

Soil microbial communities in urban ecosystems compared to nearby native grasslands and agriculture

Rebecca McCulley
Department of Biology, Duke University,
133 Biological Sciences, Durham, NC 27708

Jason Kaye
Department of Biology and Center for Environmental Studies
Arizona State University, PO Box 871501, Tempe AZ 85287-1501

Introduction

One of the fastest growing regions in the country is the Front Range of Colorado where rapid urbanization occurs within a matrix of semiarid grasslands and dryland agriculture dissected by irrigated agriculture near water sources.

In this region, the conversion of native and agricultural ecosystems to urban lawns alters ecosystem-level soil characteristics such as carbon and nitrogen storage and soil-atmosphere greenhouse gas exchange.

Because these ecosystem-level characteristics are controlled, in part, by soil microorganisms, we further hypothesized that urbanization altered the structure and function of the soil microbial community.

Here, we present data on microbial community structure in urban and non-urban ecosystems and attempt to link measured changes in the mass and type of soil microorganisms with previously observed changes in ecosystem N and C fluxes.

The Field Sites

Three replicates of each land-use type were located within 20 km of Fort Collins Colorado

Urban: turfgrass lawns bordered by trees; irrigated and fertilized

Corn: flood irrigated and fertilized

Wheat-Fallow: a dryland winter wheat cropping system with half the area planted and half left fallow; not irrigated or fertilized

Native: shortgrass steppe grassland

The Method

Microbial biomass and community composition were measured on June 18, 2001 using the **Phospholipid Fatty Acid (PLFA) method** in surface soils. Phospholipids were extracted, derivitized to fatty acid methyl esters (FAME), separated and quantified using a gas chromatograph linked to a mass spectrometer, and identified with a pre-existing fatty acid data library.

We ran a Principal Components Analysis (PCA) on the relative abundance of 19 fatty acids to extract the major sources of variance in the data set into 2 independent axes (PC 1 and PC 2). Then, in an attempt to understand what ecosystem variables are represented by the PCA axes, we ran the PC 1 and 2 loadings in regressions with data such as laboratory N mineralization, field soil respiration, and soil N₂O flux. We also used analysis of variance to look at the relationship of land-use type and the ordination results as well as the microbial biomass data.

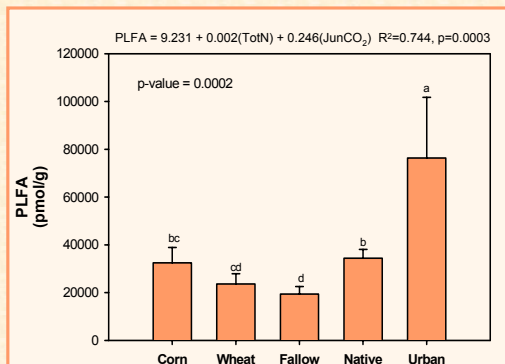


Figure 2. Urban lawns have ~2x the microbial biomass of native and/or cultivated areas. Viable microbial biomass is highly correlated with soil N content and soil CO₂ flux.

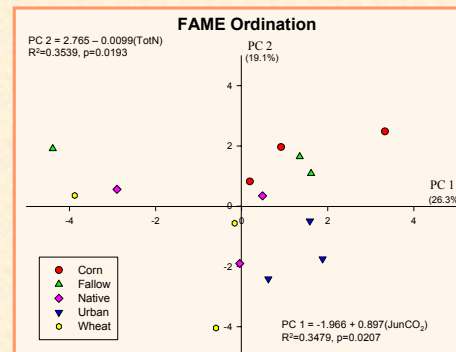


Figure 3. The ordination explains 45.4% of the variability in the FAME data, and indicates that each land-use type results in subtle, but distinct changes to the native grassland microbial community.

Table 1: Microbial fatty acids (FAME) receiving large positive (> 0.3) or negative weights (< -0.3) on the first and second principal component axes.

| FAME | Weights | Specificity as a Marker |
|------------------|---------|-----------------------------------|
| <i>PC Axis 1</i> | | |
| 16:1w7l | -0.378 | Bacteria |
| 18:1w8t | -0.302 | Fungi |
| 16:1w7c | -0.300 | Gram-negative bacteria |
| i17:0 | 0.365 | Gram-positive bacteria |
| 10Me18:0 | 0.347 | Actinomycetes |
| a17:0 | 0.319 | Gram-positive bacteria |
| 17:0 | 0.317 | Non-specific bacteria |
| <i>PC Axis 2</i> | | |
| 18:1w9c | -0.469 | Fungi |
| 18:1w8t | -0.374 | Fungi |
| i14:0 | 0.453 | Non-specific bacteria |
| cy17:0 | 0.351 | Gram-negative, anaerobic bacteria |
| 14:0 | 0.311 | Bacteria |

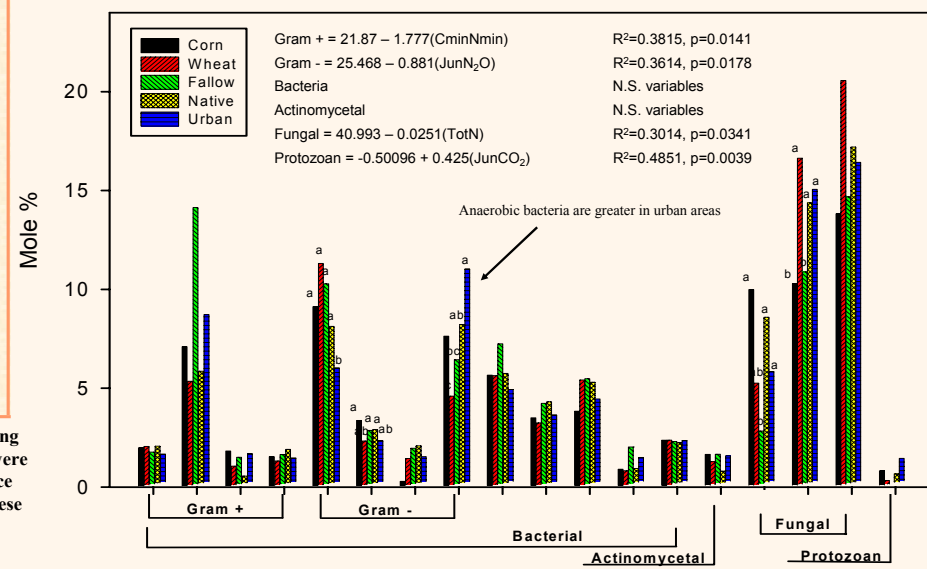


Figure 1. Soil community structure was surprisingly similar among the land-use types. However, anaerobic gram negative bacteria were more abundant in urban areas. These anaerobic bacteria produce N₂O, a greenhouse gas. In addition, the relative abundance of these broad taxonomic groups was often correlated with ecosystem nutrient and energy fluxes (see regression equations).

Conclusions

Urban lawns generally had higher microbial biomass and potential C and N mineralization rates (data not shown) than other ecosystems, suggesting that **energy and nutrient availability to microorganisms are elevated in urban ecosystems.**

The ordination indicates **changes in microbial community structure are surprisingly small across landuse types.**

However, **increased total biomass of anaerobic micro-organisms in soils that were formerly semi-arid suggests that urban irrigation practices are affecting microbial community structure.**

The alterations in the microbial biomass and community composition correlate with alterations in soil trace gas fluxes and fertility across land-use types suggesting **a link between changes in microbial community composition and the ecosystem level consequences of urbanization.**