The Morphology of Burnt Dirt: A pedologic investigation of fire history across ecosystems

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PROJECT INTRODUCTION

Research Question:
Fire is a part of natural ecosystems around the world, but with strong fire suppression efforts during the *modern era** is there still a signal of fire history in these soils?

What is the National Ecological Observatory Network (NEON)?
In order to better monitor our rapidly changing ecosystems, the National Science Foundation initiated a 30-year long observation network collecting data from 20 eco-domains representing the full range of ecological and climatic diversity in the US. There are 20 permanent core sites (paired terrestrial + aquatic observations), as well as ~25 relocatable sites that are mobile within an ecoclimatic domain every ~5 years.

Sample Collection & Handling:
During the installation of NEON infrastructure, soil auger holes were dug which acted as mini-soil pits. These five cores/site were described according to NRCS standards, and later composited to produce a 'master' soil profile for each site. Three horizons were selected for a full suite of analysis that include the A-horizon, the upper-most illuvial B-horizon, and the deepest B horizon approaching parent material.

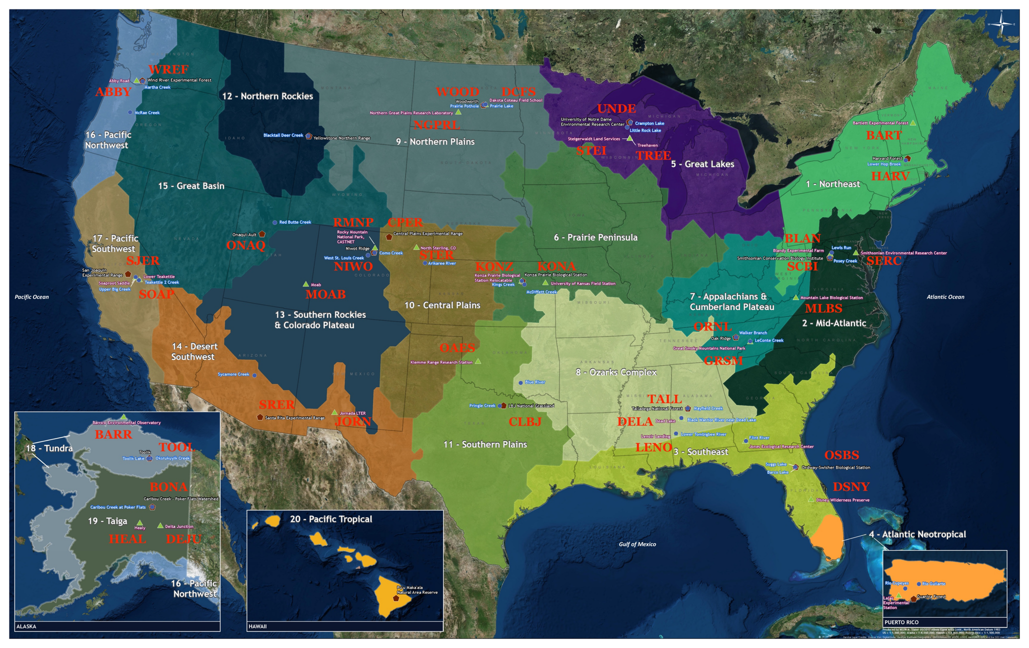
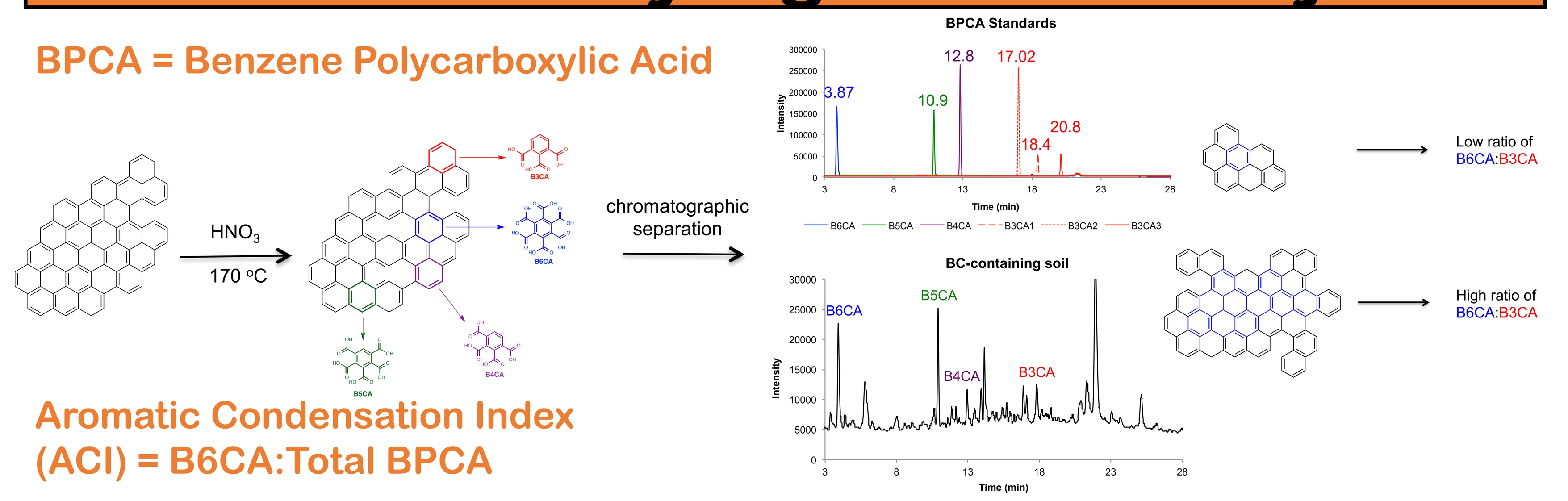


Figure 1 The NEON map displaying the 20 eco-climatic domains, their individual site locations and abbreviations in red.

METHODS: Pyrogenic-C Analysis

BPCA = Benzene Polycarboxylic Acid



Aromatic Condensation Index (ACI) = B6CA:Total BPCA

Figure 2 Pyrogenic Carbon (PyC) includes a broad range of thermally altered organic matter. Using the BPCA method (requiring thermal oxidation in nitric acid for several hours) we can (a) quantify the total PyC content in the sample and (b) understand the degree of aromatic condensation of the PyC indicating the potential rate of biological or chemical transformation.

RESULTS: Soil Profile Morphology

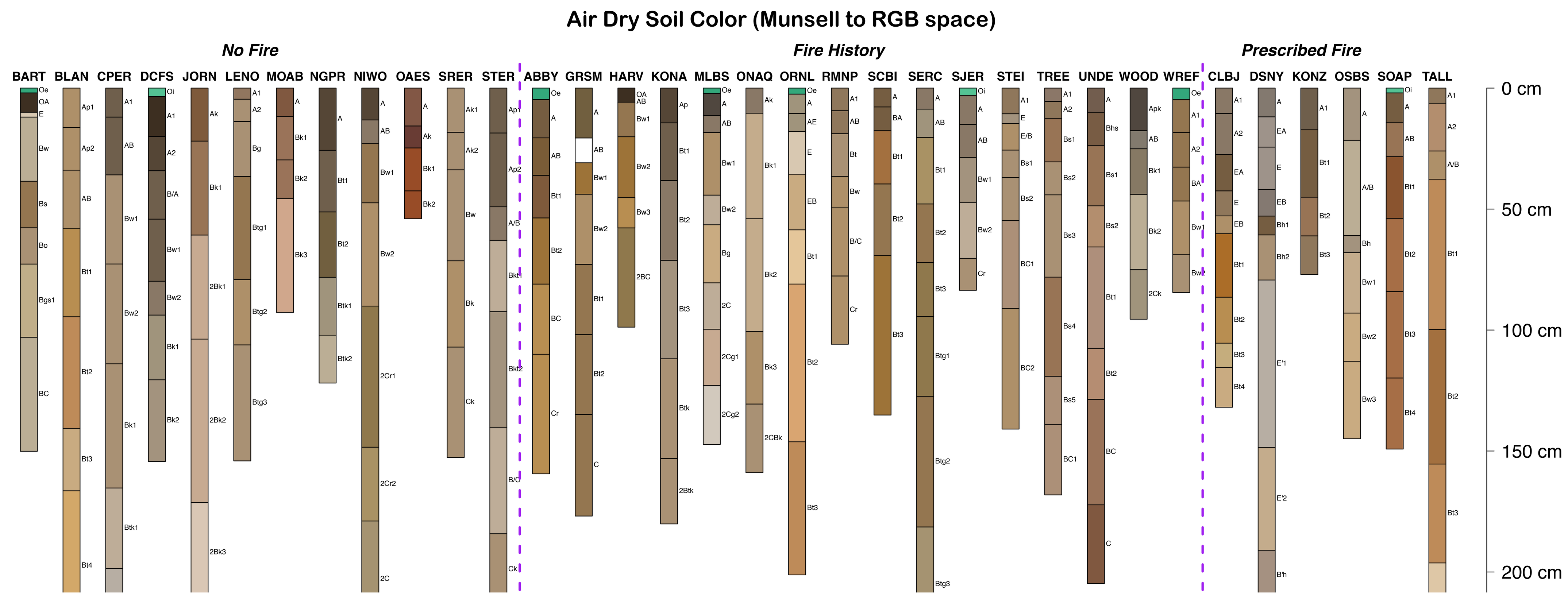


Figure 3 Fire history categories are based on the presence of fire adapted species (i.e. ponderosa pine) or if fires were described in the site notes via NEON's website. Each NEON site collected at least five soil cores that were described according to NRCS standards and later composited across genetic horizons. Depths for all horizons are averaged across the five cores described per site. All soil colors are directly measured from the composited soil horizons, subsequent analysis of soils are done on the composited horizons. O-horizons use a false green color for illustration. *Figures 3-6 made with RStudio aqp() package – special thanks to D. Beaudette*

RESULTS: Estimated Bulk Soil-C Age (^{14}C)

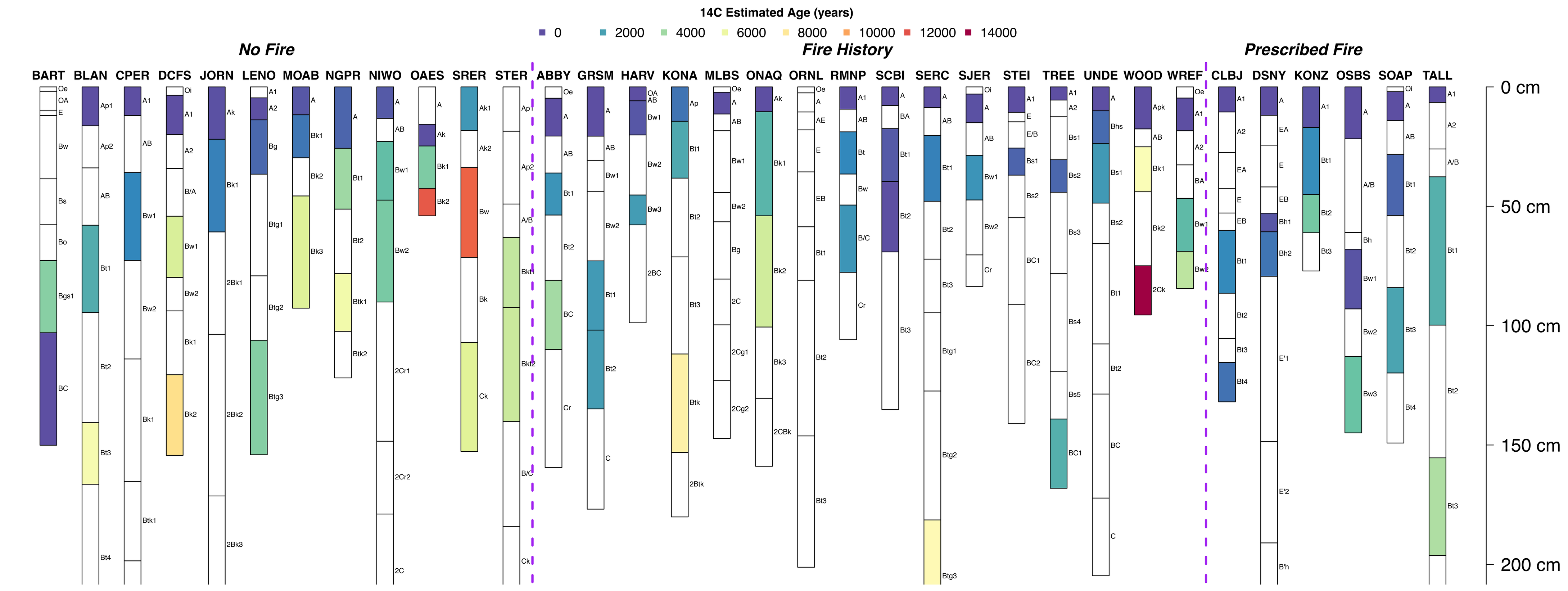


Figure 4 Using three critical horizons from each NEON site (representing the A-horizon, uppermost B-horizon, and deepest B-horizon) we estimated the bulk soil carbon age through 14C techniques, white spaces indicate analysis not available. Although we assume PyC has a very long turnover time, there does not appear to be any relationship between the the increasing prevalence of fires and radiocarbon age. Most A-horizons have a dominant contribution from modern-C, with the notable exceptions of JORN, OAES, SJER, MOAB with ages estimated between 50-200 years old. The oldest radiocarbon ages also come from desert sites (Bk & Ck horizons ~7,000 yrs old). *Special thanks to the Radiocarbon Collaborative!*

RESULTS: Total PyC Contribution

BPCA = Benzene Polycarboxylic Acid

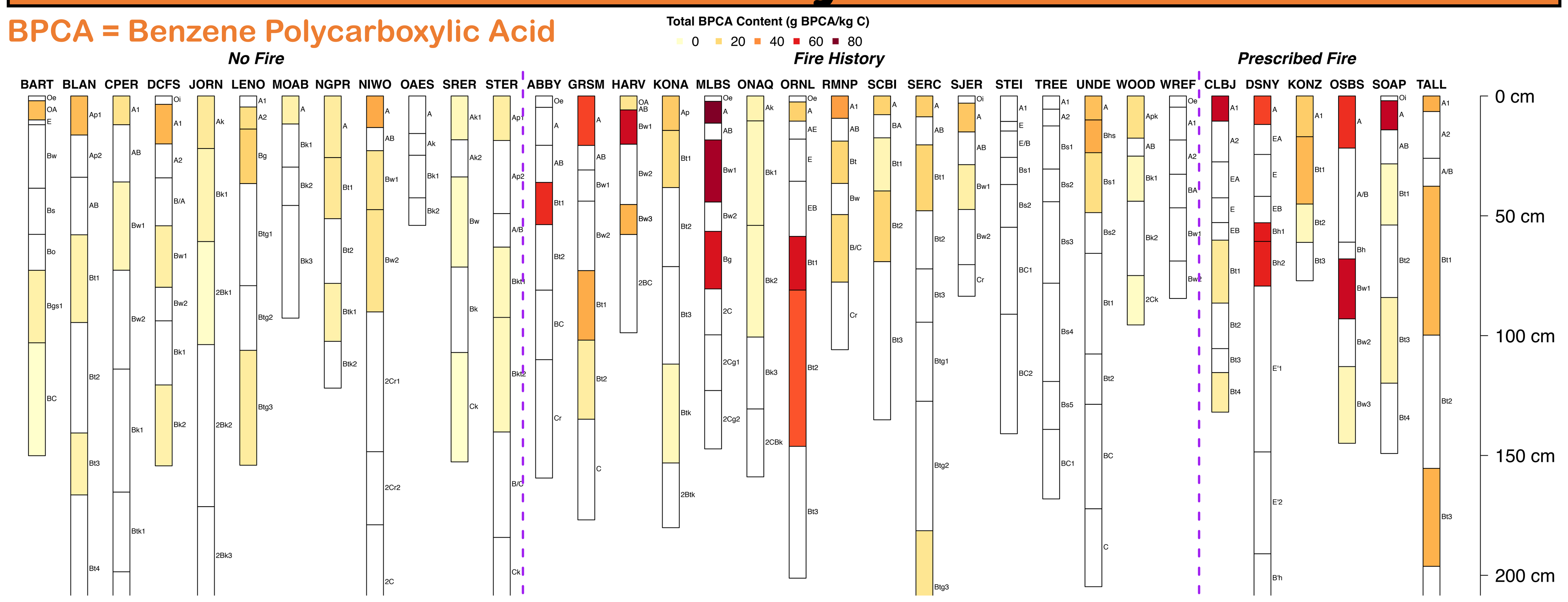


Figure 5 Using three critical horizons from each NEON site (representing the A-horizon, uppermost B-horizon, and deepest B-horizon) we quantified the contribution of PyC to total SOM. There are measurable contributions of PyC in the "No Fire" category. GRSM had burning from Native Americans, ABBY forest management in the 1950's had typical site-prep burns, MLBS had a historical fire return interval of <8 years. Curiously, HARV OA horizon shows less BPCAs but the Bw1 contain a much higher concentration suggesting the last burn may have more completely combusted the O-horizon.

RESULTS: Aromatic Condensation Index (ACI)

BPCA = Benzene Polycarboxylic Acid (ACI) = B6CA:Total BPCA

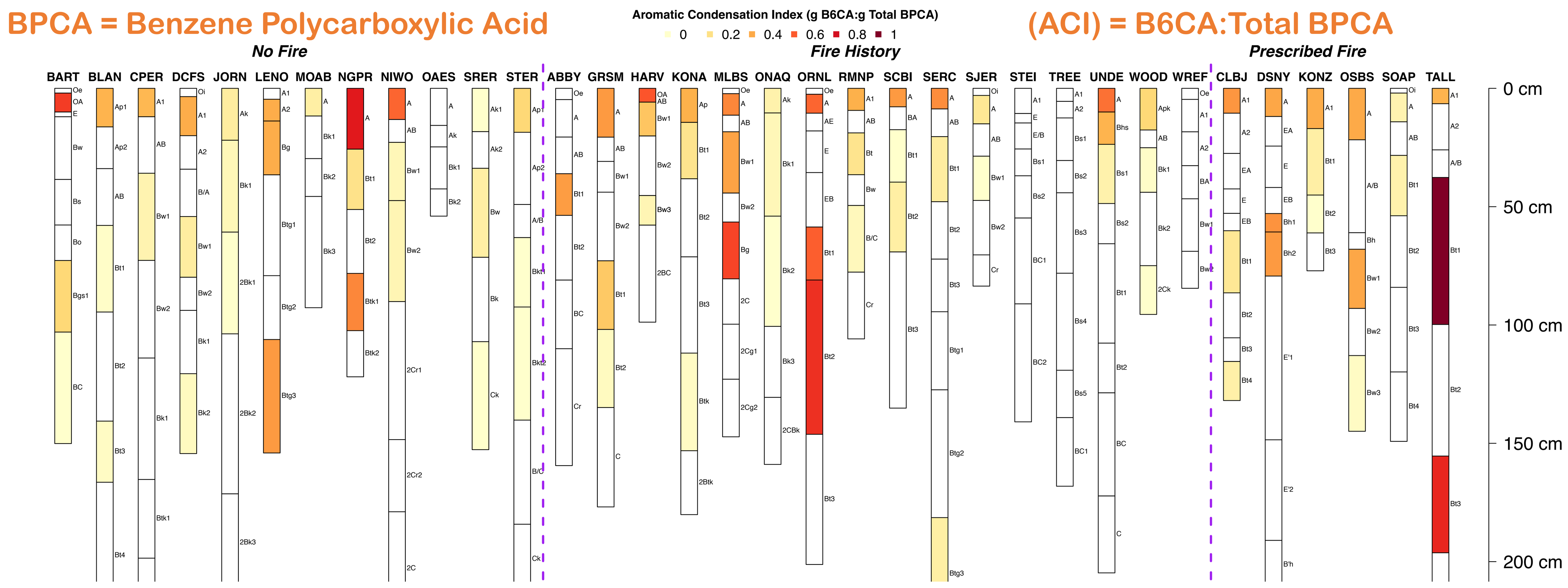


Figure 6 Using three critical horizons from each NEON site (representing the A-horizon, uppermost B-horizon, and deepest B-horizon) we quantified the relative degree of aromatic condensation in the PyC. ACI values closer to 1 indicate a more extended aromatic structure and higher thermal alteration (i.e. soot) and values closer to 0 are less thermally altered biomass. Higher ACI values common at the surface suggest many possible mechanisms: (a) soot inputs from fires, (b) highly condensed PyC remains unaltered from pervious fires, (c) faster degradation of less condensed PyC, (d) many others!

CONCLUSIONS

This broad suite of samples provided by the National Ecological Observatory Network & these unique analysis will allow greater inferences for the ensuing life of NEON. We show that bulk soil-C age has little correlation to PyC inputs, evidence of PyC is present on every landscape, & the degree of aromatic condensation is greatest in surface soil horizons. Further work includes BPCA analysis on permafrost soils & modeling to further decipher the influence of PyC on soil organic matter dynamics.

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