**Reply to: Validity of managing peatlands with fire**

**R. H. Marrs1\*, E-L Marsland1, R. Lingard1\*, P. G. Appleby2, G. T. Piliposyan2, R. J. Rose3, J. O’Reilly4, G. Milligan1, K. A. Allen1,5, J.G. Alday1,6, V. Santana,7,1, H. Lee1,8, K. Halsall1, R.C. Chiverrell1**

1School of Environmental Sciences, University of Liverpool, Liverpool L69 3GP, UK; Environmental Radioactivity Research Centre, Department of Mathematical Sciences, University of Liverpool, Liverpool L69 7ZL UK; 3Centre for Ecology & Hydrology, Bailrigg, Lancaster LA1 4AP UK; 4Ptyxis Ecology, Lambley, Northumberland CA8 7LL, UK*.*

5Present address: Institute of Integrative Biology, University of Liverpool, Liverpool, UK. 6Present address: Department of Vegetal Production & Forestry Science, University of Lleida, Lleida, Spain. 7Present address: Center for Environmental Studies in the Mediterranean (CEAM), University of Alicante, Alicante, Spain. 8Present address: National Institute of Ecology, Seocheon-gun, Republic of Korea.

\*e-mail: calluna@liverpool.ac.uk

Prescribed burning when advocated to control wildfire**1** is controversial, therefore, we welcome Baird *et al.*’s (henceforth, Baird)**2** critique of our paper questioning the generality of our finding based on a single-site experiment. In our paper, we emphasised that the experiment described was unique (mentioned thrice)**1**based on its relatively long time-span (ca. 60 years) and that four prescribed burning treatments were applied in a replicated experimental design. We were, therefore, only too aware of the problems associated with extrapolating our results to other circumstances. Moreover, we placed numerous caveats to suggest that care would be needed in such extrapolation to other regions. Indeed, when discussing the implications for managed and unmanaged peatlands globally, we emphasised that our study had implications in regions where prescribed burning was already a management practice**1**. Moreover, whilst our experiment was on a *Calluna vulgaris* (L.) Hull dominant vegetation on blanket peat, where “cool” burns were applied at a range of frequencies, we did state that application in other regions, where fire was not part of the current management regime would require a similar assessment of the impacts and to determine an appropriate prescribed burning regime, and that our stratigraphical approach could be applied to assess this. We then argued that where global warming introduces a much shorter wildfire regime return cycle , then, prescribed fires could be one way of reducing the potential damage, and that this might necessitate reversing recent reductions in the use of prescribed burning. Our results1 showed that C sequestration and biodiversity maintenance for fire-managed NW European boreal peat moorlands are not as bad as previously thought. We did not suggest that prescribed burning should be used everywhere, but that prescribed burning could perhaps be considered for wildfire prevention. We also stressed that great care would be needed in implementation, using appropriate burn frequencies followed by monitoring of impacts**3**. We also suggested that the stratigraphical approach we used might offer a mechanism for quantifying the impacts of differing managed burn frequencies on recent peat accumulation rates at other locations. This is novel. To recap we measured peat growth in two periods within the context of a manipulative experiment with different applied prescribed burning frequencies: pre-experiment (1876-1963) and post-experiment (1963-2016), the latter more or less coveringcovering the experimental period (1954/5-2016). We reported that in the 0-burn “control” plots, peat growth continued albeit at a slower rate than in the post-experiment phase, but this reduction was not significant. What we did not report was that there was also no effect of burning frequency on either peat or carbon accumulation in the pre-experiment period, indicating that the prescribed burning was not impacting deeper peat layers (Fig. 1).

Baird**2** also argues that our experimental site is a degraded and atypical moorland. Like almost all British moorland, Moor House is degraded to some extent, but the site is not atypical. The catchment in which the experiment is placed has a very wet, cold climate conducive to peat formation and is not affected by the appalling twentieth-century practice of moor gripping (drainage), prevalent on many upland British moors. Drainage from the site has not as far as we are aware, been increased directly by human activities. Unlike most moors, Moor House has not been burned recently (apart from the experiment described), has also very light sheep grazing**4** and sustains a vegetation cover typical of many moorlands in upland Britain [M19/M20 communities**5**]. In their criticism, they**2** point to the experimental plots having deep water tables, but the depths quoted of 50 cm were the “maximum values” recorded**6**, with the interquartile water table depths for the three burning treatments typical for blanket peatlands at 5-15 cm. These data were discontinuous and collected as monthly spot-measurements 6/2005 to 2/2007 which included the substantially drier-than-average conditions of 2005 (1692 mm: mean annual rainfall 2035mm)**7**. The hydraulic conductivity calculated for combined treatments at Moor House was in the same range [-3 to -8 log K (cm s-1)] as eight of the nine-comparator fen/bog vegetation sites (one of these at an unspecified Moor House location)**6**. The same paper concluded that the lowest water table depths occurred in 20-year burn plots compared to those they termed ‘unburned’, but were actually plots burned in 1954**6**; unfortunately, this comparison did not extend to the Reference plots (unburned since the 1920s). Discussion of the seasonal water table dynamics is required to give context to the minimum values. The annual pattern of water tables elsewhere on Moor House for the dry summer of 1995 shows water tables close to the surface in winter months and a summer draw-down that varies between years (max 41 cm in 1995; 20 cm in 1996)**8**. These water tables are similar to intact peat bogs, e.g. Walton Moss (Cumbria), amongst the least-disturbed in England, recorded water tables in summer of ~34 cm in 2003 and 2006**9**. Water tables at Moor House do not behave differently to that expected in healthy blanket peatlands**10**.

Ultimately, maintaining healthy peatlands is desirable and we suggested and evidenced**1**merely that,where appropriate, prescribed burning is a useful tool in the manager’s armoury and land managers should not necessarily fear to use it. The Saddleworth moorland fires, east of Manchester, in summer 2018 and winter 2019 highlighted the substantive damage that can occur when fuel load is not controlled. Equivalent severe wildfires on Moor House would have negative implications, more severe loss of biomass and carbon, triggering moorland erosion and releasing the airfall contaminant load (e.g. Pb and other metals) preserved in the surface layers of British peatlands. At Moor House Pb concentrations of 100-200 µg g-1 suggest a Pb loading of ~1g m2, which equates to 3.9 and 15 t when scaled to the entire Hard Hill (4 km2) and wider Moor House peatlands (15 km2) respectively. Severe wildfires concentrate these contaminants by removing organic matter and leaving the mineral fraction, rendering these metals available for erosion and release into watercourses. Pb concentrations are relatively low on Hard Hill, but peatlands elsewhere have much larger concentrations of residual airfall Pb in surface peats.

Wildfire is one of the biggest threats to peatlands in the UK, and in many other parts of the world; we contend that the careful application of prescribed burning should not be ruled out as a management strategy in mitigating wildfire risk where the location is appropriate. Given the recent estimates that the increasing frequency, size and intensity of wildfires in the boreal region would result in the combustion of legacy carbon in young forests on soil with high organic carbon (estimated area of 0.34 million ha)**11,12**. Therefore, whilst we do not advocate prescribed burning everywhere, we merely suggest that it be considered as a tool in our armoury for mitigating wildfire impacts, and hence our research is timely. We further suggest that research on wildfire prevention on peatlands generally be increased. In this we agree with Baird1.

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**Author Contributions**

RHM and RCC planned and carried out the field sampling with RR, E-LM, RL and KH. RCC led the geochemistry/stratigraphy with E-LM and RL; PA and GP were responsible for the radiometric dating; the vegetation survey and analyses were planned and performed by JA, KAA, HL, GM, RR, JO’R and VS. RHM and RCC produced the manuscript and all authors contributed to the final version

**Author contributions**

This paper was primarily authored by RHM, RCC and JGA; all other authors have seen and commented on the paper.

**Competing interests**

This competing interests are presented in**1**.

**Data availability**. The link to the data that support the findings of this study is presented in**1**

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Number of burns

Accumulation rate (g m-2 yr-1)

**Figure 1 |Effects of differing prescribed fire frequencies on peat (o) and C (•) accumulation rates.** Linear regressions(±95% confidence limits are illustrated); equations: peat accumulation rate = 136.20 (±8.33) + 1.58x (±2.46), F1,14 = 0.41, p = 0.54; C accumulation rate = 52.53 (±3.10) + 0.92x (±0.9135), F1,14 =1.01 on 1 and 14 DF, p = 0.33.