Poster #57

Alpine Treeline Warming Experiment: Highlights from an Experimental Test of Expected Upslope Tree Range Shifts and Alpine Community Responses

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The elevational range of subalpine trees is known to be climate sensitive. Shifts in the distribution of trees with climate change are dependent on the demographic processes of recruitment, growth and mortality, which occur over decades to centuries for long-lived species. Alpine species are adapted to short growing seasons and are also climate sensitive. We established the Alpine Treeline Warming Experiment at Niwot Ridge, CO, to examine effects of climate warming on seedling physiology and tree recruitment near the lower limit of subalpine forest, at upper treeline, and in the alpine, as well as on the alpine plant community. We used infrared heaters to increase surface temperatures and to lengthen the growing season, and watered some plots to distinguish heating from soil-drying effects. We used long-term demography plot data to quantify adult tree growth and mortality. We integrated this experimental and observational data into spatially explicit demography models to assess impacts of warming on tree population sizes and distributions over time.

Across three subalpine tree species, recruitment is similarly constrained by a combination of temperature and moisture, with warming reducing recruitment in low elevation forest but not enhancing recruitment at treeline or in the alpine due to water limitations. Physiology measurements of limber pine show that it is most robust to drought, and indicate co-limitatation of carbon assimilation by temperature and moisture in treeline and alpine sites. Warming exacerbates water limitation even in the alpine. Lodgepole pine is least tolerant of freezing, but had increased fall cold hardiness with warming. Population model results indicate century-long lags between the onset of climate changes and tree population establishment in the alpine due to seed limitation and low recruitment. Population growth is also sensitive to summer soil moisture, including in the alpine, suggesting that warming may not always result in upslope range shifts. We find rapid a decline in Engelmann spruce populations at low elevations due to recruitment failure. Alpine community productivity increases with warming only with summer water additions, an effect driven by forbs. Alpine species phenology is advanced with warming due to earlier snowmelt, with no effect of soil water. Our experimental and modeling results highlight effects of the critical interplay between summer water availability and temperature increases at individual, population, community, and landscape scales in high elevation ecosystems.