Urban ecosystems provide an opportunity to examine especially pronounced human alterations of biogeochemical cycles. Biogeochemical research in the CAP LTER has focused both on the whole ecosystem and on patterns and processes within and between urban landscape patches (Fig. 1).

**Ecosystem Scale**

**Questions at the whole ecosystem scale include:**
- Is the city a source or a sink for different elements?
- What are the hot spots of element retention in the urban landscape?
- How are elements transported in airshed-watershed interactions?

A mass balance for N showed that most of the input occurred via anthropogenic means, either deliberate (import of food, fuels, etc.) or inadvertent (conversion of N2 to NOX as a by-product of fossil fuel combustion). Furthermore, inputs exceed outputs (Fig. 2), indicating either an underestimated sink or accumulation of N in the ecosystem. Novel methods for describing the dependence of the city on external systems for food and water and assimilation of C wastes produced, based on the ecological footprint concept, reveal the extreme heterotrophic nature of the urban ecosystem (Fig. 3). Note that the size of the CAP study area is approx 4,000 km².

**Patch Scale**

**Questions at the patch scale include:**
- How does urbanization affect nutrient dynamics?
- What are the hot spots of element storage and transformation in soils?

Material storage and movement varies among patches. Examination of soil samples, although preliminary, conformed to a gradient of reduced deposition from more urban to more rural sites. Nitrogen deposition is being modeled to generate a more accurate estimation for urban areas (see posters).

**Research projects**

**Whole ecosystem scale and above:**
- Mass balances – nutrient budgets for N, C, and S
- Upstream-downstream comparison of water chemistry
- Atmospheric deposition monitoring and modeling
- Ecological footprint of CO₂ assimilation
- Lichen accumulation as indicator of elemental deposition

**Within- and between-patch scales:**
- Soil nutrient and organic matter storage (200-point survey)
- Nutrient storage on asphalt
- Nutrient transport during storms
- Recipient systems: retention basins, urban lakes, urban greenways
- Aquatic biogeochemistry

**Integrative opportunities:**
- Effects of socioeconomic setting and human use on soil biogeochemical processes and input-output balance at neighborhood scale (part of Parks Project)
- Extension of the ecological footprint to incorporate human dimensions

**Recipient systems for materials transported during storms and flash floods include retention basins, artificial urban lakes, highly modified urban washes (“greenways”), and dry river channels. Preliminary indications are that both pool sizes and flow rates are large in these systems (e.g., Table 2).**

**Aquatic biogeochemistry research includes investigations of canals, streams, and artificial lakes in the metropolitan area. Most of these systems are highly designed, manipulated, and managed as well as subject to higher nutrient loads. Experiments in an urban wash show that nutrient limitation of algal growth can occur even in this highly altered ecosystem (Fig. 6).**

**Table 1** Denitrification potentials were measured in soils of retention systems and converted to an annual basis using climatological inputs (e.g., Table 1). Nutrient loads predicted from desert soils.

**Table 2** N balances for Phoenix, AZ, measured in 1997 through 1998, based upon USGS daily flows and monthly NAQWA DOC and POC concentrations. The data include contributions from soils of different contaminant types, e.g., urban, residential, and agricultural. The data also include losses from the urban wash due to volatilization, denitrification, and runoff.

**Table 3** Nitrogen gas fluxes, soil nutrient, and nutrient loads in runoff from residential and other permanent plots will begin in spring 2001.

**Fig. 4** Two-year averages of surface water chemistry from frequent, shared wells, depth-integrated surface water samples collected from the Salt River, Phoenix Creek, and Desert Wash throughout the study period (2000-2001). The data indicate that water from Phoenix Creek and Desert Wash is more nutrient rich than water from the Salt River, indicating that water from the urban wash is a nutrient source for the Phoenix Creek and Desert Wash waterways.