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ABSTRACT TITLE: Climate Change and Soil Feedbacks to the Climate System: new process-level insights from a 22-year field study

ABSTRACT: A key question in earth system science is: Will warming lead to increased soil organic matter decay and an accelerated release soil carbon as CO_2? If the answer is yes, a self-reinforcing feedback would result with warming begetting warming. In 1991, we established a replicated, *in situ* soil-warming experiment at the Harvard Forest in central Massachusetts to address this question.

We have measured rates of soil respiration from warmed and control plots monthly from April through November over the entire course of the study. Periodically, we have also made measurements were of fine root respiration. Initially, warmed plots had higher soil respiration than controls, but after about a decade, the warming-accelerated CO_2 production decreased and returned to background levels. However, during the last seven years of the study (years 16-22), soil respiration increased in the warmed plots relative to the controls – a long-term response to soil warming never before documented.

Measurements we have made over the first 15 years of the study showed the depletion of the soil's labile carbon pool and a loss of about 30 percent of the carbon stored in the forest floor in the warmed plots. Based on a variety of measurements made in the warmed and control plots, we hypothesize that much of the carbon respired over the last seven years of the study has come from the recalcitrant soil carbon pool – "the recalcitrant decomposer hypothesis." Measurements supporting this hypothesis include: 1) an increase in oxidative enzyme potential in the warmed plots after two decades of warming; and 2) an increase in microbial carbon-use efficiency (CUE) associated with the degradation of complex (recalcitrant) carbon compounds such as phenol after long-term warming, but no change in the CUE of simple carbon compounds such as glucose[1]. We also have preliminary data showing a shift in microbial community structure in the warmed plots. Currently, we are exploring possible relationships between this microbial community restructuring and any increases in taxa or pathways adapted to recalcitrant carbon decomposition. We are also beginning to refine a microbial-enzyme model to explore the proposition that the soil microbial community will adapt to long-term warming in a way that will lead to a depletion of the recalcitrant soil carbon stocks and a self-reinforcing feedback to the climate system.

[1] Frey, S.D., J. Lee, J.M. Melillo, J. Six. 2013. Soil Carbon Cycling: The temperature response of microbial efficiency and its feedback to climate. *Nature Climate Change.* 3, 395–398 doi:10.1038/nclimate1796.