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Modeling Ecological Resilience and Human-Environment Interactions in Engineered Landscapes of the Prehistoric American Southwest

Rachel Loehman

Contemporary ecological patterns and processes that are thought to be 'native' or 'natural' may in fact be highly influenced by past human land use legacies. Alteration of natural fire regimes is one of the prime ways in which human activity shape local- to global landscapes, but disentangling anthropogenic fire signals from natural, predominantly climate-driven fire regimes is difficult. In addition, there is disagreement over whether anthropogenic fire and fuel manipulations altered fire regimes and landscapes at broad scales and in a manner sufficient to override background levels of fire, and whether these modifications were intentional. Humans have used fire and manipulated landscape flammability for millennia and worldwide. Where fire plays a keystone role in maintaining ecosystem function, such as in the dry forests of the American Southwest, human alteration of fire regimes – and thus humans themselves – may potentiate major changes in natural systems. We used the ecological process model FireBGCv2, informed by rich archaeological, ethnographic, and dendroarchaeological data sets, to reconstruct landscape-scale human-wildfire interactions in a continuously-occupied, fire-prone landscape in the Jemez Mountains of New Mexico. Prehistoric peoples likely altered forest structure, fuel properties, ignitions, and fire regimes in a density–dependent manner, but did not appear to erode long-term persistence ("resilience") of forests. We examined how plausible scenarios of human activities influenced vegetation and fire regimes ca. AD 1200-1900, and related our findings to contemporary land use and land management. Our results suggest that prehistoric populations influenced fire patterns across spatial scales but feedbacks maintained ecological resilience. We further observed an indirect effect of human activities outside of the archaeological "footprint" on the landscape, as well as changes to forest structure that support paleoecological and archaeological data. In contrast to contemporary observations, human-caused shifts in fires and forests were relatively transient, with rapid return to reference fire and forest patterns when populations were low. Results highlight the complexity and extent of long-term human-environment interactions within seemingly natural areas, and can be used as a benchmark against which to evaluate the impacts of current and proposed management activities.