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Residence time of carbon substrate for autotrophic respiration of a grassland ecosystem correlates with the carbohydrate status of its vegetation

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Ecosystem respiration is composed of two component fluxes: (1) autotrophic respiration, which comprises respiratory activity of plants and plant-associated microbes that feed on products of recent photosynthetic activity and (2) heterotrophic respiration of microbes that decompose organic matter. The mechanistic link between the availability of carbon (C) substrate for ecosystem respiration and its respiratory activity is not well understood, particularly in grasslands. Here, we explore, how the kinetic features of the supply system feeding autotrophic ecosystem respiration in a temperate humid pasture are related to the content of water-soluble carbohydrates and remobilizable protein (as potential respiratory substrates) in vegetation biomass.

During each September 2006, May 2007 and September 2007, we continuously labeled 0.8 m2 pasture plots with $13CO_2/12CO_2$ and observed ecosystem respiration and its tracer content every night during the 14-16 day long labeling periods. We analyzed the tracer kinetics with a pool model, which allowed us to precisely partition ecosystem respiration into its autotrophic and heterotrophic flux components. At the end of a labeling campaign, we harvested aboveground and belowground plant biomass and analyzed its non-structural C contents.

Approximately half of ecosystem respiration did not release any significant amount of tracer during the labeling period and was hence characterized as heterotrophic. The other half of ecosystem respiration was autotrophic, with a mean residence time of C in the respiratory substrate pool between 2 and 6 d. Both the rate of autotrophic respiration and the turnover of its substrate supply pool were correlated with plant carbohydrate content, but not with plant protein content.

These findings are in agreement with studies in controlled environments that revealed water-soluble carbohydrates as the main substrate and proteins as a marginal substrate for plant respiration under favorable growth conditions. The observed relationships suggest that the effect of plant carbohydrate status on respiration of individual plants scales to the ecosystem level, including all respiration fed by recent assimilates.