



UNDERSTANDING AND USING BIOCHAR PRACTICE GUIDELINES DEVELOPED BY THE UMPQUA BIOCHAR EDUCATION TEAM (UBET)

Kelpie Wilson
Wilson Biochar Associates

Part I: Production



AGENDA

1. Project Overview
2. Theory of Flame Carbonization
3. Simple Flame Carbonization Methods
4. Production Logistics
5. Biochar Job Estimating



On-farm production and use of biochar for composting with manure

- UBET - Umpqua Biochar Education Team
- Project of SURCP – South Umpqua Rural Community Partnership
- 2015 Conservation Innovation Grant - NRCS



UBET -- Umpqua Biochar Education Team



Jim Long and UBET



**Jim Long – founder of UBET
In Memoriam, 1935-2016**

“He surveyed the area, saw where he could contribute, and did so.”

Jim Long was a Professor of Adult and Continuing Education at Washington State University, Pullman, for 27 years.

He was involved in more than two dozen community groups in Douglas County, OR.

Founder and president of UBET for many years.

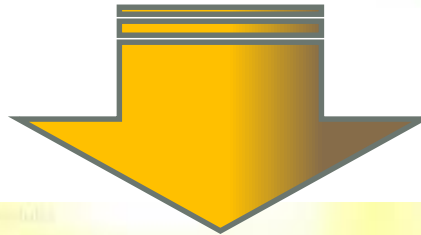
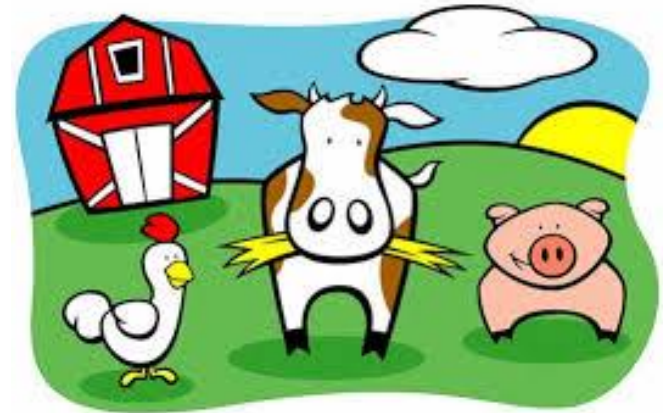


NRCS Biochar Farms & Manure CIG

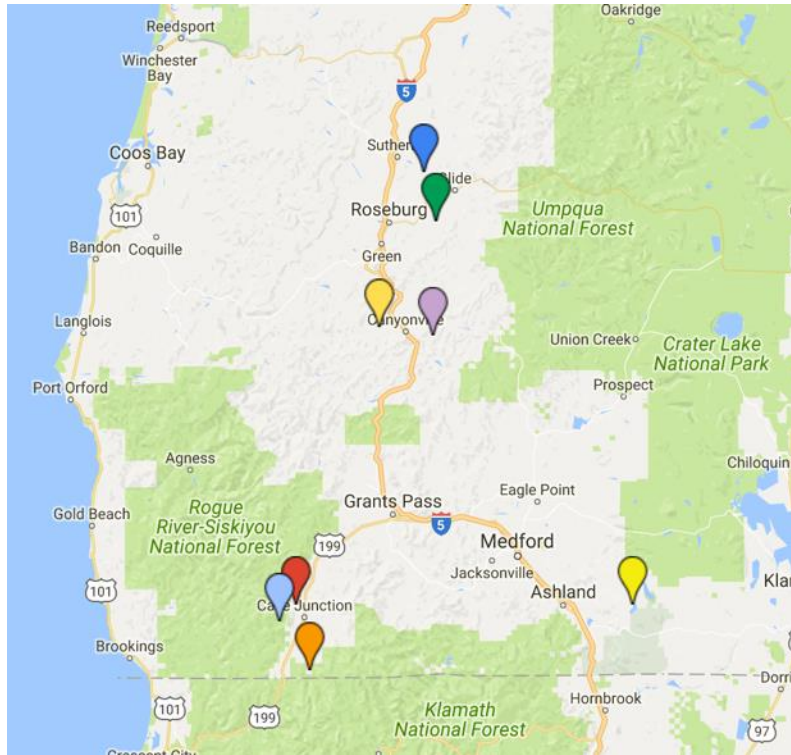
- Conservation **Innovation** Grant
- Farmers in Oregon often have forest land and forestry residue that they burn for disposal
- Farmers with livestock have manure that can be a problem to handle
- Combine two waste streams to create value



How Inventions Are Made



Oregon Small Farms/Woodlands



Farm Livestock and Acreage						
cows	pigs	sheep & goats	fowl	horses	pasture acres	woodlot acres
250					200	
600		325			1150	120
	12	37	100		35	3
		47			35	43
	60	60	200		30	250
			18		1	
		17	73		6	6
		3	36	17		
850	72	489	427	17	1457	422

Natural Resources Conservation Service (USDA)

Conservation Innovation Grant 2015-2018

Umpqua Biochar Education Team

Final Report (200+ pages!) UBETBiochar.blogspot.com



Project Deliverables

- Design and build **kilns to make biochar**
- Test different biochar composts using **Pot trials and field trials**
- Produce **Workshops and Guidelines** on biochar production, biochar use, and monitoring.
- Provide input into **NRCS CSP 384 Biochar Enhancement**



Biochar Production Results



We made 70 cubic yards of biochar during the two year project, worth \$8,750 (\$125/yard)



Origins



Kelpie's cone kiln



Den Morgan's Ring of Fire kiln



Scott Mc Kain's Ring of Fire Kiln



Design Parameters - the Oregon Kiln



Kiln Dimensions

- 5' top base,
- 4' bottom base
- 2' high sides

- Sized for feedstock
 - Sticks or logs up to 4" diameter
 - 4 to 5 feet long
- Portable but Durable
 - Less than 200 lbs
 - 14 gauge steel
 - Sloped sides allow for stacking
- Ergonomic for loading
 - Only 2 feet high
- Capacity
 - Makes > 1 cubic yard of biochar in about 4 hours
- Cost
 - \$950 for Kiln (2019 price)



Kiln Wrangling



UCC Welding Department



We hope this could be the start of a new industry in Oregon making biochar from forestry waste.

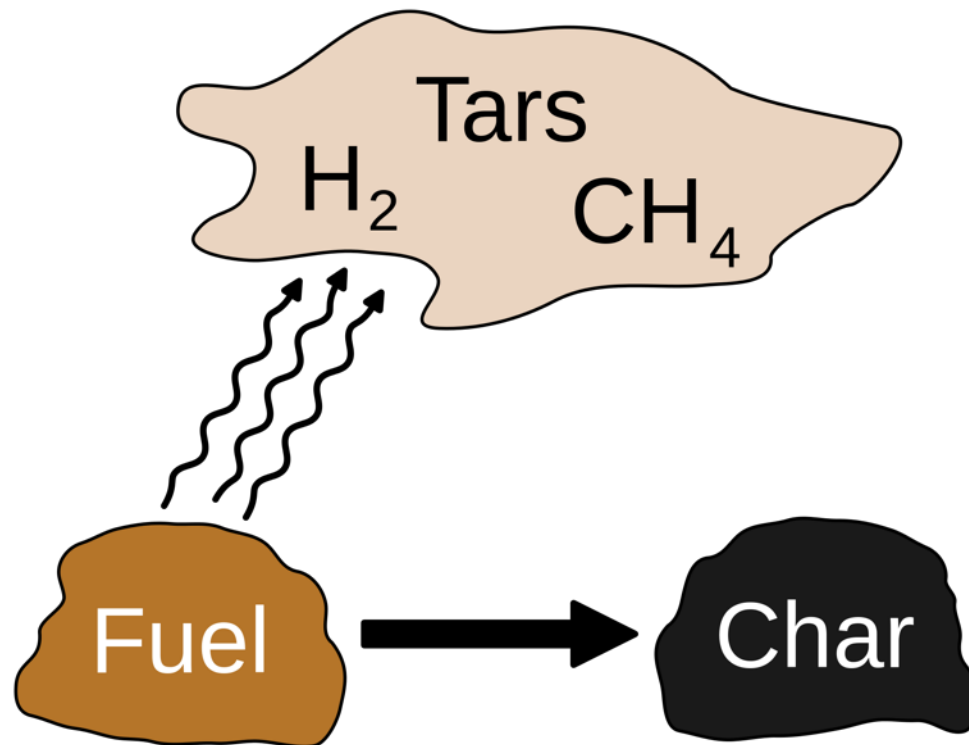


Theory of Flame Carbonization – Making Biochar in an Open Flame



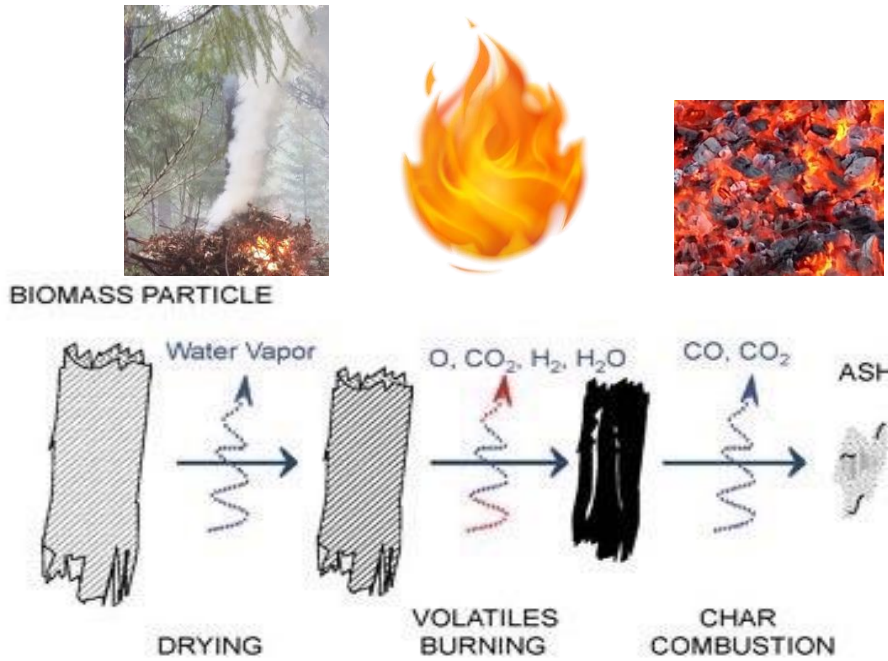
Just another form of pyrolysis

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



Flame Carbonization

Making biochar in an open flame



- Biomass burns in 3 stages.
- To make char, stop the process before it goes to ash



Tools for Flame Carbonization

1. The Rick

- Jack Daniels Distillery Rick Yard
- Making char for filtering whiskey



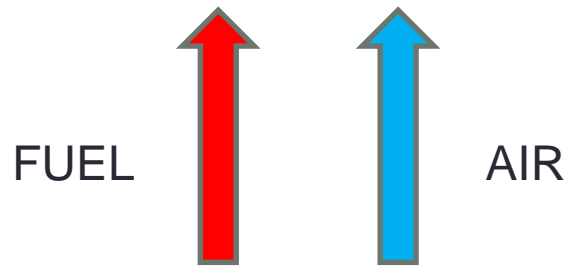
2. The Flame Cap Kiln

- Japanese Cone Kiln from the Moki Co. for charring bamboo
- 3 sizes of stainless steel, open bottom cones - .5 meter, 1.0 meter and 1.5 meter diameter

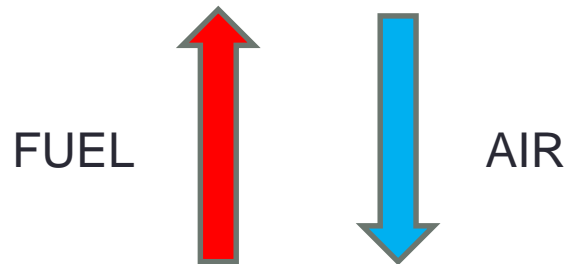


Two Flow Regimes (air & fuel flows)

RICK - Concurrent Axial Flow – air and fuel gas flow in the same direction



FLAME CAP KILN - Countercurrent Flow – fuel gas rises and air is pulled down



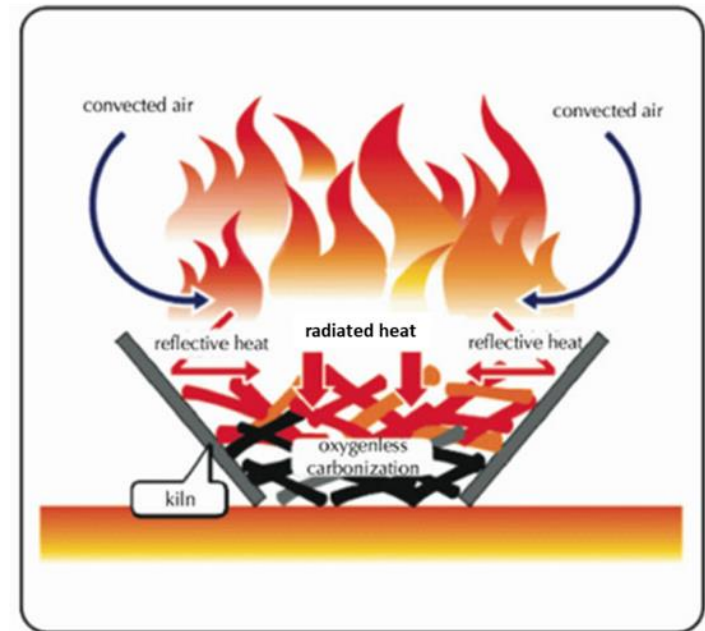
The Rick - Concurrent Axial Flow



- No external limits on air entrainment
- Flame length limits radiative heat transfer to fuel bed
- Flame tips cool, causing soot to condense out from fuel gas



Flame Cap Kiln – Countercurrent Flow



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
- No bottom air --- this keeps the flame close to the fuel



Counter-current flow



Passive counter-current flow as burning fuel draws air downward



wilsonbiochar.com





wilsonbiochar.com





wilsonbiochar.com

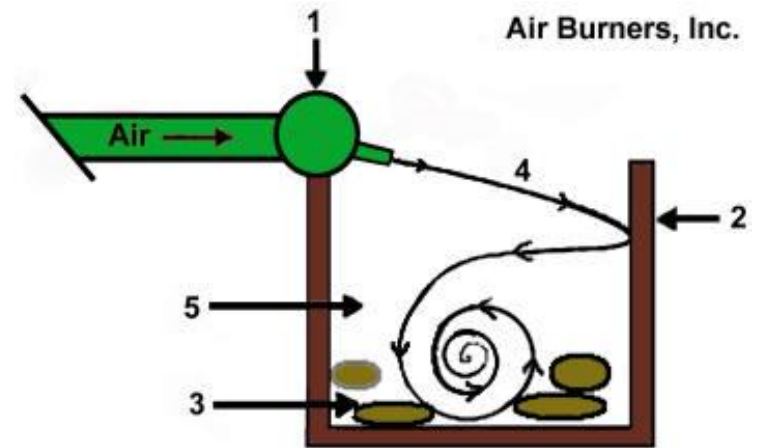


Countercurrent flow – Big Box Biochar



The Tree Service, Brandon Baron, Burns, Oregon

Air Curtain Burner – active counterflow



- Active countercurrent flow using a blower
- Designed for complete incineration, not biochar
- To make biochar, turn off the blower

How to use the Flame Cap Kiln:

- Start with a top-lit rick
- Transitions to a flame cap





- Pile loosely
- Light on top



Once the first pile burns down, add more



- Add new material, one layer at a time
- Make sure each layer has the same size material



It's all about the loading rate



Keep a Strong Flame on Top



- Especially important in wet conditions
- If you let the flame die down it can be hard to restart

Quenching Time



Quench when kiln is full and flame is gone



Water Quenching



Char holds heat amazingly well!

Three options for quenching:

- Flood
- Spread very thin and spray with water until heat is gone
- Snuff



Snuff Quenching



Ring of Fire Kiln



Oregon Kiln



Failed Flood Quench

- Oregon Kiln can quench with 50 gallons water **IF** you stir
- Otherwise, you need to completely flood it, or come back the next morning and find this:



Crushing Char



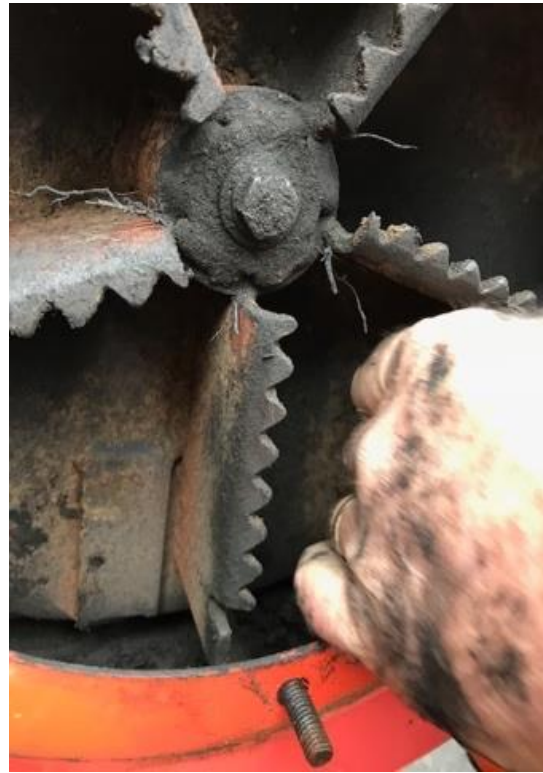
- Drive over it with a truck or tractor
- Use a lawn roller on a hard surface
- Chipper-shredder
- Roller mill
- Hammermill
- Leaf vacuum



Crushing with DR Leaf Vacuum



Leaf vacuum produces a more consistent particle size than rolling or crushing with vehicle tires



Biochar before and after crushing with DR leaf vacuum.



Hammermill



Tips for using a hammermill:

1. Wet char will get very sticky and plug up a hammermill screen
2. Dry char will make a horrible, choking dust cloud!
3. There is a sweet spot of moisture that prevents dust without making sludge



Biochar Quality



- Flame Carbonization chars are mostly high T biochars
- 500 – 1000 degrees C



Biochar Test Results

Biochar Tests											
Biochar Sample	Notes on sample origins	Date	pH	EC (mmhos/cm)	ash %	Volatile Matter %	Fixed Carbon %	Neutralizing value (% CaCO ₃)	Water Holding Capacity (ml water per 100 g dry char)	Butane Activity (g/100g dry ash free char)	Dry Bulk Density (lb/cu ft)
1. Boiler Ash 1	Tipton Ranch	4/4/16	7.2	0.562	40.9	16.5	42.6	14.6	68.5		44
2. Boiler Ash 2	Michaels Ranch	4/4/16	8.4	1.485	57.8	13.4	28.8	25.2	73.3		48
3. Morrison madrone	wet quenched	4/4/16	8.1	1.672	10.2	13.5	76.3	5.6	81.3		23
4. Morrison mixed conifer	wet quenched	2/21/18	9.2	0.61	8.6	20.4	71	6.2	107.9	7	11.7
5. Morrison mixed conifer	dry quenched	2/21/18	9.5	0.82	30.3	17.4	52.3	1.6	113.2	7.5	10
6. Morrison mixed conifer	composted (dry quenched)	2/21/18	9	1.9	14.1	0.26	85.6	14.9	124	2.8	12.5
7. Siskiyou Alpaca oak	wet quenched	2/21/18	10.1	0.55	5.4	21.5	73.1	7.4	90.1	7.1	10.1
8. Siskiyou Alpaca oak	composted	2/21/18	8.5	0.19	1.8	14.8	83.4	2.4	102.7	2.7	9.5
9. Daisy Hill grape vines	wet quenched	2/21/18	10.1	0.49	10.4	9.7	79.9	6.4	119.2	5.9	10.5
10. Oregon Biochar Solutions	commerical biochar	2/14/18	10.5	1.212	8.7			11.1		10.2	4.9



Daisy Hill Farm – Grape Prunings



Page Creek Ranch – fuel reduction thin



- This fuels project was paid for by a Community Fire Plan grant
- Biochar labor was contracted to Rogue Ecological Restoration Service

Don Morrison Forestry



Do you take the feedstock to kiln or the kiln to the feedstock?

Deluxe Ring of Fire Kiln



Don Morrison designed a more durable ROF kiln with quenching lid

Double-walled Ring of Fire



- Inner ring dimensions:
 - 6 ft diameter
 - 42"high
 - 3.7 cy capacity
- Outer rings serves as an effective heat shield:
 - Improves conversion efficiency
 - Protects operator
- Modular, light weight, easy to transport
- Cost – similar to Oregon Kiln



Tractor Kiln version with fork pockets



- Farmers were using tractors to move kilns with mixed results
- UCC Welding students made 4 new tractor-movable kilns



More Innovations: You can carbonize old boards with no smoke!



- Build a rick of old boards
- Light kindling on top
- Quench with water



Drew Biochar Project – Umpqua Biochar Education Team



- 17 acres of thinning
- Removal of small trees
- Umpqua National Forest



**Stewardship Contract awarded to South Umpqua Rural
Community Partnership – www.surcp.org**







- Three days, 166 cubic yards of forest slash, 28 cubic yards of biochar
- **16% conversion efficiency** (by volume)

Cost Scenario for Planning

Based on Drew Veg Biochar Project

Project size and volumes	
project size, ac	17
tree/ac	800
volume of piled slash, cy	396

Labor crew size	
crew size, # of kiln tenders (each tender operates 2 kilns)	6
crew size, # of machine operators	1

Total crew size: 7 people



Labor Time and Machine Hours

Machines and machine hours	
loader to place kilns and move slash, hrs/day	6
water tender for quenching, hrs/day	2

Labor hours	
crew set up time, hrs	1
biochar burning time per kiln batch, hrs	4
quenching and unloading, hrs	2

Total daily job time, including setup and quench, 7 hours



Outputs

Production volumes	
assumed conversion efficiency, biomass to biochar, by volume	16.70%
volume slash consumed per kiln batch, cy	6
biochar output per kiln batch, cy	1
number of kilns	12

Daily output	
total biochar output per day, cy	12
total slash processed per day, cy	72

- 5.5 days to process all slash
- 66 cy of biochar produced



Results

- Assume one cubic yard of biochar weighs 200 pounds
- 66 cy x 200 pounds = 6.6 tons of biochar
- 6.6 tons x 80% fixed carbon fraction x 44/12 = **19.4 tons of CO₂ sequestered from one 17 ac thinning project.**

Average American emits approx. 20 tons CO₂ per year



Biochar Farm Economics

Cost of Producing Biochar on Farms		
Farm	Biochar cost/cy	Burning anyway?
East Fork Farm	\$87	Yes
Daisy Hill Farm	\$190	Yes
Michaels Ranch	N/A	No
Morrison-Fontaine	\$100	Yes
Page Creek Ranch	\$100	Yes
Siskiyou Alpaca	\$90	No
Tierra Buena Worm Farm	\$100	No
Willow Witt Ranch	\$150	Yes

- Based on labor costs of \$20-\$25/hr
- Cost is similar to cost of purchasing biochar
- But most of the labor cost is for processing brush and slash that needs to be burned anyway



How Much Biochar Do Farmers Need?

- We have learned that it is best to add biochar in small amounts to compost.
- This means that the amount of biochar that a farmer needs to make is smaller than we had initially thought.
- For instance, a farmer with a small herd of 20 goats might only need to make two cubic yards of biochar per year in order to improve the barn environment and make better compost.
- Two cubic yards of biochar would require two days to make using one kiln and a labor force of 2 people. It would require up to 20 cubic yards of brush or slash to be hauled, cut to size, dried and covered. This is where the biggest labor effort is needed.



NRCS CSP Biochar Activity



United States Department of Agriculture

CONSERVATION ENHANCEMENT ACTIVITY
E384135Z

CONSERVATION
STEWARDSHIP
PROGRAM

Biochar production from woody residue

Conservation Practice 384: Woody Residue Treatment

APPLICABLE LAND USE: Forest, Associated Ag Land

RESOURCE CONCERN ADDRESSED: Degraded Plant Condition

ENHANCEMENT LIFE SPAN: 10 years

Enhancement Description

Uses woody debris remaining after fuel reduction harvests or wildfires to create biochar. Biochar stores carbon and is a useful soil amendment that improves Soil Organic Matter (SOM) and water-holding capacity.



Criteria

- States will apply general criteria from the NRCS National Conservation Practice Standard Woody Residue Treatment (Code 384) as listed below, and additional criteria as required by the NRCS State Office.
- The enhancement will be applied to sites where woody debris presents a fire risk or interferes with land management objectives or planned activities (e.g., impedes regeneration, limits access, interferes with livestock movement, etc.).
- Woody debris that does not have a commercial use is suitable for biochar creation.
- Where this enhancement can be coordinated with a fuel reduction treatment, woody debris should be separated by size classes if possible.
- Biochar will be created on site in kilns designed for the purpose.
- Kiln operators shall be properly trained in procedures for creating biochar, and shall adhere to state safety precautions at all times. A plan for quenching biochar will be in

E384135Z Biochar production from woody residue		
December 2017		Page 1

- Requires enrollment in NRCS CSP – contact your local NRCS office for more info
- As of 2019, per acre payment for biochar production up to \$4600/acre



Lems Ridge, California



Baskin Lems Ridge Property

Yew Creek Land Alliance, Oregon



Scaling Up – Big Box Biochar at Yew Creek Land Alliance, Nov. 2018



- Steel panels bolted together into 12' x 6' box
- Easier loading of big logs











Bin holds about 6 cubic yards of biochar



Scaling up for better economy



- Tanks
- Shipping Containers
- Grain Bin Bottoms
- Rail Cars
- Dumpsters
- ????????



North Dakota – NDSU & Menoken Farm



- Half pipe kiln
- Made from old water tank
- 3 ft diameter
- 11 ft long
- 5.7 cy capacity
- Quenched with manure



Oil Field Tank Kiln



- 12 ft diameter; 20 ft long; 42 cy capacity
- How to quench? Dirt would make it very heavy to unload
- Let's just flip it! Problem solved.



Grain Bin Bottom Cone Kiln



- 10.6 cy capacity
- Would require 1000 gals of water to flood quench
- Needs a lid for snuff quenching
- How do you unload it?



We did not have enough water to flood quench the kiln, so the char was not saved



Growing Number of Projects and Partners

- NRCS
- USFS
- USDA-ARS
- Oregon Department of Forestry
- North Dakota Forest Service
- Nebraska Forest Service
- Kansas Forest Service
- Utah State University Extension
- Oregon State University Extension
- South Umpqua Rural Community Partnership
- Long Tom Restoration Council
- Illinois Valley Community Development Organization
- Two Rivers SWCD
- Ridge to Reefs



Charring Pinyon-Juniper in Utah



Biochar Job Estimating

Considerations

- Yarding methods
- Diversion to post, pole or firewood
- Feedstock volume estimates
- Feedstock moisture content and size
- Equipment needs: kilns, loaders, hand tools
- Biochar production rates*
- Water or other quenching method

** 10 minutes per inch of biochar accumulation in flame cap kiln when using dry fuel*



Questions?



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