Reply to Referee # 1

Below we give the referee's comment in italicized text, followed by our response.

General Comments

In the discussion paper, the authors compare forest floor photosynthesis (GPPfloor "GEP") and respiration (Rfloor "Rtot") in two growing seasons on hummocks and hollows of pristine and drained parts of a continental ombrotrophic bog. Also ground vegetation and tree stand biomasses and tree stand biomass increments are compared.

The paper provides useful data for the understanding of the effects of improved drainage on the function of mire ecosystems. Considering the vast mire area in Canada and the possible water level drawdown effect of future climate change, this information is necessary.

The applied measurement and calculation methods are of good scientific quality. The quality of the presentation is good as well, and the use of English language appropriate. Some minor improvements are needed (see specific comments).

The only major problem of the paper is that the authors also make statements about net ecosystem exchange (NEE) and carbon (C) balance, even though not all major components of NEE and C balance are estimated. The lack of components is to some extent admitted, but their importance is not further analyzed. The conclusions on NEE and C balance can well be argued.

NEE is usually defined as the net exchange of CO2 between ecosystem and atmosphere, and it is the sum of ecosystem gross ecosystem photosynthesis (GEP) and ecosystem respiration (Rtot): NEE = GEP + Rtot (GEP having negative values). If transparent chambers are used to measure forest floor photosynthesis (GPPfloor) and respiration (Rfloor) as in this study, also tree stand photosynthesis (GPPtrees) and respiration of aboveground components (Rtrees_ag, incl. shoots, branches, stems) are needed for NEE:

NEE = GPPfloor + GPPtrees + Rfloor + Rtrees_ag

In the current paper, the authors use "GEP" and "Rtot", while they in fact have estimated GPPfloor and Rfloor. They also use NEE for GPPfloor Rfloor, while it should be for example forest floor net exchange (NEfloor). Further, the authors define C balance by adding the tree stand biomass increment ICbiom to forest floor exchange. But, following the definition of NEE and ICbiom (= GPPtrees □ Rtrees_ag □ Rroot □ Ltrees):

GPPfloor + Rfloor ICbiom = NEE GPPtrees Rtrees_ag + GPPtrees + Rtrees_ag + Rroot + Ltrees = NEE+ Rroot + Ltrees

This means that what is called C balance in the paper, is actually NEE (source) overestimated by the amount of tree stand litter production and tree root respiration. The normal definition of C balance would be NEE + other C fluxes (methane, leaching, etc.). I suggest that the authors abandon the rather misleading use of concepts NEE, C balance, GEP and Rtot. If statements on those will be included in the paper, a proper analysis on the missing components and discussion on their significance are needed. The tree stand components not measured cannot automatically be considered negligible. In my opinion, the estimated fluxes, biomasses and biomass increments by themselves can make a good paper, and statements on NEE, C balance, GEP and Rtot might even be omitted, or only speculated in the discussion part.

Another terminological issue is that the word "drought" is used when referring to permanent water level drawdown by artificial drainage or to drier conditions due to climate change. Usually, drought refers to a period during which a region has a consistently below average water supply. Climate change will perhaps bring along more frequent droughts, but climate changing to on average more arid or a permanent water table drawdown by improved drainage I would not call drought.

Response to general comments:

Thank you very much for endorsing our C measurement and calculation methods specifically and the research/paper as a whole generally. The highly constructive criticism and helpful suggestions on the use of terminology and some missing C components has helped us to rectify this problem. Therefore, we have adapted the suggested terminology and have properly analyzed and discussed the missing C components in the revised version of this paper. However, as noted by the reviewer, even with these components missing, we feel that the data presented are valuable and the majority of the discussion focuses on the differences in the measured components as opposed to the CO_2-C balance itself.

Using the corrected terminology, GEP is replaced with "GPP_{ff}", R_{tot} with "R_{ff}" and NEE with "NE_{ff}" throughout the manuscript. In all cases the ff indicates forest floor. The forest floor respiration (R_{ff}) included tree root respiration (R_r) as described in section 2.2.3.

For estimating incremental biomass of the tree stand, we adapted methods of (Szumigalski and Bayley, 1996), (Thormann and Bayley, 1997). In addition to the fens, (Szumigalski and Bayley, 1996) and (Thormann and Bayley, 1997) also estimated NPP of an Alberta ombrotrophic treed bog of hummock-hollow microtopography by adding incremental biomass and stand litter production of Picea mariana (Szumigalski and Bayley, 1996, Table 2). However, we could not achieve our planned litter fall estimation due to limited site access constraint. Applying their estimation of tree stand litter C value of 4 g m^{-2} yr^{-1} to our values of incremental C is not changing the estimated significance between our water table treatments sites. We have also not included belowground tree NPP in this study due to the difficulty in measuring this component without disturbing our study sites for future monitoring. We will discuss this in more detail in the revised manuscript and estimate tree fine root production using the equations presented by Li et al. (2003). We will clearly define the CO_2-C balance (with reference to (Artz et al., 2013)) and indicate those components we measure and those that are missing/estimated in the revised manuscript.

The term "drought " is corrected to "water table drawdown" throughout our manuscript.

Specific comments

p 15004 r 11. "was drained in 2001" How was it drained? Please, specify for example ditch spacing and depth to give the reader some idea of the drainage intensity.

Response (p 15004 r 11): Thanks for asking for explanation. "This site was not specifically drained for forestry but inadvertently drained during horticultural peat extraction operations on nearby sites. The drained site is located near the corner of two main ditches that have effectively drained a large quadrant of the peatland. All plots were within 50 m of the ditches". We will add this description to the text.

p 15004 r 21 "These bogs" Were not the control and drained part of the same bog as stated in r 10 11?

Response (p 15004 r 21): Thanks for correcting. Now "These bogs are classified as treed low shrub bogs" is corrected to "This bog comes under the class of treed low shrub bogs".

p 15005 r 2 3 "Black spruce (Picea mariana) is the most common tree in these bogs." Could you descrive the tree stand in more detail, e.g. tree height, canopy height, stem number, stem volume, projection coverage. You give too little information on the tree stand. The reader cannot get any idea of the possible importance of the tree stand for this ecosystem.

Response (p 15004 r 29-30): We agree that explaining tree stand will help us to give reader a better idea of the treed bog we studied. Black spruce (Picea mariana) constituted > 99% of the tree stand in the bog with 25,766 stems ha^{-1} consisted of 37% taller trees (> 137 cm height) up to 769 cm. The Black spruce stand had an average canopy height of 168 cm, projection coverage of 42% and basal area of 73.5 m^{-2} ha^{-1}. This description applies to the bog having control and drained sites. The description will be added to the end of the paragraph.

p 15005 r 6 "60×60 cm steel collar" How deep into the soil the collar was inserted? Were many tree roots cut?

Response (p 15005 r 6): Before the growing season of 2011, 60 cm × 60 cm permanent steel collars having grooves at the top, were inserted about 6 cm into the peat to keep disturbance to tree roots minimal.

p 15006 r 11 13 From this one gets the idea that model 1 was fitted separately for each year and plot, but apparently not, as only one model for each microform and site is presented in table 1? Please clarify!

Response (p 15006 r 11-13): Thanks for the suggestions that will help improve our tables. The model parameters were not given separately in Table 1, following (Chivers et al., 2009). However, we will now be giving the values for each model separately in the Table.

p 15006 r 24 25 "Two thirds of the data were used" How did you select these 1/3 and 2/3, somehow randomly?

Response (p 15006 r 24-25): Yes randomly. The sentence is updated to "Two-thirds of the data were randomly selected and used for model construction, whereas one-thirds of the data were used for independent testing of the models following Tuittila et al. (2004)".

p 15007 eqn. 2. Why not exponential form for temperature dependence? It would be good and interesting to state if you did not see an exponential relationship, as it is almost always observed.

Response (p 15007 eq 2): The text is updated to "After examining the data it appeared that the relationship of R_{ff} with soil surface temperature was not exponential. Therefore the growing season R_{ff} was estimated using multiple linear regression with soil temperature at 5 cm depth and water table position by" eq. 2.

p 15007 eqn 2. & Table 2: b has negative values. Does it mean less respiration with deeper water table, or how is the sign convention here? Could you clarify this already in 2.2 where you describe WT measurements.

Response (p 15007 eq. 2 & Table 2): Thanks for asking for explanation. We used the convention for water table depth that negative values indicated below ground water table (have now explained this convention in row 19 of section 2.2).

p 15007 r 18 20 How did you choose which plots to trench?

Response (p 15007 r 18-20): We chose the plots to be trenched, randomly from the available microtopography.

p 15007 r 21 22 "The trenches were backfilled in reverse order of removal while minimizing disturbances as much as possible". I really don't understand this sentence. Did you dig big holes for the trenching instead of just making a cut with knife/saw for the sheet?

Response (p 15007 r 21-22): The word "trenches" is corrected to "cuts". We cut the peat around the plot upto approximately 30 cm deep in three intervals (0-10, 10-20, 20-30 cm). To make the cut loose enough to insert polyethylene sheet, we had to use peat saw several times at each of the three depth intervals. Then the polyethylene sheet was inserted deep to 30 cm and filled back with soil in the reverse order of removal i.e., first we filled back the soil from 20-30 cm depth followed by 10-20 cm and lastly 0-10 cm. Although this procedure did not ensure that the backfilled soil occupied its original place, our intention was to keep the disturbance to minimal.

p 15008 r 1 2: Why did you do this? I don't see how it would be necessary, would not removal of ground vegetation rather cause an extra disturbance? Why is it needed for the estimation of tree root respiration?

Response (p 15008 r 12): Following (Hanson et al., 2000), (Riutta et al., 2007), (Hermle et al., 2010) etc., the trenched and intact plots were clipped so that we could isolate soil respiration (measured at trenched plots) from R_r + soil respiration (measured at intact plots). Had the plots not been clipped, we would have measured R_r + soil respiration + autotrophic respiration of surface vegetation at intact plots and soil respiration + autotrophic respiration of surface vegetation at trenched plots. This way we could not have R_r separated from soil respiration.

Also the surface vegetation was clipped with Fiskars power lever shears (Model # 100017192) that clips horizontally to keep disturbance minimal.

p 15009 r 3 4: Exactly how did you select these quadrats to ensure representativeness?

Response (p 15009 r 3-4): We selected these quadrats in areas directly surrounding the flux plots. The total study areas were not large and these plots covered most of the trees in the study areas.

p 15009 r 9-10: Please, describe somehow the data, this equation is based on.

Response (p 15009 r 9-10): Trees < 137cm were not measured for DBH as their total height was below a standard DBH measurement height. A subsample of 20 smaller trees >125cm were harvested parallel to the forest floor and taken back to the lab and oven dried at 80°C for 48 hours. The height and dry biomass of each tree was measured and an exponential regression was performed to generate this equation used to estimate biomass for trees < 137 cm. We will add this additional description to the methods section.

p 15010 r 20: Do you have some pre drainage vegetation data, or what does this "statistically similar" mean? Would not lower tree biomass but considerably higher tree growth at drained site (3.2, last paragraph) mean that at least the tree stands were not similar then years ago. Do you have data on that?

Response (p 15010 r 20): Thanks for suggesting this correction. The mistaken wording "considered to be statistically similar" is being updated to "assumed to be similar" as we did not have data about vegetation prior to this study period. However both sites were located in the same peatland complex (bog) with similar vegetation layers (canopy layer consisted of Picea mariana and ground layer consisted of similar shrubs and mosses).

Spatial variability in tree stands is a generic characteristic of natural/peatland ecosystems and we did not have tree stand data of prior to study period. Heterogeneity even between the three quadrats constructed at each site was large; however, the size of the study areas precluded our ability to include more replicates. Therefore, while we cannot be certain that the biomass was identical before the study, they were likely similar and we did see a clear change in tree growth (based on the tree rings) coinciding with the ditching 10 years ago. Thus are confident that the changes in incremental growth determined represent a clear response to the changing water table.

p 15010 r 21 22: Perhaps more interesting than the significance itself, would be to know the size of the difference! What where the coverages at pristine and drained sites? Was the reduction remarkable?

Response (p 15010 r 21-22): After 10 years of drainage, Sphagnum was reduced by 97% (at the drained site). This reduction was due to the unfavourable conditions of water table drawdown for Sphagnum growth.

p 15013 r 8 9: Rather turned into a source?

Response (p 15013 r 8-9): Thanks, yes it rather turned into a source of CO_2. However, including the integral component of this study "the biomass" the control site still remained a sink of CO_2-C.

p 15015 r 20 "net source" Does this equal "source" or is net source something else?

Response (p 15015 r 20): Yes this net source essentially mean source. This will be updated in the revised paper.

p 15016 r 5 "a flattening of the curve" What "curve" are you talking about?

Response (p 15016 r 5): We are referring to the "humpbacked" relationship (curve (Belyea, 2009) already mentioned in the same paragraph row 2. This wording will be clarified.

Fig. 3 "% of tatal"

Response (Fig. 3 % of tatal): Thanks for proof reading. Corrected to "% of total"

Fig 4: "without trees" without above ground parts of the trees?

Response: corrected to "without $trees_{ag}$" and explained in the caption.

References:

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