WATER USE BY URBAN LAWNS AND TREES IN LOS ANGELES

Evaluation of current irrigation practices to develop water conservation strategies

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WATER SCARCITY IS INCREASINGLY A CONCERN

2011 2012 2013 2014 2015

STATE OF WATER RESOURCES
STATE OF CALIFORNIA

SERIOUS DROUGHT
HELP SAVE WATER

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.
2008-2011: 11 LAWNS 108 TREES
WATER USE: TREES VS. TURFGRASS

- Trees: 0.3 mm/day
- Unshaded turfgrass: 7 mm/day
## WATER USE: TREES VS. TURFGRASS

<table>
<thead>
<tr>
<th>mm/d</th>
<th>type</th>
<th>growing season</th>
<th>winter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lawns</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>unshaded</td>
<td>5.5</td>
<td>1.8 – 2.5</td>
</tr>
<tr>
<td></td>
<td>shaded</td>
<td>1.8 – 3.8</td>
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<td></td>
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<tr>
<td></td>
<td>trees</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>deciduous</td>
<td>0.1 – 2.6</td>
<td>0.1 – 1.8</td>
</tr>
<tr>
<td></td>
<td>evergreen</td>
<td>0.1 – 1.8</td>
<td></td>
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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 m² 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 lawns (with landscape trees or built structures) lowers their summertime water use by up to 50%.

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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.
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 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

\[ ET = k_L ET_0 = k_d k_s k_{mc} ET_0, \]

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

- Reference tables of... “subjective” coefficients
- This approach implies that \( ET \) is proportional to \( ET_0 \)

CIMIS: [www.cimis.water.ca.gov](http://www.cimis.water.ca.gov)
WUCOLS: [http://ucanr.edu/sites/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

\[ ET = k_d k_s k_{mc} ET_0 \]

<table>
<thead>
<tr>
<th>Season</th>
<th>( k_{mc} ) of unshaded lawns</th>
<th>( k_{mc} ) of shaded lawns</th>
<th>( k_L = a - b \times TCC )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>1.13 ± 0.05 (regular conditions)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.56 ± 0.10 (Santa Ana conditions)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter</td>
<td>0.88 ± 0.13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

\( TCC \) – fractional tree canopy cover

\( a = 0.90 \pm 0.09 \)

\( b = 0.35 \pm 0.13 \)
TESTS OF LAWN IRRIGATION SYSTEMS

Automatic timer irrigation

Weather station & drip irrigation at 80% ET₀

Soil moisture sensor

25% reduction

> 50% reduction

Nearly 100% efficiency
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

<table>
<thead>
<tr>
<th>species</th>
<th>WUCOLS water use</th>
<th>measurement-based water use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinese elm</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Crape myrtle</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td>Goldenrain tree</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>Honey locust</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td>Laurel sumac</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Kurrajong</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Lacebark tree</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>California sycamore</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>London planetree</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td>Canary Island pine</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Cost redwood</td>
<td>H</td>
<td>L</td>
</tr>
</tbody>
</table>
**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 \( D = 1 \) kPa 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


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