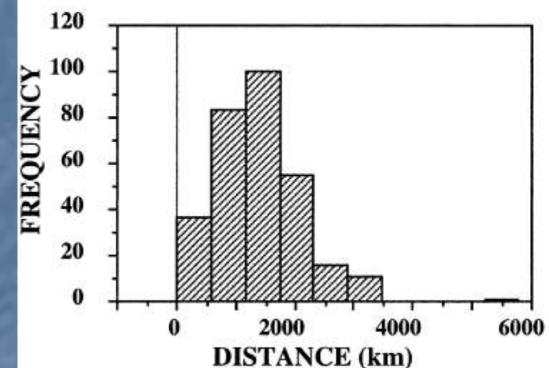
Change in size of geographic range





Distance of range shift of centroid

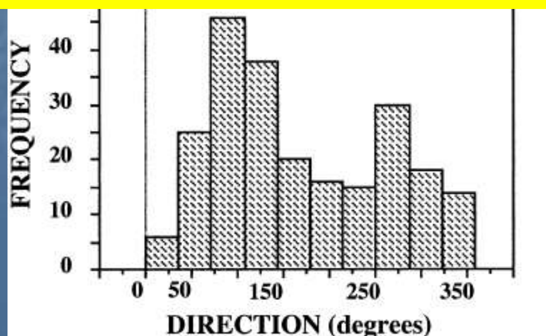


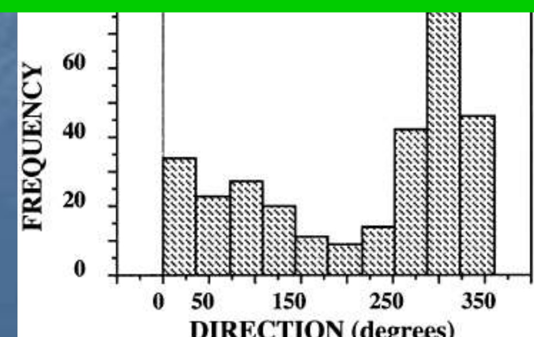


Pre-Glacial to Glacial

Glacial to Holocene

Azimuth of range shift of centroid





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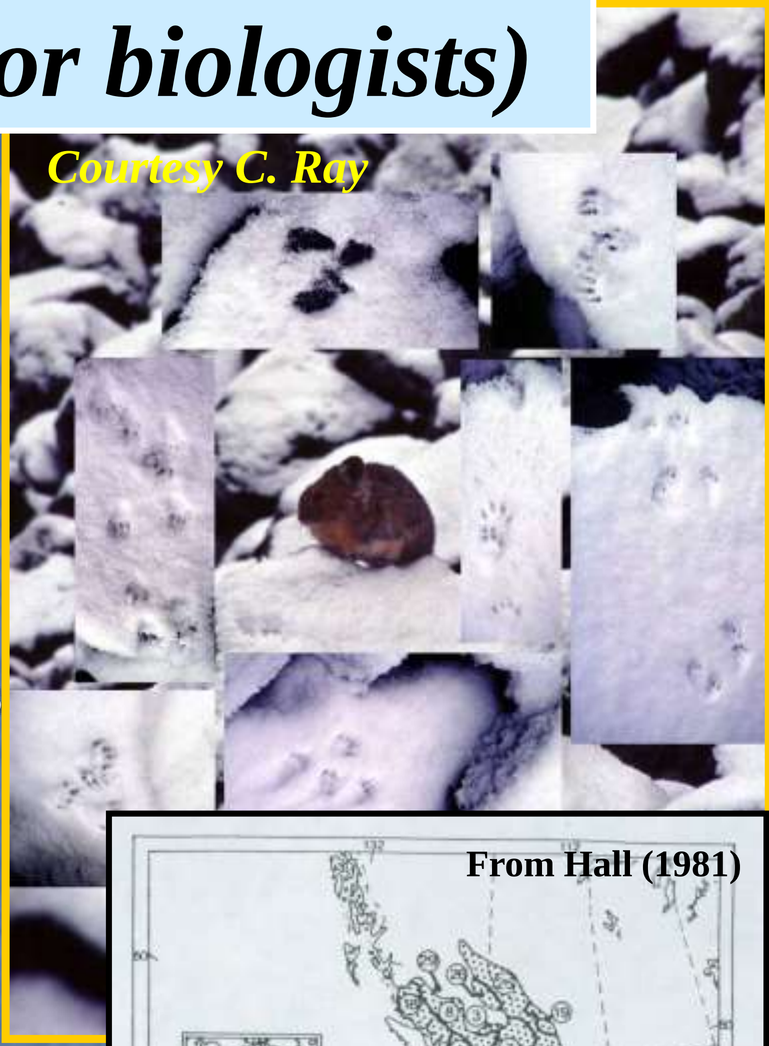
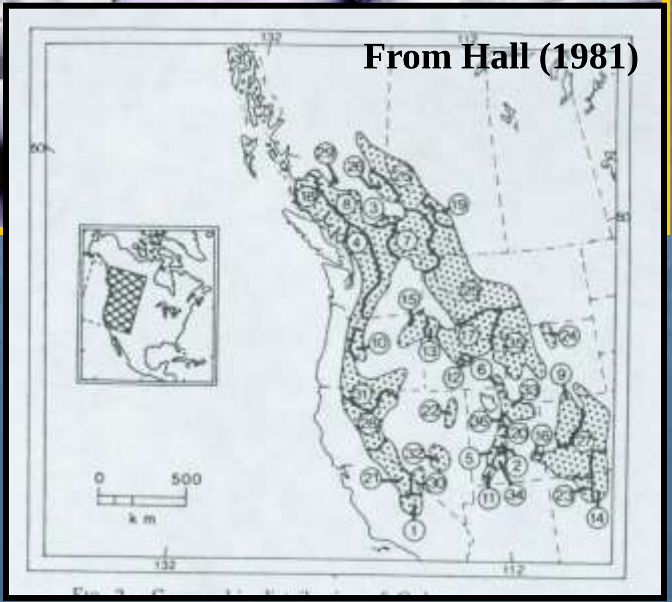
Why pikas are cool (for biologists)

- **Coprophagous**
- **Territorial**
- **Many types of calls (7)**
- **Active year-round**
- **Habitat-specialist: only talus-like areas**
- **Don't move very far ⟹ radiation**
- **Cheetah-like**





Ochotona princeps evidences

Sighting

E. Beever

Call (AKA 'vocalization')

Active haypile, sighting

E. Beever

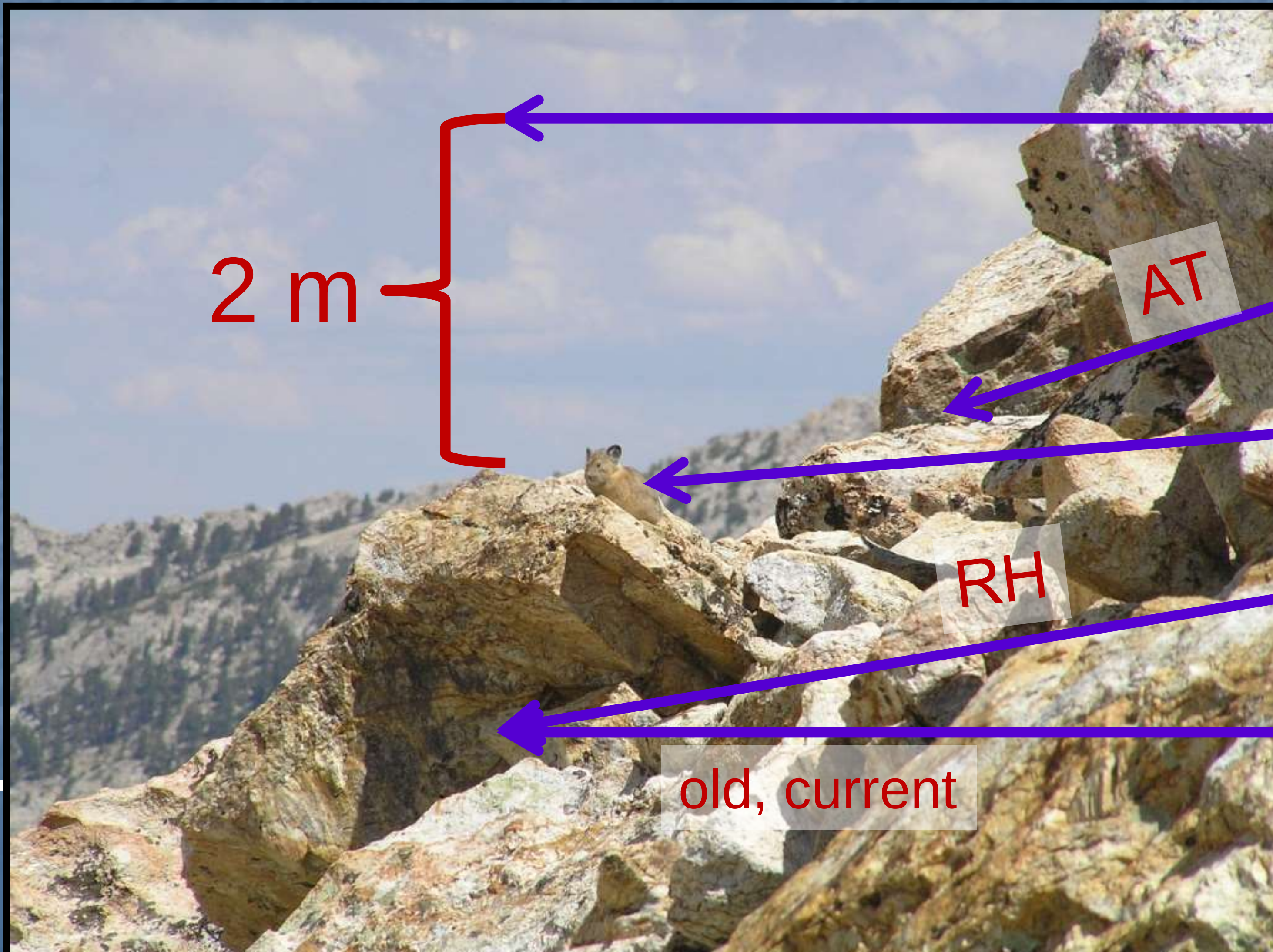
USGS

Ochotona princeps **old** evidences

All images
E. Beever

Testing effects of microclimate

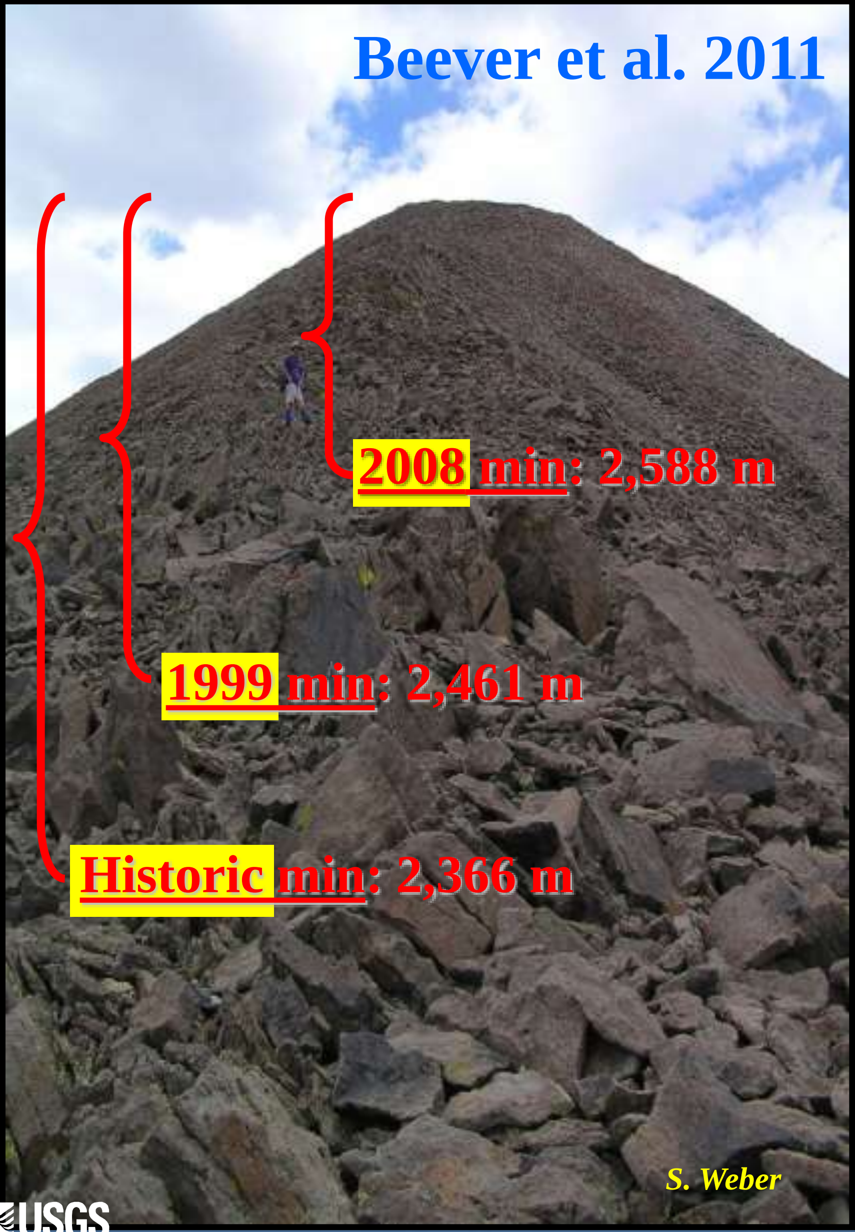
- **# of microclimate sensors, Basin-wide**



N =
23
14
8
30
196

271

Anatomy of a decline: *upslope migrations*



- **Minimum elevation of detections, Historic to my first (1990s) sampling: 13.2 m per decade**
- **Minimum elev. of detections, 1st to 2nd sampling: 145.1 m per decade**
  - **Parmesan & Yohe (2003) meta-an.: 6.1 m / decade**
  - **Chen et al. (2011) meta-analysis: 11.0 m / decade**

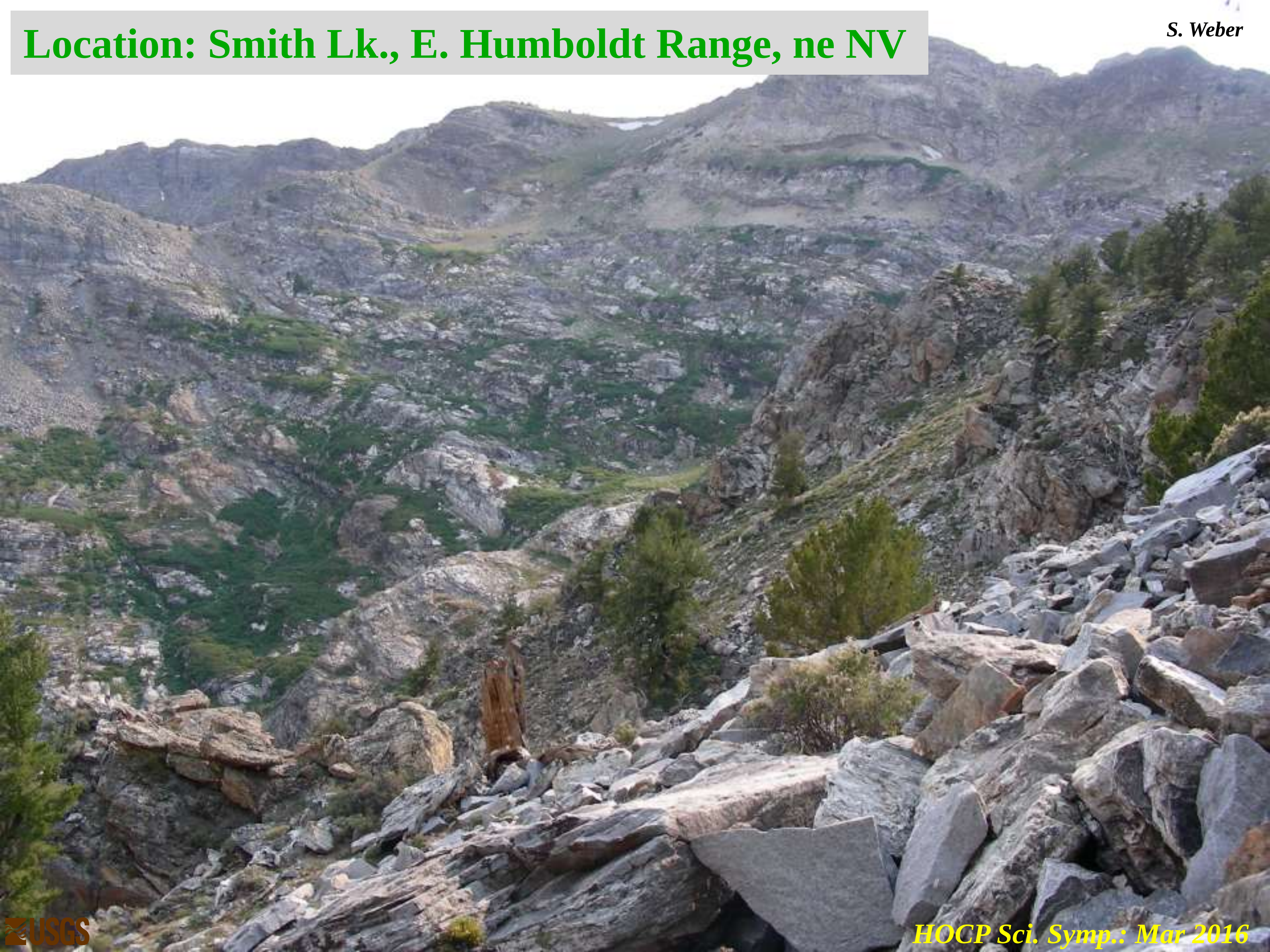
Three Lks. (Lamoille Cnyn), Ruby Mtns., ne NV (classic pika habitat)

S. Weber

Swager Cnyn, Sweetwater Mtns., Sierra NV

S. Weber

Location: Smith Lk., E. Humboldt Range, ne NV



S. Weber

Long Cnyn, Ruby Mtns., ne NV

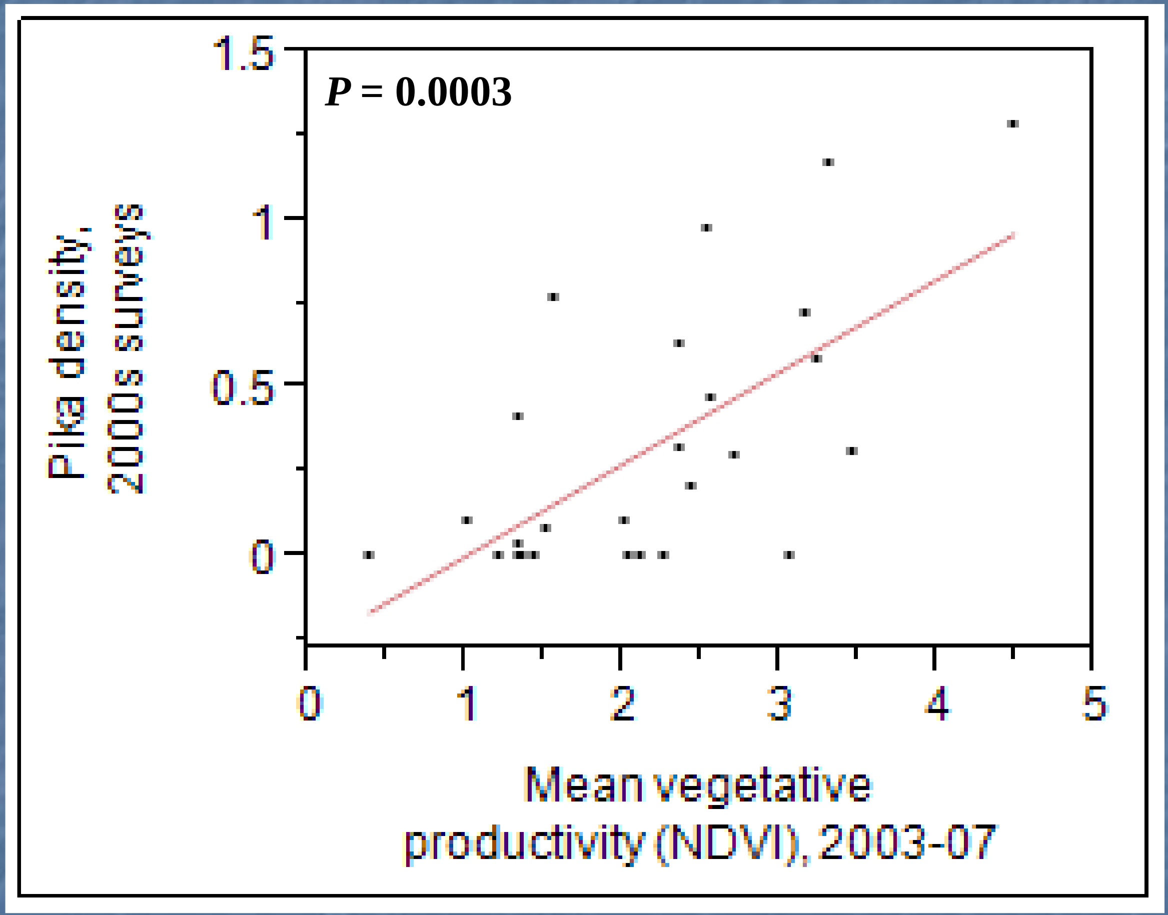
S. Weber


Pinchot Crk., White Mtns., NV-CA border
S. Weber
USGS
HOCP Sci. Symp.: Mar 2016


Greenmonster Cnyn., Monitor Range, central NV
Photo: S. Weber
USGS
HOCP Sci. Symp.: Mar 2016

Insights from density …

- Greenness (NDVI) strongly predicted pika density in 2000s surveys



Ecology, 94(7), 2013, pp. 1563–1571

Understanding relationships among abundance, extirpation, and climate at ecoregional scales

Erik A. Beever,[1,2,6] S. Z. Dobrowski,[3] J. Long,[4] A. R. Mynsberge,[3] and N. B. Piekielek[5]

USGS

The rules are changing…

Multiple working hypotheses (Chamberlin 1965)

- Biogeography
- Climate
- Direct anthropogenic

	'20th Century' (historic to 1999)	'Recent' (1999 to 2009)
Residual of Maximum elevation of local habitat on latitude		
Predictor variable (listed in order of decreasing weight per model	RngHab	***MaxElevR***
	MaxElevR	**AugMaxT**
	DistRd	RngHab
	GrzPre99	GrzPost99
	AugMaxT	DistRd
Sites correctly classified*	22/25	18/19
Average of |(weighted P[occ] – occupancy status)|†	0.185	0.169

Global Change Biology

Global Change Biology (2011), doi: 10.1111/j.1365-2486.2010.02389.x

Contemporary climate change alters the pace and drivers of extinction

ERIK A. BEEVER*†, CHRIS RAY‡, JENIFER L. WILKENING‡§, PETER F. BRUSSARD* and PHILIP W. MOTE¶

The rules are changing…

Multiple working hypotheses (Chamberlin 1965)

1990s abundance	2000s abundance
Grazed?	Precipitation
Pika-equivalent elev.	Grazing intensity
Precipitation	Pika-equivalent elev.
Grazing intensity	Amount of habitat
Amount of habitat	Grazed?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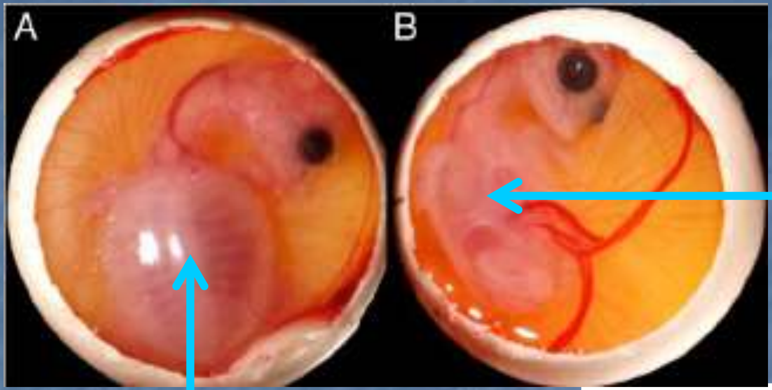
Species vulnerability to climate change

Species vulnerability to climate change

In the face of environmental change & variability …

- **Evolve in their physiological tolerances**

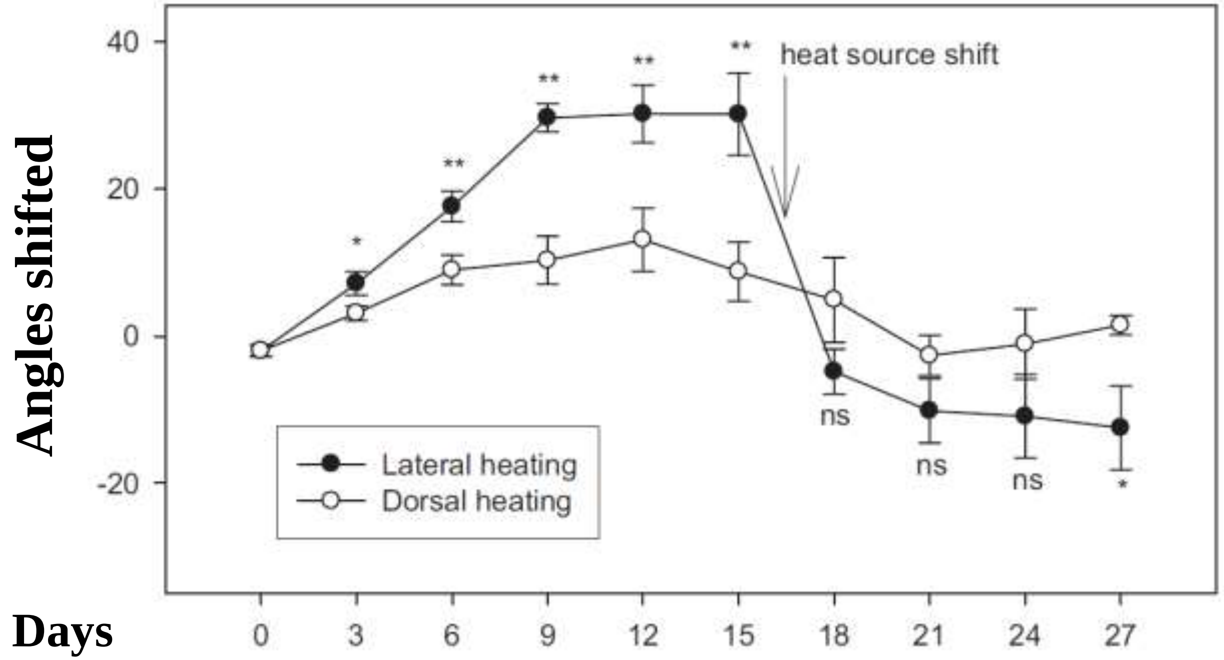
In the face of environmental change & variability …



Heat source is at left side

Heat source is above

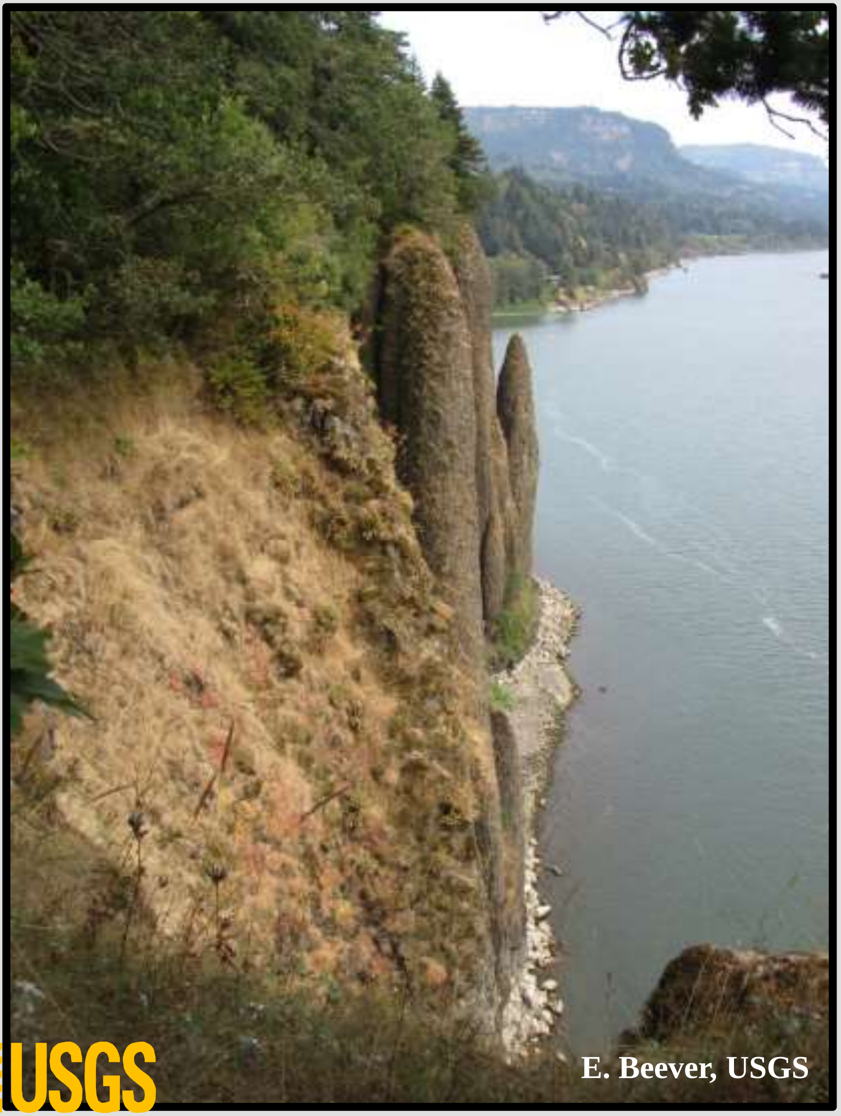
Du et al. 2011



- **Exhibit behavioral flexibility**

The Columbia R. Gorge: Microcosm of gradients

- Steep, slippery area → census of patches along trails, roads



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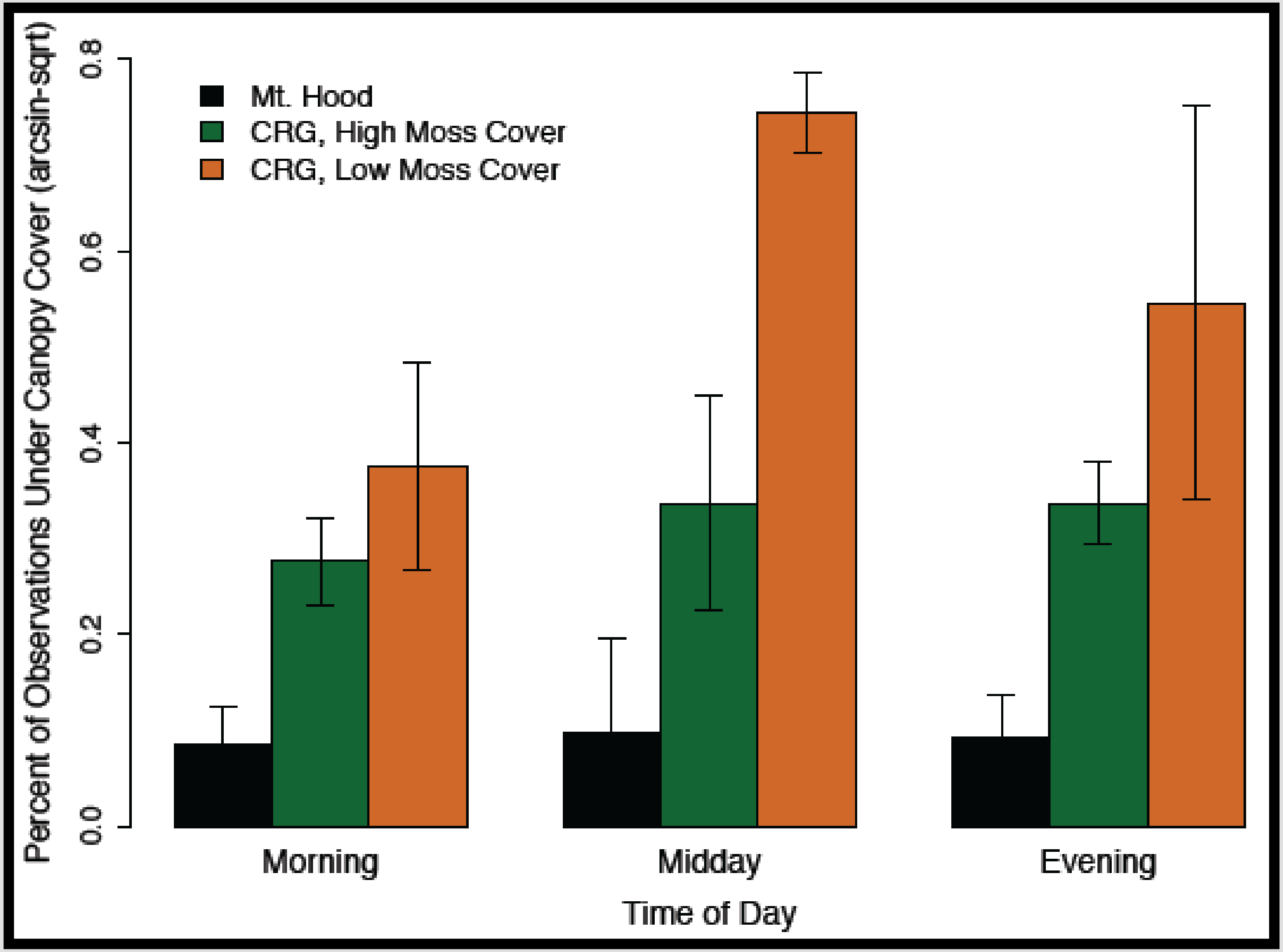
Behavioral plasticity softening boundaries

- Pikas' use of adjacent forest reflects temp, elev, time, date

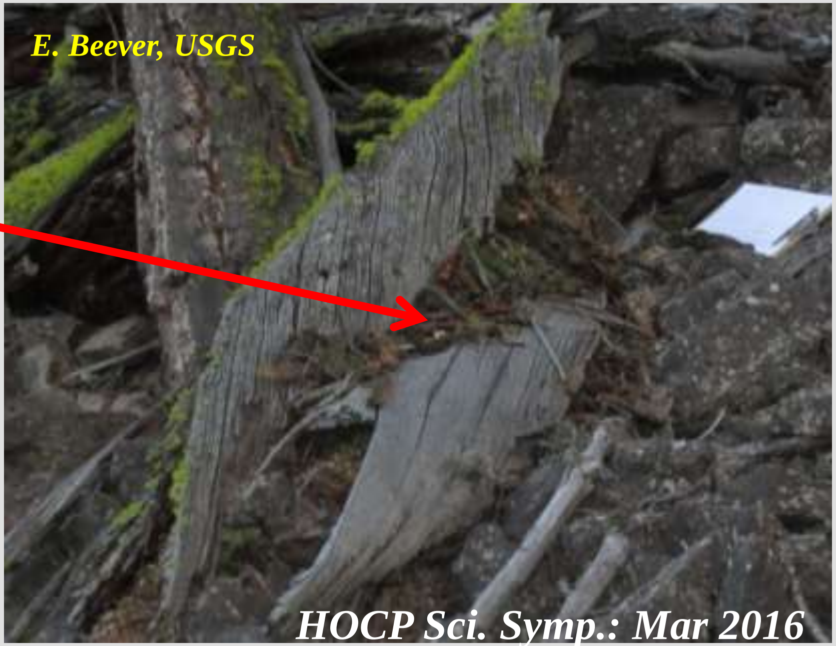
From Varner et al. 2016



USGS

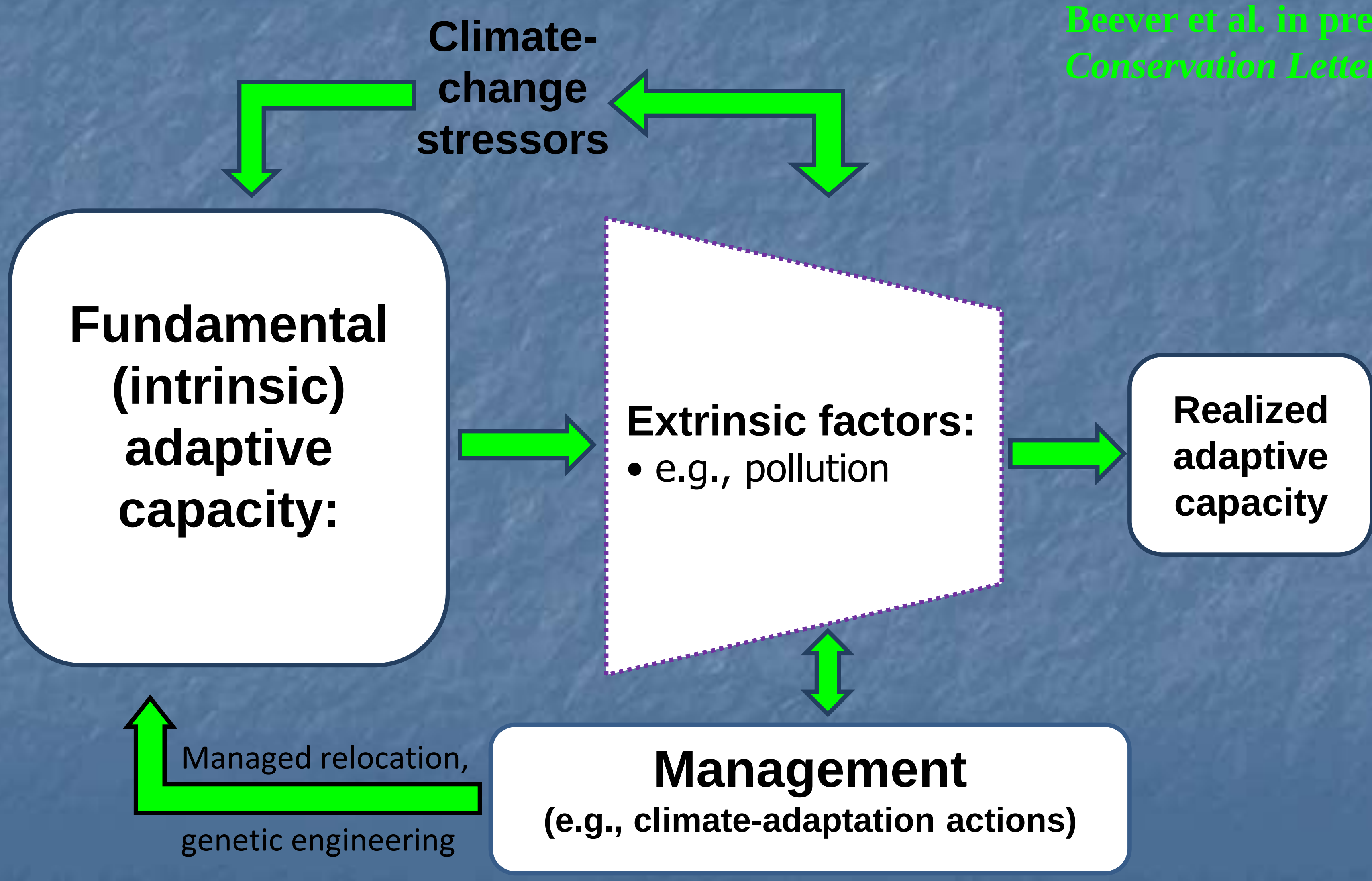
Behavioral flexibility softening boundaries

- Haypiles in unexpected locations
  - under tree branches
  - lakesides, below high-water level
  - standing-dead trees
  - slash piles
  - river riprap
  - in downed logs
- High occupancy



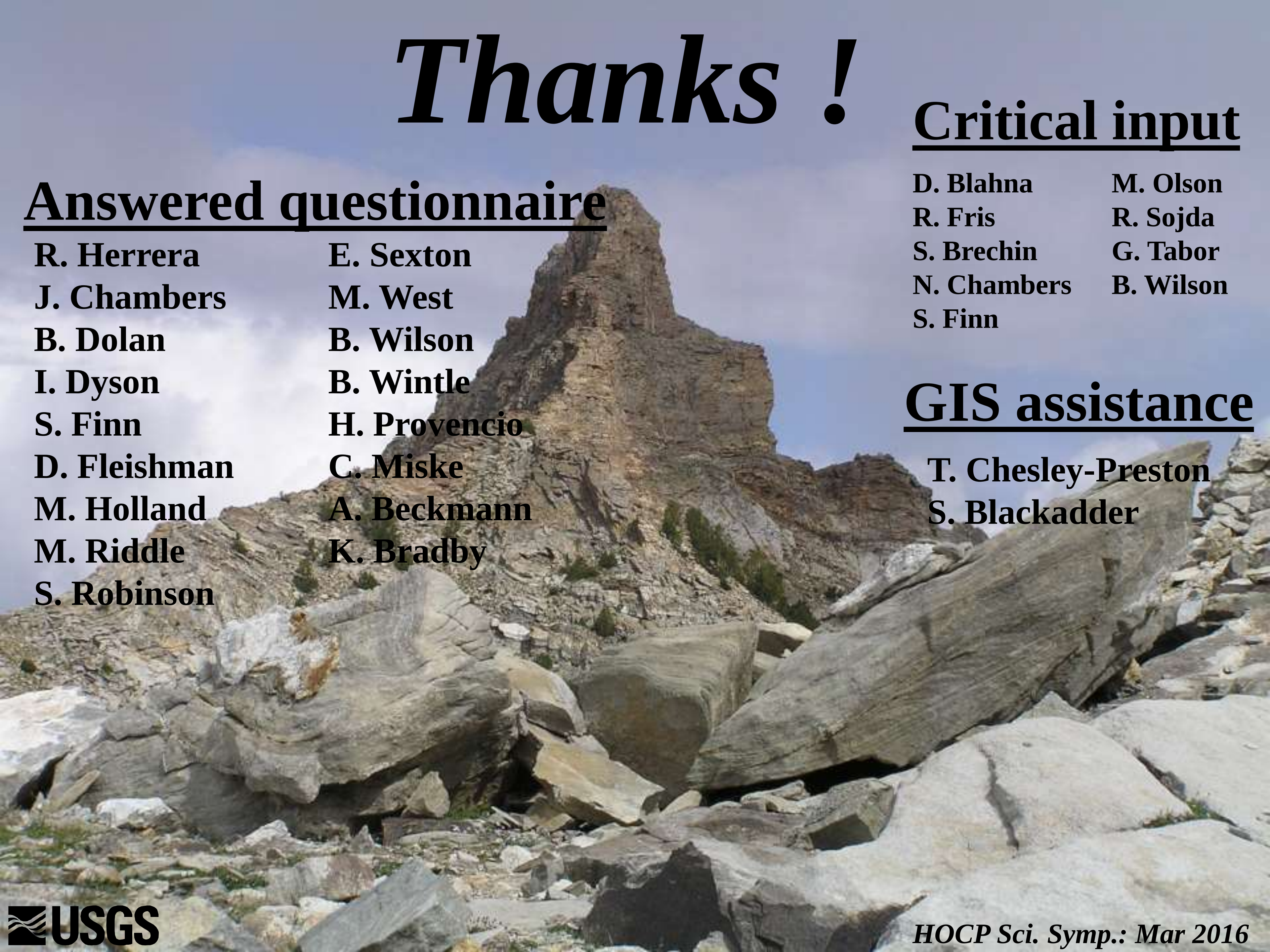
How management and conservation actions may affect *adaptive capacity*

Beever et al. in press, *Conservation Letters*



Take-home lessons: *The Big Picture*

- **Species respond individualistically**
- **Critical to know how, why species can cope**
- **Species responses can vary across space, time**
- **New technologies, approaches promising**
- **Flexibility and AC can ameliorate effects**



Thanks !

Answered questionnaire

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B. Dolan
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D. Fleishman
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M. Riddle
S. Robinson
E. Sexton
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K. Bradby

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Landscape Conservation Cooperatives