Workshop Report:

LTER Extreme Events Working Group (XEWG)
Workshop Help 24-27 June, 2004 Portland, OR

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This workshop stemmed from a working session at the 2003 LTER All-Scientist's meeting held in Seattle, WA, who's purpose was to identify a cross-site research climate initiative to follow from the highly successful CVER program. During this discussion, it was suggested that a cross-site examination of weather and climate extremes would provide a research program beneficial to the goals of LTER. A workshop was organized in Portland in June, 2004 to initiate this research program.

During the course of the two-day workshop, much of the discussion centered on exactly how to define an extreme event. One of the interesting outcomes of this discussion was recognition of the need for two definitions, one for climatic extreme events and one for extreme ecological response. I think paying attention to both of these factors is a characteristic of our project that differentiates it from other studies of extremes.

Regarding climate extremes, we came up with two broad, definitional characteristics; 1) extremes exceed some sort of limit in terms of magnitude, duration, and frequency, and 2) extremes are sensitive to the context in which they occur (i.e. the local climate) relative to some predefined time horizon (e.g. 30-500 years). Based on these two characteristics, we developed the following definition:

> *Extreme climatic events are statistically rare in frequency, magnitude, and/or duration for a single climate parameter or combination of parameters for a particular ecosystem. The ability to recognize and categorize extreme events is dependent upon the length of reliable observational records. An extreme climatic event may or may not induce an ecological response.*

This definition conforms fairly well to the definition given in existing climatic literature. The definition also "works" from a climatological, as opposed to a meteorological perspective. This is especially important, since most of the specific research goals we laid out assumed that we would search the LTER and other climate databases for longer-term anomalies.

Defining an extreme ecological "events" turned out to be a bit more complicated than the climatic definition. A number of definitional concepts were considered, most of which seemed to be framed in terms of ecosystem composition, process, or structure. Like the climatological definition, the definition of ecological response seemed to hinge on the idea of limits, but the complexity of ecological systems and their responses necessitated a more complex consideration of the idea of limits. Thus, extreme ecological effects might exceed limits at single or multiple hierarchical levels. Changes might be transient or persistent, and they may or may not affect the future response of the ecosystem of its components. Directional change and reestablishment of baselines were discussed. The consensus seemed to be that new baselines could result from a climatic disturbance, but that baseline change was not "required" in order to consider an ecological response to be important or significant. The following definition resulted from the discussion:

A extreme ecological response is a change in ecological attributes that is statistically rare in frequency, magnitude, and/or duration, or a persistent alteration of ecological properties at any level of organization.

The second day of the workshop was devoted to revisiting the definitions and working toward devising a set of framework questions to guide the analysis. It quickly became clear that there were really two sets of questions that needed to be considered. These first of these addressed how to extract information about ecological extremes, either directly (from climate and ecological data), or indirectly by soliciting information from research cooperators very familiar with one or more ecosystems. These questions tended to be fairly general.

What on site records are available, how long are they? What is the number of weather stations? What variables are measured?

Is there a regional weather stations near a site? If so, what variables are measured, what is the length of record for each variables, etc.?

As a first approximation, does it make sense to limit interest to one ecological response variable (e.g. productivity), or a small set of common (core) EVs?

What is the timing and duration of the growing season? How do you define growing season?

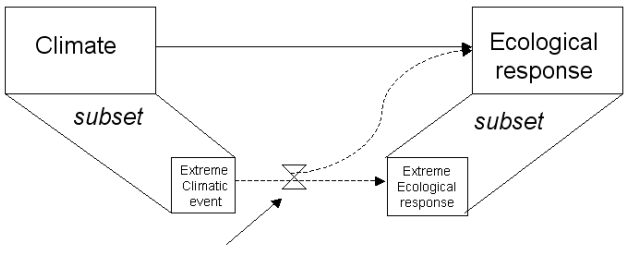
When is productivity measured?

What temperature thresholds are established for key organisms at your site?

What key organisms do you have long term datasets for?

What organisms strongly influence ecological processes at your site?

The second set of framework questions refers to how the data will be analyzed or how ecological responses will be characterized or classified. The concept behind the analysis is well-illustrated by a diagram developed by M. Smith's:



Context
1. Ecosystem sensitivity/vulnerability
2. Antecedent conditions
3. Community evolutionary history
4. Genetics
5. Anthropogenic influence (management)
6. Co-occurring stress factors

Within this context, Key research questions are aimed at understanding the nature of the contextual "switch" that determines whether a system goes on to an extreme response, or shows a non-extreme response. Some of these questions might include:

Does an ecological impact involve the disruption of existing relationships or completion of a threshold change?

Does successional stage or community age effect the conditions for or consequences of an extreme climatic event?

What is the time scale of the response (to complete response cycle)?

Is response mediated by organisms?

Is effect direct or cascading?

What antecedent conditions are required for a response to occur/must effects occur in a certain sequence?

What is the role of biota (browsers, grazers, etc.) in conditioning system?

What weather/climate variables are associated with the highest productivity and lowest productivity in a system?

Are there any extreme climatic events associated with the elimination of species and/or the establishment of new species?

Is there a seasonal component of ecological response?

What weather/climate variables are most important (precip, thermal, wind, mixture, etc.)?

Does the ecological response result from novel combinations of climate extremes?

What ecosystem variable(s) respond(s)?

What limits or thresholds must be exceeded in order for the response to occur?

Next Steps

The "roadmap" for completing the project includes milestones related to data gathering/analysis, writing, and funding issues. The most immediate task we set was to begin a pilot study focused on how to identify both climate and ecological extremes (guided by our definitions) and ways to examine the links between the two. This pilot study will serve a number of purposes. First, it will help establish working procedures for a full-scale, cross-site analysis. Second, it will form a part of an initial publication (probably slated for Bioscience) outlining the goals and objectives of the project. Third, it will serve as a springboard for seeking funding to support the full scale analysis. Our immediate task will therefore be to gather and analyze data for this initial analysis. Because of the complex nature of the questions we are asking, the pilot project will need to be simplified in terms of both number of sites analyzed, and variables analyzed at each site. We settled on use of temperature and precipitation as the climatic factors, and productivity as the ecological response variable. These data are part of the LTER core data set, and should be available (although I am certain that there will be some challenges).

•Construct probability distributions for key climatic variables (temperature, precipitation, wind) and ecological responses (productivity, diversity)

- How many extreme events? Timing? Adjacency in time in extreme events?
- Using moving window analyses?
  - At variable time windows (2 day, 10 day, etc.)
- For climate data: construct long-term (regional) and short-term (site-specific) probability distributions of climate data

Once this statistical analysis is done, we can identify extreme events in the climate record and relate them to response in productivity.

Publications and Presentations Related to LTER Workshop on Extreme Events

Presentations:

Goodin, D.G. 2007. Extreme events and landscape phenology: Past and future prospects for climate change research at LTER sites. Presented at the Annual Meeting, The Wildlife Society, Tucson, AZ September, 2007.

Goodin, D.G. And Losleben, M. 2005. Climatology of extreme preciptation events at Long Term Ecological Research sites. Paper presented at ASCE Environmental Water Resources Institute World Water Congress, May, 2005, Anchorage, AK.

Publications:

Goodin, D.G. and Losleben, M. 2005. Climatology of extreme precipitation events at Long Term Ecological Research Sites. in: Proceedings of the 2005 World Water and Environmental Resources Congress, 15-19 May, 2005. Anchorage, AK.

Articles/Chapters in Preparation:

Goodin, D.G and Henebry, G.M. Extreme events and landscape phenology: climate change and landscape response at selected LTER sites. Invited Book Chapter (Volume name TBA). In preparation.