Climate Adaptation Panel

VECAN, December 2011
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"It is not the strongest species that survives, nor the most intelligent that survives. It is the one most adaptable to change."

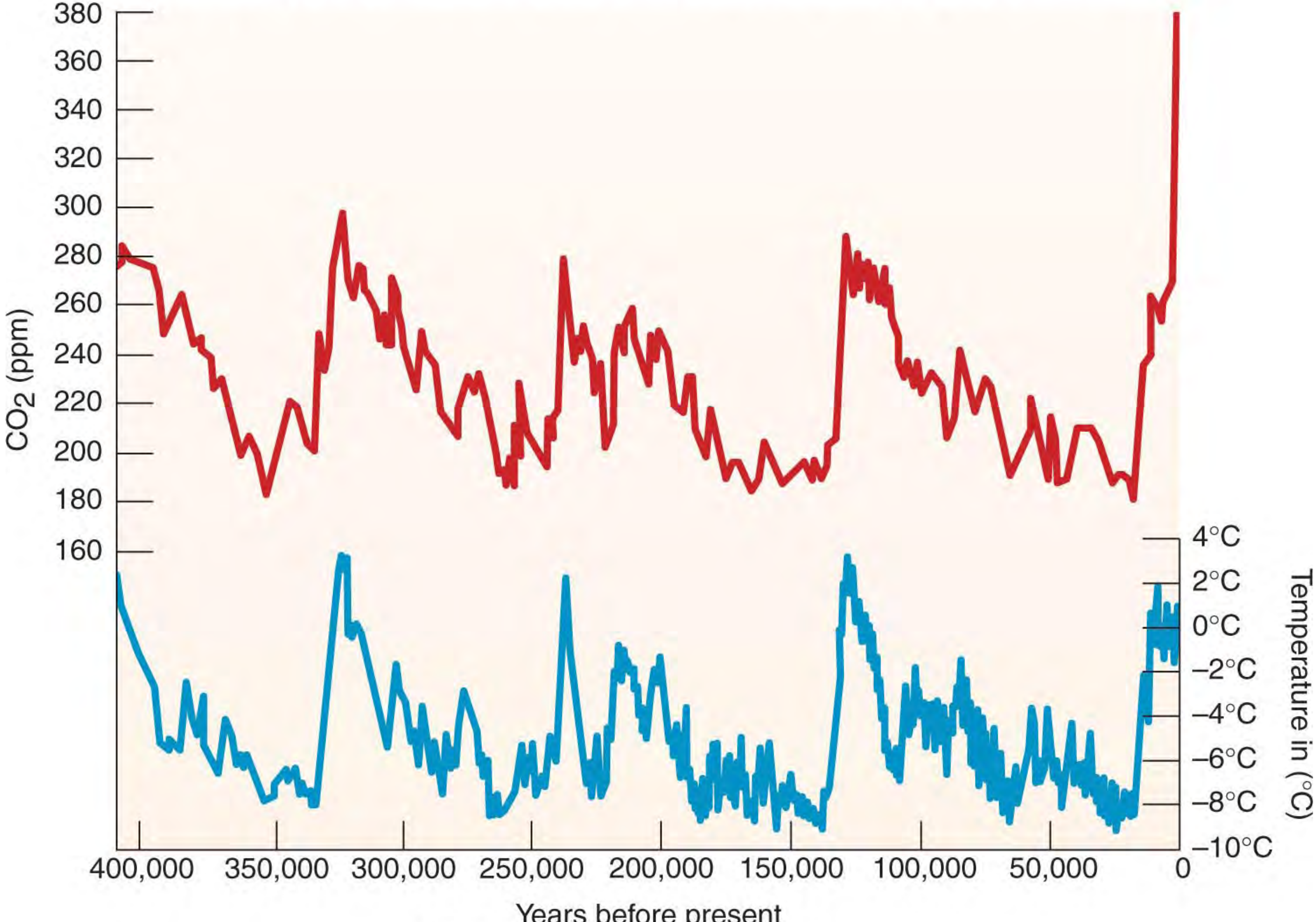
Attributed to Charles Darwin

Outline

- Differentiate climate mitigation from climate adaptation.
- Natural systems are responding ecologically and through evolution.
- Human response is an example of cultural evolution.
- Bring a systems perspective to climate change, sustainability, & community building.

Climate mitigation & climate adaptation

- mitigation – reduction of carbon/GHG emissions; 80% by 2050 is target
- adaptation – change to suit the conditions at hand; reduce the impact of climate change; prepare for uncertainty
- combination – reduce emissions & provide resilience



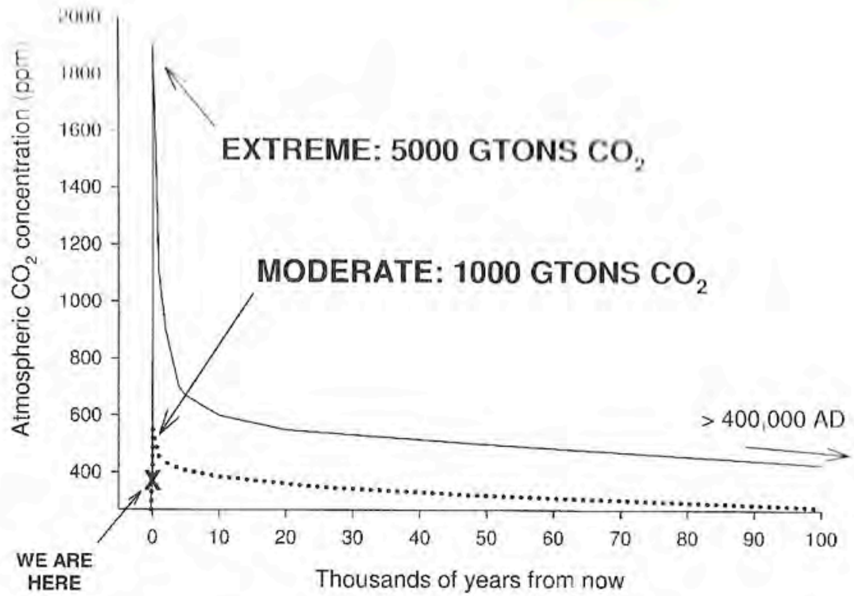
Source: Data from United Nations Environment Programme

Irreversible climate change

"It is not generally appreciated that atmospheric temperature increases are not expected to decrease significantly even if carbon emissions cease….Irreversible is defined here as a time scale exceeding the end of the millennium in the year 3000."

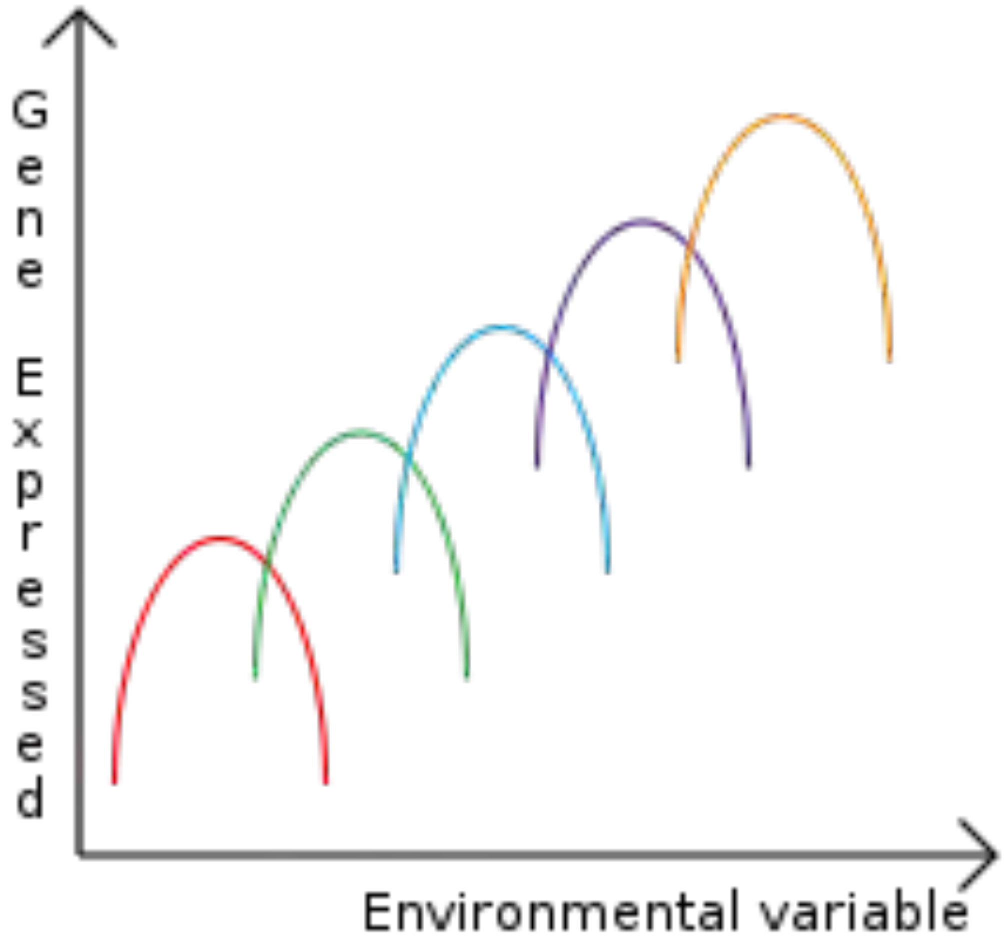
Solomon, S. et al. 2009. Irreversible climate change due to carbon emission. PNAS 106

100,000 year prediction



From Curt Stager's *Deep Future: The Next 100,000 Years of Life on Earth (2011)*

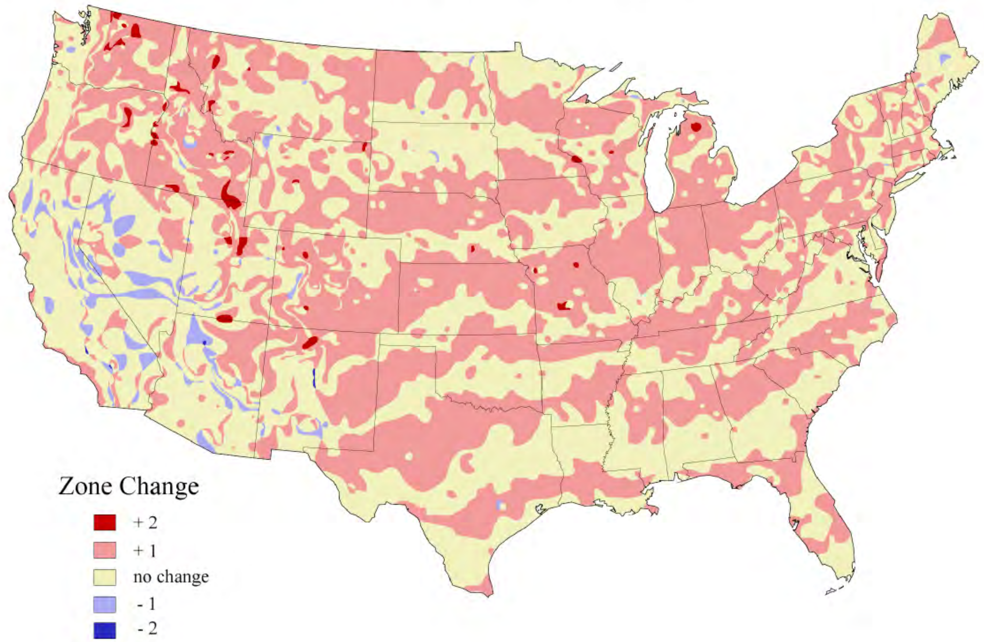
plastic response

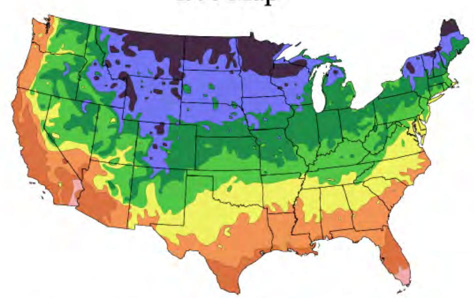


Changes in bird migration and range

Lake Ontario
Atlantic

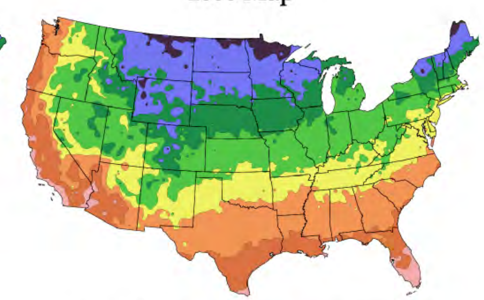
Differences between 1990 USDA hardiness zones and 2006 arborday.org hardiness zones reflect warmer climate





1990 Map

After USDA Plant Hardiness Zone Map, USDA Miscellaneous Publication No. 1475, Issued Januay 1990



2006 Map

National Arbor Day Foundation Plant Hardiness Zone Map published in 2006.

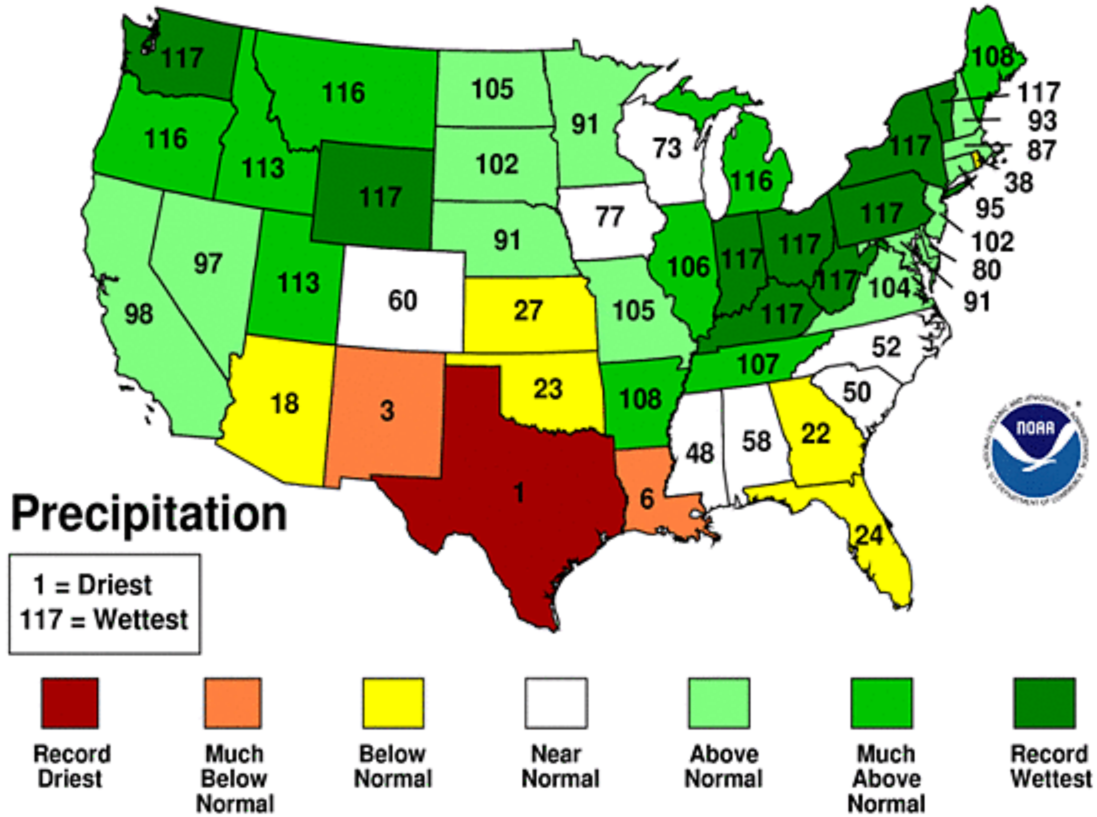
Zone

2 3 4 5 6 7 8 9 10

Extreme weather in Vermont Spring 2011

March-May 2011 Statewide Ranks

National Climatic Data Center/NESDIS/NOAA



Adaptation in Natural Systems

- to become suited to local conditions;
- traits and processes that help organisms cope with environments they live in;
- genetic change in a population due to natural selection;
- e.g., plants produce toxins to deter insects; fawns are camouflaged by their spots.

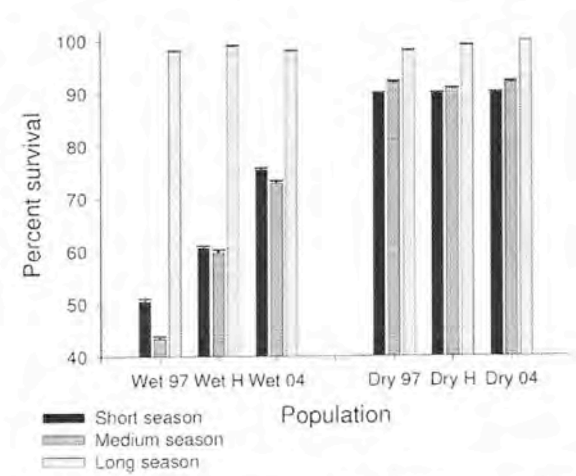


Fig. 3. Local adaptation across space and time. Shown is the percentage (mean ± SE) of *B. rapa* plants surviving from Wet Site (Wet) and Dry Site (Dry) populations from ancestral 1997 (97), descendant 2004 (04), and hybrid (H) crosses in the short (black bars), medium (dark gray bars), and long (light gray bars) season treatments. Higher survival of postdrought (2004) than predrought (1997) genotypes under short season conditions in the Wet Site shows adaptation to recent conditions. Higher survival of Dry Site than Wet Site genotypes under the short season treatment shows adaptation to local conditions. Survival was analyzed with a categorical model using a linear response function.

1280 | www.pnas.org/cgi/doi/10.1073/pnas.0608379104

Case Study #1:
Mizuna, *Brassica rapa*

		FT			
Population	Watering treatment	Ancestral	Hybrid	Descendant	χ^2
Wet Site	Short	53.4 ± 1.01	50.4 ± 0.93	46.2 ± 0.93	15.76***
Wet Site	Medium	58.2 ± 0.97	53.3 ± 0.94	49.1 ± 0.90	13.71**
Wet Site	Long	58.8 ± 0.87	54.1 ± 0.87	50.1 ± 0.86	55.88***
Dry Site	Short	42.6 ± 0.88	41.3 ± 0.88	41.0 ± 0.87	14.54***
Dry Site	Medium	42.2 ± 0.87	41.3 ± 0.88	41.4 ± 0.87	13.47**
Dry Site	Long	42.8 ± 0.87	42.1 ± 0.87	41.0 ± 0.87	10.38**

Shown are the least square means ± SE days to flowering (FT) of *B. rapa* in the Wet Site and Dry Site populations in the short, medium, and long season treatments for the ancestral (1997) and descendant (2004) collection lines and their hybrids. The χ^2 value is from a failure-time analysis testing the effect of collection year for each population by treatment group. *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$.

Franks, et al. 2007. Rapid evolution of flowering time by an annual plant in response to a climate fluctuation. PNAS 104

Case Study #2: Yukon red squirrel

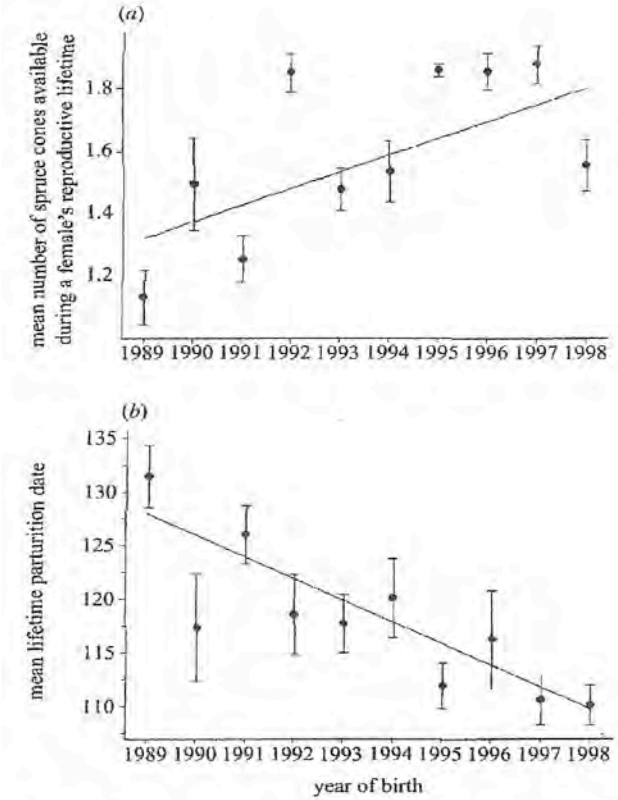


Figure 1. Variation in parturition date and food abundance in a North American red squirrel population at Kluane Lake, Yukon, Canada. (*a*) Average spruce cone index (log transformed) experienced by females during their reproductive lifetime as a function of cohort. (*b*) Average parturition date (Julian date ± s.e.) for each cohort of females born between 1989 and 1998. Each data point represents the mean for average lifetime parturition date of individuals from a given cohort corrected for age effects.

Reale, et al. 2003. Genetic and plastic responses of a northern mammal to climate change. Proc. R. Soc. Lond. B 270

Case Study #3: Pitcher plant mosquitoes

Fig. 1. Localities at 30–50°N latitude from which *W. smithii* were collected from *S. purpurea* (*Inset*) from the overwintering generation in 1972, 1988, 1993, and 1996. For each pie diagram, a blackened quadrant indicates a year that larvae were collected at that locality.

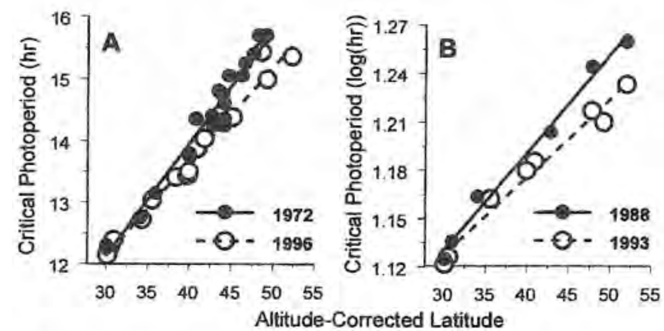


Fig. 2. Critical photoperiods of *W. smithii* collected during the overwintering generation from 1972 to 1996 determined from static (1972, 1996) or changing (1988, 1993) photoperiods. Analysis of covariance (Table 1) indicated significantly steeper slopes for the earlier year in each comparison, meaning that shifts toward shorter critical photoperiods (more southern phenotypes) increased with latitude.

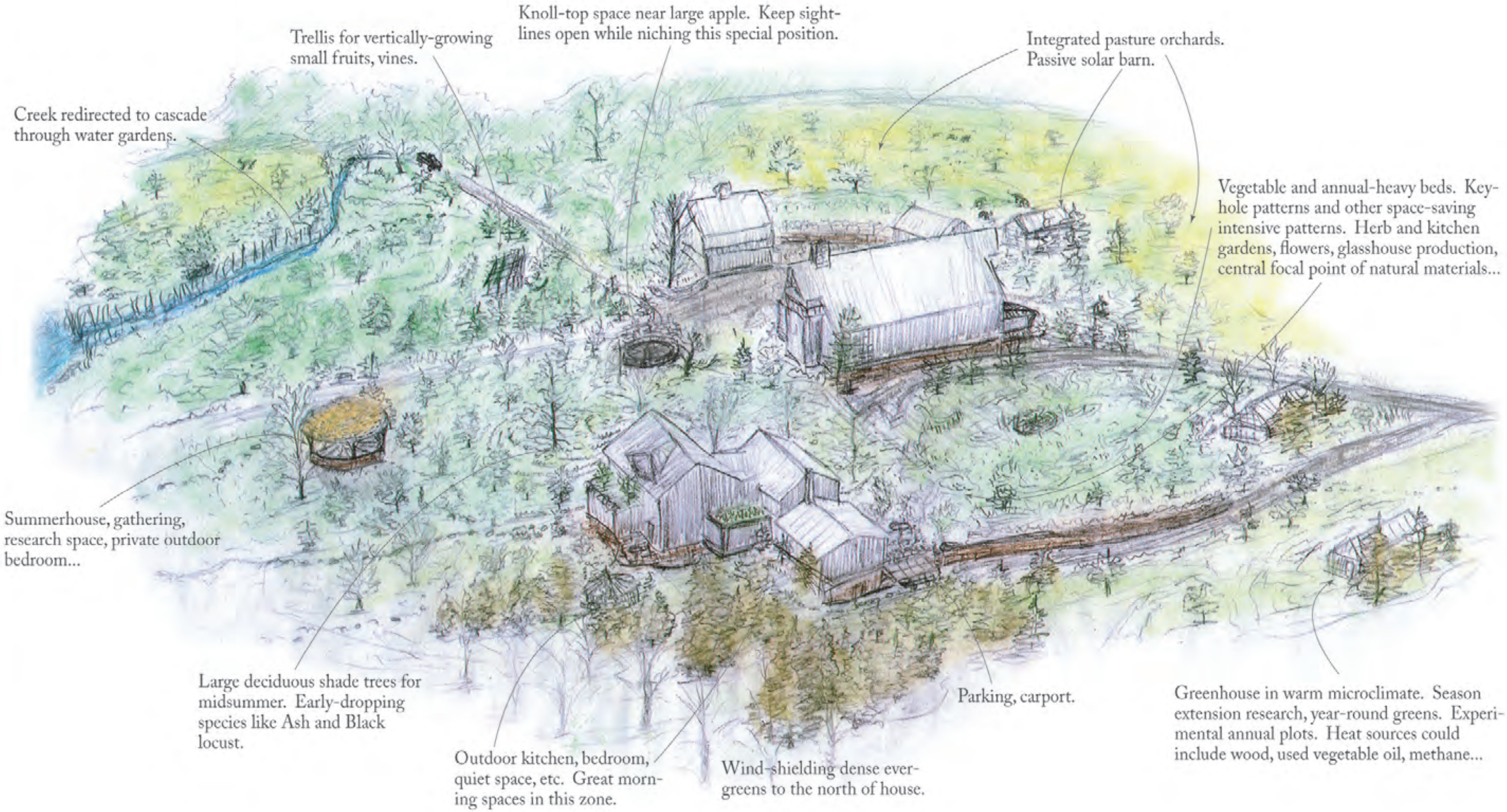
Bradshaw and Holzpfel, 2001. *Genetic shift in photoperiodic response correlated with global warming. Proc. Nat. Acad. Vol. 98.*

What to expect with climate change

- warmer temperatures, esp. nighttime
- more extreme weather
- greater drought and greater flooding
- greater variability in weather
- implications for disaster preparedness
- opportunities to build resilient systems

Adaptation in Human Systems

- to adjust to changing conditions;
- to alter one's actions to suit conditions at hand;
- to emphasize resilience and adaptive capacity



For illustrative-conceptual purposes.

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Living Future
Focus Area Concept
South-Southwest Perspective

SHEET
2





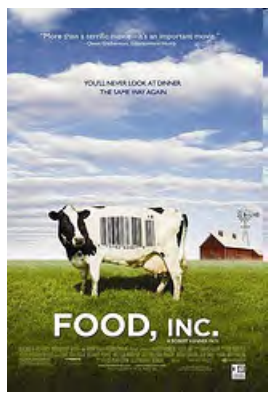






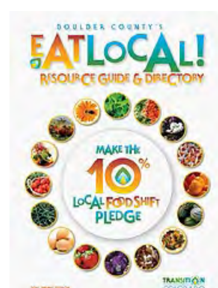

Northeast Organic
NOFA·VT
Since 1971
Farming Association of Vermont

TRANSITION
UNITED STATES



BALLE
Business Alliance for Local Living Economies

ITHACA HOURS
Local
Currency
Ithaca, NY



Resilience

- the ability of system to recover from shock;
- a characteristic of a complex adaptive system;
- in ecosystems associated with:
  - biodiversity & genetic diversity,
  - redundancy & heterogeneity in landscape;
- in social systems associated with
  - networks that learn and store knowledge,
  - create flexibility,
  - balance power among groups

From Folke, C. et al. "Resilience and sustainable development: Building adaptive capacity in a world of transformation," *Scientific Background Paper on Resilience, The World Summit on Sustainable Development* (2002).

Complex Adaptive Systems I

- Growth phase, *r*
- Conservation phase, *K*
- Release phase, *Ω*
- Reorganization phase, *α*
- Operates on differing spatial and temporal scales
- Examples:

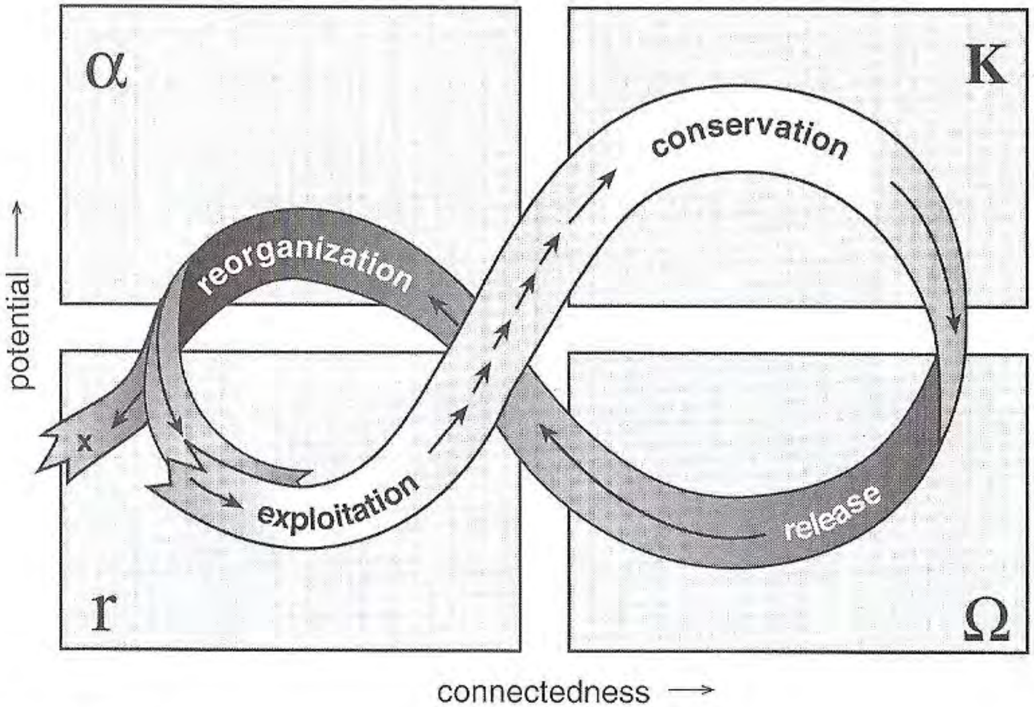


FIGURE 9 The First Version of the Adaptive Cycle

Walker, B. and D. Salt, 2006. Resilience Thinking: Sustaining Ecosystems and People in a Changing World. Island Press.

Complex Adaptive Systems II

- System components are independent & interacting
- Selection process is at work on those components
- Variation & novelty are constantly being added to the system
- System adapts as the world (conditions) change
- Capacity to manage resilience is adaptability

Adaptation Framing

- Climate change is a socio-ecological phenomenon.
- Social system is inextricably linked to ecological systems.
- Civic preparedness & responsiveness crosses political boundaries.
- Sustainable communities are resilient ones.
- Adaptation is a big idea, like democracy & peace.

Prospicience & persistence

- act of looking ahead; planning for the future; foreseeing
- enduring; continue firmly despite obstacles; survive
- adaptation counters fatalism

Conclusions

- Mitigating greenhouse gases is essential but not enough.
- Adaptation <u>and</u> mitigation describe the way forward.
- Phenological change, phenotypic plasticity, and evolutionary change are occurring in biological systems.
- Biological and cultural evolution, with attendant risks and opportunities, can be viewed in parallel.
- Opportunity to design resilient systems and sustainable communities in the context of ecological limits.
- Climate change may be the actor that releases us into a reorganization system phase.
- Adaptation is a big idea like democracy and peace.
- Dedicate ourselves to persistence.

The best way to predict the future is to invent it. Alan Kay

Key Concepts

- Climate adaptation
- Biological and cultural evolution
- Irreversibility of climate change
- Resilience
- Social-ecological systems
- Adaptive cycles
- Prospicience & persistence