(Comment)

GENERAL COMMENTS

This study assesses the effect of wildfires on the C & N stocks in boreal forests of Sweden. It uses a "space substitution for time" approach, where the authors choose "control" unburnt areas adjacent to the burnt sites and consider those to be comparable to the burnt sites before the fire. It is fully understandable to use this type of approach as, most of the times, it is the only one available when studying the impacts of wildfires. Having said that, this approach has its limitations because, many times, those "comparable" sites are not exactly the same to the burnt sites, and, actually, many times that is the reason why they did not get burn in the same place. The authors, therefore, need to: 1) demonstrate this is not the case in the selected sites (e.g. maybe using remote sensing indexes before the fire to check if they were comparable), 2) acknowledge and discuss this limitation in the manuscript.

For example, the authors state in L293: "TEM differences between paired burnt and control plots were observed to increase both with control and burnt TEM levels however not along gradients of MAT ". Unless I am misunderstanding this, it sounds like there were already differences in soil moisture between the burnt and the unburnt sites before the fire, therefore, they would have had different fire behaviours and impacts in the hypothetical case where all had been burn.

(Response)

Thanks very much for your detailed comments which we believe have substantially improved the manuscript.

We agree that the plot pair approach has both advantages and limitations, as do all experimental designs. With the appropriate precautions (listed below), we believe that we have done a more thorough job in plot pair matching than is typical in wildfire study by using several important, fine-spatial scale variables and by performing follow up analysis. We are confident that the approach still permits robust and useful conclusions to be made.

1. The plot pairs were matched with remotely sensed data as mentioned throughout the methods section (especially starting at line 104). We matched plots based on similar values of moisture (TEM, giving on an integer scale of 0 - 240, not broad moisture classes), dominant tree species, tree biomass and basal area, elevation and slope. We also used visual images to check apparent connectivity and confirm a minimum stand age of at least 30 years.
2. We feel the major limitations are clearly acknowledged in the first paragraph of section 4.3 (line 365). We state that burnt plots may be biased towards greater fire susceptibility and even hold more carbon and nitrogen. While random error in plot pair mismatch may be compensated for by high sample size (n=50), we state that systematic error may still be present due to this bias.

3. We also presented a short, follow up analysis of the control plot matching (mostly contained near line 290). We focused on moisture due to its documented effects on fuel build up and flammability (it was also the only plot-pair matching variable that apparently affected the plots across the entire gradient). Indeed, there were small differences in TEM, but that is because it was not feasible to match plots perfectly for all variables used. We demonstrated that this difference is negligibly small in several ways. First, TEM differences did not covary with our observed controls on C and N losses (i.e. C, N, MAT, MAP), and is therefore likely not involved in confounding. Second we used the organic layer C predictive model from our results using MAT, MAP and TEM to correct for TEM differences within plot pairs and this produced no significant change in the distribution of estimated C and N losses.

(Comment)

Along these same lines, more than referring to the observed differences as “losses” (which imply measurements before and after fire), it would be probably more accurate to talk simply about “differences”. Also considering that the sampling was done already 1 year after the fire (what is a pretty short time for wildfire investigation for sure but you may be seeing indirect effects already).

(Response)

We will more clearly state the limitations of assuming plot pair differences are due actual prefire to postfire changes. We also add an explanation for the timing of sampling.

Line 104: In order to estimate the effects of fire, prefire properties of each burnt plot were approximated by measurements from a single identically sized adjacent control plot centered between approximately 15 and 150 m outside the fire boundaries (100 plots total, i.e. 50 plot pairs). A major limitation to this approximation is that observed differences within plot pairs may be skewed through inaccurate or imprecise representation of prefire burnt plot properties by control measurements. An attempt to reduce these errors was made by incorporating a large sample size (n = 50) and strict controls on the matching of important ecosystem variables. To reduce mismatch…

Line 120: Site visits occurred approximately 1 year postfire over the dates August 5 to August 20 in 2019. This 1 year delay intended to capture the more immediate effects of fire due to potential rapid spikes in nutrient losses and tree mortality, which generally occur within the first year, but avoid the accumulation of discrepancies in C and N stocks relative to control due to any longer term differences in rates of decomposition, leaching and litter addition (Granath et al., 2021; Certini, 2005; Sidoroff et al.,2007).

(Comment)

Another key issue that I am missing is why there is no information about the short-term climate variables in the discussion. Theses short-term variables are key drivers of fire behaviour and therefore impacts on C&N stocks.

(Response)

We agree these are potentially important variables and used gradients of SPEI and summer 2018 temperature and precipitation anomalies to represent short term weather. A discussion of all three of these are found in the paragraph starting at line 384.

We can improve this paragraph by explicitly reminding the reader of the connection of the analyzed variables (i.e. SPEI, TEM, MAT and MAP) to processes explained.

Line 390: By incorporating measures of long (TEM, MAT, MAP) and short term moisture balance (SPEI), …

(Comment)

I believe these issues need to be resolved before a decision upon acceptance of the manuscript can be made. In additions, I have other specific comments below and in the pdf attached.

(Response)

We believe the issues above are well addressed and handled with reasonable rigor within the scope of the paper. However, we plan to make minor adjustments to the text to more explicitly state assumptions and create a more clear linkage between analyzed variables and the processes they represent.

(Comment)

SPECIFIC COMMENTS

ABSTRACT: some rephrasing will improve readability, please see my detailed comments in the pdf attached.

(Response)

Great, these comments were incorporated.

Abstract

The boreal forest landscape covers approximately 11% of the earth's land area and accounts for almost 30% of the global annual terrestrial sink of carbon (C). Increased emissions due to climate change-amplified fire frequency, size and intensity threaten to remove elements such as C and nitrogen (N) from forest soil and vegetation at rates faster than they accumulate. This may result in large areas within the region becoming a net source of greenhouse gases creating a positive feedback loop with a changing climate. Meter-scale estimates of per area fire emissions are regionally limited and knowledge of their relation to climate and ecosystem properties is sparse. This study sampled 50 separate Swedish wildfires, which occurred during an extreme fire season in 2018, providing quantitative estimates of C and N loss due to fire along a climate gradient.Mean annual precipitation had strong positive effects on total fuel, which was the strongest driver for increasing C and N losses,while mean annual temperature (MAT) had greater influence on both pre- and postfire organic layer soil bulk density and C:N Ratio which had mixed effects on C and N losses. Significant fire-induced loss of C was estimated in the 50 plots comparable to estimates in similar Eurasian forests but approximately a quarter of those found in typically more intense North American boreal wildfires. N loss was insignificant though a large amount was conserved in a low C:N surface layer of char in proportion to increased MAT. These results reveal the large discrepancies of C and N losses between global regions and variability across local climate conditions. A need exists to better incorporate these factors into models to improve estimates of global emissions of C and N due to fire in future climate scenarios. Additionally, this study demonstrated a linkage between climate and the extent of charring of residual soil fuel and discusses its potential for altering C and N dynamics in postfire recovery.

(Comment)

INTRODUCTION:

-L30: please add more updated references.

(Response)

2020 and 2019 are very recent.

(Comment)

- L45: please describe a bit more the differences between Eurasian and North American fuels and fire regimes here, as it is key to understand the implications of this study's findings.

(Response)

This can be better addressed in

Line 45 : Composition of tree species, with their associated fire adaptation strategies, has also been shown to have a strong impact on fire severity and intensity and distinguishes the boreal wildfire regimes of the North American and Eurasian continents (Rogerset al., 2015).

And

Line 60: For example, the Eurasian boreal region is dominated by relatively fire resistant overstory vegetation that avoids excessive heating by promoting lower intensity ground and surface fires than that in boreal North America, which is more prone to spread rapid flaming combustion throughout the canopy (Rogers et al., 2015; de Groot et al., 2013a)

(Comment)

-L47: the explanation about fuel chemistry also needs expanding.

(Response)

We can clarify by emphasizing that the chemistry of the fuel is dictated by the initial chemical properties of the litter inputs and their decomposability.

Line 47: Furthermore, climate has been observed to have a conditioning effect on fuel chemical composition through its control over vegetation characteristics and the decomposition state of their detrital inputs, which are often represented by the C:N weight ratio in soils (Vanhala et al., 2008; Kohl et al., 2018).

(Comment)

- L50: please update these references, there are several reviews on the topic less than 15-20 years old.

(Response)

We now reference the recent field measurements of Santín et al 2016 supporting this knowledge.

(Comment)

- L55: this is only true for some types of emissions calculations and, right now, the most commonly used models using this type of approach (e.g. GFED) are changing. Please update this part and do provide references less than 17 years older, as this is a topic that is rapidly changing.

(Response)

We alter this paragraph by including information on alternative and more recent emission estimation methods but also emphasize that our goal is to provide ground validation and meter scale assessments of landscape heterogeneity on areal C and N losses that are absent from many methodologies that are designed for the regional scale.

Line 55: Boreal C emissions due to a single wildfire can be calculated by multiplying total area burned by estimates of C emissions per area (French et al., 2004). While total area burned may be evaluated directly through remote sensing (Ruiz et al., 2012), per area C emissions are generally derived from labor intensive field sampling which is extrapolated to the larger scale either directly or through weighting by remotely sensed data (e.g. topography, vegetation cover) or poorly constrained free parameters such as total fuel load (French et al., 2004; Soja et al., 2004; van der Werf et al., 2017; Veraverbeke et al., 2015; Kaiseret al., 2012). This field sampling has been regionally limited and biased towards a few high intensity burn complexes in North America which may in turn bias global emission estimates (van Leeuwen et al., 2014; Akagi et al., 2011). For example, the Eurasian boreal region is dominated by relatively fire resistant overstory vegetation that avoids excessive heating by promoting lower intensity ground and surface fires than that in boreal North America, which is more prone to spread rapid flaming com-65bustion throughout the canopy (Rogers et al., 2015; de Groot et al., 2013a). C loss in a group of Siberian boreal forest surface fires was found to be 0.88 kg C m^{-2}(Ivanova et al., 2011) which is about a quarter of what is typical in North America Wildfire (3.3 kg C m^{-2}) (Boby et al., 2010; Walker et al., 2020) and about one fifth of an extreme wildfire in Fennoscan-dia (4.5 kg C m^{-2}) Granath et al. (2021). Although Eurasia contains over 70% of the boreal global land area (de Groot et al.,2013a) and about 50% (20 Mha yr^{-1}) of its yearly burnt area (Rogers et al., 2015), methodologies for estimating global and regional C emissions are severely lacking ground validation and meter scale assessments of drivers of C loss variability from this region (van der Werf et al., 2017; Kaiser et al., 2012).

(Comment)

- L66-70: this paragraph needs references.

(Response)

- There is only one boreal wildfire study that we know of directly measuring immediate wildfire losses of N (by measuring, not assuming, N content of the soil in burnt plots).

- To support the claim that fires are typically studied within small groups we, rather than exhaustively list the numerous studies where the statement is true, present the few conglomerate studies that contain them in line 70.

(Comment)

- Please explain somewhere how the fire 2018 was one of the two (with 2014) most extreme over the recent years, and that it was associated to drought, as this is important context for this study.

(Response)

Thanks for this, it will surely provide better context.

Line: 74 This study sampled 50 separate fire complexes spanning broad gradients of mean annual temperature (MAT) and precipitation (MAP) which ignited in Sweden during summer 2018 (Fig. 1). This summer, along with that of 2014, were two of the most extreme fire seasons within Sweden in recent history, driven by severe drought conditions (Wilcke et al., 2020)

(Comment)

- Hypothesis 3 is very long and complex, not enough information has been given in the introduction to understand it completely. Please elaborate this part and consider dividing it in two.

(Response)

We agree this hypothesis can be made more easy to digest, and is suggested to be separated as shown below.

3. A direct relation between climate variables and fire induced C and N stock changes exists.

4. The relation between climate and fire driven C and N stock changes is mediated by long term ecosystem properties that affect the combustion level of forest fuel.

(Comment)

MATERIALS AND METHODS:

- L88: please explain a bit more how the fire scars were detected (beside "remote sensing data").

(Response)

The Swedish Forest Agency manually added perimeters to apparent burn scars observed by Sentinel-2 infrared imagery.

Line 88: 50 burnt plots were selected from a pool of 325 fires identified during the summer 2018 period that had perimeters manually mapped by the Swedish Forest Agency from burn scars appearing in Sentinel-2 infrared data.

(Comment)

- L99: Sentinel-2 during the time of the fire? Were all fires long enough for them to be captured with sentinel infra-red? What if the main fire front had already passed? This does not sound like the best option for choosing the best plot.

(Response)

Good point. It is hard to determine when a forest transitions from what can be considered active fire to burn scar using infrared imagery. For many fires we could see the fire grow and were able to determine an approximate start point. We assumed, also, that after the main front had passed the ground may continue to smolder. But indeed, we can not confirm the signals were all from active fires and we can change the text to indicate this.

The most important plot selection criteria was good prefire plot-pair matching. The infrared signal was only used to avoid what appeared to be a fire's periphery as determined by low pixel intensity but was not used to compare separate fires quantitatively.

Line 99: Sentinel-2 infrared imagery was used to locate planned burnt plots near pixels showing the highest intensity within the mapped final burn scar perimeter. This gave greater certainty the plots experienced a more developed fire effect rather than peripheral heating alone.

(Comment)

- L148: one year after the fire many of the needles, specially those affected by fire (i.e. brown or black) would have fallen already. This needs to be acknowledged as a limitation of this method.

(Response)

This is acknowledged in line 141. The char layer was conglomerated and the small amount of unburnt material was easily removable from its surface. This material was assumed to be postfire additions from the canopy and was discarded and therefore disregarded from stock calculations.

(Comment)

- L156: how the representativeness of the whole understory is proved using 4 patches per plot? How were these patches chosen in areas with a very heterogeneous understory distribution? Please explain.

(Response)

Replication of understory samples was limited because of (1) The very large number of other components to be recorded and the large number of plots and (2) the relatively small contribution of understory C to total forest C storage (though a large C turnover in Sweden). Which meant that we focused our time and resources on intensively sampling the largest and most variable ecosystem C components (the soil). We tested various different sampling methods including established methods of 'random' or stratified sampling but found the small sample size and area to often produce understory estimates that were clearly not representative of the whole plot. Our solution was to perform transects through the plot noting estimated percentage dominance and coverage of the plant functional groups and then placing the square cutting perimeter to represent this. We believe this method to be much more consistent at capturing functional group dominance across plots than attempts at random or stratified sampling with such a small portion of the total plot area.

We more clearly outline this method and our reasons for its favor within the manuscript

Line 156: Understory samples were taken from control plots by cutting all non-moss, non-tree plant material at the surface of the soil from within four 40×40 cm2 patches. To reduce sampling error due to small areal coverage of the plot the sample patches were chosen by performing transects through the entire plot noting visual estimates of coverage and proportions of plant functional groups (i.e. graminoids, forbs, shrubs, and pteridophytes) and selecting representative patches for the portion of the plot that was vegetated, which was always all non bare rock surface. These values were applied to a visual estimate of non bare rock surface area of the burnt plots as an approximation of its prefire understory coverage. CCVs for understory were determined by sorting the sampled understory plant material and measuring dried weights of the functional groups graminoid, forb, shrub, and pteridophyte.

(Comment)

- For the methods used no references are given, are these new methods? If so, how do you ensure the representativeness of your measurements?

(Response)

The central methodology is the calculation of soil carbon and nitrogen by multiplying soil depth by bulk density by elemental ratio which is confirmed by dimensional analysis. Soil profiles were separated mainly due to their obvious differences in density that also followed the cited Canadian Soil Classification System that is used in many fire prediction methods. References are added for motivating separate analysis of the pyrogenic layer. Tree mortality estimation reference is added. Support for our 20 times replication of soil depth measurement per plot is now referenced. Our choice of sampling 1 year post fire is elaborated upon (in the immediately following text) and referenced.

Line 120: Site visits occurred approximately 1 year postfire over the dates August 5 to August 20 in 2019. This 1 year delay intended to capture the more immediate effects of fire due to potential rapid spikes in nutrient losses and tree mortality, which generally occur within the first year, but avoid the accumulation of discrepancies in C and N stocks relative to control due to any longer term differences in rates of decomposition, leaching and litter addition (Granath et al., 2021; Certini, 2005; Sidoroff et al.,2007).

(Comment)

- L166: “visual estimates for percentage volume of needles, broad leaves, woody material, moss and lichen were multiplied by total weight to form CCVs”: does not this assume densities of these different materials are similar, what it is obviously not true?

(Response)

The aim was to broadly test for an effect of litter composition as clarified in the following suggested change.

Line 166: Dry moss/litter samples were weighed and visual estimates for percentage volume of needles, broad leaves, woody material, moss and lichen were multiplied by total weight to form CCVs. This broadly categorized, visual estimation, along with the assumption of equal category density, is meant to test for general effects of variation in proportions of surface fuel types on total soil fuel build up and fire severity.

(Comment)

RESULTS

- L208: "transferred large amounts of C and N from lower soil layers to the highly nitrogenous surface layer of char." This was not a "transfer" but a conversion. Please rephrase.

(Response)

We have rephrased as suggested.

(Comment)

- In several places the authors talk about C and N "lost" from the different soil layers and now "found" in the char layer. This assumes that all char is coming from soil, what may be the case in some places but not in others where the understory and canopy led to charred inputs to the ground (as discussed in L315). Even if these inputs may not be too substantial in some places they can be in others. Please rephrase.

(Response)

We agree these words are ambiguous and will be reworded throughout. The purpose of comparing estimated disappearances of C&N from the various compartments to char layer C&N is because we *do not* assume where char C&N is coming from. Char C&N can come from any of the soil compartments, the understory, the overstory or even be deposited from material above. We do show across all plots that the understory cannot be a substantial contribution due to it's low overall C. We can also show that canopy blackening is rare and the amount is not correlated to char layer mass.

Based also on comments from Reviewer #1, we will include more information on canopy and its damage in an added section to the Results:

Line 204: 3.1 Survey of burnt plot vegetation

The 50 burn plot overstories were largely pine dominant with a percentage of spruce stems between 25-50% in 5 plots, between 50-75% in 3 plots and 2 plots with greater than 75%. Birch stems were less than 25% in 44 plots and between 25-50% in 6 plots, of which only 1 of the 6 was spruce dominant. All plots showed visible charring of tree boles though only 3 plots had greater than 1% plot wide canopy blackening. These plots were pine dominant with 2 having less than 1% spruce while the other had 6 spruce of the 27 stems within the sampled area. Prefire aboveground overstory C and N were estimated as4.46±0.738 kg $m^{-2}$and 0.0385±0.00621 kg m^{-2}, respectively, with 5.31% of C (0.237±0.0321 kg m^{-2}) and 12.3%8of N (0.00474±0.000641 kg m^{-2}) coming from pine and spruce needles. The 50 burnt plots had a large percentage tree mortality (45.0±8.76%) compared to control (4.21±1.63%). Total C and N loss, as well as char layer mass, was not correlated to canopy browning, blackening nor increased mortality in burnt plots relative to control.

Understory coverage was reduced to 10.2±5.15% of its estimated prefire values. This laid bare the surface layer of charred material present in all plots. This layer was conglomerated and easily separable from lower layers and new litter additions which were mostly needles. Upon breaking apart the layer, it was found to be completely blackened throughout.

(Comment)

- Also, when talking about “increases” of C/N in the mineral soil layers: did any of the fires really affect the mineral soils? If not, then a direct effect is not possible and the variability observed may be due to differences between control and burnt sites. Please clarify and discuss.

(Response)

The comparisons were made to highlight the small differences on top of their statistical insignificance to emphasize that likely little change to total C&N occurred in mineral layers due to fire. We agree this is easy to misinterpret and so have removed comparison of these insignificant values to C&N stocks in other layers.

(Comment)

DISCUSSION

- L313: “highly nitrogenous char layer”, this is not correct because, as explained several times in the Results Section, the char layer has a lower N content than the unburnt soil components.

(Response)

We used it to imply a high concentration of nitrogen, i.e. high weight of N per sample weight. We have changed this to reduce any semantic confusion.

Line 313: ...within the high N_R char layer...

(Comment)

- L314: “The char layer was likely largely produced by fire interacting with the understory and moss/litter layer”: what data are supporting this statement? There was a substantial difference between the duff layer in the burnt vs unburnt sites too, so it is expected fire did burn through this layer considerably too (as explained in the second half of the sentence). So the current wording is misleading, please rephrase.

(Response)

The assumption was that the surface char layer always had some contribution from the understory and moss/litter due to their proximity to the surface. Evidence for the duff layer being included in the char layer was given by the fact that char layer C&N was often greater than these two layers combined. It has been rephrased to the following:

Line 314: Proximity to the soil surface suggest a portion of the char layer was likely always derived from fire interacting with the understory and moss/litter layer, however averaged char layer C and N stocks were greater than losses from the two layers combined suggesting there were large contributions also from the duff.

(Comment)

- L324: please add data to support the statement of “low level of overstory damage”… for example, the charring heigh or the fraction of the canopy scorched/burnt.

(Response)

This is addressed in an additional results section

Line 204: 3.1 Survey of burnt plot vegetation

The 50 burn plot overstories were largely pine dominant with a percentage of spruce stems between 25-50% in 5 plots, between 50-75% in 3 plots and 2 plots with greater than 75%. Birch stems were less than 25% in 44 plots and between 25-50% in 6 plots, of which only 1 of the 6 was spruce dominant. All plots showed visible charring of tree boles though only 3 plots had greater than 1% plot wide canopy blackening. These plots were pine dominant with 2 having less than 1% spruce while the other had 6 spruce of the 27 stems within the sampled area. Prefire aboveground overstory C and N were estimated as4.46±0.738 kg m−2and 0.0385±0.00621 kg m−2, respectively, with 5.31% of C (0.237±0.0321 kg m−2) and 12.3%8of N (0.00474±0.000641 kg m−2) coming from pine and spruce needles. The 50 burnt plots had a large percentage tree mortality (45.0±8.76%) compared to control (4.21±1.63%). Total C and N loss, as well as char layer mass, was not correlated to canopy browning, blackening nor increased mortality in burnt plots relative to control.

Understory coverage was reduced to 10.2±5.15% of its estimated prefire values. This laid bare the surface layer of charred material present in all plots. This layer was conglomerated and easily separable from lower layers and new litter additions which were mostly needles. Upon breaking apart the layer, it was found to be completely blackened throughout.

(Comment)

- L340-345: the comparison of the char layer with the charcoal in Hart and Luckai is not appropriate. Those authors selected individual pieces of charcoal within the soil, with a high proportion very probably coming from wood and therefore displaying very specific characteristics. The char layer in this study is a mix of charred organic materials with inorganic charred materials (also called “wildland fire ash”, see Bodi et al. 2014). In addition, there will be also some unburnt components even after cleaning the samples (as the mix is not easy to separate, specially one year after fire). A better comparison would be the charred layer in Santin et al. Geoderma 264 (2016) 71–80, and other similar studies.

(Response)

We agree comparisons with studies measuring similar pyrogenic layers are more valuable and we have now adjusted the text to this.

Line 340: The strong alteration of char layer C:N relative to prefire fuel is comparable to results from studies that have incorporated similar pyrogenic layers that are observed to be a mixture of organic or inorganic material types across broad ranges of combustion completeness (Bodí et al., 2014). For example, the C:N ratio in a pyrogenic layer 1 year after a low intensity Siberian Larch forest surface fire in Russia was 31.4 (prefire 49.1), which is much lower than the 43.8 C:N ratio (prefire 39.4) observed the day after an experimental, high intensity jack spruce crown fire in Canada (Santín et al., 2016; Dymov et al., 2021), further suggesting general differences in thermolability of soil C and N under regionally varied heating regimes.

(Comment)

L346-350: along the same lines than previous comment, it may be that the inorganic N is adsorbed to char but, also, that the inorganic components of the "ash" layer are still present in your "char layer".

(Response)

This is also a good point. We have revised the text to account for it:

Line 346: The high N_R of the char layer may therefore be due to adsorption of fire mineralized N or preserved, prefire mineral N and act as a steady source of bioavailable nutrients to plant and microbial communities during succession. Alternatively, N may be stored in this layer in partially combusted organic forms (Certini, 2005).

(Comment)

- Section 4.2: why the immediate weather parameters are not discussed here (e.g. SPEI)? These will be the ones more closely related to fire characteristics and therefore differences between burnt and unburnt plots.

(Response)

This section, and the manuscript overall, was meant to highlight the climatic control pathways on C&N loss. SPEI and anomalies (as well TEM) were used as exogenous variables to test the isolation of these effects and were more of a supplement to the main message. Therefore they were reserved for the following section to better focus on these distinct aspects.

(Comment)

- L365: "ignition probability" does not relate to fuel but to ignition opportunities such as human causes (e.g. accidental) and lighting. please rephrase.

(Response)

It was left unclear whether ignition probability here considers a time aspect (concerning the chance of receiving an ignition source) or if it implies probability of ignition of a stand under receiving a given source. We can try to reduce this uncertainty by modifying the text.

Line 365: A caveat of the pair plot matching methodology is that burnt plots may have had a greater tendency to ignite due to specific properties that heighten their fire susceptibility relative to controls. As a result, the comparably low C and N losses may be due to underestimation via burnt plots being biased to a greater prefire fuel load than their paired controls (systematic error) rather than these differences being approximately random (random error).

(Comment)

- L367: What info/references support this statement? This does not necessarily has to be the case, actually, very dense forest plots may have a higher moisture and, therefore, may be less susceptible to burn (as explained in Section 4.3 actually).

(Response)

The support is given directly after, in line 368, where N was observed to have no significant difference due to fire. If there is a bias in the control plot matching method it is not likely that it results in a significant increase in control plot N stocks relative to the actual (yet unmeasured) prefire N stocks in burnt plots. This would require an unlikely fire induced increase in total N to compensate and bring the differences to 0 postfire. Therefore, any present systematic error is either likely negligible or due to *increased* prefire burnt plot stocks relative to control.

The paragraph then goes on to argue why this systematic error is not detectable within the data used in this study, suggesting either N losses are indeed minimal and/or more detailed analysis of pair plot biases are needed to explain them.

Indeed, higher moisture has been related to increased fuel loading (Walker et al. 2018 in the manuscript). But failure of the SPEI index to improve our models led us to conclude instantaneous levels of moisture did not substantially restrict the percentage availability of fuel under the extreme drought conditions of 2018. However, we did not make assumptions of typically wetter fuels being more or less flammable than typically drier ones, when both are thoroughly dried. That we left to test through CCVs, bulk density, C:N ratio etc. Also, we were not in the position to suggest flammability, in terms of C lost relative to C loading, is indeed related to fire's ability to propagate into and through a given stand, and only had done so to hypothetically introduce a discussion of a possible source of plot-pair mismatch (which is now removed from the manuscript).

(Comment)

- L370: I don´t understand this statement, was TEM not the same in the control plots than in their burnt counterparts?

(Response)

Not exactly, but they were close. It is important that we state in the methods section that TEM is made of integer values ranging from 0-240 and not based on only a few broader moisture classes as is common. This might be a source of confusion. See comment above for explanation on the TEM mismatch.

(Comment)

FIGURES

It would be very useful to have a figure with pictures showing burnt and unburnt sites.

(Response)

We agree a visual could aid in getting a feeling for the plots. There are 100 plots that all look quite different, but a few photos can be added as supplementary information if valuable.

(Comment)

TECHNICAL COMMENTS

Please see attached pdf with minor suggestions directly on the manuscript.
Citation: https://doi.org/10.5194/bg-2021-178-RC2

(Response)

Thank you, these comments were helpful and all addressed within revisions.