Landscape variations in vegetation and soil: a moisture gradient at Bonanza Creek, Alaska

Pruett, L.E.[1], Harden, J.W.[1], Turetsky, M.R.[2]

[1]USGS, 345 Middlefield Road, MS 962, Menlo Park, CA 94025

[2]Department of Plant Biology, Michigan State University, East Lansing, MI 48824

Introduction

The boreal forests of Alaska contain large reservoirs of carbon that have the potential to act as sources or sinks of CO_2.

Alaskan landscapes reflect a wide range of vegetation and soil types. It is therefore important to consider environmental differences such as water table depth and plant community in order to better understand how these reservoirs might respond to climate change.

Four different drainage settings and plant communities were analyzed in order to characterize a natural moisture gradient. In early 2005, one of these sites (II, see site description below) will be drained in an experiment designed to assess the environmental and chemical impact associated with the landscape changes that might occur as a result of climate change. To help anticipate these changes, we are characterizing natural variations with different environmental settings.

Carbon cycling studies utilize information such as carbon content and isotopic composition to help characterize soils and partition the CO_2 evolved from those soils over various landscapes. In an effort to understand this partitioning along a drainage setting, we examined $\delta^{13}CO_2$ and $\delta^{14}CO_2$ and flux rates.

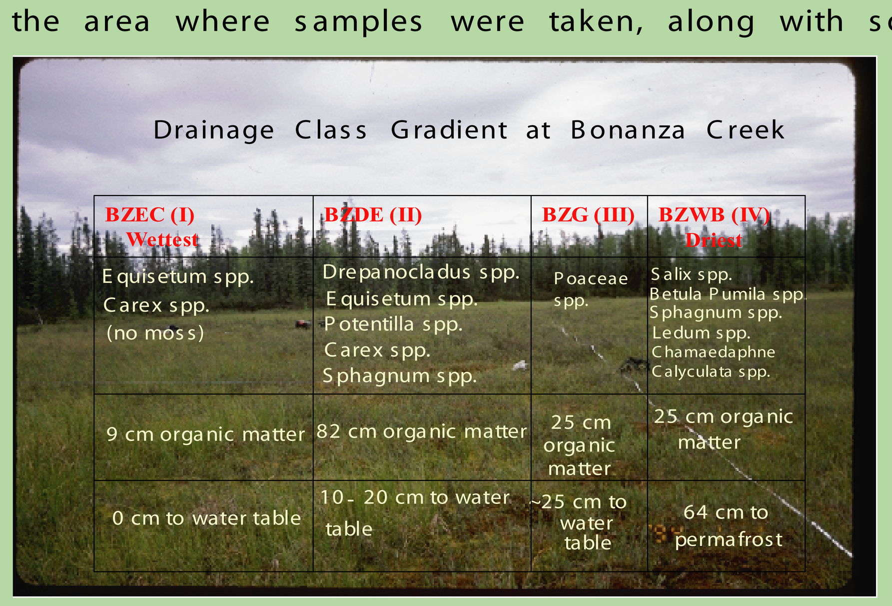
In this poster we look at the following questions:

How do environmental conditions affect CO flux rates?
How does isotopic signature vary under different landscape regimes?
What changes will we see in short term by lowering the water table?

Study Area

Location map of the Bonanza Creek Experimental Forest

Picture of the area where samples were taken, along with some physical characteristics



All samples and replicates were taken from the Bonanza Creek Experimental Forest outside of Fairbanks, AK. Floral composition, organic matter thickness and water table depth of the sites along the drainage class gradient are listed in the bottom figure.

References:

Gaudinski, J.B. and others. 2001. The age of fine-root carbon in three forests of the eastern United States measured by radiocarbon. Oecologia, 129: 420-429.

Skopp, J., M.D. Jawson and J.W. Doran. 1990. Steady-state aerobic microbial activity as a function of soil water content. Soil Sci. Soc. Am. J., 54: 1619-1625.

Methods

Four stations were established along a drainage setting located near Fairbanks, AK in July 2004. Each station varied widely in height of water table, plant community composition, and soil depth (see table in Site Description).

Samples and replicates (14 total) were collected from the top 5 cm of the moss and/or soil across the moisture gradient. These samples were removed from the site and placed into glass Ball jars with septa port lids. They were immediately transported to Menlo Park, CA and after 48 hours the gas was analyzed for CO_2 concentration. A portion of the gas was removed for $\delta^{13}CO_2$ and $\delta^{14}CO_2$ analysis.

Samples were then aired out and recapped for five 48 hour periods, over the course of a month, in order to examine changes in flux over time. After incubations 2 and 3, the samples were leached for DOC. One month into the incubation, another 60 mL of sample was removed from each sample for isotopic analysis.

CO_2 concentrations were measured in Menlo Park using a gas chromatograph.

Isotopes were analyzed at the University of California at Irvine.

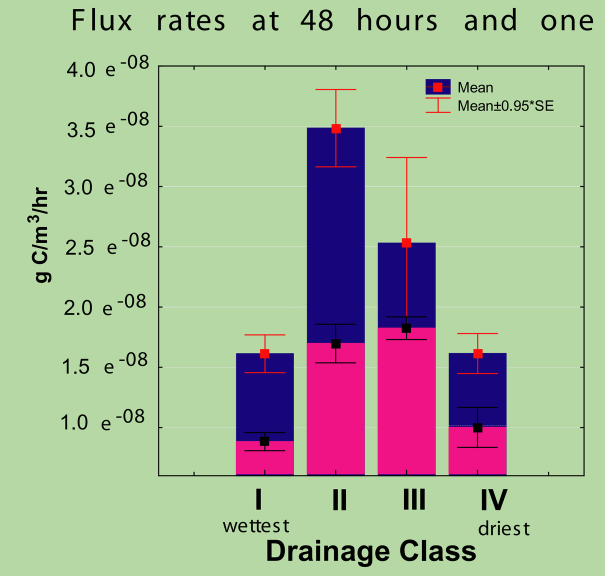
Results

Raw data from the Bonanze Creek samples. The mean from each site is used for inter-site comparison

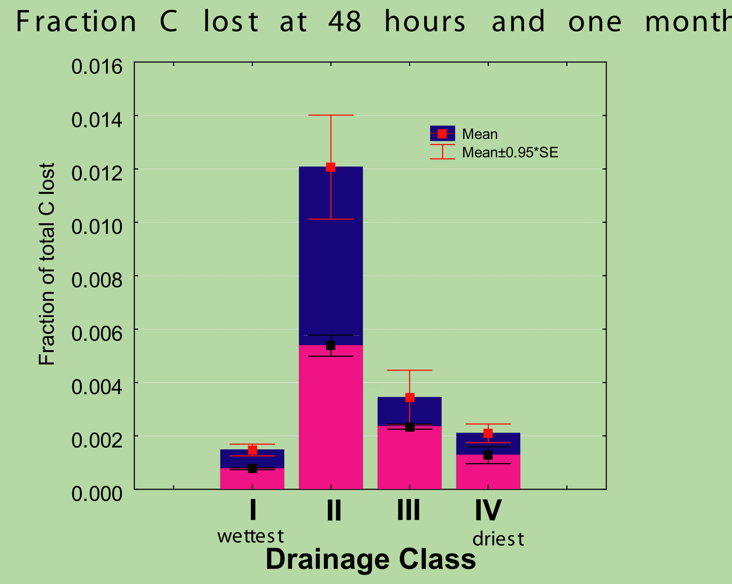
Sample	48 hr. flux gC/m^3/hr	$\delta^{13}CO_2$ (‰)	$\delta^{14}CO_2$ (‰)	1 mo. Flux gC/m^3/hr	$\delta^{13}CO_2$ (‰)	$\delta^{14}CO_2$ (‰)
BZEC1) **I**	1.84736E-08	-22.3	75.4	8.7527E-09	-24.5	97.9
BZEC2) **I**	1.29414E-08	-22.8	88.8	9.99363E-09	-23.8	111.6
BZEC3) **I**	1.69439E-08	-23.8	68.7	7.25604E-09	-23.9	64.0
BZDE1) **II**	4.20925E-08			2.29744E-08	-28.4	97.2
BZDE2) **II**	3.76047E-08	-28.1	105.2	1.44973E-08	-27.8	104.3
BZDE3) **II**	4.07285E-08	-27.6	71.1	1.4155E-08	-28.0	90.3
BZDE4) **II**	2.88124E-08	-27.4	94.9	1.79028E-08	-28.4	103.7
BZDE5) **II**	2.49915E-08	-25.9	84.6	1.45064E-08	-26.8	91.3
BZG1) **III**	3.42226E-08	-24.9	112.7	1.69752E-08	-26.8	147.5
BZG2) **III**	1.04434E-08	-23.5	97.1	1.72016E-08	-25.7	121.7
BZG3) **III**	3.12446E-08			2.00596E-08	-26.4	122.3
BZBW1) **IV**	1.84578E-08	-26.5	156.3	9.81816E-09	-27.2	185.6
BZBW2) **IV**	1.72522E-08	-26.5	127.6	1.28809E-08	-27.2	159.2
BZBW3) **IV**	1.27171E-08	-27.7	133.3	6.83879E-09	-28.0	146.5

Flux Data

Flux rates at 48 hours and one month



Fraction C lost at 48 hours and one month



Blue bars are data from the 1st 48 hour incubation and **pink bars** are the data after one month into the incubation. The left depicts the grams of C evolved on a volume basis, while the right graph shows the change in the fraction of the sample that was lost. The flux data for each drainage category are the mean of the site replicates with standard errors. The site to be manipulated (II) seems to have the most labile carbon.

Isotope Data

$\delta^{13}CO_2$ can be used to separate sources of carbon in systems where more than one source is present.

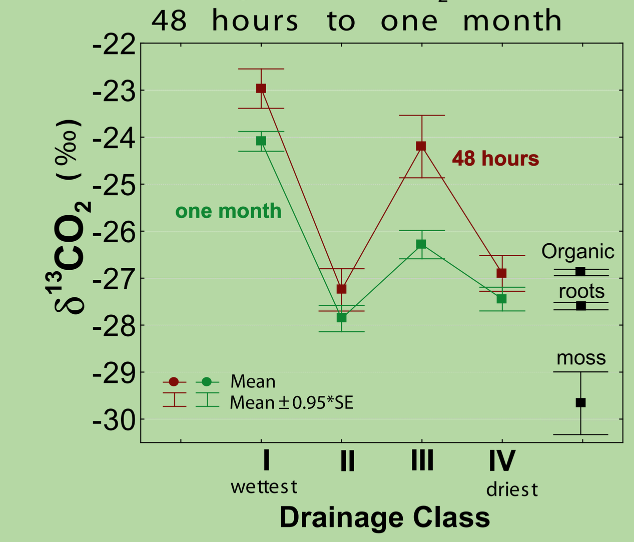
Evolved CO_2 is the product of three components: root respiration, microbial activity, moss respiration.

Analyzing the shift in isotopic composition of the $\delta^{13}CO_2$ over time can help elucidate the changes in relative importance of the three components.

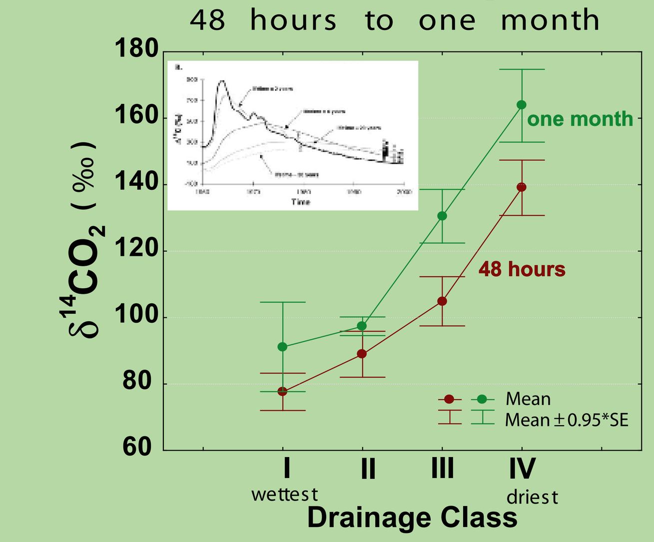
$\delta^{14}CO_2$ is often measured in order to determine the age of the terrestrial carbon reservoir at a given site. This method utilizes the observed change in atmospheric $\delta^{14}C$ from the 1960's to the present as a result of weapons testing. These data can provide useful information about turnover time and reservoir composition.

The modeled age of carbon in fine roots based on a comparison tp atmospheric changes in $\delta^{14}C$ over the last forty years is given below (Gaudinski, 2001).

Change in $\delta^{13}CO_2$ from 48 hours to one month



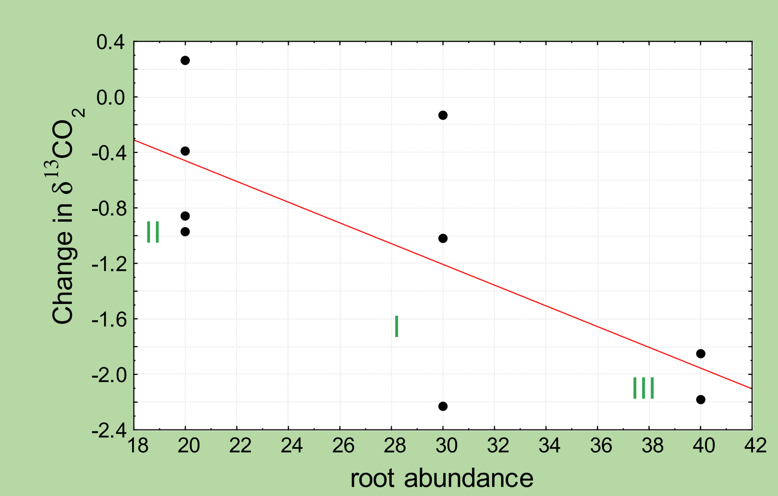
Change in $\delta^{14}CO_2$ from 48 hours to one month

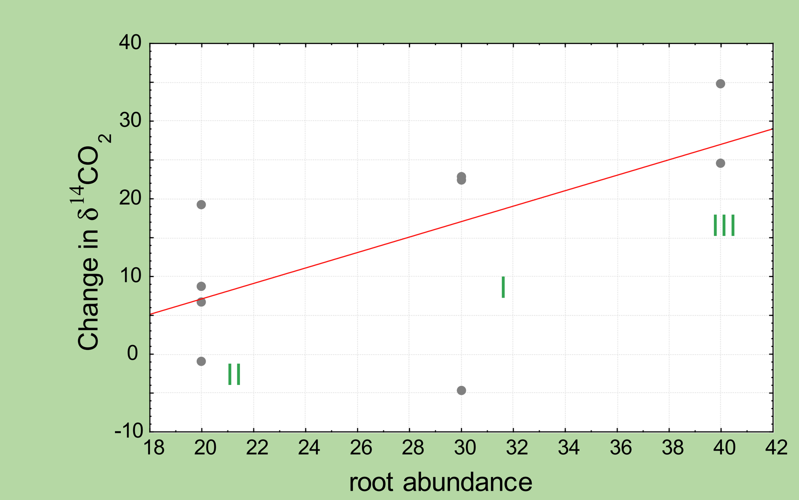


Mean isotopic composition of each site with standard errors. The red lines represent the initial (48 hour) pulse, while the green lines represent the pulse captured one month into the incubation. The figure on the left also shows the mean values of some components of the top 5 cm of soil. Those data come from sites in Alaska.

Conclusions

The relationship between root abundance and changes in isotopic composition between 48 hours and one month, with drainage class noted next to each data cluster





Root abundance is quantified by ranking (between 1-3) the number of very fine roots, fine roots and medium roots per cm^3. This rankings are then multiplied by 10 to get an estimate of root abundance.

The relationship between root abundance and the size of the isotopic shift between 48 hours and one month can be seen above. The greatest change in $\delta^{13}CO_2$ and $\delta^{14}CO_2$ from 48 hours to one month were seen in samples with the highest number of roots.

Flux rates were highest at the two intermediate sites and lowest and the driest and wettest sites. This supports the idea that water content can limit microbial activity if too high or low (Skopp, 1990).

The shift down (to a lighter composition) in the $\delta^{13}CO_2$ values after one month is most likely a reflection of the CO_2 source shifting from root-dominated to a system dominated by moss respiration and microbial activity. The shift up in $\delta^{14}CO_2$ (to enrichment in ^{14}C) is the expected shift in the age of the accessible C from younger to older with time.

Samples from drainage classes I and III had no live moss. They were also isotopically the heaviest samples, further illustrating the importance of moss in the isotopic signature.

Lowering the water table at site II will likely result in an increase in vascular plants and therefore more roots and less moss. This change can be assessed through the use of C isotopes. We expect to be able to measure this change because site II has the most labile carbon.