Pyrogenic carbon characteristics and short-term exposure to terrestrial and fluvial peatland catchment processes

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Background

Wildfires can result in significant losses of carbon from terrestrial carbon storing ecosystems, from direct smouldering of soils, combustion of vegetation and longer-term increases in soil erosion following the fire event (Turetsky et al., 2015). However, these fires have the potential to produce large quantities of pyrogenic carbon (PyC), the continuum of residues resulting from the incomplete combustion of biomass, meaning that they may have the potential to contribute to long term terrestrial carbon stores (Clay and Worrall, 2011).

Whilst PyC has been observed to have a high degree of resilience to change when exposed to environmental processes, field studies have observed changes to the characteristics of PyC-related materials at varying rates across depositional settings (Wang et al., 2016). Although peatland wildfires have received a good degree of research attention, in UK settings there has been limited investigation of the PyC produced and exposed in these settings.

Methods

PyC samples were produced from cuttings of *Calluna vulgaris* and *Eriophorum vaginatum* at 300 and 500℃ for 5 minutes in a muffle furnace. These samples were then exposed on a bare peat surface for up to 6 months (with the exception of 'fresh' samples) and were then suspended in filtered (0.45µm) peatland water for 1 month (Figure 1).

The effects of exposure to key catchment processes in UK peatlands on PyC characteristics were then studied using CHNO (Figure 2) and FTIR (Figure 3) analyses. Ratios measures (e.g. A_{800}/A_{1600} and O/C) were calculated from both of these datasets and used in subsequent analyses. These combined analyses can provide important insight into the geochemistry of fire residues (Keiluweit et al., 2010).

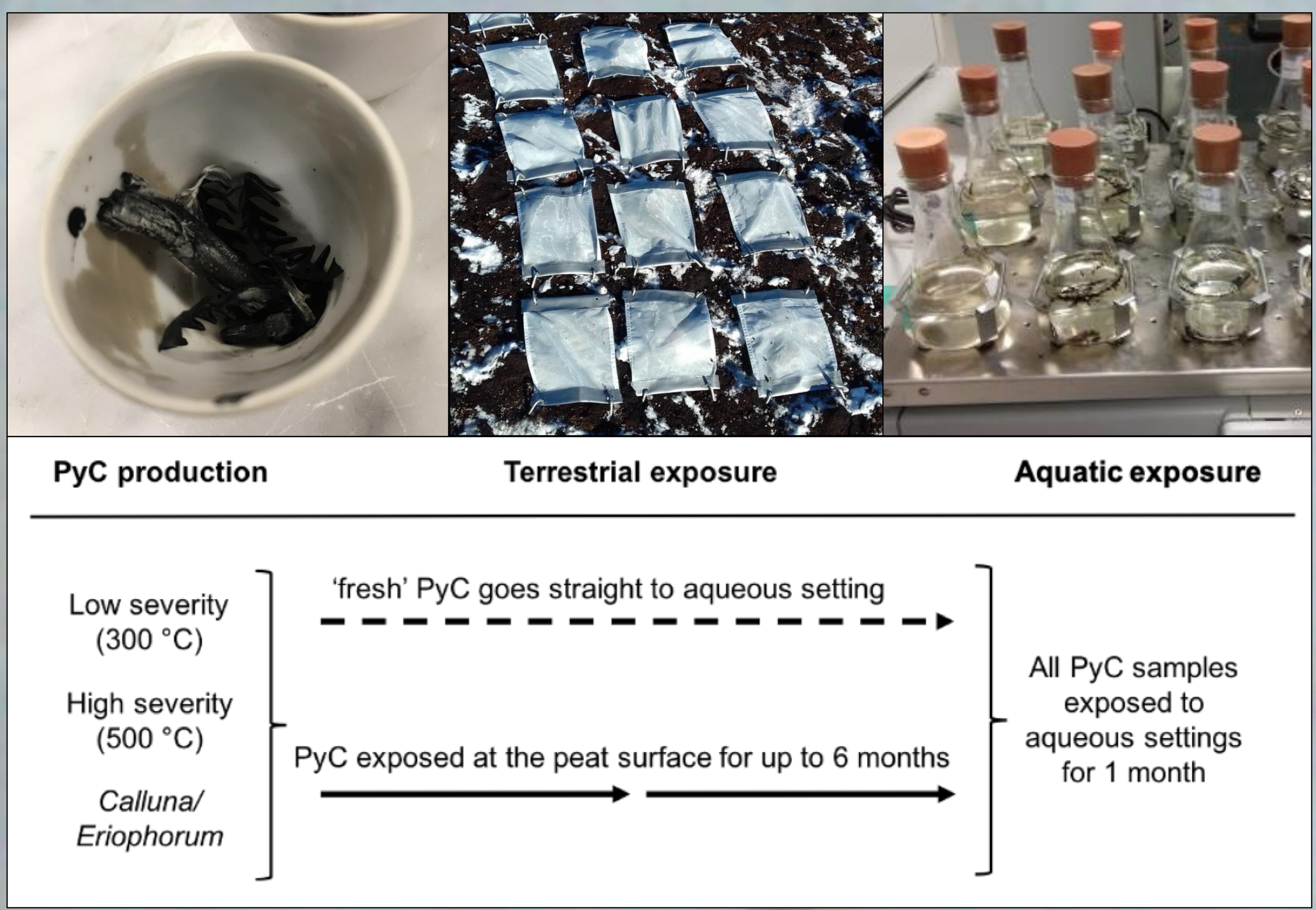

Figure 1. PyC production and degradation experimental procedure.

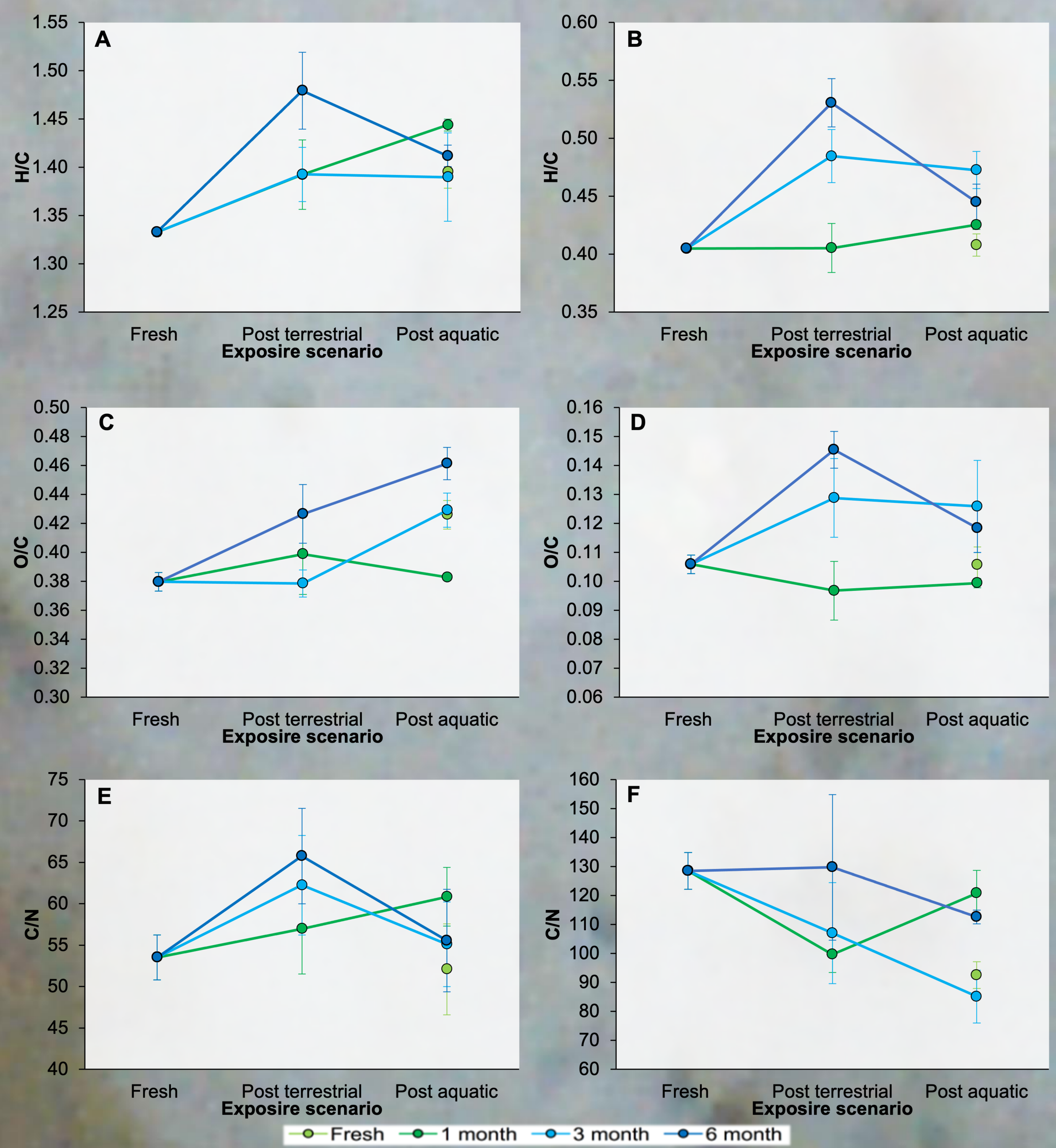

Figure 2. Elemental ratios of *Calluna vulgaris* samples. LS samples = A, C, E. HS samples = B, D, F.

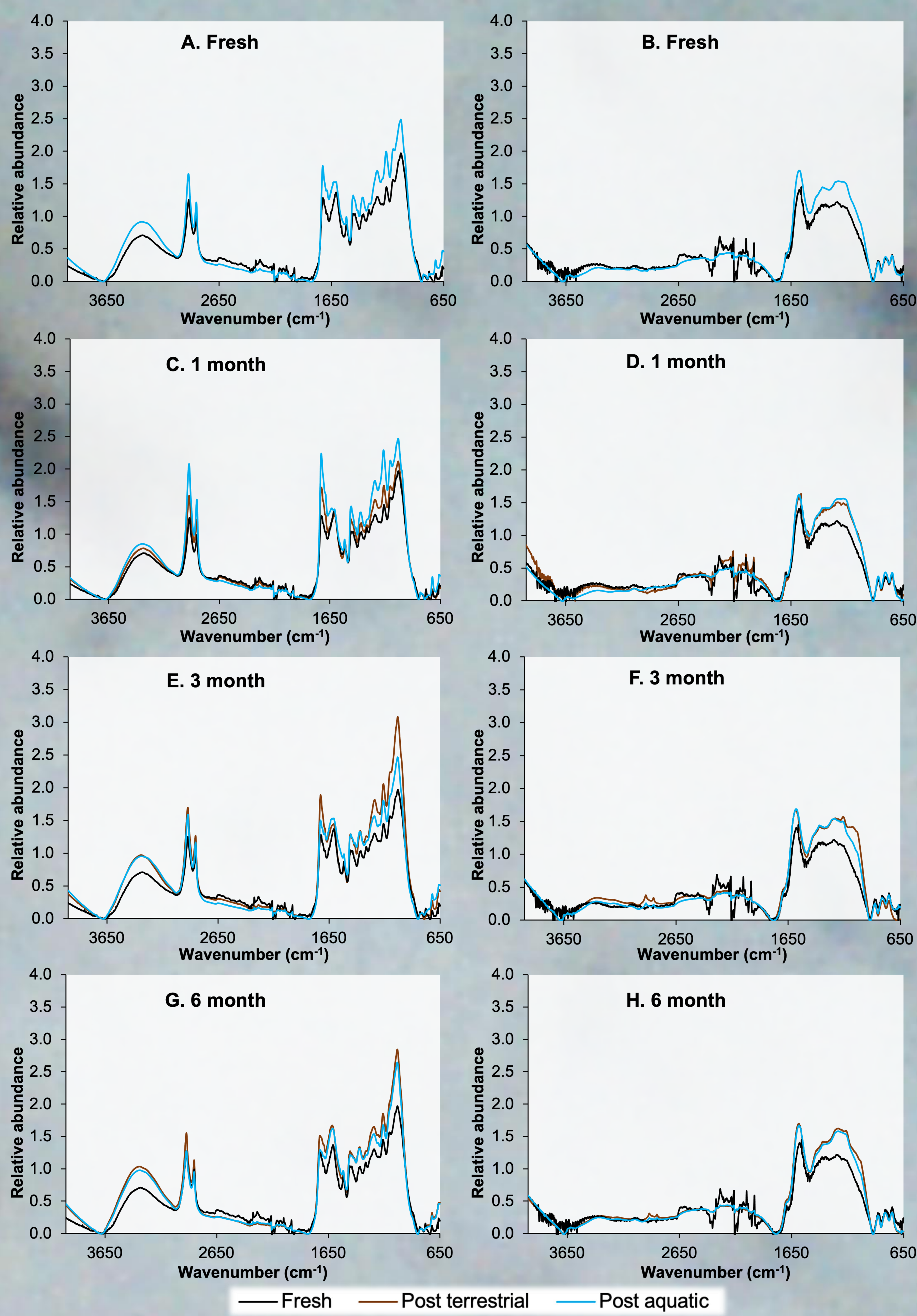

Figure 3. FTIR spectra of *Calluna vulgaris* samples. LS samples = A, C, E, G. HS samples = B, D, F, H.

(92)	Species		Severity		Scenario		Months		Cumulative
	p	η^2	p	η^2	p	η^2	p	η^2	η^2
O/C	**<0.001**	9.6	**<0.001**	66.4	0.486	-	0.341	-	76.1
H/C	0.913	-	**<0.001**	66.3	0.891	-	0.074	-	66.3
C/N	**<0.001**	13.3	**<0.001**	9.4	0.091	-	0.439	-	22.7
3340/1600	0.128	-	**<0.001**	66.3	0.400	-	0.402	-	66.3
2920/1600	0.725	-	**<0.001**	66.3	0.332	-	0.807	-	66.3
1700/1600	0.830	-	**<0.001**	66.2	0.155	-	0.940	-	66.2
1060/1600	0.079	-	**<0.001**	65.7	0.425	-	0.514	-	65.7
800/1600	**0.001**	8.4	**<0.001**	35.8	**0.043**	2.1	**0.005**	6.8	53.1

Table 1. Kruskal-Wallis output for tests of significance (p = 0.05) and effect size (η^2). n = 92. Degrees of freedom: Species = 1, Severity = 1, Scenario = 1, Months = 3.

Findings

As shown in Table 1, the only significant impacts of duration and scenario of PyC exposure was on aromatic condensation proxy measures (i.e. A_{800}/A_{1600}), where both low and high severity *Eriophorum vaginatum* samples saw declines in condensation. Conversely *Calluna vulgaris* underwent decreases in condensation following aquatic exposure, but saw increases in condensation following terrestrial exposure for 1 and 3 month samples. PyC exposure duration and scenario were found to significantly affect aromatic condensation proxies, whilst burn severity significantly affected all measured variables.

These findings were in line with preceding related works, for example with regards to the initial characteristics of PyC samples (Keiluweit et al., 2010) and subsequent degradation trends (Wang et al., 2015), whilst providing some of the first detailed analysis of PyC degradation trends in UK peatlands.

Throughout the study period there are indications of soil matrix and dissolved organic matter interactions, with the effects of terrestrial exposure being more pronounced than aquatic exposure from 3 months of sample deployment.

This research demonstrates the potential for changes to PyC characteristics during early exposure (i.e. <1 year) to catchment processes. The findings presented here suggest that previously unconsidered carbon fluxes may occur in the short term (i.e. <12 months) following wildfire events.

References

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