Ecology for Transformation

LTER – All Scientists' Meeting
Estes Park, Colorado
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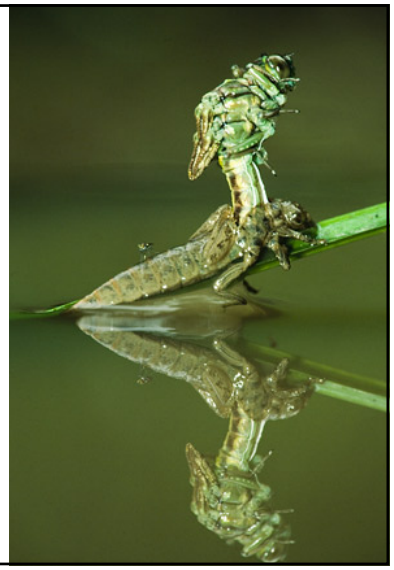


Dragonfly emerging / http://ngm.com

Main Points

Millennium Ecosystem Assessment: policies and practices for the Overshoot Century

Basics of change for social-ecological systems:
- Routine versus radical change
- Transitions between phases of change

LTER and the transformation to new social-ecological systems that maintain ecosystem services and improve human well-being

Millennium Ecosystem Assessment (MA):

Global assessment of ecosystem services and human well-being, plus 33 regional assessments

Status, trends, and plausible futures (to 2050) of 24 ecosystem services

1360 authors from 95 countries;
Independent review board of 80 experts;
850 individual reviewers

Open-source distribution of results: http://www.MAweb.org

Millennium Ecosystem Assessment

15 of 24 ecosystem services are being degraded.

Provisioning Services

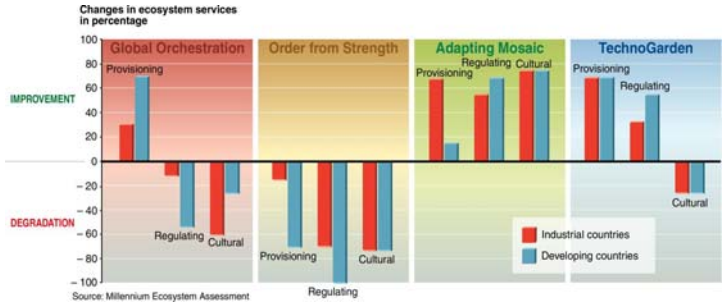
Service		Status
Food	crops	↑
	livestock	↑
	capture fisheries	↓
	aquaculture	↑
	wild foods	↓
Fiber	timber	+/–
	cotton, silk	+/–
	wood fuel	↓
Genetic resources		↓
Biochemicals, medicines		↓
Fresh water		↓

http://www.MAweb.org

	Status
Regulating Services	
Air quality regulation	↓
Climate regulation – global	↑
Climate regulation – regional and local	↓
Water regulation	+/–
Erosion regulation	↓
Water purification and waste treatment	↓
Disease regulation	+/–
Pest regulation	↓
Pollination	↓
Natural hazard regulation	↓
Cultural Services	
Spiritual and religious values	↓
Aesthetic values	↓
Recreation and ecotourism	+/–

Millennium Ecosystem Assessment

Scenarios show that improvements are possible by 2050.



Some existing polices and practices improve ecosystem services.

These policies and practices are not widespread at the present time.

Millennium Ecosystem Assessment

Examples of Policies that Improve Ecosystem Services:

Major investment in poverty reduction and in public goods (education, infrastructure)

Expanded markets for ecosystem services

Elimination of subsidies and trade barriers that distort markets that affect ecosystem services

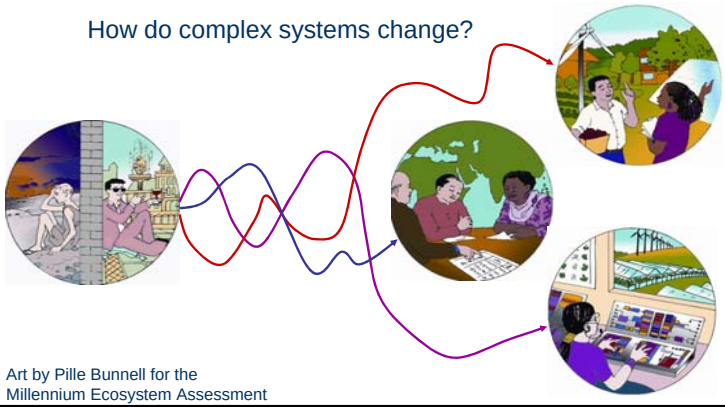
Major investment in technological innovation to improve ecosystem services

Reorganize institutions for adaptive governance

How do we get there from here?

Transformation.

How do complex systems change?



Art by Pille Bunnell for the Millennium Ecosystem Assessment

Why Study Change?

Understand the past.

Project the future.

Benchmarks for testing hypotheses and evaluating change

Change the future.

Act on our expectations to create a better situation

Routine and Radical Change

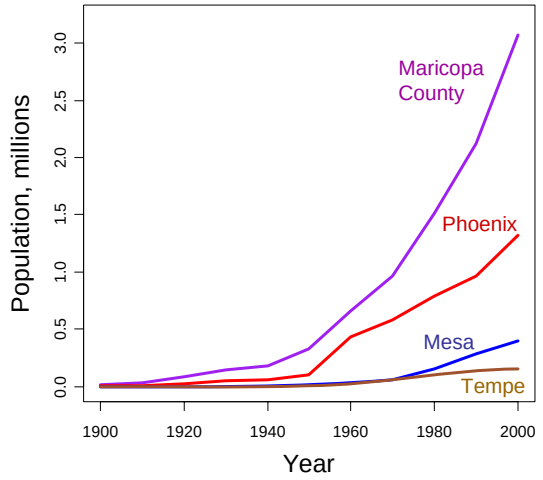
Routine change:

Time series of key variables may be:
- Constant
- Gradually trending
- Repeatably cycling

Future seems predictable

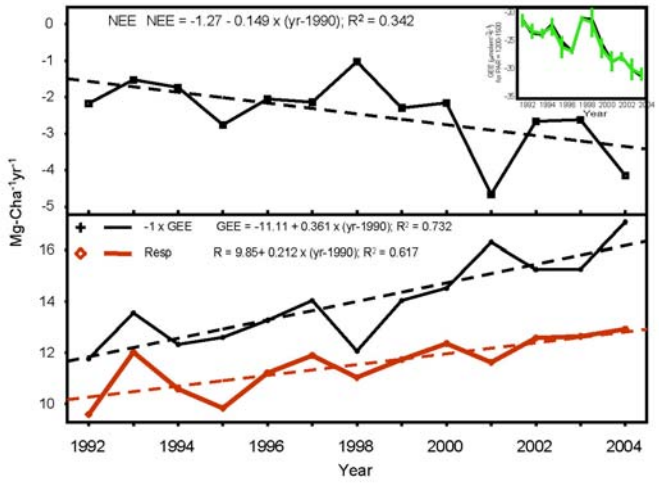
Efficiency, complexity, and vulnerability increase

Population Trends in the Central Arizona-Phoenix Region



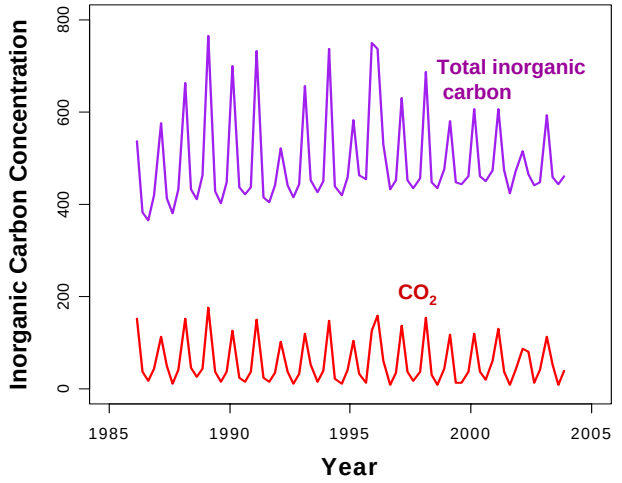
Source: Corinna Gries & Nancy Grimm, Central Arizona – Phoenix LTER site

Carbon Dynamics at Harvard Forest



Source: Bill Munger & Steve Wofsy, Harvard Forest LTER site

Inorganic Carbon Dynamics in a North Temperate Lake



Source: North Temperate Lakes LTER site
Hanson et al., Ecological Monographs 76: 343-363.

What is the relative importance of

External forcing or variability?

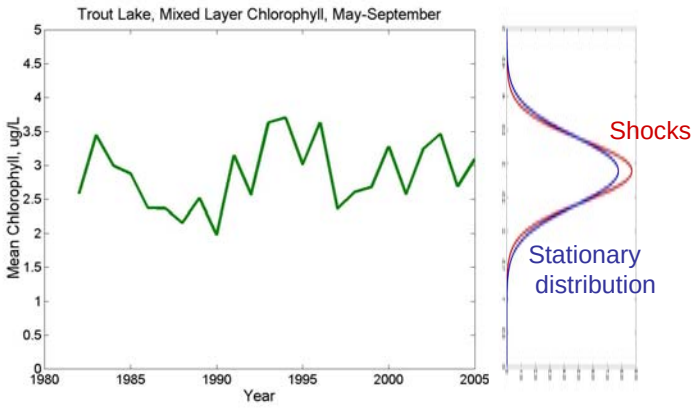
Internally-generated variability?

Internal stabilizing forces?

One simple method for LT data –

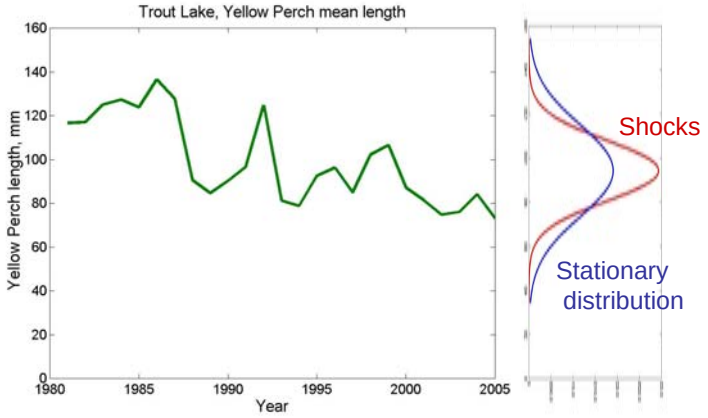
Ives et al., 2003, Ecological Monographs 73: 301-330

Example: Externally-driven variability of primary producers.



Data: North Temperate Lakes LTER;
Method: Ives et al. 2003, Ecological Monographs 73: 301-330

Example #2: Internal processes affect yellow perch variability.



Data: North Temperate Lakes LTER;
Method: Ives et al. 2003, Ecological Monographs 73: 301-330

Across LTER sites . . . .

Across physical, chemical, biological and social variables . . .

What variables are governed mainly by shocks?

Which have some degree of internal control?

What are the feedbacks?

How strong?

Routine and Radical Change

Radical change:

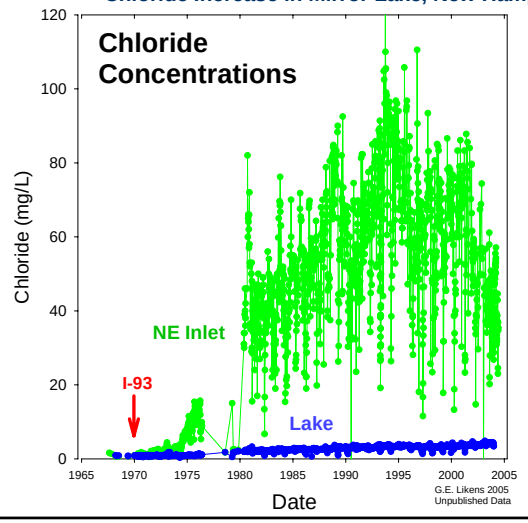
Time series change in new ways, for example:
- Abrupt shift to new level
- New cycle appears
- Variability increases or decreases

Different feedbacks dominate

Future seems unpredictable

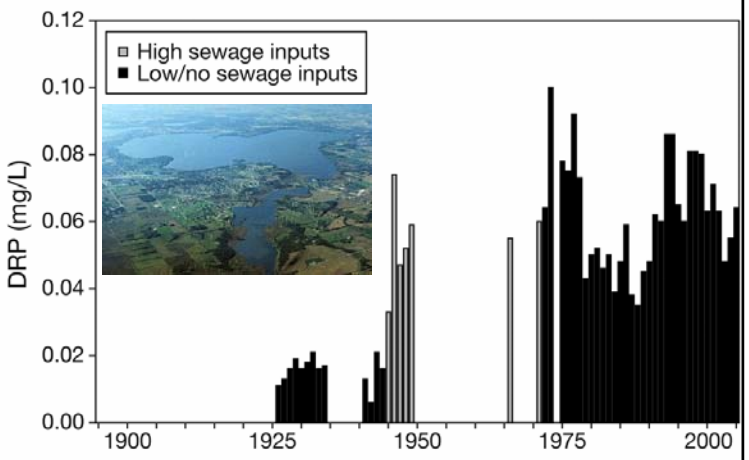
A time of inefficiency, creativity, experimentation, renewal, reorganization

Chloride Increase in Mirror Lake, New Hampshire



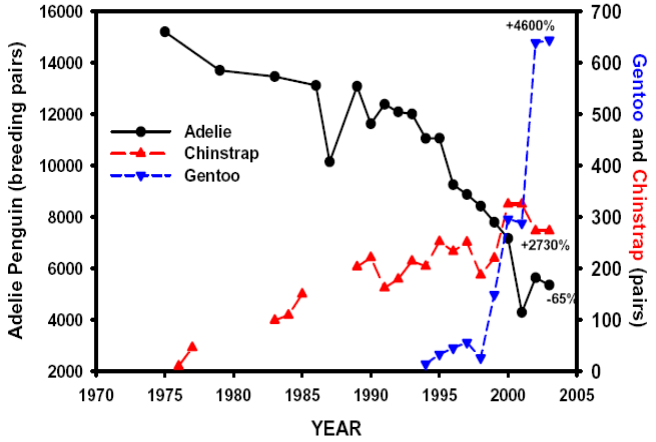
Source: Gene Likens, Hubbbard Brook LTER site

Multiple Controls of Phosphorus in Lake Mendota, Wisconsin



Source: Dick Lathrop, North Temperate Lakes LTER site

Penguin Species Shift at Palmer Station LTER



Source: Bill Fraser, Palmer Station LTER site

Public Perception of Pesticides

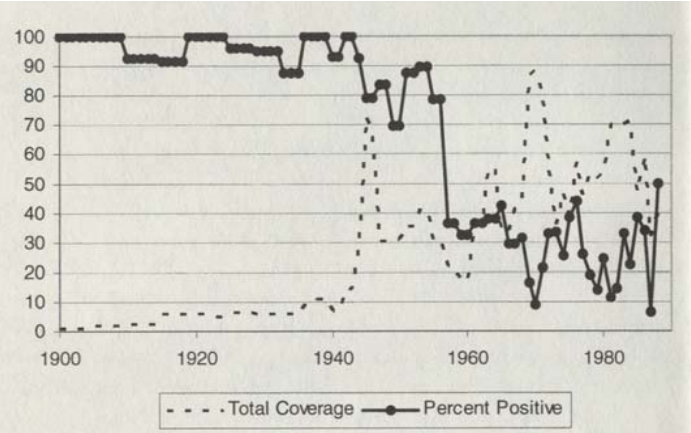


Figure 2.1. Pesticides coverage in the *Readers' Guide*, 1900–1988. *Source:* Baumgartner and Jones 1993, Fig. 5.3.

Repetto, R. (ed.), Punctuated Equilibrium and the Dynamics of U.S. Environmental Policy. Yale.

Extreme Fluctuation in U.S. Federal Spending on the Environment

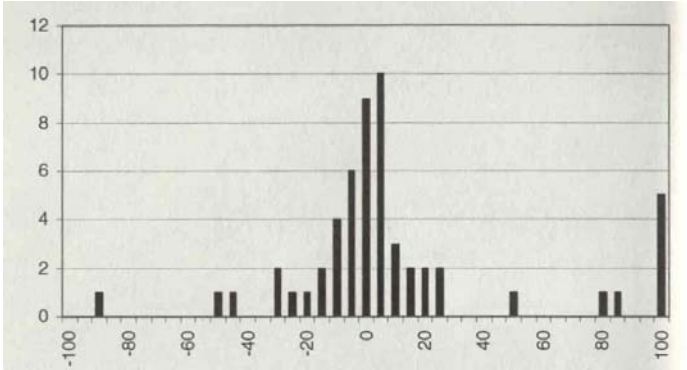


Figure 2.5. The distribution of annual percentage budget changes in federal environmental spending. The data reflect the annual percentage changes taken from the series reported in Figures 2.3 and 2.4. Five cases listed as +100% increases reflect those increases of 100 percent or more. The maximum increase in any single year was 266%. *Source:* Policy Agendas Project.

Repetto, R. (ed.), Punctuated Equilibrium and the Dynamics of U.S. Environmental Policy. Yale.

Current Understanding of Regime Shifts in Complex Systems

Infrequent, massive events – so LT perspective is essential

Multiple causes, multiple scales:

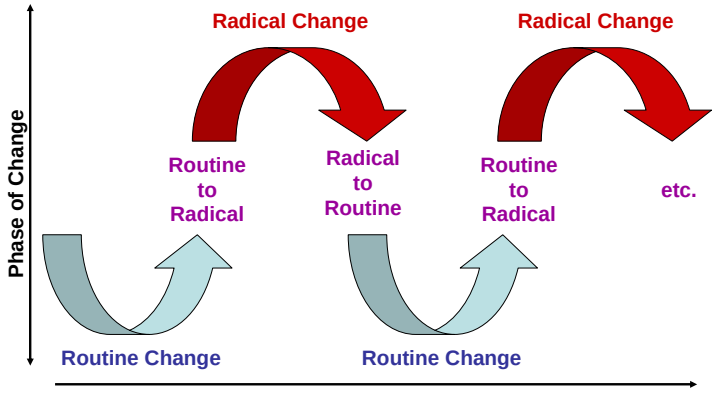
More commonly documented in spatial dynamics, perhaps because of data richness

Conjecture: At least **3** key state variables, each with a distinctive turnover time or spatial extent (or both)

Key studies use multiple tools (LT, comparison, big experiments, and models + theory)

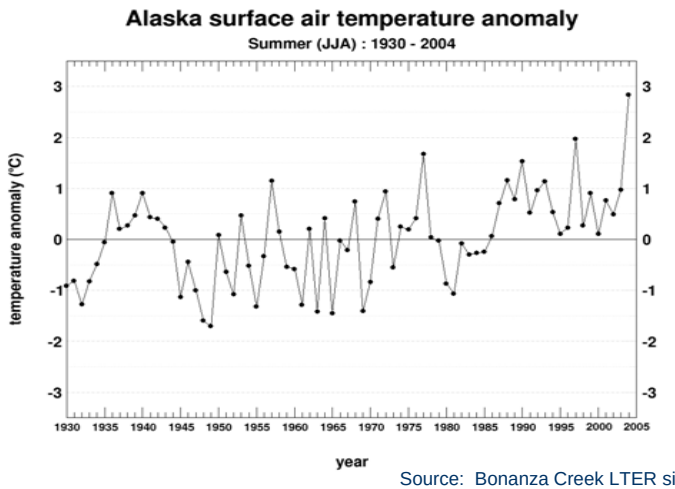
Sources: Carpenter 2003, Regime Shifts in Lake Ecosystems (http://limnology.wisc.edu/regime); Scheffer and Carpenter, 2003, TREE 12: 648 656

Transitions Between Kinds of Change

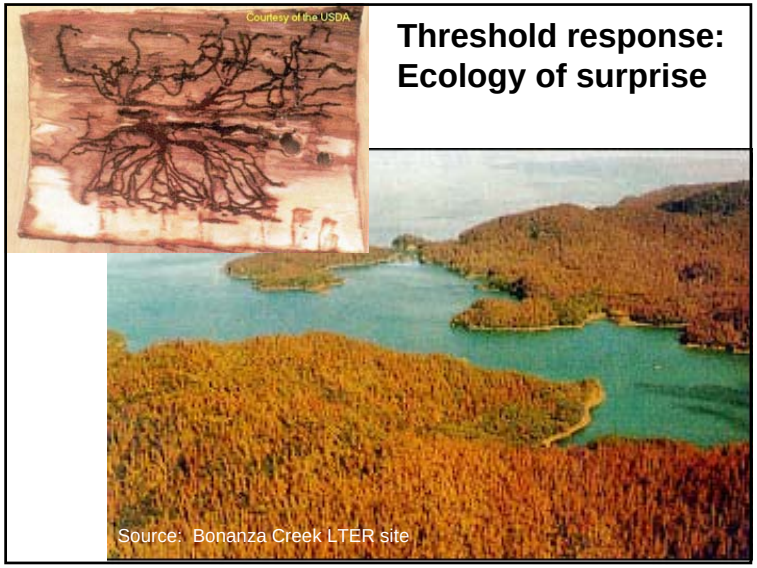


(may flow fast in some phases, slowly in others)

From Routine to Radical Change: An example from Alaska



Source: Bonanza Creek LTER site



Threshold response: Ecology of surprise

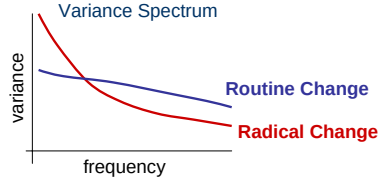
Source: Bonanza Creek LTER site

Source: Bonanza Creek LTER site

How do external shocks and internal factors (both stabilizing and variance-generating) interact during radical change?

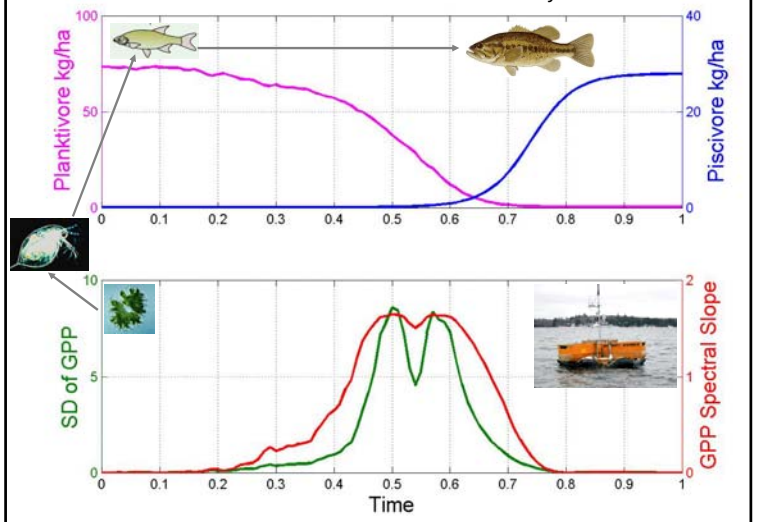
Variance increases

More variance at longer time scales (variance spectrum is "red")



Sources: Kleinen et al. *Ocean Dynamics* 53: 53-63; Carpenter and Brock *Ecology Letters* 9: 311-318.

Simulation: Control of Invasive Planktivore by Predation



Antecedents of Radical Change

Rising variance
Carpenter and Brock *Ecology Letters* 9: 311–318;
Ecology & Society 11 (2): 9. [online] URL: http://www.ecologyandsociety.org/vol11/iss2/art9/

Red shift
Kleinen et al. *Ocean Dynamics* 53: 53–63

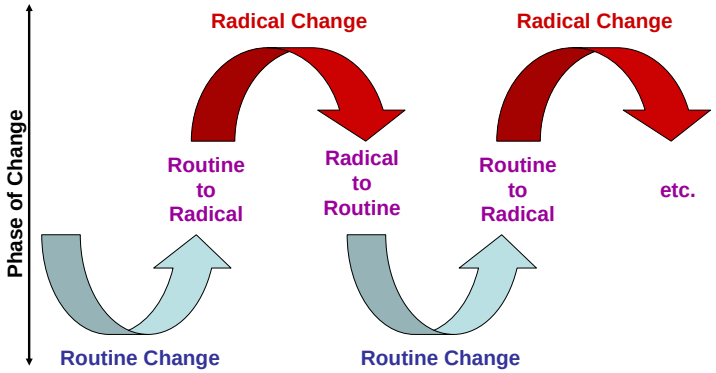
Spatial flickering
Ceronsky et al. in review, Foley et al. in review, Peterson et al in prep.

Slowed response to pulse perturbations
Scheffer and Van Nes, in review

Most examples are based on models; a few are based on long-term records or highly simplified lab experiments

An opportunity for LT time series analysis?

Transitions Between Kinds of Change



(may flow fast in some phases, slowly in others)

Radical → Routine: Emergence of a New Regime

The least-understood and most important kind of change.

Example: Kristianstad, Sweden*

Crisis: Deteriorating wetlands, water quality, and livelihoods; growing risk of catastrophic floods

Renewal and reorganization: Conservation-production system for multiple use of wetlands.

Key elements:
- Networks – key connectors among conservation, farming, NGOs and government
- Leadership
- Window (in time) of coincident interests

*Olsson et al. 2004, Ecology and Society 9 [online]: http://www.ecologyandsociety.org/vol9/iss4/art2

Radical → Routine: Emergence of a New Regime

How does novelty emerge in social-ecological systems?

What is the disturbance regime?
Which disturbances are routine and which are radical?
What is the condition of the system post-disturbance?

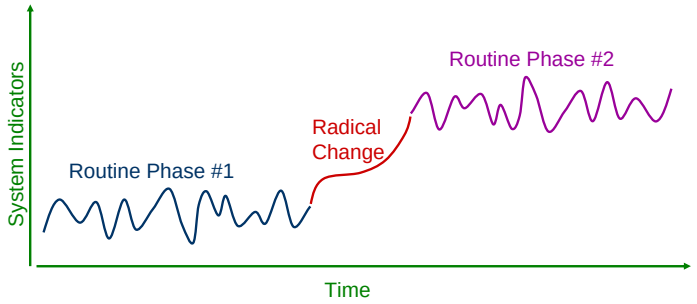
Diversity – what components are available?
How can the components be reconfigured?

What is the scope for experimentation?

How can resources be shifted from experimentation to implementation of the new routine, when the time is right?

Source: Brock, Carpenter, Folke, Gunderson, Scheffer, Westley, 2005, Creation of novelty in social-ecological systems. Unpublished manuscript

How do systems change from one routine to another?



This is a general version of the specific question posed by the Millennium Ecosystem Assessment:

How do we get there from here?

Art by Pille Bunnell for the Millennium Ecosystem Assessment

Four Big Questions for LTER Scientists

1. How do external drivers and internal factors cause routine and radical change in social-ecological systems?

How do the roles differ among contrasting systems?

How do the roles change across:

* local to regional spatial extents?

* short-term to long-term scales?

How do disturbance regimes and internal feedbacks interact to create social-ecological dynamics?

Four Big Questions for LTER Scientists

2. What enables transitions from routine to radical change?

   What are the key slow variables?

   What are the key cross-scale connections?

   Are there thresholds?

   How does variability change (magnitude and spectrum) before, during and after radical change?

Four Big Questions for LTER Scientists

3. What determines the characteristics of new phases of routine change? (How? And to what extent?)

   Legacy?

   Diversity?

   Mechanisms for novelty?

And how are these similar or different among systems?

   Ecological (self-organized from evolved components)

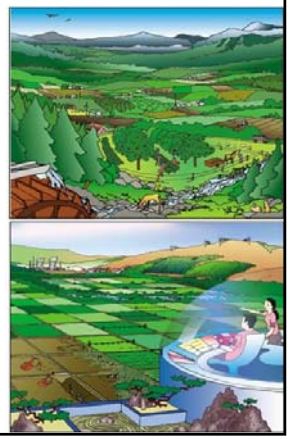
   Social (self-organized from forward-looking components)

Four Big Questions for LTER Scientists

4. How do failing social-ecological systems transform to better-adapted social-ecological systems?

Sustainability starts with open exploration of new ideas for better social-ecological systems.

Social-ecological science is a promising source of better ideas.



Carpenter & Folke, TREE 2006

Thanks to:

LTER TRENDS project – Deb Peters and Colleagues

LTER sites that contributed data:
- Bonanza Creek
- Central Arizona-Phoenix
- Harvard Forest
- Hubbard Brook
- North Temperate Lakes
- Palmer Station

Ideas from many NTL collaborators as well as Buz Brock, Carl Folke, Marten Scheffer, Frances Westley

Millennium Ecosystem Assessment
http://www.MAweb.org

Resilience Alliance
http://www.resalliance.org

Ecology for Transformation

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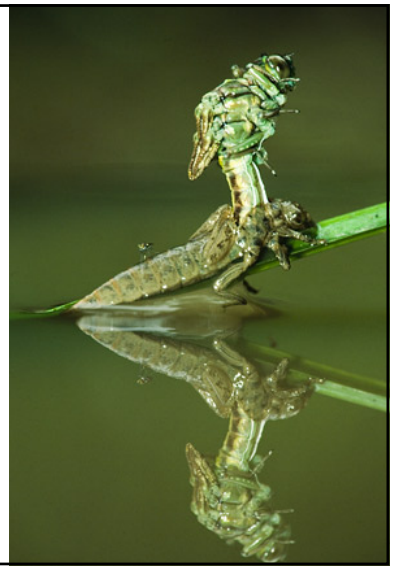
Slides posted at:

http://lter.limnology.wisc.edu



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