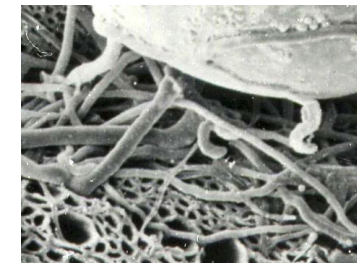


# *The Glows and Grows of Biochar Production: Biochar Products, Systems and Processes in North America*



*Tom Miles  
Executive Director  
US Biochar Initiative*



**Minnesota Biochar Summit  
June 28, 2023**



Improve  
compost  
and save  
money

Factsheets, Market, Tech Support

# ABOUT USBI

Established 2009



In-field Workshops



Producers Directory

**USBI is a not-for-profit organization promoting the sustainable production and use of biochar through research, policy, technology**



Equipment & Technology Development

## Activities:

North America Conferences, Workshops, Research, Factsheets, Newsletter, Website, Provider Directory, Social Media, Advocacy, Referrals, Technical Advisory Team, Demos, Forestry Partner, [biochar.groups.io](http://biochar.groups.io) forum, Outreach & Education

[info@biochar-us.org](mailto:info@biochar-us.org)



Trade shows & Conferences



[biochar-us.org/biochar-crop-application-guidelines](http://biochar-us.org/biochar-crop-application-guidelines)

# ***Biochar Producers Suggest Priorities***

- **Standards and grading**
- **Market development strategy, strategy meetings, messaging**
- **Field trials and meta-analyses of existing scientific studies**
- **Directory of labs and testing facilities + certified labs**
- **Industry Policy Advocates**
- **Education for NRCS field/extension offices**

# Highlights

- Products and Markets
- Science, Standards
- Systems, Processes
- Applications



VITAL Blend Soil Amendment,  
Activated BioChar charged  
with freshwater-sourced  
Humate [ambiochar.com](http://ambiochar.com)



Urban Soil Repair  
Ecotone Inc.  
[ecotoneinc.com](http://ecotoneinc.com)



Biochar Amended Compost  
Missouri Organic Recycling  
[www.missouriorganic.com](http://www.missouriorganic.com)



Biochar + No-till  
[Constantcanopy.com](http://Constantcanopy.com)  
Natural Plant  
Solutions



[Pacific Biochar.com](http://PacificBiochar.com)



Char Technologies  
[chartechnologies.com](http://chartechnologies.com)



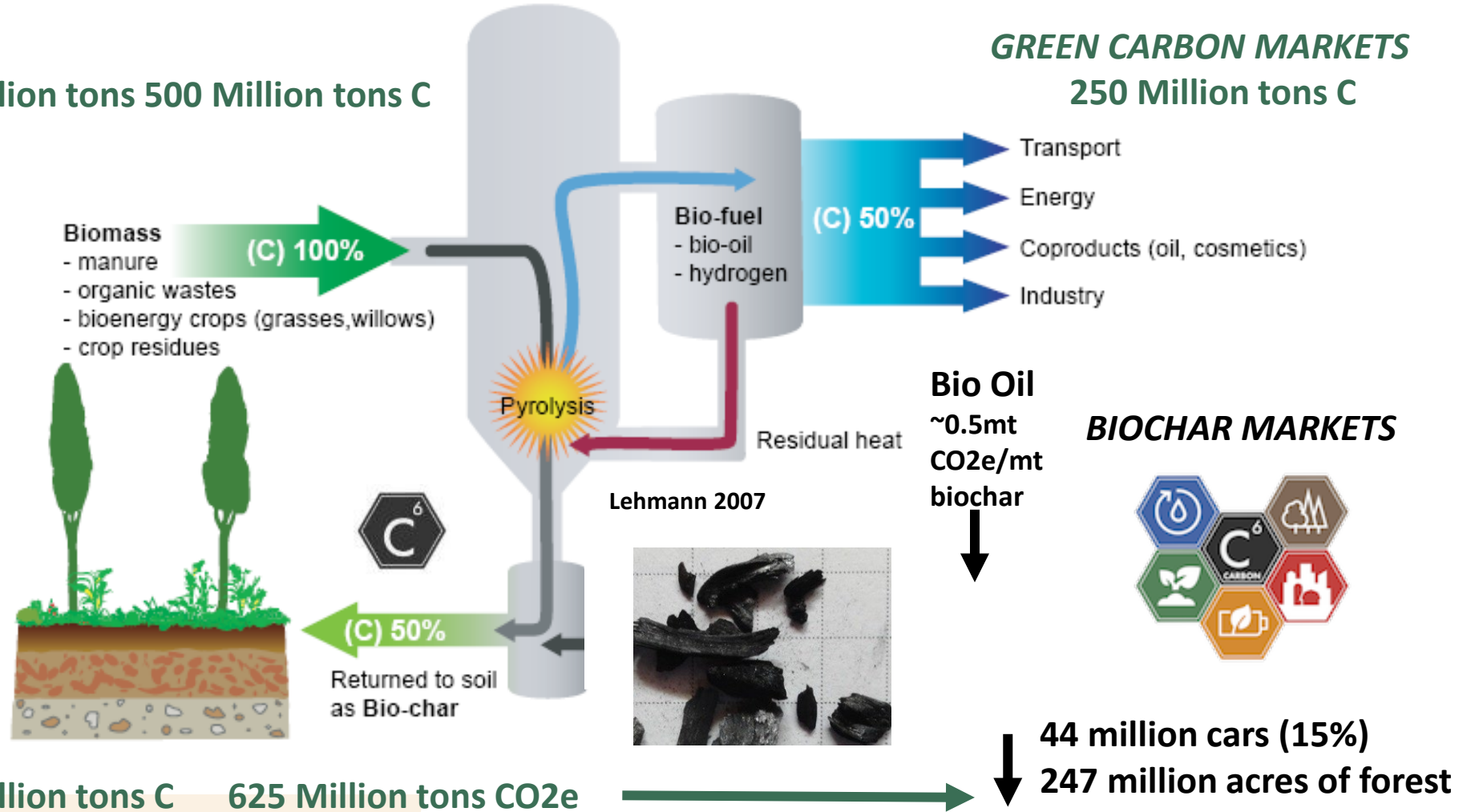
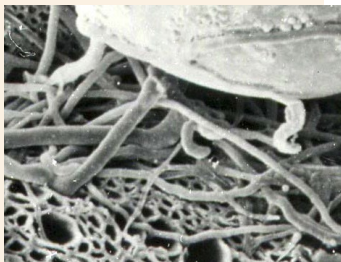
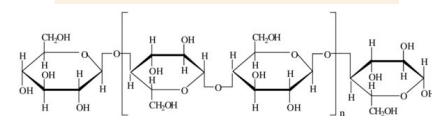
Earthcare LLC [earthcarellc.com](http://earthcarellc.com)



Biochar and Carbon Markets  
Oregon Biochar Solutions  
[Chardirect.com](http://Chardirect.com)

# Green Carbon Markets Enable Biochar Production

Sustainable Biomass 1 Billion tons 500 Million tons C

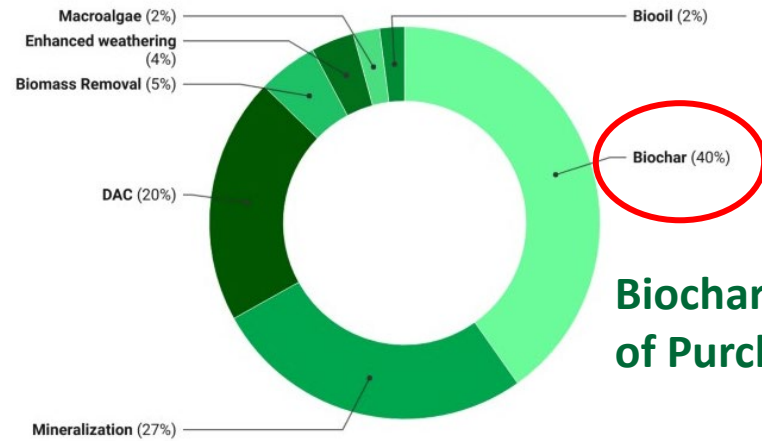


1 mt CO<sub>2</sub>e = 1 Carbon Dioxide Removal Certificate (CDR or CORC™) 2.0-3.2 CDRs/mt Biochar

# Carbon Removal Markets Fund Biochar Production

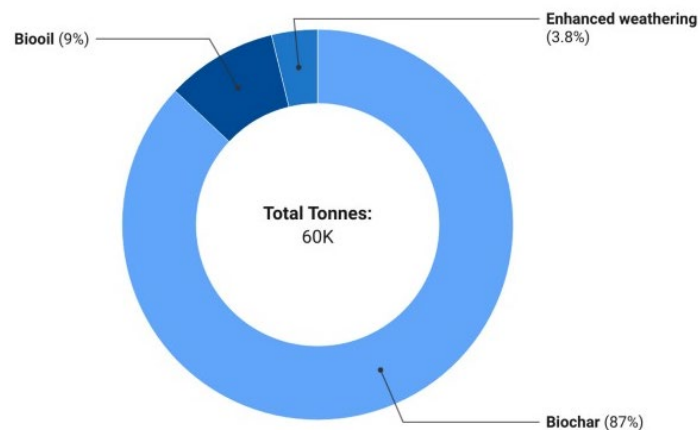


2022 CDR Purchases by Method

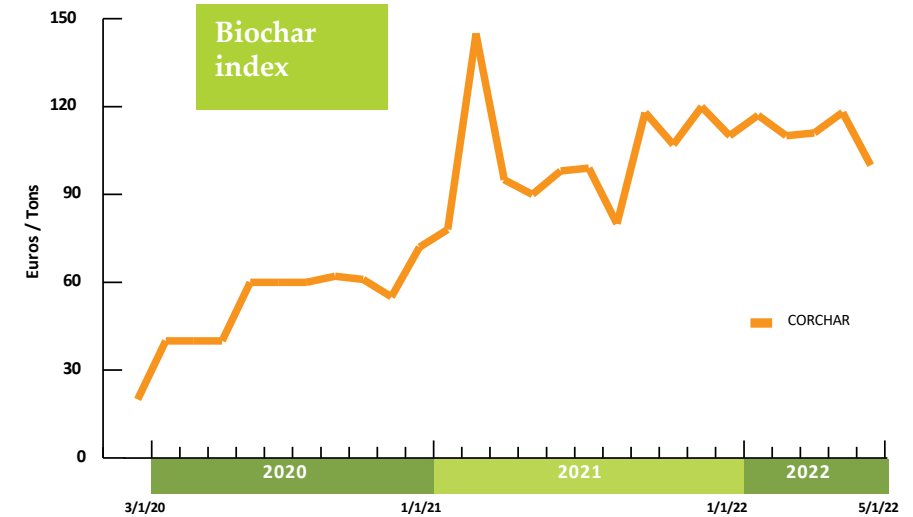


Biochar CDR 40% of Purchases

All-Time CDR Delivery by Method



## Biochar CO2e Credits Offset Production Costs, Enable Finance



CDR.fyi

See [biochar-us.org/biochar-removes-carbon](https://biochar-us.org/biochar-removes-carbon)

$$2.5 \text{ mt CO}_2\text{e/mt biochar} \times \$100 = \$250/\text{mt biochar}$$



# Biochar Markets and Uses Continue to Grow



## Soil Health: Agriculture, Retail Garden, Landscape, Turf, Trees, Orchards, Vineyards, Horticulture

Biochar, Compost, Composted biochar (5%-20% biochar)

Animal bedding, litter, feed trials

Biochar-Based Fertilizers (15%-25% biochar)

Biotic Soil Amendments (biochar + organics+ minerals and biologicals)

Granulated and liquid products for seeding, foliar sprays (extracts)

Micro/nano carbons, nanofertilizers



## Environment, Remediation, Erosion Control

Revegetation, Biosolids, Urban Soils, Erosion Control, Wetlands, Odor, Waste, Remediation Persistent Herbicides (USCC), PFOS/PFAS



## Water quality stormwater filtration, water treatment

- functionalized chars, 3d aerogels, antibiotics



## Forestry

Wildfire fuel reduction, Reforestation, Range Improvement

Growing media for nursery and out planting

Revegetation, Reclamation of mines and degraded land



## Carbon, Renewable Energy Offsets, and Non-Soil Products

Carbon markets, building products, odor control, batteries



# Product Quality



**TONY MARRERO**  
**WAKEFIELD BIOCHAR**  
**ILLINOIS**



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



# Organic Recycling



**STAN SLAUGHTER**  
**MISSOURI ORGANIC**  
**RECYCLING**  
**KANSAS CITY**



[www.missouriorganic.com/compost](http://www.missouriorganic.com/compost)



# Biochar Enhanced Products



**The Andersons®**  
**Humic DG Granular**  
**Soil Conditioner**  
**(Humic Acid) with**  
**Biochar - Humic DG**  
**CharX**



**American**  
**Biochar**  
**Company VITAL**  
**Blend Soil**  
**Amendment,**  
**Activated**  
**BioChar charged**  
**with freshwater-**  
**sourced Humate**







## Adding biochar can enhance the composting process:

- Reduces odor
- Reduces ammonia loss
- Increases nitrogen retention
- Accelerates the composting process
- Enhances the beneficial biological populations in compost !



[char-grow.com](http://char-grow.com)



# Increased Use of Solid and Liquid Biochars in Urban Tree Care



**TREE TIPS**  
TREE & SHRUB CARE FROM BARTLETT TREE EXPERTS

**Bartlett researches biochar** by Drew Zwart, PhD

Biochar is a relatively new term for the substance created from the ancient practice of converting agricultural waste into a stable, carbon-rich charcoal for soil enhancement ("terra preta" Dark Earth). The potential of biochar to reduce stress on urban plantings due to inferior soil quality has intrigued us at Bartlett Tree Experts for many years. As such, the Bartlett Tree Research Laboratories has implemented numerous studies to evaluate biochar's effects on soil and plant health. We set out individually and in partnership with universities to verify claims that biochar:

- Enhances soil fertility while reducing nutrient leaching and ground water contamination
- Increases soil microbial activity
- Increases water retention
- Stimulates plant growth
- Reduces disease and insect susceptibility

Other potential environmental benefits include the use of existing agricultural and horticultural waste debris streams, carbon sequestration from this biomass for hundreds of years or more, reduced needs for fertilizer, and reduced greenhouse gases such as nitrous oxide and methane. These possible benefits have led us to establish many research projects across the country to examine such claims using real-world and controlled scenarios. Trials are comprehensive

Continued on page 2

Biochar is mixed into soil to improve nutrition and growing conditions.

**Sudden oak death**  
by Drew Zwart, PhD

Tree mortality due to *Phytophthora ramorum*, the cause of 'sudden oak death' (SOD), continues to spread in areas known to be infested with the pathogen. Whereas the winter of 2019/2020 was not particularly wet, the wet winters of 2017/2018 and 2018/2019 led to increased infection rates, and current tree mortality is due to infections that occurred during those winters.

SOD bleeding on an oak trunk.

The two long-standing recommendations for managing SOD include potassium phosphite bark treatments to improve resistance, and removal of bay laurel foliage from within the immediate area of valuable oaks. These remain the best options, and research from UC-Berkeley has shown improvement in efficacy of these treatments when gypsum

Continued on page 2

Test tree pits at the Bartlett Tree Experts Research Laboratories.



## Urban Tree Care and New Planting

Courtesy Infinite Solutions



# Increased Use of Biochars in Urban Soil Repair

Compaction, drainage, aggregation, filtration



Urban Soil Repair - Highway /Toll Plaza Biochar Filter Strip, MD & DE



Courtesy Infinite Solutions



# Biochar Products for Environmental Management: Nutrients, Metals, Organics, Remediation



## 14. LIFE BELOW WATER

- Manage storm water
- Reduce nutrient pollution
- Clean up spills with biochar
- Carbonize aquatic invasive species



Storm water retrofits prevent water from washing into storm drains, allowing it to soak and filter into the ground.





# Innovative Biochar Products

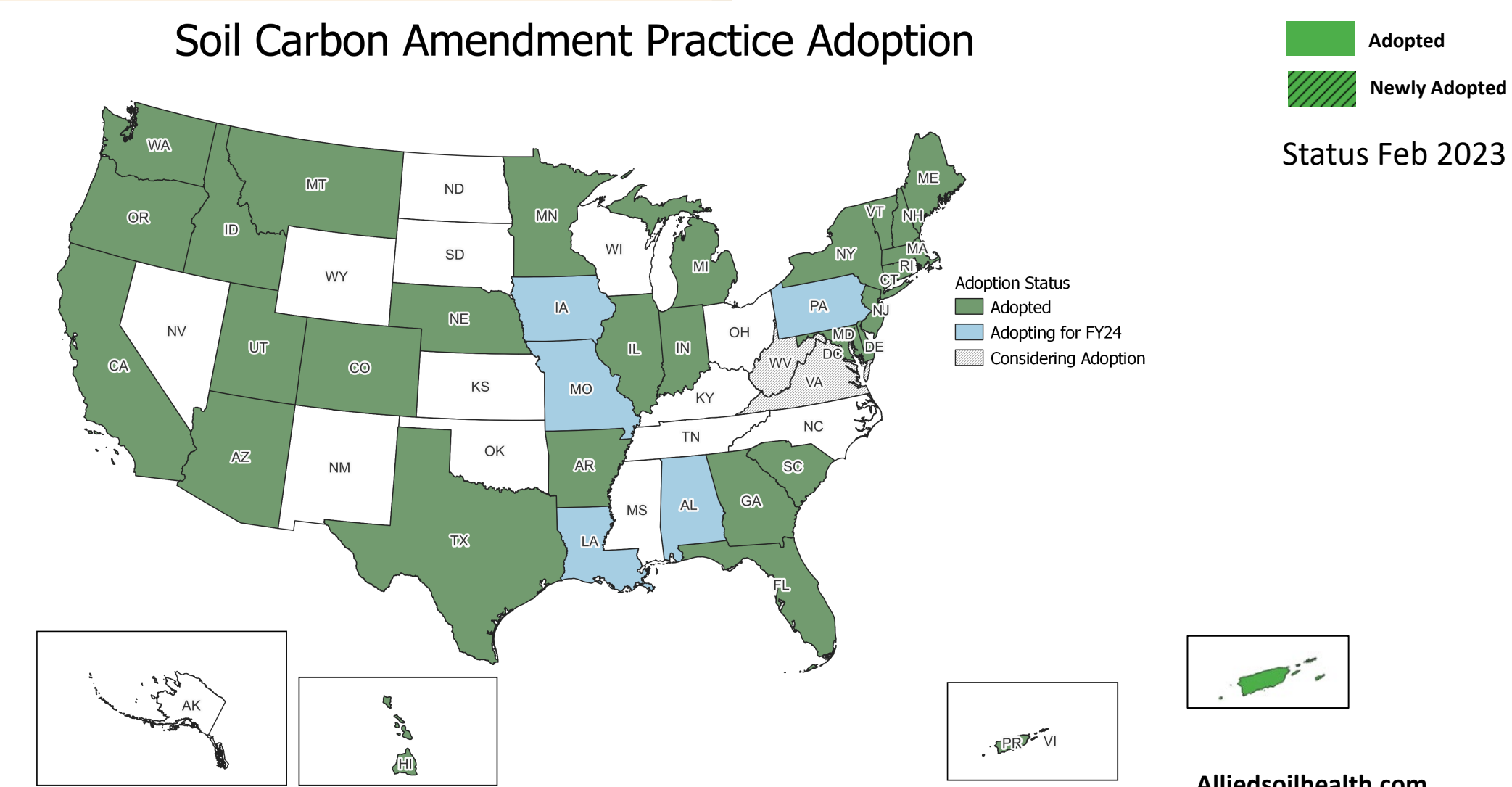


Made of Air  
[www.madeofair.com](http://www.madeofair.com)



# Incentives: Demonstrate Biochar With USDA NRCS Soil Carbon Amendment CP 336

## Soil Carbon Amendment Practice Adoption



# USDA ARS Matches Biochar Soil and Crop Needs

## BIOCHAR PRODUCERS

- DIRECT OUTREACH
- FACTSHEETS
- WEBINARS
- FEEDBACK



## USDA ARS PNW Biochar Atlas + USDA NRCS Soil Health Program

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



## BIOCHAR LIBRARY

- COLLECT &  
CHARACTERIZE  
BIOCHARS



## MODEL DEVELOPMENT

- ADD GHG AND C  
SEQUESTRATION  
ESTIMATES



## MODEL IMPLEMENTATION

### WEB DEVELOPMENT

Minnesota Biochar Summit



## FARMERS



## INREACH NRCS

- TRAININGS
- WORKSHOPS



# Biochar Qualities Help Determine Appropriate Use

**Carbon Storage Class**

H/C<sub>org</sub>

C<sub>org</sub> %  total mass, dry basis

**Fertilizer Class**

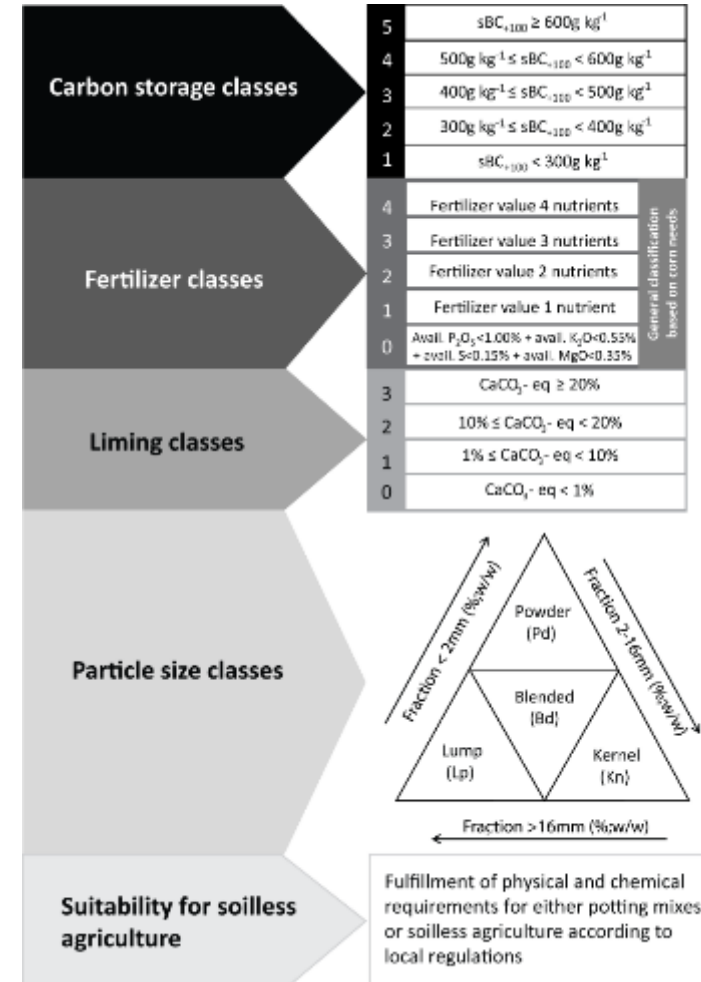
Total N	%	<input type="text" value="3.77"/>	mass basis	Avail. N	%	<input type="text" value="0.19"/>	mass basis
Total P	%	<input type="text" value="3.32"/>	mass basis	Avail. P	%	<input type="text" value="2.69"/>	mass basis
Total K	%	<input type="text" value="3.35"/>	mass basis	Avail. K	%	<input type="text" value="3.35"/>	mass basis
Total S	%	<input type="text" value="0.48"/>	mass basis	Avail. S	%	<input type="text" value="0.36"/>	mass basis
Total Mg	%	<input type="text" value="0.9"/>	mass basis	Avail. Mg	%	<input type="text" value="0.86"/>	mass basis
Total Ca	%	<input type="text" value="6.36"/>	mass basis	Avail. Ca	%	<input type="text" value="6.3"/>	mass basis

**Liming Class**

CaCO<sub>3</sub> %  equivalent

**Particle Size Class**

<0.5mm	%	<input type="text" value="42"/>	2 - <4mm	%	<input type="text" value="6"/>	16 - <25mm	%	<input type="text" value="0"/>
0.5 - <1mm	%	<input type="text" value="30"/>	4 - <8mm	%	<input type="text" value="1"/>	25 - <50mm	%	<input type="text" value="0"/>
1 - <2mm	%	<input type="text" value="21"/>	8 - <16mm	%	<input type="text" value="0"/>	≥50mm	%	<input type="text" value="0"/>



IBI Classification Tool [www.biochar-international.org/classification\\_tool](http://www.biochar-international.org/classification_tool)  
 IBI Classification Webinar Jan 30, 2017 [www.biochar-international.org/node/8730](http://www.biochar-international.org/node/8730)





# Biochar Qualities Standards and Laboratories

## Soil Carbon Amendment Requirements

### Control Laboratories

42 Hangar Way  
Watsonville, CA 95076  
www.biocharlab.com  
Tel: 831 724-5422  
Fax: 831 724-3188

Account No:  
Batch:  
CODE:

Customer

Revision 0

Date Received: 12/8/2022  
Sample ID: SOFTWOOD BIOCHAR 01  
Lab ID. Number: XXXXX-01

General Properties	Result	Units	Method
Moisture (as received)	65.5	% wet wt.	A
Bulk Density	6.6	lb/cu ft (dry)	
Organic Carbon	87.5	%	B
Hydrogen/Carbon (H:Corg)	0.21	Molar Ratio	B
pH value	8.87	units	C
Electrical Conductivity	0.985	dS/m	C
Liming (as-CaCO3)	7.3	% CaCO3	I
Carbonates (as-CaCO3)	2.2	% CaCO3	J
Butane Act.	10.0	g/100g dry	G
Surface Area Correlation	451	m <sup>2</sup> /g	G

Particle Size Distribution	Result	Units	Method
< 0.5 mm	13.1	%	F
0.5 - 1 mm	17.4	%	F
1 - 2 mm	32.9	%	F
2 - 4 mm	34.5	%	F
4 - 8 mm	2.0	%	F
8 - 16 mm	0.0	%	F
16 - 25 mm	0.0	%	F
25 - 50 mm	0.0	%	F
> 50 mm	0.0	%	F

Primary Nutrients	Result	Units	Method
Nitrogen N	0.72	%	E
Phosphorus P	0.07	%	E
Potassium K	0.74	%	B

Secondary Nutrients	Result	Units	Method
Calcium Ca	7410	mg/kg	E
Magnesium Mg	972	mg/kg	E
Sulfur S	211	mg/kg	E

Proximate Analysis	Result	Units	Method
Carbon C	87.8	%	B
Hydrogen H	1.56	%	B
Nitrogen N	0.72	%	B
Sulfur S	0.02	%	E
Oxygen O	5.3	%	Calc
Ash	4.6	%	A
	100.0	% Total	

EPA 503 Metals	Result	Units	MRL	Method
Arsenic As	0.62	mg/kg	0.45	H
Cadmium Cd	ND	mg/kg	0.18	H
Chromium Cr	39.9	mg/kg	0.45	H
Cobalt Co	1.4	mg/kg	0.45	H
Lead Pb	0.83	mg/kg	0.18	H
Mercury Hg	ND	mg/kg	0.001	K
Molybdenum Mo	0.48	mg/kg	0.45	H
Nickel Ni	19.9	mg/kg	0.45	H
Selenium Se	ND	mg/kg	0.90	H
Zinc Zn	13.6	mg/kg	0.90	H

Other Elements	Result	Units	MRL	Method
Sodium Na	553	mg/kg	451	E
Chlorine Cl	442	mg/kg	20	D
Aluminum Al	901	mg/kg	45.1	E

Trace Nutrients	Result	Units	MRL	Method
Copper Cu	7.8	mg/kg	0.45	H
Zinc Zn	13.6	mg/kg	0.90	H
Iron Fe	1307	mg/kg	22.5	E
Manganese Mn	190	mg/kg	0.45	H
Boron B	18.9	mg/kg	4.5	H

\*"ND" stands for "not detected" which means the result is below the Method Reporting Limit (MRL).

Method A ASTM D1762-84  
 B Dry Combustion - LECO  
 C TMECC (2001) 4.10 & 4.11, 1:20 dilution  
 D 1:20 dilution, Ion Chromatography  
 E EPA3050B/EPA 6010  
 F ASTM D 2862 Granular  
 G Surface area correlation based on 'Analytical Options for Biochar Adsorption...' (McLaughlin et al, 2012)  
 H EPA3050B/EPA 6020  
 I AOAC 955.01  
 J ASTM D 4373  
 K EPA 7471

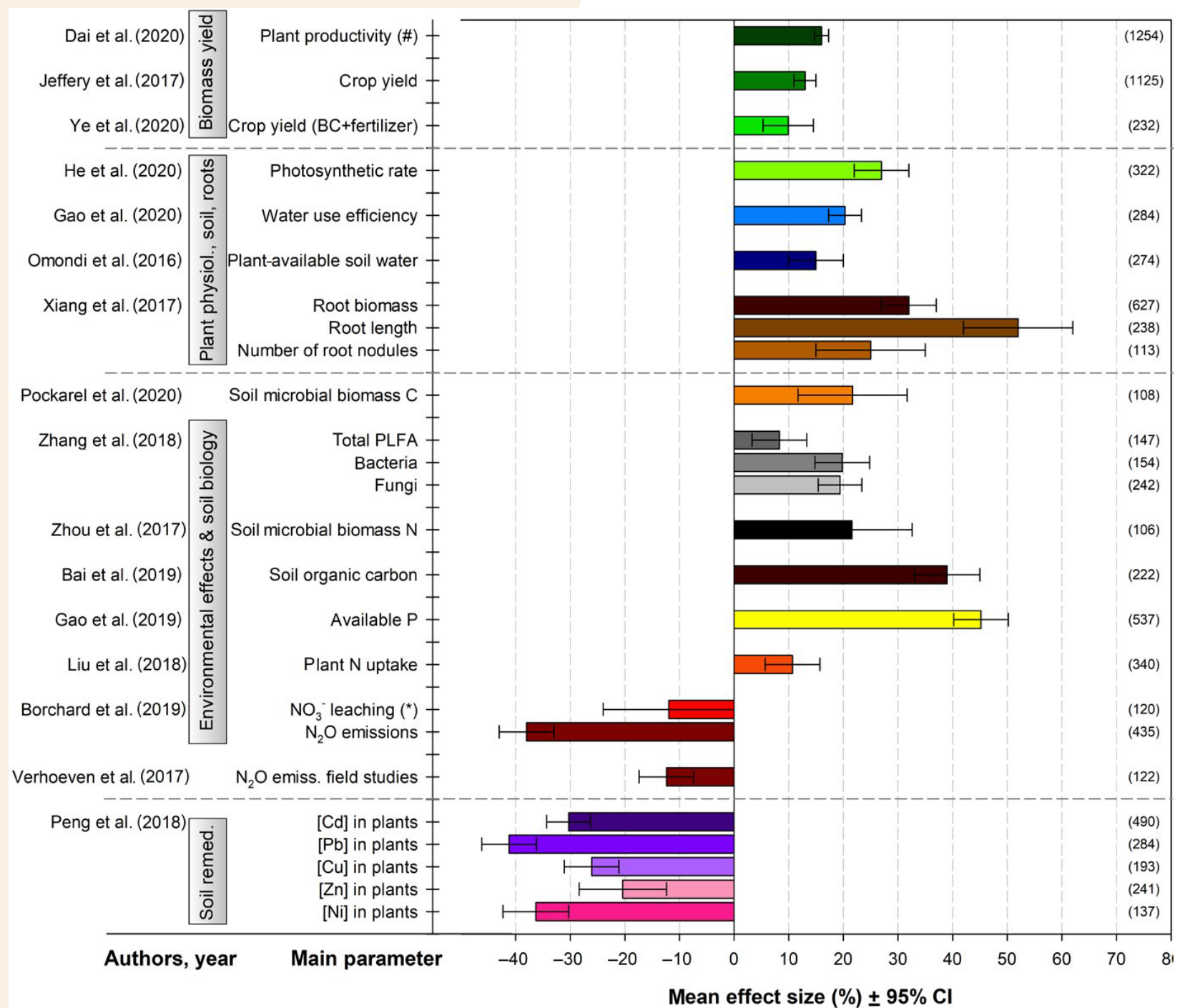
Analyst: XXXX

## International Biochar Initiative Std. Ver 2.0 Biochar-international.org



# Demonstrated Benefits from 26 Reviewed Meta-Analyses

(Schmidt et. al. 2021)



# Industrial Biochar: Urban Wood Gasifier: 100,000 tpy Biochar 15k mt, 135kpph Steam, and 7 MWe Power



Waste Wood Heats Kansas Ethanol Plant ICMinc.com



# Equipment manufacturers

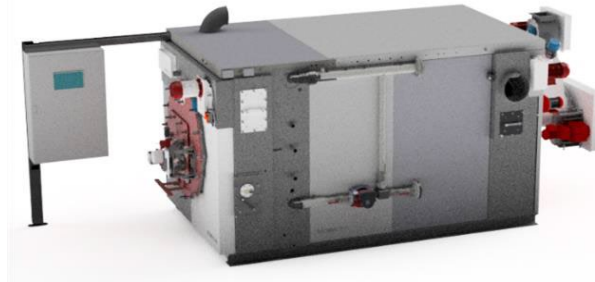
Examples for industrial equipment producing Biochar



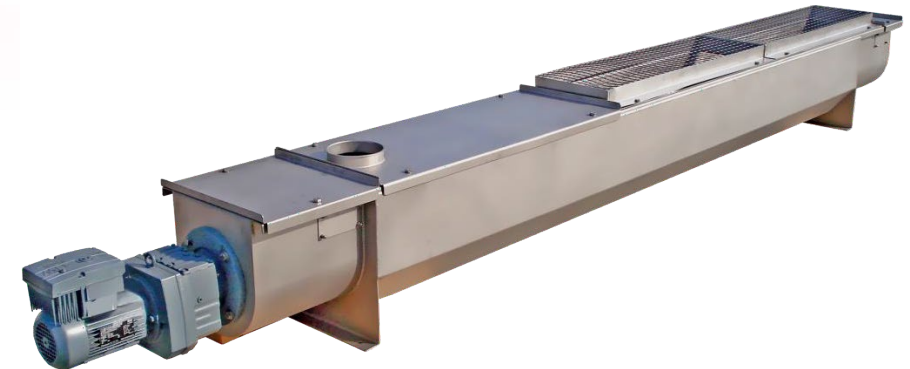
[biochar-industry.com](http://biochar-industry.com)

# Equipment manufacturers

Examples for industrial equipment producing Biochar



Biomaccon



**VOW**

[biochar-industry.com](http://biochar-industry.com)

# Auen Pflege Dienst – Flaach

Reference Project (“Small”)



- Customer: **Auen Pflege Dienst AG (CH)**
- Equipment: **Biomaccon C400-I**
- Commissioning: **2019**
- Feedstock: **Natural wood (forest and landscape management)**
- Energy utilization: **Feeding up to 400 kWth into the local district heating network and an own district heating network for industry**
- Biochar production: up to **360 t/yr of Biochar**

[biochar-industry.com](http://biochar-industry.com)

# Small Industrial Gasifiers Produce Heat and Biochar



## Earthcare LLC

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

2.5 tph fuel

Wood, Manure, Litters, Gasification, Heat



## EcoRemedy

Fluid Lift Gasification

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

Wood, Manure, Digestate, Biosolids,  
Heat



# Integrated Modular Pyrolysis Systems: Heat and Biochar – BET, ARTiChar,



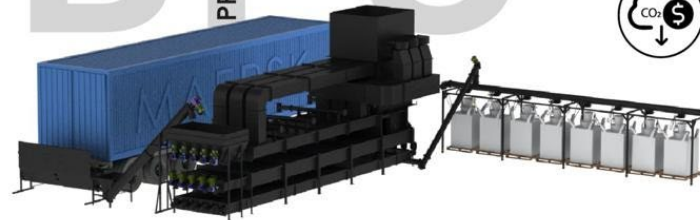
BET

biomassenergytechniques.com



## 5-train

# BIOCHAR PRODUCTION UNIT



PYROLYZES  
**40 TONS**  
of BIOMASS PER DAY



PRODUCES  
**10 TONS**  
of BIOCHAR PER DAY



SEQUESTERS  
**20 TONS**  
of CO<sub>2</sub>eq. PER DAY








Minnesota Biochar Summit

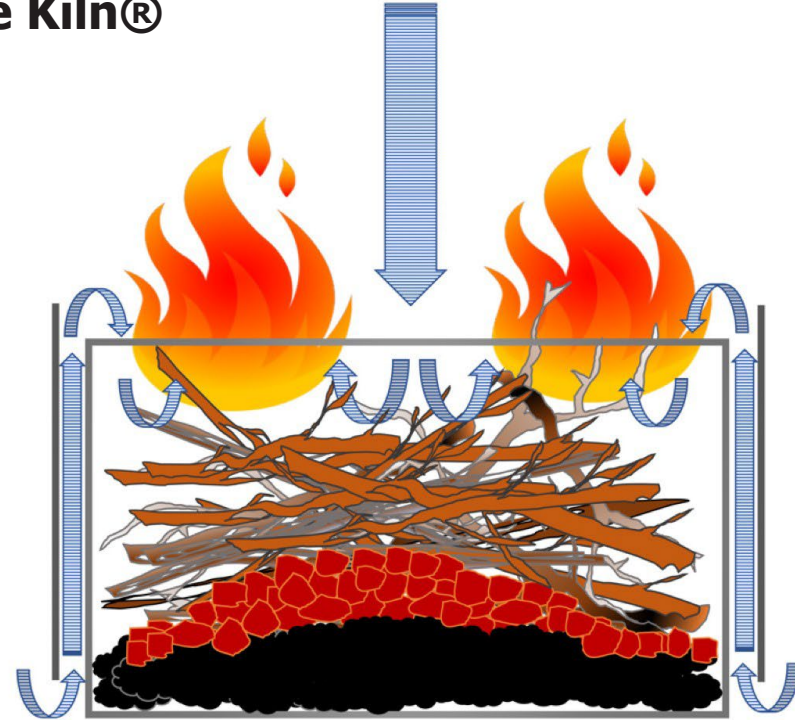


# Biochar In The Woods: Off-season firefighters make biochar in the woods using simple kilns.



Ring of Fire Kiln®

-  • Airflow
-  • Flame
-  • Biomass
-  • Embers
-  • Biochar



Wood 5.6 CY/kiln  
2 CY biochar in 4-5 hours  
1-2 people

wilsonbiochar.com

Biochar in the Woods Online Discussion, Monthly Meetings  
[biochar.groups.io/g/Biocharinthewoods](https://biochar.groups.io/g/Biocharinthewoods)



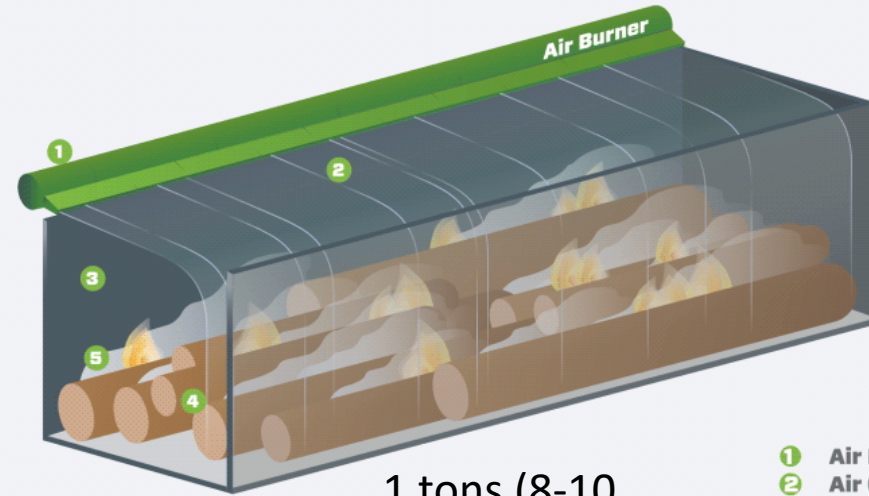
# Biochar Onsite Production: Curtain of air burns gases. Biochar withdrawn continuously through a grate.



Airburners.com

Air Burners Inc.- USFS Cooperative Research and Development Agreement  
Air Burners Inc.

Prototype – 1 ton (10-20CY) per hour IN



1 tons (8-10  
CY)/day OUT

- 1 Air Manifold
- 2 Air Curtain (left to right)
- 3 Firebox Refractory Wall
- 4 Wood Waste or Wood Fuel
- 5 Smoke (PM or Black Carbon)
- 6 Biochar Grate



airburners.com

7 CY Chamber  
4' x 4' x 12'



# CARBON CO-PRODUCTS: Biochar and Firm Renewable Energy from Biomass Plants



**JOSIAH HUNT**  
**PACIFIC BIOCHAR**  
**CALIFORNIA**



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



**Karl Strahl, VP, Oregon Biochar Solutions OREGON**



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

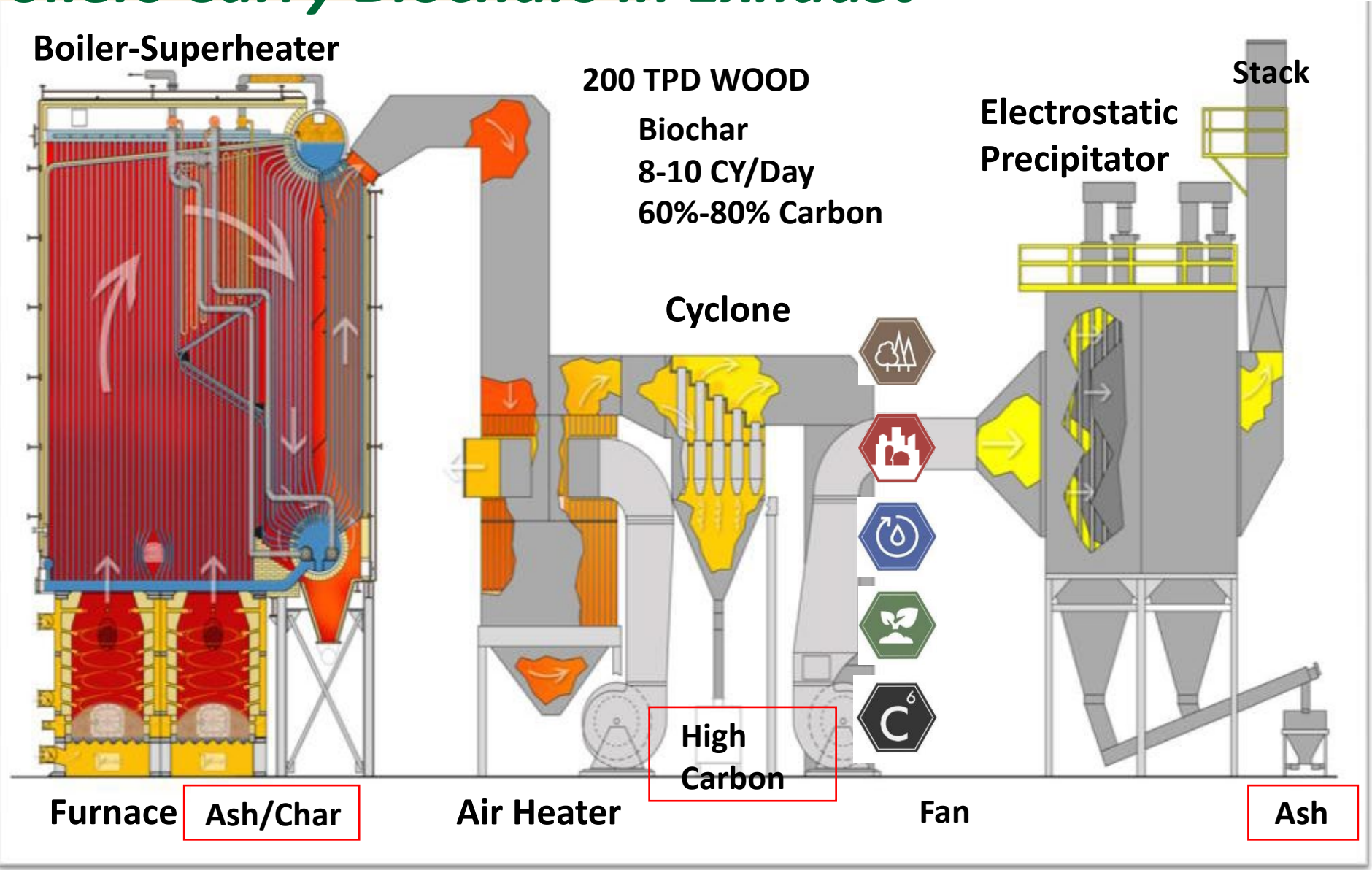
# Biomass Boilers Carry Biochars in Exhaust



Photo: Capital Press  
**Freres Lumber**



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



# *Applying Biochar With Compost: applied down planting row, then ripped into soil profile*



# Broadcast Biochar (Add Water!)



**Add Water to Reduce Dust**

**Wet Biochar Spreads Like Manure**

(these images are captured from internet)



# Progressive Farms Incorporate Biochars and Blends



Overseeding pasture applying seed, biochar and organic amendments with a No-till drill.

Natural Plant Solutions, WA [naturalplantsolutions.com](http://naturalplantsolutions.com)

**Biochar**

**Biochar-organic fertilizer**

**Biochar-based fertilizer**

**Liquid suspension**



***“Biochar Is A Change Agent”***

Jason Mauck, Constant Canopy [constantcanopy.com](http://constantcanopy.com)



# Biochar Improves Fertilizer Use in Row Crops



David Yarrow, Down the Wormhole, 2016

[terra-char.com/jr-bollingers-corn](http://terra-char.com/jr-bollingers-corn)





*Vineyard application: applied down aisle with manure/compost spreader, disked in*



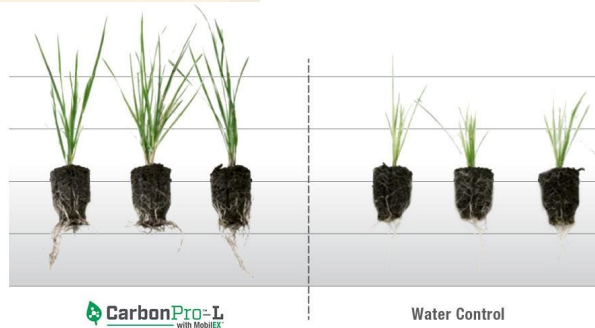
# Liquid Biochars Are Sized, Diluted 1:5 -1:20, Applied



**Biochar Slurry Fed in No Till  
Cross Slot (Don Graves, NZ)**



**Liquid or granular biotic soil amendment for golf and turf  
(LESCO CarbonPro [lesco.com](http://lesco.com))**



- Deeper stronger roots**
- Improved greening**
- Improved Soil and Seed Establishment**
- Increased Nutrient Uptake and Efficiency**
- Reduced Water Requirements**
- Targeted Benefits**

# Animals Inoculate, Distribute, and Mix Biochars in Soil, Improve Forage, Animal Health, Soil Health



- Deer, elk, cattle, pigs, chickens, goats, sheep feed on char which improves health and increases egg, milk, and meat production. Enriched biochar is passed out in the dung.
- Dung Beetles mix and inoculate biochars into soil, improving forage quality and production.
- Worms ingest biochar to form inoculated micro and nanocarbons

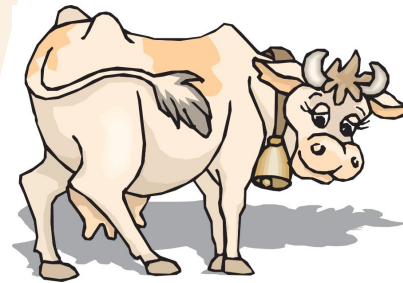
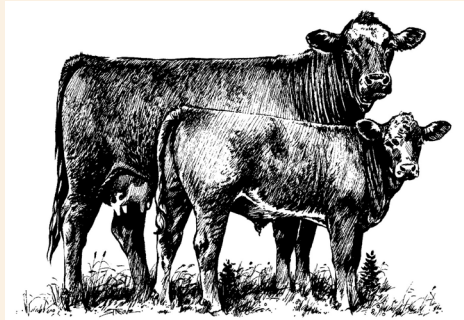
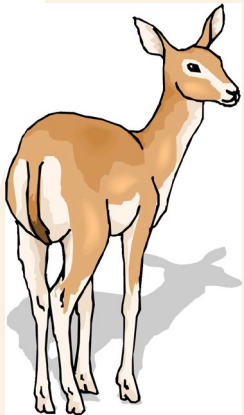


Photo: Sr. Miriam Paulette



Photo: Kathy Dawson

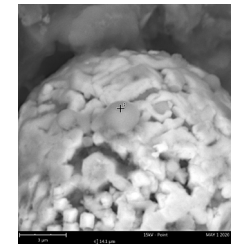


Photo: Stephen Joseph

# BIOCHAR GUIDELINES FOR AGRICULTURE APPLICATIONS

Practical insights for applying biochar to annual and perennial crops



Photo by Britt Fossum



Photo by David Laird

## A sustainable soil amendment that:<sup>1-4</sup>

- builds soil organic carbon and soil health
- increases crop yields and soil moisture
- improves nutrient retention
- boosts microbial activity
- alleviates compaction
- reduces soil acidity
- sequesters carbon



**Biochar 2024**  
**Feb 12-15, 2024**  
**Sacramento,**  
**California**



**Just Add Biochar!**



**Thank you!**

**US Biochar Initiative**

*tom@biochar-us.org*

*www.biochar-us.org*



Photo: Josiah Hunt

