TETRA TECH

Biochar for Reclamation in the Rocky Mountains: Context, Science and Policy – Can We Find a Nexus that Works

Andrew Harley, Tetra Tech, Inc

Morgan Williams, Biochar Solutions, Inc

Brian McMullen, White River National Forest, USFS

Biochar is a name for charcoal when it is used for particular purposes, especially as a soil amendment. Like all charcoal, biochar is created by pyrolysis of biomass. Biochar is under investigation as an approach to carbon sequestration to produce negative carbon dioxide emissions.[1] Biochar thus has the potential to help mitigate climate change, via carbon sequestration.[2] Independently, biochar can increase soil fertility, increase agricultural productivity and provide protection against some foliar and soil-borne diseases. Furthermore, biochar reduces pressure on forests.[3] Biochar is a stable solid, rich in carbon and can endure in soil for thousands of years.[1]

http://en.wikipedia.org/wiki/Biochar

TETRA TECH

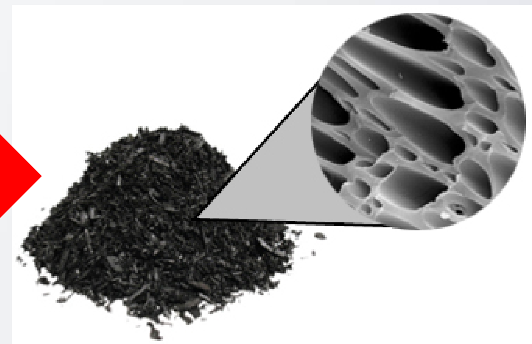
- Generalized biochar impact difficult to predict
- Literature often contradictory
- Generalized biochar improvement:
  - Improved plant access to soil nutrients
  - Improved soil water-holding capacity
  - Reduction in soil tensile-strength
  - Changes in efficiency of plant-fungal interactions
- Timescale and mechanisms not fully understood

USFS – Improving Forest Resiliency with Biochar

Climate change will likely result in an increase in the duration and intensity of drought resulting in increased frequency and severity of fire on the landscape. Wildlife habitat, water quality, loss of carbon, and declining soil productivity are all potentially affected by this. National Forests have a limited ability to remove wildland fuels to reduce the spread and impact of fire because of the large number of acres, high cost of treatment and the lack of a market for the woody material.

TETRA TECH

What if we could use **the problem as the solution** to another problem ?



Could a forestry problem

Create a carbon negative opportunity

To address a growing environmental liability

Limiting Factor	Variable	Problem	Short-term Treatment	Long-Term Treatment	Role of Biochar
Physical	Soil Structure	Soil too compact	Rip or scarify	Vegetation	Decreased soil bulk density, increased infiltration, decreased erodibility. Increased water retention due to surface area and charge characteristics.
	Soil Erosion	High erodibility	Mulch	Re-grade, Vegetation	
	Soil Moisture	Too wet	Drain	Wetland construction	
		Too dry	Organic mulch	Tolerant species	
Nutritional	Macronutrients	Nitrogen deficiency	Fertilizer	N-fixing plants e.g. leguminous trees or shrubs	Yield increases. Slow nutrient release. Soil organic matter stabilization. Retention of released nutrients. Increased microbial activity. Habitat for mycorrhizal fungal hyphae.
		Other deficiencies	Fertilizer	Fertilizer, Amendments, Tolerant species	
Toxicity	pH	Acid soils (<4.5)	Lime	Tolerant species	Designed for alkaline surface charge.
		Alkaline soils (>7.8)	Pyritic waste, Organic matter	Weathering, Tolerant species	Water retention.
	Heavy Metals	High concentrations	Organic matter, Tolerant cultivar	Inert covering, Tolerant cultivar	High surface area and cation exchange capacity allows for metal retention.
	Salinity	EC >4.0 dS/m, pH<8.5, SAR<13	Gypsum, irrigation	Weathering, Tolerant species	Mixed with gypsum to reduce soil structural issues. Nutritional values as described. High CEC for Na retention.
	Sodicity	EC <4.0 dS/m, pH>8.5, SAR≥13	Gypsum, irrigation	Weathering, Tolerant species	

TETRA TECH

THE BIOCHAR SOLUTION

E<u>ngineer</u> carbon negative products from natures most intelligent carbon sinks… **plants**.

A <u>sponge</u> for:
Water
Nutrients
Microbes
Contaminants

ENERGY

BIOMASS

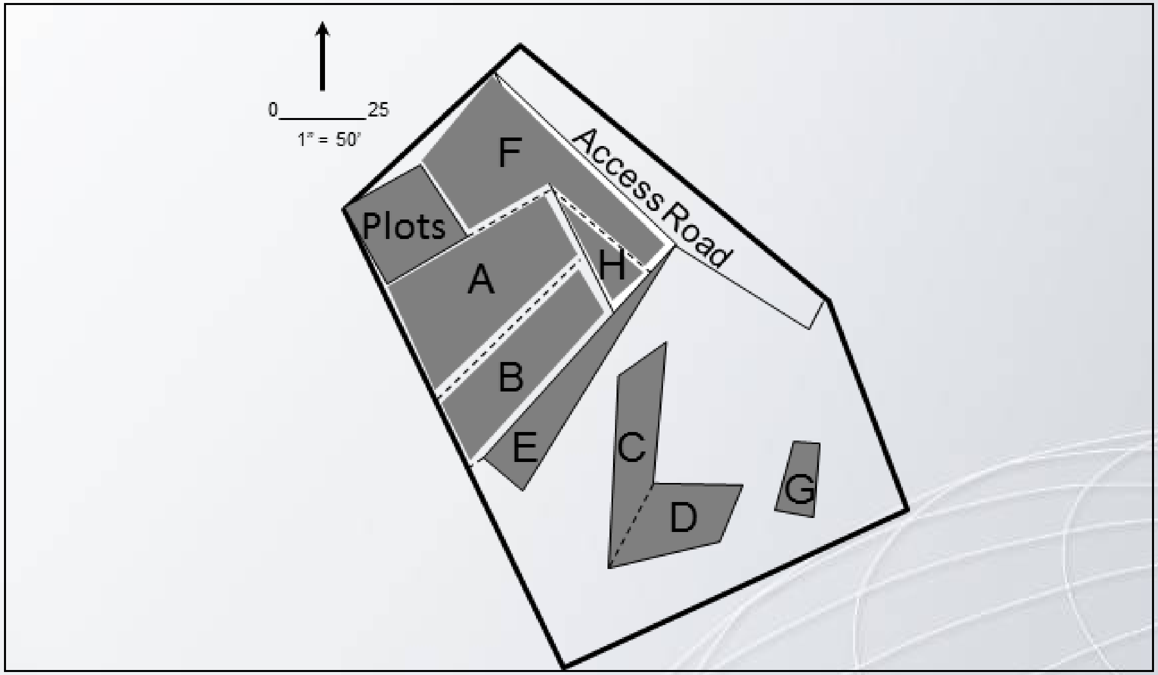
PYROLYZER

BIOCHAR

Stabilize carbon and make it useful

Hope Mine (Aspen, CO)

Hope Mine (Aspen, CO)



Area	Biochar (ton/acre)	Compost (yd^3/acre)
A	2.5	400
B	5.0	0.03
C	5.0	400
D	2.5	400
E	20	400
F	10	400
G	5	400
H	5	400

TETRA TECH

Hope Mine (Aspen, CO)

TETRA TECH

Hope Mine (Aspen, CO)

Road

4	33	39	3	16	5
37	11	22	15	21	41
7	42	13	32	25	17
18	35	30	20	14	27
28	2	6	10	19	34
38	26	8	1	23	31
9	29	36	24	40	12

River

Slope

TETRA TECH

Hope Mine (Aspen, CO)

Plot	Treatment	Plot	Treatment
1	Control (seed only)	22	Biochar 5.0 t/ac + Compost + Mycorrhizal Fungi
2	Control (seed only)	23	Biochar 5.0 t/ac + Compost + Mycorrhizal Fungi
3	Control (seed only)	24	Biochar 5.0 t/ac + Compost + Mycorrhizal Fungi
4	Compost	25	Biochar 10.0 t/ac + Compost
5	Compost	26	Biochar 10.0 t/ac + Compost
6	Compost	27	Biochar 10.0 t/ac + Compost
7	Mycorrhizal Fungi	28	Biochar 10.0 t/ac + Compost + Mycorrhizal Fungi
8	Mycorrhizal Fungi	29	Biochar 10.0 t/ac + Compost + Mycorrhizal Fungi
9	Mycorrhizal Fungi	30	Biochar 10.0 t/ac + Compost + Mycorrhizal Fungi
10	Compost + Mycorrhizal Fungi	31	Biochar 20.0 t/ac + Compost
11	Compost + Mycorrhizal Fungi	32	Biochar 20.0 t/ac + Compost
12	Compost + Mycorrhizal Fungi	33	Biochar 20.0 t/ac + Compost
13	Biochar 2.5 t/ac + Compost	34	Biochar 20.0 t/ac + Compost + Mycorrhizal Fungi
14	Biochar 2.5 t/ac + Compost	35	Biochar 20.0 t/ac + Compost + Mycorrhizal Fungi
15	Biochar 2.5 t/ac + Compost	36	Biochar 20.0 t/ac + Compost + Mycorrhizal Fungi
16	Biochar 2.5 t/ac + Compost + Mycorrhizal Fungi	37	BEC Biochar 32% v/v
17	Biochar 2.5 t/ac + Compost + Mycorrhizal Fungi	38	BEC Biochar 16% v/v
18	Biochar 2.5 t/ac + Compost + Mycorrhizal Fungi	39	BEC Biochar 8% v/v
19	Biochar 5.0 t/ac + Compost	40	BEC Biochar 4% v/v
20	Biochar 5.0 t/ac + Compost	41	BEC Biochar 2% v/v
21	Biochar 5.0 t/ac + Compost	42	BEC Biochar 1% v/v


3 HOURS
PLANTCAM
JUN.30,11 08:47 AM


3 HOURS
PLANTCAM
JUL.05,11 08:50 AM

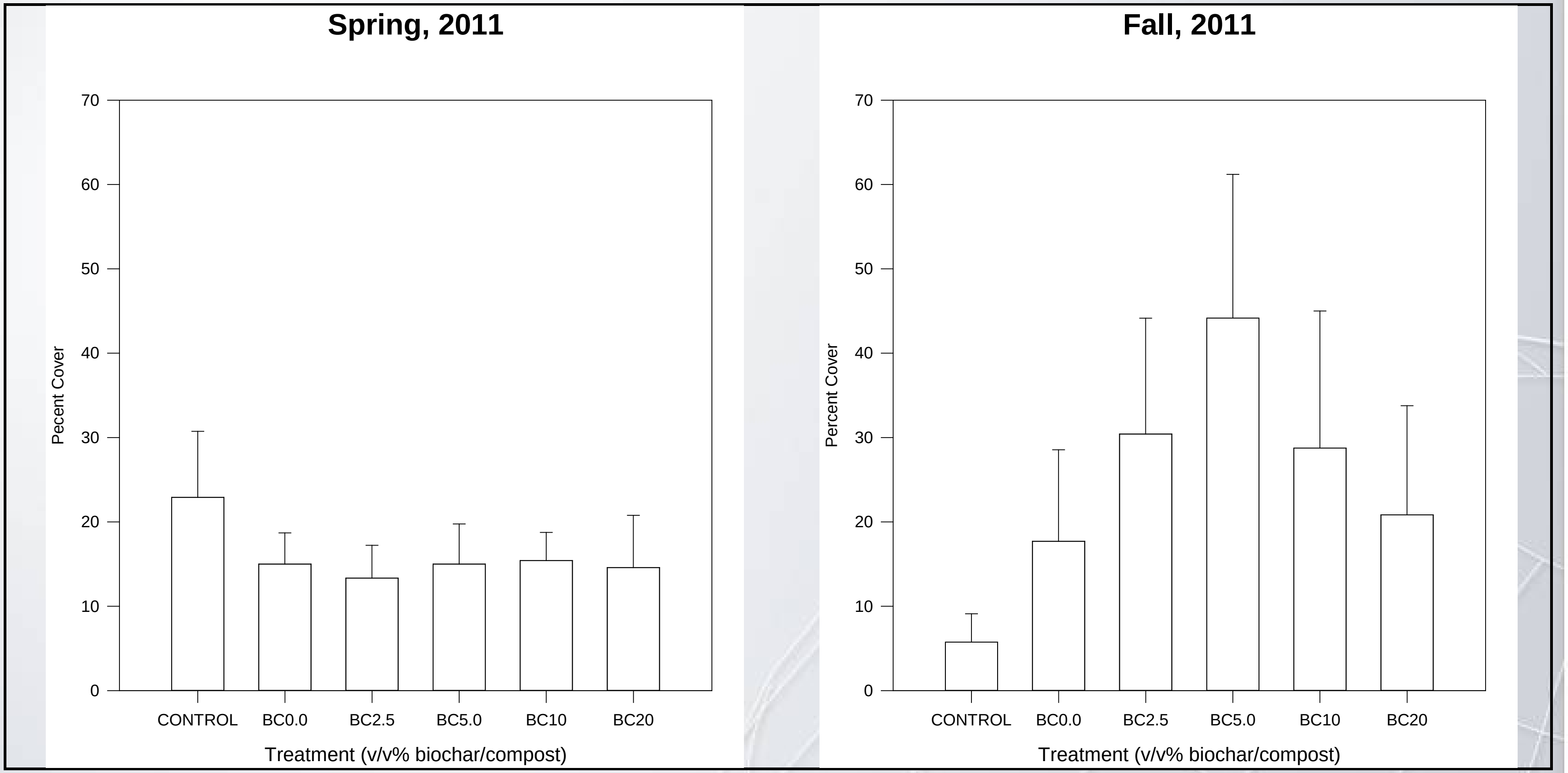

3HOURS
PLANTCAM
JUL.20,11 08:48 AM


3 HOURS
PLANTCAM
AUG.01,11 09:00 AM

Hope Mine (Aspen, CO)

TETRA TECH

Hope Mine (Aspen, CO)



TETRA TECH

Hope Mine (Aspen, CO)

TREATMENT (v/v% BIOCHAR/COMPOST)

June, 2011

	CONTROL	0.0	2.5	5.0	10	20
CONTROL		0.005	<0.001	0.005	0.008	0.003
0.0			0.990	1.000	1.000	0.999
2.5				0.994	0.982	0.997
5.0					0.976	0.996
10						0.999
20						

August, 2011

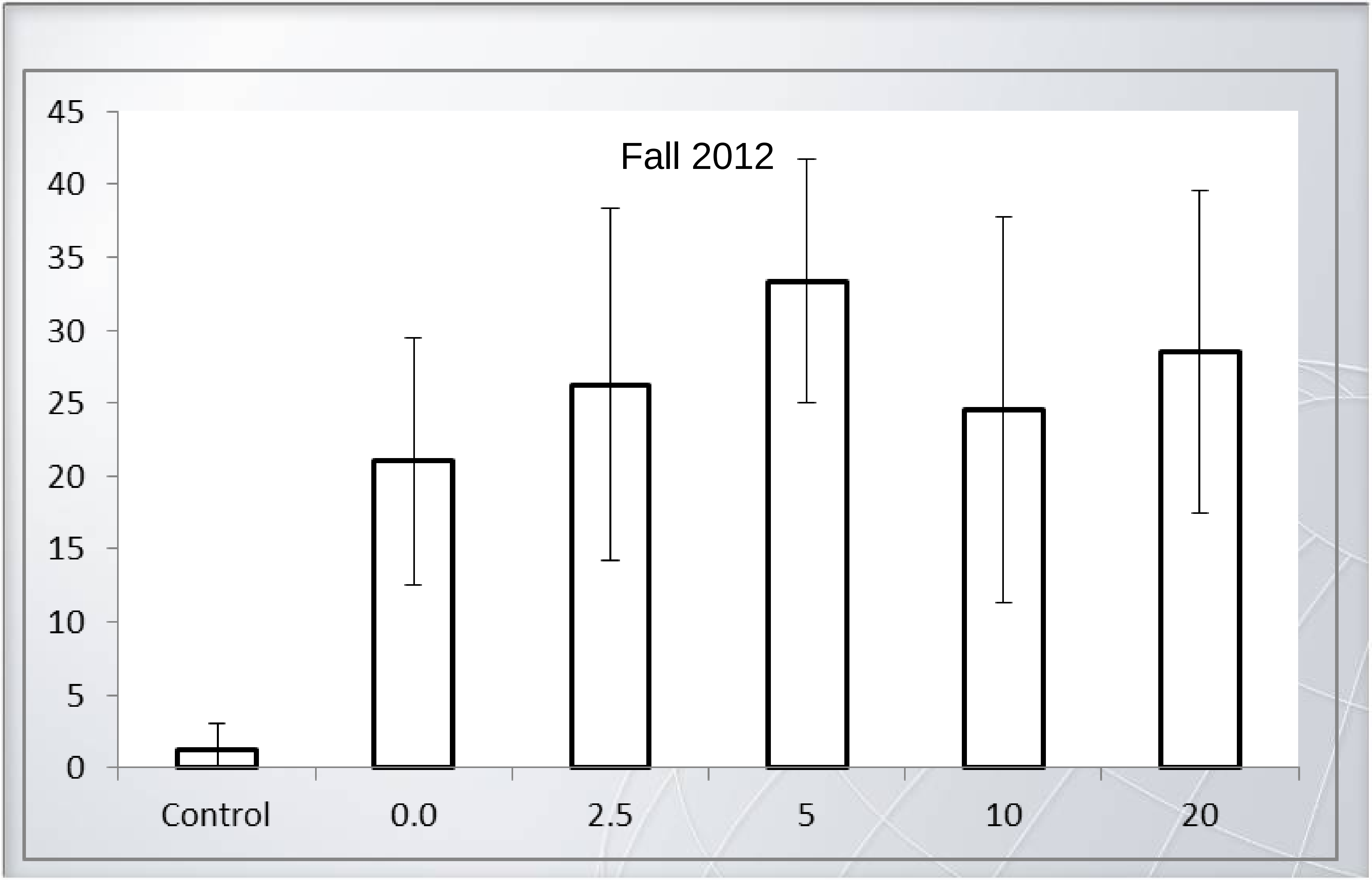
	CONTROL	0.0	2.5	5.0	10	20
CONTROL		0.164	<0.001	<0.001	<0.001	0.057
0.0			0.138	<0.001	0.201	0.809
2.5				0.098	0.757	0.281
5.0					0.054	<0.001
10						0.376
20						

TETRA TECH

Hope Mine (Aspen, CO)

Fall 2012

Hope Mine (Aspen, CO)



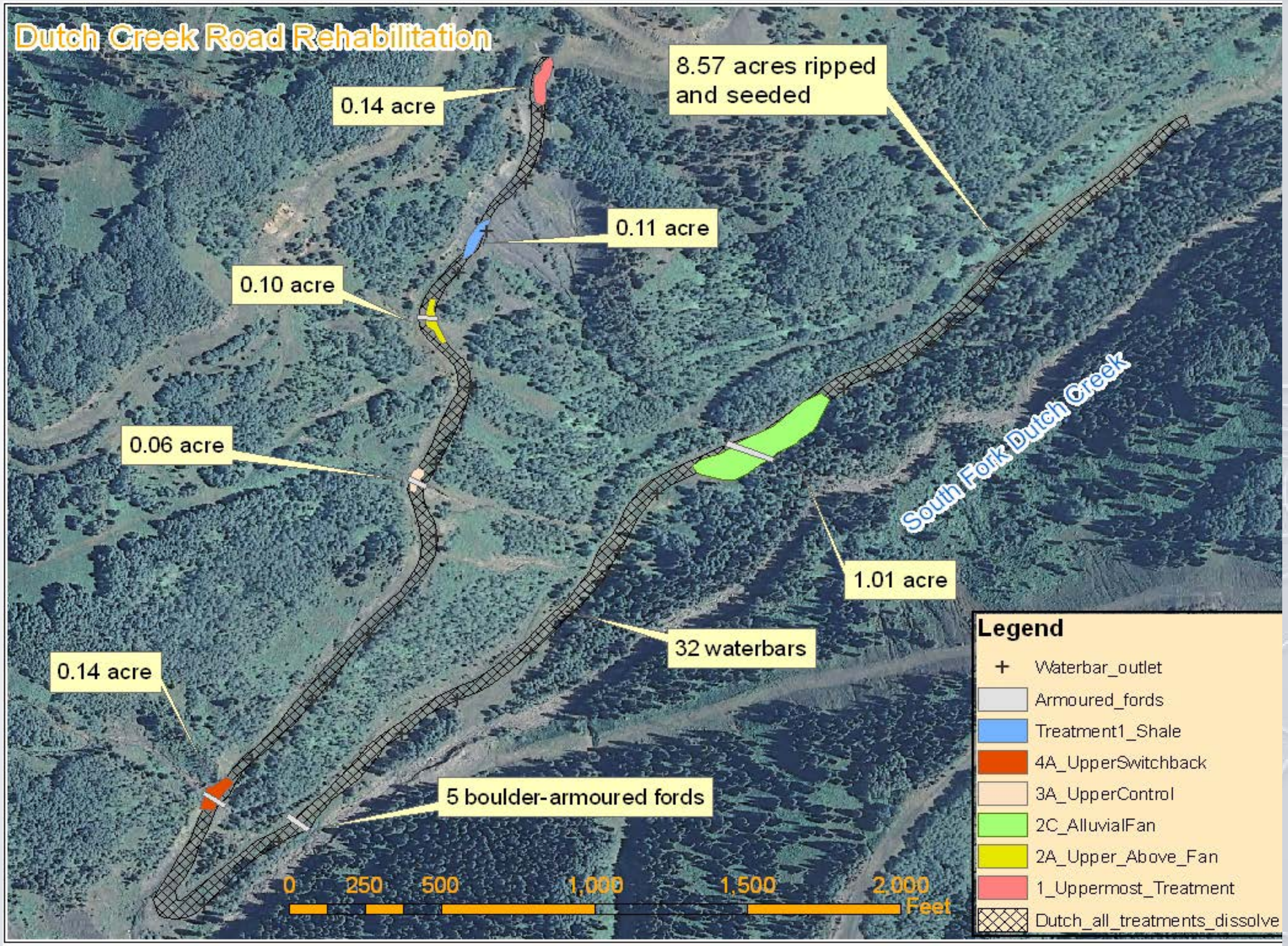
TETRA TECH

Coal Basin (Redstone, CO)

- CDRMS Reclamation 1993-2003
- Mid Continent Bankruptcy Bond ($3,000,000)
- 17 miles road
- Facilities Area
- Refuse Piles (60 acres)
- USFS in conjunction with Roaring Fork Conservancy
- Road Reclamation
- Reconstructed Alluvial Fan
- Grazing plot study

TETRA TECH

Coal Basin (Redstone, CO) – Road Reclamation



Coal Basin (Redstone, CO) – Road Reclamation

Coal Basin (Redstone, CO) – Alluvial Fan

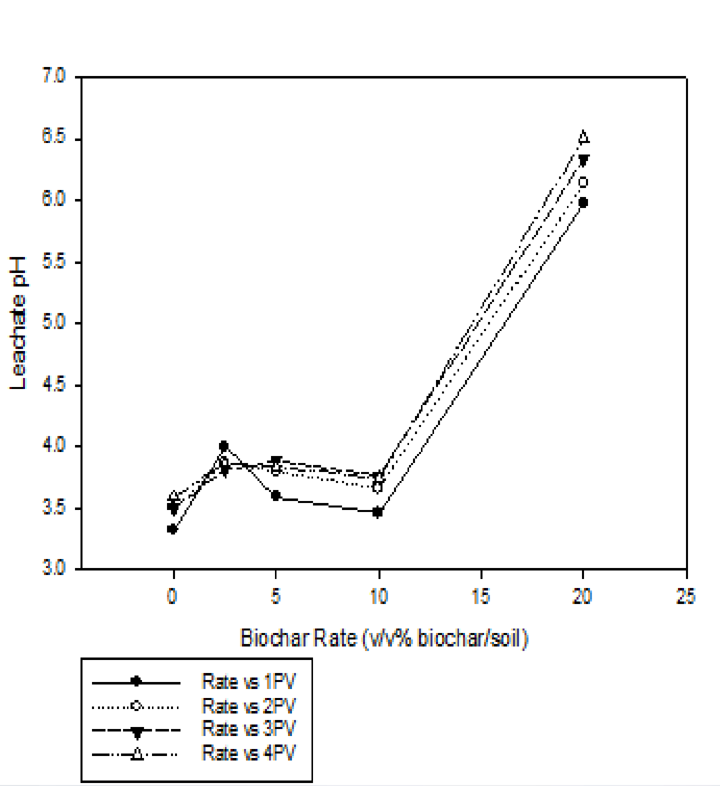
TETRA TECH

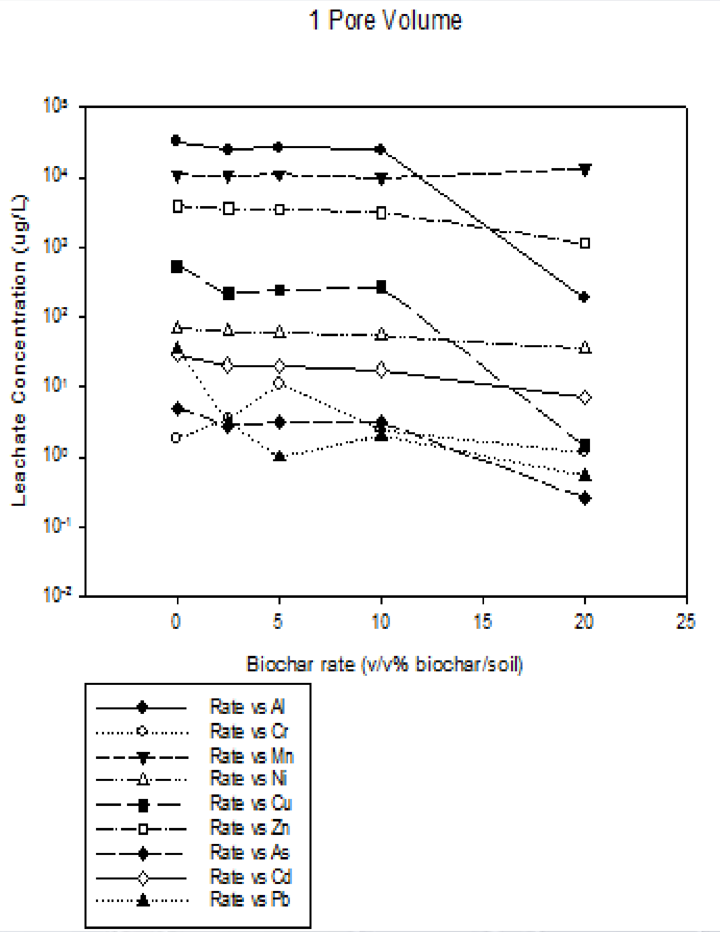
Coal Basin (Redstone, CO) – Grazing Plot Study

TETRA TECH

Metal Sorption

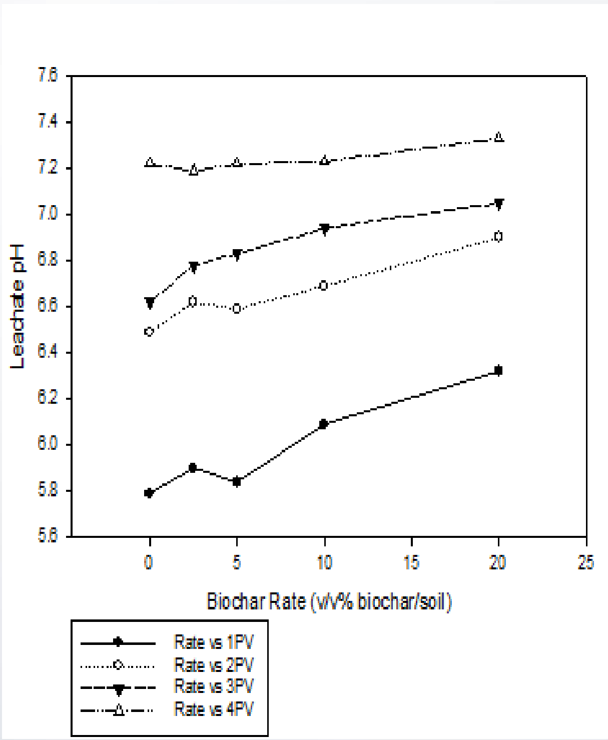
Metal Sorption – Acidic Mine Waste

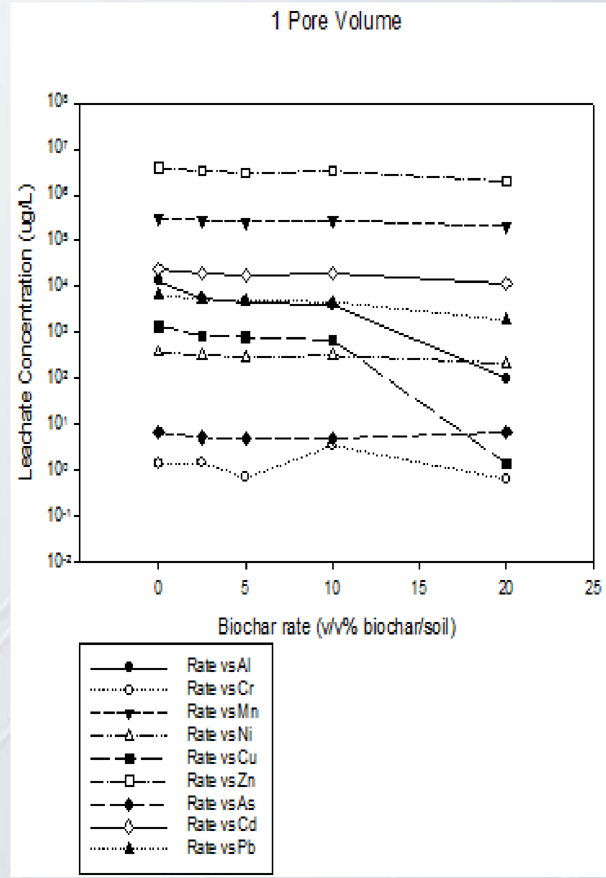




TETRA TECH

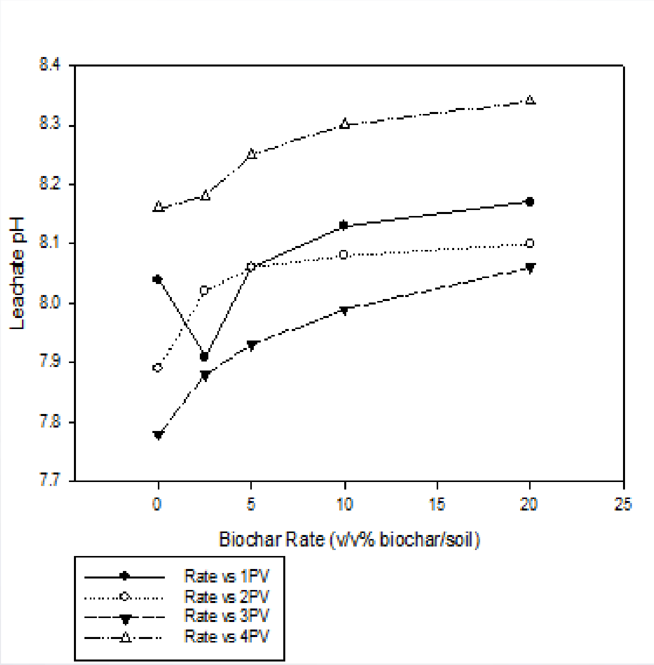
Metal Sorption – Circumneutral Mine Waste

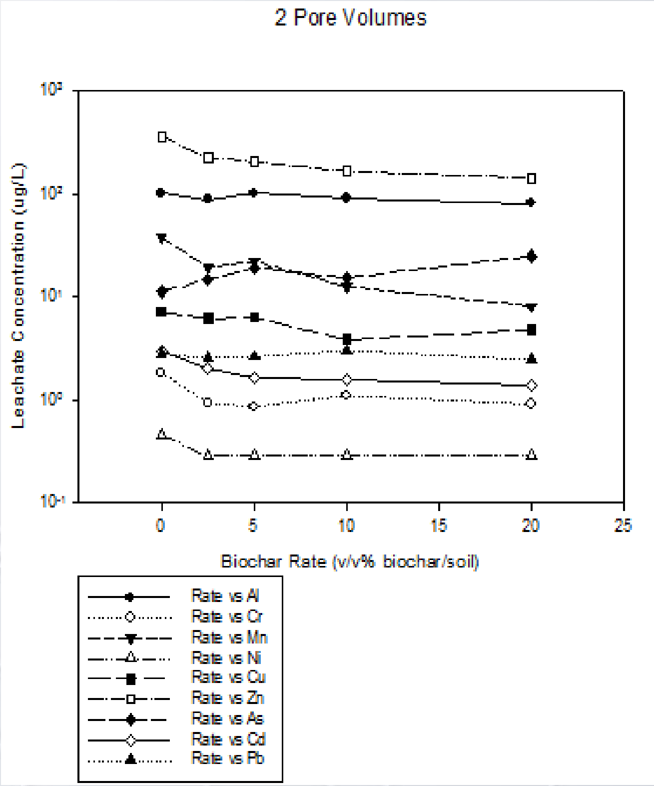




TETRA TECH

Metal Sorption – Alkaline (Carbonate) Mine Waste





TETRA TECH

Rice University

- Biochar to manage drainage:
  - K increased in clay soils – promote effective drainage
  - Decreased in sandy soils
    - retain water in sandy landscapes
    - decrease water stress
    - reduce leaching
- Biochar & Mycorrhizae:
  - Non-additive effect
  - Actual negative effect
  - Biochar sorbs non-polar organic being used by plant and fungi.

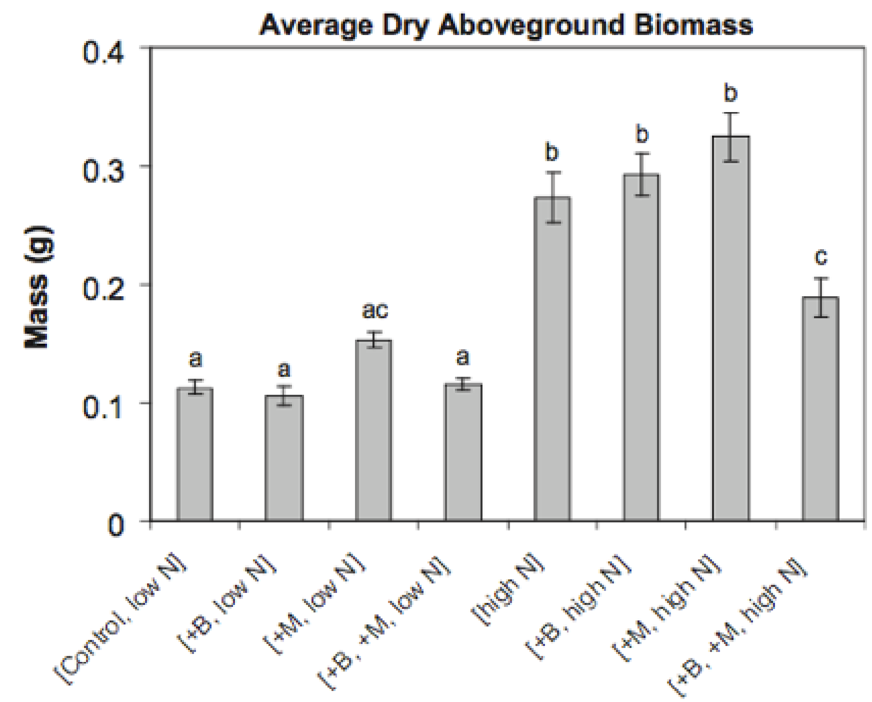


Fig. 1. Average mass of dried aboveground biomass from 30 plants per group. Different letters indicate values that are significantly different as determined by factorial ANOVA. Error bars represent standard error. ([+B]: Biochar added to soil, [+M]: Mycorrhizal inoculum added to soil, [low N]: fertilized with ammonium nitrate at 6.7 kg N/ha, [high N]: fertilized with ammonium nitrate at 34 kg N/ha.)

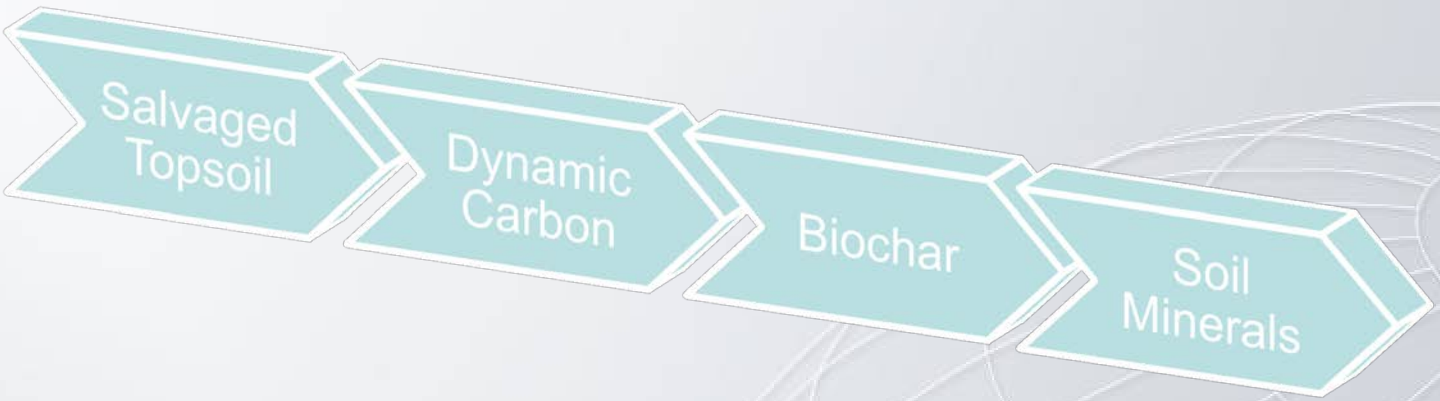
Source: Becca Barnes and Morgan Gallagher

TETRA TECH

Lawrence Berkeley Lab

- Bioelectric Properties of Biochar
  - Provide a conduit for electron transfer between cells
  - Ability to stimulate interspecies electron transfer
    - Implications for microbial respiration
  - May explain observation that biochar amendments enhance methane production in soils and digesters converting organic waste to methane.

TETRA TECH


Salvaged Topsoil
Dynamic Carbon
Biochar
Soil Minerals


Community Participation in Sustainability
Forest Health
Community Landfill
THERMAL CONVERSION SYSTEMS
Community Lumber Mill
Electricity
Heat
Biochar
YOUR COMPANY HERE
Restoration Project
Pitkin County
Restoration Project
BIOCHAR SOLUTIONS
Restoration Project
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE
Restoration Project
Restoration Project
Multi-Stakeholder Participation in Restoration

TETRA TECH