We thank the reviewer for their thoughtful and constructive comments, which help us improve the clarity, transparency, and scientific robustness of the manuscript. We appreciate the recognition of the methodological contribution and relevance of our study. Below we outline how we plan to address each of the specific comments in the revised version of the manuscript.

> ***1.) Provide a supplementary table that lists every fixed parameter, its value, units, and reference/justification. This will satisfy transparency and help future users turn the feature on in standard LPJmL runs.***

We fully agree with the importance of parameter transparency. Given the large number of parameters involved in the LPJmL model, we would follow this approach:

The general model parameters, i.e. unmodified LPJmL5 settings, are already available in the publicly accessible LPJmL-Pasture-Burning version repository. A direct link to the code is provided at the end of the manuscript in the section code availability. In addition, we have added a reference to it in the Model configuration and experimental setup subsection as follow (l. 234):

A complete list of the general parameters used during the simulations can be found in the configuration files of the model, which are available via the link provided in the Code Availability section.

To complement this, we have added a new supplementary table listing all parameters that are specific and most relevant to this study. This includes parameters related to the Chalumeau algorithm, the pasture and grazing management system (e.g., fraction of manure returned to the soil), and the nitrogen cycle (including BNF). The table reports parameter names, values, units, and where available the corresponding references or justifications. This table is included in the appendix as Table S1.

We believe this approach ensures both completeness and accessibility while keeping the main manuscript concise.

> ***2.) In the nitrogen-budget discussion the authors state that nitrogen inputs "consist of BNF and atmospheric deposition," and the decline in soil N under burning / grazing is "driven primarily by reductions in BNF. However, there is no description of how BNF is computed (symbiotic vs. asymbiotic, dependence on plant N demand, moisture, temperature, etc.) nor any parameter values.***

We thank the reviewer for pointing out the lack of detail regarding the representation of BNF in the manuscript. We acknowledge that the current version does not provide sufficient information on this important process.

The current implementation in our model is relatively simple. BNF is calculated from the 20-year average of annual evapotranspiration following the function from Cleveland et al. (1999). The resulting BNF is added to the NH4+ pool in the first soil layer. The description of this process as well as the equation are added in the section 2.1.3, Soil nitrogen pools, as follow (l. 140):

BNF is calculated from the 20-year average of annual evapotranspiration following the function from Cleveland et al. (1999). The resulting BNF is added to the NH+4 pool in the first soil layer.

$$\mathrm{BNF} = \begin{cases} \max(0, (0.0234 \cdot \mathrm{etp} - 0.172)/10/365) & \text{if } C_{\mathrm{root}} > 20\,\mathrm{g\,C\,m^{-2}} \\ 0 & \text{otherwise.} \end{cases}$$

We have also noticed that Figure 10 might be difficult to interpret, particularly regarding the nitrogen inputs, as they are not explicitly shown. The original figure focuses solely on the nitrogen deficit. To improve transparency and enhance understanding, we have decided to revise the figure to display the nitrogen inputs, namely BNF and atmospheric deposition. The revised figure follows the same structure as Figure 11, with nitrogen inputs shown above the zero axis and nitrogen outputs below.

A) Include the key BNF parameters in the requested parameter table (fixation efficiency constants, maximum rates, etc.).

As mentionned in the answer of the point 1, all parameters regarding BNF are included in the requested parameter table.

B) If possible, show one sensitivity test (e.g. ±20 % maximum BNF rate) to demonstrate that the qualitative C: N conclusions are robust.

We appreciate the reviewer's suggestion to include a sensitivity test to assess the robustness of our conclusions. However, running additional simulations is computationally expensive, especially given the scale and complexity of our current model setup.

That said, we can reasonably anticipate the direction of the effect: increasing the maximum BNF rate would enhance BNF fluxes, thereby increasing nitrogen inputs into the NH_4^+ soil pool. However, this does not translate linearly into plant growth, as higher nitrogen availability also accelerates soil transformation processes such as immobilization, denitrification, and leaching.

Conversely, a decrease in the maximum BNF rate would reduce nitrogen inputs, potentially accelerating the decline of soil nitrogen pools.

While we are confident that such a test would not change the qualitative conclusions of our study, we acknowledge its potential value and consider it a relevant avenue for future work.

3.) Nitrogen cycling clarity - The current text never states what fraction of grazed N is returned as dung/urine or how urine is handled, calling the soil-N results into question.

A. Give the exact fractions and pathways in Sect. 2.1.2.

B. Cite a data source and show that the chosen value falls within the empirical 70–95 % range.

We thank the reviewer for pointing out this omission and fully acknowledge the lack of detail in the current manuscript. This was indeed an oversight on our part.

In our model, 66.7% of the nitrogen contained in grazed biomass is returned to the soil via excreta, primarily as urine. This value lies within the lower range of empirically observed values (typically 70–95%), which reflects the fact that livestock are not permanently present in the field. Our assumption accounts for periods when animals are housed or moved, during which excreta are not deposited directly onto the grazed area.

We have included this information in the Section 2.1.2, Managed grassland and grazing, as follow (l. 134) :

For nitrogen, 66.7% of the grazed nitrogen is returned to the soil, primarily as urine and dung, and is allocated to the NO3 pool in the first soil layer. This value lies at the lower end of the empirically observed range of 70–95% reported by Selbie et al. (2015), reflecting the fact that cattle are not continuously present on the pasture. Periods during which livestock are housed or moved off-site are thus taken into account by this assumption.

> ***C. Run a quick sensitivity test (e.g. +20 % manure-N return) and state whether conclusions change.***

We thank the reviewer for this valuable suggestion. As previously mentioned in our response regarding the BNF sensitivity test, running additional simulations is computationally expensive.

Nonetheless, we can anticipate the likely effects of a ±20% change in the manure-N return fraction. Increasing the proportion of nitrogen returned to the soil would enhance nitrogen inputs to the NO_3^- soil pool. Conversely, a reduction in this return fraction would decrease nitrogen inputs, possibly accelerating the decline of soil nitrogen pools. However, as already explained for the BNF, this does not translate linearly into plant growth, as higher nitrogen availability also accelerates soil transformation processes such as immobilization, denitrification, and leaching.

> **4.) This study does not use any experimental field data for calibration or validation. Its findings are based entirely on mechanistic simulations, and while it emphasizes the importance of future field research, it would benefit from moving that discussion into a dedicated 'Limitations and Outlook' subsection**

Thank you for this helpful suggestion. We have renamed the "Conclusion" section to "Limitations and Outlook" and merged it with the final part of the Discussion (starting from l. 427). In this revised section, we have added a paragraph explicitly addressing the lack of experimental field data for calibration or validation of the burning practices. While acknowledging this limitation, we have also mentionned that the LPJmL model and its internal dynamics have been previously validated, and we have provided the corresponding reference (l. 442):

This study does not rely on experimental field data to calibrate or validate the results specific to burning practices. Indeed datasets documenting the impact of burning on vegetation structure, yields, and soil carbon and nitrogen content are either unavailable or entirely lacking for Brazil and the various locations analysed here. However, the LPJmL model itself, along with the underlying process dynamics it simulates, has been previously validated (Schaphoff et al., 2018a, b; von Bloh et al.,2018a, b).