

## Poster #60

### Eight Years of Lessons from B4WarmED: Tree Responses to Warming and Rainfall Manipulation in a Boreal Ecotone

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The B4WarmED experiment addresses the potential for projected climate change to alter plant physiology and ecology at the boreal-temperate ecotone. The study has included several cohorts of juveniles of >12 tree species planted intermixed with native vegetation on 72 plots at two sites in northeastern Minnesota, and under two canopy conditions (open and understory). Since 2009 plots received three levels of both aboveground and belowground warming (ambient, +1.7°C, +3.4°C), and since 2012 half of the open plots received ≈45% less summer rainfall. Trees adjusted their carbon and water physiology, as well as their relations with herbivorous insects and mycorrhizal fungi.

We measured tree seedling and native herb and shrub phenology across multiple growing seasons. Warming caused earlier leaf out in spring for all tree species and later leaf senescence in fall for seasonally deciduous tree species, extending the photosynthetic growing season for all species by ≈10 and ≈20 days on average for +1.7°C and +3.4°C warming, respectively. We also saw strong interannual variation in the effect size of warming. For example, in aspen the mean advance of budburst with +3.4°C warming ranged from 2 days in 2013 to 18 days in 2012. Stronger effects of warming were seen in early compared to late springs, and this was true for naturally established herbs and shrubs, as well as planted tree juveniles. Differences among species in timing of budburst were also greater in early compared to late springs suggesting that climate change could increase asynchrony of leafing in forested communities. Warming altered the phenological synchrony of aspen and paper birch vis-à-vis forest tent caterpillars simultaneously exposed to contrasting warming regimes. Warming also influenced the composition of ectomycorrhizal species colonizing four tree species tested, but had minimal effect of mycorrhizal richness and did not increase colonization of boreal trees by fungal species more characteristic of the temperate biome.

Both warming and rainfall manipulation altered *in situ* light-saturated net photosynthesis ( $A_{\text{sat}}$ ) as well as temperature-response functions and acclimation of  $V_{\text{cmax}}$ ,  $J_{\text{max}}$ , and leaf dark respiration ( $R_{\text{d}}$ ) of all species; with species varying in sensitivity to combinations of warming and drought. There was pronounced thermal acclimation of  $R_{\text{d}}$  in terms of both typical night temperatures and of high temperature tolerance. Acclimation was best explained by the mean prior 10-to-30 night temperatures, although species varied somewhat in this respect. Modest shifts in  $A_{\text{sat}}$  combined with strong thermal acclimation of  $R_{\text{d}}$  resulted in a positive relationship of  $R_{\text{d}}$ :  $A_{\text{sat}}$  to air and leaf temperatures, but with a much shallower slope than would have occurred without acclimation. In 2014 – 2016, we measured ≈440  $A_{\text{ci}}$  curves in the field at 25°C for nine species across both warming and drought treatments, as well ≈300  $A_{\text{ci}}$  curves measured for four species at three temperature levels (18, 25 and 32°C) again across contrasting treatments (warming and drought). Modest shifts were observed, but data are still being processed so final conclusions are uncertain.

Plant growth and survival were significantly influenced by warming, rainfall and their interaction. Low rainfall had more negative effects on plants in warmed than ambient temperatures, with most striking and negative responses for the boreal conifers. Temperate angiosperms were also more able to acclimate (with wider conduits and greater specific hydraulic conductivity) some hydraulic parameters to increases in temperature than were

boreal conifers, although surprisingly little shift in vulnerability of xylem to embolism was observed in relation to warming or drought across eight species tested.

In total, the results of B4WarmED help us understand and extend recent observations of temporal and spatial patterns of southern boreal ecotone responses to recent temperatures and rainfall regimes. Results are also being used to test and modify core physiological routines of land surface models such as ACME.