Comparative Nutrient Economy, Stable Isotopes, and Related Adaptive Traits in *Picea rubens, Picea mariana*, and Their Hybrids

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Nutrient- and water economy-related traits in plants have significant implications for growth and fitness. We examined and compared nutrient concentrations, use efficiencies, assimilation, and informative isotopic elements in a seedling provenance experiment, and in seedling and mature tree controlled-cross hybrid experiments of red spruce (RS) (*Picea rubens* Sarg.) and black spruce (BS) (*P. mariana* (Mill.) B.S.P.). Provenance experiment results showed RS had consistently lower carbon (C), nitrogen (N), and N assimilation ratio (NAR), but higher N-use efficiency (NUE), C:N ratio, water-use efficiency (WUE), needle calcium (Ca), and magnesium (Mg), than BS. Seedling hybrid experiment results showed similar results and additive inheritance for needle N, C:N ratio, NAR, Ca, and Mg, evident by a near linear progression from one species to the other. Within both species, seedling height showed a negative relationship with needle N and a positive relationship with NUE. However, across hybrid indices, seedling height showed a positive relationship with needle N and a negative relationship with NUE. Also across hybrid indices, seedling height showed a negative relationship to Ca and C:N, and a positive relationship with NAR and ^{13}C discrimination (without hybrid 25). Mature tree hybrid experiment results were similar to those of the seedling experiment, but with a dampening of differences caused by low nutrient availability and possibly age effects. The similarity was not true for ^{13}C discrimination as mature tree height showed a strong negative relationship to ^{13}C discrimination, indicating that BS had greater WUE. The reversal is most probably caused by the large difference in water availability.