Nutrient movements in human environment interactions: Phosphorus in Phoenix.

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Introduction / Research Goals

This research synthesizes what we know about phosphorus (P) nutrient dynamics through key stocks and flows in the Central Arizona-Phoenix Long-Term Ecological Research (CAP LTER) urban system. Phosphorus is vital nutrient for all living organisms, but as a limiting nutrient can be a pollutant in excess amounts. Humans alter the dynamics of P and other nutrients by deliberately changing material inputs and outputs, by inadvertently altering air, water, and soil conditions, and by changing material accumulation. Urban biogeochemistry can also affect human activity by directly affecting individual health and quality of life, by regulating costs of manufacturing, food, and transportation, and by controlling city-wide policy regulations (i.e. pollution control).

Our initial research characterizes the inputs, outputs, internal cycling, and accumulation of P in cities and examines the relationships between human activity and P in the city. The overall goal of this exploratory model is to improve our understanding of urban nutrient dynamics by extending the ecological concepts of whole system nutrient budgets to urban systems.

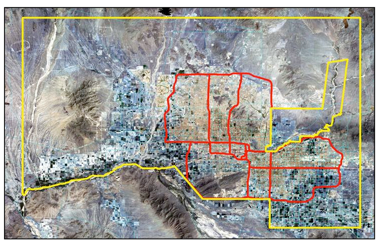

Figure 1: Map of the CAP boundary with land cover from 2005. Legend: Yellow: CAP boundary Red: Highways

Phoenix Metro, AZ

Population: ~4 million

Area: 6400km^2 with significant sprawl

Precipitation: ~190 mm/year

Air quality: Declining

Major imports: Food, fuel, building materials, industrial goods

Governance: New commitment to sustainability (i.e. Green Phoenix)

Table 1: Known stocks (Gg; A) and largest flows (Gg/year) in CAP ecosystem (B).

A. Known Stocks (2005)	**Gg P**
Asphalt	18.8
Desert soil	8.7
Agricultural soil	4.2
Xeric residential soil	3.9
Humans	3.2
Cows	1.9
Mesic residential soil	0.8
Urban non-residential soil	0.6
Pets (cat & dogs)	0.1
B. Largest flows (2005)	**Gg P /year**
Fertilizer to agricultural soils	3
Human waste to wastewater	2.6
Food to human food supply	2.2
Feed crops to cows	1.8
Wastewater to soil (irrigation)	1.8

Method: Budget Approach

Mass balance phosphorus (P) budget

Input = Output + Accumulation

(Amount of material x concentration of P)

Stocks = Gg P

Flows = Gg P/year

System boundary: CAP LTER ecosystem

Data gathered from the literature for 2005 (or nearest date) for fluxes and stocks; unknown numbers calculated where possible with mass balance

Acknowledgements

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Phosphorus Budget of Central Arizona Phoenix (CAP) Ecosystem

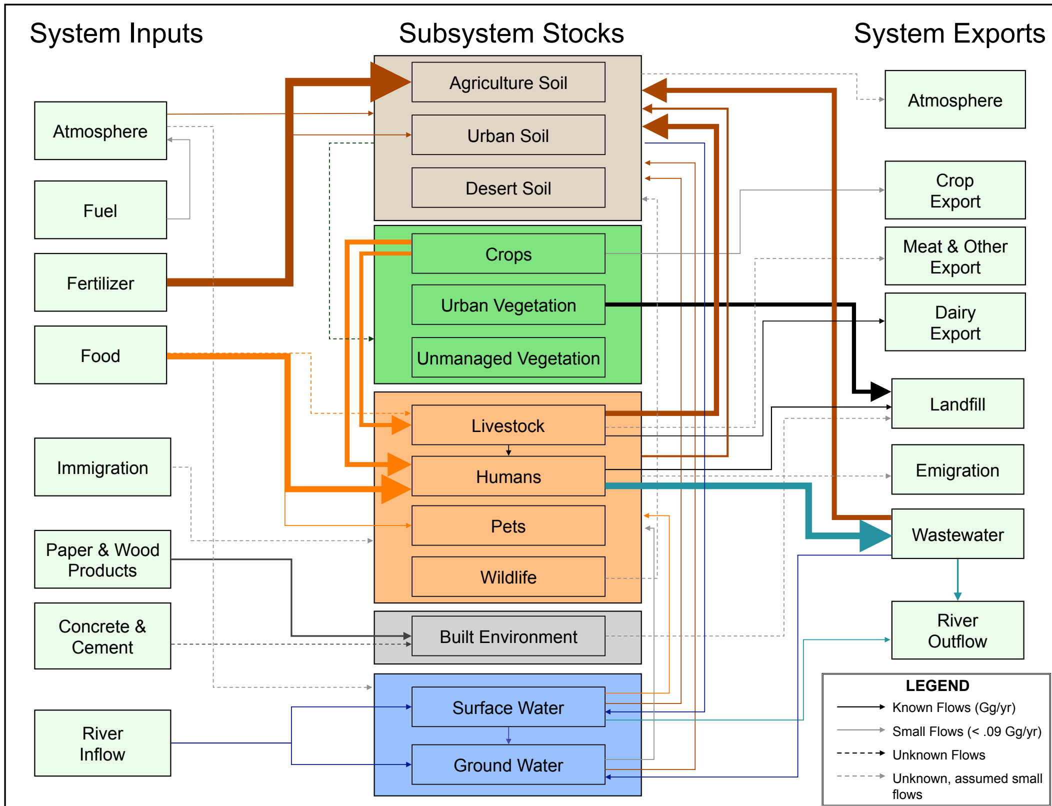

Figure 2: 2005 Central Arizona Phoenix (CAP) P budget. Boxes: subsystem stocks (e.g. soil, vegetation, animals, water). Arrows: flows into and out of the CAP ecosystem or between CAP subsystems; arrows are sized relative to the magnitude of the flow and colored based on the subsystem they enter; grey arrows are small flows (< 0.09Gg/yr); dashed arrows are unknown flows; grey dashed arrows are unknown, but assumed small flows.

Results and Conclusions

Food related flows dominate CAP urban phosphorus (P) cycling. Agricultural fertilization is the largest single flow of P. Our findings are consistent with research indicating that global anthropogenic P flows are dominated by mining P for fertilizers for food and lost mainly through runoff, food waste, and excreta (Cordell et al. 2009). In the CAP system, wastewater recycling to agriculture is the largest recycled flow. Asphalt and soils are the largest P stocks we have calculated. This is the only P budget of which we are aware that includes values for the built environment. As this is an urban system, human bodies accounted for a large amount of stored P. So far we have accounted for 42 Gg P stored within stocks of the CAP LTER system. Total inputs exceed 6.5 Gg P/yr, outputs 0.2 Gg P/yr, and the total fluxes, including internal cycling, are 20.9 Gg P/yr. These estimates are preliminary however, as some stocks and flows are missing.

Future Research: This model of urban P cycling is the first step toward a new framework to examine human-environment interactions and urban biogeochemical complexity. The Urban Stoichiometry Framework (Cook et al. 2010) will link existing carbon (C) and nitrogen (N) budgets from the CAP system to this P Budget. Development of this model deals initially with systems understanding and interdisciplinary integration, but keeps in mind issues of concern for policy makers and the community. Our ultimate goal is to use this framework to explore relevant social-ecological urban issues.