The Sky is Falling: Soil Microbial Responses to Deposition from the Urban Atmosphere

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Influence of the Urban Atmosphere:

Human activities have resulted in increased nitrogen (N) and carbon (C) deposition with potential consequences for ecosystems within and downwind of human-dominated areas. In some ecosystems, this additional resource input may result in decoupling of the interactions between plants and soil microbes, such that plants no longer require mineralized N from microbes and heterotrophic microbes no longer require organic C from plants. These effects may be particularly strong in deserts where shrubs such as creosotebush, *Larrea tridentata*, exert positive influences on soil moisture and nutrient availability, creating islands of fertility. These islands of fertility typically show increased microbial activity relative to plant interspaces. The differences between plant islands and plant interspaces, however, may diminish if atmospheric deposition to plant interspaces supplies additional N and C. We investigated the potential for decoupling between plants and soil microbes in desert remnants within urban Phoenix.

Measuring Deposition and Microbial Activity:

- Study site: 12 desert remnant sites upwind, downwind, and within the urban core of Phoenix, Arizona.
- Dry deposition was collected on glass fiber filters for 7-9 days and analyzed for water extractable organic C and total N. Mean values are reported.
- Soil samples were collected prior to and during annual monsoon rains and analyzed for organic matter, moisture, microbial biomass C and N, and respiration. Three sub-samples were collected under creosote and in plant interspaces. Mean values are reported.
- The response of soil respiration to precipitation events was evaluated using artificial wetting experiments. Following simulation of a 1 cm precipitation event, CO_2 flux was measured at 0.5, 1, 2, and 24 hour intervals. Wetting experiments were conducted under three replicate creosotebush plants and three interspace plots.

Above left: creosotebush and plant interspace at a desert remnant site. Above right: artificial wetting experiment in plant interspace plot.

Soil Moisture and Organic Matter Influence Microbial Activity:

- Microbial biomass varied significantly based on cover type and season (Fig. 1).

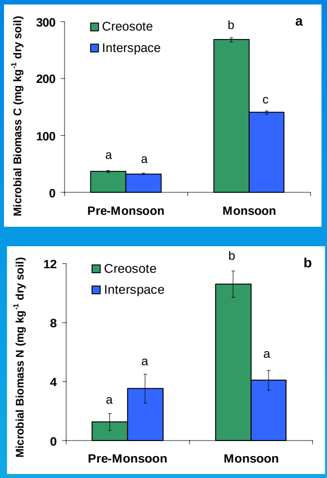

Figure 1: Microbial biomass (a) C and (b) N by cover type and season. Error bars represent SEM +/- 1 SE. Letters above bars indicate significant differences using Tukey's HSD, α = 0.05. rmANOVA C: time x treatment: $F=9.15_{1,20}$, $p=0.007$; rmANOVA N: time x treatment: $F=7.45_{1,20}$, $p=0.013$.

- We found no evidence that microbial biomass C responded to atmospheric deposition. Soil organic matter showed a positive relationship with microbial biomass C during the monsoon season and soil moisture was the strongest predictor of microbial biomass C (Fig. 2).

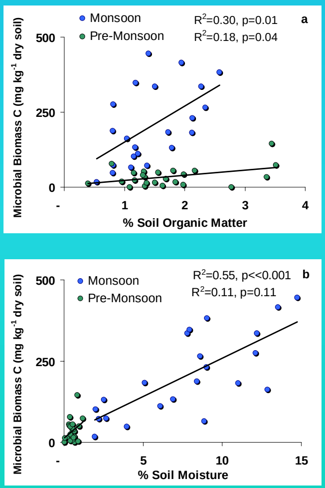

Figure 2: Microbial biomass C as a function of (a) soil organic matter and (b) soil moisture.

- Soil respiration responded positively to soil organic matter and soil moisture following artificial wetting (Fig. 3).

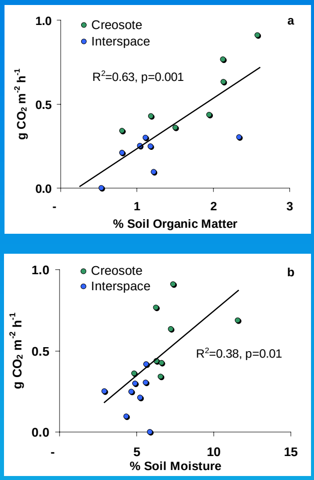

Figure 3: Soil respiration as a function of soil organic matter (a) and soil moisture (b).

- Soil respiration was different beneath creosotebush and in plant interspaces (Fig. 4).

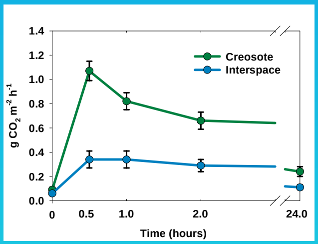

Figure 4: Average CO_2 flux rates by cover type following artificial precipitation event. Error bars represent SEM +/- 1 SE.

Conclusions and Future Research:

- Soil moisture and organic matter were better predictors of microbial biomass and soil respiration than were rates of deposition. These data suggest that based on our short-term measures of deposition rates, precipitation and desert shrubs exert greater positive influence on microbial activity than material deposition from the urban atmosphere.
- The influence of islands of fertility in desert remnant sites is apparent only following rains.
- Future research should consider the nature and effect of different organic C compounds found in atmospheric deposition on soil microbial activity.

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