Radiocarbon Isotopic Classification of Deep Tropical Forest Soils

Brooke Butler[1]; Karis J. McFarlane[2]; Katherine A. Heckman[3]; Jennifer Pett-Ridge[2]

[1]University of Tennessee, Knoxville; [2]Physical and Life Sciences Directorate, Lawrence Livermore National Laboratory; [3]U. S. Forest Service

Introduction

Tropical forest soils play an important role in the global carbon (C) cycle. Small changes in the cycling of C could drastically affect the carbon balance in forest ecosystems and ultimately atmospheric carbon dioxide (CO_2) concentrations. Currently, it is not understood how tropical forest soils will respond to increasing global temperatures and changing rainfall patterns. To examine the effects of warming/ drought on losses of older versus younger soil C pools, we measured radiocarbon (^{14}C) isotopic composition of bulk soil and soil density fractions of soils collected from multiple depths in the Luquillo Experimental Forest, Puerto Rico. The radiocarbon age of organic matter in these samples was measured using Accelerator Mass Spectrometry (AMS) in order to indicate the initial carbon residence time of these soils, which came from a site that is being experimentally warmed to simulate climate change effects. This examination was done in order to determine the age of the carbon in the soil plots before implementation of the long term warming experiment. This work attempts to answer the following question:

Is there a significant difference in radiocarbon values in the 1. bulk soil or 2. heavy and light fractions with depth?

Figure 1. Collection site located in the Luquillo Experimental Forest (LEF), Puerto Rico.

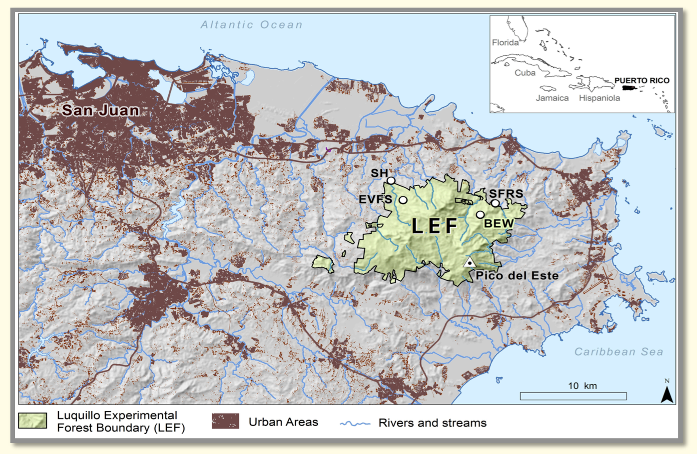


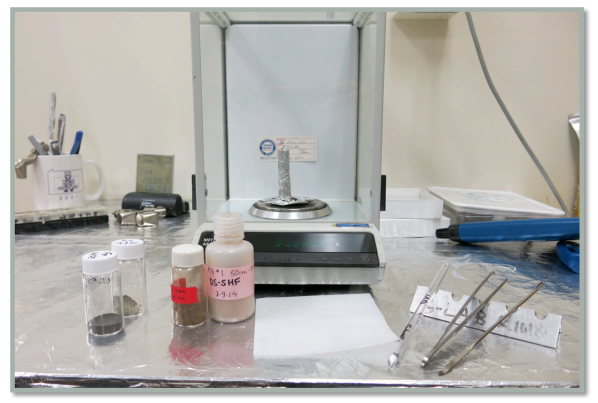
Figure 2. Map of warming site, LEF, Puerto Rico.

Sample Preparation:

1. Bulk soils (3 soil pits with 10 cm depth increments) were collected, sieved, and ground to produce homogenous mixtures (top right).

2. Samples were separated by density in Sodium polytungstate (SPT) to obtain a "free light" (<1.65 g/mL) and "heavy" fraction (>1.65 g/mL) (Sollins, et. al. 2006)

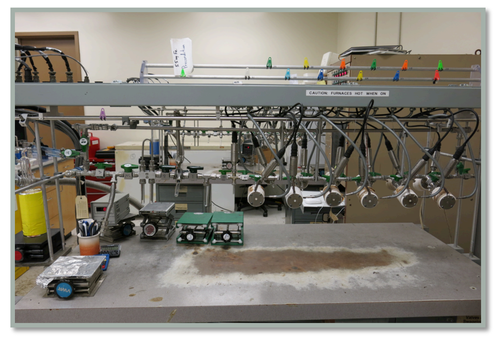
3. Bulk soil samples and light and heavy fraction soil samples were weighed (bottom right).



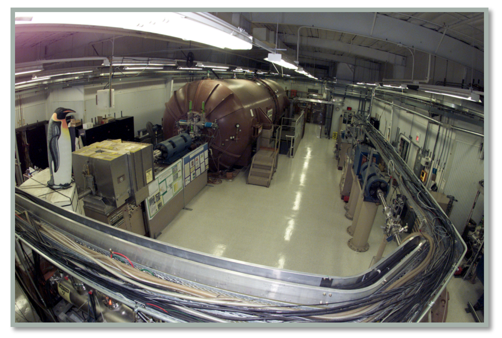
4. Soil samples were then combust via dry oxidation to yield CO_2.

Graphitization of Samples for AMS:

5. CO_2 then graphitized (Vogel et. al., 1984):
   - Samples catalytically condensed to produce graphite.



Graphite Reduction Line



Accelerated Mass Spectrometer

$$CO_2 + 2H_2 \xrightarrow[Fe]{600^\circ C} C + 2H_2O$$

6. Graphite samples were analyzed using the high precision CAMS 10 MV FN Accelerator to obtain their ^{14}C abundance.
   - AMS separates the isotopes of carbon; ^{14}C measurements were used as an indicator of the residence time of C in each fraction or depth sample.

Interpretation of Radiocarbon (^{14}C):

7. Radiocarbon values > 0 are modern and have a shorter residence time (Figure 3). Radiocarbon < 0 reflect radiocarbon decay, with more negative values indicating a longer residence time (older).

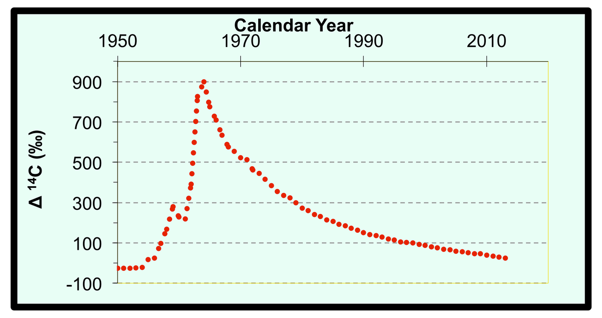


Figure 3. Radiocarbon in the atmosphere post 1950.

Results

- Bulk soil data for pit 1 and 2 (Figure 4) showed similar trends of decreasing carbon concentration with depth.
- This pattern reflected the fact that plant organic matter contributions decreased as depth increased.

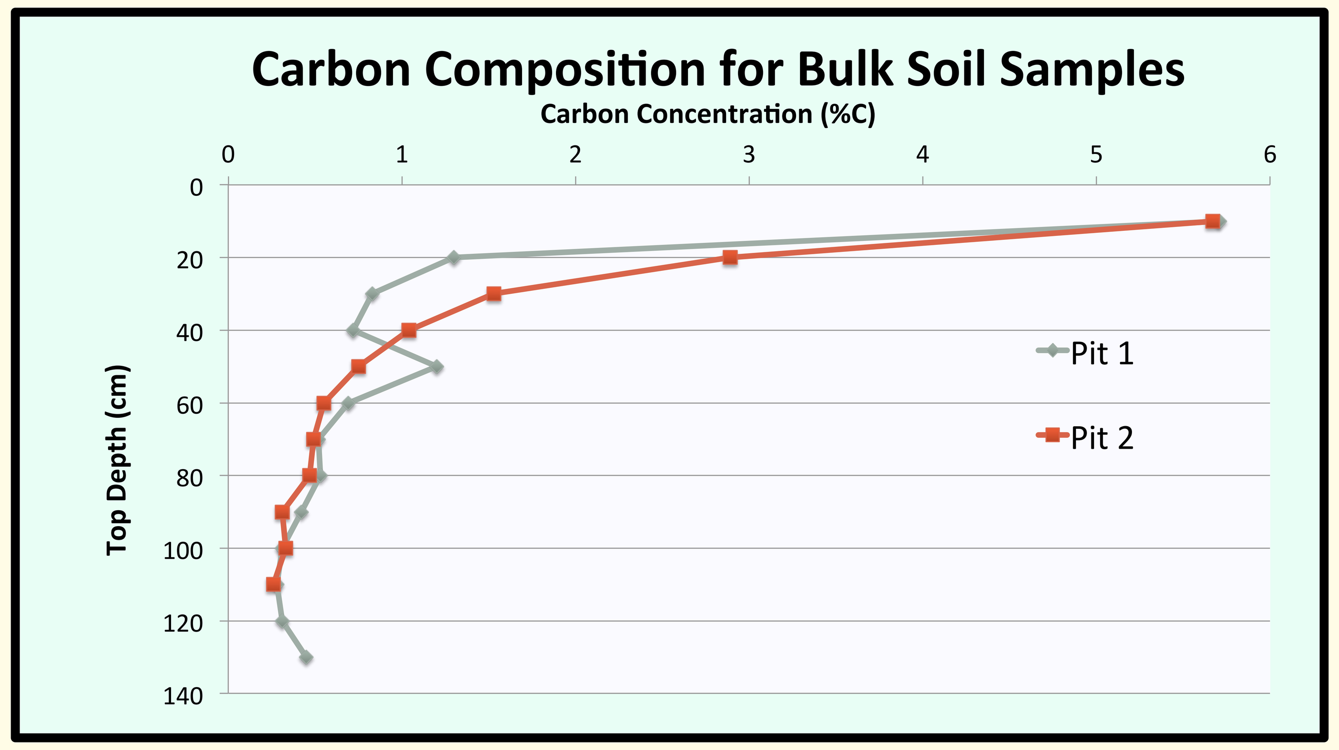


Figure 4: Bulk soil carbon concentration (%C) comparison for two replicate bulk soil sampling pits (#1 and #2) at multiple depths (0 – 140 cm).

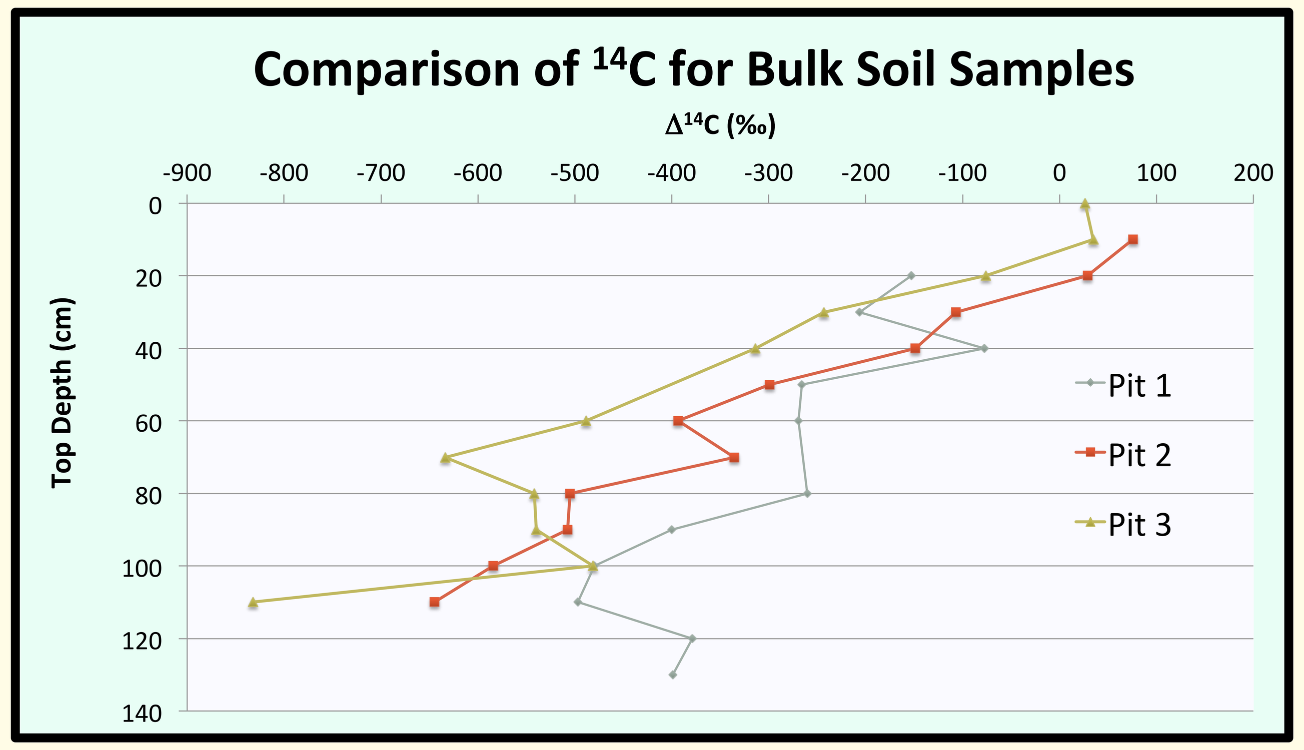


Figure 5. Radiocarbon (% ^{14}C) abundance for three different bulk soil sampling pits 1, 2, and 3 at various depths (0 – 140 cm).

- Radiocarbon (^{14}C) in the bulk soil samples for pit 1, 2, and 3 decreased with depth. There is a large variability and spread between the 3 soil pits.

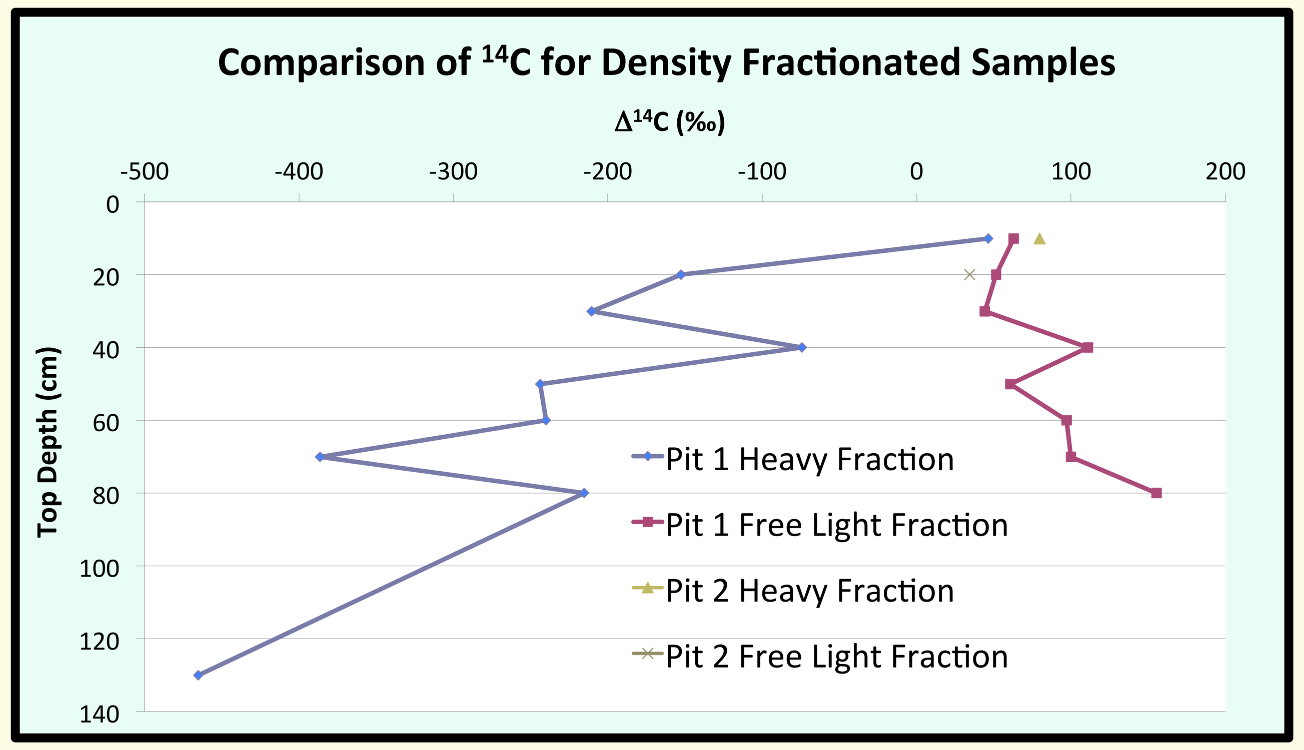


Figure 6. Differences in ^{14}C between Free Light and Heavy fractions.

- The radiocarbon values of the carbon stocks in heavy and the free light soil density fractions varied significantly. The more negative ^{14}C values indicate older mineral associated carbon located in the heavy fractions. In order to examine the actual ^{14}C ages within the fractions, use Figure 3.

Discussion & Implications

- Residence time of the carbon increases as you move down the soil profile.
- The carbon contribution from plants decreases as you move down the soil profile.
- The heavy soil density fraction soil C was much older than the light soil density aggregate fraction. This implies that soil C residence time is longer for carbon associated with soil minerals primarily found in the heavy fraction.
- In comparison to temperate deciduous forests, the ^{14}C absolute values are much larger indicating much older soil C.
- Further research will examine soil C storage and mean residence times after exposure to heat in order to model the effects of ecosystem warming.

Acknowledgments

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