ESTABLISHING A STORMWATER CREDIT FOR PLANTS:
A hydrologic perspective of plant communities
Scott Dierks, PE
GEI Consultants, Inc.
Preview of Talk

Project Background and Intent

Plant biogeochemical processes, adaptations, ecological systems, feedback loops and their impacts

Why current reference data under-predicts infiltration, recharge, evapotranspiration and cooling performance in natural, native and restored systems

Summary of Washtenaw County, Michigan rain garden monitoring – techniques, results, findings

Design and maintenance recommendations derived from this work
ACKNOWLEDGMENTS:

To the staff at the WCWRC, including Evan Pratt, Harry Sheehan, Catherine Wytychak and Susan Bryan.

Sincere thanks as well to Scott Isenberg and Emma Giese, who steadfastly assisted with field work and data analysis.

To Branko Kerkez and Brandon Wong at UM

Thanks also to Patrick Judd and Shannan Gibb-Randall, who shared rain garden plans and their plant identification expertise with this project.
ROOT RESEARCH

Dr. Jerry Glover
The Land Institute, Salinas, KS

Prairie Plants
and their Environment
A Fifty-Year Study in the Midwest
by
J. E. Weaver
Fig. 4.—From left to right are Indian grass (Sorghastrum nutans), little bluestem (Andropogon scoparius), and false brome (Bromus secalinus).

Fig. 7.—Characteristic development of the tops and roots of four bunch grasses as they occur in several upland communities. From left to right they are needlegrass (Stipa spartea), Junegrass (Koeleria cristata), little bluestem (Andropogon scoparius), and panic grass (Panicum virgatum). Note that the tops are only about half as high as the roots are deep.
Fig. 24.—A field of prairie dropseed (*Sporobolus heterolepis*).

Fig. 25.—Bunches of unmowed prairie dropseed several years old, with dead leaves removed (left) and with old leaves intact (right).
Fig. 9.—Excavation, 20 feet deep, showing the root habits of several prairie forbs. 1, Amurea uniseta, lead plant; 2, Hesperia javosa, rushlike hesperia; 3, Liatris scariosa, scaly blazing star; 4, Liatris pustulata, dotted button blazing star; 5, Rosita nigra, prairie rose; 6, Echinocea parida, pale-purple coneflower; 7, Silphium lacustre, compass plant; 8, Aster ericoides, many-flowered aster; 9, Amuraphis crassifolia, ground plum; 10, Glycyrrhiza inflata, licorice; 11, Penstemon communis, prairie turnip (turning aside into wall). Redrawn from Weaver (1919-1920), and originally published in the Rotated Gazette.

Fig. 13.—Excavation, 20 feet deep, showing the root habits of several sandhill forbs. 1, Paralea lanceolata; 2, Eriogonum microtheca; 3, Mentzelia nudicaulis; 4, Gilia longiflora; 5, Astragalus filifolius; 6, Penstemon villous; 7, Tradescantia virginiana; 8, Ipomoea latisperma; 9, Asclepias amarilla; 10, Avena carinata.
Dry Systems versus Wet Systems
Fig. 109.—Growth of tops and roots from similar vigorous bunches of little blue-stem 42 days after transplanting the sod blocks. Less than half of the root system is exposed. The control bunch (left) had a total of 130 roots that extended below the sod, but the plants that were clipped four times (right) had only 8 roots.

Fig. 110.—Development of tops and roots of similar blocks of sod of moderately grazed (left) and closely grazed (right) sand dropped 28 days after transplanting the sods (on June 10).
ADAPTATIONS & FEEDBACK LOOPS

There is a feedback loop between biotic & abiotic components of soil.

Plant roots & bacteria release secretions (exudates) that bind inorganic soil together into aggregates.

Exudates also fuel biological activity, such as nutrient and pollutant cycling.

Micro-aggregates are also bound together by root hairs, roots and fungal hyphae.

Changes in pore size distribution are made by roots, burrowing animals and dying roots.
CITY OF ANN ARBOR

MONITORED RAIN GARDENS
DIGITAL TIME-LAPSE PHOTOGRAPHY OF RAIN GARDEN WATER DEPTH (STAGE)

TimelapseCam Pro

The TimelapseCam Pro captures photos and videos during the day and at night. It will set up quickly and easily with an easy-to-use start guide right on the camera. Capture every step of your next project using the TimelapseCam Pro.

$159.99

Qty: 1

Add to Cart

* Ask a Product Question * Register Your Warranty
UNIVERSITY OF MICHIGAN REAL-TIME WATER SYSTEMS LAB SENSOR NODES
PRESTWICK
GARDEN SOILS AND DATA
Estimation of Green-Ampt Infiltration Parameters (SWMM RUNOFF Variables SUCT, HYDCON, SMDMAX)
Provisional Values Suitable for Design Storm Events Where More Detailed Soils Data Is Not Available

<table>
<thead>
<tr>
<th>USDA Soil Texture Classification</th>
<th>SUCT Avg. Capillary Suction</th>
<th>HYDCON Saturated Hydraulic Conductivity</th>
<th>SMDMAX Initial Moisture Deficit for Soil (Vol. of Air / Vol. of Voids, expressed as a fraction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>1.95 (49.5)</td>
<td>9.27 (235.6)</td>
<td>.346 (.404)</td>
</tr>
<tr>
<td>Loamy Sand</td>
<td>2.41 (61.3)</td>
<td>2.35 (59.8)</td>
<td>.312 (.382)</td>
</tr>
<tr>
<td>Sandy Loam</td>
<td>4.33 (110.1)</td>
<td>0.86 (21.8)</td>
<td>.246 (.355)</td>
</tr>
<tr>
<td>Loam</td>
<td>3.50 (88.9)</td>
<td>0.52 (21.8)</td>
<td>.246 (.355)</td>
</tr>
<tr>
<td>Silt Loam</td>
<td>6.57 (166.8)</td>
<td>0.27 (21.8)</td>
<td>.246 (.355)</td>
</tr>
<tr>
<td>Sandy Clay Loam</td>
<td>8.60 (218.5)</td>
<td>0.12 (21.8)</td>
<td>.246 (.355)</td>
</tr>
<tr>
<td>Clay Loam</td>
<td>8.22 (208.8)</td>
<td>0.08 (21.8)</td>
<td>.246 (.355)</td>
</tr>
<tr>
<td>Silty Clay Loam</td>
<td>10.75 (273.0)</td>
<td>0.08 (21.8)</td>
<td>.246 (.355)</td>
</tr>
<tr>
<td>Sandy Clay</td>
<td>9.41 (239.0)</td>
<td>0.05 (21.8)</td>
<td>.246 (.355)</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>11.50 (292.2)</td>
<td>0.04 (21.8)</td>
<td>.246 (.355)</td>
</tr>
<tr>
<td>Clay</td>
<td>12.45 (316.3)</td>
<td>0.02 (21.8)</td>
<td>.246 (.355)</td>
</tr>
</tbody>
</table>

Estimation of Soil Water Properties

W. J. Rawls, D. L. Brakensiek, K. E. Saxton
MEMBER ASAE
MEMBER ASAE
MEMBER ASAE

1982—TRANSACTIONS of the ASAE
## SUMMARY OF RAIN GARDEN MONITORING

<table>
<thead>
<tr>
<th>SITE</th>
<th>Year Planted</th>
<th>Soil Classification</th>
<th>Measurements</th>
<th>Measured Infiltration (in/hr)</th>
<th>SPAW-Estimated (in/hour)</th>
<th>Ratio of Avg. Monitored to SPAW-Estimated Infil.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barber Ave.</td>
<td>2013</td>
<td>Loam</td>
<td>12 No. Rain Events Monitored 3 No. Events with measured drawdown</td>
<td>0.93 0.62 1.26</td>
<td>0.40</td>
<td>2.3</td>
</tr>
<tr>
<td>Miller Ave.</td>
<td>2011</td>
<td>Loam</td>
<td>6 No. Rain Events Monitored 4 No. Events with measured drawdown</td>
<td>1.30 0.74 2.06</td>
<td>0.42</td>
<td>3.1</td>
</tr>
<tr>
<td>Prestwick Ct.</td>
<td>2011</td>
<td>Clay</td>
<td>24 No. Rain Events Monitored 17 No. Events with measured drawdown</td>
<td>0.59 0.33 0.90</td>
<td>0.08</td>
<td>7.4</td>
</tr>
<tr>
<td>Independence Blvd.</td>
<td>2013</td>
<td>Loam</td>
<td>4 No. Rain Events Monitored 1 No. Events with measured drawdown</td>
<td>1.78</td>
<td>0.40</td>
<td>4.5</td>
</tr>
<tr>
<td>Easy St.</td>
<td>2013</td>
<td>Loam</td>
<td>4 No. Rain Events Monitored 1 No. Events with measured drawdown</td>
<td>0.55</td>
<td>0.74</td>
<td>0.7</td>
</tr>
<tr>
<td>Arbor Oaks</td>
<td>2013</td>
<td>Loam</td>
<td>16 No. Rain Events Monitored 3 No. Events with measured drawdown</td>
<td>0.13 0.09 0.23</td>
<td>0.40</td>
<td>0.3</td>
</tr>
<tr>
<td>Vets Firehouse</td>
<td>2013</td>
<td>Silty clay</td>
<td>16 No. Rain Events Monitored 3 No. Events with measured drawdown</td>
<td>0.14 0.01 0.24</td>
<td>0.17</td>
<td>0.8</td>
</tr>
<tr>
<td>Mershon Dr.</td>
<td>2017</td>
<td>Clay loam</td>
<td>4 No. Rain Events Monitored 1 No. Events with measured drawdown</td>
<td>0.43 0.22 0.93</td>
<td>0.17</td>
<td>2.5</td>
</tr>
</tbody>
</table>
Figure 1. Distribution of measured saturated hydraulic conductivity from 24 different side by side studies of infiltration in similar soils under cultivated and natural/restored land uses (From: Dierks, 2011; See: https://ascelibrary.org/doi/10.1061/9780784413883.004)
LESSONS FROM MULTIPLE LINES OF EVIDENCE

- Plant communities can significantly alter their growing environment to better suit propagation success and perpetuity.
- Enduring plant communities thrive and fail together, they are not isolated individuals.
- Hydrologically speaking, if we want to sustain certain benefits for built environments, we should aim for appropriate plant communities.
- Successful, sustainable gardens receive active maintenance and care.
WETLAND ECOSYSTEMS

- Plants adapted to an environment marked by continuous or near-continuous flooding and little oxygen at the roots

- Structural Adaptations (morphological)
  - Aerenchyma
  - Adventitious roots
  - Stem elongation
  - Hypertrophied lenticels
  - Pneumatophores

- Physiological adaptations
  - Anaerobic respiration
  - Malate production
PRAIRIE & FOREST ECOSYSTEMS

- Adpated to areas that sometimes flood, but are also marked by periods of water scarcity and sometimes nutrient scarcity

- Plants show high plasticity in relation to their neighbors, even specific identity. Plasticity helps to adjust community composition; promoting co-existence and community diversity

- Studies have also shown grasses and forbs tend to have specific root adaptations to drought, developing thinner roots at a lower metabolic cost but with more capacity to “hunt” for water

- Wang, et.al. (2017) found that by applying a drought or flooding stress early in a plant’s life, the plant was better able to handle that stress later in its life
Mesic prairies graminoid-dominated, forb-rich communities.

Dominated by big bluestem, little bluestem, and Indian grass. Other grasses include: cordgrass (Spartina pectinate), porcupine grass (Hesperostipa spartea), prairie dropseed (Sporobolus heterolepis), and switch grass (Panicum virgatum).

Forbs, shrubs and trees include: Silphium laciniatum (compass-plant); New Jersey tea (Ceanothus americanus), tall coreopsis (Coreopsis tripteris), American hazelnut (Corylus americana), pasture rose (Rosa carolina), prairie willow (Salix humilis), stiff goldenrod (Solidago rigida), purple meadow rue (Thalictrum dasycarpum), Culver’s root (Veronicastrum virginicum), Coreopsis palmata (prairie coreopsis); Echinacea purpurea (purple coneflower); Eryngium yuccifolium (rattlesnake-master) and bur oak (Quercus macrocarpa).
DESIGN GUIDELINES

 Minimize the use of engineered soils and instead allow plants to “engineer” the soils;
 Maintain planted BMP size between 10% and 20%-25% of its drainage area
 Aim for related plant communities, not isolated individuals; Underground storage created with an aggregate layer, perhaps not necessary. It probably inhibits root growth anyway
 Upturned outlet good for nitrogen control but it also inhibits root growth depths.
 Underdrain with valve: valve open draining to foster drainage in early year(s). Valve closed to promote infiltration with mature root systems in years 2 or 3+
DESIGN GUIDELINES, CONT’D

- Acknowledge stress as an asset; i.e., planted systems should be able to withstand repeated periods of water scarcity;

- Manage plant communities rather than maintaining individual plants or species

- Successful rain garden and bioretention ecosystems have both prairie/mesic prairies and wetland areas

- Select grasses, forbs, shrubs and trees for best combination of complementary rooting strategies for that site
QUESTIONS OR FOLLOW-UP:

Scott Dierks – sdierks@geiconsultants.com