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Recruitment at treeline in the Central Rocky Mountains shifts in favor of a drought-tolerant species as climate water deficit increases

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Treeline elevation is expected to shift upward in response to climate warming. However, over half of alpine treelines worldwide appear to be lagging, possibly due to moisture limitations. Seedling niches tend to have narrower climate envelopes than those of mature, established trees, and regeneration requirements can vary substantially among species. We examined the density and species composition of recruitment at alpine treeline sites west and east of the Continental Divide, Central Rocky Mountains. In the arid Colorado Front Range, the Divide results in a rain shadow on the east side due to orographic uplift. We stratified our sampling effort by proximity to subalpine limber pine *(Pinus flexilis)*, a generalist, drought-tolerant conifer with a patchy metapopulation distribution in the Front Range. We expected to find higher abundance of limber pine regeneration than that of drought-averse Engelmann spruce *(Picea engelmannii)* and subalpine fir *(Abies lasiocarpa)* in two regeneration height categories (≤ 100 cm and ≤ 20 cm). Regeneration occurred at low densities on both sides of the Continental Divide and did not differ significantly between sites east and west of the Divide. Regeneration density also did not differ significantly between communities dominated by limber pine and communities dominated by Engelmann spruce and subalpine fir. However, the quadrats with highest regeneration densities were east of the Divide where limber pine was the dominant conifer. These sites were also in the rain shadow and associated with higher climate water deficit and lower growing season precipitation. Limber pine also comprised the majority of this regeneration. The site with the highest observed regeneration rates also had high rates of viable limber pine seed production at treeline. We observed a significantly higher proportional abundance of limber pine in the 100 cm regeneration class (relative to established trees) in quadrats east of the Divide, corresponding to establishment roughly in the last 30-70 years. The greater proportional abundance in limber pine regeneration at these treeline study sites occurred despite increasing temperatures, reduced growing season precipitation, and increased climate water deficit over the past 30 years. Drought-tolerant limber pine may therefore be the best-suited conifer in this region to persist and to migrate to higher elevations as temperatures continue to increase. Our findings underscore the importance of considering differences in seedling tolerances (niches) among different species in alpine treeline systems when aiming to predict landscape-scale treeline responses to climate warming.