ABSTRACT:
Research Objectives: Niche models and paleoecological observations indicate that climate change will alter the geographic distributions of plant species. An upward shift in the ranges of subalpine forest trees would displace alpine species and alter high elevation hydrology and carbon cycling. We established the Alpine Treeline Warming Experiment at Niwot Ridge, CO, to examine effects of climate warming on tree seedling establishment near the lower limit of subalpine forest (LSA), at upper treeline (USA), and in the alpine (ALP). We are using infrared heaters to increase growing season surface soil temperatures, and to lengthen the growing season. The warming treatment is crossed with a summer soil moisture manipulation to distinguish effects due to higher temperatures from those due to drier soil. Each plot is a common garden sown with two populations each of limber pine (Pinus flexilis), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta). We are asking, (1) Will subalpine trees move into current alpine habitat as a result of climate change? (2) Will subalpine trees be impaired in their existing range as a result of climate change? And (3) What ecophysiological, population genetic, and/or biogeochemical factors influence climate-induced changes in subalpine species success within and outside their current ranges?

Results: During 2010-2012, the snow-free period was ~one month longer at USA than at either ALP or LSA; sites also differed by more than 6 m s⁻¹ in average wind speed and 4.6 °C in daily mean temperature. ALP had higher soil moisture than USA and LSA, but had many days below 16% volumetric water content, a threshold observed to reduce seedling stomatal conductance. Heated plots have had higher soil temperature than control plot means, with larger increases (~4.5 °C) in LSA, than in ALP and USA (1.5-2 °C). Heating alone tended to slightly reduce soil moisture, even in ALP and USA, while HW plots were not systematically wetter or drier than control means, as intended by our original experimental design. In 2012, heating advanced site-average melt date by 10-40 days. Preliminary analyses of 2010-2011 seedling data show that heating reduced germination and initial seedling survival for two species and both populations in LSA, consistent with expectations of reduced recruitment at lower elevations with warming. At USA, heating effects were contingent on year and species, with increased limber pine but decreased Engelmann spruce germination with warming in 2010. In ALP, contrary to expectations of increased recruitment with warming, experimental heating did not increase germination or survival for any species or population. Soil moisture (5-10cm) was a covariate of seedling survival in 2010, with limber pine seedling photosynthesis stopping completely with soil moisture below 0.8 m³/m³; and survival correlated with number of days below 0.8 m³/m³ moisture across all sites. Further, Engelmann spruce survival to two years in treeline and alpine sites occurred only in watered plots. Taken together, these preliminary analyses suggest that warming may result in lower elevation range contraction but not upper elevation range expansion of subalpine trees in the absence of additional growing season soil moisture.