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Current photosynthate fuels the nitrogen response of soil CO_2 flux in a boreal forest

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Nitrogen addition frequently reduces CO_2 efflux from forest soils, but it has been unclear whether the effect is on fluxes of current photosynthate belowground or the oxidation of substrate to CO_2. Pulse-chase and girdling experiments have shown that current photosynthate can be a major substrate for soil CO_2 efflux, but these methods are unwieldy for describing seasonal patterns. In the current study, we placed transparent chambers on the soil surface beneath a forest canopy and measured the seasonal CO_2 flux over three growing seasons (2012-2014) in a boreal Scots pine forest under repeated, heavy nitrogen (N) addition (50-100 kg N ha^{-1} yr^{-1}). Net CO_2 fluxes were measured every half hour using a unique system comprised of four large (each 20.3 m^2 surface area) chambers, two each on the nitrogen treatment and the control. Base respiration rates (R_0) and temperature sensitivity (Q_{10}) were derived from nonlinear fits to the flux data. The Q_{10} was similar with or without N addition, but the nitrogen additions nearly halved the R_0 values. Treatment differences in R_0 appeared in May or June, peaked in July and August, and disappeared again in November. This pattern is consistent with the seasonality of photosynthesis at our boreal site. We estimated efflux in the absence of new photosynthate by extrapolating the May and November parameterization throughout the year. These extrapolations agreed with independent estimates through the winter snowpack and with the results of previous tracer and girdling experiments, supporting the contention that new photosynthate accounts for the nitrogen-induced reduction in CO_2 efflux. Soil organic matter accumulated in the N addition treatment at a rate that quantitatively matched the reduction in CO_2 efflux. We therefore conclude that the reduced CO_2 efflux following N addition is due to a decrease in the oxidation of new photosynthate, whereas its delivery belowground remains unaltered.