Physiologic Acclimation of Southern Appalachian Red Spruce to Simulated Climatic Warming

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Global air temperatures are predicted to rise 1° to 4.5° C by the year 2100 and perhaps greater at high latitudes. This climatic change can have a great effect on the succession and migration of temperate deciduous forest species, and even more so on boreal conifers where migration routes are limited. In order to correctly model the effects of climate change on tree species, the present study is an assessment of the sensitivity, response and acclimation potential of southern Appalachian red spruce (Picea rubens Sarg.) to the impact of warming. Through an examination on synthesis (instantaneous and short-term acclimation rates of photosynthesis and respiration) as well as investment (biomass accumulation and partitioning, growth rates, and carbon allocation) of carbon assimilates, this project identifies the effects of increased temperature on upland southern Appalachian red spruce.

Red spruce from two southern Appalachian populations were germinated and grown in two separate growth chambers set at day/night temperatures of 19.9/12.9°C and 23.9/16.9°C (means of 17° and 21°C). At weeks 8, 12 and 16 after germination, concurrent analyses of carbon gas exchange and biomass accumulation were conducted.

Seedlings grown at the high temperature had low photosynthetic rates at week 8, but fully acclimated by week 16 to rates equal to photosynthesis of seedlings at our low temperature. Respiration and Q_{10} values remained nearly equal throughout the study duration and showed minimal dependence on treatment temperature. Regardless of intercepts, photosynthetic temperature response curves at week 16 had statistically equal slopes for seedlings grown at 17ºC and 21ºC.

Seedlings grown at the low temperature had significantly lower whole plant mass at every measurement date. Throughout the study duration, plants grown at 17ºC allocated more mass to roots, while seedlings in our elevated temperature partitioned more to foliage. Relative growth rate was 154% greater for plants grown at 21ºC, than for plants at 17ºC. As a result of near equal rates of photosynthesis and lower growth rates, supply of photosynthate surpassed demand for seedlings grown under ambient conditions. Hence, spruce seedlings grown at 17ºC had higher concentrations of non-structural carbohydrates in both roots and shoots.

We conclude that gas exchange in southern Appalachian red spruce has the potential for physiological acclimation to temperature. As the boreal adapted spruce seedlings preformed better at 21ºC rather than at 17ºC, as displayed by increased growth rate and dry mass accumulation, we question the temperature limitations of the deciduous-boreal ecotone as it relates to this species. Interspecific variations to warmer temperatures leading to modifications in interspecific competition may be a greater determinate of a displacement of this ecotone. As alpine environments are often dynamic, high-stress ecosystems, evidence is needed to address the potential expansion of deciduous species under current and future alpine climates.