# Recommendations to Scale Up Sustainable Biochar Research & Commercialization for Agriculture & Conservation

MARCH 2023

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# Suggested Citation


Hassebrook, C, R. Seman-Varner, R. Brown, T. Miles, B. Moebius-Clune. 2023. Recommendations to Scale Up Sustainable Biochar Research & Commercialization for Agriculture & Conservation Benefits [White paper]. Washington, DC: AFT-NCAT-USBI.

This publication is available to the public in pdf format from American Farmland Trust's Farmland Information Center:

farmlandinfo.org/publications/biochar-recommendations

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# Contents

# Executive Summary of Recommendations

The Foundation for Food & Agriculture Research (FFAR), the National Center for Appropriate Technology (NCAT), and American Farmland Trust (AFT) co-hosted a 2-day virtual convening event on biochar research and commercialization in March 2022 and published a summary. This whitepaper, published by AFT, NCAT, and US Biochar Initiative (USBI) focuses on policy recommendations derived from that convening. The recommendations are not intended to be all-inclusive or predictive of future needs; this white paper concludes by identifying known gaps.

- Through the US Department of Agriculture (USDA) Agricultural Research Service (ARS), conduct research at multiple sites across the nation to test the effects of various biochars and soils on soil health, productivity, water, carbon sequestration, and greenhouse gas emissions.
- Fund site-specific biochar research through the USDA National Institute of Food and Agriculture (NIFA) Agricultural Food and Research Initiative (AFRI) to develop regional systems to produce biochar from local feedstocks and apply it in the region.
- Conduct outreach, extension, and education on biochar and develop, disseminate, and continually update decision support tools through collaboration across land grant colleges, Natural Resources Conservation Service (NRCS), Forest Service (USFS), cooperative extension system, nongovernmental organizations, and others.
- Through the USFS, continue efforts to advance production of biochar from unmerchantable wood for use in forests and farms.
- Through NRCS, integrate biochar into soil health management and conservation systems toolbox. Promote the Soil Carbon Amendment Practice Standard (Code 336) to provide financial assistance for biochar use and revise the standard to allow crop residues as feedstocks from management systems that protect and build soil and soil organic matter.
- Develop a cross agency US Department of Energy (DOE) and USDA action plan to support development of a pyrolysis-based biochar and biofuel industry that provides low-carbon fuels for transportation, aviation, and shipping, and facilitates sustainable production of biochar for use in farm and forest systems as part of the soil health management toolbox.
- Foster development of a pyrolysis-based biochar and biofuel industry by investing in production capacity, utilizing existing biomass energy infrastructure for biomass heat and power, and building markets for biochar-based carbon credits and low carbon fuels. Provide additional evaluation points for biofuel facilities that coproduce biochar in awarding DOE Bioenergy Technologies Office investments in pilot and demonstration bioenergy facilities.
- Through US Environmental Protection Agency (EPA), reform the Renewable Fuel Standard regulations that prevent biofuels coproduced with biochar from qualifying as low carbon cellulosic biofuels simply because the fuels were processed at multiple facilities.
- Through all federal agencies, land grant colleges, and other partners, collaborate on cross organizational biochar data sharing, interoperability, and compilation.
- Through private industry, make volumetric commitments to purchase biochar-based carbon credits and aviation and shipping fuels coproduced with biochar.
- Through biochar carbon credit markets (e.g., Puro Earth, Carbon Future, Verra), certifiers, and organizations like the USBI, establish standards and protocols to certify biochars from sustainably sourced feedstocks for long-term soil carbon sequestration, beneficial life cycle analysis, purity and reductions in soil nitrous oxide and methane emissions.

# Introduction

Biochar is a charcoal-like stable carbon product made by heating biomass in no or low oxygen conditions—a process called pyrolysis. The unique promise of biochar is that it provides "recalcitrant" carbon that can last for hundreds to thousands of years in soil. In addition, appropriately designed and managed biochar can slow the breakdown of other soil carbon. Thus, biochar integrated into broader soil health management systems may increase the capacity of soil to sequester carbon.

The potential of biochar extends beyond carbon sequestration. A growing body of research suggests that sustainably produced, appropriately designed, fit-for-purpose biochar can enhance soil health, improve crop yields, and reduce soil emissions of nitrous oxide and methane in some systems. Some biochars can also improve soil structure, infiltration, water holding capacity, and plant available water, thereby building resilience to drought and extreme rainfall events. Furthermore, renewable, climate-neutral biofuels can be coproduced with biochar through pyrolysis.

To realize these potential benefits of biochar, a sustainable pyrolysis biochar and biofuel industry must be developed. But development of such an industry is constrained by lack of production capacity and the lack of markets for biochar or its energy co-products (such as heat, power, and biofuel) that provide a means to monetize the benefits of biochar. It is also limited by the lack of standards and certification of biochars with positive life cycle carbon sequestration produced from sustainable biomass derived from management systems that sustain soil and forest carbon and health.

Furthermore, biochar will not be widely applied by farmers, foresters, or other users until they know how to apply which type of biochar to produce positive results in their soils and circumstances. Early research findings on biochar were inconsistent because many different types of biochar were tested in varying soils and systems. Knowledge gaps must be filled, and decision support tools developed to enable a pyrolysis biochar and biofuel industry to flourish.

In an effort to galvanize the necessary coordination to create a sustainable Pyrolysis-Biochar-Bioenergy Industry, the Foundation for Food & Agriculture Research (FFAR), the National Center for Appropriate Technology (NCAT), and American Farmland Trust (AFT) co-hosted a 2-day virtual convening event on biochar research and commercialization. The discussions at the convening reflected broad agreement that building a pyrolysis biochar and bioenergy industry is one of the most promising near-term strategies for carbon removal. Sustainable fit-for-purpose biochar integrated in soil health management systems has great potential to address climate change, build the productivity and resilience of farms and forests, and create jobs and opportunity across rural America. Scaling Biochar Research & Commercialization for Agriculture & Conservation Benefits: A Summary of a Stakeholder Convening was published summarizing the two-day event and insights from subsequent stakeholder engagement.

This complementary whitepaper, published by AFT, NCAT, and the US Biochar Initiative, presents policy recommendations derived from that convening. The recommendations are not intended to be all-inclusive or predictive of future needs and this white paper concludes by identifying known gaps in the recommendations presented here.

Building a sustainable pyrolysis biochar bioenergy industry will require a coordinated, multi-faceted strategy. Supportive public policy is needed to prompt investment in production capacity and development of markets. Convening participants stressed that commercially relevant results are needed in the next five years. We cannot wait 50 years to realize the potential of biochar. We present these policy recommendations to meet that challenge.

# Core Recommendations

The overarching recommendations include integrated development and deployment of research, sustainable industry support, outreach, extension, education, and decision support that is collaborative across organizations. An essential recommendation is for all federal and non-federal collaborating organizations to coordinate data sharing approaches and contribute data into nationally coordinated, interoperable data compilations, products, and decision support tools. This will allow for leveraging of resources and organizational strengths to achieve rapid, broad, and effective transitions across the industry and working lands management.

**An essential recommendation is for all federal and non-federal collaborating organizations to coordinate data sharing approaches and contribute data into nationally coordinated, interoperable data compilations, products, and decision support tools.**

## Coordinated Biochar Research Initiative

The Convening began with a discussion of Integrated Biochar Research: A roadmap by Dr. James Amonette and others, which was shared prior to the start of the convening. Conversations reflected broad agreement on the need for the two elements of the Roadmap:

- *Cross-site research, common to all sites, to develop fundamental knowledge on the impact of different types of biochar on:*
  - Soil carbon cycle and upper potential thresholds of sequestration
  - Emissions of nitrous oxide, methane, and carbon dioxide from soil
  - Soil microbial composition and function
  - Plant growth, crop productivity, yield, and quality
  - pH, nutrient availability, and nutrient cycling
  - Soil water dynamics, including capacity to absorb heavy downpours and store plant available water for later periods of moisture deficit
- *Site-specific research to develop regionally promising systems* using local feedstocks to produce biochar with characteristics that improve soils and production systems in the region, including economic analysis of such systems at varying carbon prices. Wide variation in soil, climate, production system, and biochar properties require site-specific research that can lead to site-specific recommendations, which are essential for successful adoption of biochar by farmers.

**TWO ELEMENTS OF THE ROADMAP**

**1. Cross-site research, common to all sites, to develop fundamental knowledge on the impact of different types of biochar.**

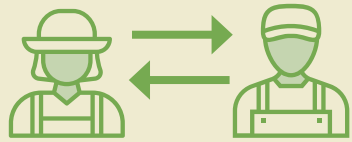
**2. Site-specific research to develop regional systems using local feedstocks on local soils.**

The Biochar Research Network Act, a bipartisan bill, was introduced in 2022 the U.S. House of Representatives (H.R. 8596) by Representatives Miller-Meeks, Pingree, Panetta, Feenstra, Kuster, and Schrier and in the U.S. Senate (S. 4895) by Senators Grassley, Brown, Thune, and Tester, and includes these two critical elements of biochar research.

Convening participants also called for a consistent system for reporting biochar research design and results, including the type of biochar studied, its characteristics, feedstock, and production process (including temperature and duration), and the method by which the biochar is treated and applied.

## Biochar Outreach, Extension, and Education Needs

There was also broad agreement on the need for education and extension on biochar including support for farmer-to-farmer knowledge exchange, on-farm demonstration trials, development of decision support tools and public-private partnerships to support biochar adoption and knowledge transfer. Convening participants said that outreach on biochar must be research-based and set realistic expectations. Because of great variation in soil and biochar properties, technical assistance must be specific to the location, soil, and production system. Decision support tools should include those levels of specificity and be adaptable to local conditions and continually updated with the latest science. Outreach and education materials must be practical and timely. A biochar information hub integrated with a regularly updated, structured national decision support tool (i.e., PNW Biochar Atlas ) would be extremely valuable.



**There was broad agreement on the need for education and extension on biochar including support for:**

- **farmer-to-farmer knowledge exchange**
- **on-farm demonstration trials**
- **development of decision support tools**
- **public-private partnerships to support biochar adoption and knowledge transfer**

Convening participants also suggested that outreach on biochar feature farmers actively using biochar and plug into existing networks such as National Association of Conservation Districts' Soil Health Champions, Natural Resources Conservation Service's (NRCS) Soil Health Demonstration Trials, and state soil health efforts. They suggested creating a network of "Biochar Champions" successfully using biochar, similar to the established Soil Health Champions. Participants also stressed the importance of integrating biochar applications with broader soil health management systems and leveraging the ongoing momentum of work on soil health.

Participants offered several examples of needed site-specific outreach and information, including use of biochar to:

- Produce low-carbon corn to lower the carbon intensity (CI) scores of ethanol plants,
- Address site-specific soil problems, such as acidic soil that can be improved with biochar,

- Make more effective use of livestock manure by mixing in biochar for application or composting,
- Make productive use of forest slash, invasive species and combustible materials removed from forests,
- Use dead ash trees and other hardwoods or carbon-based waste streams in urban settings to produce biochar for use in parks and other tree plantings, compost, stormwater mitigation, urban and organic gardening, greenhouses, etc.
- Be incorporated as a core practice in regenerative agriculture and soil health management.

## Support for Commercialization of Biochar & Development of a Sustainable Biochar & Biofuel Industry

There was broad agreement among convening participants on the critical need to rapidly develop a sustainable pyrolysis biochar and biofuel industry at scale to realize its great potential to mitigate climate change, build healthy soils, and create opportunities in rural and underserved communities. Low carbon fuel standards and growing interest in sustainable fuels for aviation and ocean-going vessels can create markets for a pyrolysis-based biofuel industry. Growing demand for lasting and additional carbon removal can create markets for biochar-based carbon credits. However, lack of production is holding these markets back and undeveloped markets are holding back production. We do not have the luxury of waiting for markets and production to align. Strategic incentives and investments are needed to develop the biochar and biofuel industry, similar to measures that developed the biomass energy and ethanol industry a generation ago. Governments and private industry can provide the markets to launch a pyrolysis biochar biofuel industry by making commitments to purchase low carbon biofuels coproduced with biochar and biochar carbon credits.

**We do not have the luxury of waiting for markets and production to align. Strategic incentives and investments are needed to develop the biochar and biofuel industry.**

Some convening participants suggested that small, community-based pilot and demonstration facilities are a good place to start with a higher likelihood of early success than large, centralized facilities with higher capital requirements. The high cost of transportation and logistics for biomass feedstock provide an economic advantage for decentralized pyrolysis facilities closer to, or even co-located with, the feedstock source. The biocrude oil produced by pyrolysis can subsequently be co-processed at existing, large oil refineries.

## Cross Agency Action Plan

The U.S. Departments of Agriculture (USDA) and Energy (DOE) are uniquely positioned to collaborate on the development of a pyrolysis biochar-bioenergy industry and other climate priorities such as smart solar, which are beyond the scope of this white paper. A USDA and DOE cross agency action plan for biochar-bioenergy should facilitate sustainable production of biochar and its application on working lands as a tool in the soil health management systems toolbox and the use of bioenergy from the pyrolysis process. The joint USDA and DOE Biomass Research and Development Technical Advisory Committee should contribute to development of the plan. Other departments, agencies, and organizations should also play a role to ensure activities are coordinated across the stakeholder community and effectively leverage resources across a joint effort.

The overarching cross agency action plan should include integrated research, outreach, extension, education, sustainable industry deployment support, and decision support. Data sharing approaches and contribution of data to inform nationally coordinated, interoperable data compilations, products, and decision support tools are essential recommendations for development and collaboration across all agencies. Interoperable data and decision support development must include partnerships across the biochar community, leveraging non-agency collaborators to achieve rapid, broad, and effective transitions across the industry and working lands management.

# Recommendations to Agency Partners

## USDA Agricultural Research Service (ARS)

- Establish long-term biochar research sites across the nation through Long-Term Agroecosystem Research Network sites, or other ARS research sites, ensuring coordination with, and integration of biochar into, soil health management systems transitions research.
- Conduct cross-site research to develop fundamental understanding of effects of different biochar types in varying soils and circumstances.
- Seek dedicated appropriations of $25 million in year one and $50 million in out-years for cross site biochar research.
- Collaborate with stakeholders like existing biochar producers, users, and organizations such as AFT and USBI to develop new tools, technologies, models and strategies for biochar production and use, as well as quantification of its long-term agronomic impacts, including models to predict biochar effects and inform decision support tools for biochar users.

- Establish an ARS "Grand Challenge" on biochar research and education. Grand Challenges are transdisciplinary efforts to solve complex problems that often span multiple areas within ARS and engage universities, NGOs, or other government agency partners.
- Collaborate with other USDA and DOE agencies and land-grant universities to develop complementary plans for biochar research.
- Establish a Partnership for Data Innovation to ensure a shared/interoperable data pipeline is available for all agencies and stakeholders involved in biochar research and on-farm implementation/demonstration, including states and land grant colleges. The partnership should leverage and integrate with emerging national standardized interoperable datasets for soil health management systems across agencies and public-private partnerships.
- Work with USDA NRCS and other partners and stakeholders to develop, regularly update, and disseminate biochar decision support tools, with national consistency and local adaptability of recommendations, to farmers, ranchers, and other land managers across the nation.

## USDA National Institute for Food and Agriculture (NIFA)

- Commit $25 million annually to competitive grants for site-specific research focused on integration of biochar into regionally relevant production and soil health management systems. Research should support development and implementation of regionally promising production systems that use sustainable local feedstocks to produce biochar with characteristics that improve soils and production systems in the region. Such grants should also support research on pyrolysis and other processes for biochar production.

## USDA Forest Service (FS)

- Work in collaboration with ARS to implement ARS cross-site research described above on forest sites following a common, cross-site protocol.
- Establish pilot plots on use of biochar to reclaim abandoned mine lands through the Memorandum of Understanding with the U.S. Environmental Protection Agency Center for Public Health and Environmental Assessment.
- Work with ARS, NRCS, land-grant universities, and other partners to make biochar from non-merchantable wood available for use on nearby agricultural soils that would benefit.
- Continue current research on efficient production of biochar from forest thinnings and deadwood removed from forests to reduce wildfire risk, including:
    - Co-production of energy
    - Biochar use to enhance forest health, reestablishment, and productivity
    - Technology and business development
    - Use of biochar to reclaim abandoned mine lands

## USDA Natural Resources Conservation Service (NRCS)

- Translate research to enable farmers and land managers to use biochar as a tool in the soil health management toolbox to build soil health, sequester carbon, and meet other conservation needs.
- Work with other agencies and stakeholders to compile biochar data in interoperable databases with standardized data collection to make research and implementation results accessible.
- Leverage existing Conservation Innovation Grants (CIGs) and on-farm trials to continue to support innovative approaches to using biochar to improve soil health, and to contribute data relevant for commercial on-farm use of biochar.
- Collect baseline and continuing data on effects of biochar at Natural Resource Inventory Sites.
- Work with ARS and other partners to develop and disseminate biochar decision support tools to farmers, ranchers, and other land managers across the nation.
- Leverage the conservation planning and ranking processes to promote sustainable, fit-for purpose biochar application as a soil health and climate-smart practice.
- Promote the recently adopted Soil Carbon Amendment Conservation Practice Standard (Code 336) to expand support for land application of biochar through USDA conservation programs.
- Review the exclusion of biochar produced from crop residue in CPS 336 and consider an allowance for biochar produced from crop residue harvested under an adequate conservation plan that would be required to maintain soil health by, for example, providing year-round soil cover; maintaining or increasing soil carbon; and limiting erosion to no more than the soil loss tolerance level (T). The current exclusion addresses valid concerns over the potential for increased soil erosion and reduced soil health from excessive removal of crop residue. However, there is a significant opportunity to gain a net increase in soil carbon and health by converting quickly decomposed crop residue to more stable biochar carbon. Enabling sustainable biochar production from crop residue could also help manage excess residue, which in some cases limits crop productivity.
- Work with other agencies, non-profits (e.g., USBI) and/or private biochar certifiers to facilitate the development of certification programs for biochar produced from crop residue and other feedstocks, derived from management systems that sustain soil and forest carbon and health. That will ensure that agency technical and financial assistance for biochar amendments lead to the desired resource conservation.
- Work with other agencies and stakeholders to support applications of biochar with climate neutral or better life cycle assessment, which includes feedstock, production, transport, application, and long-term effects.

## USDA National Organic Program (NOP)

- Educate organic farmers on uses of biochar products that comply with organic standards to mitigate climate change and increase climate resilience in organic production systems. Biochar produced from untreated plant or animal materials is considered non-synthetic and allowed but biochar from manure and biochar with any prohibited additives during pyrolysis or post-production are prohibited.
- Consider recent and future petitions to allow sustainably produced biochar from manure feedstocks.

## Foundation for Food & Agriculture Research (FFAR)

- Work with ARS and NIFA to fill funding gaps for ARS cross site biochar research and NIFA competitive grants for site-specific biochar research.
- Fund public-private partnerships and other systems and approaches to identify and address gaps and barriers through pilots, and to test levers to scale up demand for environmentally, socially, and economically sustainable biochar integration into agricultural systems.

## U.S. DOE Bioenergy Technologies Office (BETO)

- Provide additional evaluation points for coproduction of biochar and its carbon removal benefits in awarding investments in pilot and demonstration bioenergy facilities.
- Evaluate the costs and benefits of decentralized facilities, including the savings and climate benefits from reducing shipping distances for bulky biomass feedstock.
- Support co-located facilities to produce green hydrogen for use in stabilizing biocrude produced by pyrolysis, to prepare it for direct use as bunker fuel by ocean-going vessels or for shipment to refineries for processing into biodiesel or aviation fuel.
- Continue to explore the role of biochar in bioenergy production and apply the findings of the BETO workshop on bioenergy and soil carbon in future funding opportunities.

## U.S. Environmental Protection Agency (EPA)

- Remove unintended barriers that prevent low carbon biofuels coproduced with biochar from qualifying as low carbon cellulosic biofuels under the federal Renewable Fuel Standard. The Standard provides a price floor of over $4.00 per gallon and a price premium over gasoline for low carbon cellulosic biofuels. That offers a significant incentive for coproduction of biofuels and biochar.
- We urge EPA to 1) strategically relax restrictions on biofuels produced at one facility and processed at a second, specifically to allow pyrolysis oil and sugars to

be transferred to separate facilities for processing into ready to use fuels, and 2) to administer appropriate tracking to allow two products to be shipped to separate facilities for processing. The change is needed because it is not feasible to build pyrolysis facilities at the scale required to support an ethanol plant for processing the sugars and a refinery for processing the pyrolysis oil. Large, centralized pyrolysis facilities would have high greenhouse gas, transportation, and logistics costs for shipping large volumes of bulky biomass over long distances.

- An amendment to the Renewable Fuel Standard is needed to allow biomass/biochar-based electricity as a transport fuel and low carbon cellulosic biofuels co-produced with biochar to be used in ocean-going vessels to count toward the volumetric requirement for such fuels.

# Recommendations to Land-grant Universities and the Cooperative Extension System

- Conduct site-specific research focused on developing promising production and soil health management systems that use biochar from local feedstocks with characteristics that improve soils and production systems in the state and region.
- Conduct locally relevant research on pyrolysis and other processes for biochar production from sustainable local feedstocks.
- Monitor and test the performance of commercial biochars and biochar-based products.
- Use farmer-to-farmer knowledge exchange, on-farm demonstration trials, and public-private partnerships with USBI, AFT, NCAT, and other organizations, industries, states, and cities, to support sustainable biochar adoption and knowledge transfer.
- Promote and provide training on regularly updated biochar decision support tools.

# Recommendations to Non-Governmental Organizations (NGOs)

- NGOs like NCAT, AFT, and USBI are playing an increasing role in supporting development and adoption of biochar and the development of biochar standards. We recommend that NGOs continue and grow their involvement in biochar outreach, information transfer, research, and decision support. NGOs should partner strategically with agencies, industry, land grant universities, and the cooperative extension system in the activities described here to fill gaps, build bridges, and coordinate impact, especially when other types of entities may be unable to address these needs.

# Recommendations to Industry Partners

## Corporate Buyers

- Airlines and shipping companies: Commit to purchasing pyrolysis-based biofuels co-produced with biochar to meet a portion of corporate targets for use of low carbon fuels for aviation and ocean-going vessels.
- Corporate buyers of carbon credits: make commitments to purchase biochar-based carbon credits.
- Corporations with agricultural supply chains: promote biochar as a tool in the soil health management systems toolbox to improve soil health, climate mitigation and climate resilience in their supply chains. Evaluate opportunities to support, promote, incentivize, incorporate, and provide technical and financial assistance for increasing sustainable production and use of biochar and biochar-based products in businesses and supply chains.

## Certifiers

- Establish North American standards for testing and use to certify biochars for sustainably sourced feedstocks, long-term soil carbon sequestration, and environmental safety. Producers now sell biochar carbon removal credits in voluntary markets based on the European Biochar Certificate (EBC). Each market (e.g., Puro earth, Carbon Future, Verra) has rules regarding biochar product quality,

energy recovery and sustainability. North America standards and certification would ensure product quality and improve access to capital.

- Facilitate establishment of tools and facilities for rapid testing and on-site characterization of biochar. Collaborate with laboratories to expand testing to include biochar.

- Establish a task force of leading soil scientists, biochar researchers, farmers, and other appropriate stakeholders to guide development of certifiable carbon credit protocols for use of biochar to; 1) reduce soil nitrous oxide and methane emissions, and 2) slow breakdown of native soil organic carbon and thereby increase the carbon sequestration potential of biochar amended soils. Develop carbon protocols for the liquid products of pyrolysis including wood vinegars, tars and oils.

# Potential Future Recommendations

The recommendations presented here are not all-inclusive. Future recommendations will be needed to address unforeseen gaps and future needs. Currently known gaps in the recommendations include, but are not limited to the following:

- A biomass feedstock supply roadmap is needed, that indicates quantities and types of biomass available geographically, and mechanisms for sustainable approaches to acquisition, production, and short distance delivery to agricultural lands and other potential sinks/markets.

- Support is needed for scaling-up biochar testing facilities for product characterization.

- A roadmap is needed for providing carbon credits for biochar production and use on working lands and beyond in the United States that is transparent to all relevant stakeholders.

- There is potential to develop explicit recommendations for Congress to help scale up a pyrolysis biochar and bioenergy industry.

- Effective mechanisms for engagement and collaboration across additional agencies and stakeholders could bring their strengths, resources, and roles to integration of pyrolysis biochar and bioenergy in agriculture, forestry, carbon markets and beyond.

# Conclusions

The two-day virtual convening event on biochar research and commercialization brought together experts to recommend a path forward for sustainable production and use of fit-for-purpose biochar as a critical tool in the soil health and climate-smart toolbox. These recommendations are intended to support rapid development of a pyrolysis biochar bioenergy industry and integration of biochar in soil health and climate smart systems.

# Resources

For more information on these policy recommendations, contact:

- Chuck Hassebrook, Biochar Policy Project, National Center for Appropriate Technology, hassebrook@gmail.com, and visit NCAT's biochar resources at attra.ncat.org/topics/biochar.
- Rachel Seman-Varner (RSeman-Varner@farmland.org), Senior Soil Health and Biochar Scientist and Bianca Moebius-Clune (BMoebius-Clune@farmland.org), Climate and Soil Health Director of American Farmland Trust and visit AFT's biochar resources at farmland.org/biochar.
- Tom Miles, Executive Director, US Biochar Initiative, usbiochar@gmail.com, and visit USBI's biochar resources at biochar-us.org.




# Recommendations to Scale Up Sustainable Biochar Research & Commercialization for Agriculture & Conservation