


Biochar - What and Why?

Tom Miles, NW Biochar Working Group

www.nwbiochar.org

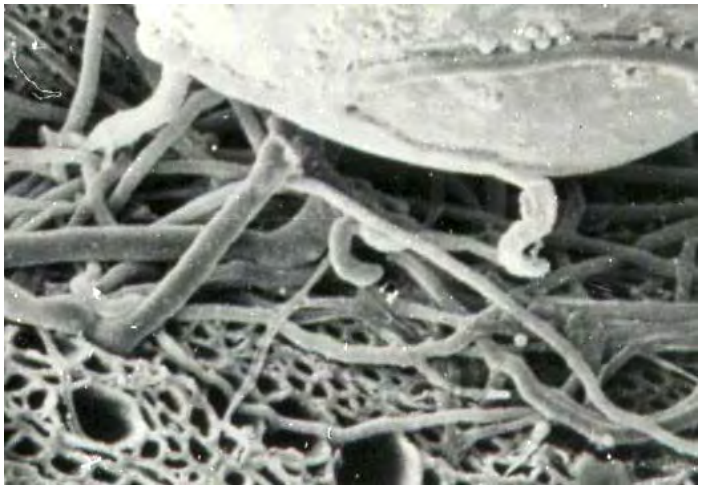
Renel Anderson, Biochar Supreme

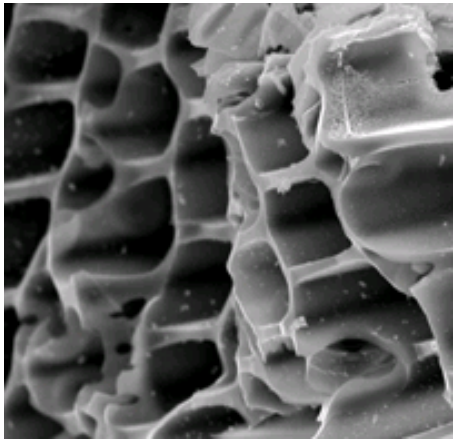
www.biocharsupreme.com


San Juan Islands Agricultural Summit
San Juan Country Agricultural Resource Committee
Orcas Island High School
March 8, 2014
sjcarc.org

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

Brazil Field Trip, September 2010

International Biochar Initiative

www.biochar-international.org

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

www.ibi2010.org/field-trip-to-the-amazonexcursao-tecnica-para-a-amazonia

Abundant Crops Grow on Enriched Soils

Native
Ferralsol
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

EMBRAPA Caldeirão, Amazonas, BR

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**

IBI

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

URBAN FARMING

GREEN ANCHORS
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

- Reduces nitrous oxide emissions 50-80%
  (Rondon, Ramirez, and Lehmann, 2005)
- Reduces phosphorus and nitrogen in groundwater
- Increases soil carbon- reduce atmospheric CO2
- Reduces forest fuel load
- Revitalizes Brownfield sites
- Sequesters 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

Direct Application

Or

Keyline Plow

www.yeomansplow.com.au

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

食卓から地球を冷そう! クルベジ™

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

AD SOLIDS

FORAGE

HOPS MINT

GREEN WASTE

CO-COMPOST

Carbon Smart Food

食卓から地球を冷そう！クルベジ™

Row Crops
Orchard
Berries
Vineyards

"surface oxidation can be accelerated by microbial aging"

Wiedner, Glaser 2012

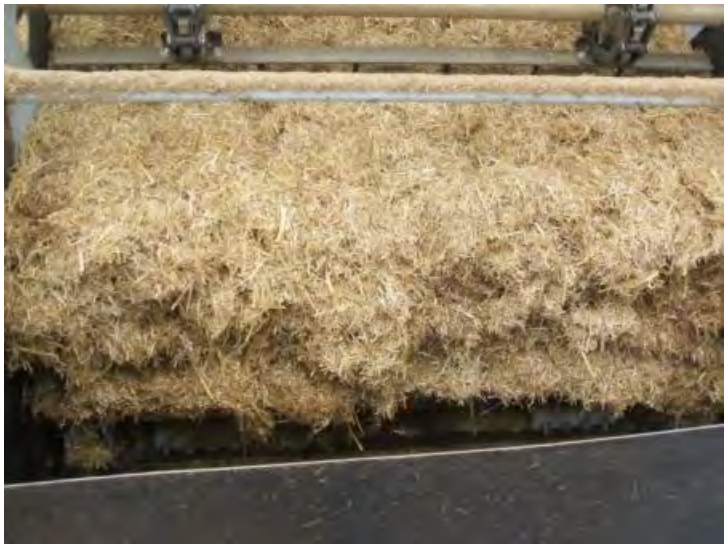
Making Biochar

- **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 10-20 CY/day
- **Farm Scale**
  - Adam Retort 1-2 CY/day
- **Small scale** –
  - Top Lit Burn Pile – >0.5CY/day
  - Small Ovens – <10 ft3/day, Firepit kiln, Jolly Roger, Gasifiers
  - Stoves, BBQ – <ft3/day

Biochar Can Be Made From Different Feedstocks

Urban and Forest Wood

Wood Char



Wheat Straw or Corn Stover

Straw Char

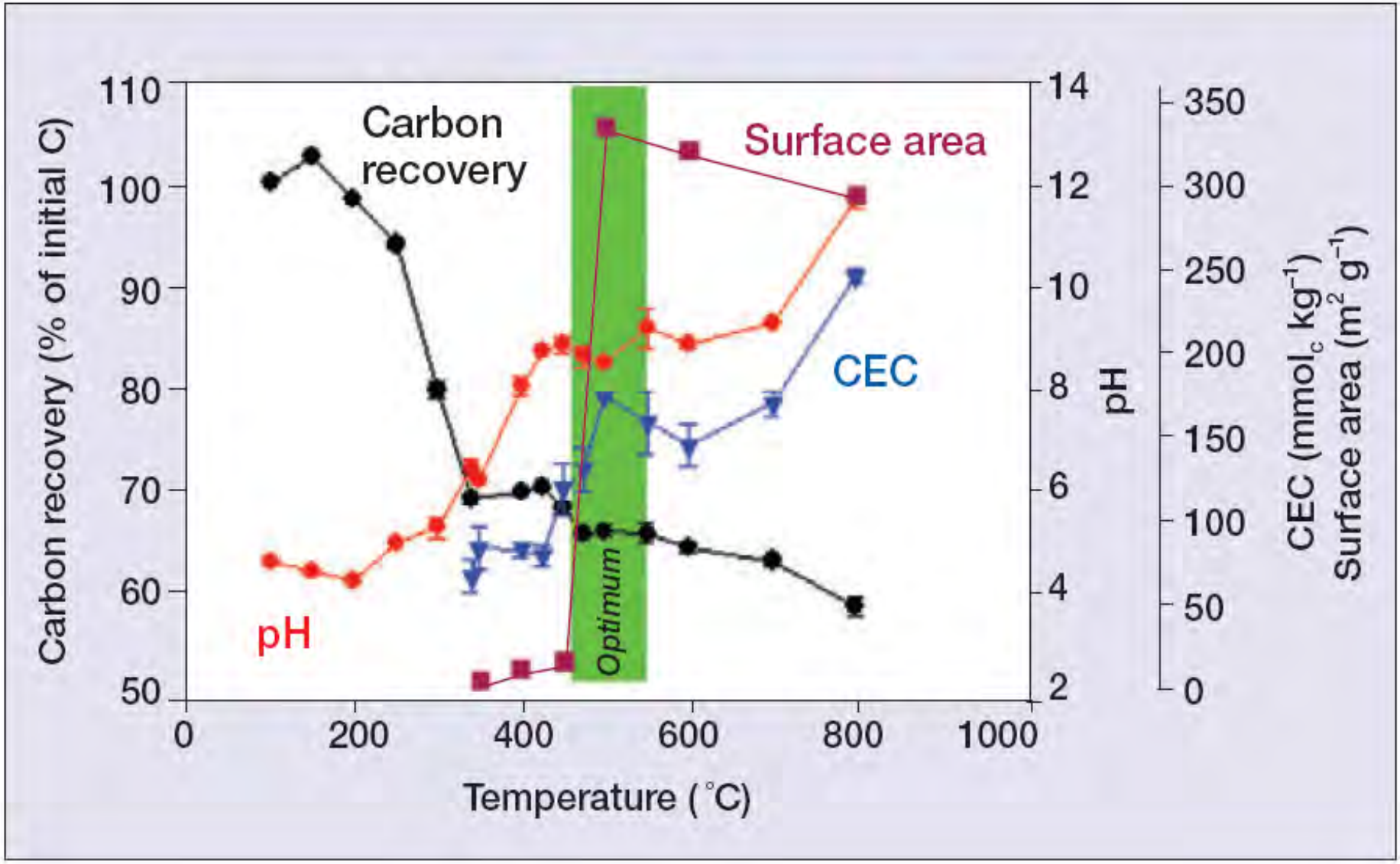
Do-It-Yourself Biochars Have Different Qualities Than Processed Biochars

Biochar Supreme

photo: Biochar Supreme biocharsupreme.com

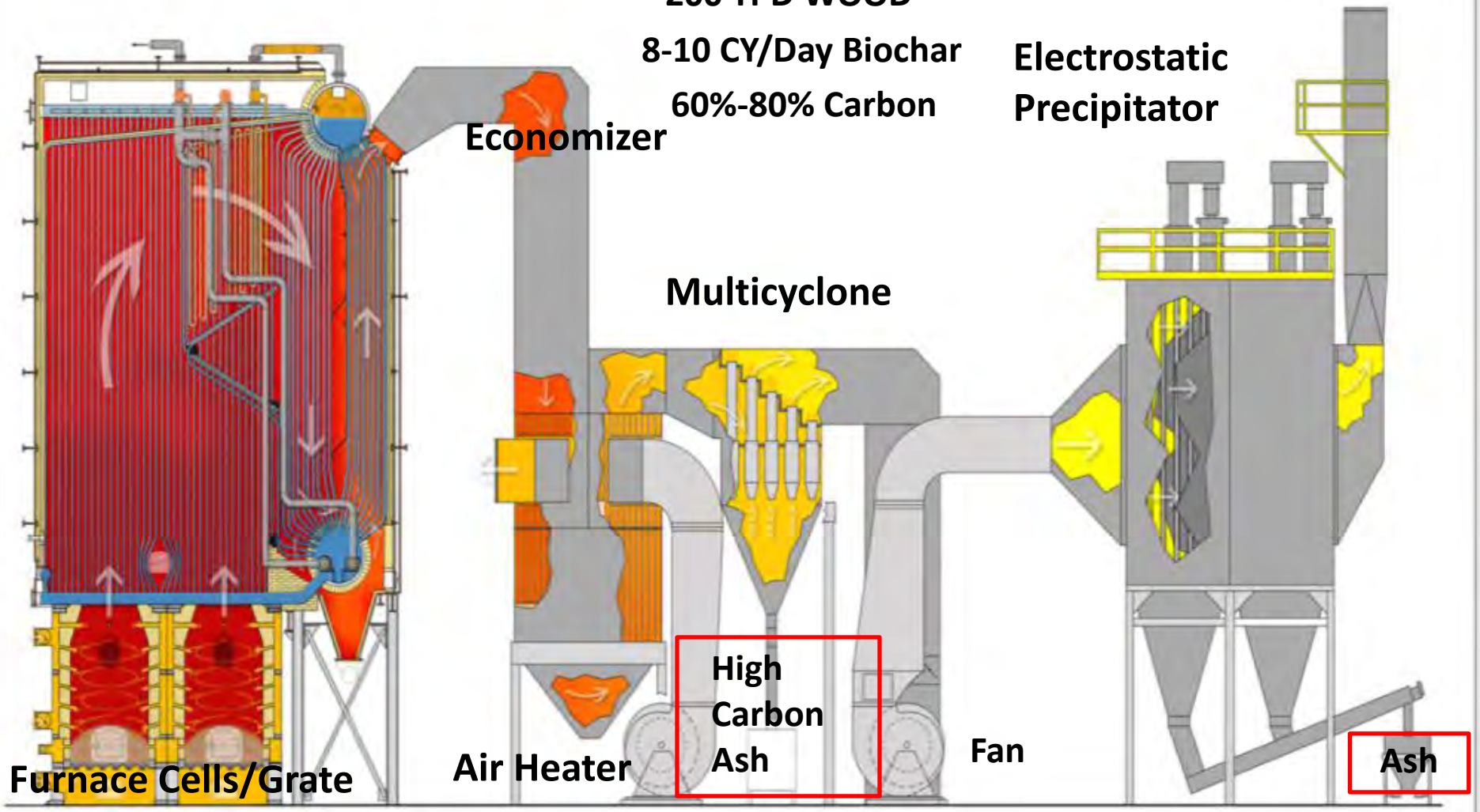
SELECT BIOCHARS TO SUIT SOILS AND CROP NEEDS

Temperatures Affect Biochar Properties



LEHMANN

Some Industrial Biomass Boilers Can Produce High Carbon Wood Ash With Biochar-like Properties



Source: Wellons, Inc. www.wellonsusa.com

Industrial Systems Convert Wood/Straw to Heat, Power and Biochar

Makes 40 TPD 400 CY/Day BIOCHAR

ICM 200 tpd Gasifier
Wood, Straw, Stover
www.icminc.com

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

Mobile Charmaker

20 CY/DAY

2 ton 10 CY/4 hours

Fully automated

Earth Systems (Aus)

USD $345,000

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

Mobile Retort Makes Char from Cordwood and Waste Wood

1 Cord (4 CY) wood /Batch
8 hr burn ->1-2 CY Biochar

Living Web Farm
www.biochar.bioenergylists.org/living-web-biochar-workshop-2013

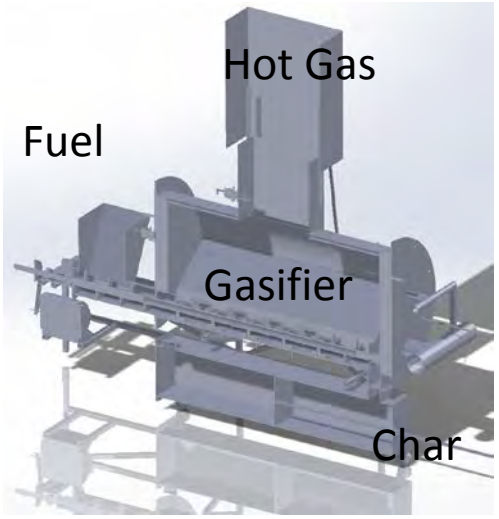
New England Biochar
www.newenglandbiochar.org

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

Make Char Though Gasification Without Heat Recovery

Carbon Gold UK

www.carbongold.com

BIGCHAR AUS

www.bigchar.com.au

Continuous Mobile Kilns $300k

Cordwood Carbonizer and Boiler

Combined Heat and Biochar

Hot Water Heater
with Heat Storage

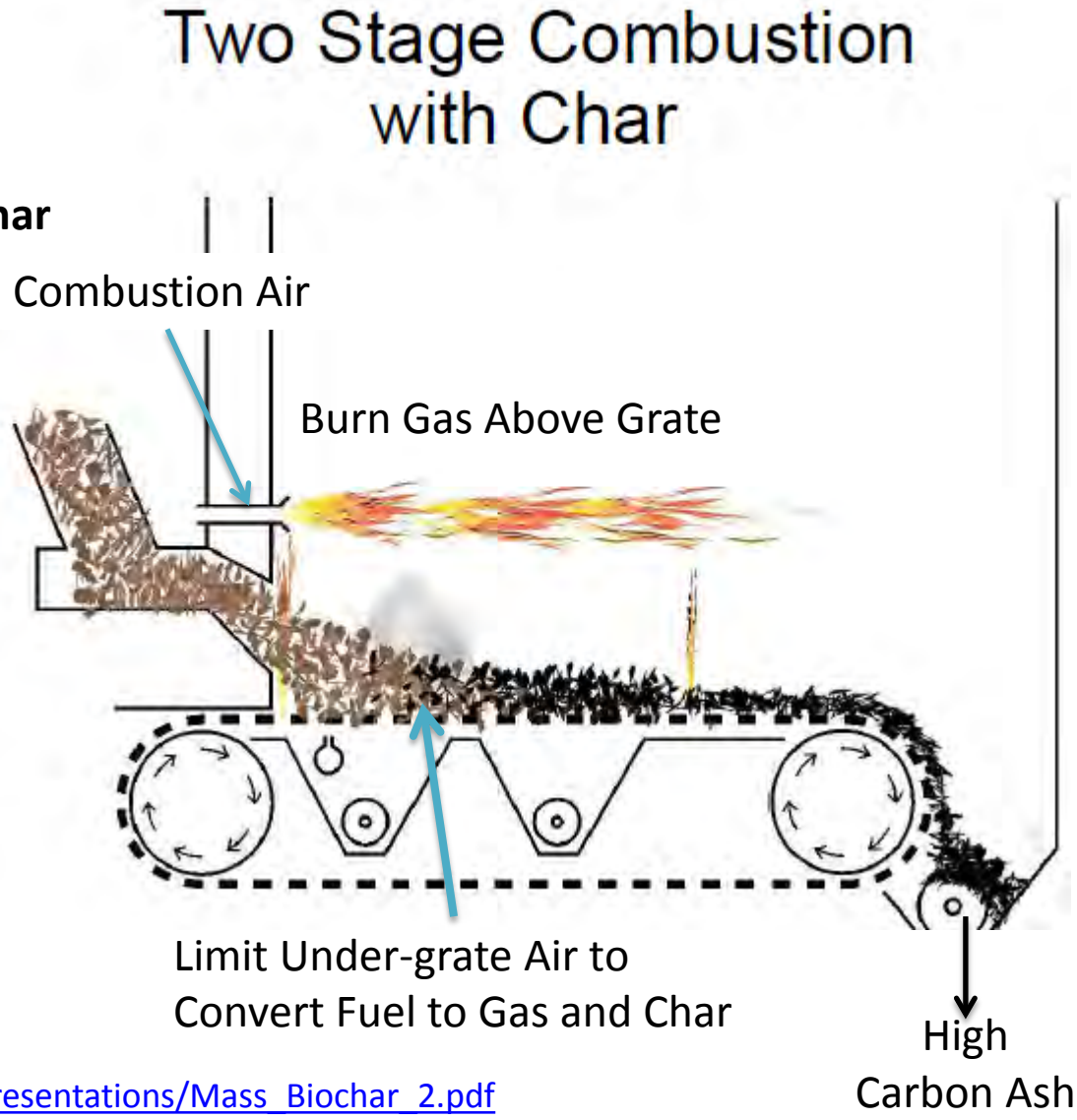
Char Oven (left) heated by gases from Furnace (right) for hot water.

Woodstock Char Grill
Prototype by Clearstak
www.clearstak.com

Adapting a Greenhouse Boiler to make Biochar

10 MMBtuh Heat From Boiler
Chain Grate Stoker
1 ton fuel/hr->5-10 CY/day biochar

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



http://www.cns.umass.edu/biochar09/presentations/Mass_Biochar_2.pdf

Small Scale Biochar Production

Firepit Cone Kiln

Gasifier

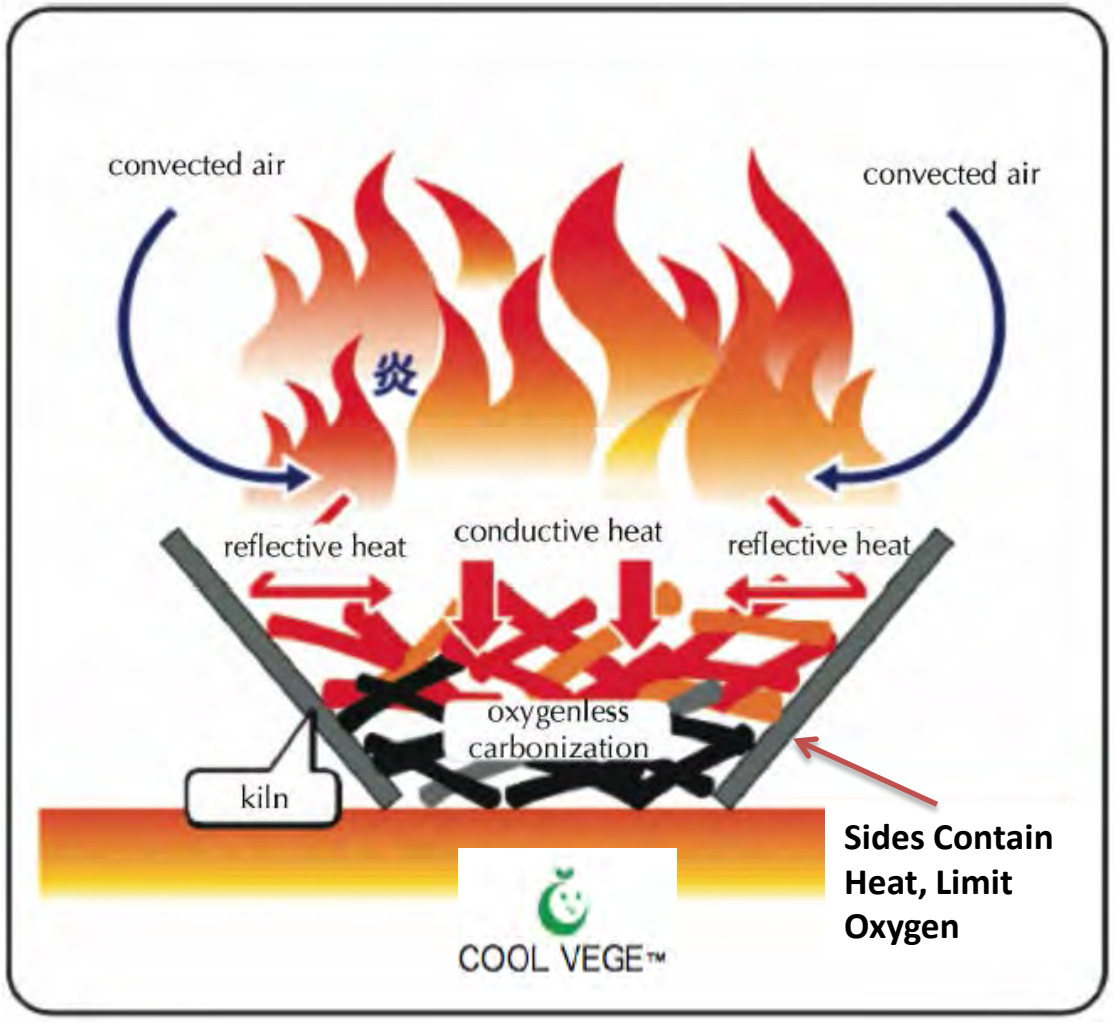
“J-RO” Jolly Roger Oven
Top Lit Gasifier + Barrel Oven

Top Lit Burn Pile

Top Lit TLUD Gasifying Cook Stove

Top Lit (Firepit) Cone Kiln

Makes Char by Limiting Oxygen at Base of Fire



Sides Contain Heat, Limit Oxygen

Bluesky Biochar

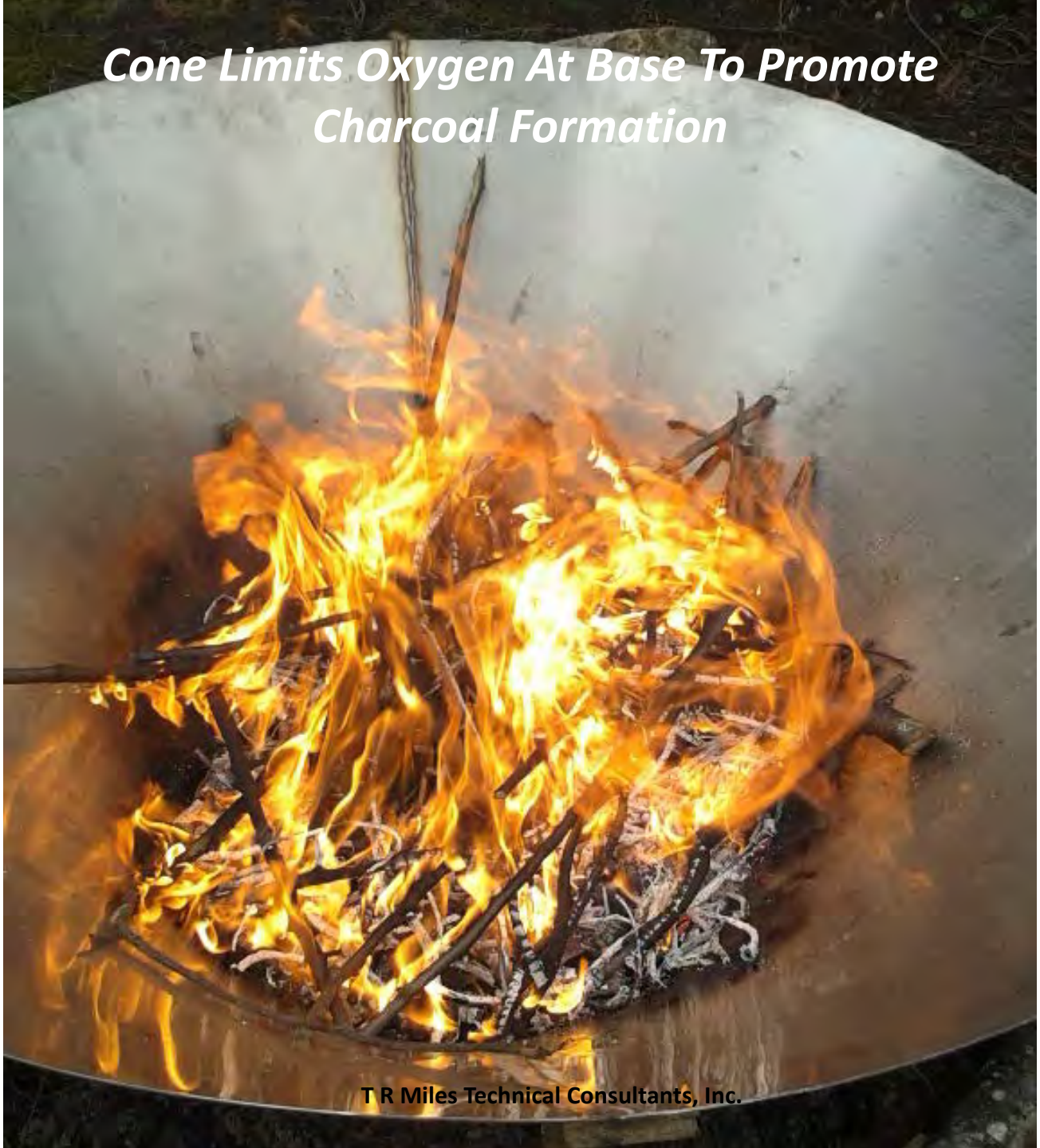
http://youtu.be/bO9-RBaAq3U

Wilson Biomass Associates

www.wilsonbiochar.com

Burn 2 hrs with dry wood
Biochar ~4.5 ft3/burn
(0.17 CY) Cost $400

Cone Limits Oxygen At Base To Promote Charcoal Formation



Top Lit Burn Reduces Oxygen Increases Char

Light From Top

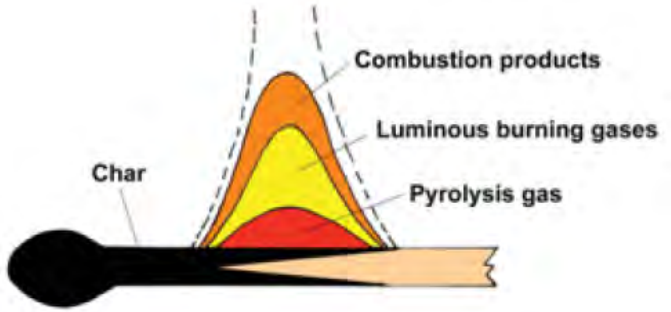
Smoke is consumed

Water Quench at Base

Char residue

Quench

Burn 5 hrs dry wood
Biochar ~13-27 ft3/burn (0.5-1 CY)



World's smalles 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

Wilson Biochar

http://tcia.org/digital_magazine/tci-magazine/2014/02/index.htm#?page=26

The mini Moxham: Char in a Barrel Burner

Dolf Cooke, The Biochar Project, Australia

biocharproject.org/charmasters-log/organic-farmer-mini-moxham-turn-waste-biochar/

Carbon Cultures Gasifier

Limits combustion air to make gas and char
Gas burns cleanly above kiln

Wood size max 3” diameter
Burn 3-5 hrs with dry wood
Biochar ~20 ft3/burn (0.75 CY)

- Prevents heat damage to soil organisms
- Reduces pollution from gas and particulate
- Recovers biochar

carboncultures.com

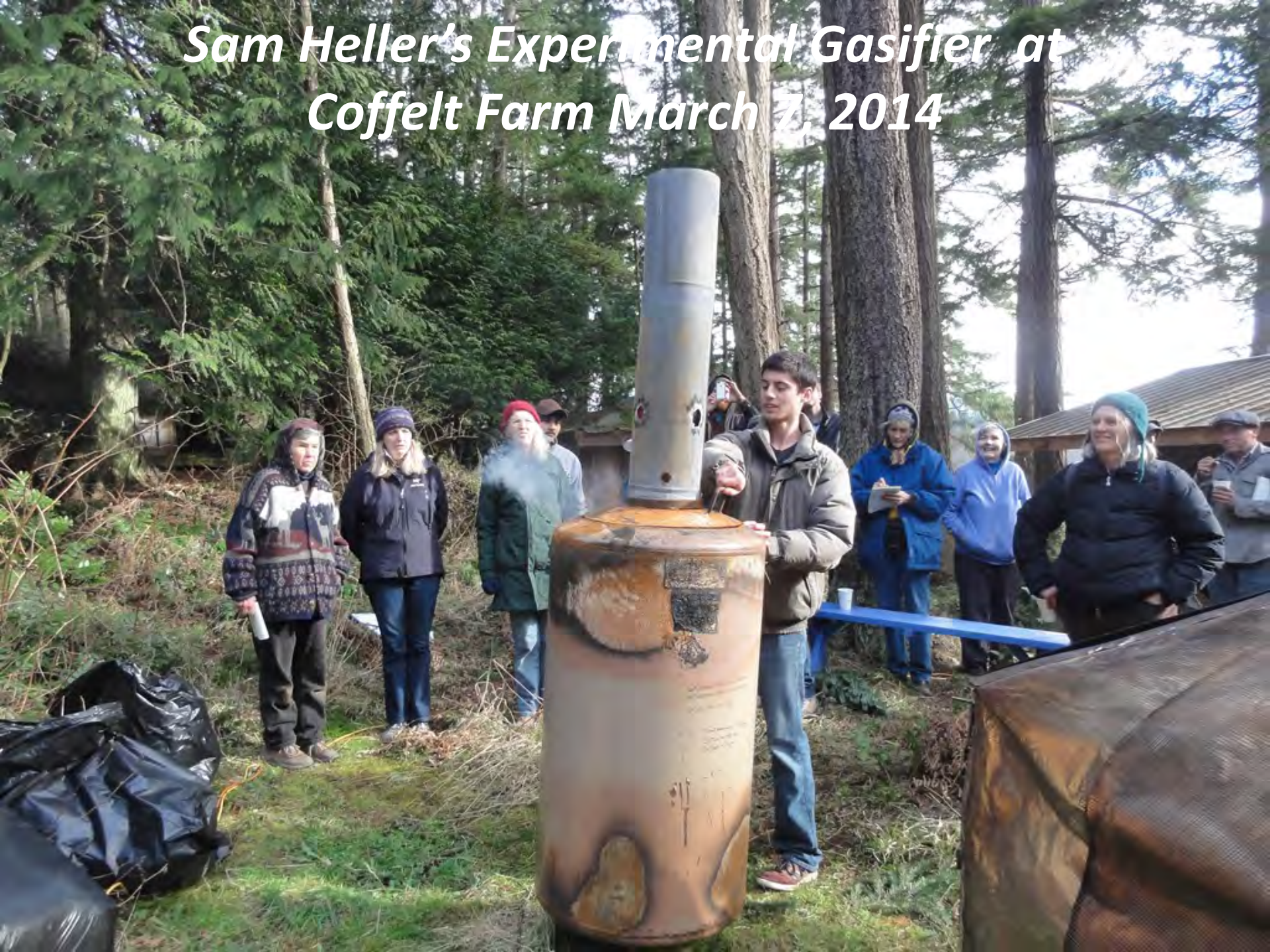

Carbon Cultures Glacier Kiln at Coffelt Farm March 7, 2014
GAS BURNER
AIR ADJUSTMENT
Carboncultures.com

Partial Combustion in a Gasifier Makes Char

Limit air to make gas and char

Lopez Biochar Kiln

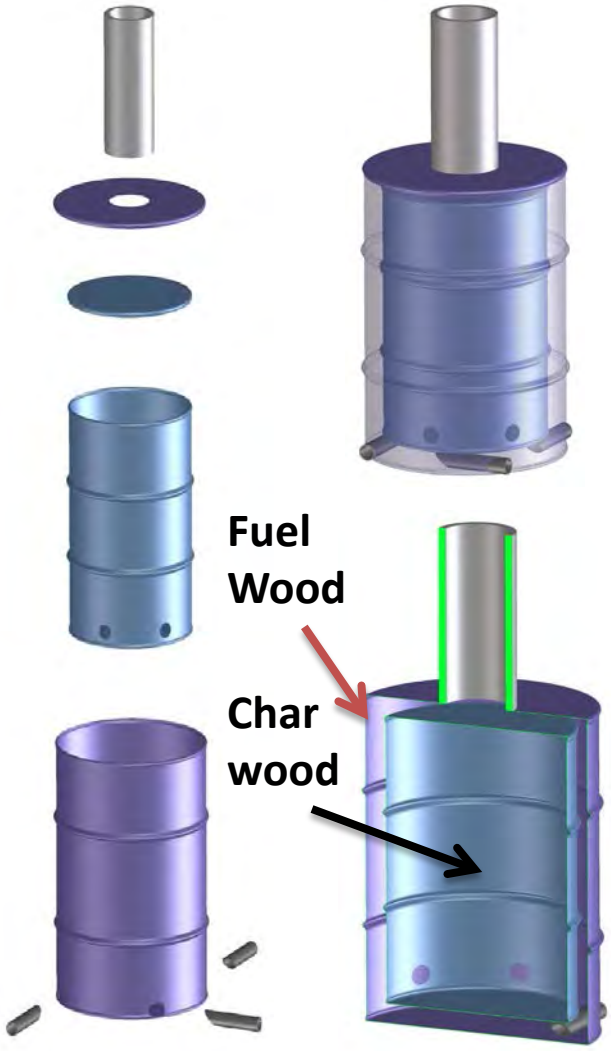
Sam Heller's Experimental Gasifier at Coffelt Farm March 7, 2014



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 ft3/Burn

Wells Retort

Wood charred in rotating barrel by heat from an inner tube.

Amherst, MA

Fuel 5 lb/hr
Biochar 1.5 lb/hr

Rotate Barrel

Firebox

Single Chamber Top Lit (TLUD) Batch Ovens

David Yarrow 55 Gal TLUD
Barrel Burner 3 ft3/burn .2CY

www.dyarrow.org/CarbonSmart

Karl Frogner, Doug Clayton
55 Gal TLUD Ovens

www.youtube.com/watch?v=IGsdma-2CkQ

www.youtube.com/watch?v=Kg95KYrH8PI

Making Biochar in TLUD Ovens for Water Treatment in Burma

55-gal TLUD drum pyrolyzer design can be made using only a machete – no electricity or power tools required. (**Josh Kearns, Aqueous Solutions**)

https://www.facebook.com/media/set/?set=a.409998402469204.1073741830.119213051547742&type=3

Top Lit Up Draft (TLUD) Stoves Make Gas for Cooking and Char for the Garden

(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 ft3/burn

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.char.**
- **Heat from flame and partial burning drives volatile gases from fuel.**
- ***Char* remains after volatiles burn**

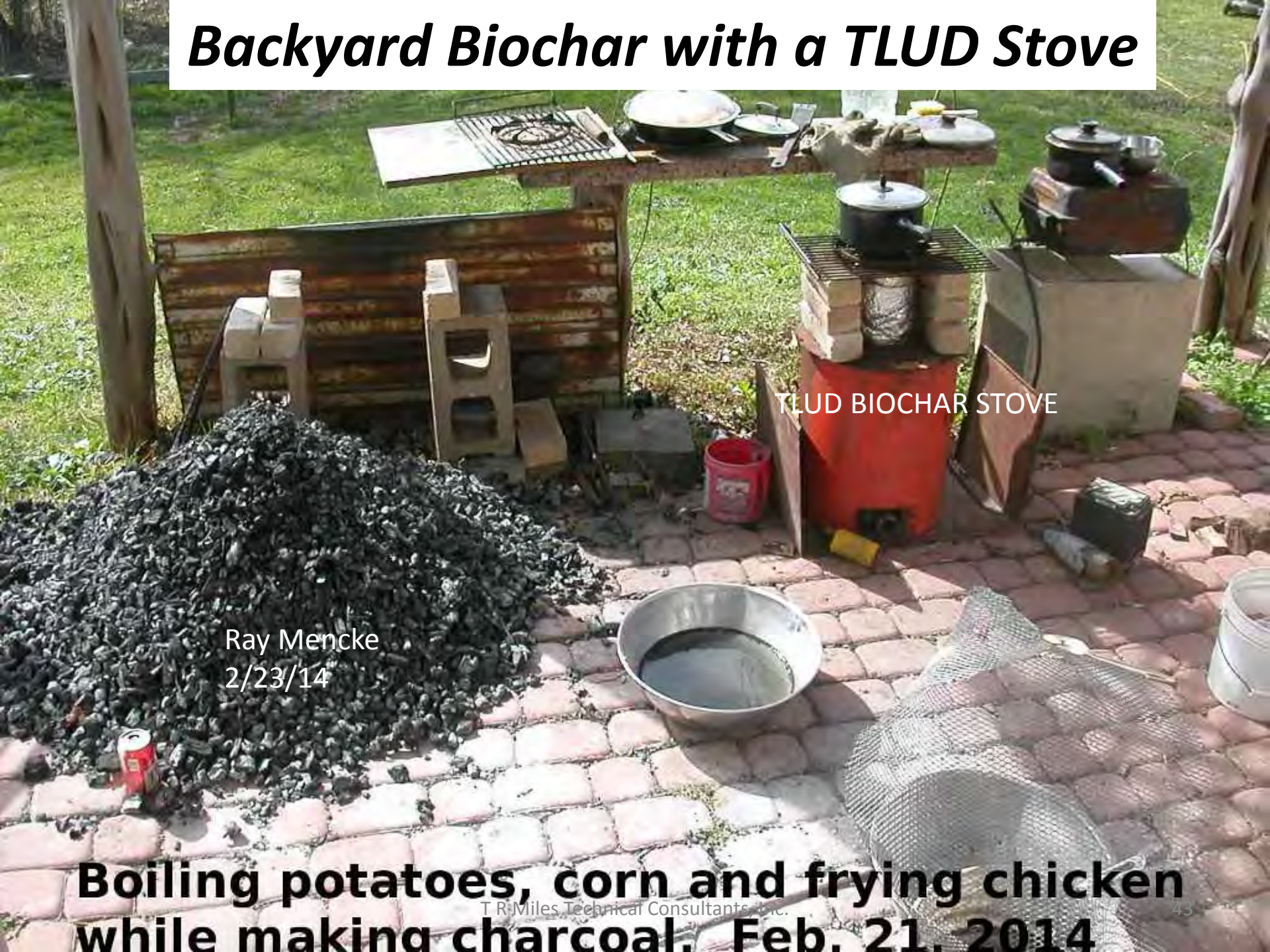
BioChar Cook Stove
Seachar.org

Cooking on the TLUD "Estufa Finca" in Costa Rica

Dr TLUD's Stoves For Developing Countries

Paul Anderson
www.drtlud.com

Backyard Biochar with a TLUD Stove



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

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

NW Biochar Working Group

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