Refining expectations of soil organic carbon storage under future climate change with observational studies

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The effects of multiple global change factors on soil carbon stocks are difficult to capture in short-term experiments. Urbanization and other microsite qualities can impose long-term, gradual increases in temperature, carbon dioxide and ozone levels that fluctuate over time and interact freely with other ecosystem attributes. These increases can simulate realistic, near-future climate change conditions.

At 62 golf courses in the temperate, mesic, mid-Atlantic region of the U.S., I conducted an observational study of soil carbon in minimally managed soils at varying distances from urbanized areas, where cool-season turfgrasses had been grown without soil disturbance for ≥ 25 years. Replicate soil cores were taken to a depth of 30 cm, hourly soil temperatures were recorded for seven months, tropospheric ozone levels were passively monitored during the late-summer peak season, and site and management variables were recorded. Soil chemistry, texture, and total and active carbon content were measured from the composite soil core samples. Correlations of total and active soil carbon with potential explanatory factors were explored using multiple regression analysis.

Total soil carbon was positively correlated with increasing February-only mean daily minimum soil temperature, which ranged from 0.3 - 2.7 °C. Mechanisms may include freeze/thaw disruption and subsequent mineralization of soil organic carbon, and/or reduced plant inputs to soil resulting from increased cold stress. No relationships were detected between total or active soil C and overall mean Dec.-May temperature, which ranged from 6.0 – 9.0 °C, or maximum May-only temperature, which ranged from 18.0 – 23.3 °C. Total and active soil carbon were positively correlated with increasing ozone levels and negatively correlated with fertilization; potential mechanisms include recalcitrance of ozone-oxidized plant tissues, ozone inhibition of soil microbial respiration, and fertilizer-induced carbon consumption by soil microbial biomass. Total soil carbon was also positively correlated with soil lead content and CEC.

Together, the suite of detected correlations suggests that within a climatic region, factors impacting soil carbon availability explain a large part of the variation in soil carbon storage. These results also highlight that small increases in temperature ranges can have important effects, and that commonly-held expectations based on controlled experiments and models are not always observed in complex natural systems.