Increasing wildfires threaten historic carbon sink of boreal forest soils

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Background: When boreal forests burn, large amounts of carbon are released, primarily through the combustion of soil organic matter. Underneath the burned layer, a layer of organic soil ("legacy carbon", LC) may escape combustion, leading to a net accumulation of carbon in forests over multiple fire events. If LC combusts, it may shift the carbon balance of the boreal ecosystem from net accumulation of carbon to net loss.

Methods: This study utilizes soil radiocarbon dating to quantitatively assess LC loss in the Northwest Territories, Canada in 2014, when wildfires burned the largest area annually on record for the region. The burn area was extensive and complex, allowing comparison of wet, dry, and moist ecosystems as well young and older forest stands.

Results:

- No evidence was found for the combustion of LC in forests that were older than the historic fire-return interval.
- In dry landscapes and forests less than 60 years old at the time of the fire, LC was combusted.
- It was estimated that 0.34 million hectares of young forests (<60 years) burned in the 2014 fires could have experienced LC combustion.

Significance: The results imply a shift in which forests become a net source—instead of a sink—of carbon to the atmosphere over consecutive fires. As boreal wildfires continue to increase in size, frequency and intensity, the area of young forests that experience LC combustion will likely increase This may play a key role in shifting boreal carbon balance.

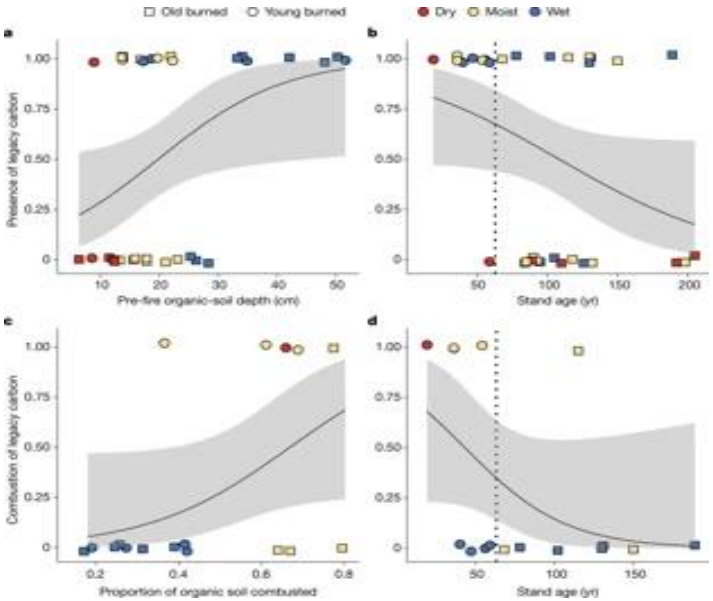

Figure: Predicted presence and combustion of legacy carbon. a–d, Data are grouped according to stand age at the time of fire (old or young burned) and moisture (dry, moist or wet). Shading represents the 95% prediction intervals and symbols are staggered for visual differentiation. The vertical dotted line represents the age threshold used to differentiate between young burned and old burned plots. The presence of legacy carbon was modelled as a function of pre-fire organic soil depth (a) and stand age at the time of burning (b; pseudo-R2 of 0.26, n = 32 plots). The combustion of legacy carbon was modelled as a function of the proportion of organic soil combusted (c) and stand age at the time of burning (d; pseudo-R2 of 0.43, n = 17 plots). See Extended Data Table 1 for model results.