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Increased fire frequency optimization of black carbon mixing and storage

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Soil carbon makes up a substantial part of the global carbon budget and black carbon (BC – produced from incomplete combustion of biomass) can be significant fraction of soil carbon. Soil BC cycling is still poorly understood – very old BC is observed in soils, suggesting recalcitrance, yet in short term lab and field studies BC sometimes breaks down rapidly. Climate change is predicted to increase the frequency of fires, which will increase global production of BC. As up to 80% of BC produced in wildfires can remain at the fire location, increased fire frequency will cause significant perturbations to soil BC accumulation. This creates a challenge in estimating soil BC storage, in light of a changing climate and an increased likelihood of fire.

While the chemical properties of BC are relatively well-studied, its physical properties are much less well understood, and may play crucial roles in its landscape residence time. One important property is density. When BC density is less than 1 g/cm3 (i.e. the density of water), it is highly mobile and can easily leave the landscape. This landscape mobility following rainfall may inflate estimates of its degradability, making it crucial to understand both the short- and long term density of BC particles. As BC pores fill with minerals, making particles denser, or become ingrown with root and hyphal anchors, BC is likely to become protected from erosion. Consequently, how quickly BC is mixed deeper into the soil column is likely a primary controller on BC accumulation. Additionally the post-fire recovery of soil litter layers caps BC belowground, protecting it from erosional forces and re-combustion in subsequent fires, but still allowing bioturbation deeper into the soil column.

We have taken advantage of a fire chronosequence in the Pine Barrens of New Jersey to investigate how density of BC particles change over time, and how an increase in fire frequency affects soil BC storage and soil column movement. Our plots have variable fire return rates, but a similar plant history and soil quality. The area is typified by highly sandy, acidic soils, allowing us to measure the effect of fire frequency on BC storage and mixing without the complication of secondary soil minerals.

Here we will present results from a variety of BC tracers we are using to detect ‘pulses’ of fire material moving down the soil column. Additionally we will present data on the density of macro BC particles picked from soils to define the density changes of BC that has been stored from previous fires. We hypothesize that increases in fire frequency will increase BC soil stocks up to a point, and then begin decreasing with increasing frequency, due to insufficient time allowed for particle mixing, and that particles deeper in the soil column will have greater bioaccumulation than shallower particles. Additionally we expect to see pulses in BC tracers moving down the soil column that smear over time in the deeper layers, due to the chaotic nature of soil mixing.