Climate Change in Wildland Management: Taking the Long View[1]

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Climate constitutes one of the great determinants of all natural environments. As such, it goes a long way in accounting for the distributions of the plant and animal species that inhabit the Sierra Nevada today. Most land managers are well aware that climate has changed over geologic time—indeed, one needs to look no farther than the polished rock of high Sierra Nevadan canyons to see evidence that a climate conducive to large-scale glaciations existed in the past. And most land managers accept that these past climate changes must have brought about shifts in distributions of the biota. But many still tend to view modern climate (defined, for present purposes, as that of the past 120 years) as being both long established and "normal." In this view, climates of the pre-modern period are treated as long gone (and thus largely irrelevant to land management) and as mere deviations from "normality."

Two primary factors contribute to this tendency. First, many scientists lack an appreciation for time scales that exceed a few human generations in length, considering 1,000 years ago as the distant past. Second, many assume that the pre-instrumental past cannot be well known or understood and that the inferences drawn from proxy records, such as pollen records in lake sediment cores, therefore constitute an insufficient basis for high-stakes management decisions.

Proxy records of Sierra Nevadan climate spanning the past millennium suggest that these views are flawed in ways that have consequences for management and mismanagement of the land. Specifically, proxy records indicate that

- the Sierra Nevada's modern climate is, by the standards of the past millennium (or the past 2, 3, or 4 millennia, for that matter), abnormally wet and warm;
- wide, multi-decade-scale fluctuations in moisture availability, unlike any seen in modern time, have characterized the Sierra Nevada over the past millennium; and
- many such swings—naturally or artificially induced, or both—must be expected to recur within a time period relevant to current land management practices and decisions.

This paper summarizes some of the multi-decade to century-scale records, examining first the Sierra Nevadan climate of late Medieval time (from roughly A.D. 900 to 1350) and then the climate of the Little Ice Age (from roughly A.D. 1350 to 1880). The final section considers some of the management implications of the records.

The Sierra Nevada Droughts of Medieval Time

Radiocarbon-dated evidence from an increasing number of localities in and adjacent to the Sierra Nevada indicate that on two occasions—the first encompassing the roughly 200 years

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before about 1100 A.D. and the second spanning the century-and-a-half before approximately 1350 A.D.—the Sierra Nevada was, by modern standards, remarkably dry. Hydrographically closed lakes of the western Great Basin, which receive the bulk of their inflow from Sierra Nevadan runoff, fell to levels far below those that would exist today under natural conditions. Hydrographically open lakes of the Sierra Nevada's middle and high elevations fell to and were maintained at levels as much as 70 feet below their spillways; Sierra Nevadan rivers were greatly diminished in size and presently existing marshes desiccated.

Many types of evidence reveal these hydrologic and hydrographic responses to Sierra Nevadan drought. Most conspicuous, perhaps, are the stumps of shrubs and trees, rooted in growth positions, at sites that are today too wet (in many places, too aquatic) to support woody vegetation. Thus, the stumps of trees and shrubs that grew during the earliest of the two droughts (hereafter the Generation 1, or "G-1" stumps) and those that grew during the second drought (hereafter the "G-2" stumps) can today be found rooted on the artificially exposed shorelands of Mono Lake at sites that would, given natural conditions, be under more than 50 feet of water. Tree stumps of G-1 can be seen rooted on the artificially exposed Walker Lake shorelands at elevations that would today, under natural conditions, be covered with as much as 140 feet of water. And shrub stumps of G-1 are found rooted near the lowest elevations on the (now artificially exposed) Owens Playa, indicating that Owens Lake must have desiccated, or nearly desiccated, during G-1 time.

The upright trunks of trees protruding from the depths of Sierra Nevadan lakes tell a similar story. At Tenaya Lake, both G-1 and G-2 trunks stand in as much as 70 feet of water; at Fallen Leaf Lake G-1 trunks are rooted in tens of feet of water; so too are G-2 trunks at Independence Lake. Because all three of these water bodies have stable spillpoints, drought-induced drawdown is the most likely explanation for the presence of the relict trees. Such drawdown would also best explain the presence of G-1 conifer stumps rooted in what is today a virtually conifer-free marshland—Osgood Swamp between Echo Summit and Lake Tahoe.

Rooted on the bed of the West Walker River, between its junction with the Little Walker and the lower end of Chris Flat, are more than 100 stumps and trunks of trees. The 30 individuals that have thus far been radiometrically assayed all date from one or the other of the two Medieval droughts. This reach of the river runs through the very narrow West Walker River Canyon—a defile in which the stream has little room to move laterally over time. Today's river is far too large to permit trees to grow on the lowest areas of the canyon floor. The presence of the rooted paleo-trunks thus seems to indicate that the stream was considerably smaller than those in modern times during two periods of the Medieval past—the same two periods that would be inferred from the stump- and trunk-studded water bodies noted above.

Evidence for these Sierra Nevadan droughts is not limited to derelict shrubs and trees. Both sedimentary and geomorphic records confirm that lakes were drawn to abnormally low levels during the Middle Ages (Stine 1990a, 1994b). Moreover, tree-ring records highlight the severity of the Medieval droughts. Graumlich's (1993) dendroclimatic reconstructions from foxtail pines (*P. balfouriana*) and western junipers (*Juniperus occidentalis*) of the southern Sierra Nevada indicate that the two driest 50-year intervals in the past 1,000 years (from A.D. 1250 to 1299, and from A.D. 1315 to 1364) occurred during the second of the two Medieval droughts and that the third-driest 50-year interval of her records (A.D. 1021–1070) occurred during the first of the two droughts. LaMarche's (1974) work on the bristlecone pines of the nearby White Mountains likewise identifies these two periods as anomalously dry. Like Graumlich, LaMarche characterizes the first of the droughts as being cool relative to the modern climate and the second as being warmer than modern (though note that his "modern" did not include the very warm 1980s and 1990s).