SOIL ROOT EXCLUSION BAGS AT ORNL FACE EXPERIMENT

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THE SITE

The research site is a planted sweetgum monoculture located on the Oak Ridge National Environmental Research Park in the Ridge and Valley province between the Cumberland and Blue Ridge Mountains of eastern Tennessee.

The plantation was established in fall, 1988, on an old terrace of the Clinch River. In 1997 a free-air CO_2 exposure (FACE) facility comprising 25m circular plots was constructed. The experimental design includes 2

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The Site

2 plots with elevated CO_2 and 2 plots with ambient CO_2. Each plot is surrounded by 24 vent pipes spaced 3.3m apart suspended from towers.

The CO_2 treatment was initiated in April 1998, prior to leaf out, and has been maintained 24 hours per day every year between April and November. The CO_2 set point in 1998 was a constant 565ppm. In 1999 a dual set-point (565 ppm day and 645 ppm night) was used to better represent the diurnal variation in ambient CO_2.

The soil at the site, which is classified as an Aquic Hapludult, developed in alluvium washed from upland soils derived from a variety of rocks including dolomite, sandstone, and shale. It has a silty clay loam texture and is moderately well drained. The soil is slightly acid (water pH approximately 5.5-6.0) with high base saturation largely dominated by exchangeable Ca.

HYPOTHESES:

- Does exposure of a forest ecosystem to elevated atmospheric CO_2 concentrations result in changes in the amount of soil organic carbon?
- Does exposure to elevated CO_2 result in changes in the input rate and decomposition rate of soil organic carbon?

THE EXPERIMENT

In 1999, intact soil cores (4.6 cm diameter, 30 cm long) were taken from six random locations inside each of the two treatment, control, and ambient rings at the FACE site. 10cm sections were marked for 0-10cm, 10-20cm, and 20-30cm depths. An amount evenly distributed over each 10cm increment was gently scraped from the side of the intact core and placed into a scintillation vial. Enough soil was removed to fill a vial for each depth increment. The cores were then wrapped in filter membrane, placed

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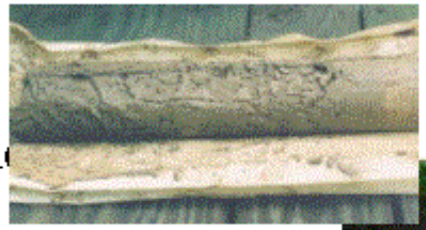
inside apple mesh bags, and tagged before being reinserted into the original hole with minimum disturbance.

In 2001, two years after the last sampling, the cores were again removed and samples gathered for analysis. While most cores had maintained their appearance, several cores had significantly altered. Some had partially disintegrated due to water seepage while others had been compromised by the penetration of fine root growth and the occasional earthworm.

Along with the core samples, additional samples were taken from the ground immediately adjacent to the buried cores. Th 2.5cm diameter samples were taken to a depth of 30cm. The purpose of these samples was to



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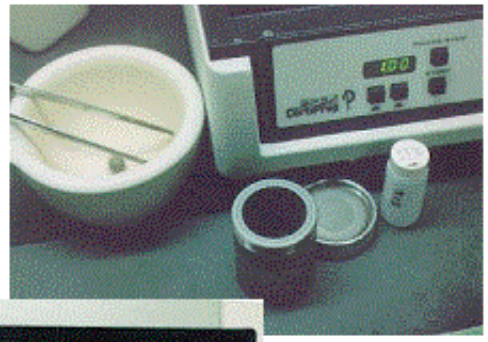
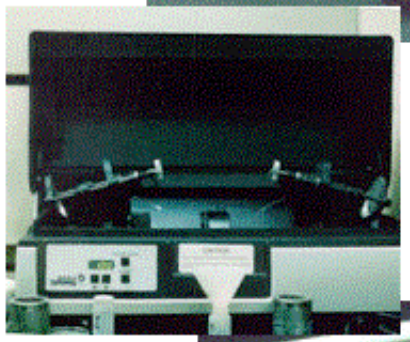
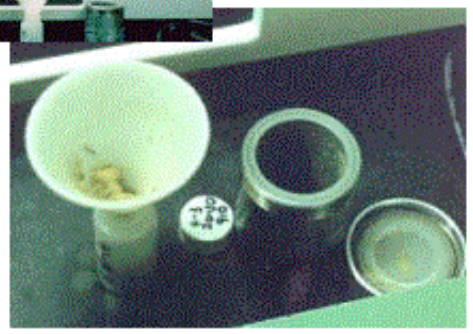
Methods

compare the soil in the cores with soil that had been exposed to new organic matter inputs from the surface and roots.

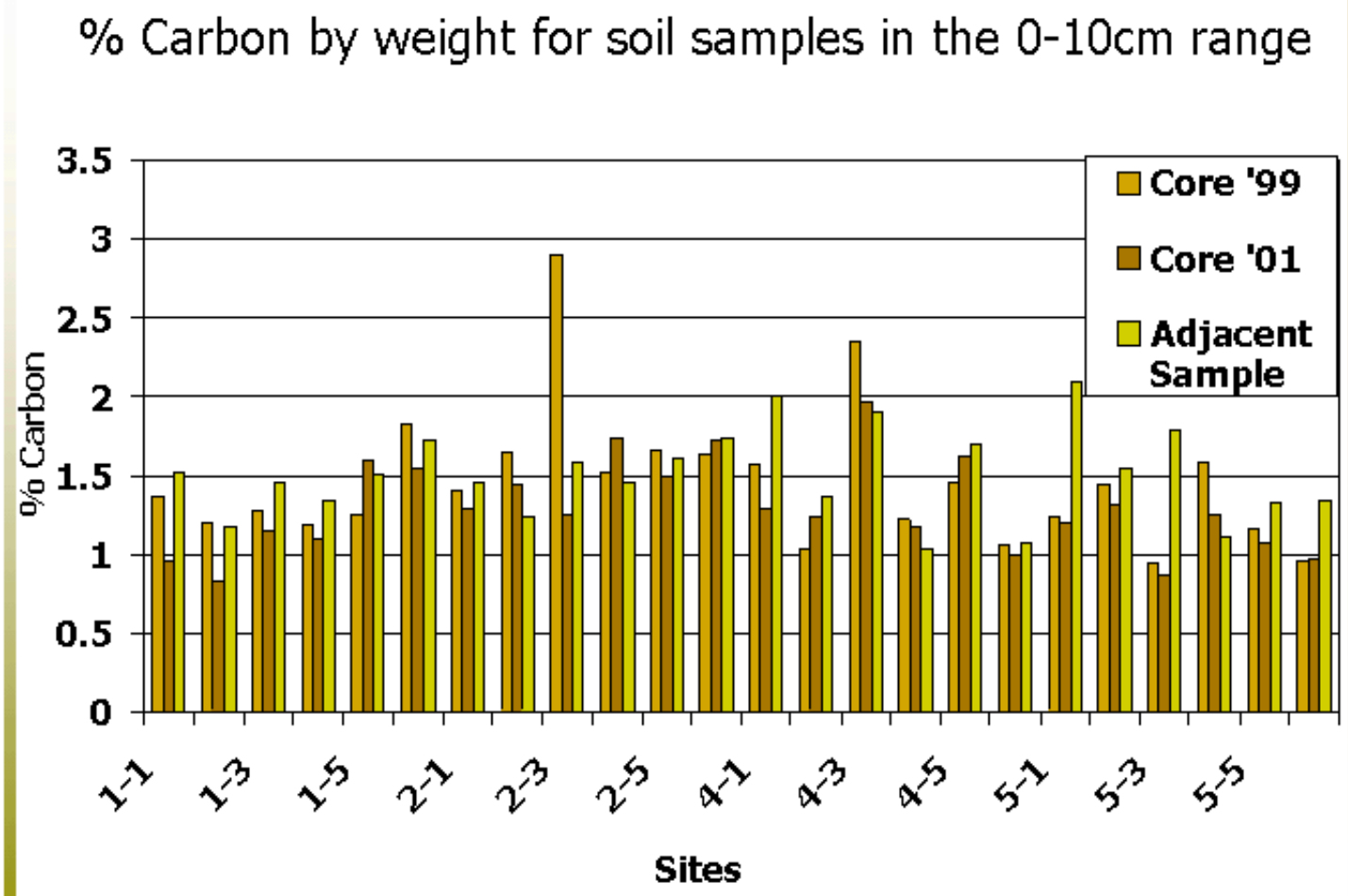
All samples were oven dried at 60°C and then ground for analysis using a Spex CertiPrep 8000-D Mixer Mill at one-minute intervals. Samples were analyzed using a LECO CN-2000 machine.



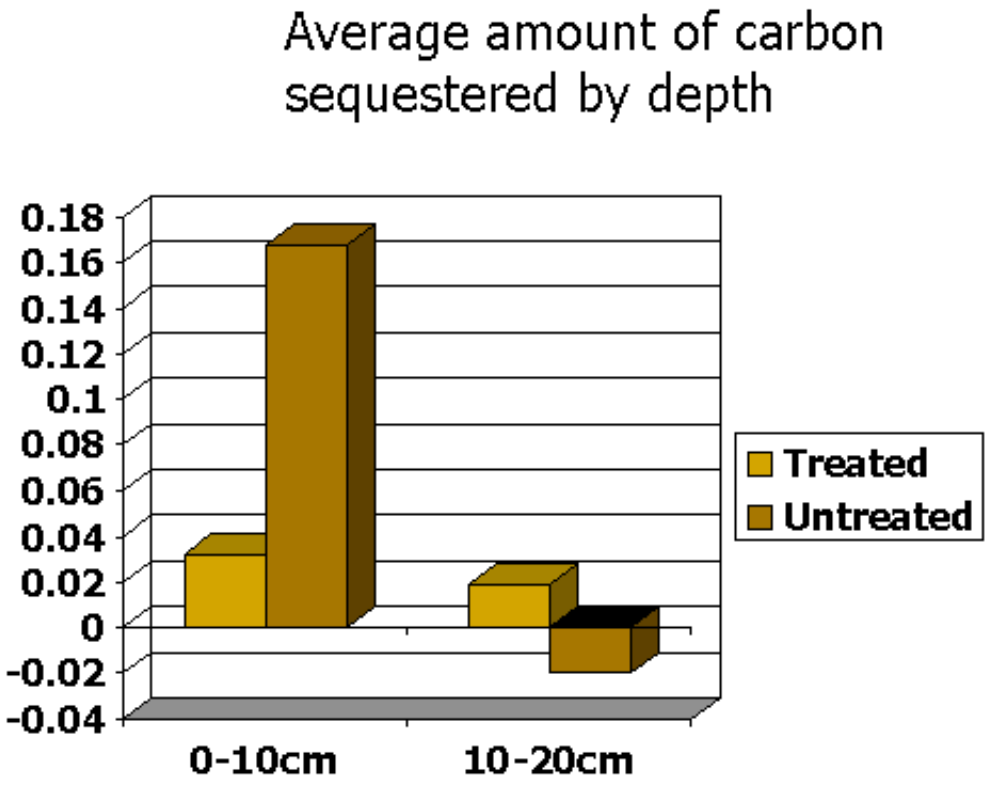




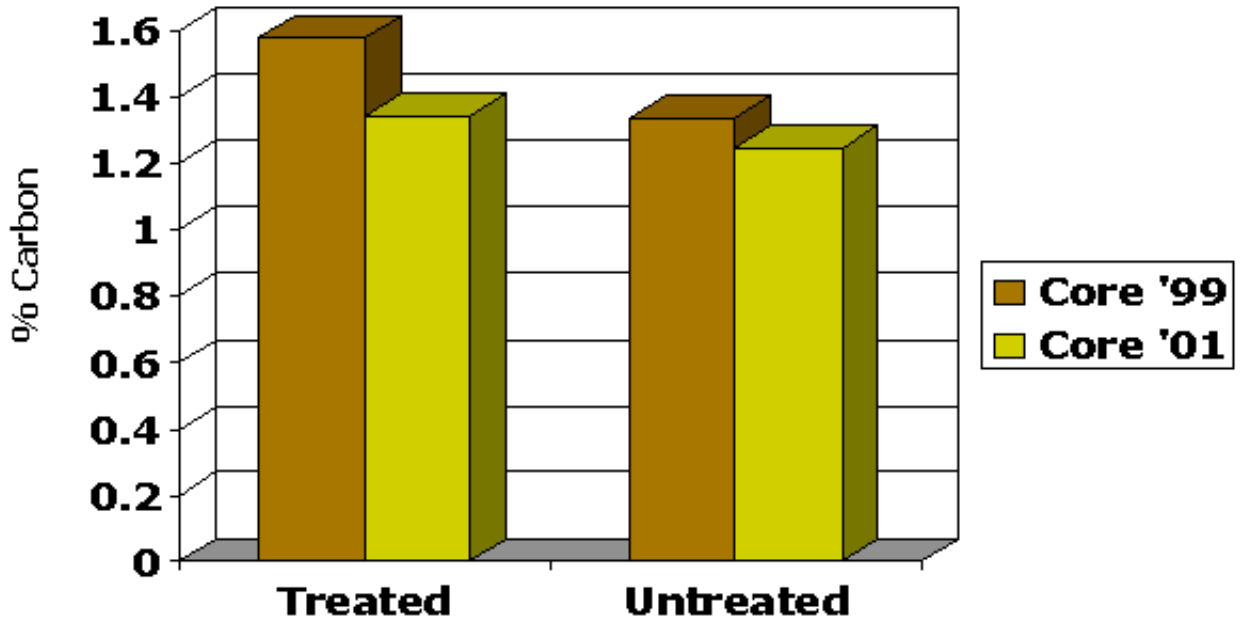
Results


% Carbon by weight for soil samples in the 0-10cm range
3.5
3
2.5
2
1.5
1
0.5
0
% Carbon
Core '99
Core '01
Adjacent Sample
1-1
1-3
1-5
2-1
2-3
2-5
4-1
4-3
4-5
5-1
5-3
5-5
Sites

Results

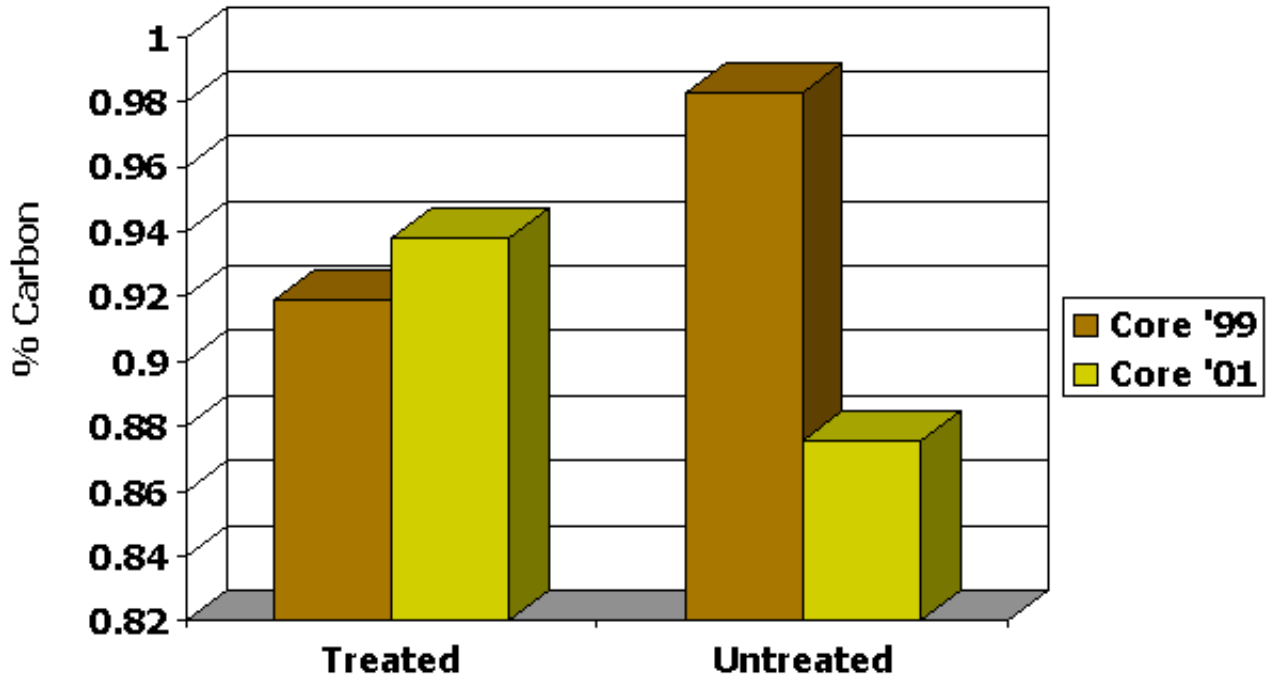

Average amount of carbon sequestered by depth
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
0-10cm
10-20cm
Treated
Untreated

Average % carbon (by weight) for soil samples in 0-10cm range of both treated and untreated sites.



Results

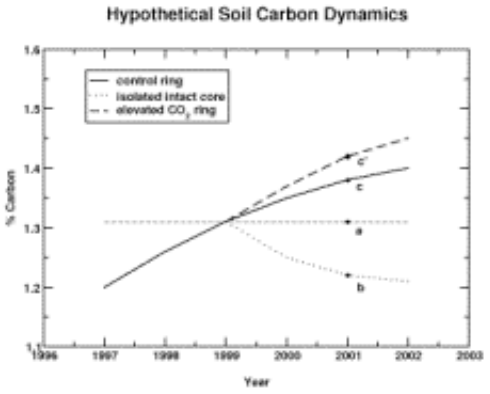
Average % carbon (by weight) for soil samples in 10-20cm range of both treated and untreated sites



Results

In the analysis of sequestered carbon at this time no difference was found between the treated and untreated rings of the FACE site. These findings are in accordance with those published concerning the Duke FACE site (Schlesinger and Lichter, 2001).

Since the FACE site is an aggrading forest plantation it is not likely that the amount of soil carbon is at equilibrium. Our sampling strategy allows additional investigation into the dynamics of soil carbon turnover. By supplementing the experimental samples with adjacent intact soil samples we were able to define three rates of change in addition to the side-by-side comparison of carbon from each sample. By subtracting the amount of carbon found



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2001 sample from the amount found in the core 1999 sample we were able to determine the amount lost to decomposition. The amount of carbon sequestered was determined by subtracting the amount of carbon in the core 1999 sample from the amount found in the adjacent 2001 sample. Each site's estimated gain of new carbon was found by subtracting the amount of carbon in the core 2001 sample from the amount in the adjacent 2001 sample.

LOSS TO DECOMPOSITION

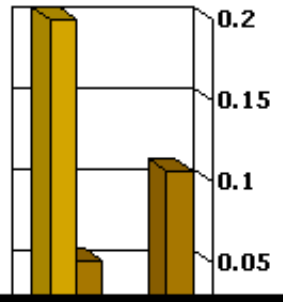
In the samples taken at the surface to 10cm depth, those samples from the rings receiving enhanced amounts of CO_2 were found to have lost more carbon than the samples taken from the control ring. The data from the 10-20cm depth was quite different from the data gathered from the previous layer. Samples taken from the enhanced CO_2 treatment rings didn't lose carbon to decomposition, yet, samples taken from the control rings were

(continued)

Results

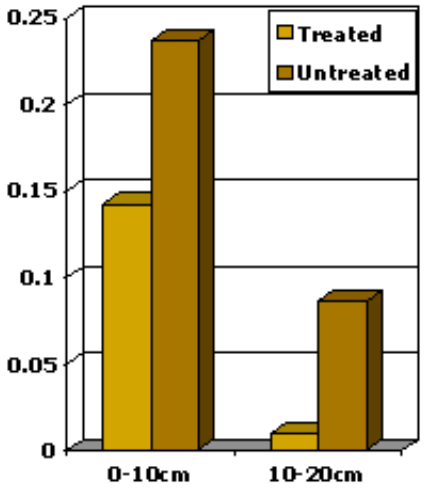
found to have lost significant amounts of carbon. The switch in carbon loss between levels leads to important questions regarding the mechanisms of the migration of dissolved organic carbon and soil moisture. Higher concentrations of atmospheric CO_2 lead to greater photosynthetic efficiency, reducing the amount that stomates need to open and thereby greatly reducing a plants evaporative losses. Less H_20 lost to evaporation means that the plant does not uptake as much from the soil, leading to a higher soil moisture content. A higher soil moisture content

Average loss to decomposition, by depth



NEW CARBON

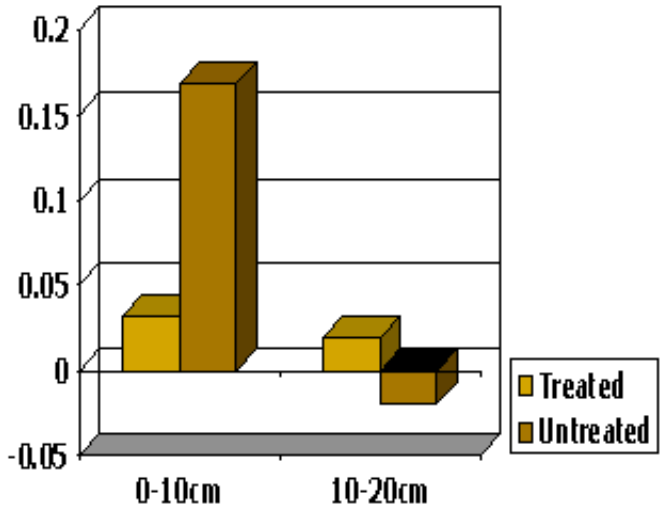
The results gathered concerning the accumulation of new carbon throughout the FACE experiment was consistent, but not significantly so. The control rings were found to have higher levels of new carbon at both the 0-10cm and 10-20cm depths. However the accumulation of new carbon in the control rings was not found to greatly outweigh the amount of new carbon gained by the treatment rings. If, in fact, the rings treated with elevated levels of CO_2 do have higher soil moisture content, then the question can again be raised about the rate of decomposition of new material relative to elevated CO_2. Or, is there a greater allocation of carbon to labile material under conditions of elevated CO_2?



Average amount of new carbon by depth

CARBON SEQUESTERED

As to the amount of carbon sequestered in both the treated and untreated rings, the control ring was found to have a slightly higher amount of carbon at the 0-10cm depth. Meanwhile, more carbon was found in the treatment ring at the depth of 10-20cm, although in neither case was the rise in carbon significant. However, the significant result of loss to decomposition is lost in the sum of difference between new carbon – loss to decomposition.



Average amount of carbon sequestered by depth

new carbon – loss to decomposition = (c-b) – (a-b) = c-a = amount sequestered

DISCUSSION

The results retrieved from this experiment are tantalizing in that they suggest several of the hypotheses. However, more time and samples are needed before the data can be shown to significantly support the hypothesis. Additional analysis (such as a test for the isotope ^{13}C) may shed added light on the dynamics of soil carbon. An isotope analysis could answer certain question about possible "new carbon" such as; whether or not any new carbon is getting into the cores and messing up the analysis, if there is a downward migration of dissolved organic carbon , and whether the calculations made for new carbon are consistent with changes in $d^{13}C$ isotope. Data concerning the soil moisture content between sampling could also provide valuable information in regards to understanding the distribution and accumulation of carbon in the soil.

QUESTIONS TO CONSIDER:

Where does the excess carbon go?

Does it only last until the litterfall has completely decomposed?

Is it being released as a gas by the microbes and fungi decomposing the leaves?

If the enhanced carbon inputs are being transformed by organisms into soil carbon then why didn't we see that increased carbon in the side samples?

If the carbon is not being retained by the soil, then can we continue to consider soil to be a long-term carbon sink?