Spatial distribution of ecologically relevant urban air pollutants in Sonoran Desert

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Urban air quality can be a resource or stressor

Cities occupy a small area of Earth's land, but urban-generated compounds, such as **carbon dioxide (CO_2), ozone (O_3)** and **reactive nitrogen (N)**, impact air quality at local to global scales.

Despite their ecological relevance as a *resource* or *stressor* to primary producers (**Table 1**) the co-occurring distribution of elevated CO_2, O_3 and N and net ecological impacts in protected ecosystems is unknown.

Table 1: Urban atmospheric compounds act *individually* as either a *resource* or *stressor* affecting primary production. Their net ecological impact is unknown.

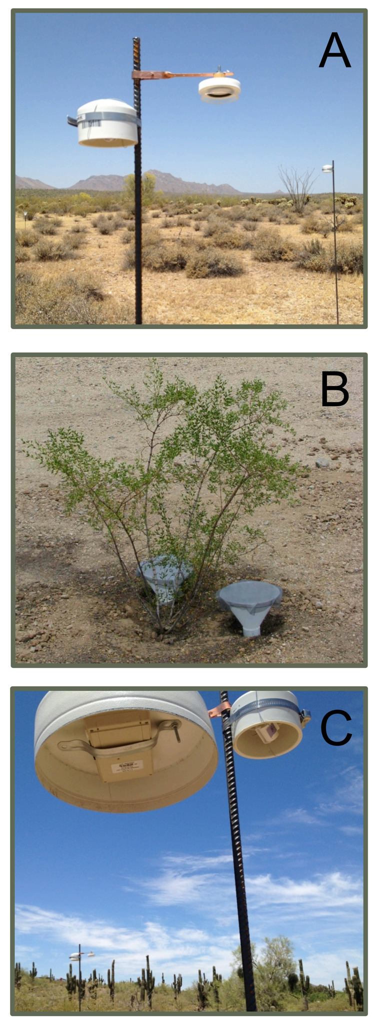
Atmospheric compounds		*Ecological relevance*
Carbon Dioxide (CO_2)	↑	Increase water-use and nitrogen-use efficiency; ***stimulate primary production***
Ozone (O_3)	↓	Foliar cell damage; ***inhibit photosynthesis*** and stomatal conductance; early senescence
Reactive Nitrogen (NO_x, NH_3, HNO_3)	↑	Alleviate nutrient limitation; ***stimulate primary production;*** alter species composition

Monitoring air quality in protected desert areas

Local air quality agencies monitor O_3 and nitrogen oxides (NO_x) for human health concerns, but monitoring is often restricted to residential areas. Ecologically important compounds, such as nitric acid (HNO_3), ammonia (NH_3), and ground level CO_2 are rarely monitored in cities or protected lands.

Using co-located passive samplers (**A**: HNO_3, NO_x, NH_3, and O_3), ion exchange resin (IER) collectors (**B**: NH_4-NO_3), and infrared gas analyzers (**C**: CO_2), **we examined the spatial distribution of ecologically relevant compounds in the protected desert areas in and surrounding Phoenix, Arizona.**

Additionally, we examined reactive N and O_3 concentrations along a small spatial scale 1500 m transect from the exterior to interior of one large desert protected area in the city.



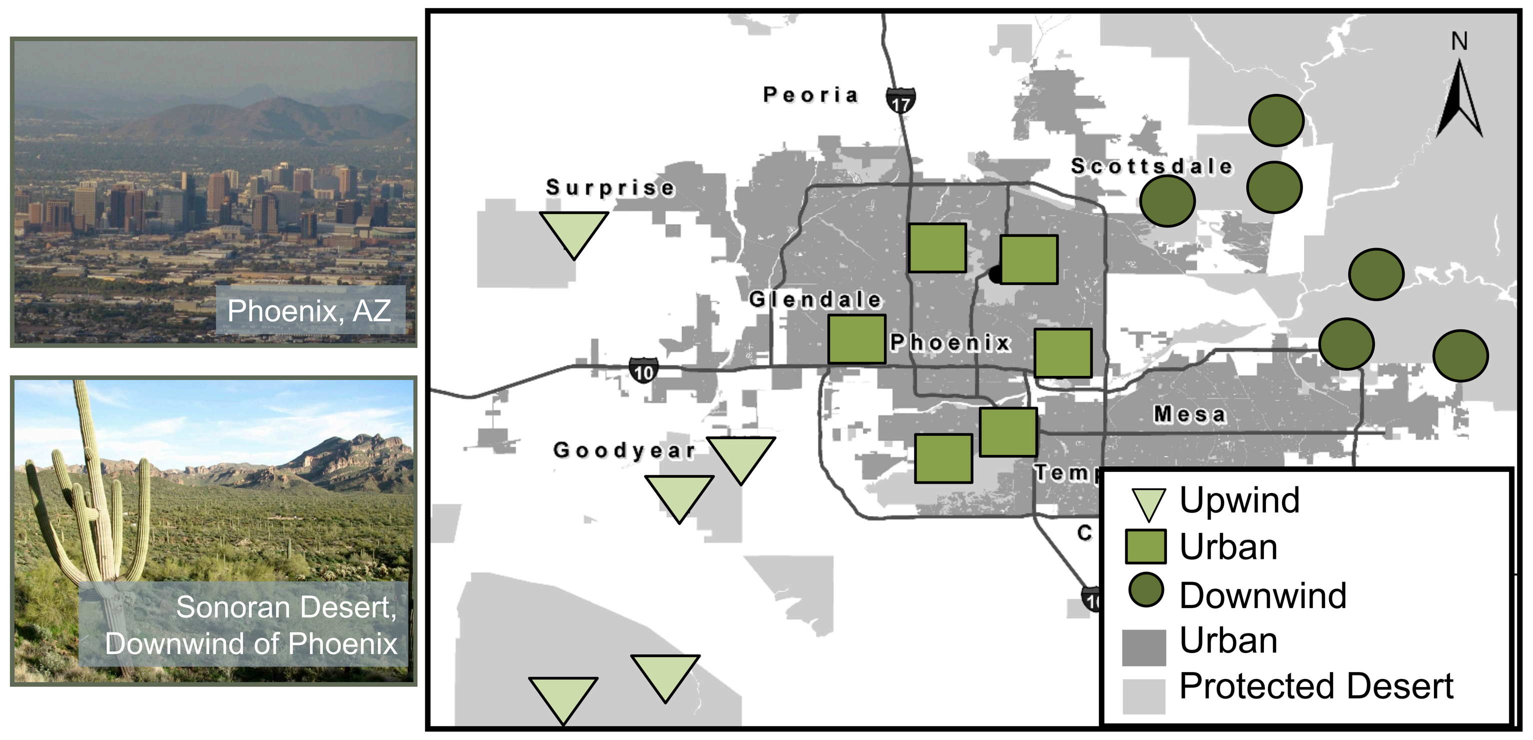


Figure 1: Ongoing monitoring sites in protected desert in and around Phoenix, Arizona for N deposition (17 sites), O_3 (10 sites), and CO_2 (3 sites).

Long-term total N deposition greatest in the city and during summer monsoon season

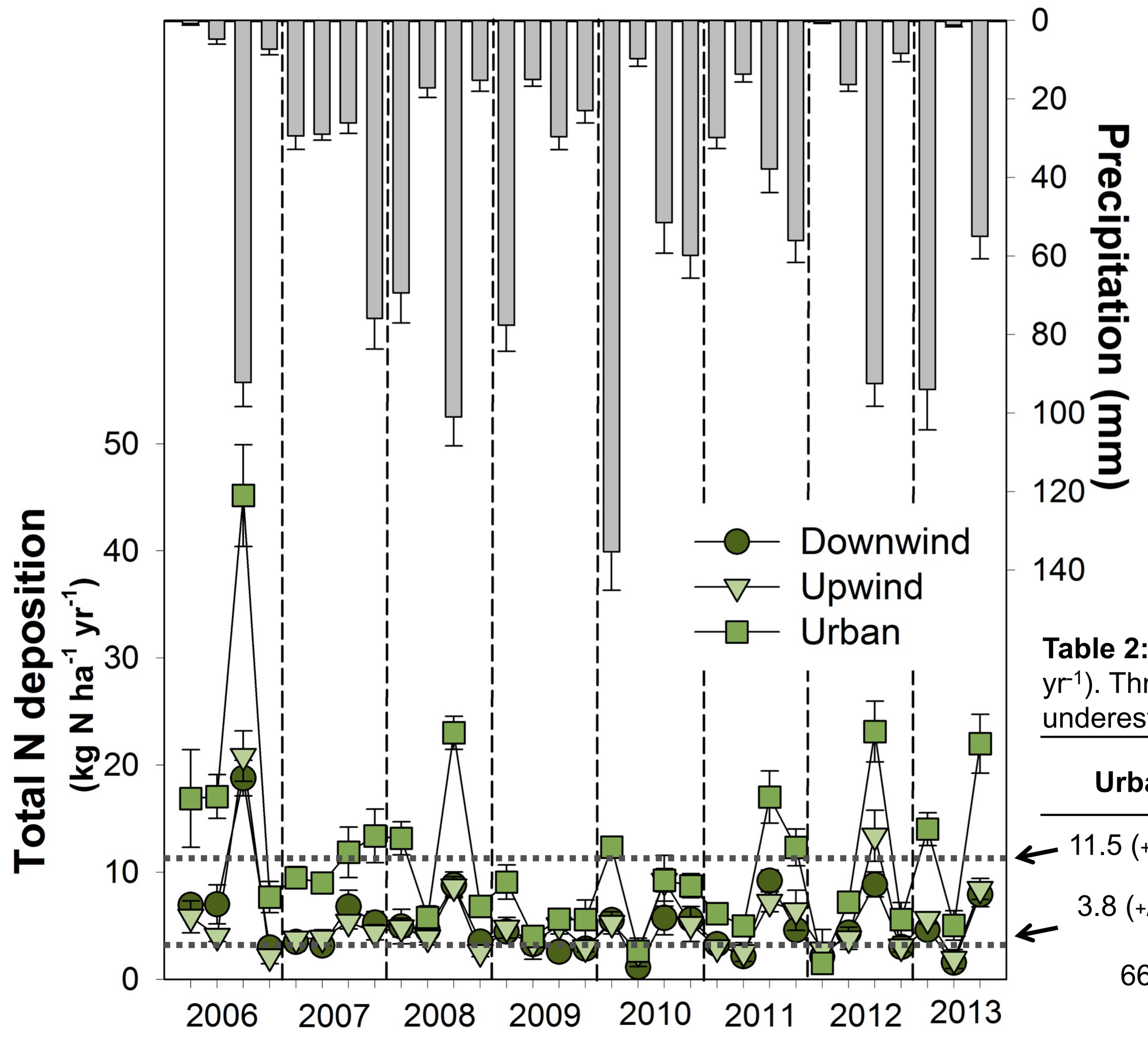


Table 2: Average total N deposition (kgN ha^{-1} yr^{-1}). Throughfall (wet + dry) deposition may underestimate dry deposition.

Urban	Outlying Desert	
11.5 (+/- 0.8)	5.2 (+/- 0.3)	Estimated total
3.8 (+/- 0.3)	3.1 (+/- 0.8)	Throughfall
66%	40%	Underestimation of total deposition by throughfall

Figure 2: Long-term total N deposition (kgN ha^{-1} yr^{-1} +/-1SE) calculated with IER throughfall estimates adjusted for potential underestimation of dry deposition. Accounting for dry deposition, N deposition is significantly greater in urban region and during the summer monsoon period (June-September).

Gaseous dry NH_3 deposition is a significant contribution to nitrogen inputs in the city

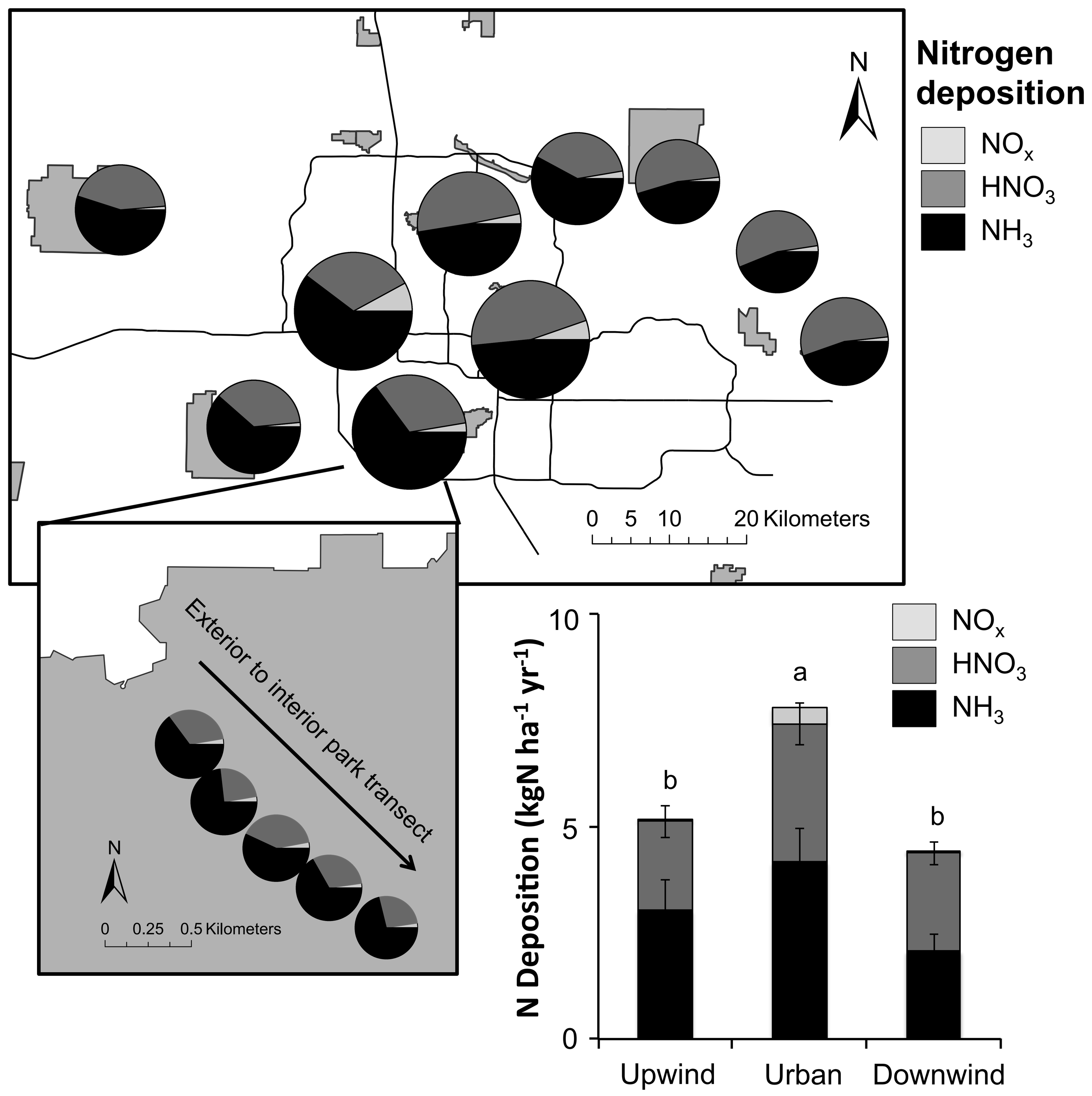
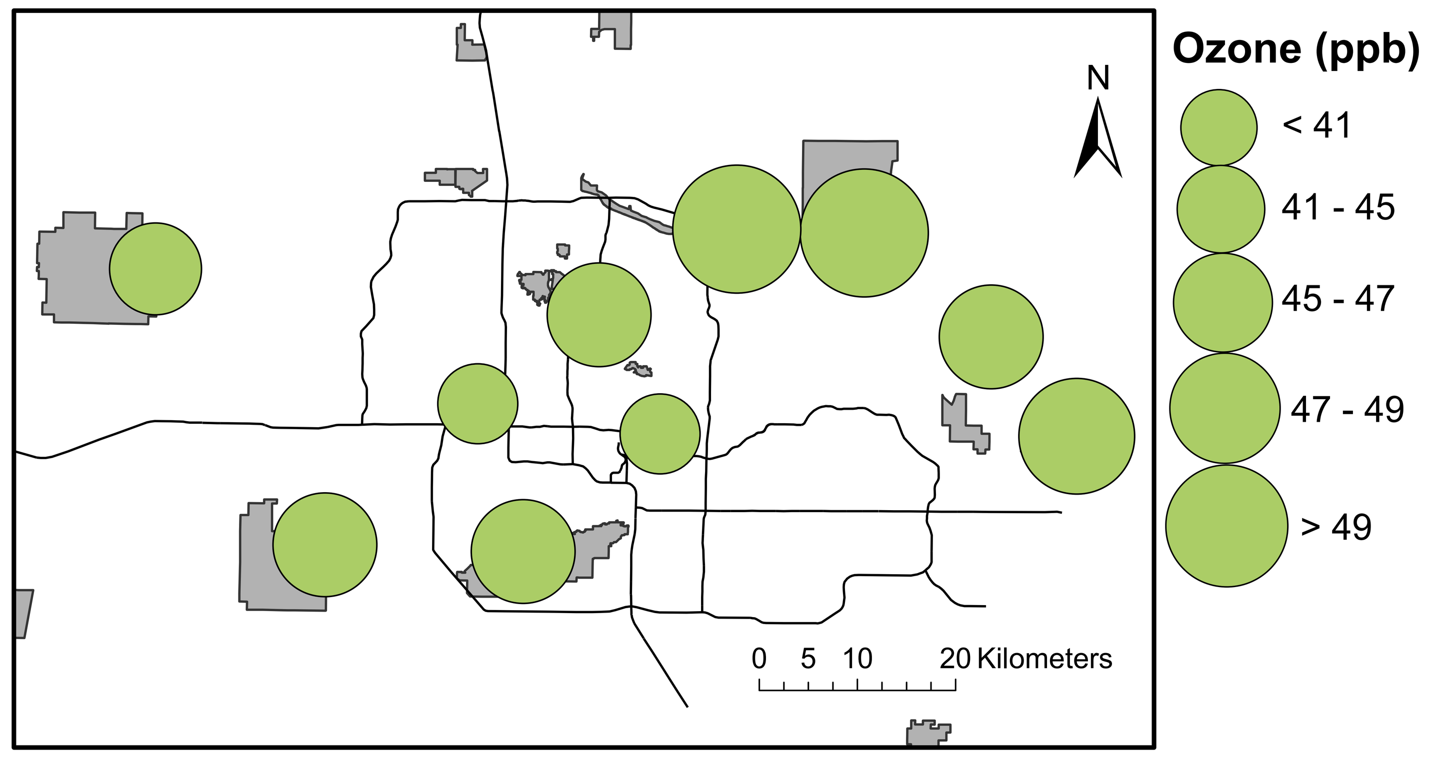


Figure 3: Summer gaseous dry N deposition (NO_x, HNO_3, and NH_3, kgN ha^{-1} yr^{-1}) estimated from passive samplers is greater in urban than upwind or downwind regions. Larger circles represent higher total N deposition.

O_3 concentrations significantly higher in protected desert downwind of the city



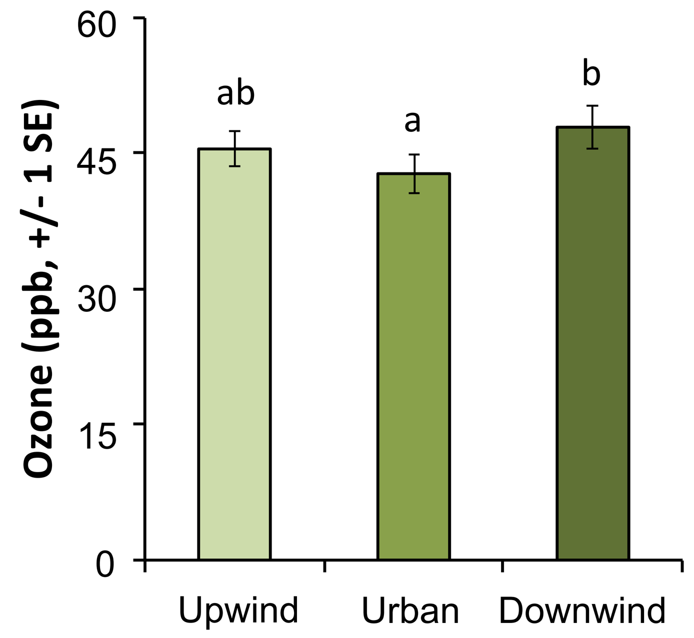


Figure 4: Ozone (ppb) concentrations estimated from passive samplers (average over 2-3 week periods) is significantly greater downwind than in urban protected desert parks. Ozone does not vary between park interior and exterior. Larger circles represent higher ozone concentrations.

CO_2 varies little among regions

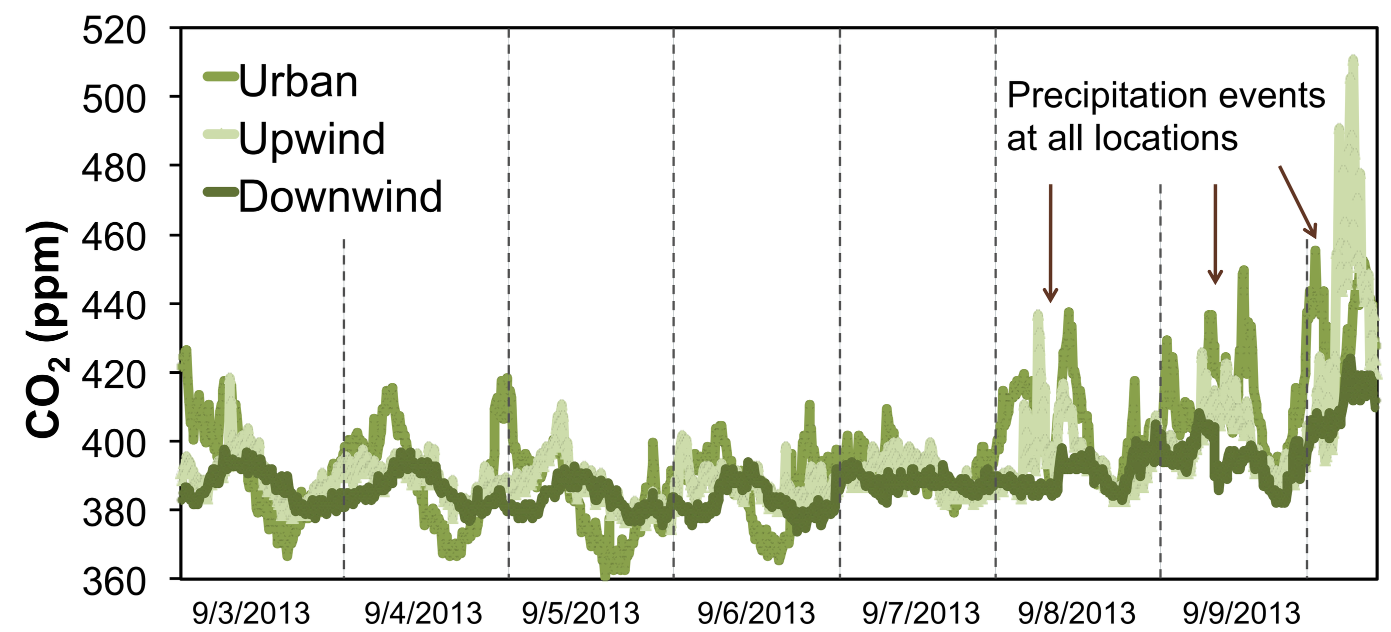


Figure 5: Average ground level (2 meter) CO_2 (ppm) concentrations varied little among locations, although diurnal variation in the urban site was greater than upwind and downwind sites. CO_2 levels spike during rain events.

Next steps toward multi-pollutant critical load

Our findings highlight the need to **monitor and regulate ecologically relevant atmospheric compounds that impact ecosystem structure, functioning and services at multiple spatial scales**.

In addition to continued monitoring over multiple seasons, we plan to develop a **spatially explicit multi-pollutant critical load** to address the ecological impacts of co-occurring elevated urban pollutants.

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