

We sincerely thank the reviewer for the constructive comments and suggestions, which helped us to substantially improve our manuscript. Please find the point-to-point responses (blue) to the comments (black) as listed below.

Reviewer #2:

Major comments:

1. To support your view and/or hypotheses of S dynamics and interactions between many forms of S, Fig 1 should be more highlighted in Introduction and Methods sections, and should be involved with procedures of extraction and calculation of S forms; I think it is necessary to discriminate what form of S was analyzed directly by extraction procedure and what form of S was calculated indirectly from concentrations of analyzed forms.

Response: Thanks for the helpful suggestion. As per suggestion, we incorporated related information in Figure 1 to discriminate which form of S was analyzed directly by extraction procedure and which S was calculated indirectly from concentrations of analyzed forms. We highlighted Figure 1 in both Introduction (P.4 L16-20) and methods sections (P.11 L11).

2. The path structure of SEM analysis and underlying idea should be introduced in Methods section (P12 L15~). The variables can be divided into three categories [related to practices (mowing, N rate), independent variables (pH, TIN, SOC etc.), and dependent ones (forms of S)], while all of the items are boxed in same way in the current figures (Fig. 7c, d). Please explain the assumptions and/or typical, expected interactions among these items as a status of pre-analysis. It will be also effective to integrate with research hypotheses (in P7 L8~15).

Response: As suggested, we introduced the path structure of SEM analysis and underlying idea by building a *priori* model in Method section (Fig. S1a; P.13 L21-P.14 L5). Here, we combined the three categories of variables in one model (Fig. S1a) and added the expected interactions among these items and described as “soil S fractions could be directly affected by N addition frequency, intensity and mowing, or indirectly by altering soil pH, plant biomass return and organic S mineralization” (P.13 L21-P.14 L3). Moreover, we integrated these expected interactions with our hypotheses as described in the caption of Fig. S1. To obtain the best-fit final model, insignificant pathways and parameters that had no effect on inorganic fractions were excluded from the model sequentially (see Fig. S1b, c). This information was also mentioned in P.14 L3-5.

3. Are the treatments of mowing, intensity and frequency of N addition is comparable to the conventional management of the grassland in this region? How much is the amount of N added to the experimental plots compared to N deposition rate in this

region and N fertilizers conventionally used for this grassland?

Response: We sincerely appreciate the valuable comment. Mowing for hay harvesting by local people in late August is very common in this region (P.6 L15-17). Nitrogen deposition rate is about 1~2 g N⁻² year⁻¹ in this area which equal to the low N addition intensity of this experiment. We added higher amount of N to mimic accumulative N deposition in the long-term and/or extreme N inputs in the future (P.9 L6-7). Due to the fact that infrequent N addition (i.e. 1 or 2 time per year) is commonly used in manipulative experiments to mimic N deposition, a more frequent and even way of N addition (i.e. 12 times yr⁻¹, high N frequency) was set to simulate natural N deposition to compare whether changing frequency of N input would affect grassland ecosystem. This information has been added in subsection of 'experimental design' (P.8 L21-P.9 L1-5).

Specific comments:

1. P10 L8: "nitrite" is NO₂⁻. Here, this may be "nitrate (NO₃⁻)".

Response: Thanks. We have corrected the "nitrite" into "nitrate" (P.11 L5).

2. P10 L20: What is "acacia solution"? Is this a kind of chemical used for stabilizing solutes?

Response: Yes, the gum acacia solution was used to stabilize the solutes. This information has been added in P.11 L19.

3. P11 L3-4: Equations should be enumerated; one equation by one line, and numbered.

Response: As per suggestion, each equation has been numbered in a separated line (P. 12 L3-5 & L14).

4. P11 L12: What is "i" in this equation? This equation should also be numbered continuously following the previous equations.

Response: "i" denotes the plant species *i*, which has been defined in P.12 L15. All the equations have been numbered continuously now.

5. P13 L17: Fig. 1b -> Fig. 2b

Response: We corrected "Fig. 1b" into "Fig. 2b" (P.15 L4).

6. P14 L8, L16: Are these percentages (55%, 43% and 40%) average among all N addition intensities?

Response: We calculated the percentages within each N intensity and N frequency. 55% (now it's 95% after data re-analysis following the suggestion from Reviewer #1) is the

highest percentage change among all N treatments across both N intensity and frequency. 43% and 40% are the highest percentage changes among N intensities for low N frequency and high N frequency, respectively. These have been clarified in the main text (P.16 L3-4).

8. P16 L19: characters -> characteristics

Response: We changed “characters” into “characteristics” (P.18 L4).

9. P17 L16-18: I could not understand the indirect positive effect of N rate on adsorbed S from Fig. 7c. Is it mediated by pH? Is “positive” effect derived from two negative effects, N rate -> pH and pH -> adsorbed S? From that interpretation, the direct and indirect effects of N rate on adsorbed S is strange (Fig. 7d); the indirect effects of N rate on adsorbed S mediated by pH should be positive because both arrows are negative, while the direct effects of N rate on adsorbed S is negative.

Response: Thanks for mentioning this. For the indirect effect, two negative effects indeed result in one positive effect but it’s still an indirect effect; and the total effect size depends on the relative size of direct and indirect effects. After carefully considering this comment and the general comment #3, we re-ran the SEM model by combining three treatments, independent soil variables and dependent ones and then corrected our interpretation (P.18 L16-P.19 L5).

10. Fig. 1: It is unclear that Available S is sum of Water-soluble S and Adsorbed S. Also, I could not see the difference between hollow and solid arrows.

Response: The Figure 1 has been modified by involving with procedures of extraction and calculation of S forms. Related information has been added in Methods section (P.11 L10-14 and P.12 L1-5) and in caption of Figure 1. We utilized green and red arrows to represent opposite processes affecting soil S fractions.

11. Fig. 4: Alphabets indicating significant difference according to multiple comparison should be added to Insoluble S in Fig. 4b

Response: In the previous version, we did not label with alphabets where insoluble S concentrations were insignificant among N intensities. After considering the comments from Reviewer #1, we recalculated the proportional data as inorganic S fractions relative to total S concentration because proportions of S fractions could not reflect their transformation very well. The figure has been moved to supplementary material as Figure S5 and all significant difference has been labeled.

12. Fig. 7c, d: “N rate” should be “N addition intensity”. Please indicate that the bars right side of Fig. 7a, b, changing color red to blue, represent correlations

Response: As suggested, “N rate” has been corrected into “N addition intensity”. We added the description of the changing color red to blue of the bars representing correlations.