A Distinct Urban Biogeochemistry?

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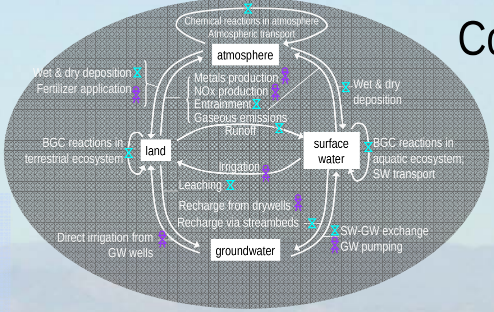


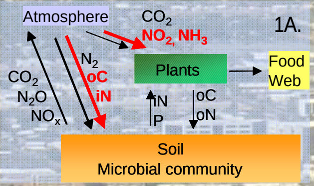
Conceptual Model

Transfers of materials among air, land, water, and groundwater components. Human-mediated or enhanced fluxes indicated by stick-figure bowties.

Research Question

Do patterns and processes of urban biogeochemistry differ fundamentally from those of non-urban ecosystems?

1. Inputs: Atmosphere-Land



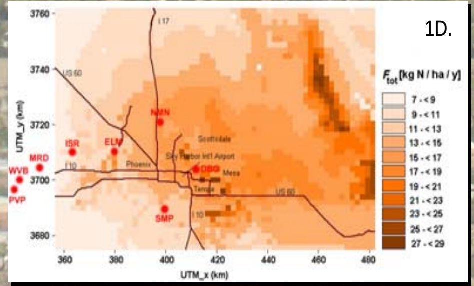
1B. Organic Carbon Deposition

- Phoenix aerosol organic carbon (oC)
  - Fine aerosol oC ~4 µg/m^3 (40% of $PM_{2.5}$)
  - Coarse aerosol oC ~3.5 µg/m^3 (20% of PM_{10})
- Deposition Velocity (v_d)
  - Measurements for sagebrush
  - 5 µm particles: v_d = 1.5-3.4 cm/s (Nikola & Clark 1976)
  - 2.5 µm particles: v_d = 0.5 cm/s (Simpson 1961)
- Total oC flux ~25 kg ha^{-1} y^{-1}
  - 90% with coarse particles

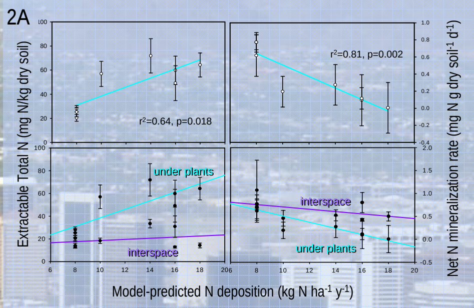
1C. Inorganic Nitrogen

- NOx (from cars) comprises 30% of total N input
- Most is likely deposited

Inputs of inorganic nitrogen (Baker et al. 2001, Box 1C) and organic carbon (Box 1B) are substantially higher in the Phoenix metro area than in the surrounding desert. Owing to airflow patterns and topography, a gradient of iN deposition from SW-NE exists in the study area (Fig.1D, Fenn et al. 2000). Therefore, INPUTS of nutrients to soil microbial communities and plants are enhanced over non-urban ecosystems (Fig. 1A). We do not know how these materials enter bgc cyles, nor whether microbes can use the oC.

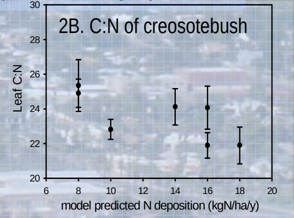


2. Intrasystem Transport, Transformations, and Storage



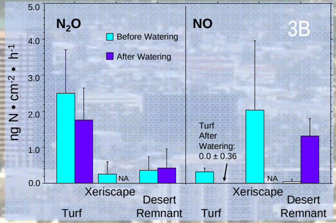
Once deposited, materials may be stored, enter biogeochemical cycles via plant or microbial uptake, or be redistributed within the ecosystem. A preliminary study of soil pools and transformations was conducted along the gradient (points shown in red in Fig. ID). Although we found that more total N was stored at the high-deposition end of the gradient (Fig. 2A), mineralization rate was lower, and the significant trend was wholly attributable to soils under plants. This suggests that plant uptake is a primary entry point for deposited atmospheric N into bgc cyles.

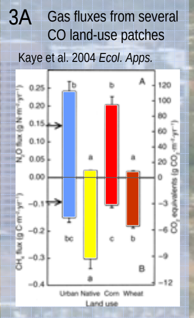
We also found that plants were storing more N relative to C at the high end of the gradient (Fig. 2B), which may transfer to higher trophic levels. Rango & Schade (unpublished) showed evidence for P limitation in herbivores feeding on such N-rich plant material.

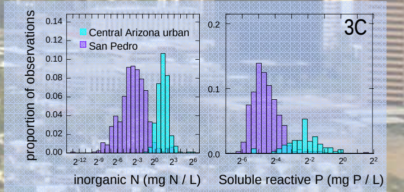


3. Outputs: Land-Water & Land-Atmosphere

Outputs from the urban landscape occur as gas fluxes and stream export. In terms of N, urban lawns are "hot spots" for fluxes of greenhouse gas N_2O (Kaye et al. 2004; Fig. 3A) and human management (irrigation, planting style) in these areas increases gaseous N loss (Fig. 3B).







Losses to aquatic ecosystems (export loads) differ from those typical of desert streams (Fig. 3C) in being N-rich, which may lead to P limitation rather than N limitation in urban aquatic ecosystems.

SUMMARY AND PROSPECTS

There are many ways in which biogeochemistry of urban ecosystems potentially differs from non-urban biogeochemistry (Fig. 4). We are beginning a new project to explore the rates and fates of inorganic nitrogen (iN) and organic carbon (oC) deposition to desert patches in the central Arizona region. We will use sampling along the gradient and field and laboratory experiments to test two hypotheses:

- If deposited oC is a significant C source fueling heterotrophic microbial metabolism, then microbial processes may be decoupled from plant processes
- Because of subsidies of N and C, ecosystems are pushed toward phosphorus limitation. We predict that we will find evidence of P limitation from measurements of tissue stoichiometry and fertilization experiments.