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Carbon sequestration from boreal wildfires via Pyrogenic Carbon production

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Fire releases important quantities of carbon (C) to the atmosphere. Every year, an average of 460 Million ha burn around the globe, generating C emissions equivalent to a third of the current annual contribution from fossil fuel combustion. Over the longer-term wildfires are widely considered as 'net zero C emission events', because C emissions from fires, excluding those associated with deforestation and peatland fires, are balanced by C uptake by regenerating vegetation. This 'zero C emission' scenario, however, may be flawed, as it does not consider the production of pyrogenic C (PyC). During fire, part of the biomass C burnt is emitted to the atmosphere but part is transformed into PyC (i.e. charcoal). The enhanced resistance of PyC to environmental degradation compared to unburnt biomass gives it the potential to sequester C over the medium/long term. Therefore, after complete regeneration of the vegetation, the PyC generated may represent an additional C pool and, hence, recurring fire-regrowth cycles could represent net sinks of atmospheric C.

To estimate the quantitative importance of PyC production, accurate data on PyC generation with respect to the fuel combusted are needed. Unfortunately, detailed quantification of fuel prior to fire is normally only available for prescribed and experimental fires, which are usually of low-intensity and therefore not representative of higher-intensity wildfires. Furthermore, what little data is available is usually based on only a specific fraction of the PyC present following burning rather than the whole range of PyC products and pools (i.e. PyC in soil, ash, downed wood and standing vegetation).

To address this research gap, we utilized the globally unique FireSmart experimental forest fires in North-west Canada. They are aimed to reproduce wildfire conditions typical for boreal forest and, at the same time, allow pre-fire fuel assessment, fire behaviour monitoring and immediate post-fire fuel and PyC inventory. This allowed, for the first time, quantifying the whole range of PyC components found in-situ immediately after a typical boreal forest fire.

The fire examined had a fireline intensity of $\sim$8000 kw/m, which is typical of boreal fires in NW Canada and we found that more than 18% of the fuel consumed was converted to PyC. This rate by far exceeds previous estimates (1-3%) and suggests that PyC production has indeed been substantially underestimated. As boreal forests are the world's largest terrestrial biome and contain half of the forest ecosystem C with a third its net primary productivity being consumed by fire every year, our findings could imply that PyC production from wildfires is a potential carbon sequestration mechanism of sufficient magnitude that warrants inclusion in boreal and perhaps global C budget estimations.