Spatial distribution of ecologically relevant atmospheric compounds in native Sonoran Desert protected areas within and surrounding Phoenix, Arizona

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Urban air quality is expected to have significant impacts on protected lands both within the urban boundary and the surrounding native ecosystem. Atmospheric reactive nitrogen (N) compounds, ozone (O_3) and carbon dioxide (CO_2) are elevated near human dominated ecosystems and individually act as a resource or stressor to ecosystems, but their co-occurring distribution and ecological effects in protected lands is uncertain. Local urban air quality monitoring programs routinely measure O_3 and nitrogen oxides (NO_x) to meet human health regulations, but the spatial resolution is often restricted to residential areas. In contrast, ecologically important compounds such as ground-level CO_2 and highly reactive N compounds are not monitored in either cities or remote protected lands. We compared the spatial distribution of atmospheric nitric acid (HNO_3), ammonia (NH_3), NO_x, O_3, and CO_2 concentrations in native Sonoran Desert parks within and surrounding Phoenix, Arizona. Using a spatially extensive design, we monitored reactive N and O_3 with co-located passive samplers and CO_2 with three portable infrared gas analyzers in 10 protected open space parks. Additionally, using a 1500 meter transect within one large desert open space within the city, we examined reactive N and O_3 concentrations along a gradient from the exterior to the interior of the park.

Concentrations of reactive N are higher in desert open space parks within the city compared to the surrounding desert. For example, HNO_3 concentrations were not significantly different between four desert parks within the city (5.1 +/- 0.23 ug/m^3), but together, they were higher than HNO_3 concentrations in surrounding desert parks east (3.4 +/- 0.4 ug/m^3) or west (3.2 +/- 0.3 ug/m^3) of the metropolitan region. Along the interior park transect, HNO_3 concentrations were up to 60% lower within the park (2.7 +/- 1.0 ug/m^3) than at the outer urban edge (4.7 ug/m^3). These results suggest that the interior of large open, protected spaces may experience minimal pollutant loading, similar to surrounding desert areas. Accounting for diurnal variation, atmospheric CO_2 concentrations varied surprisingly little among locations, remaining consistently elevated near 380–400 ppm. This study is the first to identify the distinct spatial pattern of co-occurring, ecologically important urban pollutants within protected lands. To preserve the integrity of key ecosystem services for people, 50-75% of whom live in cities, our findings highlight the need for air quality monitoring at multiple spatial scales, including an expanded repertoire of compounds that are known to affect ecosystem structure and functioning.

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