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Multi-Scale Interactions between Soil Water Deficit and Drought Induced Leaf Area Index Decline

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Abstract

The mechanisms that cause tree mortality due to hydraulic stress are still uncertain, although recently abundant research is focused on understanding the physiological mechanisms that ultimately lead to tree failure. However, less attention is being paid about how this process scales from individual trees to an entire region. We use a greenhouse experiment combined with Ech2o, a spatially distributed ecohydrologic model, to examine the relationship between important physiological variables and plant mortality and how this relationship scales upwards from plot to watershed scale. We set a population of 250 two-year-old Ponderosa pine seedlings in a greenhouse where they experienced a drought treatment of increasing intensity. As plants dried and eventually died, mortality probabilities, hydrologic and physiological parameters were estimated to build physiology-based mortality curves. Using Ech2o, we simulated growth in plants in a flat environment exposed to the same temperature, solar radiation, and water regime as was used in the greenhouse, and calibrated the physiological parameters to match readings of plant hydraulic conductivity and leaf water potentials. We also simulate leaf water potential, leaf area index, soil water content, and actual tree transpiration for the Priest River Experimental Forest using environmental conditions from 2002 to 2005. Model results are compared with observations at 3 different sites from 2004 and 2005. Greenhouse experiments indicate that mortality and loss of LAI can be moderately predicted from Predawn leaf water potentials.