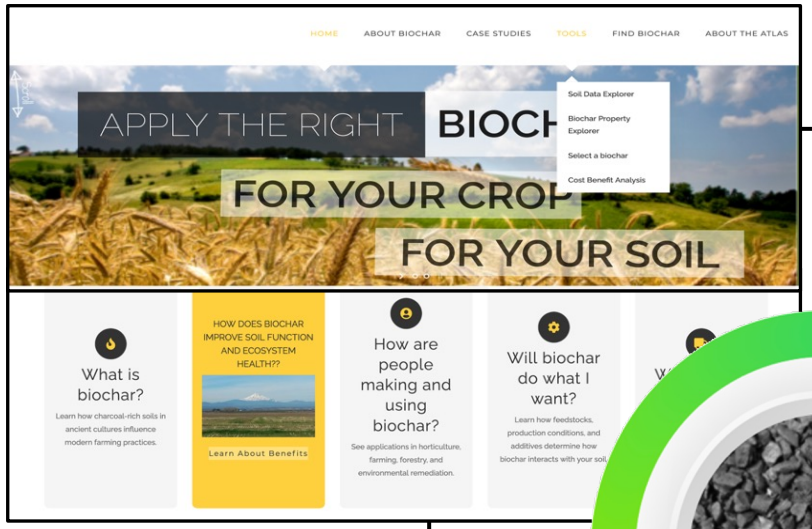
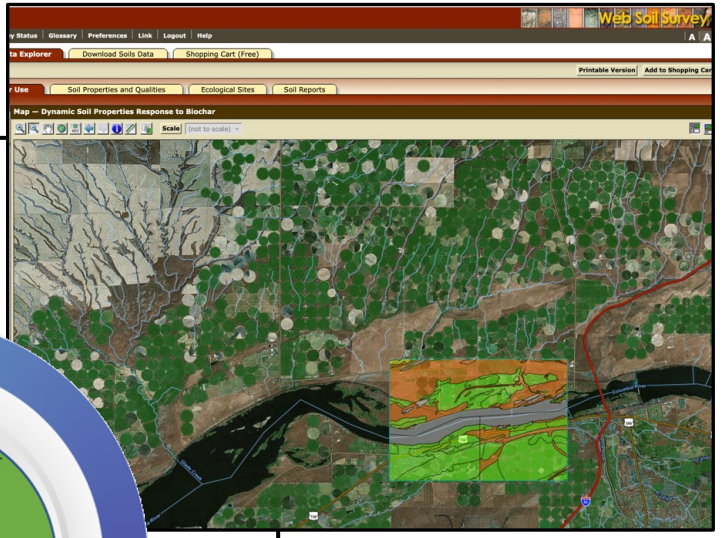
The 3Rs of Biochar Application: Using online decision support tools to apply the *right* biochar in the *right* place





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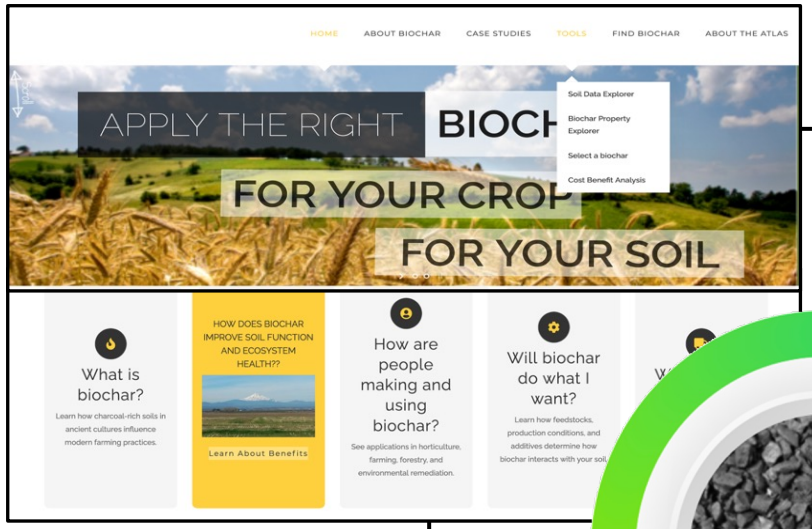
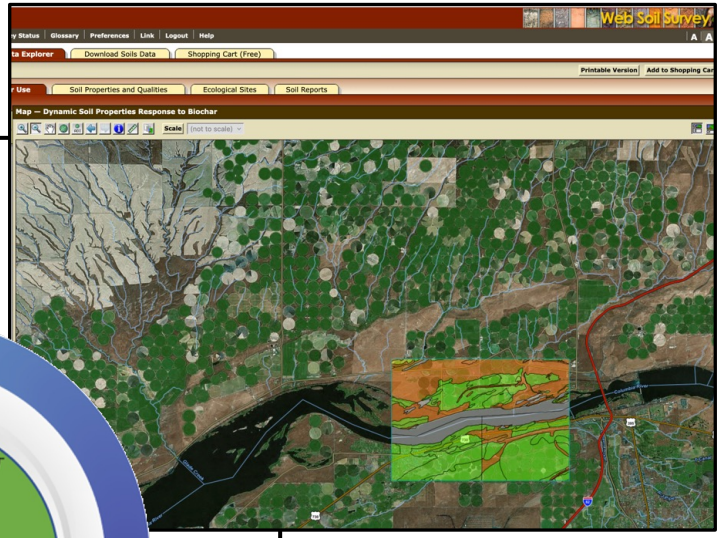
Building the future from the ground up.

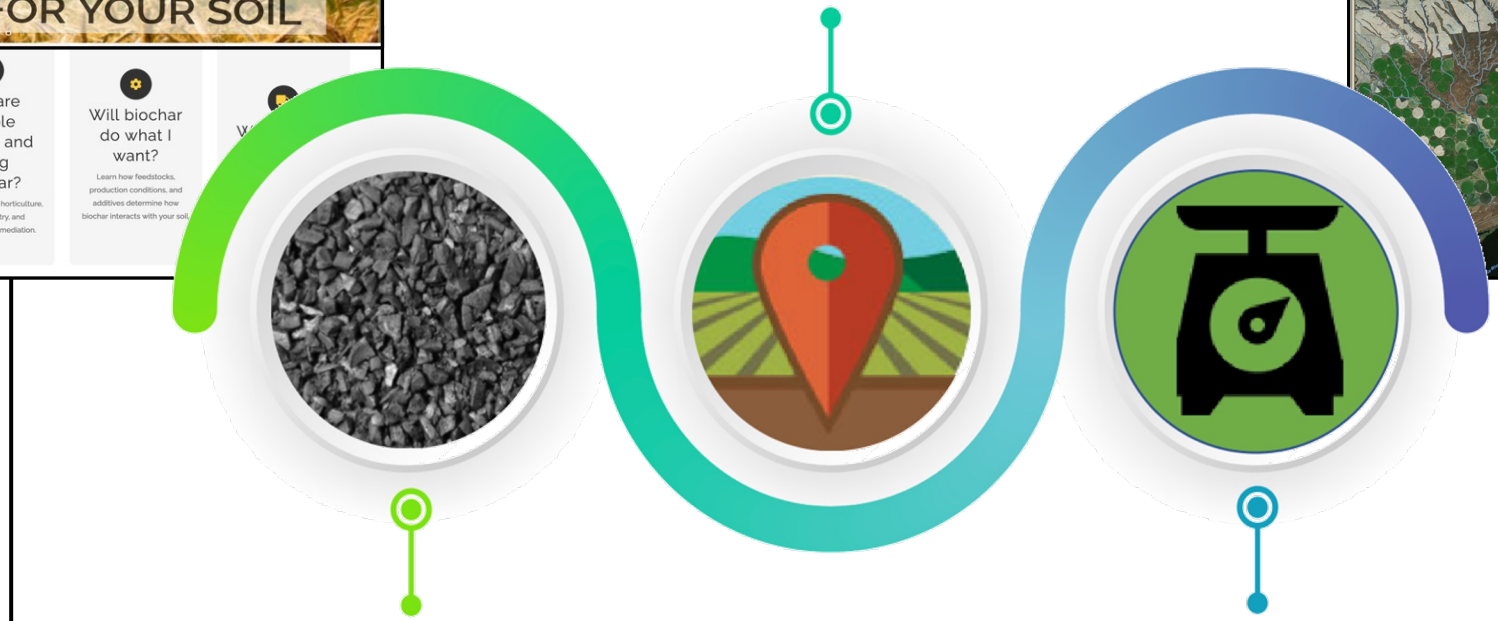
USDA

2024 NORTH AMERICAN BIOCHAR CONFERENCE
USBI
CALIFORNIA, USA

The 3Rs of Biochar Application: Using online decision support tools to apply the *right* biochar in the *right* place





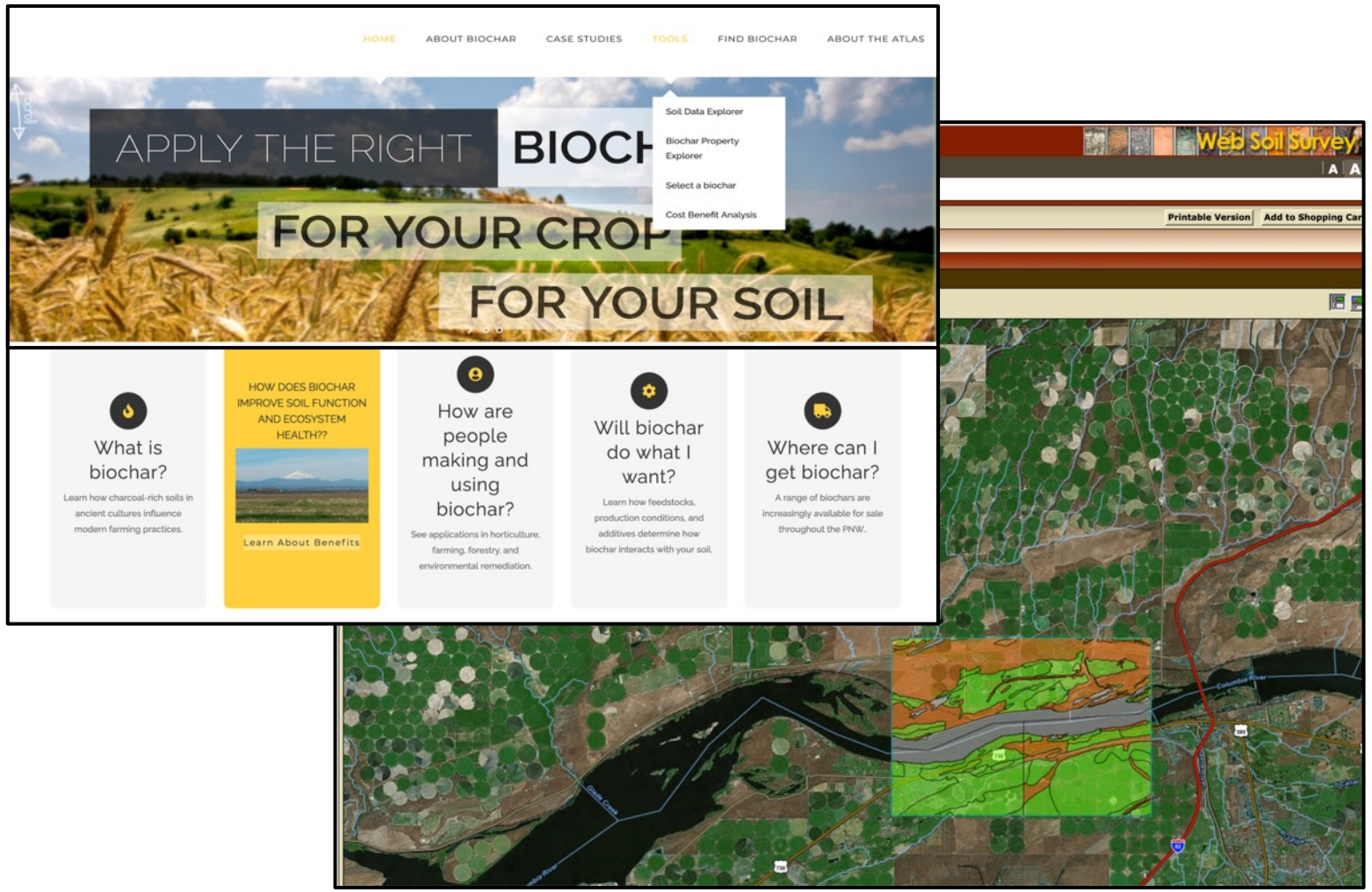


American Farmland Trust

USBI
Building the future from the ground up.

USDA

Using Decision Support to Implement the 3Rs



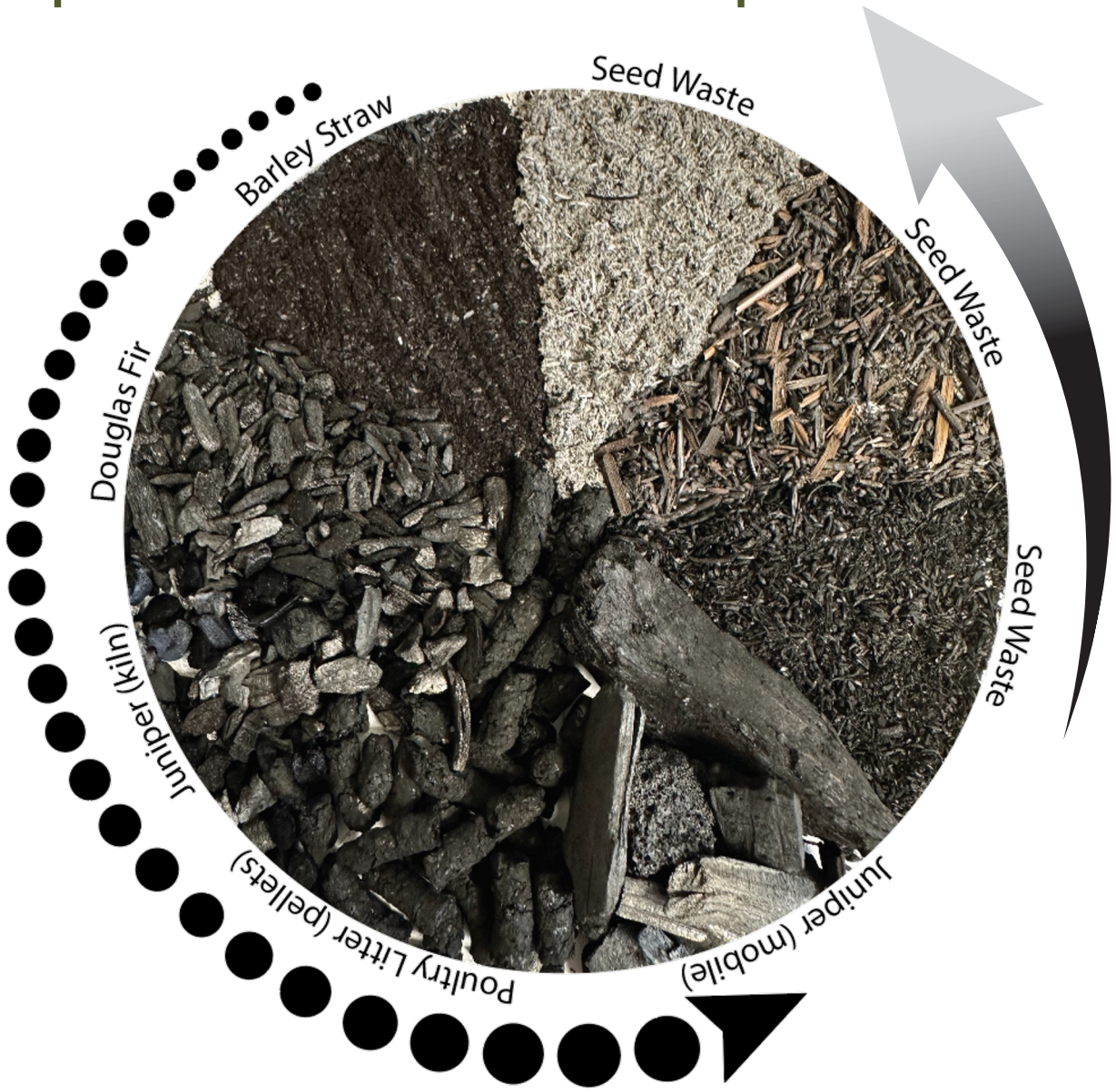
KRISTIN TRIPPE
USDA
Agricultural Research Service
Corvallis, Oregon

- Web Soil Survey
- PNW Biochar Atlas
- Biochar Calculator

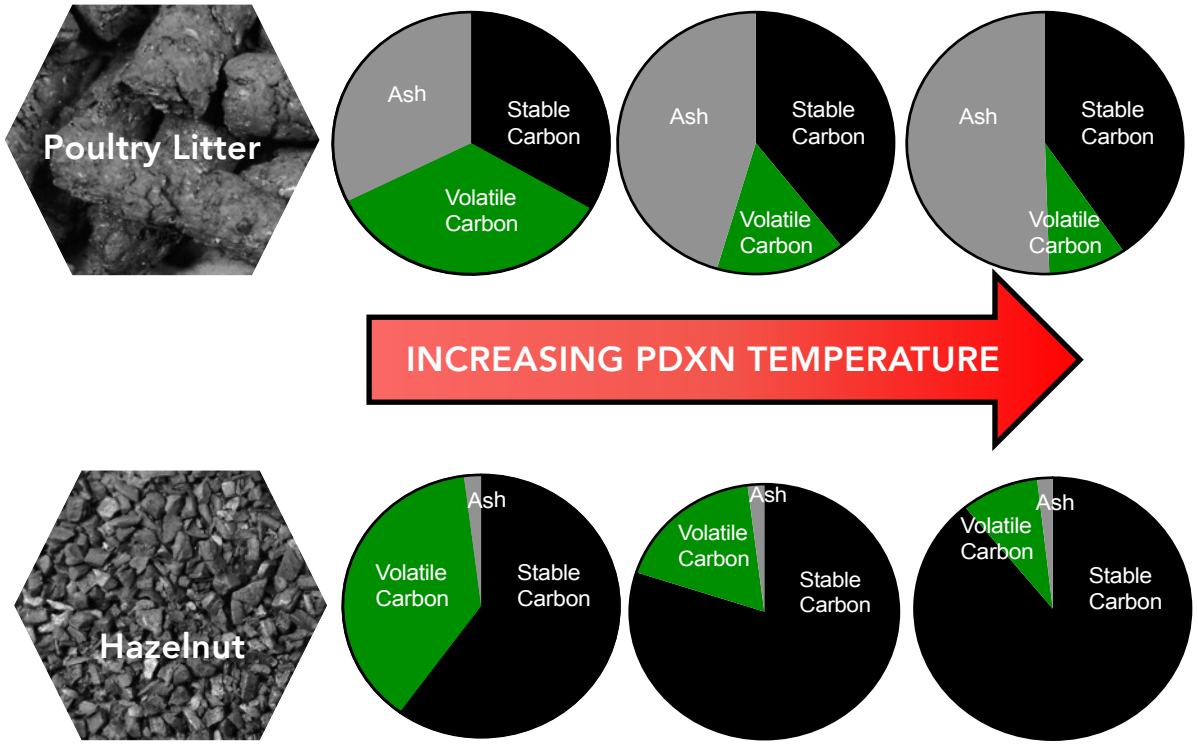
Technical understanding of biochar has not resulted in increased adoption

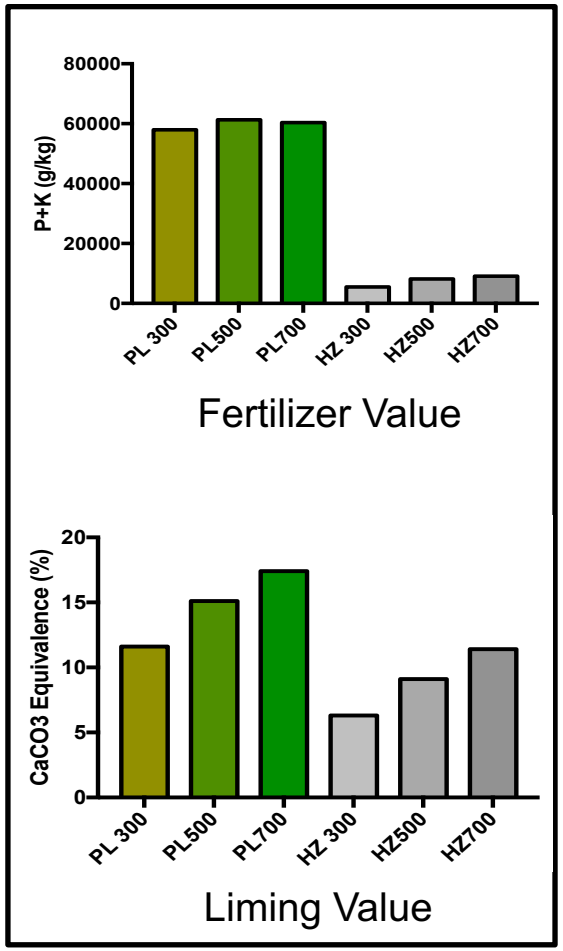
The right source

Feedstock origin and production conditions impact end use



BIOCHAR: feedstock origin & production conditions impact physiochemical properties





Difficult to predict how biochar will interact with soils and plants

CAN WE MATCH BIOCHAR PROPERTIES WITH SOIL & CROP NEEDS?

USING BIOCHAR EFFECTIVELY REQUIRES IDENTIFYING MANAGEMENT GOALS

Identify Goals

↓

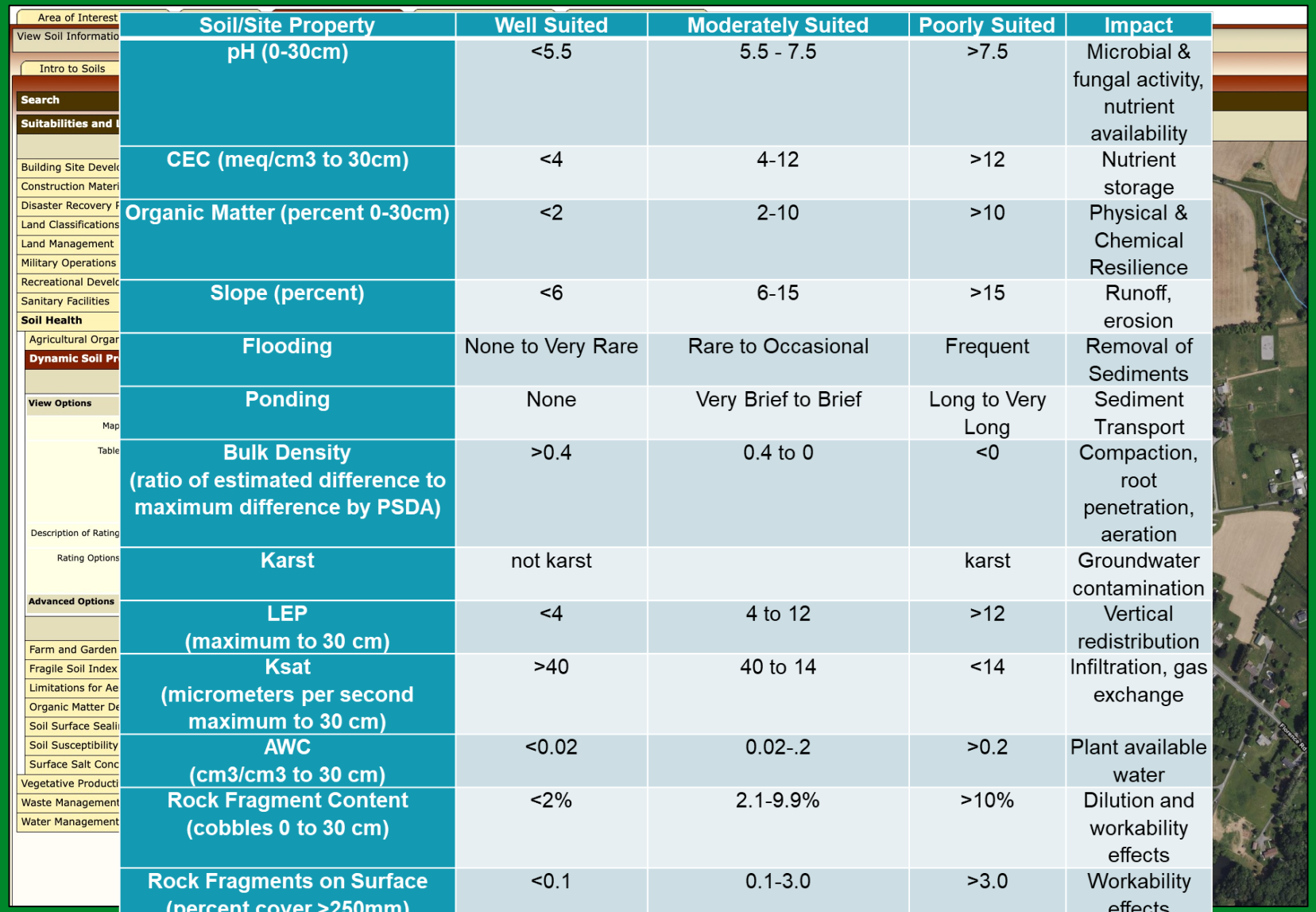
Find product that meets needs

↓

Find rate that meets needs

Use principles from nutrient management to inform amendment strategy

Right Place



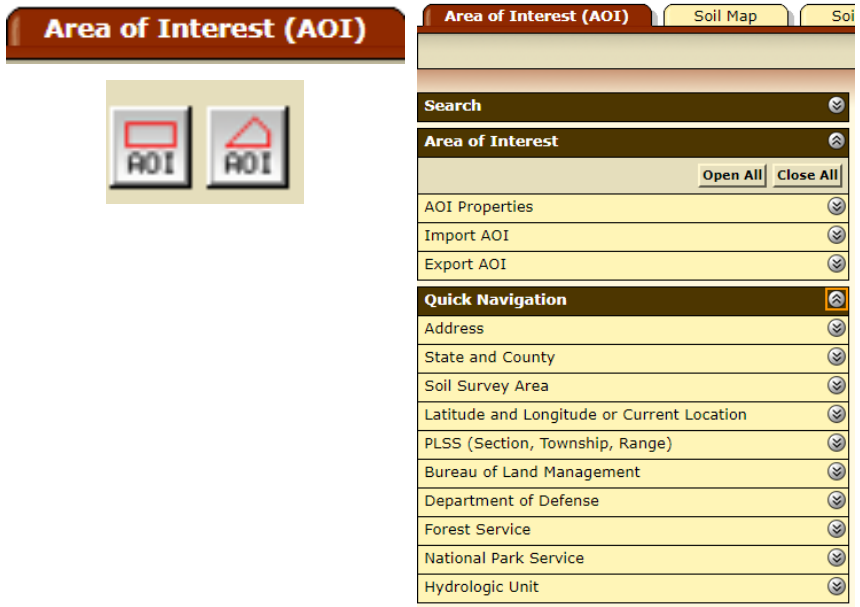
Soil/Site Property	Well Suited	Moderately Suited	Poorly Suited	Impact
pH (0-30cm)	<5.5	5.5 - 7.5	>7.5	Microbial & fungal activity, nutrient availability
CEC (meq/cm3 to 30cm)	<4	4-12	>12	Nutrient storage
Organic Matter (percent 0-30cm)	<2	2-10	>10	Physical & Chemical Resilience
Slope (percent)	<6	6-15	>15	Runoff, erosion
Flooding	None to Very Rare	Rare to Occasional	Frequent	Removal of Sediments
Ponding	None	Very Brief to Brief	Long to Very Long	Sediment Transport
Bulk Density (ratio of estimated difference to maximum difference by PSDA)	>0.4	0.4 to 0	<0	Compaction, root penetration, aeration
Karst	not karst		karst	Groundwater contamination
LEP (maximum to 30 cm)	<4	4 to 12	>12	Vertical redistribution
Ksat (micrometers per second maximum to 30 cm)	>40	40 to 14	<14	Infiltration, gas exchange
AWC (cm3/cm3 to 30 cm)	<0.02	0.02-.2	>0.2	Plant available water
Rock Fragment Content (cobbles 0 to 30 cm)	<2%	2.1-9.9%	>10%	Dilution and workability effects
Rock Fragments on Surface (percent cover >250mm)	<0.1	0.1-3.0	>3.0	Workability effects

Decision Support Tools Help Farmers Put Biochar In the Right Place

Web Soil Survey

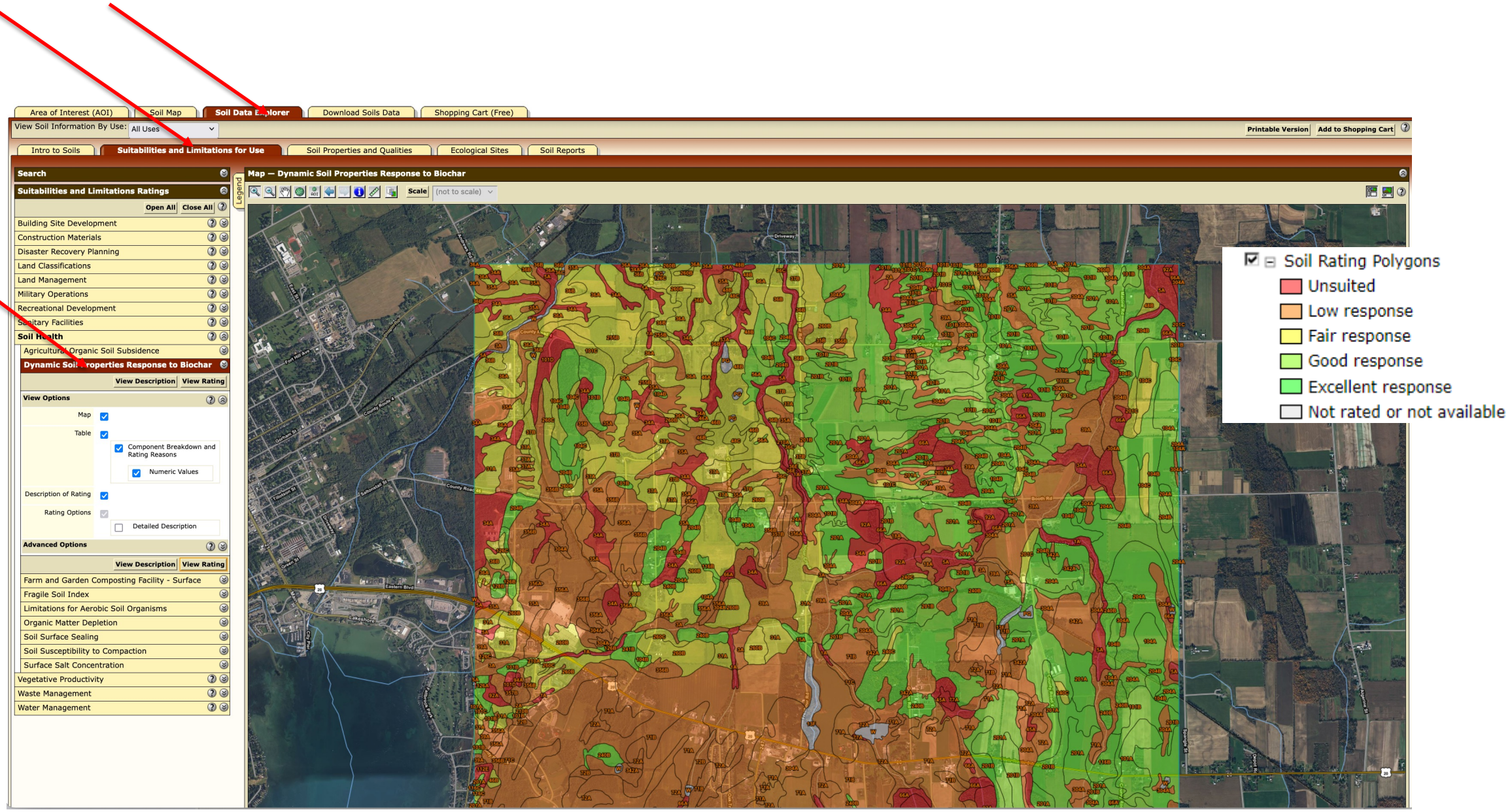
https://websoilsurvey.nrcs.usda.gov/app/

1. 

2. 

3. 

HOW CAN FARMERS CHOOSE THE RIGHT BIOCHAR?


Area of Interest (AOI)
Soil Map
Soil Data Explorer
Download Soils Data
Shopping Cart (Free)
View Soil Information By Use:
All Uses
Printable Version
Add to Shopping Cart
Intro to Soils
Suitabilities and Limitations for Use
Soil Properties and Qualities
Ecological Sites
Soil Reports
Search
Suitabilities and Limitations Ratings
Open All
Close All
Building Site Development
Construction Materials
Disaster Recovery Planning
Land Classifications
Land Management
Military Operations
Recreational Development
Sanitary Facilities
Soil Health
Agricultural Organic Soil Subsidence
Dynamic Soil Properties Response to Biochar
View Description
View Rating
View Options
Map
Table
Component Breakdown and Rating Reasons
Numeric Values
Description of Rating
Rating Options
Detailed Description
Advanced Options
View Description
View Rating
Farm and Garden Composting Facility - Surface
Fragile Soil Index
Limitations for Aerobic Soil Organisms
Organic Matter Depletion
Soil Surface Sealing
Soil Susceptibility to Compaction
Surface Salt Concentration
Vegetative Productivity
Waste Management
Water Management
Legend
Map — Dynamic Soil Properties Response to Biochar
Scale
(not to scale)
Soil Rating Polygons
Unsuited
Low response
Fair response
Good response
Excellent response
Not rated or not available

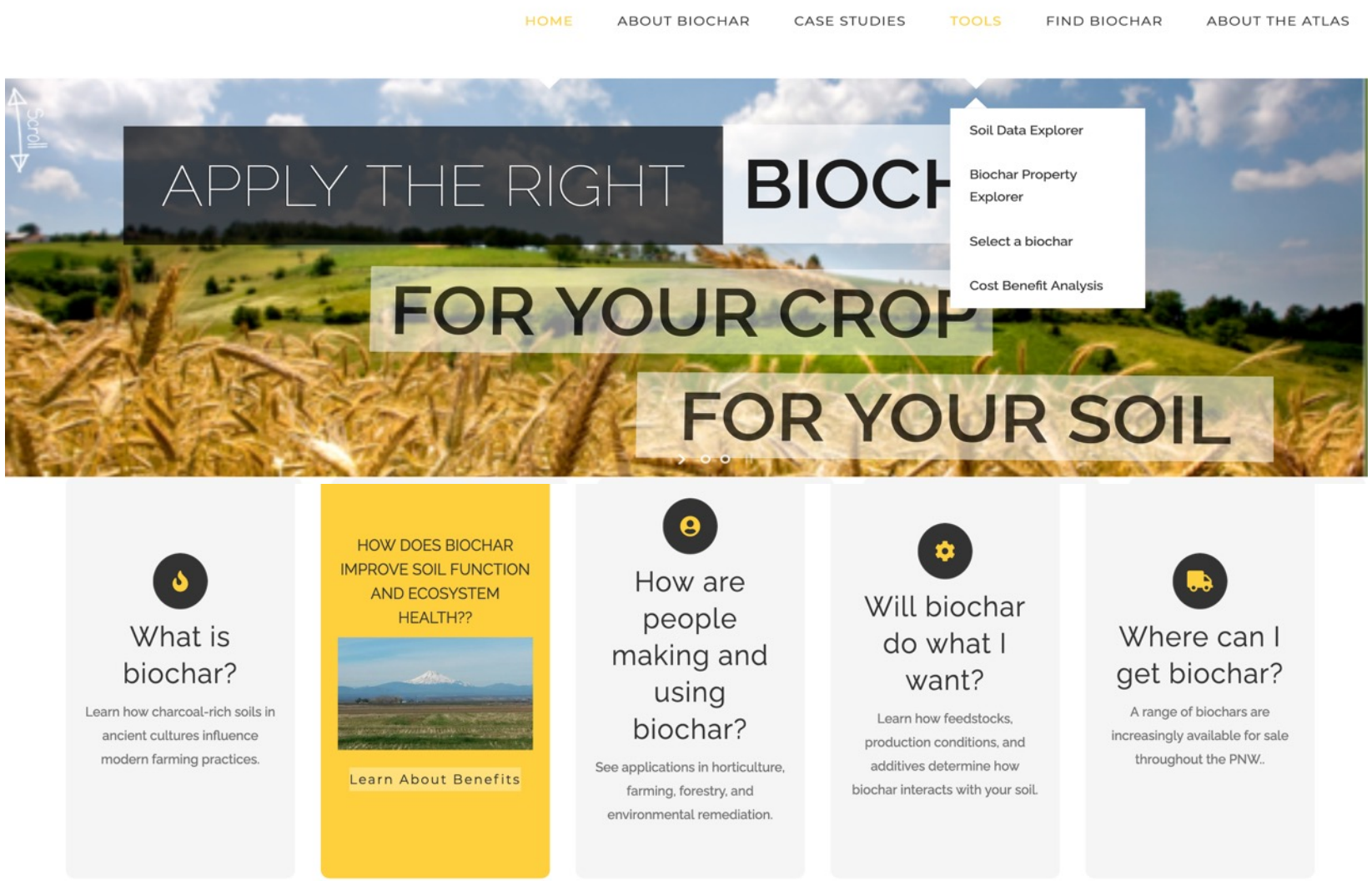
WRONG/
RIGHT PLACE

RIGHT SOURCE

RIGHT RATE

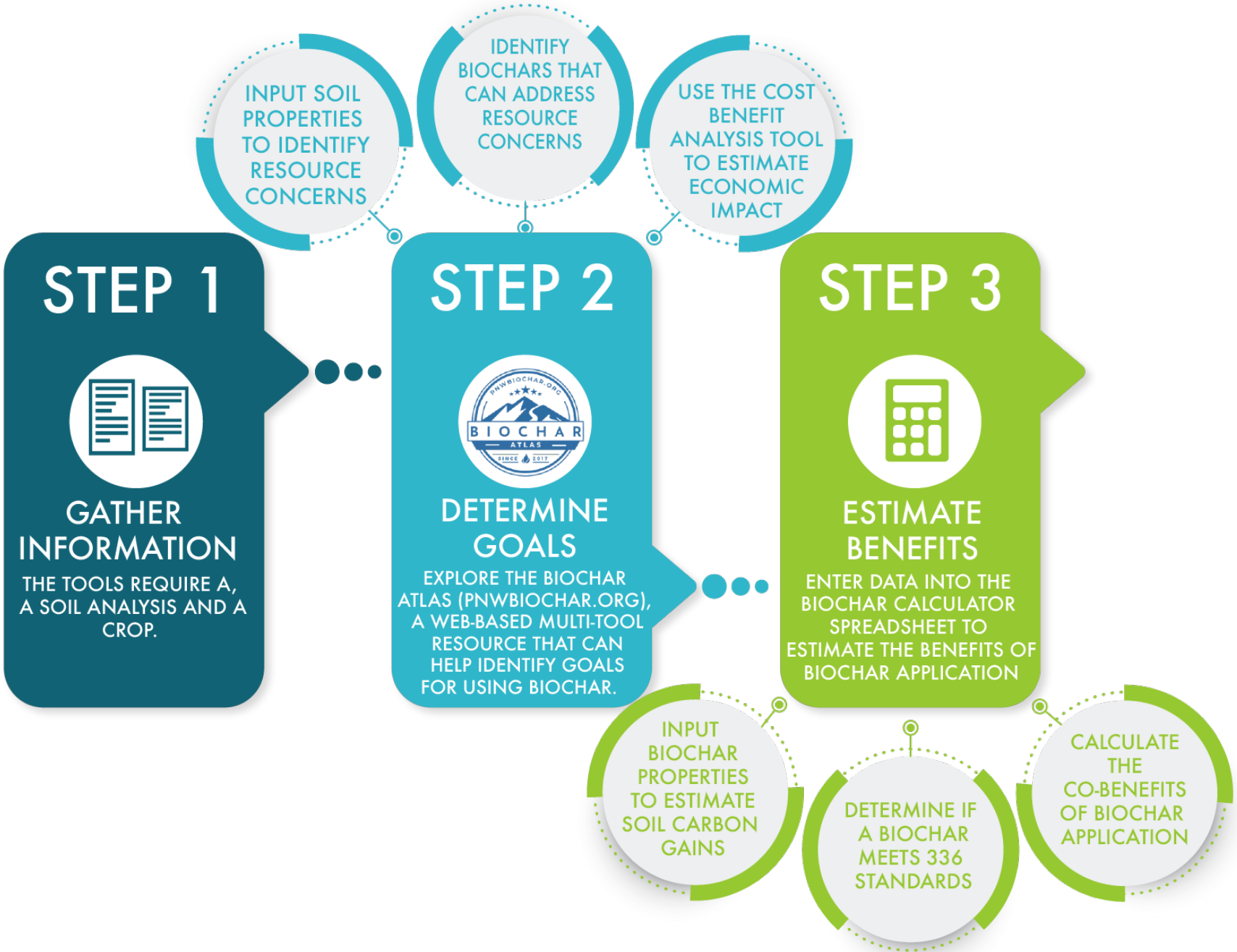
Use principles from nutrient management to inform amendment strategy

WWW.PNWBIOCHAR.ORG



- LEARN ABOUT BIOCHAR
- FIND A BIOCHAR THAT MEETS YOUR NEEDS
- READ CASE STUDIES
- FIND PRODUCERS
- COMPARE BIOCHARS

BIOCHAR DECISIONS IN THREE STEPS



BIOCHAR DECISIONS IN THREE STEPS

STEP 1

GATHER INFORMATION

THE TOOLS REQUIRE AN APPLICATION SCENARIO, A SOIL ANALYSIS, AND A BIOCHAR CERTIFICATE OF ANALYSIS.

INPUT SOIL PROPERTIES TO IDENTIFY RESOURCE CONCERNS

IDENTIFY BIOCHARS THAT CAN ADDRESS RESOURCE CONCERNS

STEP 2

DETERMINE GOALS

EXPLORE THE BIOCHAR ATLAS (PNWBIOCHAR.ORG), A WEB-BASED MULTI-TOOL RESOURCE THAT CAN HELP IDENTIFY GOALS FOR USING BIOCHAR.

STEP 3

ESTIMATE BENEFITS

ENTER DATA INTO THE BIOCHAR CALCULATOR SPREADSHEET TO ESTIMATE THE BENEFITS OF BIOCHAR APPLICATION

INPUT BIOCHAR PROPERTIES TO ESTIMATE SOIL CARBON GAINS

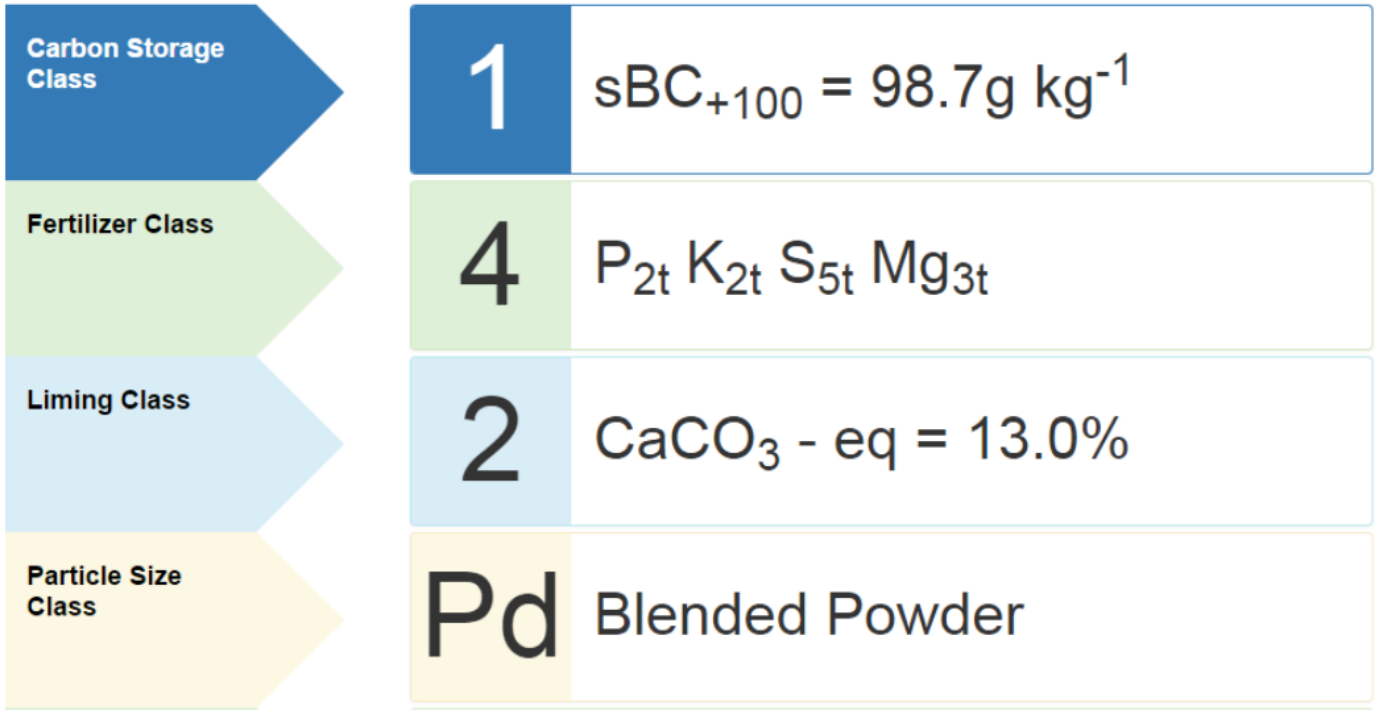
CALCULATE THE CO-BENEFITS OF BIOCHAR APPLICATION

Resource Concern

"a condition of the soil, water, air, plant, animal or energy resource base that does not meet minimum acceptable standards established by NRCS, a condition that impairs the sustainability or intended used of the resource"

Why Should I apply Biochar?

IBI Classification System

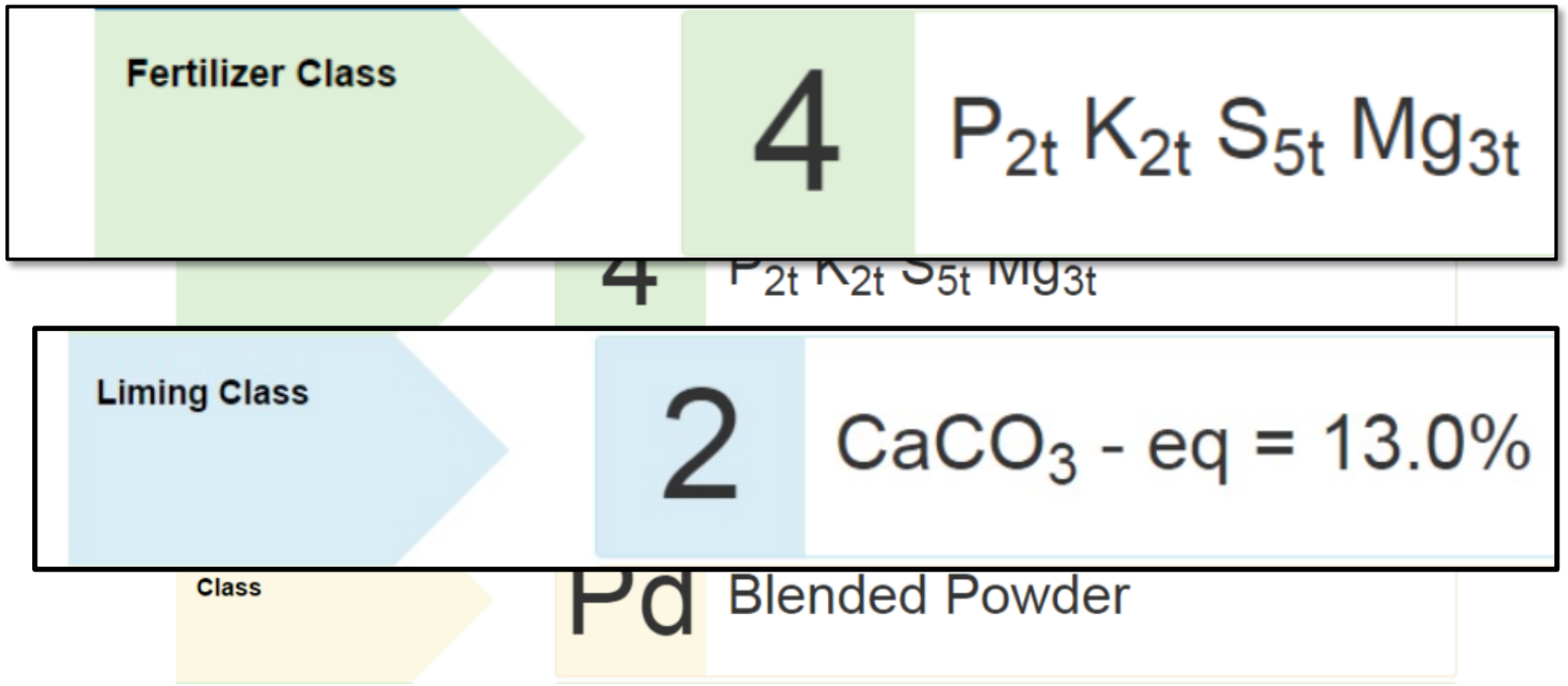


https://www.biochar-international.org/biochar-classification-tool/

Camps Arbestain M, J.E. Amonette, B. Singh, T. Wang, H-P. Schmidt. 2015. *A Biochar Classification System and Associated Test Methods*. In: Biochar for Environmental Management – Science and Technology, 2nd edition. J. Lehmann and S. Joseph (eds.). Routledge.

Biochar classification can inform right rate and right source

IBI Classification System



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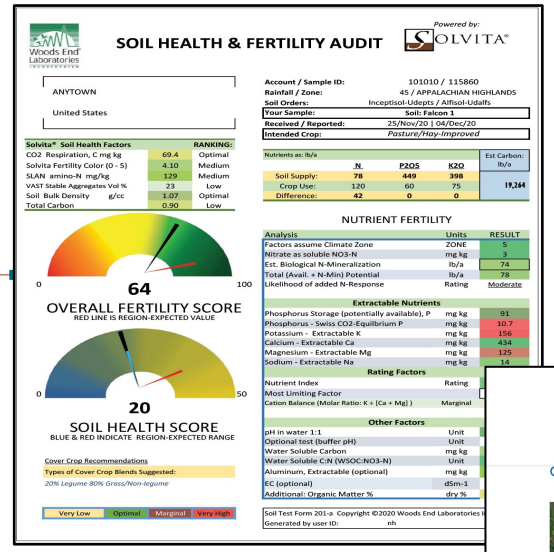
The IBI Classification system was the inspiration for our approach to carbon, fertility and pH management.

STEP 1

GATHER INFORMATION

THE TOOLS REQUIRE A SOIL ANALYSIS AND A CROP CHOICE.



SOIL HEALTH & FERTILITY AUDIT

Powered by: SOLVITA

Woods End Laboratories

ANYTOWN

United States

Account / Sample ID:	101010 / 115860
Rainfall / Zone:	45 / APPALACHIAN HIGHLANDS
Soil Orders:	Inceptisol-Udepts / Alfisol-Udalfs
Your Sample:	Soil: Falcon 1
Received / Reported:	25/Nov/20 | 04/Dec/20
Intended Crop:	Pasture/Hay-Improved

Solvita® Soil Health Factors		RANKING:
CO2 Respiration, C mg kg	69.4	Optimal
Solvita Fertility Color (0 - 5)	4.10	Medium
SLAN amino-N mg/kg	1.29	Medium
VAST Stable Aggregates Vol %	23	Low
Soil Bulk Density g/cc	1.07	Optimal
Total Carbon	0.90	Low

Nutrients as: lb/a	N	P2O5	K2O	Est Carbon: lb/a
Soil Supply:	78	449	398	
Crop Use:	120	60	75	19,264
Difference:	42	0	0	

0 64 100

OVERALL FERTILITY SCORE

RED LINE IS REGION-EXPECTED VALUE

0 20 50

SOIL HEALTH SCORE

BLUE & RED INDICATE REGION-EXPECTED RANGE

Cover Crop Recommendations

Types of Cover Crop Blends Suggested:

20% Legume 80% Grass/Non-legume

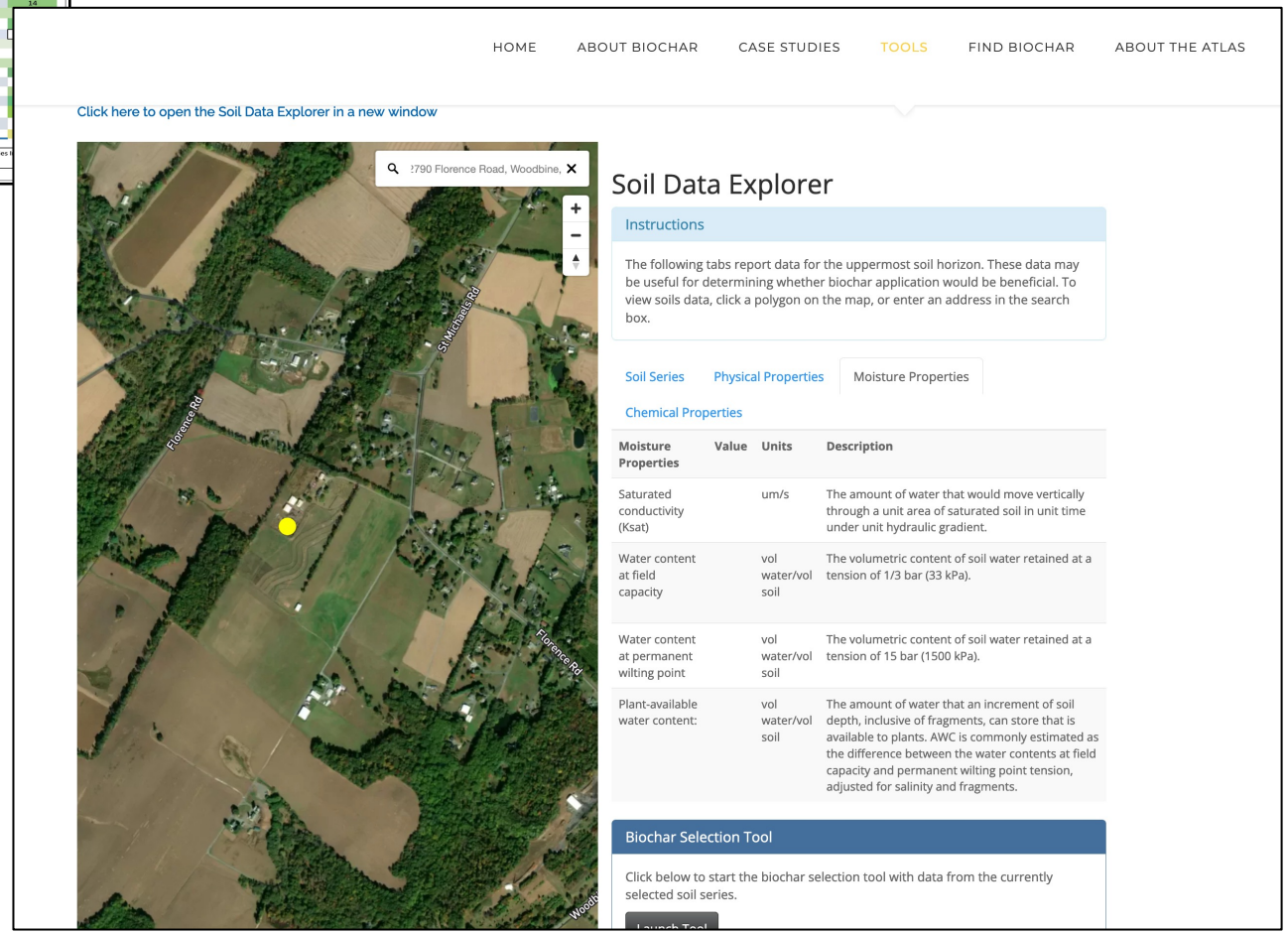
Very Low | Optimal | Marginal | Very High

NUTRIENT FERTILITY

Analysis	Units	RESULT
Factors assume Climate Zone	ZONE	5
Nitrate as soluble NO3-N	mg kg	3
Est. Biological N-Mineralization	lb/a	74
Total (Avail. + N-Min) Potential	lb/a	78
Likelihood of added N-Response	Rating	Moderate
Extractable Nutrients		
Phosphorus Storage (potentially available), P	mg kg	91
Phosphorus - Swiss CO2-Equilibrium P	mg kg	10.7
Potassium - Extractable K	mg kg	156
Calcium - Extractable Ca	mg kg	434
Magnesium - Extractable Mg	mg kg	125
Sodium - Extractable Na	mg kg	14
Rating Factors		
Nutrient Index	Rating	
Most Limiting Factor		
Cation Balance (Molar Ratio: K + [Ca + Mg])	Marginal	
Other Factors		
pH in water 1:1	Unit	
Optional test (buffer pH)	Unit	
Water Soluble Carbon	mg kg	
Water Soluble C:N (WSOC:NO3-N)	Unit	
Aluminum, Extractable (optional)	mg kg	
EC (optional)	dSm-1	
Additional: Organic Matter %	dry %	

Soil Test Form 201-a Copyright ©2020 Woods End Laboratories I

Generated by user ID: nh



HOME ABOUT BIOCHAR CASE STUDIES TOOLS FIND BIOCHAR ABOUT THE ATLAS

Click here to open the Soil Data Explorer in a new window

?790 Florence Road, Woodbine,

St Michaels Rd

Florence Rd

Florence Rd

Soil Data Explorer

Instructions

The following tabs report data for the uppermost soil horizon. These data may be useful for determining whether biochar application would be beneficial. To view soils data, click a polygon on the map, or enter an address in the search box.

Soil Series | Physical Properties | Moisture Properties | Chemical Properties

Moisture Properties	Value	Units	Description
Saturated conductivity (Ksat)		um/s	The amount of water that would move vertically through a unit area of saturated soil in unit time under unit hydraulic gradient.
Water content at field capacity		vol water/vol soil	The volumetric content of soil water retained at a tension of 1/3 bar (33 kPa).
Water content at permanent wilting point		vol water/vol soil	The volumetric content of soil water retained at a tension of 15 bar (1500 kPa).
Plant-available water content:		vol water/vol soil	The amount of water that an increment of soil depth, inclusive of fragments, can store that is available to plants. AWC is commonly estimated as the difference between the water contents at field capacity and permanent wilting point tension, adjusted for salinity and fragments.

Biochar Selection Tool

Click below to start the biochar selection tool with data from the currently selected soil series.

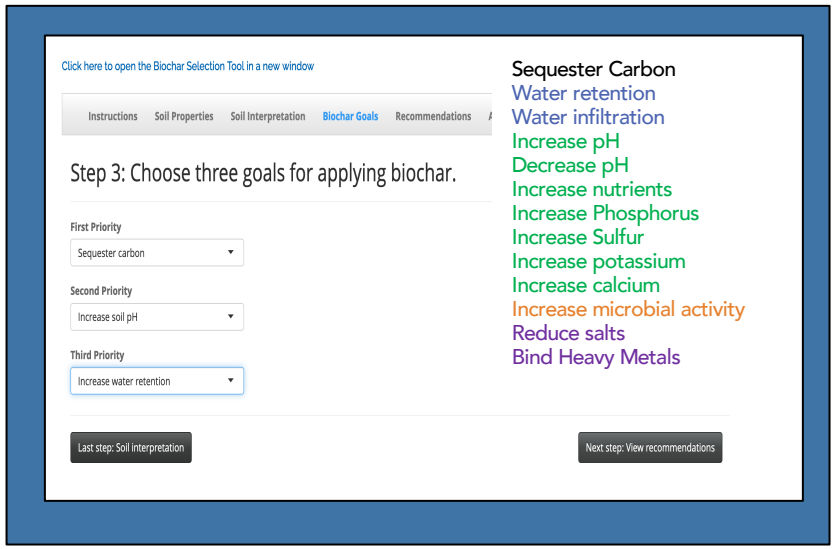
Launch Tool

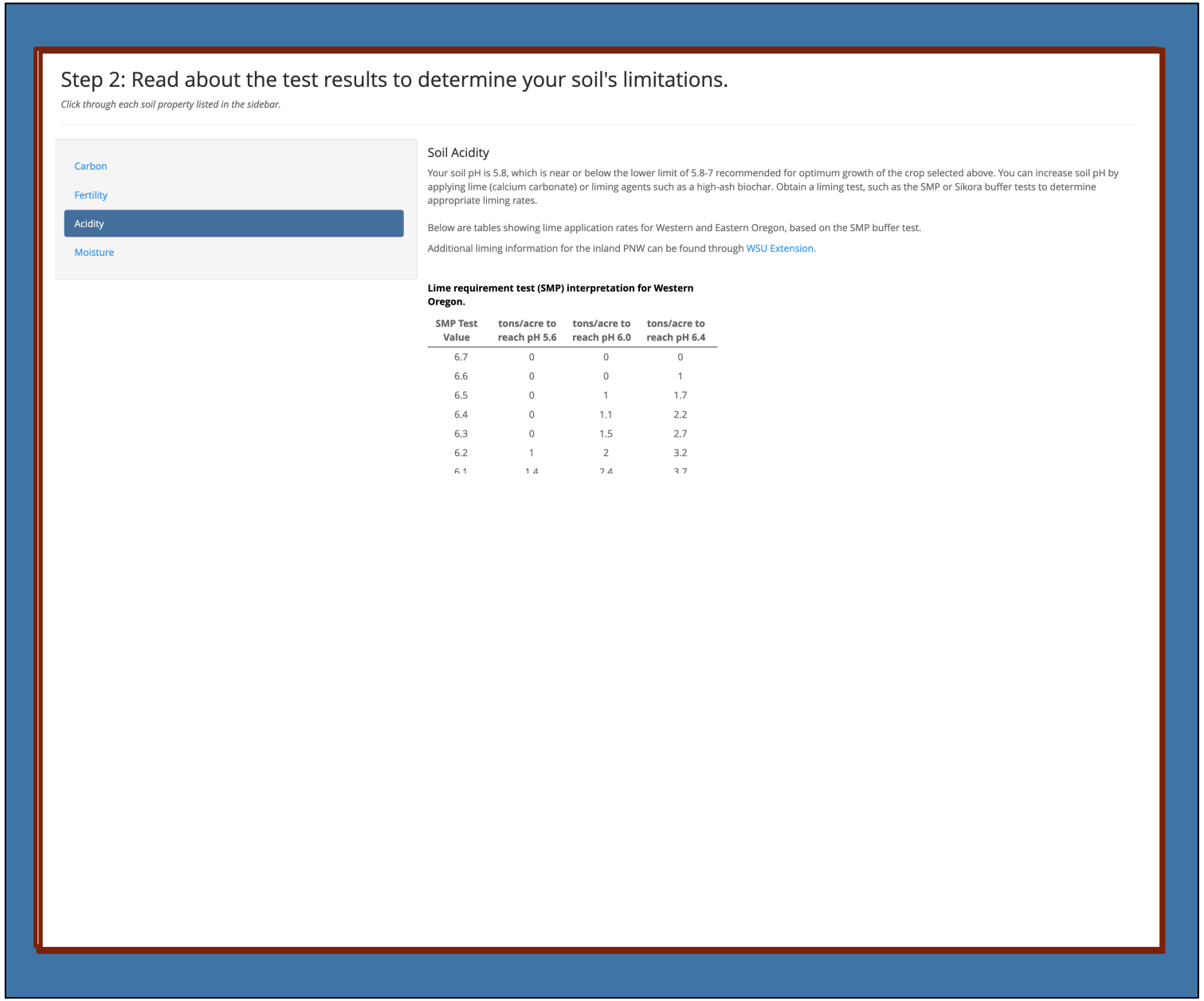
STEP 2

INPUT SOIL PROPERTIES TO IDENTIFY RESOURCE CONCERNS

DETERMINE GOALS

EXPLORE THE BIOCHAR ATLAS (PNWBIOCHAR.ORG), A WEB-BASED MULTI-TOOL RESOURCE THAT CAN HELP IDENTIFY GOALS FOR USING BIOCHAR.





Step 4: Read about which biochars can meet your goals.

Click through each goal in the sidebar. See more about these biochars using the Biochar Property Explorer.

First Priority

Second Priority

Third Priority

Summary

Putting it together

A single biochar may not meet all of your goals. Here is a summary of how the biochars in our database meet your needs.

How do you choose? The ranking suggested below is based on assigning 3 points to biochars that meet your first priority, 2 points to those meeting your second priority, and 1 point to those meeting your third priority.

Biochar Recommendations

Biochars	Priority 1	Priority 2	Priority 3	Rank
Douglas fir 700 C	X			Second
Gasified Juniper			X	
Gasified Straw AgEnergy			X	
Hazelnut shells 700 C	X			Third
Oregon White Oak 700 C	X	X	X	First
Poultry Litter Pellets 500 C		X		
Poultry Litter Pellets 700 C		X		

Last step: Choose goals

Next step: Determine amendment rate

STEP 3

ESTIMATE BENEFITS

ENTER DATA INTO THE BIOCHAR CALCULATOR SPREADSHEET TO ESTIMATE THE BENEFITS OF BIOCHAR APPLICATION

Biochar Cost-Benefit Analysis Tool

- Instructions
- Biochar Costs
- Crop Value
- Other Crop Inputs
- Results

Impact of Biochar over 5 Years

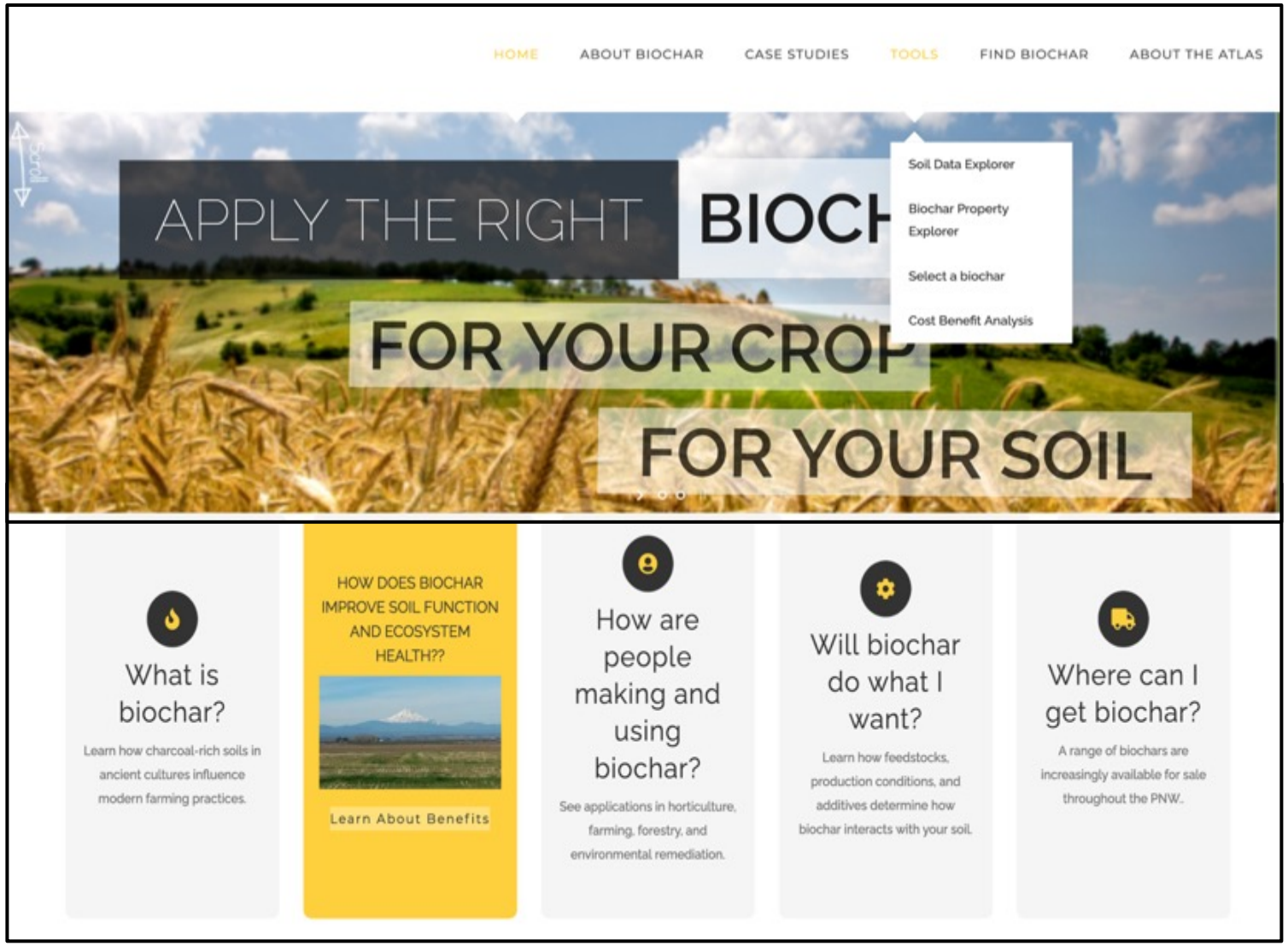
☐ Include changes in other crop inputs?

☐ Discount benefits in the future?

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Biochar Cost	-$500	$0	$0	$0	$0	-$500
Change in Crop Margin	$297	$297	$297	$297	$297	$1,485
Net Benefit	**-$203**	**$297**	**$297**	**$297**	**$297**	**$986**

Note: This table will only populate after you go through the previous tabs.

WWW.PNWBIOCHAR.ORG



Limitations of the Tool

- **Map function**
- **Crops**
- **Directory**
- **Biochar database**
- **Success = yield**

STEP 3

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Financial and Technical Assistance for Biochar Application

Soil Carbon Amendment: Conservation Practice Standard 336

Offsets the financial cost of biochar, compost, or biochar:compost mixtures

Changes the value proposition of biochar from yield to conservation

Expansion of the Biochar Atlas

Partnership liasoning & stakeholder engagement

USDA

Develop Biochar Database

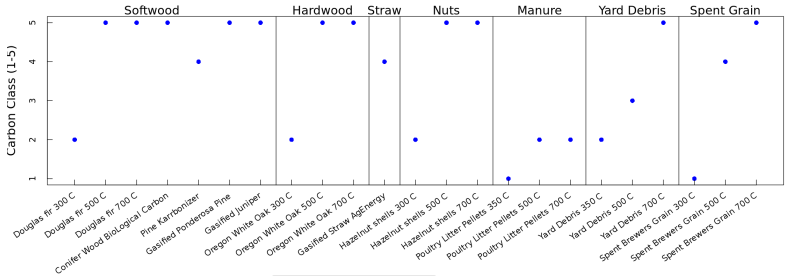
Expanding the Biochar Atlas Database

Biochar Property Explorer

Douglas fir 700 C

	Class	Details	Meaning
Carbon Storage Class	5	sBC_{100} = 878.5g kg^{-1}	Scale from 1 to 5 based on quantity of carbon estimated to persist >100 years.
Fertilizer Class	0	None	Number of plant nutrients (P, K, S, and Mg) sufficiently available to meet the demand of a corn crop.
Liming Class	1	$CaCO_3$ - eq = 4.4%	Scale from 0 to 3 based on $CaCO_3$ equivalence.
Particle Size Class	Pd	Blended powder	Four main classes: Lump (>50% large particles), Kernel (>50% medium), Powder (>50% fine), and Blended (mixture).

Biochar Classification Tool



Characterizing more biochar products

Select a Biochar

Step 4: Read about which biochars can meet your goals.

Click through each goal in the sidebar. See more about these biochars using the Biochar Property Explorer.

First Priority
Second Priority
Third Priority
Summary

Priority 1: Sequester carbon

Good choices for carbon sequestration are biochars that have high carbon content, such as wood, and that are thoroughly charred.

The biochars from our database with the largest content of highly-charred carbon, (i.e. highest sBC_{100}) include:

- Hazelnut shells 700 C (sBC_{100} = 915 g/kg)
- Douglas fir 700 C (sBC_{100} = 878 g/kg)
- Oregon White Oak 700 C (sBC_{100} = 806 g/kg)

First Priority
Second Priority
Third Priority
Summary

Putting it together

A single biochar may not meet all of your goals. Here is a summary of how the biochars in our database meet your needs.

How do you choose? The ranking suggested below is based on assigning 3 points to biochars that meet your first priority, 2 points to those meeting your second priority, and 1 point to those meeting your third priority.

Biochar Recommendations

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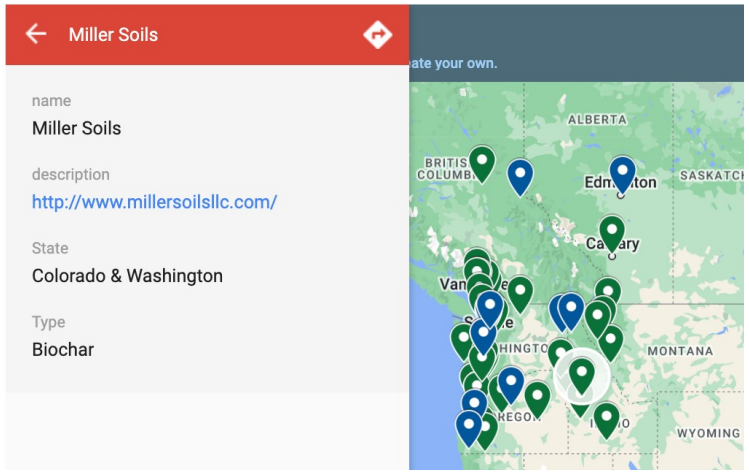
Hazelnut shells 700 C	X			Second
Oregon White Oak 700 C	X			Third
Poultry Litter Pellets 350 C		X		
Poultry Litter Pellets 500 C		X		
Poultry Litter Pellets 700 C		X		

Increasing biochar product options that meet grower's soil health goals

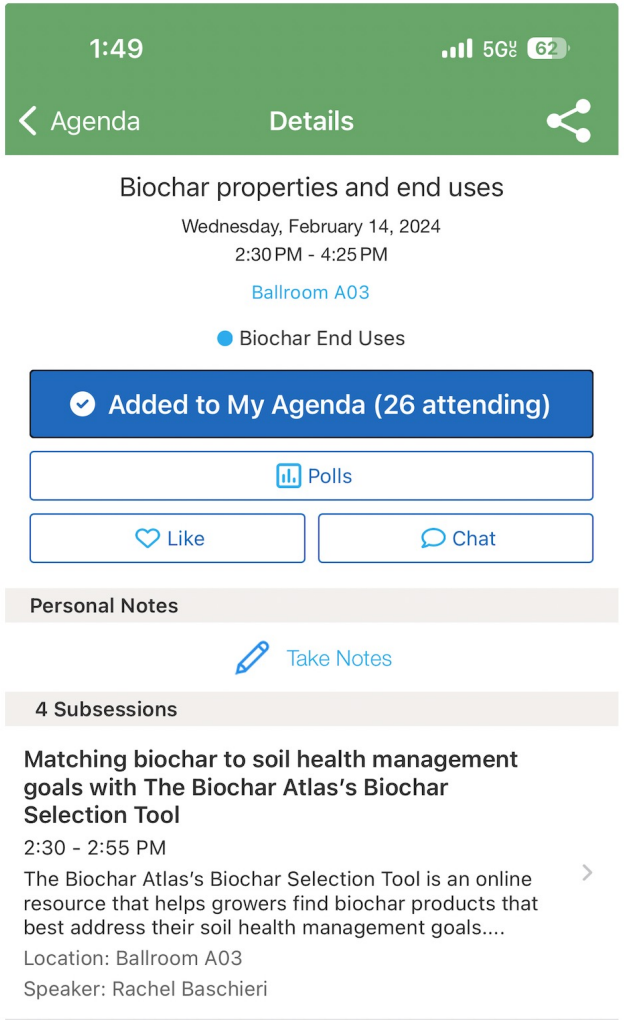
Find Biochar



Adding biochar producers across the US so growers can order locally

pnwbiochar.org

Get included- Submit a sample to the Biochar Atlas!



- Sample analysis is free
- Biochar product info and analysis results are added to the Biochar Atlas database
- Analysis results are not applicable toward USDA or IBI certification

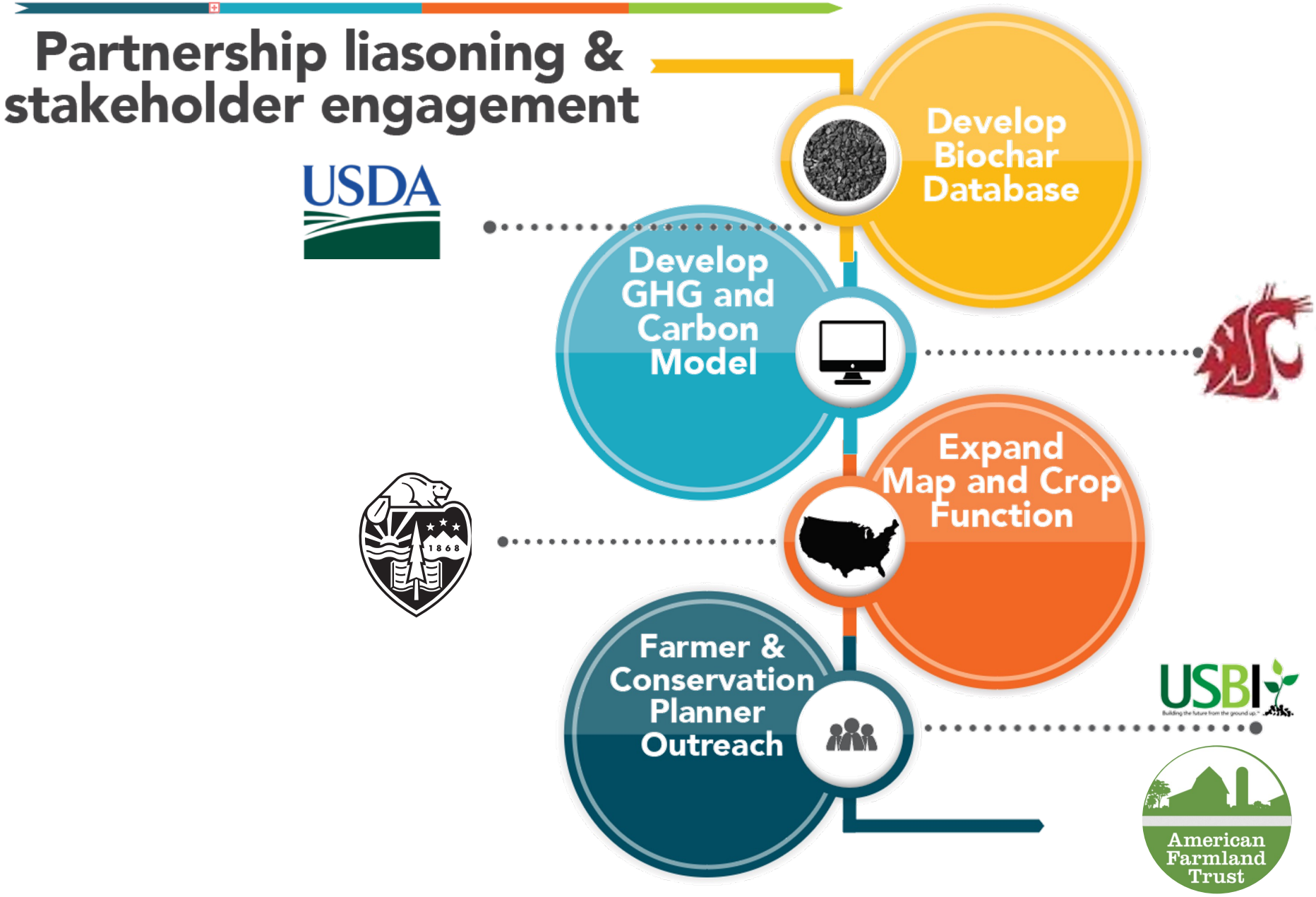
Contact Rachel Baschieri for details:

rachel.baschieri@usda.gov

(541)738-4168

Or visit https://www.pnwbiochar.org/home/submit_sample/

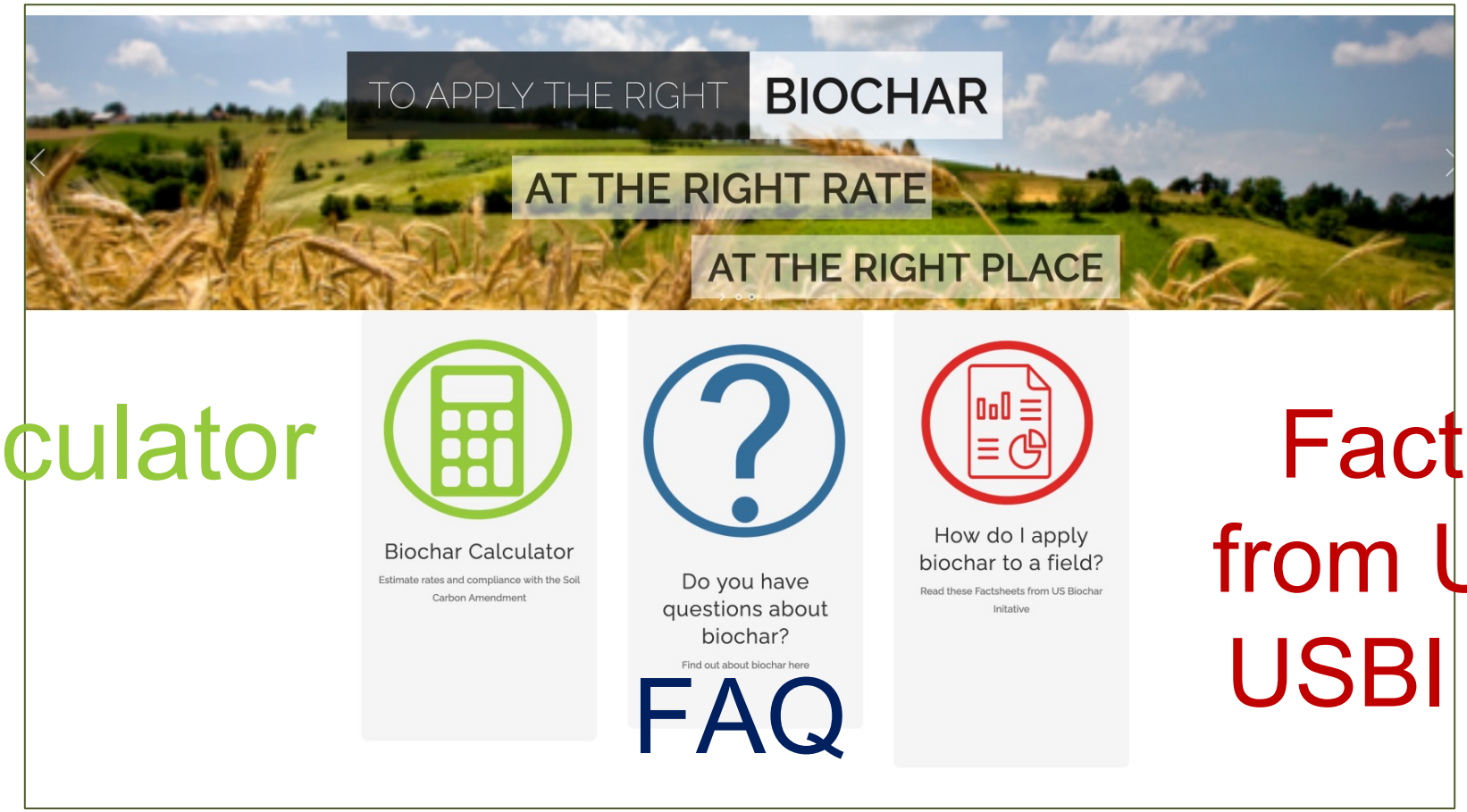
Expansion of the Biochar Atlas



To improve agricultural yields and address resource concerns

But….I need information now!

3R Calculator



Fact sheets from USBI and USBI partners

http://www.pnwbiochar.org/tools/tools_336

But….I need information now!

3R Calculator

Certificate of Analysis

International BioChar Initiative (IBI) Laboratory Tests for Certification Program

	Dry Basis Unless Stated:	Range	Units	Method
Moisture (time of analysis)	50.2		% wet wt.	ASTM D1762-84 (105c)
Bulk Density	11.3		lb/cu ft	
Organic Carbon	83.0		% of total dry mass	Dry Combust-ASTM D 4373
Hydrogen/Carbon (H:C)	0.57	0.7 Max	Molar Ratio	H dry combustion/C(above)
Total Ash	2.4		% of total dry mass	ASTM D-1762-84
Total Nitrogen	0.41		% of total dry mass	Dry Combustion
pH value	9.24		units	4.11USCC:dil. Rajkovich
Electrical Conductivity (EC20 w/w)	0.237		dS/m	4.10USCC:dil. Rajkovich
Liming (neut. Value as-CaCO3)	2.5		%CaCO3	AOAC 955.01
Carbonates (as-CaCO3)	2.1		%CaCO3	ASTM D 4373
Butane Act.	2.5		g/100g dry	ASTM D 5742-95
Surface Area Correlation	213		m2/g dry	G

All units mg/kg dry unless stated:		Results	Range of Max. Levels	Reporting Limit (ppm)	Method
Arsenic	(As)	**ND**	13 to 100	0.44	J
Cadmium	(Cd)	0.19	1.4 to 39	0.18	J
Chromium	(Cr)	4.6	93 to 1200	0.44	J
Cobalt	(Co)	**ND**	34 to 100	0.44	J
Copper	(Cu)	9.6	143 to 6000	0.44	J
Lead	(Pb)	0.46	121 to 300	0.18	J
Molybdenum	(Mo)	0.60	5 to 75	0.44	J
Mercury	(Hg)	**ND**	1 to 17	0.001	EPA 7471
Nickel	(Ni)	4.7	47 to 420	0.44	J
Selenium	(Se)	**ND**	2 to 200	0.88	J
Zinc	(Zn)	35.6	416 to 7400	0.88	J
Boron	(B)	8.1	Declaration	4.4	TMECC
Chlorine	(Cl)	118	Declaration	20.0	TMECC
Sodium	(Na)	**ND**	Declaration	440	E
Iron	(Fe)	1566	Declaration	22.0	E
Manganese	(Mn)	233	Declaration	0.44	J

Particle Size Distribution	Results	Units	Method
< 0.5mm	7.8	percent	F
0.5-1mm	5.6	percent	F
1-2mm	9.2	percent	F
2-4mm	16.9	percent	F
4-8mm	27.6	percent	F
8-16mm	26.2	percent	F
16-25mm	6.5	percent	F
25-50mm	0.0	percent	F
>50mm	0.0	percent	F

Basic Soil Enhancement Properties			
Total (K)	3985	mg/kg	E
Total (P)	460	mg/kg	E
Ammonia (NH4-N)	7.1	mg/kg	A
Nitrate (NO3-N)	3.0	mg/kg	A
Organic (Org-N)	4048	mg/kg	Calc.
Volatile Matter	22.2	percent dw	D

* "ND" stands for "not detected" which means the result is below the reporting limit.

Method A Rayment & Higginson
D ASTM D1762-84
E EPA3050B/EPA 6010
F ASTM D 2862 Granular
G Butane Activity Surface Area Correlation Based on McLaughlin, Shields, Jagiello, & Thiele's 2012 paper: Analytical Options for Biochar Adsorption and Surface Area
J EPA3050B/EPA 6020

Does it Meet Standard?

Variable	Value	Unit	Meets NRCS 336 Standard
Bulk Density	11.3	lbs/ft^3	N/A
Moisture Content	50.20%	Percent	N/A
Organic Carbon (Corg)	83.00%	Percent	Meets Criteria
H: Corg	0.57	Ratio	Meets Criteria
pH	9.24	pH Units	Reported as Needed
Liming, $CaCO_3$ equivalent %	2.50%	Percent	Reported as Needed
Ash	2.40%	Percent	Reported as Needed
Nitrogen	4100	ppm (dry weight)	Reported as Needed
Phosphorous	460	ppm (dry weight)	Reported as Needed
Potassium	3985	ppm (dry weight)	Reported as Needed
Arsenic, As	0	ppm (dry weight)	Meets Criteria
Cadmium, Cd	0.19	ppm (dry weight)	Meets Criteria
Calcium, Ca		ppm (dry weight)	Needs to be Reported
Chromium, Cr	4.6	ppm (dry weight)	Meets Criteria
Copper, Cu	9.6	ppm (dry weight)	Meets Criteria
Lead, Pb	0.46	ppm (dry weight)	Meets Criteria
Molybdenum, Mo	0.6	ppm (dry weight)	Reported as Needed
Mercury, Hg	0	ppm (dry weight)	Meets Criteria
Magnesium, Mg		ppm (dry weight)	Needs to be Reported
Nickel, Ni	4.7	ppm (dry weight)	Meets Criteria
Selenium, Se	0	ppm (dry weight)	Meets Criteria
Zinc, Zn	35.6	ppm (dry weight)	Meets Criteria
Boron, B	8.1	ppm (dry weight)	N/A
Chlorine, Cl	118	ppm (dry weight)	N/A
Sulfur, S		ppm (dry weight)	N/A
Sodium, Na	0	ppm (dry weight)	N/A
Aluminium, Al	25	ppm (dry weight)	N/A
Iron, Fe	1566	ppm (dry weight)	N/A
Manganese, Mn	233	ppm (dry weight)	N/A

Biochar Application Rate Calculator

- **Excel-Based**
- **Determines compliance**
- **Determines carbon and nutrient outcomes**

Soil Fertility per yd^3 Biochar

Nutrient	Biochar Characteristics	Unit
Lime	$CaCO_3$ equivalent %	2.50%
	Tons $CaCO_3e$ per yard biochar	0.0038138
Nitrogen	N ppm	4100.00
	lbs N /yd^3 biochar	1.25091
Phosphorus	P ppm	20.00
	lbs P / yd^3 biochar	0.006102
Potassium	K ppm	3705
	lbs K / yd^3 biochar	1.1303955
Calcium	Total Ca ppm	0
	lbs Ca / yd^3 biochar	0
Magnesium	Total Mg ppm	0
	lbs Mg / yd^3 biochar	0
Sulfur	Total S ppm	0
	lbs S / yd^3 biochar	0
Sodium (Na)	Total Na ppm	0
	lbs Na / yd^3 biochar	0
Chlorine	Total Cl ppm	118
	lbs Cl / yd^3 biochar	0.0360018
Aluminum	Total Al ppm	25
	lbs Al / yd^3 biochar	0.0076275
Copper	Total Cu ppm	9.6
	lbs Cu / yd^3 biochar	0.002929
Zinc	Total Zn ppm	35.6
	lbs Zn / yd^3 biochar	0.0108616
Iron	Total Fe ppm	1566
	lbs Fe / yd^3 biochar	0.4777866
Manganese	Total Mn ppm	233
	lbs Mn / yd^3 biochar	0.0710883
Boron	Total B ppm	8.1
	lbs B / yd^3 biochar	0.0024713

Soil Fertility per Application (yd^3)

Liming and NPK Outcomes per acre		
yards biochar applied per acre	*20*	
Percent of field amended with biochar	30.00%	
Nutrient	Total lbs per acre	Total lbs per amended acre
Liming equivalent, $CaCO_3$ (tons)	0.08	**0.25**
N added	25.02	**83.39**
P added	0.12	**0.41**
P_2O_5 added	0.28	**0.93**
K added	22.61	**75.36**
K_2O added	27.23	**90.78**
Ca added	0.00	**0.00**
Mg added	0.00	**0.00**
S added	0.00	**0.00**
SO_4 added	0.00	**0.00**
Na added	0.00	**0.00**
Cl added	0.72	**2.40**
Al added	0.15	**0.51**
Cu added	0.06	**0.20**
Zn added	0.22	**0.72**
Fe added	9.56	**31.85**
Mn added	1.42	**4.74**
B added	0.05	**0.16**

Soil fertility per yd3 | Soil Fertility per ton

Biochar Application Rate Calculator

- **Excel-Based**
- **Determines compliance**
- **Determines C and nutrient outcomes**

Soil Organic Carbon inputs and outcomes

Cultivation specs

Incorporation depth	Percent of field amended with biochar
8	30%

How much biochar do you need to achive a specific increase in soil organic carbon?

% SOC increase desired	Tons Corg needed	Tons Biochar required (dry)	Tons Biochar required (we	yd^3 required (wet)
1.00%	3.62	4.36	8.75	28.6

How much soil carbon will you apply given a specific application rate? (in tons)

Tons Biochar (wet)	Tons Corg applied	Achieved Rate (SOC%)
4	1.65	0.46%

How much soil carbon will you apply given a specific application rate? (in yards)

yd^3 biochar	Tons Biochar (wet)	Tons Corg applied	Achieved Rate (SOC%)
20	6.13	2.53	0.70%

Soil Volume and Weight

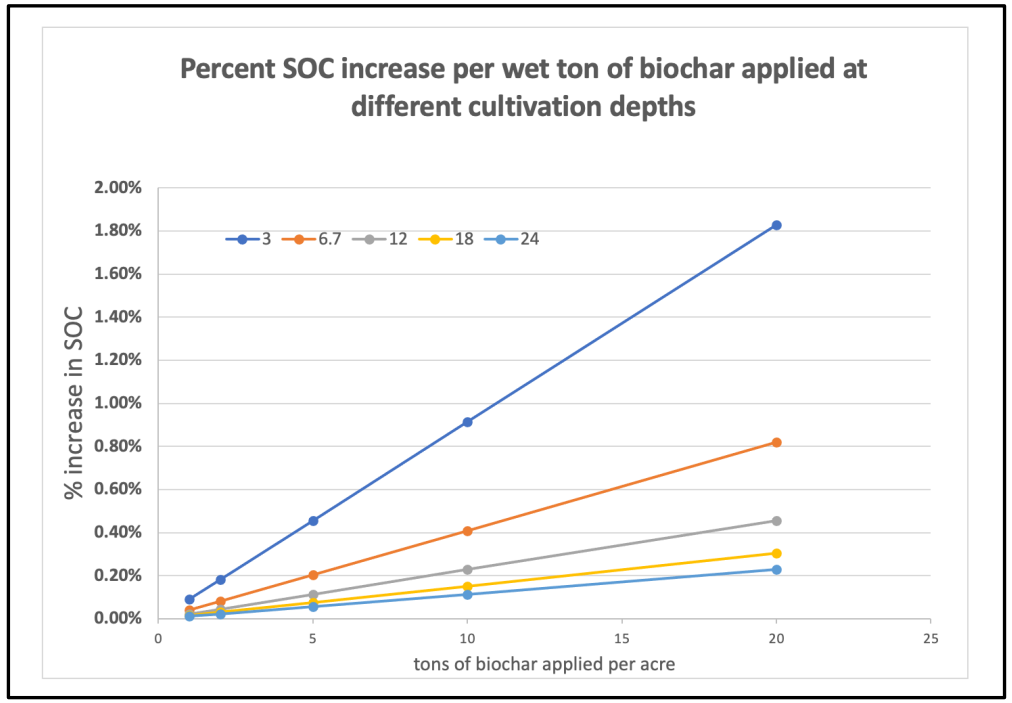
ft^3 / acre	yd^3 / acre	soil density ton/yd^3	tons soil/acre (treated)
29,040	1076	1.12	1205.47

Biochar Application Rate Calculator

- **Excel-Based**
- **Determines compliance**
- **Determines C and nutrient outcomes**

% Soil Organic Carbon outcomes per application (wet ton) under different cultivation depths and application rates

Biochar tons/acre (applied as delivered)	1	2	5	10	20
3	0.09%	0.18%	0.46%	0.91%	1.83%
6.7	0.04%	0.08%	0.20%	0.41%	0.82%
12	0.02%	0.05%	0.11%	0.23%	0.46%
18	0.02%	0.03%	0.08%	0.15%	0.30%
24	0.01%	0.02%	0.06%	0.11%	0.23%



Biochar Application Rate Calculator

- **Excel-Based**
- **Determines compliance**
- **Determines C and nutrient outcomes**

Insert information about the project here.

Variable	Value	Unit	Meets NRCS 336 Standard
Bulk Density	11.3	lbs/ft3	N/A
Moisture Content	50.20%	Percent	N/A
Organic Carbon (Corg)	83.00%	Percent	Meets Criteria
H: Corg	0.57	Ratio	Meets Criteria
pH	9.24	pH Units	Reported as Needed
Liming, $CaCO_3$ equivalent	2.50%	Percent	Reported as Needed
Ash	2.40%	Percent	Reported as Needed
Nitrogen	4100	ppm (dry weight)	Reported as Needed
Phosphorous	20	ppm (dry weight)	Reported as Needed
Potassium	3705	ppm (dry weight)	Reported as Needed
Arsenic, As	0	ppm (dry weight)	Meets Criteria
Cadmium, Cd	0.19	ppm (dry weight)	Meets Criteria
Calcium, Ca	0	ppm (dry weight)	Needs to be Reported
Chromium, Cr	4.6	ppm (dry weight)	Meets Criteria
Copper, Cu	9.6	ppm (dry weight)	Meets Criteria
Lead, Pb	0.46	ppm (dry weight)	Meets Criteria
Molybdenum, Mo	0.6	ppm (dry weight)	Reported as Needed
Mercury, Hg	0	ppm (dry weight)	Meets Criteria
Magnesium, Mg	0	ppm (dry weight)	Needs to be Reported
Nickel, Ni	4.7	ppm (dry weight)	Meets Criteria
Selenium, Se	0	ppm (dry weight)	Meets Criteria
Zinc, Zn	35.6	ppm (dry weight)	Meets Criteria
Boron, B	8.1	ppm (dry weight)	N/A
Chlorine, Cl	118	ppm (dry weight)	N/A
Sulfur, S	0	ppm (dry weight)	N/A
Sodium, Na	0	ppm (dry weight)	N/A
Aluminium, Al	25	ppm (dry weight)	N/A
Iron, Fe	1566	ppm (dry weight)	N/A
Manganese, Mn	233	ppm (dry weight)	N/A

%SOC outcomes per application

Cultivation specs

Inches depth	Percent acreage cultivated
8	0.3

How much biochar do you need to achive a specific increase in soil organic carbon?

% SOC increase desired	Tons Corg needed	Tons Biochar required (d	Tons Biochar required (w	yd^3 required (wet)
1.00%	3.62	4.36	8.75	28.6

How much soil carbon will you apply given a specific application rate? (in tons)

Tons Biochar (wet)	Tons Corg applied	Achieved Rate (SOC%)
4	1.65	0.46%

How much soil carbon will you apply given a specific application rate? (in yards)

yd^3 biochar	Tons Biochar (wet)	Tons Corg applied	Achieved Rate (SOC%)
20	6.13	2.53	0.70%

Liming and NPK Outcomes per acre		
Tons biochar applied per acre (wet)	0	
Percent of field cultivated	100.00%	
	0	
Nutrient	Total lbs per	lbs/ cultivated acre
Liming equivalent, $CaCO_3$ (tons)	0	0
N added	0	0
P added	0.00	0
P_2O_5 added	0.00	0
K added	0.00	0
K_2O added	0.00	0
Ca added	0.00	0
Mg added	0.00	0
S added	0.00	0
SO_4 added	0.00	0
Na added	0.00	0
Cl added	0.00	0
Al added	0.00	0
Cu added	0.00	0
Zn added	0.00	0
Fe added	0.00	0
Mn added	0.00	0
B added	0.00	0

Liming and NPK Outcomes per acre		
yards biochar applied per acre	*6.6*	
Percent of field cultivated	60.00%	
Nutrient	Total lbs	lbs/ cultivated acre
Liming equivalent, CaCO3 (tons)	0.08	0.25
N added	25.02	83.39
P added	0.12	0.41
P2O5 added	0.28	0.93
K added	22.61	75.36
K2O added	27.23	90.78
Ca added	0.00	0.00
Mg added	0.00	0.00
S added	0.00	0.00
SO4 added	0.00	0.00
Na added	0.00	0.00
Cl added	0.72	2.40
Al added	0.15	0.51
Cu added	0.06	0.20
Zn added	0.22	0.72
Fe added	9.56	31.85
Mn added	1.42	4.74
B added	0.05	0.16

Biochar Application Rate Calculator

- **Excel-Based**
- **Determines compliance**
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Certificate of Analysis

International BioChar Initiative (IBI) Laboratory Tests for Certification Program

	Dry Basis Unless Stated:	Range	Units	Method
Moisture (time of analysis)	50.2		% wet wt.	ASTM D1762-84 (105c)
Bulk Density	11.3		lb/cu ft	
Organic Carbon	83.0		% of total dry mass	Dry Combust-ASTM D 4373
Hydrogen/Carbon (H:C)	0.57	0.7 Max	Molar Ratio	H dry combustion/C(above)
Total Ash	2.4		% of total dry mass	ASTM D-1762-84
Total Nitrogen	0.41		% of total dry mass	Dry Combustion
pH value	9.24		units	4.11USCC:dil. Rajkovich
Electrical Conductivity (EC20 w/w)	0.237		dS/m	4.10USCC:dil. Rajkovich
Liming (neut. Value as-CaCO3)	2.5		%CaCO3	AOAC 955.01
Carbonates (as-CaCO3)	2.1		%CaCO3	ASTM D 4373
Butane Act.	2.5		g/100g dry	ASTM D 5742-95
Surface Area Correlation	213		m2/g dry	G

All units mg/kg dry unless stated:		Results	Range of Max. Levels	Reporting Limit (ppm)	Method
Arsenic	(As)	**ND**	13 to 100	0.44	J
Cadmium	(Cd)	0.19	1.4 to 39	0.18	J
Chromium	(Cr)	4.6	93 to 1200	0.44	J
Cobalt	(Co)	**ND**	34 to 100	0.44	J
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Boron	(B)	8.1	Declaration	4.4	TMECC
Chlorine	(Cl)	118	Declaration	20.0	TMECC
Sodium	(Na)	**ND**	Declaration	440	E
Iron	(Fe)	1566	Declaration	22.0	E
Manganese	(Mn)	233	Declaration	0.44	J

Particle Size Distribution	Results	Units	Method
< 0.5mm	7.8	percent	F
0.5-1mm	5.6	percent	F
1-2mm	9.2	percent	F
2-4mm	16.9	percent	F
4-8mm	27.6	percent	F
8-16mm	26.2	percent	F
16-25mm	6.5	percent	F
25-50mm	0.0	percent	F
>50mm	0.0	percent	F

Basic Soil Enhancement Properties			
Total (K)	3985	mg/kg	E
Total (P)	460	mg/kg	E
Ammonia (NH4-N)	7.1	mg/kg	A
Nitrate (NO3-N)	3.0	mg/kg	A
Organic (Org-N)	4048	mg/kg	Calc.
Volatile Matter	22.2	percent dw	D

* "ND" stands for "not detected" which means the result is below the reporting limit.

Method A Rayment & Higginson
D ASTM D1762-84
E EPA3050B/EPA 6010
F ASTM D 2862 Granular
G Butane Activity Surface Area Correlation Based on McLaughlin, Shields, Jagiello, & Thiele's 2012 paper: Analytical Options for Biochar Adsorption and Surface Area
J EPA3050B/EPA 6020

Does it Meet Standard?

Biochar Characteristics Input

Variable	Value	Unit	Meets NRCS 336 Standard
Bulk Density	11.3	lbs/ft^3	N/A
Moisture Content	50.20%	Percent	Meets Criteria
Organic Carbon (Corg)	83.00%	Percent	Meets Criteria
H: Corg	0.57	Ratio	Meets Criteria
Electrical Conductivity (EC)	0.24	dS/m or mS/cm	Reported as Needed
pH	9.24	pH Units	Reported as Needed
Liming, $CaCO_3$ equivalent %	2.50%	Percent	Reported as Needed
Ash	2.40%	Percent	Reported as Needed
Nitrogen	4100	ppm (dry weight)	Reported as Needed
Phosphorous	460	ppm (dry weight)	Reported as Needed
Potassium	3,985	ppm (dry weight)	Reported as Needed
Arsenic, As	0	ppm (dry weight)	Meets Criteria
Cadmium, Cd	0.19	ppm (dry weight)	Meets Criteria
Calcium, Ca		ppm (dry weight)	**Needs to be Reported**
Chromium, Cr	4.6	ppm (dry weight)	Meets Criteria
Copper, Cu	9.6	ppm (dry weight)	Meets Criteria
Lead, Pb	0.46	ppm (dry weight)	Meets Criteria
Molybdenum, Mo	0.6	ppm (dry weight)	Reported as Needed
Mercury, Hg	0	ppm (dry weight)	Meets Criteria
Magnesium, Mg		ppm (dry weight)	**Needs to be Reported**
Nickel, Ni	4.7	ppm (dry weight)	Meets Criteria
Selenium, Se	0	ppm (dry weight)	Meets Criteria
Zinc, Zn	35.4	ppm (dry weight)	Meets Criteria
Boron, B	8.1	ppm (dry weight)	N/A
Chlorine, Cl	118	ppm (dry weight)	N/A
Sulfur, S		ppm (dry weight)	N/A
Sodium, Na	0	ppm (dry weight)	N/A
Aluminium, Al	25	ppm (dry weight)	N/A
Iron, Fe	1566	ppm (dry weight)	N/A
Manganese, Mn	7554	ppm (dry weight)	N/A
Feedstock		none	**Needs to be Reported**
Production Temperature		degrees C	**Needs to be Reported**

Biochar Application Rate Calculator

What it can't do:

- **Choose Goals**
- **Compare or find biochars**
- **Does not integrate soil or crop needs**

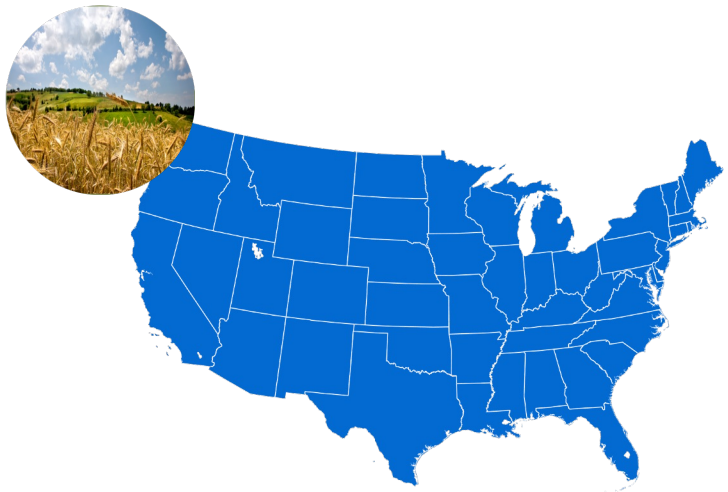
The Gady Family invested in on-farm power

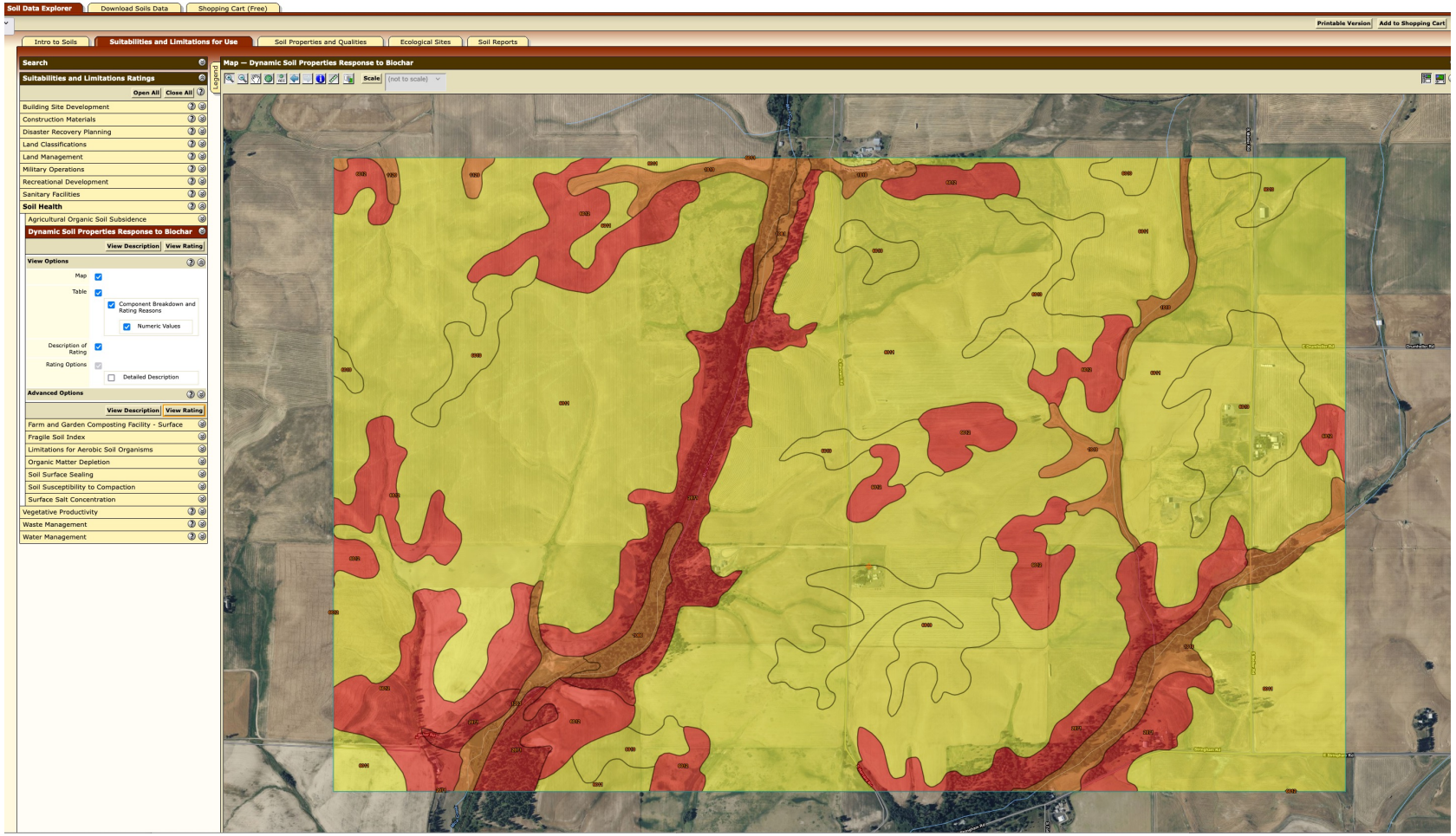
Residues from seed cleaning mill

Seed screening biochar

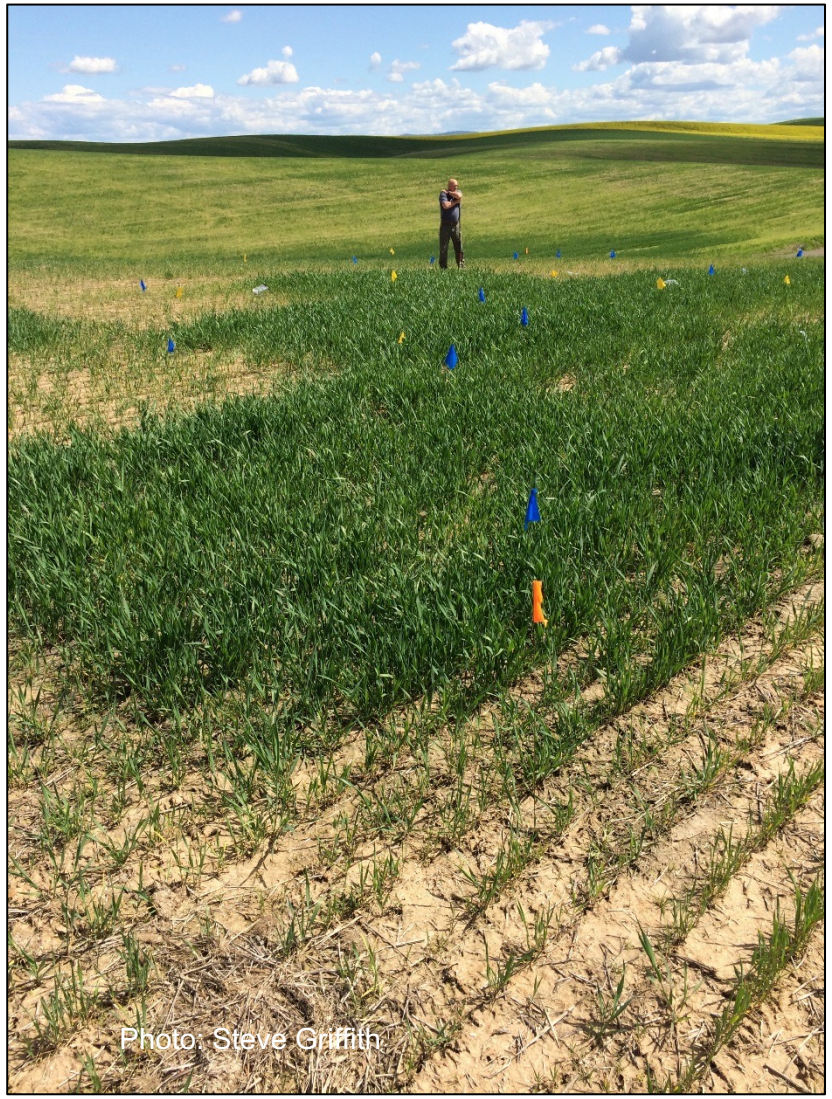
Photos Claire Phillips

Spring Wheat, Washington

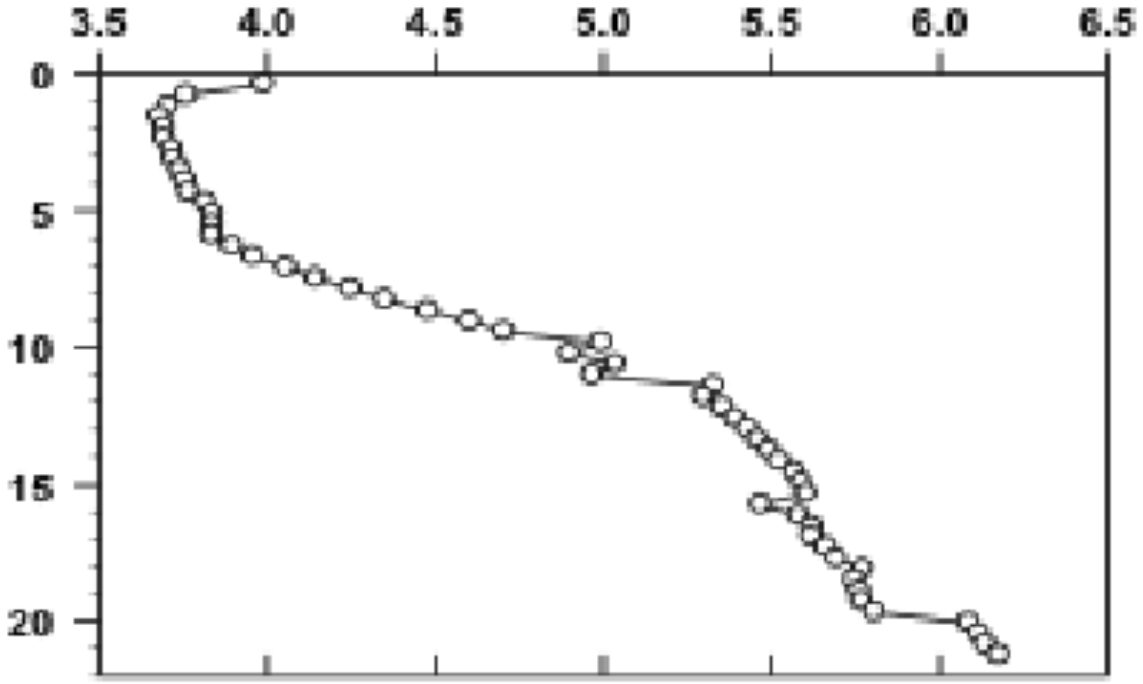




Goals: Increase pH, sequester C, increase water



Ammonia-based fertilizers acidify soils



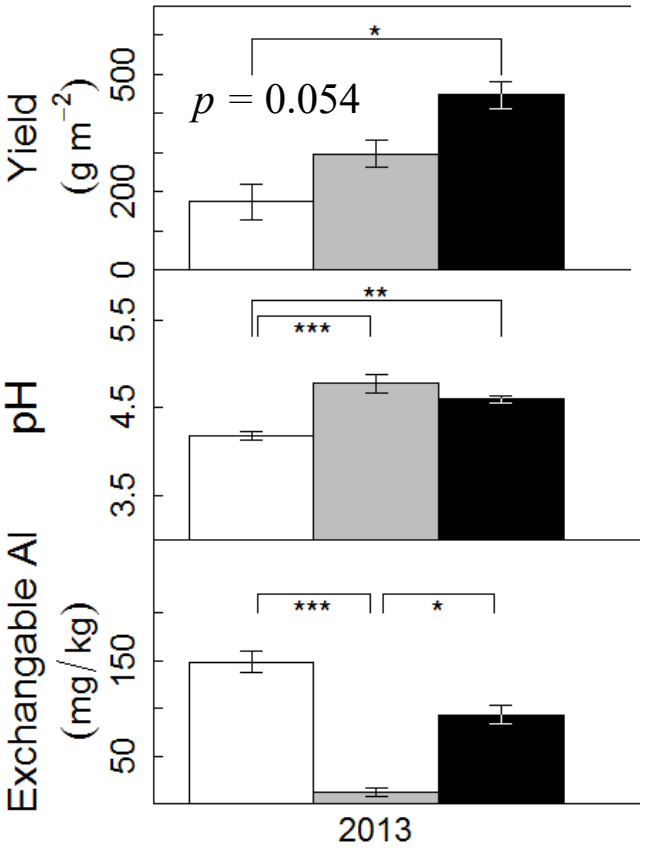
Can biochar can be used to increase soil pH?

- **Kentucky Bluegrass Seed Screening Biochar (12 - 16% $CaCO_3$-eq)**
  8 tons/acre
- **Hydrated lime (136% $CaCO_3$-eq)**
  1 ton/acre
- **Non-amended Control**

Rototilled 0-10 cm depth

Biochar improved yield 2.88X!

- Biochar increased yield by 2.88×
- Lime increased yield by 1.88×
- Both amendments increased pH similarly
- Both decreased soluble aluminum, but lime did better than biochar



Biochar Characteristics Input

Variable	Value	Unit	Meets NRCS 336 Standard
Bulk Density		lbs/ft^3	N/A
Moisture Content	20.00%	Percent	Meets Criteria
Organic Carbon (Corg)	45.00%	Percent	Meets Criteria
H: Corg	0,02	Ratio	Meets Criteria
Electrical Conductivity (EC)	2.98	dS/m or mS/cm	Reported as Needed
pH	10.20	pH Units	Reported as Needed
Liming, $CaCO_3$ equivalent %	17.00%	Percent	Reported as Needed
Ash	33.00%	Percent	Reported as Needed
Nitrogen	22000	ppm (dry weight)	Reported as Needed
Phosphorous	15320	ppm (dry weight)	Reported as Needed
Potassium	36,358	ppm (dry weight)	Reported as Needed
Arsenic, As	0	ppm (dry weight)	Meets Criteria
Cadmium, Cd	0	ppm (dry weight)	Meets Criteria
Calcium, Ca	13300	ppm (dry weight)	Reported as Needed
Chromium, Cr	0	ppm (dry weight)	Meets Criteria
Copper, Cu	36	ppm (dry weight)	Meets Criteria
Lead, Pb	0	ppm (dry weight)	Meets Criteria
Molybdenum, Mo	0	ppm (dry weight)	Reported as Needed
Mercury, Hg	0	ppm (dry weight)	Meets Criteria
Magnesium, Mg	6342	ppm (dry weight)	Reported as Needed
Nickel, Ni	0	ppm (dry weight)	Meets Criteria
Selenium, Se	0	ppm (dry weight)	Meets Criteria
Zinc, Zn	143	ppm (dry weight)	Meets Criteria
Boron, B		ppm (dry weight)	N/A
Chlorine, Cl		ppm (dry weight)	N/A
Sulfur, S		ppm (dry weight)	N/A
Sodium, Na	411	ppm (dry weight)	N/A
Aluminium, Al	854	ppm (dry weight)	N/A
Iron, Fe	1125	ppm (dry weight)	N/A
Manganese, Mn	7554	ppm (dry weight)	N/A
Feedstock	seed waste	none	FALSE
Production Temperature	1100	degrees C	Reported as Needed

Percent	PPM
	0

Key

Input cell (required values)	
Input cell (optional values)	
Output cell	
Constant	

Soil Fertility per biochar application (wet weight)

Liming and NPK Outcomes per acre	
Tons biochar applied per acre (wet)	8
Percent of field amended with biochar	100.00%

Nutrient	Total lbs per acre	Total lbs per amended acre
Liming equivalent, $CaCO_3$	2176.00	**2176.00**
N added	281.60	**281.60**
P added	196.10	**196.10**
P_2O_5 added	449.06	**449.06**
K added	465.38	**465.38**
K_2O added	560.60	**560.60**
Ca added	170.24	**170.24**
Mg added	81.18	**81.18**
S added	0.00	**0.00**
SO_4 added	0.00	**0.00**
Na added	5.26	**5.26**
Cl added	0.00	**0.00**
Al added	10.93	**10.93**
Cu added	0.46	**0.46**
Zn added	1.83	**1.83**
Fe added	14.40	**14.40**
Mn added	96.69	**96.69**
B added	0.00	**0.00**

Cultivation specs

Incorporation depth (inches)	Percent of field amended with biochar
5	100%

How much biochar do you need to achive a specific increase in soil organic carbon?

% SOC increase desired	Tons Corg needed	Tons Biochar required (dry)	Tons Biochar required (wet)
1.00%	8.50	18.88	23.60

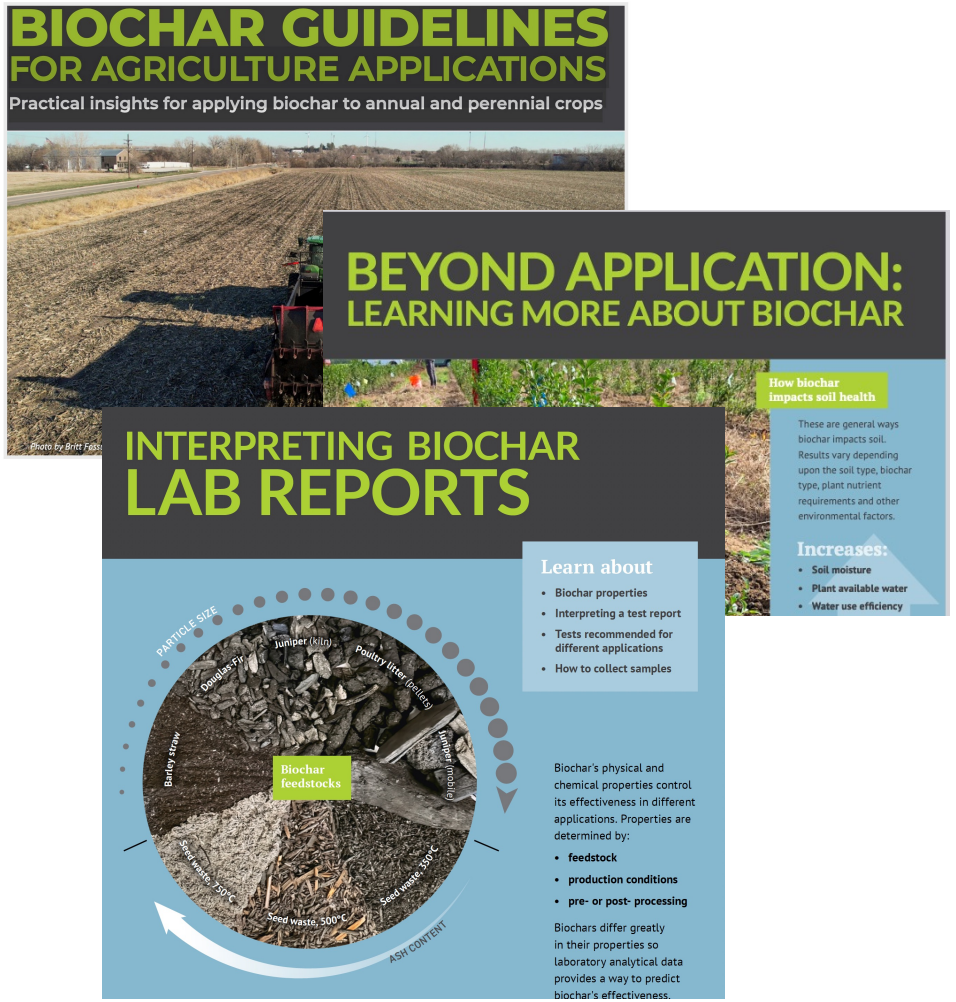
How much soil carbon will you apply given a specific application rate? (in tons)

Tons Biochar (wet)	Tons Corg applied	Achieved Rate (SOC%)
8	2.88	0.34%

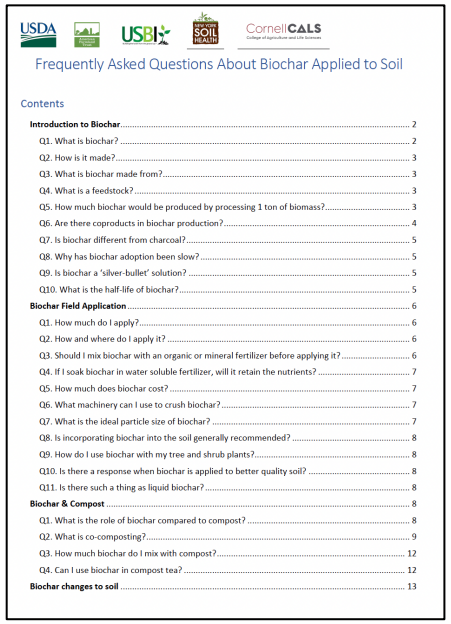
Biochar Application Rate Calculator

- **Excel-Based**
- **Determines compliance**
- **Determines carbon and nutrient outcomes**

ADDITIONAL TOOLS

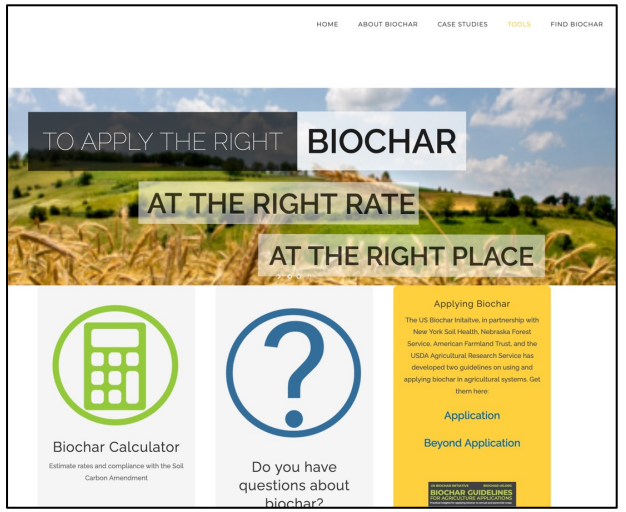


http://www.pnwbiochar.org/tools/tools_336



Biochar Characteristics Input

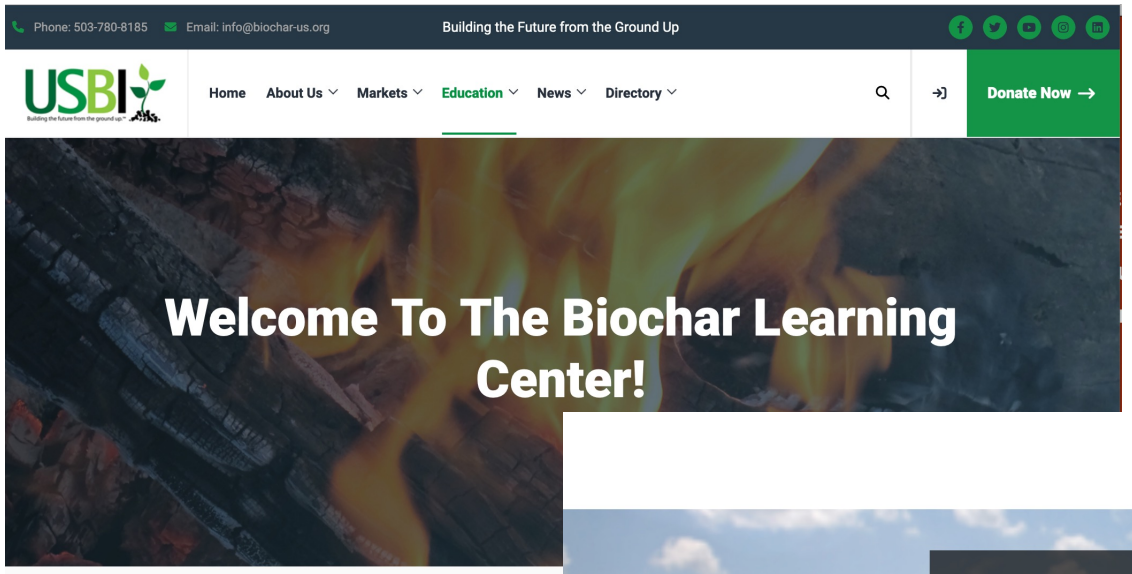
Variable	Value	Unit	Meets NRCS 336 Standard
Bulk Density	11.3	lbs/ft^3	N/A
Moisture Content	50.20%	Percent	N/A
Organic Carbon (Corg)	83.00%	Percent	Meets Criteria
H: Corg	0.57	Ratio	Meets Criteria
pH	9.24	pH Units	Reported as Needed
Liming, $CaCO_3$ equivalent %	2.50%	Percent	Reported as Needed
Ash	2.40%	Percent	Reported as Needed
Nitrogen	4100	ppm (dry weight)	Reported as Needed
Phosphorous	20	ppm (dry weight)	Reported as Needed
Potassium	3705	ppm (dry weight)	Reported as Needed
Arsenic, As	0	ppm (dry weight)	Meets Criteria
Cadmium, Cd	0.19	ppm (dry weight)	Meets Criteria
Calcium, Ca		ppm (dry weight)	Needs to be Reported
Chromium, Cr	4.6	ppm (dry weight)	Meets Criteria
Copper, Cu	9.6	ppm (dry weight)	Meets Criteria
Lead, Pb	0.46	ppm (dry weight)	Meets Criteria
Molybdenum, Mo	0.6	ppm (dry weight)	Reported as Needed
Mercury, Hg	0	ppm (dry weight)	Meets Criteria
Magnesium, Mg		ppm (dry weight)	Needs to be Reported
Nickel, Ni	4.7	ppm (dry weight)	Meets Criteria
Selenium, Se	0	ppm (dry weight)	Meets Criteria
Zinc, Zn	35.6	ppm (dry weight)	Meets Criteria
Boron, B	8.1	ppm (dry weight)	N/A
Chlorine, Cl	118	ppm (dry weight)	N/A
Sulfur, S		ppm (dry weight)	N/A
Sodium, Na	0	ppm (dry weight)	N/A
Aluminium, Al	25	ppm (dry weight)	N/A
Iron, Fe	1566	ppm (dry weight)	N/A
Manganese, Mn	233	ppm (dry weight)	N/A

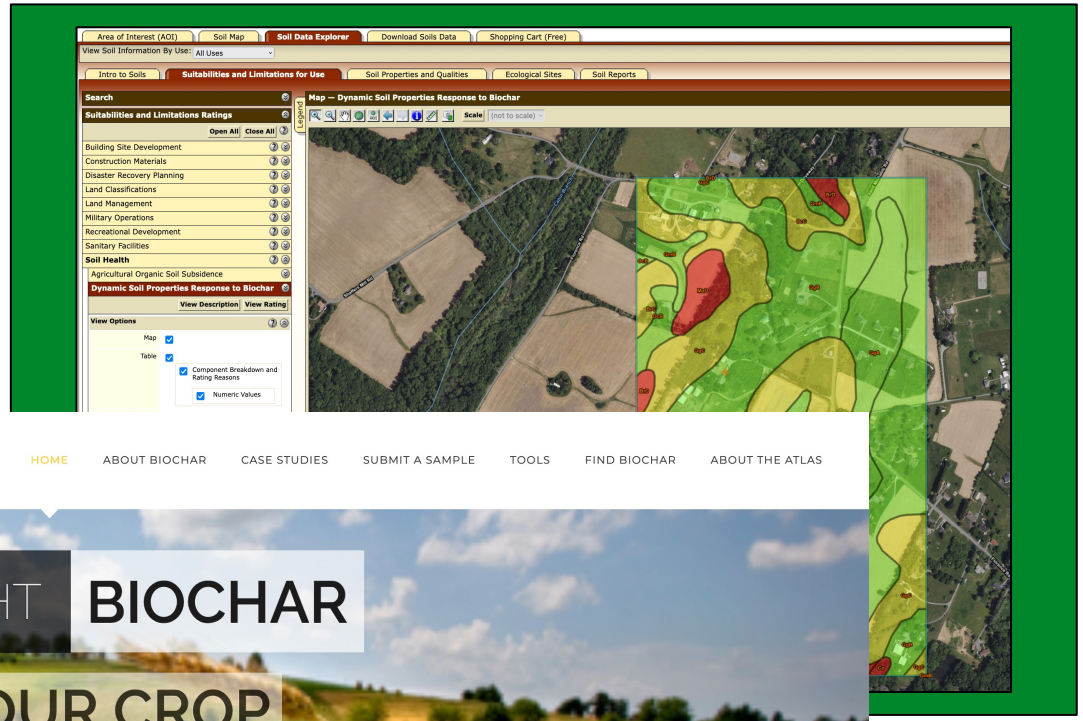


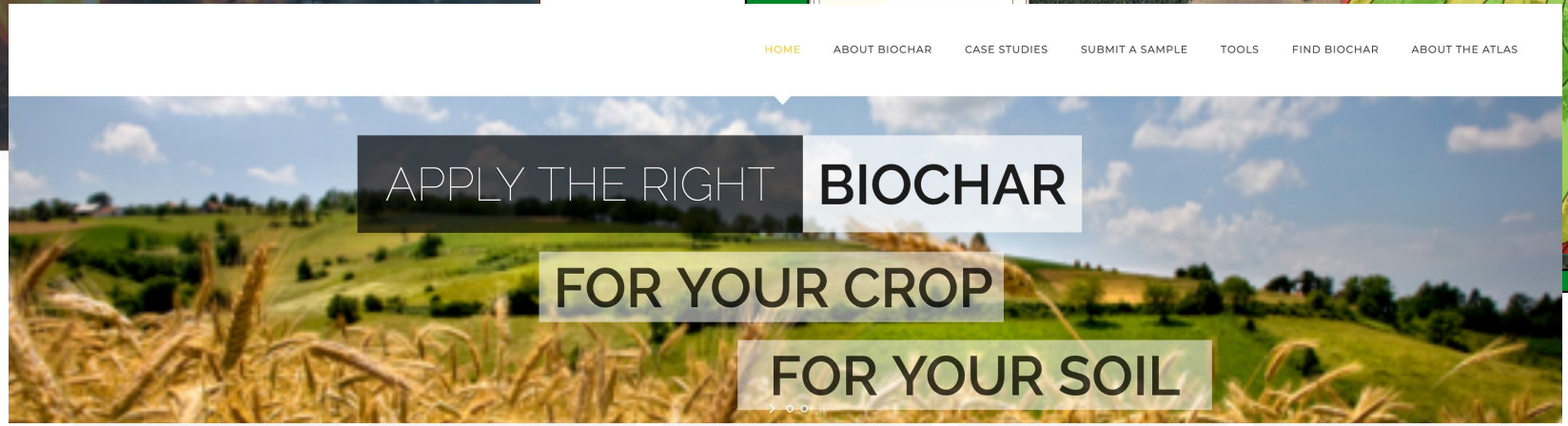
- Manure management
- Stormwater management
- Carbon Markets
- Compost:biochar synergies
- Lab analysis Interpretation
- 336 carbon amendment

https://biochar-us.org/welcome-biochar-learning-center

ONLINE RESOURCES







What is biochar?

Learn how charcoal-rich soils in ancient cultures influence modern farming practices.

What are the benefits of biochar?

Learn how biochar can benefit agriculture, natural ecosystems, and rural livelihoods.

How are people making and using biochar?

See applications in horticulture, farming, forestry, and environmental remediation.

Will biochar do what I want?

Learn how feedstocks, production conditions, and additives determine how biochar interacts with your soil.

Where can I get biochar?

A range of biochars are increasingly available for sale throughout the PNW.

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