Plant Gas Exchange in Urban Landscapes

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Introduction

An urban forest is displacing indigenous Sonoran Desert vegetation as the Phoenix metropolitan area expands. Some of the ecological benefits associated with growth of the urban forest are carbon dioxide and nutrient recycling, energy conservation, and enhanced human well being (Botkin and Beveridge, 1997).

Knowledge of how the urban forest differs from native Sonoran Desert vegetation in terms of carbon and water cycling is lacking. **Of particular interest is how land use changes and landscape design affect primary productivity and water use in various urban landscape patch types**. Long-term monitoring of gas exchange, irrigation practices, and microclimate in urban landscape plants was initiated in 1998 to research this question.

Methods

Effects of landscape design and land use history on plant gas exchange parameters were evaluated in a factorial site matrix of formerly desert or agricultural land uses and xeric or mesic residential landscape designs within the Phoenix metropolitan area. Remnant Sonoran Desert sites and an irrigated alfalfa agricultural field were controls. Instantaneous measurements of maximum shoot carbon assimilation (A), conductance (gs), and transpiration (E) were made monthly within three replicates of each site type during 1998. The time-of-day for maximum A was estimated based on preliminary seasonal measurements of diel gas exchange patterns (McDowell and Martin, 1998). Measurements were made on three plant life forms; trees, shrubs, and ground covers. Data analysis was conducted using the SAS GLM analysis of variance procedure.

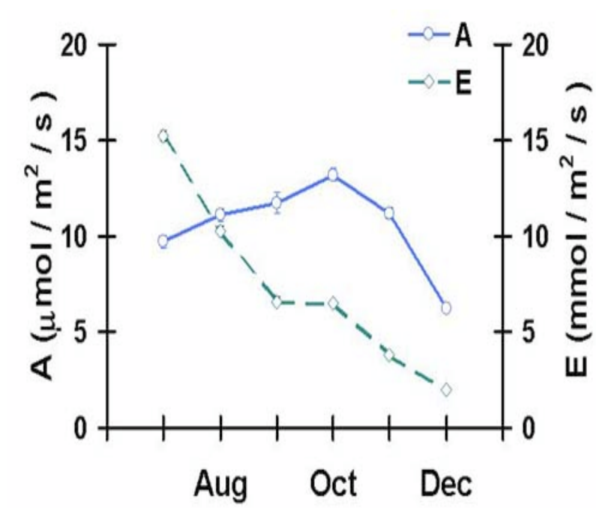

Figure 1. Seasonal patterns of carbon assimilation (A) and transpirational water loss

Results

- Assimilation fluxes were lowest in December and highest in October. Transpiration fluxes were highest in July and declined each month thereafter (Figure 1).

- Assimilation fluxes were not related to former land use, but were higher for plants in mesic compared with those in xeric landscapes.
- Transpiration fluxes were higher for plants in formerly agricultural sites compared with those in formerly desert sites, and higher for plants in mesic than for those in xeric landscape designs.
- Instantaneous transpiration efficiency (ITE) increased seasonally during the study period and was negatively correlated with shoot temperature (r= -0.65) (Figure 2).
- Seasonal patterns of shoot conductance (gs) and shoot to air vapor pressure deficit (VPD) were similar, and these parameters were affected by land use history, but not by landscape design type (Figure 3).

Conclusions

- Seasonal changes in A, E, gs and temperature suggest that maximum C assimilation was not limited by shoot conductance, but was more responsive to temperature in irrigated landscapes.
- Similarities in ITE between plants in irrigatedl xeric and mesic landscape design types suggest that these patch types did not differ in terms of plant water use efficiency.
- Land use history appears to have a significant impact on gas exchange parameters in residential landscape patches.
- Patterns of gs and VPD suggest that shoot conductance was regulated by air temperature and relative humidity.

Citations

Botkin, D.B. and Beveridge, C.E. (1997) Cities as environments. *Urban Ecosystems* 1, 3-19.

McDowell, L.B. and Martin, C.A. (1998) Plant gas exchange and water status in Sonoran Desert landscapes. Second Annual Life Sciences Graduate Symposium, Arizona State University.

(E).*

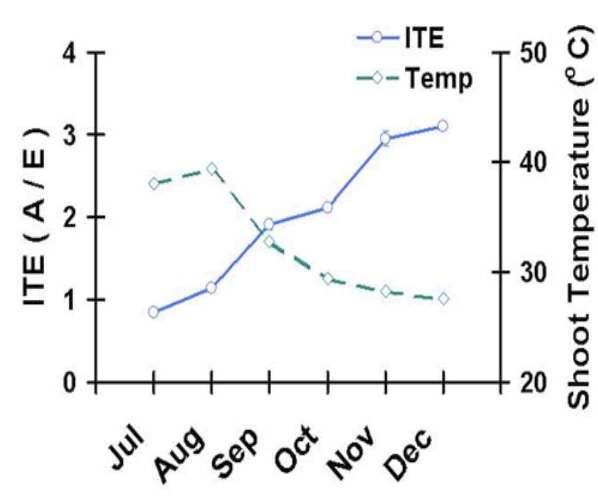

Figure 2. Seasonal patterns of shoot temperature and instantaneous transpiration efficiency (ITE = A/E). *

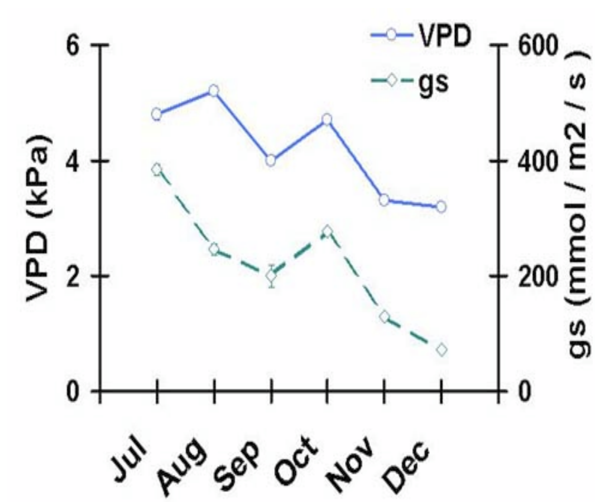

Figure 3. Seasonal patterns of shoot to air vapor pressure deficit (VPD) and stomatal conductance (gs). *

* Values are monthly means for all plants measured, n=1736. Where error bars are not visible they are obscured by the symbol.