CALIFORNIA FIRE SCIENCE CONSORTIUM

JOINT FIRE SCIENCE PROGRAM

Research Synthesis for Resource Managers

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Pre-settlement and contemporary forest structures and fire regimes in the Lake Tahoe Basin

Beaty, M.R., A.H. Taylor. 2008. Fire history and the structure and dynamics of a mixed conifer forest landscape in the northern Sierra Nevada, Lake Tahoe Basin, California USA. Forest Ecology and Management 255: 707-719.

Beaty, M.R., A.H. Taylor. 2009. A 14,000 year sedimentary charcoal record of fire from the northern Sierra Nevada, Lake Tahoe Basin, California, USA. The Holocene 19(3): 347-358.

Taylor, A. H. 2004. Identifying forest reference conditions on early cut-over lands, Lake Tahoe Basin, USA. Ecological Applications 14(6): 1903-1920

Management Implications

- Forest heterogeneity in the Lake Tahoe Basin (LTB) is related to topography, climate, fire severity and fuel and forest structural characteristics. There is a strong link between climate variability and fire regimes.
- Euro-American management has led to a more homogenous landscape with a shift to higher stand densities and more fire intolerant species.
- Fire frequency is at one of its lowest points in the last 14,000 years. Patterns in the paleo-record suggest that future projected climate warming will increase fire frequency in the LTB.
- The authors suggest that forest restoration in the LTB include: (1) an emphasis on Jeffrey pine-white fir forests, with a focus on reintroduction of frequent, low-severity fire; (2) selective removal of lodgepole pine from red fir-western white pine forest; (3) reductions in tree density and basal area and increases in structural heterogeneity in all forest types.

Forests in the Lake Tahoe Basin and other public and private lands in the eastern Sierra Nevada have been greatly altered by human management over the past 150 years. Ecological restoration is a major focus area for forest managers throughout the Sierra Nevada. A prerequisite for restoration is the identification of current conditions and trends in the focus forest type, and the identification of historical reference conditions. These reference conditions can provide guidance as to the nature of "proper function" in ecosystem processes and the capacity of certain forest structures and functions to be resilient to environmental change. It is widely thought that restoration practices based on a thorough understanding of past, pre-Euro-American settlement conditions are more likely to be sustainable over time. Three complementary studies reviewed here examine how forest structure and fire regimes have varied spatially and temporally in the Lake Tahoe Basin, CA and NV.

Beaty and Taylor (2008) investigated how topography and climate influence variability in fire regimes and forest structure over time in the General Creek Watershed (GCW), on the west

shore of Lake Tahoe. The authors found that Euro-American settlement has led to more homogenous forest structure and a shift to higher stand densities and more fire intolerant species. The greatest compositional changes in the GCW are in pine-dominated stands in valley bottoms and on southern aspects. The abundance of fire intolerant white fir has increased dramatically in much of the forest at the expense of more fire tolerant species like Jeffrey pine, sugar pine, and incense-cedar. In addition, montane chaparral has been invaded by trees, especially white fir.

In the GCW, spatial variation in stand structure reflects burn severity as it is related to slope, aspect and slope position. In general, high severity fire is most common on upper slopes and most rare on lower slopes. The spatial variation in length of fire return interval (FRI) is related to topographic factors and species composition, as well as the production, moisture, structure and flammability of fuels; all of these factors are interrelated. In general, the authors found that fuel production was higher in pine than fir dominated forests. Fire timing and extent were linked to inter-annual and inter-decadal climate variation, particularly drought.

Beaty and Taylor (2009) reconstructed fire history at Lily Pond in the General Creek watershed (GCW) using dendrochronology and high-resolution charcoal analysis from a sediment core taken from the pond. The Lily Pond core, which stretches back to 14,000 years before present (ybp), provides the first high-resolution charcoal chronology for the Lake Tahoe Basin. Such long-term records of fire provide a tool to understand how fire regimes are linked to changes in climate and in turn help us better understand how future climate warming may influence fire regimes.

The authors report that, for the period of their fire scar analysis (1616-1893), median composite FRI for their GCW sites ranged from 8 to 17 years. The longest fire-free period was 47 years, the shortest, two years.
The fire scar data represent (relatively recent) local fire history, whereas the 14,000-year record from the Lily Pond core is more representative of Basin-wide fire activity. The authors found that years of high fire activity in the Lake Tahoe Basin have tended to occur with a mean return interval of 100-150 years. The periodicity of "high fire activity episodes" has varied over the last 14,000 years, ranging from a low of 4 episodes/1000 years to a high of 17 episodes/1000 years.

During the Late Glacial period (14,000-11,000 ybp), climate was cool and moist and fire frequency was low. In the early to middle Holocene (11,000-4000 ybp) climate was warmer and drier and fire frequency was high. The highest peak in fire episode frequency corresponds with the Holocene thermal maximum (7000-4000 ybp). During the late Holocene (4000-0 ybp) summer temperatures decreased and precipitation increased and there was a trend of decreasing fire frequency. Despite this general trend, another peak in fire episode frequency occurred in the Medieval Warm Period (1000-600 ybp), followed by a decline in episode frequency during the Little Ice Age (500-200 ybp). Current fire episode frequency on the west shore of Lake Tahoe is at one of the lowest points in last 14,000 years, but climate warming projections for the next century suggest that momentum for increased fire frequency is rising.

Taylor (2004) used measurements of tree stumps from late 19th century logging to investigate how contemporary forest structure and fire regimes in the Carson Range on the east shore of Lake Tahoe are different from pre-settlement conditions.

Prior to European settlement (1160-1871) there was little temporal variation in fire frequency. Small fires occurred more frequently than large fires. The pre-settlement mean FRI for Jeffrey pine-white fir forests was 11.4 years, with >90% of fires burning in the dormant season (late summer- early fall). Fires burned during seasonal peaks in lightning ignitions and periods of low fuel moisture. Frequent low to moderate severity fires promoted the development of open forested stands dominated by large diameter trees.

The authors conclude that, compared to pre-settlement forests, contemporary forests are less structurally diverse and are generally denser. Size class distributions have also changed, with current stands supporting a (much) greater

number of smaller trees and fewer large trees. In Jeffrey pine-white fir forests, contemporary basal areas are also higher. Red fir-western white pine forests have experienced increases in the density of lodgepole pine. Because of differing decomposition rates, pre-settlement density and basal area estimates may be more reliable for pine than fir and for large trees compared to small trees.

Taylor (2004) provides data on pre-settlement forest structure, and recommendations for restoration objectives for Jeffrey pine-white fir forests, red fir-western white pine forests, and lodgepole pine forests. General restoration suggestions include: 1) focus primarily on Jeffrey pine-white fir forests, which have been the most altered by human management; 2) reduce density and basal area (primarily of smaller trees) in all forest types; 3) selectively remove pioneer lodgepole pine from red fir-western white pine forest; 4) increase structural heterogeneity by moving from a clumped to a more random spatial pattern; and 5) reintroduce frequent fire into Jeffrey pine-white fir forests.

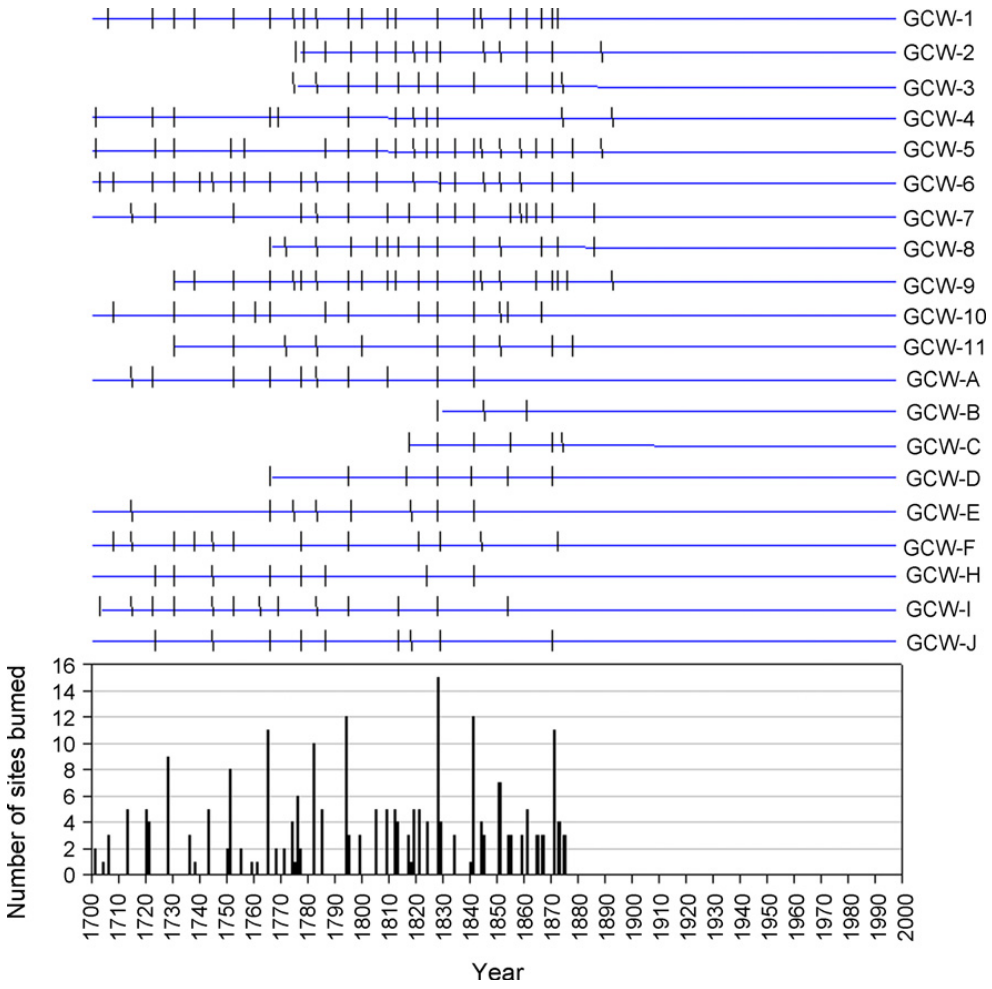

Fig. 4 from Beaty and Taylor 2008. Fire scar record for 20 sites in the General Creek Watershed, Lake Tahoe Basin. Fire in the Basin essentially ceased after Euro-American settlement in the second half of the 19th century.