Proposal for ASM workshop follow-up (coPIs: Rusak, Fraterrigo and Turner)
**Disturbance and Variance: Detecting change in terrestrial and aquatic ecosystems**

**Rationale and Conceptual Framework**

Populations, communities, and ecosystems vary in space and time. Variability is a fundamental property of natural systems, and its quantification and interpretation cross boundaries between many different disciplines. However, our understanding of how the temporal and spatial variability of ecological properties respond to disturbance is incomplete. Ecologists typically focus on changes in the mean to characterize system response to disturbance, but this may result in the loss of considerable information about the response. Although mathematical theory (e.g., Rosenzweig 1971) and verbal (e.g., Odum 1979) and statistical (e.g., Underwood 1991) models all predict altered variability as a result of disturbance, empirical attempts to test this relationship have been few (Cottingham 2000). Given the pervasiveness of disturbance as a structuring force in ecosystems, as well as the potential for increased variance to mask system response to experimental treatments and management scenarios, we feel that this relationship is critical to improving our understanding of the temporal and spatial determinants of ecosystem dynamics.

We began our workshop with a number of questions in mind. How often do perturbations affect system variability? Is altered variance a useful metric for detecting either direct effects or legacies of disturbance? What are the best approaches to detect changes in variability at different spatial and temporal scales or levels of organization? Given the wide variety of natural and anthropogenic disturbances occurring at LTER sites (e.g., hurricanes, drought, fire, eutrophication, exotic invasions, and land-use change) and the broad range of ecological characteristics measured, our network is ideally suited to address such issues. We propose to use both LTER and non-LTER datasets to investigate the ability of disturbance to alter the variability of populations, communities and ecosystems across a wide range of habitats. The questions above, as well as those identified in the workshop discussion below, provide a starting point for these investigations.

**Outcome of ASM workshop**

During our ASM workshop, Jennifer Fraterrigo (Coweeta) opened the talks with a comprehensive examination of changes in spatial variability of terrestrial forest ecosystems in the Appalachians as a result of historical land use change. She showed that despite little or no changes in mean values for soil chemistry and structure, historical land use practices had dramatically altered the variance (both increases and decreases) of these parameters compared with relatively undisturbed sites. James Rusak (North Temperate Lakes) provided an overview of disturbance-variance relationships over time in a variety of aquatic ecosystems. He demonstrated large increases in population, community and ecosystem variability (again often with no detectable difference in mean response) in multiple whole-lake experiments that mimicked current anthropogenic stresses on aquatic ecosystems (eutrophication, acidification, species introductions). Pierre Legendre (invited speaker, U. of Montreal) presented an innovative multivariate technique capable of partitioning variation at essentially all spatial and/or temporal scales present in a dataset (biological or physical) as they relate to measured environmental (or disturbance) variables. Using a variety of terrestrial and aquatic datasets, sampled over both space and time, he showed the usefulness of this new technique at extracting patterns that would otherwise have gone unnoticed.

In the half hour discussion that followed, the audience generated a number of further questions and issues. Were there certain types of disturbance that always elicited a similar

response in variance? Were there thresholds that had to be crossed before variance responded? How could the effects of multiple disturbances on ecosystem variance be reconciled? How does altered variance affect predictability of ecosystem function? The workshop was very well attended and researchers from a number of LTER sites expressed an interest in collaboration given the prevalence of disturbance as an important process in generating a wide variety of ecosystem behaviors across a wide range of ecosystem types.

**Plan for synthesis working group (goals, participants, timing, and products)**

We propose to convene a working group of interested participants in the spring and fall of 2004 with three goals:

1) Draft a proposal for an NCEAS working group focused on the relationship between variability and disturbance. While the specific research questions will depend on the datasets available for synthesis, we anticipate highlighting a subset of the questions indicated here as well as others to address the generality of disturbance-driven changes in variance and to establish a research agenda for examining such patterns.
2) After surveying interested sites prior to convening, determine the most appropriate datasets currently available for a cross-site synthetic effort on this topic.
3) As an initial synthetic project, using the LTER and non-LTER datasets available to the workshop, address how commonly disturbance alters variance across space and time in different ecosystem types and develop a framework for investigating these patterns. We will focus our efforts on three areas: 1) how and when disturbance events generate changes in variance; 2) the scale-dependency of global (i.e., total) and structural (i.e., spatial and temporal) changes in variance; and 3) appropriate methods for detecting altered variability, both global and structural. We expect this first attempt at synthesis to generate a paper for *Ecology* that examines this issue in a few well-studied systems and sets the stage for future synthetic efforts at NCEAS or in additional meetings of working group participants.

The first two goals will be completed at our spring meeting, while the last goal will be the focus of the fall meeting. Our desire is to have participation from a total of 7-8 non-LTER and LTER individuals that capture the gradients (space-time, terrestrial-aquatic) inherent in our project, as well as representation from ecological statisticians familiar with these issues (see below). To reduce travel and accommodation costs (given participation from at least 3 investigators from University of Wisconsin), the spring meeting will be held at the Center for Limnology at UW-Madison and the fall meeting at the Center's Trout Lake Biological Station.

**List of potential participants (*confirmed)**

*James Rusak (University of Wisconsin - Madison, Trout Lake Station: NTL)
*Jennifer Fraterrigo (University of Wisconsin - Madison: CWT)
*Monica Turner (University of Wisconsin – Madison: NTL/CWT)
Brandon Bestelmeyer (New Mexico State University: JRN)
Terry Chapin (University of Alaska: BNZ)
Kathy Cottingham (Dartmouth College)
Philip Dixon (Iowa State University)
Marie-Josee Fortin (University of Toronto)
George Kling (University of Michigan: ARC)
Tim Schowalter (Louisiana State University: AND)
Michael Palmer (Oklahoma State University)

**Budget**

*Spring Meeting (3 nights)*
Airfare and Transportation (6 people): 6 X $500 = $3000
Accommodation: 6 X $210 = $1260
Meals: 8 X 4 X $22.5 = $720

*Fall Meeting (3 nights)*
Airfare and Transportation (6 people): 6 X $500 = $3000
Accommodation: 7 X $30 = $210
Meals: 8 X 4 X $22.5 = $720
Page charges: $1000

TOTAL: $9910

**References**

Cottingham, K.L., J.A. Rusak, and P.R. Leavitt. 2000. Increased ecosystem variability and reduced predictability following nutrient enrichment: evidence from paleolimnology. Ecology Letters 3: 340-348.

Odum E.P., Finn J.T. and Franz E.H. 1979. Perturbation theory and the subsidy-stress gradient. BioScience, 29: 349-352.

Rosenzweig M.L. 1971. Paradox of enrichment: destabilization of exploitation ecosystems in ecological time. Science, 171: 385-387.

Underwood A.J. 1991. Beyond BACI: Experimental designs for detecting human environmental impacts on temporal variations in natural populations. Australian Journal of Marine and Freshwater Research, 42: 569-587.