Northwest Biocarbon Summit
Monday, June 10th
University of Washington's Center for Urban Horticulture

The Sustainable Biochar System

Terrestrial Carbon Harvesting for Green Energy Production, Soil Building, Environmental Remediation and Carbon Sequestration

Collaborative Biochar Research Initiative

John Miedema, BioLogical Carbon, LLC, Philomath, OR

Markus Kleber, Oregon State University, Corvallis, OR

Overarching Goal- Resilient Sustainable Communities

- **Necessarily Local**
- **Local Food-Local Energy-Local Employment—Local PEOPLE**
- **A Technological Revolution**
- Creating **new pathways** in resource management
- **Involves** Comprehensive Anticipatory Design Science
- Co-Location of systems
- **Requires New methodologies** which can reverse the destructive trends that current economic methodologies have brought about.
- **Turning Wastes into Resources**, continually looking to improve the use efficiency of energy and materials
- **A shift** in the economic emphasis of continual growth to an emphasis on the **Economics of Permanence** ---

Our Challenges in Agriculture

1. Improve productivity of our soils:

   There is limited potential for land expansion for cultivation; 85 per cent of future growth in food production must come from lands already under production. (Banowetz USDA-ARS)

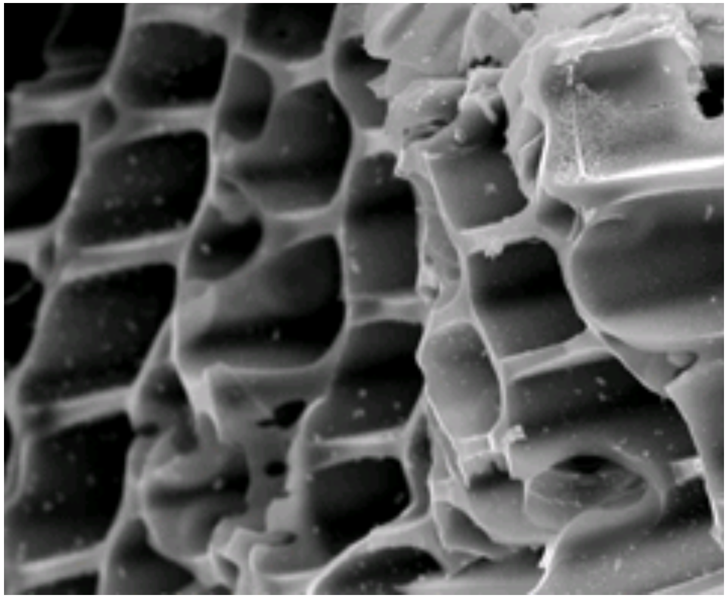
2. Reduce the cost of production

   - Revive rural economies
   - Replace purchased inputs with locally-produced alternatives (energy, fertilizers, etc).

3. Create sustainable rural jobs and decentralized (integrated) power production.

What is Biochar?

Biochar is a fine-grained, highly porous charcoal that helps
soils retain nutrients and water. IBI



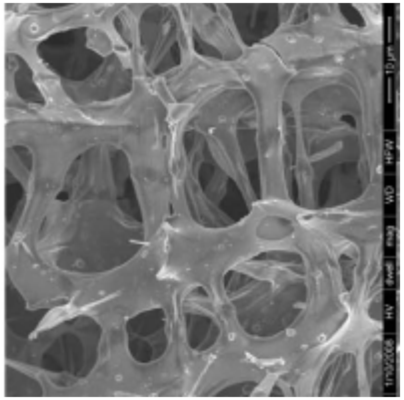
COLLINS

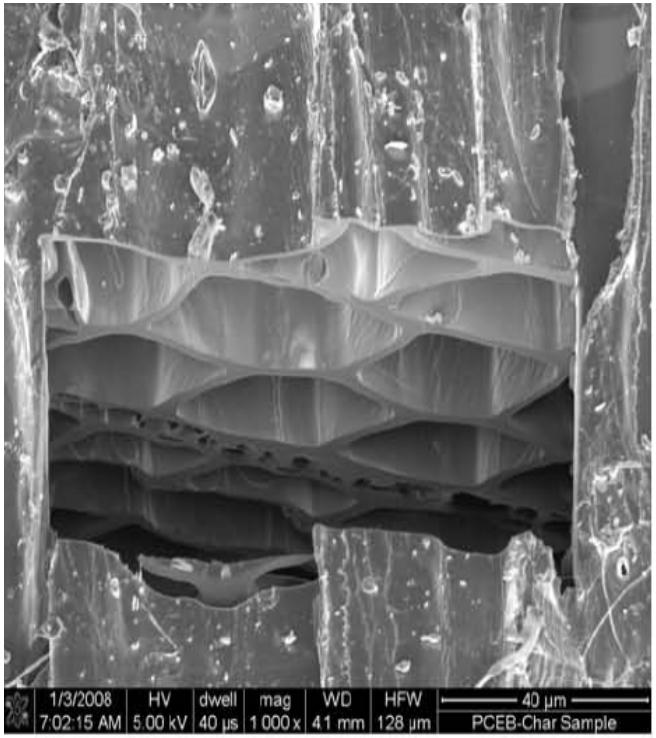
What is Biochar?

Is produced by the thermal cracking of biomass in an oxygen <u>controlled environment</u>.

Results In:

- Stable compounds of single and condensing ring aromatic carbon
- High surface area
- Nutrient retention and capture (NH_4^+, K^+, Ca^{2+}, Mg^{2+}, P etc.)
- High ion exchange capacities (CEC and AEC)
- Increased pH
- Changes in physical properties
  - water retention
  - reduced soil density
  - increased porosity/aeration





Corn Cob and Pine Wood Char
Courtesy of J. Amonette

The Origin of Biochar:

Amazonian Dark Earth (Terra Preta de Indio)

Heavy clay soils on high bluffs above Amazon river
low pH (3.5-4), high iron, high alumina, high leaching

Abundant Crops Grow on Enriched Soils

No Char
Hi Iron
pH 3.6

Char Only
Terra Mulata
pH 4.4

Char + Waste
Terra Preta de Indio
pH 5.3-5.7

Papaya
Biochar+ Fertilizer

Cupuaçu

Cacao Pod and Bean

Manioc root

IBI

BIOCHAR AMENDED SOILS HAVE HIGH FERTILITY

General Philosophy – biochar investigation

The potential benefits of sustainable biochar production:

Food Security

Energy Security

Job Creation

Water Clean-up

Environmental Revitalization

Carbon Sequestration

are so great, we would be remiss for not engaging wholly in rigorous study of the entire biochar system, to scientifically prove or disprove the validity of the system…

Production Pathways

Major Techniques:

Slow Pyrolysis-- chars produced in presence of steam at 350-600 C tend to be acidic to slightly basic (carboxylic acid groups activated)

traditional (dirty, low char yields) and **modern** (clean, high char yields)

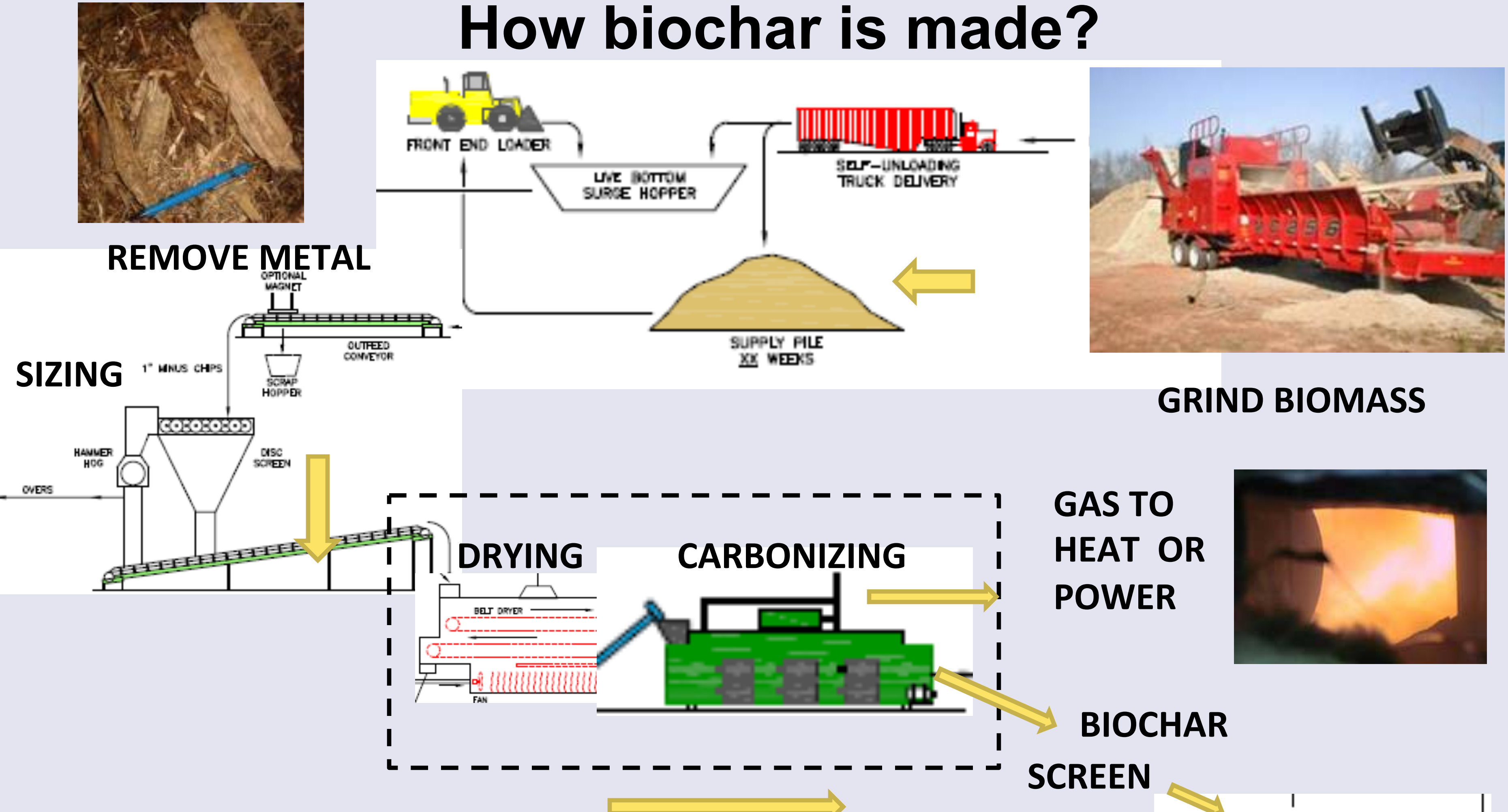
Fast Pyrolysis-- chars produced in absence of steam at 500 C tend to be slightly basic

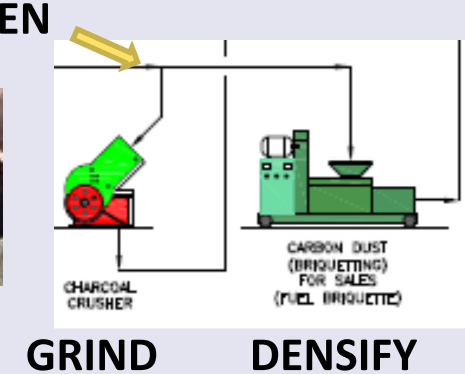
modern, maximizes bio-oil production, low char yields

Gasification-- chars produced in presence of oxygen or steam at 700°C tend to be very basic and make good liming agents

modern, maximizes gas production, minimizes bio-oil production, low char yields but highly recalcitrant

How biochar is made?





Pyrolysis: 3 DRY TON BIOMASS--> 1 TON BIOCHAR + 16 MMBtu (1 MWhe)

Gasification: 8 DRY TON BIOMASS->1 TON BIOCHAR + 100 MMBtu (6.3 MWhe)

T R Miles Technical Consultants, Inc.

Biochar Can Be Made From Different Feedstocks

Urban and Forest Wood

ICM GASIFIER

Wood Char

Wheat Straw or Corn Stover

Straw Char

www.icminc.com/services/gasifiers

Biochar Is Made at Small and Large Scales

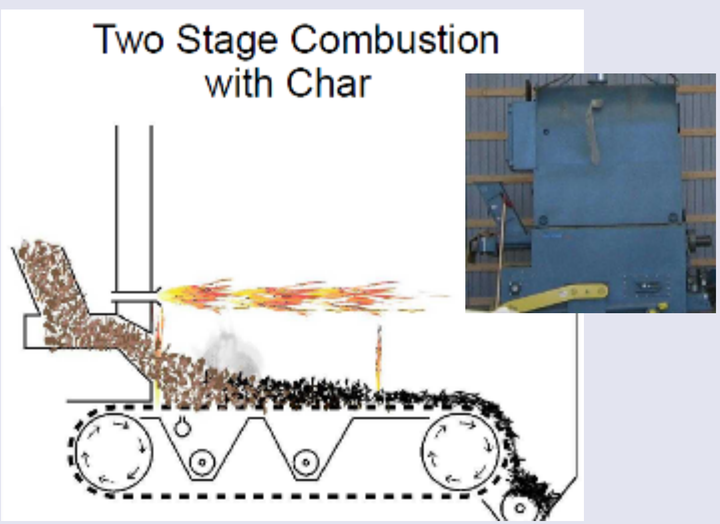
Greenhouse scale heat and biochar NE Biochar 1 t/10h

BOILERS

3 MMBtuh Hot Water 25% Char+Ash

GASIFIERS

ICM 4-8 tph



Burt's Greenhouses Ontario, CAN

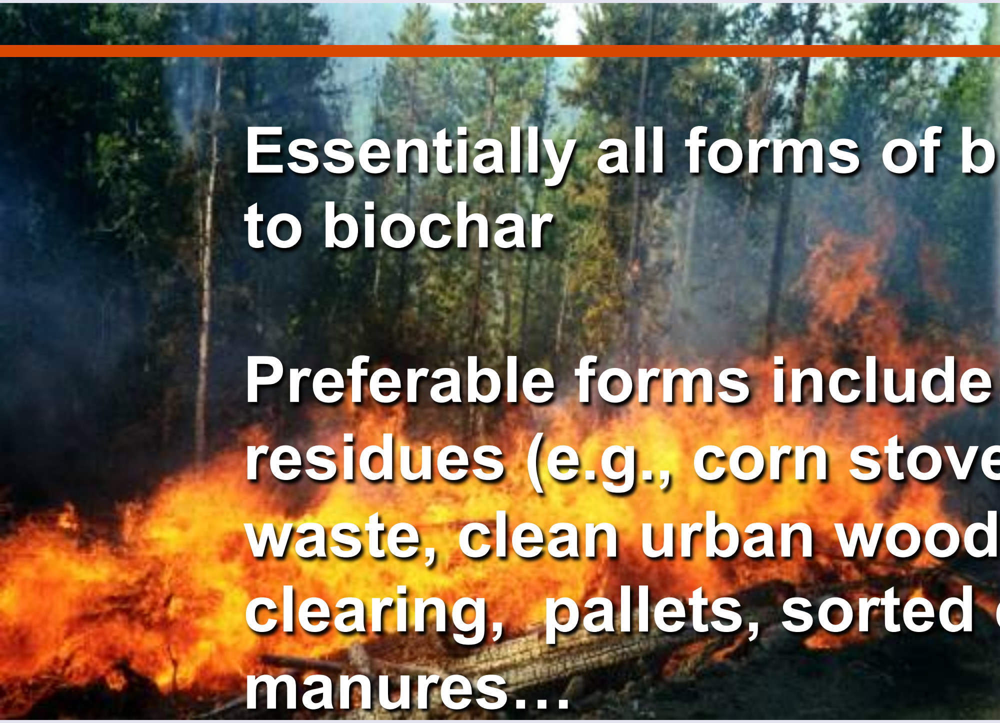
BioChar TLUD Cook Stove Seachar.org

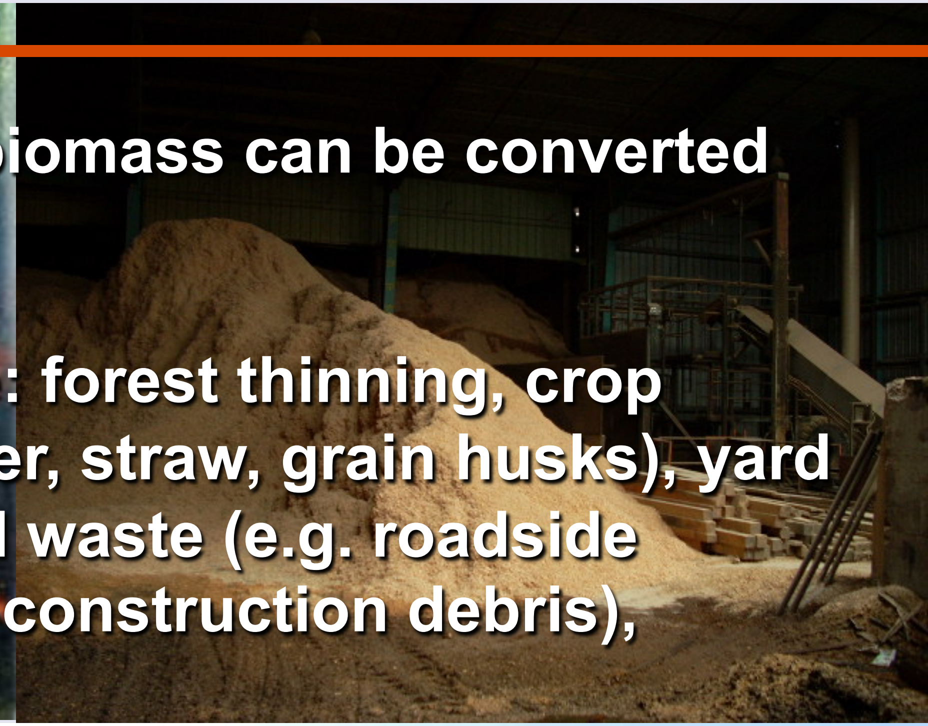
Mobile Pyrolysis Black is Green (BIG) AUS

Sources of Feedstock

Essentially all forms of biomass can be converted to biochar

Preferable forms include: forest thinning, crop residues (e.g., corn stover, straw, grain husks), yard waste, clean urban wood waste (e.g. roadside clearing, pallets, sorted construction debris), manures…





Fossil Carbon Energy System

vs.

Terrestrial Carbon Biochar System

Fossil fuels are carbon-positive – they add more carbon to the air.

Ordinary biomass fuels are carbon neutral – the carbon captured in the biomass by photosynthesis would have eventually returned to the atmosphere through natural processes – burning plants for energy just speeds this process up.

Biochar systems can be carbon negative
because they retain a substantial portion of the carbon fixed by plants.

The result
is a net reduction of carbon dioxide in the atmosphere.

The positive feedback loop--

Utilization of low value material for energy production while creating a value added product.

Sustainable biochar production
based on sound **integrated design science** offers recurring economic, social, and environmental benefits in a positive feedback loop–

•Marginal lands show dramatic gains in net primary productivity when biochar is added to the system**.**

•Bioenergy co-product being utilized as a tool in nutrient control, storm water clean up and contaminated land remediation **--- metal and organic toxin adsorption**

•**Properly Designed Systems** reduce atmospheric CO_2 while building environmental health

Integrated Systems

: the key to sustainability

On The Farm

- energy production, process heat for food production, home, shop, green house and barn heating, vermiculite substitute, nutrient control…

In The Forest

-fuel load reduction/ energy densification

Nutrient control

Greenhouse, boiler, biochar stirling engine (DK)

Green Industrial Parks

-locations at former mill sites

utilization as thermal drive for industrial processes

Co-Location with other renewable energy systems

-In order to gain reliability – sun and wind intermittent,

utilization of waste heat for process energy in biofuel production

Co-Location with biological waste streams

-Inherent ability of to turn waste into energy, value added products

Research Philosophy: Specific

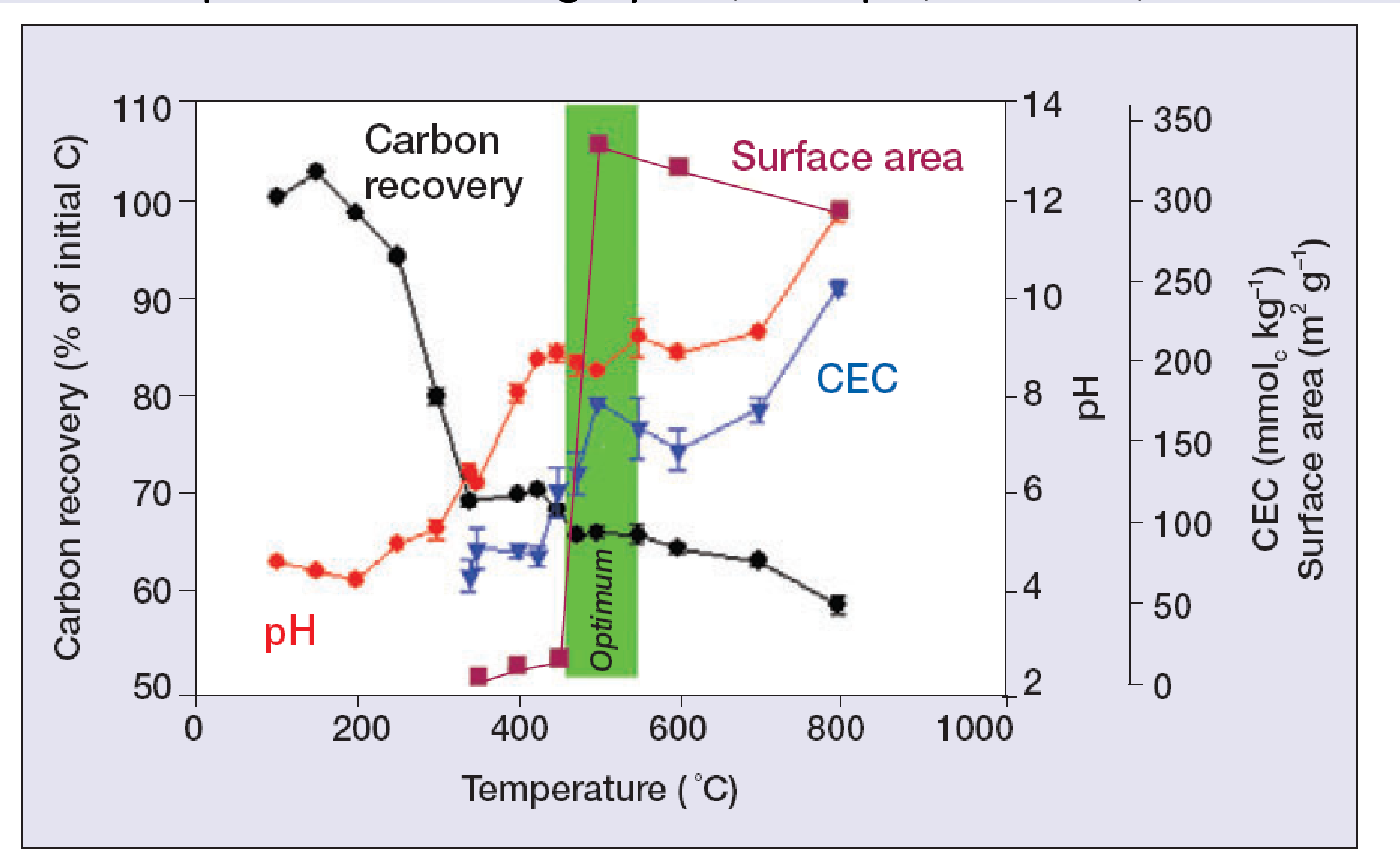
1.) Produce **energy from biomass,** ensuring that no additional carbon is released into the atmosphere

2.) **Remove CO_2 from the atmosphere** by converting part of the feedstock not into energy, but into a “stable” form (= char) from which it will not return to the atmosphere for a long time

3.) **Improve soil** by taking advantage of the unique physicochemical properties of artfully prepared chars to enhance fertility, modify physical properties, decontaminate soil and water resources

Feedstocks and Process Conditions
Determine Biochar Properties

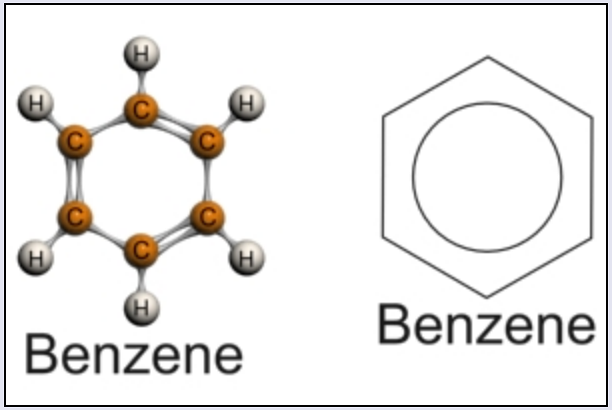
High temperatures -> Low yield, high CEC, high BET
Low temperature -> High yield, mid pH, mid CEC,



LEHMANN

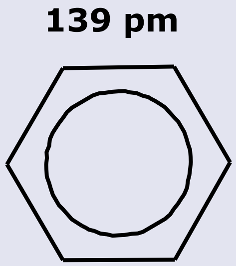
The aromatic ring

is kinetically **stable**



This is accounted for by **delocalization**.

The more the electrons are spread around (= delocalized) - the more stable a molecule becomes.



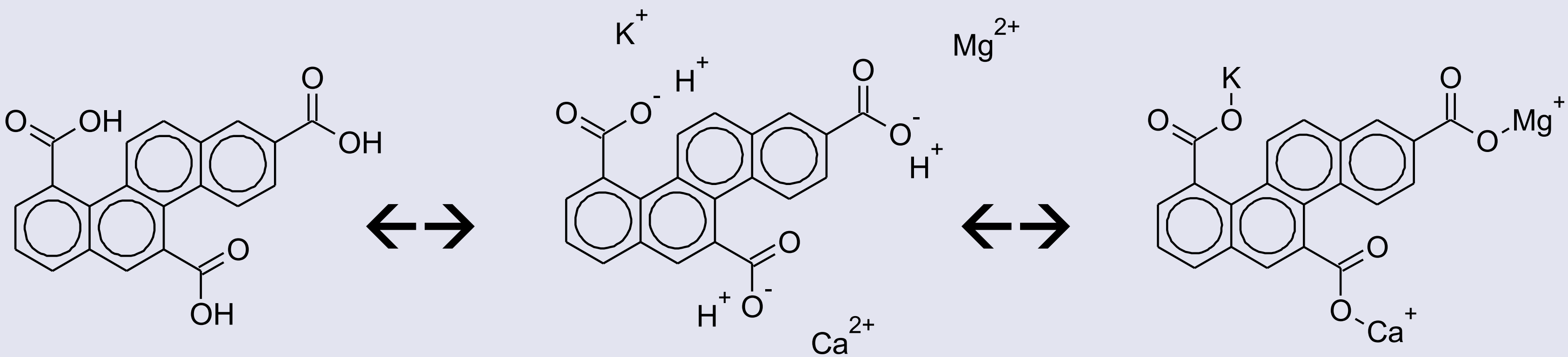
This extra stability is often referred to as "delocalization energy".

Long bonds = **weak** !

Short bonds = **strong** !

How can aromatic carbon increase health?

Oxygen containing groups can ionize (develop negative charge) and so electrostatically attract ions that are positively charged (exchangeable cations).



Many critical mineral nutrients of plants are cations, such as Potassium (K^+) , Calcium (Ca^{2+}), Magnesium (Mg^{2+})

These mechanisms aid in the capture and sorption of inorganic and organic toxins

Biochar Markets Ready For Development

Soil remediation and storm water nutrient management
- urban
- industrial
- agriculture
- mine tailings
- Brownfields/Superfund sites

Horticultural Products
- nursery
- urban landscaping
- community gardens

Turf establishment and maintenance
- parks
- golf courses
- sports fields

Agricultural Crops
- soil amendment, e.g. biochar + digested solids, composting

Research Partner Inspecting Seedlings Grown in Media with Biochar

All testing except where noted, has been performed by an independent accredited lab
Copies of the lab test results are available for varification to facts stated below.

Test Date	Item Tested For	Pre Treatment Result	Post Treatment Result	Removal Efficiency
7/27/2011	COPPER	323 µg/L	120 µg/L	63%
	LEAD	12.7 µg/L	7.72 µg/L	39%
	ZINC	1600 µg/L	474 µg/L	70%
5/13/2011	Phosphorus	.62 mg/L	.52 mg/L	16%
	Total Suspended Solids	2600 mg/L	270 mg/L	90%
	COPPER	.053 mg/L	.027 mg/L	49%
	LEAD	.045 mg/L	.019 mg/L	58%
	ZINC	.24 mg/L	.13 mg/L	46%
4/18/2011	ZINC	1400 µg/L	120 µg/L	91%
3/31/2011	ZINC	4800 µg/L	130 µg/L	97%
1/20/2011	Turbidity* (done onsite with LaMotte 2020e meter)	62.2 NTU	9.59 NTU	85%
	ZINC	730 µg/L	40 µg/L	95%
1/6/2011	ZINC	2100 µg/L	260 µg/L	88%
1/6/2011	ZINC	3670 µg/L	402 µg/L	89%
	ZINC	2710 µg/L	193 µg/L	93%
12/27/2010	ZINC	430 µg/L	61 µg/L	86%
	Dissolved ZINC	200 µg/L	8.5 µg/L	96%
	COPPER	49 µg/L	9.6 µg/L	80%
	Dissolved Copper	1.4 µg/L	1.1 µg/L	21%
12/27/2010	ZINC	273 µg/L	60.1 µg/L	78%
8/25/2010	ZINC	1700 µg/L	26 µg/L	98%
	LEAD	5.4 µg/L	1.8 µg/L	67%
6/24/2010	ZINC	420 µg/L	170 µg/L	60%
	LEAD	12 µg/L	8.3 µg/L	31%
	COPPER	41 µg/L	21 µg/L	49%

Biochar Improves Storm Water Clean Up

A roof drain tote built for *zinc* removal

Biochar in Filtration Mix

Improved storm water quality

Sunmark Environmental

Sustainable Urban Strategies

Street runoff filtered through vegetation and compost/biochar/ soil

Biochar Aids Revegatation

Jory clay cut slope where nothing had grown for 10 years.

After revegetation with PermaMatrix and biochar

Sunmark Environmental

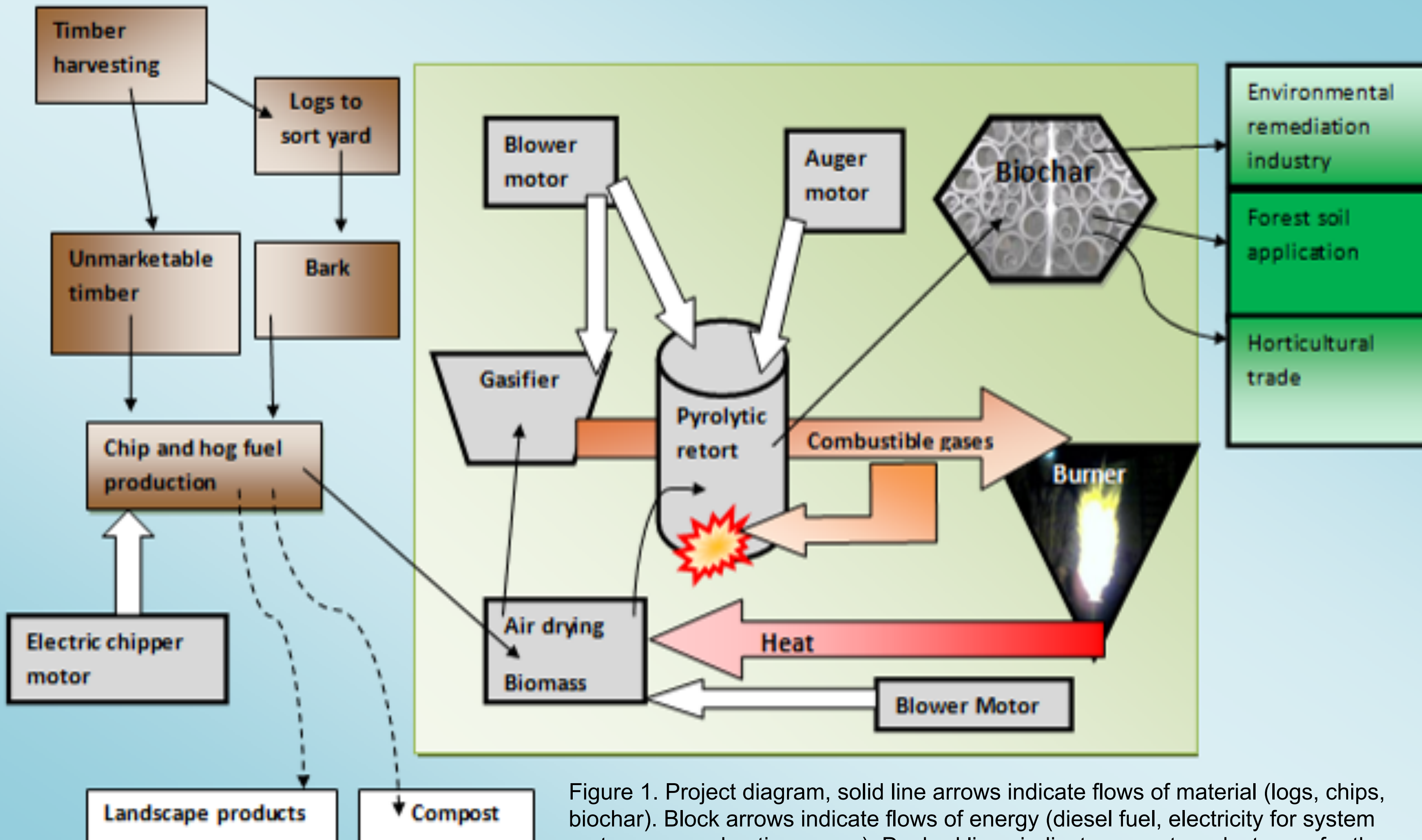


Figure 1. Project diagram, solid line arrows indicate flows of material (logs, chips, biochar). Block arrows indicate flows of energy (diesel fuel, electricity for system motors, or combustion gases). Dashed lines indicate current product uses for the wood waste.

The Fluidyne Pacific Class Gasifier

www.fluidynenz.250x.com/

Thermal Drive

Fuel use:

45 kg/hr

Flame temp

1000 C

500,000 BTU

37 KW

Industrial Lego's

SAM—Sustainability Advancement Machine

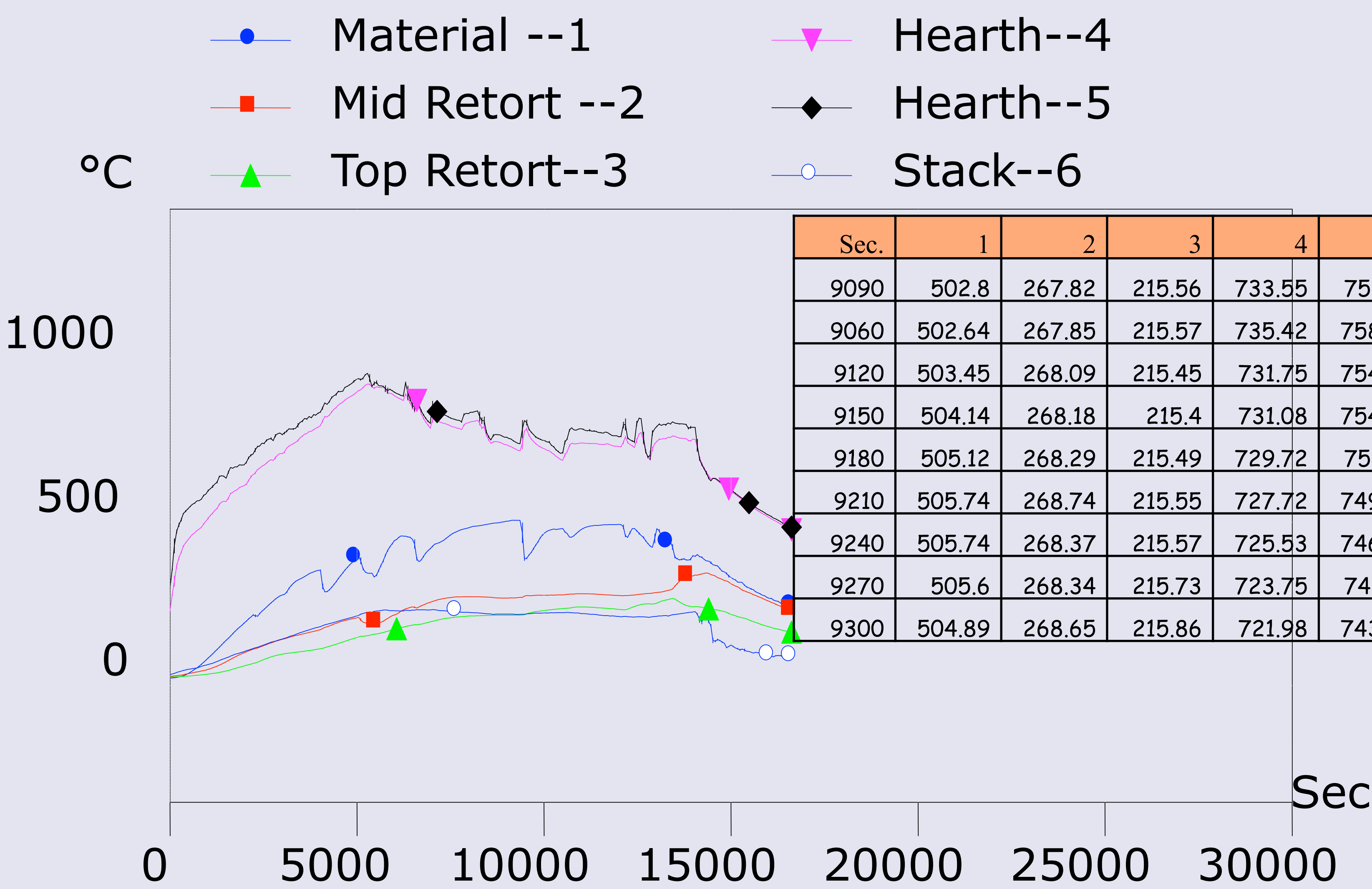
Would give me the ability to make chars under controlled conditions so we could investigate the efficacy of use

In-feed hopper and valve

Pyrolytic Flare

Biochar

Initial Data



Sec.	1	2	3	4	5	6
9090	502.8	267.82	215.56	733.55	756.31	218.7
9060	502.64	267.85	215.57	735.42	758.94	218.96
9120	503.45	268.09	215.45	731.75	754.48	218.61
9150	504.14	268.18	215.4	731.08	754.86	218.6
9180	505.12	268.29	215.49	729.72	752.81	218.57
9210	505.74	268.74	215.55	727.72	749.72	218.53
9240	505.74	268.37	215.57	725.53	746.82	218.2
9270	505.6	268.34	215.73	723.75	745.14	217.92
9300	504.89	268.65	215.86	721.98	743.44	217.76

Further Information and Contacts

John Miedema
jmiedema@peak.org
BioLogical Carbon, LLC
Philomath Oregon
541-619-0007

Tom Miles
tmiles@trmiles.com
www.trmiles.com
TR Miles Technical Consultants,
Portland Oregon
503-292-0107

Markus Kleber
Markus.Kleber@oregonstate.edu
Professor, Crop and Soil Science
Department
Oregon State University