How do we steward nature through climate change?

Erika Zavaleta
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It's not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change. *Charles Darwin*

Four parts

- A future without analogs
- What is the role of historical knowledge?
- The right goals, at the right scales
- A resilient implementation process

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Species will move individualistically

1 2 3 4 5 6

A B *C* D E

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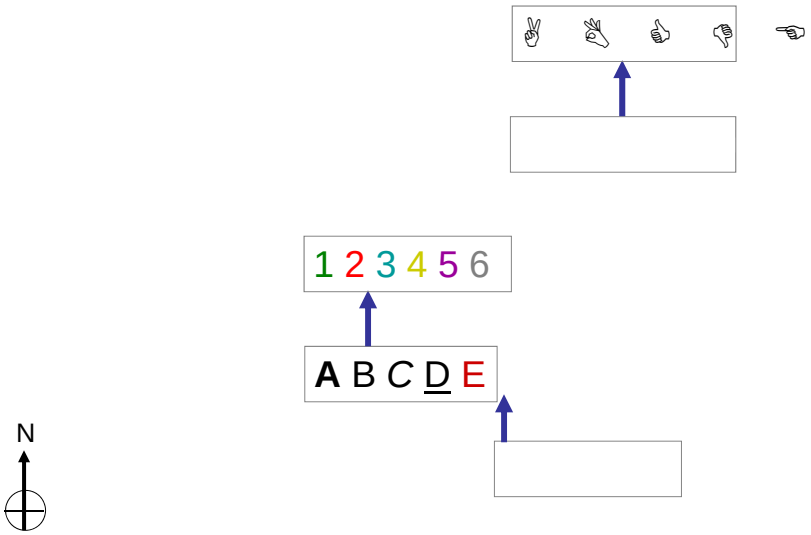

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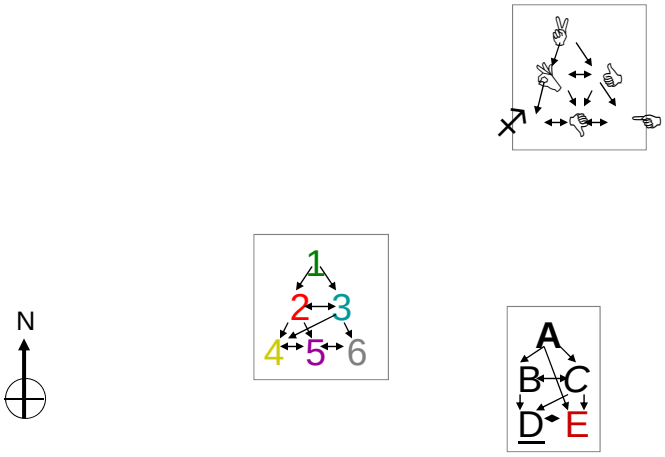

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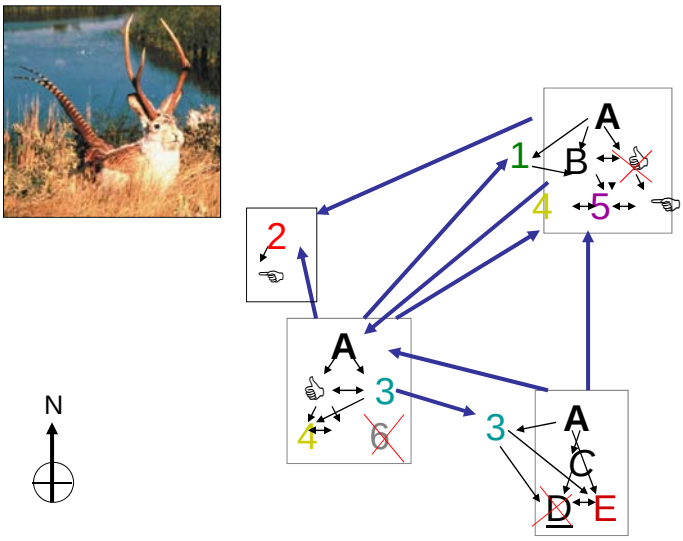
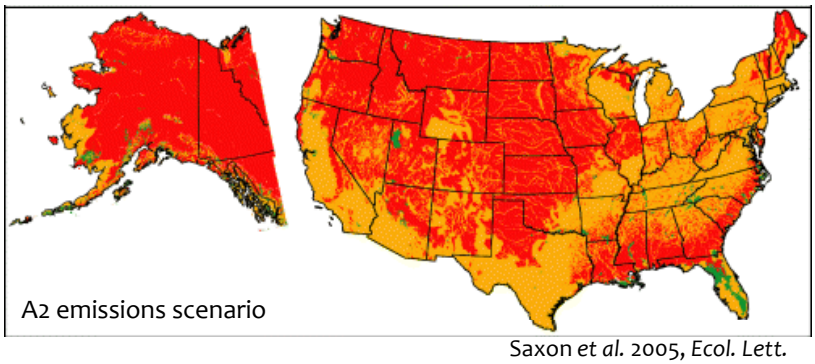


Most local environments will disappear



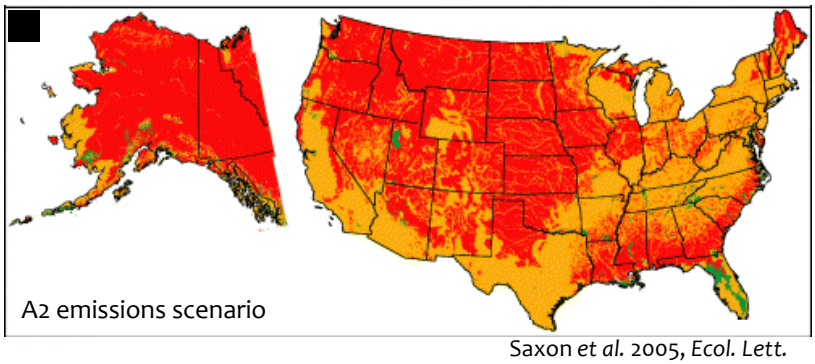
Saxon *et al.* 2005, *Ecol. Lett.*

- Conditions that will disappear from U.S.
- Conditions that will decrease in extent in U.S.
- Conditions that will increase in extent in U.S.

A future without analogs

- New biological communities, local climates
- Can't just adopt what is south, downhill
- Need to monitor and adjust course

Climate change: the future cannot look like the past



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- The trouble with history
- The danger (and impossibility) of neglecting history
- History as guide to resilience and transformation

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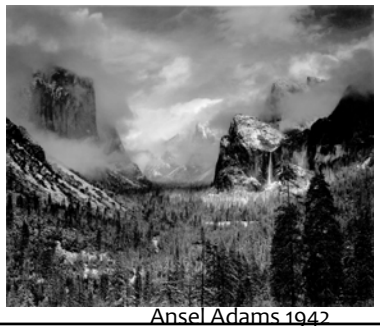
Historical fidelity, range of variability

- A goal of stasis, stability
- Based on scenery, communities, structure
- Post-Euro-American time scale



Ansel Adams 1942

Swetnam 1993

- The trouble with history
- The danger (and impossibility) of neglecting history
- History to guide resilience and transformation

The fact of change need not mean that we accept any change

Conservation grazing
Herbicide spraying
Prescribed fire

(At least) three types of goals for stewardship:

- What was
- What will be
- What we want

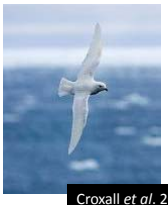
What will be?

Biro *et al*. 2007, *Animal Behavio*

- We cannot know.
- We might not like it.

Spiller & Schoener 2008

Dormann & Woodin 2002.



Croxall *et al*. 2002

Weidermann *et al*. 2007

Arft *et al*. 1999

"Some effects are inconsistent between species and areas, some in opposite directions at different stages of breeding and life cycles, and others remain paradoxical." (Croxall *et al*. 2002)

Zavaleta *et al*. 2003

Bertness & Ewanchuck 2001, Gedan & Bertness 2009

Post & Stenseth 1999

Stenseth *et al*. 1999

Loya *et al*. 2001

What we want

- Who is "we?"
- What we want will change.
- We don't know enough to define how to get it long-term.
- Resilience involves a move away from engineering ecosystems for "what we want" in a narrow sense.

We need "what was"

- Over longer time frames
- About different aspects of ecosystems
- For slightly different purposes

- The trouble with history
- The danger (and impossibility) of neglecting history
- History as guide to resilience and transformation

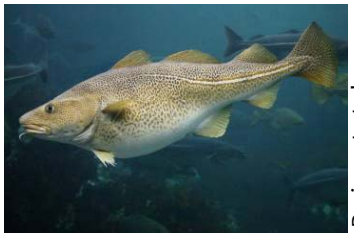
1. Historical knowledge: where ecosystems should be coming from.
2. Key aspects: adaptive capacity, processes
   - Past coping
   - Native diversity, complexity (trophic, landscape)
   - Evolutionary capacity, rates, pressures
3. Combine long view of past adaptive capacity, short view of how humans have changed it.

Santa Clara Valley dudleya
(federally endangered)

Altered adaptive capacity in recent decades

Trait changes

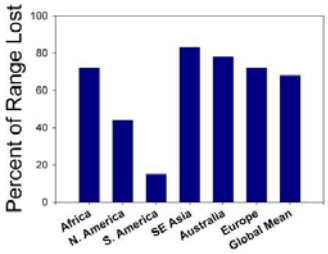
Morphology: 18.3% decrease, n=282



Life history: 24.9% change, n=173

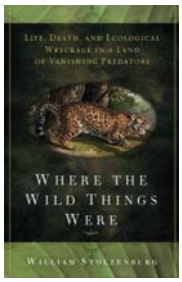
Darimont et al. 2009

Reduced extents



mammals

Ceballos and Ehrlich 2001



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Three strategic endpoints

Resistance to change
- Engineering approach
- Keep it the same

Resilience of the current system
- Of what?

Transformation to new sustainable state
- New cast, new regimes

Heller and Zavaleta 2009

Three strategic endpoints

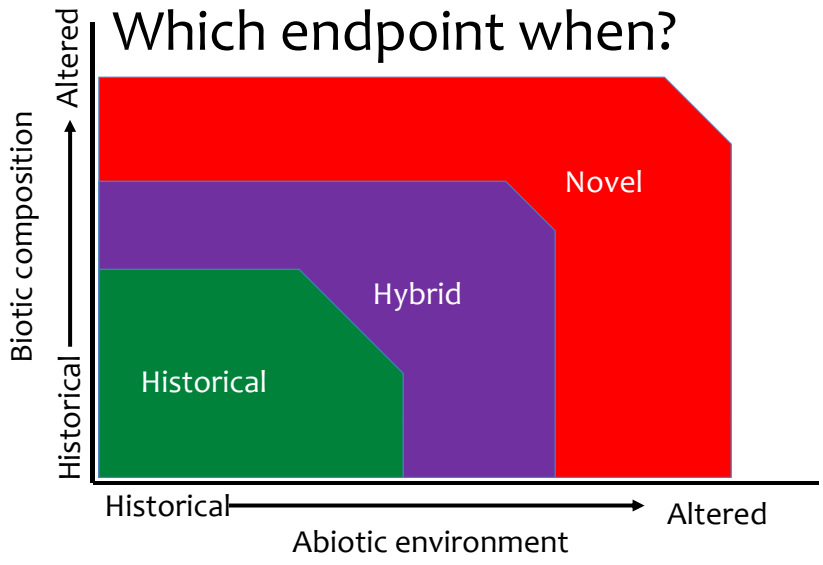
Resistance to change
- Engineering approach
- Keep it the same

Resilience of the current system
- Of what?

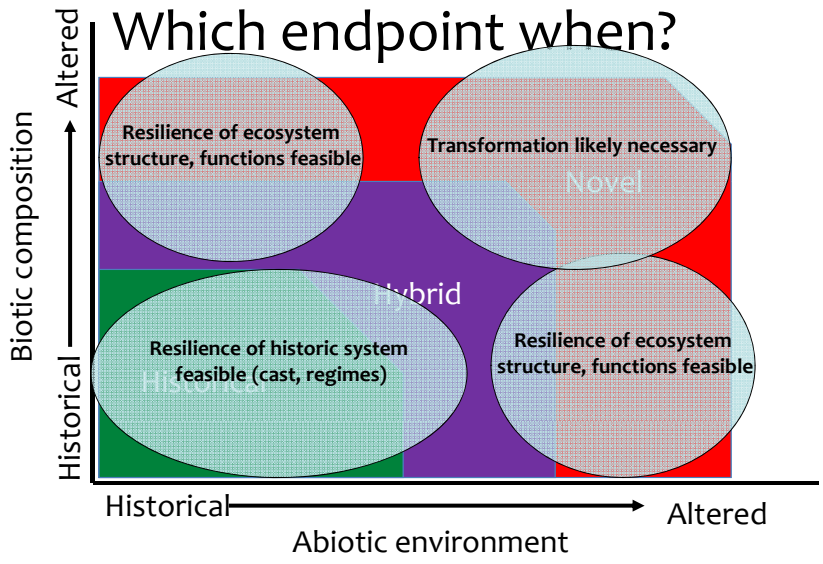
Trend over 25 years

Transformation to new sustainable state
- New cast, new regimes

Heller and Zavaleta 2009



(Modified from Hobbs, Higgs & Harris, TREE, in press)



(Modified from Hobbs, Higgs & Harris, TREE, in press)

When to shift strategies?

Resilience of the current system	**Transformation to new sustainable state**
Of specific assemblages	Of most valued ecosystem processes and services
Within sites	
Within or across regions	

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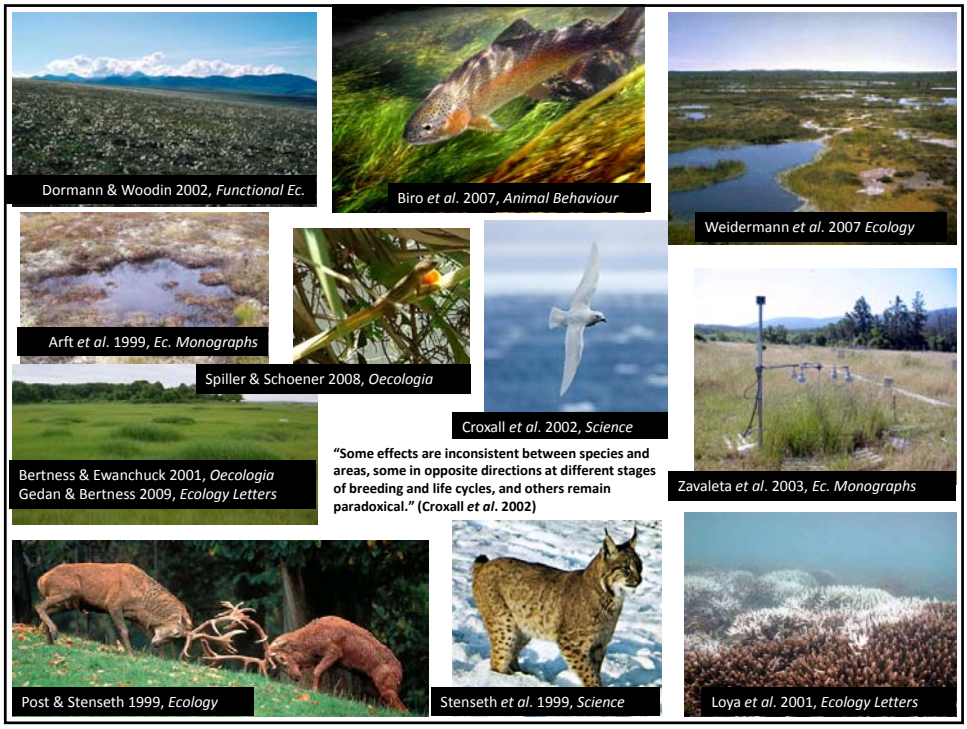


Three features of a resilient process

- Diversity

  multiple strategies, scales, tools, partners
- Modularity

  if one fails, one fails
- Tight feedbacks

  Monitoring, learning exchange, specified decision points

Build a diverse portfolio

Risk averse ⟷ Risk prone

Boost resilience
More of the same

Mitigate other threats, protect maximum area

Trend- and model-informed decisions

Scenarios

Sensitivity analysis

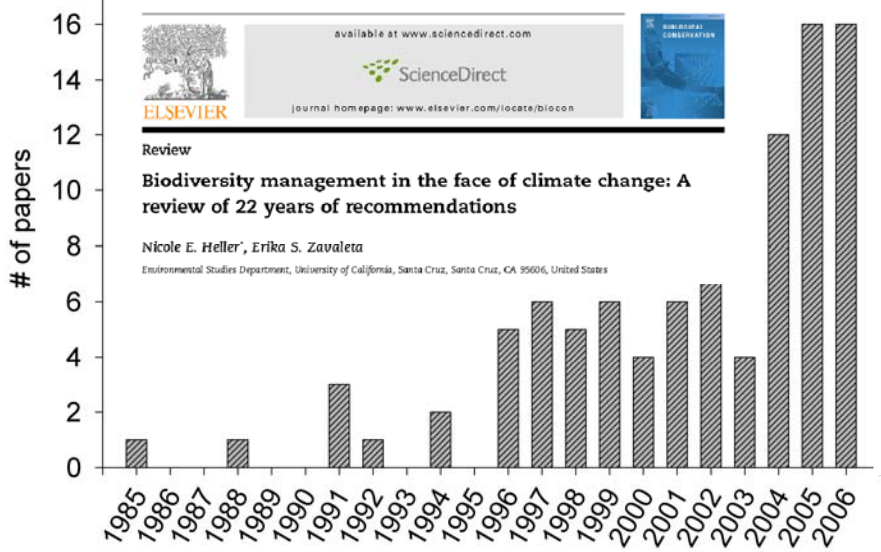
Pre-empt specific predictions

Translocate species to future habitat

Protect future hotspots

Heller and Zavaleta 2009

Rapid increase in published papers



Review

Biodiversity management in the face of climate change: A review of 22 years of recommendations

Nicole E. Heller, Erika S. Zavaleta*

Environmental Studies Department, University of California, Santa Cruz, Santa Cruz, CA 95606, United States

Top 5 recommendations (of 113)

1. **Increase connectivity** (corridors, remove dispersal barriers, new reserves, reforest)
2. **Integrate climate change into planning** (e.g. reserve selection, pest prediction, harvest and grazing schedules)
3. **Study species responses to climate** (physiology, behavior, demography)
4. **Translocate species**
5. **Manage intensely to secure populations**

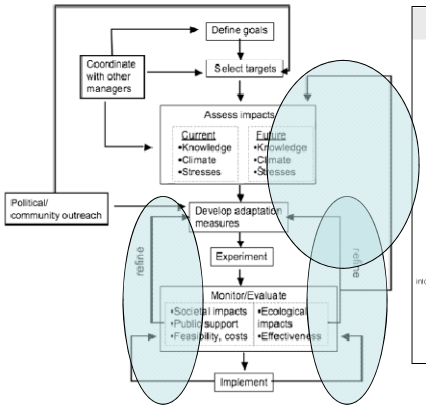
Heller and Zavaleta 2009

Evaluate potential actions

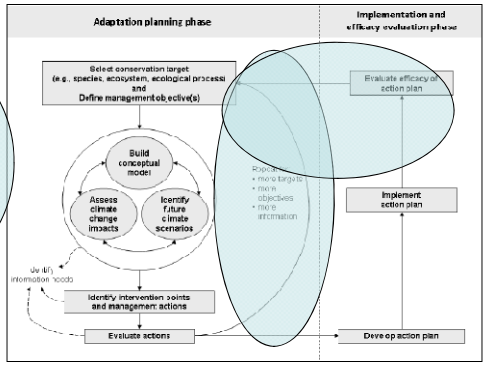
- **Effectiveness, complexity, cost** TNC 2009
- Pilotability
- Reversibility
- Robustness to uncertainty
- Potential for unintended consequences

TNC Conservation Learning Unit; Cross ,Zavaleta et al. in press

Iterative feedback loops



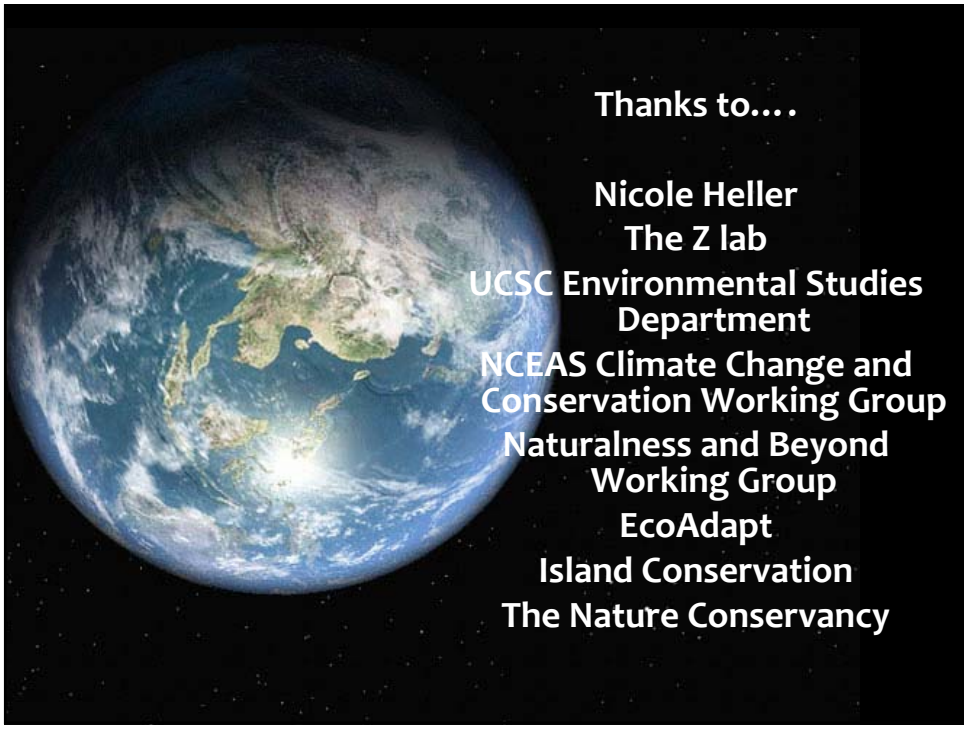
Heller & Zavaleta 2009



Cross, Zavaleta, et al. in press

In summary

- The great reshuffling
- History has its role
- Work across and link scales
- Build resilience, plan for transformation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EcoAdapt
Island Conservation
The Nature Conservancy