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Biogeosciences Discussions

Interactive comment on "Rapid transfer of photosynthetic carbon through the plant-soil system in differently managed grasslands" *by* G. B. De Deyn et al.

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1. The way you sampled the soil deserves to be clarified. You indicate that soil samples were collected by a single and relatively small core (3,4 cm diameter). Given the size of this core, there was likely only one plant species above the soil sample. How did you determine the location for the sampling and, for this sampling, how did you take into account the abundance of different plant species. This question is important because the rate of 13C assimilation by the plant and the rate of transfer of plant-derived 13C to microorganisms may change with plant species.

Reply: We agree that the way we sampled the soils would benefit from a more detailed

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description. We like to point out that the grassland was composed of a rather dense sward in which the plant species were inter-mixed. This means that within each soil core there were roots of many species, and it was therefore not possible to distinguish the roots of each species. To clarify this, we have added the following text to the methods section: 'Soil cores and vegetation samples were taken such that at each sampling time a different quarter from within the labeled areas was used. All plant species sampled were present in all quarters of the labeled area, but the plant species were so intermixed that it was not possible to quantify their belowground abundances in the soil cores.'

2. The study uses changes in delta 13C of plant biomass and PLFA in order to estimate the rate of C fixation plants and its transfer to microbial communities. However, this delta 13C represents only a part of the reality. Changes in delta 13C reflect mean residence times (MRT) of C in the studied compartments. MRT is defined as the ratio between the size of compartment and the flux of C that goes through. Thus, a plant with high standing biomass and fixation rate of CO2 and a plant with low standing biomass and fixation rate of CO2 may present the same MRT of C in their tissue although these two plants have contrasted roles in term of CO2 fixation and C incorporation in soil. This means that the biomass of plants and microbial communities should also be taken into account in order to estimate the role of these biota on ecosystem fixation and storage of carbon. This could moderate and change some conclusions of the present study. For example, based on the long retention of C in moss tissue, the study suggests that this functional group of plant could promote sequestration of C in grasslands. However, biomass of moss is typically low as their abundance in grasslands (i.e. Fig 1). Thus, the capacity of this functional group to fix and accumulate C in their biomass is limited. The lack of effects of fertilizer application on the C uptake suggested by the present study could also be explained by this focus on delta 13C.

Reply: The referee is right that the delta 13C values reflect the mean residence times of C in the compartments under study and that it is essential to also take abundances/biomasses of the compartments into account when estimating the role of the biota (plants and microbes) for C-fixation and -storage. To deal with this aspect we have now included data on PLFA abundances (as also requested by referee 1). We found that the management treatments did not affect the PLFA abundances in our study so that, combined with similar levels of 13C signature across the treatments, indicates that the role of the different microbial groups was consistently different across the management treatments. With respect to the amount of C stored in moss we would like to stress that the biomass a of moss was a very important component in total community biomass in February, representing most of the community biomass, which was similar to the grass biomass in unfertilised plots in summer.

3. A conclusion of the study is that using a priori defined functional groups of grasses, forbs and legumes may not the best way of aggregating plants in relation to C cycling. Although I am convinced by the conclusion, what do you propose as alternative approach? Do you think that the approach based on plant and microbial traits currently developed by many researchers is more relevant?

Reply: We agree with the referee that it is useful to point out an alternative approach rather than merely dismissing one. Indeed we would advocate to pursuit a trait based approach and stated this in the discussion section in the form of following text: 'Instead of focusing on pre-defined functional groups, future studies could benefit from taking a trait-based approach, using measurable characteristics of the different components of communities (across trophic levels) rather than categorical groups, as has recently become the focus in biodiversity-ecosystem functioning research (De Deyn et al. 2008; Hillebrand and Matthiessen, 2009; Reiss et al., 2009).'

De Deyn, G. B., Cornelissen, J. H. C., and Bardgett, R. D.: Plant functional traits and soil carbon sequestration in contrasting biomes, Ecol. Lett., 11, 516-531, 2008. Hillebrand, H., and Matthiessen, B.: Biodiversity in a complex world: consolidation and progress in functional biodiversity research, Ecol. Lett., 12, 1405-1419, 2009. Reiss, J., Bridle, J. R., Montoya, J. M., and Woodward, G.: Emerging horizons in biodiversity and ecosystem functioning research, Trend. Ecol. Evol., 24, 505-514, 2009.

4. Another conclusion of the study is that the cessation of fertilizer could promote C sequestration of C in grassland by favouring moss over grass and fungi over bacteria. The rationale is that moss and fungi have greater C retention than grass and fungi. I find this conclusion rather simplistic. The carbon stored in plant and fungi represent only few % of total carbon stock present in grasslands. Most of grassland carbon is stored in soil organic matters particularly in the recalcitrant part of these SOM. Moreover, the cessation of fertilizer, probably combined with the maintenance of plant cutting (this information is lacking in the Material & Methods section), will induce a penury of available (soluble) nutrients in soils. In response to this penury, micro-organisms intensify their enzymatic activities and mine nutrients in SOM releasing large amount of C from the soil. In this scenario, and in the absence of legumes that compensate for the lack of nitrogen, the cessation of fertilizer decreases the sequestration of carbon in grasslands. Thus, the conclusion of the study should be moderate and include some processes that are not studied in this work but could reverse the prediction made by this study.

Reply: We agree with the referee that our discussion on the impact of fertiliser use on C sequestration was oversimplified as we only addressed the link with the biomass (and the C pool they represent) of the vegetation and soil microbes rather then their functioning in the system. In order to provide a more balanced discussion we included an extra paragraph at the end of the discussion: ‘The net effect of changes in grassland management on ecosystem C storage is ultimately dependent on the longer-term balance between C-influx via photosynthesis and C release. This balance can not be directly be predicted from short-term C flows and standing biomass, as most C in grasslands is in the form of non-living soil organic C which is mostly plant-derived and has been processed by soil microbes to varying degrees. In the current study, we found that C flow of recent photosynthate was not altered by management practices of mineral fertiliser use or seeding, while in another study we did find significant impacts of these long-term treatments on soil C and N sequestration (De Deyn et al., 2011). In the latter study, using the same field site, but including one additional treatment (i.e. seeding of the legume species Trifolium pratense), we found that the cessation of mineral fertiliser use significantly increased soil C and N sequestration, but especially when combined with seeding of T. pratense which stimulated biological N influx, reduced activities of key enzymes involved in recalcitrant organic matter degradation and changed soil structure.'

5. Finally, I find that the main result of the study, which is the temporal tightness of C transfer between plants and micro-organisms in grasslands, and its consequences for our understanding of plantsoil interactions deserves more discussions. For example, this result indicates that the activity of micro-organisms, which contributes to the release of N from recalcitrant SOM, follows the photosynthetic activity of plants in grasslands. This synchronisation of plant and microbe activities could explain to the synchronisation of soil nutrient availability to plant requirement of nutrients (defined by the photosynthetic activity and the stoichiometric contrains of the plant) as demonstrated the very low amount of N leached below this ecsosytem (Fontaine et al. 2011 and Drake et al, 2011). This high retention of nutrients in grasslands promotes SOM accumulation and C sequestration over long term.

Reply: We agree with the referee that we could make more of discussing the implications of our results and thank the referee for pointing this out. As very last part in the discussion we therefore included following discussion: 'Although we did not detect management effects in our study, we do clearly demonstrate the tight temporal linkage of C transfer between plants and microbes in grasslands, showing that the activity of many soil microbes is tightly linked to the photosynthetic activity of plants. Given that these soil microbes are regulators of the release of plant available N from recalcitrant soil organic matter (SOM), such synchronisation of plant and soil microbial activities will likely promote the retention of nutrients in the system, as demonstrated by the low amount of N leached from extensively managed grasslands (Di and Cameron, 2002;

Fontaine et al., 2011). This high retention of nutrients in grasslands could then promote SOM accumulation and C sequestration over time.'

Di, H. J., and Cameron, K. C.: Nitrate leaching in temperate agroecosystems: sources, factors and mitigating strategies, Nutient Cycling in Agroecosystems, 64, 237-256, 2002. Fontaine, S. , Henault, C., Aamor, A., Bdioui, N., Bloor, J. M. G., Maire, V., Mary, B., Revaillot, S., and Maron, P. A.: Fungi mediate long term sequestration of carbon and nitrogen in soil through their priming effect, Soil Biol. Biochem., 43, 86-96, 2011.

Some specific points Abstract L20-25 This sentence is long and deserves to rewritten. You could recycle the sentence L7-10 of the conclusion section.

Reply: We rewrote and shortened the sentence by following the advice of the referee on using the sentence from the conclusion section. The sentence now reads as: 'Overall, our findings suggest that plant diversity restoration management may not directly affect the C assimilation or retention by distinct plant taxa or groups of soil microbes, but can impact the fate of recent C by changing their abundances in the ecosystem.'

Discussion P929 L23-P930 L1-2 This sentence should be clarified since T. repens belong to the particular group of legumes.

Reply: We agree that we needed to clarify the sentence and included 'the legume species' before 'T. repens' on line 2 page 930.

Interactive comment on Biogeosciences Discuss., 8, 921, 2011.