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Interactive comment on "Prescribed-burning vs. wildfire: management implications for annual carbon emissions along a latitudinal gradient of *Calluna vulgaris*-dominated vegetation" *by* V. M. Santana et al.

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We would like to thank Referee 2 for the provided comments and thoughts because they can be very helpful to improve this manuscript. Questions and comments are addressed below:

RC1: This manuscript presents simulation results on carbon emissions from different prescribed fire frequencies and different wildfire frequencies in moorlands. The manuscript does an insufficient job of explaining how wildfire was simulated and ac-

counting for the effects of wildfire. The model does not include the impacts of fire on the peat in the system, nor does it explain whether or not this peat is combustible under typical prescribed and wildfire conditions. Furthermore, wildfire is a stochastic process and it was simulated in a deterministic manner. As much as the climatic conditions vary between sites, I would expect that the probability of wildfire varies. If wildfire is treated stochastically and an ignition occurs in the year following a prescribed fire, first principles would dictate that the ignition would not result in much of a wildfire because of the limited biomass available to burn. Alternatively, if by removing vegetation cover, prescribed fire changes the biophysical environment and the peat dries out, an ignition following wildfire could have substantial C emissions.

AC1: Accounting C loss from the underneath peat is outside the scope of this paper. It is self-evident that where peat is affected by fire the amount of C released could be affected, because the huge amounts of C stored on these compartment. However, modelling peat losses need an approximation completely different to our approximation because:

(1) Peat should not be affected by prescribed burning, peat should only be affected when it is burnt during wildfires of high intensity, usually in summer.

(2) Prescribed fires are performed during the legal burning period (October to mid-April,) when soils are wet and/or frozen.

(3) Wildfires occur mainly in spring (March to April) and summer (July and August). Spring wildfires comprise only the above-ground vegetation because soils are usually still very wet (Davies and Legg, 2008).

(4) Extraordinarily damaging wildfires usually occur in summer, especially during a drought when the dry surface peat can ignite. Once ignited, it can smoulder for many months (Rein et al. 2008). But, even these peat fires are not frequent in summer wildfires.

Therefore, we can affirm that aboveground-fires and peat-fires can be considered as practically two independent processes and they don't occur at the same time in the great part of times. From our point of view these two types of fires can be modelled independently. In case a wildfire leads a peat fire, peat is a different compartment and follows different processes of regeneration, burning and C losses. Once peat is burned its regeneration until similar values can last for centuries or millennia and, therefore it is out of the scope when developing current management practices. In addition, peat fires produce high damages in vegetation roots, reducing the possibility of vegetation regeneration in the short- or medium-time frames. Modelling peat burning is complex and driven for different parameters used in this paper. Peat burning is slow and highly dependent of its moisture, therefore when ignited these fires can last months. The C loss depends of the amount of peat accumulated and depth and this is very difficult of knowing and modelling. Finally, the C accumulated in peat is of several degrees of magnitude superior to that stored in vegetation. Therefore, there is no sense in including peat in this modelling (Rein et al. 2008). The referee is quite correct in that wildfires do occur stochastically with no human intervention, where humans are concerned this is less random because of vandalism and willful fire-raising. In the case of Calluna heathlands/moorlands human-induced causes are the predominant and for this reason, we have imposed a standard wildfire regime for comparative purposes – this is inherent in any modeling approach.

RC2: There is one even bigger shortcoming of this manuscript. The authors did not simulate emissions from wildfire in the absence of prescribed burning. To effectively compare wildfire and prescribed fire emissions and make any sort of evaluation about the carbon implications, wildfire will need to be simulated in the absence of prescribed fire. It will also need to be simulated stochastically with regard to both occurrence and size.

AC2: We think this is not an important shortcoming and it can be easily solved. In our modelling, the amount of biomass in situations without prescribed burning corresponds

to that found in equilibrium 50 years after fire, and shown in figure 2. For scenarios with 50 years wildfire return interval the carbon released is four times these values, for 100 years twice the values, and for 200 years once the value. These values can be easily added to Table 2 to solve the lack of these interesting values (See values in the table included at the end of this file as supplement).

RC3: P20 L10: Fire severity isn't the best metric to use in the context of how much biomass is combusted and it isn't clear why the authors state that it should be expected that wildfire will result in higher CC than prescribed fire. This is going to be highly system dependent and a function of the fire intensity as defined by Keeley (2009).

AC3: We disagree with Referee 2. As defined by Keeley (2009), fire severity is "above-ground and below-ground organic matter consumption from fire" and, thus, we think it completely fits with the concept of "combustion completeness (CC)" used in this work. Fire intensity refers to the energy output from fire. On the other hand, on moorlands/heathlands dominated by Calluna, prescribed fires are always performed in wet conditions mainly autumn-winter (October to mid-April, the legal burning period), when soils are wet and/or frozen and damage to plant species and peat is minimized. However, wildfires occur mainly in spring (March to April) and summer (July and August) when environmental conditions are suitable for fire (severe drought and windy) (Albertson et al. 2009). In addition, fire severity in wildfires is even more enhanced because shrub stems are highly desiccated as consequence of winter frosts (Davies and Legg, 2008). Therefore, we can confirm that wildfires are commonly more severe than prescribed fires. See for example references supporting this affirmation in Maltby et al. (1990), and Davies et al. (2010).

RC4: P20 L23: Krawchuk et al. (2009) does not include support for the statement about combustion completeness.

AC4: Yes, the referee is right. We can modify the text to avoid this confusion.

RC5: P22 H1 and P32 L4-6: The authors had site data about temperature, precipitation, and soils. Why then propose a hypothesis that suggests there will be a temp/precip gradient that follows latitude?

AC5: We proposed a gradient in biomass accumulation along the climatic-latitudinal gradient, which were practically equivalent. We don't propose a hypothesis comparing latitude and climate.

RC6: P23: The site descriptions include statements about previous sampling and burn intervals, but provide no information about biomass accumulation. A table presenting biomass values for different times since fire at each site is necessary to determine if the model results make sense.

AC6: Results of biomass accumulation after fire along time are shown in clearly in Figure 2. These are the curves derived from these samplings, as we explain in the methods.

RC7: P28: How was wildfire superimposed? There were three different intervals, but how did the size vary? Was there any interaction between time since prescribed fire and wildfire size? The effects of wildfire are important for the overall prescribed fire-C emissions story and this aspect of the modeling needs to be better described. Citing Allen et al. (2013) for details is insufficient.

AC7: there was no variation in size for the different wildfires simulated. We fixed this variable for all wildfires and always comprised the whole area modelled (100%). This part is explained in the text P17828, L26-28, but probably as reviewer suggest, bigger effort in explaining this part is needed.

RC8: P33 L2: The authors did not evaluate the effects of productivity drivers and cannot actually say anything about the influence of climate on productivity.

AC8: We agree with the referee in the fact that we did not measured productivity and we cannot talk about the effect of climate on productivity. This sentence aimed to give arguments about why biomass accumulation was higher in warmer sites. Probably the

sentence should be modified to avoid confusion.

RC9: Table 2: Closspb200? Why not cumulative C emissions?

AC9: Yes, but we think this nomenclature is more descriptive. It means cumulative carbon loss along 200 years, as we explain in Page 17828, Lines 23-24.

RC10: Fig2: How is it possible that the Moor House litter value is constant? Calluna starts at zero following fire, but litter starts at 9? If the fire is sufficient to completely combust all of the Calluna, it seems logical that it would combust the majority of the litter as well. Without having the site specific data, there are two possibilities: 1) either the model is parameterized incorrectly, or 2) the field data have error.

AC10: We disagree with referee 2. As explained above prescribed fires on these systems are performed in autumn-winter, when soils are completely wet and frozen and it is possible that no effect on litter is observed. This can be especially possible in Moor House, where environmental conditions are less suitable for prescribed burning. It is the wettest site and with the highest altitude, and the performing active prescribed fires affecting the litter lying on the soil is difficult.

References:

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Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/12/C9232/2016/bgd-12-C9232-2016-supplement.pdf

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Interactive comment on Biogeosciences Discuss., 12, 17817, 2015.