Passive optical imagery for the rapid determination of above ground biomass and vegetation status in pinon-juniper woodlands

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Piñon-juniper (PJ) woodlands, the most expansive biome across the Southwestern US, are on the cusp of an imminent transition in vegetation structure, as piñon pine mortality escalates across the region. In response to considerable climatic stress in the past decade, these woodlands have experienced more mortality in piñon (*Pinus edulis*), due to combination of a weaker hydraulic strategy and increased vulnerability to pests like bark beetles, while the juniper (*Juniperus monosperma*), have largely remained intact. Given the sensitivity of this extensive semi-arid biome to drought and pest pressures, rapid and accurate techniques for monitoring mortality and quantifying the subsequent reallocation of above ground biomass from live to dead pools play a critical role in improving our understanding of how large scale, differential disturbance events impact ecosystem function, and catalyze climate feedbacks at local and regional scales. We have been studying the coupled impacts of drought and pest pressures at a pair of eddy covariance instrumented PJ woodlands in central NM since 2009. In one site, we girdled all of the large piñon to simulate bark beetle driven mortality, and left the other intact as a control. The study area has been experiencing significant drought since 2011, and subsequently mortality of piñon pine in our control site has increased dramatically since 2013.

During the progression of the overstory mortality, intensive ground monitoring campaigns coupled with remote sensing data sets have afforded us a very high resolution look at the distribution of mortality through time. We also acquired 4-band (visible, near-infrared) aerial imagery across the 2,033 ha region surrounding our 4 ha study areas in September of 2014. Using modern structure-from-motion processing techniques, we produced a canopy height model from the imagery at 0.35 cm resolution. This 3D structural data paired with the 1 inch resolution 4-band imagery permits an extremely high resolution look at the height, volume, and vegetation status (live / dead) of the vegetation across the research site. This data set, contextualized further by previously flown waveform lidar and repeated Worldview-2 (2-meter, 8-band imagery) satellite acquisitions, is allowing us to conduct an integrated assessment not only of the evolution of canopy mortality through time, but also the ability of the various remote sensing components involved to contribute to the analysis framework. Here we present the following: 1) high resolution remote sensing and field based maps of the progression of canopy mortality of piñon pine during a 3 year period of severe drought, and 2) crown level biomass estimates for the flux tower fetch through time, binned into standing live and dead pools, and 3) an analysis of how the progression of mortality has altered eddy-covariance energy and carbon fluxes from this PJ woodland. Our overall goal is to use this information to scale up to the region to quantify how continued mortality events will likely alter carbon, water and energy dynamics across the region.