Effect of FACE on Wood Chemistry

(Free Air Carbon-dioxide Enrichment)

Research Object and Plan

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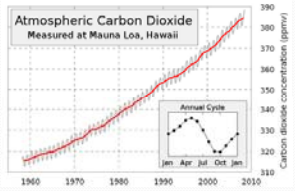
Background

CO_2 concentration has risen 35% since industrial revolution.

*Natural factors
*Human activities
*Industrial pollutions

Background

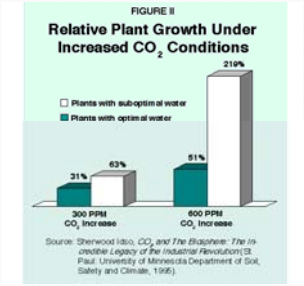


www.esrl.noaa.gov
National Oceanic and Atmospheric administration

Atmospheric CO_2 level for May 2010 is 392.94ppm

Predict additional 50% by 2050.

Background



CO_2 is essential to photosynthesis

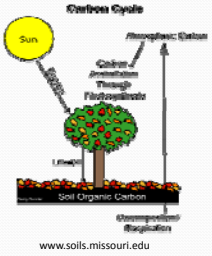
$6CO_2 + 6H_2O + Energy \rightarrow C_6H_{12}O_6 + 6O_2$

Botanists have long realized that CO_2 enhances plant growth

Pump CO_2 into greenhouses

Are there only positive effects for elevated CO_2 in atmosphere?

Background



www.soils.missouri.edu

Plant growth relies on lots of factors.

Consider other factors in plants growth (CO_2, light, soil, insects, pathogen…)

We can't only search plant itself to figure out differences on plants between high CO_2 and ambient CO_2

Good or Bad - we need to identify the effects of high CO_2 level on plants

What is FACE?

1. Free-Air Carbon dioxide Enrichment (FACE) - method that raises the concentration of CO_2 in a specified open area and allows the response of plant growth to be measured.

2. A typical FACE plot is circular and surrounded by a ring of pipes that release CO_2 or air enriched with CO_2 at vertical intervals.

Research Sites

*Global project
*Can provide perhaps the best estimate of how plants and ecosystem will respond in a future high CO_2 world.

Objectives

The goal of this research is to assess the effects of elevated carbon dioxide on various tree species such as sweetgum, aspen, paper birch.

1. Compare chemical properties of sweetgum, birch, and aspen wood harvested from control and elevated carbon dioxide treatments of two FACE experiment sites.

2. Changes in wood structural and chemical properties after 10-year of CO_2 treatments.

Justification

1. Trees that have developed for 10 years in a FACE
   - very rare opportunity to assess long term changes in real open field

2. Sweetgum, Aspen, Birch and Loblolly Pine
   - important commercial species also being studied as a bio energy crops because of their high productivity.

3. Thus it is important to understand how future conditions will influence strength properties, cell wall structure, and chemical composition.

Research results from literatures

- After 3 years of treatment of paper birch (Aspen FACE)
  - Annual ring width, and concentrations of extractives and starch were increased
  - Concentrations of cellulose and gravimetric lignin were decreased
  (Kostiainen 2006 Global Change. Biology. 12,1230)
- After 5 years of treatment (Aspen FACE)
  - Aspen : decreased uronic acids (constituents of hemicellulose) and tended to increase stem diameter
  - Paper birch : decreased starch concentration
  (Kostiainen 2008 Tree Physiology 28,805)
- A dense poplar plantation was exposed to a CO_2 of 550 ppm for 3 growing season. (EURO FACE)
  - Aboveground biomass increased by 15 to 27%
  - Belowground biomass also increased by 22 to 38%
  - No effect of CO_2 on stem wood density
  (Calfapietra 2003 Tree Physiology 23,805)

Hypothesis

Elevated CO_2 concentration in atmosphere will affect wood properties.

Site Description

There are three FACE experimental systems involving forest trees in the USA.

1.DUKE FACE site

-Loblolly pine plantation
-Duke University forest near Durham, NC
-4 Elevated CO_2 plots (200ppm+ambient CO_2)
4 Control plots (ambient CO_2)
-Operation started Jun 1994

Site Description

There are three FACE experimental systems involving forest trees in the USA.

2. Aspen FACE site

-Aspen, Paper birch, Maple
-Rhinelander, WI
-12 treatment "Rings"
  control
  elevated CO_2 (560ppm)
  elevated O_3 (ambient O_3 x 1.5)
  elevated CO_2+O_3
-Trees planted in 1997
-Treatment initiated in 1998

Site Description

There are three FACE experimental systems involving forest trees in the USA.

3.ORNL FACE site

-Sweetgum plantation
-Oak Ridge, TN
-2 plots of elevated CO_2 (565ppm)
 3 plots of control (ambient CO_2)
-1 year old sweetgum planted in 1988
-CO_2 treatment initiated in 1998

*** ORNL FACE – Sample harvesting (July,2009)**

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* Aspen FACE – Sample harvesting (July, 2009)

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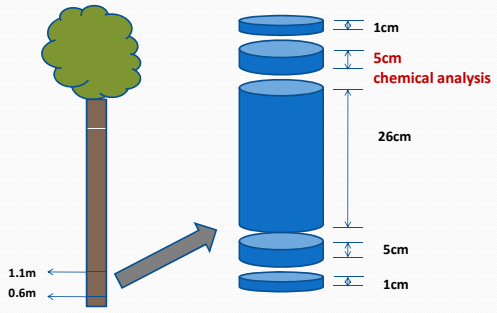
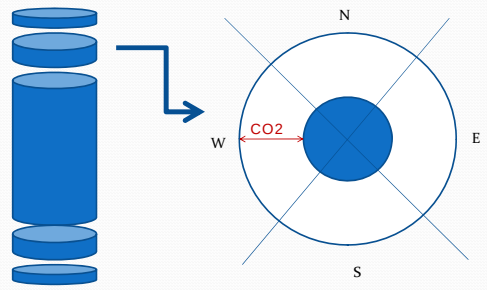
Sample Preparation



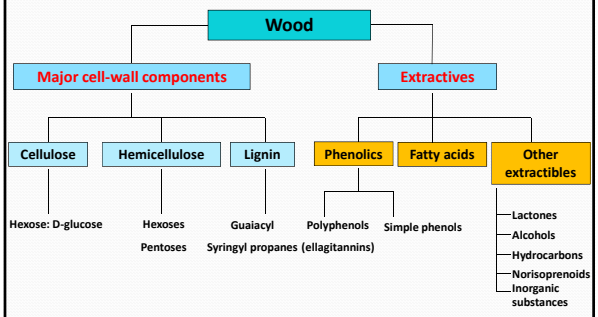
Sample Preparation



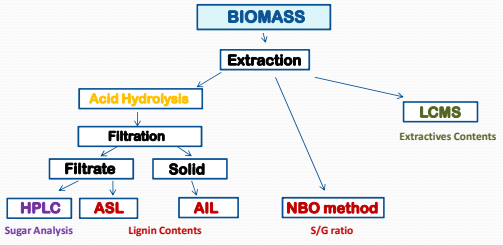
Sample Preparation

- In preparation for chemical analyses, the bark, phloem and cambium were removed from the wood cookies.
- The cookies were divided by 4 directions and cut in 1cm-diameter block shape.
- Each sample was freeze dried, chipped and milled with 40 mesh Wiley mill which maintained cool temperature with liquid nitrogen.

Biomass Composition



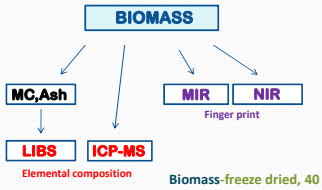
Research Plan



Acid Hydrolysis- two step dilute acid hydrolysis
HPLC- high-pressure liquid chromatography
LCMS- Liquid chromatography-mass spectrometry
NBO- Nitrobenzene Oxidation Method(Nures et al 2010)

Research Plan

*Model development



Biomass-freeze dried, 40 mesh milled
LIBS-Laser-induced breakdown spectroscopy
ICP-MS-inductively coupled plasma mass spectroscopy
MIR-Mid infrared
NIR-Near infrared

Acknowledgement

Primary Advisor :Dr. Nicole Labbe
Center for Renewable Carbon, UT

For samples : ORNL – Dr. Richard Norby & Dr. Jeff Warren
Aspen – US Forest Service Northern Research Station
Dr. Mark Kubiske
UT – Dr. Nicolas Andre, Dr. Jennifer Franklin
Dr. David Harper, Lindsey Kline

Financial Support : Forestry, Wildlife and Fisheries UT
USDA – Wood Utilization Research
US-Forest Service, Southern Research Station