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Resilience of an old-growth coniferous forest in the Pacific Northwest, USA in warmer and drier summers

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Coniferous forests in the US Pacific Northwest can store a tremendous amount of carbon, among the highest of any forest ecosystems. As climate warms in this region, drought- and heat-induced physiological stresses will occur more frequently, substantially affecting plant water transport and changing forest carbon fluxes. Understanding and predicting water and carbon fluxes, and the succession of these coniferous forests under climatic change requires comprehensive simulations of both fast- (e.g., photosynthesis) and slow-response (e.g., stand dynamics) ecosystem processes. In this work, we applied the Ecosystem Demography model (ED2) for an old-growth coniferous forest in the region. Potential ecophysiological and allometric changes in dominant conifers are linked in the model's structure to physiological constraints, such as soil water limitation and higher vapor pressure deficits. Based on stand-level calibrations, we ran regional simulations driven by downscaled climate for the period of 1950 to 2100, projected from three general circulation models (GCMs) under Representative Concentration Pathway 4.5 and 8.5. Simulated historical mass fluxes and vegetation composition change were compared to flux tower and FIA inventory data. This study tested the following hypotheses: 1) hydraulic stress caused by a warming and drying environment will reduce carbon assimilation rates and increase water-use efficiency of the old-growth forest ecosystem in the Pacific Northwest; 2) changes in plant allometry tend to enhance root water uptake and conserve water loss while stomatal conductance is simultaneously lowered due to soil and atmospheric constraints; 3) patterns of adaptation to climatic change and consequent hydraulic stresses will slow down the replacement of Douglas-fir with western hemlock trees. This study is intended to provide a foundation for applying a cohort-based model at regional scales across the Pacific Northwest, and to provide insight on forest resilience to future environmental change and its implications for forest management strategies.