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Interactive Comment

Interactive comment on "Free atmospheric CO_2 enrichment did not affect symbiotic N_2-fixation and soil carbon dynamics in a mixed deciduous stand in Wales" *by* M. R. Hoosbeek et al.

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Reply to referee #1

We would like to thank referee #1 for providing useful comments.

Indeed, next to symbiotic N2-fixation we should, in a revised version of our manuscript, also discuss heterotrophic N2-fixation (free-living N2-fixers). Hofmockel and Schlesinger (2007) hypothesized that heterotrophic N2-fixation would be enhanced due to increased litter production under elevated CO2. Increased N availability to plants would, in turn, meet the additional N required to sustain increased NPP under elevated CO2. They conducted series of experiments in which nitrogenase activity was measured in slurries and intact soil cores in response to different levels of substrate, moisture and nutrients. Forest floor and mineral soil samples were obtained from ambient and elevated CO2 plots at the Duke Forest FACE site. Hofmockel and Schlesinger (2007) did not detect a FACE effect on potential nitrogenase activity and concluded that heterotrophic N2-fixation was not enhanced in temperate pine forests under elevated CO2. Based on these results we assume that heterotrophic N2-fixation at the Bangor-FACE experiment was not affected by elevated CO2 and did not affect the outcome of our experiment.

The decline of NH4+ under elevated CO2 was observed in 2008 (Fig 2; Hoosbeek et al., 2010). During this year total soil N did not change as compared to 2007. As mentioned, the decline of NH4+ may have been due to a combination of increased nitrification, microbial activity (N-fixation in SOM) or increased plant uptake under FACE. Indeed, based on the δ15N values of Betula we may infer that N sources have not changed due to FACE. Moreover, we agree that it would have been interesting to know the δ15N values of NH4+ and NO3- in order to compare these with plant δ15N values. Unfortunately, these data are not available.

The classical cascade model in which fresh SOM first enters the ‘fast’ or ‘labile’ pool after which it flows into the ‘intermediate’ pool and eventually end up in the ‘slow’ or ‘stable’ pool has been discussed and criticized for a while. The data presented by Lichter et al. (2008) support the conceptual model in which a part of OM entering the soil may be relatively quickly stabilized by, for instance, occlusion in aggregates or adsorption onto mineral surfaces (e.g: Golchin et al., 1994;Jastrow, 1996;Von Lützow et al., 2006;Von Lutzow et al., 2008). It would have been interesting to apply this conceptual model to the BangorFACE experiment, but isotopic data of soil fractions are not available.

The Duke Forest is a N-limited system in which adding labile substrate due to FACE will not result in a noticeable priming effect. However, priming may occur in forest FACE experiments established on former agricultural soils. For instance, Hoosbeek

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et al. (2004) observed a priming effect during the second and third year of a FACE experiment with poplar trees established on former agricultural soils in central Italy. This temporal priming effect and the associated loss of older SOM was driven by the experiment, i.e. higher labile C availability due to FACE, and by the change of land use, i.e. going from a high fertility agricultural soil to a forest soil with a declining soil fertility status (Hoosbeek and Scarascia-Mugnozza, 2009). At BangorFACE we also observed that total soil C increased less and total N decreased more under FACE during the second year (Fig 1; Hoosbeek et al., 2010). We infer that soil microbial populations increased under FACE (higher labile C availability) and available N was taken up from this former agricultural soil (lower NH4+ concentration under FACE in 2006). In a next step, or in addition, the extended microbial population decomposed N-rich older SOM making N available to the microbial population and plants. Since this source of N requires more energy, the population will decrease and adjust itself to the new availably of substrate and nutrients. After the increased decomposition of SOM diminished, concentrations of NH4+ and NO3- will also go down again and adjust to levels that fit the new nutrient status of a young forest soil. This is in line with our observations, i.e. NH4+ decreased after 2007 under FACE, while in the ambient CO2 plots NH4+ did not decrease yet. While NO3- decreased both under FACE and ambient CO2 with lower concentrations under FACE. We postulate that the priming effect and subsequent lowering of soil NH4+ and NO3- concentrations (not observed yet for NH4+ in the ambient plots) are largely due to the change of land use and that these transitional processes were enhanced under elevated CO2.

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