Biochar Uses in the Dairy Industry

INNOVATION CENTER FOR U.S. DAIRY®

HEALTHY PEOPLE • HEALTHY PRODUCTS • HEALTHY PLANET

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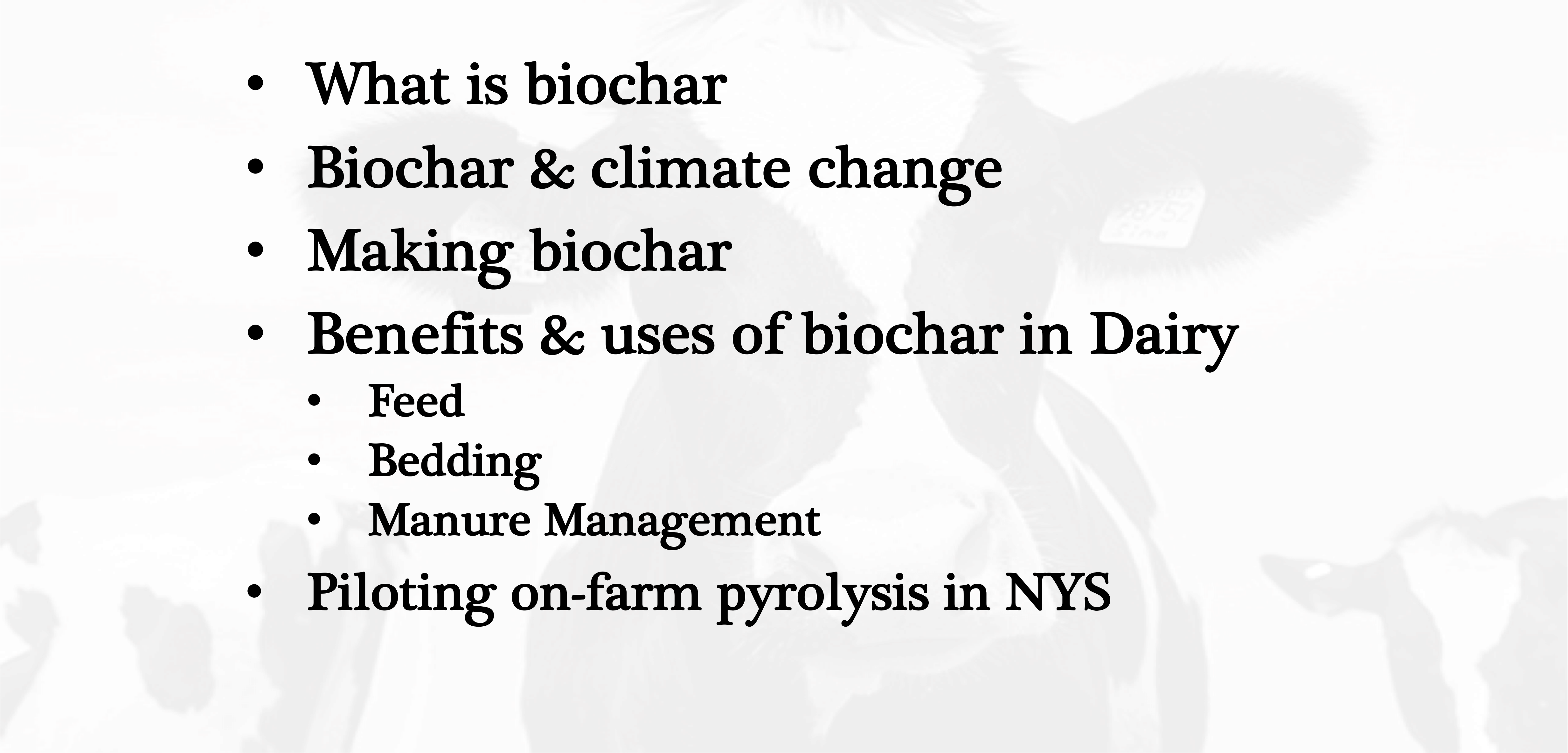
Agenda

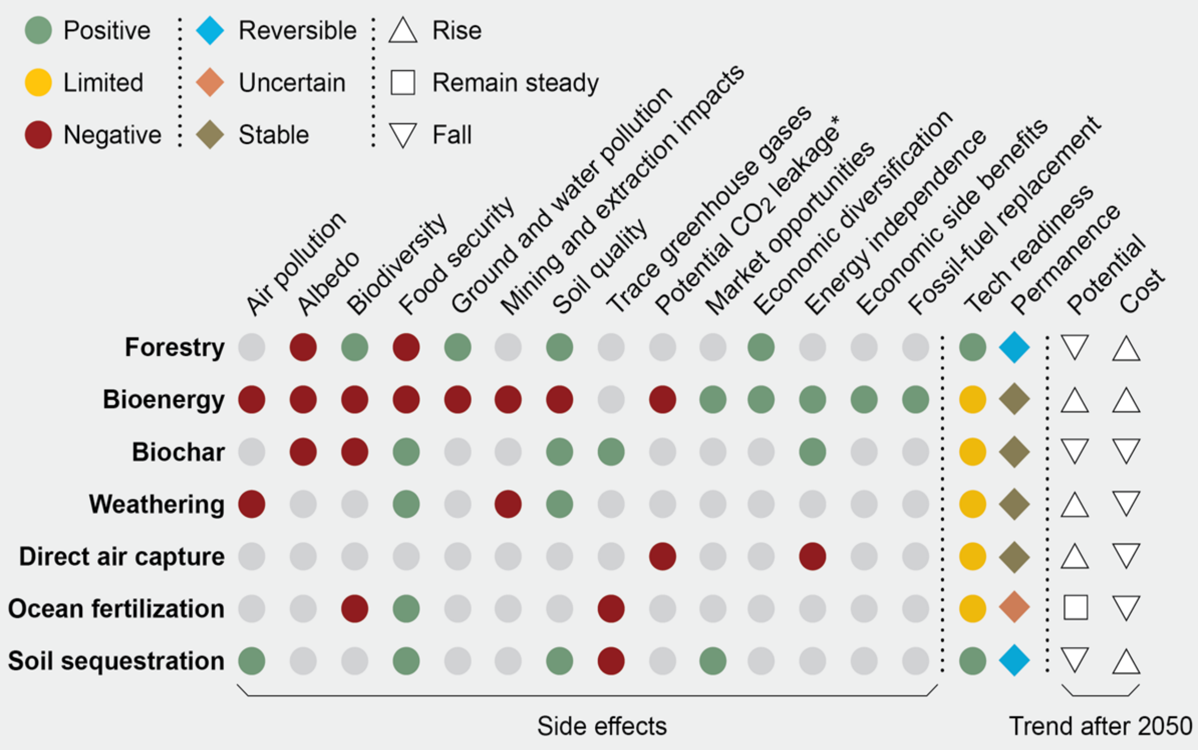


- What is biochar
- Biochar & climate change
- Making biochar
- Benefits & uses of biochar in Dairy
  - Feed
  - Bedding
  - Manure Management
- Piloting on-farm pyrolysis in NYS

What is Biochar?

	Charcoal	Biochar	Activated Carbon
Feedstock	Hardwood, sawdust + Binding Agents	Ag, forestry & other organic materials/waste	Coconut shells, peat, coal, petroleum pitch
Common Uses	Fuel (Cooking)	Soil Amendment Remediation Filtration Binding Agent (livestock)	Filtration Odor Control Remediation Binding Agent (humans)
Relevant Qualities	Burnability Low smoke	Adsorption/Porosity CEC Sequestration	Adsorption
Cost	$ - $$	$$	$$$
Production	Slow Pyrolysis; Kiln	Slow Pyrolysis; Kiln; Gasification	Pyrolyzed at 600 – 900C + activated at 250C OR Chemically impregnated & cooked @ 450 – 900C
Carbon Footprint	Carbon Neutral: May lead to Deforestation	Carbon Negative (in many situations) ★	Carbon Positive

Biochar & Climate Change



🟢 Positive ⋮ 🔷 Reversible ⋮ △ Rise
🟡 Limited ⋮ 🔶 Uncertain ⋮ □ Remain steady
🔴 Negative ⋮ ◆ Stable ⋮ ▽ Fall

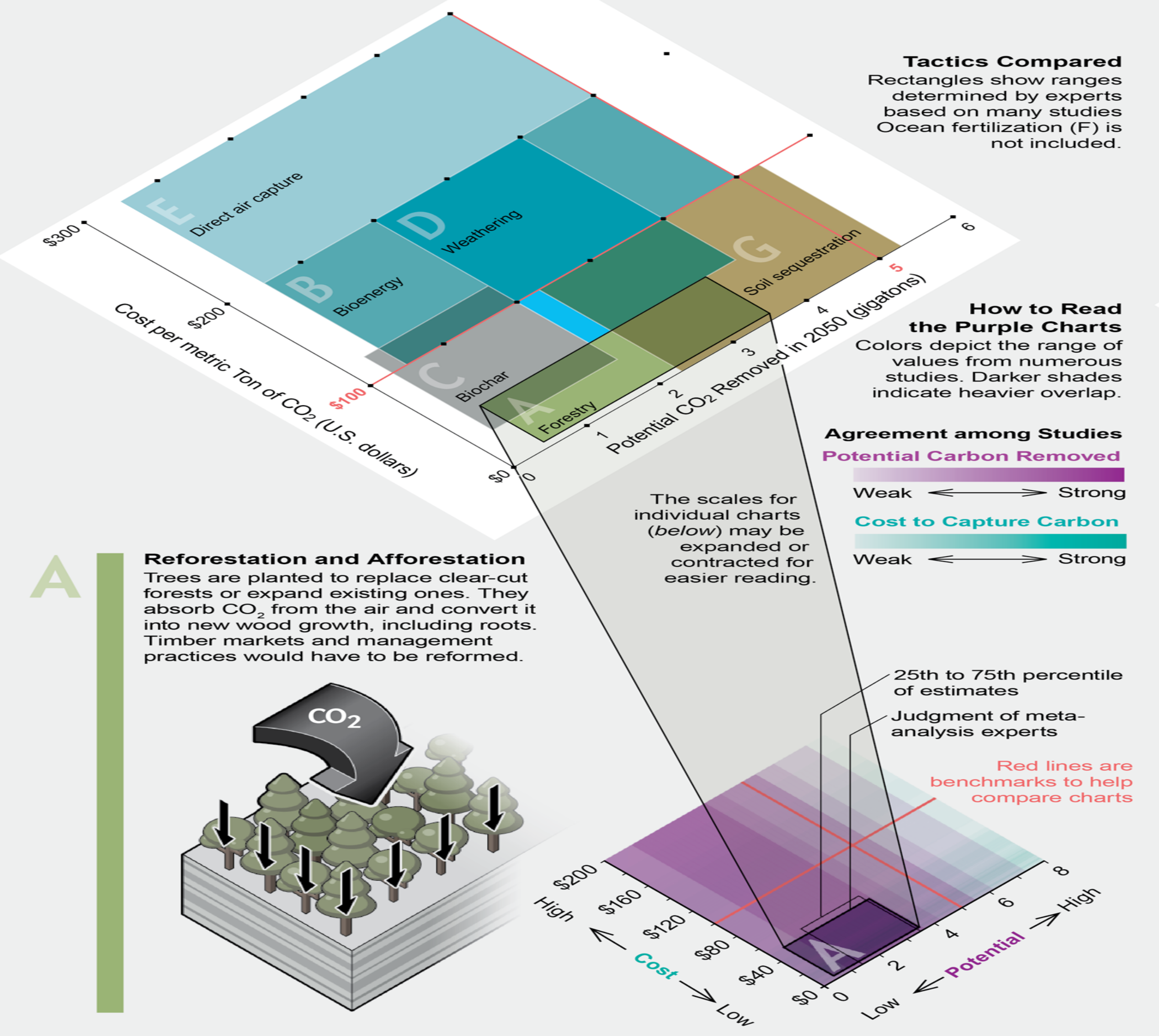
	Air pollution	Albedo	Biodiversity	Food security	Ground and water pollution	Mining and extraction impacts	Soil quality	Trace greenhouse gases	Potential CO_2 leakage*	Market opportunities	Economic diversification	Energy independence	Economic side benefits	Fossil-fuel replacement	Tech readiness	Permanence	Potential	Cost
Forestry	⚪	🔴	🟢	🔴	🟢	⚪	🟢	⚪	⚪	⚪	🟢	⚪	⚪	⚪	🟢	🔷	▽	△
Bioenergy	🔴	🔴	🔴	🔴	🔴	🔴	🔴	⚪	🔴	🟢	🟢	🟢	🟢	🟢	🟡	◆	△	△
Biochar	⚪	🔴	🔴	🟢	⚪	⚪	🟢	🟢	⚪	⚪	⚪	🟢	⚪	⚪	🟡	◆	▽	▽
Weathering	🔴	⚪	⚪	🟢	⚪	🔴	🟢	⚪	⚪	⚪	⚪	⚪	⚪	⚪	🟡	◆	△	▽
Direct air capture	⚪	⚪	⚪	⚪	⚪	⚪	⚪	⚪	🔴	⚪	⚪	🔴	⚪	⚪	🟡	◆	△	▽
Ocean fertilization	⚪	⚪	🔴	🟢	⚪	⚪	⚪	🔴	⚪	⚪	⚪	⚪	⚪	⚪	🟡	🔶	□	▽
Soil sequestration	🟢	⚪	⚪	🟢	⚪	⚪	🟢	🔴	⚪	🟢	⚪	⚪	⚪	⚪	🟢	🔷	▽	△

Side effects | Trend after 2050

*"Potential CO_2 leakage" is from underground storage.

How the Carbon Capture Strategies Stack Up

Which techniques could sequester the most carbon dioxide in 2050? How expensive will they be? The large square compares approaches. The numbers come from a meta-analysis of numerous studies, performed by economist Sabine Fuss and her colleagues. Each breakout chart shows a detailed assessment from the studies and the expert judgment of Fuss's team.



Tactics Compared
Rectangles show ranges determined by experts based on many studies Ocean fertilization (F) is not included.

How to Read the Purple Charts
Colors depict the range of values from numerous studies. Darker shades indicate heavier overlap.

Agreement among Studies

Potential Carbon Removed
Weak ⟷ Strong

Cost to Capture Carbon
Weak ⟷ Strong

The scales for individual charts (*below*) may be expanded or contracted for easier reading.

A

Reforestation and Afforestation

Trees are planted to replace clear-cut forests or expand existing ones. They absorb CO_2 from the air and convert it into new wood growth, including roots. Timber markets and management practices would have to be reformed.

25th to 75th percentile of estimates

Judgment of meta-analysis experts

Red lines are benchmarks to help compare charts

https://www.scientificamerican.com/article/scrubbing-carbon-from-the-sky/

Making Biochar: Thermo-chemical Conversion

Pyrolysis & Gasification

(but NOT Incineration)

Biomass Controls
USA

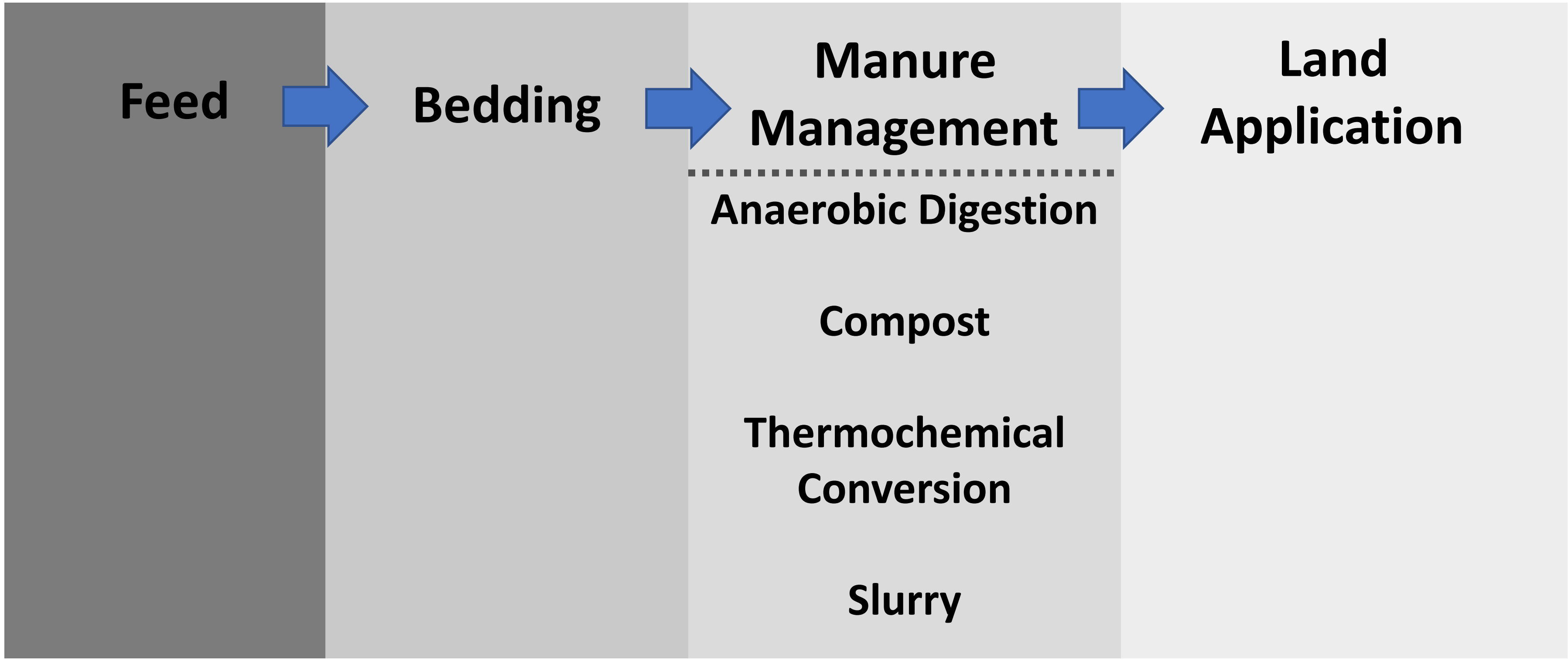
Kon-tiki
global

Pyreg
Germany

All Power Labs
USA

Benefits & Uses

Potential Entry Points for biochar in livestock farming



Feed → Bedding → Manure Management → Land Application

Manure Management:
- Anaerobic Digestion
- Compost
- Thermochemical Conversion
- Slurry

The earlier biochar enters the system, the more benefits that will accrue.

Benefits of Biochar at Different Entry Points

Feed & Feed Storage	Bedding	Manure Management	Land Application

• Improved feed conversion
• Animals finished earlier
• Lower Vet bills
• Reduced reliance on pharmaceuticals and disinfectants
• Binds toxins (aflatoxins, C. botulinum)
• Reduced H2S
• Reduced GHG emissions
	• Lower Vet bills
	• Consistent & healthier milk production
	• Reduced pathogen load
	• Reduced reliance on pharmaceuticals & disinfectants
	• Less labor
	• Lower NH_3
	• Eliminates vapors, odors, flies, rodents
	• Absorbs/retains N
	• Improved N/P ratio
	• Less water
		• **AD**
		  • Improved CH4 production
		  • Reduced H2S
		• **COMPOST**
		  • Improved nutrient retention
		  • Reduced GHG
		• **THERMOCHEMICAL CONVERSION**
		  • Renewable heat
		  • Reduction of manure
		• **SLURRY**
		  • Odor reduction
		  • Reduces NH3 & CH4 emissions
			• Reduced use of chemical fertilizer
			• Reduced odors
			• Improved WHC
			• Nutrient Holding
			  • Reduced leaching
			  • Reduced eutrophication & groundwater contamination
			• Reduced soil emissions (esp. when co-applied with slurry)
			• Carbon sequestration

Manure Management & Biochar

ANEAROBIC DIGESTION

- **Add char to substrate**
  - Boosts CH4 yield & quality
  - Reduces lag time
  - Adsorbs H2S & CO2
  - Reduces ammonium inhibition
- **Carbonize digestate**
  - Reduce volume by 65 – 90%
  - Provides renewable energy, bio-oil & syngas
  - Produce soil amendment with improved WHC, surface area, C stability
- **Filter AD effluent**
  - Reduce/harvest P

COMPOST

Blend char with manure to:

- Improve N retention
- Reduce N_2O, CH4 emissions
- Reduce composting period
- Increase pH
- Increase peak temperature
- Increase abundance of denitrifying bacteria
- Decrease N2O producing bacteria

THERMOCHEMICAL CONVERSION

Carbonize manure to:

- Provide renewable heat to dry manure
- Harvest nutrients in manures
- Significantly reduce quantity of manure
- Reduce odors
- Reduce pathogens, pharmaceuticals
- Immobilize metals (e.g. Cu, As, Z)
- Reduce GHG

Manure Management & Biochar: Slurry

A manure pit at Shelburne Farms is covered with biochar, to reduce odors and runoff from dairy farms. Photo by Elizabeth Gribkoff/VTDigger

SLURRY

- **Cover lagoon for:**
  - Odor reduction
  - NH_3 & CH_4 reductions
- **Filter dairy wastewater for:**
  - Ammonium & P reduction/ harvesting
  - COD reduction

Land application: Biochar's impact on soil

Bulk

Biochar's Soil Function Impacts

Water Holding

Due to the large size of the pores (macro-pores) and its stability within the soil, biochar can provide a long term positive impact on soil water holding capacity. In sandy soils in particular, biochar can increase water holding capacity by as much as 50% at high application rates

Nutrient Holding

Most biochars have a strong surface charge (i.e. CEC) which helps hold nutrients in the soil while still making them available to plants. Soils enriched with biochar will need less fertilizer and will have less nutrient leaching thereby pre-venting eco-system damage.

N-P-K

Biochar made from certain types of feedstocks such as poultry litter has material amounts of N-P-K. Biochar made from woody biomass generally does not have any significant N-P-K. When combined with nitrogen fertilizer the efficiency is improved resulting in higher yields and requiring less fertilizer use.

Filtration

The sorptive properties (i.e. ability to attract and hold) of biochar help it to render toxins unavailable to plants. Biochar can help filter storm water and is useful in remediation efforts where toxic chemicals are found such as mine land remediation, fracking, chemical spills, etc.

Microbial Activity

Due to biochar's highly porous and stable nature, It provides an ideal environment for microbes. The amount & diversity of microbial activity in soils is a measure of its quality with higher activity indicating better soil. Adding biochar to compost speeds up the decomposition process due to Increased microbial activity.

PH

Most biochars are alkaline and will therefore help to reduce soil acidity and reduces short term liming needs. For alkaline soils, biochar may have no appreciable impact on yield. Maintaining proper soil ph improves nutrient efficiency and enables strong plant growth.

Organic Material

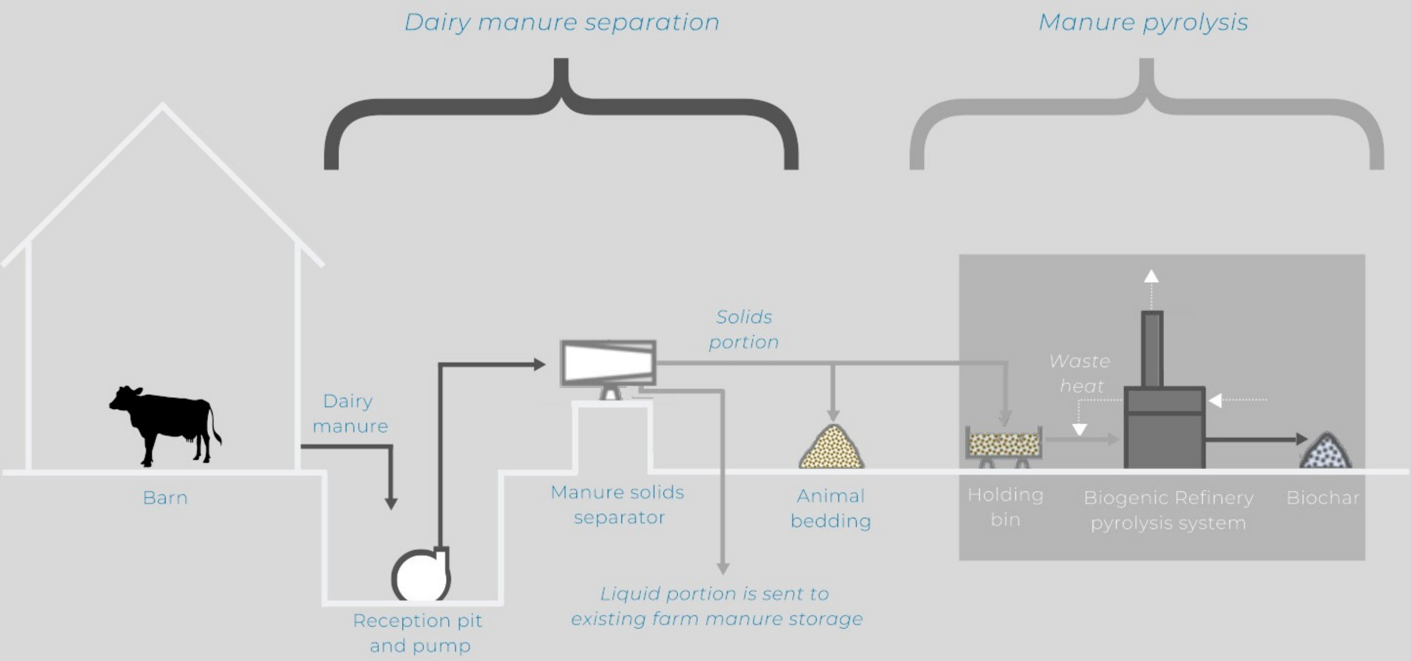
Adds stable carbon to soils which stays in soil for hundreds of years. *Other OM additions (e.g. manure, compost) bio-degrade in a few years.* OM provides energy & nutrients to plants, stabilizes soil structures, improves resistance to erosion. Increased OM improves bioactivity which improves resistance to disease & pests

Bulk Density

Biochar is extremely light weight & highly porous giving it very low Bulk Density (BD). Soils with high BD (e.g. highly compacted soils) have poor root growth, low aeration and inefficient water filtration. Biochar added to compacted soils helps improve these soils functions.

DAIRY MANURE TO BIOCHAR PILOT PROJECT

AN INNOVATIVE APPROACH TO NUTRIENT MANAGEMENT, FARM WASTE REDUCTION, AND GREENHOUSE GAS MITIGATION



Dairy manure separation

Manure pyrolysis

Barn

Dairy manure

Reception pit and pump

Manure solids separator

Solids portion

Liquid portion is sent to existing farm manure storage

Animal bedding

Holding bin

Waste heat

Biogenic Refinery pyrolysis system

Biochar

BENEFITS OF BIOCHAR

- A valuable soil amendment through improved retention of nutrients and water
- Lowers farm's manure storage/hauling costs by reducing the mass and volume of manure waste
- Sequesters greenhouse gases by transforming carbon into a stable form
- Integrates with manure solids separation systems, which provide bedding and manure storage/hauling savings to the farm and greenhouse gas reductions by lowering manure storage methane emissions

PROJECT PARTNERS:

native energy
A Public Benefit Corporation
Burlington, VT

BIOMASS CONTROLS PBC
Putnam, CT

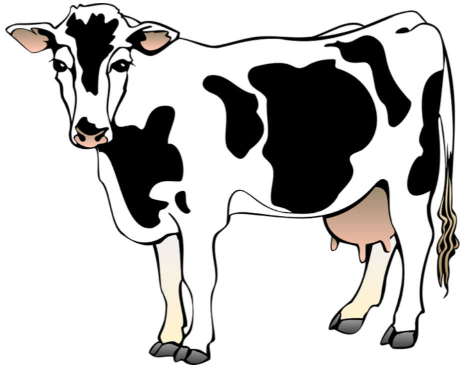
USDA

This work is supported by the Conservation Innovation Grants program at USDA's Natural Resources Conservation Service

Evaluating the economic viability and commercialization potential of on-farm pyrolysis of dairy manure

NEW YORK STATE OF OPPORTUNITY. | NYSERDA Supported

1. Looking for at least seven NY dairy farmers to talk with me about their current manure management and nutrient balance strategies
   - What are some pros and cons of different strategies
   - Distances manure is hauled for spreading
   - Amounts of manure typically spread
   - Costs associated with manure management



2. Will choose one farm to locate a pyrolysis kiln on for three years that would process manure from ~200 cows to make ~170 kilograms of biochar per day (with input of ~500kg/day)
   - The farm must have a separator
   - The farm preferably would have a digester and a dedicated manure management team (so probably a farm with at least 500 cows)
   - The farmer will work with myself and other Cornell staff to use this as a research opportunity and a way to help manage manure in a novel way

Interested in learning more?

Thermochemical Conversion & Biochar Workshop: Opportunities for climate change mitigation, organics upcycling, sustainable agriculture & energy, and economic development in NYS

NEW DATE: MAY 27th

RIT Inn & Conference Center
Henrietta Ballroom
9:00am - 5:00pm

This workshop is designed to bring together researchers, practitioners, and policy makers to discuss the emerging role of thermochemical conversion technologies and conversion byproducts in New York State's comprehensive climate change, clean energy generation, and organic materials management goals.

Register here for the free biochar workshop in Rochester, NY!

We encourage anyone and everyone to attend! If you would like information about possible travel reimbursements contact Shannan (sks289@cornell.edu)

- White paper on Dairy & Biochar due out soon.
- IBI webinar on Dairy & Biochar in April.
- International Biochar Initiative website

Questions?

Contact us!
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