

Review LTS

Title: Carbon, nitrogen, and phosphorus stoichiometry of organic matter in Swedish forest soils and its relationship with climate, tree species, and soil texture

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General comments:

There is an unredeemed potential for interesting publications in the large databases of national forest/soil inventories. This is also the case for the Swedish Forest Soil Inventory, publications using these data are highly welcome. The present study focuses on carbon (C), nitrogen (N) and phosphorus (P) and the ratios C:N, C:P, and N:P in both organic and mineral soil layers which particularly the P and the ratio aspect are novel. After reading the paper, I am however, a bit puzzled. The manuscript/title and objective promises to explore relationship with climate, tree species and soil texture, and it delivers on showing these relationships, but the discussion offers very little or patchy interpretation. My greatest concern with regard to this manuscript is the lack of discussion of the results and relationship against important factors known to regulate the accumulation/loss of C from soil -the balance of input of organic material against decomposition. Instead the main part of the discussion is linked to changes in N and here the focus is on three hypotheses "*first, the higher N deposition towards the south/southwest of Sweden that enriches the organic layer in South/Southwest Sweden with N. Second, it could potentially be that the rate with which N is taken up by trees increases with decreasing MAT, leading to N depletion of the organic layer at sites with low MAT. Third, it might be that N₂ fixation decreases strongly with decreasing MAT.*" While I do not dispute that these could be relevant hypotheses, I find it strange that forest productivity and decomposition processes are not discussed more in full. The same criticism could be directed towards the discussion of the P, here I had expected that the regional distribution of P in parent material (geology) would have included, also a reflection regarding limits P net-immobilisation and net-mineralisation. The text is also drawn down by some unnecessary errors which could easily have been corrected before submission (see comments below). My conclusion is therefore that the manuscript is not ready for publishing, there are too many errors, and insufficient discussion of the results, see comments below for more specific reasons for my conclusion.

1. Does the paper address relevant scientific questions within the scope of BG?
 - a. yes
2. Does the paper present novel concepts, ideas, tools, or data?
 - a. Novel concepts: to some degree
 - b. Novel Ideas: the background for the first hypotheses is not clearly stated, but with better explanation it could be considered novel. I suggest that the authors should consider e.g. Sundqvist, M. K., Liu, Z. F., Giesler, R., Wardle, D. A., 2014, Plant and microbial responses to nitrogen and phosphorus addition across an elevational gradient in subarctic tundra, Ecology 95(7):1819-1835. Which presents N:P ratios in relationship with temperature gradient that coincide with the findings in the current study.
 - c. Novel tools: no
 - d. Novel data: yes
3. Are substantial conclusions reached?
 - a. To some degree (hypothesis 1 is not treated satisfactory)
4. Are the scientific methods and assumptions valid and clearly outlined?
 - a. More or less - with some concerns the most important listed here:

- b. How are the ratios calculated, are they based on mass (concentration) or are they based on Molar ratio. The standard method in soil science is on mass - this is not that apparent for C:N ratio but will have large implications when calculating C:P and N:P ratios. Clarity in method is essential to know when comparing with other studies - though the relationship with MAT, tree species, texture will not be affected. Please check the C:P ratios given in figure 3e.
- c. What is "organic layer stock" and how is it calculated
- d. Several analyses that are referred to in the materials and methods are not used in the texts, Two of them I would hope you have considered and probably you have reason for not including - the pH and the P in the parent material?
5. Are the results sufficient to support the interpretations and conclusions?
 - a. Yes and No, see specific comments below
6. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)?
 - a. Some improvements needed - see comments below
7. Do the authors give proper credit to related work and clearly indicate their own new/original contribution?
 - a. yes
8. Does the title clearly reflect the contents of the paper?
 - a. yes
9. Does the abstract provide a concise and complete summary?
 - a. The abstract only refers to relative distributions - I would recommend to include the range or levels of the ratios, concentrations, stocks.
10. Is the overall presentation well-structured and clear?
 - a. Yes, in general
11. Is the language fluent and precise?
 - a. Yes in general, see comments below
12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used?
 - a. Formulas for calculation of stocks is missing and should be better explained, Also a specification of how the ratios were calculated should be included - from the figures I gather it is Molar ratio, but in the text it is not specified (both ratio and molar ratio is referred to)
13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?
 - a. See comments below
14. Are the number and quality of references appropriate?
 - a. Yes, sufficient
15. Is the amount and quality of supplementary material appropriate?
 - a. yes

Specific comments:

L 15-16, repetition of >60 years- consider deleting one place or merging the two sentences
 L17, and L26 "organic layer stock" stock of what? should be it be "organic layer C stock"? or are we talking about layer thickness? volume? density? Mass?

Line 19: "went along with" - better "followed"

L24-25 "OP adsorbs very rigidly to mineral surfaces." Could this not also be an effect of higher P availability in fine textured soils?

Line 26. "C and N concentration in the mineral soil" is a rather unprecise term as these concentrations normally are measured in several different horizons and are expected to differ

significantly with depth and genetic horizon. If you were talking about stocks however, the correlations would appear more valid/informative.

L51: «most soils in Northern Europe are only between 9,000 and 14,000 years old”. I believe you should then define Northern Europe - you need only to go to Denmark to find older soils. Perhaps it is better to write “Sweden” or “Scandinavia” instead of “Northern Europe”.

L50-55. It would be interesting to know at what limit, N:P ratio, you would expect P to become limiting.

L78-80 “The soils are a representative subsample of Swedish forest soils with a stand age >60 years that were sampled for the Swedish Forest Soil Inventory. We selected sites with a stand age >60 years in order to minimize the effect of forest management on the results” will these cover both self-drained and poorly drained soils?

L104 - what are the numbers in the brackets referring to? - are they necessary?

L 105-106: “and living and dead roots >1 mm diameter are removed.” This is nearly an impossible task on dried soils - and according to personal experience would also introduce a bias - thin roots are easier to remove from coarse textured soils than from fine textured soils. I suggest that a better description would be “(where possible) living and dead roots were removed from the sample prior to sieving (<2mm) and homogenizing” of course only if this is the case.

L109 -use “covered” instead of “vegetated”

L113-114: “each three soils were classified as either leptosol, gleysol or cambisol, while one soil was an umbrisol” - Here I suggest a rephrasing: 3 were leptosol, 3 were gleysol, 3 were cambisol, and one was umbrisol

L145: unclear “Organic layer element stocks were calculated by multiplying the organic layer stock with the respective element concentration.” What is the “organic layer stock”? how is it calculated?

L168-169: There must be an error “The C:N ratio of the organic layer was negatively correlated with MAT ($R_2=0.08$, Supplement Fig. S1) and with the log-transformed N deposition ($R_2=0.11$) and latitude ($R_2=0.08$; Table1).” C:N ratios cannot be negatively correlated to latitude - they must be positive. It would have been better to have r values in table 1 showing either negative or positive correlations not just “ R^2 ”.

L169-170: The molar C:N ratio is referred to for the first time -- are all ratios molar ratios? - not described in the M&M

L178-179: “Furthermore, C, N and OP in the mineral soil were only weakly correlated with latitude, MAT, and N deposition (Table 1).” Table may show correlations but no indication whether positive or negative.

L185.” the C:N ratio of the mineral soil in spruce forests” should it not be pine? The same error applies for L189 with regard to C:P ratio

L187: “Some pine forests had very high C:N and C:P ratios due to low N and P contents.” In the materials and methods you should introduce some rules for discarding “unusual” ratios based on the detection limits of the elements. These ratios are “artifact” and any interpretation of these may be useless.

L192-194, "The organic layer stock differed also between forests with different dominant tree species (Supplement Fig. S2b). In deciduous forests, it was on average 2.2 times higher than in pine forests and 1.9 times higher than in spruce forests." This does not sound right - what is "organic layer stock"?

L202-204 : "The mean C:N ratio and C:OP ratio were 1.5 and 1.4 times higher in soils with the texture clay or fine silt than in soils with the texture sand or coarse sand (Fig. 4d and e)." Error - the opposite → The mean C:N ratio and C:OP ratio were 1.5 and 1.4 times **lower** in soils with the texture clay or fine silt than in soils with the texture sand or coarse sand (Fig. 4d and e).

L244-246. Both "organic layer stock" and "organic matter stock" are used about the same parameter - stick to one (I believe it should be either better described and defined as well, see earlier comments)

L253 254: "the stem growth rate of trees **decreased** with MAT (Fig. 2d)" but figure 2 d show that the growth rate **increases** with MAT!

L279 "foliage N:P ratio **decreases** with increasing N inputs" should be increase?

L307 "miner" should be "mineral"?

L309-310 " However, this is the first study to show that this difference in the C:N ratio between forest dominated by different tree species is also visible in the mineral subsoil, in a depth of 55-65 cm, to our knowledge." But is this really confirmed by figure 3d? How have you handled the very low concentrations and detection limits?

L320 "changed" should be "charged",

L337 "changed" should be "charged"

L320-340 -4.4. Organic P and N contents are high in fine-textured soils, I find this paragraph too superficially discussed.

L337: "Thus, the high capacity of N- and P-containing organic compounds to adsorb to charged surfaces in soils is likely the reason why N, and particularly OP has higher concentrations in the fine-textured soils compared to the coarse-textured soils than C." - this is not only due to sorption. These fine textured soils are more productive nutrient rich system - (P -rich included) - also the water holding capacity and pH increases fine textured soils. and what about regional distribution of P containing minerals?

L345 - 355 : 4.5 P and K contents are negatively related to the organic layer stock. The discussion in this paragraph is poor. These two elements behave very different in soil the potassium is a cation more or less only found in inorganic forms, while P mostly would be present as a anionic molecule and in organic form be part of organic molecule . K+ could easily be leached, even more so in acid conditions, while P-is retained and we would not expect any "fast leaching of P" I would find it highly unlikely that "P follows the same dynamic as K"

L 365 "the results show that the N:P ratio of the organic layer was most strongly related to MAT" showing a positive relationship, while the CN ratio showed a negative relationship with MAT. This confirms that the boreal forest are N deprived, any increase in N availability will increase forest productivity P is not the limiting factor

L570 figure 3e the molar C:P ratio of the organic layer is high - are you sure they are correct?

L570 figures b, c, d, and f, why do some of the means depict “Inf”?