Interactive comment on "Modelled potential forest area in the forest-steppe of central Mongolia is about three times of actual forest area" *by* Michael Klinge et al.

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A note upfront from the submitting person: This review was prepared by four master students in geography at the University of Zurich. The review was part of an exercise during a second semester master level seminar on "the biogeochemistry of plant-soil systems in a changing world", which is organized by prof. Dr. Michael Schmidt and myself. We would like to highlight that the depth of scientific knowledge and technical understanding of these reviewers represents that of master students. We enjoyed discussing the manuscript in the seminar, and hope that the comments will be helpful for the authors.

The authors goals were to relate relief and climatic factors to the distribution and biomass of forest in a steppe in central Mongolia. In order to achieve this, they made use of remote sensing and GIS data, meteorological data as well as in situ measurements of tree growth and soil parameters. Therefore, the authors compared forest sites characterized by varying forest types and site conditions. Furthermore, the authors computed the potential forest extent via two models; one based on climatic and the other on relief parameters. By comparing the potential forest area to the current and past forest extent, the authors conclude that the forest distribution is strongly related to relief-controlled climatic factors, such as for example precipitation and the presence of permafrost. They further state that NDVI is not a suitable method for forest steppe and that detrimental fires mostly affected large forest stands in the high mountains between 1986 and 2017. Additionally, the modelled forest biomass and distribution largely surpass the observed extent.

The article aims to investigate the question of how the spatial forest distribution and biomass relate to and is influenced by climatic and topographic parameters. The article is generally well structured, clearly leading the reader through different aspects of the study. However, one major point that came up during our discussion is the broadness of assessed aspects. As such, the study not only raises the question of the forest's areal potential and present extent but also its biomass, factors, such as edge effects or permafrost, influencing the former two, the influence and history of fire as well as human disturbance. Additionally, each aspect is accounted for in multiple forms and categories (e.g. forest size, dominant vegetation). Therefore, we would advise to rethink the title of the manuscript and more precisely formulate the intended goals.

The introduction is well structured and gives a clear overview about the topic. We appreciated that the hypotheses and research questions are presented clearly.

The study area is clearly described and figure 1 gives an overview of where the study area is located. It would be helpful to indicate the exact location of the study area (the northern slopes of the Khangai Mountains) and to label all mentioned locations on the

map. Further, the temperature and precipitation are mentioned only at Tosontsengel. We wonder how big the temperature difference within the study area is, which is located on a higher altitude.

In general, the methods are nicely presented, the materials are clearly named, the concepts and the relationships are well explained. The general structure is coherent and understandable. The different steps are well divided into paragraphs, which helps the comprehension. The authors clearly explain how data was acquired through field work and remote sensing. It is explained how the data were calculated and employed. The general methods are coherent with the objective, confront the field results with the results obtained through remote sensing and the GIS approach. Furthermore, some details could be improved: (1) The role of the auxiliary data named in the text, such as ground vegetation structure, soil profile and detection of permafrost, could require some information about its use. (2) The selection of the reference year is not clear to us; there are no sources or measurements or data, which states that 1986 is a year of transition from "few fire events" to "extensive ones". Could be interesting if some indications about the selection of this year are provided. (3) The authors used the NDVI to highlight relations with the biomass. However, the role of the NDVI is not completely clear. If it serves to demonstrate that the NDVI is not recommended in such situation, which is supported by the results or if it is used to find a relation with the biomass. However, the NDVI is not recommended, since it is strongly affected by other components. (4) The forest distribution analysis was pursued using climatic parameters: mean annual precipitation (MAP), mean growing season temperature (MGST) and mean potential evaporation (MAE). The creation of a potential forest distribution based on climate is very interesting, however, these data used for the analysis are strongly correlated, which may disturb the outputs. (5) About the classification of site condition, it is well explained how the data are retrieved and how they are divided and used. However, all the classes were displayed together in Figure 4, which results quite chaotic and difficult to distinguish between the type of forests and/or the soil type. Maybe the removal of some classes in the image could improve the display.

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The results are clearly structured in a logical order. The first part (4.1) indicates the general distribution of different factors. However, these factors could better be described in two different subparts, as the burnt areas and permafrost areas were examined in very different ways and thus are better presented separately. The two different PFA estimation approaches are described well and are easy to understand. Additionally, the aggregation of the results in the last part (4.5) nicely summarise the results section. To a certain degree, we are not sure about the accuracy of the determination of total tree biomass with the chosen method, as on the one hand the authors reject the NDVI method due to low correlation but on the other hand you just use another method which might also induce an unknown error.

The discussion points out important findings of the study, starting with the variation in tree biomass and the characteristics of investigated alluvial forests. Furthermore, the authors present the different factors influencing forest distribution and size, with a focus on the importance of fires and permafrost. The discussion of the latter would profit from more literature and data to back it up. The authors nicely connect the reciprocal effects different parameters exert on each other and tie in the anthropogenic stress caused to the forest. We wonder, however, why windthrow was not included in the list of disturbances such as logging or fire. Additionally, we suggest revisiting the topic of climate change and the steppe's sensitivity, first mentioned in the introduction. In this context it would also be interesting to discuss the probability of forest establishment to full potential, for example after decreases in permafrost.

We would suggest limiting the variables investigated in the study and instead focus more specifically on either the goal of forest area or else forest biomass. Either one would make an interesting paper. Additionally, some elements such as alluvial forest might be omitted, in favour of the paper's comprehensiveness, cohesion and length.

Minor points and suggestions:

- P2L53: Newer data available? - P4L101: Please, add citation regarding intensity

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of forest fires - P5L124f: Replace summer/winter with months, to avoid confusion - P6L140: Indicate the location of "Ider Gol" in figure 1 - P8L183: Typo → ... are provided in the auxiliary... - P9L189: Indication about the choice of the reference year - P9L200: Use of the NDVI suited? - P9L206: We suggest to move Figure 3 to appendix. - P10L215f: Variables seem too strongly correlated for an analysis (PE, temp and prec). Please elaborate on this. - P10L224: Selection of some classes to display in the image? - P14L297: Figure: a bit hard to distinguish between different classes, especially with different categories visualized in one map with somehow similar colours; additionally, maybe check color scheme (red-green colour-blindness); add abbreviations of different landscape types in brackets behind each one (SDA, FDA, HMA, etc.) - P16L323: We suggest to change the colours of the data points (not green and red) - P19L351: Typo → MSG instead of MGS - P21L383ff: Does PFAr in that case not influence the outcome of PFAc? Should that not be avoided? - P22L393: Figure seems somewhat overloaded → difficult to assess differences, colour choice - General: a add table with abbreviations could be added