Peer Community In Ecology

Resolving herbivore influences under climate variability

Jennifer Krumins *based on peer reviews by 3 anonymous reviewers*

Catherine Picon-Cochard, Nathalie Vassal, Raphaël Martin, Damien Herfurth, Priscilla Note, Frédérique Louault (2021) Intra and inter-annual climatic conditions have stronger effect than grazing intensity on root growth of permanent grasslands. Missing preprint_server, ver. Missing article_version, peer-reviewed and recommended by Peer Community in Ecology. https://doi.org/10.1101/2020.08.23.263137

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We know that herbivory can have profound influences on plant communities with respect to their distribution and productivity (recently reviewed by Jia et al. 2018). However, the degree to which these effects are realized belowground in the rhizosphere is far less understood. Indeed, many independent studies and synthesis find that the environmental context can be more important than the direct effects of herbivore activity and its removal of plant biomass (Andriuzzi and Wall 2017, Schrama et al. 2013). In spite of dedicated attention, generalizable conclusions remain a bit elusive (Sitters and Venterink 2015). Picon-Cochard and colleagues (2021) help address this research conundrum in an elegant analysis that demonstrates the interaction between long-term cattle grazing and climatic variability on primary production aboveground and belowground.

Over the course of two years, Picon-Cochard et al. (2021) measured above and belowground net primary productivity in French grasslands that had been subject to ten years of managed cattle grazing. When they compared these data with climatic trends, they find an interesting interaction among grazing intensity and climatic factors influencing plant growth. In short, and as expected, plants allocate more resources to root growth in dry years and more to above ground biomass in wet and cooler years. However, this study reveals the degree to which this is affected by cattle grazing. Grazed grasslands support warmer and dryer soils creating feedback that further and significantly promotes root growth over green biomass production.

The implications of this work to understanding the capacity of grassland soils to store carbon is profound. This study addresses one brief moment in time of the long trajectory of this grazed ecosystem. The legacy of grazing does not appear to influence soil ecosystem functioning with respect to root growth except within the environmental context, in this case, climate. This supports the notion that long-term research in animal husbandry and grazing effects on landscapes is deeded. It is my hope that this study is one of many that can

be used to synthesize many different data sets and build a deeper understanding of the long-term effects of grazing and herd management within the context of a changing climate. Herbivory has a profound influence upon ecosystem health and the distribution of plant communities (Speed and Austrheim 2017), global carbon storage (Chen and Frank 2020) and nutrient cycling (Sitters et al. 2020). The analysis and results presented by Picon-Cochard (2021) help to resolve the mechanisms that underly these complex effects and ultimately make projections for the future.

References:

Andriuzzi WS, Wall DH. 2017. Responses of belowground communities to large aboveground herbivores: Meta-analysis reveals biome-dependent patterns and critical research gaps. Global Change Biology 23:3857-3868. doi: https://doi.org/10.1111/gcb.13675

Chen J, Frank DA. 2020. Herbivores stimulate respiration from labile and recalcitrant soil carbon pools in grasslands of Yellowstone National Park. Land Degradation & Development 31:2620-2634. doi: https://doi.org/10.1002/ldr.3656

Jia S, Wang X, Yuan Z, Lin F, Ye J, Hao Z, Luskin MS. 2018. Global signal of top-down control of terrestrial plant communities by herbivores. Proceedings of the National Academy of Sciences 115:6237-6242. doi: https://doi.org/10.1073/pnas.1707984115

Picon-Cochard C, Vassal N, Martin R, Herfurth D, Note P, Louault F. 2021. Intra and inter-annual climatic conditions have stronger effect than grazing intensity on root growth of permanent grasslands. bioRxiv, 2020.08.23.263137, version 6 peer-reviewed and recommended by PCI Ecology. doi: https://doi.org/10.1101/2020.08.23.263137

Schrama M, Veen GC, Bakker EL, Ruifrok JL, Bakker JP, Olff H. 2013. An integrated perspective to explain nitrogen mineralization in grazed ecosystems. Perspectives in Plant Ecology, Evolution and Systematics 15:32-44. doi: https://doi.org/10.1016/j.ppees.2012.12.001

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Sitters J, Wubs EJ, Bakker ES, Crowther TW, Adler PB, Bagchi S, Bakker JD, Biederman L, Borer ET, Cleland EE. 2020. Nutrient availability controls the impact of mammalian herbivores on soil carbon and nitrogen pools in grasslands. Global Change Biology 26:2060-2071. doi: https://doi.org/10.1111/gcb.15023

Speed JD, Austrheim G. 2017. The importance of herbivore density and management as determinants of the distribution of rare plant species. Biological Conservation 205:77-84. doi: https://doi.org/10.1016/j.biocon.2016.11.030

Reviews

Evaluation round #2

DOI or URL of the preprint: **https://doi.org/10.1101/2020.08.23.263137**

Authors' reply, 17 March 2021

The final version of the preprint has been corrected by a native English speaking profesional editor

Decision by Jennifer Krumins, posted 17 February 2021

In need of English usage editing

The article of Picon-Cochard is significantly improved, and I see they have addressed the reviewers' comments and suggestions. However, the English usage is still quite awkward and grammatically flawed. This is the case in the rebuttal to me the editor and the reviewer comments, and it is especially pronounced in the new text added to the manuscript itself. The authors state that the manuscript was previously reviewed by a native English speaking editor, but it is not clear if this was done prior to the revision. Please address this concern, and then, I will be happy to recommend this manuscript.

Evaluation round #1

DOI or URL of the preprint: https://doi.org/10.1101/2020.08.23.263137

Authors' reply, 29 January 2021

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Decision by Jennifer Krumins, posted 24 December 2020

Intra and inter-annual climatic conditions have stronger effect than grazing intensity on root growth of permanent grasslands

The authors find that annual variation, and the climatic variability of two years, affect primary production more than herbivory. The herbivore treatments have been ongoing for 10 years, and the legacy of that grazing cannot override effects of soil moisture and interannual climate. This preprint was reviewed favorably by three independent reviewers that all contribute constructive and thoughtful comments. I agree with the assessments of the reviewers and encourage these authors to incorporate them. All comments are focused on clarity of presentation of objectives, methods and goals of statistical analysis.

I agree with the reviewers that sample size was small and meaningful conclusions should be presented with care. Further, if more than 2 years of data had been collected some of the treatment effects of grazing may have been revealed within the inter-annual climatic effects. If more data had been collected it might be possible to statistically control for the random effects of climate and resolve differences among grazing treatments. That all said, this is still a nice study demonstrating complex interactions between grazing and environmental variables. All reviewers are familiar with large herbivore field experiments and understand the challenges of replication and heterogeneity of sampling.

I understand and appreciate the use of PCA here to describe the role of the different variables affecting root and shoot responses to grazing. However, I urge the authors to clarify their goals with respect to this statistic so that it is useful to the reader.

Jennifer Adams Krumins, PhD

Additional requirements of the managing board:

As indicated in the 'How does it work?' section and in the code of conduct, please make sure that:
-Data are available to readers, either in the text or through an open data repository such as Zenodo (free), Dryad (to pay) or some other institutional repository. Data must be reusable, thus metadata or accompanying text must carefully describe the data.
-Details on quantitative analyses (e.g., data treatment and statistical scripts in R, bioinformatic pipeline scripts, etc.) and details concerning simulations (scripts, codes) are available to readers in the text, as appendices, or through an open data repository, such as Zenodo, Dryad or some other institutional repository. The scripts or codes must be carefully described so that they can be reused.

-Details on experimental procedures are available to readers in the text or as appendices.
-Authors have no financial conflict of interest relating to the article. The article must contain a ”Conflict of interest disclosure” paragraph before the reference section containing this sentence: ”The authors of this preprint declare that they have no financial conflict of interest with the content of this article.” If appropriate, this disclosure may be completed by a sentence indicating that some of the authors are PCI recommenders: “XXX is one of the PCI XXX recommenders.”

Reviewed by anonymous reviewer 3, 05 November 2020

In this impressive and well-designed work, the authors explored the role of grazing intensity (cattle) and drought on above and below biomass production in a Lolium + Trifolium dominated grassland over ten years. Root production was assessed monthly by cores, and leaf biomass by cutting and weighing. Other roots and leaf traits such as root length, density, and area, as well as community-weighted mean, dry matter content, and specific lead area and reproductive plant height, were also recorded and considered. The authors tested the following hypothesis: Whether grazing intensity increases above-ground biomass and other related traits (e.g., length, density, area) at expenses of root production (I), whether inter-annual weather conditions influences the effects of grazing (II), and finally whether root traits and thus below net primary production respond to treatments. On the other hand, the authors also describe weather conditions, soil temperature, and water content dynamics throughout the experiment. These additional objectives, however, have not properly been introduced in the aims of the study. The authors conclude that root production did not differ between grazing intensities. Below net primary production, however, decreased in ungrazed plots. Grass species composition varied across grazing treatments (e.g., Lolium grasses are more abundant in highly grazed areas), and specific root length and area were slightly lower in cattle-free areas. I think this work provides an exhaustive and detailed description of the temporal dynamics of the above and below biomass, as well as other related rood and leaf traits, in a very well managed grassland. Cattle pressure is low and rotational and thus is expected to have little impact on the traits considered. On the other hand, grasslands have been fertilized increasing the resilience of grasslands on the inter-annual variations in weather conditions. In summary, the authors have shown the outcomes of an excellent grassland management practice. To my understanding, grazing intensity plays a secondary role in this work. I have included an attached file with other minor comments and suggestions in the main body of the manuscript as popup notes. Check the use of acronyms through the manuscript, they are sometimes confusing and repetitive. I strongly recommend deep proofreading and editing by a native speaker. I hope my comments will be useful for your investigation.

Download the review

Reviewed by anonymous reviewer 1, 01 November 2020

This is an interesting study, which describes the productive response of grass at different levels of grazing intensity comparing a wet year with a dry year. The subject of study is interesting, despite the fact that already there are some related works, more information is still needed to understand the effect of the interaction between grazing and environmental conditions on pasture functioning.
The introduction is very extensive, greater concretion would be desirable. Some expressions are difficult to understand, changing long sentences for several short sentences will make understanding easier, for example, L53-56 or L62-66. Furthermore, in general, the use of language sometimes makes it difficult to understand the content. Perhaps the review of the work by someone specialized can help make the speech more fluid.
Regarding the statistical analysis, I have a doubt. The use of the plot nested in the block as a radon factor in the linear mixed-effects model is considered for accounting for temporal pseudo-replication, however, in my opinion at the same time it can control the spatial pseudo-replication and therefore it would not be necessary to calculate the mean values for each plot, being able to use the data of each ingrowth-cores which would increase the degrees of freedom and with it the statistical power of the test.

I am not sure I understand what is the intention of carrying out a PCA, since, in the results, I miss that each of the plots is represented in figure 3. Its representation would allow us to observe if the set of measures of the variables separate the different plots depending on the treatment to which they belong. Otherwise, if the objective is only to observe the correlation between variables, a matrix of correlations between parameters would be more suitable than a PCA, since it would allow us to observe the correlation values and their significance for each pair of variables. In the discussion, the authors state "in our field conditions and after 10 years of treatment application, soil moisture was not affected by the rotational grazing, probably because the temporal scale used (monthly-based) buffer shorter-term response", however, there are other possible explanations for it. Is it possible that the livestock loads used do not increase the apparent density of the soil? Or does the change in plant species between treatments compensate for the lower LAI in the grazed areas? Not all plant species have the same efficiency in the use of water. Authors affirmed "these treatments seem to be better adapted to buffering the negative effect of drought on grassland production than for abandoned grasslands. This is consistent with previous work showing that moderate grazing could be more beneficial than no grazing for drought resistance and recovery of ANPP and BNPP" I'm not sure if the data showed reflects this. Figure 2 shows a marked decrease in the dry year with respect to the wet year in the ANPP for grazing treatments, while the abandoned treatment maintains a similar value in both years. Therefore, the interpretation that I give to these results is that in wet years grazing increases productivity with respect to abandonment, but this increase in productivity disappears in the event of a drought, therefore, the grazing treatment is more sensitive to drought than the abandoned ones. In this context, it would be interesting to know how the years prior to the study have been, at least 2012 and 2013, to know if there is any type of accumulated effect from one year to the next.

On some occasions the authors do not find the expected effect regarding the grazing treatment, giving different explanations for it. However, a possible explanation not considered is the low number of replicates used in this study. When the expected differences between treatments are small, high statistical power is necessary to detect them, which means a sufficient number of replications. Even more so when the effects are heterogeneous in space, as the authors well indicate since the impact of livestock is highly variable in space. Perhaps reanalyze the data without calculating the means per plot can give new results. But regardless of this, I would not disregard the need for a broader sampling to be able to detect the impacts of grazing on the functional characteristics of the roots.

It seems that there is some confusion among tables S1; S2 and S3 since in the text name S2 to refer to the information shown in S3 and names S1 for the information shown in S2.

References:

There is a lack of some important studies as:

Li, W., Li, X., Zhao, Y., Zheng, S., & Bai, Y. (2018). Ecosystem structure, functioning, and stability under climate change and grazing in grasslands: current status and future prospects. Current Opinion in Environmental Sustainability, 33, 124-135.

Aldezabal, A., Odriozola, I., & García-Baquero, G. (2019). Grazing abandonment delays the effect of temperature on aboveground net primary production in Atlantic grasslands. Rangeland Ecology & Management, 72(5), 822-831.

In the manuscript authors indicate that "Data are available online: https://zenodo.org/deposit/4034903#" however, the web page indicates Permission required, so in reality, data are not available.

In general, I consider it to be a very interesting article that provides interesting data on certain aspects of pasture operations that are not yet clear, and that will certainly be cited after its publication.

Reviewed by anonymous reviewer 2, 03 November 2020

General The paper "Intra and inter-annual climatic conditions have stronger effect than grazing intensity on root growth of permanent grasslands" addresses the important question of how climate and management (herbivory) influences the main drivers of soil C sequestration or soil organic carbon (SOC), i.e. above and

belowground plant growth. The manuscriopt is well written and clear in its objectives to address the importance of root growth, soil fertility, and species composition as drivers of SOC.

The approach using an existing long-term trial is appropriate to capture short-term changes. While we know that SOC changes occur over decadal and longer time periods, and thus a longer trial would have been ideal, the scarcity of such trials must be acknowledged. Neverthless, their findings that climate has a larger influence than management (in this case a gradient of grazing regimes) is in agreement with other studies, and thus supports the overall idea that SOC is driven primarily by climate, and how this affects ANPP (and BNPP). The observations regarding grazing, relatively increased root growth and drought tolerance are not novel (see Klumpp et al 2011 in manuscript) but an important confirmation. An important contribution of the work is that they had access to different grazing intensities, as it is the variety of grazing intensities in various studies that confounds generalizations on its effect on SOC or other components of the biosphere.

As a suggestion, I would have liked to see more than 2 years of data, at least for the ANPP and possibly this is available for an existing 10-year trial? If they have 2 years of BNPP and ANPP as well as longer-term ANPP data available, this would allow some estimation of BNPP over the 10 years. Also once they have data over the longer time period it becomes viable to model time periods applicable to climate models. Without this longer term data I would say the paper still provides valuable data, especially considering the paucity of belowground studies of roots and SOC.

Specific comments:

The abstract could be improved with some result details