



# MONTEREY PACIFIC



# Biochar



# Why Use of Biochar is Attractive for Farming

- Increases water holding capacity of soil, increasing crop tolerance to drought by increasing the ability of soils to retain water and nutrients.
- Increases soil capacity to absorb chemicals and minerals, providing nutrients to plants rather than being lost to groundwater (eg. absorbs phosphate)
- Biochar still contains most of the nutrients in the feedstock and will release these nutrients over time
- Biochar is a relatively low density material that helps to lower the bulk density of heavy soils, increasing drainage, aeration, and root penetration.
- Biochar is a liming agent that will help offset the acidifying effects of N fertilizers, thereby reducing the need for liming.
- Soil incorporation improves resource use by soil biota, creating healthier soils

# Current Drawbacks to Increased Biochar Use in Agriculture

- Limited availability
- High cost (due to biochar scarcity and transport of feedstocks)
- Lack of comprehensive knowledge re biochar benefits
- Similar manufacturing methods can still produce a variable product
- Farmers grow their own carbon, so are reticent to purchase carbon as a fertilizer
- Sometimes advertised as such, but not a silver bullet

# How Biochar use in Ag can reduce GHG

- Avoiding the emissions from biomass decomposition at land fill sites.
- Avoiding emissions from burning of ag waste
- Biochar is a stable form of carbon and will remain in the soil for many hundreds of years (effective sequestration).
- $N_2O$  and  $CH_4$  emissions from soil can be reduced by biochar application.
- Reduced emissions associated with fertilizer usage, less N and P lost
- The energy produced in the pyrolysis process is 2-4x what it takes to make it

# How to Increase Biochar Use in Ag

- Utilize abundant local sources of carbon for pyrolysis – agricultural and woody waste
- Focus on high value crops with a long-term payback
- Develop biochar standards and testing (IBI)
- Develop standardized trials to test feedstocks/pyrolysis so benefits can be confirmed
  
- Credits of some kind for biochar use?
- Bring biochar production to the local level

# Solution: Mobile Pyrolysis Plant that follows the feedstock





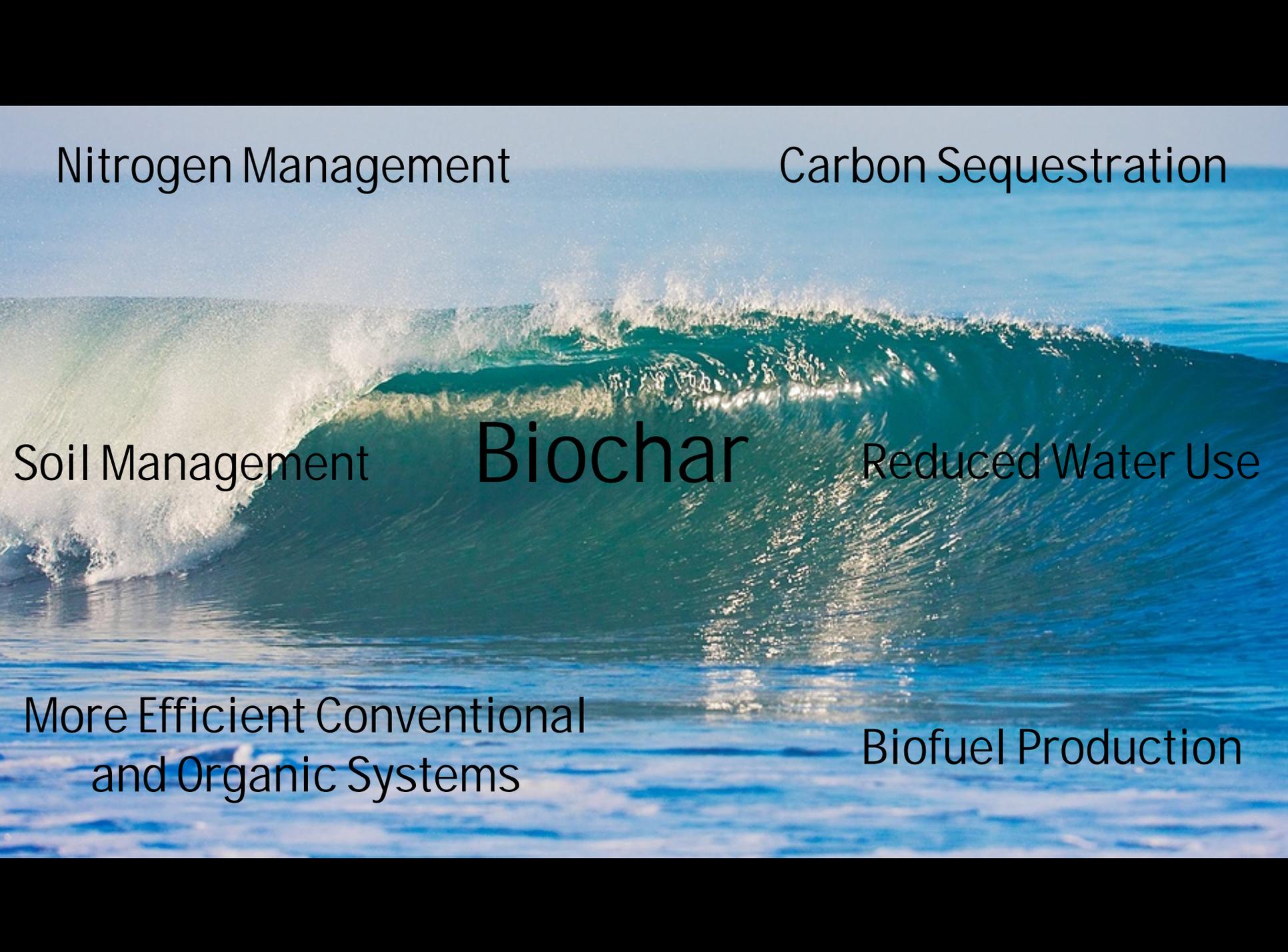
# Immediate applications for use of mobile pyrolysis



½ mile long, 80 year old eucalyptus windbreak along Hwy 101 to be removed by CALTRANS in 2015 (alongside ranch managed by MPI)

A photograph showing a dirt path or road winding through a dense thicket of dark, leafless or sparsely-leaved trees and bushes. The sky is filled with heavy, grey clouds, with some light breaking through near the horizon. The overall scene is somewhat somber and overcast.

**Salinas River channel removal of invasive woody weeds for improved flow and flood control 2015-?**



Nitrogen Management

Carbon Sequestration

Soil Management

Biochar

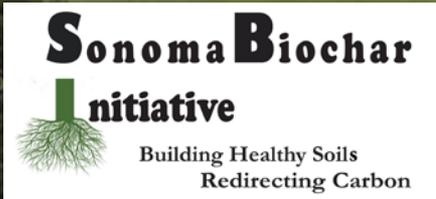
Reduced Water Use

More Efficient Conventional  
and Organic Systems

Biofuel Production

# Biochar for Water Conservation

Environmental Farming Act Science Advisory Panel  
Meeting - December 19, 2014



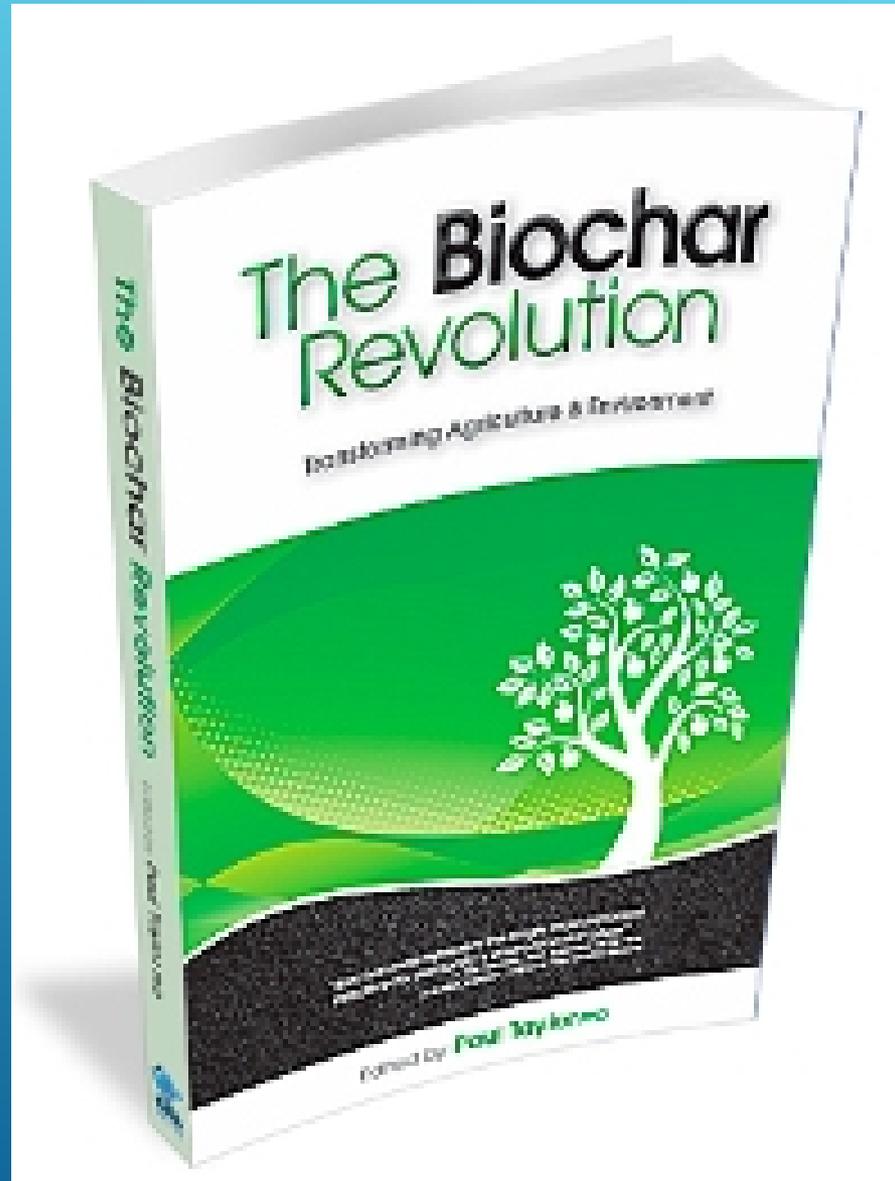
Peter Hirst  
Sonoma Biochar Initiative  
New England Biochar LLC

















Triple Adam  
Retort at  
Living Web  
Farm, NC

13-Foot tall  
tomatoes in  
second set: 22lbs  
per plant to date,  
Nov 12, 2013





2012 US Biochar Initiative National Conference - Sonoma State University

CAFF Workshop  
at Santa Rosa  
Junior College  
Shone Farm



SBI Workshop  
Circle Bar Ranch  
Carneros



Inaugural Session of The Biochar School  
November 7th-11th / Swallow Valley Farm  
Valley Ford, California

Photo: Raymond Baltar





Swallow Valley Farm  
Valley Ford



Green String Farm  
Petaluma



Oak Hill Farm  
Glen Ellen

NASA calculates that it will take 11 trillion gallons of water to turn this red patch blue again.



**“Field trials are a potentially  
powerful communication tool . . .”**

--Field Trials as an Extension Technique:  
David G. Ablor, Ganesh P.  
Rauniyar, and Frank M. Goode, 1992

A decorative graphic consisting of several parallel white lines of varying lengths, slanted diagonally from the bottom right towards the top right, set against a blue gradient background.



**Rick Green, 3d  
generation family  
rice farmer,  
Willows**

**Biochar compost trials  
finding faster rates of  
maturation**





USDA

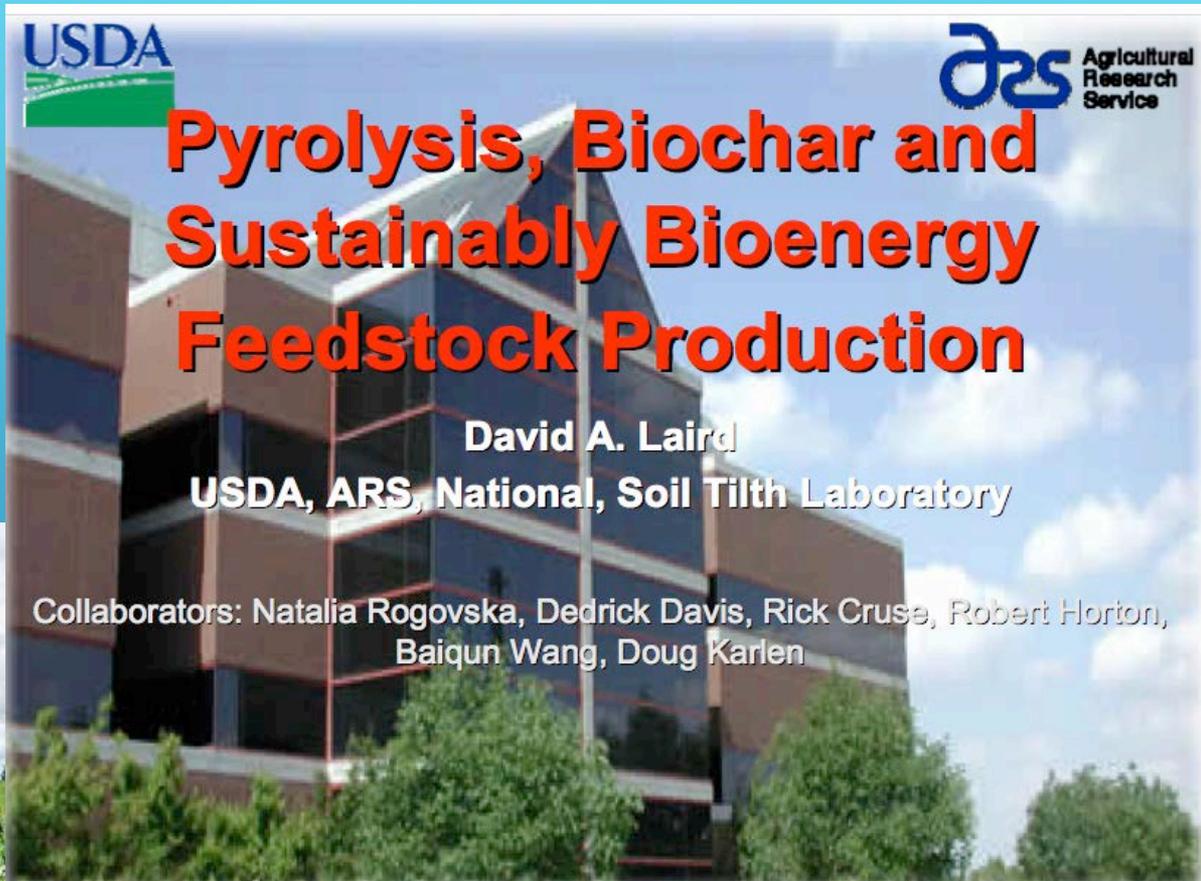
ARS  
Agricultural  
Research  
Service

# Pyrolysis, Biochar and Sustainably Bioenergy Feedstock Production

David A. Laird

USDA, ARS, National, Soil Tilth Laboratory

Collaborators: Natalia Rogovska, Dedrick Davis, Rick Cruse, Robert Horton,  
Baiqun Wang, Doug Karlen



# CA Suppliers/Consultants

- Greenleaf Energy, Scotia Biomass Plant
  - New England Biochar LLC, Valley Ford
  - Pacific Biochar, Willows
  - Blue Sky Biochar, Thousand Oaks
  - Phoenix Energy, Merced, Modesto, Cabin Creek
  - Cool Planet Energy, Camarillo
  - Charborn, Santa Barbara
  - BioCharm, San Rafael
  - Full Circle Biochar, San Francisco
  - Sonoma Compost, Petaluma
- 

# CA Labs- Biochar

Dr. Sanjai Parikh, Environmental Soil Chemistry, UCD

Dr. David Smart, Oakville Station, UCD

Frank Shields-Soil Control Lab, Watsonville

reNUWit Research Center, Stanford University

Dr. Gerardo Diaz, Dept. of Engineering, UC Merced

A decorative graphic consisting of several parallel white lines of varying lengths, slanted diagonally from the bottom right towards the top right, located in the lower right corner of the slide.

- SBI-Sonoma County Biochar Project
  - Southern CA Biochar Initiative, Thousand Oaks
  - Rick Green, 3d gen family rice grower, Willows
  - City of Manteca & MUSD - Teaching Farm
  - Steve McIntyre - Monterey Pacific
  - Bob Cannard/Alice Waters- Green String Farm
  - Redwood Forest Foundation Inc., Usal Forest,  
Mendocino
  - Randall Grahm, Bonny Doon Vineyards
  - Regenerative Design Institute, Penny Livingston,  
Bolinas
  - Dixon Ridge Farms, Winters
- 

"As most biochar research has been conducted at the laboratory- or bench-scale, large-scale field applications of biochar practices and technologies are needed..."

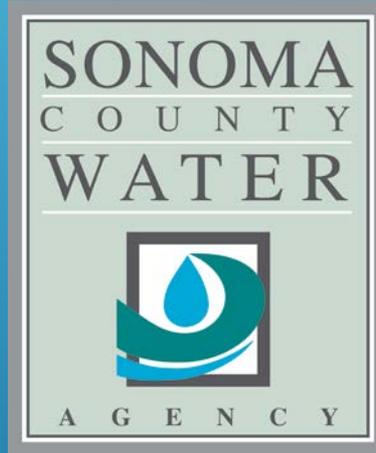
Eric Byous, Physical Scientist, Water Efficiency  
Sustainable Infrastructure Office, USEPA, Region 9

A decorative graphic consisting of several parallel white lines of varying lengths, slanted diagonally from the bottom right towards the top right, located in the lower right corner of the slide.

**“The country needs and, unless I mistake its temper, the country demands bold, persistent experimentation. It is common sense to take a method and try it: If it fails, admit it frankly and try another. But above all, try something.”**

**-Franklin Delano Roosevelt-**

Oglethorpe University Commencement Address  
22 May 1932



# Biochar Systems: Climate Mitigation and Soil Fertility Management

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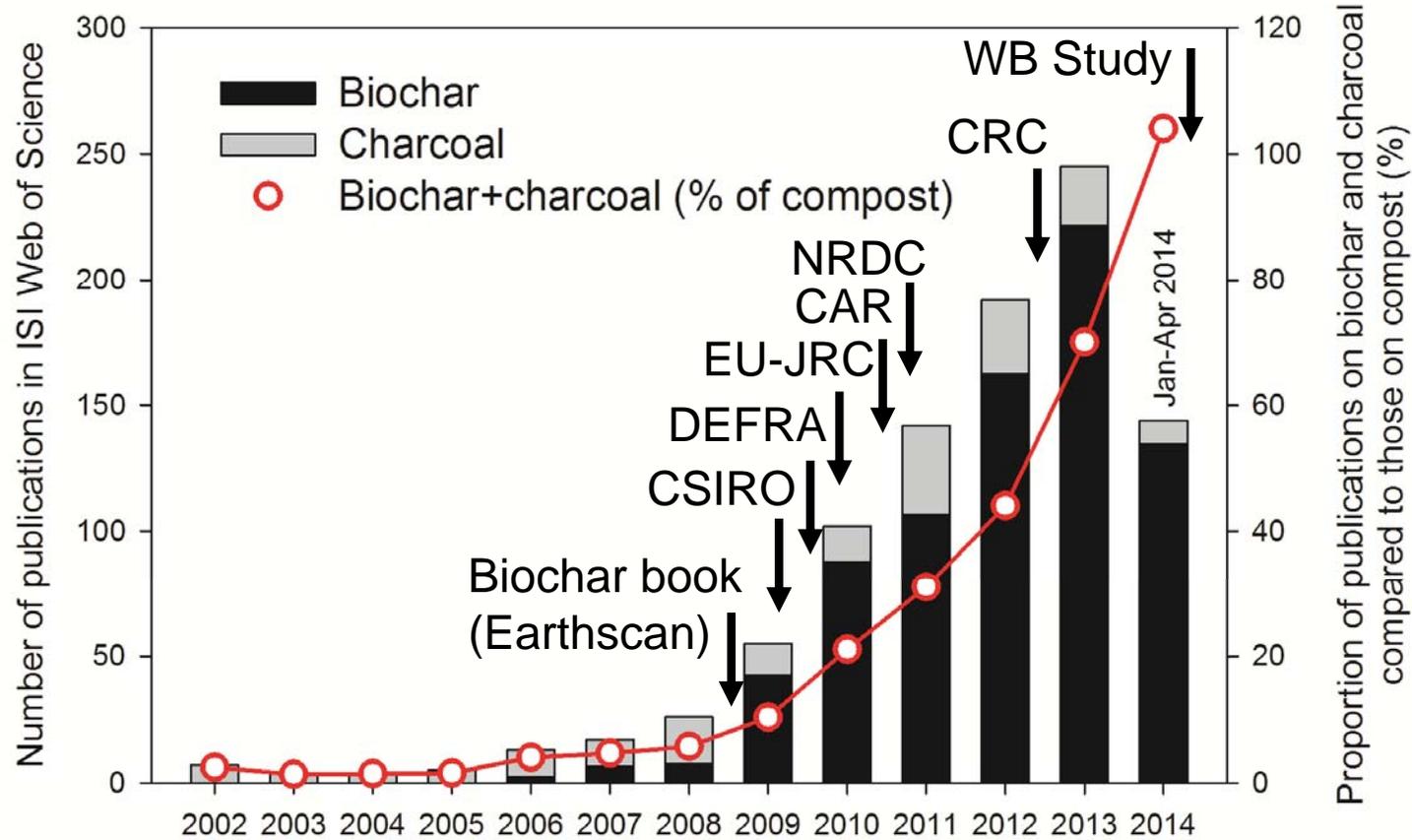
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**Johannes Lehmann**  
*Cornell University*  
*International Biochar Initiative*



International Biochar Initiative

# Biochar Science over the Past Decade



**Biochar research has accelerated over the past 5 years**

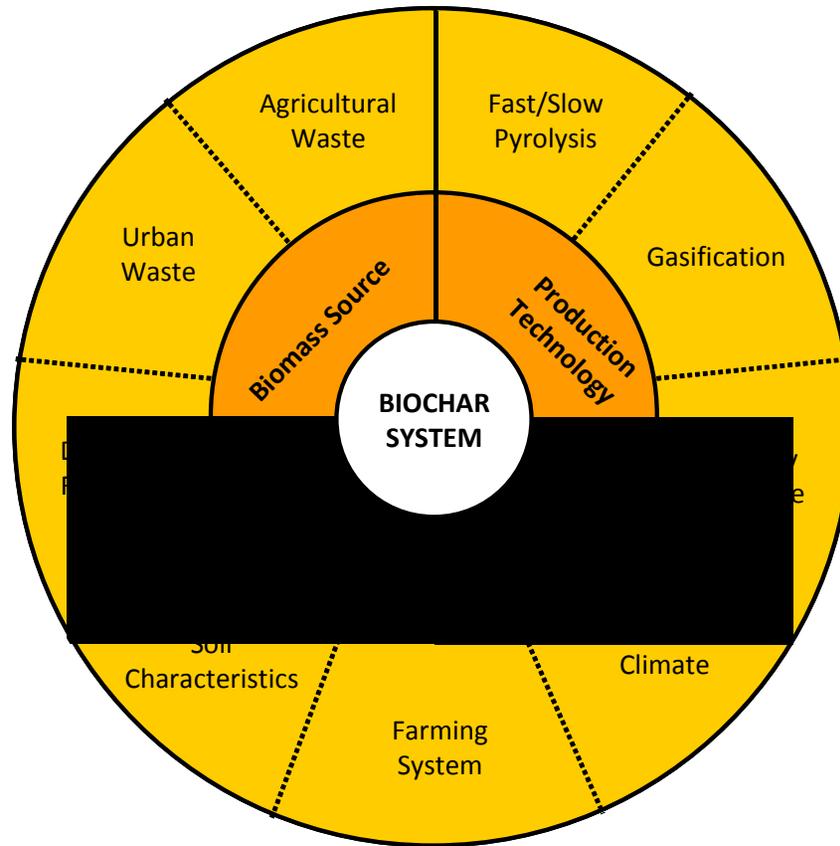


Cornell University

Lehmann and Joseph, 2015, *Earthscan*

# Biochar Systems

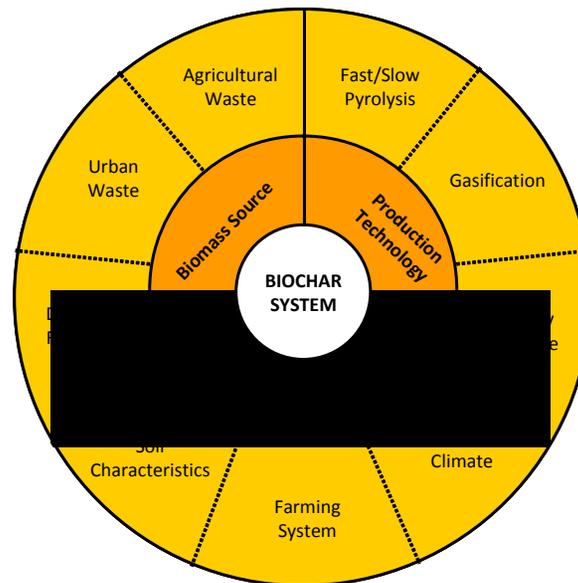
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# Biochar ≠ Biochar

## Biochar system ≠ Biochar system



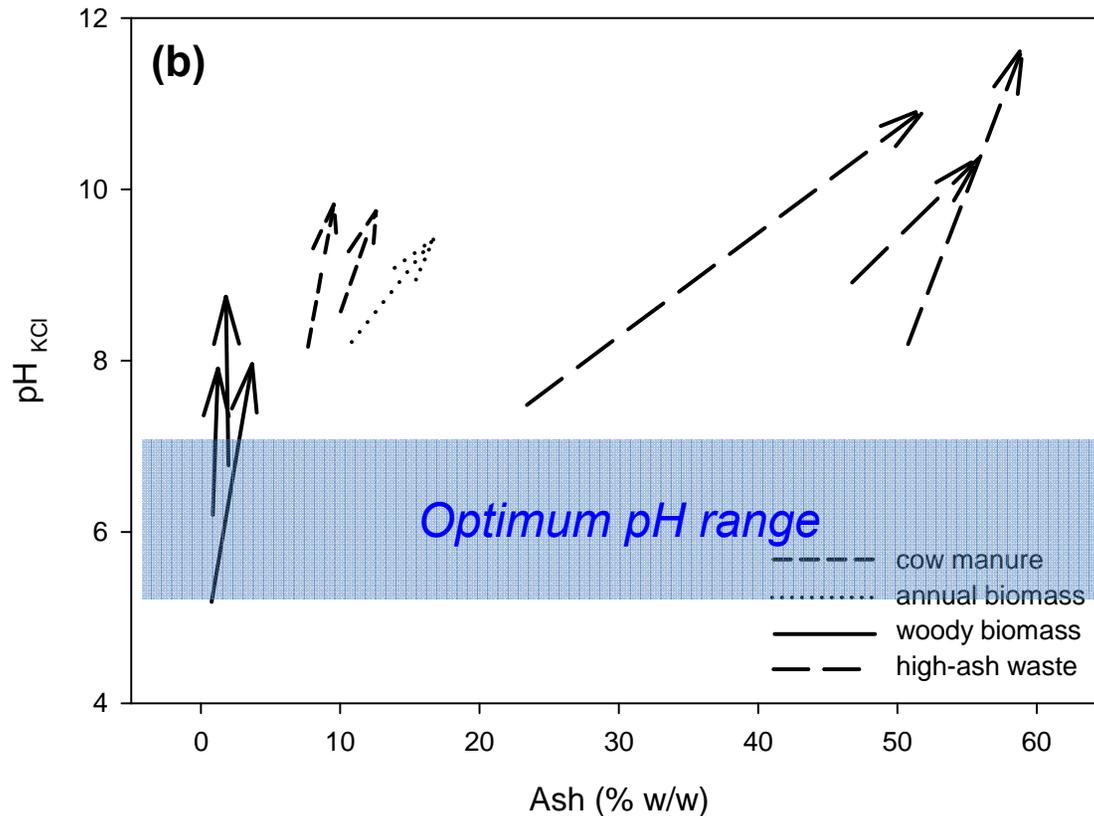
# Key Biochar Properties

	Other organic amendments	Biochars
Persistence (MRT)	weeks to years	years to millenia
Water retention	↑↑↑	↑↑↑
Nutrient retention	↑↑↑	↑↑↑↑ (after oxidation)
Plant diseases	↓↓↓	↓↓↓
Nutrient additions	↓ to ↑↑↑	↓ to ↑↑↑↑
Liming effect	↓	↓ to ↑↑↑
Pollutant remediation	↓ to ↑	↓ to ↑↑↑↑↑

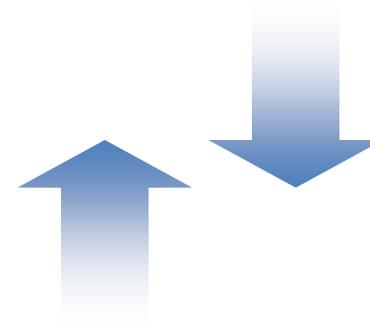
“Tunable”  
Not fully combinable (trade-offs)



# Biochar Properties



Arrows from lowest to highest temperature within a given feedstock



**Example pH: biochars can be generated with pH above or below optimum soil pH – opportunity for tuning biochar to soil needs (within limits)**

Slow pyrolysis

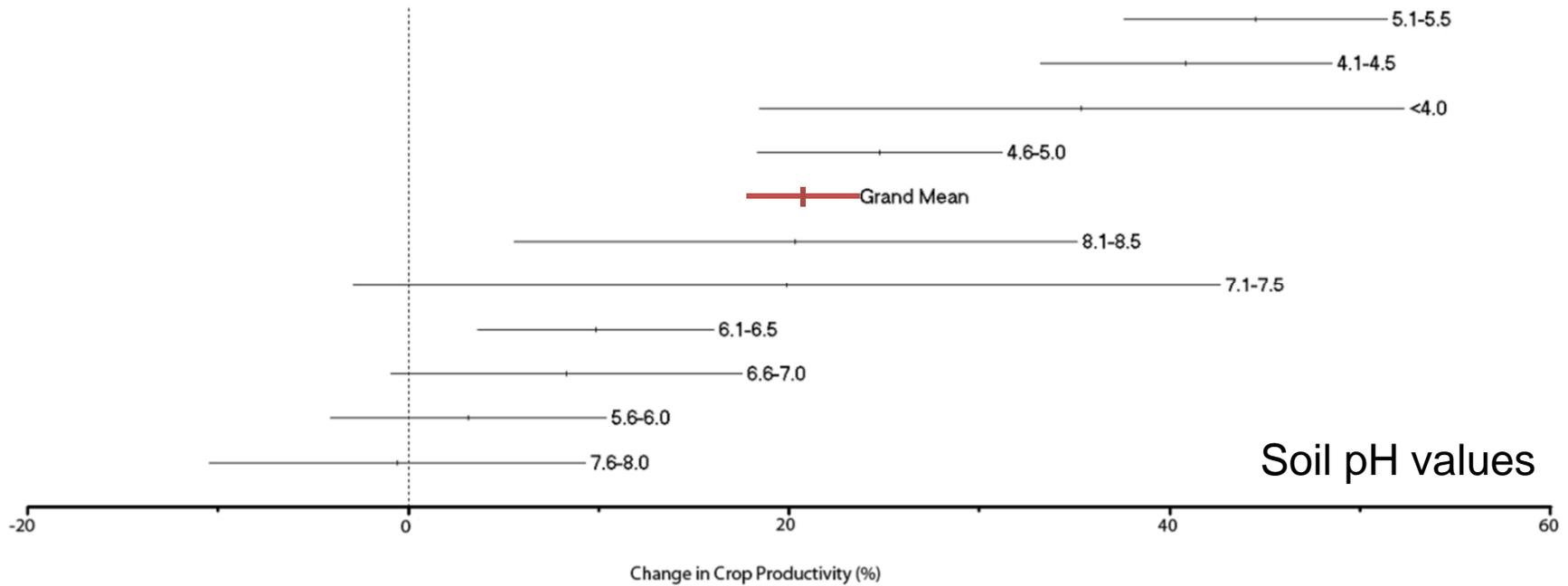


Cornell University

Enders et al., 2012, Bioresource Technology 114, 644-653

# Yield Effects of Biochars

## Meta-analysis



(n=60 studies)

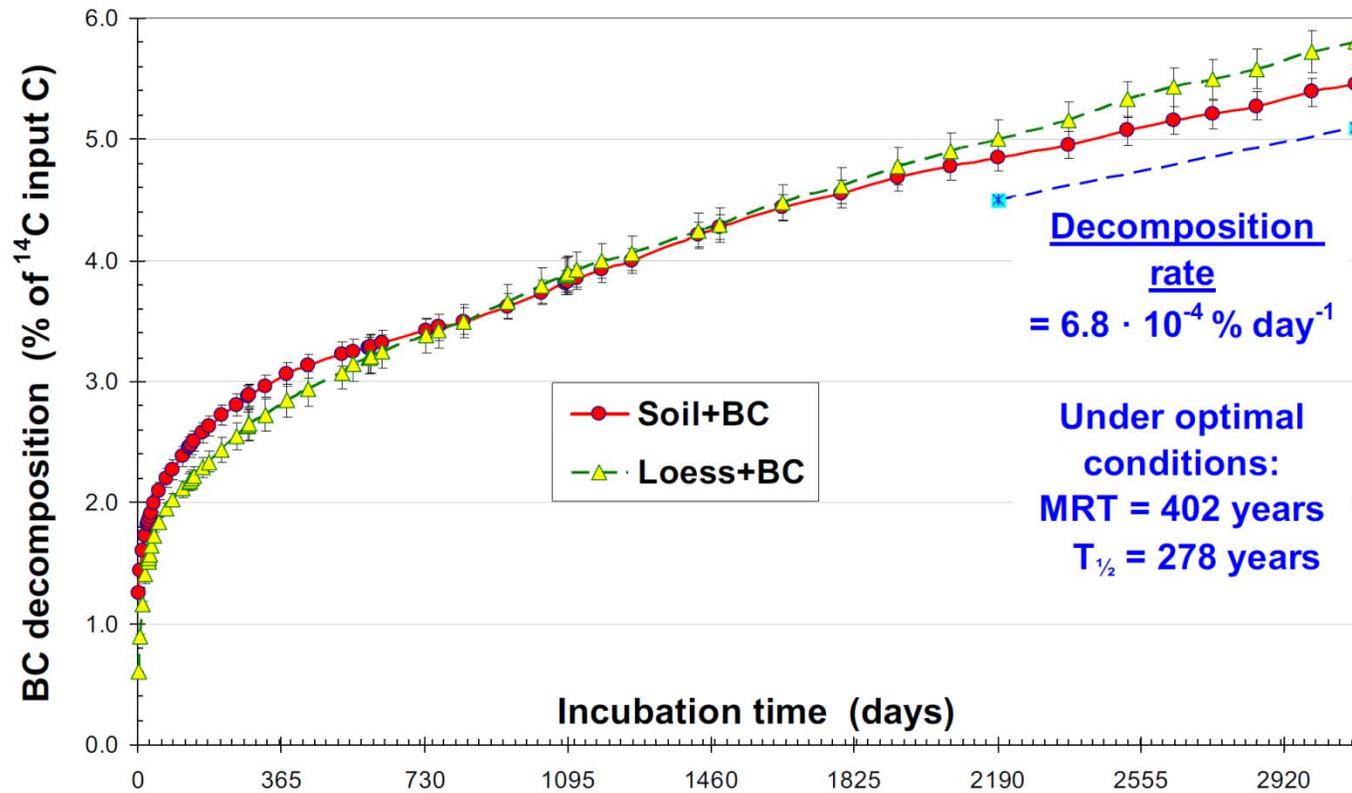


Cornell University

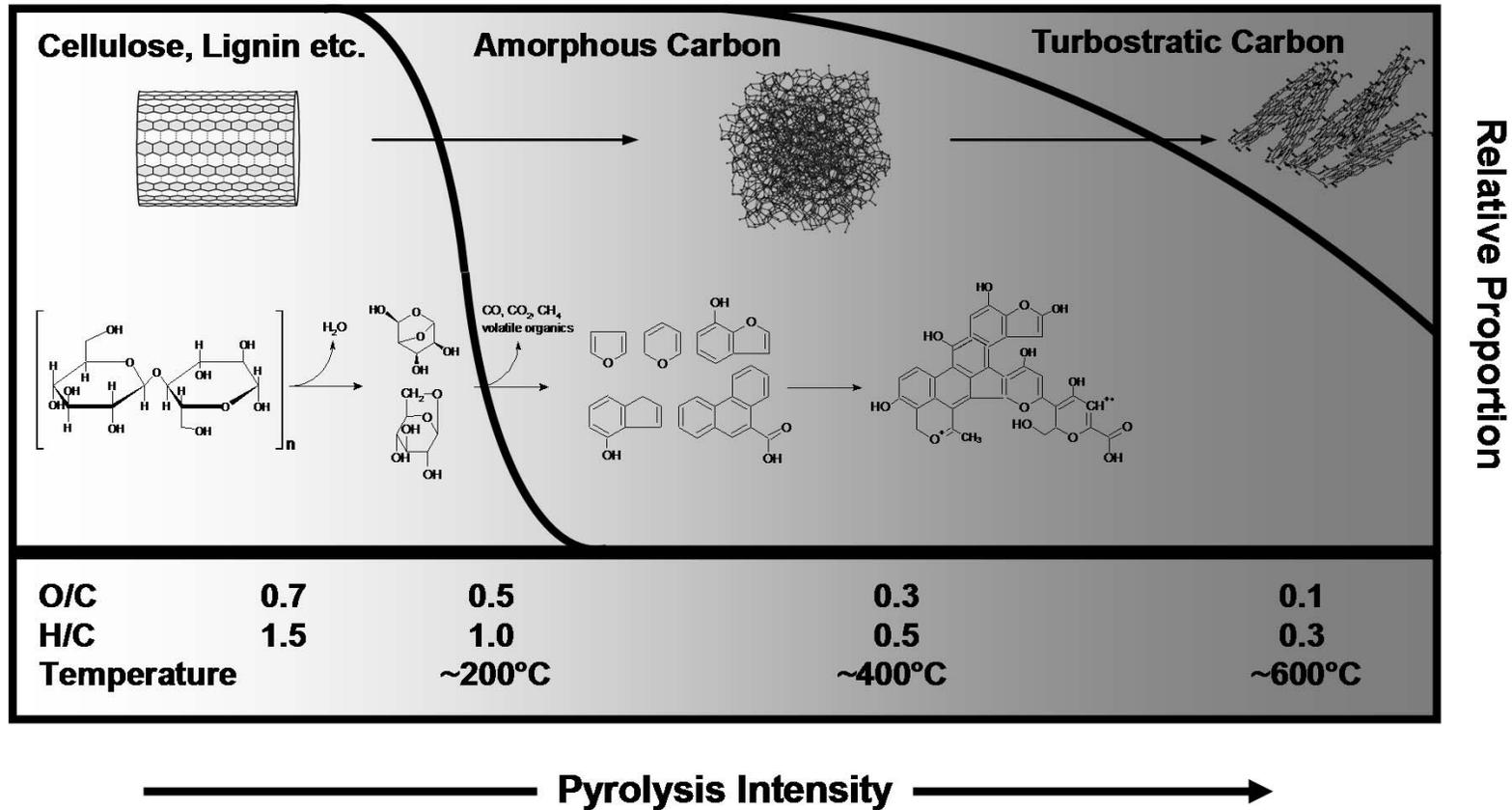
Jeffery et al, 2015, *Earthscan*

# Biochar Persistence in Soil

Mean residence time of 400 years under optimum water and temperature  
(calculated to 4,000 years in the field)



# What happens during Pyrolysis?



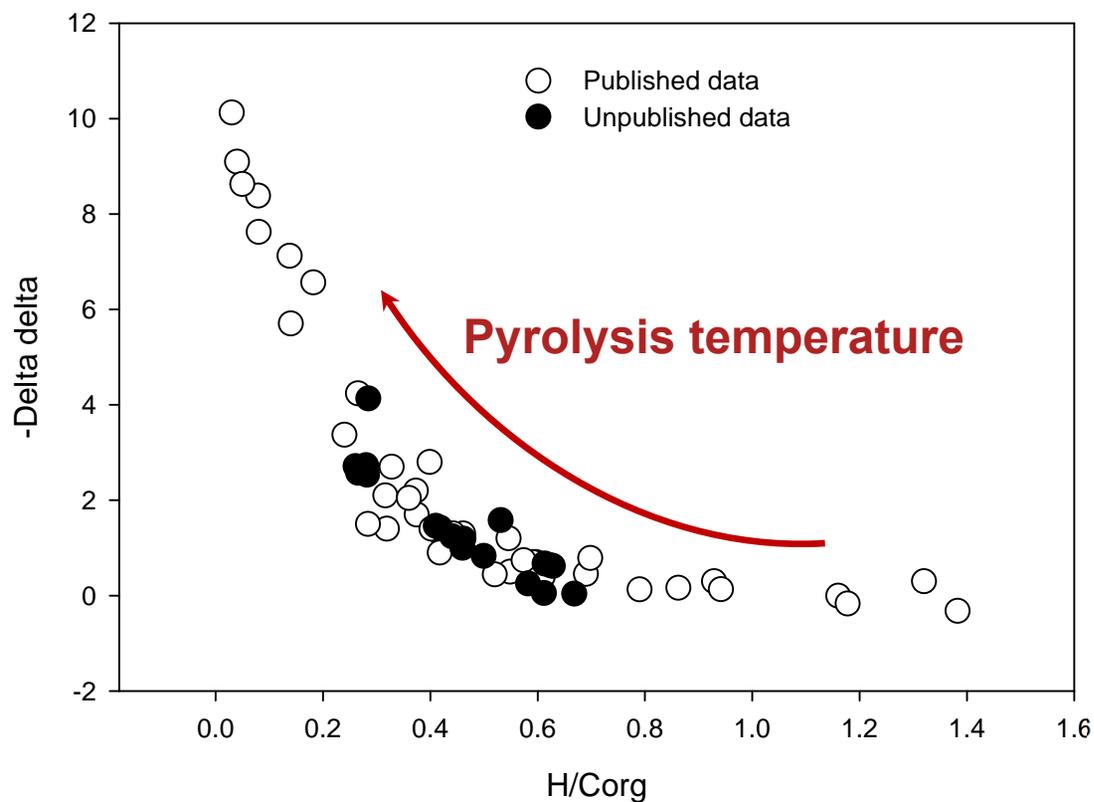
Relative Proportion



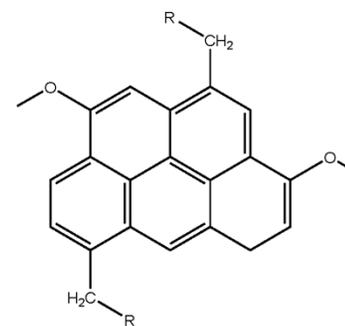
Cornell University

Lehmann et al., 2010, in: Imperial College Press, London

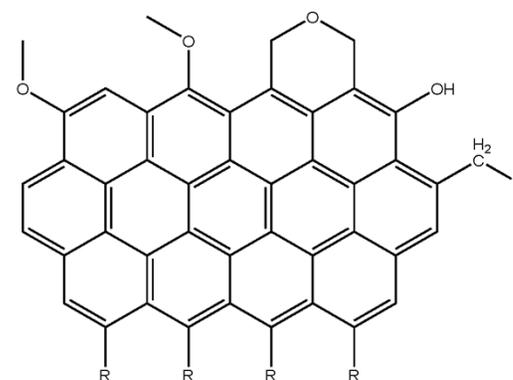
# H/Corg as a Proxy for Fused Aromatic C



Corn-350-BC



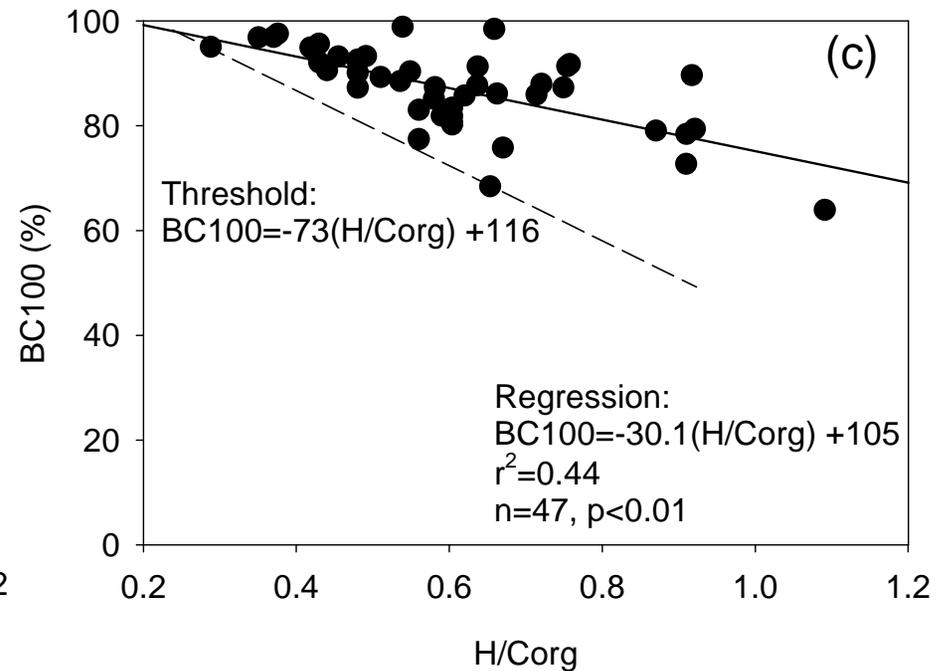
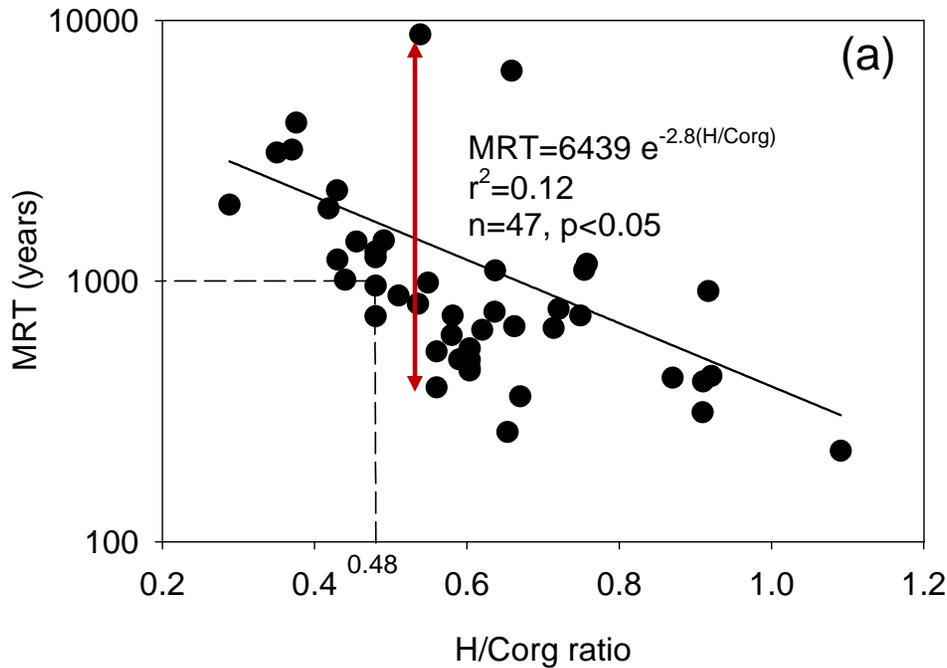
Corn-600-BC



Cornell University

Nguyen et al. 2010, ES&T  
McBeath and Smernik, 2009, OG  
McBeath et al., 2011, OG  
Sydney Expert meeting 2014, unpubl.

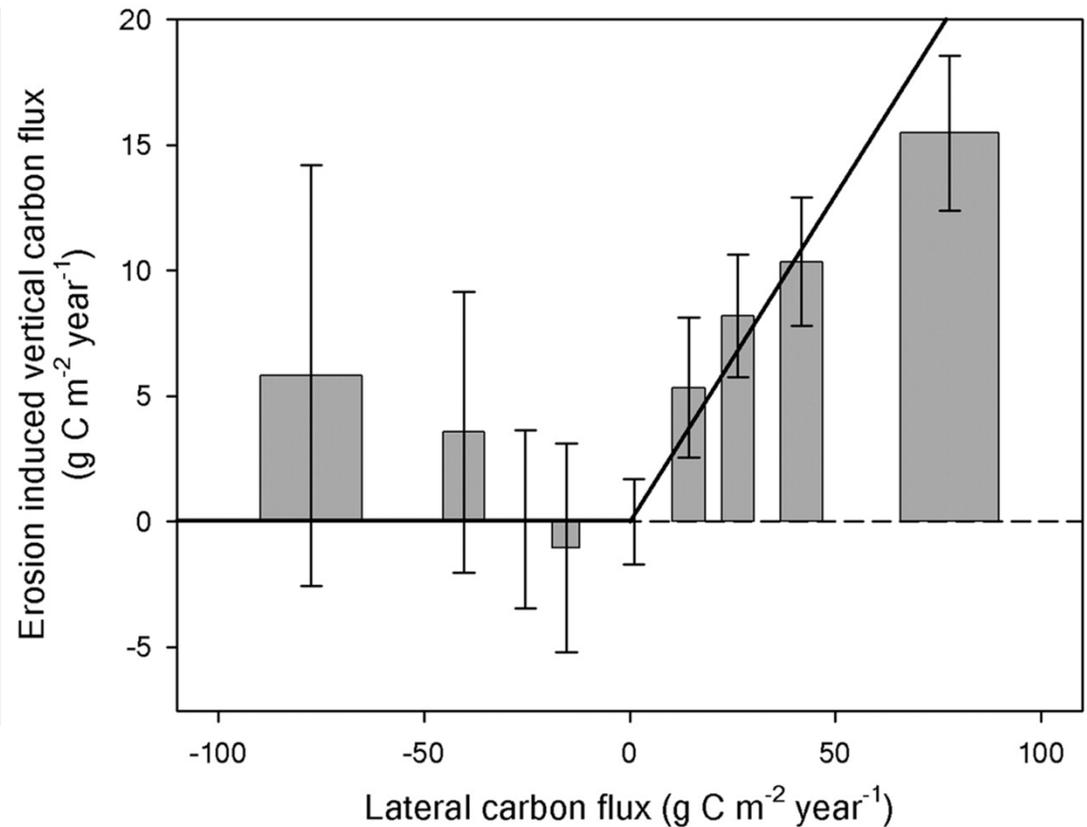
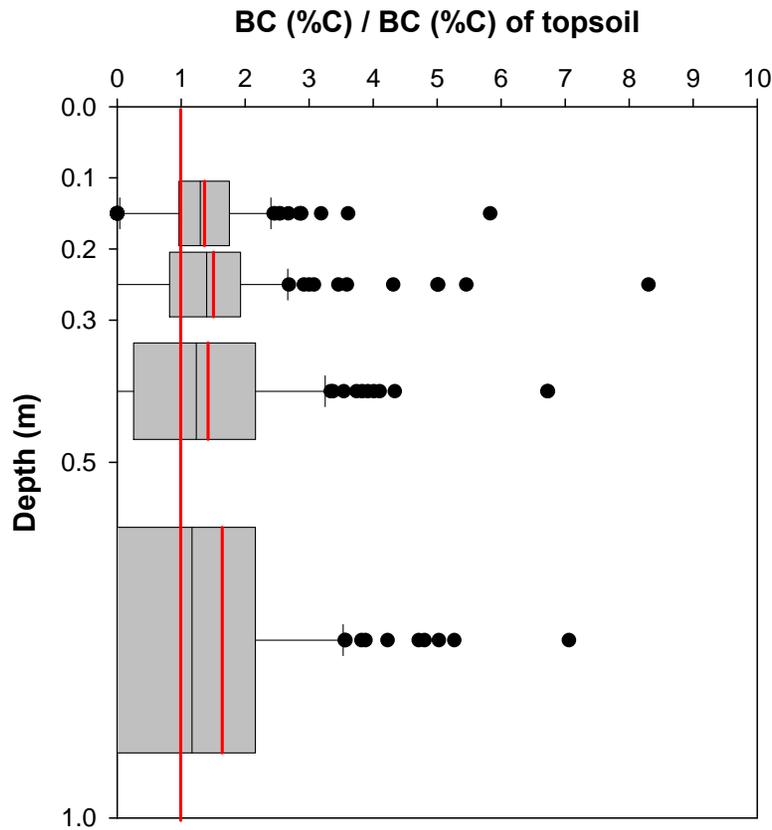
# Biochar Persistence in Soil



- Biochars with low H/Corg ratios have high persistence**
- Biochars made at >500°C from wood have H/Corg < 0.48**
- Biomass has H/Corg > 1.4**
- Very conservative, includes field and laboratory experiments**



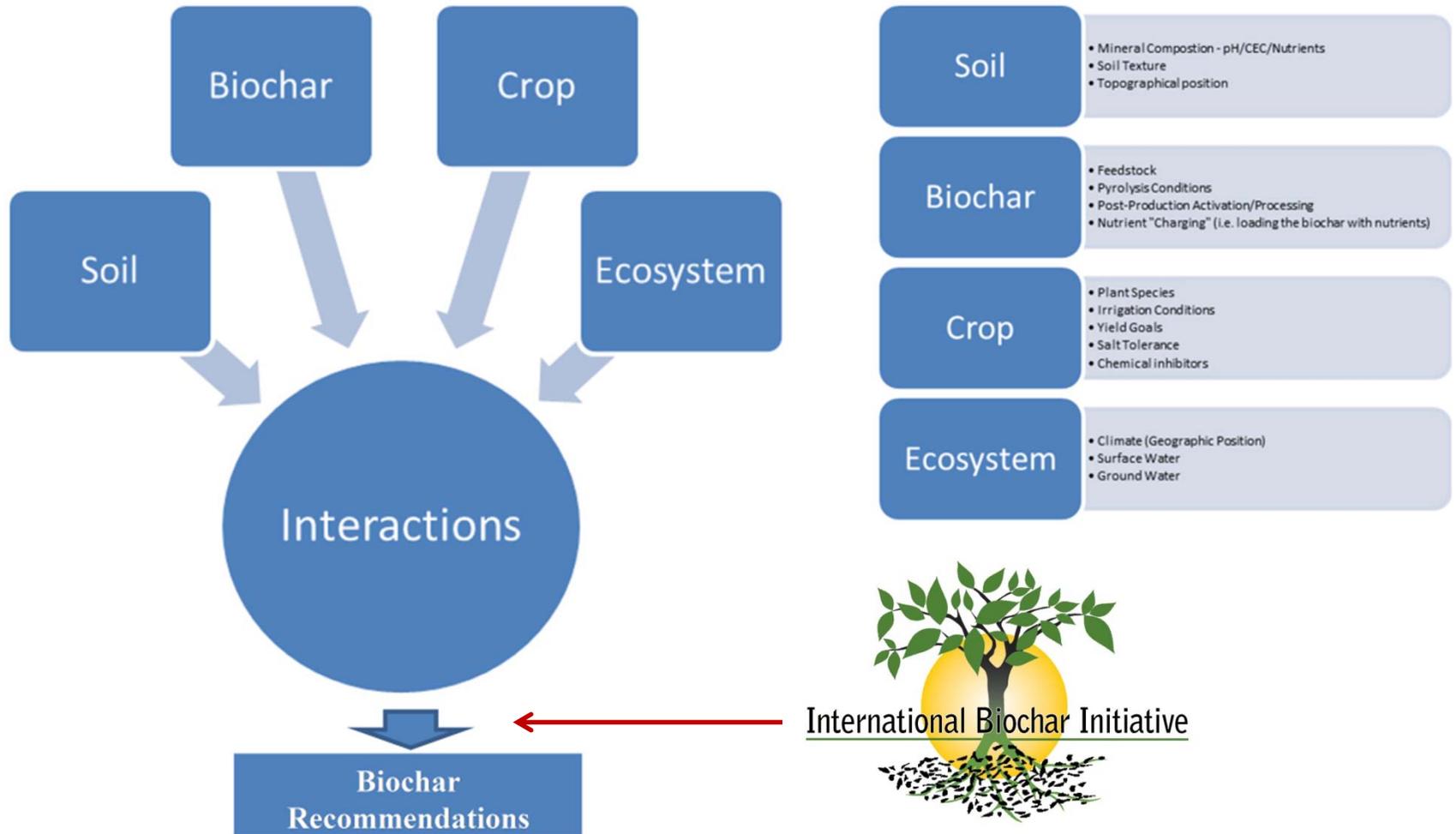
# Movement ≠ Mineralization



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Van Oost et al., 2007, Science 318:626-629  
Disaggregated from  
Lehmann et al., 2008, Nature Geo. 1: 832-835

# Biochar Decision System



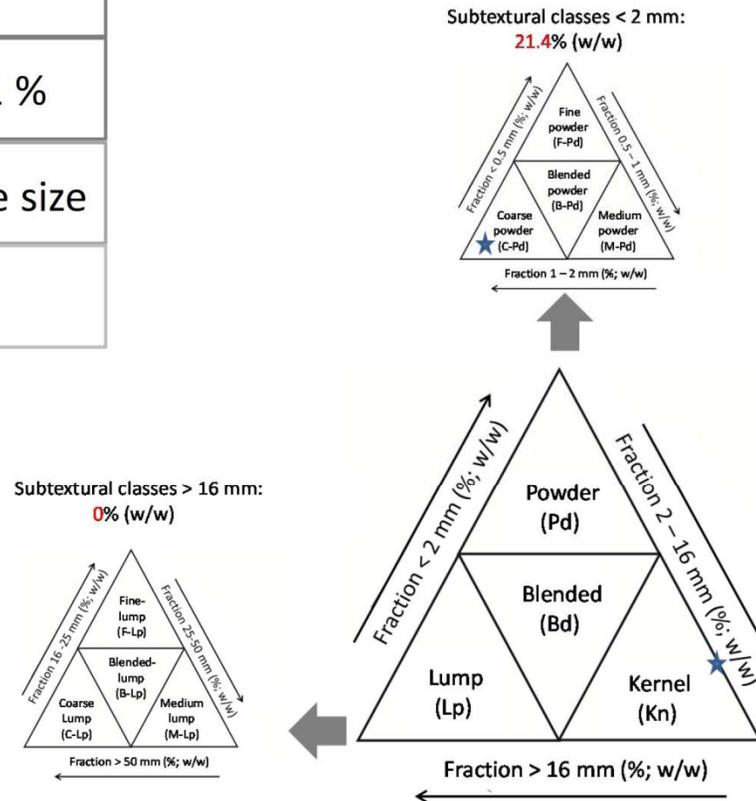
# Biochar Decision System

Carbon storage classes	1	$sBC_{+100} = 240 \text{ g kg}^{-1}$
Fertiliser classes	2	$P_{3t} \text{ Mg}_{9t}$
Liming classes	3	$\text{Liming}_{\text{eq}} 15.1 \%$
Particle size classes	Kn	Kernel particle size
Suitability for soilless agriculture		Not tested

Example: Biochar from biosolids mixed with eucalyptus wood produced at 550°C

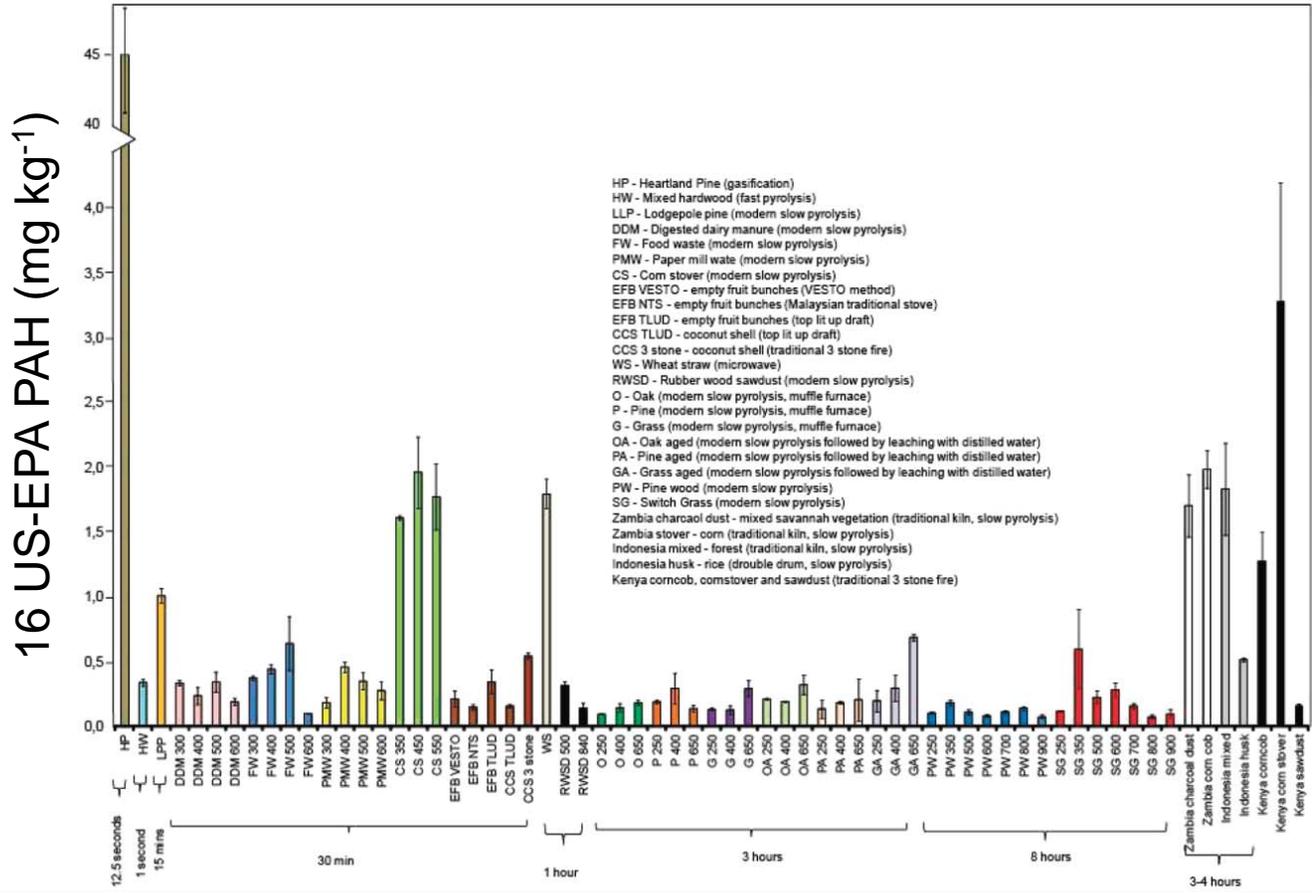
**FERTILISER GRADE**

Total N = 1.66%	Avail. N/total N = 4.6%
Total $P_2O_5$ = 11.60%	Avail. P/total P = 36.4%
Total $K_2O$ = 0.84%	Avail. K/total K = 53.6%
Total S = 0.21%	Avail. S/total S = 34.9%
Total MgO = 0.52%	Avail. Mg/total Mg = 79.3 %
Total CaO = 3.22%	Avail. Ca/total Ca = 84.5 %



# Biochar Toxins

Heavy metal in = heavy metal out, but for PAH:



PAH (mg kg<sup>-1</sup>):

Australian regulation on soil amendments: 300

Cattle manure slurries: 87–309  
 Pig slurries: 66–339  
 Sewage sludge: 1.7–126  
 Compost: 0.8–2.7



Cornell University

Hale et al, 2012, *ES&T* 46, 2830–2838

# Guidelines and Certification

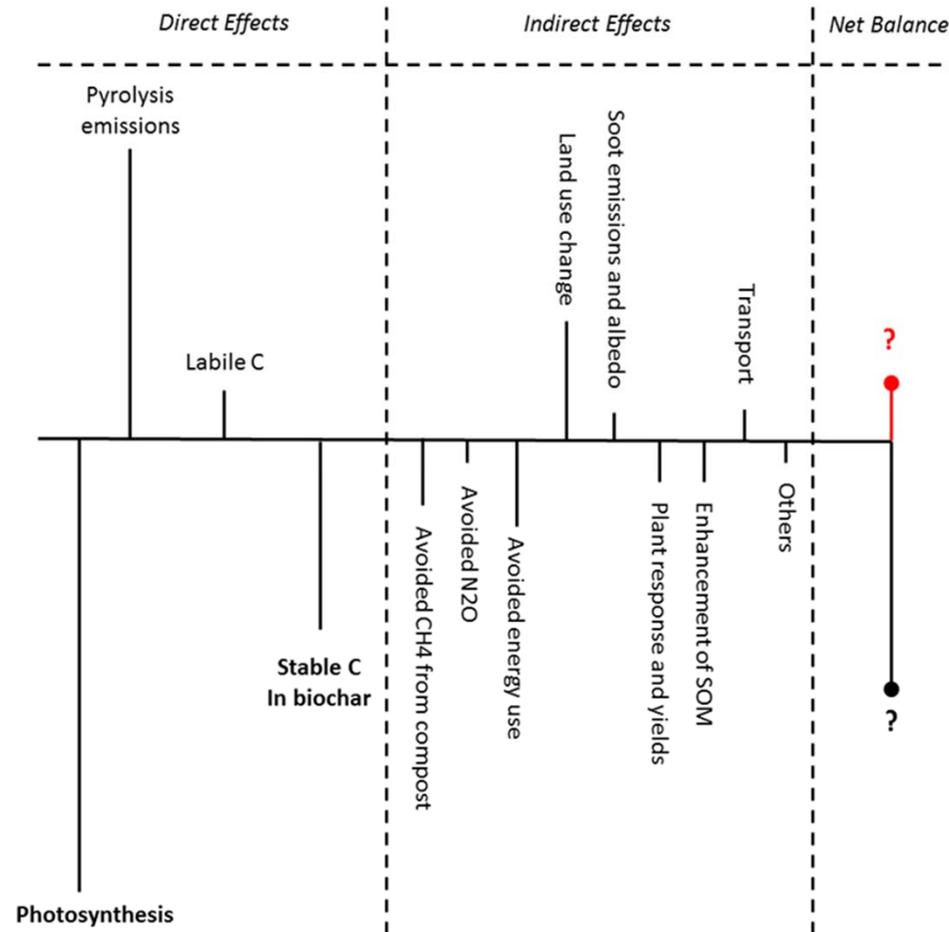


A. Basic Utility Properties	B. Basic Toxin Assessment	C. Supplemental Toxin Assessment	D. Advanced Analysis and Soil Enhancement Properties
Measures the most basic parameters required to assess the utility of biochars for use in soil.	Analyzes potential toxins that are not feedstock-dependent that can be produced by the thermochemical processes used to make biochar – Polycyclic Aromatic Hydrocarbons (PAH), dioxin and furan. Tests for vegetative and invertebrate vigor are also required.	Tests for additional toxins and elements that may be found in processed feedstocks – heavy metals, other metals and PCB.	Tests for additional biochar characteristics. Biochar advanced analysis characteristics are the electrical conductivity, porosity and surface area of biochars. Biochar soil enhancement properties identify plant nutrients contained in the biochar.
<b>Required for all biochars</b>	<b>Required for all biochars</b>	<b>Required</b> for Processed Feedstocks	<b>Optional.</b> Producers may report on all, some or none.

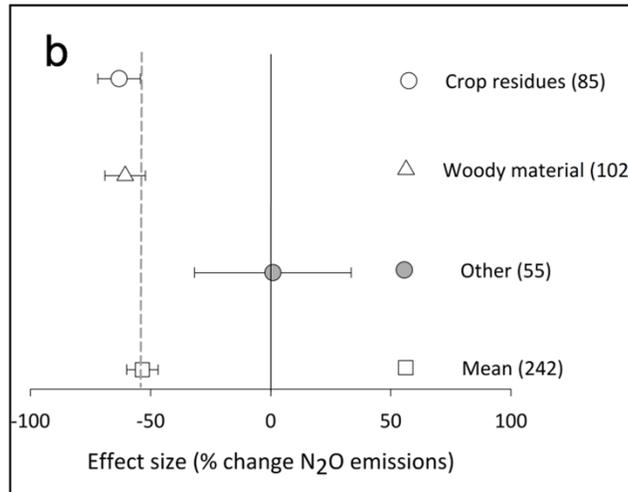
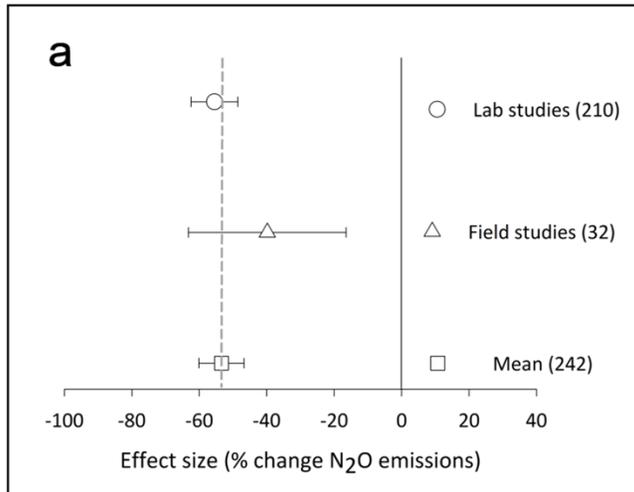


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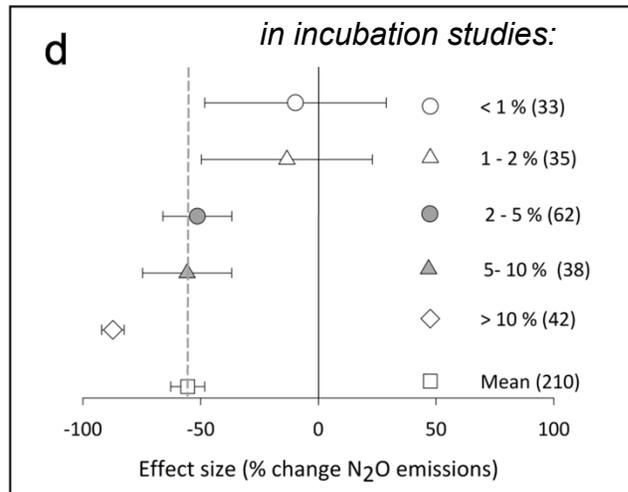
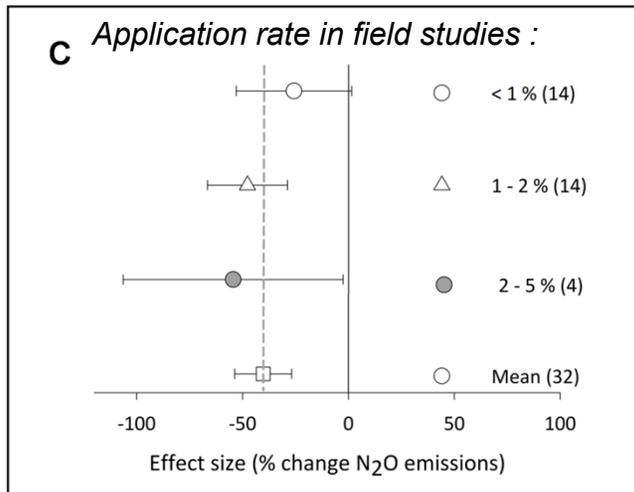
# Greenhouse Gas Emission Reductions



# Soil Nitrous Oxide Emissions with Biochar



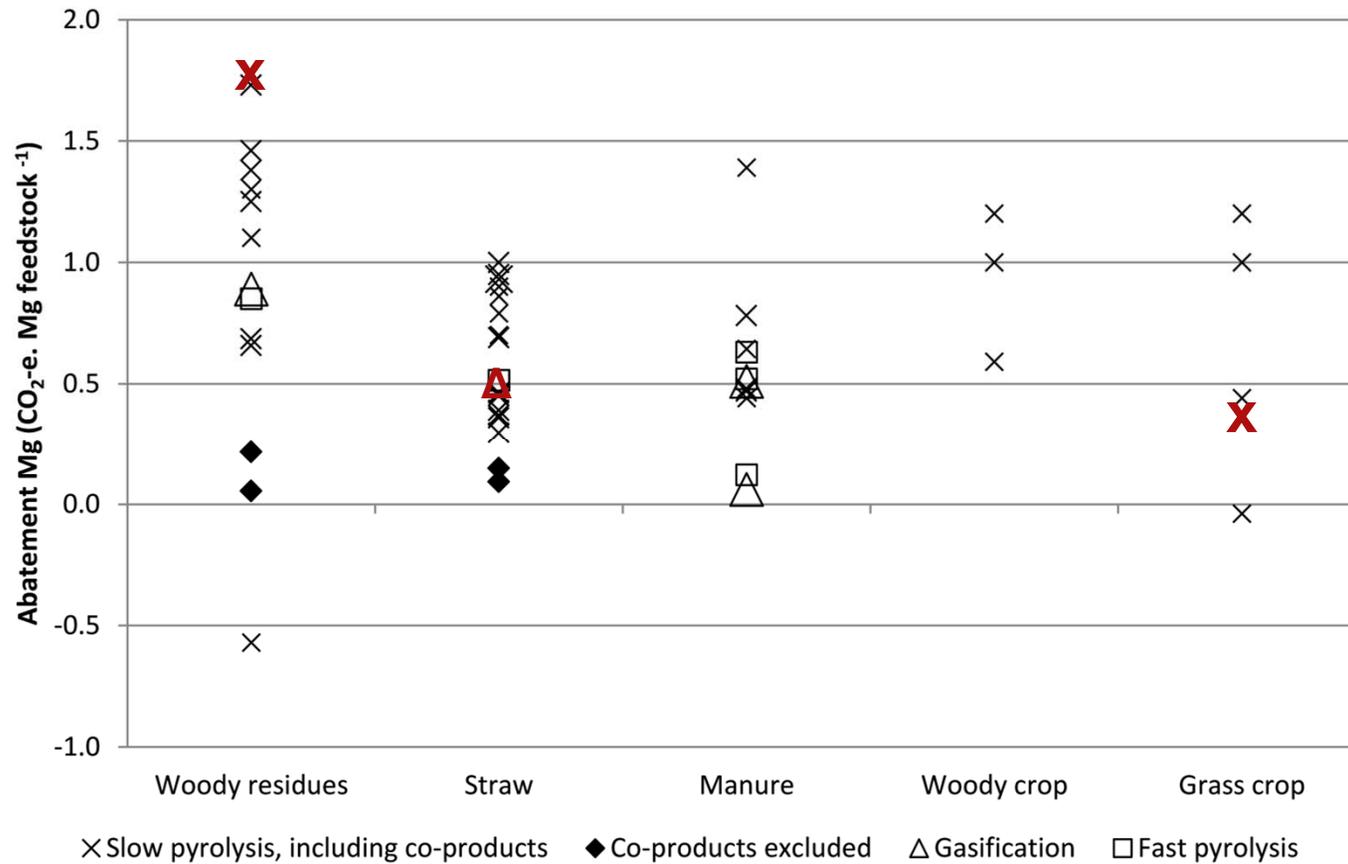
Average reduction 55%



(n=30 studies)



# Biochar Systems Effects on GHG



n=16 studies with 51 scenarios



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Cowie et al., 2015, *Earthscan*

Red: WB Report, 2014

# Biochar Offset Protocols/Carbon Market

Registry/ Market	Voluntary or Compliance Market	Region of Applicability or Use	Status	Notes
American Carbon Registry	Voluntary Market	N. America (registry); global applicability	ACR Internal Anonymous Peer Review Process	Undergoing 2 <sup>nd</sup> round of two anonymous peer reviews
CAPCOA GHG Rx	Voluntary Market	Placer County CA; can be adopted by any CA Air Districts	Final review completed; submission to Placer County in preparation.	Anticipated adoption by Placer County in January 2015
Verified Carbon Standard	Voluntary Market	Global	Inactive	No response submitted to peer reviewers



# The Way Forward?

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- **Development of biochar platforms**
- **Systems energy, GHG balance and economics**

