Linking Soil Nitrogen & Carbon to Post-Wildfire Water Quality

Chuck Rhoades, Tim Fegel, Derek Pierson - USDA Forest Service; **Alex Chow, Kuo-Pei Tsai** - Clemson University

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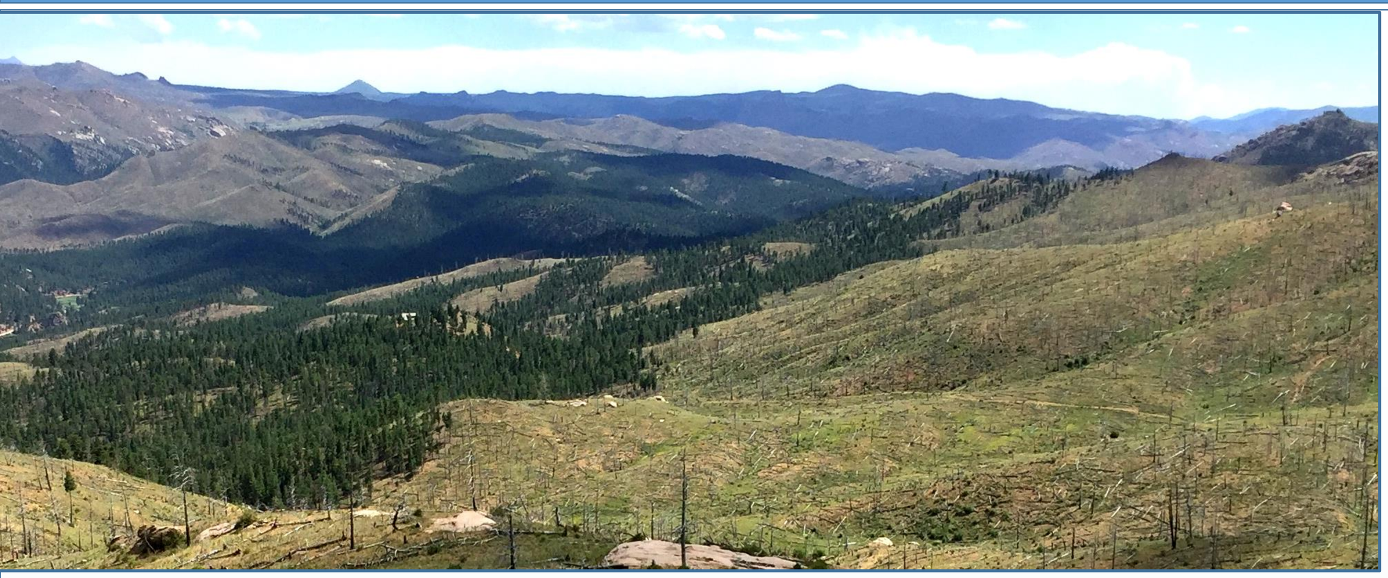
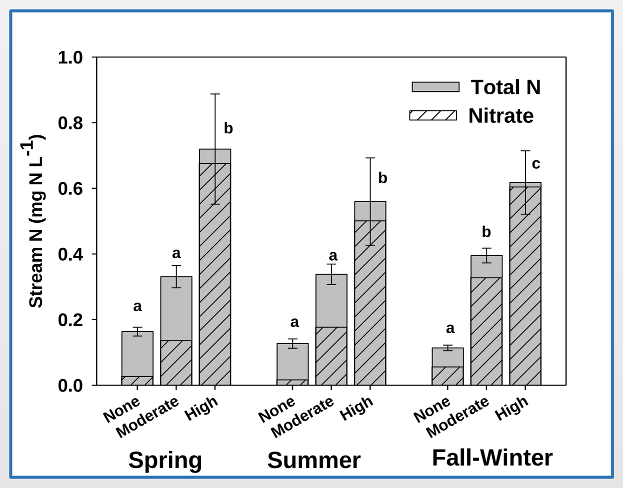


BACKGROUND

Forest fires create lasting biogeochemical changes with implications for watershed processes and stream water quality. Decreased plant nutrient uptake and increased mineralization of soil organic matter are the mechanisms commonly held responsible for persistent changes. Our work after the 2002 Hayman Fire shows that increased stream nitrogen (N) is proportional to the extent of a catchment burned by high severity wildfire, but the specific processes responsible for the patterns are uncertain.



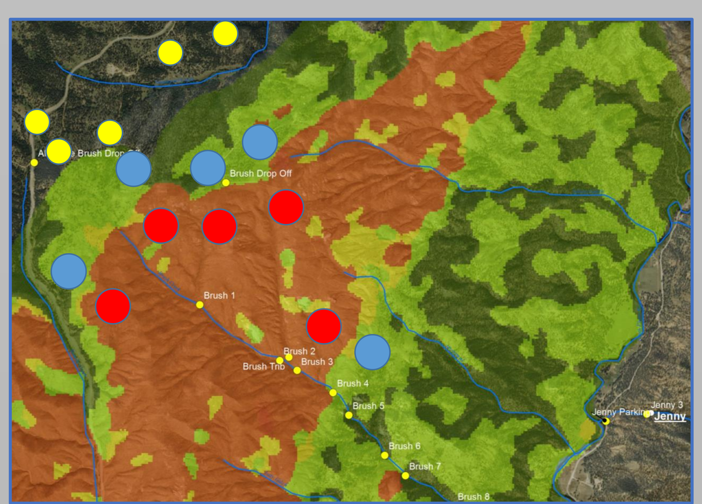
14 years after the Fire, nitrate levels in catchments with extensive high severity wildfire are 5-12 times above unburned streams (0.02 mg L^{-1}); well above EPA ecoregion reference streams (0.01 mg NO_3-N L^{-1}).

Heating organic soil layers creates char layers that can persist for many years. Temperature and rate of fire spread vary for moderate and high severity wildfire and may influence char layer composition.

OBJECTIVES

To elucidate factors that regulate persistent elevated stream N, as well as post-fire stream carbon (C) export, we examined soil N and C pools and processes across ecotones extending from unburned forests to areas of moderate and high wildfire severity. We analyzed 1-2 cm thick charred organic layers that remain visible 14 years after the fire, underlying mineral soils, and leachate from both layers.

Wildfire Burn Severity



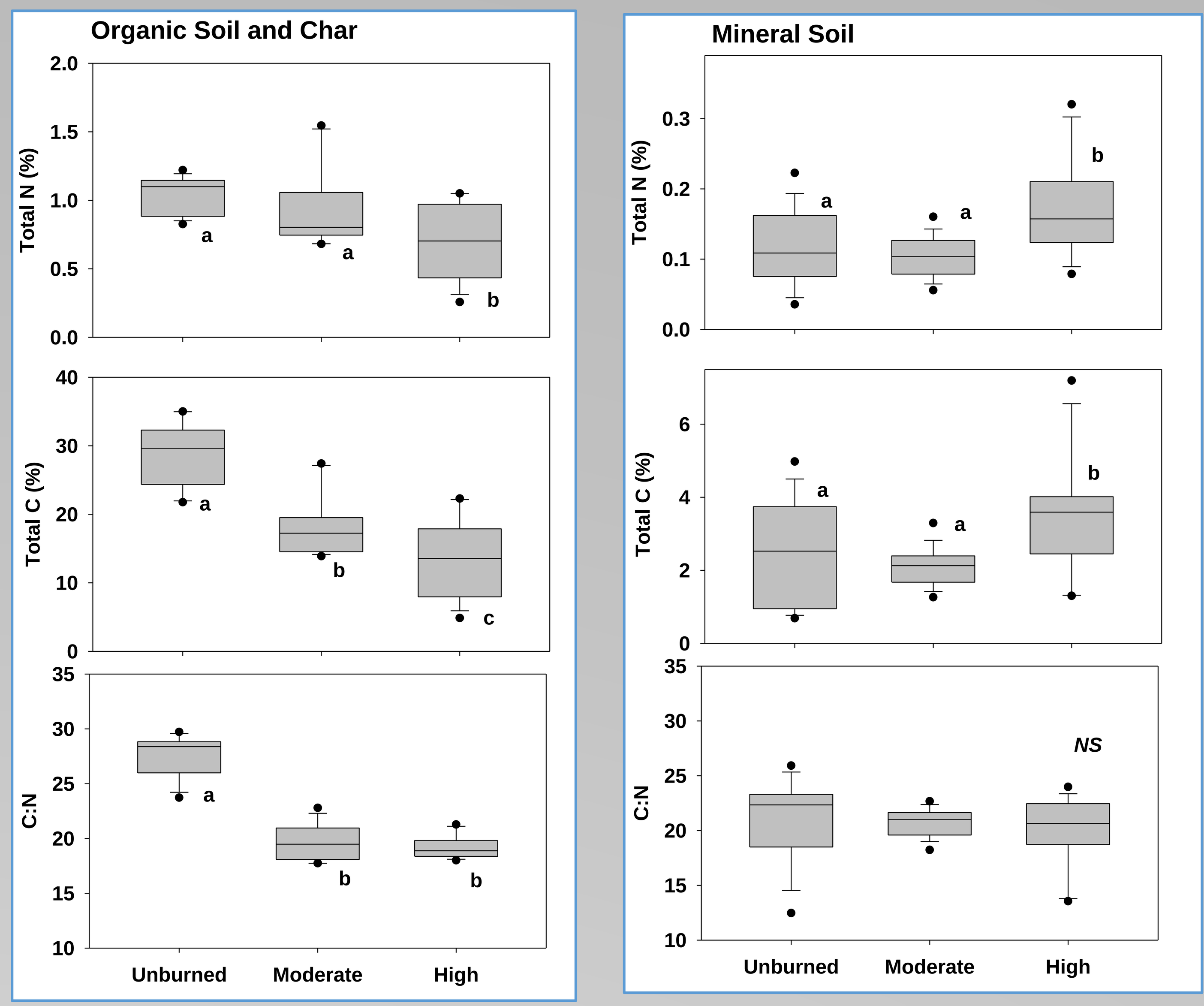
High Severity All/nearly all pre-fire ground cover, surface OM consumed.

Moderate Severity Most (≤80%) ground cover, OM consumed. Foliage may remain in tree canopies.

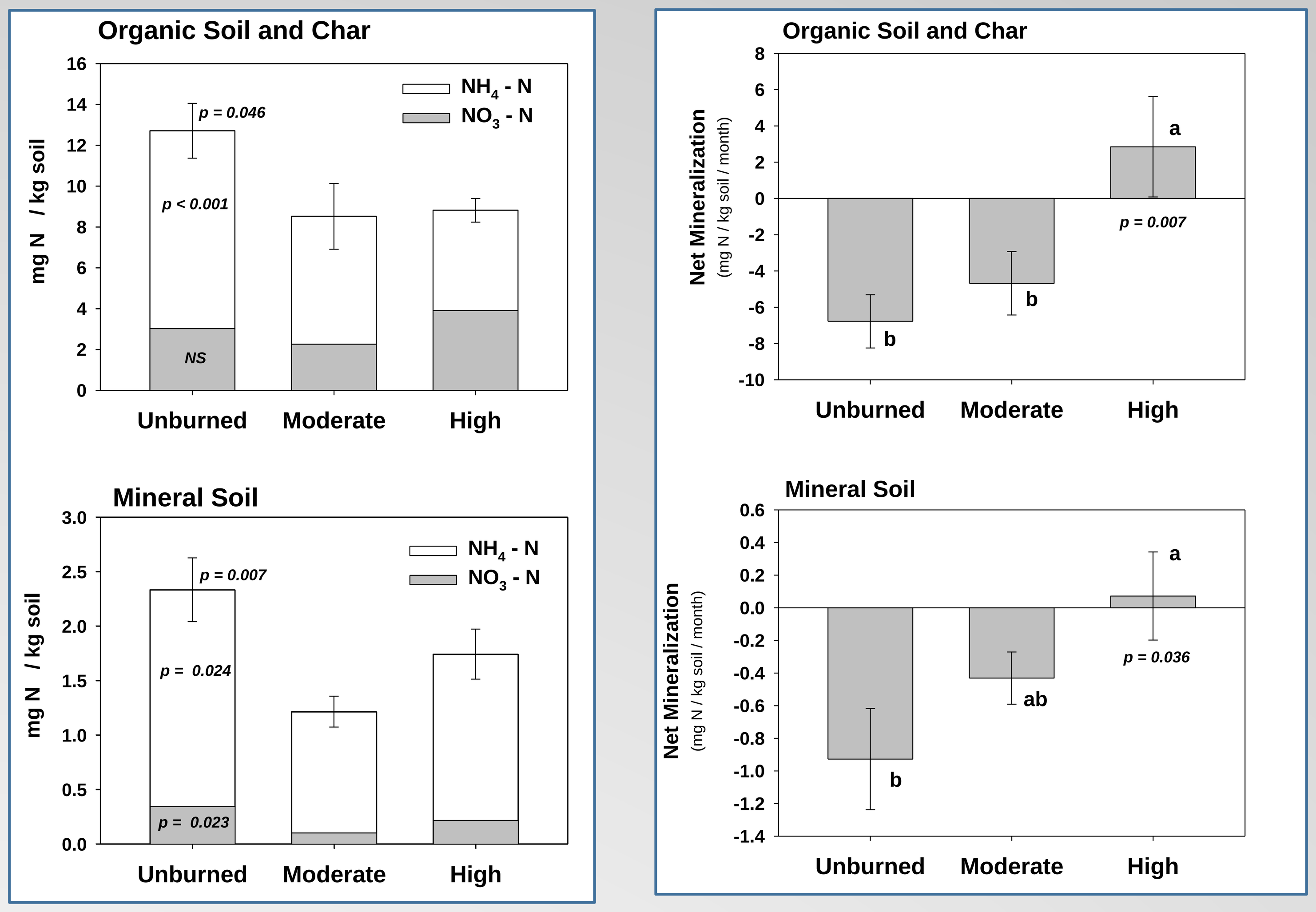
Unburned

In 2016 we sampled high & moderate severity sites and areas outside the burn with similar pre-fire forest & soils. Soils are shallow, sandy-skeletal Typic Ustorthents weathered from granite.

CHAR PROPERTIES



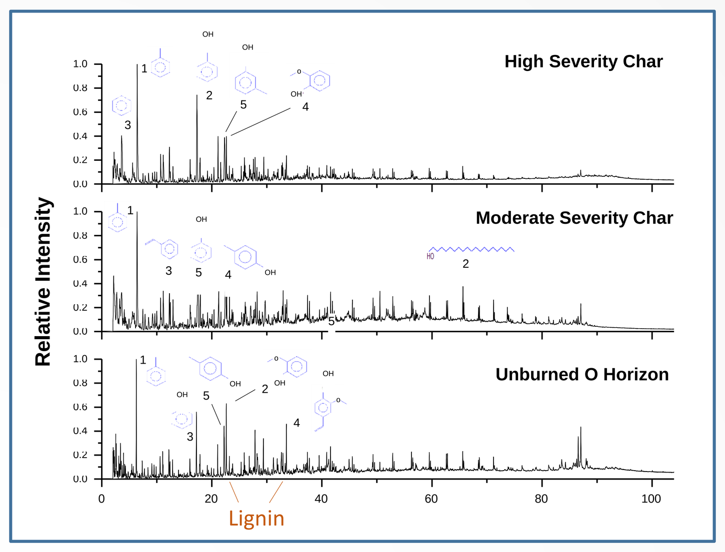
C and N concentrations in organic soil layers of unburned forests were higher than char layers sampled across burn severity ecotones. Mineral soil (0-5 cm depth) beneath char layers in high severity portions of the Hayman Fire had significantly more soil N and C and lower pH.



Extractable soil ammonium, total plant available N and gravimetric moisture (not shown) were all significantly higher in unburned organic and mineral soils than in char layers of burned mineral soils. Extractable nitrate was also higher for unburned mineral soils.

Potential net mineralization – an index of the supply of plant-available nitrogen – differed between the severely burned areas and the unburned and moderate burn areas. Negative net mineralization indicates consumption or immobilization of the inorganic N produced in unburned and moderately burned soils. In contrast, soils burned at high burn severity produced inorganic N available for plants or leachate or gas losses. Ammonium represented 90% of the inorganic N supply and net nitrification differed little between burn severity levels.

Pyrolosis GCMS - Fire Severity Influence Organic Layer Composition /Stability



Largest aromaticity unit (peak 3) in high severity char layer.

Benzene / toluene ratio, potentially related to heating temperature, is highest in high severity char (peak 1 / peak 3), > moderate severity & > unburned organic layers.

Relatively high lignin peaks in unburned organic layers.

Long chain C units (repetitive peaks after 50 min.) - possibly lipid groups - in unburned and moderate char.

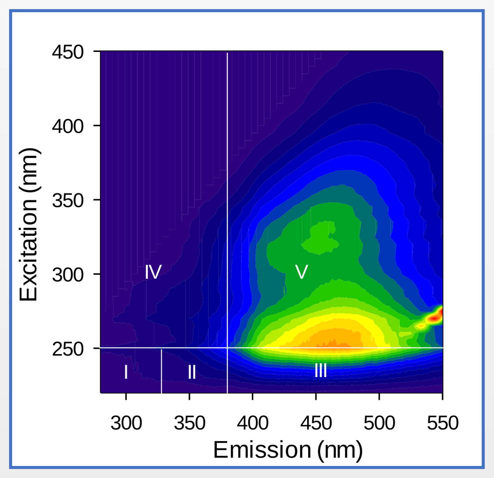
CHAR LEACHATE

	Organic Soil					Mineral Soil			
	Unburned	Moderate	High	$p =$		Unburned	Moderate	High	$p =$
DOC	43.36	24.26	19.47	< 0.001	DOC	10.20	7.70	6.93	0.001
TDN	8.91	4.78	4.88	0.017	TDN	1.84	1.74	1.87	NS
DON	7.88	4.01	4.10	0.006	DON	1.78	1.67	1.69	NS
NO_3-N	0.33	0.35	0.46	NS	NO_3-N	0.03	0.05	0.13	< 0.1
NH_4-N	0.70	0.42	0.31	< 0.1	NH_4-N	0.03	0.03	0.06	NS
DIN	1.03	0.77	0.77	NS	DIN	0.06	0.07	0.18	< 0.1
NO_3-N:DIN	0.32	0.41	0.56	< 0.1	NO_3-N:DIN	0.50	0.59	0.65	NS
DON:DOC	0.18	0.16	0.21	NS	DON:DOC	0.17	0.22	0.24	0.05
TDN:DOC	0.21	0.20	0.25	NS	TDN:DOC	0.18	0.23	0.27	0.008
pH	6.14	7.36	7.20	< 0.001	pH	6.16	6.94	6.47	NS
ANC	259.14	676.87	898.85	0.007	ANC	61.22	362.89	129.11	NS

Leachate DOC was higher in unburned soils for both organic and mineral layers. TDN, DON and NH4-N were higher in unburned soils for the organic layer only.

Nitrate comprised a larger proportion of DIN leaching from the organic soil for high burn severity sites.

For severely-burned mineral soils there was higher nitrate and DIN, as well as more DON and TDN per unit of DOC in leachate.



	Organic Soil		
EEMs Index	Unburned	Moderate	High
DOM Source			
FI	1.35	1.37	1.41
β/α	0.46	0.53	0.52
Humification			
HIX	9.88	10.99	14.40

Unlike DOC concentrations, the relative contribution to the dissolved organic matter fractions defined using Fluorescence Regional Integration differed little between unburned and burned organic layers. Humic and fulvic acid-like fractions, contained in regions V and III comprised the majority of the fluorescing DOM (39 and 33%, respectively). Protein-like compounds (regions I and II) and microbial byproducts (region IV) made up a significantly smaller portion of the total fluorescing DOM for both unburned and char layers.

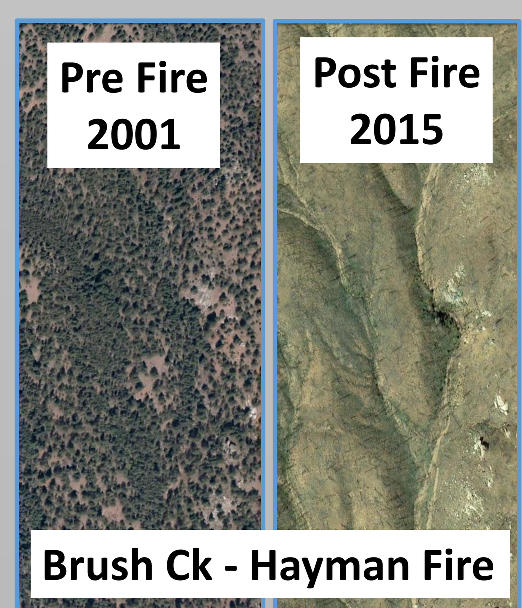
Two EEMs indices (FI & β/α) indicate similar DOM sources in both unburned organic and char layers.

However, an index of humification (HIX) suggests that DOM leached from char in high severity areas may have higher aromaticity than DOM leached from unburned organic layers.

POST-FIRE WATERSHEDS

The N and C characteristics of soils inside the Hayman burn perimeter differed from unburned soils 14 years after the fire. Similarity in the composition of DOM leached from unburned and char layers suggests that char layers contain significant amounts of unaltered OM. Compositional analysis of char layers (GCMS) and DOM leachate (EEMs) suggests greater abundance of aromatic compounds in high severity burned areas.

The total N pool size, net production of inorganic N, and amount of N leached per unit C was greater in severely-burned areas. Nitrate comprised more of the DIN leached from severely-burned soils. Some suggestion that higher N in high burn severity may originate from N cycling in upland soils rather than entirely from lack of nutrient demand by plants or stream biota.



For More Information

Fall AGU 2016, San Francisco, CA

- Persistent Influences of the 2002 Hayman Fire on Stream Nitrate & Dissolved Organic Carbon (B23A-0558)
- Lasting Effect of Wildfire & Fire Extent on the Chlorine Reactivity of Dissolved Organic Matter after the 2002 Hayman Fire, Colorado (B23A-0560)

Contact: crhoades@fs.fed.us

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