Effects of Biochar on Forest Soil and Plant Growth

Kristin McElligott IFTNC
Mark Coleman IFTNC
Debbie Dumroese RMRS

Biochar and Forest Soils

Presentation Overview

- Benefits of Biochar?
- Research Results
  - Amendments to four forest soils
  - Bioassay: Poplar growth response to biochar additions
- Current Research
- Future Research

Biochar Application in Forestry

- Need for fuels reduction; residual biomass removal
- Portable in-woods pyrolysis units
- Mitigate nutrient loss via biochar reapplication

Benefits of Biochar

- Long-term carbon sinks (MRT1000-2000 yr)
- Carbon negative production
- Enhances soil nutrient retention and bioavailability to plants
- Improves soil quality, fertility and plant productivity
- Enhances moisture retention
- Inhibits nutrient leaching into ground and surface waters
- Reduces N20, CH4 emissions

Research Justification

- Current Biochar Research
  - Agricultural Soil
  - Crop-growth response
  - Highly degraded soils
  - Tropical and Arid Regions

- Research Gaps
  - Forest Soils
  - Tree-growth response
  - Temperate regions

Research Objectives

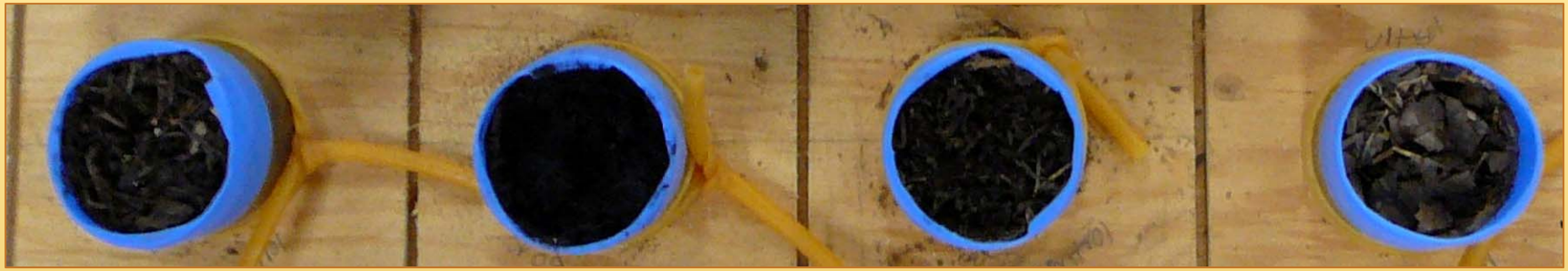
- Demonstrate effects of biochar on forest soils and woody biomass growth
  - Biochar as a forest soil amendment:
    - Compare effects of biochar additions on forest soil chemical and physical properties
  - Greenhouse bioassay:
    - Investigate if soil nutrient supply, uptake and plant growth can be increased through biochar additions

Dynamotive CQuest Biochar

- Initial nutrient concentrations
  - Carbon 72.48 %
  - Ash 10.85 %
  - Hydrogen 3.16 %
  - Moisture 2.01 %
  - Nitrogen 0.45 %
  - Sulfur 0.02 %
  - Oxygen 11.03 %
  - C:N 160
- Average bulk density: 250 kg/m³

Forest Soil Application

- Undisturbed forest soils cores
  - Spodosol, Ultisol, coarse and fine Andisol
  - Forest floor layer + 10cm depth from mineral layer
  - Char Application: top dressing
  - Rates: 5 and 25Mg/ha

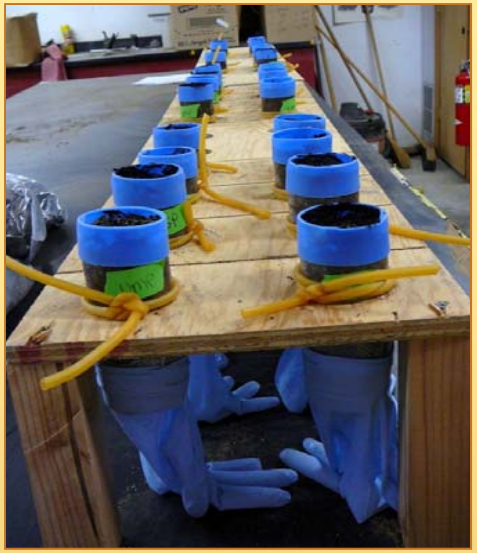


Soil Analysis and Results

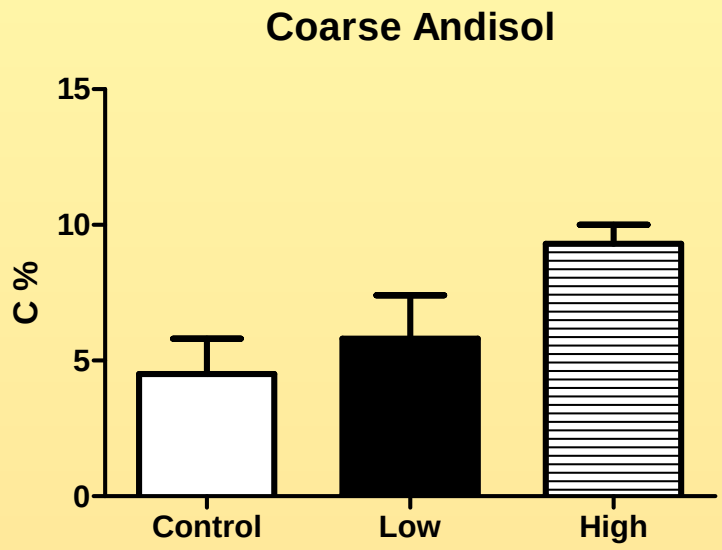
- Soil analyzed for pH, CEC, Ca, Mg, K, Total % C & N and water holding capacity

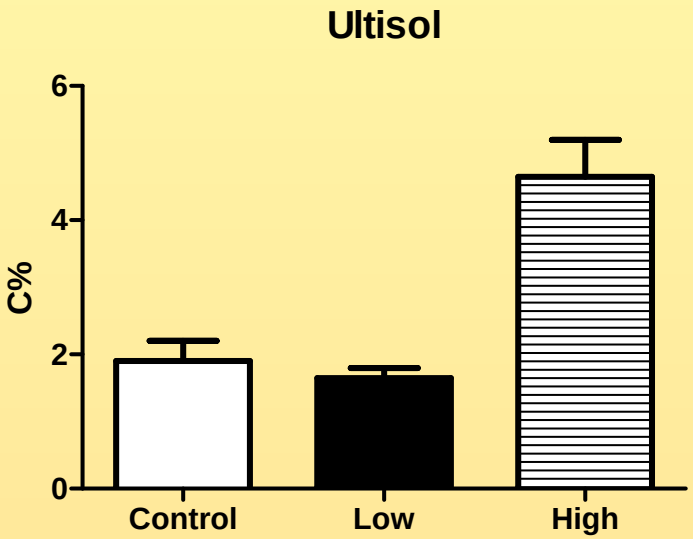
- Findings: Effects of Biochar amendments vary among soil type and application rate

- Significant effects: pH (p=.0194); Mg (p=.0575); K (p=.0008); Total C (p=.012)



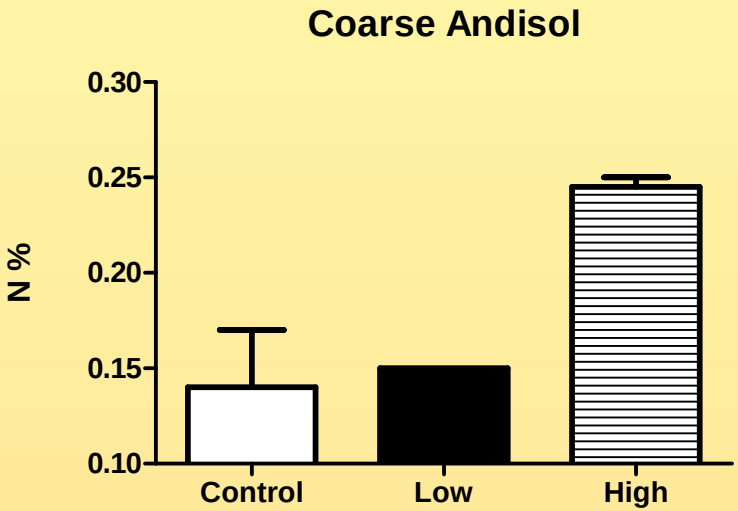
Total C

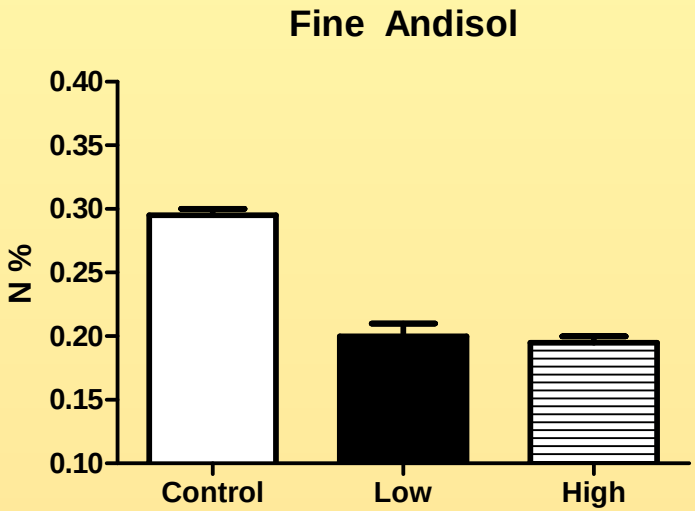




•High biochar additions increased Total C in the coarse Andisol (p=.009) and Ultisol (p=.075).

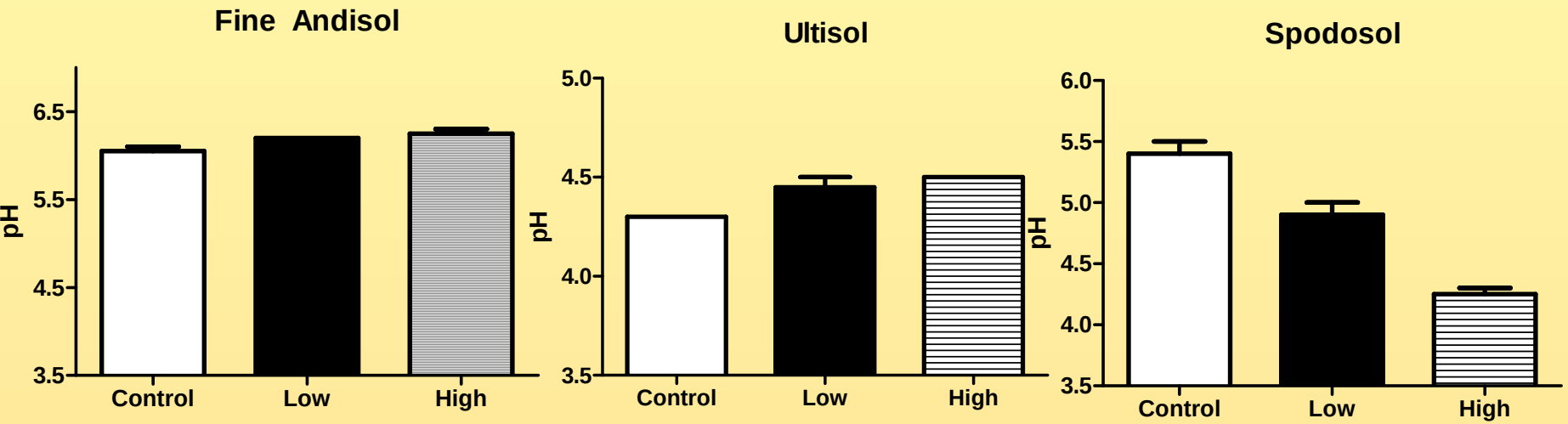
Total N





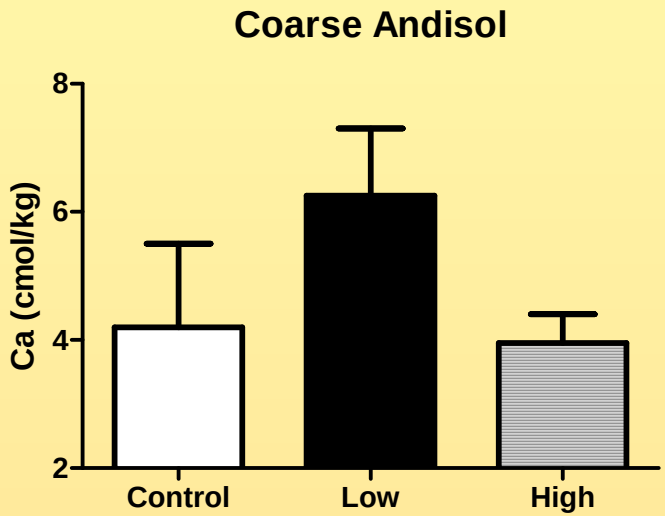
- High biochar treatment increased Total N in the coarse Andisol ($p=0.052$)
- Both high and low biochar treatments decreased total N ($p=0.063$ and 0.075, respectively) in the fine Andisol

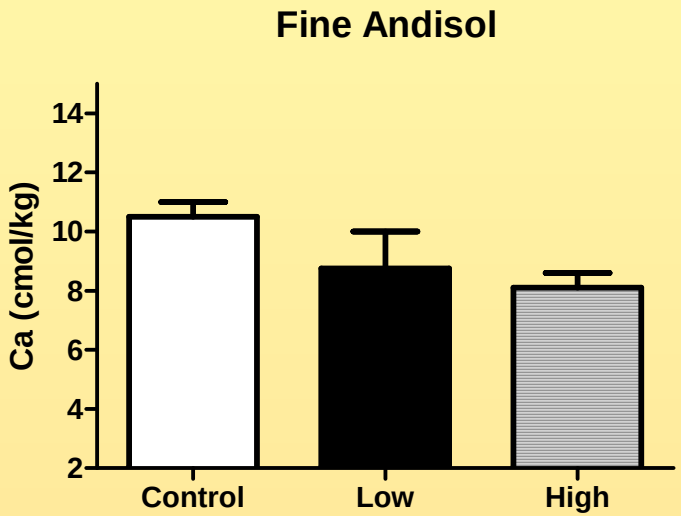
pH



- High biochar additions increased pH in the fine Andisol and Ultisol (p=.053)
- pH decreased in Spodosol in high (p=<.0001) and low (0.0002) treatments

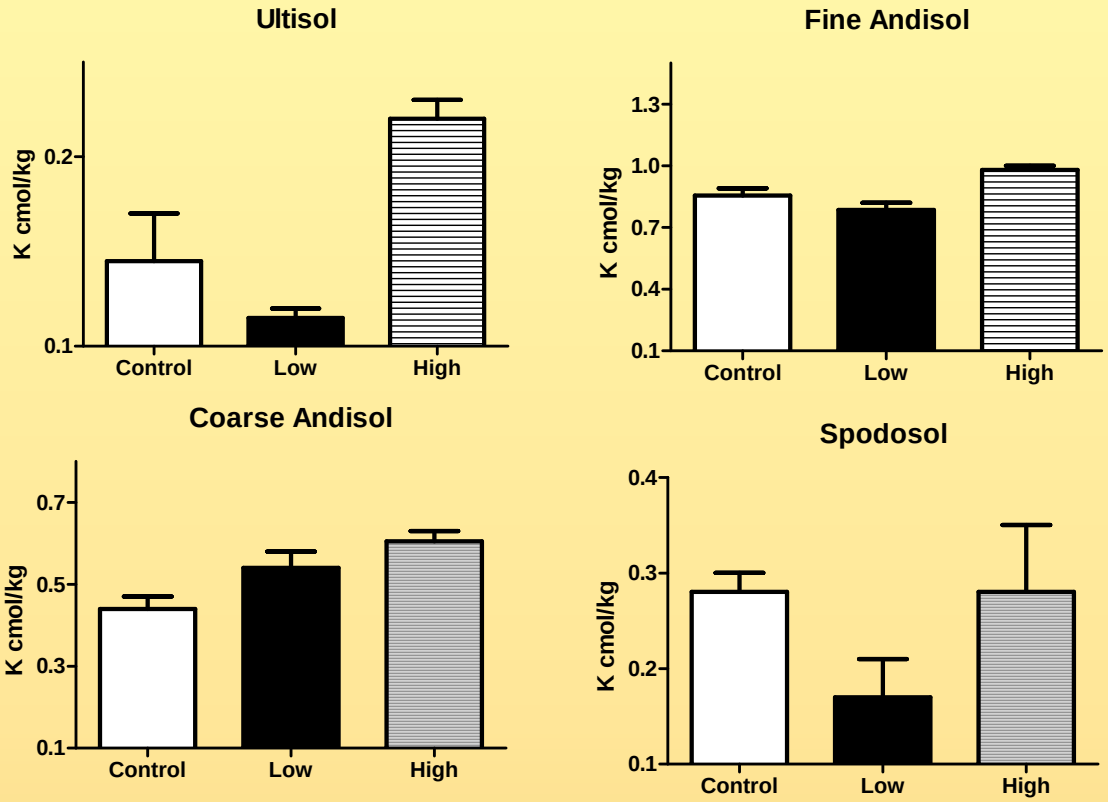
Calcium





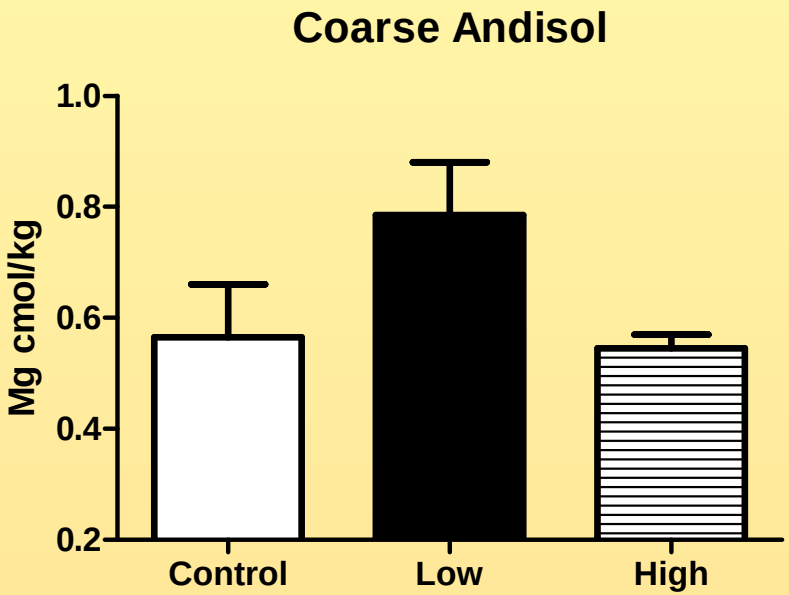
- Low biochar additions increased Ca in the coarse Andisol ($p=0.046$)
- Low and high biochar additions decreased Ca in the fine Andisol ($p=0.023$ and 0.082, respectively)

Potassium



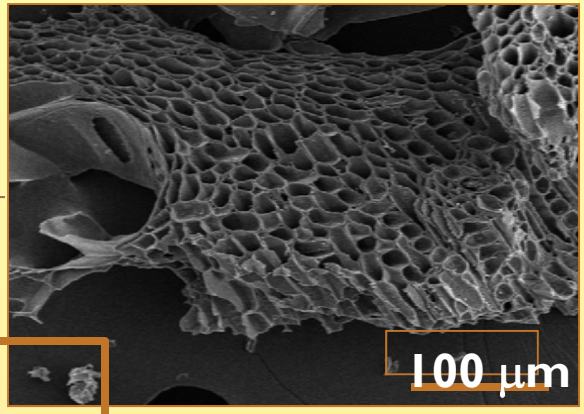
- High and low biochar additions increased K in the coarse Andisol ($p=0.004$, and 0.05, respectively)
- High biochar additions increased K in the fine Andisol ($p=0.022$)
- High biochar additions increased K in the Ultisol ($p=0.048$)
- Low biochar additions decreased K in the Spodosol ($p=0.039$)

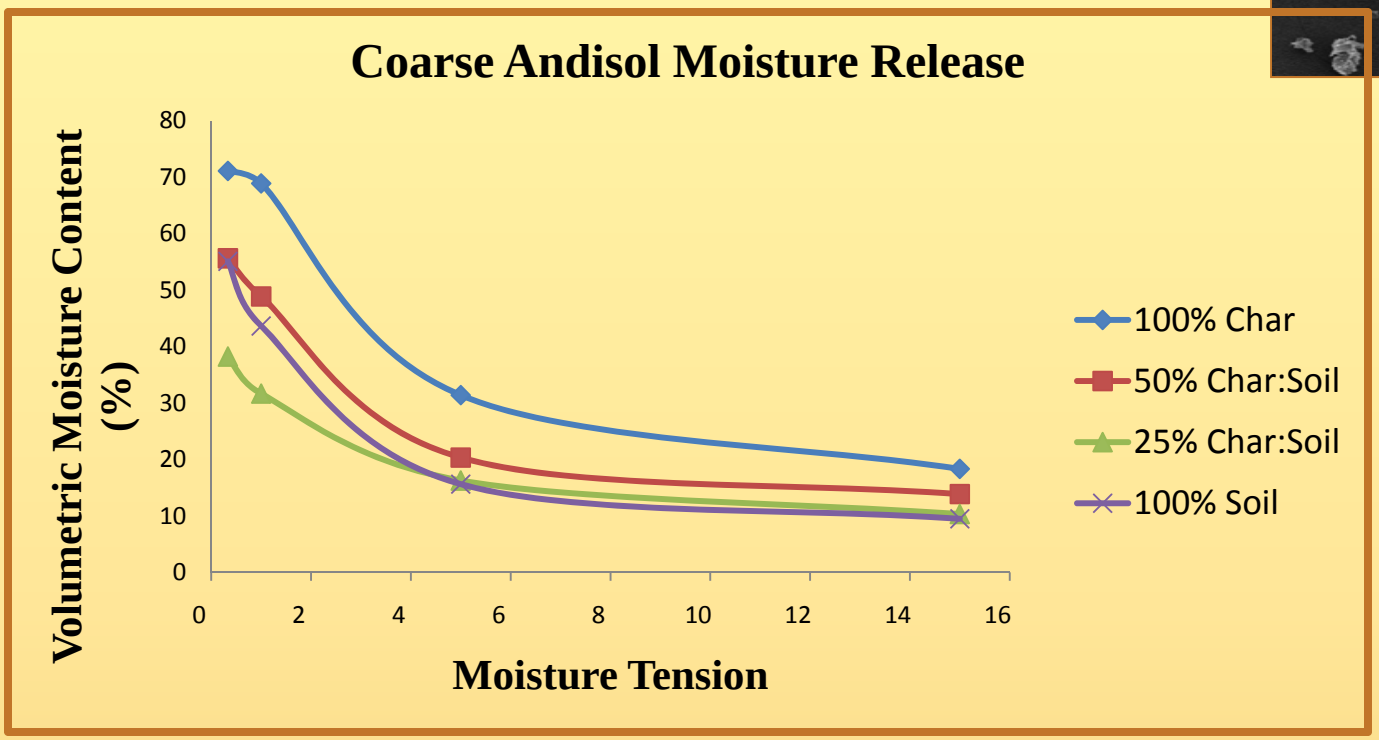
Magnesium



- Low biochar additions increased Mg in the coarse Andisol ($p=0.007$)

Moisture Retention





- Biochar has a higher water holding capacity than soil alone
- Adding biochar to soil improves the water holding capacity

Soil Summary

- Response to biochar additions varies among soil types
- Coarse Andisol benefits most from biochar additions:
  - Increased Total C, Total N, K, Ca and Mg
  - Improved water holding capacity
- Conversely:
  - Fine Andisol- decreased total N, Ca
  - Spodosol- decreased pH, K
- Direct nutrient additions from char?
- N Immobilization?
- What's next?

Research in progress

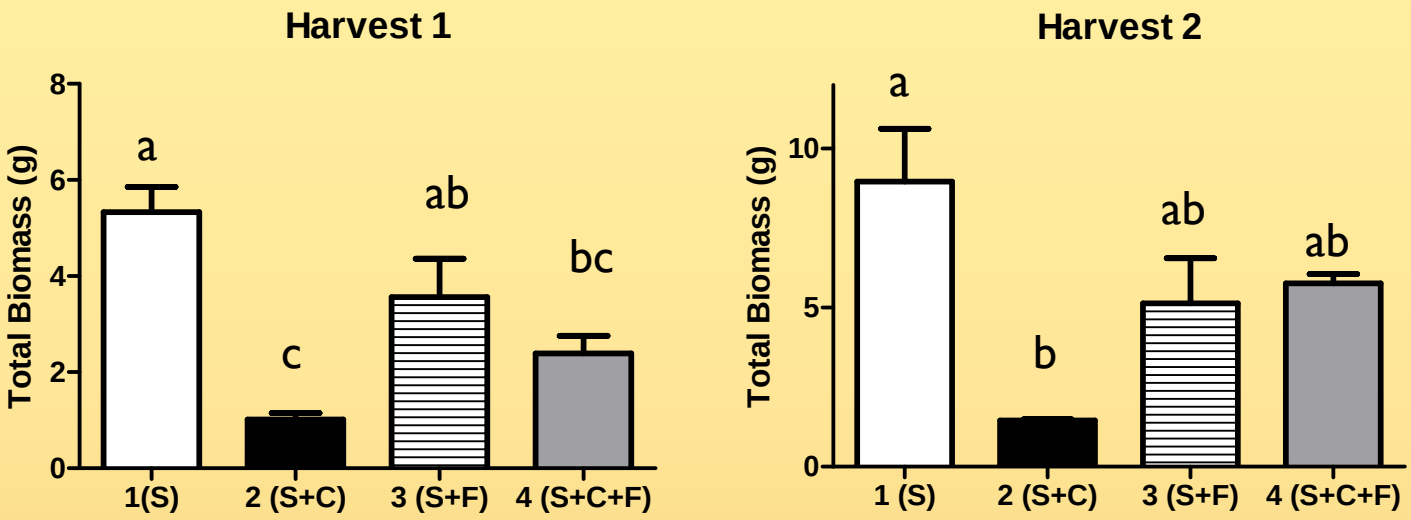
- Biochar Incubation Study
  - Determine if char will increase pH, C, N, Ca, Mg, K, water holding capacity, ECEC, soil respiration, microbial biomass and lower bulk density within three different soil types
  - Leachate analyzed for pH, EC, NO_3 and NH_4
  - 3 soils; surface vs incorporation application
  - Duration: Jan-Aug , 2010

Greenhouse Bioassay

- Poplar cuttings grown in forest Andisol
  - Treatments
    - 1) No Char No Fert 2) No Char+Fert 3) Char (50% w/w) No Fert 4) Char(50% w/w)+Fert

Results

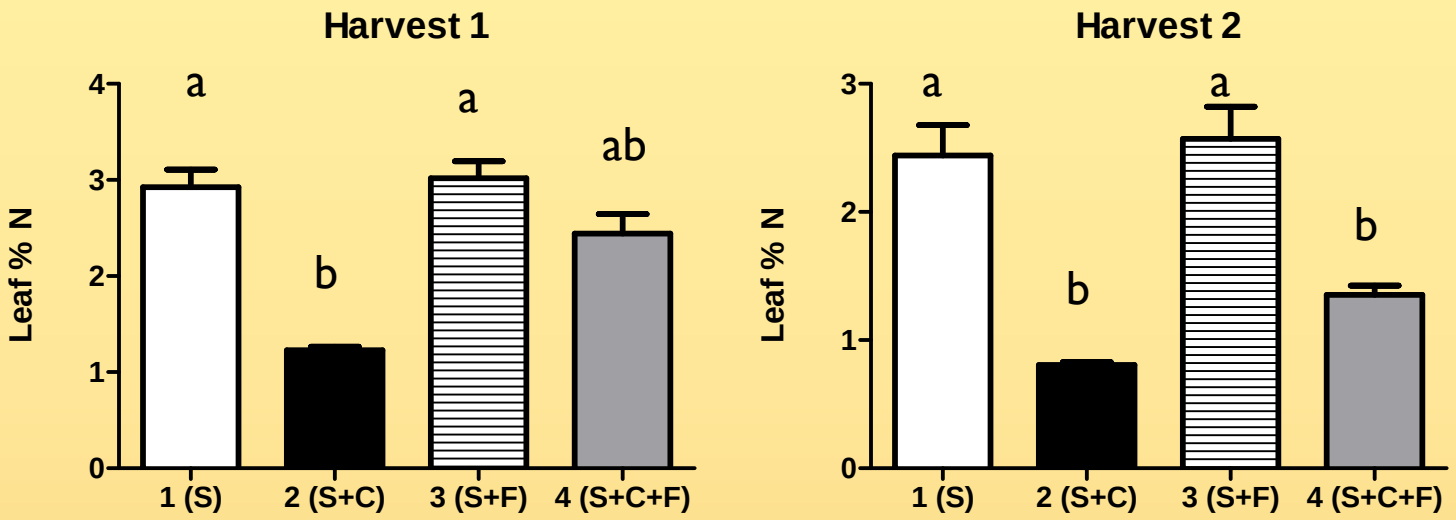
- Char additions decreased total biomass



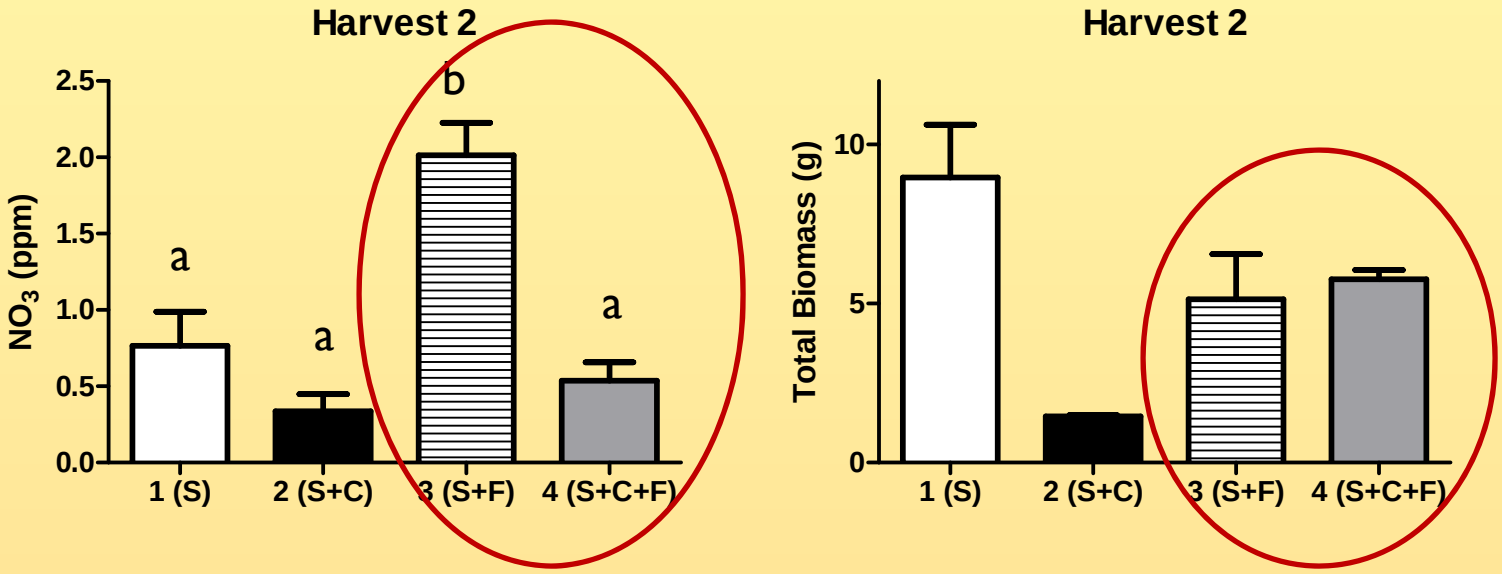
•Significant char effect (p=0.014) and char*fert interaction (p=0.006)

Leaf Nitrogen

- Char significantly decreases leaf N



Leachate Ammonium and Nitrate



- Char enhances fertilizer retention

Results

Bioassay Summary

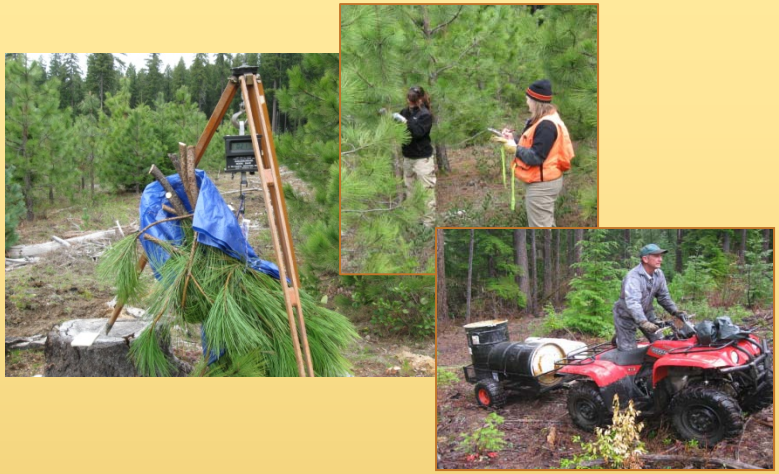
- Biochar additions:
  - Decrease plant growth
  - Decrease leaf Nitrogen
  - Reduce fertilizer leaching
- What's next?

Research in Progress

- Greenhouse Bioassay #2
  - Investigate influence of fresh vs. organic-acid saturated biochar on growth Poplar trees grown in a forest Andisol, with and without fertilizer additions
  - Organic Acid Extracts
    - Leaf Litter
    - Peat Moss
    - Humic Acid

Biochar Application to Forests

- Biochar applied at 2x the live biomass equivalent (20 tons/acre)
- Biochar applied at 0.25x the live biomass equivalent (2.5 tons/acre)
- Control
- Forest biomass only
- Pre-harvest soil and vegetation measures
- Post-treatment follow-up



Acknowledgements

- We thank the USDA Rocky Mountain Research Station and the University of Idaho Intermountain Forest Tree Nutrition Cooperative. Dynamotive Energy Systems Corp. for biochar donations, Felipe Sanchez for providing Ultisol soil cores, Jim Archuleta for collaboration and Joanne Tirocke for lab and field assistance.

University of Idaho
College of Natural Resources

FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE
Rocky Mountain Research Station