

# Climate Mitigation, Waste Recycling, and Soil Health for NYS Economic Development using Pyrolysis

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**Collaborations with Syracuse University, RIT, CUNY, SUNY**  
**ESF**  
**Private Companies**  
**Farmers**  
**NGO**

# Biochar as a Soil Amendment

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## Carbon Product

Carbon persistence  
Surface area and functional groups  
Electron shuttle and fused arom.

### Soil Health

**GHG reduction + C sequestration**  
**Pollution reduction by leaching  
and gas emissions**  
**Soil remediation**  
**Inoculant carriers**  
**Signaling (plant-plant; plant-MO)**

## Nutrient Product

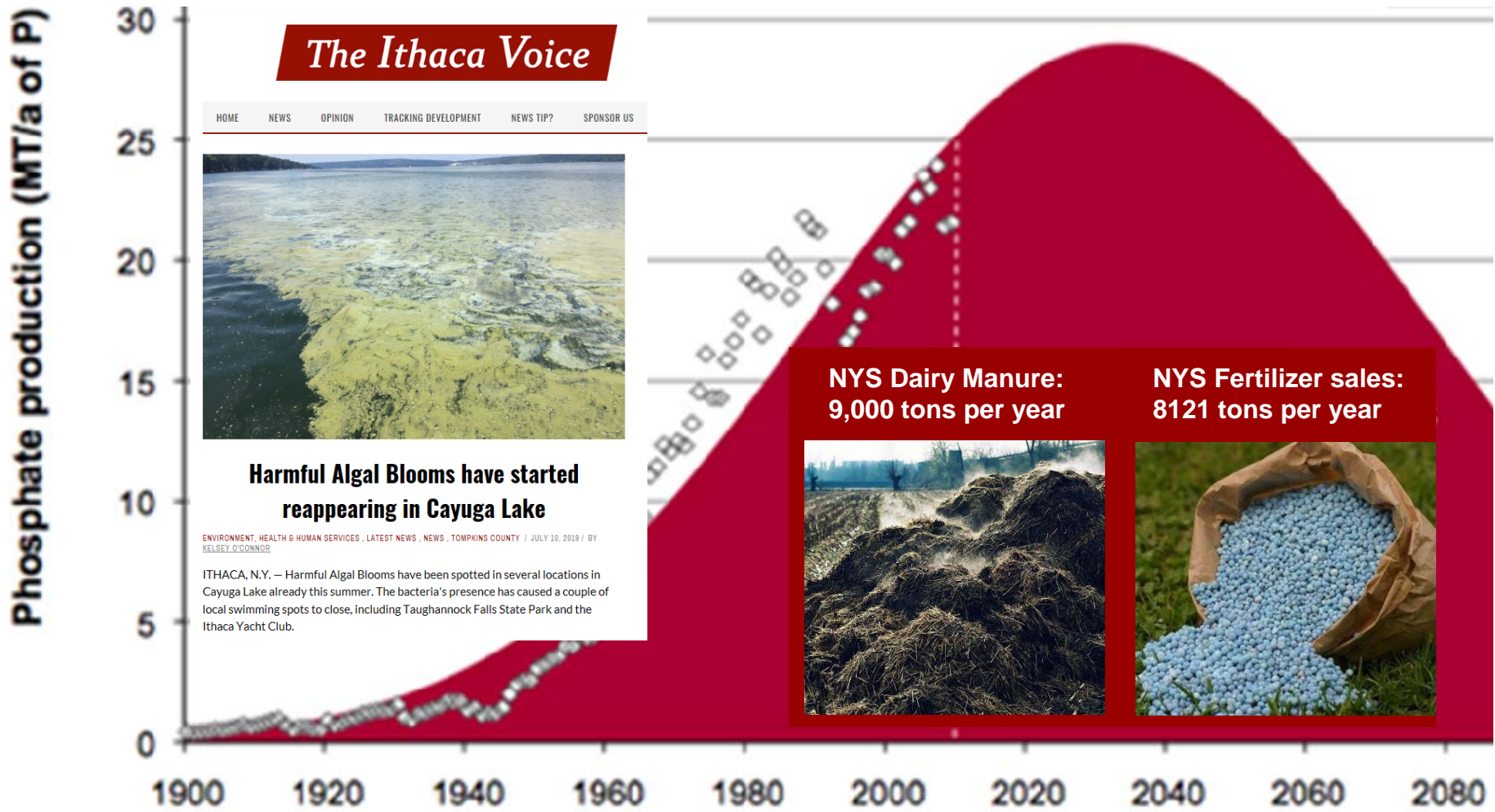
Nutrient enrichment  
Nutrient availability  
Sterilization  
Denaturing of pollutants

### Fertilization

**Pollution avoidance**  
**GHG reduction (+ C sequestration)**



# Global Supplies and New York Phosphate



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Cordell et al. 2011, *Sustainability* 3, 2027-2049  
Ketterings and Czymmek K 2012 *What's Cropping Up*



# Recycling of Dairy Manure using Pyrolysis

No contaminants (heavy metal, PAH, PCB, dioxin/furans, etc.)  
No pollutants from manure (pathogens, hormones, antibiotic)

100 kg liquid dairy manure  
0.1% phosphorus



4 kg biochar  
2% phosphorus



[www.pyrolysis.cals.cornell.edu](http://www.pyrolysis.cals.cornell.edu)

**INNOVATION**  
CENTER FOR U.S. DAIRY  
HEALTHY PEOPLE • HEALTHY PRODUCTS • HEALTHY PLANET



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Enders et al., 2019, Soil Sci Soc Am. Ann. Meeting

# Recycling of Dairy Manure using Pyrolysis

Value as ingredient of potting mix: appr. \$1,900 ton<sup>-1</sup>  
83% from C value  
(as potting mix)

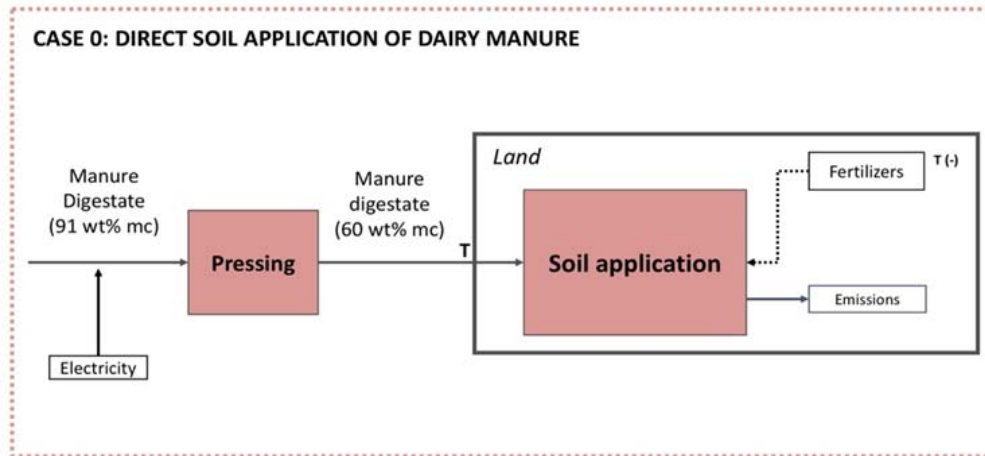
Maximum Potential (NYS per year):  
\$272M value for farmer  
\$1.3B value for retail  
\$114M reduced transportation  
\$4-15M reduced GHG (\$20-80/t CO<sub>2</sub>e)

**Nutrients better available to plants, but less leachable!**

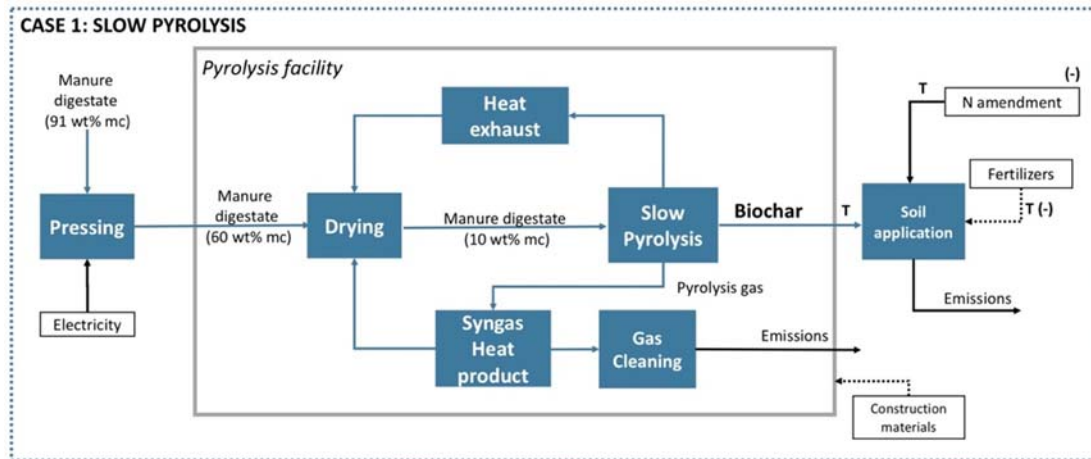
Element	Manure		Biochar		Change due to pyrolysis	
	Leachable	Available	Leachable	Available	Leachable	Available
	mg/kg	mg/kg	mg/kg	mg/kg		
Phosphorous	409.8	4505.9	35.8	5088.2	-91%	13%
Potassium	7372.8	8114.2	9399.9	12891.2	27%	59%
Calcium	31257.5	80671.0	33720.8	142276.8	8%	76%
Magnesium	2785.9	6578.6	291.1	7654.5	-90%	16%



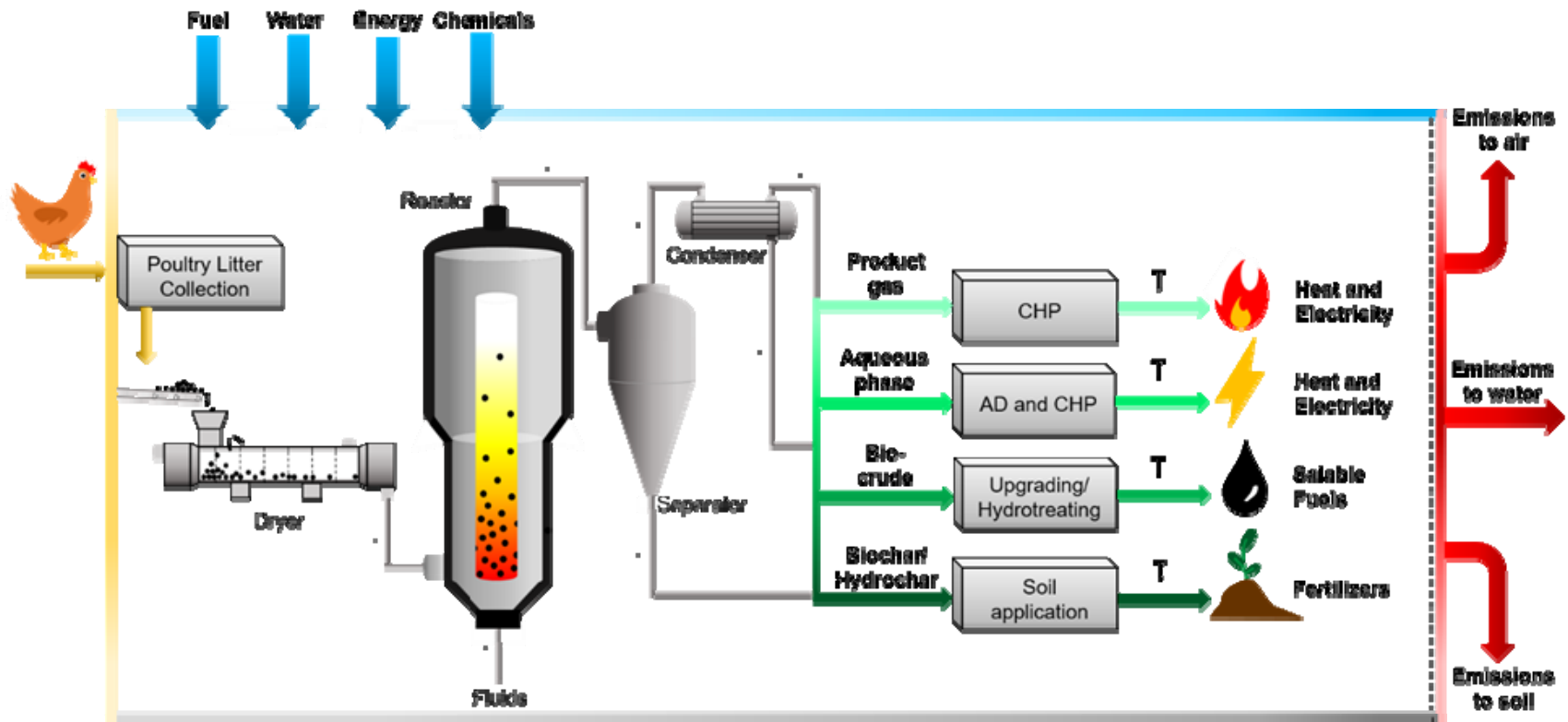
# Dairy Manure Processing-Life Cycle Analysis



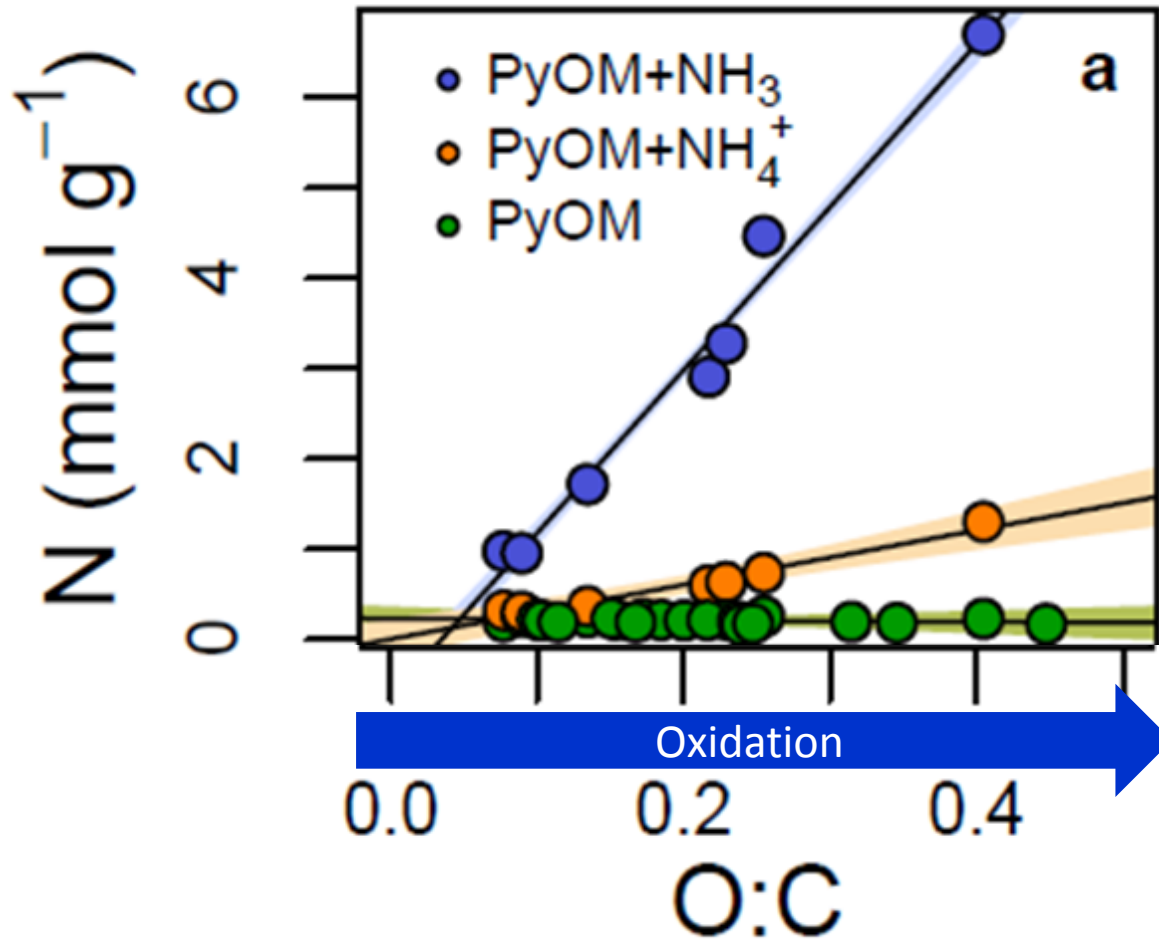
Alternatives to storage and direct soil application of dairy manure digestate



# Poultry Litter Processing

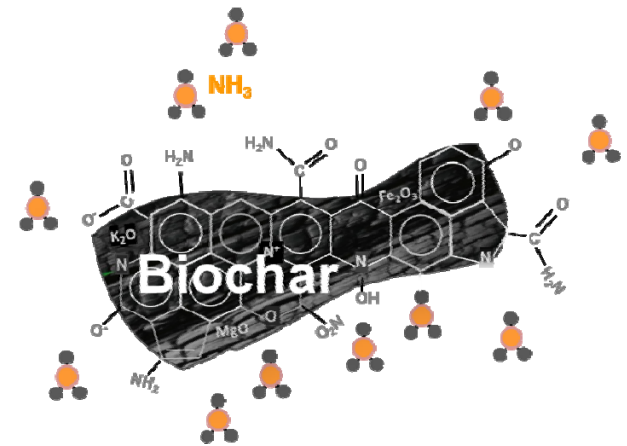


# Ammonia Capture with Biochar



Up to 18% N in biochar  
(more than dairy manure)

- Less odor
- Better N recycling
- Fewer nitrates in lakes



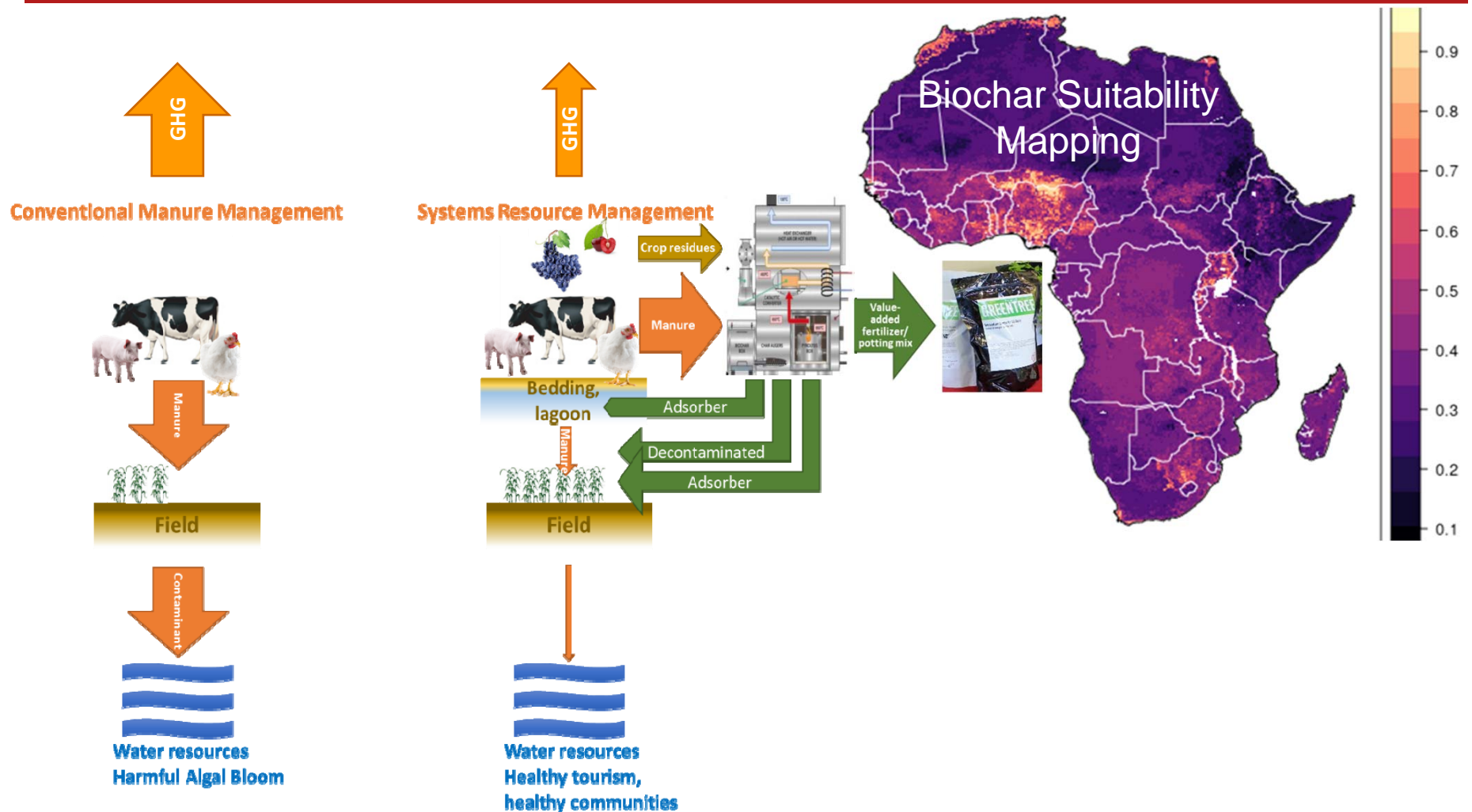
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Hestrin et al, 2019, *Nature Communications* 10, 664

Krounbi et al., submitted

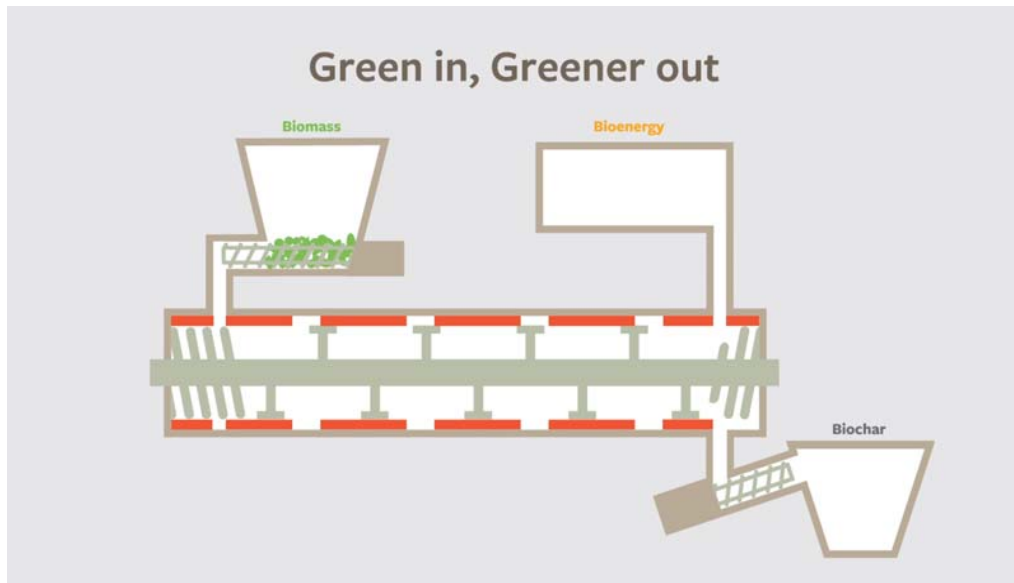


# Biochar Management in NYS – where to next

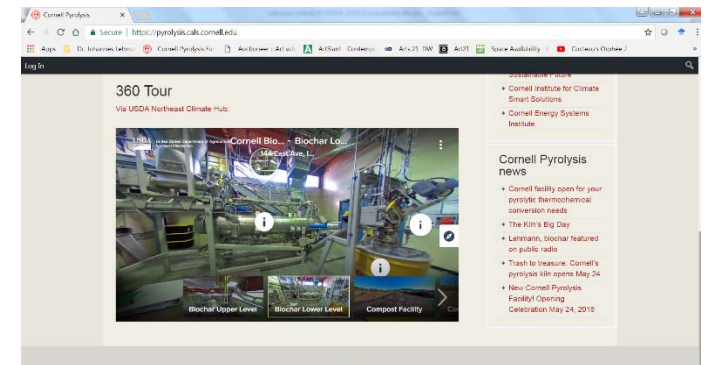
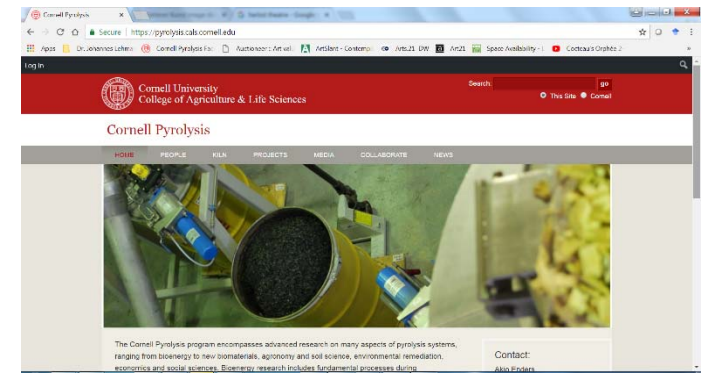


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# Cornell Pyrolysis Facility – NYS Resource



[www.pyrolysis.cals.cornell.edu](http://www.pyrolysis.cals.cornell.edu)



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