Thermal Alteration of Peat Soil By Low-Severity Fire Reduces Net Carbon Loss to Microbial Respiration

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Perception of Wetland Fires- Pocosins (Example Deep Peat Fire)

Photo Credit USFWS

Reality of Most Wetland Fires (Surface Fires)

Wet burn in the Green Swamp, Brunswick County, NC. Photo: Gary Curcio, NC Division of Forest Resources.

Reardon and Curcio, 2011

Photo by Caleb Spiegel, US FWS

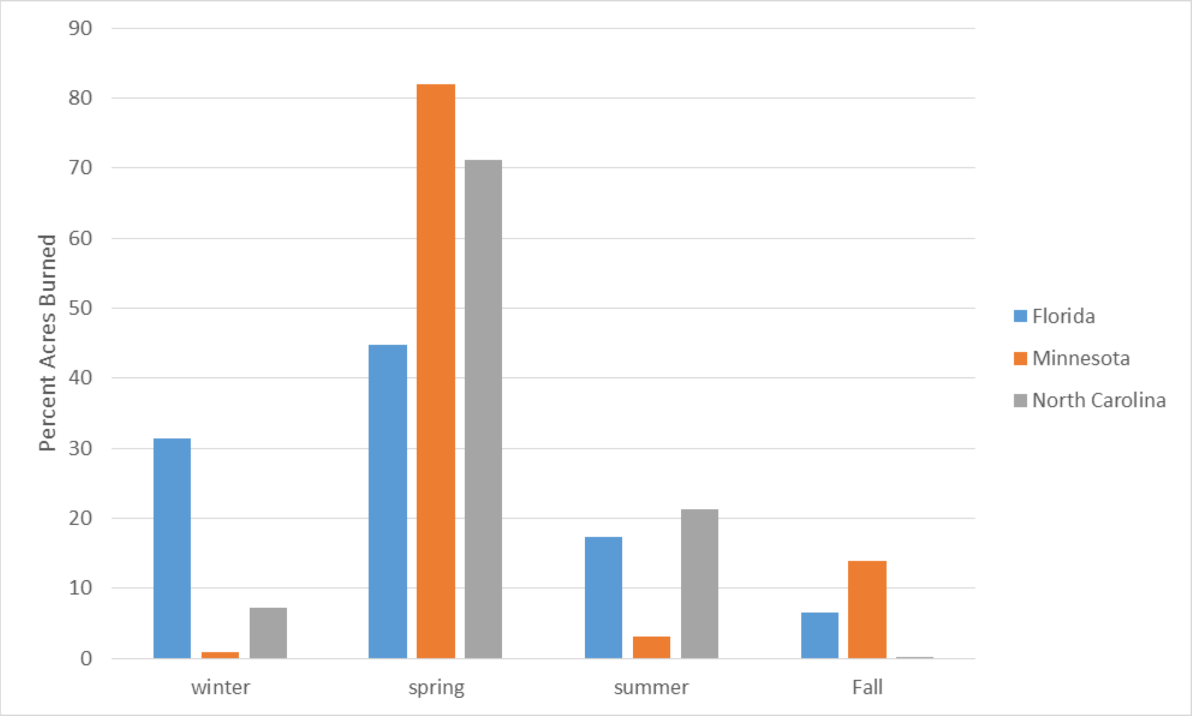
US FWS https://www.flickr.com/photos/usfwssoutheast/

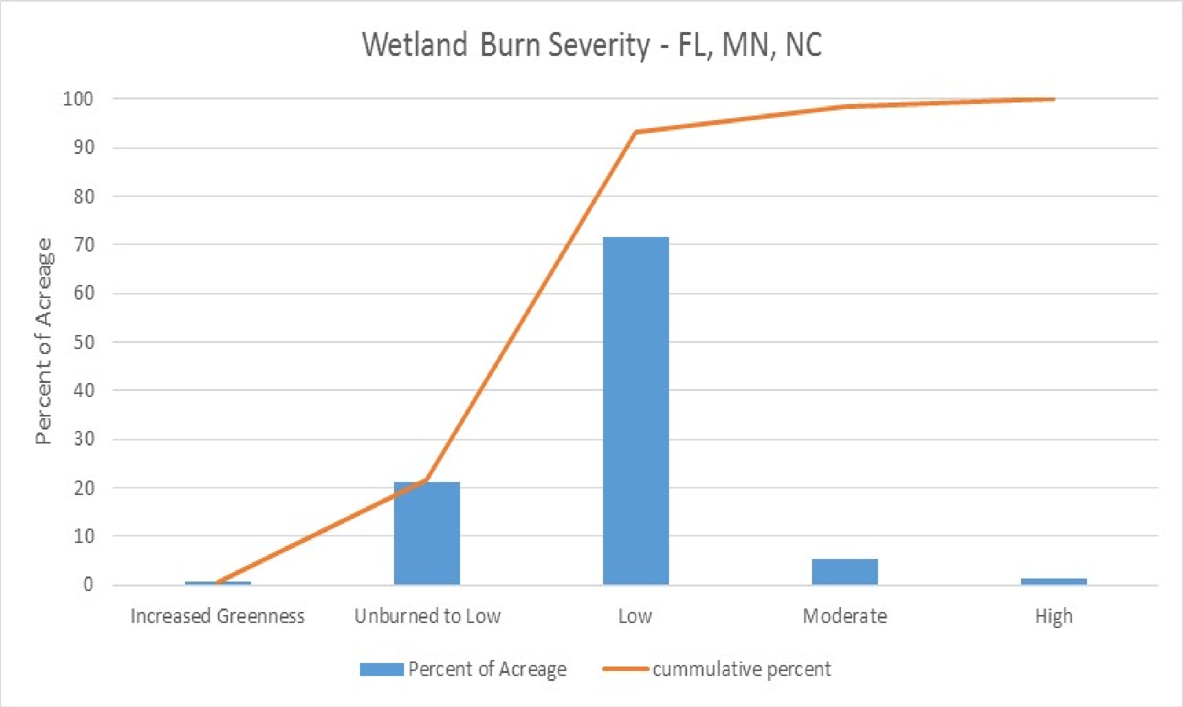
Croatan NF, Spring 2017

More Typical Endpoint of Wetland Fires (Pocosin Prescribed Burn)

< 2 years

Severity and Seasonality of Wetland Fires





Monitoring Trends in Burn Severity (MTBS)

http://www.mtbs.gov/dataaccess.html

Low Severity -Areas where more than a small proportion of the site burned. Duff, woody debris typically exhibit some change [but is not consumed].

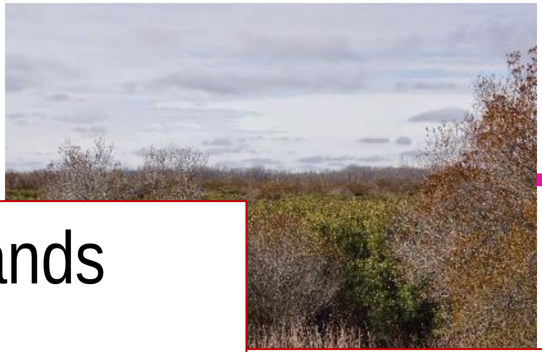
Question:
Do these low-severity Fires Affect Peat Recalcitrance?

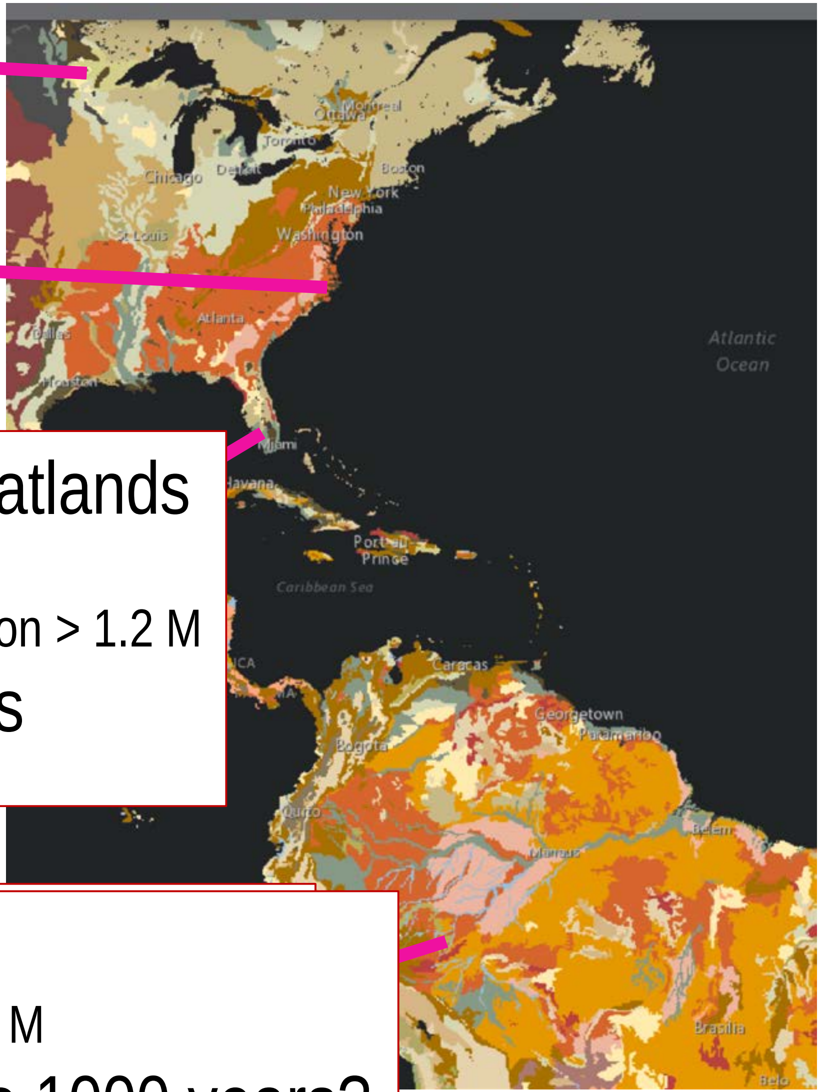
Possible Mechanisms for increase peat recalcitrance (i.e. reduce microbial respiration):

1. Selective removal of labile compounds by thermal alteration thus concentrating recalcitrant fractions
2. Alteration of physical structure of SOM
   - Hydrophobic/aromatic coating on soil aggregates
   - Physical protection of SOM
3. Formation of charcoal / Black Carbon

Sites

Soil Order





Blackspruce-sphagnum peatlands

- Cool summer temperatures
- Seasonal (summer) water table recession 0.3 m
- Fire Return Interval 50 to 150 years

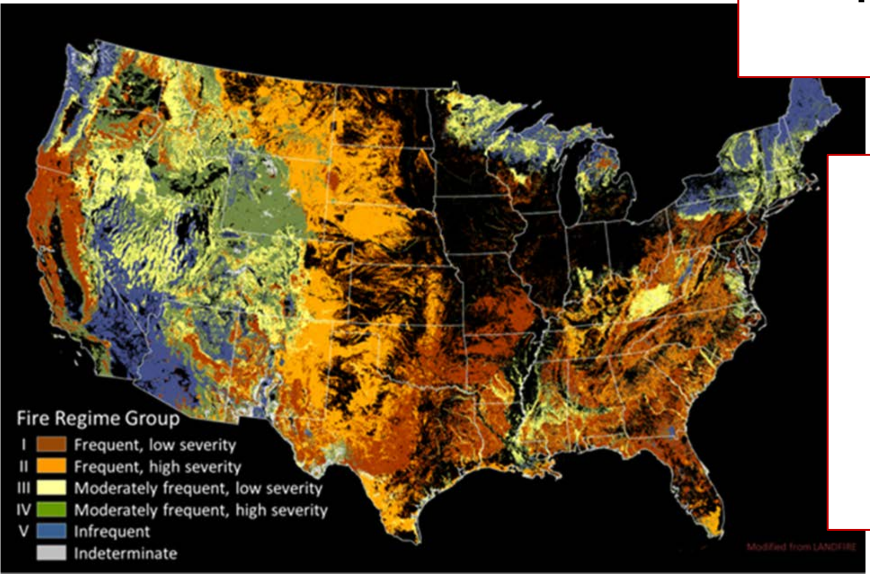
...hrub (Pocosin) Peatlands

...r temperatures

...mmer) water table recession > 1.2 M

Fire Return Interval 1 to 6 years

Fire Frequency



Mauritia Palm Peatlands

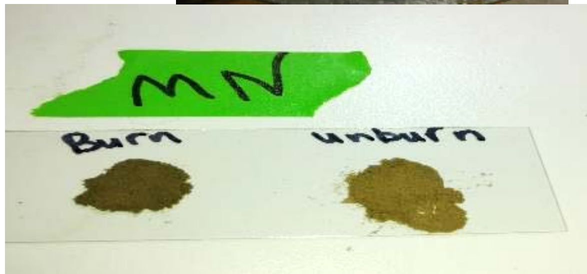
- Little water table variation > 0.3 M

Fire Return Interval 500 to 1000 years?

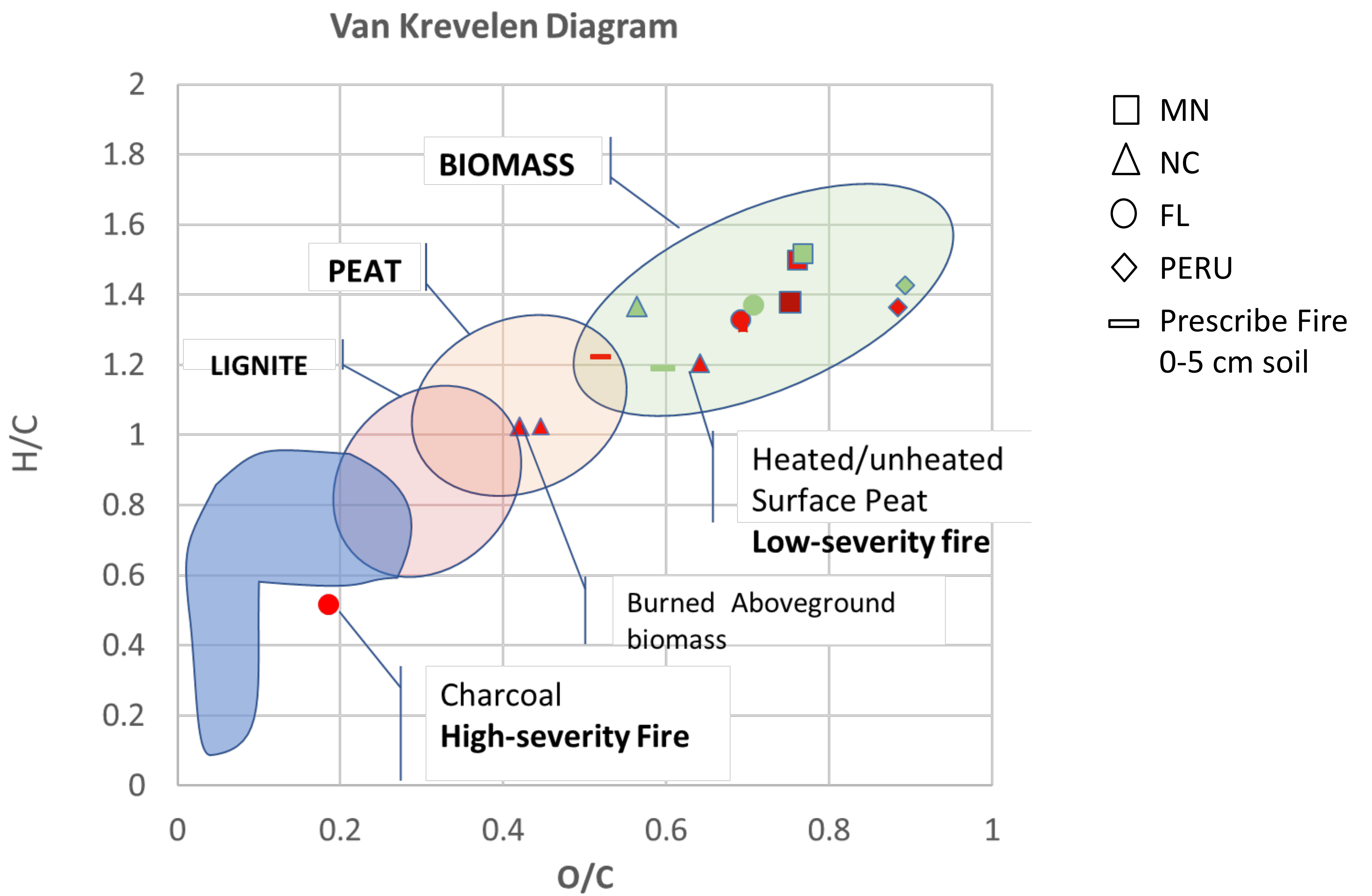
Los Amigos, Peru

Methods

- Monitored Prescribed Burn at Pocosin Lakes NWR
  - Soil temperature, moisture and depth to water table
  - Collected soil and litter before and after fire
- Collected soil and litter from all sites (MN, NC, FL, PERU)
- Performed simulated burns of surface layer in lab at DUWC
  - Mimic temperature pattern of prescribed burn (450°C, 10 minutes)
  - Soil moisture 350%
  - Burned samples inoculated or “reseeded” with unburned soil slurry after cooling
- Aerobic, near-saturated incubation of burned and unburned litter at 5, 15 and 25°C for six months
- Analyzed structure of burned and unburned soils using XPS, FTIR-ATR and SEM



Elemental Analysis of Bulk Chemistry



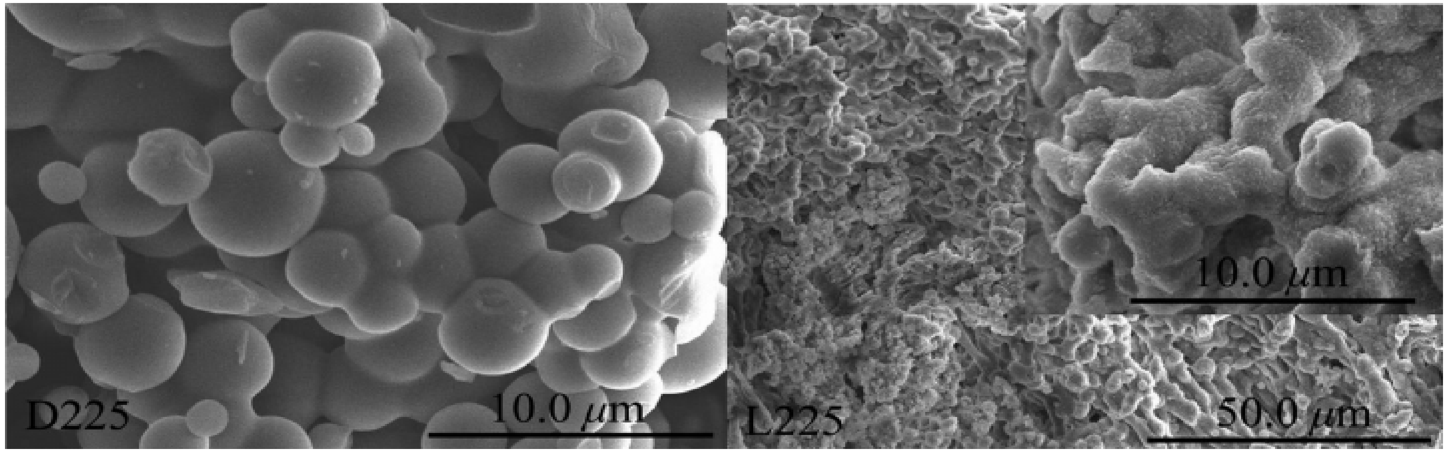
Structural Changes to peat

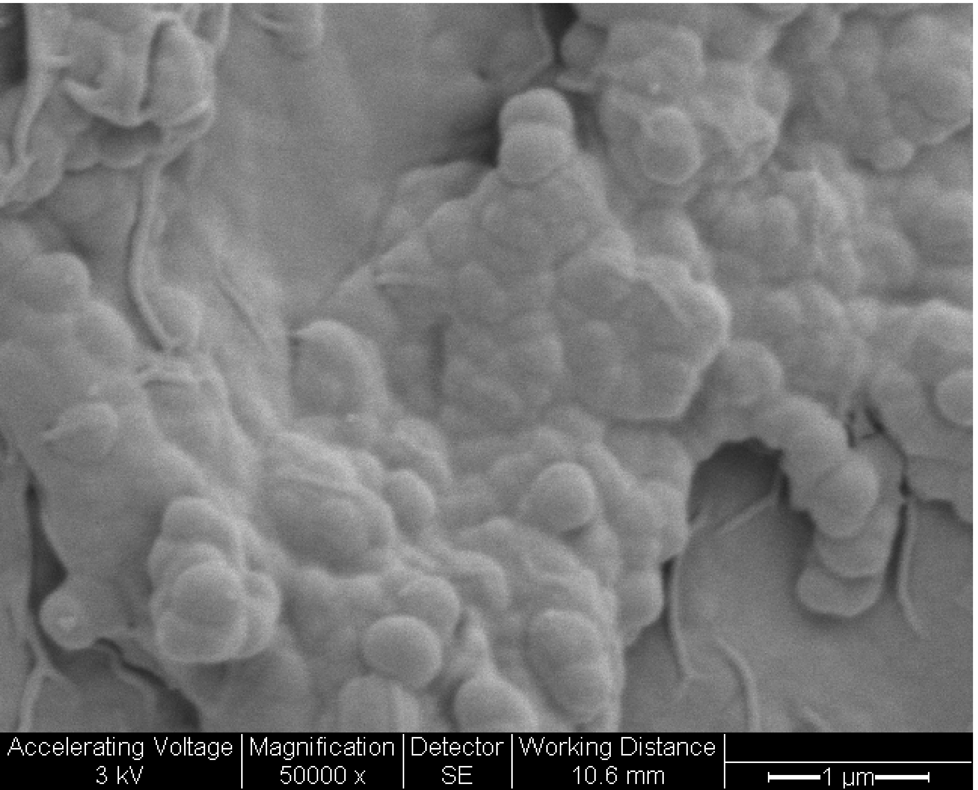
Unburned litter SEM

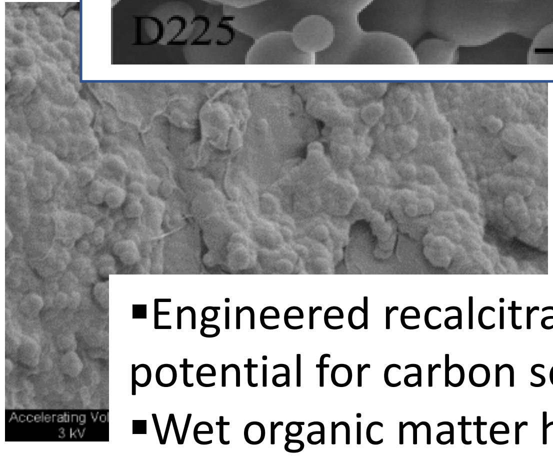
Coatings reminisce of hydrochar

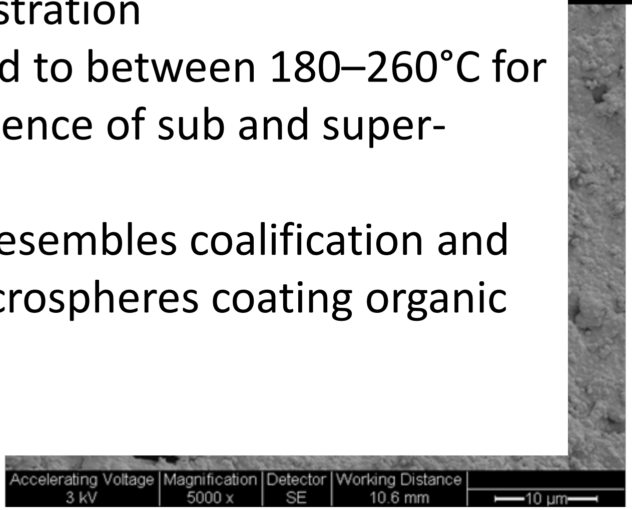
- Physical protection of SOM

Hydrochar



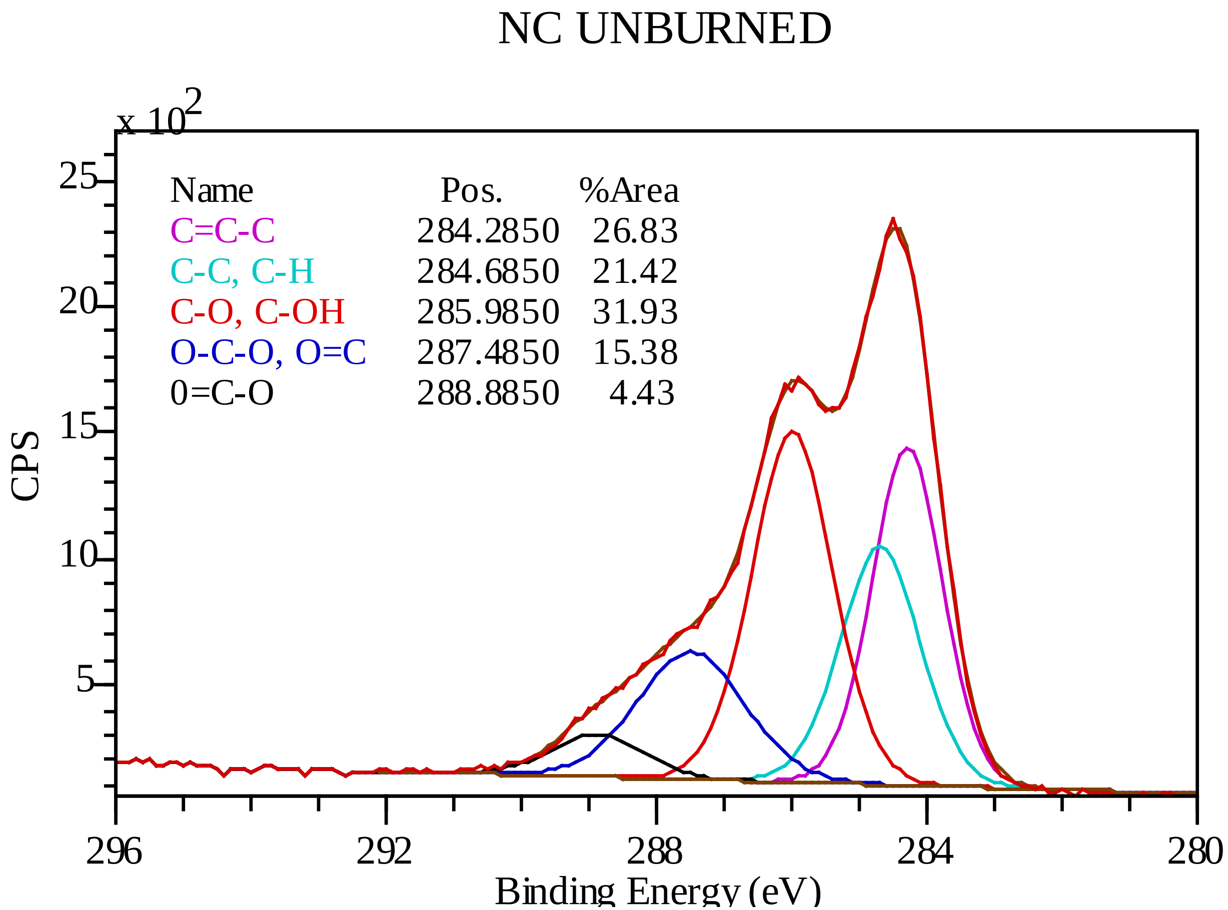


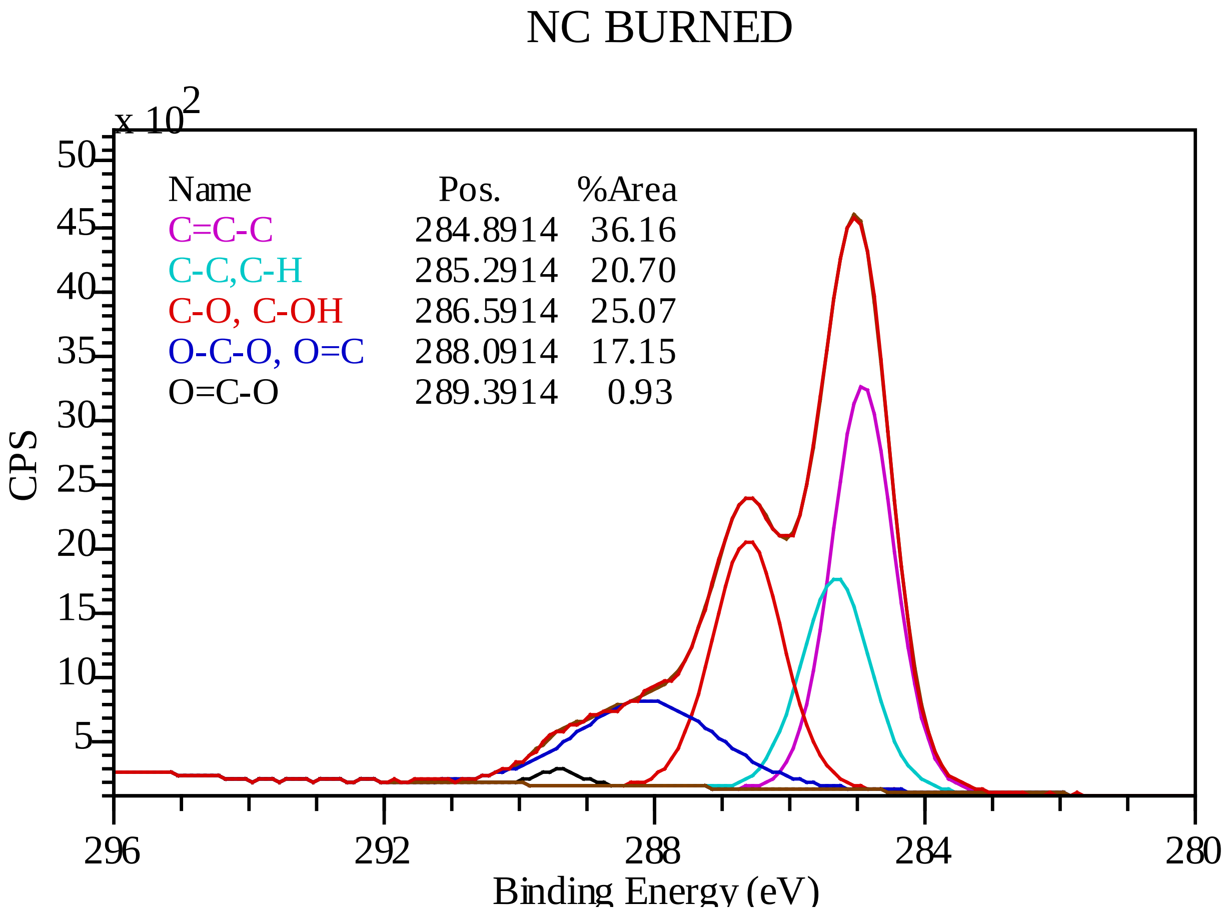




- Engineered recalcitrant soil amendment with potential for carbon sequestration
- Wet organic matter heated to between 180–260°C for 5min to 2 hours in the presence of sub and super-critically heated water
- Results in a process that resembles coalification and produces characteristic microspheres coating organic matter

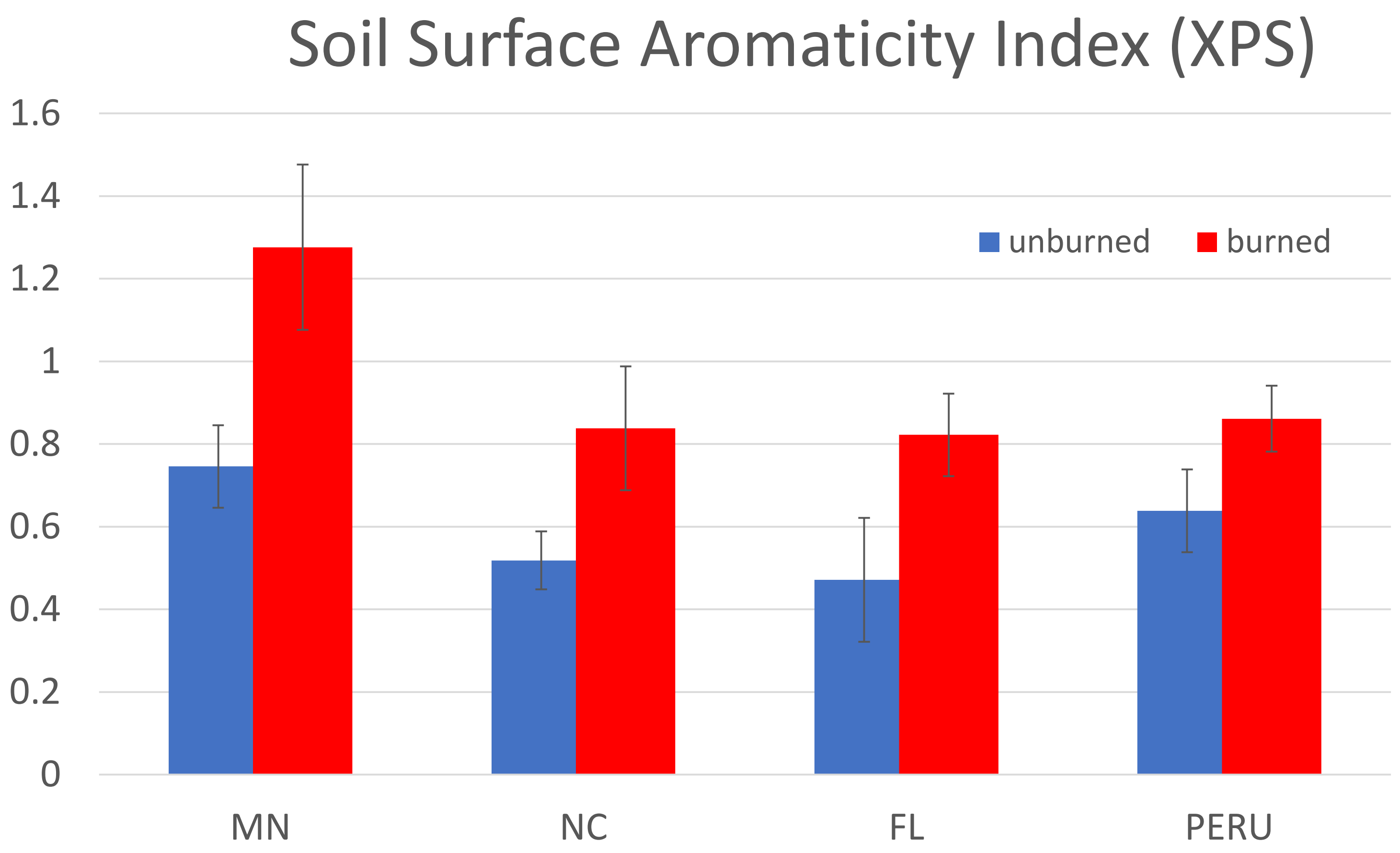
XPS Peat Surface Carbon Functional Groups





Aromatic, Aliphatic, Alcohol/ Ether, Carbonyl/acetal , Carboxylic

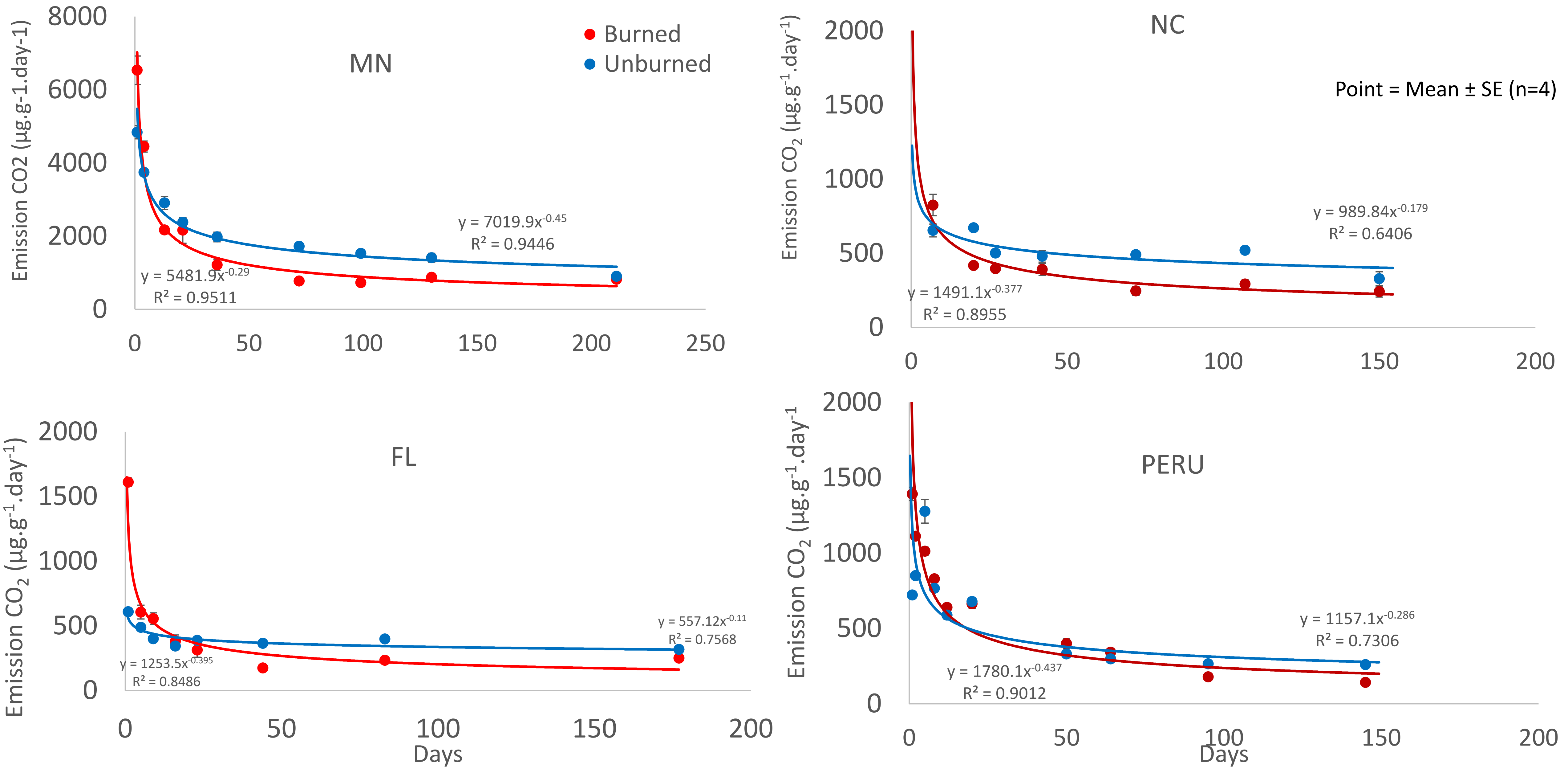
Soil Aggregate Alteration



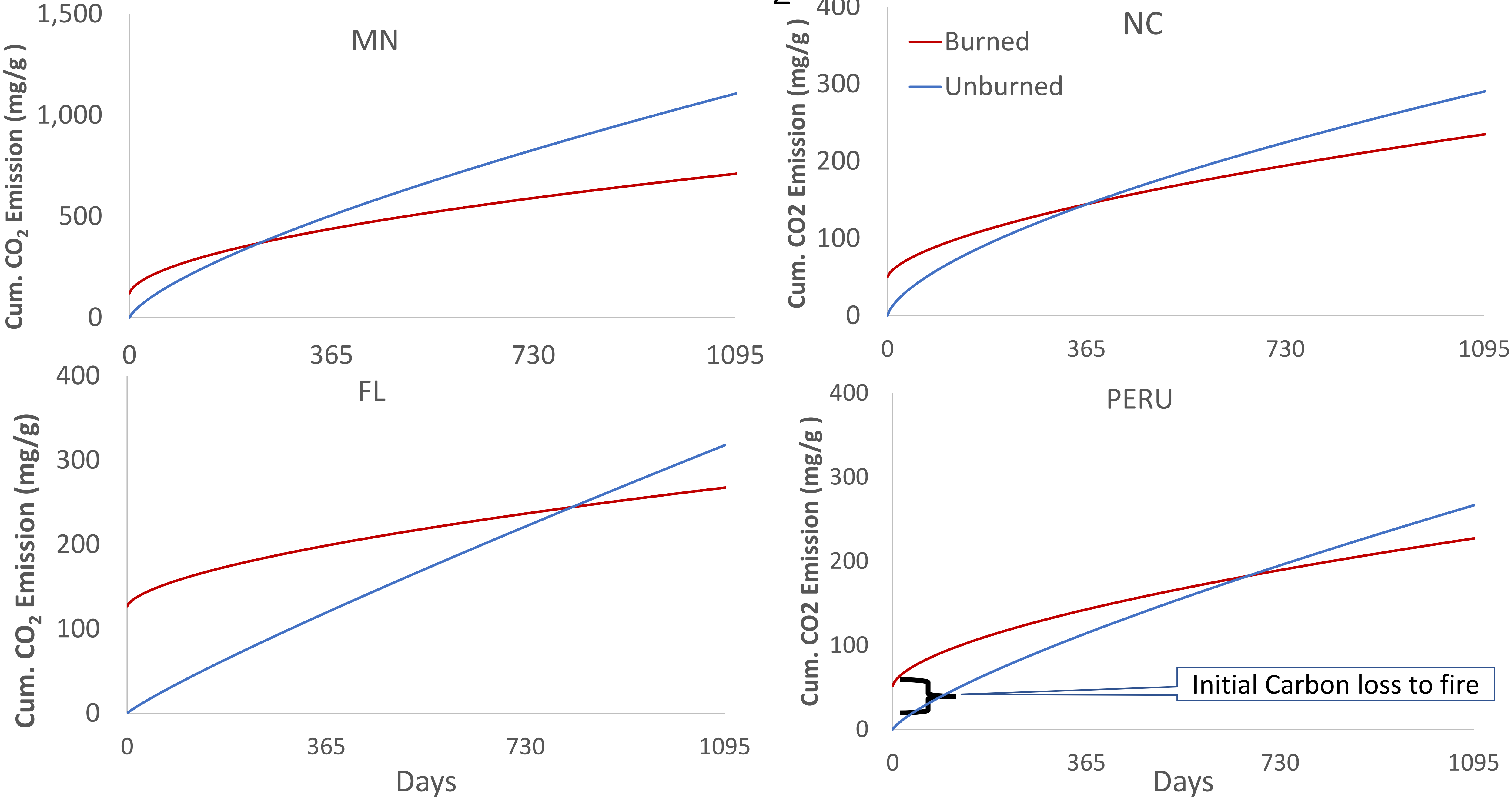
Pocosin unburned litter

Pocosin “coffee ground” soil aggregates

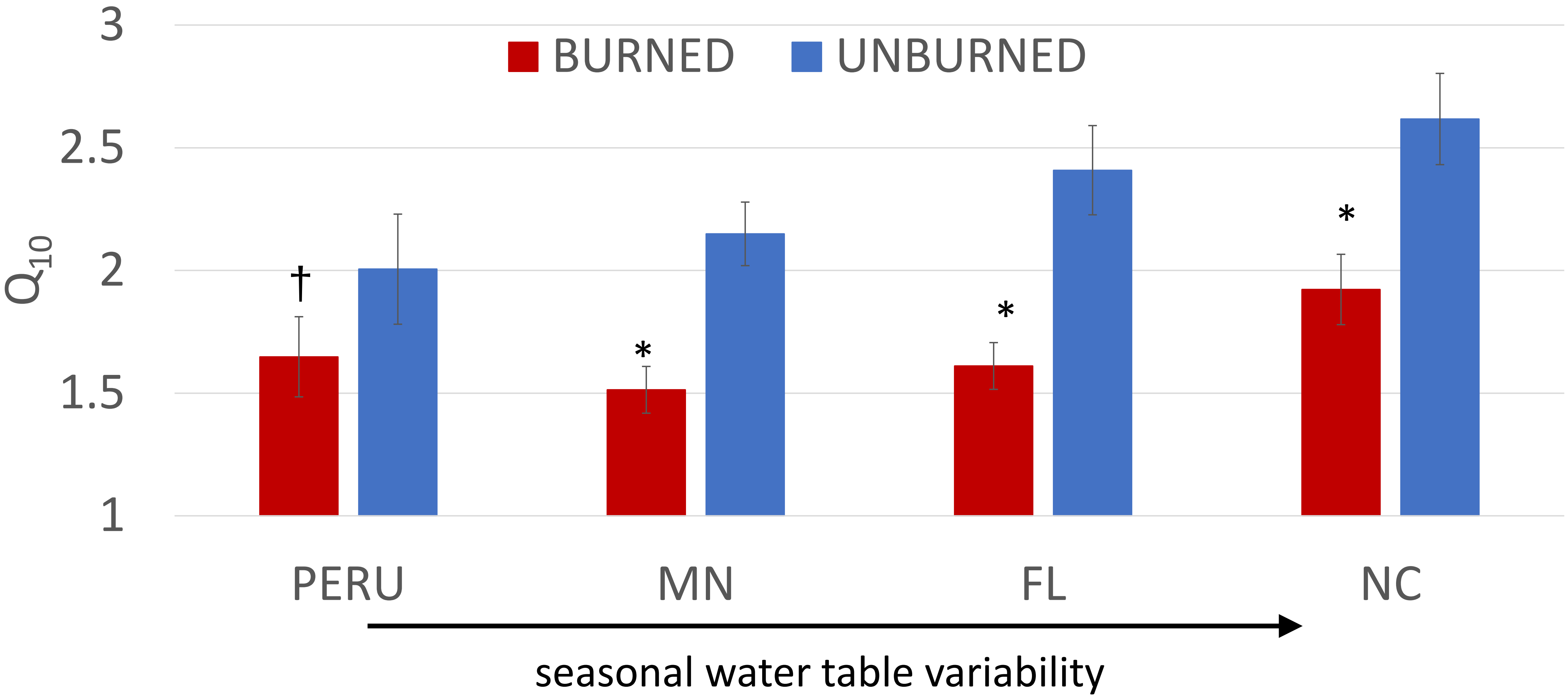
Fire (simulated burn) Effect on Microbial Respiration 25°C



Cumulative CO_2 Emissions



Effect of Fire on Temperature Kinetics of Decomposition

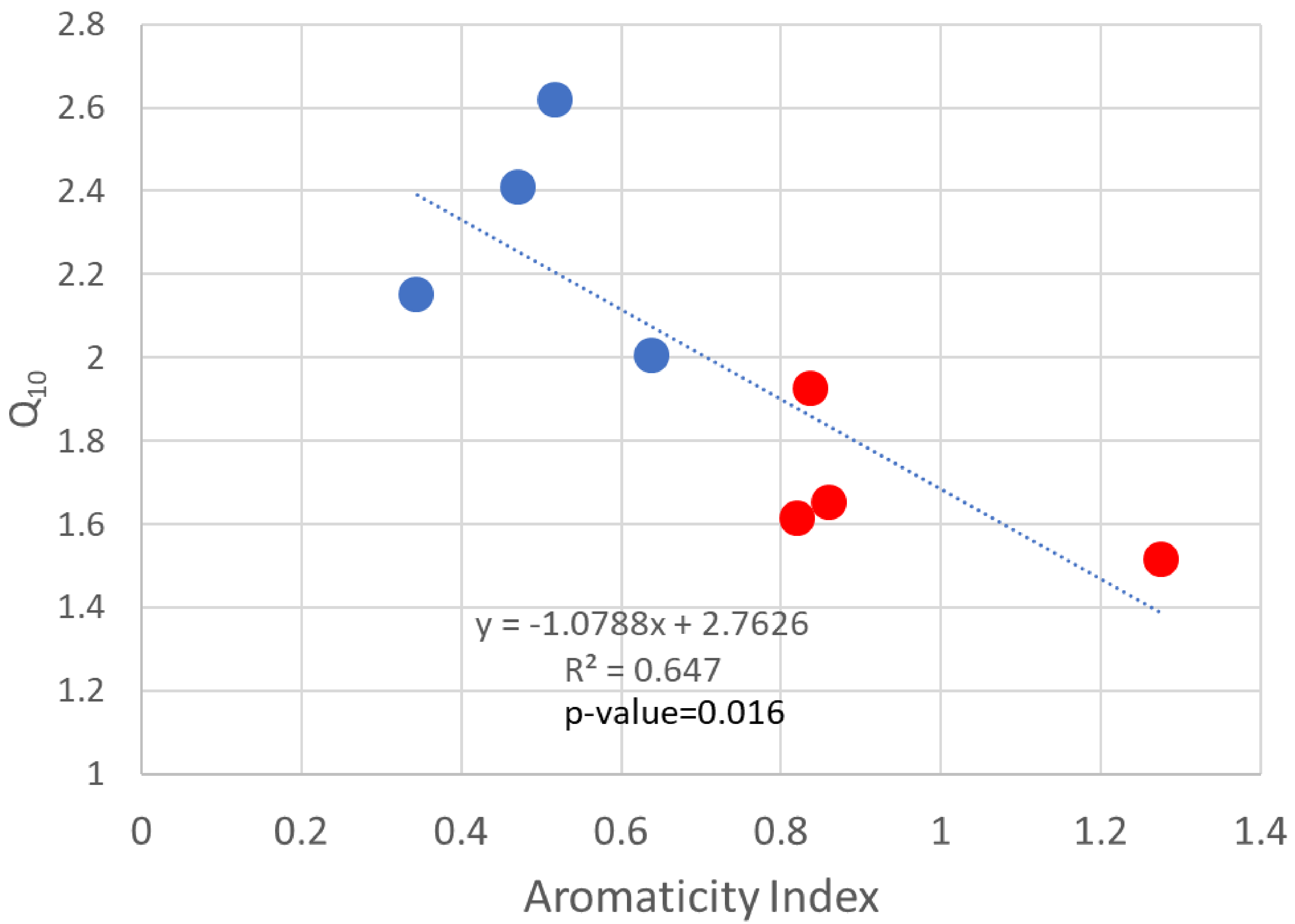


Mean ± SE,

*P < 0.05 between burned and unburned within a given site

† P < 0.1

Surface Chemistry vs. Temperature Sensitivity



Conclusions

- Thermal alteration of peat by Low-severity fire may be wide-spread in peatlands having regimes of frequent fire
- Large changes to bulk carbon chemistry are not necessary to influence recalcitrance to microbial respiration,
  - Low-severity fires can alter surface chemistry
  - Physical protection of SOM is supported by reduced Q_{10} and SEM images
- Direct organic matter losses to low-severity fire was offset by reduced microbial respiration after 1 to 3 years
- All is predicated on maintaining high soil moisture content during typical fire season (drainage, climate change).

Acknowledgements

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- Pocosin Lakes National Wildlife Refuge
- USFWS at Arthur R. Marshall Loxahatchee National Wildlife Refuge

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