**Microbial Growth and Metabolism in Soil – Refining the Interpretation of Carbon Use Efficiency**

Kevin Geyer,[1] Kristen M. DeAngelis[2]* (email@address.gov), and **Serita Frey**[2]

[1]University of New Hampshire, Durham; [2]University of Massachusetts, Amherst

**Project Goals: Our long-term goal is to better predict the fate of soil C by developing mathematical and ecosystem models of SOM decomposition that incorporate a genetic and physiological understanding of CUE. Specifically, we propose to define the genomic basis of soil microbial CUE in the context of changing environments, and use this new knowledge to generate more realistic models of SOM decomposition.**

Carbon use efficiency (CUE) describes a critical step in the terrestrial carbon cycle where microorganisms partition organic carbon (C) between stabilized organic forms and $CO_2$. Application of this concept, however, begins with accurate measurements of CUE. Both traditional and developing approaches still depend on numerous assumptions that render them difficult to interpret and potentially incompatible with one another. Here we explore the soil processes inherent to traditional (e.g., substrate-based, biomass-based) and emerging (e.g., growth rate-based, calorimetry) CUE techniques in order to better understand the information they provide. Soil from the Harvard Forest Long Term Ecological Research (LTER) site in Massachusetts, USA, was amended with both $^{13}$C-glucose and $^{18}$O-water and monitored over 72 h for changes in dissolved organic carbon (DOC), respiration (R), microbial biomass (MB), DNA synthesis, and heat flux (Q). Four different CUE estimates were calculated: 1) ($\Delta$DOC – R)/$\Delta$DOC (substrate-based), 2) $\Delta^{13}$C-MB/($\Delta^{13}$C-MB + R) (biomass-based), 3) $\Delta^{18}$O-DNA/($\Delta^{18}$O-DNA + R) (growth rate-based), 4) Q/R (energy-based). Our results indicate that microbial growth (estimated by both $^{13}$C and $^{18}$O techniques) was delayed for ~40 h after amendment even though DOC had declined to pre-amendment levels within ~48 h. Respiration and heat flux also peaked after 40 h. Although these soils have a relatively high organic C content (5% C), respired $CO_2$ was greater than 88% glucose-derived throughout the experiment. All estimates of microbial growth (Spearman's $\rho$ >0.83, p<0.01) and efficiency (Spearman's $\rho$ >0.65, p<0.05) were positively correlated, but strong differences in the magnitude of CUE suggest incomplete C accounting. This work increases the transparency of CUE techniques for researchers looking to choose the most appropriate measure for their scale of inquiry or to use CUE estimates in modeling applications.

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