Human impacts on fire history and forest structure over 1300 years in the Sierra Nevada

Research Brief • January, 2026

MANAGEMENT IMPLICATIONS

- Pollen-based reconstructions show that cultural fires set by Native Americans in the Sierra National Forest notably altered forest composition and canopy openness, and these changes could occur within decades. This knowledge is useful for discussing the timelines of current forest management strategies such as prescribed burning and mechanical thinning.
- The pollen record, which shows the impact of natural and anthropogenic fires on forests under different climate regimes and levels of fire suppression, can be used to identify pre-colonial forest compositions and canopy conditions, helping to set appropriate modern restoration targets under expected climatic conditions.
- Paleodata strongly supports the idea that Indigenous people in the Sierra Nevada used fire for most of the last millennium (at least) to create open forest conditions that facilitated access to a variety of ecosystem services. The pollen record documents that human actions, in this case intentionally-set low intensity fires, can buffer against climatically-driven changes in vegetation composition and canopy density. Modern public land managers should consider drawing from traditional ecological knowledge to improve forest health, reduce biomass, and buffer forests against projected climate warming.

The increased frequency of large, destructive wildfires in the Sierra Nevada has been in part driven by historical management decisions that have altered the structure of forests, creating dense stands dominated by shade tolerant species with thick, flammable understory fuels. Prior to European settlement c. 1850 and the onset of fire suppression policies, abundant archaeological evidence suggests that Indigenous groups occupying the Sierra National Forest (SNF) set frequent, low-intensity fires to maintain "park-like" woodlands with clear travel corridors, productive food and game forage patches, and culturally-important plant materials such as basket-weaving grasses and oak acorns. The history of frequent fire in the SNF has been documented in the paleorecord over at least the past 1700 years as fire scars on tree rings. To this point, this fire history and coincident and subsequent shifts in forest structure have been largely attributed to climate and lightning trends rather than anthropogenic causes, even though Native Americans occupied the area since at least 6000 B.C.E. This discrepancy may be partly due to the low-intensity, slow-moving nature of Indigenous burning, potentially reducing the likelihood of scarring trees and producing sedimentary charcoal. Partitioning the effects of human vs. climatically-induced fire on Sierra Nevada forests over time is essential for understanding baseline forest structures pre-fire suppression and guiding modern restoration.

Researchers at the University of Nevada - Reno and Sacramento State University used pollen-based reconstructions of fire and vegetation history to identify periods of climate and human-dominated fire regimes at Markwood Meadow (MWM) in the SNF and the impacts of these regimes on regional forest structure. They recovered and carbon-dated sediment cores from the meadow in 2019, using an age-depth model to correlate each core segment to its approximate age. To reconstruct vegetation history, sediment samples capturing 650 C.E. to 2019 were used to calculate pollen concentration and accumulation rates, and pollen grains were identified by species using keys from the Nevada Paleoenvironmental Analysis Laboratory. A statistical cluster analysis was performed to identify groupings of species over time in the pollen dataset. The North American Drought Atlas provided 1300 years of annual paleo-drought reconstructions from tree rings via the Palmer Drought Severity Index.

A vegetation response index (VRI) was calculated as a proxy for forest canopy openness, where positive values indicate a more closed canopy via the dominance of fire-sensitive, shade-tolerant Abies (fir species) and negative values indicate a more open canopy via the dominance of fire adapted, shade-intolerant Quercus (oak species). VRI values were compared to Palmer Drought Severity Index values over time to track changes in canopy openness against climatic expectations. The Medieval Climate Anomaly (MCA) represents the time period between 900 and 1200 C.E. and is generally associated with a warm, dry climate, while the Little Ice Age occurred between 1200 and 1850 C.E, and was characterized by a wetter, cooler climate. If fire history at MWM was predominantly a product of climate rather than TEK-fires, then researchers expected the VRI to directly track these periods, with the MCA corresponding to more negative VRI values (more open canopy) and the Little Ice Age corresponding to more positive VRI values (more closed canopy).

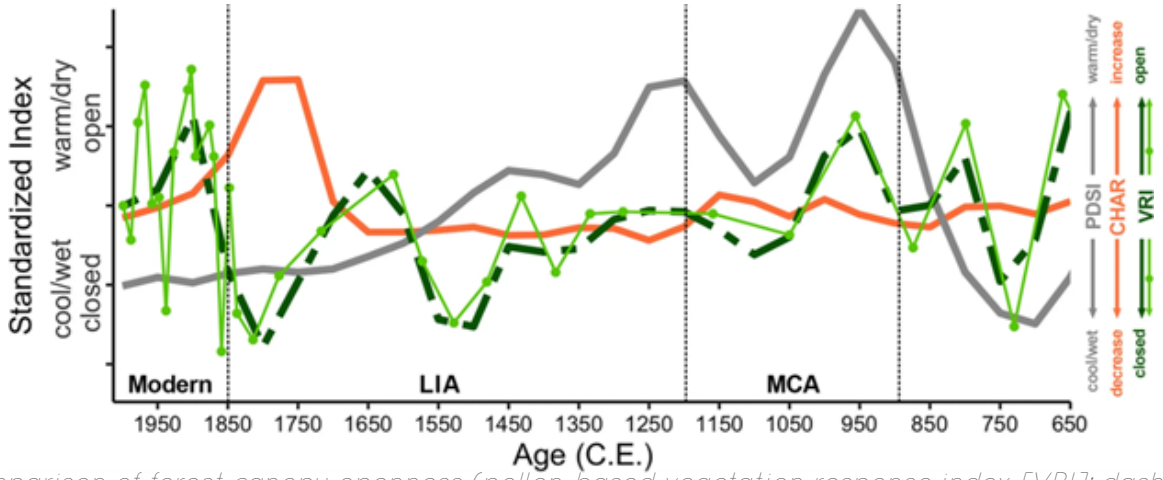

Fig. 1 Comparison of forest canopy openness (pollen-based vegetation response index [VRI]; dashed green line), fire (charcoal accumulation rate [CHAR]; orange line), and climate (Palmer Drought Severity Index [PDSI]; grey solid line) trends at Markwood Meadow, California, USA. Pollen and charcoal came from a sediment core extracted from the meadow in 2019. Thick lines represent 50-year smoothed splines. Dots on the thin green line show un-splined VRI data points. Data are scaled for presentation, normalizing each dataset's mean value and standard deviation to allow for comparison. LIA: Little Ice Age (1200 – 1850). MCA: Medieval Climate Anomaly (900 – 1200). Modern (1850 – 2019).

The pollen record indicated fluctuations in the dominance of taxonomic groups over time. Between 650 and 875 C.E., forests and meadows were dominated by yellow pines (Jeffrey, ponderosa, and lodgepole pine), grasses (Poaceae), and sedges (Cyperaceae). Between 875 and 1680, meadows came to be dominated by umbellifers (Apiaceae) and the percentage of white pines (mostly sugar pine) increased. Between 1680 and 1850, yellow pines, firs (Abies), oaks (Quercus), and cedars and junipers (Cupressaceae) increased in prevalence, while meadows returned to sedge-dominated with a dramatic increase in buckwheat species (Eriogonum). Mostly notably, in the period between Euroamerican settlement (1850) and current, there was a steady decline in fire-adapted yellow pines (50% pre-settlement to 30% post-1850) and replacement by shade-tolerant Cupressaceae (incense cedar; 20% post-settlement compared to 5% for most of history).

VRI (canopy openness) was consistent with PDSI (drought/climate index) from 900 to 1500 C.E., but acted in opposition to climate between 1550 and 1750 C.E., indicating an opening canopy at a time when climate was cooling and a closing canopy was ecologically expected (Fig. 1). After 1850, VRI sharply increased, driven by large-scale timber harvest that opened the canopy in the late 19th century. This VRI interpretation suggests that Indigenous burning maintained periods of MCA-like open forest composition during the Little Ice Age. Broader analysis of the pollen taxa was consistent with the VRI, which demonstrated that the early 1800s showed a strong Quercus influence. The modern period is markedly different than the previous 1000 years, with logging and related activities resulting in a sharp decrease in Pinus and increases in shade tolerant species like incense cedar (Cupressaceae). This demonstrates that modern forest management policy maintains the post-Euroamerican settlement novel composition state. Changes in VRI at MWM are concurrent with similar changes at Wawona Meadow and Swamp Lake, historically Sierra Miwok territory, and at Trout Meadow, the hunting range of the Tubatulabal people.

While pollen analysis suggests that climate was the primary driver of forest composition during the MCA and onset of the LIA, the authors argue that the opening of forest structure after 1550 C.E. was driven largely by Indigenous burning during a time of cooler and wetter climate. This implies that the late 19th and early twentieth century forest structure that land managers most often seek to emulate was in part the result of anthropogenic fire and precolonial resource management. Therefore, modern management strategies should consider incorporating Native American burning practices and using pollen-based reconstruction techniques to establish pre-settlement structural targets for restoration.

Additional Information

This brief is based on the following article:
Klimaszewski-Patterson, Anna, Theodore Dingemans, Christopher T. Morgan, and Scott A. Mensing. 2024. Human Influence on Late Holocene Fire History in a Mixed-Conifer Forest, Sierra National Forest, California. Fire Ecology 20 (1): 3. doi:10.1186/s42408-023-00245-9.

This brief was written by Sachi Srivastava, reviewed by Hugh Safford and produced by the CFSC Sierra Nevada Subregion. For additional information, contact: cafirescience@gmail.com