Urban Resilience across the Terrestrial-Aquatic Continuum: Mechanisms to Mass Balance

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Over 70% of the world's population is predicted to live in urban areas by the end of the century, yet the impacts of urbanization on coastal ecosystems are poorly understood. These systems disproportionately impact the global carbon (C) cycle, and in turn, are key to understanding climate change. My vision is to develop a process-based understanding of urban C cycling and its response to disturbances from land to sea.

Across the urban terrestrial-aquatic continuum, a plethora of land uses and associated anthropogenic activities contribute excess C and nutrients (nitrogen [N] and phosphorous [P]) to soils and waterways, which in turn generate distinct biogeochemical processes. Extreme precipitation events heighten these impacts by flushing materials into aquatic ecosystems and ultimately into the coastal ocean. However, despite the common selective pressures imposed by these factors, each urban system is uniquely designed and managed, so deriving generalized knowledge remains challenging. Here, I focus on unraveling the interplay of molecular controls, nutrient supply, and hydrologic factors that drive microbial metabolism of organic matter (OM), the primary constituent of organic C in most ecosystems, in urban coastal systems. I hypothesize that commonalities in urban microbial community function create generalizable mechanisms regulating OM decomposition in the context of anthropogenic activities.

I specifically seek to (1) identify specific locations (control points) most critical to C flux into urban coastal zones; (2) determine the impact of anthropogenic activities on microbial organic matter (OM) decomposition under ambient conditions and extreme precipitation; and (3) uncover generalizable processes across urban centers. To do so, I am teaming with 16 collaborators that routinely collect hydrologic and biogeochemical measurements in three coastal urban centers with different population densities, land uses, and climates. This team includes a mixture of federally funded, university, and nonprofit groups to create a one-of-a-kind network while also supporting place-based learning and inclusivity of underrepresented groups in science. We will use field surveys and a model-experiment workflow to discover hydrologic and biogeochemical processes that regulate C cycling from source to sink across urban ecosystems.

Collectively, this research will generate a mechanistic framework of coastal urban C cycles that incorporates molecular-scale responses to precipitation. It provides a basis for alleviating key uncertainties in the Office of Science, Biological and Environmental Research's existing multiscale models that will enable enhanced predictions of the global climate system.

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