LTER in the future: synthesis across time, over space and among disciplines

Scott L. Collins
Department of Biology
University of New Mexico
Sevilleta LTER
Studying the few and rapidly shrinking undisturbed ecosystems is important, but now is the time to focus on an ecology for the future (Palmer et al. 2004).
Structure of presentation:

Cross-site syntheses
  N deposition
  Shrub encroachment
  Microbial diversity

Conceptual Framework
  Integrating Ecological, Geological and Social Science
  Ecosystem services

LTER Planning process: Synthesis for the future
  over time
  across space
  among disciplines

Challenge: Ecosystem tipping points and ecological services
Brook 2005 (based on Siegenthaler et al. 2005 and Spahni et al. 2005 Science)
US Long-term Ecological Research Network (LTER)

Suding et al. 2005 PNAS
Soil pH

Fierer and Jackson 2006 PNAS
A DECADE OF SYNTHESIS:
GOALS OF THE LTER PLANNING PROCESS (from the proposal):

This proposal describes an ambitious planning activity to develop a new LTER science agenda that when implemented will use the Network to its maximum potential and take LTER science to a higher level of research collaboration, synthesis and integration.

• Objective 1: establish activities that will lead to multi-site, highly collaborative and integrated research initiatives that explicitly include synthesis components and, where appropriate, will be coupled with novel training opportunities in graduate and undergraduate education.

• Objective 2: evaluate existing LTER Network governance structure and further stimulate the culture of collaboration within the LTER Network.

• Objective 3: envision and develop education and training activities that will infuse LTER science into the K-12 science curriculum.
Build on the strengths of the existing LTER Network:

• Research on
  • climate variability and climate change
  • biogeochemical cycles
  • biotic structure and dynamics

• Experience Integrating Ecology, Geosciences and Social Sciences

• Well Defined Organizational Structure

• Common Network-level Goals

• Cyberinfrastructure and Information Management

• Strong Graduate and Undergraduate Education

• Schoolyard LTER
OVERARCHING QUESTION

How do changes in human populations and their behavior, climate variation, altered biogeochemical cycles, and biotic structure interact to affect ecosystem structure and function and their services to society?

- Changes in human population density
- Redistribution of population nationally and locally
- Increased availability and distribution of limiting resources
- Altered biotic composition and structure
- Increased variability in environmental drivers (e.g. climate, sea level rise)
Hierarchical structure of the LTER Planning Framework
Questions to link components of the conceptual framework:

**Q1:** How do long-term press disturbances and short-term pulse disturbances interact to alter ecosystem structure and function?

**Q2:** How can biotic structure be both a cause and consequence of ecological fluxes of energy & matter?

**Q3:** How do altered ecosystem dynamics affect ecosystem services?

**Q4:** How do changes in vital ecosystem services feed back to alter human behavior?

**Q5:** Which human actions influence the frequency, magnitude, or form of press and pulse disturbance regimes across ecosystems, and how do these change across ecosystem types?
Model: Inter-Regional Population Distribution, Trade:
-water scarcity; landscape; climate; natural resource base for economy or quality of life; cost of living; regional economic policy; shipping access.

Observational/natural experiments/data on policy

Multi-site Ecology Experiments inform: landscape and biotic conditions.

Model: Local Population Distribution:
- Drivers: local water scarcity; transport, telecom, house cost; landscape to urban amenity gradient; biotic diversity; land use control, incentive policies.

Economic incentives/policy experiments affecting land use: fragmentation, nutrients, carbon, water

Implications: Spatio-temporal press and pulse disturbances or inflows to ecosystem
- range of nutrient concentration, location;
- Habitat fragmentation, invasion
- Water stresses

Outcomes/Scenarios inform LTER/companion experiments; stakeholder/scientist futuring

From LTER
Press – increase the strength of press variables
Pulse – alter the frequency and intensity of pulse events

**Presses:**
- Sea level rise
- Atmospheric CO$_2$
- Nitrogen deposition
- Average temperature
- Grazing

**Pulse events:**
- Hurricanes
- Fires
- Land use change
- Drought cycles
- Disease outbreaks
- Extreme events
System Response Trajectories

Press (e.g. N deposition)

Rapid community-level response

Invasive species

Pulse (e.g., fire)

Community re-ordering

Organismal response

Ecosystem change

Very resistant system

Biotic Response

Time
How representative is the current LTER Network?
US Long-term Ecological Research Network (LTER)
Key Features

• Explicitly integrates social and ecological science
• Iterative, interactive, and adaptive
• Site-based and synthetic, can include participation by all LTER sites
• Multi-site, coordinated
• Includes both long-term and short-term research
• Will take advantage of existing knowledge and strengths of the LTER network
• Will expand beyond the existing LTER network
• Will complement and enhance NEON and other networks
• Will offer novel education and training initiatives
• Will foster novel solutions to new CI challenges
• Will yield information relevant to decision makers
• Does not come at a cost to existing site-based science
What can we do now?

Global Climate Change Tipping Points produced by climatologist Hans Joachim Schellnhuber and published in Nature (Kemp 2005).
No tipping points in North America?
CHALLENGE: Identify causes and consequences of ecosystem tipping points in North America.
## Global Change and Ecosystem Services

**Land-use change (%)***

<table>
<thead>
<tr>
<th>Category</th>
<th>B1 HadCM3</th>
<th>B2 HadCM3</th>
<th>A1FI HadCM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropland (for food production)</td>
<td>−7.0</td>
<td>−6.4</td>
<td>−10.7</td>
</tr>
<tr>
<td>Grassland (for livestock)</td>
<td>−1.1</td>
<td>−6.7</td>
<td>−8.7</td>
</tr>
<tr>
<td>Forest</td>
<td>3.5</td>
<td>5.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Urban</td>
<td>3.4</td>
<td>7.4</td>
<td>8.7</td>
</tr>
<tr>
<td>Bioenergy production</td>
<td>0.05</td>
<td>0.06</td>
<td>0.09</td>
</tr>
<tr>
<td>Protected</td>
<td>6.1</td>
<td>6.1</td>
<td>6.1</td>
</tr>
<tr>
<td>Surplus</td>
<td>1.1</td>
<td>0.0</td>
<td>9.8</td>
</tr>
</tbody>
</table>

**Additional people living under water stress (10^6)‡**

<table>
<thead>
<tr>
<th>Category</th>
<th>B1 HadCM3</th>
<th>B2 HadCM3</th>
<th>A1FI HadCM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional people living under water stress (10^6)‡</td>
<td>44.3</td>
<td>25.8</td>
<td>44.3</td>
</tr>
</tbody>
</table>

**People living under increased water stress (10^6)§**

<table>
<thead>
<tr>
<th>Category</th>
<th>B1 HadCM3</th>
<th>B2 HadCM3</th>
<th>A1FI HadCM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>People living under increased water stress (10^6)§</td>
<td>31.0</td>
<td>38.2</td>
<td>45.7</td>
</tr>
</tbody>
</table>

**Δ Alpine summer runoff (%)‖**

<table>
<thead>
<tr>
<th>Category</th>
<th>B1 HadCM3</th>
<th>B2 HadCM3</th>
<th>A1FI HadCM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ Alpine summer runoff (%)‖</td>
<td>−24</td>
<td>−23</td>
<td>−46</td>
</tr>
</tbody>
</table>

**Δ Elevation of reliable snow cover (m)‖**

<table>
<thead>
<tr>
<th>Category</th>
<th>B1 HadCM3</th>
<th>B2 HadCM3</th>
<th>A1FI HadCM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ Elevation of reliable snow cover (m)‖</td>
<td>230</td>
<td>180</td>
<td>450</td>
</tr>
</tbody>
</table>

**Species loss per grid cell (minimum to maximum %)¶**

<table>
<thead>
<tr>
<th>Category</th>
<th>B1 HadCM3</th>
<th>B2 HadCM3</th>
<th>A1FI HadCM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species loss per grid cell (minimum to maximum %)¶</td>
<td>−7 to −58</td>
<td>−8 to −53</td>
<td>−8 to −59</td>
</tr>
</tbody>
</table>

**Δ Area burnt, Iberian Peninsula (%)**

<table>
<thead>
<tr>
<th>Category</th>
<th>B1 HadCM3</th>
<th>B2 HadCM3</th>
<th>A1FI HadCM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ Area burnt, Iberian Peninsula (%)</td>
<td>112</td>
<td>57</td>
<td>80</td>
</tr>
</tbody>
</table>

**Δ Wood increment (%)**

<table>
<thead>
<tr>
<th>Category</th>
<th>B1 HadCM3</th>
<th>B2 HadCM3</th>
<th>A1FI HadCM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ Wood increment (%)</td>
<td>−10.0</td>
<td>9.7</td>
<td>3.8</td>
</tr>
</tbody>
</table>

**Cumulative carbon balance (Pg C)#**

<table>
<thead>
<tr>
<th>Category</th>
<th>B1 HadCM3</th>
<th>B2 HadCM3</th>
<th>A1FI HadCM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative carbon balance (Pg C)#</td>
<td>2.2</td>
<td>2.4</td>
<td>1.8</td>
</tr>
</tbody>
</table>

**Average carbon flux (% of emissions)**

<table>
<thead>
<tr>
<th>Category</th>
<th>B1 HadCM3</th>
<th>B2 HadCM3</th>
<th>A1FI HadCM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average carbon flux (% of emissions) **</td>
<td>2.5</td>
<td>2.7</td>
<td>2.1</td>
</tr>
</tbody>
</table>

**Δ Soil organic carbon (Pg C)††**

<table>
<thead>
<tr>
<th>Category</th>
<th>B1 HadCM3</th>
<th>B2 HadCM3</th>
<th>A1FI HadCM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ Soil organic carbon (Pg C)††</td>
<td>−0.1</td>
<td>−0.9</td>
<td>−4.1</td>
</tr>
<tr>
<td>Total</td>
<td>−0.1</td>
<td>−0.9</td>
<td>−4.1</td>
</tr>
<tr>
<td>Cropland</td>
<td>−4.3</td>
<td>−4.3</td>
<td>−5.9</td>
</tr>
<tr>
<td>Grassland</td>
<td>1.5</td>
<td>−1.2</td>
<td>−2.2</td>
</tr>
<tr>
<td>Forest</td>
<td>2.8</td>
<td>3.6</td>
<td>1.0</td>
</tr>
</tbody>
</table>

---

Schroter et al. 2005 Science