

Mechanisms and traits associated with plant survival and mortality during drought

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Drought-related, continental-scale forest mortality events have been observed with increasing frequency during the past 20 years. In the future, higher frequency of droughts is predicted to be accompanied with increasing temperatures that could lead to large-scale forest mortality. At Los Alamos National Laboratory we have built new capabilities to study how different traits in plant anatomy and physiology influence plant performance and survival/mortality during drought and elevated temperatures. By combining studies on microfluidics inside a tree with detailed anatomical studies and tree- and ecosystem-scale experiments we aim at understanding the fundamental connections between plant traits and plant mortality, and using this information for improving predictions of future vegetation changes in DOE-sponsored Earth System Models. At the microfluidics scale we use 3D x-ray tomography, combined with neutron radiography and Nuclear Magnetic Resonance techniques to reveal how anatomy of different species affects their water use and vulnerability to hydraulic failure or carbon starvation. With plant-scale manipulation experiments we measure key parameters determining the vulnerability of plant hydraulics and carbon transport systems during drought, and with ecosystem-scale climate-manipulation experiments of mature trees we detect how these traits manifest during drought and under elevated temperature.

Our results show trait differences in desiccation tolerant and desiccation avoiding plants that influence the internal water and carbon cycling, and may have implications to maintaining hydraulic connection with the soil during drought. But, interestingly no theoretically predicted anatomical differences that could explain the observed differences in vulnerability to hydraulic failure of these species were found. Combined with observations of plant adaptations to dry growth conditions, these results indicate that drought mortality of both desiccation tolerant and desiccation avoiding plants is influenced jointly by carbohydrates storage and transport dynamics.