Reconstructing Fire Intensity Leveraging Infrared Imaging Microscopy Of Charcoal Materials And NASA Remote Sensing Products

Presenter:

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Background:

- Fire intensity (measure of the time-averaged energy flux) is difficult to measure in situ (Keeley 2009).
- Previous research developed and applied a novel way to measure fire intensity using charcoal from South American species (Gosling et al. 2019).
- Can we infer combustion temperatures from charcoal of trees common in the western United States?
- Can we differentiate charcoal between different species ?

Methods:

Tree samples were wrapped in aluminum foil and surrounded by sand in crucibles. Samples were then combusted at various temperatures in a muffle furnace from 200-800°C at 100°C intervals.

Tree species used included:
Ponderosa pine (*Pinus ponderosa*) designated PIPO in graphs
Aspen (*Populus tremuloides*) designated POTR in graphs
White fir (*Abies concolor*) designated ABCO in graphs
Red fir (*Abies magnifica*) designated ABMA in graphs

Species selected are based on a subset of dominant species in the western United States mixed conifer forests (Stephens et al. 2018).

Combusted samples were ground and sieved to below 53 microns.

Samples were then analyzed using the Nicolet™ iN™10 IMX Fourier Transform Infrared (FTIR) microscope.

Results:

Comparison of all burn temperatures in the spectra wavenumbers that correspond with cellulose and lignin show that you can differentiate between temperatures and species. (press play below to view all graphs)

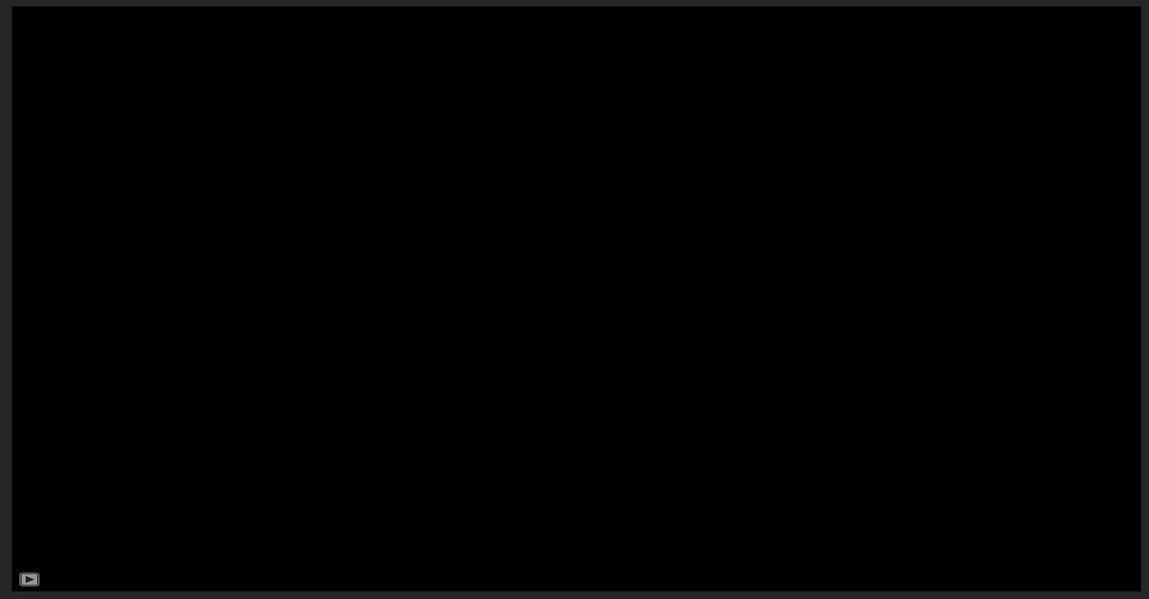


Figure 1

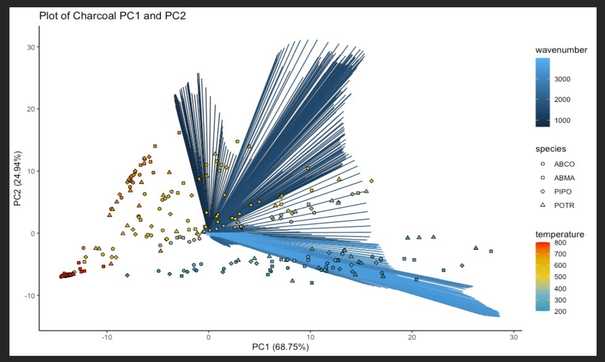


Figure 2

Principal Components Analysis (PCA) performed on FTIR data shows clustering based on combustion temperature (Figure 2). Species combusted at low temperatures explain the most variation for PC1, as well as wavenumbers above 3000 cm^{-1}. Samples combusted between 500-700°C and wavenumbers from 1000-2000 cm^{-1} explain the variation on PC2.

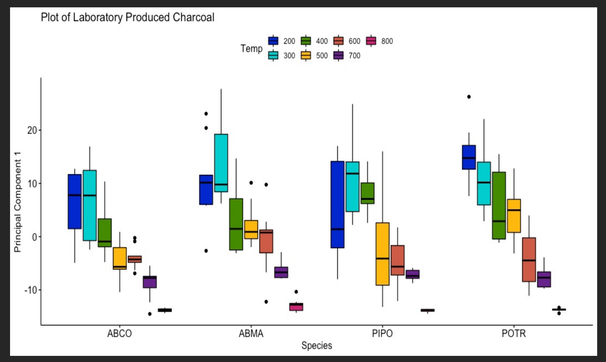


Figure 3

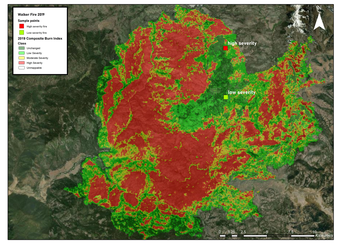
An Analysis of Variance (ANOVA) was performed on the components of PC1 (Figure 3) and a Multivariate Analysis of Variance (MANOVA) was performed on wavenumbers of interest from the first and second axis of the PCA. This indicated that species and temperature had an impact on the spectra produced from the FTIR microscope.

2019 Walker Fire

- Fire severity fire refers to the loss or decomposition of organic matter aboveground and belowground (Keeley 2009)

Low severity burn area Walker fire, CA (photo taken 10/2019 by Mary Brady)

High severity burn area Walker fire, CA (photo taken 10/2019 by Mary Brady)



Comparison to Wildfire Charcoal

Charcoal was collected from two plots classified as "low" and "high" severity at the 2019 Walker fire in Plumas County, California (Figure 4). "Low" severity samples were collected from a torched log and so are more likely to be from higher temperature burning.

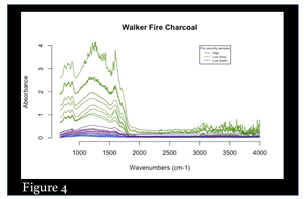


Figure 4

These samples (grey points in Figure 5), when included in the Principal Components Analysis, cluster with the laboratory samples combusted at 700-800°C.

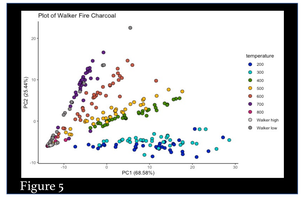


Figure 5

Future Work

In future work, I would like to include a more robust field collection of charcoal from thermocouple instrumented prescribed fires and wildfires in order to collect representative samples from different fire severity classes. I will use these samples to quantify fire severity to compare to remote sensing data. Additional work will include comparing laboratory created samples to charcoal from lake core sediments and possibly fire scars from tree rings.

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References:
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