Meeting Reviews

Fire, Climate, and Vegetation in the Americas

"Fire and Climate History in Western North and South America," a workshop held in Tucson, Arizona, 23–28 March 2002. Sponsors of the workshop included the USDA Forest Service PNW Research Station (Forest and Inventory Analysis Program), the IGBP Past Global Changes Program, the U.S. Interagency Joint Fire Sciences Program, the NSF Earth Systems History Program, the Inter-American Institute, and the University of Arizona.

Fire, climate, and vegetation jointly act to shape forest ecosystems in the midlatitudes of western North and South America, but the strength and nature of the linkages among the external controls (i.e., climate) and internal responses (i.e., fire and vegetation) vary depending on the temporal and spatial scale of interest. The objective of the workshop was to share recent advances in fire history and fire climate research in the temperate forests of western North and South America, and to consider ways of integrating different methodological approaches to studying fire in order to develop a better understanding of the vegetation–fire–climate system. The workshop brought together researchers who study past variations in fire activity as recorded by tree ring and sediment data, and who consider the climatic controls of fire on annual, decadal, and longer time scales. The participants included scientists from Argentina, Australia, Canada, Chile, England, Mexico, Russia, Switzerland, and the United States.

The workshop focused on the temperate forests of western North and South America because these regions present an opportunity to study the response of fire under an array of climate and vegetation conditions.

Topics discussed at the workshop included:

- specific mechanisms that link large-scale and secondary circulation features with the occurrence of fire in particular regions;
- analysis of past climatic variability and changing fire regimes on annual-to-millennial time scales;
- regional, interregional, and interhemispheric comparisons of the records of climate, fire, and vegetation on multiple time scales;
- integration of annual-to-decadal resolution reconstructions of fire history (provided by dendrochronological records) and decadal-to-centennial resolution fire history reconstructions (provided by lake sediment records);
- importance of fire, vegetation, and climate histories for improving fire management strategies.

The workshop focused on two types of fire proxy data: (1) dendrochronologic tree ring, fire scar, and tree stand age records, which provide high spatial and temporal resolution of fire activity over the past few centuries; and (2) stratigraphic records of charred particulate matter (charcoal) from varved and nonvarved lake and marine sediments, ice cores, peatlands, debris flows, and soils, which provide records of fire on centennial-to-millennial time scales. Because charcoal records of fire span thousands of years, they provide information on the role of fire during past periods of climate and vegetation change. Networks of both dendrochronological and charcoal records are now available for the western United States and southern South America, and they reveal temporally and spatially coherent patterns in fire occurrence for both regions.

Workshop participants strongly encouraged the use of multiple lines of proxy evidence to reconstruct past fire regimes. A study of a wetland from Chile, for example, examined both plant macrofossils and charcoal in a sediment core and found that periods of drought, inferred from the plant remains, were also associated with periods of increased burning. In this study, the paleobotanical record provided a climate signal that could be used to help interpret the charcoal record. Close-interval pollen sampling was proposed as another approach that might shed light on the long-term ecological responses to changes in disturbance regimes. Analysis of pollen and charcoal data at the same time resolution has provided considerable insight into forest response to fires in Europe and eastern North America, but has not been undertaken in the western United States. Another study used charcoal in alluvial fans in Yellowstone National Park to reveal that periods of fire-related debris flows were also times when fires occurred in a wide range of environmental settings. Several studies presented at the workshop combined charcoal and tree ring records to reconstruct the fire history of particular watersheds. New collaborations between tree ring and lake sediment research, disciplines that have generally worked in isolation, are now underway in Argentina and Chile as a result of workshop discussions.

The broad-scale climatic controls that give rise to conditions conducive to fires at individual locations were also discussed at the workshop. These controls include the location of upper-level ridges, broad-scale areas of rising or sinking motions, and seasonal variations in convection and lightning occurrence. Understanding these broad-scale climatic controls of fire is particularly challenging, because the synoptic-scale circulation patterns that favor fire often differ substantially from the specific daily circulation patterns that prevail during the initiation of fires.

Fire and climate proxy records also show the strong influence of annual-to-decadal scale climate variability in fire occurrence. Although the importance of El Niño-Southern

Oscillation (ENSO) effects in the American Southwest and northern Patagonia was acknowledged, most researchers agreed that ENSO did not explain all of the fire variability on annual and decadal time scales. Research documenting, comparing, and assessing such patterns in other regions of the western United States and southern South America will advance the predictive capability of climate–ecosystem response models.

The examination of fire occurrence on different time scales provided an opportunity to reevaluate some of the basic concepts used to describe fire regimes. The concept of a "mean fire-return interval," or the average period of time between fires, was critiqued by both the tree ring and charcoal communities. Tree ring and charcoal data show quite clearly that fire frequency is nonstationary through time and strongly tracks variations in climate.

The workshop also provided an opportunity to identify current methodological limitations. The source area represented by charcoal in sediment records, for example, is often uncertain and could be better identified with additional studies of charcoal deposition in sediments during and after modern fires. The impact of different sampling strategies for tree ring studies also needs to be examined more closely to determine the effect of sampling methods on reconstructions of fire area. Conflicts in terminology used by the tree ring and charcoal communities were also discussed at the workshop. For example, intervals in lake sediment records with high levels of charcoal accumulation, the so-called charcoal peaks, are inferred to represent a period of time in which one or more fires took place. It was agreed that these peaks should be referred to as fire *episodes* to convey the imprecision in the age of the peaks, and the number of fires and source areas represented by each peak.

The workshop addressed the importance of retrospective fire climate studies as a tool for fire management. Long-term perspectives emphasize that fire regimes vary over time and that climate variability is the primary control in shaping fire regimes on long time scales. The legacies of past fires, as well as periods without fire activity, also need to be considered in developing fire management strategies. Although the effects of fire suppression policies are evident in low-elevation dry forests, fire history data suggest that fire suppression may have only limited impact in wet forests at higher elevations and along the coast. Moreover, projections of future climate changes indicate that fire activity in most regions will increase, suggesting the need for an adaptive approach to fire management.

Workshop participants observed that tree ring and charcoal research is also important to other global change research efforts. In addition to providing a long-term perspective on the incidence of fire and its covariation with climate and vegetation, the fire-proxy records discussed at the workshop could also be used to test and validate a variety of models, such as dynamic ecosystem models, that simulate fires.

Products of the workshop will include the development of an international fire history database that includes both tree ring and high-resolution lake sediment records; a web page for further exchange of research ideas and public information; and a series of synthesis papers that describe fire climate variations both within and between continents. For more information about the workshop, please contact Cathy Whitlock, Patrick Bartlein, or Tom Swetnam (see e-mail addresses below).

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