

SPECIAL ISSUE FIRE HISTORY IN CALIFORNIA

A common refrain that fire historians hear from managers and scientists is: “Haven’t we done enough fire history studies already, especially in ponderosa pine? What more is there to learn?” It is true that there are dozens of published studies in western North America using tree rings to evaluate the historical range and variability of past fire regimes. It is also true that the majority of these studies were conducted in pine dominant or mixed-conifer forests where moderate to high frequency surface fire regimes prevailed for centuries before the fire suppression era. Despite the substantial body of existing fire history literature, this special issue of *Fire Ecology* serves to demonstrate that, in fact, there is still much more to learn.

This set of seven papers expands our understanding of long-term fire history, climate, and land use effects on fire regimes in several new geographic locales and ecosystems in California. In three papers (Vaillant and Stephens, North *et al.*, and Gill and Taylor), we learn about fire history on the eastern slope of the Sierra Nevada, where little previous work has been done. All of these studies (plus the Skinner *et al.* study located in northern California) rely in part on ponderosa pine (*Pinus ponderosa* C. Lawson) or Jeffrey pine (*Pinus jeffreyi* Balf.) fire scarred trees to reconstruct detailed fire history. The North *et al.* study also extends to higher elevation forests of lodgepole pine (*Pinus contorta* Douglas ex Louden), foxtail pine (*Pinus balfouriana* Balf.), and bristlecone pine (*Pinus longaeva* D.K. Bailey).

Although we are generally familiar with ponderosa, Jeffrey pine, and mixed-conifer fire regimes, the details of new studies like these reveal both specific and novel differences from general patterns, leading to new perspectives and understanding. For example, these four papers reveal the specific importance of local (bottom up) controls, such as topographic isolation, elevation gradients, slope and aspect, vegetation and fuels, and past human land uses. One of the novel findings is that twentieth century fire occurrences were much more variable in some places along the east side of the Sierra Nevada than commonly seen on the west side, or many other places in the western US (North *et al.*). The timing of surface fire regime disruption due to human land uses was highly dependent on local history of livestock grazing, access by roads, and degree of topographic isolation.

Common findings of these four papers on pines (and also the Swetnam *et al.* study in giant sequoia-mixed conifer forests from the west slope of the Sierra Nevada) were that fire frequencies in relatively drier pine dominant or mixed conifer forests were often sub-decadal (i.e., <10 yr intervals between fires). Fire free intervals in relatively mesic mixed-conifer forests (at spatial scales of <100 ha) were often <20 yr. At some locations and time periods (e.g., the period from about 800 to 1300 C.E. [Common Era] in sequoia groves), fire-free intervals in relatively mesic forests were also sub-decadal. Another common finding was that the intra-ring position of fire scars was predominately in the latewood or on the ring boundary (dormant season), indicating late summer to fall fires. There was, however, considerable variability in the seasonal timing of past fires in some comparisons between study areas and different time periods. A shift in seasonal timing was evident. For example, in the Skinner *et al.* study, there was a shift from a mix of earlywood (early summer) and latewood-dormant (late summer to fall) scars in the pre-1850 period

to predominately latewood-dormant scars after this time. Skinner *et al.* interpret this as evidence that fires set by Native Americans in early to mid-summer may have been an important element of the pre-1850 fire regime.

The fire scar studies in this special issue located in northern, eastern, and central California also evaluated broad-scale (top down) controls of variations in fire regimes, i.e., inter-annual to decadal climate influences. The role of drought and ocean-atmosphere patterns (such as the El Niño-Southern Oscillation and Pacific Decadal Oscillation) were shown to be of varying importance in driving widespread or synchronous fire events at different scales. Both drought and warm temperatures were typically associated with extensive or frequent fire occurrence over past centuries and millennia, with important implications for fire management in the context of anticipated warming due to rising greenhouse gases (Swetnam *et al.*).

Three of the papers in this issue are entirely unique in some respects. Mallek and Lombardo *et al.* used tree rings to record fires in two ecosystems that had no previous fire history studies. The third paper includes the longest tree-ring reconstruction of fire history in the world (Swetnam *et al.*). Mallek's study in McNab cypress (*Hesperocyparis macnabiana* [A. Murray bis] Bartel) contends with the challenging problem of reconstructing fire history using tree rings in a forest type that apparently sustained primarily stand-replacing crown fires. Fire scarred trees are rare or absent in this case, so the primary lines of evidence are based on tree ages, field observations, and documentary records. Mallek shows that most stands were even-aged and originated following past crown fires. Although some stand-replacing fire regimes in North America seem to have been less affected by twentieth century fire suppression than surface fire regimes, both Mallek and Lombardo *et al.* do detect some apparent changes. In Mallek's McNab cypress study, he found fewer stand-replacing events in the twentieth century than occurred earlier.

The Lombardo *et al.* study is both surprising and unusual. Who would have guessed that a 400+ yr fire history of interior chaparral in southern California might be reconstructed from a conifer tree, the bigcone Douglas-fir (*Pseudotsuga macrocarpa* [Vasey] Mayr)? These remarkable, fire adapted trees exist in small islands of forest within a sea of chaparral. Strictly speaking, this fire-scar based study is most directly a reconstruction of fire history in bigcone Douglas-fir stands. But in comparisons of the dates and locations of tree-ring based fire events with twentieth century mapped fire perimeters from documents, Lombardo *et al.* build a case that the bigcone tree-ring record also provides a reasonable estimate of past fire occurrences and relative extent within the surrounding chaparral. More studies of this type are needed to test this novel approach and the findings of this case study. For now, the results suggest that large (extensive) fires have been a common feature of bigcone stands and the surrounding chaparral on the Los Padres National Forest for at least four centuries. The twentieth century, however, was somewhat different, with fewer small (localized) fire events than earlier centuries. We expect that these and future findings will be of considerable interest in this region where "megafires" and very active debates about fire ecology and management have raged in recent years.

Finally, Swetnam *et al.* extend the record of giant sequoia fire history in one of the most magnificent groves in the world, the Giant Forest of Sequoia National Park. This work builds on earlier studies in five giant sequoia groves, including the Giant Forest. A useful aspect of the giant se-

quoia fire history is that it is temporally long enough (about 3000 yr) to encompass a broad range of climatic variations. This includes perhaps the warmest and driest and coolest and wettest periods of the past several millennia, the so-called Medieval Warm Period (circa 800 to 1300 C.E.) and Little Ice Age (circa 1300 to 1850 C.E.), when fire frequencies were generally high and low, respectively. Using independently derived charcoal-based fire histories from the Giant Forest and other groves, we find similar decade-to-century scale fire frequency trends and patterns in both the tree-ring and sedimentary records.

Fire history, like all history, is a combination of the general and the specific. Scientists seek the general and repeated patterns in hopes that we might derive a rule, or perhaps even a law, by which we might make a prediction. Ecosystems and history, however, are full of contingencies and particularities that defy generality or prediction. The late evolutionary biologist Stephen Jay Gould (1988) referred to this duality as “Time’s Arrow, Time’s Cycle.” Among the many implications of this understanding is that, when it comes to ecological history, there is no end to what we can learn from probing the past at different places and times. This is not to say that fire history is merely an exercise in collection of new case studies and description of their particulars. Clearly, there are many gaps in the biogeographic and temporal coverage of fire history, as well as in our knowledge of the controls of past and present fire regimes. As the seven papers in this special issue demonstrate, we can learn from the local-scale and historical particulars of case studies, and we can also begin to see broad-scale patterns that demonstrate ecological generality and linkages to regional and global climate variations.

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LITERATURE CITED

Gould, S.J. 1988. *Time’s arrow, time’s cycle: myth and metaphor in the discovery of geological time*. Harvard University Press, Cambridge, Massachusetts, USA.

The editor, Jan van Wagtendonk, managed the review process for the papers authored and co-authored by T.W. Swetnam, and for the paper by Vaillant and Stephens. T.W. Swetnam managed the review process for the four other papers in this special issue.