Impacts of past climate change on species distributions of woody plants in North America

The modern distributions and genetic structure of North American tree species represent, in part, legacies of climate changes of the past 25,000 years and more. Development of extensive networks of pollen and plant-macrofossil records from lakes, wetlands, and woodrat-middens across North America are revealing the magnitude and complexity of climate-change effects. Climate changes since the last glacial maximum have affected the geographic distributions of every tree species on the continent. However, not all species have been affected in the same way. In fact, a broad spectrum of responses is observed in the fossil record. Species responses have ranged from complete geographic displacements to relatively minor shifts along local habitat gradients. Many species that were widespread and dominant during the last glacial maximum continue to be widespread and dominant today, although in different locations. However, other dominant, widespread species of the past are now highly restricted (and in one case, extinct), while several minor glacial-age species have expanded to become dominant over wide regions today. Several species, rare today and rare during the last glacial maximum, were regionally dominant during the late-glacial transition. Some species have even contracted their ranges southward since the last glacial period. The diversity of responses observed in the fossil record can be explained by the diversity of ecological niches represented by tree species, together with the complex and multivariate nature of climate change. Many of the unexpected distributional changes (e.g., southward migration during a glacial-to-interglacial transition) and peculiar species assemblages (e.g., forests of spruce, elm, ash, and hornbeam) observed in the fossil record are attributable to past climates that have no counterparts in the modern world. A major challenge for the future is to determine whether we can develop capability to predict responses to ongoing and future climate change. This task is not as straightforward as it might seem; future climates are likely to have no modern analogs, and may be as different from those of the 20th Century as were climates of 11,000 years ago. It is thus essential to integrate our understanding of past responses from the fossil record with knowledge of modern ecology and genetics to identify the critical climate controls of abundance and distribution.