Title: **Microbial Control Over Soil Carbon Saturation**

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Project Abstract: Increasing soil carbon (C) storage is a key strategy to mitigate rising atmospheric CO_2, yet soil C pools often appear to approach a maximum value, or saturate, with increasing C inputs. The mechanisms underlying this phenomenon are poorly understood. Soil C saturation is commonly hypothesized to result from the finite amount of reactive mineral surface area available for forming mineral-associated C – the largest soil C pool in most systems. However, inputs to mineral-associated C are largely supplied by microbial activity, and the response of microbial biomass to C inputs might be limited by density-dependent factors – i.e. factors that alter growth or turnover as microbial density increases (e.g. competition or predation). Thus, we hypothesize that density-dependent constraints on soil microbial biomass represent an alternative or complementary mechanism by which soil C saturates. To evaluate this hypothesis, we first synthesized C addition studies to examine the premise that microbial biomass should exhibit a constrained, or sub-linear, response to increasing C inputs. We then explored the consequences of these microbial constraints by simulating microbial-explicit soil C models with alternative hypotheses about microbial growth and turnover in the multi-assumption architecture and testbed (MAAT). Our dataset – which contained more than 350 microbial biomass observations from *ca.* 100 C addition experiments – revealed a clear sub-linear relationship between organic input rates and soil microbial biomass. Based on ancillary measurements, we suggest that this constrained microbial biomass response was driven by less efficient growth or faster microbial turnover as C inputs and microbial biomass increased. Representing both of these effects in a three-pool soil C model led to saturation of the mineral-associated C pool but not the particulate C pool, a pattern often observed in saturation studies. Moreover, by manipulating the relative strength of growth versus turnover density-dependence, we were able to simulate three other previously observed saturation patterns: 1) insensitivity of particulate and mineral-associated C to inputs, 2) insensitivity of mineral-associated C with increasing particulate C, and 3) saturation of all soil C pools. Thus density-dependent controls on microbial growth versus turnover might differentially affect the response of soil C pools to increasing inputs. We conclude that soil C responses to altered C inputs – or indeed any environmental change – are likely influenced by the ecological factors that limit microbial populations. Considering these microbial constraints might better enable us to model soil C sequestration efforts.