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ABSTRACT TITLE: Responses of pinon and juniper to rainfall manipulation: mechanisms of drought-induced mortality and the implications of long-term acclimation.

ABSTRACT: In 2000-2003, extensive drought-induced pinon mortality (> 90% at some sites) occurred in pinon-juniper woodlands in the southwest US while mortality of co-occurring juniper was low (< 25%). In August 2007, we began a rainfall manipulation study at the Sevilleta LTER to test the proposed mechanisms behind this differential mortality: 1) hydraulic failure – the complete loss of water transport due to xylem cavitation, 2) carbon starvation - energetic limitations associated with water stress and prolonged stomatal closure to avoid hydraulic failure, and 3) interactions among these two mechanisms and plant pathogens. We imposed four treatments spanning long-term precipitation extremes on twelve 40 x 40 m plots in a pinon-juniper woodland: ambient control, drought diverting 45% of rainfall using clear plastic troughs, cover-control to assess effects of plastic troughs without diverting precipitation, and irrigation of 4-6 19 mm events to increase growing season water availability. We measured soil moisture, air and soil temperature, and sap flow of target trees, with periodic measurements of plant water potential, canopy leaf area, leaf level gas exchange and non-structural carbohydrates (NSC).

In August 2008, pinon mortality began on the two hillslope drought plots with shallow soils and was complete by summer 2009. Starting in 2010, after three years of treatment, juniper in these plots exhibited progressive dieback leading to mortality. A hydraulic model parameterized with site data, indicated that in 2008 hydraulic limitations in both species were greater in the drought plots, with pinon experiencing the greatest reduction of conductivity, but did not predict outright hydraulic failure. Dying pinon in 2008 exhibited high levels of bark beetle activity and infection by xylem-occluding *Ophiostoma* fungi, potentially exacerbating the hydraulic limitation of drought by occluding the xylem. Growing season accumulation of foliar NSC was reduced in individuals of both species that died compared to ambient control trees. Although clear treatment differences were evident in the third, relatively flat, block with deeper soils, neither pinon nor juniper have exhibited drought related mortality until 2012. These data support the interdependence of hydraulic failure and carbon starvation in tree mortality.

The protracted-survival of both species on the flat block with deeper soils provided an opportunity to study the response of both species to precipitation anomalies of several years duration. On irrigation plots juniper, but not pinon, exhibited increased xylem vulnerability to cavitation but both species exhibited increased specific hydraulic conductance in stem xylem associated with larger tracheid diameters. Drought treatment led to decreased cavitation vulnerability only in juniper but no change xylem hydraulic conductance in either species compared to ambient controls. Juniper shifted its stomatal regulation of leaf water potential, closing stomata earlier in irrigated plots and at lower water potentials in drought plots. Pinon exhibited no change in stomatal regulation. These data suggest that the acclimation state of each species, driven by prevailing precipitation conditions in years preceding drought, may contribute to the conditions required to induce mortality during a drought event.