Ecology for Transformation

LTER – All Scientists’ Meeting
Estes Park, Colorado
September 2006

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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

Provisioning Services

15 of 24 ecosystem services are being degraded.

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<th>Service</th>
<th>Status</th>
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<td>Food</td>
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<td>crops</td>
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<td>fisheries</td>
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<td>Fiber</td>
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<td>cotton, silk</td>
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<td>wood fuel</td>
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<td>Genetic resources</td>
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<td>Biochemicals, medicines</td>
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<td>Fresh water</td>
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http://www.MAweb.org
Scenarios show that improvements are possible by 2050. Some existing policies and practices improve ecosystem services. These policies and practices are not widespread at the present time.

**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?

**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
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.

Example #2: Internal processes affect yellow perch variability.

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

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Chloride Increase in Mirror Lake, New Hampshire

Source: Gene Likens, Hubbard Brook LTER site

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Multiple Controls of Phosphorus in Lake Mendota, Wisconsin

Source: Dick Lathrop, North Temperate Lakes LTER site

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Penguin Species Shift at Palmer Station LTER

Source: Bill Fraser, Palmer Station LTER site
**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: 648-66
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")

Antecedents of Radical Change

Rising variance

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

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

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?

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?

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

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?

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)

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

END