Bob Pitt, Emeritus Cudworth Professor of Urban Water Systems
Department of Civil, Construction, and Environmental Engineering
University of Alabama, Tuscaloosa, AL USA

B.S. Engineering Science, Humboldt State University, Arcata, CA 1970.
MSCE, San Jose State University, San Jose, CA 1971.
Ph.D., Environmental Engineering, University of Wisconsin, Madison, WI 1987.

50 years working in the area of urban water and wet weather flows, focusing on the effects, sources, and control of stormwater. About 100 publications, including several books.

1

1

Small Urban Tree Rainfall Interception Measurements for Inclusion into WinSLAMM, the Source Loading and Management Model

Follow-up of Last Year's Presentation on Interception by Large Urban Trees

Bob Pitt, Emeritus Cudworth Professor of Urban Water Systems, University of Alabama
Ryan Bean, PhD student, University of Alabama
John Voorhees, Principal, PV & Associates
Mark Elliott, Associate Professor, University of Alabama

2

2

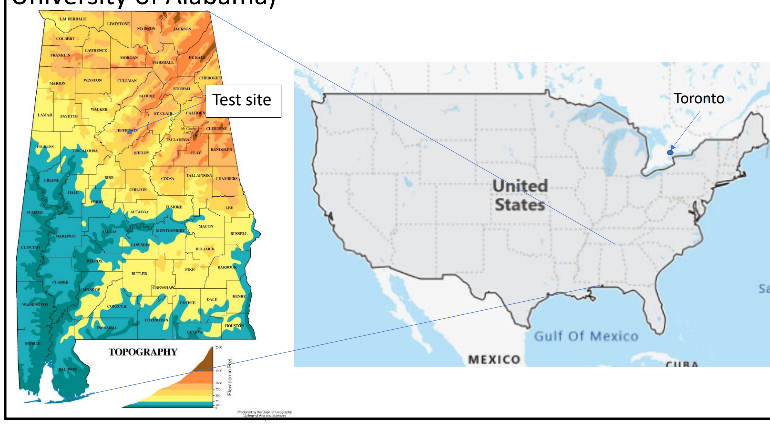
Objectives of Urban Tree Interception Measurements Described in this Presentation

- The experiments described in this presentation and associated paper were conducted to examine canopy interception by direct measurements of throughfall under isolated or low density stands of small urban deciduous trees in the Southeast US.
- These measurements are a follow-up of the results presented last year that investigated throughfall under large deciduous and evergreen urban trees.
- These measurements of interception by small trees were conducted during 83 rains over all seasons to determine statistically significant relationships for use in the WinSLAMM stormwater quality model. The prior measurements for large urban trees were also conducted for about the same number of rains for all seasons. These large data sets allow the identification of the significant factors affecting runoff beneath a range of trees in urban areas.

3

3

Test site location on topographic map of Alabama (Dept. of Geology, University of Alabama)



4

4

This lot was developed in 1957 with most of the large pines and oaks likely present before home construction. The site is well-wooded with mature trees in the front and sides of the lot, with open grass areas in the rear of the lot and along the streets.

5

5

HOBO recording rain gage and Davis weather station in open area

The total annual rainfall for Birmingham, AL, in 2020 (the year with most of the data collected for these analyses) was 185 cm (73.05 inches), 49 cm (19.33 inches) above normal, which was the 5th wettest year on record. Central Alabama was directly impacted by two tropical systems, Hurricanes Sally and Zeta, and 35 tornadoes in 2020.

83 rains were monitored, 8 during winter (December only), 18 during spring (mostly April plus May), 39 during summer (June through August), and 18 during fall (September through November). The largest rain was 84 mm. The interevent periods ranged from about 7 h to 14 d. Rain durations ranged from about 0.1 h to 39 h.

6

6

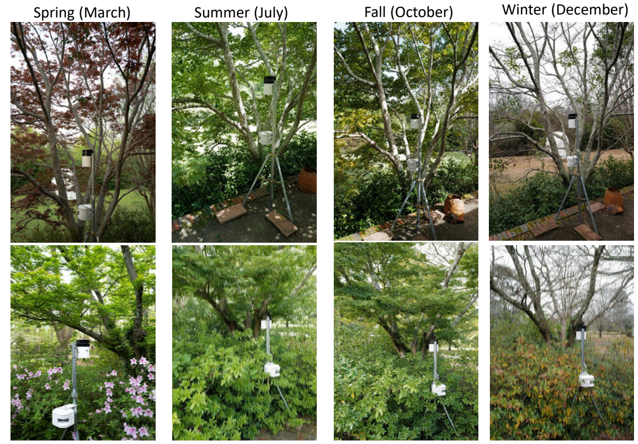
Rain Gages Located under two Japanese Maple Trees (*Acer palmatum*)

The two test trees were upright versions of Japanese maples (*Acer palmatum),* about 5 m tall, and were planted about 10 years ago. They are very popular urban trees and thrive in most of the U.S., except for the northern central plains/upper Midwest, New England, and extreme southern areas. They originated in Asia where they are also common.

7

7

Spring (March) | Summer (July) | Fall (October) | Winter (December)



Monitored Japanese Maples during Different Seasons

8

8

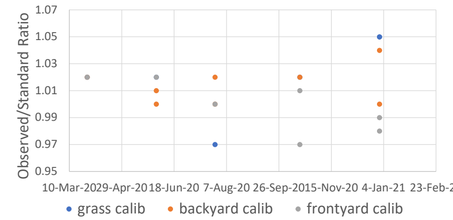
Tree Canopies of Japanese Maples for Different Seasons

9

9

The following 5 dates were when the data were downloaded, and the calibrations conducted:

March 27, 2020 (initiation of monitoring period)
June 1, 2020
July 27, 2020
October 16, 2020
December 31, 2020 (end of reporting period)

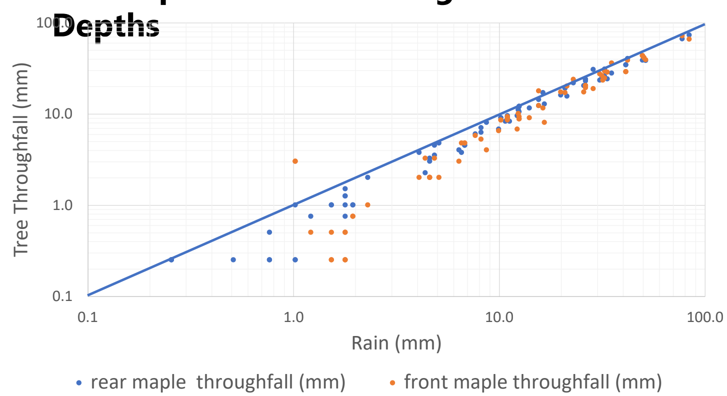


	grass rain calibrations	backyard J. Maple calibrations	frontyard J. maple calibrations
number	6	8	7
minimum	0.97	1.00	0.97
maximum	1.05	1.04	1.02
average	1.02	1.01	1.00
COV	0.03	0.01	0.02

10

10

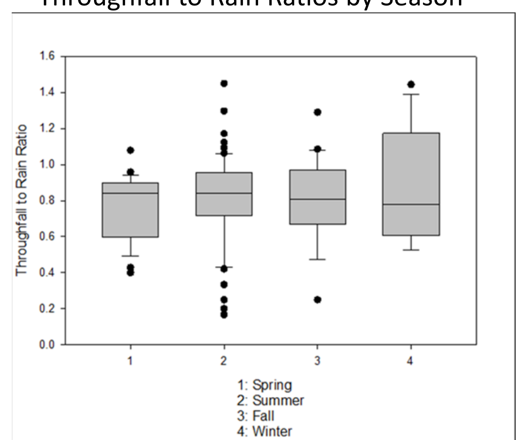
Scatterplot of Tree Throughfall vs. Rain Depths



11

11

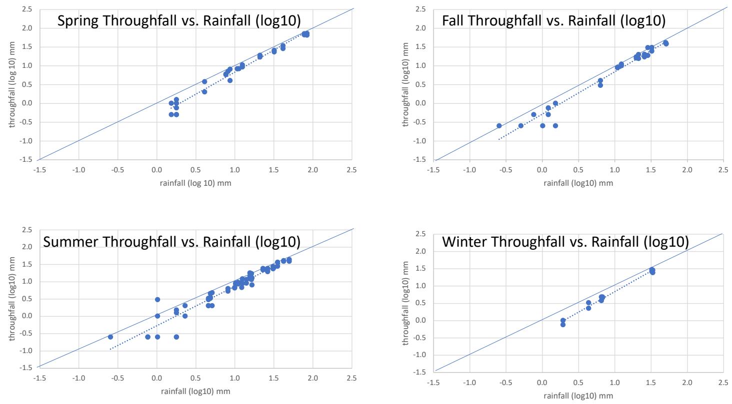
Throughfall to Rain Ratios by Season



12

12

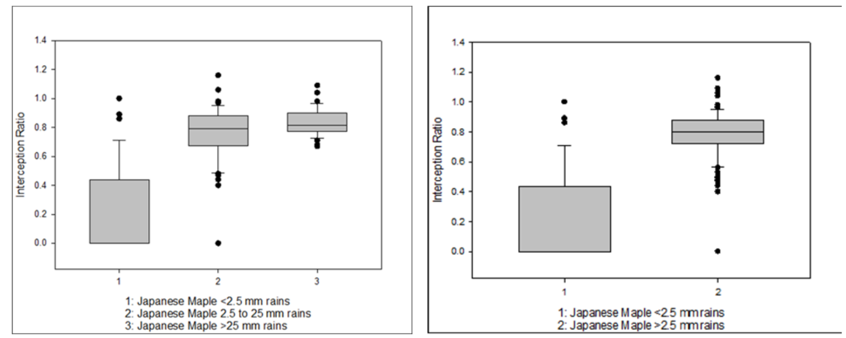
Regressions of Rainfall (log10) vs. Throughfall (log10) by Season



Very similar rainfall vs. throughfall relationships for all seasons

13

Interception Ratio (Throughfall/Rainfall) for Different Rain Depth Ranges



However, 2.5 to 25 mm rain range and >25 mm rain range were not significantly different, so those ranges were combined.

14

- If a tree is located in a pervious area of the watershed (over lawns or other non-paved areas), interception may not affect outfall runoff quantities much; most of the un-intercepted rainfall is likely to be infiltrated with or without the trees.
- However, trees likely maintain good soil characteristics and minimize compaction, which would improve the infiltration of rainfall.
- The largest hydrological benefit of urban trees would be when directly connected impervious areas (roofs, walkways, parking areas, and streets) are heavily covered by an overstory of trees.
- If tree-covered impervious areas are directly connected to the drainage system, these benefits would be the greatest, but if the tree-covered impervious areas drain to pervious areas (such as disconnected roofs or walks surrounded by lawns), the benefits would be lower.

15

Mature Trees Over Paved Parking Areas Result in Significant Interception

Newly Planted Trees will Require Many Years before Significant Interception

Photos from misc. Internet sources

16

Conclusions

- Urban trees add substantially to the standard of living of residents and are highly desirable.
- Urban trees have been recommended as a solution for urban drainage and flooding problems.
- Few data are available quantifying these benefits under actual field conditions, especially under a wide range of rain conditions for different tree species and seasons.
- Literature describing urban tree interception at many international locations indicate that canopy interception benefits are limited.
- During the measurements described in this, and last year's presentation, tree specie type and rainfall amount had the greatest effect on throughfall; the large deciduous tree (even with few leaves during winter conditions) intercepted much more rainfall than the large conifer tree, or the small deciduous trees, likely due to the massive branch structure.
- Small and/or immature trees have much smaller interception benefits per canopy area compared to large trees due to the short distance rain falls through the canopy, decreasing the interception opportunities.

Conclusions (continued)

- For the small urban trees, no significant differences were noted for the different seasons, and only the smallest rains (<2.5 mm or 0.1 in) had interception values that were significantly different from the larger rains.
- No throughfall (100% interception) was generally recorded for rains <1 mm, the throughfall was about 25% of the rainfall (75% interception) for rains up to about 2.5 mm, and about 85% for larger rains (15% interception) for the small urban trees.
- Small urban trees have limited spread and reduced coverage (shadow) over adjacent impervious areas compared to large trees and therefore have limited runoff reducing benefits, especially considering their limited interception for most rains.