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Prehistoric human influence on the abundance and distribution of deadwood in alpine landscapes

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Abstract

Scientists have long inferred the locations of past treelines from the distribution of deadwood above modern tree boundaries. Although it is recognized that deadwood above treeline may have decayed, the absence of such wood is routinely taken to imply the absence of trees for periods ranging from the past few millennia to the entire Holocene. Reconstructed treeline histories are then explained in terms of such variables as slope, drainage, temperature, solar insolation, and precipitation. While these variables certainly help determine where deadwood is to be found above treeline today, we suggest that they cannot always explain where it is not to be found. In the alpine environments of the western United States, archeological work has established a human presence during nearly the entire Holocene in portions of the Rocky Mountains and for over 5000 radiocarbon years in the Great Basin and Sierra Nevada. We suggest that prehistoric occupations may have stripped deadwood from the landscape in all of these areas. To the extent that this is true, reconstructions of past treelines from deadwood may reflect the human prehistory of an area as much as it reflects treeline history itself. We encourage evaluation of this hypothesis in areas of active dendrochronological and archeological research.

Keywords: Alpine treeline; Western USA; Holocene; Anthropogenic impacts; Archeology; Dendrochronology

Introduction

Recent models predict that by the end of the 21st century, annual temperatures in California will have risen between 2.3 and 5.8 °C (Hayhoe et al., 2004; see also Christensen et al., 2007). In response, California's Sierra Nevada has been projected to lose 75–90% of its subalpine forests. A loss of this magnitude would dramatically alter the high elevation landscapes of the Sierra Nevada and would have enormous implications for all subalpine forest species.

Empirical information on treeline history clashes with this prediction. Millar et al. (2006a) have documented that between about AD 900 and 1350 (the Medieval Climatic Anomaly, or MCA), some areas just east of the Sierran crest saw an increase in the extent and species richness of the subalpine forest. In the headwaters of Owens Valley, eastern California (Fig. 1), this response appears to reflect increased temperatures coupled with precipitation levels only slightly different from those of today. Given that average annual MCA temperatures here are estimated to have been about 3.2 °C greater

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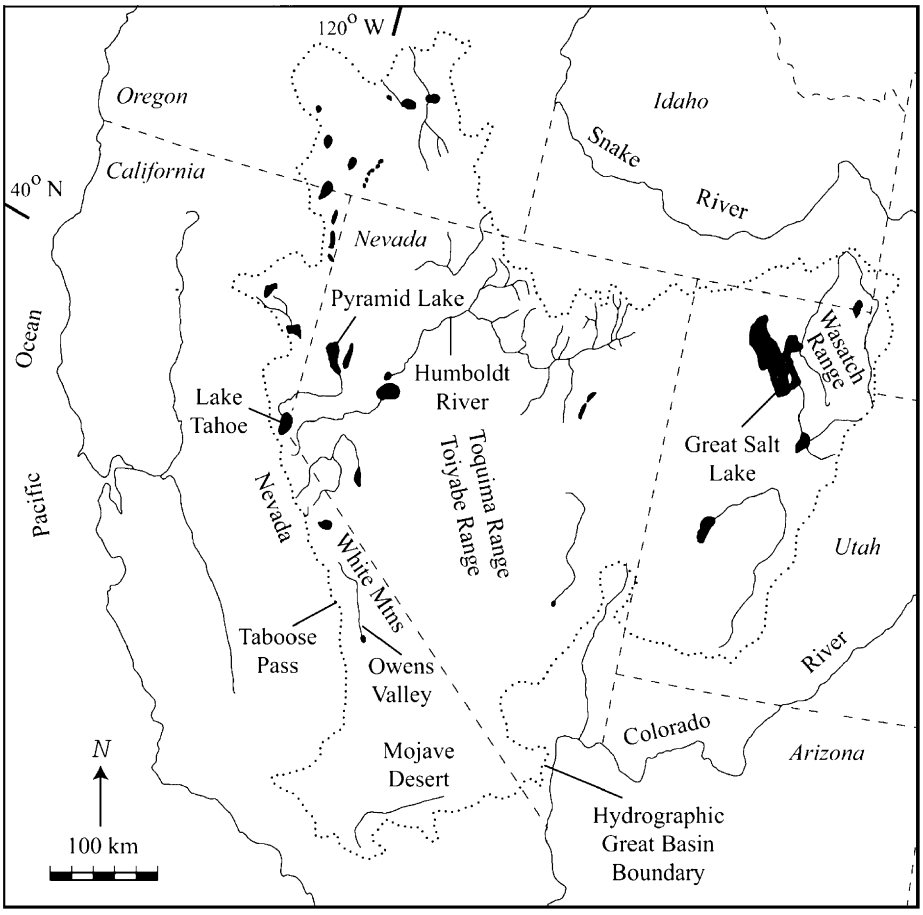

Fig. 1. The Great Basin with selected place names, including those mentioned in the text.

than modern, and thus within the temperature range predicted by the models discussed by Hayhoe et al. (2004), the results of Millar et al. (2006a) suggest that the model-based predictions for the future of western North America's alpine forests may contain significant inaccuracies. Similarly, while Lloyd and Graumlich (1997) have shown that treeline elevation and tree abundance declined along the Sierran Crest in Sequoia National Park and the Inyo National Forest during the MCA, that decline seems to have been a response to drought alone, treelines having expanded upslope during the early MCA when water stress was low.

If the empirical data are correct, the modeled predictions for the future of Sierran subalpine forest may be wrong. But may the empirical data themselves be wrong? How accurate are the indicators that have been used to reconstruct past treeline altitudes?

Deadwood and ancient treelines

For at least the past 70 years, scientists have inferred the locations of past treelines and upper montane forest conditions from the distribution of deadwood above contemporary treelines and from within the forests that form them (e.g., Griggs, 1937, 1938). During the past 40 years, treeline studies based on the distribution of deadwood have been conducted throughout the world to address a range of climatic and ecological questions (e.g., Richmond, 1962; McCulloch and Hopkins, 1966; LaMarche and Mooney, 1967, 1972; La Marche, 1973; Kearney and Luckman, 1983; Grant, 1984; Scuderi, 1987; Clague and Mathewes, 1989; Payette et al., 1989; Hughes and Funkhouser, 1999; Kullman and Kjällgren, 2000; Cuevas, 2002).

The logic behind these studies is simple. The presence of deadwood in alpine landscapes and in the upper live tree zone is assumed to indicate the presence of living trees in the past, since few natural mechanisms exist that can transport such wood significantly beyond treeline and those that are known (for instance, volcanic events) are generally easy to detect (e.g., Millar et al., 2006a). The deadwood can be dated either by dendrochronology or radiocarbon dating and the results used to reconstruct a chronology of past treeline movements. Similarly, dendroclimatological methods can be used to reconstruct past climates directly from the deadwood itself (e.g., LaMarche and Mooney, 1972; Hughes and Funkhouser, 1999), or climate inferred from the overlapping climatic requirements of the species represented