



# ***Biochar - What and Why?***

Tom Miles, NW Biochar Working Group

[www.nwbiochar.org](http://www.nwbiochar.org)

Renel Anderson, Biochar Supreme

[www.biocharsupreme.com](http://www.biocharsupreme.com)



**San Juan Islands Agricultural Summit**

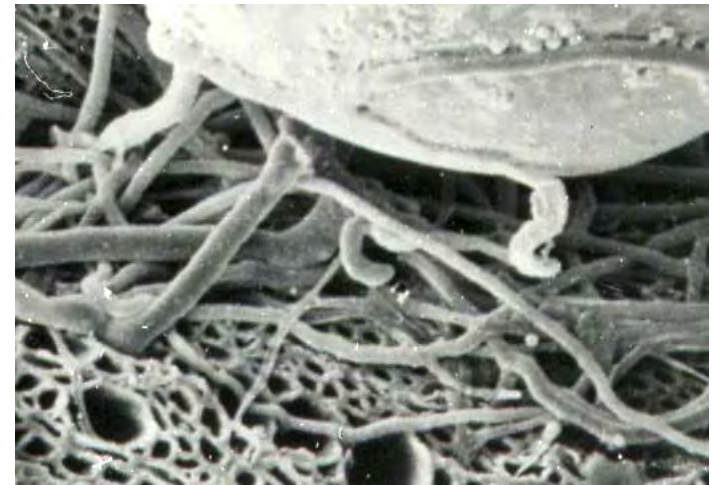
**Orcas Island High School**

**March 8, 2014**



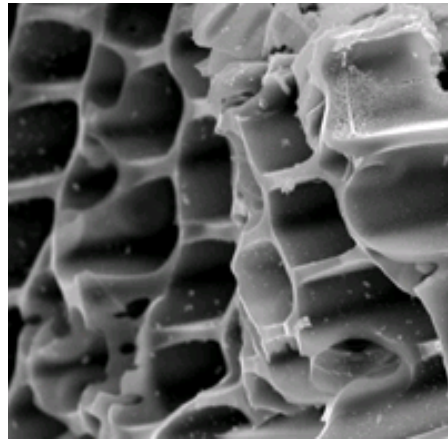
# *What is Biochar?*

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



**Mycorrhizal fungal hyphae  
growing from spore base invade  
large charcoal pores**

**Ogawa 2004**



**Collins 2009**





# ***The Origins 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



International Biochar Initiative  
Brazil Field Trip, September 2010



# ***Charcoal and Nutrients Enriched Poor Soil***

- Terra Preta Ingredients: charcoal, fish bones, food waste, excrement, soil
- Anthropogenic soil: 30 in (75 cm) pH 5-6; P 100-300x; Zn 10 x; high base sat; low Fe sat
- Crops: Manioc, papaya, mango, corn, oranges, cacao, banana, cupuaçu



Costa Laranjal, Amazonas, BR





# Abundant Crops Grow on Enriched Soils



No Char  
Ferralsol  
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 (Cassava) root

# Why Biochar Today?

- **Carbon Smart** - Grow carbon **negative** food
  - Add carbon to soil, reduce fossil inputs
- **Improve soil fertility**
  - Physical (texture)
  - Chemical (pH, cation exchange)
  - Microbial habitat
  - Suppress root borne disease
  - Remediate soils
  - Retain water
- **Improve nutrient management**
  - Improve nutrient use (N, P, K, micro)
  - Recycle manure (Co-composting w/char)
- **Improve water quality**
  - Reduce nutrient loss
  - Reduce metal contamination
  - Improve bioremediation





# ***Biochar Promotes Healthier Soils and Crops***

## **Agronomic Benefits**

### **SOIL STRUCTURE-**

**Amend root zone**

**Increase porosity, WHC, CEC**

**Reduce compaction**

### **PLANT HEALTH -**

**Resist disease Pythium, Fusarium**

### **ENHANCED ROOT GROWTH**

**Frankia Sp. N fixing**

### **NUTRIENT FILTER -**

**Capture, use NPK  
efficiently**

### **ESTABLISHMENT**

**Seed coating**

**Microbe Carrier**



**0% biochar on left,  
20% biochar on right**



**Corn in poor soil (Left) and  
Biochar Amended Soil (Right)**

# *Biochar Helps Grow Trees*

## Agronomic Benefits

### SOIL STRUCTURE-

Vermiculite substitute

### COMPOST AID -

Peat substitute = Compost + Biochar

### PLANT HEALTH -

Inhibits root disease

Nutrient (P) carrier for poor soils



2008  
Calforest  
Nurseries



Ponderosa Pine in Soilless Media with  
Vermiculite (Left) and Biochar (Right)



# Biochar Helps Re-vegetation, Environmental Remediation, and Urban Farming



## BIOCHAR IN HYDROSEEDING AND FILTERS

[www.permamatrix.com](http://www.permamatrix.com)

## URBAN FARMING

GREEN ANCHORS

[www.facebook.com/greenanchorspdx](https://www.facebook.com/greenanchorspdx)

# Biochar Improves Water Quality



## LOW IMPACT DESIGN:RAIN GARDENS/STORM DRAINS

WSU Low Impact Development Center



DEMOS: 8 Cities  
RESEARCH:

- OSU – MS, MBA
- EPA Corvallis
- WSU Puyallup
- Stanford/CSM



## ROOF DRAINS



## BIOCHAR IN COMPOST ROLLS AND BIO BAG FILTERS FOR SURFACE RUNOFF



# ***Biochar Improves the Environment***

- Reduce nitrous oxide emissions 50-80%  
(Rondon, Ramirez, and Lehmann, 2005)
- Reduce phosphorus and nitrogen in groundwater
- Increase soil carbon- reduce atmospheric CO<sub>2</sub>
- Reduce forest fuel load
- Revitalize Brownfield sites
- Sequester carbon



**Opportunity:** Provide sustainable carbon to production agriculture.

**Challenges:** affordable conversion, field application.

**Method:**

Add **200 lb biochar**/acre/year to grow sustainable

## Carbon Smart Food

[www.dyarrow.org/cool-food](http://www.dyarrow.org/cool-food)



**Direct Application**

*Or*



Keyline Plow

[www.yeomansplow.com.au](http://www.yeomansplow.com.au)

**Add 5% - 100lb biochar/ton – to compost**





# Biochar + Compost

**1 CY Biochar + 5 CY Organics = 3 t/a**

FOREST  
RESIDUES

PRUNINGS

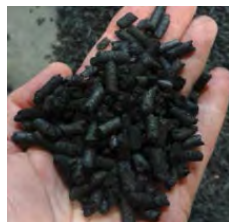
TEAR OUTS

URBAN  
WOOD

SEEDS  
HUSKS  
HULLS

BIOMASS  
ASH

HEAT AND  
POWER



ORGANICS

CO-COMPOST

AD SOLIDS

FORAGE

HOPS  
MINT

GREEN  
WASTE



Carbon  
Smart Food



Row Crops  
Orchard  
Berries  
Vineyards

***“surface oxidation can be accelerated by microbial aging”***

Wiedner, Glaser 2012

# Making Biochar

- **Dry Fuel** – Air Dried or Less than 20% MC
- **Temperatures** – 400°C, 600 °C, 800 °C
- **Industrial Scale**
  - High Carbon Flyash, 10 CY/day
  - ICM Biochar 400 CY/day
  - Earth Systems 20 CY/day
- **Farm Scale**
  - Adam Retort 1-2 CY/day
- **Small scale** –
  - Top Lit Burn Pile – >0.5CY/day
  - Small Ovens – <10's ft<sup>3</sup>/day, Sam's Kiln, Cone kiln, Jolly Roger
  - Stoves, BBQ – <ft<sup>3</sup>/day





# ***Biochar Can Be Made From Different Feedstocks***



**Urban and Forest Wood**



**Wood Char**



**Wheat Straw or Corn Stover**



**Straw Char**

# ***Do-It-Yourself Biochars*** ***Have Different Qualities than and Processed Biochars***



***SELECT BIOCHARS TO SUIT SOILS  
AND CROP NEEDS***

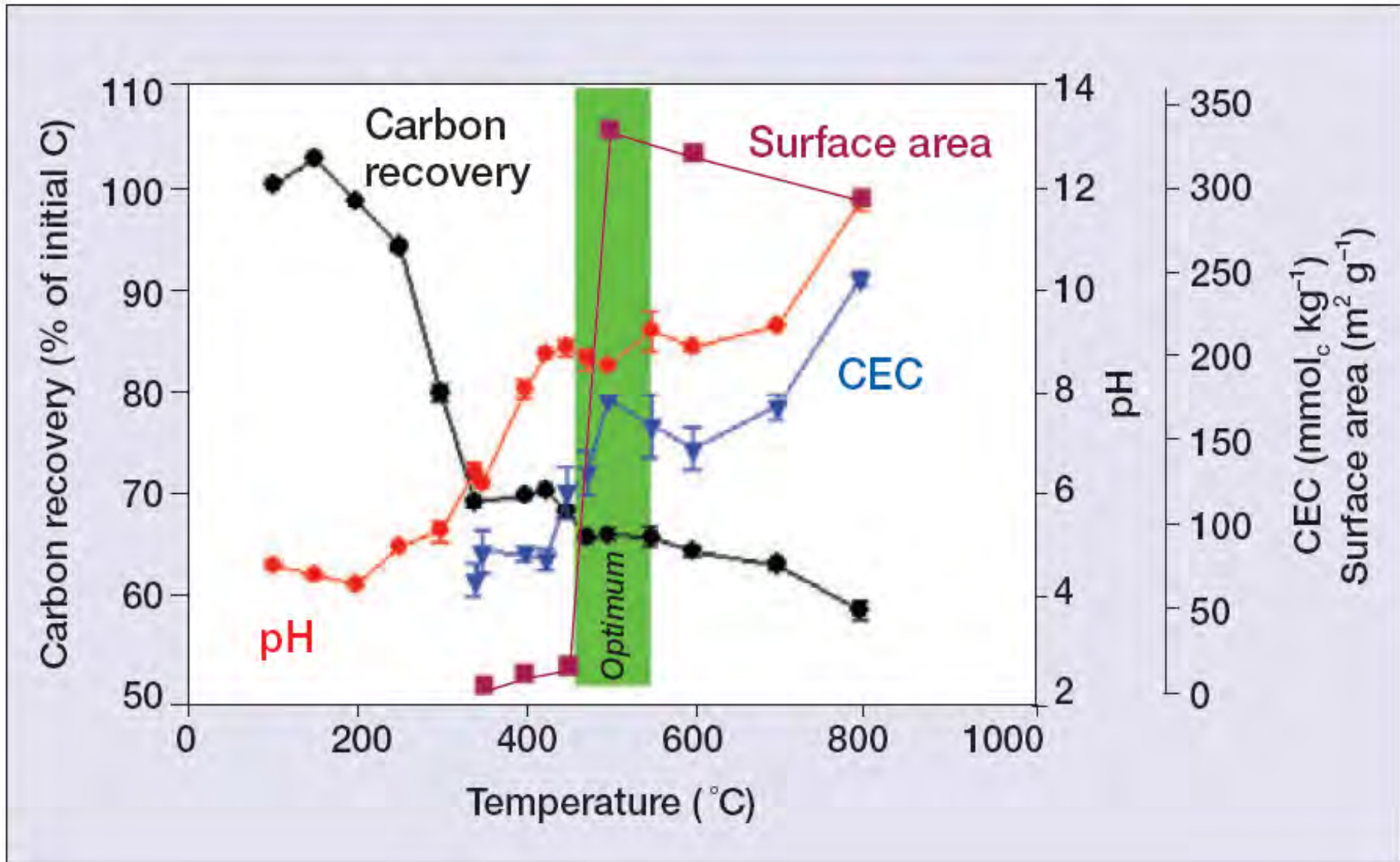


**Biochar Supreme**

photo: Biochar Supreme [biocharsupreme.com](http://biocharsupreme.com)



# Temperatures Affect Biochar Properties



LEHMANN



# Industrial Biomass Boilers Can Produce High Carbon Wood Ash



Boiler-Superheater

200 TPD WOOD

8-10 CY/Day Biochar

60%-80% Carbon

Electrostatic Precipitator

Economizer

Multicyclone

Furnace Cells/Grate

Air Heater

Ash

Fan

Ash

Source: Wellons, Inc. [www.wellonsusa.com](http://www.wellonsusa.com) and

T R Miles Technical Consultants, Inc. [www.trmiles.com](http://www.trmiles.com)

Ash

# *Industrial Conversion of Wood/Straw to Heat, Power and Biochar*

Makes 40 TPD 400 CY/Day BIOCHAR



ICM 200 tpd Gasifier  
Wood, Straw, Stover  
[www.icminc.com](http://www.icminc.com)

4-8 TPH 2-5 MWe  
30-60,000 BDT/y

T R Miles Technical Consultants, Inc.



Full-scale  
MPP20/40

**Mobile Charmaker**  
**MPP20 2 ton biochar**  
**10 CY/4 hours 20 CY/DAY**  
**Fully automated**  
**Earth Systems (Aus)**  
**USD \$345,000**

<http://www.esenergy.com.au/services/charmaker/charmaker-techprocess>



**EARTH SYSTEMS**  
Environment - Water - Sustainability



T.R. Miles Technical Consultants Inc.



# Mobile Retort

1 Cord ~ 4 CY/Batch

8 hr burn ->1-2 CY Biochar



**Living Web Farm**

[www.biochar.bioenergylists.org/living-web-biochar-workshop-2013](http://www.biochar.bioenergylists.org/living-web-biochar-workshop-2013)

**New England Biochar**

[www.newenglandbiochar.org](http://www.newenglandbiochar.org)

# *Stationary Retort with Greenhouse Heating*

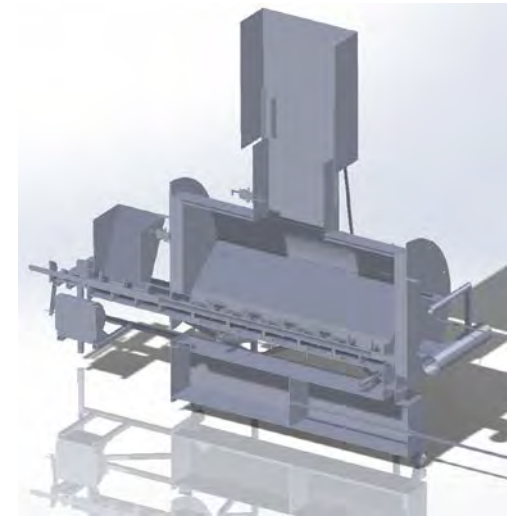


Sullivan Center for Sustainable  
Agriculture and CSA, NH  
sullivancsa.com  
New England Biochar  
newenglandbiochar.org

**1 Cord ~ 4 CY**  
**8 hr burn 1-2 CY Biochar**  
**+ 300,000 Btuh Hot Water**



# Trough Gasifier For Bark, Litter, Sawdust



**Biomass 800 lb/hr chips, litter**  
**Heat 1.4 MMBtuh**  
**Biochar 140 lb/hr 4-12 CY/Day**  
**Cost \$150,000**

**BES Australia Stephen Joseph 2014**



# *Mobile, Batch and Continuous Kilns*



**Carbon Gold UK**  
[www.carbongold.com](http://www.carbongold.com)



**BIGCHAR AUS**  
[www.bigchar.com.au](http://www.bigchar.com.au)

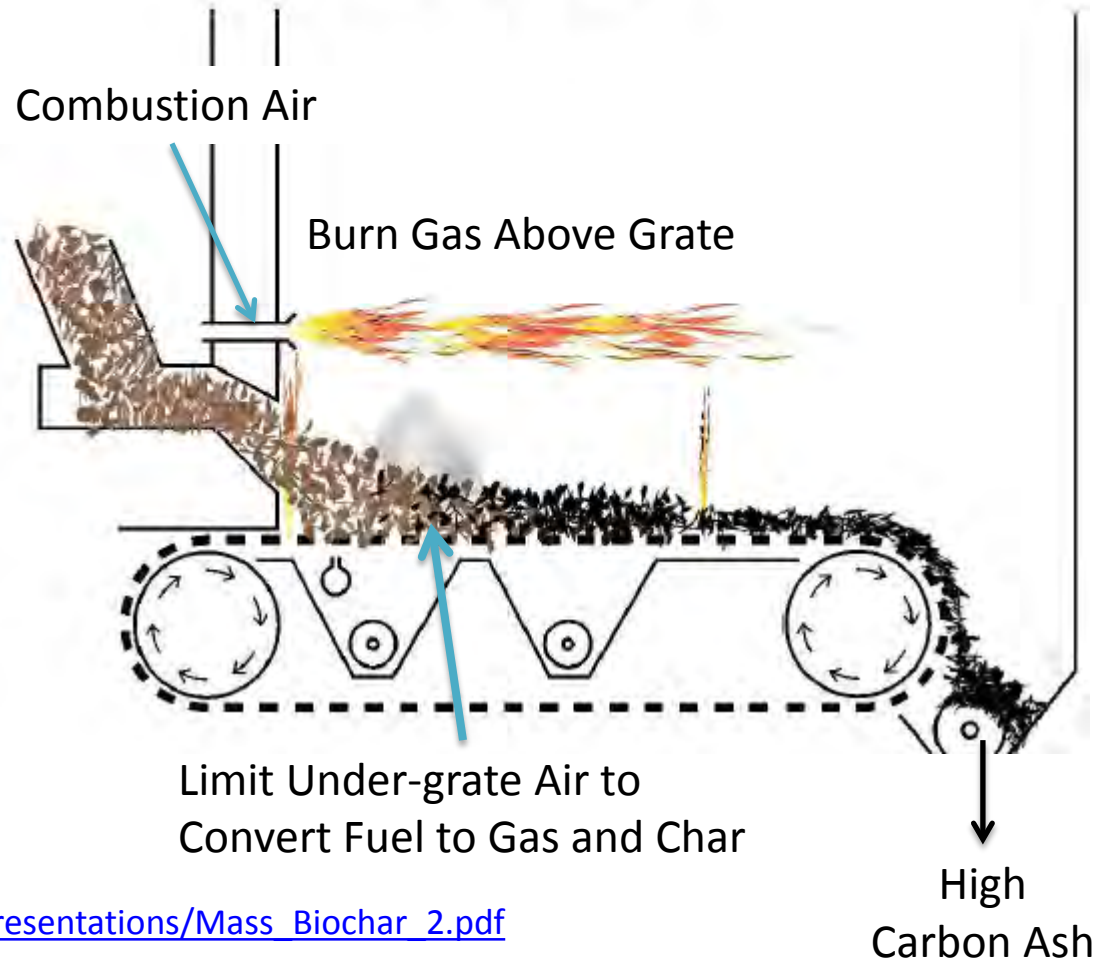
Continuous Mobile Kilns \$300k

# Adapting a Greenhouse Boiler to make Biochar

10 MMBtuh Boiler  
Chain Gate Stoker  
1 ton fuel/hr->5-10 CY/day



## Two Stage Combustion with Char



Burt's Greenhouses, Ontario, CAN  
Alex English  
NE Biochar Symposium 2009

[http://www.cns.umass.edu/biochar09/presentations/Mass\\_Biochar\\_2.pdf](http://www.cns.umass.edu/biochar09/presentations/Mass_Biochar_2.pdf)



# ***Cordwood Carbonizer and Boiler***

**Combined Heat and Biochar**



Hot Water Heater  
with Heat Storage

Oven (left) heated by gases from  
Furnace (right) for hot water.

Woodstock Char Grill  
Prototype by Clearstak  
[www.clearstak.com](http://www.clearstak.com)





# Small Scale Biochar Production



**Top Lit Burn Pile**



**Gasifier**



**"J-RO" Jolly Roger Oven**

[www.youtube.com/watch?v=Kg95KYrH8PI](http://www.youtube.com/watch?v=Kg95KYrH8PI)



**Cone Kiln**

[youtu.be/bO9-RBaAq3U](http://youtu.be/bO9-RBaAq3U)



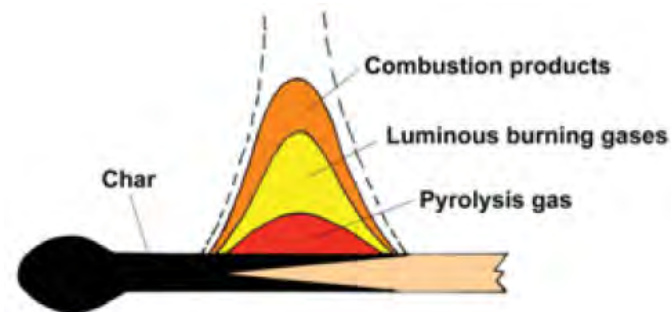
**Top Lit TLUD  
Cook Stove**  
Seachar.org

# Top Lit Burn Reduces Oxygen Increases Char

Light From Top



Smoke is consumed



World's smallest biochar reactor

- Heat transfers by radiation into the wood
- Heated wood releases gases that rise
- When hot gases rise they are exposed to air and they burn
- Heat converts remaining wood to charcoal
- Charcoal will not burn if it is protected from oxygen by the gas flare
- If rising gases cool too fast or do not get enough air, smoke results

Char residue



Quench



Burn 5 hrs dry wood  
Biochar ~13-27 ft<sup>3</sup>/burn  
(0.5-1 CY)

## Wilson Biochar

[http://tcia.org/digital\\_magazine/tci-magazine/2014/02/index.htm#?page=26](http://tcia.org/digital_magazine/tci-magazine/2014/02/index.htm#?page=26)



# Top Lit (Firepit) Cone Kiln

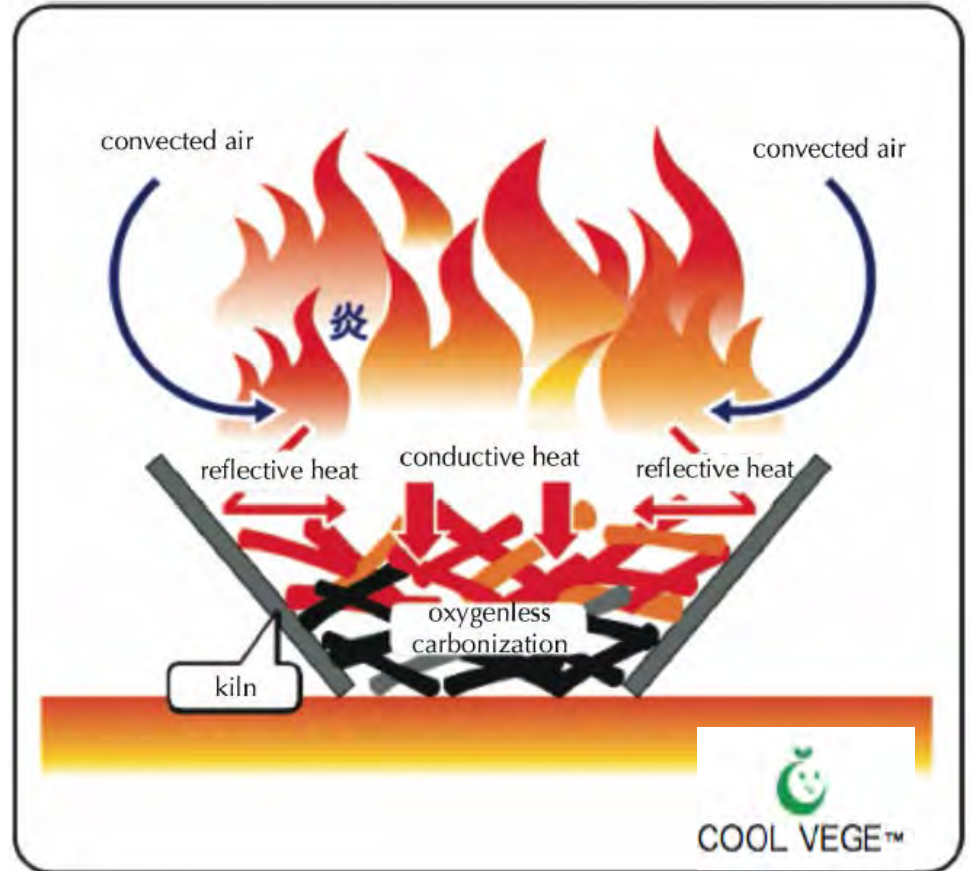
Burn 2 hrs with dry wood  
Biochar ~4.5 ft<sup>3</sup>/burn  
(0.17 CY) Cost \$400



**Wilson Biomass Associates**  
[www.wilsonbiochar.com](http://www.wilsonbiochar.com)



**Bluesky Biochar**  
<http://youtu.be/bO9-RBaAq3U>



# *Carbon Cultures Gasifier*



**Limit combustion air to gas and char**

**Wood size max 3" diameter**

**Burn 3-5 hrs with dry wood**

**Biochar ~20 ft<sup>3</sup>/burn (0.75 CY)**

[carboncultures.com](http://carboncultures.com)



# *Partial Combustion in a Gasifier Makes Char*



**Use 1/3 of air needed  
for combustion to  
make gas and char**



**Lopez Biochar Kiln (Sam and Ron)**

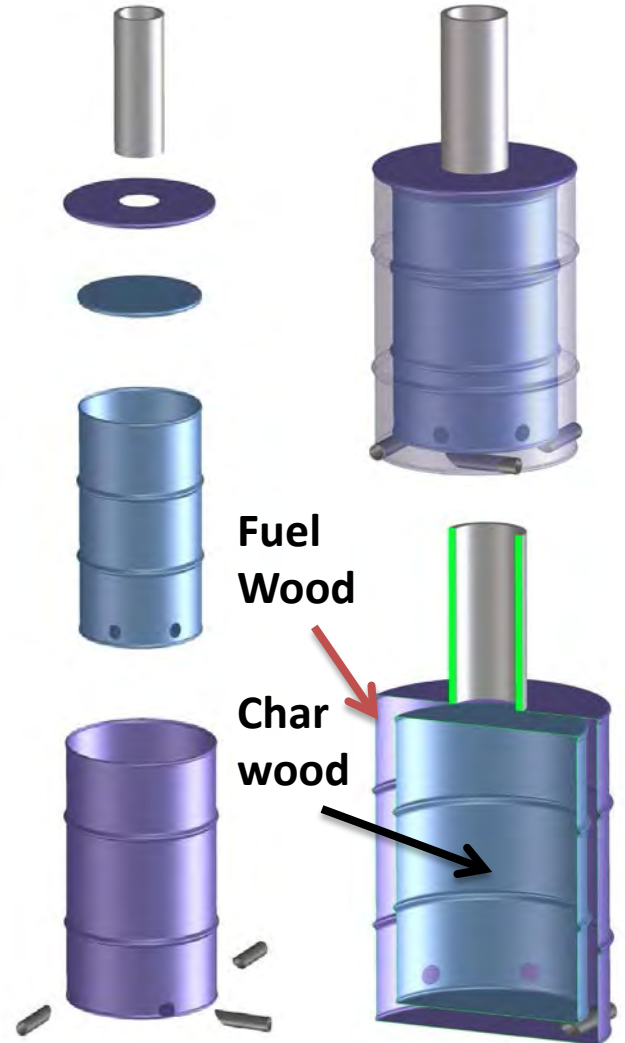
# Heating Wood to Make Char in a Barrel Oven



Max Henderson  
Kelpie Wilson



SIMPLE CHAR KILN  
Folke Gunther



30 Gal in 50 Gal Barrel  
1.5 ft<sup>3</sup>/Burn



# Wells Retort

Amherst, MA

Fuel 5 lb/hr  
Biochar 1.5 lb/hr



DISTILLATES  
REMOVED HERE

CHAR COMES OUT  
DOWN HERE

CONDENSATE  
REMOVED HERE





# Single Chamber Top Lit (TLUD) Retorts



**David Yarrow** 55 Gal TLUD  
Barrel Burner 3 ft<sup>3</sup>/burn .2CY

[www.dyarrow.org/CarbonSmart](http://www.dyarrow.org/CarbonSmart)



**Karl Frogner**  
55 Gal TLUD Ovens



# Top Lit Up Draft (TLUD) Stoves

(micro gasification)



Champion TLUD



Estufa Finca



Planetstove Firepit BBQ

**Flame consumes oxygen and carbonizes wood as it burns**  
**Stop burning before the char is consumed ~ 20-24% of fuel.**

Cost \$100 Burn 1/2 hr with dry wood, Biochar ~0.05-0.25 ft<sup>3</sup>/burn

[https://energypedia.info/wiki/File:Micro\\_Gasification\\_Cooking\\_with\\_gas\\_from\\_biomass.pdf](https://energypedia.info/wiki/File:Micro_Gasification_Cooking_with_gas_from_biomass.pdf)

# *Char From Top Lit Updraft Gasifiers*

- Batch load.
- Gases burn above fuel.
- Heat from flame and partial burning drives volatile gases from fuel.
- Char remains after volatiles burn



**Wood Pellet Gasifier**  
Christa Roth



**BioChar Cook  
Stove**  
Seachar.org



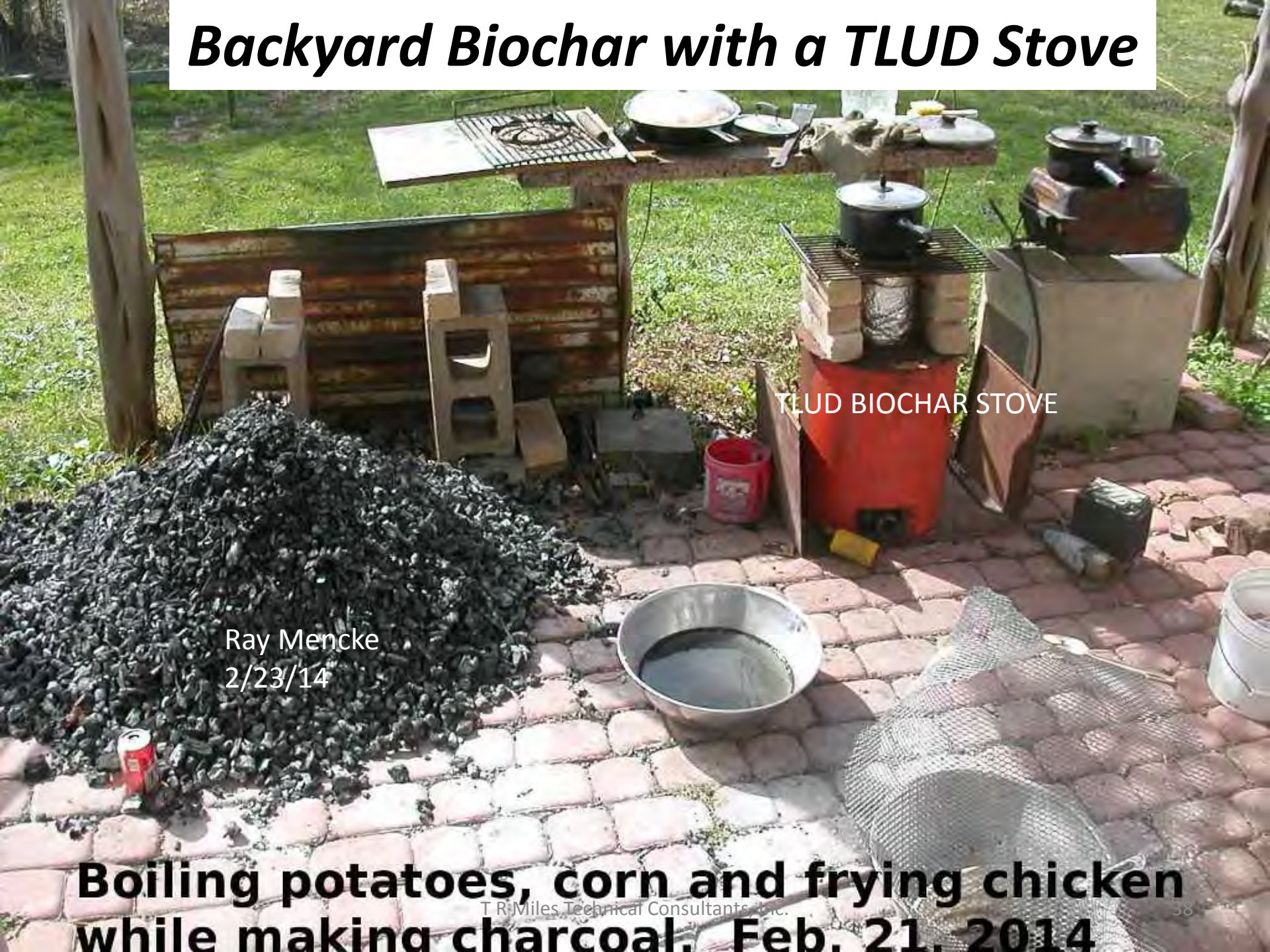
# *Dr TLUD with Stoves For Developing Countries*



[www.drTLUD.com](http://www.drTLUD.com)



# *Backyard Biochar with a TLUD Stove*



TLUD BIOCHAR STOVE

Ray Mencke  
2/23/14

**Boiling potatoes, corn and frying chicken  
while making charcoal. Feb. 21, 2014**



# Pyro ☉ Grilling: TLUD CharBQ



## Weber with TLUD Burner

- Tastes better
- Clean burning
- Less expensive than store bought charcoal
- Great for your garden
- Good for the environment

**Jock Gill**

[biochar.bioenergylists.org/pyro-grill](http://biochar.bioenergylists.org/pyro-grill)



## Toucan TLUD

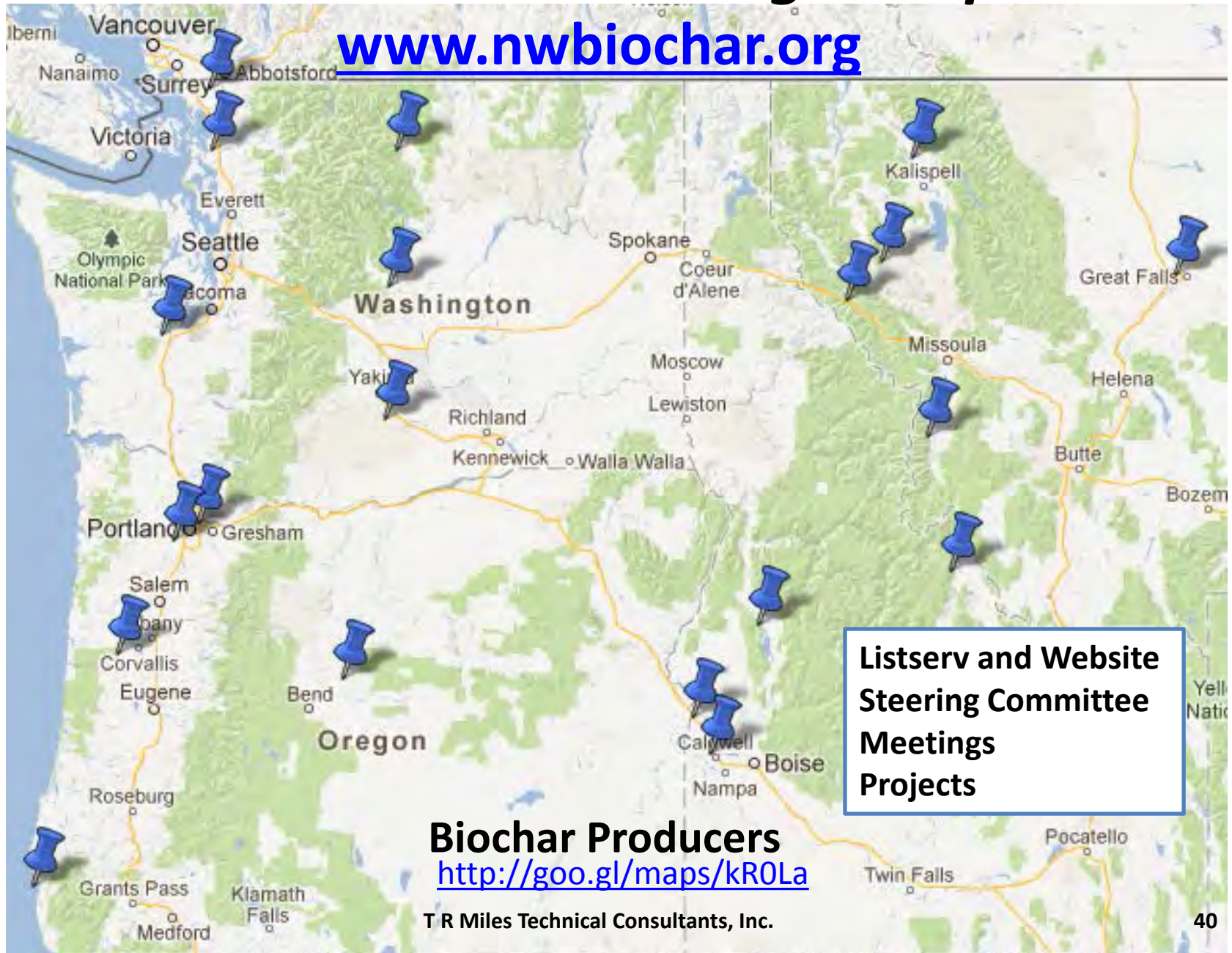
- Chips or pellets 2 Cans
- 45 min burn

**Hugh McLoughlin**

[www.biochar-international.org/sites/default/files/1G\\_Toucan\\_TLUD\\_for\\_Biochar.pdf](http://www.biochar-international.org/sites/default/files/1G_Toucan_TLUD_for_Biochar.pdf)

# NW Biochar Working Group

[www.nwbiochar.org](http://www.nwbiochar.org)



**Listserv and Website  
Steering Committee  
Meetings  
Projects**

**Biochar Producers**

<http://goo.gl/maps/kR0La>