Referee report on "Distribution of phosphorus fractions of different plant availability in German forest soils and their relationship to common soil properties and foliar concentrations" by J. Niederberger et al.

Overview and general comments

The quantification of plant available nutrients in soils is one aim of the National Forest Soil Inventory in Germany (NFSI). Plant availability of phosphorus is dependent on several factors. Up to now, no method to quantify plant available phosphorus, which could be used in a soil inventory like the NFSI, has been established. To overcome this problem, the authors extracted phosphorus from NFSI soil samples according to the Hedley fractionation scheme, which separates total phosphorus into fractions of different solubility. They investigated the statistical relationship between these Hedley fractions and soil properties that were measured during the NFSI, in order to find parameters that can predict phosphorus fractions of different solubility. In addition, the authors investigated the statistical relationship between the Hedley fractions and foliar phosphorus contents, in order to test if Hedley fractions represent phosphorus fractions of different plant availability.

Up to now, foliar phosphorus contents are the only reliable measure for phosphorus supply and availability at a site. For sustainable forest management a predictor of foliar P contents that can easily be determined during inventories would be of great help, since foliar analyses are time and resource consuming. The study successfully contributes to find such a predictor.

The results presented in the manuscript are of great importance for the field of research. The authors did a thorough data analysis and described the results well. However, the manuscript has some lacks of clarity. Especially, the discussion is not always easy to understand. I would recommend to revise the English language by a native speaker.

Overall, I recommend to publish the manuscript after minor revision.

Specific comments

In the entire manuscript:

1. The English name and abbreviation for the inventory referring to in this study is "National Forest Soil Inventory in Germany (NFSI)".
2. Both "soil P (C, N) contents" and "soil P (C, N) concentrations" and both "foliar P contents" and "foliar P concentrations" have been used throughout the manuscript. Concentrations are defined as mass per volume (e.g., mg l^{-1}); mass per mass (mg g^{-1}) is called a content. Hence, please write "soil P (C, N) contents" and "foliar P contents" throughout the entire manuscript.
3. At some places expressions have been used that are – to my knowledge – not appropriate in the respective context or that have not been adequately explained/defined. For example P2 L8-9 "P cycling" and "intern reallocation (transfer) processes", P2 L14 "nutritional status", P3 L2 "population of inference", P10 L22 "distribution patterns", P12 L27 "distinct fractionation schemes".

Introduction:

4. P2 L7: Forest stands in Germany have partially been fertilized. Especially for stand establishment, fertilization including phosphorus has been a common measure in some regions. Additionally, phosphorus has been added in forest soil liming in some regions where total soil phosphorus pools are low.

5. P2 L10-12: Not only biomass harvesting is leading to nutrient deficiencies. Nitrogen input to forest ecosystems is also a driver for the establishment of nutrient deficiencies (e.g., increased growth and therewith higher nutrient demand; changes in mycorrhizal symbioses; soil acidification).
6. P2 L14: Define "nutritional status". From the following text it is obvious that foliar phosphorus contents are used as indicator for the nutritional status, but here it remains open.
7. P3 L8: Which were the selection criteria for the subset? Why didn't you use all NFSI plots for which foliar phosphorus contents are available?

Material and methods:

8. Soil extraction methods indicative of the foliar P nutritional status are not only needed since the determination of foliar P contents is laborious and expensive, but also since foliar P contents have a large variability (among trees and among years). This large variability demands sampling of a large number of trees in several subsequent years in order to be able to evaluate the foliar P nutrition (Wehrmann 1959). Unfortunately, during NFSI only three trees in just one year have been sampled per plot. Hence, the NFSI dataset is on the one hand the largest forest soil dataset available in Germany, on the other hand foliar nutrient contents are afflicted with uncertainty due to the sampling design. Both the sampling design and the resulting uncertainty should be stated in the manuscript. This uncertainty in foliar phosphorus contents might be the reason for the small coefficient of determination in the regression analysis.
9. P3 L23: In Table 1 the total P content is listed and in the abstract it is written that total P is commonly the only information on soil phosphorus in inventories; here you do not list the total P content as a parameter that was determined during the NFSI and on P4 L22-24 you describe the method used to determine total P. This is a bit confusing for the reader – did you determine total P by yourself or was the parameter provided by others?
10. P4 L9-10: Beech trees just have current year leaves. Better write that the leaves were sampled from the upper crown. It is very uncommon that the most recent whorl is sampled. At least the NFSI samples taken by the Northwest German Research Institute were from the 7^{th} to 12^{th} whorl.

Results:

11. P8 L21-28: What about the negative relationship between foliar P and SOC in the model for *F. sylvatica*?

Discussion:

12. P9 L12-13: Your results show that soil properties have an influence on Hedley P fractions and pools and that Hedley P fractions and pools do not explain the variance in foliar P contents very well. Hence, from your results, it is questionable if Hedley P fractions represent plant available P fractions.
13. P9 L30: What do you mean with "within soil depth"? a) within one soil depth, b) within the soil profile
14. P20 L21: Do you mean "DNA and phosphonate were only found in very acidic soils" or "DNA and phosphonate were found in most acidic soils"?
15. P10 L30-32: Later on you discuss the effect of clay on P availability in detail. However, it is missing here, though it is necessary to understand your statement: Increased decomposition should increase labile P; however, many soils with high pH and large decomposition rates

and intensive bioturbation probably have low sand/high clay contents leading to adsorption of P to clay minerals and therewith to small amounts of labile P.

16. P10 L33-P11 L1: Did you also include clay content instead of sand content in your regression analyses?
17. P11 L10-11: Here and elsewhere you write about SOC, while in the material and methods section only the total C content is mentioned. Did you quantify carbonates in soils, too? Or did you exclude calcareous soils (seems not to be the case according to the pH values presented)?
18. P11 L27-28: Talkner et al. 2009 found a significant relationship between the clay content and organically bound P, too.
19. P12 L6-8: Where is this result shown (not in Table 5)?
20. P12 L 26: It was organic phosphorus (not carbon) and clay content that explained the variance in foliar P contents best.
21. P12 L33-P13 L1: Do you mean the negative relationship between SOC and foliar P content?
22. P13 L13-15 and L19-21: Foliar P contents have a large variability (among trees and among years). This large variability demands sampling of a large number of trees in several subsequent years in order to be able to evaluate the foliar P nutrition (Wehrmann 1959). Unfortunately, during NFSI only three trees in just one year have been sampled per plot. Hence, foliar nutrient contents are afflicted with uncertainty due to the sampling design. This uncertainty in foliar phosphorus contents might be the reason for the small coefficient of determination in the regression analyses.

Technical corrections

23. Different names have been used for the same thing. For example "foliage P contents" and "foliar P contents". Please harmonize the names.
24. P3 L22: "North-West" -> "Northwest"
25. P4 L28-29: "subject to" seems not to be the right word here.
26. P5 L4 (and elsewhere): Better write "Hedley P pools", since the word "pools" is also used for masses related to an area (kg ha^{-1}).
27. At several places (e.g., P5 L4) hyphens occur in the middle of words.
28. P5 L5: "Pools" probably has to be "P pools".
29. P5 L20 (and elsewhere): mg kg-1 -> mg kg^{-1}
30. P8 L2: Delete the "and" at the end of the sentence.
31. P8 L23: "considerably" -> "considerable"
32. P9 L1: (and elsewhere): "regressions models" -> "regression models"
33. P9 L20: "org. C content" -> "organic C content"
34. P10 L5: "microorganism" -> "microorganisms"
35. P10 L13: "These effect" -> "This effect"
36. P10 L20: "even if there are" -> "even if there is"
37. P11 L32: "In forest soils of northern Germany" -> "In forest soils of northern and central Germany"
38. The bibliographical references are sometimes written with comma, sometimes without.
39. P12 L5: "negative influence of P content in soils" -> "negative influence on P content in soils"
40. P12 L16: "Pi. abies" -> "P. abies"
41. P12 L23: "P fertilization lead to" -> "P fertilization leads to"
42. P15 L18-19: The reference is incomplete.
43. P15 L33: "soils nutrients" -> "soil nutrients"

44. P16 L1-2: The reference is incomplete.
45. P26 Figure 2: “Po ready mineralizable” -> : “Po readily mineralizable” and “HNO3 65% + H2O2” -> “HNO_3 65% + H_2O_2” and “grey boxes indicates” -> “grey boxes indicate” and “dashed line separates” -> “dashed lines separate”
46. P28 Figure 4: “The column” -> “The columns”

References:

Talkner U, Jansen M, Beese FO (2009) Soil phosphorus status and turnover in central-European beech forest ecosystems with differing tree species diversity. European Journal of Soil Science 60:338–346. doi: 10.1111/j.1365-2389.2008.01117.x

Wehrmann J (1959) Methodische Untersuchungen zur Durchführung von Nadelanalysen in Kiefernbeständen. Forstwissenschaftliches Centralblatt 78:77–97. doi: 10.1007/BF01822233