



Biochar Use With Livestock and Poultry

Report prepared by :

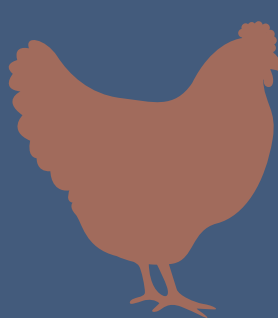


Biochar is made by heating organic feedstocks like wood chips, rice husks, or corn stover in a low oxygen environment to produce a granular high-carbon product with a huge surface area—much like activated carbon. Biochar has been successfully used in livestock operations as a feed additive and as a manure management tool. Using biochar as a feed additive is widespread in Europe however, its use has been limited in the US due to the FDA's feed additive regulations, but current research efforts and state level approvals have opened both pilot-level and production usage.

An unregulated opportunity for biochar used in poultry and livestock operations comes from the manure and litter management. No approvals are needed for this application and there is a large body of research and experience supporting biochar's benefits in bedding, manure management, anaerobic digestion, compost, and soils. Most biochar used with livestock and poultry will end up in the soil, where its benefits are supported by extensive research as well as being well established in practice. Biochar has shown to reduce ammonia levels and retain nitrogen compounds in manures and it provides increased water holding capacity and soil organic matter in soils. Another benefit from using biochar is its longevity—measured in decades to millennia—which opens the potential for economic benefit from the developing carbon credit markets.

there are over **250 million tons of feed** for livestock consumed annually in the US, with about **1.4 billion tons of manure** produced.

If **1%** of those input and output streams use biochar (at rates of 0.3% and 10% respectively,) the **1.5 million tons** of biochar used would not only capture tons of methane but offset up to **5M tons of CO2 emissions.**



Biochar Use with Livestock and Poultry: Project Team

- ▶ Kathleen Draper, Chair, *International Biochar Initiative*
- ▶ Harry Groot, *Dovetail Partners*
- ▶ Ashley McFarland, *Dovetail Partners*
- ▶ Tom Miles, Chair, *US Biochar Initiative*



The work upon which this presentation is based is funded through a grant awarded by the US Forest Service Wood Education Resource Center's Wood Innovation Grant 20-DG-11083150-011



Project Overview

- ▶ The project explored the potential for using biochar in three applications:
 - Viticulture, Livestock and Poultry, and Stormwater Management.
- ▶ The process used was to:
 - Interview experienced users
 - Review relevant published scientific research
 - Analyze needs of users and other market data
 - Provide educational outreach
 - Reports
 - Webinars

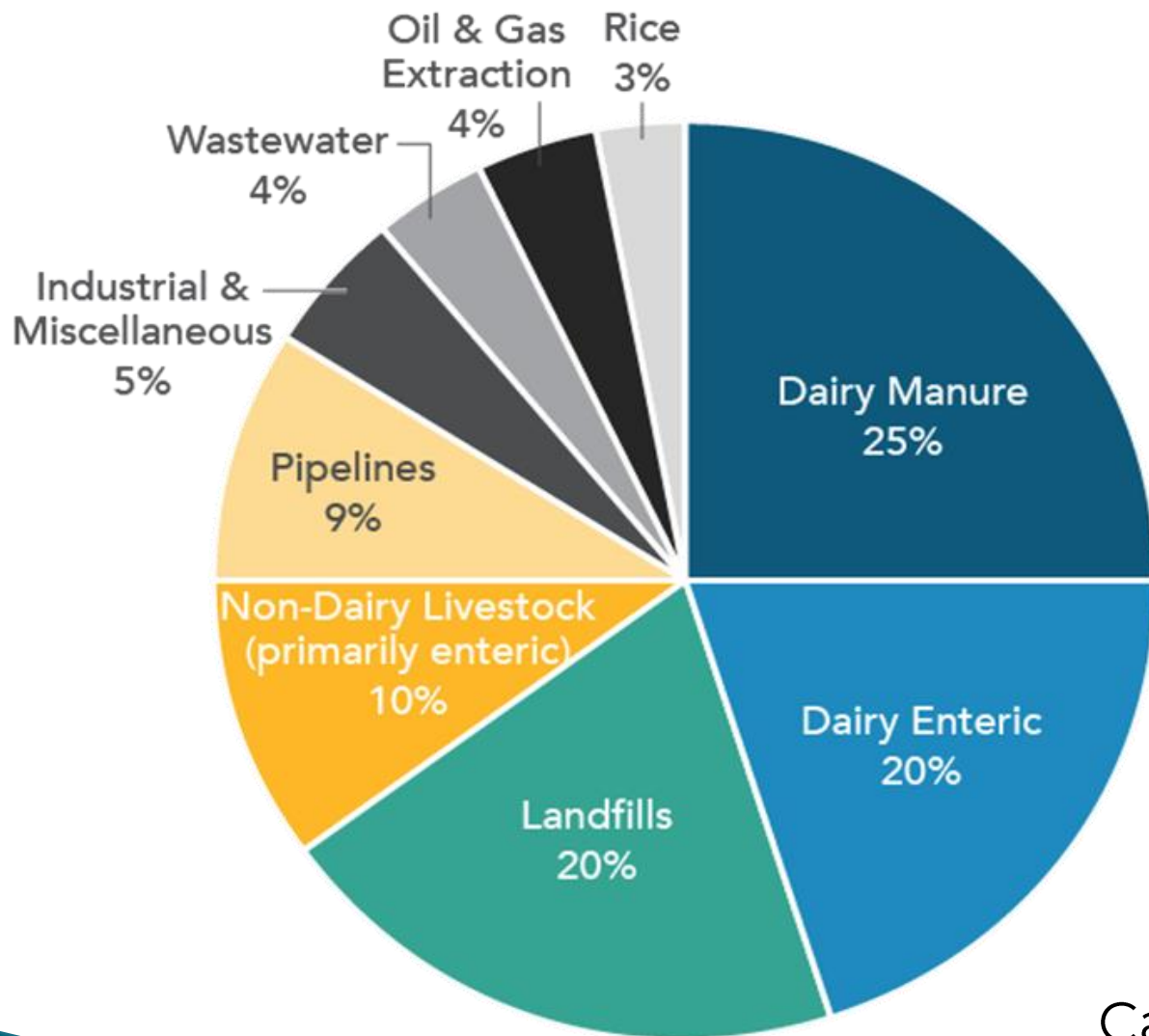


Report Highlights

- ▶ There is a large body of research supporting the reduction of methane and ammonia in manure management, and supporting the benefits of biochar in soils and compost.
- ▶ Biochar has been successfully used as a feed additive for livestock and poultry to boost productivity by individual growers, however the North American research has been inconclusive and animal feed regulations hinder the practice's adoption.
- ▶ There are many suppliers of biochar in US. Biochar's specific characteristics are important and analysis is critical.



2013 Methane: 118 MMTCO₂e (20-yr GWP)



“Composting manure preserves the nitrogen, preventing runoff losses (and environmental challenges) giving the nitrogen a time-release property. And composting mitigates pathogen spread if done correctly.”

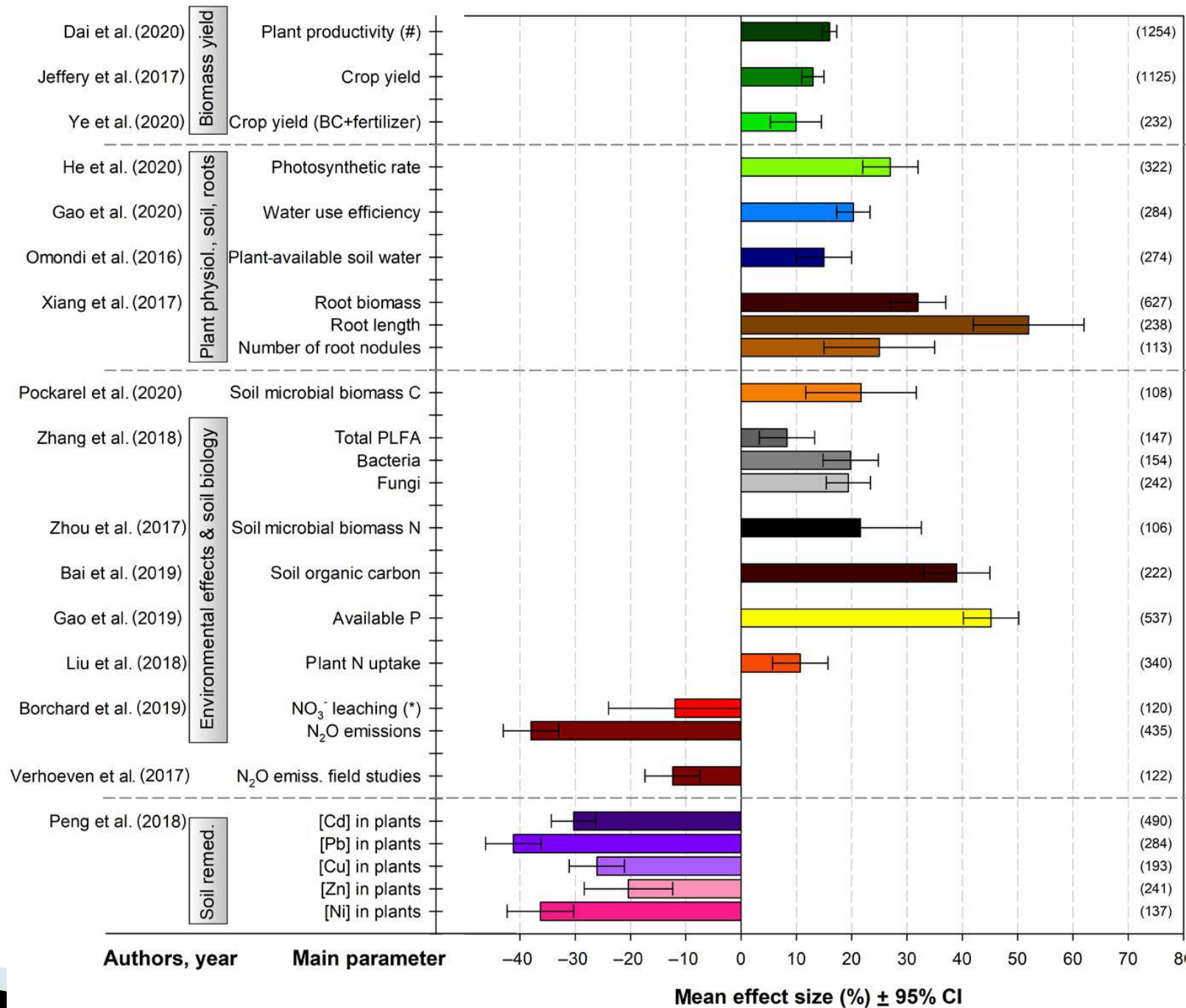
Rick Wilson 1/17/2022 Biochar Discussion List

California Air Resources Board: **GHG Short-Lived Climate Pollutant Inventory**



Meta Study of Biochar Meta Studies

Biochar in agriculture –A
systematic review of 26 global
meta–analyses;
Schmidt et al, 2021



Biochar Animal Feed Regulations

- ▶ FDA regulates animal feed in the US for interstate commerce
- ▶ The Association of American Feed Control Officials (AAFCO) define what is acceptable for use in animal foods.
- ▶ AAFCO withdrew charcoal as an animal feed in 2010
- ▶ Biochar as an animal feed flourishes in Europe due to their established certification process



FDA and AAFCO's Position

- ▶ “Currently, no food additive regulation, no feed term, and no feed ingredient definition exist for any type of charcoal, meaning no acceptable animal food use has been established for "charcoal" in general.”
- ▶ **Wood charcoal has been documented to contain dioxins, furans, and heavy metals. Therefore use of charcoal in animal food would require review of data to demonstrate its safety for the intended use. Before charcoal could be used in animal food, data are needed to demonstrate that it can be produced without contaminants, such as dioxins, furans, and heavy metals. Data are also needed to establish that feeding wood charcoal to livestock has utility for an appropriate food use and would not result in tissue residues impacting human food safety. These reviews could be accomplished through the animal food additive petition regulatory pathway.**



Seeking Your Help!

- ▶ Biochar is not the same as generic charcoal, but standards are needed and questions by regulators addressed!
- ▶ A working group is forming to find out what's required and determine next steps.
- ▶ If you'd like to express your interest in that effort, please put your name in the chat with a "Working Group" header or drop a note to usbiochar@gmail.com



Today's Speakers

- ▶ **Kathleen Draper**–Finger Lakes Biochar (NY), Co–Author of *Burn–Using Fire to Cool the Earth*, IBI Chair, USBI Board member
- ▶ **Mike Callicrate**–Callicarate Beef (KS) and Ranch Direct (CO)
- ▶ **Wayne Teel**–James Madison University (VA)
- ▶ **Joining us for the Q&A:**
 - Andrea Watson–University of Nebraska–Lincoln
 - Heather Kingery–University of Nebraska–Lincoln

Webinar Series Part 2:

Using Biochar in Livestock & Poultry

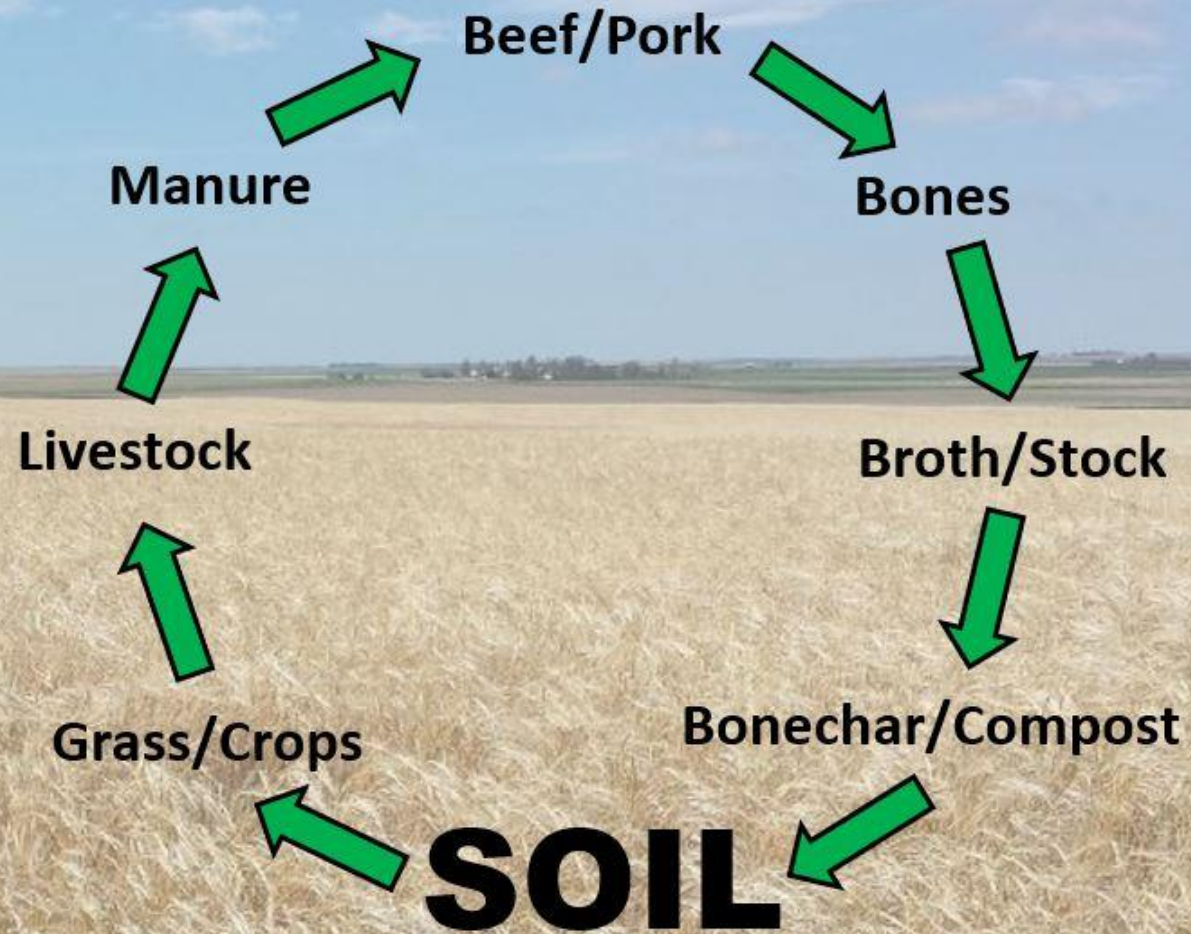


January 26, 2022
2:00 PM EST

Speakers include:

- Kathleen Draper, International Biochar Initiative
- Mike Callicrate, Callicrate Beef and Ranch Foods Direct
- Wayne Teel, James Madison University working with Shenandoah Valley Poultry Producers
- Harry Groot, Dovetail Partners, Inc.

Regenerative Farming and Ranching Callicrate Cattle Co.



Healthy Soils – Healthy People - Healthy Communities!

Retort for making biochar and bonechar

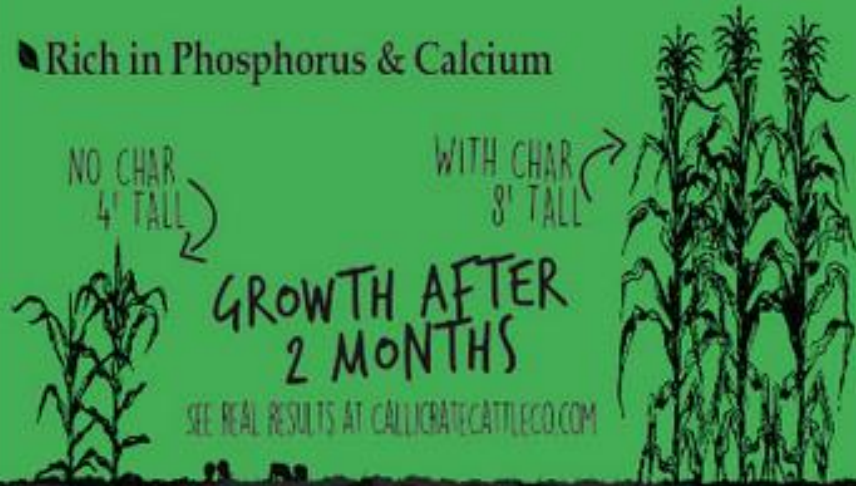


CALLICRATE
CATTLE CO

BONECHAR

THE NATURAL WAY TO PUT NEW LIFE IN YOUR SOIL

- Speeds Plant Growth, Boosts Nutritional Content
- Improves Soil Structure for Better Water Absorption & Nutrient Retention
- Stimulates Active Microbial Life
- Rich in Phosphorus & Calcium



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MADE IN ST FRANCIS, KANSAS, USA



Designed to help you re-create earth's ancient super soils, Callicrate Cattle Co. Bonechar adds a living blend of nature's most potent plant nutrients, beneficial bacteria, and stable, organic carbons, enabling your plants to reach their peak potential.

HOW TO REVITALIZE YOUR SOIL

Mix at a rate of 10% with blend of compost and soil. Premix with compost prior to mixing with soil to populate the bonechar with beneficial microbes.

Add to any non-soil hydroponic base mix for accelerated nutrient performance and explosive root growth.

100% ORGANIC INGREDIENTS

Callicrate Cattle Co. is dedicated to restoring land health and vitality for future generations with a regenerative approach to agriculture.

Learn more about the benefits of all of our char products by visiting CallicrateCattleCo.com



Biochar as a feed ingredient

“Biochar, that is, carbonized biomass similar to charcoal, has been used in acute medical treatment of animals for many centuries. Since 2010, livestock farmers increasingly use biochar as a regular feed supplement to improve animal health, increase nutrient intake efficiency and thus productivity.”



< ZOOLOGICAL SCIENCE

The use of biochar in animal feeding

Literature review

Agricultural Science

Ecology

Soil Science

Veterinary Medicine

Environmental Impacts

Hans-Peter Schmidt¹, Nikolas Hagemann^{1,2}, Kathleen Draper³, Claudia Kammann⁴

Published July 31, 2019

<https://peerj.com/articles/7373/>

Cattle

As evidenced by farmer practice, veterinary advice, and European regulations, biochar is already widely used as a regular feed supplement in cattle farming especially in Germany, Austria and Switzerland (European Biochar Certification body, Hans-Peter Schmidt, 2018, personal communication). However, there are only very few scientific studies on biochar feed additives for cattle so far.

During the first decade of modern biochar research summarized in [Lehmann & Joseph \(2015\)](#), biochar was usually tested as a soil amendment that was applied pure to soils in large quantities (>10 t/ha) revealing modest to large yield increases for a multitude of crops in the tropics but only rarely in temperate climates ([Jeffery et al., 2017](#)). More recently it was (re-)discovered that blending biochar with organic amendments such as manure, cattle urine or compost may increase yields more significantly and in a broader spectrum of climates and soils ([Steiner et al., 2010](#); [Kammann, Glaser & Schmidt, 2016](#); [Godlewska et al., 2017](#); [Schmidt et al., 2017](#)). As quality biochar is non-toxic and thus even feedable and edible ([European Biochar Foundation \(EBC\), 2012](#)), this apparently favorable combination of organic residues with biochar prompted researchers and a rapidly increasing number of practitioners to conduct trials where biochar was not only mixed with manure but also included as an input into animal farming systems. The incremental addition of biochar to silage, feed, bedding material and liquid manure pit demonstrated that biochar can be used in cascades. In addition to the direct benefits for animal husbandry as discussed below in detail, biochar becomes thus enhanced with organic nutrients which increases the economic viability of biochar application while providing numerous environmental benefits along the (cascading) way.

Since 2011, the German veterinarian Achim Gerlach has been feeding 100–400 g of high temperature wood biochar (HTT 700 °C) per cow per day to numerous herds of cattle **without detecting negative side effects** ([Gerlach & Schmidt, 2012](#); Hans-Peter Schmidt, 2018, personal communication). His survey of 21 farmers with at least 150 cattle revealed that **overall health and vitality had improved** since they had started biochar feeding.

For 98 days, Leng, Preston & Inthapanya fed four cattle 0.6% of a rice hull-derived biochar, with another four in a control group without biochar in their feed. The biochar feeding resulted in a **25% higher weight gain** compared to the control animals ([Leng, Preston & Inthapanya, 2013](#)).

When combined with silage, biochar can reduce mycotoxin formation, bind pesticides, suppress butyric acid formation and enhance the quantity of lactic bacteria ([Calvelo Pereira et al., 2014](#)).

Farmers observed that when biochar was combined with straw or saw dust bedding at 5–10% (vol) hoof diseases, odors and nutrient losses were reduced ([O'Toole et al., 2016](#)).



National Organic Program; Amendments to the National List of Allowed and Prohibited Substances (Crops, Livestock and Handling)

A Rule by the [Agricultural Marketing Service](#) on 12/27/2018



ACTIVATED CHARCOAL

This final rule adds activated charcoal to § 205.603(a) for use in organic livestock production. Paragraph (a)(6) is amended in § 205.603 to read as follows:

Activated charcoal (CAS # 7440-44-0)—must be from vegetative sources. After the effective date of this final rule, organic livestock producers may use activated charcoal as a therapeutic treatment on an as-needed basis with mammalian livestock in cases of suspected ingestion of toxic plants and control of diarrhea caused by moldy silage. Synthetic forms of activated charcoal derived from other non-vegetative sources continue to be prohibited in organic livestock production. AMS has reviewed and agrees with the NOSB recommendation that activated charcoal be allowed for use in organic livestock production. AMS received comments on the proposed rule for amending activated charcoal onto § 205.603 [↗](#)

How can biochar gain wider general use and acceptance in livestock diets?

A cautionary note:

AltEn Owner Tries to Sell Toxic Biochar

Biochar Sale Halted, But State Regulators Approve Water Treatment at Defunct Ethanol Plant

1/19/2022 | 3:15 PM CST



By [Chris Clayton](#), DTN Ag Policy Editor

Connect with Chris:

[@ChrisClaytonDTN](#)



OMAHA (DTN) -- Nebraska officials have approved a preliminary plan to treat 150 million gallons of contaminated water at the defunct AltEn ethanol plant in eastern Nebraska, just a week after officials from two states were able to halt plans by AltEn's owner to sell potentially pesticide-contaminated biochar from the facility.

A group comprised of major seed companies and a remediation company continue to work with Nebraska state regulators to clean up the ethanol plant, which had accepted pesticide-treated corn seed for multiple years to process into ethanol at the 25-million-gallon plant.

Carbon catches a free ride to a permanent home

The Ruminant/Dung Beetle partnership - *Doug Pow, Australia
Putting carbon in the ground permanently without using a machine

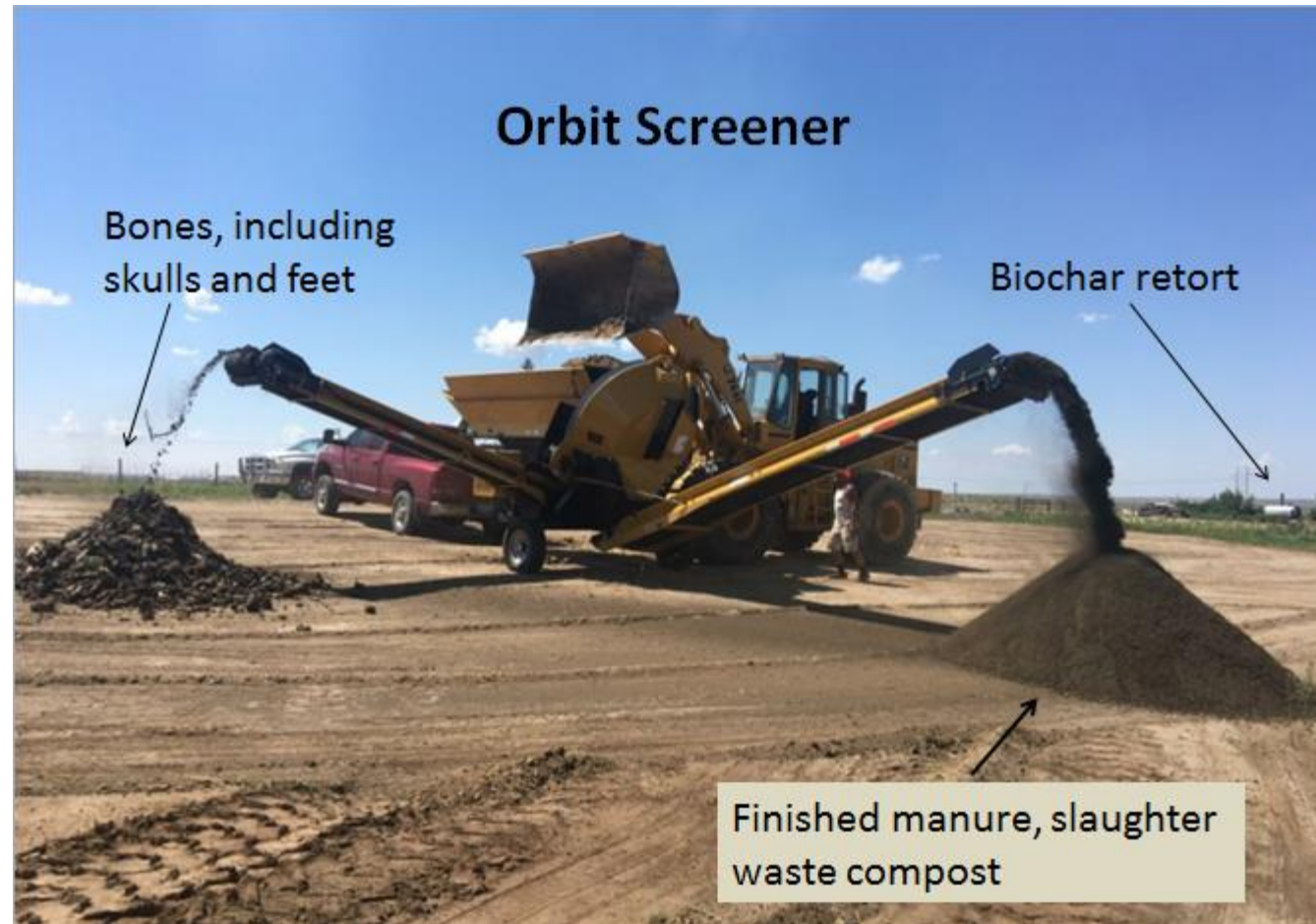


Dung beetles bury manure containing inoculated biochar, improving aeration, permeability, and fertility.

“All parameters are up, and we’re doing it economically, biologically, and profitably. It’s something the cows don’t mind eating, and the beetles don’t mind burying.”

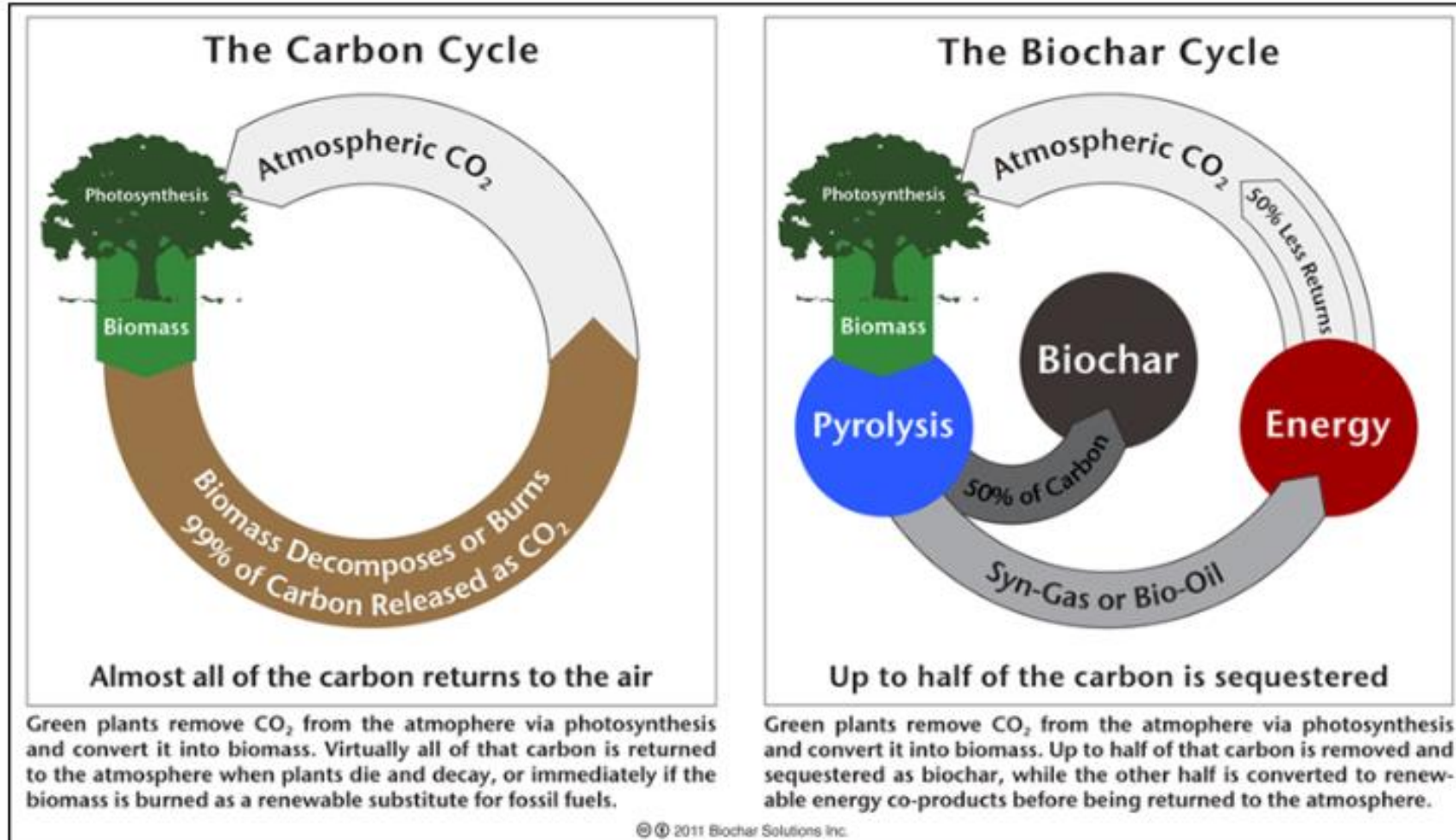
* <https://www.callicratecattleco.com/soilproducts.htm>

Manure, slaughter waste, biochar, and other composted biomass returns to the soil.



[The SOIL Initiative](#)

How the Biochar Cycle can change the Carbon Cycle



Biochar comparison at West TN Ag Research Center

With and without biochar (wood source)

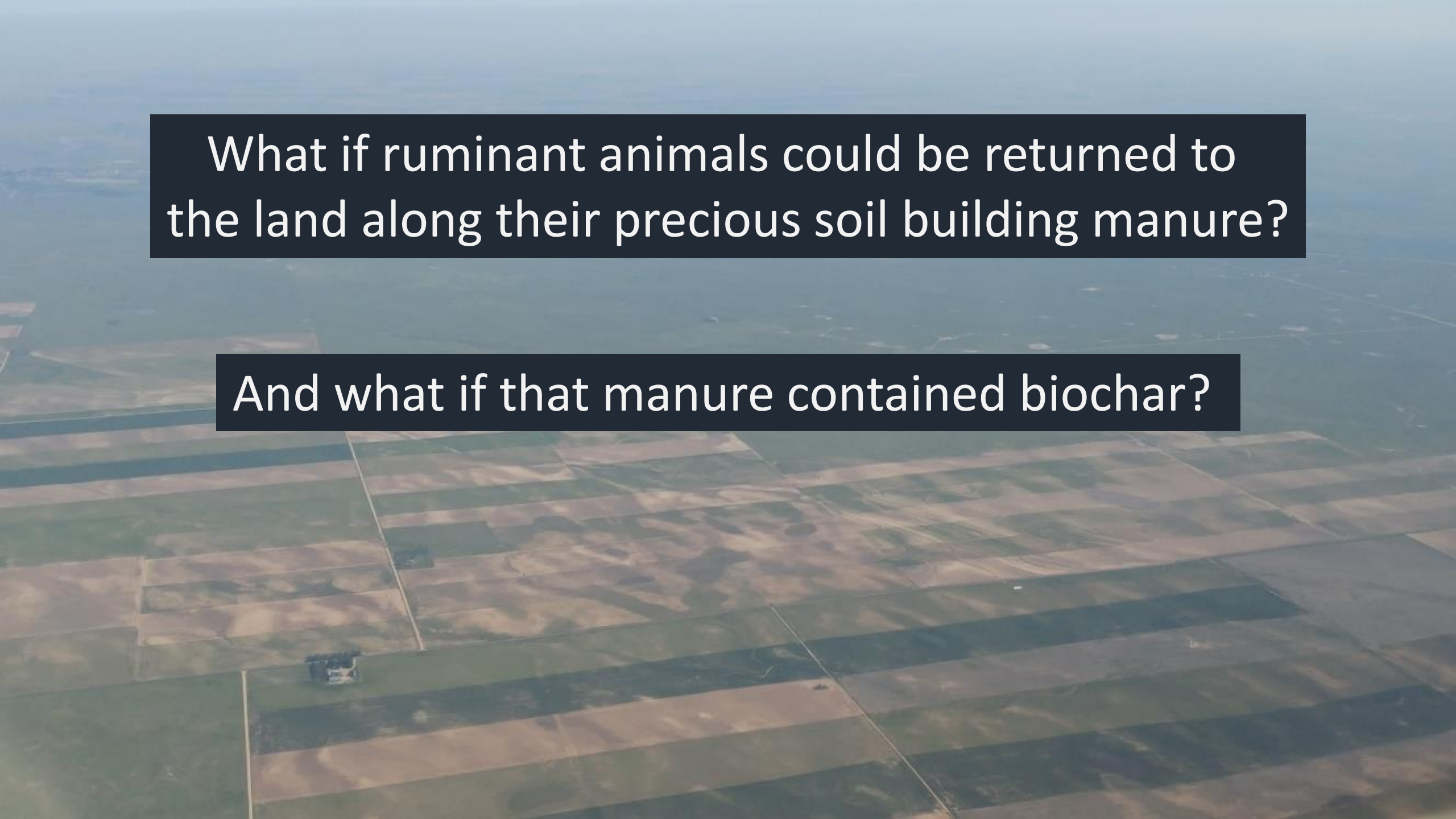
July 19, 2018



Completing the Soil to Soil Circle



A specially designed compost spreader applies a uniform blend of manure, slaughter waste and biochar/bonechar to crop and pastureland.

An aerial photograph of a vast agricultural landscape, showing a grid of rectangular plots in various shades of brown, tan, and green, suggesting different crops or stages of land use. The perspective is from a high altitude, looking down on the terrain.

What if ruminant animals could be returned to the land along their precious soil building manure?

And what if that manure contained biochar?

We believe the ideal farm is family owned and operated, diversified and livestock-centered, responsibly grazing and feeding the farm's production, with animal manure going back to the land.

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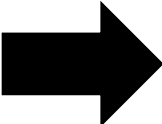


Biochar Market Opportunities *Livestock & Poultry*



Kathleen Draper
biocharro2@gmail.com

Biochar: what's old is new again?



Afforestation/Reforestation
Planting of trees to store atmospheric carbon in biomass and soils

Biochar
Converting biomass to biochar and using the biochar as a soil amendment

Soil Carbon Sequestration
Adopting agricultural practices to increase carbon storage in soils

Negative Emissions Technologies
2018 IPCC Special Report

BECCS
Bioenergy with Carbon Capture & Sequestration
Removal of CO2 from the air by plants into biomass, combustion of the biomass to produce energy and CO2, which is captured & stored

DACCS
Direct Air Capture
Removal of CO2 from ambient air by engineered systems

Enhanced Weathering
Enhancing the weathering of minerals, where CO2 in the atmosphere reacts with silicate minerals to form carbonate rocks

ithaka institute



More information available at:

Websites & newsletters:

International Biochar Initiative: <https://biochar-international.org/>

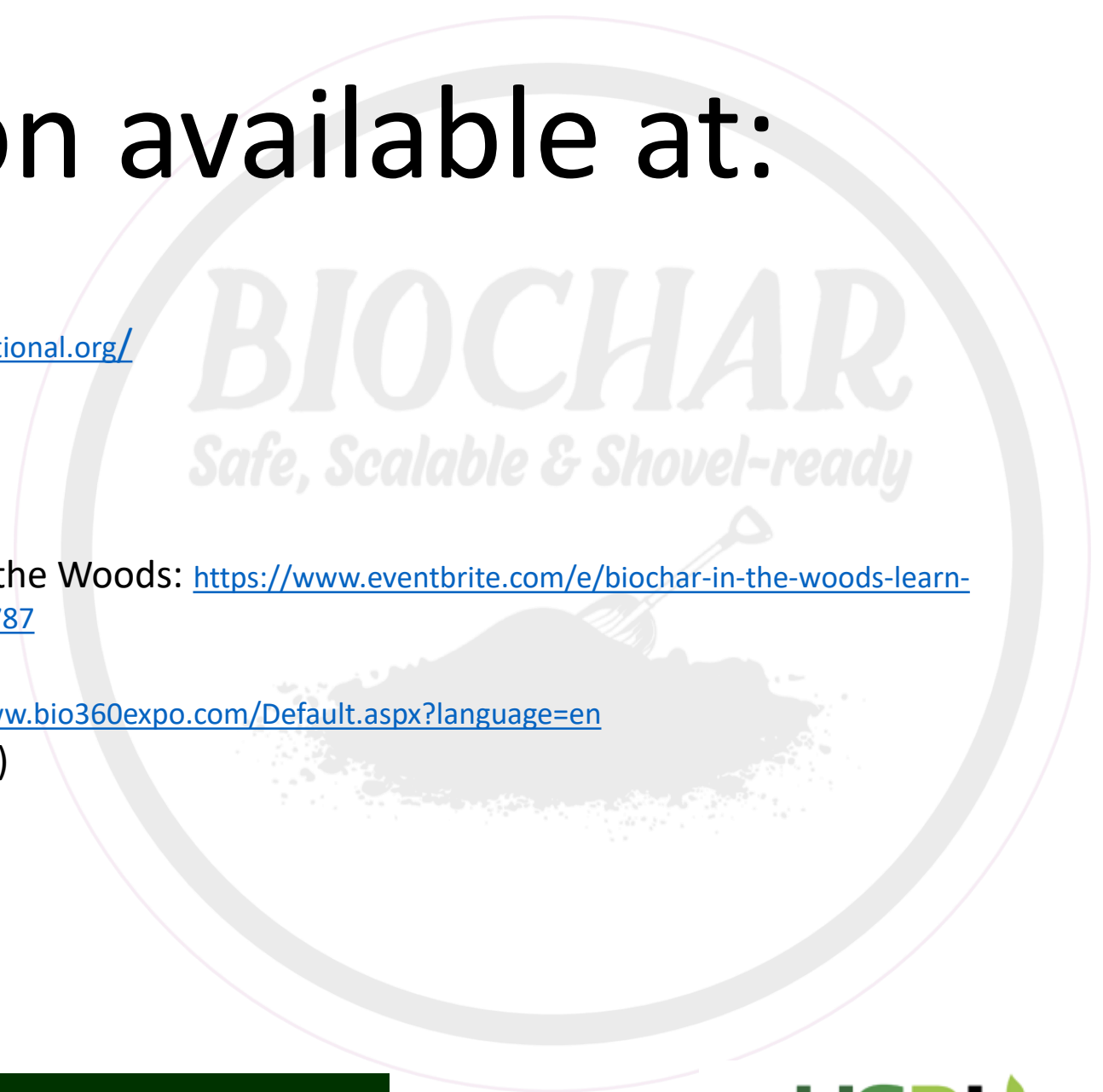
US Biochar Initiative: <https://biochar-us.org/>

Biochar Journal: <https://www.biochar-journal.org/en>

Webinars, Workshops, Conferences and more:

- Jan 27 (virtual), Feb 1 -3 (Chico, CA) Biochar in the Woods: <https://www.eventbrite.com/e/biochar-in-the-woods-learn-how-to-use-biochar-for-forest-resilience-tickets-207366166787>
- IBI Podcast series!
- March 30 – 31 Bio360: Nantes, France <https://www.bio360expo.com/Default.aspx?language=en>
- Aug 9 – 11 USBI Conference (Morgantown, WV)

On-line biochar forum: <https://biochar.groups.io/g/main/topics>



Kathleen Draper
biocharro2@gmail.com



Which best biochar from bamboo or wood materials?

KD: There is no 'best' biochar. It depends on what you are trying to do with biochar and what the properties of relevance are!

Can you point me to a synthesis article demonstrating that the CO2 emissions to make biochar are less than the CO2 removed from the atmosphere and sequestered in soil by using biochar?

KD: This depends on many factors including the technology used and the related emissions for that technology. Here is a good overview article: Review The Role of Pyrolysis and Gasification in a Carbon Negative Economy Robert C. Brown <file:///C:/Users/Owner/Downloads/processes-09-00882.pdf>

Do you have dung beetles to bury the biochar-loaded cattle manure?

Answered live; see [recording](#)

Beef aside - what about dairy production?

KD: This white paper on biochar & dairy might be of interest: [https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/c/8159/files/2020/09/Dairy-Manure-Biochar-Synthesis-Report Innovation-Center 2020.pdf](https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/c/8159/files/2020/09/Dairy-Manure-Biochar-Synthesis-Report-Innovation-Center-2020.pdf)

Is there any work been done to create a compliance standard for Biochar? Is there a differentiation standard between biochar and activated carbons?

Live answered; [recording](#)

In Australia , our governing livestock industry body has a problem with using animal bones as a stock feed . What regulations do you have to allow it , or is it only for land use?

Live answered; [recording](#)

Costs - Assuming regulations allow someday I could afford to feed a few ounces per head per day to my cattle and hogs. Using biochar in my bedding for the pigs is expensive though. I haven't figured out how to get a large volume of biochar at a price that works. Any ideas on that front?

Live answered; [recording](#)

How is the Callicrate retort fueled? Where is the fuel sourced? Can organs, particularly bowel, be turned to useful biochar?

Live answered; [recording](#)

How to manage the quality of biochar with different quality of inputs and pyrolysis conditions? Is any standard protocol for tackling toxicants or harmful content like polycyclic hydro carbon etc. from biochars?

KD: IBI has a material standard for biochar used in soils which you can find here: <https://biochar-international.org/characterizationstandard/> Currently IBI doesn't have a standard for use in feed but the European Biochar Certificate does have one!

Do you Pyrolyze the [poultry] bedding afterwards ?

HG: It could be, but not in these trials. It would also make more sense to use bedding with biochar already in it as a compost than to re-pyrolyze it.

Do any [poultry] producers use heat recovery ventilation in the winter?

Wayne, Do you have a feel for the potential value of biochar in this poultry application?

HG: Wayne said he doesn't at this point. There are still too much unknown and too many variables to put a value on it.

Wayne, have you considered the use of larger pyrolysis units that can be used at the farm scale to produce both heat to heat the poultry houses and produce biochar/bonechar as a by-product?

HG: energy/biochar systems have been proposed by some "appropriate technology" entrepreneurs to provide dry heat (as natural gas tends to introduce moisture) and biochar. To my knowledge none have been installed due to the capital cost and the low cost of gas.

The first speaker emphasized removing industrial style farming, however why are the cattle plots exposed and without cover crops (which increases carbon release)?

What is fuel source of retort?

Live answered

Or gasification units?

Can the reduction of carbon/regeneration of land and large scale industrial farming go hand and hand?

HG: it can, but the economics are difficult to both define and refine as costs of biochar and its application vary, soil conditions vary widely, and crops have different needs. It's a lofty goal on which many are working!

Wayne: Have you re-run the trial with the suggestions/ improvements you stated in the end?

That's a work in process.

Did I hear you say that your retort gives 50% yield of biochar from woody biomass? If yes, that means every carbon atom in the wood is captured in the form of biochar. I don't think that's right?

HG: not sure about the mass balance, but yes, my experience with a pyrolysis retort is that it yields about 50% volumetrically. For a flame capped unit, we get 15% or less. Mike runs the same retort, but also buys from a commercial supplier; different technologies yield differently as you'd expect.

Could biochar be used in bedding for pigs to reduce smell?

HG: No personal experience, but Yes would be my answer. Biochar isn't species specific! It should work well for any of them and I'd guess the wetter the manure, the better. If you do try it, let me know how it goes.

What is done with beaks and skin/feathers and claws in poultry industry? Is there enough mass to char it in a useful product?

Live answered; [recording](#)

What's the heat source for your Exeter retort?

Live answered; [recording](#)

Is anybody using the International Biochar Initiative testing protocol to determine the quality of the "Biochar" products added to the animal applications?

Live answered; [recording](#)

What is the difference between the process of manufacturing charcoal from wood and making biochar from wood?

Live answered; [recording](#)

Does the use of ample biochar reduce the costs of ventilation or any other energy inputs?

Live answered; [recording](#)

Mike, what do you mean by saying the biochar should be 'charged' before applying it to the soil as an amendment?

MC: Soaking biochar in compost tea is a good way to "charge" the biochar with microorganisms [and nutrients], or mix it in a compost pile.

What was the source of the biochar used in NE

Live answered

AW: we have done experiments with biochar made from Ponderosa Pine wood waste and Pistachio shells

Can biochar be fed to Goats? Biochars are suitable for all ruminants uniformly?

Live answered; [recording](#)

If activated carbon was approved for use in livestock in the Federal Register announcement a few years ago, what is needed to "activate" biochar in a way that will meet those standards???

HG: The activation process is typically via steam or chemical treatment. Much of the carbon is lost in the process and there's considerable added cost. Also, the "approval" was only for health reasons (i.e., poisoning.)

Is any work been done to charge biochar with wood vinegars as a source of additional nutrition for animals?

Live answered; [recording](#)

Is there any improvement in the health of the animals

Live answered; [recording](#)

You can charge a home gardener a much higher price than a farmer for a smaller amount of biochar. Is selling the bone char to gardeners a way to build your business up before entering bulk production?

MC: We do both already.

What percentage by weight is biochar used in feed for ruminants, poultry, etc..

AW: In the research conducted at UNL biochar was fed at 0.5 to 0.8% of daily feed rations

How long would you take to charge biochar?

A couple of weeks if moistened well

Mike said he has an Exeter retort, but has ideas for improvement over long-term use. Is it big enough? Any suggestions for kilns big enough to produce farm scale amounts of biochar?

HG: There are quite a few "farm scale" units commercially available, as well as plans for DIY units on-line. It all depends on the scale and the availability of feedstocks. The pyrolysis process is not complex, but the design of the equipment and choice of materials from which it's built are critical.

Is there a particular crop that high calcium phosphorous or bone char is particularly apt for?

Calcium is essential for all plants, but the following are especially responsive: **apples**, broccoli, brussels sprouts, cabbage, carrots, cauliflower, celery, cherries, citrus, conifers, cotton, curcubits, melons, grapes, legumes, lettuce, peaches, peanuts, pears, peppers, potatoes, tobacco, and tomatoes.

Most annual plants (plants that grow, reproduce and die in one year) require large amounts of phosphorus as they begin to grow. Plants grown in cold weather which have limited roots and rapid top growth, such as lettuce, are high phosphorus users. **Legumes** also require plentiful amounts of phosphorus.

Could a veterinarian prescribe biochar?

Live answered; [recording](#)

Did I hear correctly the recommended ration for cattle is one ounce per animal per day?

AW: we fed biochar as a % of the diet, so amount fed each day varied a little, but was close to 1 ounce per day

Does anyone have any experience with Moringa biochar for animal feed? I understand that animals can overdose on Moring.

HG: there was no response, so I'd take not within our group. Join the USBI biochar discussion list to ask a wider audience of experienced users.

Was there a reduction in the methane emissions from feeding biochar?

HG: in some studies, yes, but the percentages have varied widely in the research.

AW: in experiments conducted at University of Nebraska no reductions in methane emissions were measured when feeding biochar, this is similar to some recent research done in Alberta Canada (Lethbridge Research & Development Centre) that measured no reduction in methane emissions when feeding biochar to cattle

If activated carbon is approved for use in livestock operations, what is needed to "activate" biochar in a way that will appease the FDA?

See response to Question 29.

Could the extra cost of buying a larger pyrolizer be offset by the extra fertilizer that could be produced and sold? How large and potentially profitable is the market for the fertilizer?

HG: Biochar from most feedstocks are not fertilizers as they don't have significant NPK. The exceptions are bone and manure feedstock chars. That's why adding biochars to compost is a compelling business strategy—the biochar “supercharges” the compost—and there's a lot of research and experience to support that model. See the [Dovetail report](#) for more details.

What bedding material is used for poultry in your use application rate in bedding

HG: Typically sawdust or chips is the bedding material of choice as being absorbent (if dried) and relatively cheap. Wayne's trial just applied a layer on the floor before putting the bedding in, but he noted he hoped to do additional applications in the future to prevent capping. There's so little research and experience, application rates have not been determined.

Is there a good paper on poultry that describes the characteristics of the biochar used with poultry? Feedstocks, temperature, etc?

HG: Not that I've found. However, what to look for in biochar characteristics is covered broadly in the full [Dovetail report](#).

What is a good biochar application rate to land in kg/ha?

HG: That all depends on the soil analysis, the biochar analysis, and the objectives for the land.

Does the biochar the chickens eat have any effect on the chickens?

HG: We see no difference with the biochar our chickens eat. No analysis has been done of the meat or eggs, but otherwise we see no effects, nor have I seen any mention in the literature.

Can Dung Beetles can be purchased in bulk? Can they be raised?

HG: I believe this was addressed in the Chat with a caution that they're common throughout the world and shouldn't be “imported” at the risk of becoming invasive.

What role if any do Veterinarians play in this?

HG: currently, they can prescribe activated charcoal—which *could* be a biochar product.

Is it necessary to add molasses to entice cattle to eat it?

AW: the molasses is helpful to keep the biochar in a more suitable form for slow intake and keep it from blowing away when feeding in open settings

Mike, you mentioned the biochar being “safe”. How did you know that?

HG: Mike responded with a third party, IBI standards analysis of his biochar fed to cattle—so “yes”.