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Interactive comment on "Can a bog drained for forestry be a stronger carbon sink than a natural bog forest?" *by* J. Hommeltenberg et al.

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General comments

(A) The manuscript of Hommeltenberg et al. presents two years of eddy covariance measurements of CO2 fluxes at a near-pristine forested bog and a bog drained for forestry, respectively. Since the drained and natural bogs are located near to each other, climatic differences can be neglected, and thus the effect of different land use can be directly examined. Such a direct comparison between the CO2 balances of bogs of similar genesis and climate but different land use is scientifically very interesting and can help us to better understand the complex effects of drainage and forest growth on the carbon budget of managed peatlands. The study found that the bog that was drained for forestry is now (44 years after forest plantation) a much stronger CO2 sink

than the natural bog. This effect is at the first glance surprising since a dominating effect of increased soil respiration is typically expected due to drainage. However, some previous studies have already shown that the enhanced forest growth can lead to a strong CO2 uptake that can overcompensate the increased soil carbon loss (e.g. Minkkinen et al. 2002). In this context, I think that the presented literature research on previous work on the topic of the effect of draining peatlands for forestry needs to be improved. Some important studies on the topic from the boreal climate region (Minkkinen and Laine 1998, Minkkinen et al. 2002, von Arnold et al. 2005a,b,c, Ojanen et al. 2013) are not considered; also some relevant studies on such effects in the temperate climate region, especially from the UK and Ireland, should be considered (Cannell et al. 1993, Hargreaves et al. 2003, Byrne and Farrell 2005, Artz et al. 2013, Yamulki et al. 2013).

(B) Unfortunately, the comparison of CO2 balances between the two bog forests is complicated by the use of two different measurement set-ups (open-path CO2 analyser at the natural site vs. closed-path analyser at the drained site). The potential bias which might be introduced due to the usage of different measurement set-ups should be considered when assessing the uncertainty of the measurements. Since at one site an open-path instrument was used, the potential effects of instrument surface heat exchange on the measurements should be discussed (Burba et al. 2008). Considerable uncertainties due to these effects have been described, e.g., by Amiro (2010) for boreal forests. Even more important is that the authors should clarify for which data streams which exact density corrections have been applied. In the respective section (2.3 Data handling), they write that they applied the WPL-correction only to the open-path flux measurements. However, WPL-corrections are also important to apply for (en)closed analysers like the LI-7200. While the water dilution effect is in closed-path CO2/H2O analysers of similar importance as in open-path instruments, the thermal expansion and contraction effect is probably reduced in closed-path-analysers due to attenuation of temperature fluctuations by the intake tube; however, it is not negligible if intake tubes are short as typically applied with the enclosed-path analyser LI-7000 (Burba et

al. 2012). Please clarify if you really have not applied these important density corrections to the closed-path fluxes or if the description in the text was incomplete. This information is essential for the interpretation of the presented data.

(C) Another problem I see with the manuscript is the strong emphasis on the long-term carbon sink/source functions of the two bogs in the conclusions, which is based on a rather weak data basis. The comparison of the depth of one recently taken peat core with one peat depth value that was indicated on an "old map" involves a quite high uncertainty. How heterogeneous is the peat depth within the bog? On how many measurements the peat depth value in the old map was based? Is it reasonable to assume that peat subsidence between the 1940s and 1967 (under agricultural use) was the same as between 1967 and 2011 (under forestry use)? Why an assumed bulk density of 0.15 g cm-3? What is the reasoning that this bulk density value should be representative for the about 60 cm of peat that was estimated to have been lost at the surface of the Mooseurach bog since 1967? I agree that such a rough estimation of long-term carbon loss is useful to set the results of the two-year eddy covariance flux campaign into perspective; however, I recommend to not focusing the conclusions on this rough estimate but on the interesting results of the eddy covariance campaigns. Especially the last paragraph appears questionable to me. I do not think that "this study serves to underline the potential benefits provided by peatland restoration". I would agree that the presented carbon loss estimates might show the benefits of not having drained the bog 100 years ago. However, the main results of the study (the EC measurements) indicate that the bog drained for forestry is now a robust carbon sink. On the other hand, the study does not present data on possible effects of rewetting/restoration the drained forested bog on its CO2 balance. Depending on the considered time scale, such rewetting could be also negative for the carbon sink function of this degraded bog.

(D) The manuscript is well written using clear and fluent language. Only the placements of commas is often not correct and should be carefully checked before re-submission.

(E) I recommend the manuscript of Hommeltenberg et al. for publication after major revisions addressing my comments listed above and below.

Specific comments

Page 2191, lines 2-3: The reference does not really fit to the statement. Post et al. (1982) do neither talk much about carbon exchange nor about peatlands' area.

Page 2192, lines 10-12: Please consider the paper of Hargreaves et al. (2003).

Page 2193, line 17: Is this average LAI of the whole canopy or of individual trees?

Page 2194, line 21: Better "soil material is mineral"

Page 2194, lines 25-27: Please give more information about this map? What type of map? Topographic? Geologic? What scale? Please give a full reference for the map.

Page 2195, line 25: Better "thermistor temperature probes (type 107, Campbell Scientific)"

Page 2196, lines 2-6: See general comments, paragraph(B)

Page 2196, lines 6-7: Please give more details on how many wind direction sectors, how long average time?

Page 2196, lines 22-25: Specify how large the target area around the tower was.

Page 2197, lines 14-16: Please write more precise: . . .that you calculated moving window averages and 99% confidence intervals for these averages.

Page 2198, lines 17-18: This is surprising. Could you please give some more details on how this was checked?

Page 2199, lines 8-11: R2 is not the correlation coefficient. It is the coefficient of determination. It is not a sufficient measure of similarity of the meteorological conditions at the two sites. You should also look at the slope and offset of a linear regression line that relate the two compared time series. (E.g., if precipitation at the one site would be

always exactly double the precipitation at the other site, the R and R2 would be still 1.)

Page 2200, lines 17-18: Do you use “carbon uptake” in this sentence synonymously to GPP or to NEE?

Page 2204, lines 25ff. See General comments, paragraph (C)

Page 2206, line 26: Do you mean here with “carbon uptake” GPP or NEE (or both)?

Page 2207, lines 6-7. Please write more precise: “. . .resulted in an average annual carbon loss of +550 gCm-2 a-1 over the last 70 years.

Page 2207, lines 18ff: See general comments, paragraph (C)

Page 2217, Table 1: Why only 2011 is shown and compared to the reference period? The meteorological conditions of 2010 and 2012 would be also interesting.

Technical comments:

Page 2190, line 4: I suggest “. . .same soil formation. . .”

Page 2190, line 18: Remove commas before “if” and before “since”.

Page 2191, line 17: I suggest hyphenating: “climate change-induced”

Page 2191, line 23: Remove comma before “and”

Page 2191, line 24, remove comma after “it”

Page 2191, line 25: Remove comma before “or”

Page 2192, line 12: remove comma after “although”

Page 2193, lines 26-27: I suggest hyphenating: “water-saturated” (also below)

Page 2194, line 1: Rewrite sentence. Elemental analyses cannot show pH-values.

Page 2194, line 2: Remove “very”

Page 2194, lines 4-5: remove commas before “as” and after “composition”

Page 2201, line17: Remove commas before “as” and after “as”. Use plural form: were” instead of “was”

Page 2202, line 3: Better: “mea annual CO2 uptake”

Page 2202, line 13: Remove “very”

Page 2202, lines 23-25: I would move these lines to the end of the previous section (3.3.).

Page 2203, line14: Place comma before “we”

Page 2203, line 16: Place comma before “and”.

Page 2204, line13: Remove commas before “caused” and after “level”

Page 2204, line 23: I suggest hyphenating: “peat loss-induced”

Page 2205, line 29; Place comma before “and”

Additional references on GHG fluxes from forested bogs:

Artz, R. R. E., Chapman, S. J., Saunders, M., Evans, C. D., & Matthews, R. B. (2013). Comment on" Soil CO 2, CH 4 and N 2 O fluxes from an afforested lowland raised peat bog in Scotland: implications for drainage and restoration" by Yamulki et al.(2013). Biogeosciences, 10(11).

Byrne, K. A., & Farrell, E. P. (2005). The effect of afforestation on soil carbon dioxide emissions in blanket peatland in Ireland. Forestry, 78(3), 217-227.

Cannell, M. G. R., Dewar, R. C., and Pyatt, D. G.: Conifer plantations on drained peatlands in Britain – A net gain or loss of Carbon, Forestry, 66, 353–369, 1993.

Hargreaves, K. J., Milne, R., & Cannell, M. G. R. (2003). Carbon balance of afforested peatland in Scotland. Forestry, 76(3), 299-317.

Minkkinen, K. and Laine, J.: Long-term effect of forest drainage on the peat carbon stores of pine mires in Finland, Can. J. Forest Res., 28, 1267–1275, 1998.

Minkkinen, K., Korhonen, R., Savolainen, I., and Laine, J.: Carbon balance and radiative forcing of Finish peatlands 1900–2100 – the impact of forestry drainage, Global Change Biol., 8, 785– 799, 2002.

Ojanen, P., Minkkinen, K., & Penttilä, T. (2013). The current greenhouse gas impact of forestry-drained boreal peatlands. Forest ecology and management, 289, 201-208.

von Arnold, K., Hanell, B., Stendahl, J., and Klemedtsson, L.: Greenhouse gas fluxes from drained organic forestland in Sweden, Scand. J. Forest Res., 20, 400–411, 2005a.

von Arnold, K., Nilsson, M., Hanell, B.,Weslien, P., and Klemedtsson, L.: Fluxes of CO2, CH4 and N2O from drained organic soils in deciduous forests, Soil Biol. Biochem., 37, 1059–1071, 2005b.

von Arnold, K., Weslien, P., Nilsson, M., Svensson, B. H., and Klemedtsson, L.: Fluxes of CO2, CH4 and N2O from drained coniferous forest on organic soils, Forest Ecol. Manag., 210, 239–254, 2005c.

Yamulki, S., Anderson, R., Peace, A., and Morison, J. I. L.: Soil CO2 CH4 and N2O fluxes from an afforested lowland raised peatbog in Scotland: implications for drainage and restoration, Biogeosciences, 10, 1051–1065, doi:10.5194/bg-10-1051-2013, 2013.

Yamulki, S.: Interactive comment on “Comment on “Soil CO2, CH4 and N2O fluxes from an afforested lowland raised peatbog in Scotland: implications for drainage and restoration” by Yamulki et al. (2013)” by R. R. E. Artz et al., Biogeosciences Discuss., 10, C4228–C4228, 2013.

References on density corrections for open- and closed path instruments.

Burba, G. G., McDermitt, D. K., Grelle, A., Anderson, D. J., & Xu, L. (2008). Addressing the influence of instrument surface heat exchange on the measurements of CO2 flux

from openâĂŘpath gas analyzers. Global Change Biology, 14(8), 1854-1876.

Amiro, B. (2010). Estimating annual carbon dioxide eddy fluxes using open-path analysers for cold forest sites. Agricultural and forest meteorology, 150(10), 1366-1372.

Burba, George, et al. "Calculating CO2 and H2O eddy covariance fluxes from an enclosed gas analyzer using an instantaneous mixing ratio." Global change biology 18.1 (2012): 385-399.

Interactive comment on Biogeosciences Discuss., 11, 2189, 2014.