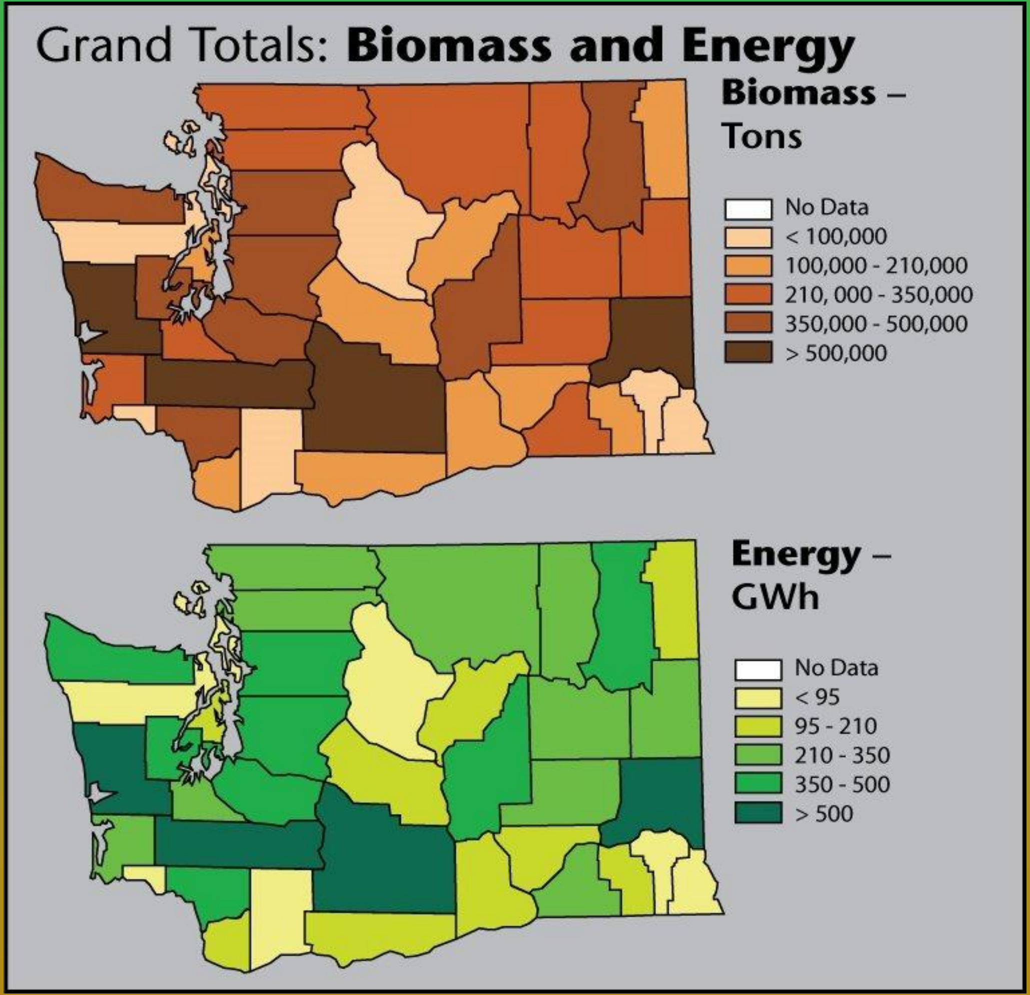
Reducing Organic Waste and Improving Soil Systems with Biochar in Washington State

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Mark Fuchs November 15, 2017

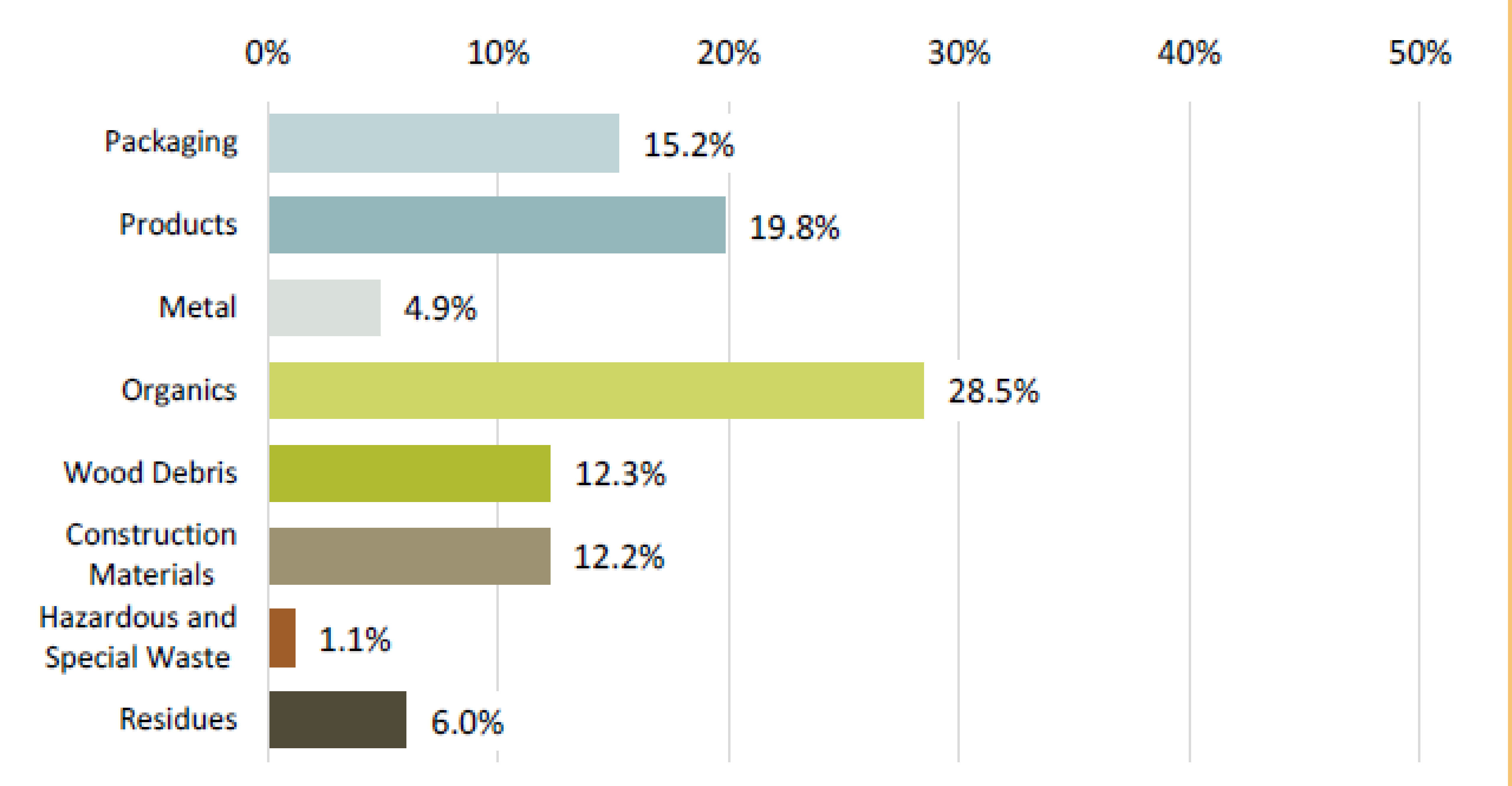
WA Biomass Inventory – 2013 update



Sector	Mbdt/yr
Grand Total	**10.6**
Field Residue	2.6
Animal Waste	0.8
Forestry	5.8
Food Packing	0.15
Food Processing	0.14
Animal Processing	0.05
Municipal	1.0

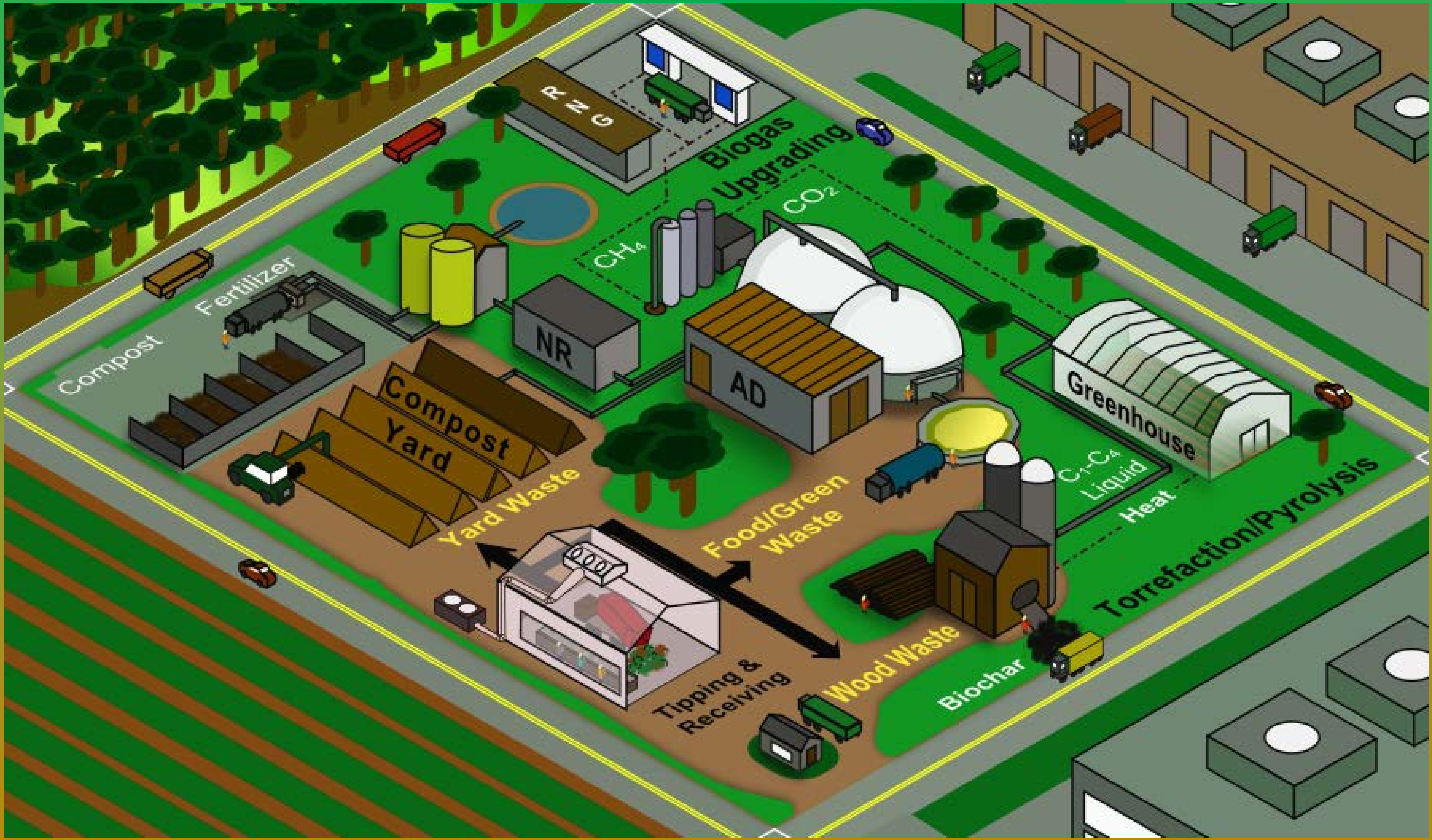
http://pacificbiomass.org

2015-16 Waste Characterization Study



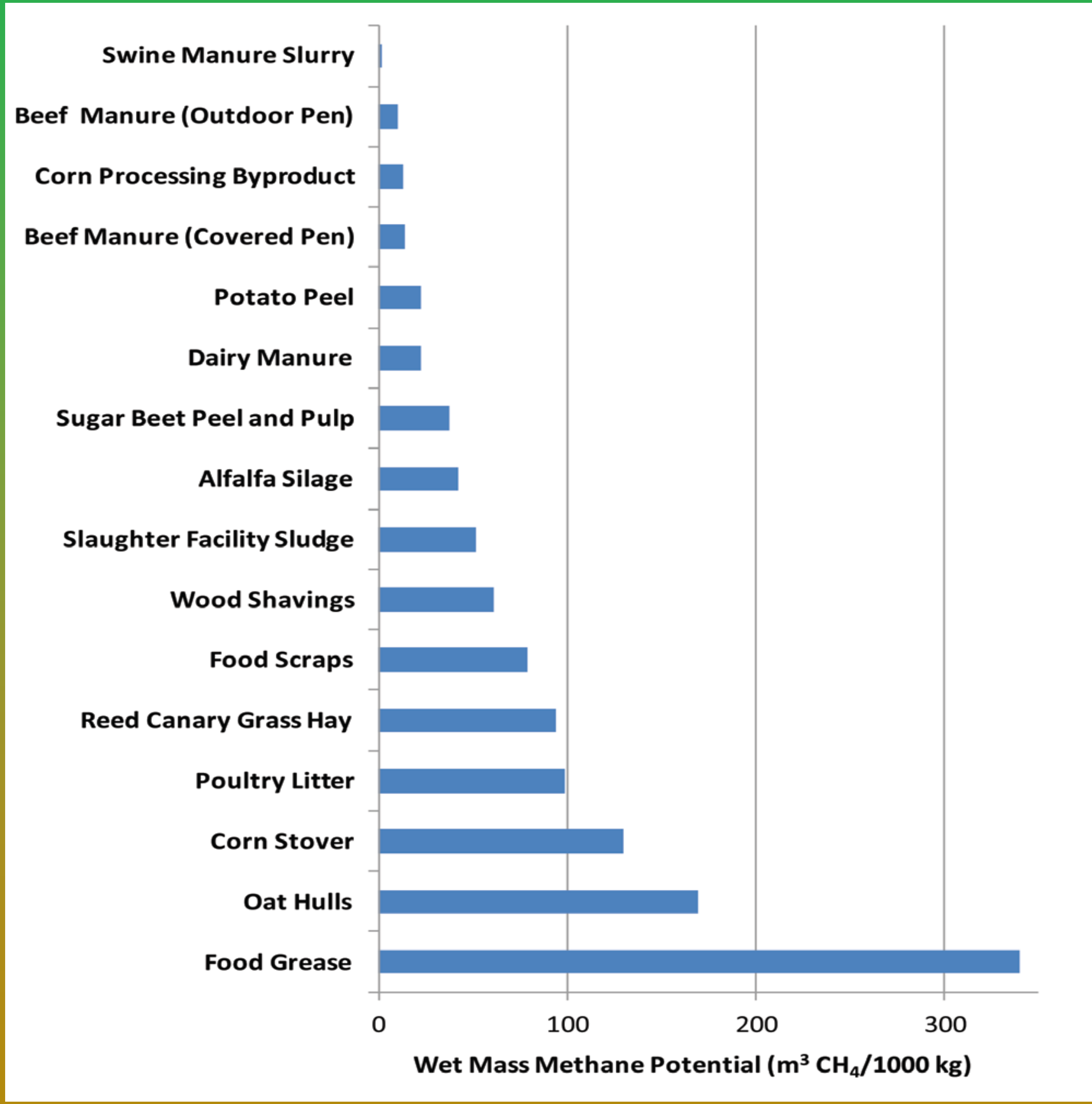
Mark Fuchs November 15, 2017

Organic Biorefinery



Mark Fuchs November 15, 2017

Biomass Methane Potential

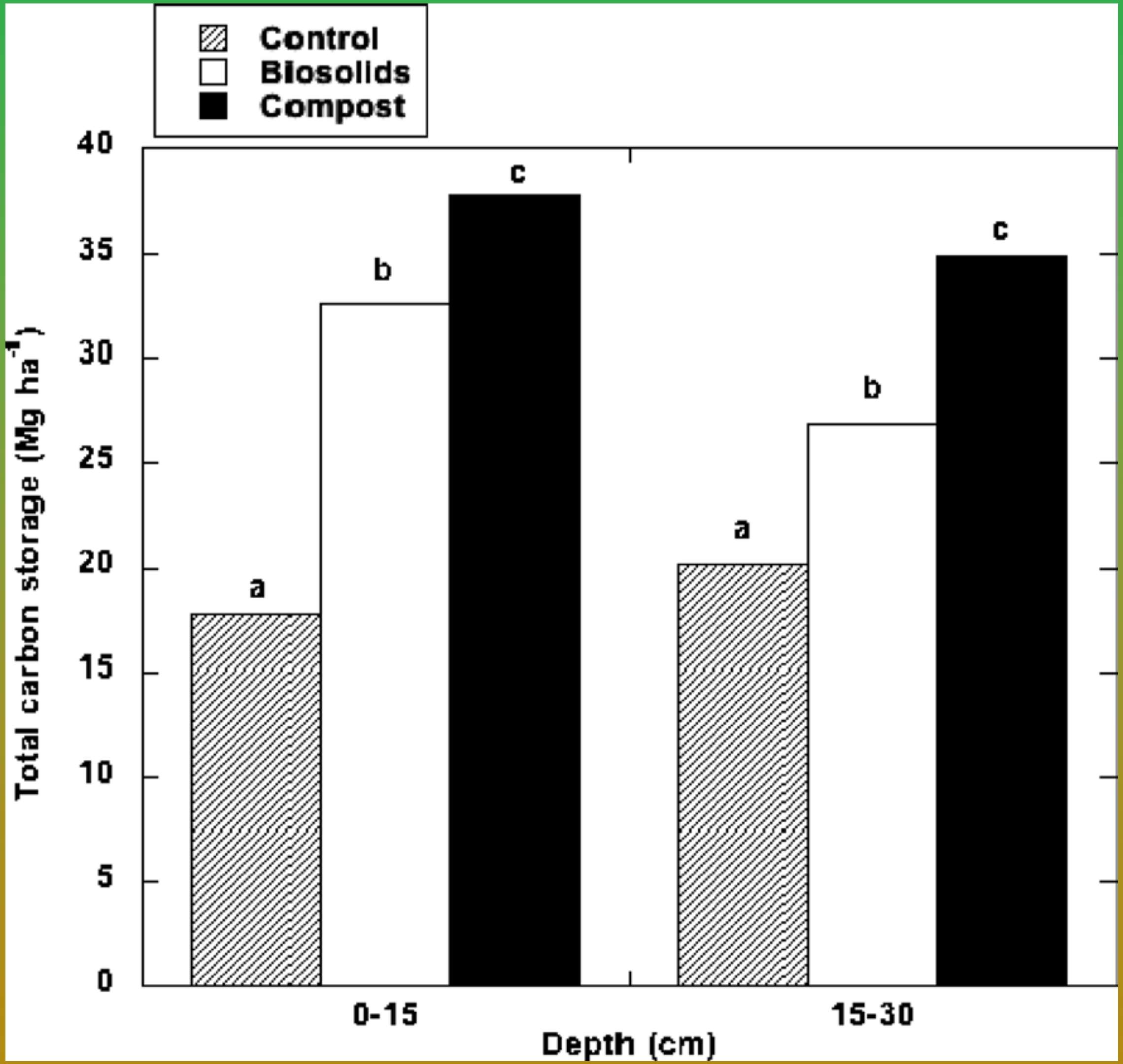


Moody et al., 2011

Compost and Biosolids applications

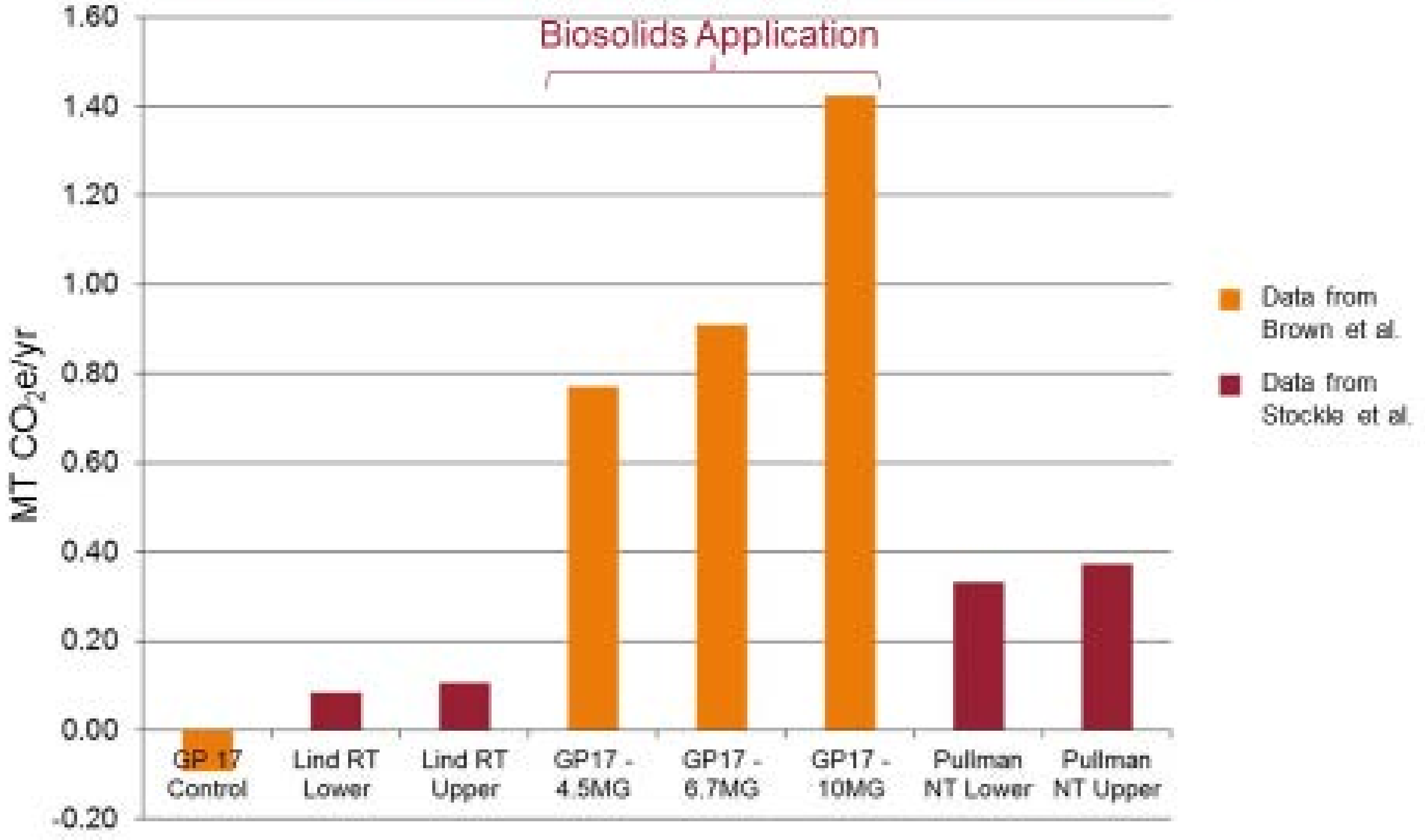
12 sites monitored 2 to 18 years after application:

- Soil carbon and nitrogen remained above control soils ↑
- Soil water holding capacity also above control soils ↑



Brown et al., 2011

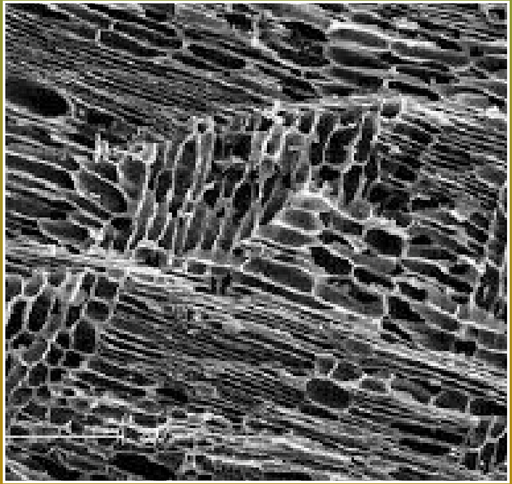
SOC Change in Dryland Systems from Reductions in Tillage Compared to Biosolids Application



Brown et al. 2011, Stockle et al. 2012

What is Biochar

Biochar is a fine-grained, highly porous material created by the thermo-chemical transformation of wood (& straw ….) biomass.



Biochar helps soils retain nutrients and water due to its large surface area. The greater the surface area the better the biochar.

Courtesy Phil Small
“Biomass to Biochar”
June 2017

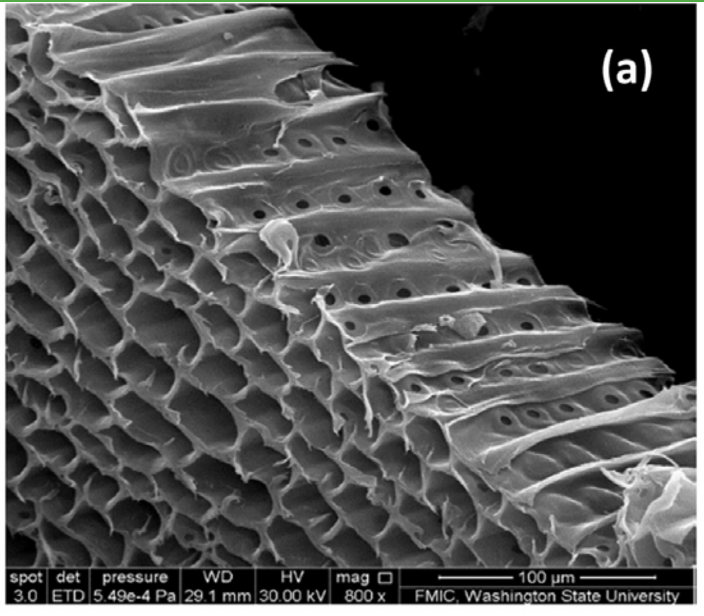
Biochar is similar to activated carbon

Activated carbon properties

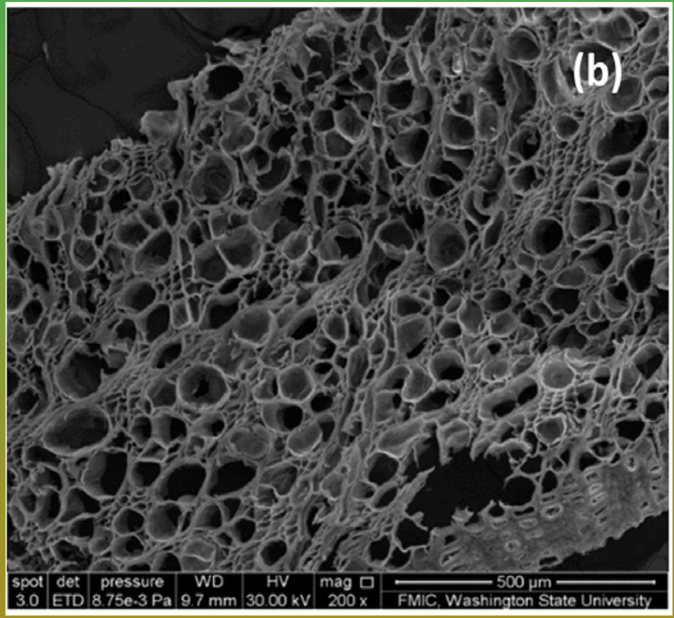
- High Surface area/gram
- High sorption capacity
- Can be designed for high cation and/or anion exchange
- High water holding capacity and increased aeration

Scanning Electron Micrograph : WSU

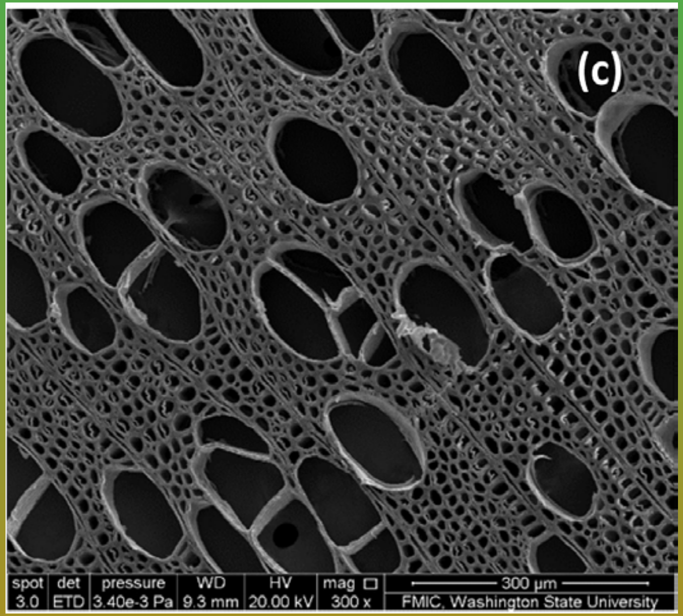
Douglas Fir Wood



Douglas Fir Bark

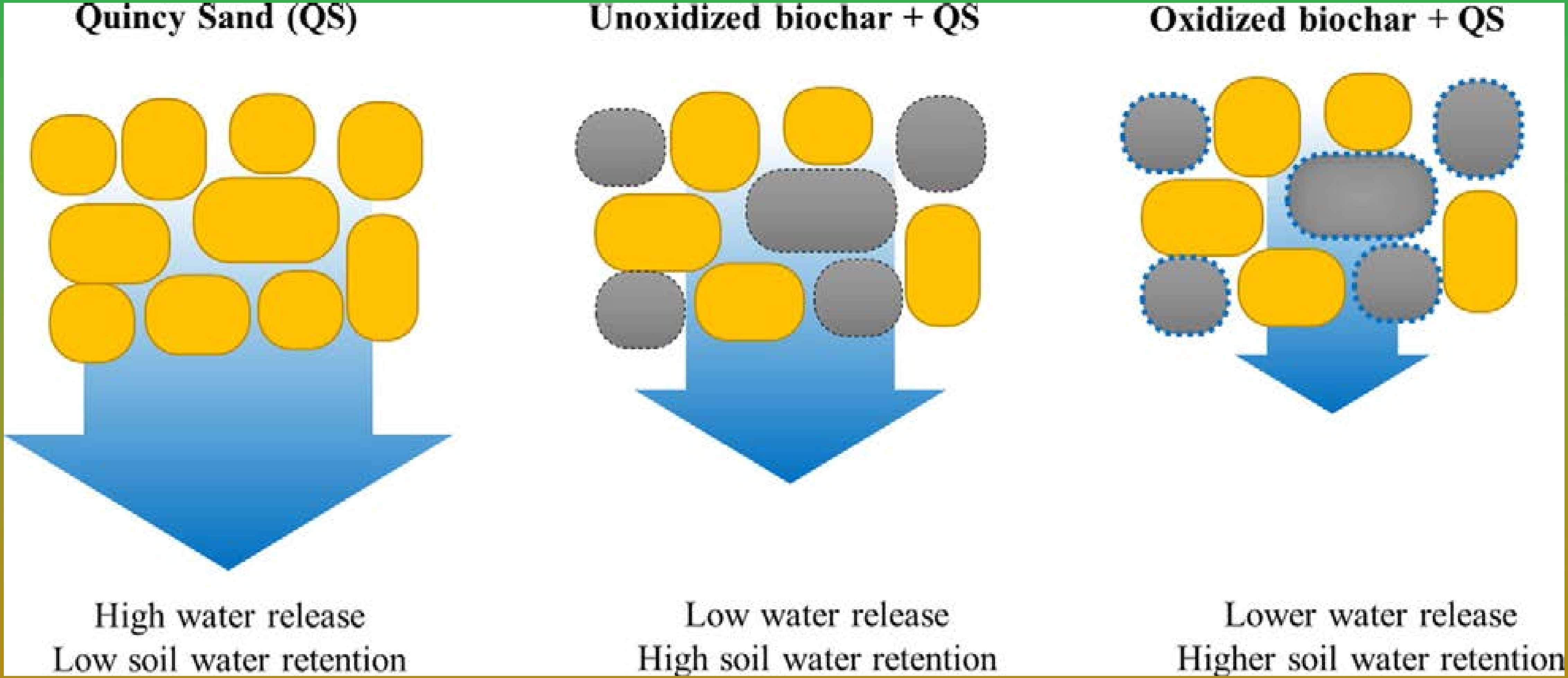


Hybrid Poplar wood



Suliman et al., 2016

Soil and added Biochar : Water Holding Capacity



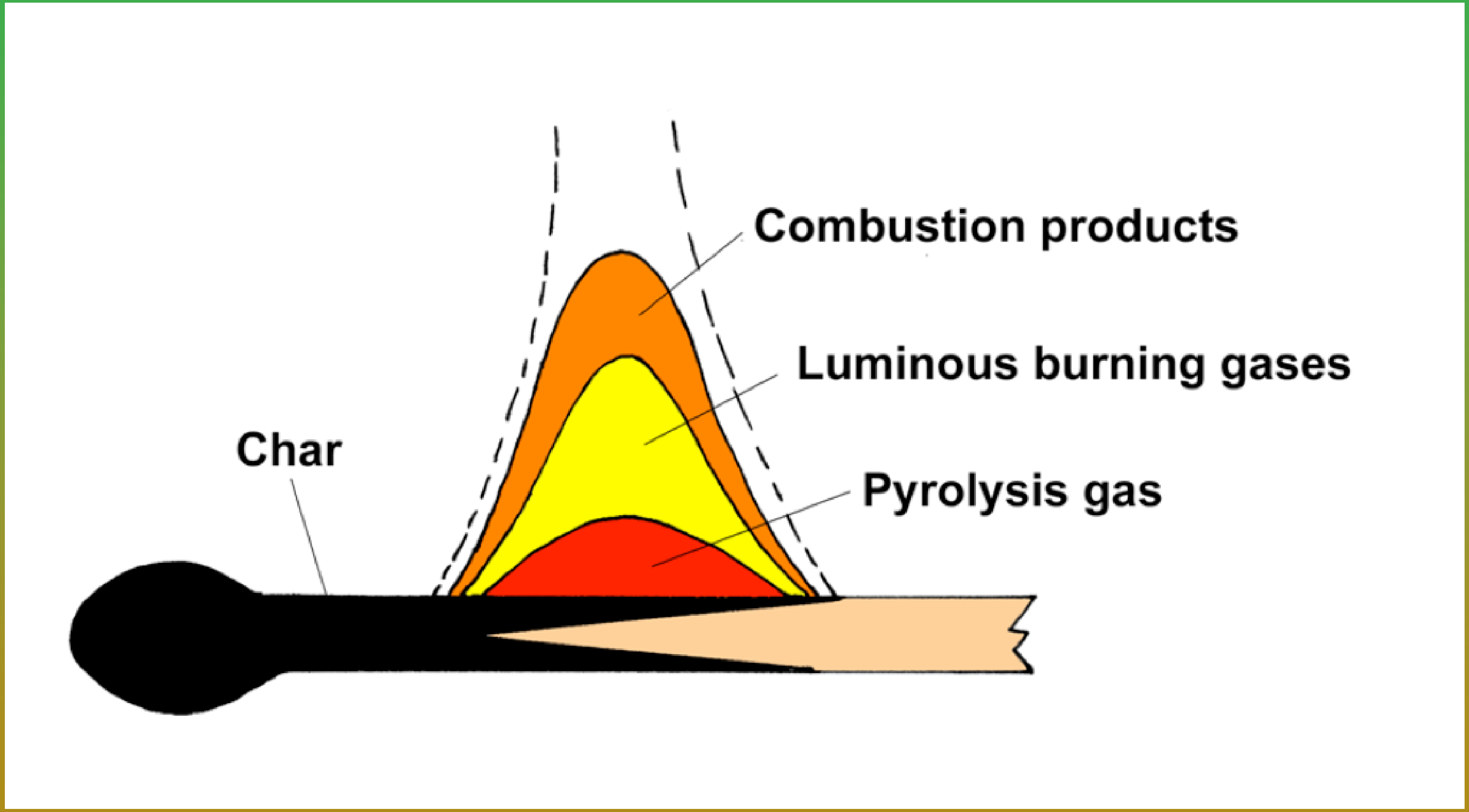
Suliman et al., 2017

Biochar impact on Soils

- Significantly ↑ water holding capacity
- Improve fertilizer N use, & legume nodulation
- biochar provides other macro/micro nutrients
- biochar ↓ N_2O off-gassing & ↑ CH_4 uptake in soils
  - GHG impact of N_2O & CH_4 - 296 and 23 times CO_2

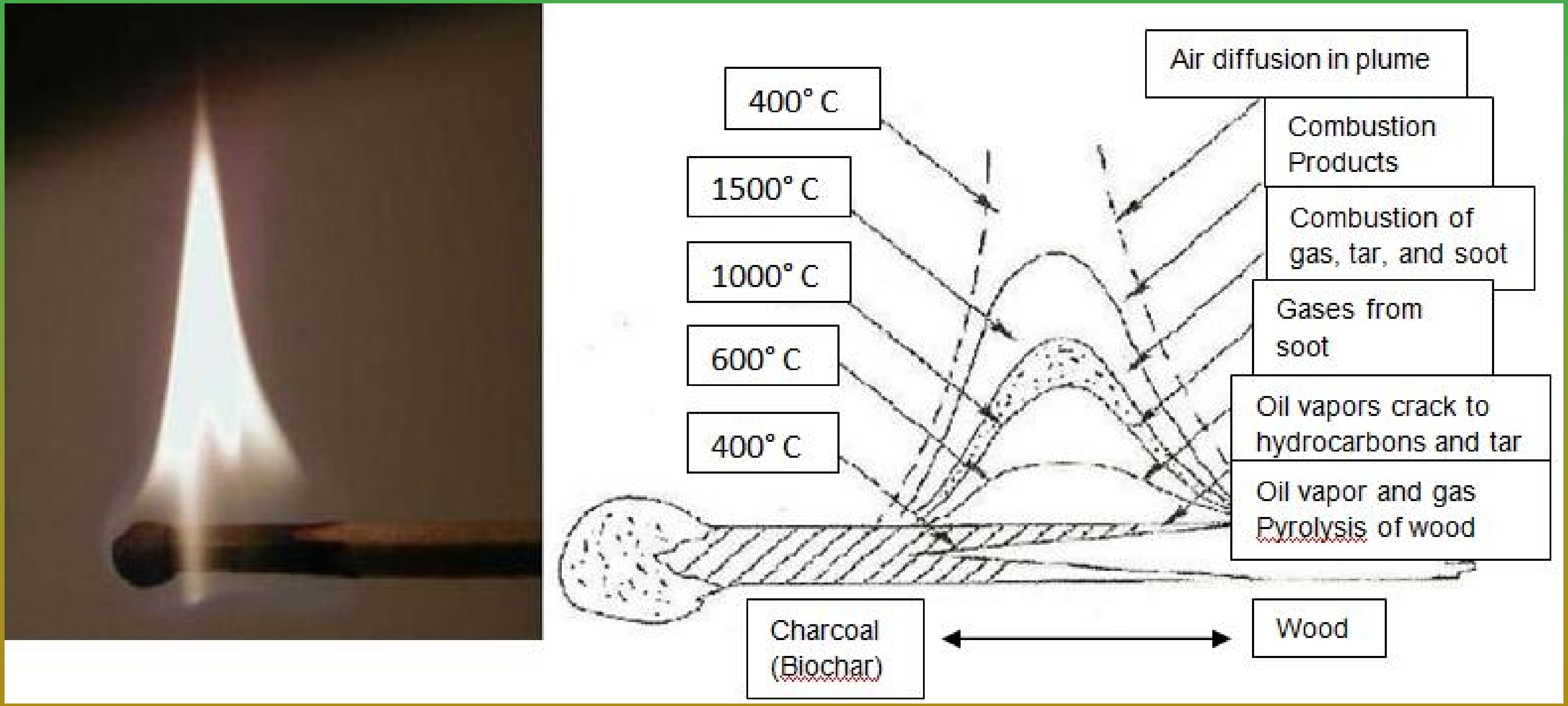
Mark Fuchs November 15, 2017

How is biochar made?



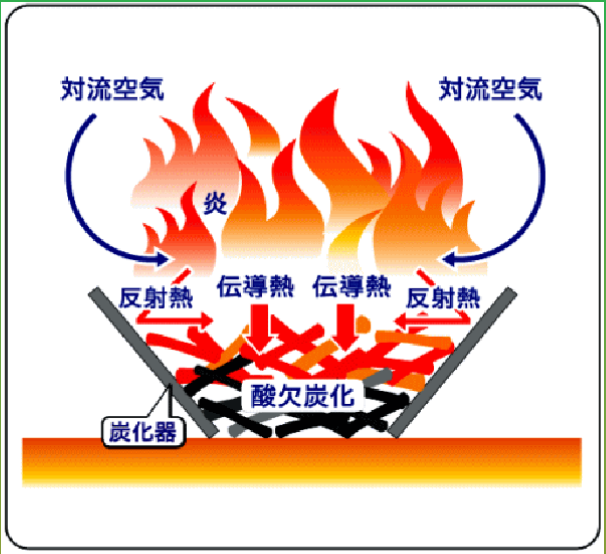
Courtesy Kelpie Wilson
http://www.greenyourhead.com

World's smallest biochar reactor



Courtesy Hugh McLaughlin

Biochar is made & used around the world



JOURNAL OF BUSINESS
Serving Spokane & Kootenai Counties
In Print · Online · On the Go

Ag Energy Solutions finds unexpected market for biochar

Waste-to-power byproduct becomes company's focus

By Mike McLean

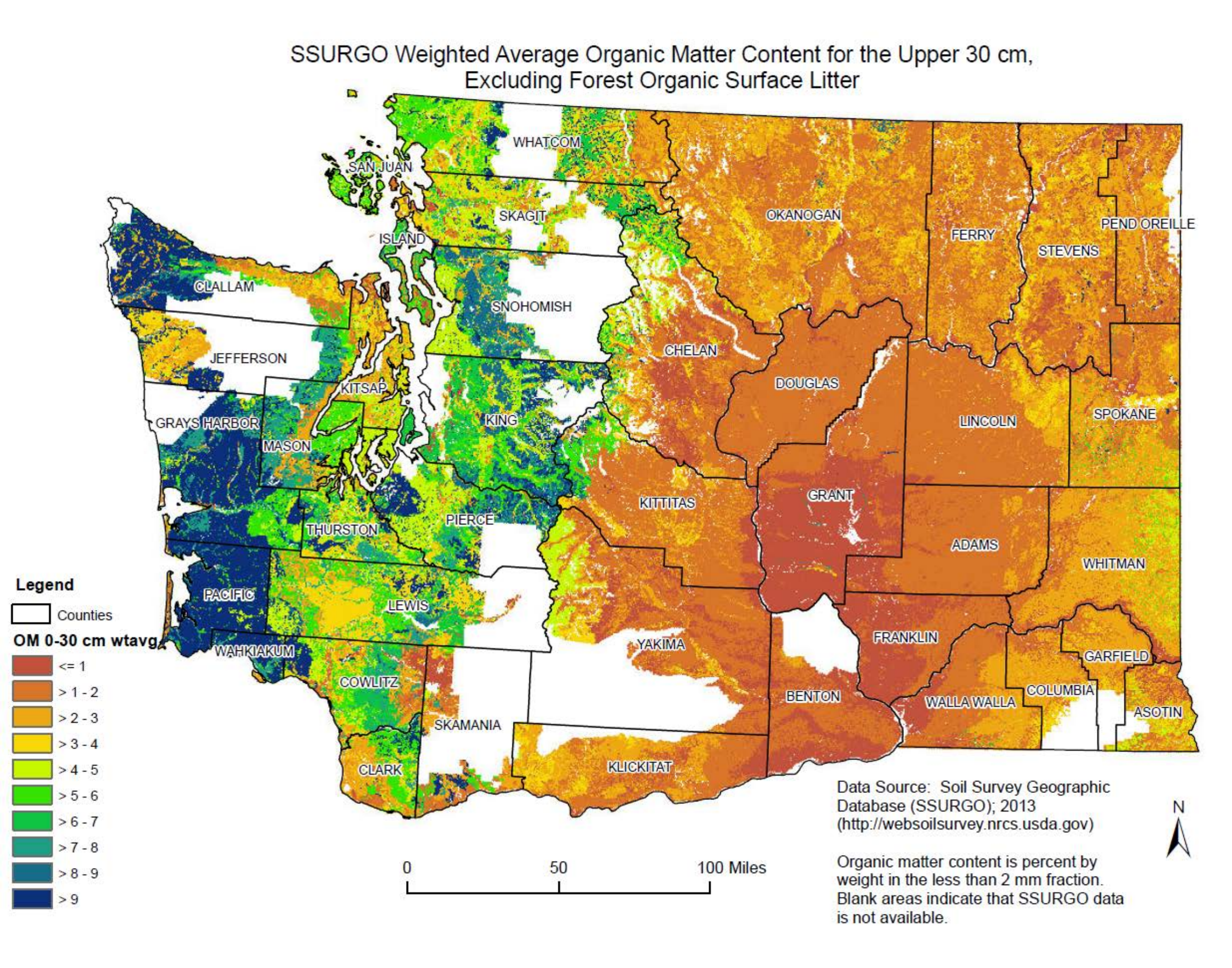
September 14th, 2017

- Numerous crops and other uses being evaluated
- Marijuana produces well with AgEnergy biochar
- Expect to be profitable next year

Biochar Solutions Inc. Chips to Biochar
2 Dry tph chips - > 2 CY/hr biochar + MMBtuh thermal

Courtesy TRMiles

Organic matter in WA soils



Mark Fuchs November 15, 2017

Palouse silt loam - near Pullman, WA

- Soil organic carbon 4% to 5% (topsoil)
- Depth interval 4" (10 centimeters)

quasargroupconsulting.com

Terra Preta Soil of the Amazon Basin

Left - an oxisol poor in nutrients.

- typical soil of the hot/humid tropics

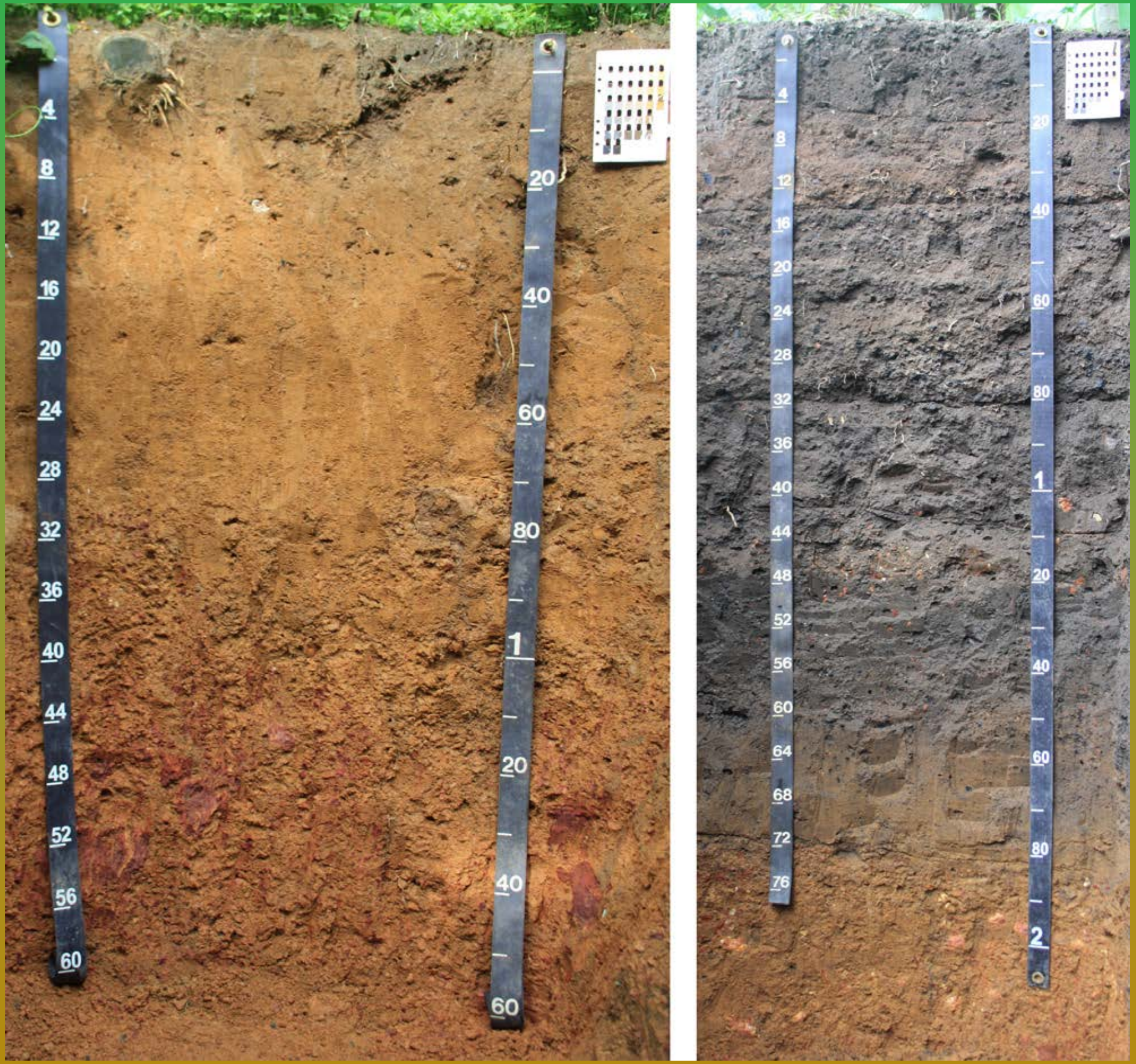
Right - fertile terra preta soil

- transformed by human activity
- Very high in stable carbon

Depth interval - 10 cm

Glaser, et al., 2001

African Dark Earth Soils



Mark Fuchs November 15, 2017

Left – Typical African soil

- **Hot/humid Liberia and Ghana.**

Right - fertile African Dark Earth soil

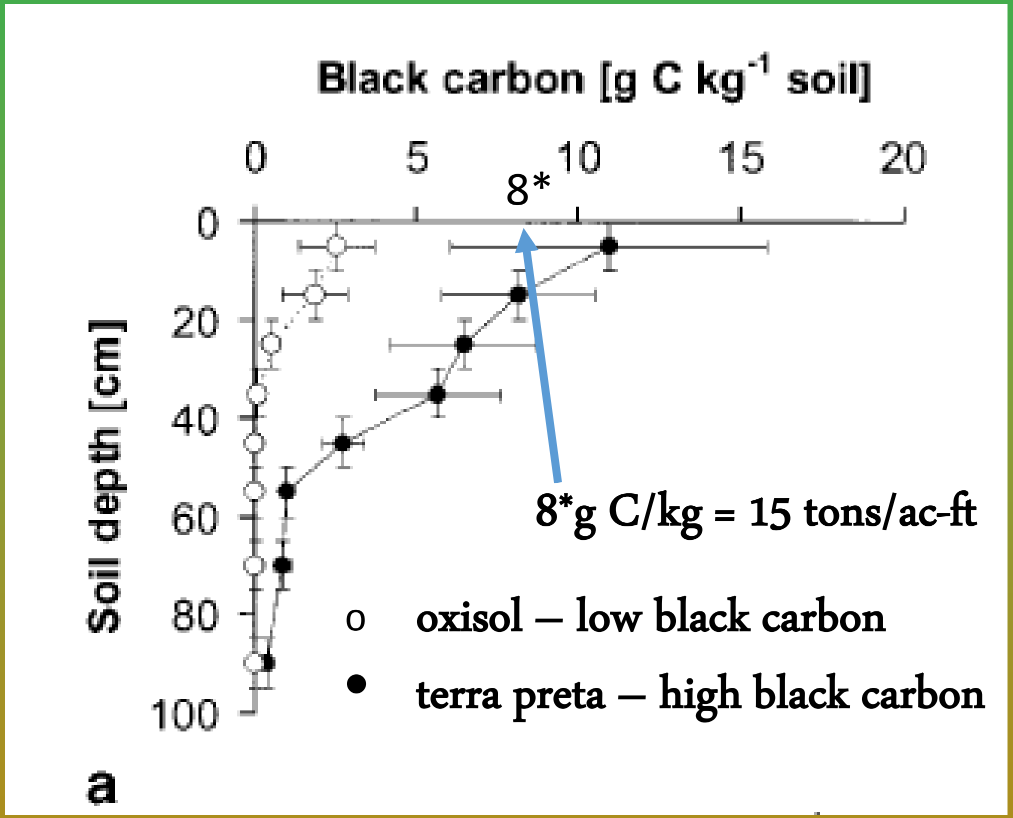
- **transformed by human activity**
- **Very high in stable carbon**

Depth interval - 10 cm

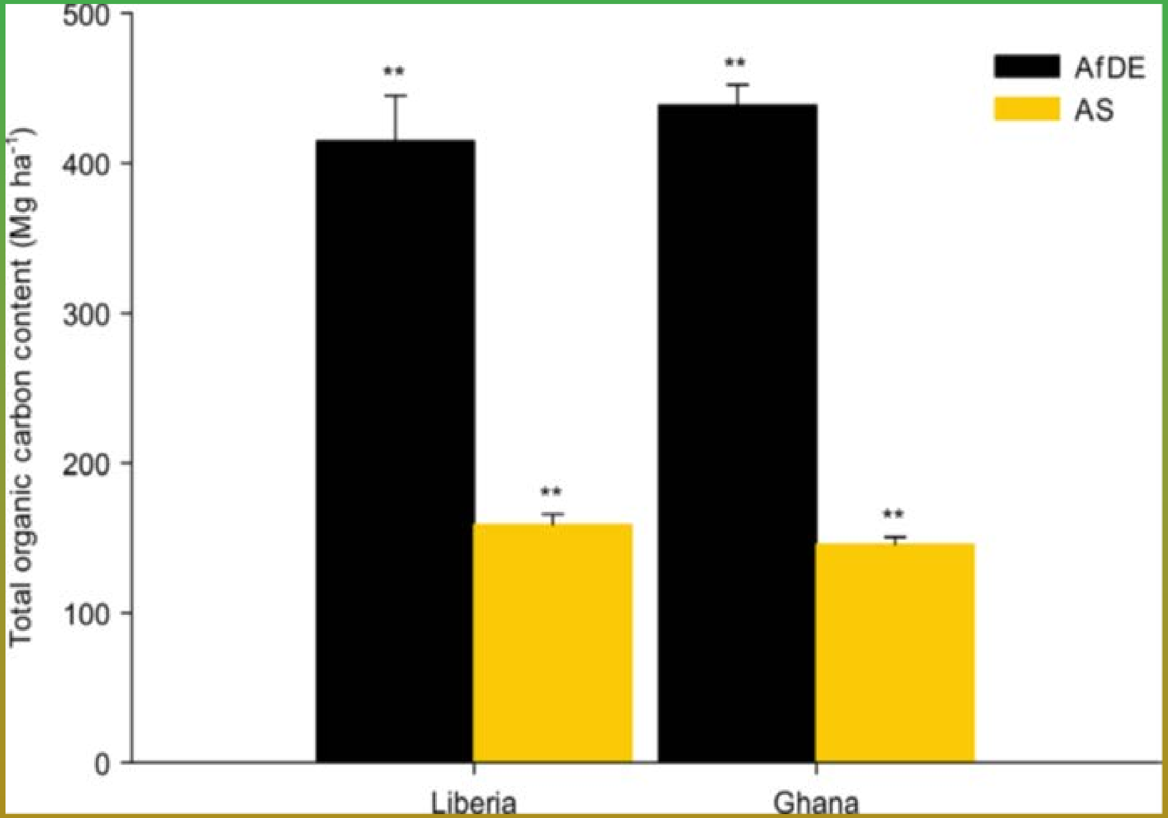
Solomon et al., 2016

Terra Preta

African Dark Earth



from Glaser, et al., 2001



Solomon et al., 2016

Soils of the Illinois Plain

Drummer Silty Clay Loam

- State Soil of Illinois
- Depth interval – inches
- Deep, well mixed, extremely fertile organic rich soils

Illinois State Soil, NRCS - USDA

Odor in Commercial Scale Compost: Literature Review and Critical Analysis, 2013

Four main strategies to reduce compost odor:

(**ECY 13-07-066** https://fortress.wa.gov/ecy/publications/documents/1307066.pdf)

- **Enhance emissions control infrastructure (more air quality control equipment),**
- **Biological optimization of compost piles (changes in windrow size, aeration, etc.),**
- **Add anaerobic pre-processing for the highly biodegradable wastes (high solids anaerobic digestion), and**
- **Amending compost materials with high-carbon products (biochar).**

Mark Fuchs November 15, 2017

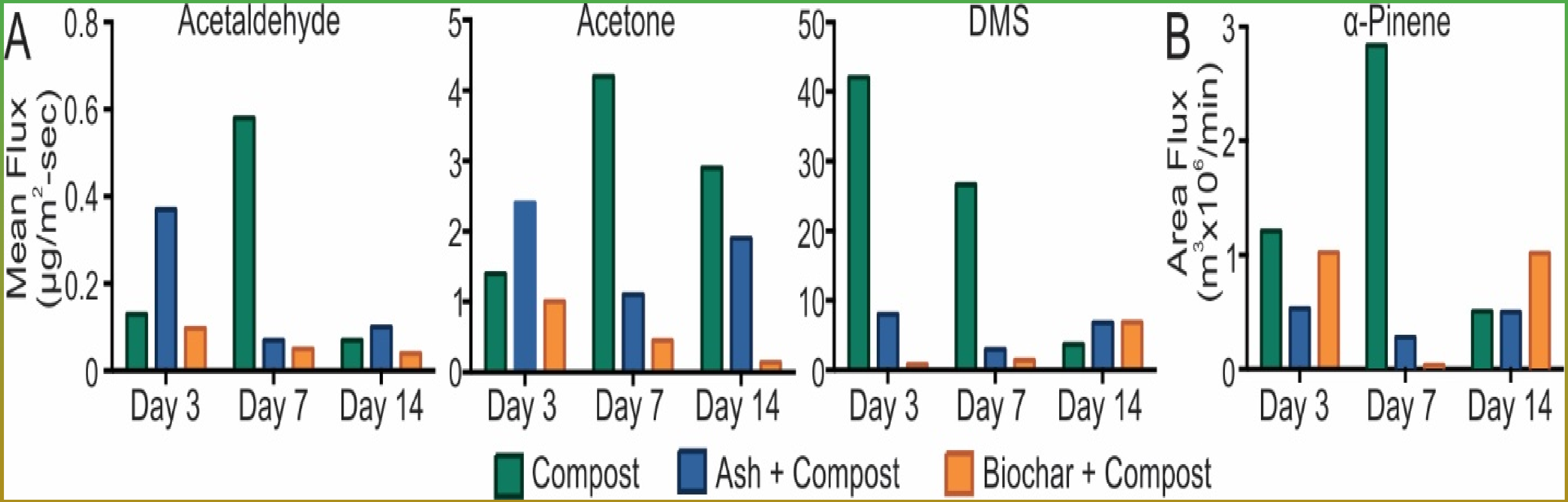
Typical Odor Causing compounds from Composting

Compound Name	Chemical Formula	Primary Odor Characteristic
Acetaldehyde	CH_3CHO	Pungent
Ammonia	NH_3	Urine, pungent
Butyric acid	$CH_3CH_2CH_2COOH$	Rancid, sour
Diethyl sulfide	$C_2H_5C_2H_5S$	Garlic
Dimethyl amine	CH_3CH_3NH	Fishy
Dimethyl sulfide	CH_3CH_3S	Foul, decayed
Ethyl mercaptan	C_2H_5SH	Decayed cabbage
Formaldehyde	HCHO	Pungent
Hydrogen sulfide	H_2S	Rotten eggs
Indole		Fecal
Methyl mercaptan	CH_3SH	Foul, decayed
Phenol	C_6H_5OH	Medicinal
Propyl mercaptan	C_3H_7SH	Unpleasant
Sulfur dioxide	SO_2	Pungent
Trimethyl amine	$CH_3CH_3CH_3N$	Fishy, ammonical
Valeric acid	$CH_3CH_2CH_2CH_2COOH$	Body odor

Mark Fuchs November 15, 2017

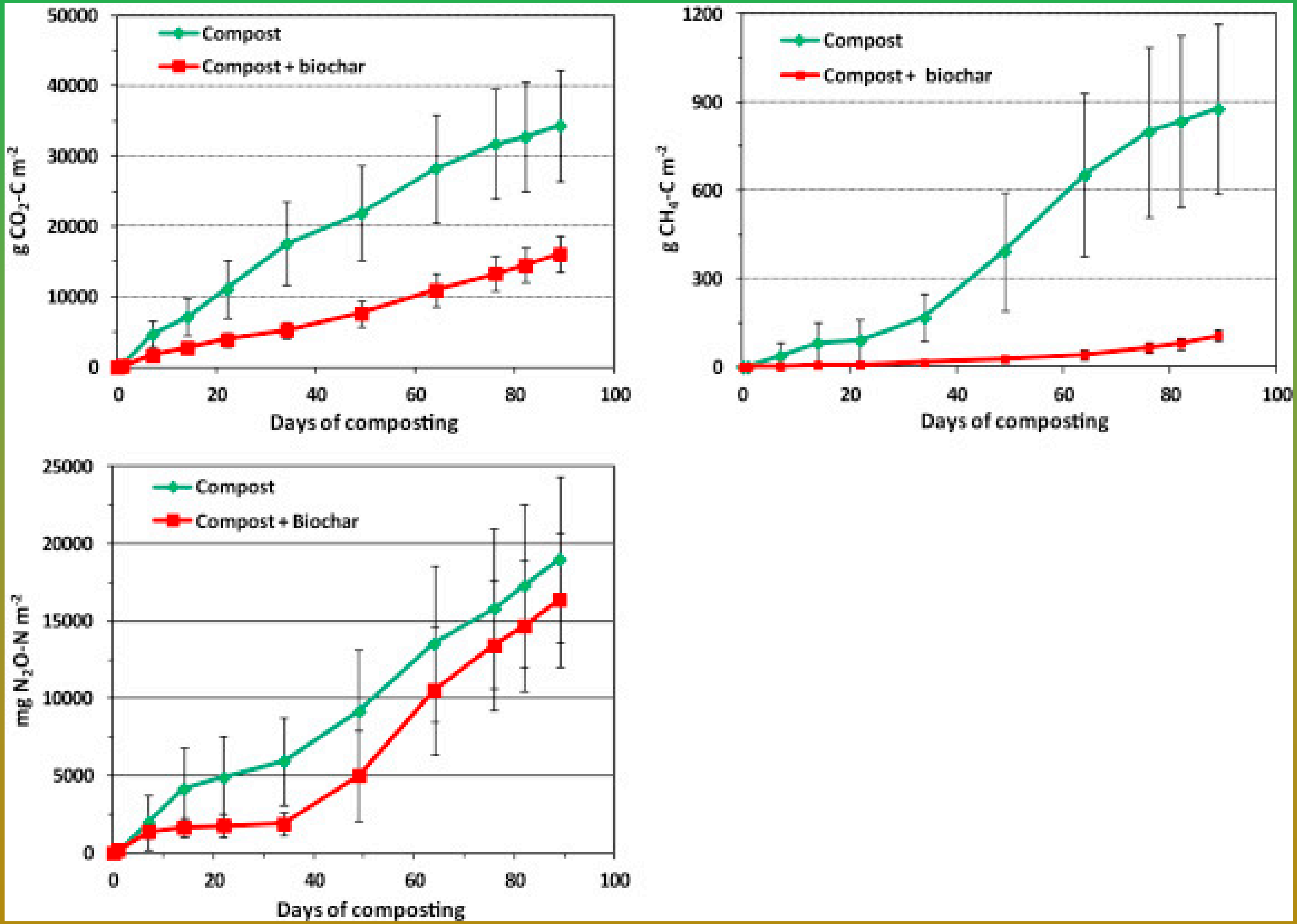
Calrecycle.CA.Gov

Compost Emissions from control, 5% ash, and 5% biochar mixtures in the first 2 weeks



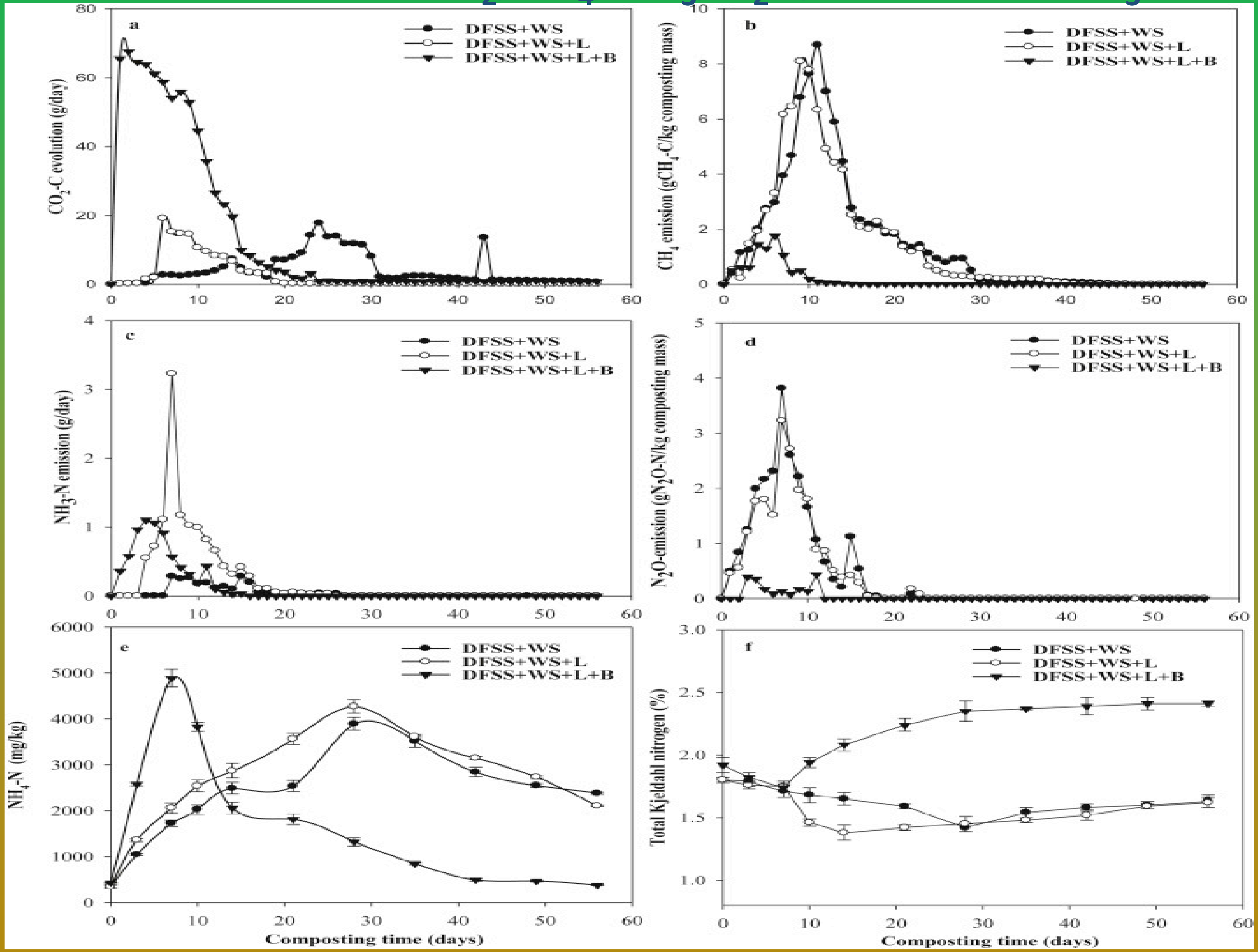
Mark Fuchs November 15, 2017

Cumulative CO_2, CH_4, & N_2O during compost & biochar blended compost



Vandecasteele et al 2016.

Evolution of CO_2, CH_4, NH_3, N_2O, extractable NH_3 & TKN during composting



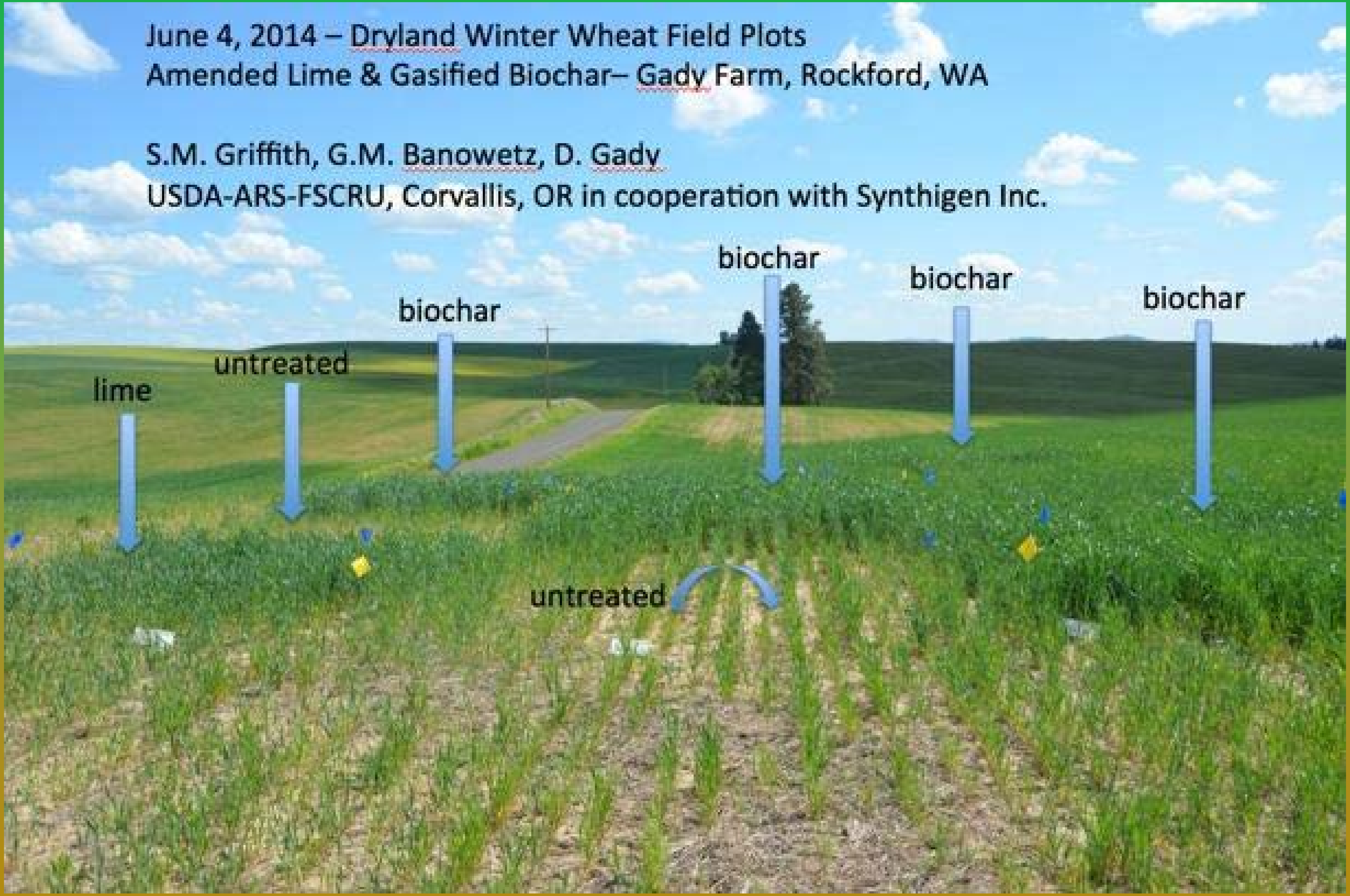
DFSS – De-watered fresh biosolids

WS – Wheat Straw

L – Lime

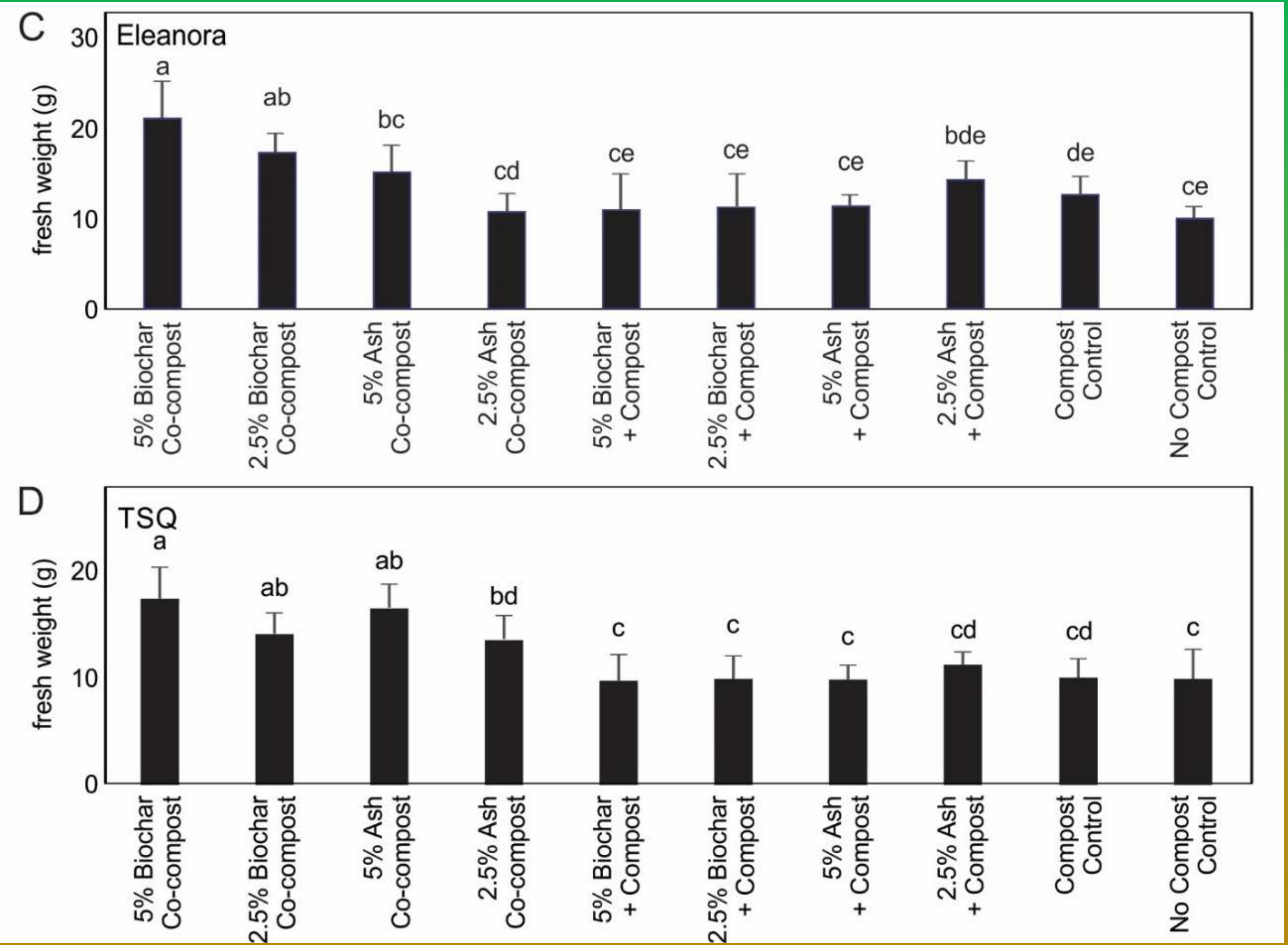
B – Biochar

Awasthi et al, 2016

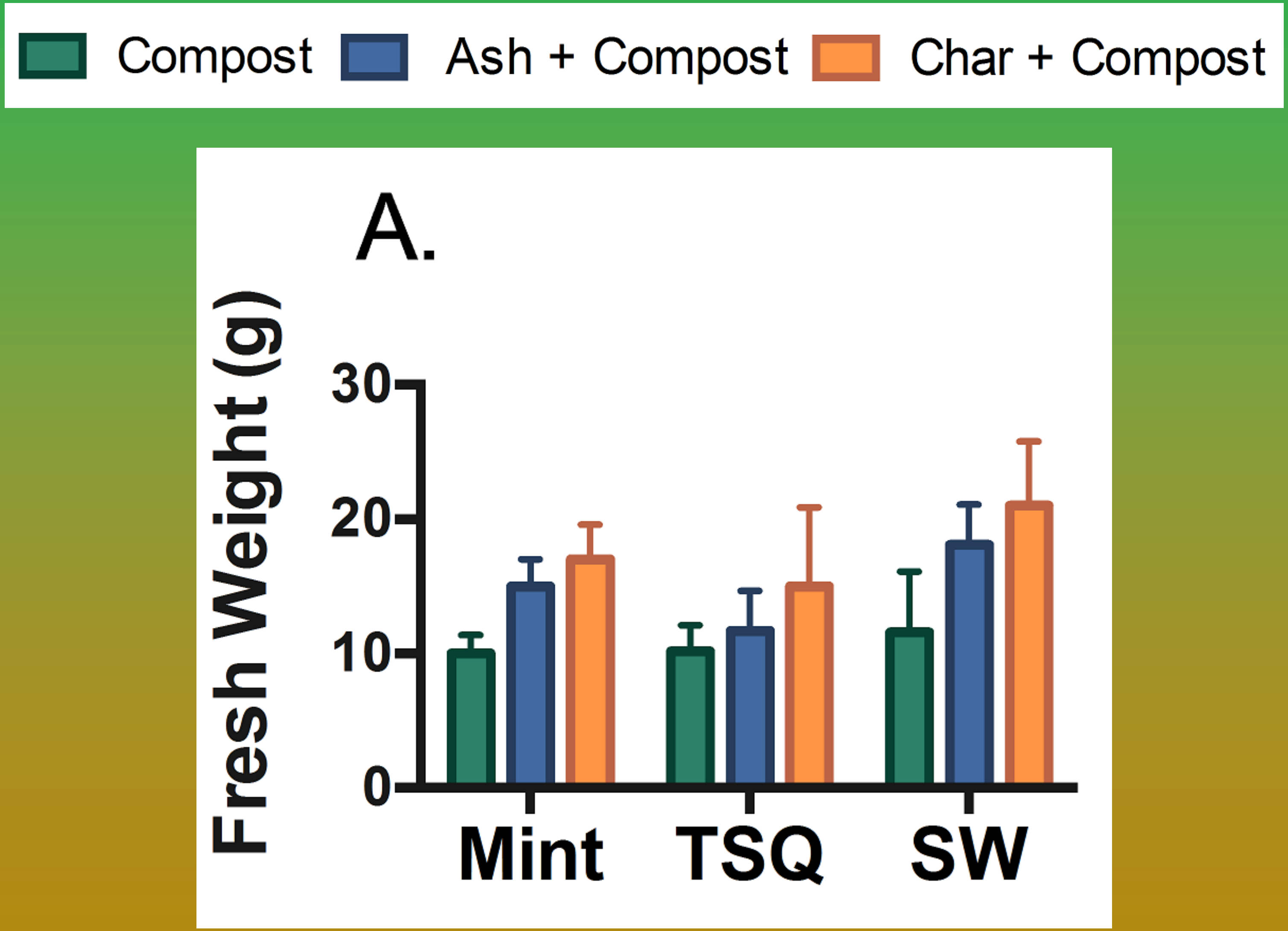


Mark Fuchs November 15, 2017

Biochar co-compost, Basil greenhouse study at WSU


C
Eleanora
fresh weight (g)
0
10
20
30
a
ab
bc
cd
ce
ce
ce
bde
de
ce
5% Biochar Co-compost
2.5% Biochar Co-compost
5% Ash Co-compost
2.5% Ash Co-compost
5% Biochar + Compost
2.5% Biochar + Compost
5% Ash + Compost
2.5% Ash + Compost
Compost Control
No Compost Control
D
TSQ
fresh weight (g)
0
10
20
a
ab
ab
bd
c
c
c
cd
cd
c
5% Biochar Co-compost
2.5% Biochar Co-compost
5% Ash Co-compost
2.5% Ash Co-compost
5% Biochar + Compost
2.5% Biochar + Compost
5% Ash + Compost
2.5% Ash + Compost
Compost Control
No Compost Control

Biochar co-compost, Basil greenhouse study at WSU



Mark Fuchs November 15, 2017

Greenhouse gas analysis for 70,000 cows, 20% v/v food waste

AD w/ Nutrient Recovery	Atmospheric Carbon offset in MMT CO2e/yr
AD methane capture	0.342
Co-digestion methane capture	0.611
Electrical Offset	0.114
Peat replacement (separated fiber)	0.019
Bio-Phosphorous (P recovered from digester solids)	0.003
Bio-Nitrogen (from NH_3 stripping)	0.014
Total	1.103

Mark Fuchs November 15, 2017

Acknowledgements:

- Chad Kruger, Georgine Yorgey, WSU CSANR scientists and staff
  - Shulin Chen, Manuel Garcia-Perez, Craig Cogger …..
- Sally Brown – UW, Forest & Environ. Science
- James Amonette – Soil Scientist, PNNL/WSU
- WSU Energy Program
- USDA, ARS - Steve Griffith, Gary Banowetz
- Philip Small, Kelpie Wilson, Gloria Flora, Tom Miles