We thank Prof. Butterbach-Bahl (referee 1) and Prof. Pilegaard (referee 2) for valuable comments and their time reviewing this manuscript. Both referees have been added to the Acknowledgements of the manuscript. This response includes all the comments from the referees, although we only answer the criticism and suggestions. The referee comments are in red, and author responses in black.

Referee 1:

The paper by Korhonen et al on the nitrogen balance of a boreal Scots pine forest is a great read and provides a wealth of measuring data and a very felicitous synopsis.

The major short-come – which cannot be resolved easily – is the lack of an idea about N2 losses due to denitrification. As it stands now, it seems that the system is accumulating nitrogen at a rate of approx. 7 kg N ha-1 yr-1. I think that this estimate is uncertain since N2 emissions may easily be in this range. It would be good if this is directly mentioned in the abstract too.

The uncertainty of N_2 fluxes is now included in the abstract. While we cannot quantify these fluxes, we hope that showing what is unknown can guide the future research in the right direction.

Also Fig. 4 should be amended accordingly, indicating that no information on N2 fluxes (fixation as well as denitrification losses) are available. As it stands now the Fig. is incomplete.

N_2 inputs and outputs are now included in Fig. 4, with estimated range of the fluxes.

If possibly it would also be good to see some uncertainty estimates. Fig. 2 would be a good place for this.

We have included the uncertainty estimates to the Fig. 2 and for the fluxes in Fig. 4.

This manuscript is highly valuable due to the integrated provision of N flux and pool data for a boreal forest ecosystem. It is an outflow of a long-term monitoring and measurement program and this work may stimulate other LTER site managers to draw such budgets too.

Referee 2:

The authors presents a very nice study of pools and fluxes of N in a boreal forest ecosystem. They have done a great job at measuring the main compartments and main fluxes and the study could stand as an example of future studies in other ecosystems.

The main shortcomings are as pointed out by the authors themselves a lack of measurements of N-fixation and N_2 loss.

Nitrogen fixation is addressed in the Discussion-section. We have consulted Maija Salemaa from Finnish Forest Research institute, who has studied N2 fixation of mosses near Hyytiälä. Based on our own experiments, literature and personal communication with Maija Salemaa, we estimate that moss-related N-fixation is probably much less than 0.5 kg N ha^{-1} yr^{-1}. However, the N-fixation not related to mosses remains uncertain.

We have included N_2 fixation and N_2 emission to the figure 4 and we have added bit more discussion about N_2 fluxes in the discussion and mentioned that these fluxes are unknown in the abstract.

Also, it would have been nice to have some more information about the N pools in the root system.

Nitrogen storage in root system is discussed in the Discussion-section. However, since the uncertainty of the root N storage and especially is N cycling in roots is so high, that we decided not to include in the results. However, the root N pools are now included in Fig. 4.

In the abstract I miss a statement about the accumulation mainly taken place in the above ground woody biomass.

It is now written to the abstract: "N was accumulating in the system, mainly to woody biomass, at a rate of 7 kg N ha^{-1} yr^{-1}."

However, it should be expected that some N is also accumulated in the roots?

The N accumulation to the roots is now mentioned in section 4.2 in the Discussion: "The increase in coarse root biomass given by biomass equations was 0.7 kg N ha^{-1} yr^{-1}, but it is very difficult to estimate the validity of this value."

In the Materials and Methods section, I miss a description/definition of the "minicatchments".

The paragraph describing the micro-catchments have been moved from section 2.3.4 (p.11209, row 10 – 18.) to a more logical place to section 2.1. More importantly, the amount of information and clarity of the paragraph has been improved.

The tables and illustrations are generally very good, however, I miss a root compartment in Fig. 4.

Estimation of root N pools is now added to Fig. 4.

I highly recommend publishing this paper after some minor revisions as indicated below.

Some language revision is needed (especially definite and indefinite articles are missing, see some examples under specific comments).

The manuscript has been revised by a native English speaker, and indeed there were plenty of grammatical mistakes. We are sure that the language is now much better.

2 Specific comments
Here I also give suggestions for rewording in several cases.
p.11202, l.3: In what way has the increased N-deposition altered the functioning?

Inserted to text: "by increasing the availability of reactive nitrogen".

*p.11202, l.8: I think it should read: "N was accumulating **in** the ecosystem ..."*

Changed as suggested.

p.11202, l.15: But N is still limiting?

Yes. Inserted to the end of the abstract: “, but there are no signs of N saturation.”

p.11203, l.19: “take up” or “uptake” rather than just “take”

Changed from “take” to “take up”.

*p.11203, l.24: The reduced plant-available-N is probably not **because** of fertilization. Maybe it should just read: “**and** forests in general benefit from N-fertilization.*

Changed the latter part of the sentence to: “This is concluded from the fact, that N-fertilization in general increases the productivity of boreal forests.“

*p.11204, l.12: ”... and **the** total N atmospheric deposition.“*

Changed as suggested.

*p.11204, l.17: ”... at **the** SMEAR II-station ...“*

Changed as suggested.

*p.11204, l.20: ”... it **was** regenerated ...“*

Changed as suggested.

*p.11205, l.10: ”**The** total soil-N pool was determined ...“*

Changed as suggested.

p.11205, l.21: ”The extractable pools of soil ammonium ...“

Changed as suggested.

*p.11205, l.17: ”... using **a** layer specific ...“*

Changed as suggested.

*p.11205, l.23: ”... collected with **a** Westman soil auger ...“’*

Changed as suggested.

*p.11206, l.3: ”Nitrogen pools **on** soil particle surfaces ...“*

Changed as suggested.

*p.11206, l.4: ”... in **the** uppermost 0.3m depth ...“*

Changed as suggested.

*p.11206, l.7: ”The **pools** of ... **were** calculated ...“*

Changed as suggested.

*p.11206, l.13: "... were collected **in** weekly to **fortnightly** intervals ..."*

Changed as suggested.

p.11209, eq.2: The constants 889 and 301 are presumably the area of the two catchments, but this information is not given until the following paragraph. I suggest that you write C1 and C2 in the formula and explain what these constants are. But in Table 3 "C1" and "C2" denotes soil horizons!

The description of the catchment areas was moved to earlier in the manuscript (chapter 2.1) and the numbers are now changed to "A_{c1} and A_{c2}", and explained.

p.11210, l.10-11: One mentioning of "above the forest canopy" should be enough.

Changed as suggested.

*p.11212, l.8:"... two manual chambers **were** located ..."*

Changed as suggested.

p.12212, l.15: What were the dimensions and material of the manual chambers?

The dimensions and material of the manual chambers are now included in the manuscript.

p.12212, l.21: What does "robust" exactly mean? It is now much more common to use nonlinear regression for static chambers.

By "robust" we mean that the regression is less sensitive to the noise in the data.

This is an important and interesting topic, so let us explain it a bit more:

The problem with linear regression is that it underestimates the fluxes. In our case the underestimation is estimated to be in the range of 20% (calculated from the ratio of fluxes calculated by linear and exponential regression). In general, non-linear regression is thought to be less sensitive to systematic errors.

In linear regression two parameters are estimated, as in exponential regression three parameters are estimated. In addition, in exponential regression the function is extrapolated to the moment of the closure of the chamber. Together this causes the random error of exponential regression to be larger than of linear regression. When linear regression is used, the noise in the data causes on normally distributed error in the flux estimate. This means that noise does not cause a systematic error to the annual average of the fluxes.

However, exponential regression is more complicated, and the error distribution caused by noise in the data is much wider, and to our understanding, not normally distributed. When using exponential regression, noise causes uncontrolled systematic error on the flux estimate. This leads to higher random uncertainty of the average flux, as well as systematic errors. This is especially problematic in cases when the fluxes measured are close or under the detection limit. When using a linear regression, an average flux can be calculated reliably even if single measurements are under the detection limit, as long as number of measurements is high enough. Use of nonlinear regression is recommended when noise is low compared to the signal and the data has been through careful quality control.

To put it simple, random component of uncertainty is better controlled by using a linear regression. We believe that the use of linear regression is justified in some cases, but in general nonlinear regression should be used.

p.11213, l.7: How was the NO flux calculated?

A reference where the flux calculation is explained is added to the manuscript. In addition, a reference for chamber measurement principle is added.

*p.11214, l. : "... is concentration of N **in** green needles ..."*

Changed to: "… is N concentration of green needles …"

p.11215, l.1: Delete the second instance of "of N"

Changed as suggested.

p.11215, eq.8: More explanation needed. I assume it is just the sum of the 5 years?

It was the sum of the five biomass classes, described in the previous formula. The manuscript has been simplified by removing the formula explaining the same thing verbally.

*p.11215, l.16: "The change of **the** non-soluble soil N pool ..."*

Changed as suggested.

*p.11216, l.4: "... bound to **the** soil matrix ..."*

Changed as suggested.

p.11216, l.10: What is the exact uncertainty of this number?

The uncertainty is now mentioned in the manuscript, and it is +/- 8 kg ha^{-1} yr^{-1}. The uncertainties of the fluxes have been added to the Fig. 2 and Fig. 4. Comparison to soil N pool accumulation from Berg and Dise (2004) has been mostly removed from the discussion (section 4.2), because their result in fact is not different from our estimate, when uncertainty is taken into account.

p.11216, l.13: Please go through the whole manuscript and insert correct definite ("the") and indefinite articles ("a/an") where needed.

This has now been done, as explained above.

p.11220, l.7: I suggest to add that the accumulated N is in the tree biomass.

This is mentioned in chapter 4.2. (page 11221, lines 24-25).

p.11221, l.18: I do not understand how the lifetime of wood could be that long?

In natural boreal forests Scots pine is known to live several hundreds of years. Even forest fires usually do not kill the pines, because of the thick bark. After dying, Scots pine stems can be standing decades or even more before falling. Finally when the tree falls. it again takes at least several decades to decompose. Pine wood consists of high portion resin, which slows down the decomposition process. The oldest living Scots pine, found in Finnish

Lapland, was about 780 years old (http://www.metla.fi/tiedotteet/2007/2007-08-06-vanhin-puu.htm, in Finnish). In southern boreal areas the pines die younger.

p.11222, l.16-17: ”study site“ mentioned twice - delete one.

Changed as suggested.

p.11222, l.17: I do not think you really mean ”respectable“ here; exchange with ”corresponding“.

Changed as suggested.

p.11222, l.25: Does this mean that only the woody biomass pool is increasing?

It suggests that, yes, if also bark and branches are taken into account as woody biomass.

p.11223, l.9: No ”the“ here - just ”in line“

Changed as suggested.

p.11237, Fig.4: The legend should also explain that the _ values are annual changes in pools.

Changed as suggested.