# Spatial Patterns of Belowground Respiration and Related Soil Parameters in a Simulated Xeric Urban Landscape

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## Abstract

Soil respiration accounts for about 25% of global $CO_2$ evolution, but it is one of the most variable soil parameters and is therefore difficult to quantify. Because soil respiration samples are likely to be autocorrelated, it is essential to understand their spatial and temporal patterns so that sampling designs capture the variability present. Little research has focused on spatial heterogeneity of soil respiration, and none has been performed in an arid urban environment. This research project will quantify the spatial heterogeneity of soil respiration and other soil parameters present in a simulated urban landscape at the Desert Botanical Garden in Phoenix, Arizona. Two 9.2 × 9.2 m plots planted with six species of woody landscape plants were overlaid with grids of one hundred 92 × 92 cm quadrats. In each plot, 46 × 46 cm quadrats are nested within the grid in areas surrounding plants. $CO_2$ evolution will be measured at the center of each quadrat with an infrared gas analyzer once each season. Soil cores will be sampled from each quadrat once per season to quantify root biomass, arbuscular mycorrhizal colonization, and gravimetric moisture. Soil pH, total N, total C, and available P will also be measured for each quadrat. Multivariate statistics will be used to determine the correlation matrix for all of the soil parameters. Geostatistical methods will be used to quantify the scale and degree of soil heterogeneity in the plot. Preliminary data indicate a great deal of heterogeneity in soil respiration at the plot scale.

## Introduction

Soil respiration is a major source of $CO_2$ exchange between the biosphere and the atmosphere, accounting for as much as 25% of global $CO_2$ exchange (Bouwmann and Germon 1998). Detailed information on soil $CO_2$ fluxes are thus crucial to understanding terrrestrial carbon budgets and to determining whether terrestrial ecosystems are carbon sources or sinks (Lindroth et al. 1998). Soil $CO_2$ evolution originates from plant root respiration and microbial repiration. Several factors influence soil respiration, including temperature, precipitation, and land-use (Buchmann 2000). Changes in any of these factors may alter soil $CO_2$ fluxes, thereby affecting the carbon budget in an ecosystem.

Soil $CO_2$ evolution rates often show great spatial variability. However, conventional sampling techniques and statistical analyses may not accurately capture the variability in soil $CO_2$ fluxes since samples are likely to be autocorrelated (that is, samples close to one another are more similar than those farther apart). For example, Stoyan et al. (2000) found strong spatial structuring in soil respiration and other soil parameters associated with poplar trees in Michigan. Likewise, temporal differences in soil respiration rates are often encountered. Buchmann (2000) found slight diurnal variability and large seasonal variability in soil respiration rates in *Picea abies* stands.

Such spatial and temporal heterogeneity of soil respiration must be understood before adequate sampling schemes for landscape-scale carbon budget studies can be designed. This project will quantify the spatial and temporal patterns of belowground respiration in a xeric simulated urban landscape. This work will be useful for designing future sampling schemes for carbon budgets in urban areas.

**Figure 1.** CAP LTER long-term monitoring plot: Simulated xeric urban landscapes at the Desert Botanical Garden, Phoenix, Arizona.

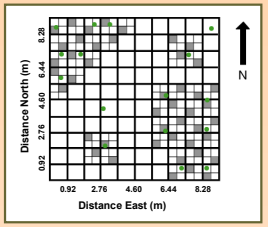


**Figure 2.** Map of simulated xeric urban landscape. Gray squares represent sampled small quadrats. Green points represent locations of plants.

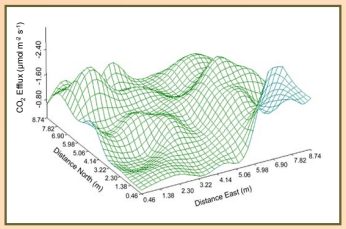


**Figure 3.** Isopleth for $CO_2$ efflux at simulated xeric urban landscape. Measurements taken 3 November 2000.

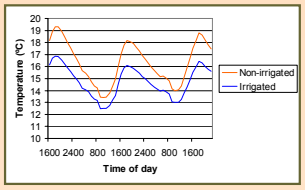


**Figure 4**. Time course of temperatures (° C) 20 cm below the soil surface that were either irrigated and subjacent to plant canopies or non-irrigated with no plant canopy cover. Measurements taken December 2000.

## Materials and Methods

Two 9.2 × 9.2 m simulated landscape plots were established at the Desert Botanical Museum in Phoenix, Arizona. The plots are located within a creosote flat with Rillito gravelly loam soils. Each plot contains six *Leucophyllum frutescens* 'Green Cloud™', six *Nerium oleander*, and one each of *Quercus virginiana, Eucalyptus microtheca* 'Blue Ghost', *Rosmarinus officinalis*, and *Opuntia violacea* var. *santa-rita*, which were all planted in the summer of 1999 (Figure 1). All plants are maintained under standard horticultural practices with regular drip irrigations applied at the base of each plant. A grid of one hundred 92 × 92 cm quadrats was established on each plot. Nested within these larger quadrats were 188 additional 46 × 46 cm quadrats in areas around the bases of plants.

PVC collars (10 cm in diameter) were placed in the center of each large quadrat and in the center of 45 of the smaller quadrats (Figure 2). Measurements of $CO_2$ efflux from each collar will be taken once each season for one year using a LI-COR LI-6200 Infrared Gas Analyzer. Soil cores will be taken from the center of each of these quadrats to quantify root biomass, gravimetric moisture, pH, total N, total C, and available P. Thermocouples measure temperature every 15 min at a depth of 20 cm in both irrigated and non-irrigated areas near the plot. Initial data from each of these procedures will be analyzed and the sampling scheme will be adjusted if necessary to ensure that maximum variability in the plot is being captured. If diurnal patterns in respiration are apparent, sampling will be done during the time of day when $CO_2$ efflux is greatest. A correlation matrix of all of the soil parameters will be determined using multivariate statistics.

Spatial patterns of soil respiration and the other soil parameters will be analyzed for each season using appropriate geostatistical methods, including semivariance analysis and kriged maps. Semivariance analysis is used to quantify the degree to which samples are autocorrelated and the scale at which this autocorrelation exists (Morris 1999). Once spatial dependency of samples is established, values not measured can be interpolated using kriging algorithms. Maps of spatial dependency across the entire sampling area can then be generated (Robertson 1987).

## Results and Discussion

- Preliminary results indicate high spatial heterogeneity of soil respiration across a single plot, with $CO_2$ efflux ranging from -0.20 µmol $CO_2$ $m^{-2}$ $s^{-1}$ to -3.67 µmol $CO_2$ $m^{-2}$ $s^{-1}$ (Figure 3).
- Soil temperatures show considerable diurnal variability in both irrigated and non-irrigated areas (Figure 4), which may lead to significant diurnal variability in soil respiration in the plot.

## References

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