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The effects of individual tree competition on growth-based resilience to a fast-changing climate

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Climate change poses a significant threat to forest ecosystems worldwide, intensifying the frequency and severity of extreme droughts that challenge tree survival, growth and carbon sequestration. In addition to climate variability, one of the most significant factors affecting tree growth is competition, which ultimately shapes resource availability, stand structure, and microclimatic conditions. However, our understanding of how individual traits and stand-level characteristics influence the resilience of different tree species to climate stressors remains limited. While competition is recognized as a key driver of tree growth dynamics, its impact on the climate sensitivity and coping strategies of trees to drought conditions is poorly understood.

In this study, we investigate the interplay between individual tree competition and tree size characteristics such as diameter at breast height (DBH) and social status in modulating growth and responses to climate variability. Specifically, we examine how various growth-based resilience indicators (resilience, resistance, recovery and recovery period) and climate-growth relationships are affected by stand-level competition obtained by measuring DBH of each competitor tree within a 10-meter radius of our focal trees. By integrating competition data with dendrochronological analyses, we assessed how current competition status affects the resilience of Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*), and Silver fir (*Abies alba*) to warmer and drier climate, both in past and present contexts, between two sites with differing productivity levels.

We hypothesize that smaller trees and those under strong competition are less exposed, as shading from larger trees may buffer them against extreme environmental conditions such as high temperatures and water stress. This shading effect likely creates a more stable microclimate, mitigating drought conditions. However, these benefits may come at the cost of slower growth rates and reduced access to resources under competitive pressure.

This study provides valuable insights into the relationship between stand dynamics and tree resilience to climate stressors. Understanding how competition and tree status concurrently shape climate sensitivity and potentially moderate drought consequences, can help achieve a more nuanced perspective on forest management. These insights can inform strategies to promote forest resilience by fostering greater species diversity and vertical structural complexity, creating forests that are better suited to withstand increased frequency of climatic extremes. Promoting diverse and vertically layered forests not only supports sustainable and adaptive forestry practices but also enhances ecosystem stability and the capacity to mitigate environmental challenges.

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