Community-level modeling of abrupt changes in paleoforests

Tanjona H. Ramiadantsoa[1], M. Allison Stegner[1], John W. (Jack) Williams[2] and Anthony R. Ives[1], (1)Zoology, University of Wisconsin-Madison, Madison, WI, (2)Geography, University of Wisconsin-Madison, Madison, WI

Background/Question/Methods

Abundant pollen records have revealed that over the last 11,700 years, there have been abrupt changes in relative abundance of several tree species. For instance, across many sites in northeastern North America, *Tsuga* (hemlock) declined ca. 5500 BP, and at some locations in less than 10 years. Other abrupt changes include declines in New England *Quercus* (oak) populations coincident with the *Tsuga* decline, *Fagus grandifolia* (American beech) declines during the last 3,000 years, and *Picea* (spruce) declines across eastern North America at the Pleistocene-Holocene transition.

A prevailing hypothesis is that environmental changes (i.e., extrinsic factors) cause such abrupt changes. This hypothesis is usually assessed either by matching paleoecological time series to independent paleoenvironmental times series, or by searching for regional patterns of synchrony, time-transgression, or clustering among paleoecological records of abrupt change. Few studies, however, have attempted to directly model the extrinsic and intrinsic processes that may cause past abrupt ecological change.

In this study, we examined whether abrupt changes can arise without associated changes in external drivers. Do abrupt changes in the relative abundance of species in pollen records result from changes in climate?

Results/Conclusions

We developed a mathematical model for changes in the frequency of five species. First, we show that abrupt declines can be generated without any long-term climate change: instead, competitive interactions can lead to near-random-walk dynamics that include – by chance – abrupt declines. Second, while the simultaneous declines at many sites might implicate a broad-scale climatic change, we show that broad-scale declines can also be caused by spatial synchrony caused by dispersal. Therefore, for spatial scales at which dispersal can enable spatial synchrony, the simultaneous declines of a species at multiple sites is not strong evidence that climate change is the cause. Finally, we show that even good data for climatic drivers do not necessarily solve the difficulties of trying to infer the role of climatic factors in species declines.

A partial solution to these problems is to analyze and model the temporal dynamics in multiple species and sites simultaneously. Time series of community changes have more information that time series for single species. Process-based models of past community dynamics that include community-level processes such as species competition and external forcings such as climate change offer the opportunity for better testing hypotheses of past ecological abrupt changes.