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Title: Causes and impacts of woody canopy dieoff in a semi-arid woodland: Role of climate, pathogens, and phenology

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Abstract:
Extreme climatologic events are projected to increase in frequency and intensity as global warming progresses. The recent protracted drought (2000-2005) in the southwestern U.S., in conjunction with warmer temperatures and bark beetle (*Ips confusus*) infestations, contributed to the subcontinental-scale mortality of overstory piñon pines (*Pinus edulis*). This rapid, widespread mortality will alter ecosystem structure and function for decades. Our goals are twofold: 1) to determine the driving forces behind the piñon mortality by assessing the respective roles of abiotic climatic factors versus biotic host/pathogen population dynamics; and 2) to investigate phenological responses of productivity, in terms of timing and degree of "greenup." Results of spatio-temporal pattern analysis demonstrate that mortality was primarily related to sustained low precipitation combined with increased temperatures and, secondarily, to stand properties associated with bark beetle infestation. In conjunction with drought, the temperature and beetle components were key to the epidemic proportion of the mortality. The phenological response of the mixed woody-herbaceous ecosystem to the climatologic event was two-phased: overstory woody plant mortality followed by herbaceous greenup subsequent to wet periods after the drought. This response highlights how ecosystem reductions in productivity of the slower, more stable evergreen woody component can rapidly be offset by increased resources made available to the relatively more responsive herbaceous component. We hypothesize that such two-phase phenological responses, with a transient phase of depressed productivity followed by recovery phase of near normal or elevated productivity, are characteristic of ecosystem responses to many extreme events.

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