Hyperspectral Reflectance of Pre- and Post-Fire Soils: Toward Remote Sensing of Fire Induced Soil Hydrophobicity

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Introduction

- Wildfire activity and intensity in the western U.S. have greatly increased, mainly due to a warming climate, population growth, land use changes, and fuel accumulation [1].
- Forest fires modify physical and chemical soil properties and generally cause Fire-Induced Soil Hydrophobicity (FISH), which reduces water infiltration into the soil and accelerates runoff after precipitation events [2].
- In this research, we have sampled surface soils from one of the recent California (US) megafires: the Dixie, Beckwourth Complex, Caldor, and Mosquito (Table 1) and we studied the optical, chemical, and hydrological properties of unburned and burned soil samples.
- We aim to find correlations between the optical, chemical, and hydrological measurements, as needed for using hyperspectral remote sensing to understand, predict, and mitigate postfire, watershed-wide hydrological responses including flooding, landslides, and deterioration of water quality.

Study Site

Table 1. Description of four recent California fires

Fire Name	Start Date – End Date	Fire Area (km2)	Total % of Moderate Severely Burned Soil	Total % of High and Very High Soil Erosion Hazard
Dixie	7/13/21 – 10/25/21	3,898	54	20
Beckwourth Complex	7/04/21 – 9/22/21	428	57	38
Caldor	8/12/21 – 10/21/21	898	56	28
Mosquito	9/06/22 – 10/27/22	311	34	N/A

Methods

WDPT and goniometer measurements

Figure 2. Water drop penetration time (WDPT) measurements in the field, shortly after the Dixie fire was contained, showing water drops siting on burned soil

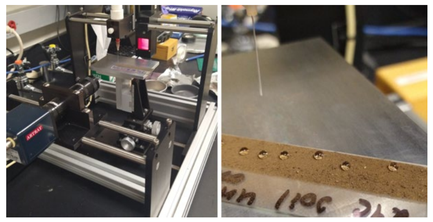

Figure 3. Goniometer instrument used for apparent contact angle measurements (ACA) on a microscope glass loaded with sample

Figure 4. Soil samples (top row collected in 2022, from left to right: ash, burned and unburned, bottom row collected in 2021, from left to right: ash, burned and unburned)

ASD FieldSpec3 measurements

Figure 5. ASD FieldSpec3 set up for measurements at DRI rooftop

Results

Raw Data

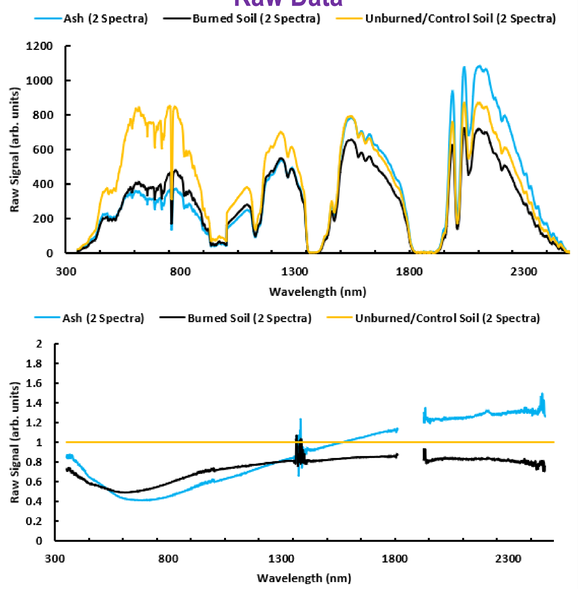

Figure 6. Signal spectra for soil samples collected one year after the Dixie megafire including averages of (blue curve) 2 spectra for the ash layer; (black curve) 2 spectra of burned soil; and (orange curve) 2 spectra of nearby unburned soil

Reflectance Data

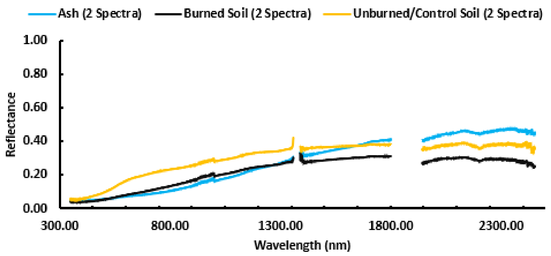

Figure 7. Reflectance spectra for soil samples collected one year after the Dixie megafire including averages of (blue curve) 2 spectra for the ash layer; (black curve) 2 spectra of burned soil; and (orange curve) 2 spectra of nearby unburned soil

Conclusions

- Strong absorption features related to water are observed around 1400 nm and 1900 nm regions.
- The reflectance of burned soil is significantly lower than that of unburned soil in the visible and near visible spectral regions.

Next steps

- Chemical analysis (chemical functional groups) of the collected soils with FTIR spectroscopy.

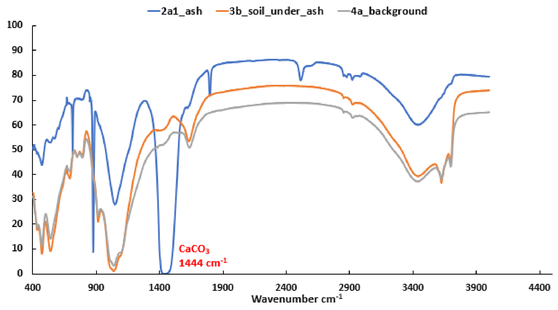

Figure 8. FTIR spectra for collected soil samples after Dixie fire in 2021

- Run correlations between soil water repellency measurements (WDPT and ACA) and soil reflectance spectra.
- Run correlations between soil reflectance spectra acquired with ASD FieldSpec3 and chemistry of analyzed soils and ash (FTIR method).
- Perform control combustion experiments with soils and biomass fuels typical for Nevada (NSF EPSCoR).

Acknowledgements

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2. Samburova, V., Shillito, R. M., Berli, M., Khlystov, A. Y., & Moosmüller, H. (2021). Effect of Biomass-Burning Emissions on Soil Water Repellency: A Pilot Laboratory Study. *Fire*, *4*(2), 24..

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