Project Summary: Massive tree mortality in the Sierra Nevada: Consequences for forest health, carbon storage and wildfire hazard

The epic California drought of 2012 to 2016 has reshaped the structure and function of ecosystems throughout the state. An estimated 102 million trees have died since 2010 with highest mortality concentrated in the southern Sierra Nevada. This unprecedented level of tree mortality, driven by the interacting disturbances of drought and a bark beetle epidemic, will have profound effects on forest health, wildfire hazard, carbon storage, hydrological function, and forest biodiversity. In response to this rapid die-off, we have assembled a large team of collaborators in order to capture strategic, on-the-ground measurements of tree mortality and forest characteristics that complement remotely sensed data. To predict crucial processes such as the risk of sustained bark beetle outbreaks and the rate of tree-fall, we need to know the relative contribution of beetle kill as well as the species composition and size distribution of dead trees. Motivated by the extent of the problem and by the perishable nature of the vital information required, our team will have the necessary field data from 8-12 forests affected by the drought-induced mortality by the end of the 2017. With this vital first step complete, we seek support from ANR to re-measure key forest metrics in 2019 and develop the analytical tools and outreach venues necessary to address near-term threats to forest health.

The major questions that we seek to answer are: (1) What is the probability of the bark beetle outbreak expanding in the northern Sierra Nevada? (2) What is the impact of tree mortality on forest carbon storage? (3) How does the increase in standing, and eventual downed, dead trees affect the timing and magnitude of wildfire hazard? In a pilot site at Sequoia Kings Canyon National Park (SEKI), 18% of the trees died between 2014 and 2016. This decline led to a 38% decrease in live tree biomass since mortality was concentrated in the larger pine trees, presumably due to bark beetle infestations. With this preliminary data, we have begun to develop the means to estimate the risk of beetle spread and the rates of carbon transfer. For example, our analysis of treefall rates at SEKI suggests a short window of opportunity for intervention followed by an extended period of elevated fire hazard. The model also projects a sustained reduction in carbon stored in live trees. The challenge is to extend the capacity to understand the drought impacts on forest health beyond a single site. We need to build robust tools to inform management and policy across the extensive biophysical and land-use gradients in the Sierra Nevada landscape.

Our proposal includes a multidisciplinary team that works across agency domains with complementary expertise to address our research questions. This team will contribute field sites and data, and their expertise to train UC student field crews, and guide analyses and research products. The results of this research will be communicated annually with landowners and managers in an extensive outreach program. An intended outcome is that forest managers take action in priority areas in order to maintain or even enhance forest health and resilience so that massive tree die-back is averted in the next, but inevitable drought. For natural resource managers, we will hold round-tables and workshops with state, federal and non-governmental agencies to disseminate results and make management recommendations in priority areas. For family forest owners, we will hold workshops so that they may understand impacts on their own lands in the larger context and provide best practices guidelines on maintaining forest resilience through stand density management and restoration.