Timing of moisture drives trait variation in isolated Great Basin Pinus ponderosa

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Topic: Natural areas management in light of climate change
Proposal Type: Symposium - select this if you are part of an organized session

Abstract:
Tessa Putz, Sarah Bisbing, Alexandra Urza Combined effects of rising temperatures and drought are threatening forests globally. These unprecedented conditions are likely to decrease forest resilience, leading to widespread tree mortality and loss of associated forest ecosystem services. Drought adaptations may, however, confer success under these projected extreme conditions and be key to the perpetuation of long-lived tree species. Water availability varies widely across lower montane forest ecosystems of western North America, but moisture stress is characteristic of the lowest extents of these coniferous forests. The timing, amount, and type of moisture strongly influence the degree of drought adaptation in a given population, and local topographic heterogeneity may exacerbate or mitigate these effects, driving variation in trait response both within and among populations. Although drought adaptations are well-studied in widespread tree species, knowledge is limited on the extent of drought-responsive traits in disjunct conifer populations. In the arid Basin and Range province of the western United States, Pinus ponderosa var. scopulorum is isolated to montane sky islands, making it a model system for testing the effects of climate and topography on conifer species trait variation. We sampled 57 populations across six ranges in the Great Basin and Mojave Desert to quantify trait variation in cone volume, wood density, specific leaf area, and needle lifespan. To investigate the relationship between interacting climatic and topographic conditions on drought adaptations we explored the role of seasonal climatic moisture deficit (CMD), monsoonality, and aspect on trait variation using generalized linear mixed models. Traits varied widely both within and among populations, with timing of moisture most influential in trait response. Cone volumes increased with increasing summer CMD but decreased in areas with a heavy monsoon influence. Needle lifespan was also influenced by summer CMD and monsoonality, declining as both early summer CMD and monsoonality increased and indicating that late summer precipitation leads to earlier needle shed and reduced retention. The seasonality of moisture similarly influenced wood density, with densities increasing with increasing winter CMD, signaling the importance of winter moisture for tree growth. Only SLA was influenced by local topographic variation, where hotter, drier aspects combined with high summer CMD