Biochar in Field Trials & Characterization Studies

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ISTC

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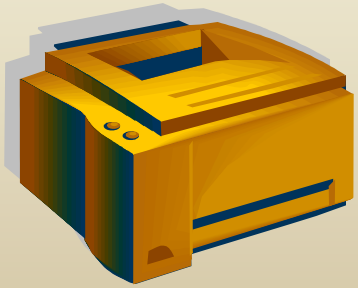
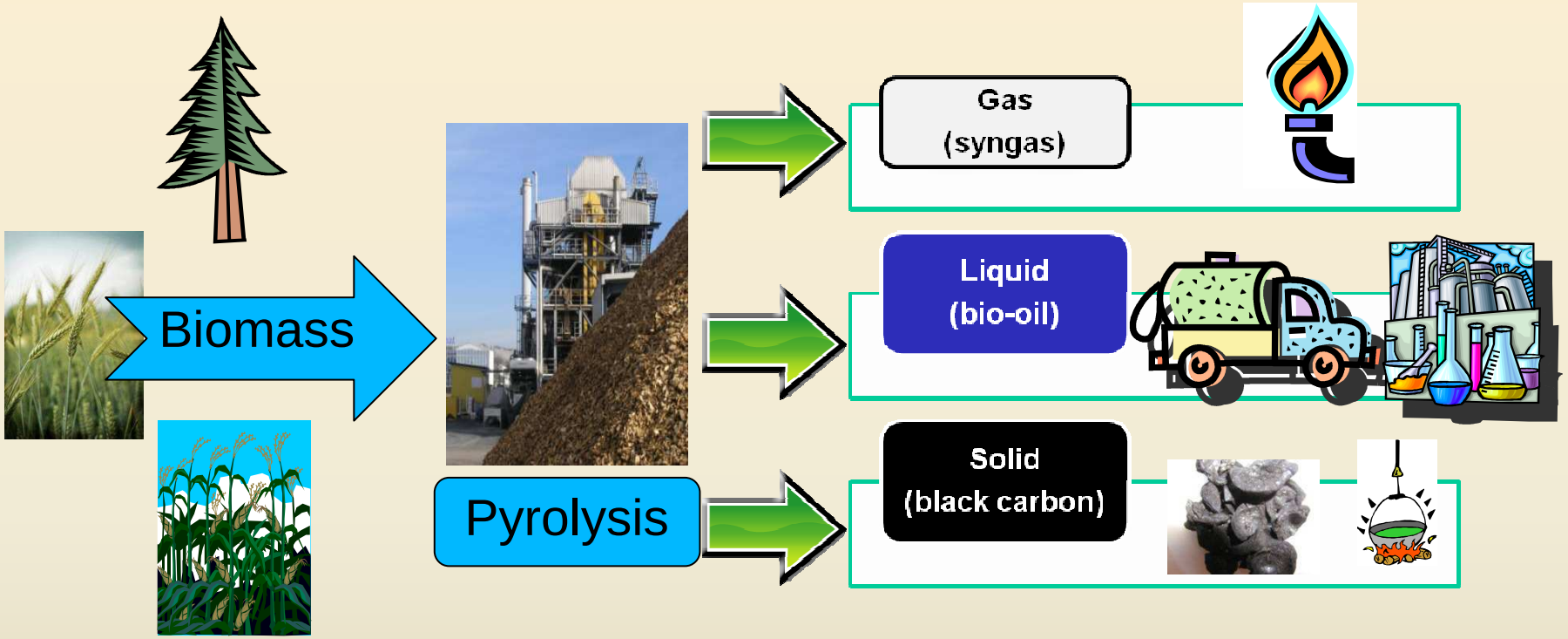
Biochar
What is it ?

Black Carbon

•*Black carbon* is the range of solid residual products resulting from the chemical and/or thermal conversion of any carbon containing material (e.g., fossil fuels and biomass) (Jones et al., 1997)

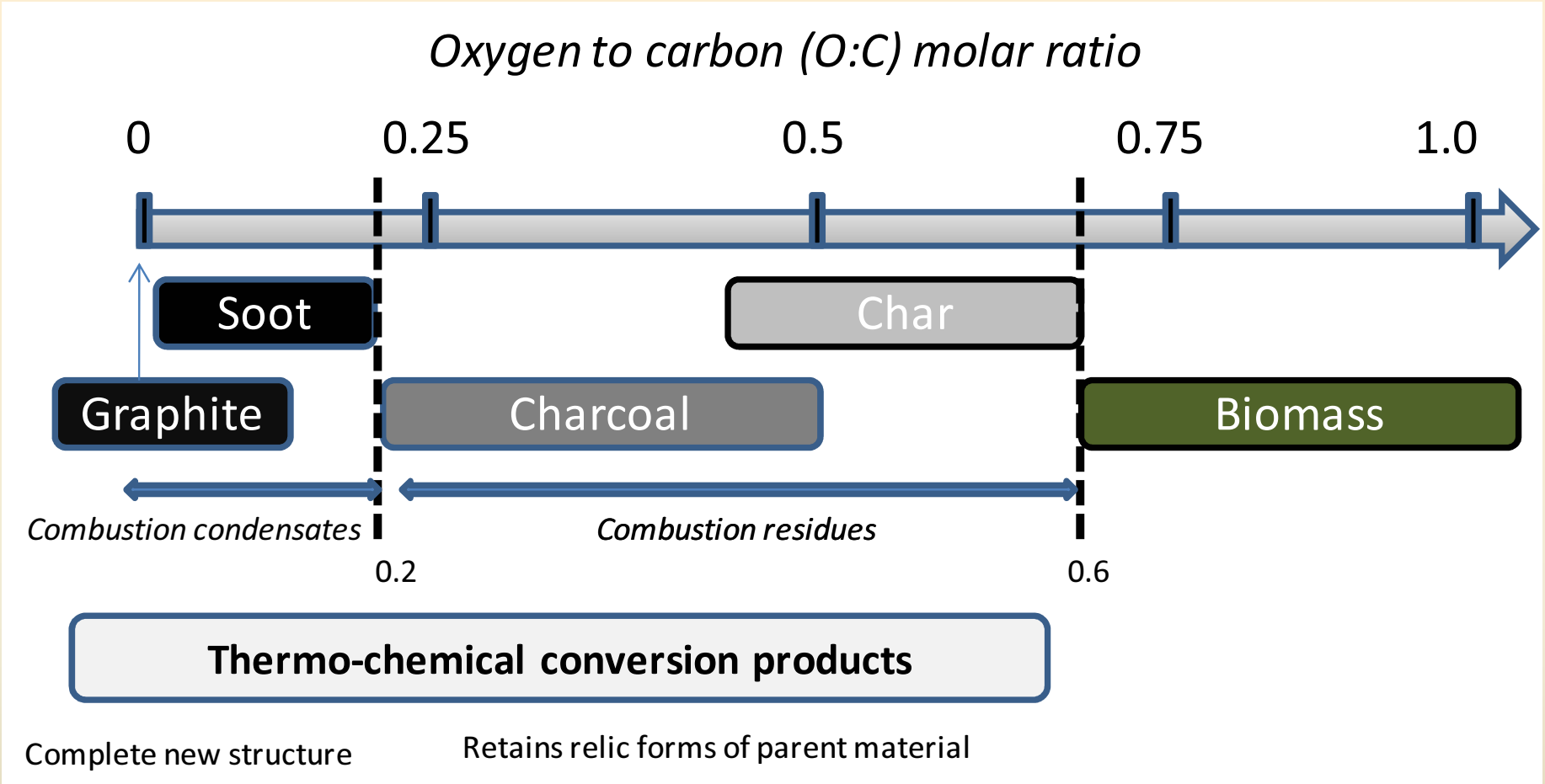


Overview of Pyrolysis



Building Blocks→ Tear apart and reorganize → Form new compounds and chemicals

Black Carbon "Spectrum"



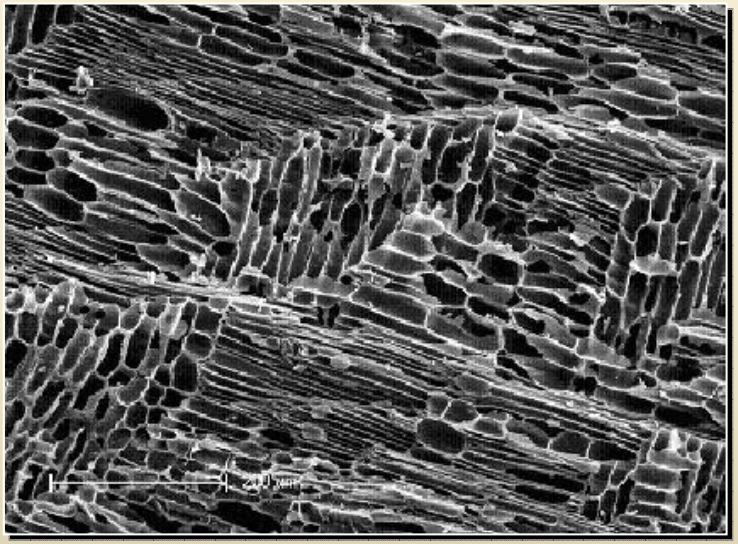
Adapted from Hedges et al., 2000; Elmquist et al., 2006; Spokas, 2010

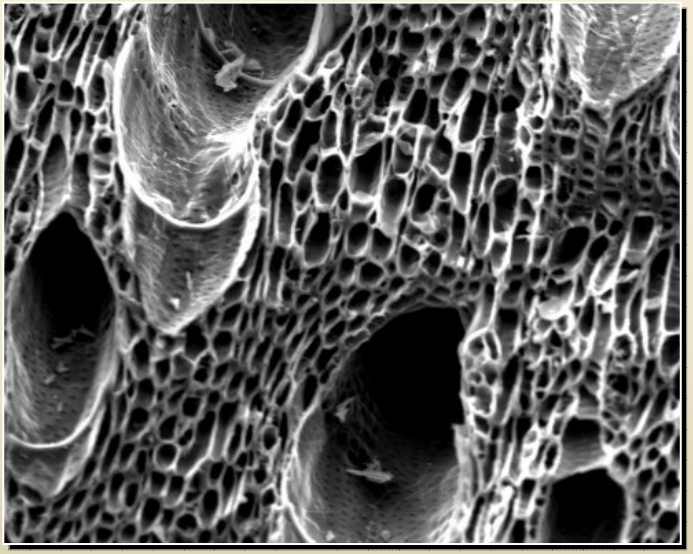
Problem → Lack of nomenclature uniformity

(Jones et al., 1997)

Biochar: Structure

Pyrolysis (biochar)

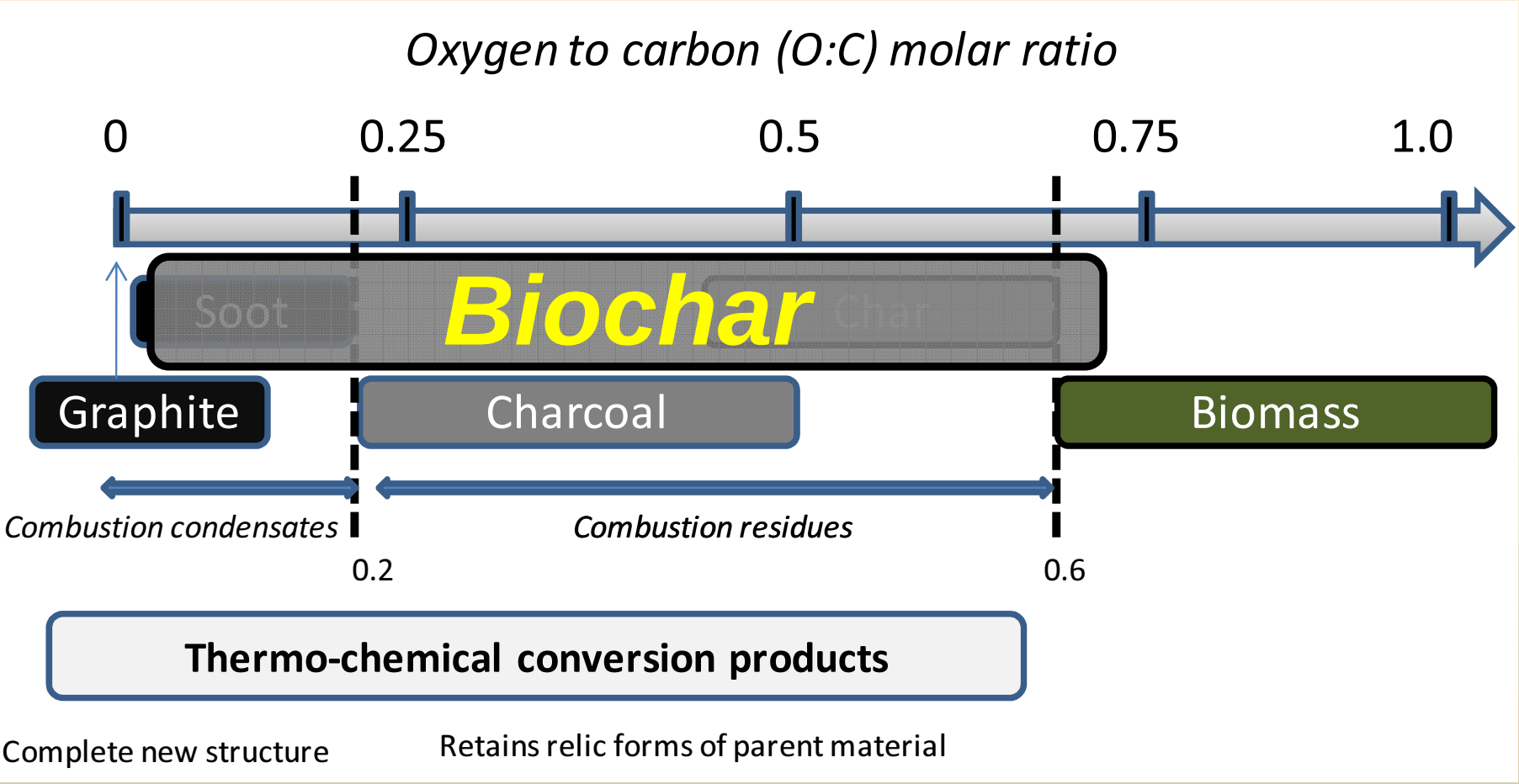




- Biochar : Majority still show relic structures in the biochar

Biochar: Black Carbon Continuum

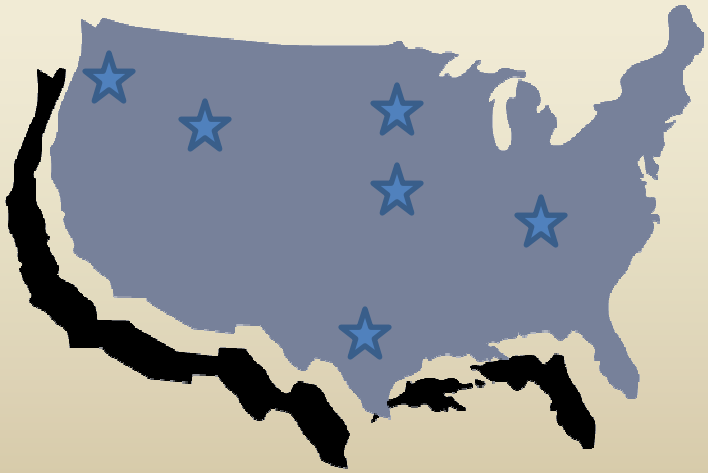
Biochar – Spans across multiple divisions in the Black C Continuum
However, *biochar is NOT a new division or material…*



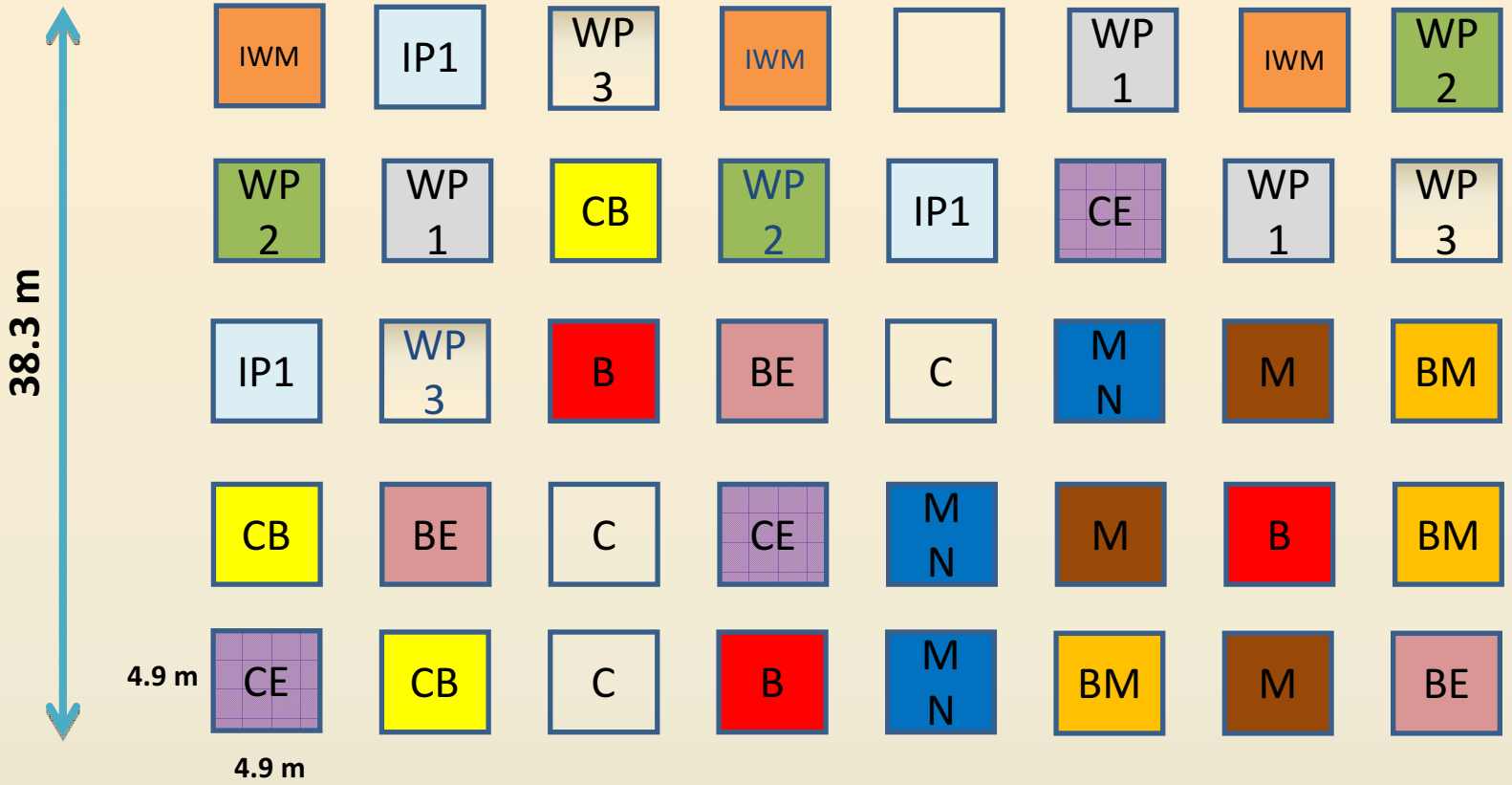
Adapted from Hedges et al., 2000; Elmquist et al., 2006

Multi-location USDA-ARS Effort

- Dynamotive Biochar Project (started Fall 2008)
  - CHARnet :
    - Meeting in Ames, IA (Feb 2012)
    - Continuing project at least another year.
    - No significant differences noted in corn yield
    - 3 manuscripts planned –
      - Soil quality, agronomic impacts, and GHG summary across the 6 locations



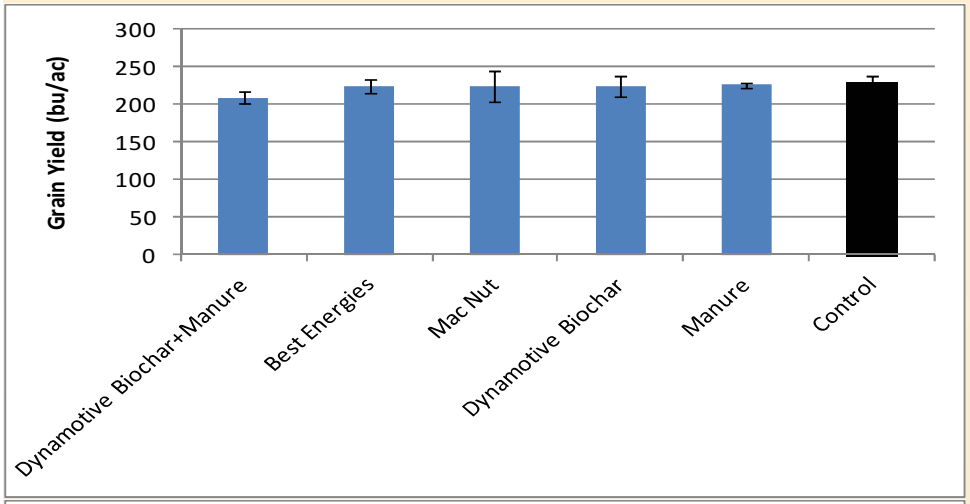
Rosemount, MN : Biochar Field Plots (mini-plots) : 7 different biochars currently



Fall 2008 /Spring 2009
C-CONTROL
B – DYNAMOTIVE FAST PYROLYSIS BIOCHAR (20,000 lb/ac)
BM – DYNAMOTIVE FAST PYRLOYSIS BIOCHAR + MANURE
M – MANURE ONLY
BE - BEST ENERGIES SLOW PYROLYSIS CHAR (20,000 lb/ac)
MN – MACADEMIA NUT BIOCHAR (20,000 lb/ac)
Spring 2010 applications
CE - Chip Energy (wood pellet biochar) (20,000 lb/ac)
CB - Cowboy Lump (hardwood) Charcoal (20,000 lb/ac)

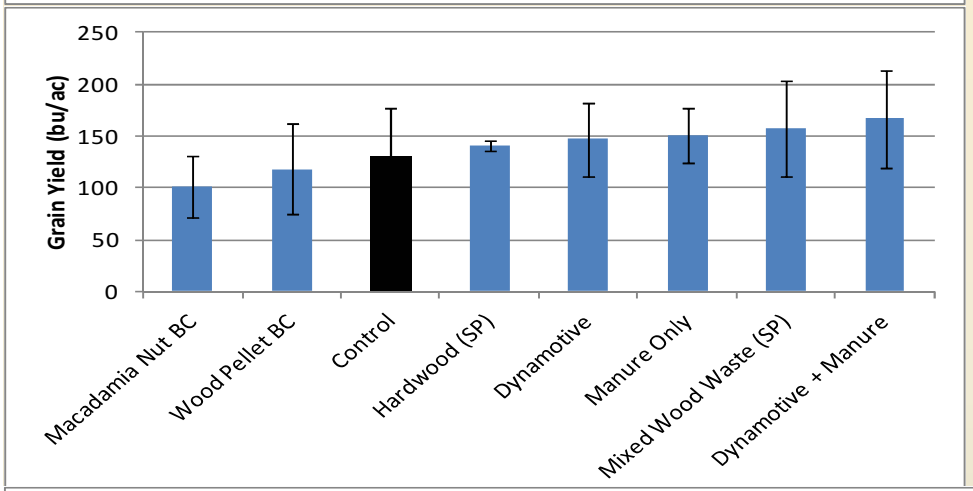
Spring 2011 Applied
WP1 – Wood Pellet (5,000 lb/ac)
WP2 – Wood Pellet (10,000 lb/ac)
WP3 – Wood Pellet (20,000 lb/ac)
IP1 – Pine chip BC from ICM (20,000 lb/ac)
IWM – Wheat midds BC from ICM (20,000 lb/ac)

2012 – Variable rate wood pellet BC (?)
Wheat straw BC (?)



2009 Grain Yields

(no statistically significant differences)

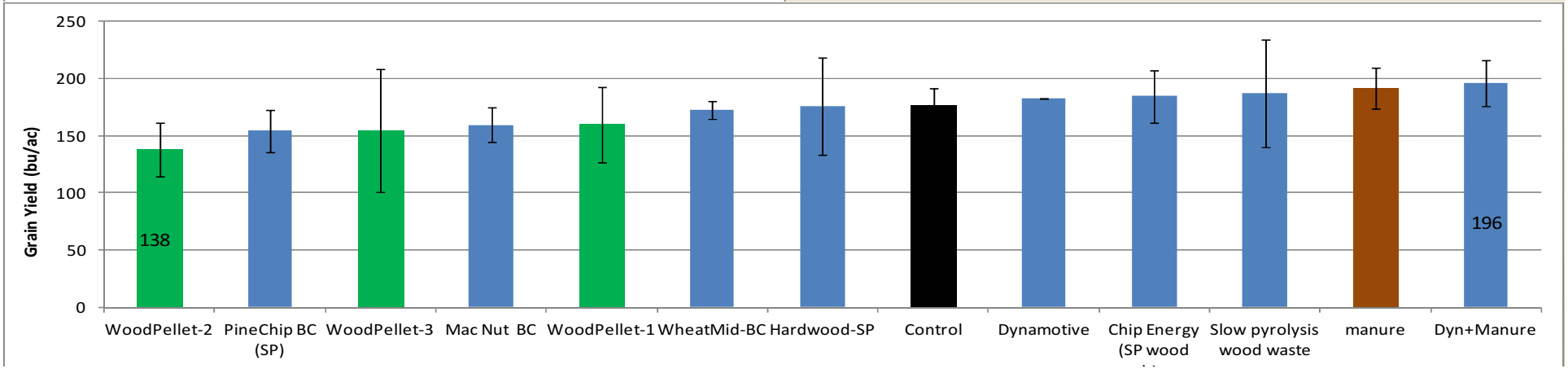


2010 Grain Yields

(no statistically significant differences)
Lower yields than 2009 (no-till residue)

2011 Grain Yields

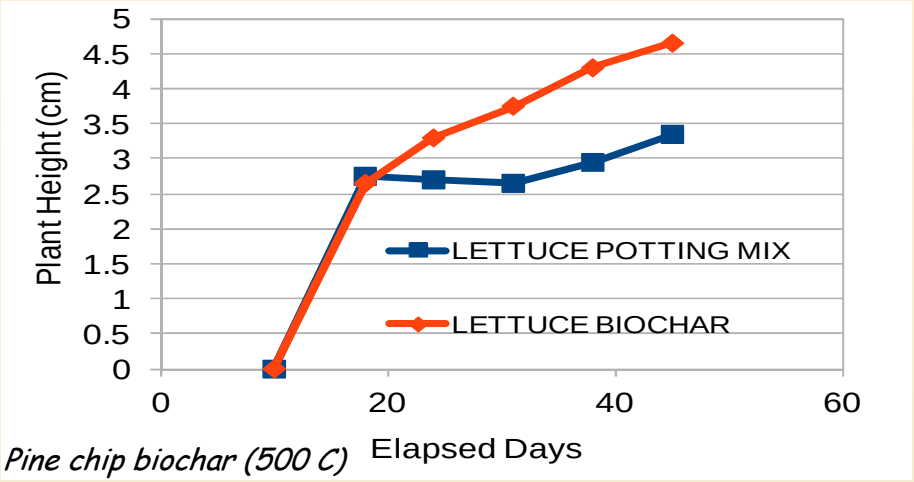
(only sig. dif b/w wood pellet-2 and dyn+manure)



Variability in Biochar Composition

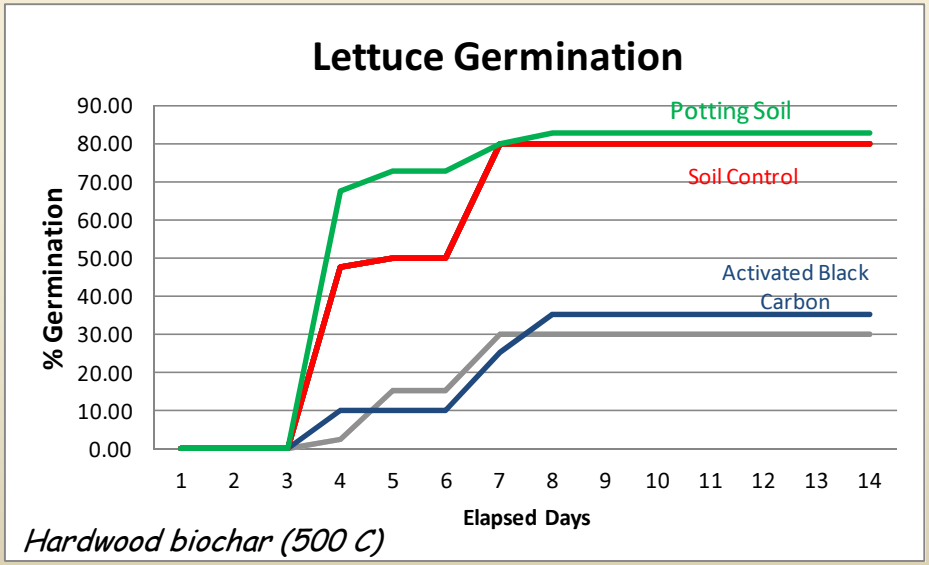
Comparison of compositional analyses* conducted on Dynamotive biochar supplied to ARS locations.							
Characteristic	Florence , SC	Kimberly, ID	St. Paul				*St. Paul*
	---------- % (dry) ----------						*% dry*
			Barrel A	*Triplicates from the same barrel (B) sent to Hazen*			*Barrel C*
Carbon	**72.55**	**67.52**	**74.12**	**62.88**	**69.52**	**63.86**	***61.81***
Hydrogen	2.84	3.18	2.50	2.80	3.06	3.03	
Nitrogen	0.34	0.15	0.11	0.32	0.32	0.22	*0.21*
Organic N							*0.21*
Sulfur	0.02	0.01	0.01	0.01	0.01	0.01	*n.d.*
Potassium (K2O)	0.74	0.41					*0.63*
Calcium	0.52	0.37					*0.42*
Iron	2046 (ppm)	1400 (ppm)					*7353 (ppm)*
Nickel	8.5 (ppm)	4.9 (ppm)					*14.9 (ppm)*
Zinc	6.7 (ppm)	14 (ppm)					*13.2 (ppm)*
Cadmium	0.2 (ppm)	<0.05 ppm					*1.1 (ppm)*
Magnesium	741 (ppm)	1500 (ppm)					*0.04 %*
Manganese	113 (ppm)	118 (ppm)					*199 (ppm)*
pH (DI water slurry)	**5.7**	**6.8**	**1.4**	**5.8**	**4.5**	**5.5**	***0.8***
Oxygen+	15.33	15.15	17.76	11.84	13.06	11.78	
Ash	**8.92**	**14.0**	**5.50**	**22.15**	**14.03**	**21.1**	***15.80***
Volatile	33.69	70.7	54.55	24.52	26.09	26.06	
Fixed C	**57.71**		**39.95**	**53.33**	**56.88**	**52.82**	
O/C	0.158	0.168	0.18	0.14	0.14	0.14	
H/C	0.466	0.561	0.47	0.53	0.53	0.57	
*Ultimate analysis conducted by Hazen, Inc. +By difference							*Midwest Laboratories (Omaha, NE)*

MN Department of Agriculture Project



Pine chip biochar (500 C)

- Varied responses of different crops to various biochars
- Different soil and biochar combinations have different impacts: Some positive and some negative
- Bioaccumulation of sorbed organics on biochar into specialty crops: PAH compounds focus



Hardwood biochar (500 C)

MINNESOTA DEPARTMENT OF AGRICULTURE

No-BC compared to BC (macadamia nut shell – sweet corn)

No Biochar Amendment

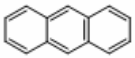
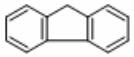
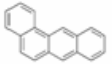
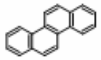
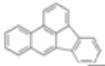
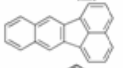
Biochar Amendment

What influences sorbed PAH levels?

- Results to date have been identical to black carbon literature:
  - Moisture content of the biomass
  - Oxygen presence – during production and/or cooling
  - Combustion→

  Presence of “flames” during pyrolysis [↑ levels]

Table 1. The US EPA's 16 priority-pollutant PAHs, chemical structure, CAS number, and chemical formula.

	Polycyclic aromatic hydrocarbon (PAH)	Structure	CAS #	Chemical Formula
1	Naphthalene		91-20-3	$C_{10}H_8$
2	Acenaphthene		83-32-9	$C_{12}H_{10}$
3	Acenaphthylene		208-96-8	$C_{12}H_8$
4	Anthracene		120-12-7	$C_{14}H_{10}$
5	Phenanthrene		85-01-8	$C_{14}H_{10}$
6	Fluorene		86-73-7	$C_{13}H_{10}$
7	Fluoranthene		206-44-0	$C_{16}H_{10}$
8	Benzo(a)anthracene		56-55-3	$C_{18}H_{12}$
9	Chrysene		218-01-9	$C_{18}H_{12}$
10	Pyrene		129-00-0	$C_{16}H_{10}$
11	Benzo(a)pyrene		50-32-8	$C_{20}H_{12}$
12	Benzo(b)fluoranthene		205-99-2	$C_{20}H_{12}$
13	Benzo(k)fluoranthene		207-08-9	$C_{20}H_{12}$
14	Dibenz(a,h)anthracene		53-70-3	$C_{22}H_{14}$
15	Benzo(g,h,i)perylene		191-24-2	$C_{22}H_{12}$
16	Indeno[1,2,3-cd]pyrene		193-39-5	$C_{22}H_{12}$

- **ASA biochar group**
  - Meeting will be in October 21-24, 2012 at the ASA/SSSA/CSSA annual meetings in Cincinnati
    - "Biochar researcher of the year award" (nominations being accepted)
    - Graduate Student Award
    - Best Presentation Award – Voted on by attendees

- Be sure to submit abstracts to :

  Biochar Effects On Soils, Plants, Waters, and Greenhouse Gas Emissions

  - We will be electing new "vice-president" of the biochar community in Cincinnati