

Biogeosciences Discuss., author comment AC2
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Reply on RC1

Angelica Feurdean

Author comment on "Experimental production of charcoal morphologies to discriminate fuel source and fire type: an example from Siberian taiga" by Angelica Feurdean,
Biogeosciences Discuss., <https://doi.org/10.5194/bg-2021-1-AC2>, 2021

Reviewer 1 *This is an interesting and useful combination of field work observation, sampling and lab experimentation to examine modern plant communities and charcoalized plant parts at different roasting temperatures for the purpose of improving the development and interpretation of palaeoenvironmental records of charcoal (a proxy for fire) in boreal forests. The results should be of interest to a wide variety of researchers in EGU fields and interested in biogeosciences related to fire at local to large spatial scales, palaeovegetation research, and archaeology.*

OVERVIEW: Overall I suggest some changes to clarify the intent of the author for certain words like "burned", 'impact', 'intensity' etc - detailed below.. And some expansion on the discussion with respect to additional charcoal morphology literature in paleoenvironmental studies and archaeological studies. There should be some refinement on how explicit the 'decomposition' technique of the vegetation fuels was and thus, the use of the word "burned". Is it known if the material flamed in the oven? Was it roasted? combustion? Pyrolysis? The oxygen and time variables are largely ignored and this should be written as a caveat in the experimental design to be explored elsewhere or in future studies. Similarly, the words charcoal, charred, and (roasted, unused term in the study) may need to be defined early. 'Ashed' is also used but not fully discussed - I suppose it meant a more complete combustion generating white ash that then crumbled apart into soot and flyash? Was there an explicit purpose statement? Something like, characterising the diversity of charcoal morphologies produced by boreal forest vegetation fuels at X study site?

R: Many thanks for the positive response that this paper was interesting and a useful contribution to the community, and for the useful and thoughtful comments to further improve it. In revising this manuscript, I am working to 1) Clarify some of the terms used and expanded on the caveats of experimental design; 2) Expand on the discussion concerning additional charcoal morphology literature in paleoenvironmental studies and archaeological studies. However, a comprehensive comparison with archaeological studies is beyond the scope of this study. The same is valid for an extensive comparison with studies focusing on transport and sorting of morphologies, which was the not subject of the current study.

SPECIFIC COMMENTS:

L36 - This might be semantic, or a question of (spatial and time) scale and thus the need for clarity. The word impact is a bit ambiguous without further clarity on the context and use of this term. What is meant here '[a] fire impacts boreal forest". Over the long duree, is it the changing attributes of fires and the fire regime that impact the boreal forests? Does this mean one fire is impactful? Boreal forests have a lot of spatial heterogeneity in vegetation structure that is in part caused by fire and in part also influences fire itself. A changing fire regime has significant outcomes on the land cover. But if fire is a process in boreal forests itself, it seems more of a feature than of the biome rather than something that just impacts it. Throughout the paper the framing of the disturbance regimes needs to be balanced with how these disturbance regimes (mostly fire explored here) are a part of the system, and not something that just happens to the boreal forest and changes (impacts) it.

R: Thank you. I have rephrased this to acknowledge the role of disturbance by fire in the functioning of boreal forests, but also the concerns on the impact of changes in fire frequency or intensity. It reads: "Disturbance by wildfires is among the most common disturbance types in boreal forests, triggering gap dynamics or stand-scale forest replacement depending on intensity and frequency (Goldammer, 2015). Ongoing and anticipating increase in the frequency and severity of wildfire in boreal forests is raising concerns on its impact on the composition of these forests as well as climate (Jones et al., 2020).

L40 - Fire intensities in nature have been shown to be able to reach much higher temperatures, even flame temperatures can be higher than the range explored here. Is this really the gamut of temperatures in hot boreal fires? This needs to be framed as a subset (or modal?) temperatures of fires (maybe this can be estimated from MODIS intensities? i.e. energy output detected by satellite, or if there are some published field-based measurements.).

R: Thank you for pointing this out. Indeed, a wildfire burns at much higher temperatures than 500 degrees, but with this sentence, I highlight the temperature range that leads to the charcoal formation. In the revised paper I introduce an additional sentence clarify the range of fire temperatures and those resulting in charcoal formation (Rein, 2014).

L49 - worth stating somewhere that the Courtney-Mustaphi and Pisaric, 2014 study discussed potential for not just focusing on known-fuel morphotypes for charcoal analysis but for categorising all morphologies found in a local-scale study to examine the variability; as this would be useful to explore relationships to not just the known-fuel-sources of charcoal but taphonomic processes and possibly fire types (or another variable).

R: Added: "Courtney-Mustaphi and Pisaric (2014) also discussed the potential for categorising of charcoal morphologies to explore relationships to taphonomic processes and possibly fire types.

L60 - It would be useful to make distinctions between studies using ovens, flames, and other pyrolysis and combustion methods.

R: I am working to distinguish between results originating from studies that have used muffle over, open flame, or calorimetric methods.

L68 - spp? Or taxa? What was the minimal taxonomic resolution?

R: Genus is the minimum taxonomic resolution used here, however, most plants have been identified at the species level.

L69 - was there any testing in this study? It appears to be mostly a characterization study, which has merit. The purpose, objective, aims are not congruent with the content

R: I have replaced the word test with evaluating. The three main objectives presented in the introduction are then detailed in the Results /Discussion.

L79 - complete dryness. Was this checked? Before burning in the oven were the samples dried? Often one would dry at 105°C for 24 hours to drive off most moisture. Of course this may only influence the combustion to a limited extent in this study - but worth documenting for future comparison studies.

R: Thank you, I removed the word completely dryness. The material was air-dried for several weeks, but the moisture content was not measured. The plant appearance was dry and brittle in all instances.

L87 - what was the rationale for limiting oxygen? Were there any comparisons with oxygen not-limited burning and open flame burning?

R: To slow the burning processes in order to better replicate the natural conditions where fuels are more abundant and layered, thus the oxygen is more limited. I have not attempted experiments under non-limiting oxygen nor under open flame conditions.

L198 - is Ericaceae ever investigated in this study?

R: Ledum, Vaccinium, Camadaphne, Oxycoccus are all part of the Ericaceae family, this is what I ment here, instead of listing their names I have used their family name, see also Table 1.

L231 - 'rounder", was this intended to mean circular? (as in 2-Dimensional), or roundedness as in the degree angles are eroded or not produced? Can these terms be written more explicitly for the reader. Note that both how circular something is, and roundedness can be quantified, semi-quantified or categorised. Was this done? Discussing if this may or may not be useful in future studies would be useful for readers and future analysts (Note Vanniere et al 2003 Journal of Archaeological Science, 30(10), pp.1283-1299, with reference to eroded charcoal in agricultural soils).

R: Rounder, intended as circular, as in 2-Dimensional scale. I have not quantified the degrees of angels. I am working to point out clearly the differences and the potential usefulness of additional measurements on roundedness.

L264 - Add a caveat about the need to do detailed comparative studies on graminoid versus conifer needle fuels and subsequent charcoal. And perhaps among Graminoid growth forms themselves: Poaceae subfamilies, Cyperaceae, and others.

R: Added. Comparative studies on graminoid charcoal originating from Poaceae (grass) versus Cyperaceae (sedge) family will further improve the identification of fuel types given the ecological differences of the two groups i.e., Cyperaceae growing on wetlands, and Poaceae often on dry habitats. Misidentification of charcoal morphotypes from graminoid and conifer needle and subsequently of fuel types is another caveat that could be improved through detailed comparative studies of these fuel types.

L279 - a useful document for comparing mosses etc for readers to compare in Quaternary and temperature ecosystems is Levesque et al 1988. Lévesque, P. E. M., Dinel, H., Larouche, A. 1988. Guide to the identification of plant macrofossils in Canadian peatlands. Land Resource Research Centre, Research Branch, Agriculture Canada, Ottawa.

R: I am trying to get access to it.

L315 - intensity, as in heat/energy given off by fire?

R: The sentence adjusted to denote intensity as high-energy release

General comments: Introduction in general:

I think there needs to be a distinction between flame combustion, roasting by hot air (ovens), pyrolysis. This needs to come out more obvious to the reader beginning in the abstract, methods, and discussions. It needs to be stated that dry roasting in an oven is a proxy for one type of heating of vegetation in a natural fire, different to flame burning, etc. This is evident in the statement by the authors on L124 that 'All plant tissue was reduced to ash at 450 °C (Fig. S1).' In natural fires, flame and air temperatures do reach higher. I think the main items that need to be acknowledged is that the oven approximates some aspects of the heating conditions of natural fuels and that a crucial variable that is not explored is time at a (burning) temperature. With roasting in an oven the influence of flame dynamics and turbulent air flow is missing to the same degree as fires outdoors. This needs to be acknowledged as part of the experimental design and open the need for additional research.

R: Many thanks for pointing out the inconsistent use of burning types i.e, roasting by hot air (ovens), and pyrolysis, which is in the current form of the paper were sometimes used interchangeably. In the revised version I will make it clear that all combustions were in the oven thus roasting by hot air. I will additionally acknowledge the limitation of the experimental design to some aspects of the heating conditions of natural fuels, especially on the relation between time and the burning temperature.

It would be useful throughout and within this paper (if anything was combusted in a different method) to add the categorical naming of how the material was 'burned'. See Table1 in the following publication: [https://doi.org/10.1016/S0031-0182\(00\)00174-7](https://doi.org/10.1016/S0031-0182(00)00174-7)

R: All plant material used for burning experiments was dried before and burning conditions (muffle oven, preheating) were the same for all measurements. The only difference is the use of different temperatures. This information was added in the caption of **Table 1**. List of plant materials burned. All plants are from Siberia, Russia, except *Picea abies*, originating from Taunus, Germany. All plant material was dried before the combustion in the muffle oven.

I have some broad suggestions on how certain details are communicated.-The plant anatomy of bryophytes is treated rather colloquially and requires refinement. - Are the species names known for the bryophytes? Many burn differently at low temperature because they hold water droplets differently, making some taxa more difficult to ignite even under the same fire weather conditions.

R: I have used Sphagnum spp. (likely *S. medium/S. divinum*) and brown moss (*Polytrichum commune*). Their names are visible in all graphs and Table 1. I acknowledged that moss burned differently but have not discussed the reasons for this. I am working to find anatomical differences between them, however, the fact that different moss species hold water droplets differently, making some taxa more difficult to ignite under the same fire weather conditions, holds in nature but not in laboratory burning experiments, where all plants were dried prior combustion.

-The use of the word 'twig' needs some level of description here as twigs are different in deciduous, coniferous, herbaceous? and colloquial terms. Can this be more explicit throughout the paper as it may vary by plant types.

R: The term twig was used only for woody species i.e, deciduous and coniferous trees as well as deciduous shrubs, and denotes small branches close to where the leaves are attached to the plant. I will add this specification in Table 1.

-There is a lot of comparison with Mustaphi and Pisaric 2014; could this be expanded to many of the other morphology papers. A table on charcoal morphometric technique studies and the usefulness could help link with the editors comment on this study not presenting a tangible application of the study in its current form.

R: To accommodate this comment (and from Rev 1) I am working towards adding an extra table comparing morphometrics results from this study to those from other publications.

FIGURES:

-Perhaps the black font text would be best placed outside the photograph because of the overlap and poor contrast between the letters and charcoal fragments.

R: Thank you, I will revise the figures according to this suggestion

FIGURE4 - are some of these not charcoal? Again the Levesque et al 1988 publication might be worth comparing.

R: All pictures come from laboratory-produced charcoal.

FIGURE5 - 'chacoal production' spelling in bold (bottom left). Can you quantify the aspect ratios?

R: Corrected to charcoal production. Aspect ratio equals L:W ratio.

TABLE1 - can you add growth forms of plants? (sort of in the plant type column) and the anatomical parts investigated in this study? For instance, Does 'leaves' include the Petiole? The veins? Does twig also just mean wood? Or something else? Soft young wood? High water content?

R: Where possible or needed I have included the growth form of plants.

ADDITIONAL PUBLICATIONS

Some important morphology studies are not discussed in the context of this study. It would be appropriate to discuss these studies in a comparative manner and to build the case for the overall usefulness of morphological metrics.

R: Many thanks for providing such an extended list of literature on charcoal. I am working towards incorporating the most relevant ones into the revised form of the paper.

Additional literature on charcoal and lab burning: