Opportunities for network-level analyses emerging from the TRENDS project

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Objectives of Trends

(1) to *create a platform for synthesis* by producing a compendium of easily accessible long term graphs and data from long-term ecological research sites

(2) to *illustrate the utility of this platform* in addressing important within-site and network-level scientific questions
Trends in Long Term Ecological Data

48 sites: 26 LTER, 17 USFS, 9 ARS, 1 UA

[Map showing 48 sites with different symbols and colors, each representing a specific agency such as LTER, USFS, ARS, or University of Arizona.]
Products

1. Folio-sized book to be published by Oxford Univ. Press
2. Website (data, metadata) for synthesis and analysis

Requirements of a dataset for inclusion

1. Ideally: $\geq 10$ years data
2. Derived data (response over time) with links to raw data
3. Metadata: preferably in Ecological Metadata Language (EML)
Trends in Long Term Ecological Data

LTER sites (PIs, IMs)
- Develop EML for long term datasets
- Provide long term data, metadata

Jornada LTER-ARS
- Collect long term datasets, metadata
- Develop derived data and document procedure
- Produce initial graphs for QA/QC
- Organize editorial comm mtgs
- Initial support for project coordinator
- Produce graphs for the book
- Initial web page and database development

LTE Network Office
- Assist sites in EML development
- Fund editorial committee mtgs
- Store final datasets and web page

TRENDS editorial committee
Book and web page content and design

Web page and database

NCEAS
- Assist Jornada LTER & LNO with automated EML harvesting, storage, and generation
- Fund NCEAS travel to editorial comm mtg
- Fund project coordinator travel to NCEAS for training

NSF
Fund project coordinator and staff
**Book organization**

1. **Introduction**: value and importance of long-term research
2. **Within-site graphs/tables** arranged by four themes in the LTER Planning Process
   - Climate and variability in the physical environment, including disturbance characteristics
   - Human population and economy
   - Biogeochemistry (e.g., atmospheric deposition, surface water chemistry)
   - Biotic structure (e.g., ANPP, plant biomass, species richness)

   Standard graphs and illustrative graphs

3. **Among-site comparison** graphs
   - e.g., atmospheric chemistry, N fertilization, climate variability

4. **Site descriptions** and photos organized by biomes

**Website organization**: static and dynamic data and their associated metadata by themes with search, graph, and analysis tools
How were variables selected for the book? (page limits)

1. Submitted broad request for long-term data from all sites.
2. Examined submitted data for consistent variables across sites (e.g., climate)
3. Requested additional data from sites for variables that should exist, but may not have been submitted (e.g., ANPP, species richness, N mineralization)
4. Made a “wish list” of variables that may be important for cross-site and network-level questions, but long-term data don’t exist yet at very many sites (e.g., soil respiration, foliar nutrients).
5. Book will include variables from 2. and 3. Information from 2-4 is useful for the LTER Planning Process and Strategic Analysis.

How were variables selected for the web page?

1. Use all variables from book in static form first
2. Update data sets with time and include additional variables
1. Introduction: value of long-term data and research

2. Within site section of book: climate

Arikaree Glacier

Net Balance (cm W.E.)

Trend = -2.43 cm/yr
$R^2 = 0.132$

Niwot Ridge LTER (Colorado)

Net loss of a glacier through time

Drought accelerated loss
Figure 4.8. Reconstructed time line of hurricane occurrence and intensity at the Harvard Forest since 1620. Although hurricanes have had a frequent impact on the area, the 1938 storm stands out as the most intense in recorded history.

Source = Forests in Time

Harvard Forest: Hurricane history in New England
Sevilleta: Variability in urban population as proportion of total for three counties

1790-1960 Database compiled by Chris Boone, Arizona State University
1970-2000 Database compiled by Nichole Rosamilia and Ted Gragson, University of Georgia
Within site: Human population (Palmer LTER)

1992-2007 ANTARCTIC TOURIST TRENDS - Landed
[Includes Ship and Land-based passenger numbers. 1997-98 onwards includes commercial yacht activity.]
Within site: biogeochemistry
Hubbard Brook LTER (New Hampshire)

SO\textsubscript{2} Emissions (Tg/yr)

Sulfate Concentration (µmol/L)

Streamwater

Precipitation

HBEF 24-hr Source Area (Likens et al. 2005 JEM)

R\textsuperscript{2}=0.66

R\textsuperscript{2}=0.61
Within site: biotic structure

Palmer LTER (Antarctica)
Change in penguin species composition with time
3. Among sites section of book: People, landuse, and vegetation cover

1790-1960 Database compiled by Chris Boone, Arizona State University
1970-2000 Database compiled by Nichole Rosamilia and Ted Gragson, University of Georgia
Trends in Long Term Ecological Data

Palmer Drought severity index (1895-2003)

- LTER: http://www.lternet.edu
- USDA FS: http://www.fs.fed.us/
- USDA ARS: http://ars.usda.gov
- University of Arizona: http://www.arizona.edu/
Among sites: state changes

Fig. 4. Dynamics of shrub (●) and grass (○) cover from 1937 to 2003. Results are based on the merged classification of levels 1 and 2 of the image object hierarchy. (Laliberte et al. 2004)

Jornada ARS- LTER (New Mexico)  
State changes through time

Santa Barbara Coastal LTER (California)  
Change in fish species composition with time
Step 1. Graph similar data through time for sites with those data.
Step 2. Determine trend line by site.
Step 3. Compare slopes of trend lines among sites.

Mean change in total deposition of N from Nitrate by precipitation per year
Step 4. Compare spatial distribution of slopes of trend lines

Nitrate deposition in rainfall (slopes)

- Positive slope
- 0 slope
- Negative slope

LUQ

Trends in Long Term Ecological Data
Trends in Long Term Ecological Data

**Sea Level, San Diego**
- Raw sea level, monthly averages

**Sea Level anomalies, San Diego**
- Anomalies from the monthly mean sea level, with a linear trend
  - Equation: $y = 1.00902x - 3953.94267$
  - $R^2 = 0.32724$

**Detrended anomalies** (i.e., residual after subtraction of linear trend)
- An index of El Niño in mid-latitudes
Hubbard Brook Experimental Forest (HBEF) was established in 1955 as a center for hydrologic research in New England. The site is located within the White Mountain National Forest in central New Hampshire. Early studies focused on the impacts of forest management on water yield and quality. The Hubbard Brook Ecosystem Study (HIES) originated in the early 1960s as a joint research program between the USDA Forest Service and Dartmouth College to use the small watershed approach to study element flux and cycling. In 1988, the HBEF was designated as a Long Term Ecological Research site by the National Science Foundation. Today, over 40 scientists from approximately 20 institutions participate in the HIES. The Northeastern Forest Experiment Station of the USDA Forest Service manages the site for long-term ecosystem research.

Hubbard Brook Experimental Forest (HBEF) is representative of the Northern Forest, which covers more than 26 million acres stretching from the northern woods of Maine down into the Adirondack and Tug Hill regions of New York. Most of the Northern Forest is undeveloped forest that includes a mixture of mountain ranges, rivers, lakes, and wetlands that provide habitat for many wildlife species, including moose, pine martens, Canada lynx, songbirds, peregrine falcons and bald eagles. Critical environmental issues for the Northern Forest are land development, air pollution, climate change, introduced species, water supply and quality and carbon management.

The primary goals of the HIES are: 1) to advance scientific understanding of forest and aquatic ecosystems, their ability to provide ecosystem services to humans, their response to natural and human-induced disturbances, and provide a scientific baseline for management and policy decisions; 2) to offer educational and research opportunities to students; and 3) to promote greater public awareness of ecosystem science, with a focus on the Northern Forest.

**Site Description and Characteristics** The HBEF is a 3.138-ha, bowl-shaped Valley, ranging from 222 to 1,015 m in altitude. A network of precipitation and stream-gauging stations, weather instrumentation, as well as soil, vegetation and animal monitoring sites are established at the HBEF. There are ten gauged experimental watersheds, including several used for long-term experiments. Annual precipitation averages about 1,400 mm, with one-third to one-quarter as snow. A snowpack usually persists from mid-December until mid-April, with a peak depth in March. January temperature averages -9°C and July is 18°C. The growing season for trees is considered to be from 15 May to 15 September. The estimated annual evapotranspiration is about 500 mm. Soils at Hubbard Brook are predominantly well-drained Spodosols, Typic Haplotrods, derived from glacial till, with sandy loam textures. These soils are acidic (pH about 4.5 or less) and relatively infertile (base saturation of mineral soil ~ 10%). A 20- to 200-mm thick forest floor layer is present. The HBEF is entirely forested, mainly with deciduous northern hardwoods: sugar maple (Acer saccharum), beech (Fagus grandifolia), and yellow birch (Betula allegheniensis). Red spruce (Picea rubens), balsam fir (Abies balsamea), and mountain paper birch (Betula papyrifera var. cordifolia) are abundant at higher elevations and on rock outcrops. Pin cherry (Prunus pensylvanica), a shade intolerant species, dominates all sites for the first decade following a major forest disturbance. Logging operations ending around 1915-1917 removed large portions of the conifers and better quality, accessible hardwoods. The present second-growth forest is even-aged and composed of about 80 to 90% hardwoods and 10 to 20% conifers.

**Research Focuses** The small watershed ecosystem approach to nutrient cycling was pioneered at Hubbard Brook. This method uses the forest as a living laboratory in which scientists conduct experiments on an entire watershed and monitor resulting long-term changes in streamflow, nutrient cycling, forest growth and habitat. Whole ecosystem manipulations conducted at Hubbard Brook include experiments that simulate typical forest management practices, such as forest clear-cutting, strip cutting, herbicide application and base cation additions, and provide a scientific basis for improved forest management.

A strength of the HBEF is the long-term monitoring program. Our long-term data show that short-term observations are often misleading and that decades may be required to detect real changes in complex ecosystems. The long-term record at the HBEF provides: 1) insight into ecosystem function, 2) empirical data for testing models and generating hypothesis, 3) a record of extreme or unusual events, and 4) information that is relevant to regional, national and global issues.
The Trends Project

The Trends project is a collaborative effort among agencies and institutions to make long-term ecological data easy to access, analyze, and compare across sites. Data from Long Term Ecological Research (LTER) sites funded by the National Science Foundation (NSF), from US. Department of Agriculture Forest Service (USFS) and Agricultural Research Service (USDA ARS) sites, and from sites operated by universities are being accumulated into a central portal for access.

This website is the portal to:

- a large and diverse collection of derived and current long-term ecological data
- unique data exploration graphing and synthesis tools
- information about our large array of collaborating agencies and their individual sites.

These data, tools and information are freely available to researchers who wish to pursue cross-site synthetic studies or students interested in learning more about resources available to them.

In addition, the graphs found in our book, *Our Changing World: Insights From Long Term Ecological Research*, as well as the data used to generate them, can be easily browsed and viewed here.

[Click here](#) to learn more about the background of the Trends project, or browse our site using the buttons to the left.

**What's New?**

This website was unveiled to enthusiastic scientists and information managers at the LTER All Scientists' Meeting (ASM) September 19-24, 2006.

**Featured Dataset**

Featured dataset will go here (random dynamic display?)
Progress to date

Contributors: 26 LTER (84%), 15 FS (12%), 6 ARS sites (3%) & Santa Rita ER (<1%)

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<td>Others</td>
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<td>Total</td>
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Illustrative graphs: 190

Human population and economy: collected for all LTER sites from census data (funded by NSF supplement)

Metadata: Most data have at least rudimentary metadata, few have full EML with attribute level description of the datasets.
Goals

Sept. 2006 (LTER ASM)
- Book ca. 80% complete
- Website front-end plus static data sets

Improve collaboration with CUAHSI

2007-
- Submission of book for publication
- Addition of dynamic datasets, more advanced querying, graphing, and analysis tools to website

Long term
- Link to education community (e.g., TIEE)
CUAHSI: Trends Sites that have Aboveground Net Primary Production (ANPP) data
Opportunities


2. Submit long-term data for the book (Oct. 15, 2006) and web page (Jan 2007)

3. Participate in synthetic analyses

ENSO signals and responses – Mark Ohman (mohman@ucsd.edu)
Response to climate variability – Tim Kratz (tkkratz@wisc.edu)
People, landuse, and vegetation – Morgan Grove (jmgrove@gmail.com)
Disturbances – Ariel Lugo (hanael@caribe.net)
N Fertilization – Scott Collins (scollins@sevilleta.unm.edu)
Atmospheric chemistry – Charley Driscoll (ctdrisco@syr.edu)
State changes – Deb Peters (debpeter@nmsu.edu)