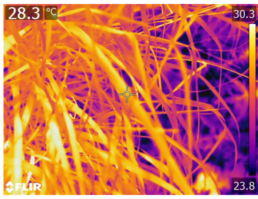

ECOSYSTEM SERVICES FROM NEW YORK GREEN ROOFS: DIFFERENCES IN WATER-USE BETWEEN PLANT SPECIES

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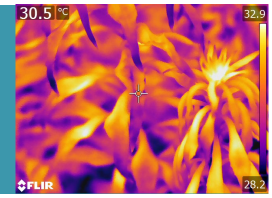


Abstract

As global urbanization increases, it will be essential to understand how green infrastructure can alleviate wastewater management issues in cities. Though green roofs are often designed for to mitigate storm-water overflow, they are generally planted with species most likely to survive, rather than those most likely to take up the most water. This study examines traits associated with water-use in species found on New York green roofs, using two primary approaches:

i) Diurnal Course. Over the course of the day, measurements were regularly taken on dynamic, leaf-level plant traits associated with water-use: stomatal conductance and leaf temperature.
ii) Soil Moisture Drawdown Trial. Greenhouse plants grown at different watering frequencies were watered once to saturation, then weighed on subsequent days to detect water-loss from evapotranspiration.

Significant species differences were found in diurnal stomatal conductance, suggesting species-difference in water-use. Leaf temperature also indicated species-differences in water-use, but these results were complicated by the effects of environmental variables. Along with significant species-differences in water-loss, the soil moisture drawdown trial revealed significant difference in water-loss between drought-stressed and well-watered plants in *Andropogon*, *Pycnanthemum*, and *Sorghastrum*. These results should inform future green roof design.

Introduction

- Prevalence of impervious surfaces leads to inadequate drainage of storm water in urban centers.
- Urban wastewater management infrastructure is often too antiquated to manage storm surges effectively and safely (Fig. 1).
- Green infrastructure can reduce excess storm-water through permeability of soil and water-use by plants.
- Both leaf-level (stomatal conductance, leaf temperature) and full-plant (soil moisture drawdown) measurements are used to indicate plant water-use.

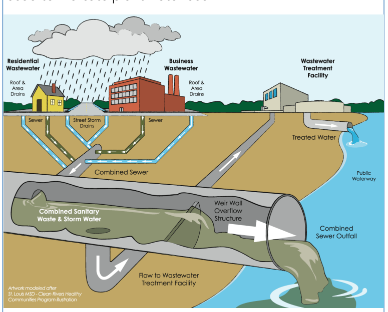


Figure 1. Schematic of a Combined Sewer System. Sewage and storm-water are siphoned into the same system to be treated in the same facilities, but can overflow during storm surges, pouring sewage and city storm-water into local ecosystems.

Thesis Statement: *I studied plant traits indicative of water use in plant species grown on green roofs in New York City, in order to investigate methods of testing water-use, and ultimately determine which species are most likely to positively contribute to urban storm water management.*

Methods: Diurnal Course

- Sites:
  1. Diana Center (2 courses)
  2. Ranaqua, Bronx Park Headquarters (2 courses)
  3. Jackie Robinson Recreation Center (2 courses)
  4. E3B greenhouse (1 course)
- Species chosen by frequency across roofs and abundance within roofs.
- Measurements were taken every 2 hours starting before dawn (when possible), and ending in the mid-afternoon.
- Stomatal conductance is a leaf-level measurement of gaseous water-flux, and was measured using a hand-held SC-1 Leaf Porometer.
- Leaf temperature can indicate degree of transpiration, which is an evaporative, and therefore cooling process. Thermal images were taken using a T-series FLIR thermal camera.

Statistics:

- Diurnal conductance was analyzed using General Additive Modeling.
- Leaf temperature was compared to conductance by linear regression.

Results: Diurnal Course

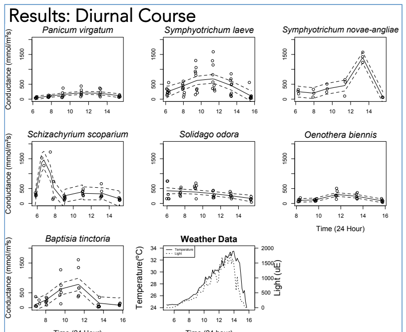


Figure 2. General Additive Models (GAM) of diurnal stomatal conductance on 7-8-15 on the Diana Center green roof for i) *Panicum virgatum*, ii) *Symphyotrichum laeve*, iii) *Symphyotrichm novae-angliae*, iv), *Schizachyrium scoparium*, v) *Solidago odora*, vi) *Oenothera biennis*, vii) *Baptisia tinctoria*. Dashed lines represent 95% confidence intervals. Conductance curves are significantly different between species, suggesting that species differ in when they take up water, as well as overall level of water-use.

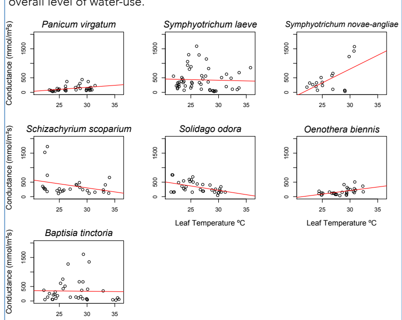
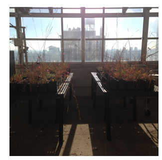


Figure 3. Conductance vs. leaf temperature for species measured on the Diana Center green roof 7-8-15. Red lines represent linear regression. With respect to transpiration, negative correlation is expected, but degree and direction of correlation are also strongly affected by ambient temperature. R^2 values as follows: i) 0.1054, ii) -0.01815, iii) 0.2756, iv) 0.05185, v) 0.2083, vi) 0.2334, vii) -0.02987 (Numbering as in Fig. 2).

Methods: Soil Moisture Drawdown Trial

- Species chosen by frequency across roofs, and availability.
- Plants were randomly split into 2 watering treatments:
  - I. Drought-stressed: watered once per week
  - II. Well-watered: watered twice per week
- Plants were grown for 6 weeks under split watering treatments.
- All plants were watered to saturation on Day 0, then left un-watered for the following 20 days.
- Plant pots were weighed throughout the 20-day drawdown, to detect water-loss.
- At the end of the drawdown, plants were dried and measured for dry aboveground biomass.



Results: Soil Moisture Drawdown

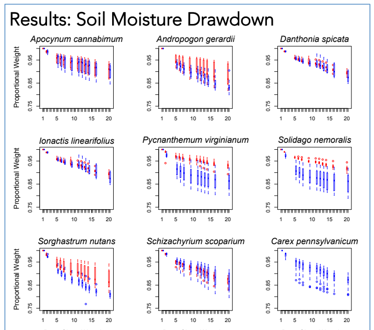


Figure 4. Weight of plants proportional to weight on Day 1, over 20-day drawdown period. Red box plots represent plants grown in drought-stressed conditions, and blue box plots represent plants grown in well-watered conditions. Decrease in proportional weight indicates degree of water-loss. Significance difference in final proportional weight by species ($F_{8,175}$=9.153, p=1.73E-10) and treatment ($F_{1,175}$=76.572, p=1.74E-15).

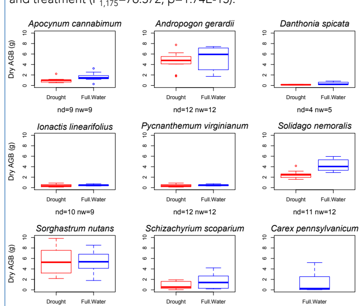


Figure 5. Dry aboveground biomass (AGB) for plants grown in drought-stressed (red box plots) and well-watered (blue box plots) conditions for each species.

Implications and Recommendations

- Plant species that use the most water should be planted on green roofs most frequently.
- Species differences in water-use were found in conductance and thermal data: thermal data is easier to collect in the field, but is also more complexly influenced by environmental variables, and should be used carefully.
- Some species acclimatize to drought-stress by decreasing water-use—these species should be most effective in reducing storm-water runoff on irrigated roofs.

Further Questions of Interest:

- How do larger-scale ecosystem effects influence overall water-use?
- How do these results compare with water-use on other types of green infrastructure?
- How can these results be scaled up to compare the effects of plants and soil on storm-water overflow reduction?

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