Review BG-2011-208
Yang & Post

General Comments:

This manuscript investigates how P fractions and C:N:Po stoichiometry differ among soil orders, and how this variability relates to the degree of soil weathering. The paper is well within the scope of papers published in Biogeosciences. The subject is highly relevant, and the findings significantly contribute to our understanding of P transformations in soils. However, poorly defined and inconsistent terminology made the paper very difficult to follow and as such diminished the quality of the paper. My general recommendations are as follows:

1. The authors need to very clearly define the different forms of P. I would also suggest the authors restrict the number of terms used. The multiple variations on the different forms of P (e.g., at least 11 different descriptors of P were used) made the manuscript very difficult to follow. I also noticed that the terminology was not always consistent throughout the paper. A table that clearly defines the different definitions would be helpful.

2. I would also suggest the authors define how the soil orders were grouped earlier in the paper than the discussion, and possibly show these classifications in the figures. At one point, soils were defined as young rather than lightly weathered and age had not been previously mentioned. The soil classifications should also be consistent throughout the paper.

3. Some of the trends the authors describe were not visually apparent in Figure 3.

Specific Comments:

Introduction:

Page 1, Lines 8-12. The discussion of the different P methodologies could be clarified further. The Hedley fractionation is a sequential extraction of the same soil and is used to determine all of the different forms of P ranging from the most available to the most recalcitrant P. In contrast, the Olsen, Bray, and Mehlich extractions are single soil extractions used to evaluate the labile soil P pool only and do not provide information on either the occluded forms of P or total P (e.g., they are equivalent to steps 1-3 in the Hedley Fractionation). You can theoretically establish the proportion of phosphorus held in each form by combining results from different soil extractions (e.g., a strong acid digestion (Total P), Olsen/Bray extraction (Labile P). The Hedley Fractionation as a whole isn't really comparable to the other methods listed unless you restrict the comparison to the labile forms.

All in all, this paper really focuses on how P fractions vary among soil types over time and does not really evaluate how labile P pools differ depending on methodology. As such, this should really be re-framed to note that there are other measures of labile P outside of what is included in the Hedley Fractionation but this study restricts analysis to Hedley labile P because it is not clear how comparable these measures of P are.

Page 3-4, lines 24-28; lines 1-4, lines 10-15: The discussion of the different forms of P is not clear and should be better defined throughout the paper. For example, the authors use the following terms to discuss the different forms of P in the introduction: mineral P, dissolved P,

non-occluded P, labile P, organic P, inorganic P, occluded P, secondary mineral P, available P, plant available P, solution P. A table that defines the different forms of P, including the relevant timeframe could help. The authors might also consider restricting the number of terms used to describe the forms of P so that the terminology is more consistent throughout the paper.

Page 4, line 6: Crews et al. 1995 is another relevant citation.

Page 5, Line 5: It is true that the Total Soil P discussed in these studies includes both occluded and labile forms of P, but as I understand it they don't really include P in parent material. Typically total P is measured in the upper soil horizons using a strong acid digestion, which is basically equivalent to Field 7 in table 1. Perhaps a more appropriate way to frame this point would be a statement to the effect of "Comparing CNP ratios using available forms of P, rather than total P, could be a more relevant analysis because x, y, z."

Page 5, Line 10. It would help if it this were rephrased to "Since nearly all Hedley fractionation method studies also measured soil organic C and N, we were also able to investigate C:N:Po stoichiometry in soils."

Methods:
Page 6, Lines 15-19. Which extractions give you Bicarb Pi and Bicarb Po? This is not defined in Table 1. Does this correspond to Field 4 and 5? If so, this should be more clearly labeled.

Data Analysis: Need a statement about which soil orders were included in each "weathering stage".

Results:
Page 8, Line 3: Is secondary inorganic P the same as Secondary Pi? On previous page, is secondary mineral P the same as Secondary Pi? The terminology could be more clear and consistent throughout the paper.

Page 8, Line 6: Other than Table 2, this is the first time in the paper that the Apatite P pool is mentioned. This pool should be described earlier in the paper.

Section 3.2. I don't see some of the trends that are discussed. See comments on Figure 3. It would be helpful if the classification of each of the soil orders into lightly weathered versus highly weathered was explicitly defined somewhere in the paper.

Page 8, Line 21. In section 2.2 these pools are called bicarbonate Pi and biocarbonate Po not HCO3- Pi and Po. Labels for the different P pools should be consistent throughout paper.

Page 8, Line 22. This is the first that soil age is mentioned (e.g., young soils versus highly weathered soils). Which soils are young versus lightly weathered versus highly weathered, etc. Because weathering rates differ based on climate, so the age of the soil may not reflect the degree of weathering. This should be clarified.

Page 8, Line 25-26: This statement needs further clarification. Are you stating that because highly weathered tropical soils have similar labile P relative to lightly weathered systems that the decline in total P is likely due to leaching losses? The logic is not clear to me.

Page 9, Line 8-9. The analysis really refers to labile P requirement for plants in forested ecosystems. Other terrestrial ecosystems aren't really considered.

Page 10, line 5-10. These definitions of lightly to highly weathered should be included in the methods. It would also be helpful if there were some indication of how these soil orders are grouped in the figures, or figure heading.

Discussion

Page 11, line 14. The following citations are relevant here: Chacon et al. 2006-Biogeochemistry; Liptzin and Silver 2009-Soil Biology & Biochemistry. These papers discuss the release of Fe-bound P under anaerobic conditions in wet tropical forests.

Page 11, Line 25. However, see the citations listed above. In wet forests, Fe can fluctuate between oxidized and reduced forms. During wet conditions, Fe is reduced and releases Fe-bound P. There is also seasonal variability in the available forms of P, which could be related to this process (Chacon et al. 2006, Wood & Lawrence 2008-Plant & Soil).

Page 12, line 26. However, "fertilization" with litterfall in a wet tropical forest in Costa Rica led to a significant increase in forest productivity within 5 months of litter application. This increase in productivity was positively correlated with the total P in the litter, suggesting a strong link between litter P and forest productivity. In the tropics, roots grow within the litter layer. Hence, it could be that the labile P measured in tropical soils does not capture the rapid uptake of P mineralized in the litter layer.

Page 14, Line 10. Higher P resorption rate in plants, not soils.

Page 15. Something to consider: The bray extract is often used to analyze available P in acidic soils rather than a bicarbonate extract (see Cross & Schlesinger). It is therefore possible that the Hedley fractionation is not the most appropriate analysis of the available P fraction in tropical soils.

Table 1:

The fields should match the specific terminology used in the paper. This will help clarify the various definitions of P used in the paper.

Table 2:

The terminology should match the field labels listed in Table 1. This will clarify the definitions of the different P fractions.

Figure 2:

It would help if the heading stated that soils are organized from least to most weathered, and also showed how the soils are classified (e.g., lightly vs. intermediately, vs. highly weathered).

Figure 3:
If the soil orders are organized from lightly weathered to highly weathered then the figure doesn't really reflect some of the trends discussed in Results 3.2. For example, I don't see the decrease in the % of Apatite with weathering. It works if you start with the Aridisol and work your way to the Oxisol, but not if you look across all soil orders. Even if you exclude the Aridisol, the Andisol and Histosol have less apatite P than the Entisol. Also, the Histosols have a lot of occluded P relative to the other "lightly weathered" soil orders. It is difficult visualize trends in the various forms in this figure.

Technical Corrections:
Page 3, Line 2: delete "element"
Page 3, Line 6: delete "as"
Page 12, Line 10: higher "than" that of
Figure 3: Change Oxidosol to Oxisol