Increasing drought-induced forest mortality has been recognized as a global phenomenon. In the Southwestern US, increased temperatures and decreased precipitation have increased drought severity, exacerbated ecosystem stress, and ultimately triggered widespread forest mortality, which is expected to increase dramatically in the coming decades. Such abrupt change can be irreversible when an ecosystem passes a ‘tipping point’, eliciting a strong non-linear response. Forests and woodlands may be particularly prone to non-linear responses because of strong coupling between hydrological and carbon cycles.

In 2009, we girdled all adult piñon trees on a heavily instrumented 4 ha plot to produce rapid mortality, and have continuously monitored biogeochemical responses there and at a corresponding control site since 2009 to quantify both the consequences of large scale mortality for ecosystem function and rates of recovery. In 2013, our intact control site experienced large scale bark beetle driven mortality, which continued through 2015, giving us the opportunity to compare consequences of natural vs. induced large scale mortality events in this biome. Previous studies suggest that abrupt tree death should “release” soil water (“moisture release hypothesis”) facilitating water uptake by surviving woody plants, understory herbs and tree recruits. We report here on new methods we have used to quantify the extent of mortality in PJ woodlands, using high-resolution repeat measurements of vegetation using structure-from-motion(SfM) techniques, and on the ecohydrological results that have emerged from both the natural mortality event and our ecosystem-scale manipulation that test this hypothesis.

Contrary to our expectation that piñon mortality would increase water availability for the remaining trees, total 0-30 cm integrated soil water content under dead piñon and the remaining juniper trees progressively decreased at the girdled site, relative to the control site, from 2010 to 2012, while 0-30 cm soil water under bare, inter-canopy areas between the girdled and control site did not change. As a result of this decrease in soil moisture, sap flow of the remaining trees and total canopy transpiration progressively decreased (juniper sap flow declined faster and more consistently than the remaining small piñon) at the girdled site, relative to the intact control site over this time period.

These results suggest piñon mortality has made this PJ woodland progressively drier and hotter relative to a nearby intact PJ woodland. We propose this could be a result of tree density and site hydrology being linked by unrecognized positive feedbacks, such that the loss of trees can trigger aridification. Such links provides a framework to propose several mechanisms that might explain how piñon mortality could alter the temporal dynamics and spatial distribution of soil moisture to the detriment of surviving plants, and the future trajectory in the structure and function of PJ woodlands. We describe recently funded work will build upon these findings and begin to investigate these mechanisms.