OVERVIEW OF BIOCHAR IN THE WOODS

JANUARY-FEBRUARY 2022

Kelpie Wilson CV

- Biochar consultant since 2012 – technology assessment, market analysis, biochar kiln development, workshops and training, biochar kiln manufacturing and sales
- 2008-2012 -- International Biochar Initiative working in communications and project development
- 2004 -2008 – freelance journalist covering environment, energy and climate change
- 1990 -- 2003 forest protection advocate in SW Oregon working for Siskiyou Regional Education Project
- BS in Mechanical Engineering, CSU, Chico, 1987

Biochar in the Woods Training Workshop

Who should attend?

- Forestry contractors
- Arborists
- Workforce development crew supervisors
- Environmental NGOs
- Natural resource agencies
- Forest land owners
- Residents of the WUI (Wildland Urban Interface)
- Anyone who cares about forest health and climate change

Outline

- What is the Problem?
- How Can Biochar in the Woods Help?
- What is Biochar?
- Technology and Techniques
- Economics
- Carbon and Climate Impact
- Knowledge Gaps
- Where we are going

What is the problem?

- In the western US, climate change, drought, and a century of fire suppression have created a wildfire crisis that threatens ecosystems and communities.

- As forests go up in smoke, we are also experiencing the loss of one of our most important natural carbon sinks, at a time when we must rely more and more on natural climate solutions to drawdown carbon.

Old Growth Forests of the Pacific NW

- Coastal Oregon stands store on average, 1127 Mg C/ha*
- More than any other ecosystem on the planet

*Smithwick, E. A., Harmon, M. E., Remillard, S. M., Acker, S. A., & Franklin, J. F. (2002). Potential upper bounds of carbon stores in forests of the Pacific Northwest. *Ecological Applications*, *12*(5), 1303-1317.

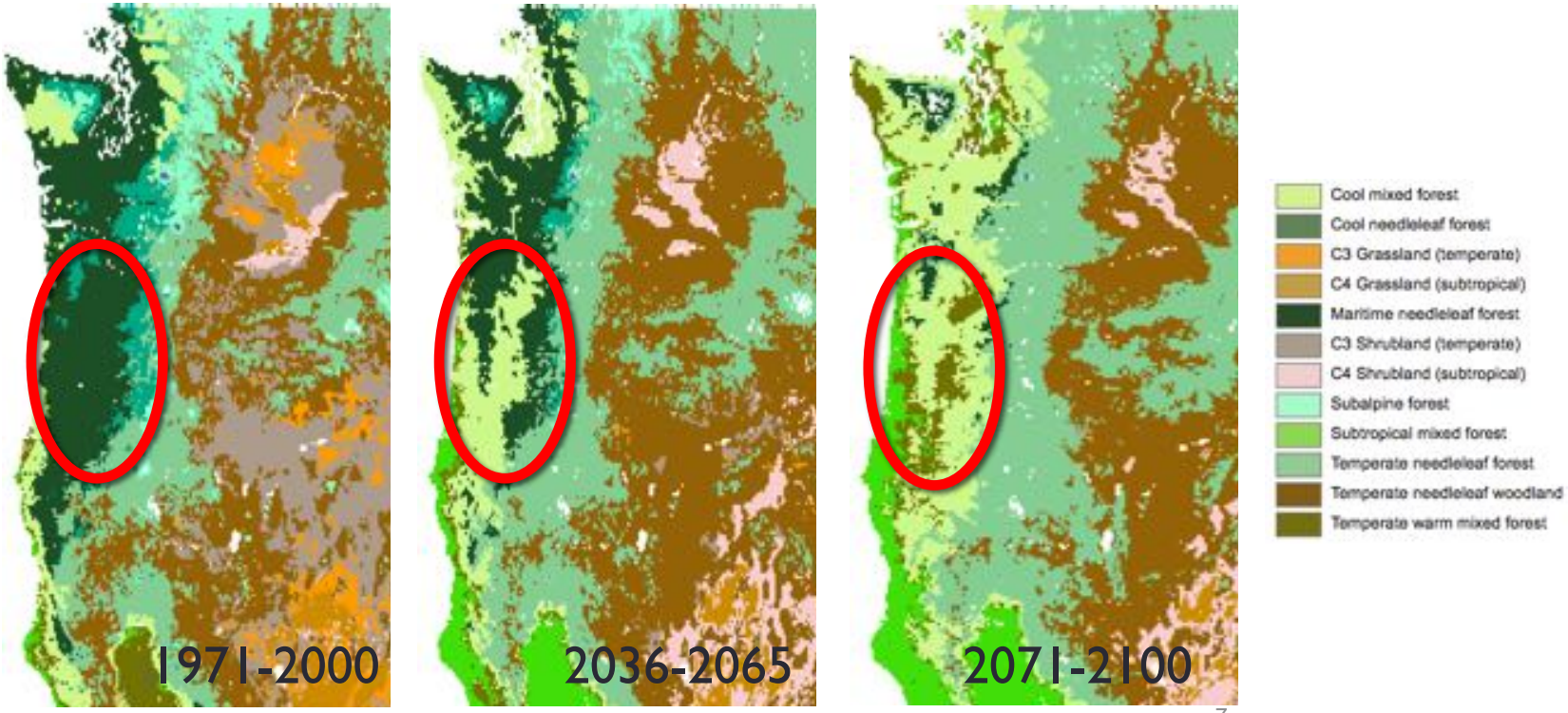
Drastic Changes in Forest Structure

Simulating Vegetation Shifts by Mid-Century

Pure evergreen forests

MIROC5 (Japan) RCP8.5

Mixed type forests



Warmer subtropical type forests

Dr. Dominique Bachelet, Dept of Biological and Ecological Engineering, OSU. *Maintaining a Healthy Forest in an Uncertain Climate, Tiller, OR – 15 February 2020*

We need to plan now for climate adaptation

High Severity Fire – Slater Fire 2020

How are we addressing the fire problem?

- Pre-fire Vegetation Management:
  - Fuels reduction projects taking place across the landscape remove thick undergrowth and either burn in place, or chip and transport it.
- Post-fire Management:
  - Fire leaves behind massive amounts of dead trees that are a safety hazard. This biomass must also be removed.
- ***How can we leverage these mandatory activities to improve forest soil?***

Paradise, California-January 2020

Natural Biochar from Wildfires

The amount of charcoal generated by wildfire depends on fire intensity, fire return interval, vegetation type, fuel loading and fire behavior. **From 10-50% of the carbon found in forest soils is charcoal** (Pingree 2012).

Fire adapted forest soils need char

- Activities that exclude fire … eliminate the contribution of this stable, yet biochemically important form of C to the soil ecosystem.

- *DeLuca, T. H., & Aplet, G. H. (2008). Charcoal and carbon storage in forest soils of the Rocky Mountain West. Frontiers in Ecology and the Environment, 6(1), 18–24. http://doi.org/10.1890/070070*

Management effects on forest char

Management that reduces char in forest soils:

- Fire suppression
- Forest thinning with no prescribed fire

Management that increases char in forest soils:

1. Frequent, low-intensity fire – Brimmer (2006) found that sites that experience multiple fires contained 3x more char than sites where fire was excluded
2. Forest thinning followed by prescribed fire
3. **Biochar in the Woods**

#Biocharinthewoods

What are the Goals of Biochar in the Woods?

Long-term Goal:

- **Protect and enhance forests as natural carbon sinks and sources of clean water, air and biological diversity**

Strategies:

- Vegetation thinning for fuels reduction
- Make biochar onsite to leave onsite
- Follow by prescribed fire with the goal of returning frequent, low intensity fire for natural regeneration, nutrient cycling and char formation/C sequestration

Biochar in the Woods
Short-term Goals:

- **Sequester carbon**
- **Avoid impacts from burn piles**

Strategies:

- Make biochar and leave onsite for measurable C sequestration
- Reduce smoke emissions by using biochar burn techniques
- Avoid burn pile impacts

Eroding Burn Pile Scar


Smoke fills the air from hundreds
of burning slash piles - 2009

Biochar in the Woods Medium-term Goals:

Apply biochar in the forest to help with forest regeneration, post-fire recovery and drought resistance

Strategies:

- Apply biochar to reduce soil bulk density, alleviate compaction and improve soil aggregates
- Use biochar to absorb toxic compounds from mining or other industrial activities, such as oil spills
- Use biochar to hold more soil moisture around legacy trees
- Use pH-adjusted biochar in nursery pots and tree planting holes to retain moisture and nutrients
- Use biochar inoculated with mycorrhizal spores to restore soil microbiome

Forest Tree Nursery

Photo: Tom Jopson, Cal Forest Nurseries

Left: No biochar. Right: Biochar

Photo: Oregon Biochar Solutions

Left: No biochar.
Right: Biochar

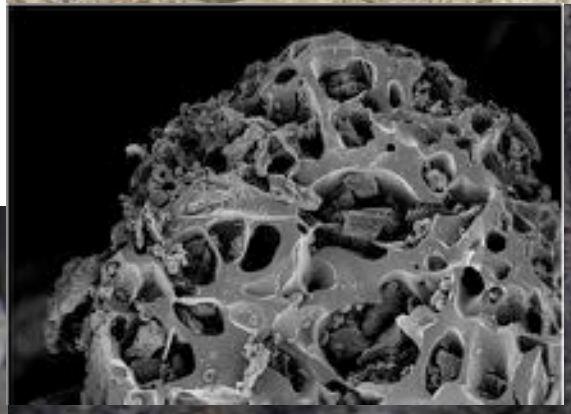
Biochar is an economical substitute for peat and perlite

Research Questions:

- Will biochar mixed with wood mulch build soil faster than either one alone?
- Can we use hydrophilic biochar in post-fire recovery to rehab hydrophobic soils?
- How do we identify microsites in forests that can benefit most from biochar?

WHAT IS BIOCHAR?

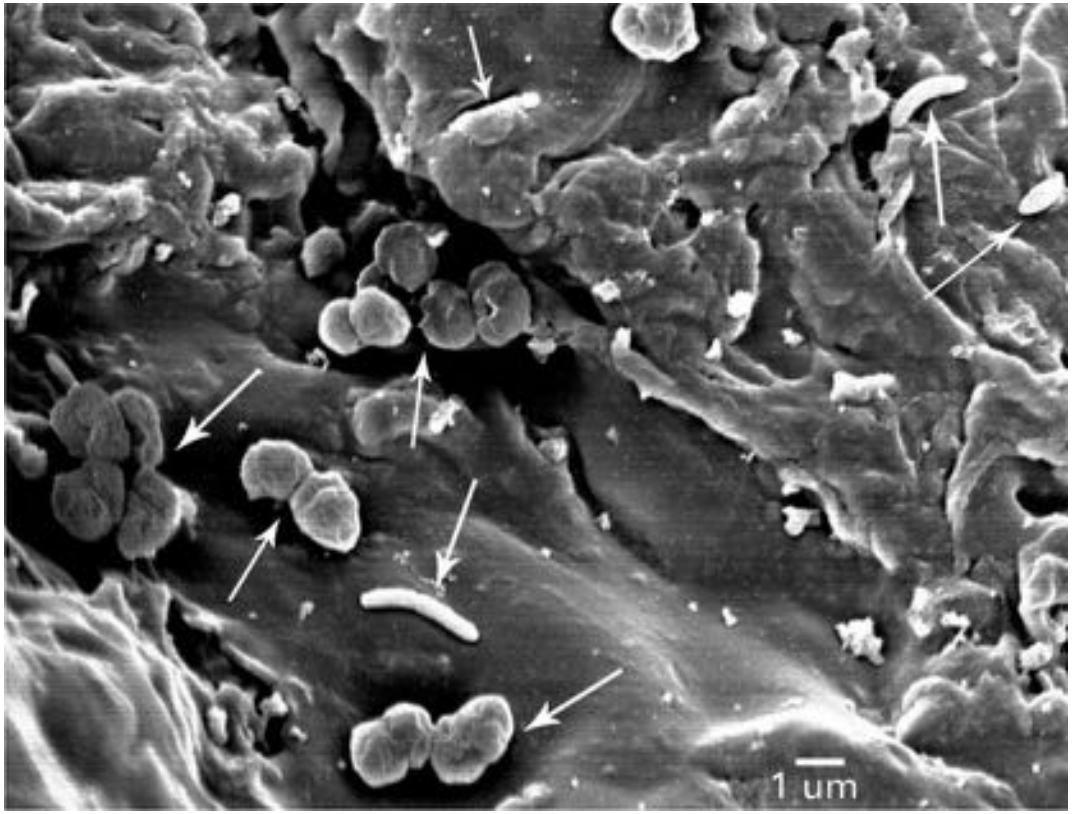
Biochar is charcoal that you can add to soil*



*Biochar: A solid material obtained from thermochemical conversion of biomass in an oxygen-limited environment. (IBI, 2012)

Biochar provides condos for microbes

Microbes like to sit down when they eat



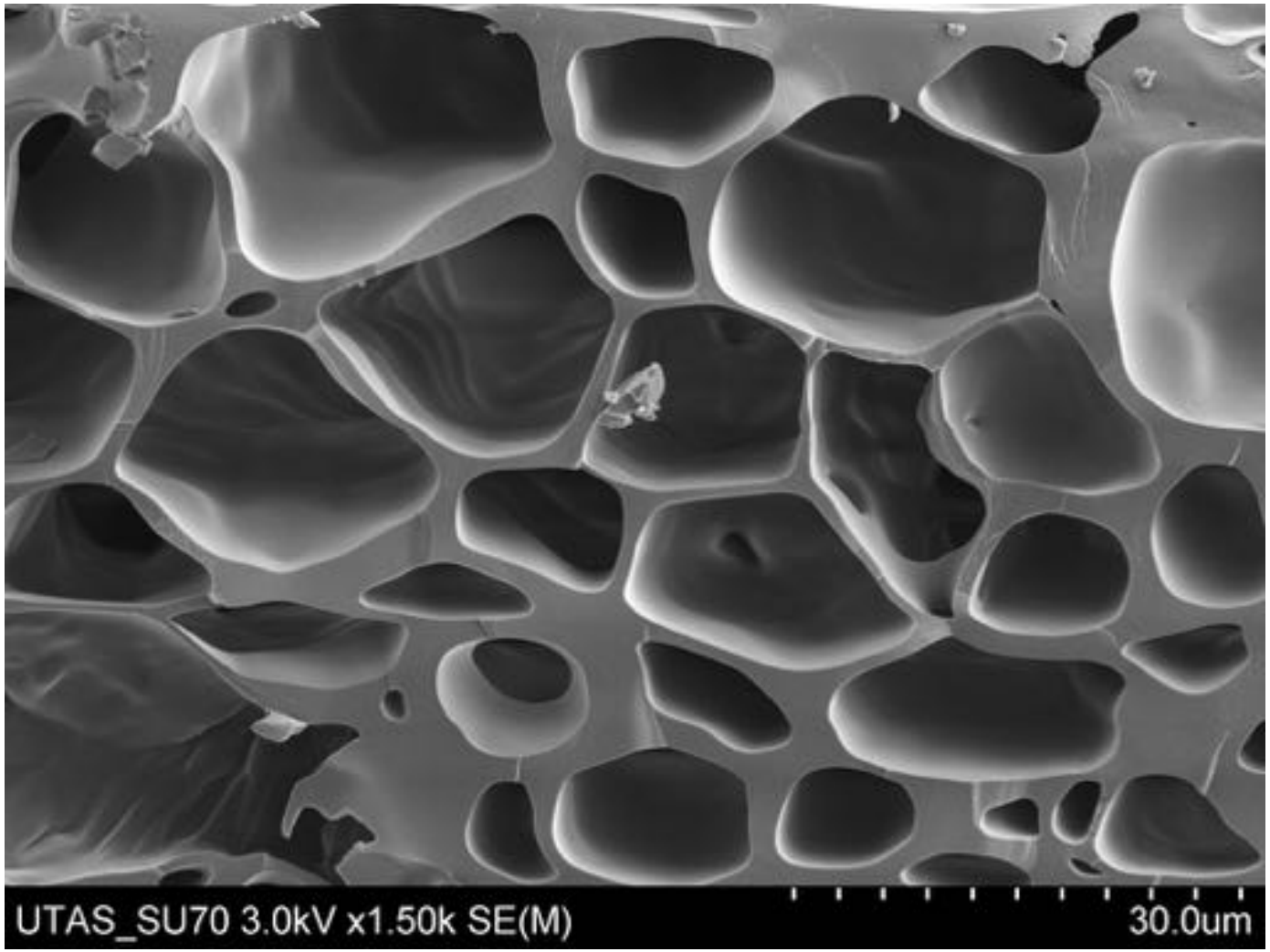
Included:

1. Electric
2. Water
3. Food

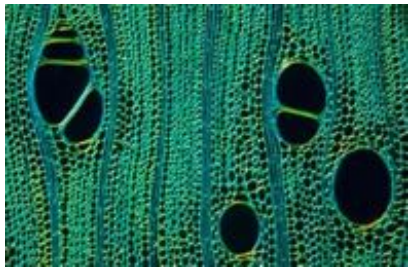
Let's Party!

Picture from: *Chen, Shanshan, et al.* ***"Promoting interspecies electron transfer with biochar."*** *Scientific reports 4 (2014).*

How is biochar formed?



Biochar is formed by heat

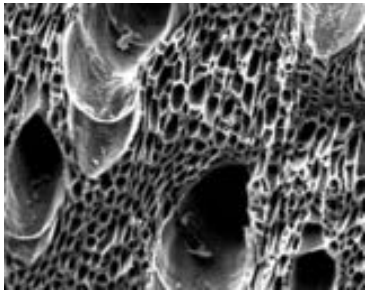


Wood:

- Has cellular structure

Cellular
Micro-scale

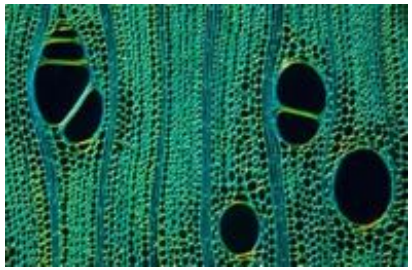
HEAT



Biochar:

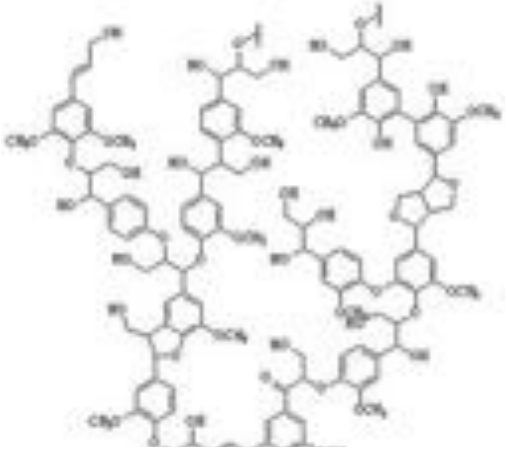
- Biomass shrinks but retains structure

Biochar is formed by heat



Wood:

- Has cellular structure



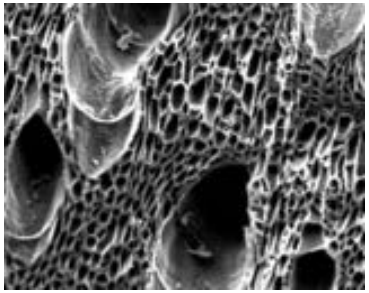
Lignin molecule:

- Has many carbon rings already

Cellular
Micro-scale

HEAT

Molecular
Nano-scale



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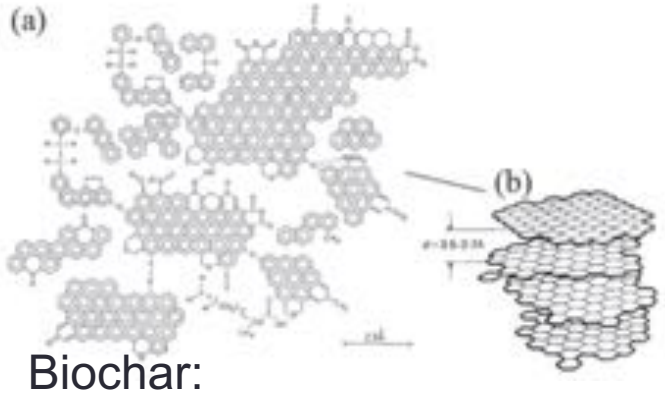
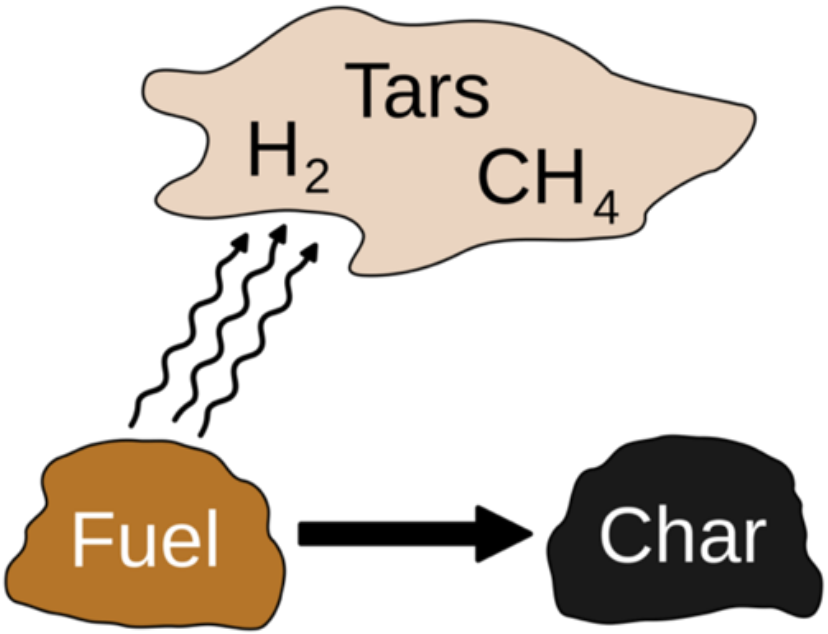


Biochar:

- Carbon rings fuse and condense

Pyrolysis Overview

Pyro-lysis: from pyro (fire) and lysis (separation)



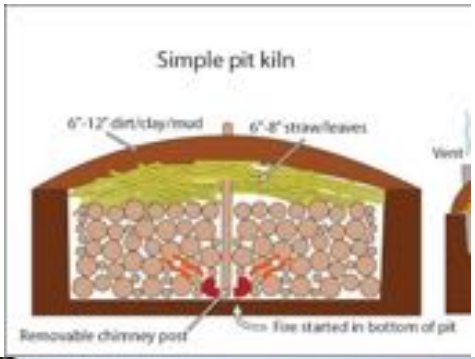
Human
Macro-scale

On-Site Production Techniques

1. How NOT to make biochar
2. How Flame Carbonization works
3. Conservation Burns
4. Flame Cap Kilns
5. Air Curtain Burners

Traditional Kilns: How NOT to make biochar

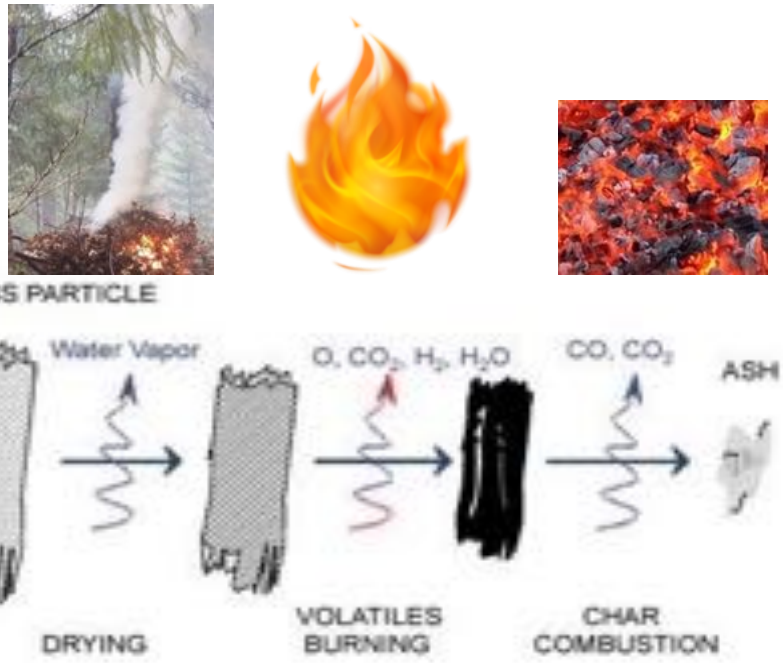
- Traditional kilns – low temperature smoldering combustion – no flame, lots of smoke
- Fuel charcoal is high in condensed volatiles – makes good fuel, not so good biochar



Flame Carbonization: Jack Daniels Rick

Flame Carbonization

Making biochar in an open flame



- Biomass burns in 3 stages.
- To make char, stop the process before it goes to ash
- Small pieces char more efficiently than large pieces

Techniques for Flame Carbonization

- Conservation Burn – an open pile burn that has three characteristics:
  1. Loosely stacked pile for good air flow
  2. Light on the top so a flame is present to burn smoke
  3. Quench at glowing coal stage to save the char and reduce soil heating
- Flame Cap Kiln
  1. Like a Conservation Burn, but inside a container
  2. Once the initial pile has charred, continue to add more biomass until the container is full
  3. Quench at the end to save the char

Conservation Burn

- Light piles on top to reduce smoke emissions
- Quench piles with water to save the biochar and avoid scorching soil

Bottom Lit vs. Top Lit Burn Pile

- Conventional: Flame under cold biomass makes smoke
- Top Lit: Light on top – heat transfers to pile by radiation
- Flame on top burns smoke

Standard Burn Pile

- Designed so that piles burn completely to ash
- Generate smoke
- Destroy forest soil
- Increase soil erosion, invasive species

Burn pile scars are long-lasting

Pile burning can create grass and forb-filled openings that often remain treeless for decades, as can be seen in this aerial photo of a 40-year-old regenerating lodgepole pine stand in Grand County, Colorado. (Photo by C. Rhoades)

Is there another way to treat problem fuels?

Conservation Burn: Rake and Quench

Raked and quenched:

- Unburned fir needles under char
- Organic soil is fine

Not quenched:

- More ash
- Organic soil all gone

What do you need for a Conservation Burn?

- Hand crew
- Light on piles on top
- Crew tends piles and quenches with water spray and raking
- Water tender with 1” line to reach piles, or backpack pumps

Large Conservation Burn

Umpqua Biochar Education Team – forest slash

Sonoma Biochar Initiative – grape vines

Piles made by mini-excavator: dropping slash onto pile to make “fluffy” piles without dirt.

What do you need for a Large Conservation Burn?

- Instead of bulldozer piles, use excavator to make loosely stacked piles – up to 10’ tall. No dirt in piles
- Add kindling pocket for lighting
- Cover if possible to keep dry
- Light on top
- Water tender and skid steer with rake to spray and rake for quenching and saving char

The Flame Cap Kiln

Flame Cap Kiln – Burn Pile in a Pan

Smokeless Carbonizing Kiln Charring Schematic
MOKI Manufacturing Co. Ltd.
Nagano, Japan

- Pan excludes air from side and bottom
- Flame on top uses up all the oxygen
- Char is protected from air and does not burn
- Keep loading until it is full

Can be any shape:

pit, pyramid, cone, ring, trench, box, barrel

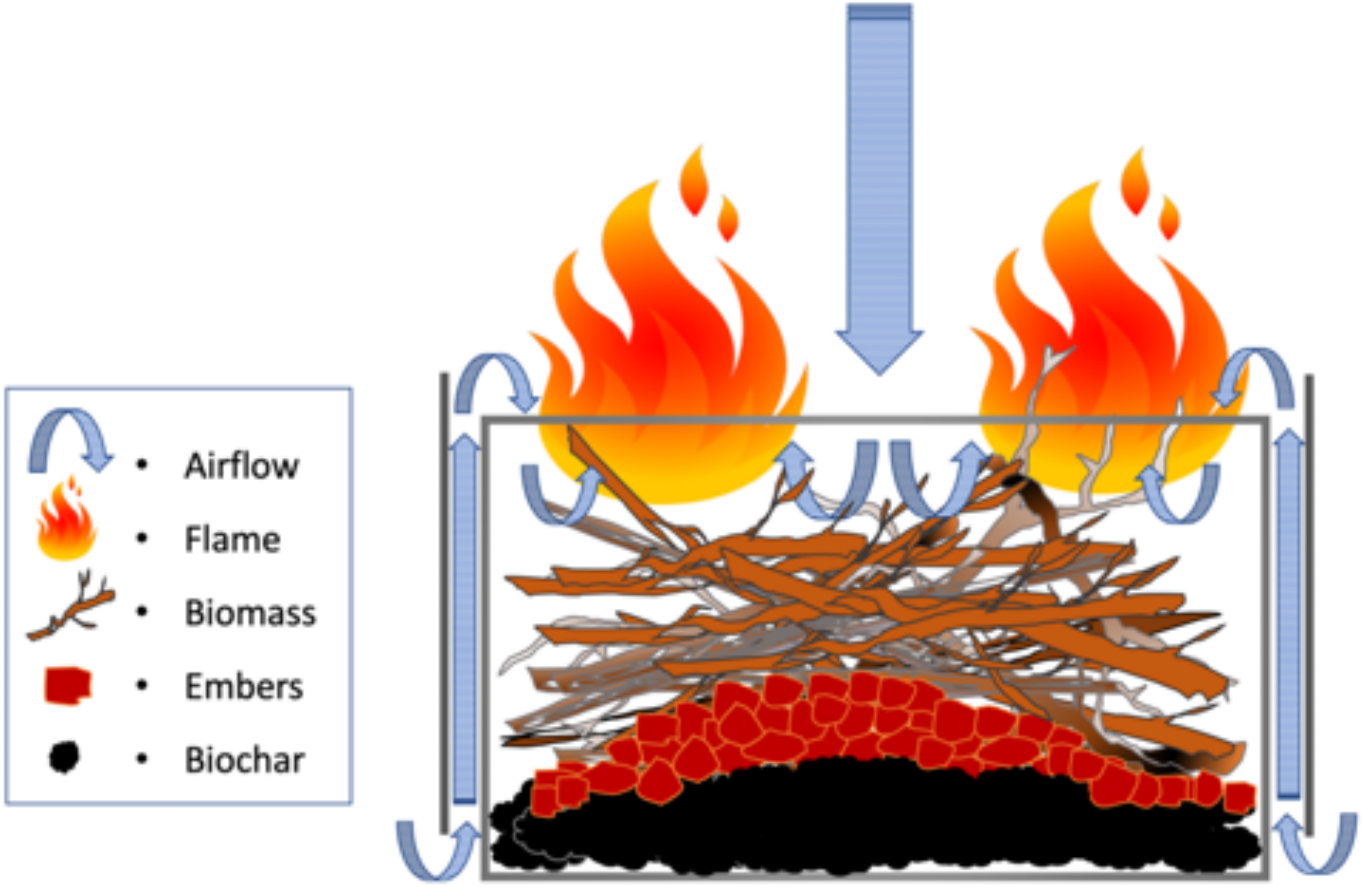
Counter-current flow

Passive counter-current flow as burning fuel draws air downward. Flame stays in the kiln, burning the smoke.

The Ring of Fire Kiln

Easily mobile. Heat shield improves carbonization efficiency and reduces emissions. Makes 1.5 cubic yards in about 4 hours.

How the Ring of Fire Works



Ring of Fire Biochar Kiln

Airflow and Flames

www.wilsonbiochar.com

Ring of Fire Kiln Burns Smoke

WILSON BIOCHAR
WilsonBiochar.com

RING OF FIRE™ BIOCHAR KILN

Made in the USA. Manufactured in Jackson County, Oregon

Ring of Fire Biochar Kiln Specifications

Kiln diameter (with heat shield)	77 inches
Kiln height (with heat shield)	44 inches
Kiln total volume:	3 cubic yards
Kiln weight (fully assembled)	240 pounds
Number of kiln body sections	3
Weight of one kiln body section	40 pounds
Burn time to make 1 cubic yard biochar	4 hours

January 2022 price: $1,295

Pre-order form at WilsonBiochar.com

Expandable up to 5 panels

Three Types of Forestry Kilns

	Small Bin Kilns	Large Bin Kilns	Panel Kilns-expandable
Mobility	ATV, Hand Crew	Road-based	Hand Crew
Feedstock diameter	Up to 4”	Up to 8”	4” – 8”
Feeding	Hand fed	Machine or hand fed	Machine or hand fed
Quenching	Flood	Flood	Spray and Rake

Oregon Kiln

Utah Big Box Kiln

Ring of Fire Kiln®

Small Bin Kiln - The Oregon Kiln

- Dimensions: 5 foot top base; 4 foot bottom base, 2 feet high
- Weight: 200 lbs
- Makes one cubic yard of biochar in about 4 hours

Drew Veg project – Umpqua Biochar Education Team
Three days,166 cubic yards of forest slash, 7 tons of CO_2 sequestered

Large Bin Kiln

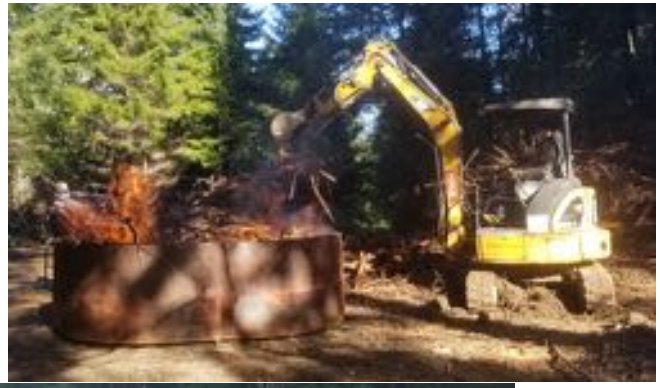
The Tree Service, Brandon Baron, Burns, Oregon
10,000 gallon water tank cut in half

Small Panel Kiln

Production Process:

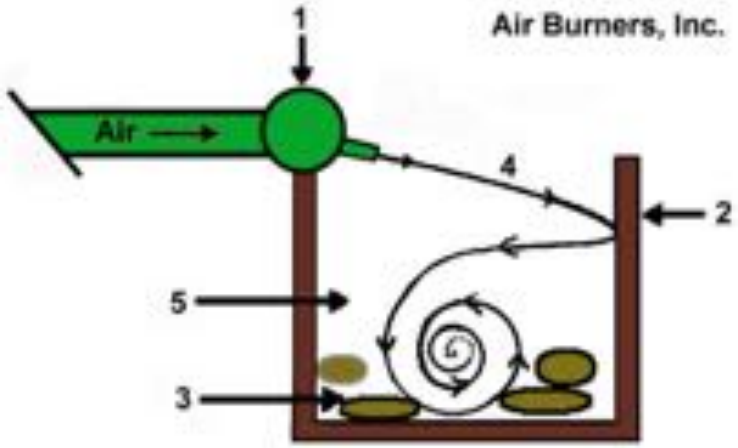
1. Lighting
2. Loading
3. Unloading and Quenching

Panel Kiln - Expandable



Five panel Ring of Fire Kiln is 9.6’ in diameter

Air Curtain Burner – active counterflow



- Active countercurrent flow using a blower
- Designed for complete incineration, not biochar
- To make biochar:
  - turn off or turn down the blower
  - change the loading rate

What do you need for a small kiln?

- Feedstock prep options:
  - Yard and stack on roadside
  - Pile or windrow in place
- Material forwarding options for feeding kilns:
  - Hand crew for moving feedstock to kilns
  - ATV or tractor support for moving feedstock to kilns
- Quenching options:
  - Garden hose
  - Water truck or trailer with fire hose
  - 5-gallon backpack pumps

What do you need for a large kiln?

- Yarding system for whole, small trees
  - Forwarder/skidder/loader/mini-excavator/ATV
  - Cable yarding
- Cut to length and stack on roadside (hand crew)
  - Pile
  - Windrow
- Machine loader for feeding kilns – large bin or panel kilns
  - Use loader or auxiliary machine support for moving feedstock to kilns
- Quenching system
  - Flood quench if using bin kiln
  - Spray and rake with machine (loader or skid steer) if using panel kiln

Biochar in the Woods Technology Matrix

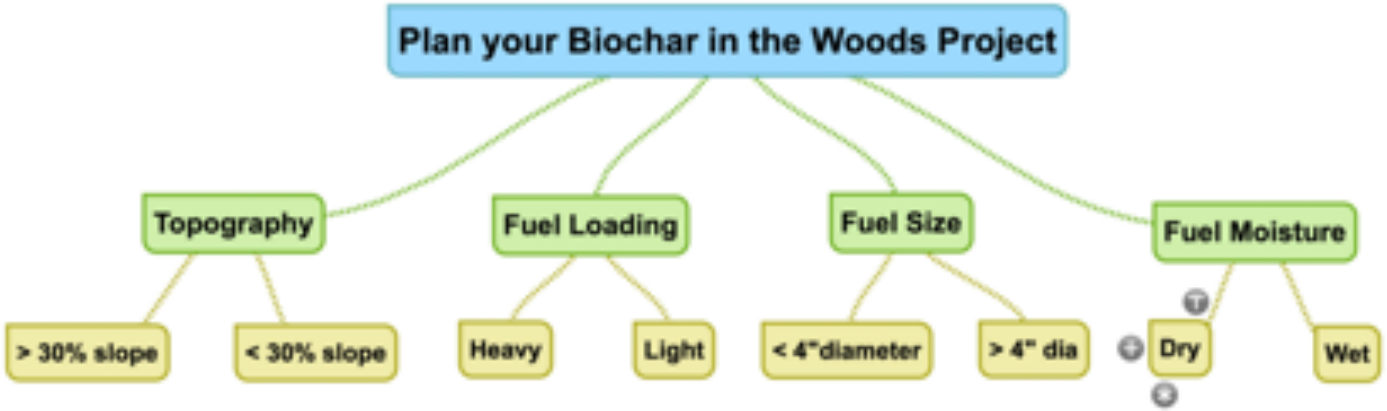
Site Conditions

- Topography
  - steep slopes
  - moderate slopes
- Fuel loading on landscape
  - light
  - heavy
- Fuel size
  - less than 4” dia
  - greater than 4” dia
- Fuel moisture
  - dry
  - wet

Technology Options

- Conservation Burn
- Large Conservation Burn
- Small Kiln
- Large Kiln
- Air Curtain Burner

Biochar in the Woods Decision Tree



Costs and Outputs – BIW Methods

	CB	SK	LCB	LK	ACB
	Hand Crews		**Mechanized Operations**		
Equipment Cost	low	low	low	low	high
Mobilization cost	low	low	medium	medium	high
Labor cost	medium	high	low	low	low
Biochar production efficiency*	low	high	low	high	medium
Fuel incineration efficiency**	high	low	high	low	medium
Emissions	medium	low	medium	low	low

CB – Conservation Burn
LCB – Large Conservation Burn
SK – Small Kiln
LK – Large Kiln
ACB – Air Curtain Burner

* Biochar production efficiency = biomass input/biochar output
** Fuel incineration efficiency = time spent/biomass removed

Civilian Conservation Corps

- President Franklin Delano Roosevelt proposed the CCC program to Congress on March 21, 1933:

"I propose to create [the CCC] to be used in complex work… [in] … forestry, the prevention of soil erosion, flood control, and similar projects."

Carbon Conservation Corps

- A service year for young people
- Improve forest health and protect communities from wildfire
- Pay them to sequester carbon in biochar

  - PHYSICAL FITNESS
  - A SENSE OF PURPOSE
  - HOPE FOR THE FUTURE

Planting trees in biochar – Lomakatsi Restoration Project, Ashland, Oregon

Simple Metrics for Estimating GHG Impact

- One foot of biochar in the 6 foot diameter Ring of Fire Kiln equals one cubic yard of biochar.
- Assume one cubic yard of biochar weighs 200 pounds, then ten cubic yards of biochar weigh 2000 pounds = one ton
- Rule of thumb: one ton of biochar = 2.5 tons of sequestered CO_2
- **Shovel-ready and measurable!**

Critical Knowledge Gaps and Future Work

- Pilot projects with good data collection to establish costs and benefits
- Emissions testing of kilns to help air quality regulators understand benefits of flame carbonization
- Advocacy and funding to establish BIW programs
- Resource sharing networks for small landowners
- Training programs for contractors, forestry workers, managers and landowners

Biochar in the Woods Topic List for USFS GTR (General Technical Report)

Technology

- Kiln Design
- Quenching methods
- Field Logistics
- Feedstock yarding methods
- Feedstock assessment and prep
- Feedstock handling
- Feedstock drying and covering
- Charring green wood
- Burn windows, weather and climate
- Project planning considerations
- Landscape tiers

Ecology

- Biochar applications in the forest
- Post fire recovery
- Invasive species as feedstock
- Conservation burn impacts
- Prescribed burning
- Biochar to suppress invasive species
- Soil water holding capacity
- Tree planting with biochar
- Biochar for erosion control
- Ecological monitoring
- Emissions and permitting

Economics

- Project economics - costs
- Project economics - benefits
- Comparison to alternatives (chipping)
- Workforce development
- Conversion efficiency measurements
- Carbon sequestration metrics
- Life Cycle Analysis
- Carbon credits
- Policy support

We need to refine and document our Biochar in the Woods practices so that agencies and organizations can specify, fund, and implement these techniques.

Join our Biochar in the Woods Discussion Forum:

send email to:Biocharinthewoods+subscribe@Biochar.groups.io.

Acknowledgments

- ***Wilson Biochar Associates would like to thank the many collaborators who have helped develop and sponsor demonstration projects using flame cap kilns and other onsite biochar technologies for forest restoration, including but not limited to:***
- Natural Resources Conservation Service, US Forest Service, USDA-ARS, US Biochar Initiative, Sonoma Biochar Initiative, Sonoma Ecology Center, Grayback Forestry Inc., Lomakatsi Restoration Project, Illinois Valley Community Development Organization, South Umpqua Rural Community Project, Umpqua Biochar Education Team, Umpqua Community College Welding Department, Ithaka Institute, Consortium for Research on Renewable Industrial Materials, Utah State University, North Dakota Forest Service, Nebraska Forest Service, Kansas Forest Service, Oregon State University, Yew Creek Alliance, Butte Community College, Butte Fire Safe Council, Institute for Sustainable Forestry, Northwest Permaculture Convergence, Redwood Forest Foundation, Inc., Long Tom Restoration Council, International Society of Arborists, Table Rock Foundation, Project Youth Plus, Soil and Water Conservation Districts in multiple states…
- ***…and hundreds of small woodland owners, farmers, and biochar enthusiasts who have attended workshops and demonstrations to help pitch slash into kilns and make biochar.***

Today's BIW Presenters – Morning

- 9:50 – Carlos Rodriguez Franco, Senior Forester, USDA Forest Service Research and Development: Forest Service Programs that Support Biochar
- 10:00 -- Deborah Dumroese, USDA Forest Service Research Soil Scientist: Opportunities to Improve Forest Soil Health
- 11:00 – Karen Youngblood, Forest Conservation Specialist, Redwood Forest Foundation, Inc.: Biochar in the Redwoods
- 11:20 – Kai Hoffman-Krull, Forest Health Manager, San Juan Islands Conservation District: Biochar in the Woods with the Island Conservation Corps

Today's BIW Presenters – Logistics and Economics

- 12:45 Laurie Schoonhoven, NRCS National Forester: NRCS Programs that Support Biochar
- 1:00 Ken Carloni, Yew Creek Land Alliance: NRCS Biochar CSP Implementation – a Landowner's View
- 1:15 Joe Pongratz, Pongratz Forestry and Dan Hanson, Nighswander Resources, LLC: NRCS CSP Implementation – A Forestry Contractor's View
- 1:30 Mark Vander Meer, Principal Partner, Watershed Consulting, Inc.: Time and Motion Study Results Using an In-Woods Flame-Cap Kiln

Today's BIW Presenters – Environmental and Social Impacts

- 2:00 Abby Colehour, Restoration Projects Manager, Long Tom Watershed Council: Ecological monitoring: biochar's impact on oak-prairie plant communities
- 2:15 Gloria Flora, Executive Director, Sustainable Obtainable Solutions – Fire Ecology Restoration Project of the Permaculture Institute of North America: Developing Social Forestry as a Permaculture Practice
- 2:30 Dylan Maxwell, CEO, CarbonFace: How to Use the CarbonFace Platform to Build Biochar Communities

Today's BIW Presenters – Technology Development

- 3:00 Ken Carloni, Yew Creek Land Alliance – Measuring Production Efficiencies and Applying Lessons Learned
- 3:15 Darren McAvoy, Utah State University -- In-Woods Biochar Production Using Big Box Kilns
- 3:30 Raymond Baltar, Sonoma Biochar Initiative – Measuring Emissions from Conservation Burns and Flame Cap Kilns
- 3:45 Jim Archuleta, Regional Wood Innovations Coordinator
- USDA USFS – New Approaches to Landing Piles and Air Curtain Burners
- 4:00 – Thankyous and Closing
- 4:15-5:00 – Shop Talk! Stick around and continue the discussion if you like.



Thank You!

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Wilson Biochar specializes in biochar technology and market development. We provide strategic advice and services to businesses and organizations.

- Technology Assessment
- Research and Analysis
- Equipment Manufacturing and Sales

More info at: WilsonBiochar.com