Reviewer 2: The authors examined key soil properties (e.g., pH, Nitrogen content, and Phosphorus content) and microbial diversity composition, comparing a *Eucalyptus* monoculture site with a *Eucalyptus-Acacia* mixed plantation site. They found significant differences in both soil chemical properties and microbial diversity composition between the two sites. This work and its topic align with the scope of *Biogeosciences*. However, the manuscript's organization and overall quality require significant improvement before it meets the publication standards of *Biogeosciences*.

Response: We greatly appreciate your comments and suggestions, which are valuable in improving the quality of our manuscript and we will make necessary modification throughout the text. We believe the revision is much improved as a result of our modifications.

General comments:

1. The key message emphasized throughout the manuscript—that "increased soil microbial diversity and network complexity has resulted in enhanced Phosphorus transformation" —appears to be overstated for several reasons:

While soil "P transformation" is repeatedly mentioned throughout the manuscript and included in data analyses (e.g., Figure 9), there is no clear definition or quantification methodology provided for this index. Phosphorus exists in soil in both organic and inorganic forms and undergoes continuous transformations through chemical, physical, and biological processes, making its transformation quantification complex. The authors only measured two P-related soil properties—total P (TP) and available P (AP), with AP notably absent from many follow-up analyses (Figure 8). It is unclear how the authors quantified "P-transformation" (which appears to be simply the Total P content) and drew conclusions about factors influencing this process.

Response: Thanks for pointing this out. We have checked the entire text and read numerous relevant references carefully. Phosphomonoesterase (i.e., ACP) mineralization is an essential strategy for P transformation (Nannipieri et al., 2011; Yu et al., 2022; Wang et al., 2023), so we employed soil ACP activity to analyse the dynamics of P transformation. In addition, we added some detailed description of P transformation to avoid the confusion.

References:

[1] Nannipieri, P., Giagnoni, L., Landi, L., Renella, G.: Role of phosphatase enzymes in soil. Phosphorus in action: biological processes in soil phosphorus cycling, 215-243, https://doi.org/10.1007/978-3-642-15271-9_9, 2011.

[2] Yu, Q., Ma, S., Ni, X., Ni, X., Guo, Z., Tan, X., Zhong, M., Hanif, M. A., Zhu,

J., Ji, C., Zhu, B., Fang, J.: Long-term phosphorus addition inhibits phosphorus transformations involved in soil arbuscular mycorrhizal fungi and acid phosphatase in two tropical rainforests. Geoderma, 425, 116076, https://doi.org/10.1016/j.geoderma.2022.11607,2022.

[3] Wang, Y., Luo, D., Xiong, Z., Wang, Z., Gao, M.: Changes in rhizosphere phosphorus fractions and phosphate-mineralizing microbial populations in acid soil as influenced by organic acid exudation. Soil Till. Res., 225, 105543, https://doi.org/10.1016/j.still.2022.105543, 2023.

2. The authors appear to have conflated correlation with causation in their narrative. While the *Eucalyptus* plantations were established in 2004 (approximately 20 years ago), soil sampling and analysis were conducted in 2021, providing only a recent snapshot. While it is reasonable to describe the observed differences in key soil chemical properties and microbial diversity between the two types of *Eucalyptus* plantations, the causal claim that increased soil microbial diversity and network complexity resulted in enhanced Phosphorus transformation is not adequately supported by the presented data and results.

Response: Thanks for your constructive feedback. The objective of our study is to investigate the mechanisms of microbial influence on phosphorus transformation in pure *Eucalyptus* plantations and mixed plantations of *Eucalyptus* and N-fixing trees species. So we think our observational data are convincing enough. Furthermore, in the future, we will continue to conduct relevant research.

3. Furthermore, according to the correlation matrix plot presented in Figure 8, Total P (TP) shows no significant correlations with either soil chemical properties or soil microbial diversity indices for most of the variable pairs. This lack of correlation directly contradicts the authors' main argument about the relationship between microbial diversity and Phosphorus transformation.

Response: Thanks for pointing this out. We apologize for confusing the reviewer. In the original manuscript we employed soil ACP activity to analyse the dynamics of P transformation. In addition, we will add some detailed description of P transformation to avoid the confusion.

4. The "Introduction"section requires substantial revision. It contains excessive methodological descriptions, such as Microbiome co-occurrence networks analysis and Functional gene markers, while lacking crucial discussions of key questions, mechanisms, patterns, and processes. Methodology merely describes the work conducted rather than establishing research significance. The interesting aspects that should be emphasized include the relationship

between N and P, the role of N-fixing plants in P transformation, the key players involved in these processes, and the main processes and influencing factors. Once these processes and key issues are clearly articulated, the methodological details would naturally fit into the Materials and Methods section. While the final paragraph includes hypotheses, these would be better integrated into the earlier parts of the Introduction.

Response: Thank you for your valuable suggestion. We will carefully check the entire Introduction section again and make appropriate.

5. The Introduction should address whether findings from *Eucalyptus* plantations can be generalized to other plantation types globally. Given the wide variety of both monoculture and mixed-species plantations worldwide, the authors should discuss how their research on *Eucalyptus* plantations relates to or differs from other plantation systems, and clarify the broader applicability of their findings.

Response: Thanks for good suggestions. We will improve the Introduction section based on your suggestions.

6. All expressions of "significant ($P < 0.05$)"should be revised to include the appropriate test statistics. Throughout the manuscript, the authors need to add the corresponding test statistics (g., t or F values) alongside the P-values to comply with standard statistical reporting conventions. For t-tests, results should be reported as ($t = XX$, $P < 0.05$), and for ANOVA tests, results should be reported as ($F = XX$, $P < 0.05$).

Response: We have revised it as suggested.

7. The manuscript contains numerous formatting errors in English text and symbols. For example:L2, Hyphens in title require spaces on both sides (e.g., "word - word" instead of "word-word"); redundant punctuation marks (e.g., double commas in L93); improper spacing in ratios (e.g., "C:N ratio" and "N:P ratio" should not have spaces around the colon); inconsistent hyphenation and capitalization in statistical terms (e.g., "z score" and "c score" should be "Z-score" and "C-score"). The authors should carefully review and correct all formatting issues throughout the manuscript, paying particular attention to: (1) proper use of hyphens and spaces; consistent capitalization; standard formatting of statistical terms; correct punctuation; proper ratio expressions

Response: We will carefully check the entire manuscript and make appropriate about the organization and language of the content to make it more readable.

Specific comments:

1. L48-51, The opening statement about Phosphorus being an essential nutrient is too absolute and lacks proper context.

Response: Thanks for your constructive suggestions. We have added some relevant contents to enrich the paragraph and made it appropriate.

2. L79-81, The statement "... is crucial for developing forest management strategies aimed at enhancing soil fertility and optimizing ecosystem functionality" is an overreaching conclusion that lacks sufficient support. In particular, the concept of ecosystem functionality was never a focus of this study.

Response: Thanks for your insightful comment. We have checked the sentence carefully and made necessary modification to avoid the confusion.

3. L236-237, the rationale for choosing these specific metrics (ACE, Chao1, and Shannon indices here in this study) over other available diversity measures for microbial community analysis should be explained.

Response: Thank you for your comment. We have read numerous relevant references carefully. Chao 1 and ACE indexes were used to estimate the richness of the bacterial and fungal community, while Shannon index was used to evaluate the diversity of bacterial and fungal community (Wang et al., 2018; Sun et al.,2021; Qiu et al., 2021; Malard et al., 2022). Therefore, these indices combined provide a more reliable and comprehensive view of microbial community structure and its potential links to soil nutrient cycling.

Relevant references are as follows:

Wang, C., Liu, D., Bai, E.: Decreasing soil microbial diversity is associated with decreasing microbial biomass under nitrogen addition. Soil Biol. Biochem., 120, 126-133, https://doi.org/10.1016/j.soilbio.2018.02.003, 2018.

Sun, Y., Ren, X., Rene, E. R., Wang, Z., Zhou, L., Zhang, Z., Wang, Q.: The degradation performance of different microplastics and their effect on microbial community during composting process. Bioresource Technol., 332, 125133, https://doi.org/10.1016/j.biortech.2021.12513, 2021.

Qiu, L., Zhang, Q., Zhu, H., Reich, P. B., Banerjee, S., van der Heijden, M. G., Sadowsky M. J., Ishii S., Jia X., Shao M., Liu B., Jiao H., Li H., Wei, X.: Erosion reduces soil microbial diversity, network complexity and multifunctionality. ISME J., 15(8), 2474-2489, https://doi.org/10.1038/s41396-021-00913-1, 2021.

Malard, L. A., Mod, H. K., Guex, N., Broennimann, O., Yashiro, E., Lara, E., Mitchell, A. D. E., Niculita-Hirzel, H., Guisan, A.: Comparative analysis of diversity and environmental niches of soil bacterial, archaeal, fungal and protist communities reveal niche divergences along environmental gradients in the Alps. Soil Biol. Biochem., 169, 108674, https://doi.org/10.1016/j.soilbio.2022.108674, 2022.

4. L262-263, The description of results is unclear regarding which group showed an increase when compared to which group.

Response: Thank you for your suggestion. We have rephrased the sentence to avoid the confusion

"Significant ($P < 0.05$) higher of SOC, TN, NO_3^--N, C: P, N: P, and pH were determined in both two investigated soil layers in MPs than those in PPs (Table 1)."

5. L245, There are inconsistent statements about the correlation analysis method used: L245 mentions Pearson correlation, L362 refers to Spearman correlation analysis, and Fig. 8 (L372) again states Pearson correlations. The authors need to clarify which correlation method was actually used and maintain consistency throughout the manuscript.

Response: Thanks for your careful checks. We used Pearson's correlation analysis and made appropriate modified to make the word harmonized throughout the text.

6. L372, Figure 8's readability is poor due to the excessive number of correlated variables. With many variables showing covariation, it is difficult to identify meaningful relationships. The authors should justify the purpose of including so many variables in the correlation analysis and consider focusing on key variables that address their research questions.

Response: Phosphorus transformation is directly or indirectly influenced by a variety of biotic and abiotic factors, and there exist unknown interactions among the factors. Therefore, we need to systematically explore the interactions among the factors in order to support the subsequent discussions.

For example: "In line with our results, a higher abundance and diversity of *phoD*-, *phoC*-, and *pqqC*-bearing soil microorganisms; higher abundances of these genes in soil were correlated with higher soil SOC and TN contents (Fig. 8) (Luo et al., 2019; Cao et al., 2022). Our study also identified significantly positive correlations between most N and P functional genes and 16S rRNA as well as the ACE, Chao1, and Shannon indexes in bacterial communities, whereas a significant positive correlation was determined only between the ITS region and the Shannon index in fungal communities (Fig. 8)."

7. L389-393, The meaning and purpose of Figure 9 are unclear. The figure caption only describes the visual elements but lacks explanation of what the figure aims to demonstrate or illustrate.

Response: Thanks for pointing this out. We added some detailed descriptions and made it clear and specific.
"Fig. 9a shows the directed graph of the partial least squares path models (PLS-PM), and Fig. 9b shows the Standardized total effects (direct plus indirect effects) on P transformation derived from the PLS-PM."

8. L406-408 There is a logical inconsistency in the manuscript's core arguments. While L406-408 emphasizes how soil properties influence microbial community composition ("Soil properties are key in influencing the composition of microbial communities..."), the main thesis appears to argue that differences in microbial community diversity lead to variations in soil P transformation.

Response: Thanks for pointing these out. We have carefully checked the entire manuscript again and will make necessary modification to avoid the confusion.

9. L465-468, the text here is redundant as similar sentences appear in the Introduction. Moreover, this background information belongs in the Introduction section rather than the Discussion, where the focus should be on interpreting results and their implications.

Response: Thank you for your feedback. We will reorganize the Discussion section and expand our discussion which correspond tightly to the hypotheses and core findings of our study.

10. L508-L512 This is for sure. The introduced trees are N-fixing trees.

Response: Thank you for your suggestion. We have rephrased the sentence to avoid the confusion.