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Carbon allocation and end-season resource reallocation in alpine treeline trees

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Carbon allocation and reallocation (or remobilization) determine plant growth and defense. Analyzing and understanding the carbon allocation patterns and resource remobilization efficiency of trees growing at the alpine treeline can help understand and better explain whether the alpine treeline is source- or sink-limited.

To study the carbon allocation, we pulse-labelled whole Betula ermanii Cham. trees (n=3; 1.5 – 2.0 m in height) grown at the alpine treeline (2000 m a.s.l.) and at lower elevation (1700 m) on Changbai Mountain, northeastern China. We found that the treeline trees had higher photosynthetic activity per unit leaf area than low-elevation trees. Both leaf 13C and shoot 13C concentrations in low-elevation trees did not differ with those in treeline trees, respectively, whereas root 13C concentrations were significantly lower in treeline trees than in low-elevation trees. Root 13C pool size was higher in low-elevation trees than in treeline trees. These results indicate reduced allocation of newly assimilated carbon to roots in treeline trees compared to low-elevation trees.

We also investigated the resource concentration and end-season resource remobilization from leaves to woody tissues in B. ermanii trees (n=6) along an elevational gradient from 1700 m to 2187 m a.s.l. on Changbai Mt. To avoid phenological effects of end-season leaves on remobilization, fallen leaves were collected at the end-season. Except for non-structural carbohydrates (NSCs) in July-shoot and K in July-leaves, tissue concentrations of NSC, N, P, and K did not decrease with increasing elevation for both growing season and end-season. We found, however, that the end-season resource reallocation rate from leaves to woody tissues tended to decrease with increasing elevation, which may cause reduced resource storage over-winter and thus reduced resource availability in early spring in trees at high elevations.

In summary, our results indicate that, compared to low-elevation trees, the alpine treeline trees allocated less carbon to roots during the growing season, and reallocated less resources from leaves to roots at the end of growing season. These may result in resource limitation in treeline trees, which may contribute to the alpine treeline formation. Our results also contribute to better understand the resource-related ecophysiological mechanisms underlying treeline dynamics in response to global climate change.