WATER USE BY URBAN LAWNS AND TREES IN LOS ANGELES

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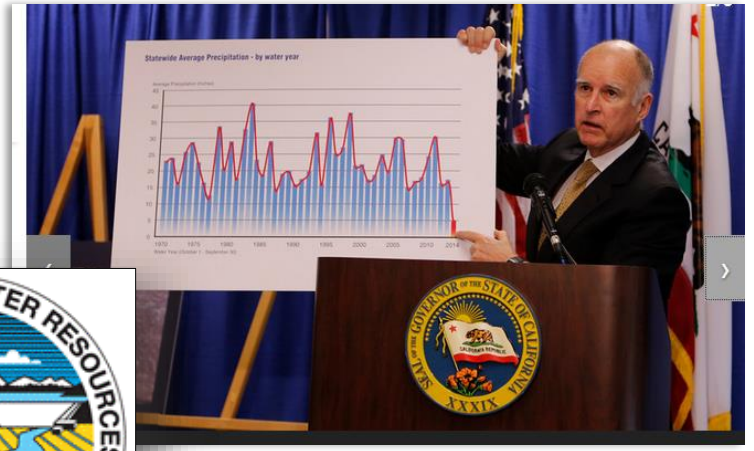
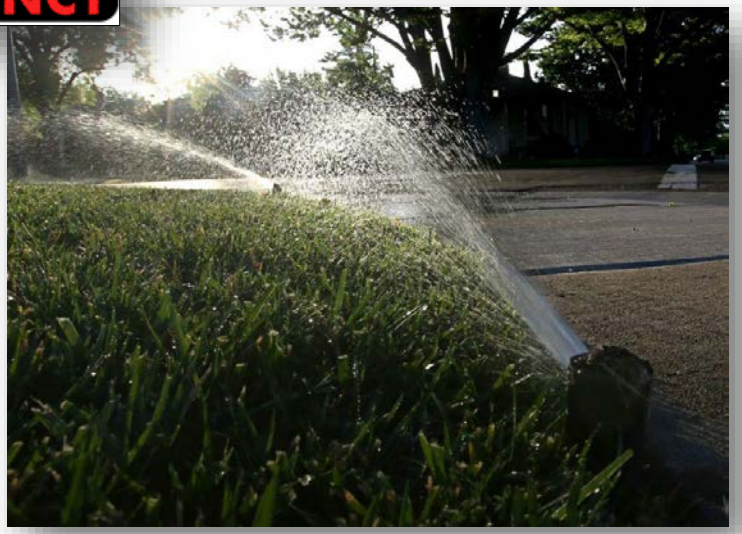
Evaluation of current irrigation practices to develop water conservation strategies

WATER SCARCITY IS INCREASINGLY A CONCERN



DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA

STATE OF
EMERGENCY



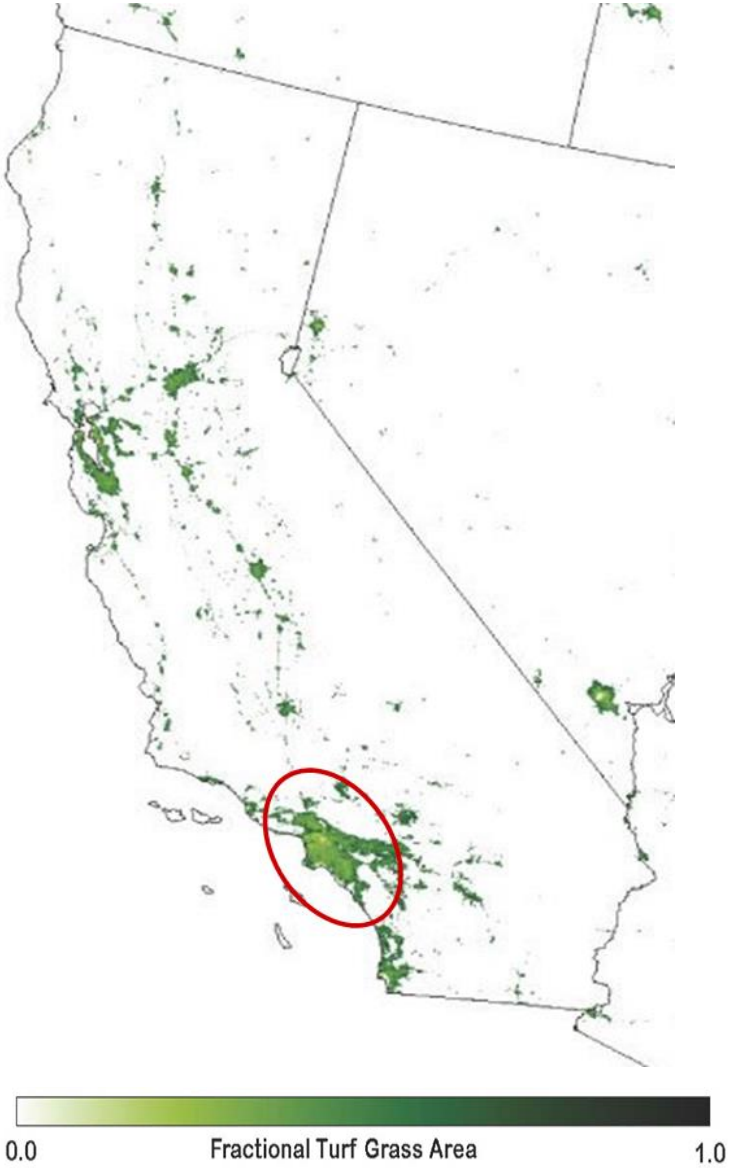
LANDSCAPE WATER CONSUMPTION

has not been scientifically evaluated under real urban conditions –

in actual residences, parks, and street plantings.

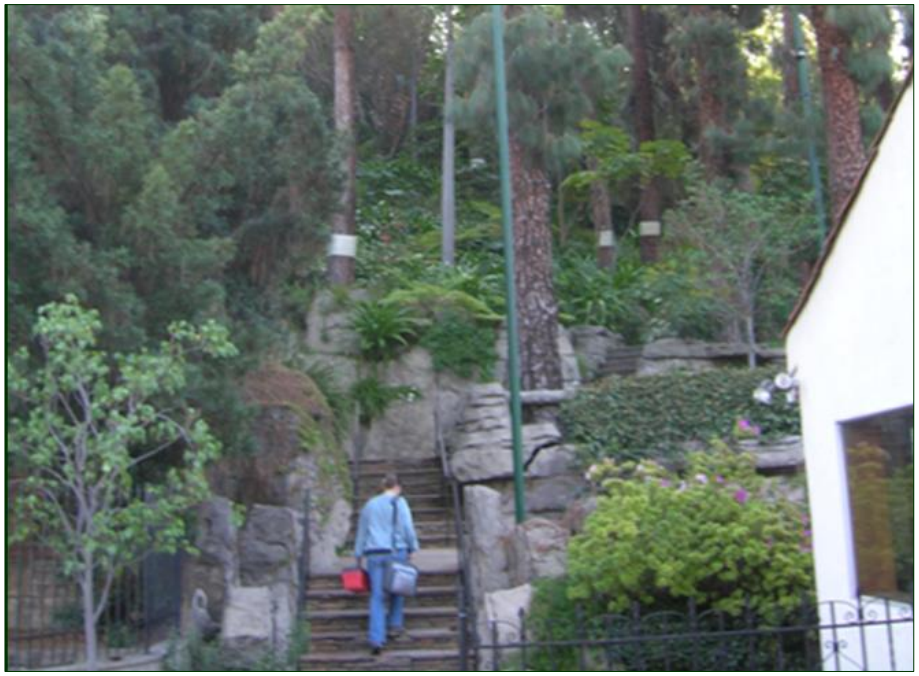
There is a critical need for empirical data on the water use of irrigated plants throughout Los Angeles

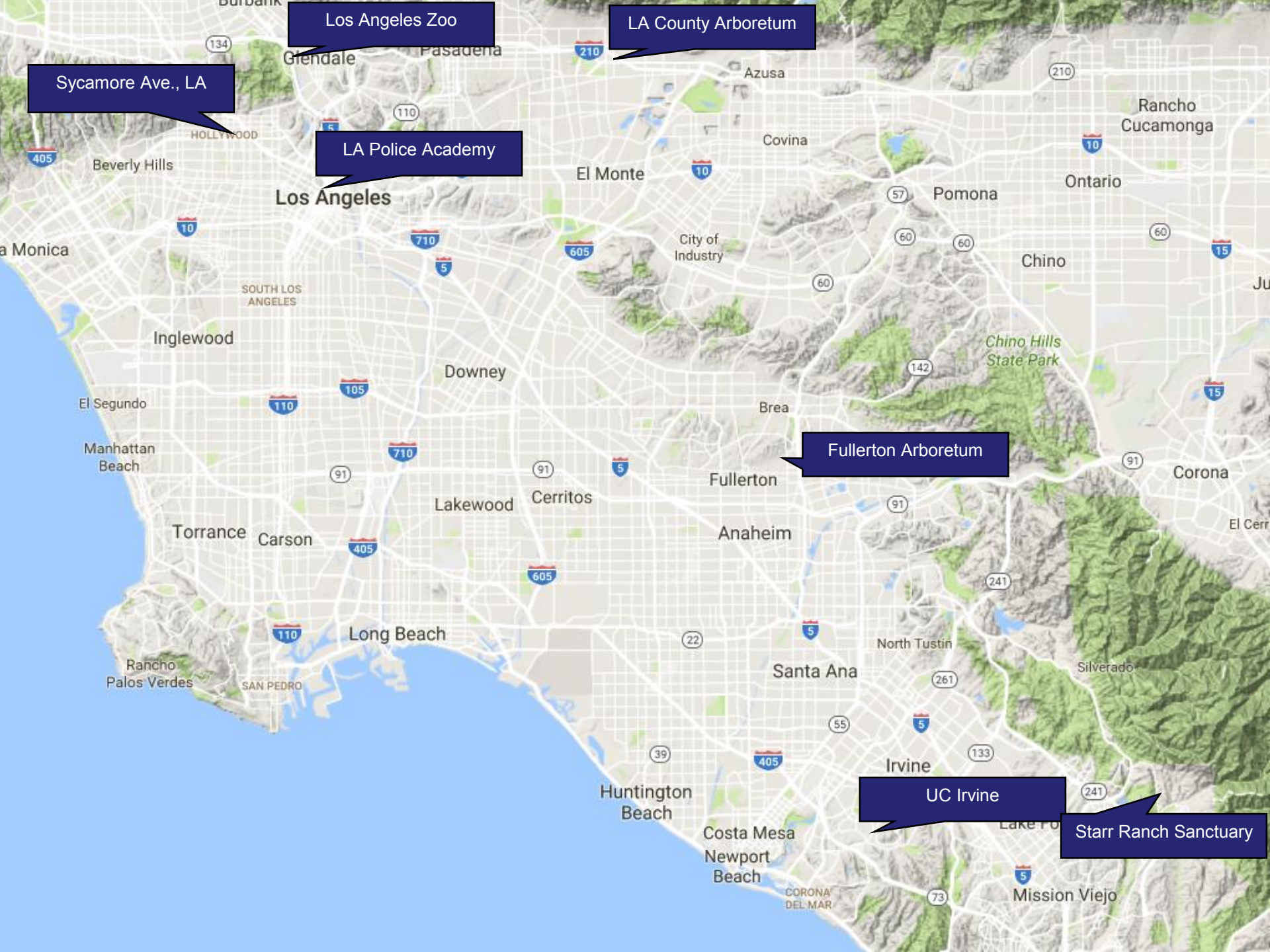
DIRECT MEASUREMENTS OF LANDSCAPE WATER USE



earthobservatory.nasa.gov

2008-2011: 11 LAWNS 108 TREES




Los Angeles Zoo
LA County Arboretum
Sycamore Ave., LA
LA Police Academy
Fullerton Arboretum
UC Irvine
Starr Ranch Sanctuary
Glendale
Pasadena
Azusa
Rancho Cucamonga
Covina
Beverly Hills
El Monte
Ontario
Los Angeles
Pomona
City of Industry
Chino
Inglewood
Downey
Chino Hills State Park
El Segundo
Brea
Manhattan Beach
Fullerton
Corona
Lakewood
Cerritos
Torrance
Carson
Anaheim
Long Beach
North Tustin
Rancho Palos Verdes
Santa Ana
Silverado
Irvine
Huntington Beach
Costa Mesa
Newport Beach
Mission Viejo

WATER USE: TREES VS. TURFGRASS

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mm/d	type	growing season	winter
lawns	unshaded	5.5	1.8 – 2.5
	shaded	1.8 – 3.8	
trees	deciduous	0.1 – 2.6	0.1 – 1.8
	evergreen	0.1 – 1.8	

Before the implementation of mandatory watering restrictions, lawns received at least 40% (2 mm/day) more water in summer in excess of current WUCOLS recommendations.

For a typical small 130 m^2 residential yard, it is 30 extra gallons of water per day.

For the city of Los Angeles, it is 15 million extra gallons of water per day.

SHADING OF LAWNS IS A WATER SAVING MEASURE

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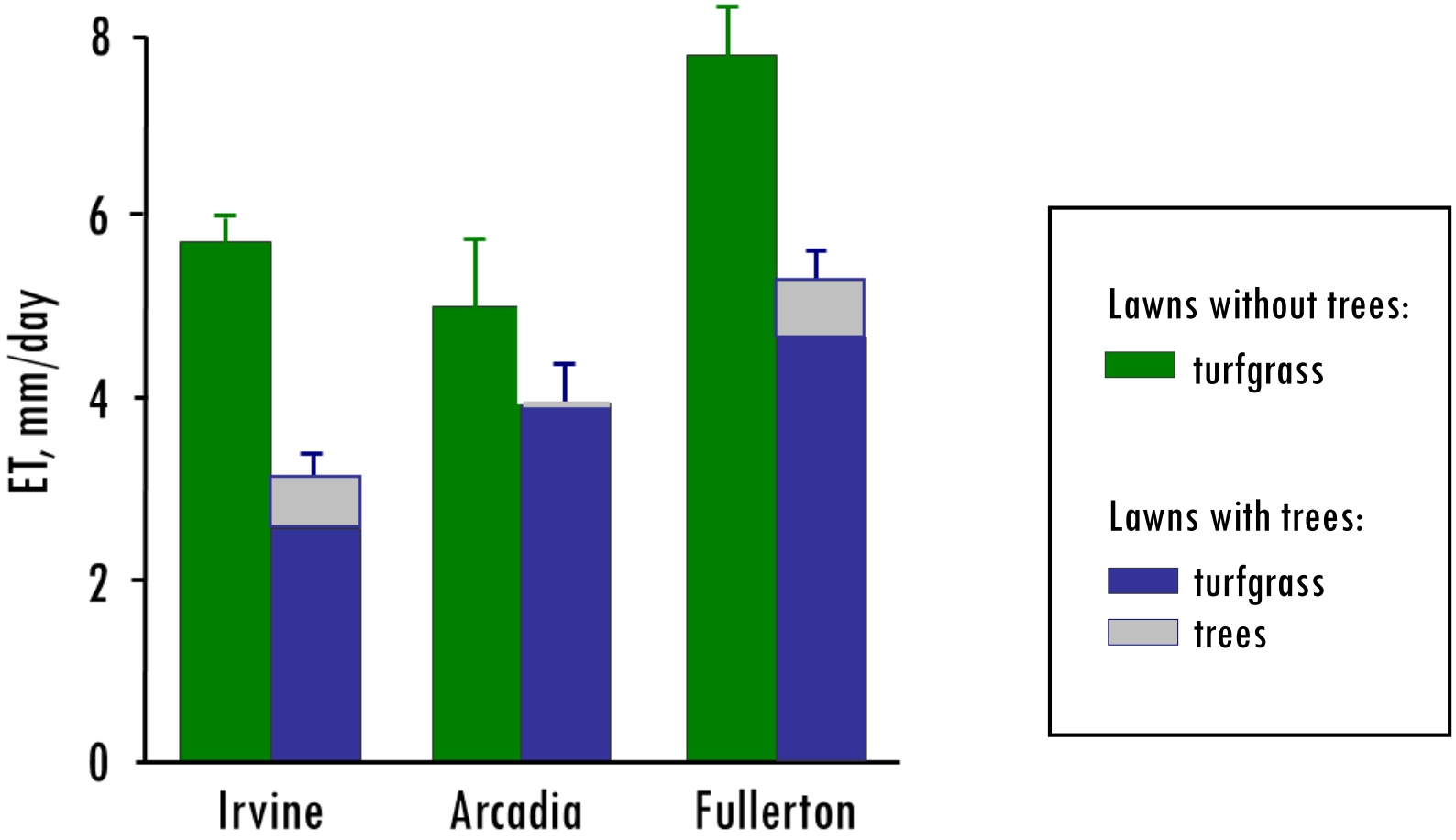
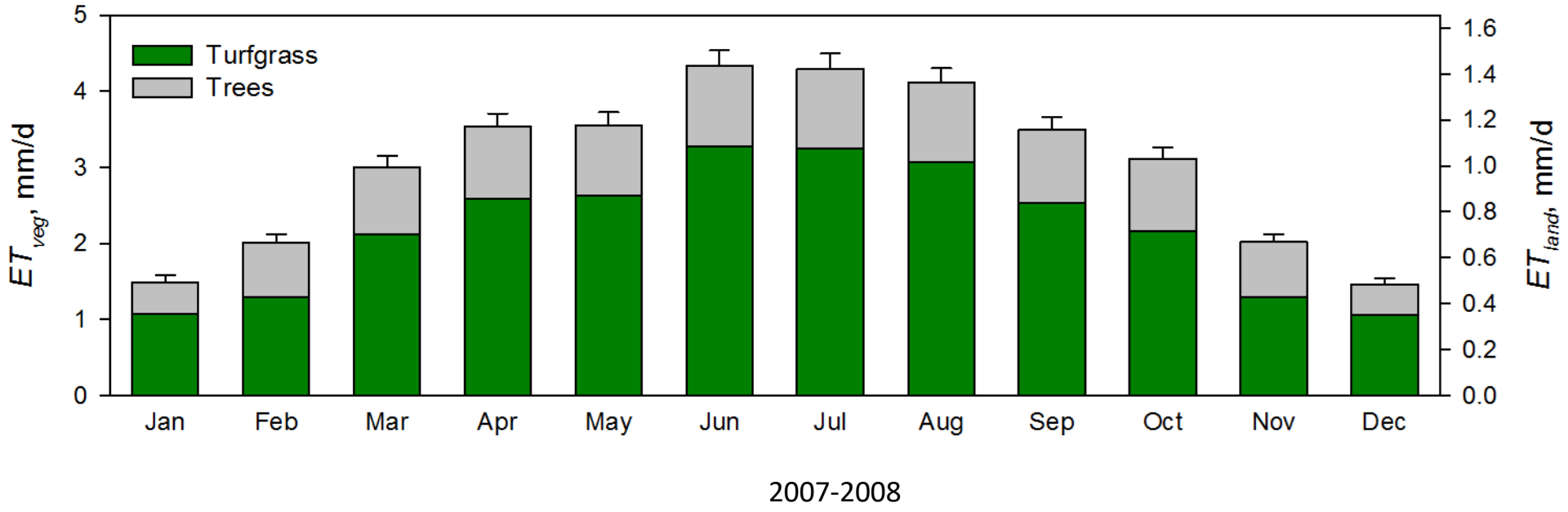
Shading lawns (with landscape trees or built structures) lowers their summertime water use by up to 50%.

SHADING OF LAWNS IS A WATER SAVING MEASURE



Because trees use much less water than lawns, total landscape water use of landscapes that include lawns + shade trees is less than landscapes that include only lawns.

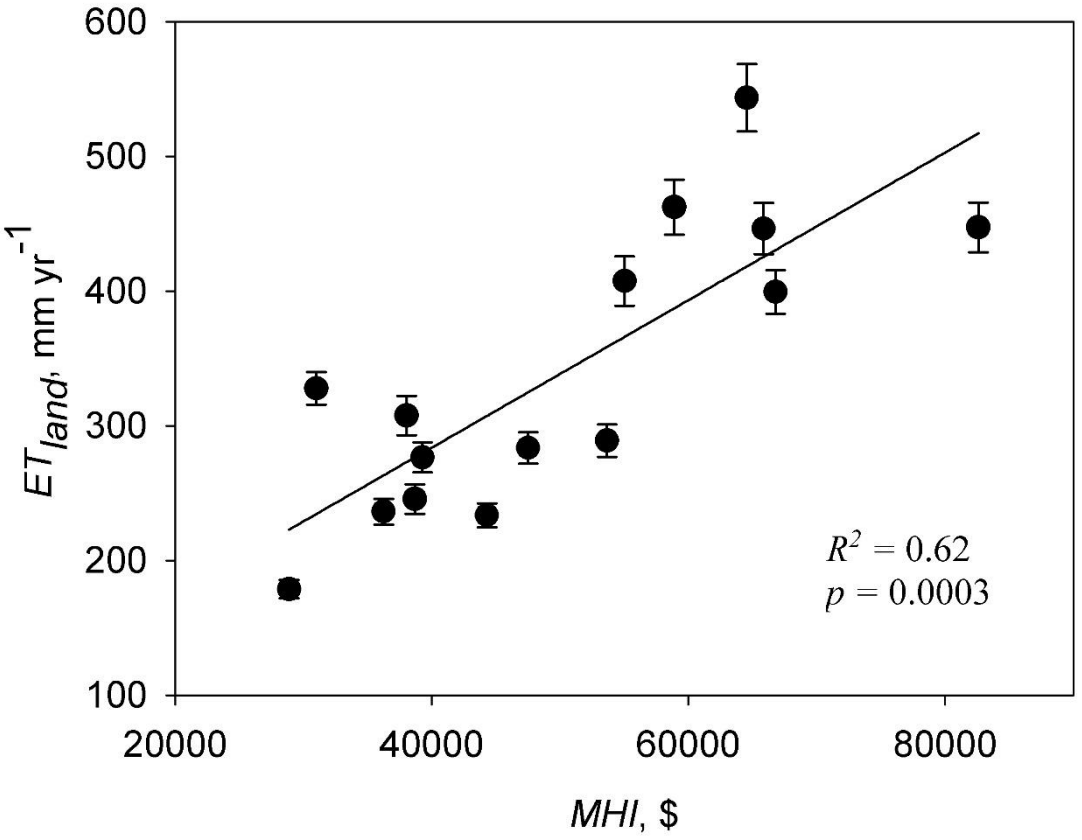
LANDSCAPE WATER USE IN LOS ANGELES



Across the city as a whole, landscapes in Los Angeles consumed nearly 100 billion gallons of water per year.

Lawns accounted for 70% of the total.

LANDSCAPE WATER USE VS. HOUSEHOLD INCOME



Landscape water use in the most affluent areas of the city was approximately double the water use in the poorest neighborhoods.

This leads to lower air and surface temperatures in wealthier parts of the city.

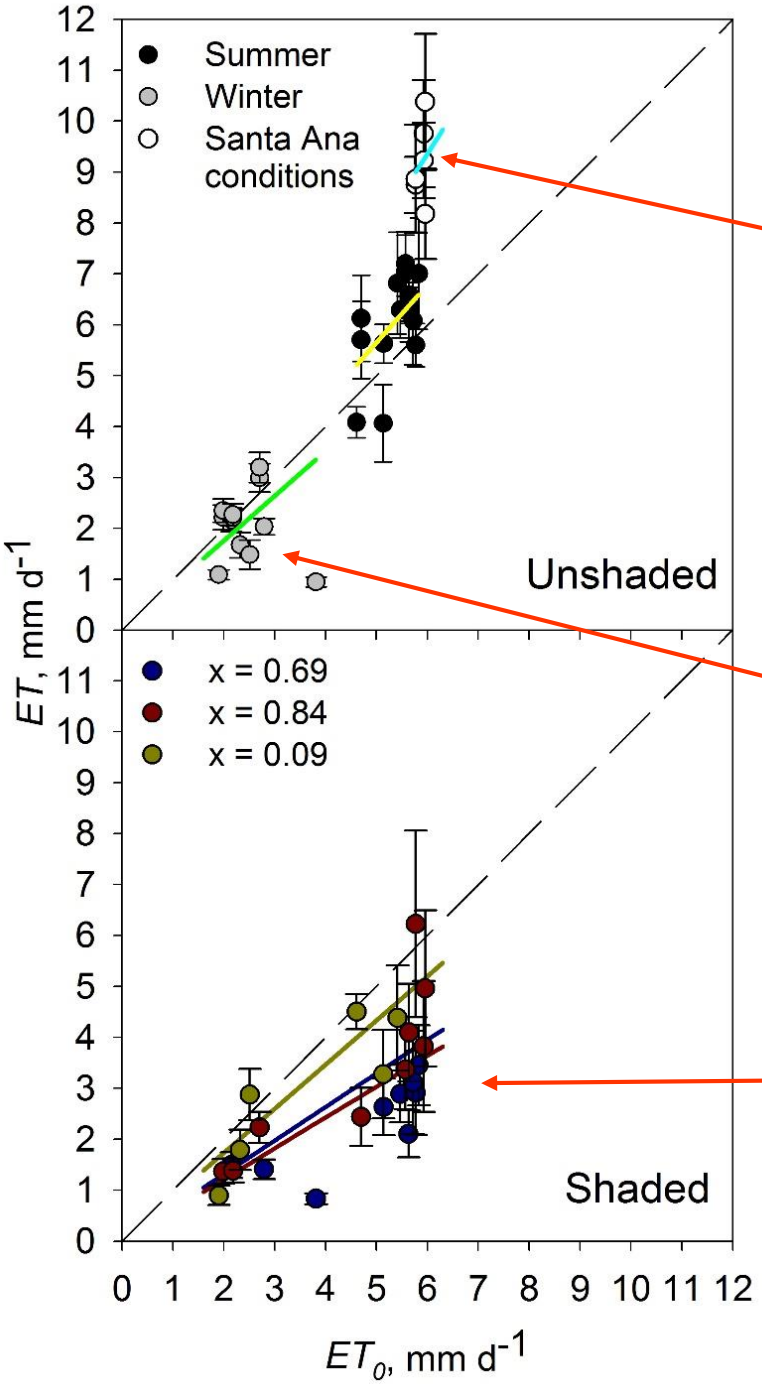
CURRENT WATERING RECOMMENDATIONS: LANDSCAPE COEFFICIENT METHOD

ET_0 is reference *ET* from CIMIS weather stations
k_L – landscape coefficient
k_d – density coefficient
k_s – species coefficient
k_{mc} – microclimate coefficient

$$ET = k_L ET_0 = k_d k_s k_{mc} ET_0,$$

- Reference tables of… "subjective" coefficients
- This approach implies that *ET* is proportional to ET_o

CIMIS: www.cimis.water.ca.gov
WUCOLS: http://ucanr.edu/sites/WUCOLS



During extremely dry weather caused by Santa Ana winds, unshaded lawns use more water than the maximum recommended irrigation.

During winter, unshaded lawns may use less water than minimum recommended irrigation.

Lawns shaded by trees and buildings also use less water than recommended minimum.

MEASUREMENT-BASED COEFFICIENTS FOR LAWNS

$$ET = k_d k_s k_{mc} ET_0$$

Season	k_{mc} of unshaded lawns	k_{mc} of shaded lawns
Summer	1.13 ± 0.05 (regular conditions) 1.56 ± 0.10 (Santa Ana conditions)	$k_L = a - b \times TCC$ $a = 0.90 \pm 0.09$ $b = 0.35 \pm 0.13$ TCC – fractional tree canopy cover
Winter	0.88 ± 0.13	

Species composition of lawns does not strongly affect water consumption under non-limiting irrigation

TESTS OF LAWN IRRIGATION SYSTEMS

Automatic timer irrigation

Weather station & drip irrigation at 80% ET_0

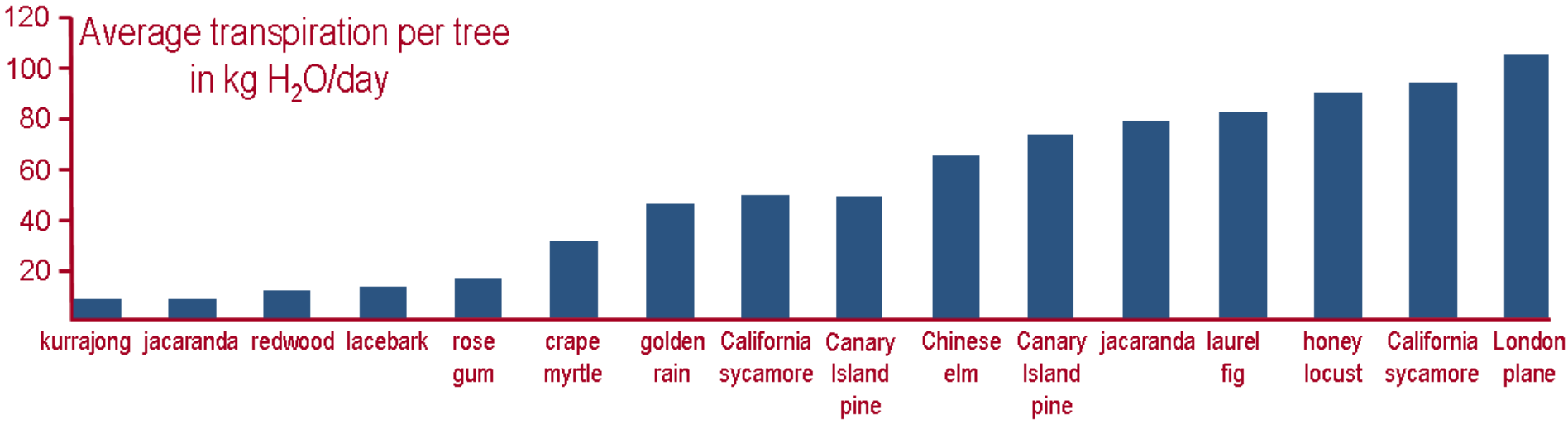
25% reduction

Soil moisture sensor

> 50% reduction

Nearly100% efficiency

MEASURED WATER USE BY URBAN TREES



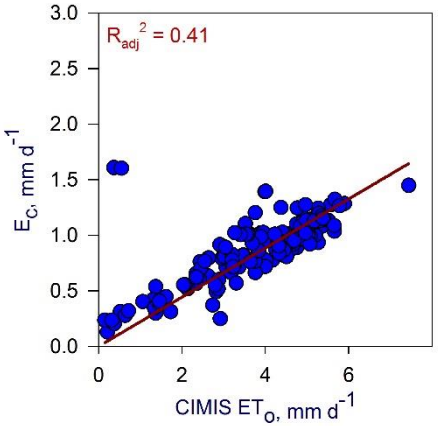
We used *in situ* measurements of urban tree transpiration in greater Los Angeles

- to evaluate the landscape coefficient method and
- to construct equations for estimating water use

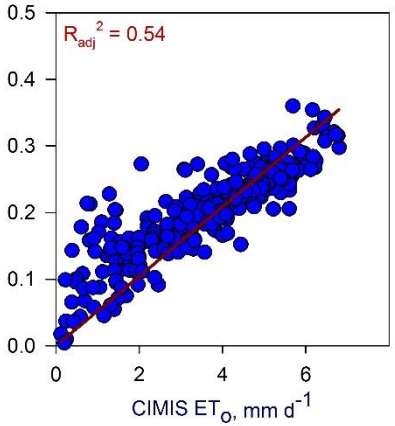
LANDSCAPE COEFFICIENT METHOD

WORKS WELL FOR LAWNS, BUT NOT FOR URBAN TREES

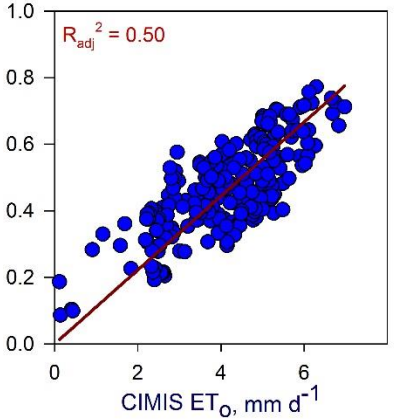
Sycamore



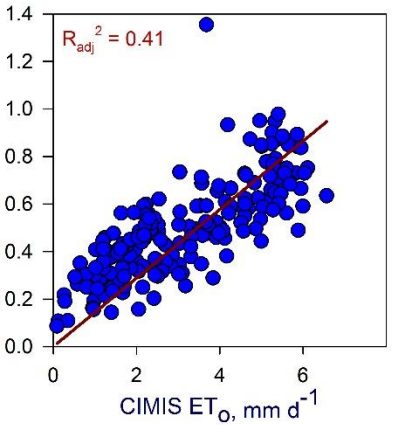
Redwood



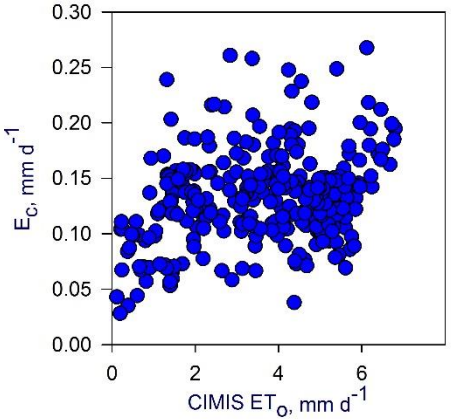
Crape myrtle



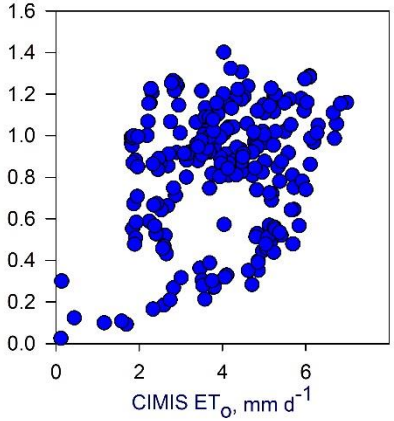
Canary Island pine



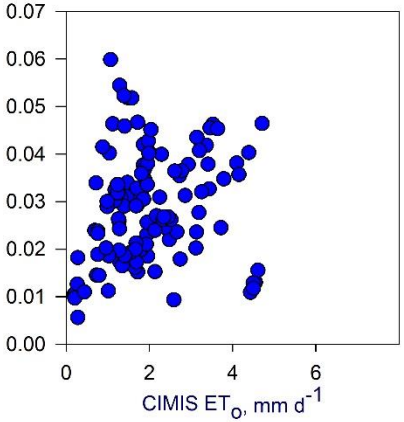
Eucalyptus



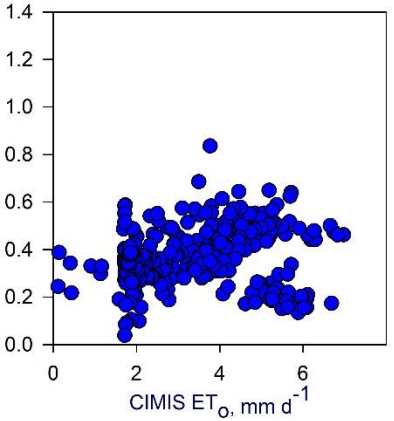
Jacaranda



Sumac



Canary Island pine



CURRENT METHOD DOES NOT CORRECTLY ACCOUNT FOR SPECIES DIFFERENCES

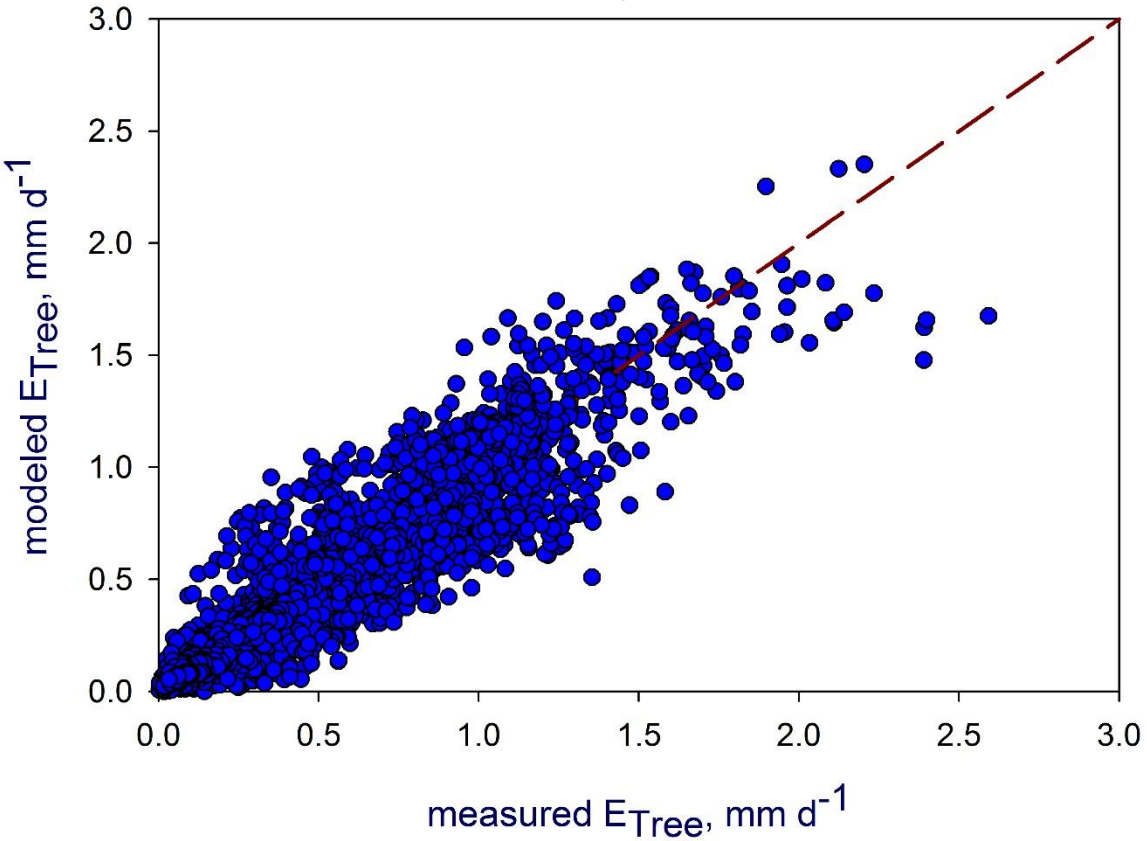
species	WUCOLS water use	measurement-based water use
Chinese elm	M	M
Crape myrtle	M	H
Goldenrain tree	L	H
Honey locust	M	H
Laurel sumac	L	L
Kurrajong	L	L
Lacebark tree	L	L
California sycamore	M	M
London planetree	M	H
Canary Island pine	L	L
Cost redwood	H	L

MEASUREMENT-BASED METHOD TO ESTIMATE WATER USE BY URBAN TREES

$$E_{Trees} = E_{ref}(0.55 + 0.23lnD + 0.002I_0),$$

where $E_{ref} = 0.0012A_S$ for angiosperm trees,

$E_{ref} = 0.0004A_S$ for gymnosperm trees.



- E_{ref} is a parameter that represents E_{Tree} at D = 1kPa for planting density of 100 tree/ha
- D is vapor pressure deficit of the air
- I_0 is incoming solar radiation
- A_S is sapwood area

SUMMARY

- Current irrigation practices lead to over-watering
- Current watering recommendations are excessive
- Intentional shading of turfgrass is an effective water-saving measure
- Landscape water use in Los Angeles is dominated by lawns

RECOMMENDATIONS

- **Revise municipal watering recommendations**
  - Landscape coefficient method – apply to lawns only.
  - Update the coefficients – shade and seasonal changes in water use.
  - Use an appropriate methodology to estimate water use of trees.
- **Avoid over-irrigation**
  - Introduce and disseminate new irrigation guidelines.
  - Update irrigation systems.
- **Strategically modify existing landscapes to conserve water**
  - Plant water-conserving trees.
  - Consider tree-planting programs to shade existing lawns.
  - Irrigation systems should support deep tree roots.

CITATIONS

1. Litvak E., Manago K., Hogue T. S. and Pataki D. E., 2017: Evapotranspiration of urban landscapes in Los Angeles, California at the municipal scale. Water Resources Research, 53, DOI: 10.1002/2016WR020254.
2. Litvak E., McCarthy H. R. and Pataki D. E., 2017: A method for estimating transpiration from irrigated urban trees in California. Landscape and Urban Planning, 158, 48-61.
3. Litvak E. and Pataki D. E., 2016: Evapotranspiration of urban lawns in a semi-arid environment: an in situ evaluation of microclimatic conditions and watering recommendations. Journal of Arid Environments, 134, 87-96.
4. Bijoor, N. S., Pataki D. E., Haver D. and Famiglietti J. S., 2014: A comparative study of the water budgets of lawns under three management scenarios. Urban Ecosystems, 17 (4), 1095–1117.

FUNDING

National Science Foundation IOS 1147057 and EAR 1204442

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