BIOCHAR INCREASES TEMPERATURE SENSITIVITY OF SOIL RESPIRATION AND N_2O FLUX

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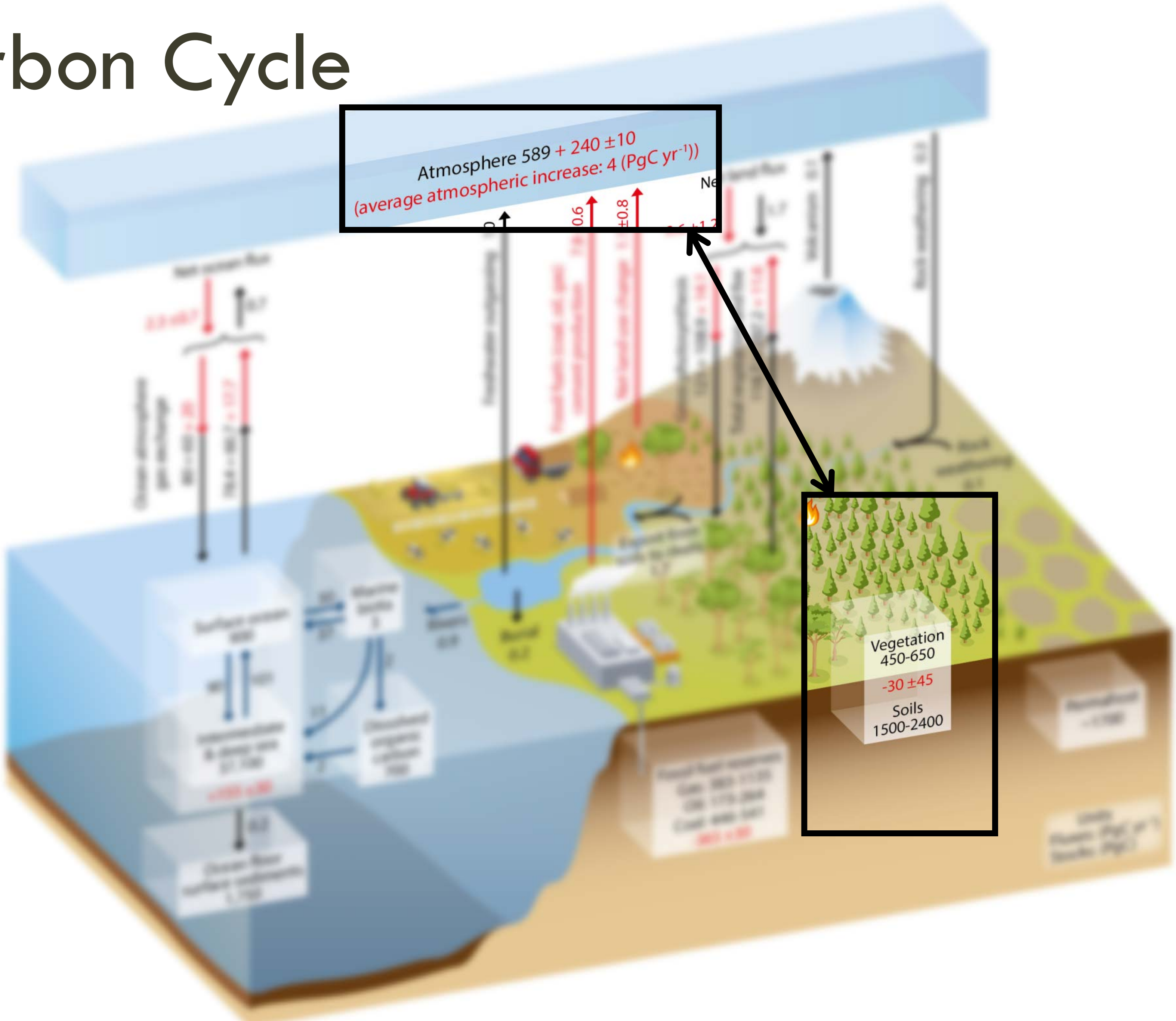
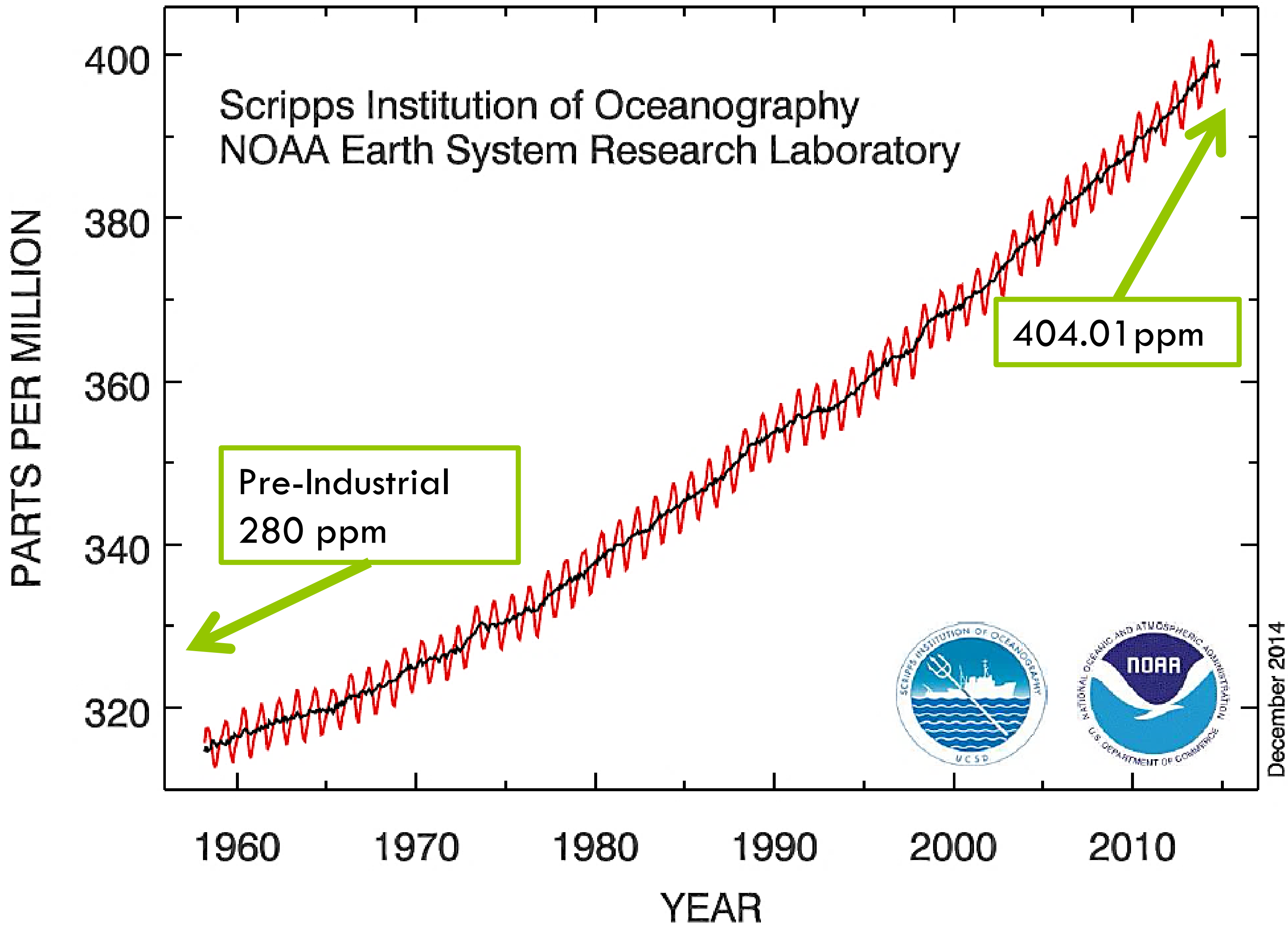
Carbon Cycle

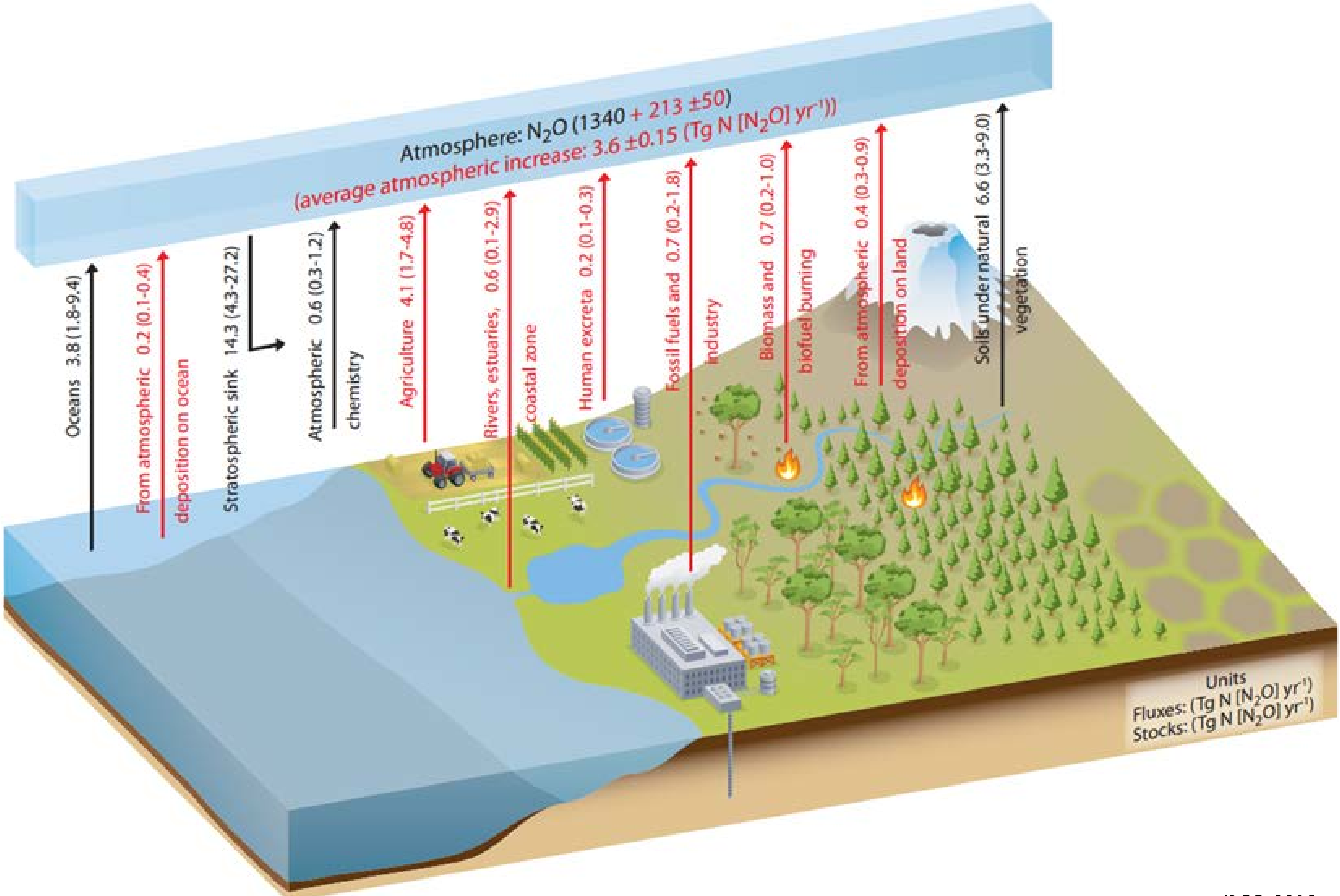


IPCC, 2013

Atmospheric CO_2 at Mauna Loa Observatory

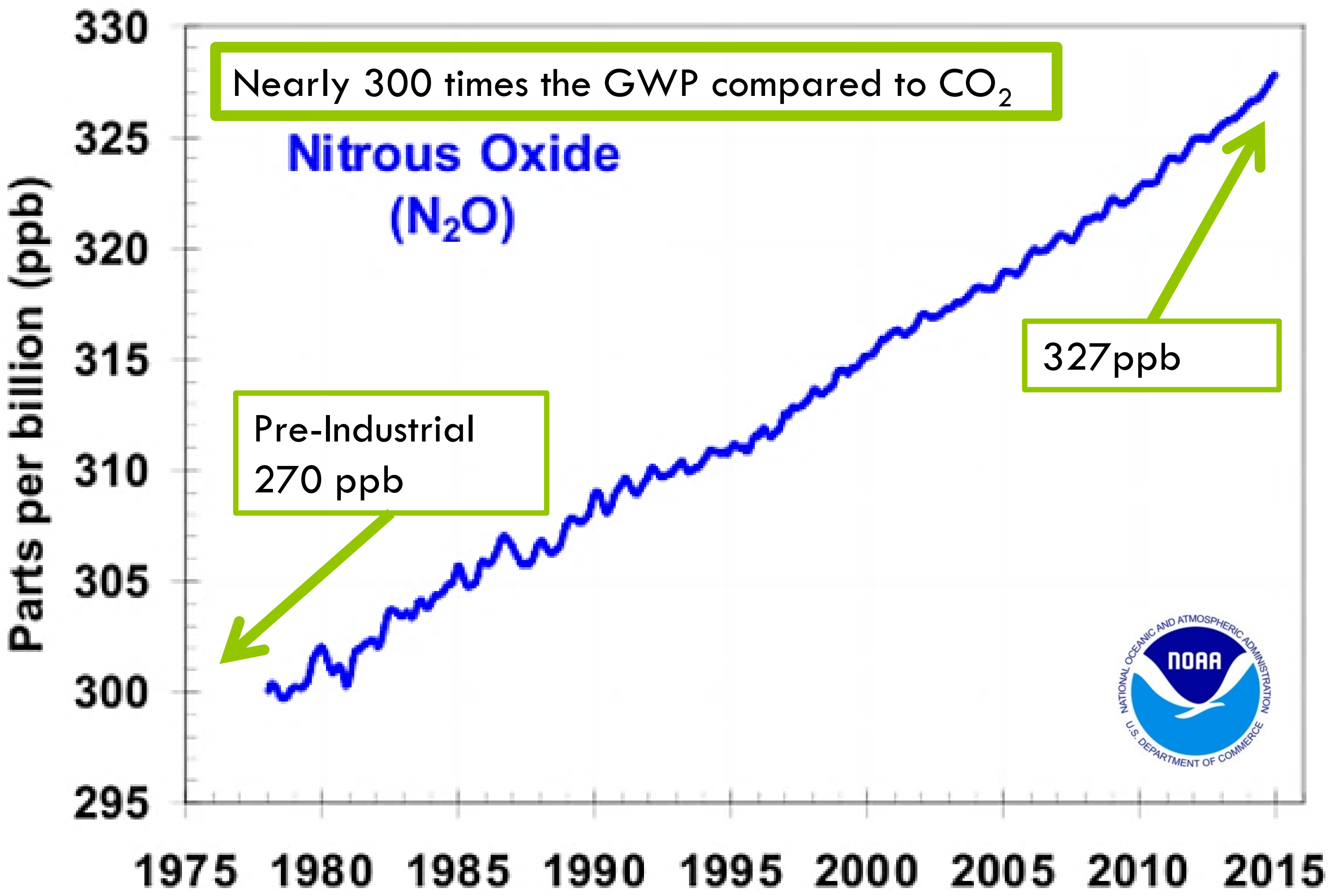


Nitrous Oxide



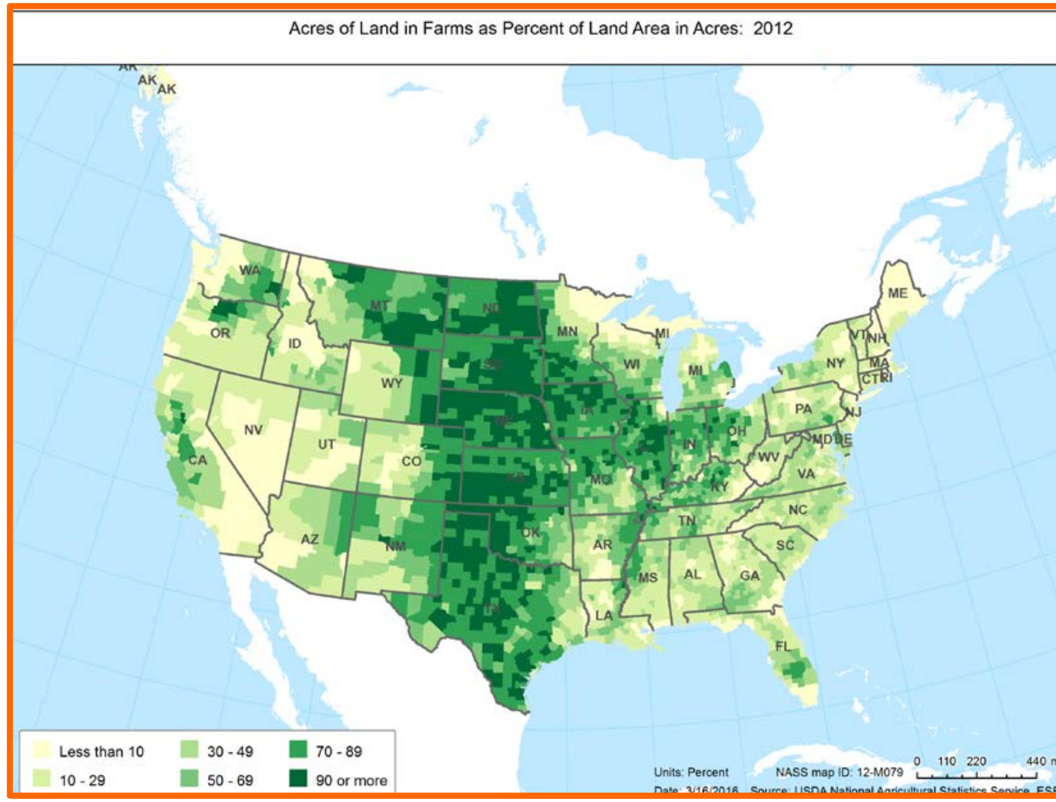
IPCC, 2013

Atmospheric N_2O at Mauna Loa Observatory



Agricultural Land

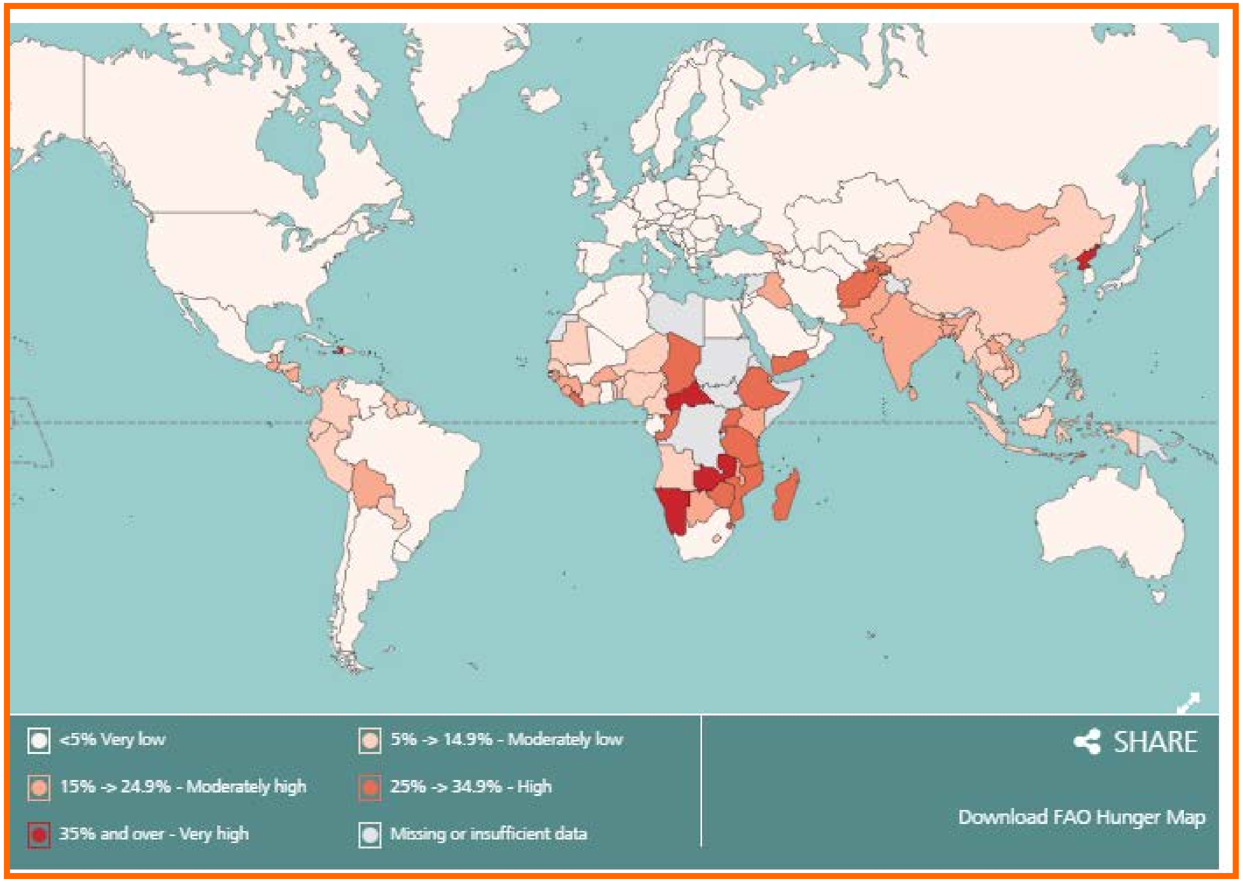
- 45% of US land
- Responsible for 10% of U.S. greenhouse gas emissions
- Agricultural soils have lost 50% of soil C



Food Security

- "When all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active lifestyle" – World Food Summit, 1996
  - 870 million people between 2010 – 2012 did not meet this criteria

2015 Hunger Map

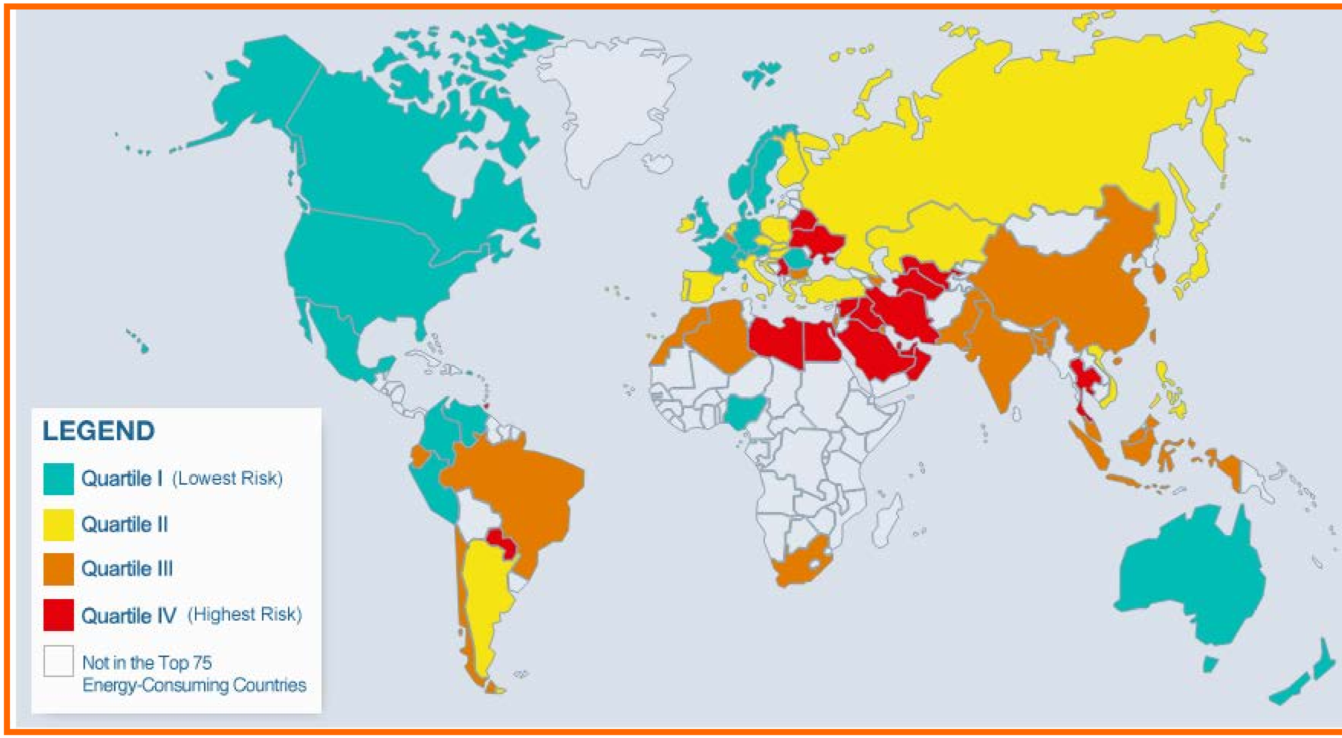


www.fao.org

Energy Security

- "The uninterrupted availability of energy sources at an affordable price"
  – International Energy Agency

2015 Energy Security Risk

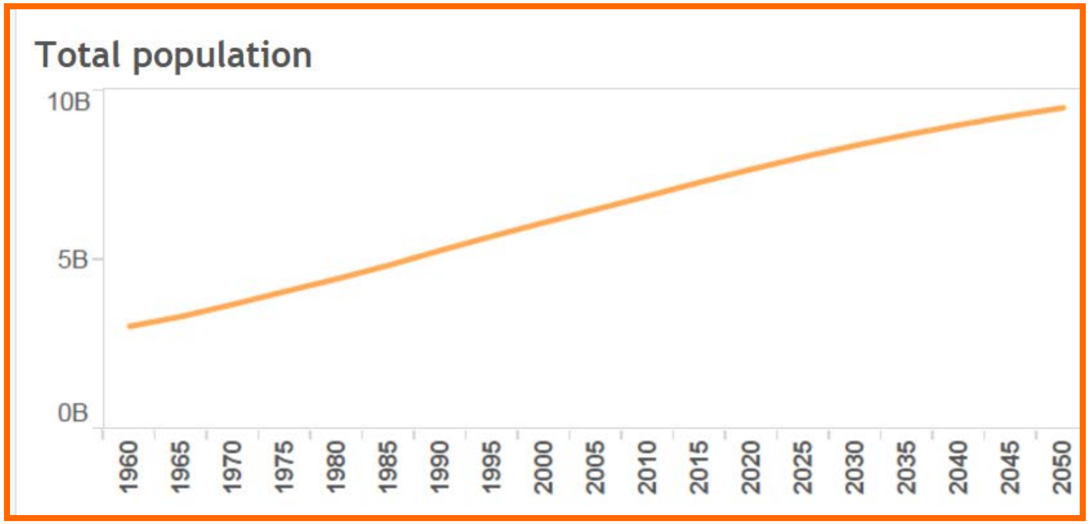


http://www.energyxxi.org/international-energy-security-risk-index

Food and Energy Security

- As populations increase, the demand for food and energy will also increase
  - Need to sustainably intensify agriculture for both food and bioenergy to meet this demand
    - Next green revolution

Population Projection



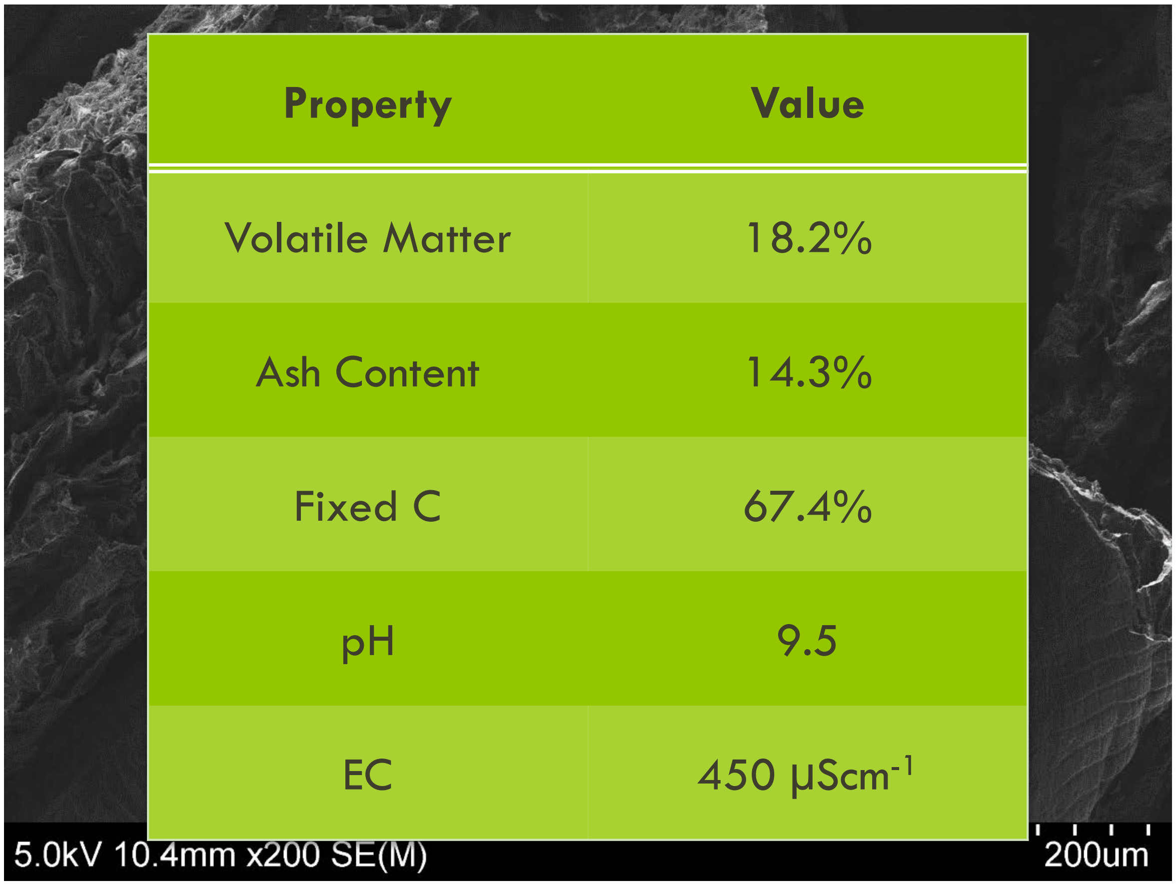
www.datatopics.worldbank.org

Sustainable Intensification

- Management decisions
  - No till systems
  - Leaving crop resides
  - Additions of organic matter
  - Using a cover crop
  - Biochar

Cowpea Cover Crop

My Biochar



Property	Value
Volatile Matter	18.2%
Ash Content	14.3%
Fixed C	67.4%
pH	9.5
EC	450 μScm^{-1}

Anaerobic Digester Biochar

Field Project Overview

- Two soils on Oahu
  - Oxisol – low fertility
  - Mollisol – high fertility
- Anaerobic Digester Biochar
- Two crops
  - Napiergrass – Ratoon harvest
  - Sweet Corn – Conventional tillage and harvest


Oxisol and Mollisol

Pennisetum purpureum


Napiergrass


Biochar

Zea Mays


Sweet Corn

Poamoho Research Station

Initial field view

Applying biochar, fish bone meal, and lime

Growing Napiergrass

Waimanalo Research Station

Biochar plots

Newly planted corn

Corn before harvest

Methods

Sample Preparation

19°C 23°C 26°C

29°C 31°C

33°C 35°C 40°C

Temperatures

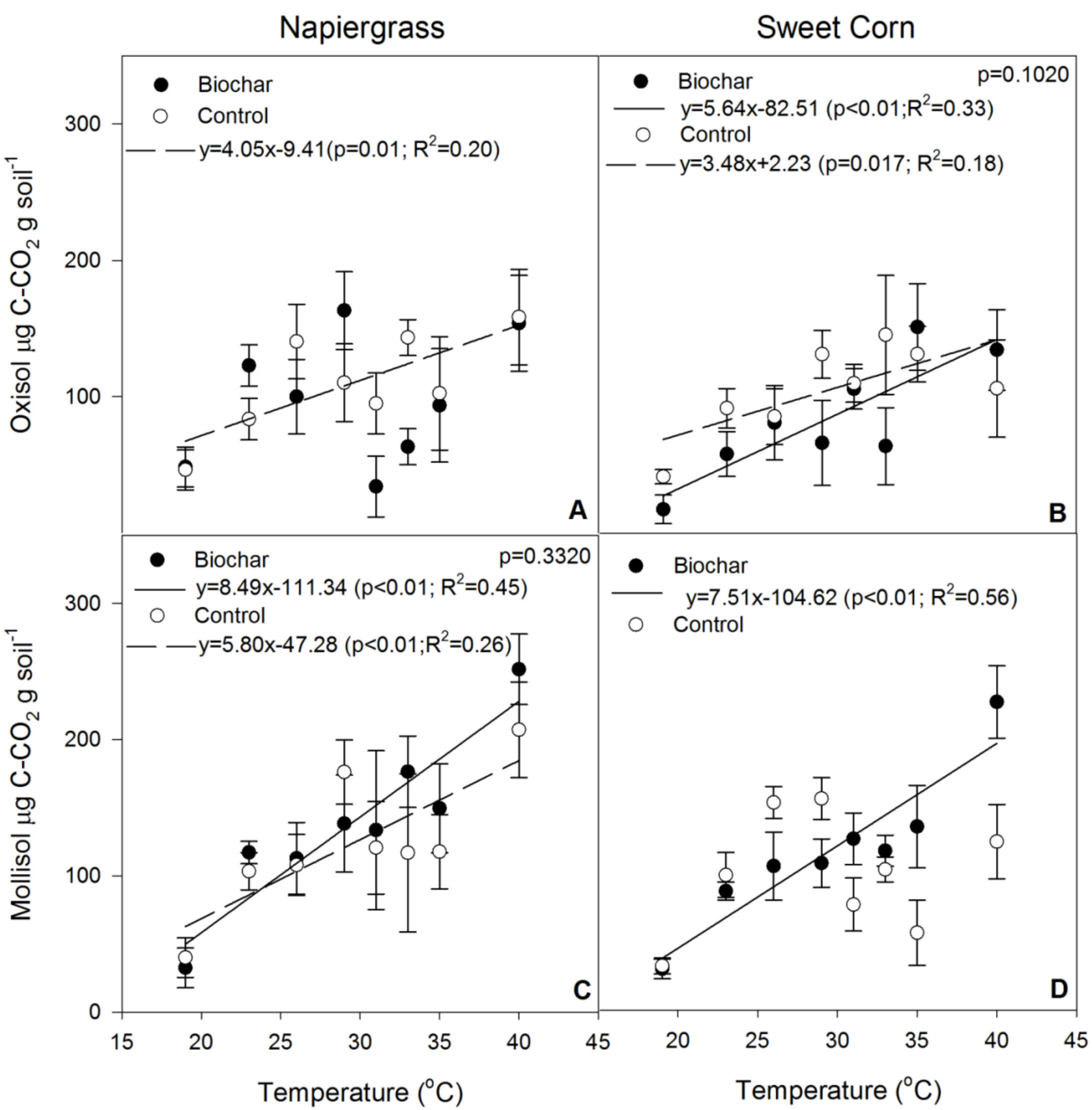
Incubation Chambers

Chambers and lids with septa

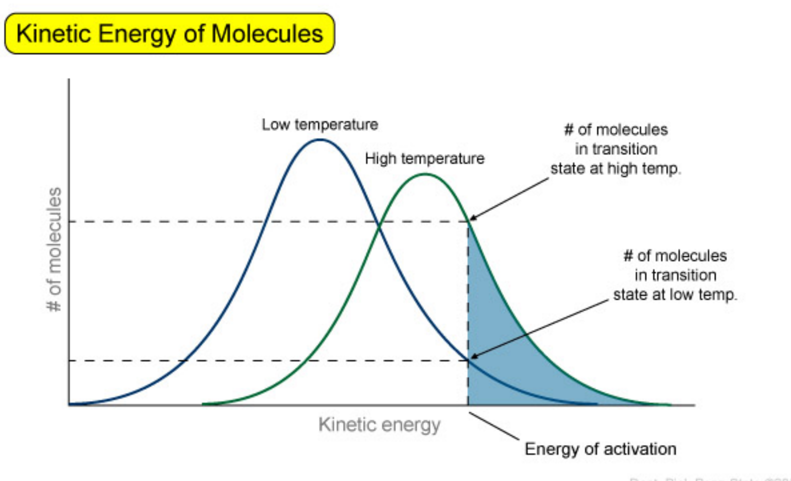
GHG sampling

Shimadzu GC-2014

Respiration increases with temperature

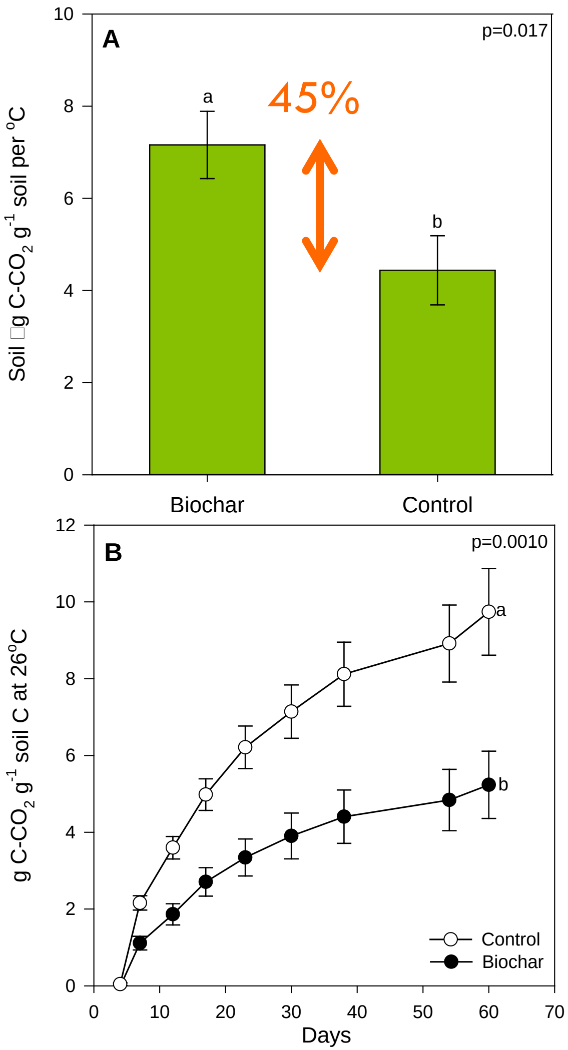


- Temperature increases soil respiration
  - Microbial turnover
  - Reaction rates
  - Enzyme activation energy
- No threshold effects



Penn State University

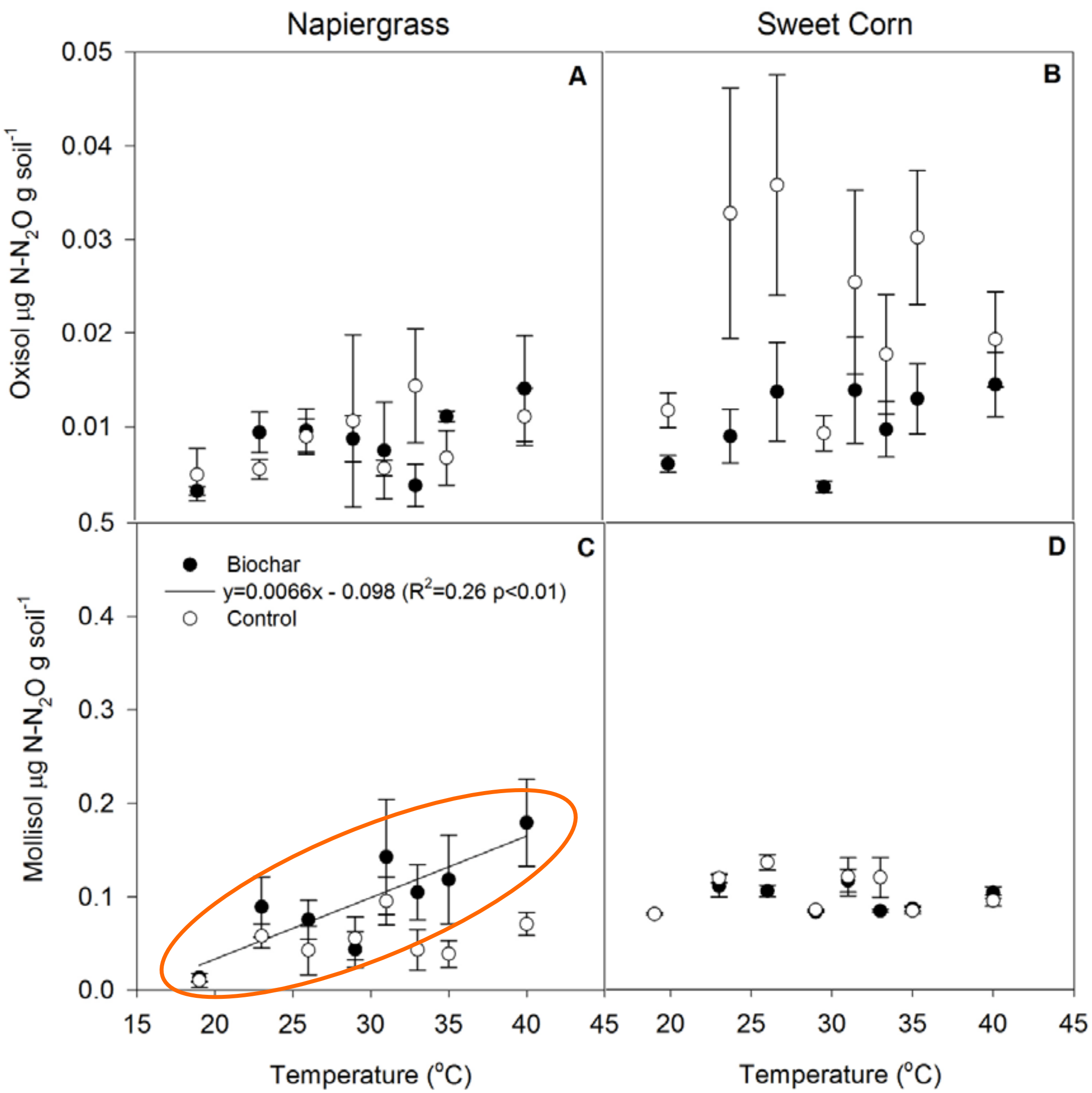
Biochar nearly doubles temperature sensitivity



- Biochar may be decomposing
- Conditions favorable for certain microbial communities
- Stable C more susceptible to degradation at higher temperatures

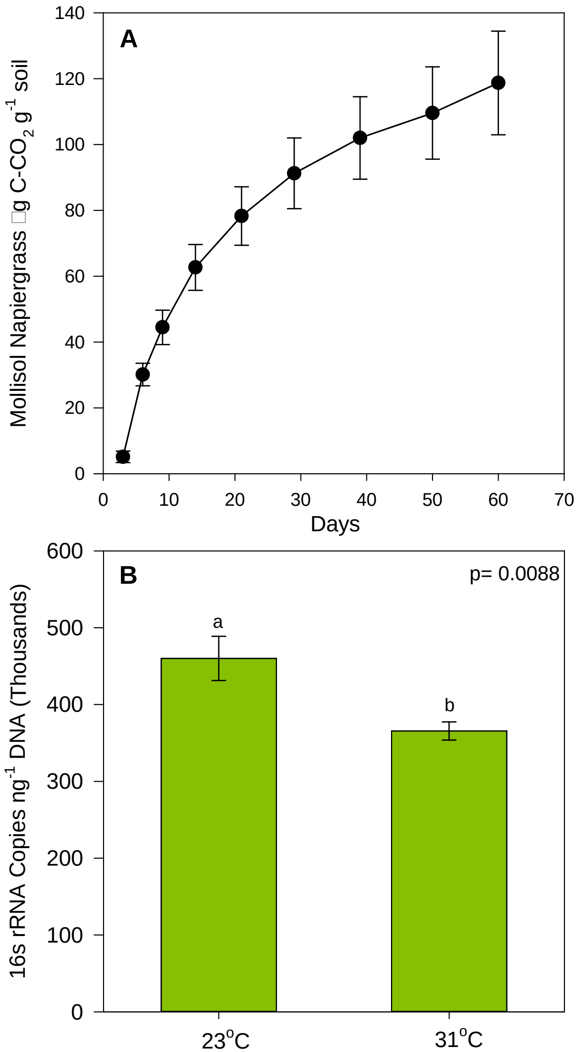
- Carbon quality is lower in the biochar soils
  - Increased soil C sequestration
  - Less available to organisms

N_2O flux temperature insensitive



- N_2O Flux temperature insensitive
  - Initial N concentrations
  - N cycle balance
- Mollisol Napiergrass Biochar
  - N mineralization rates
  - BNF
  - Sorption of N
  - Electron shuttle

Lower abundance at higher temperature

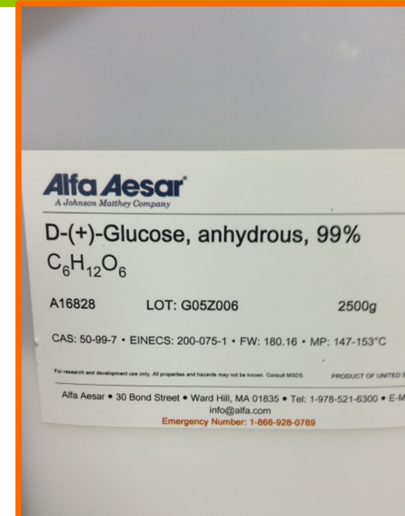


- No biochar or temperature effects
  - High variability
- Smaller community at higher temperatures
  - Increased respiration rates
- While not significant, nosZ (nitrous oxide reductase) abundance was higher in the 31°C
  - 43% difference
  - No flux differences
  - No biochar differences
- But agricultural systems are dynamic

Methods

Day 60 samples
Labile Samples

Mollisol Napiergrass → Control → 23°C, 31°C
Mollisol Napiergrass → Biochar → 23°C, 31°C



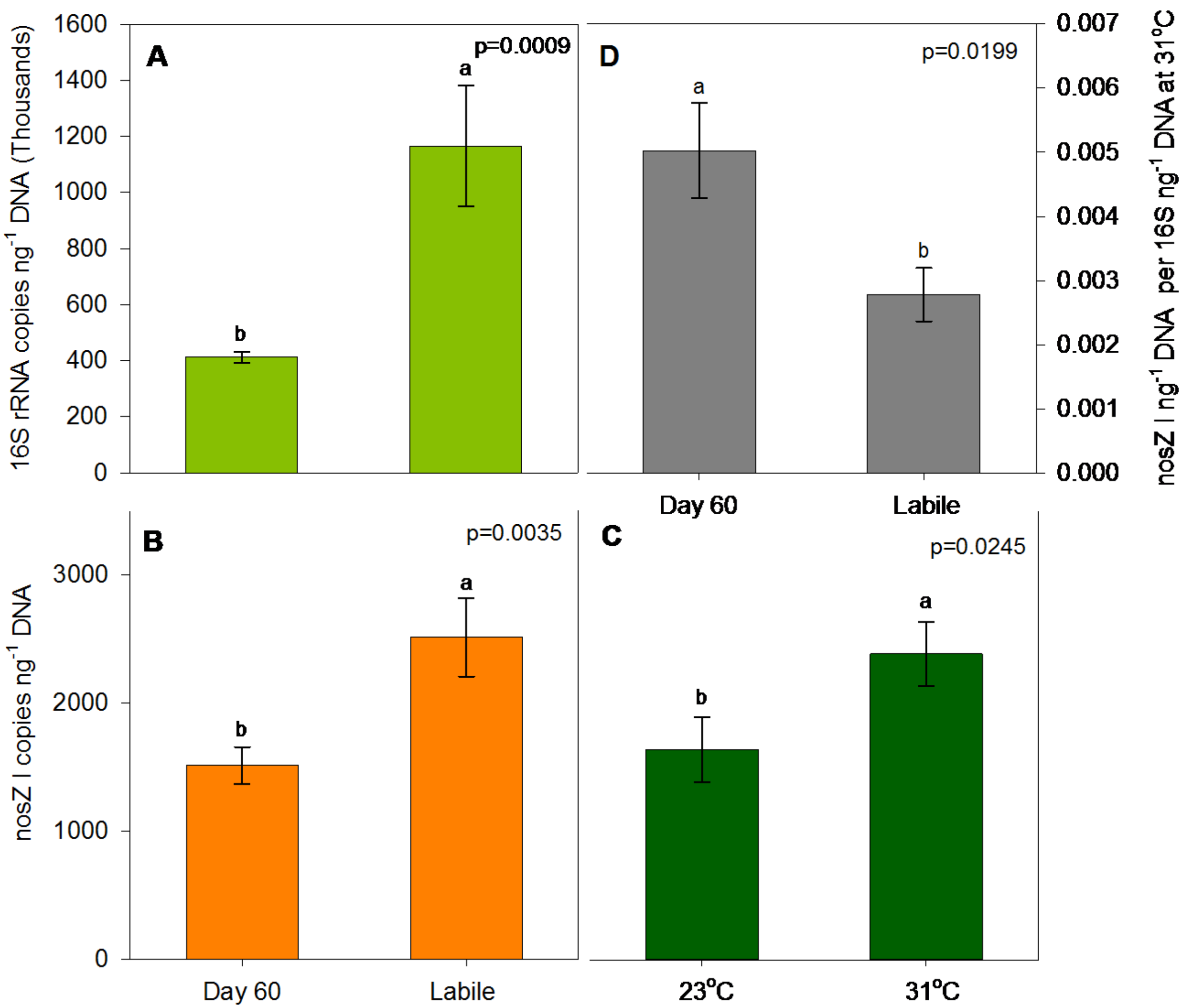
Glucose

Final Sample

Initial Sample

Soil DNA extractions and qPCR

Microbial Community Response



- Glucose increases populations
- nosZ abundance responds differently than the overall microbial community abundance
  - Differences in carbon lability
  - Available N
- Biochar effect?

Implications

- Biochar amended soil had increased temperature sensitivity of respiration and N_2O flux
- Mechanisms are unclear
  - shift in the ratio of the bacteria that possess the nosZ gene
  - Other pathways to N_2O production
- Biochar will sequester carbon in the soil, but may act as a positive feedback to climate change as temperatures increase.

Acknowledgements

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Hawai'i Powered
Hawai'i Clean Energy Initiative

HAWAII IS THE MOST FOSSIL FUEL DEPENDENT STATE IN THE NATION.

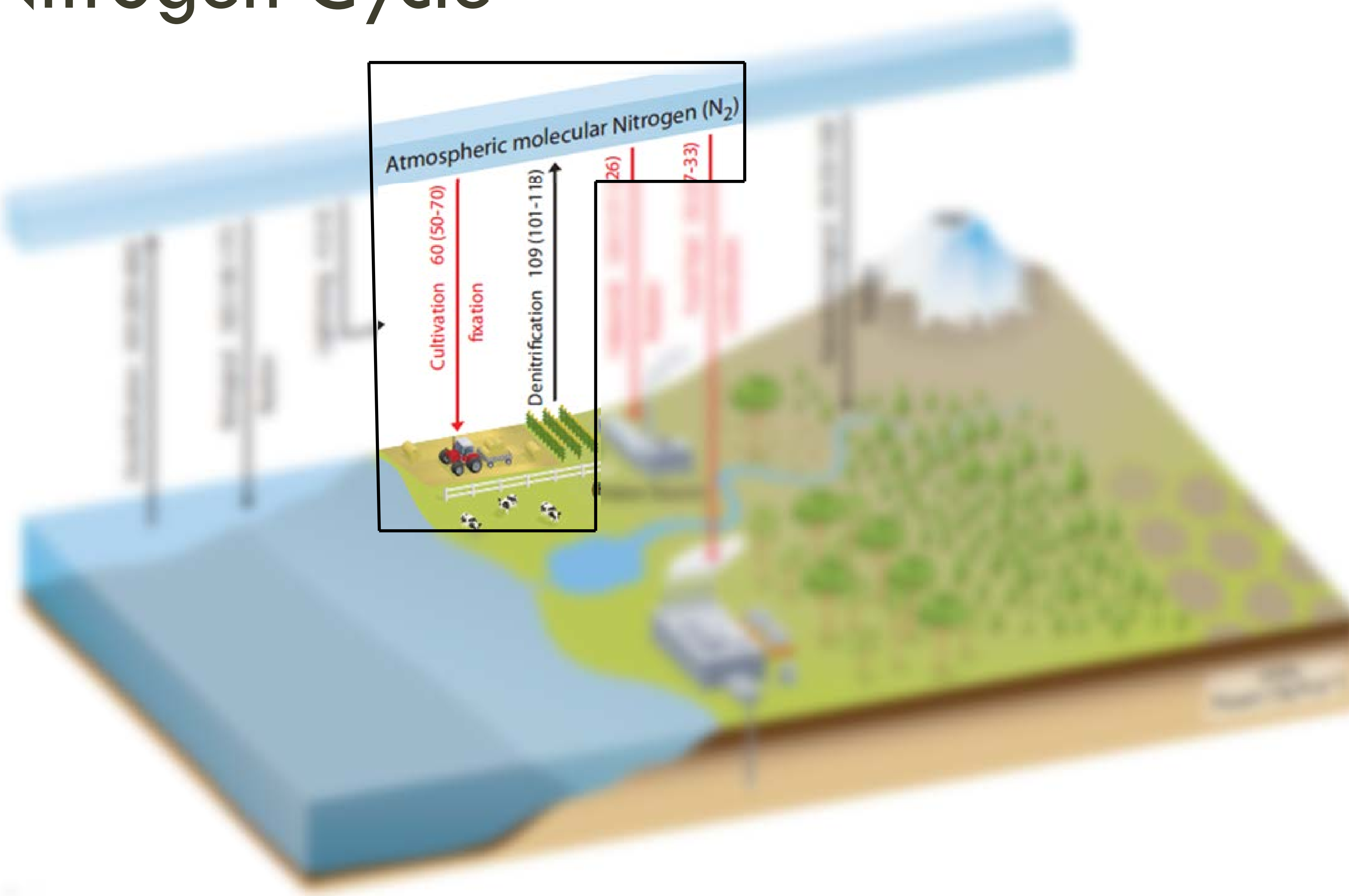
This can be explained in large part because of our dependence on tourism and the military – together, they make up roughly 50% of our total economy. That's a dangerous scenario for the future because of the finite nature of fossil fuel and the fact that our state is more and more vulnerable to fluctuations in oil prices and availability.

The Hawaii Clean Energy Initiative is leading the way in relieving our dependence on oil by setting goals to achieve 100% clean energy by 2045.

Hawaii's clean energy goals are the most aggressive in the nation – and if we succeed, we will become a world leader in clean energy. Along the way, we'll begin to solve several core challenges:

1. We can be more independent and less reliant on other economies.
2. We can achieve greater security.
3. This will help Hawaii become more economically prosperous by keeping an estimated $5.1 billion in the state that would otherwise be spent on imported oil.
4. Establishing a new, green economic sector will counter-balance our reliance on tourism and the military.

Nitrogen Cycle

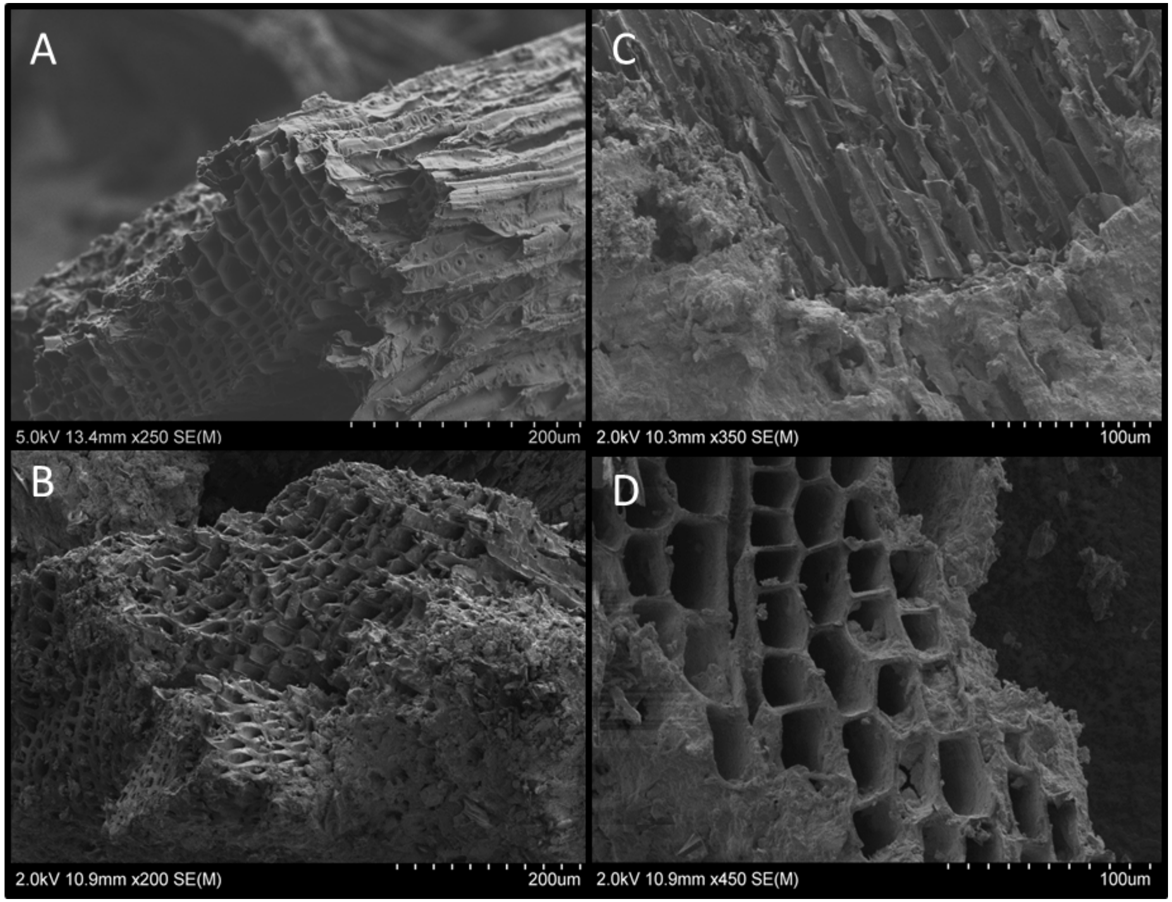


IPCC, 2013

SEM - Biochar

A) Initial biochar sample prior to amendment

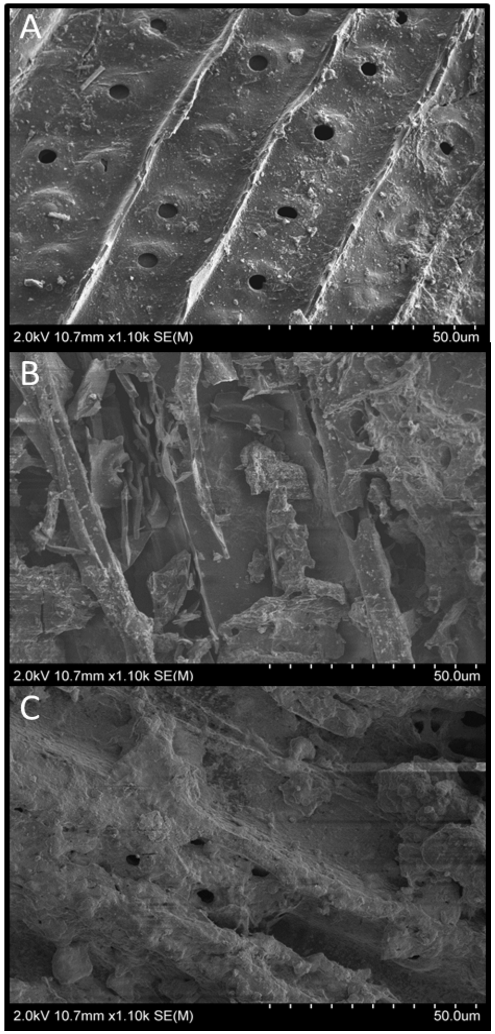
B) Biochar removed from year 1 soils from the Mollisol Napiergrass



C) Biochar removed from year 1 soils from the Oxisol Sweet Corn

D) Biochar removed from year 1 soils from the Mollisol Napiergrass

SEM – Biochar



A) The initial biochar sample prior to amendment in the field.

B) Biochar after 1 year in the bag from the Oxisol napiergrass plots

C) Biochar after 1 year in the field from the Oxisol napiergrass plots