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Long-term nitrogen additions and the intrinsic water-use efficiency of boreal Scots pine.

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Nitrogen fertilization nearly always increases productivity in boreal forests, at least in terms of wood production, but it is unclear how. In a mature (80 yrs. old) Scots pine forest in northern Sweden, we tested the extent to which nitrogen fertilization increased intrinsic photosynthetic water-use efficiency. We measured δ^{13}C both discretely, in biweekly phloem sampling, and continuously, by monitoring of bole respiration. The original experiment was designed as a test of eddy covariance methods and is not therefore strictly replicated. Nonetheless, we compared phloem contents among fifteen trees from each plot and stem respiration from four per plot. The treatments included addition of 100 kg N/ha for eight years and a control. Phloem contents have the advantage of integrating over the whole canopy and undergoing complete and rapid turnover. Their disadvantage is that some have observed isotopic drift with transport down the length of the stem, presumably as a result of preferential export and/or reloading. We also measured the isotopic composition of stem respiration from four trees on each plot using a Picarro G1101-I CRDS attached to the vent flow from a continuous gas-exchange system. We detected consistent differences in δ^{13}C between the treatments in phloem contents. Within each treatment, the phloem δ^{13}C was negatively correlated with antecedent temperature (R^2= 0.65) and no other measured climate variable. The isotopic composition of stem CO_2 efflux will be compared to that of phloem contents. However, when converted to intrinsic water-use efficiency, the increase amounted to only about 4%. This is a small relative to the near doubling in wood production. Although we were able to detect a clear and consistent increase in water-use efficiency with N-fertilization, it constitutes but a minor cause of the observed increase in wood production.