Effect of Landscape Design and Irrigation on Summertime Gas Exchange of Landscape Trees, Shrubs, and Herbs.

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North Desert Village landscape design treatments

Introduction

Development in the Phoenix metropolitan area has displaced native Sonoran Desert vegetation with the dominant urban land use type by area coverage being residential. The spatial arrangement of residential vegetation is mostly intentional and highly variable reflecting both the diverse historical and contemporary preferences of area residents for landscape appearance. Here we present the effects of four landscape design arrangements on summertime plant gas exchange to elucidate how landscape design influences instantaneous landscape carbon assimilation and water use efficiency.

Methods

Diurnal patterns of summertime gas exchange were measured on an assortment of landscape trees, shrubs and herbs (Table 1) during summer 2007 that are a part of the North Desert Village (NDV) long-term experiment on the ASU Polytechnic campus. The NDV experiment consists of four treatments of six homes surrounding a common area that are each variously designed and irrigated to represent different landscape design and irrigation practices observed across the greater Phoenix metropolitan area. The four treatments areas are named for their dominant landscape elements: 1) Mesic [turf grass, sprinkler irrigated (77.4 l/m2/month) exotic trees and shrubs]; 2) Oasis [turfgrass and decomposing granite, drip irrigated (16.4 l/m2/month) exotic trees, shrubs and herbs]; 3) Xeric [decomposing granite, drip irrigated (1.8 l/m2/month) exotic, shrubs and herbs]; and 4) Native (decomposing granite, non-irrigated native trees, shrubs and herbs). During June and July 2007, gas exchange measurements were made with an LI-6200 portable photosynthesis system under clear sky conditions during morning (700 to 900 Hr), midday (1130 to 1330 Hr), and late afternoon (600 to 1800 Hr). Parameters measured included CO_2 assimilation (A), leaf transpiration (E) and conductance (gs), shoot temperature, and leaf to air vapor pressure deficit (VPD). The ratio of internal leaf CO_2 to ambient CO_2 (CiCa) was calculated. All gas exchange measurements were made on days with clear sky conditions and light to no wind.

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Table 1. Landscape Taxa at North Desert Village (NDV) on which gas exchange measurements were made.

	Landscape Taxa	NDV Treatment
T [A]	Acacia stenophylla (shoestring acacia)	O, X [B]
S	Bougainvillea hybrid (bougainvillea)	O
T	Brachychiton populneus (bottle tree)	M, X
S	Caesalpinia gilliesii (desert bird-of-paradise)	X
S	Caesalpinina pulcherrima (red bird-of-paradise)	O
S	Calliandra californica (red fairy duster)	X
S	Carissa grandiflora (natal plum)	O
P	Chamaerops humilis (Mediterranean fan palm)	O
H	Encelia farinosa (brittle bush)	X, N
T	Eucalyptus papuana (ghost gum)	O
T	Eucalyptus polyanthemos (silver dollar gum)	M
S	Justicia californica (chuparosa)	N
H	Lantana hybrid (lantana)	O
S	Larrea tridentata (creosote bush)	N
S	Leucophyllum frutescens (Texas sage)	O, X
H	Macfadyena unguis cati (cat's claw vine)	O
S	Nerium oleander (oleander)	M, O, X, N
T	Olneya tesota (desert ironwood)	N
T	Pinus eldarica (Afghan pine)	M, O
T	Pistacia chinensis (Chinese pistache)	M
T	Platycladus orientalis (arborvitae)	O
T	Parkinsonia hybrid (hybrid palo verde)	X
T	Parkinsonia florida (blue palo verde)	N
T	Platanus wrightii (Arizona sycamore)	M
T	Prosopis hybrid (South American mesquite)	X
T	Prosopis velutina (Arizona mesquite)	N
S	Ruellia brittoniana (common ruellia)	O
S	Simmondsia chinensis (jojoba)	N
T	Ulmus parvifolia (Chinese elm)	M, O

[A] T=tree; S=shrub; H=herb

[B] M = mesic treatment; O = oasis treatment; X = xeric treatment; N = native treatment

Overview of Results

For all trees, shrubs and herbs, summer gas exchanges fluxes were generally highest during the morning except for herbs in the xeric and native treatments which had highest gas exchange fluxes at midday. Summer gas exchange fluxes were generally lowest for trees in the mesic treatment. Summertime gas exchange inhibitions of vegetation at the NDV site were apparently related to excessively heat, high VPD, and partial stomatal closure (Table 2). Gas exchange inhibitions did not appear to be related to non-stomatal regulation of photosynthesis as evidenced by limited diurnal changes in CiCa.

Table 2. Effect of landscape design treatment on mean (±SE) diurnal gas exchange of woody trees, shrubs and herbs shown in Table 1.

	A umol/m²/s	Gs mmol/m²/s	E mmol/m²/s
Morning			
Mesic	6.76±0.36	84.6±4.1	5.16±0.26
Oasis	12.04±0.59	159.4±7.8	6.67±0.29
Xeric	9.85±0.57	159.0±9.3	7.99±0.53
Native	10.15±0.53	155.0±9.5	6.71±0.32
Noon			
Mesic	4.55±0.44	82.4±5.3	7.14±0.38
Oasis	6.92±0.52	106.6±6.9	7.79±0.46
Xeric	6.98±0.74	117.9±8.5	10.54±0.75
Native	8.67±1.07	115.0±9.5	9.40±0.76
Afternoon			
Mesic	5.61±0.58	81.6±7.1	6.11±0.48
Oasis	5.95±0.47	97.9±6.4	7.75±0.47
Xeric	3.74±0.34	74.8±5.8	7.16±0.60
Native	7.47±0.49	117.0±6.4	9.08±0.48

A = Net carbon assimilation; Gs = Leaf conductance
E = Leaf transpiration

	Tleaf °C	VPD KPa	CiCa
Morning			
Mesic	42.3±0.3	7.53±0.94	0.634±0.006
Oasis	34.3±0.3	4.50±0.97	0.601±0.007
Xeric	35.4±0.4	5.03±1.39	0.642±0.009
Native	35.0±0.2	4.64±0.82	0.638±0.008
Noon			
Mesic	45.2±0.2	8.80±0.99	0.675±0.011
Oasis	42.7±0.1	7.37±0.52	0.625±0.009
Xeric	45.3±0.4	8.73±0.91	0.652±0.011
Native	45.0±0.2	8.49±0.96	0.602±0.012
Afternoon			
Mesic	42.9±0.1	7.54±0.73	0.632±0.012
Oasis	43.9±0.8	7.81±0.47	0.643±0.008
Xeric	45.7±0.2	8.99±1.00	0.685±0.011
Native	43.1±0.1	7.62±0.45	0.636+0.010

Tleaf = Leaf temperature; VPD = Leaf to air vapor pressure deficit; CiCa = Ratio of internal leaf CO_2 to ambient CO_2 levels.