Using Carbon to Achieve Chesapeake Bay (and Watershed) Water Quality Goals and Climate Resiliency:

The Science, Gaps, Implementation Activities and Opportunities

BIOCHAR OPPORTUNITIES IN CLIMATE SMART AGRICULTURE AND FORESTRY

Chuck Hegberg - RES, LLC / Infinite Solutions, STAC Biochar Committee Chair
Brandon R. Smith, Ph.D. – Allied Soil Health Services, LLC, STAC Biochar SME

November 21, 2024

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Workshop Objective & Goals

To convene a workshop with leading national and local experts to *elevate the use of biochar in practice Bay-wide* by evaluating and *translating current research for integration into current Chesapeake Bay protocols*.

Workshop Goals

1. Evaluate and Synthesis Current Biochar Research
2. Translate Biochar Research & Empirical Evidence into Protocols, Standards & Specifications
3. To Promote Biochar Adoption & Use in the CBw
4. Advance Empirical Evidence for Biochar Protocols, Standards & Specifications
5. Foster Networking & Collaboration (Community of Practice)
6. Identify Actionable Recommendations

Biochar Workshop Attendees		
	DAY 1	**DAY 2**
ROMOTE	82	92
IN PERSON	54	45
TOTAL	136	137

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Workshop Steering Committee, Technical Experts & Practitioners

Workshop Steering Committee

- Jason Hubbart, Ph.D.*, West Virginia University (Workshop co-chair)
- Chris Brosch*, DE Department of Agriculture
- Charles Hegberg, USBI/RES, LLC (Workshop Chair)
- Jennifer Egan, UM Environmental Finance Center (Workshop co-chair)
- Tom Miles, USBI/TR Miles Consultants, Inc.
- Paul Imhoff, University of Delaware
- Wayne Teel, James Madison University
- David Wood, Chesapeake Stormwater Network
- Dominique Lueckenhoff, Hugo Neu, Inc.
- Kenneth Pantuck, USA EPA Region 3

Technical Subject Matter Experts

- Gary Shenk*, USGS
- Carol Wong, PE, Center for Watershed Protection
- Larry Trout, PE, Straughan Environmental Services
- Brandon Smith, Ph.D., Allied Soil Health Services
- Kristin Trippe, Ph.D., USDA
- Debbie Aller, Ph.D., Cornell University
- Sabina Dhungana, USDA Forest Service, (formerly VA Dept of Forestry)
- Carolyn Voter, Ph.D., University of Delaware
- Jim Doten, City of Minneapolis (Technical & Guest Speaker)
- Isabel Lima, Ph.D., USDA ARS
- Charles Glass, Ph.D., PE, Maryland Environmental Services (Guest Speaker)
- Mark Johnson, Ph.D., US EPA
- Sean Sweeney, PR, Barton & Loguidice

Acknowledgements

- Meg Cole, STAC Coordinator, Chesapeake Research Consortium
- Tou Matthews, STAC Projects Manager, Chesapeake Research Consortium
- Rachel Tardiff, Rachel Tardiff, LLC
- UM CCC Student Support
- US Biochar Initiative – Travel & Lodging Accommodations for many of the biochar subject matter experts.

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Biochar in CBw – Condensed Timeline

Pre - 1990
- Biochar name rebranding (1987)
- 1st Biochar Paper Published (1989)
- Frye Energy, LLC – 1st Poultry Litter to Char

2009
- US Biochar Initiative Established
- S. River/S. Fork Shenandoah Mercury Remediation Demo, VA

2010
- Advancing Biochar in the Chesapeake Report (**207 Published Papers**)
- University of Delaware begins biochar research

2014
- CBP STAC Biochar Review (1st Biochar Consideration) (**2,005 Published Papers**)
- Strategies for Implementing Soil Restoration using Biochar and Subsoiling Techniques throughout the CBw Strategy White Paper

2014-2023
- CBw Biochar Research & Installations Expanded.
- Leaders – UD, DelDOT, MDTA, several non-profits and consulting firms

2022-2024
- CBP STAC Workshop, Report & Presentation (2nd Biochar Consideration) (**34,288 Published Papers – 2023**)
- Scaling Up Biochar Applications for Accelerated Stormwater Runoff Reduction in the CBw" grant NFWF (#0602.22.074143).

10-year Gap

Using Carbon to Achieve Chesapeake Bay (and Watershed) Water Quality Goals and Climate Resiliency: The Science, Gaps, Implementation Activities and Opportunities

The diverse array of biochars available (photo credit Sanjal Parikh)
Image credit: https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=22132

STAC Workshop Report and Research Synthesis (DRAFT)
Workshop Held May 25-26, 2023
Hershey, PA

stac

STAC Publication 2024

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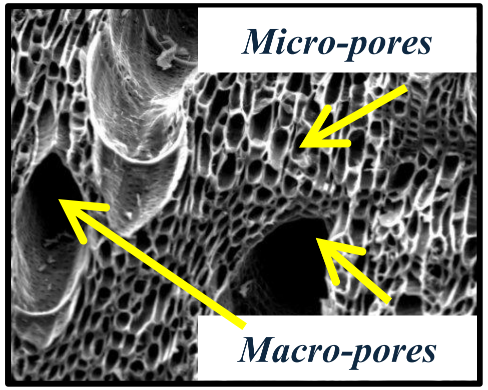
What is Biochar(s)?

- Produced from the carbonization of biomass using little or no oxygen
  - Solid carbon material
  - Produced from organic matter
  - Resistant to decomposition
  - Unlike charcoal, not used for energy
- An Ancient Technology, Rediscovered – Terra Preta “Dark Earth”
- Carbon-Negative Process CO_2:C ratio = 2:1-3.1
- Biochar’s Are Not Created Equal
- Microbial Real Estate – 1 cy=~16,000 acres of surface area.



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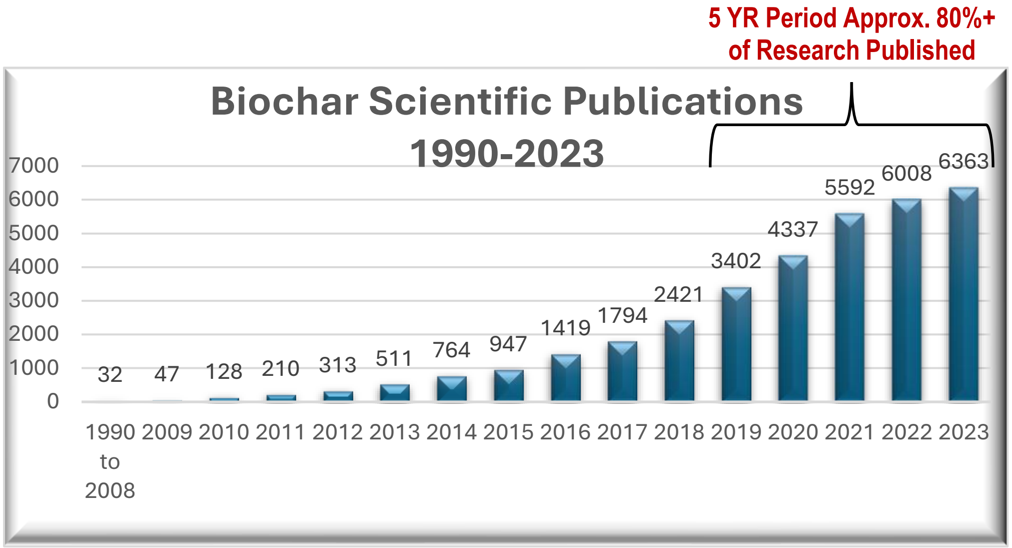
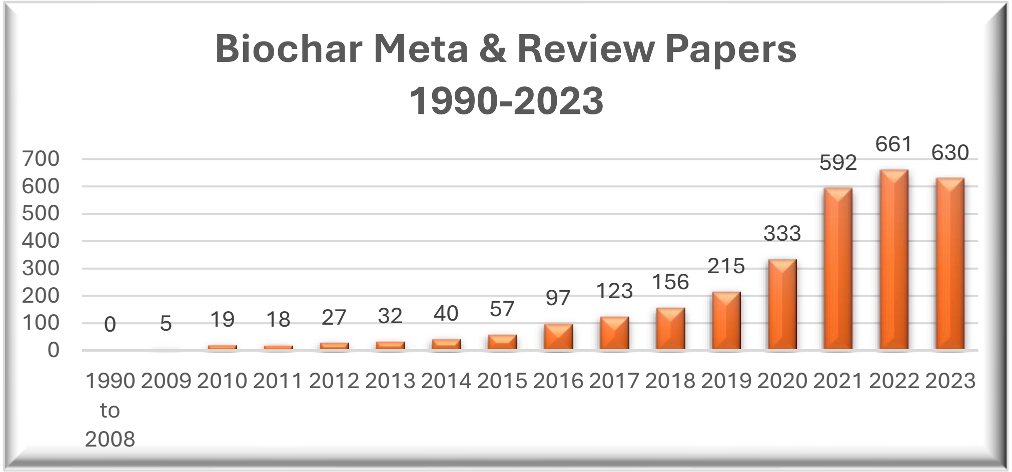
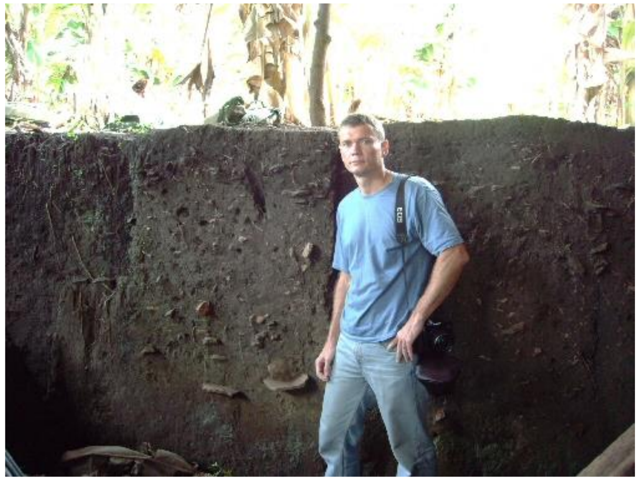
Ancient Technology, Re-Discovered & Research Momentum

- Terra Preta ("Dark Earth")
- Dates back more than 7,000 years in the Amazon (Valev et al., 2022)
- 1st documented in Amazon by James Orton (1870)
- 1st researcher of Terra Preta soils by Wim Sombroek (1966)
- International Awareness 2001-2002 led by Johannes Lehmann, Cornell
- Still actively being created in small clusters throughout Southeast Asia and Africa







Anthropogenic Dark Earth (terra preta), Manaus, Brazil (Photograph by Manuel Arroyo-Kalin).

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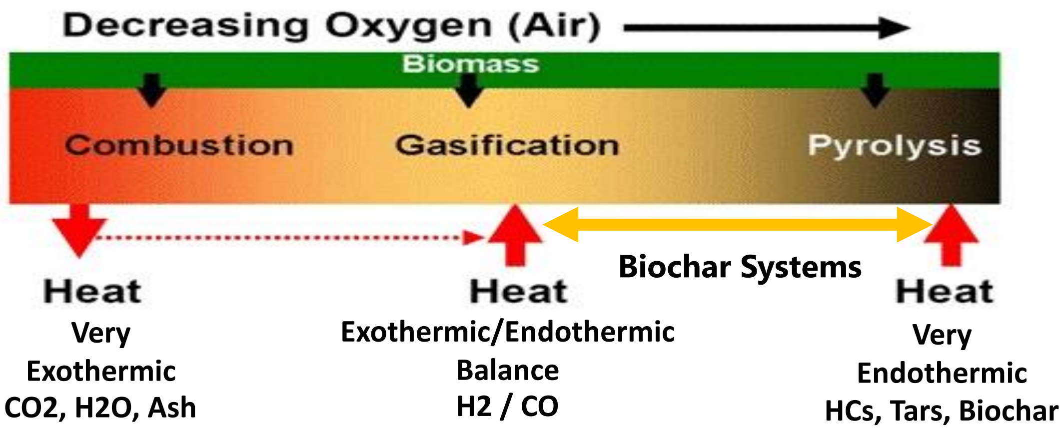
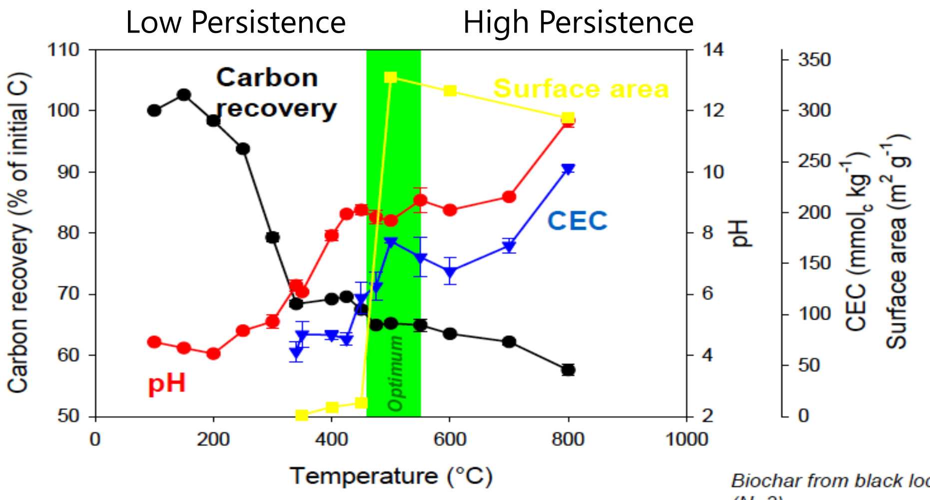
Thermochemical Processes & Production Systems



CharBoss (airburners.com)

Pyreg 500 (Pyreg.de)



Biochar from black locust (N=3)

ARTIchar (artichar.com)

Earthcare, LLC (Earthcarellc.com)

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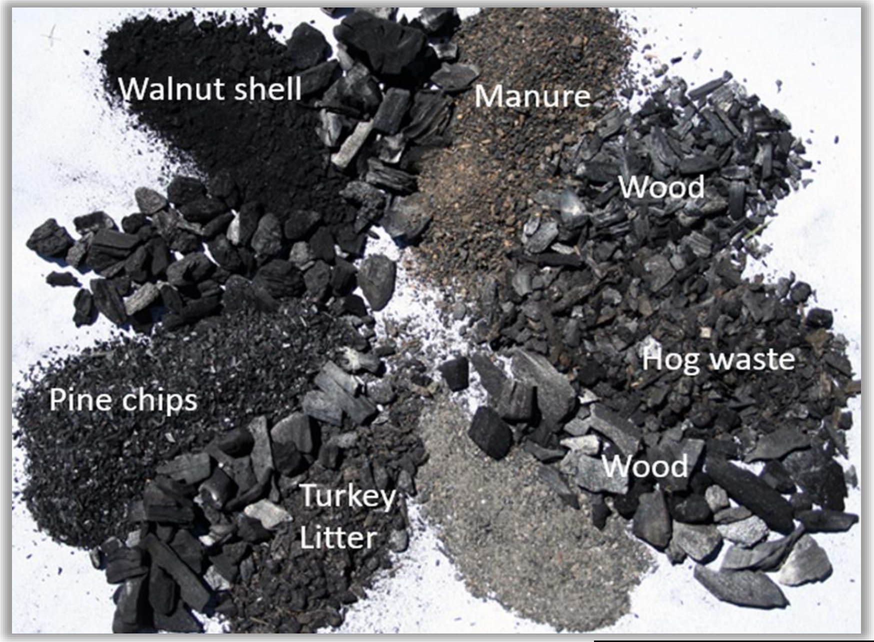
BIOCHAR'S DIFFERENT FORMS & USES



BIOCHAR'S ARE NOT CREATED EQUAL

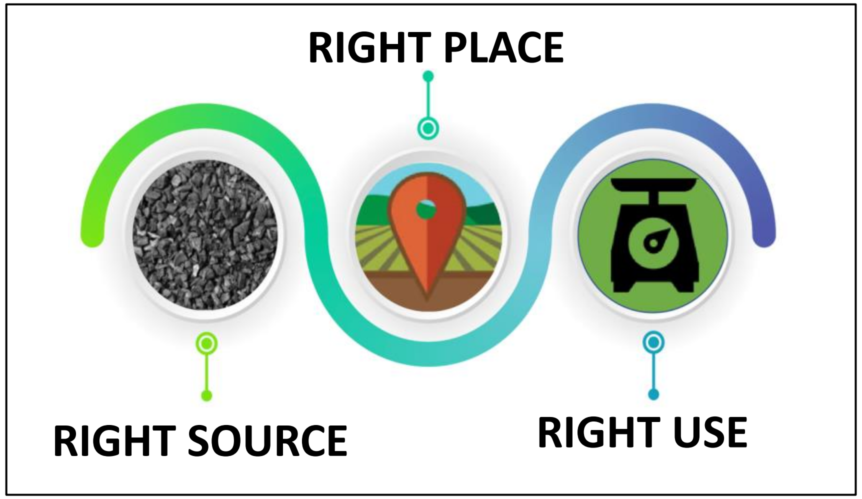


Image source: Adapted from original graphics provided by K.M. Trippe

Raw Biochar

Pelletized Biochar

Granular Biochar

Blended Biochar

Liquid Biochar

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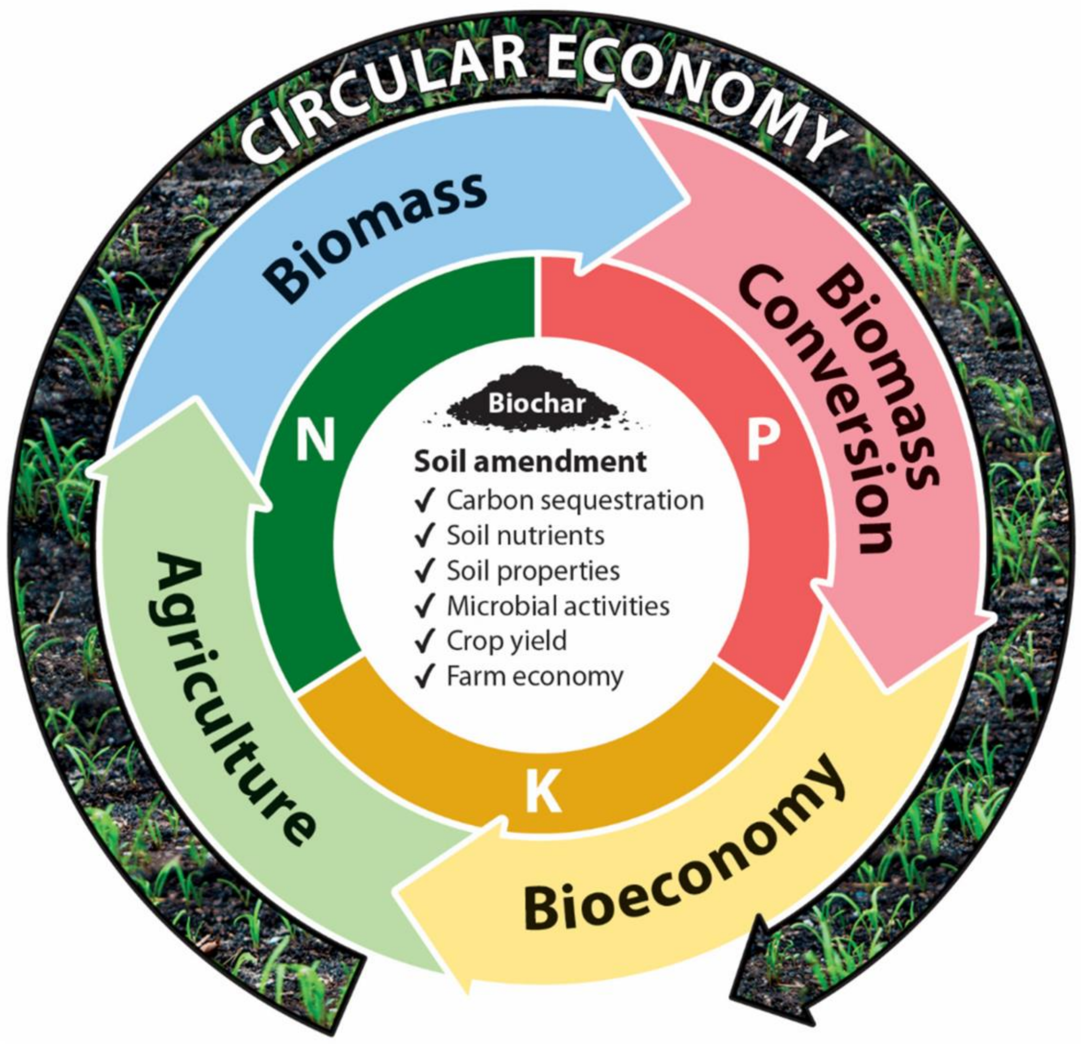
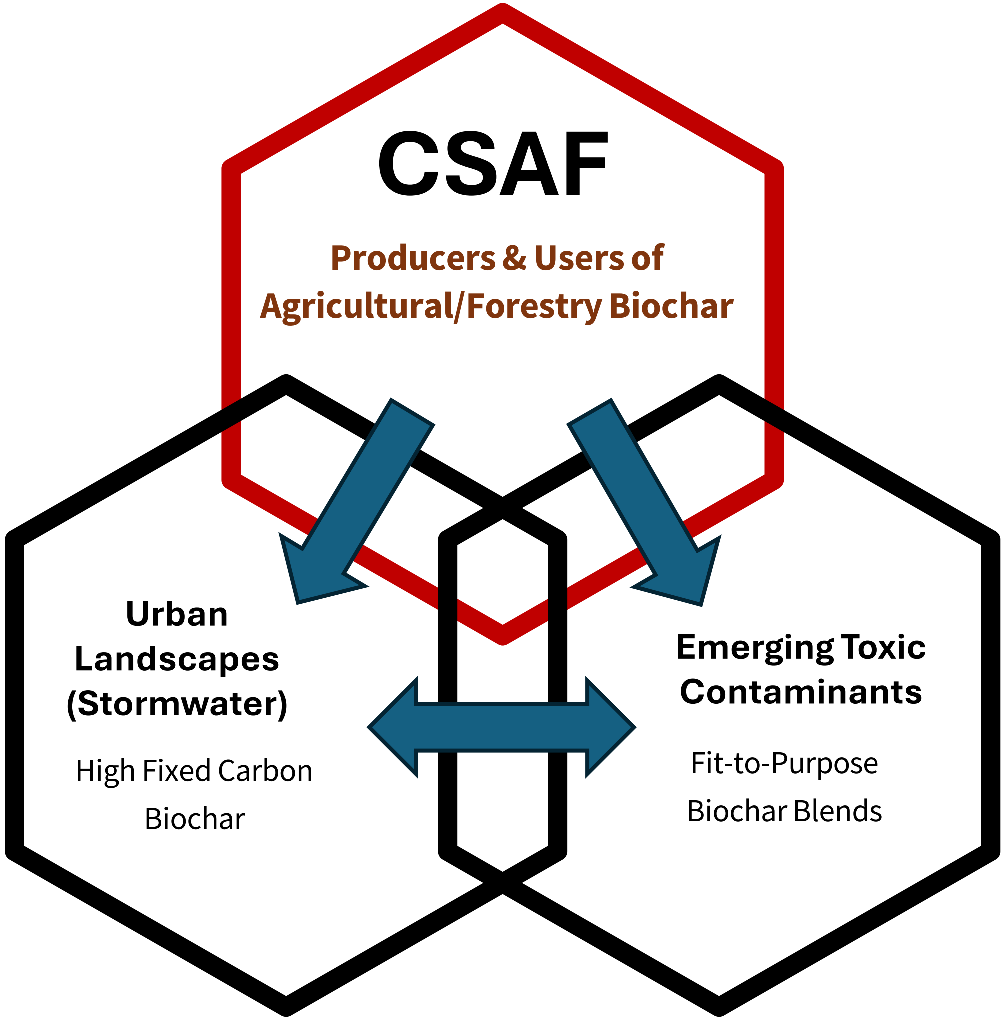
STAC Biochar CSAF Opportunities & Focus





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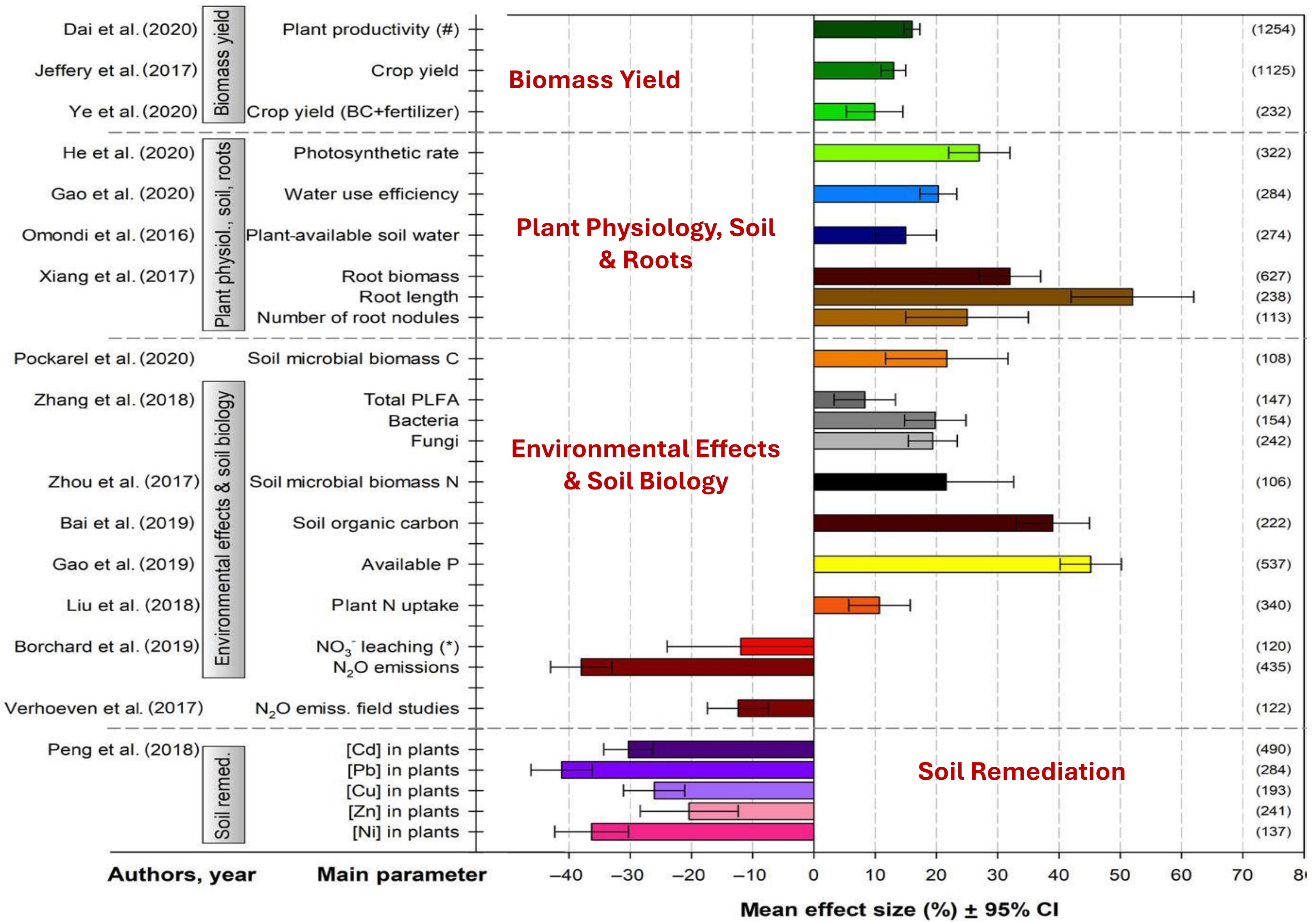
Biochar Agronomic & Environmental Benefits Based on 26 Reviewed Meta-Analysis

(Schmidt et. al. 2021)

- **NO^3- Leaching Mitigation**: Biochar reduces nitrate (NO^3-) leaching an average of 26% to 32%. (Borchard et al., 2019; Liu et al., 2019).
- **Soil Structure Enhancement**: Reduces soil bulk density by 8%, improves water-holding capacity by 15% and hydraulic conductivity by 25% (Omondi et al., 2016). Depends on biochar porosity.
- **Water Efficiency by Texture**: Increases water availability by 47% in sandy soils, 9% in medium-textured soils, negligible impact on clayey soils (Razzaghi et al., 2020).
- **Biochar's Agricultural Impact:** Boosts SOC by 39%, surpassing other climate-smart soil health and carbon sequestration practices (Bai et al., 2019).



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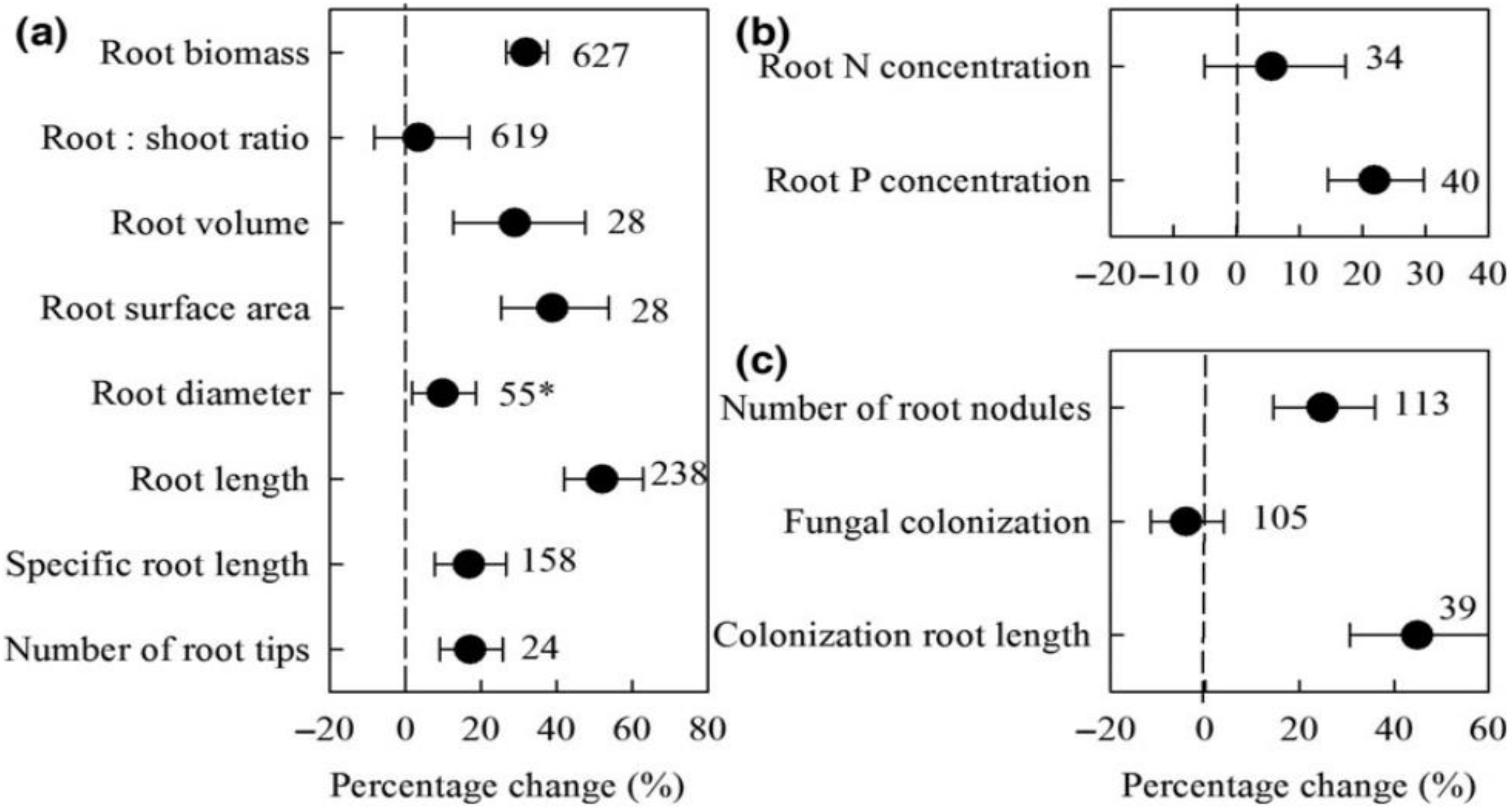
Effects of Biochar Application on Root Traits: A Meta-Analysis



Xiang, Yangzhou, Qi Deng, Honglang Duan, and Ying Guo. "Effects of Biochar Application on Root Traits: A Meta-Analysis." *GCB Bioenergy* 9, no. 10 (October 1, 2017): 1563–72. https://doi.org/10.1111/gcbb.12449.

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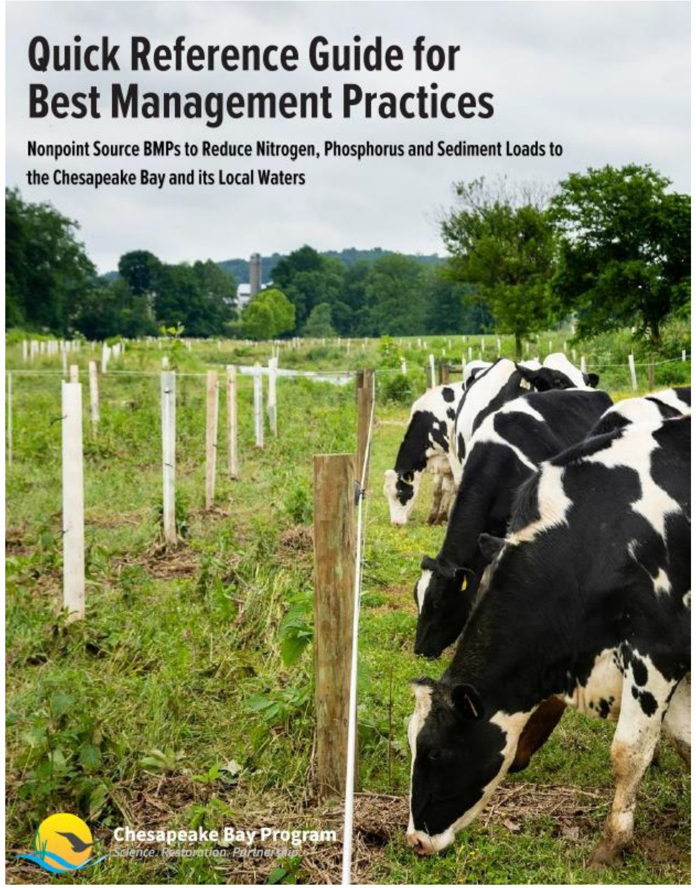
CBw BMP Enhancement Opportunities with Biochar



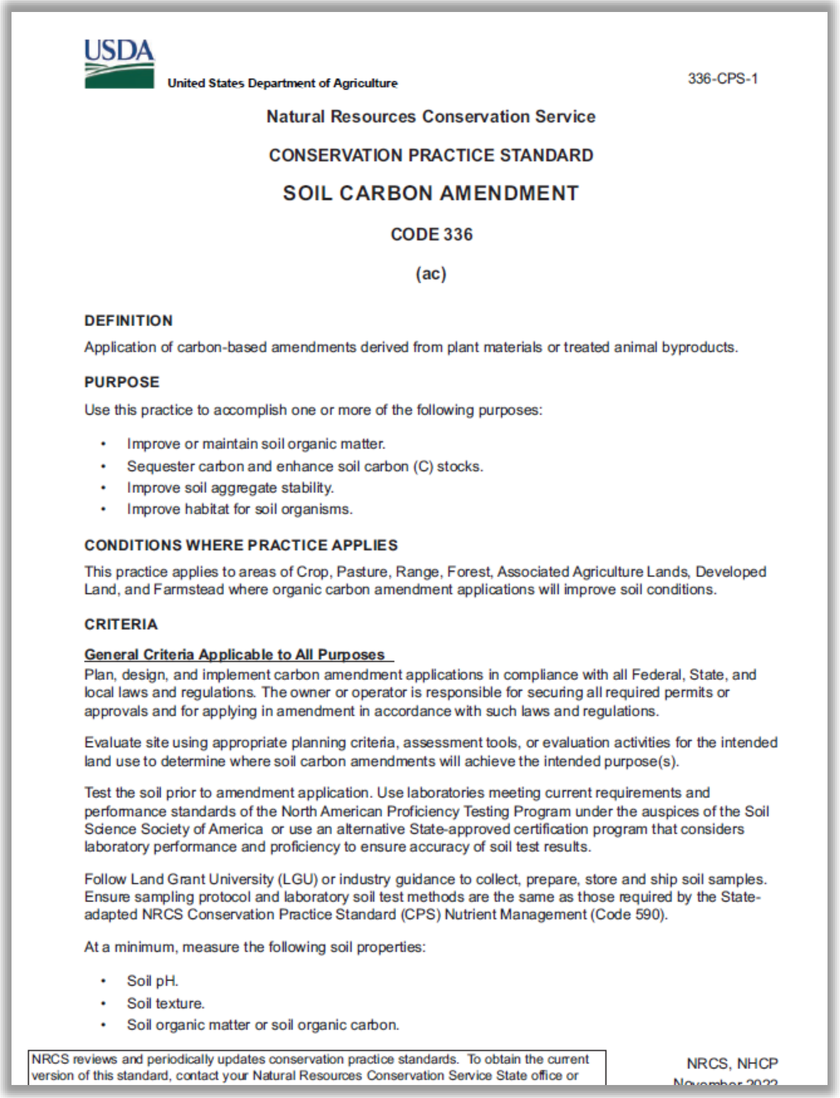
- NRCS CPS 336 - Soil Carbon Amendment
- Manure Treatment (Co-Composting)
- Ammonia & Odor Management
- Manure Treatment (Thermochemical)
- Barnyard Runoff Control, Loafing Lot Management & Biofilters
- Forest Buffers , Grass Buffers & Tree Plantings
- Stream Restoration (Ag)
- Lagoon Covers
- Manure Incorporation or Injection
- Miscellaneous Opportunities
  - Broadscale Farm Quality/Quantity

National Water Quality Initiative Practices

Core Practice	*Code*	*Avoiding*	*Controlling*	*Trapping*
Composting Facility	317	■	■	
Conservation Cover	327	■		■
Cover Crop	340	■		■
Critical Area Planting	342		■	■
Denitrifying Bioreactor	605			■
Drainage Water Management	554		■	
Field Border	386		■	■
Filter Strip	393		■	■
Grassed Waterway	412		■	
Nutrient Managaement	590	■		
Riparian Forest Buffer	391			■
Riparian Herbaceous Cover	390			■
Tree/Shrub Establishment	612	■		■
Waste Storage Facility	313	■	■	
Waste Treatment Lagoon	359		■	

Biochar as Soil Carbon Amendment

NRCS CPS 336 – Soil Carbon (Biochar) Amendment



USDA
United States Department of Agriculture

336-CPS-1

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

SOIL CARBON AMENDMENT

CODE 336

(ac)

DEFINITION

Application of carbon-based amendments derived from plant materials or treated animal byproducts.

PURPOSE

Use this practice to accomplish one or more of the following purposes:

- Improve or maintain soil organic matter.
- Sequester carbon and enhance soil carbon (C) stocks.
- Improve soil aggregate stability.
- Improve habitat for soil organisms.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to areas of Crop, Pasture, Range, Forest, Associated Agriculture Lands, Developed Land, and Farmstead where organic carbon amendment applications will improve soil conditions.

CRITERIA

General Criteria Applicable to All Purposes

Plan, design, and implement carbon amendment applications in compliance with all Federal, State, and local laws and regulations. The owner or operator is responsible for securing all required permits or approvals and for applying in amendment in accordance with such laws and regulations.

Evaluate site using appropriate planning criteria, assessment tools, or evaluation activities for the intended land use to determine where soil carbon amendments will achieve the intended purpose(s).

Test the soil prior to amendment application. Use laboratories meeting current requirements and performance standards of the North American Proficiency Testing Program under the auspices of the Soil Science Society of America or use an alternative State-approved certification program that considers laboratory performance and proficiency to ensure accuracy of soil test results.

Follow Land Grant University (LGU) or industry guidance to collect, prepare, store and ship soil samples. Ensure sampling protocol and laboratory soil test methods are the same as those required by the State-adapted NRCS Conservation Practice Standard (CPS) Nutrient Management (Code 590).

At a minimum, measure the following soil properties:

- Soil pH.
- Soil texture.
- Soil organic matter or soil organic carbon.

NRCS reviews and periodically updates conservation practice standards. To obtain the current version of this standard, contact your Natural Resources Conservation Service State office or

NRCS, NHCP

Purpose: Supports the application of biochar, compost, and other state-approved carbon amendments (for example, harvested aquatic plant biomass, bagasse, distillation residue) to increase soil carbon sequestration and improve soil health on all land uses. The evaluation and monitoring of soil properties, amendment characterization, and short and long-term conservation objectives form the basis for the soil carbon amendment practice plan.

Definition: Using amendments derived from plant or animal residues to improve the physical, chemical, and biological properties of the soil.
Adoption Status: Nationwide

Excluded: No Biosolids or Sewage Sludge

Allowed: Biochar Imported, Compost+Biochar Imported

Requirements: May require nutrient management plan

Payments: Paid for biochar by cy, delivery and installation

Funding: Managed by each adopting State. Major funding available

National Practice: https://www.nrcs.usda.gov/sites/default/files/2022-11/336-NHCP-CPS-Soil-Carbon-Amendment-2022.pdf

Biochar as Soil Carbon Amendment

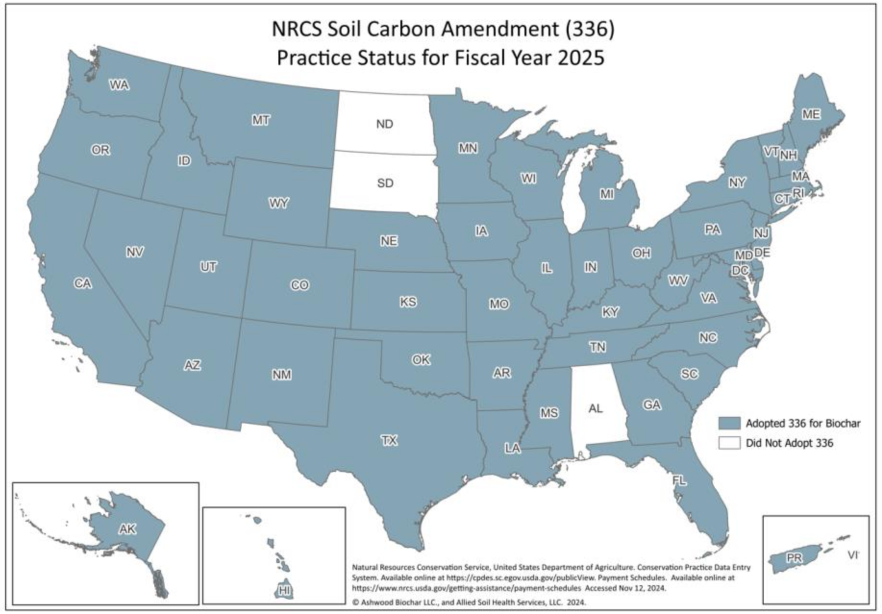
Biochar as Soil Carbon Amendment

	NRCS 336 Biochar Scenarios Payment Rates						
	Practice Reimbursement	Scenario					
		100% Biochar	100% Biochar	>=60% Biochar and <= 40%Compost	<=40% Biochar and >= 60%Compost	Biochar and Compost <10 Acres	Biochar and Compost Small Areas
		ACRE	CUBIC YARD	ACRE	ACRE	kSQFT	CUBIC YARD
DE	90%	$1,749	$247	$993	$836	$98	$873
	75%	$1,457	$206	$778	$697	$82	$727
MD	90%	$1,559	$219	$827	$741	$88	$792
	75%	$1,299	$182	$690	$617	$74	$660
NY	90%	$1,567	$222	$831	$744	$94	$866
	75%	$1,306	$185	$692	$620	$78	$722
PA	90%	$1,564	$220	$832	$745	$89	$805
	75%	$1,303	$184	$693	$621	$75	$671
VA	90%	$1,559	X	$785	$698	$65	X
	75%	$1,229	X	$654	$582	$54	X
WV	90%	$1,558	X	$784	$697	$64	X
	75%	$1,298	X	$653	$581	$53	X

*Acre rates based on 4 cubic yards per acre
**Small areas based on <10,000 square feet
***<10 acre scenarios require >50% biochar

	NRCS EQIP RANKING DATES				
DE	11/15/2024	12/13/2024	3/14/2024	5/16/2024	
MD	10/25/2024	11/15/2024	12/15/2024	12/20/2024	2/7/2024
NY	11/1/2024				
PA	11/1/2024				
VA	10/11/2024				
WV	9/13/2024				

*Applications are taken year-round



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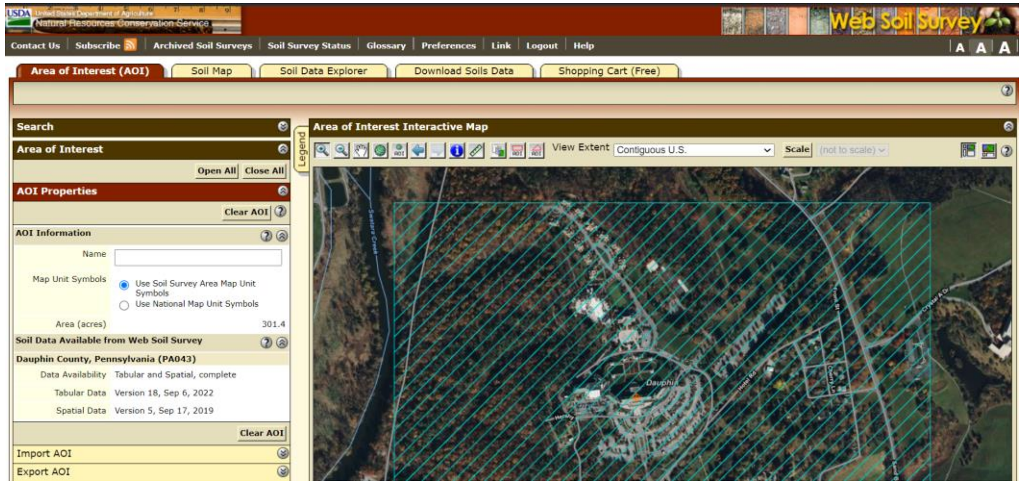
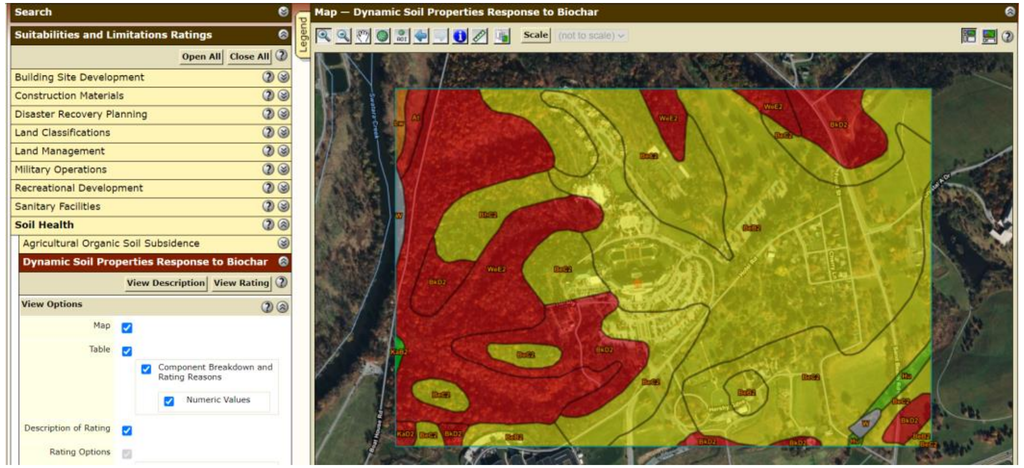
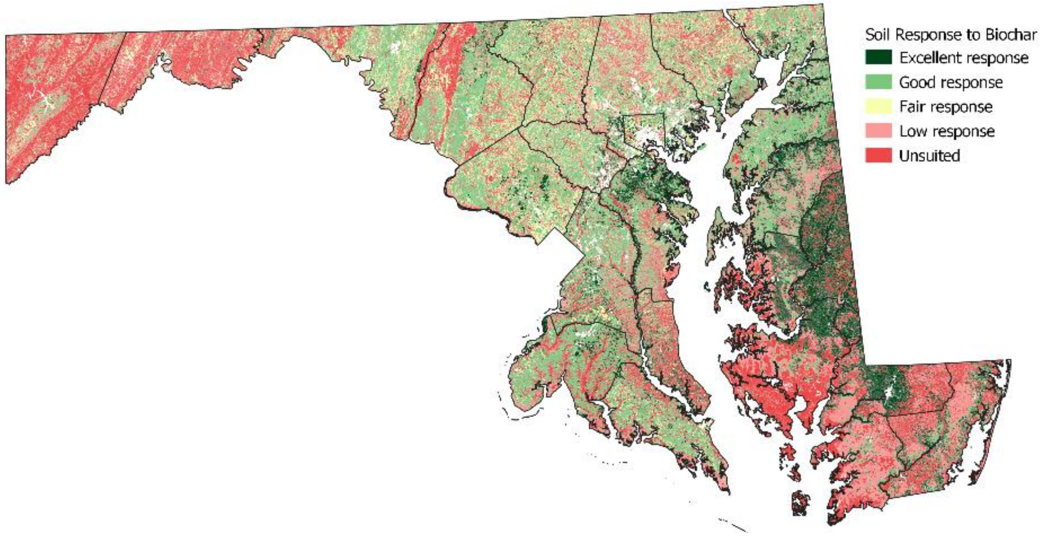
Dynamic Soil Properties Response to Biochar Application





USDA Soil Health - Dynamic Soil Properties Response to Biochar								
	Delaware	Maryland	New York	Virginia	Pennsylvania	Washington DC	West Virginia	Totals
Dynamic Soil Properties Rating	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Excellent	188,405	772,554	53,177	1,360,295	167,624	1,342	3,285	2,546,683
Good	41,289	1,786,528	449,315	3,140,234	1,074,121	335	161,446	6,653,268
Fair	5,319	614,195	1,141,060	2,407,422	1,807,790	646	289,012	6,265,445
Low	74,437	593,757	1,112,457	456,180	642,372	-	200,745	3,079,947
Total (including not suited and not rated)	547,741	7,424,887	4,114,057	14,822,035	14,600,161	2,887	2,395,878	43,907,646

Soil/Site Properties – pH, CEC, Organic Matter, Slope, Flooding, Ponding, Bulk Density, Ksat (Saturated Hydrologic Conductivity, AWC (Available Water Capacity)



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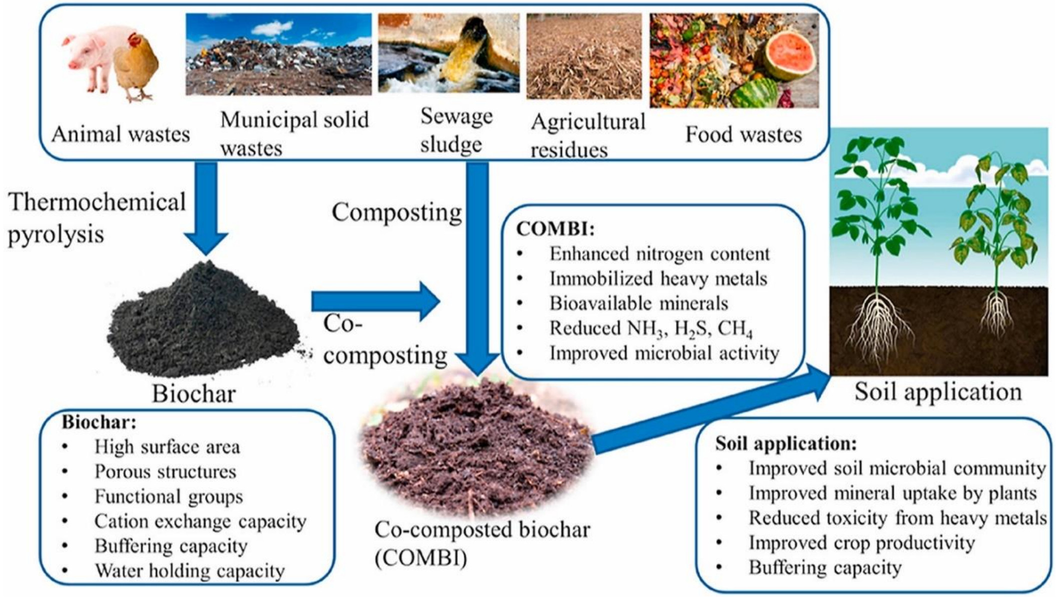
Co-Composting with Biochar

Co-Composting with Biochar

- **Biochar as a Compost Additive:** 10% biochar amendment to compost enhances nutrient cycling and reduces nitrogen loss by up to 50%, while also reducing odor emissions and improves soil carbon sequestration, boosting compost quality and yielding (Lehmann et al., 2006; Nguyen et al., 2023; Steiner et al., 2014).
- **Improving Compost Quality:** Biochar amendments improve compost's nutrient profile, decrease organic matter loss by 35%, and boost microbial activity, contributing to long-term carbon storage (Waqas et al., 2018).
- **Revolutionizing Waste Management:** Biochar's role in composting extends to climate change mitigation, showcasing its value in sustainable agricultural practices and waste management strategies.



The Benefits of Biochar & Co-Composting Different Compost Wastes
(Antonangelo, J.A. et al, 2021)

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Co-Composting with Biochar

Composting Odor Control

Biochar Use in Odor Removal Systems:

- Applications include compost additive and biocover
- Significant (>90%) reduction in ammonia (NH_3), hydrogen sulfide (H_2S) and other malodorous emissions with increased biochar (~20%)

Biochar as Compost Additive:

- Significant reduction in NH_3 and Volatile Sulfur Compounds (VSC) emissions when mixed with compost.
- Improves the degradation of volatile fatty acids and microbial abundance.
- Effect of biochar on temperature and moisture content during composting.
- Enhances microbial activity and quality of end products.

Biochar in Biocover Applications:

- Reduces emissions from liquid and solid waste, particularly in animal manures.
- Effective in reducing the concentration of NH_3 and H_2S.

Steiner et.al., Duann et.al., Awasthi, et.al.)

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Water Quality & Restoration Opportunities

Biofilters/Barnyard Runoff Control

Forest & Grass Buffers/Tree Plantings

Soil Restoration/Meadows/Subsoiling

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Manure Treatment Opportunities

Manure Injection/Incorporation

Agriculture Slurry/Lagoon Covers

Thermochemical Treatment/Biochar Production

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STAC Biochar Workshop Recommendations

- **Recommend and expand applied research and knowledge filling:**
  - **Prioritize Biochar Research** - Focus on practical and field-scale studies to advance biochar knowledge.
  - **Commit to Science-Backed Solutions** - Investment in scientific research to address biochar application gaps.
  - **Support Data Collection** - Collect field data to validate biochar's benefits and best practices.
  - **Understand Contextual Effectiveness** - Assess biochar's effects in diverse Chesapeake Bay watershed scenarios.
  - **Refine Biochar Protocols** - Use research insights to improve biochar usage guidelines.
- **Support scaling up scientifically effective application of biochar use:**
  - **Expand Biochar Use Across Sectors** - Implement biochar in agriculture, forestry, and urban areas within the watershed.
  - **Address Contaminants** - Apply biochar to mitigate emerging and toxic substances.
  - **Develop Biochar Guidelines** - Establish clear guidelines for biochar application across various contexts.
  - **Set Biochar Standards** - Create standards to ensure biochar's effectiveness and safety.
  - **Accredit Biochar Practices** - Introduce accreditation programs to certify biochar application methods.

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STAC Biochar Workshop Recommendations

- **Support pursuing biochar enhancement credit for approved BMP Protocols:**
  - **Integrate Biochar in Nutrient Models -** Include biochar impacts in Chesapeake Bay nutrient management tools.
  - **Inform Policy with Biochar Data -** Use biochar data to guide policymakers and stakeholders on water quality strategies.
  - **Understand Biochar's Role -** Clarify biochar's contributions to water quality and climate resilience.
  - **Follow CBP Urban Stormwater Guidelines -** Adopt CBP’s process for incorporating biochar into urban BMPs.
- **Provide letters of support to expand collaborative partnerships**
  - **Strengthen Multi-Sector Collaboration** - Unite government, academia, NGOs, and businesses around biochar adoption.
  - **Streamline Biochar Research** - Coordinate research activities to optimize biochar use.
  - **Share Best Practices** - Disseminate successful biochar applications and case studies.
  - **Accelerate Biochar Projects** - Fast-track biochar initiatives through joint funding and resources.
  - **Build a Biochar Community of Practice** - Create networks to support and promote biochar integration.

Presentation Discussion

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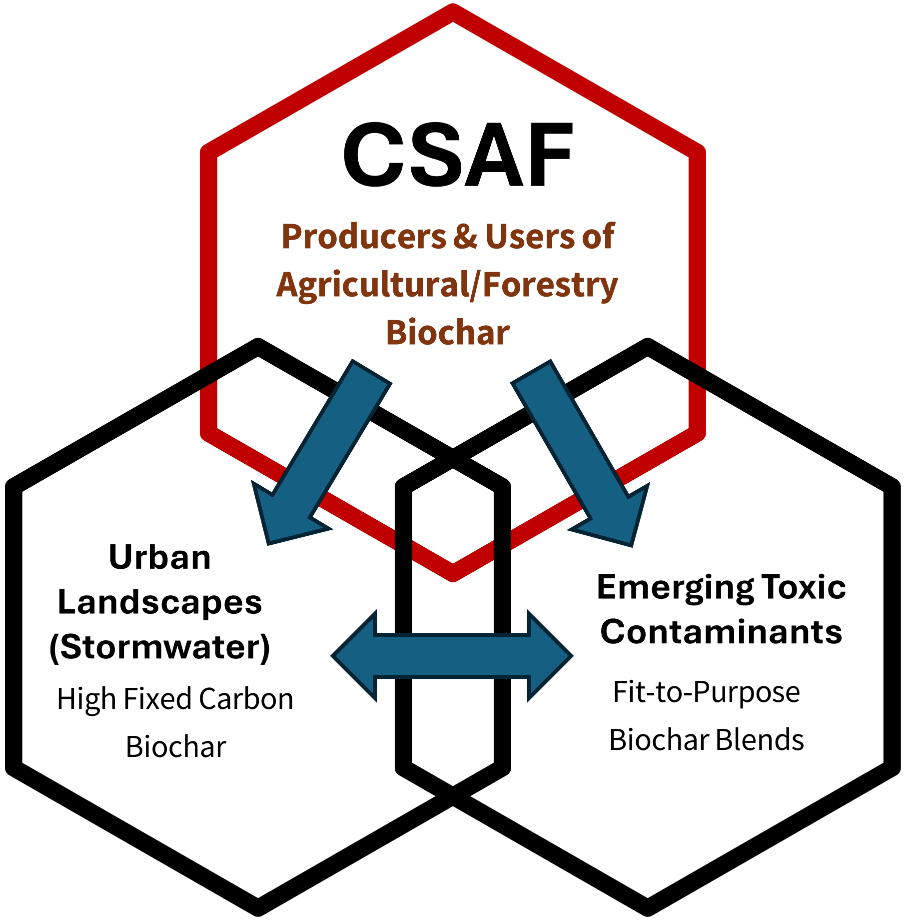

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