Not so vacant? Evaluating vacant lots as passive green infrastructure for the rendering of hydrologic ecosystem services

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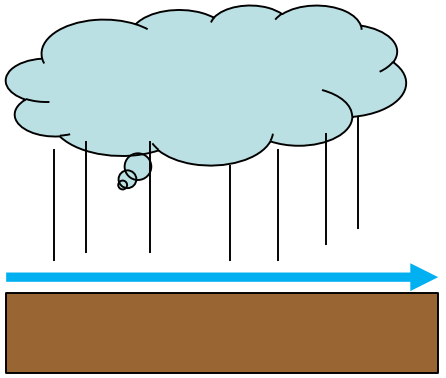
Urban Soils as a basis for GI

- A great deal of city acreage has been left vacant from demolition as blight control
- Disturbance history affects layering of urban soils
- Changes in layering predict changes in hydrologic functions
- Field measurements help us understand changes and what urban soils offer
- May minimize risks of unintended consequences of management and maximize ecosystem services

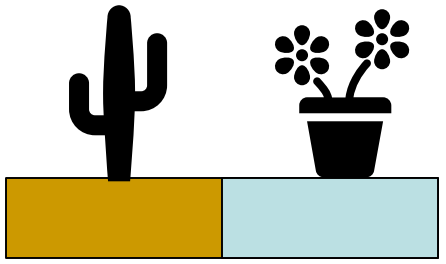
Concept and approach

Target ecosystem services:

Regulating: *Runoff Formation:* how often does hydraulic head (Ψ) at soil surface approach zero?



Supporting: *Plant Growth:* how often does rooting zone water content approach wilting point?

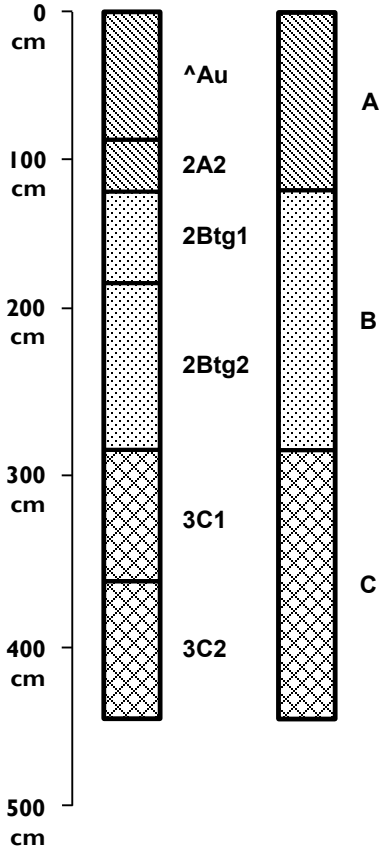


Urban Soil Assessments

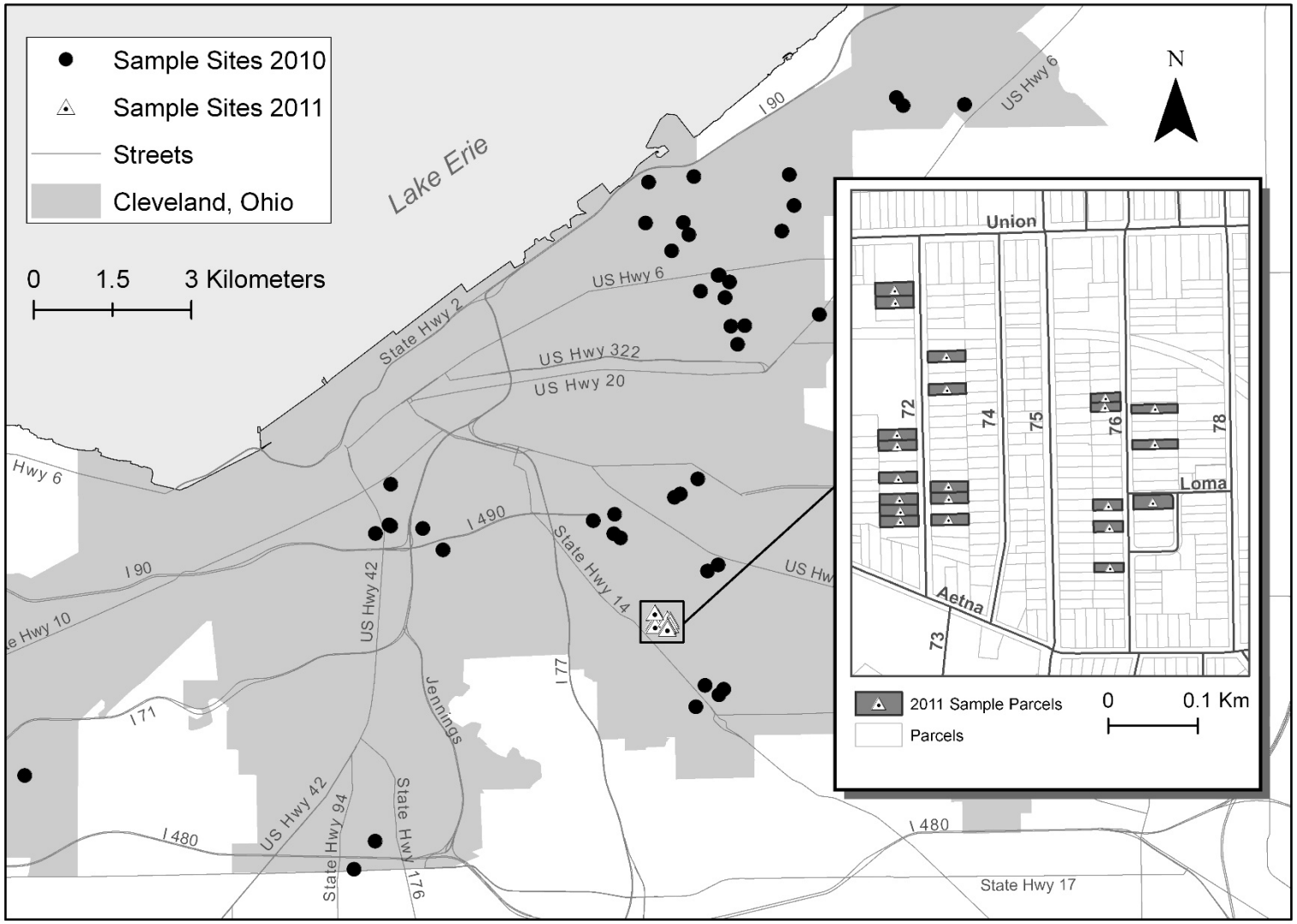
Basic - Urban soils are not assessed for many urban centers, GI target areas suffer from poor data support

Practical - Hydrologic suitability of urban soils for a broad range of ecosystem services

Response - Develop observed dataset of paired pre -, post-urban; *field hydropedological data*



Assessment effort: Cleveland 2010, 2011



Assessment effort: Detroit 2013

Urban and reference soil profiles

Compared to reference profiles (A-B-C), urbanized soil profiles were:

- ✓ Missing B horizons,
- ✓ …had deeper A, shallower C horizons,
- ✓ …and we found that overall, *A-C sequence was predominant*

City	Urban profiles	Soil series	"Pre – urban" Reference profiles
Cleveland	72	9	28
Detroit	57	13	28
Total (all 12 cities)	332	75	181

Herrmann, Schifman, Shuster; 2017, *Widespread loss of intermediate soil horizons in urban landscapes. In revision, Proc. Natl. Acad. Sci.*

Concept and approach

- HYDRUS 1D parameterized for each of reference and urbanized profiles.
- Combination of ROSETTA predictions for van Genuchten parameters and actual field data for:
  - horizon texture
  - thickness
  - surface bulk density
  - Infiltration (Kunsat)
  - drainage (Ksat)
- Precipitation: 2017 hourly-resolution records for Cleveland OH, Detroit MI (https://giovanni.gsfc.nasa.gov/giovanni/)

Case study: soils in Great Lakes cities

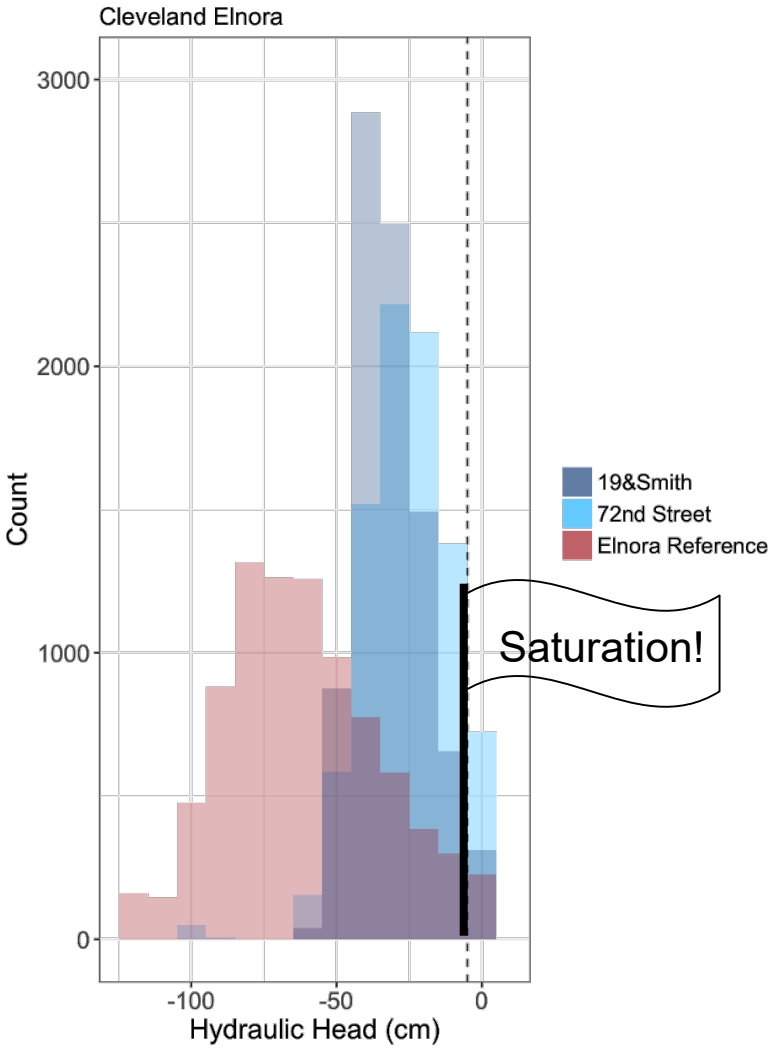
- Cleveland

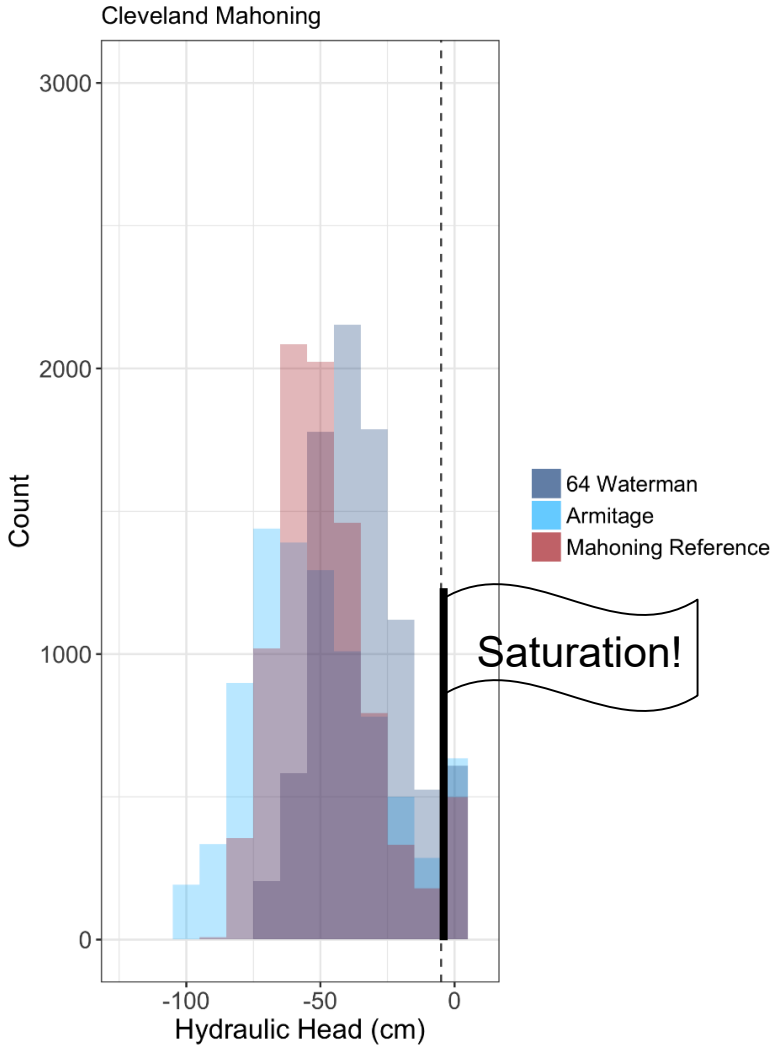
Pre-Urban	Urbanized:
Elnora (A-C):	W19th (A-B-C), East 72nd (A-C) *coarser*
Mahoning (A-B-C):	Armitage (A-C), 64th (A-C-B-C) *finer*

- Detroit

Pre-Urban	Urbanized:
Kibbie (A-C-B-C):	Chapel (A-B-C), Stout (A-C) "*coarser*"
Rapson (A-B-C):	Pierson (A-B-C), Lyndon (A-C) "*finer*"

Cleveland: Ψ at surface, influence on runoff formation

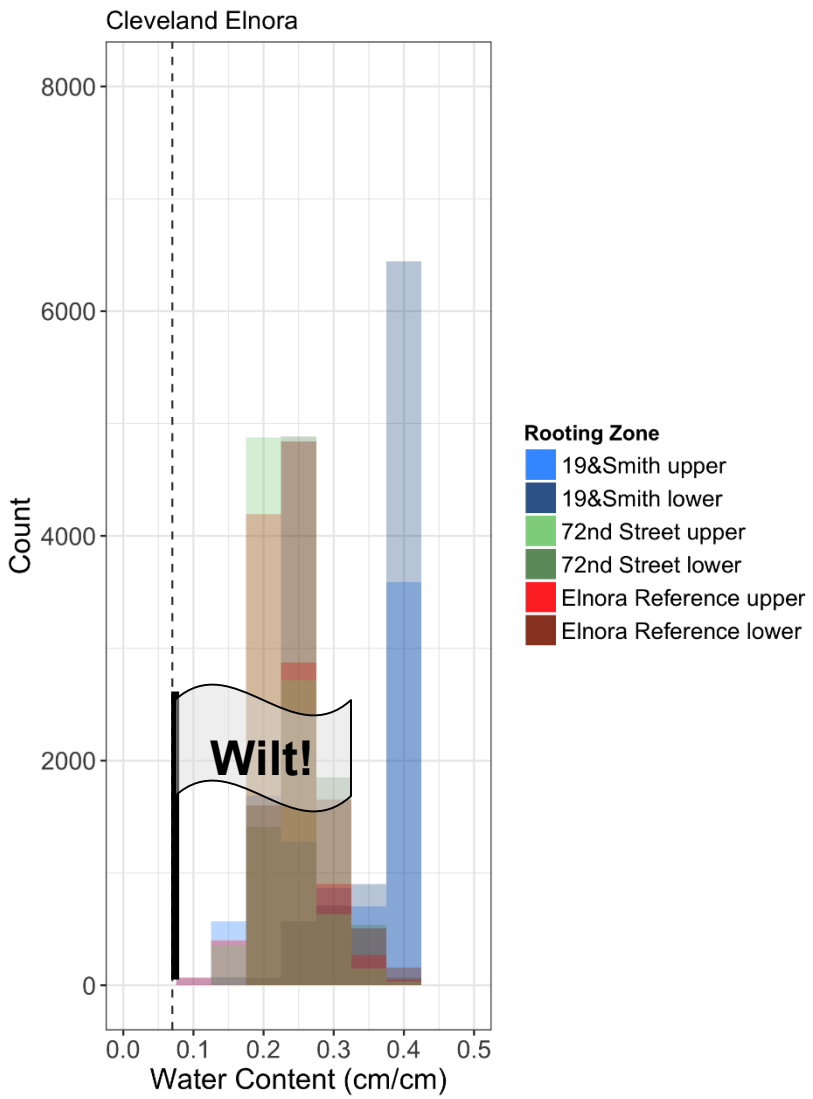


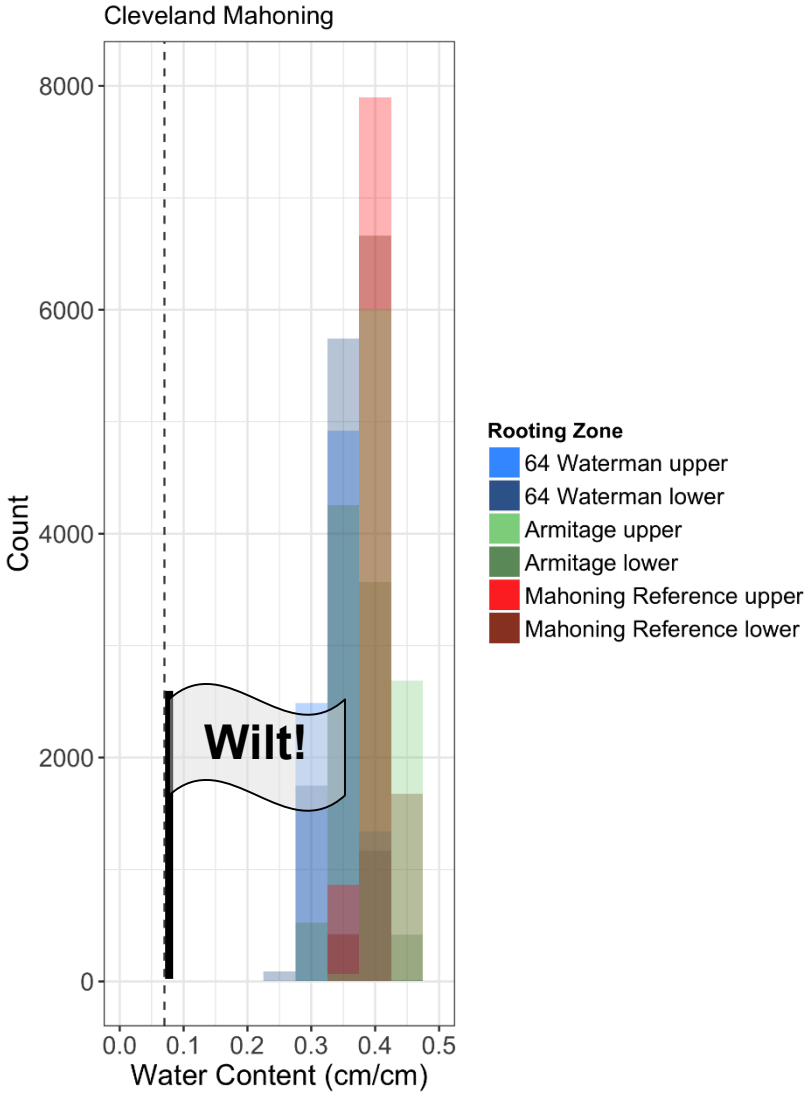


Urbanized profiles make this once drier profile wetter, more susceptible to runoff production

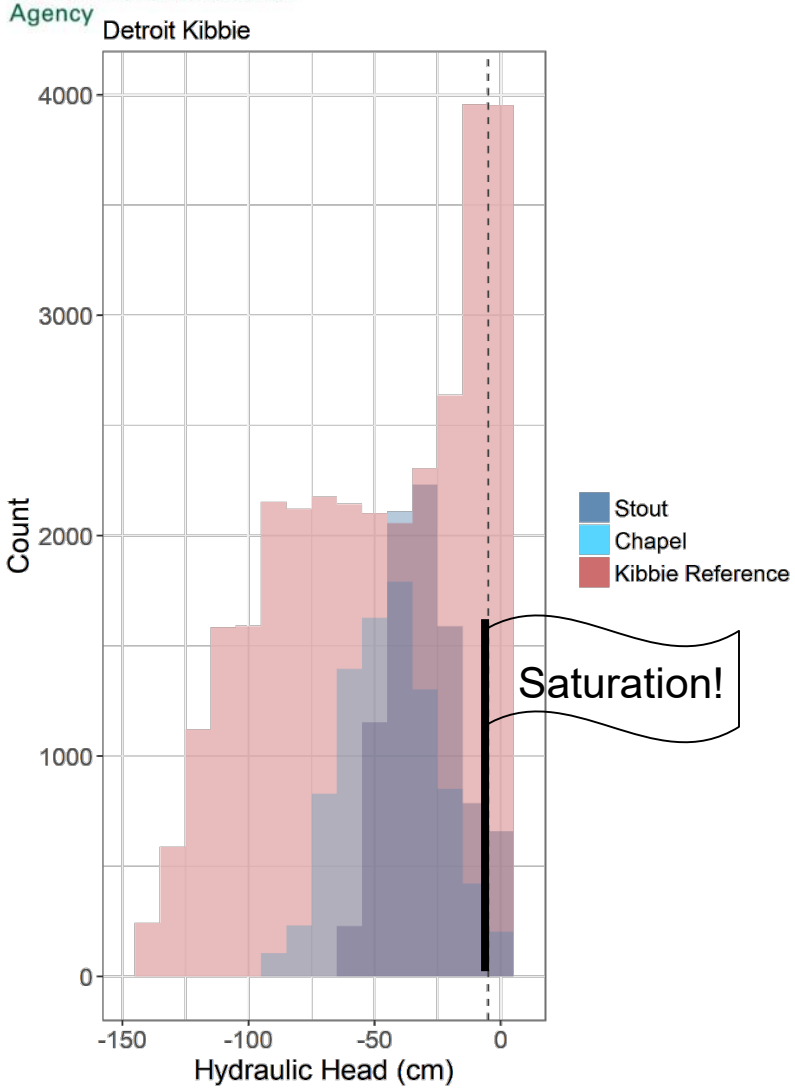
Similar finer texture in pre-urban and urbanized soil results in similar runoff pattern, though urban soils still wetter

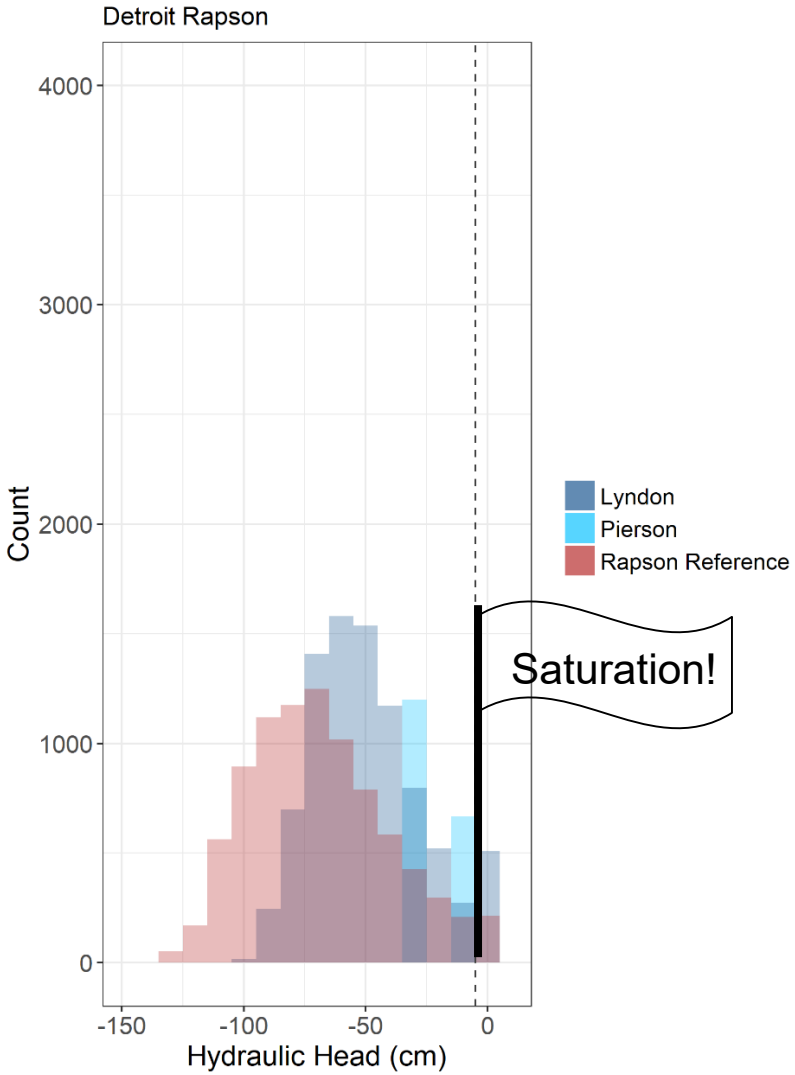
Cleveland: no issues with rooting zone moisture, may be too wet for some species





Detroit: Ψ at surface, runoff formation

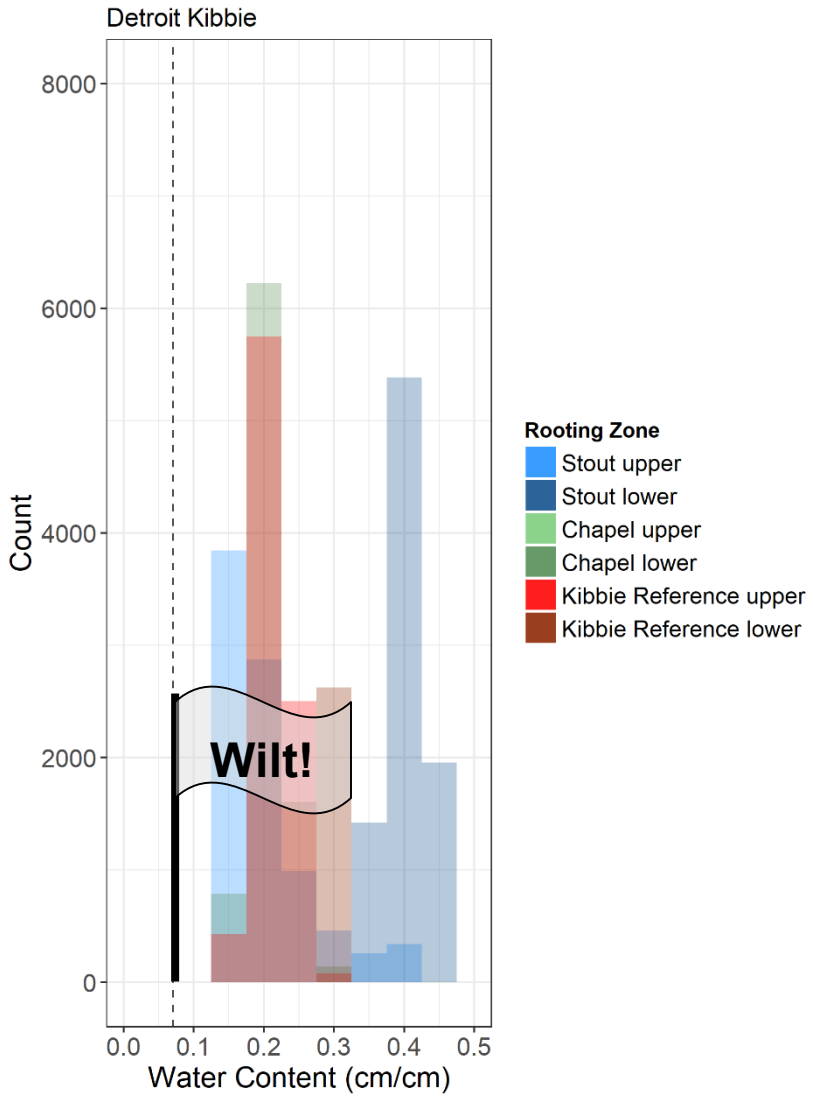


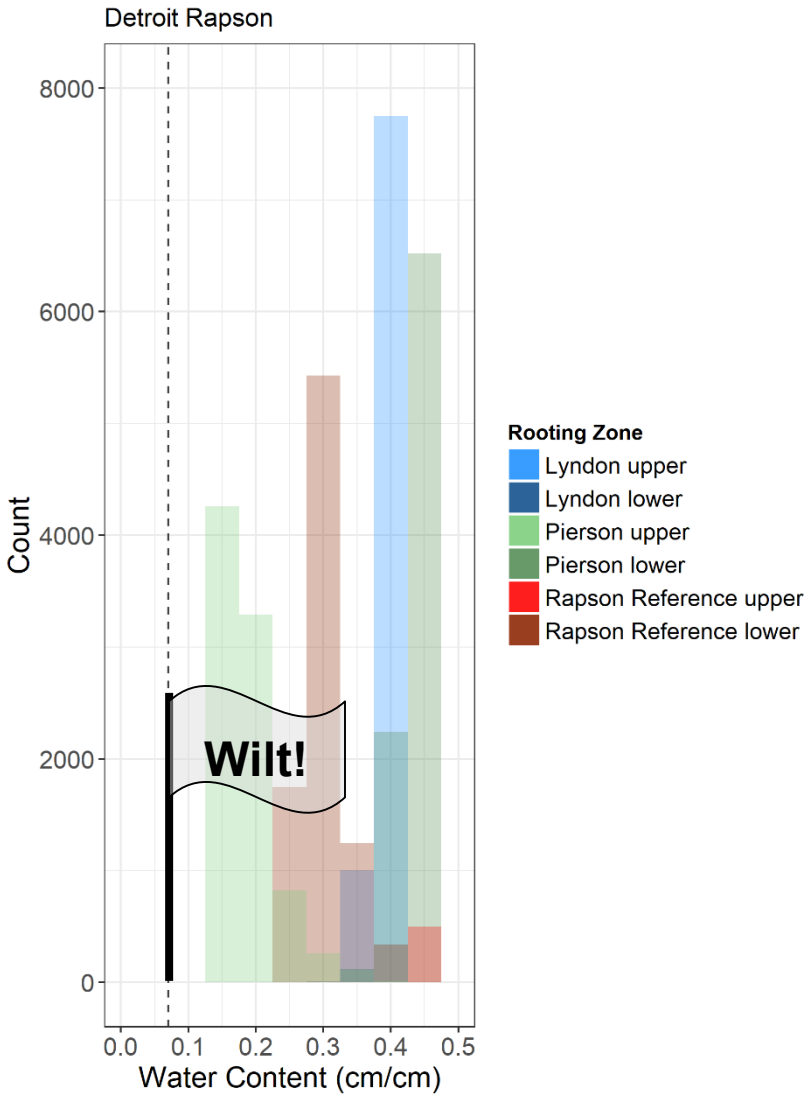


Underlain by very fine clay soils – urbanization actually improved on runoff formation!

More soil layers with finer material, though urbanized profiles are wetter and produce runoff more often

Detroit: urban soils have more complex layering and texture, and therefore variable soil moisture capacity





Conclusions, runoff

- Without explicitly accounting for evapotranspiration losses, we found that:
- Urbanized soil profiles show both higher tendency and frequency to produce runoff
- Urbanization actually improved on reference soil runoff hydrology in a single case (Elnora)
- There are layering-specific tradeoffs between how runoff is produced (infiltration excess vs. saturation excess) and soil water retention
- When these soils *don't produce runoff*, they offer detention capacity as passive, infiltrative green infrastructure that is decentralized across our urban centers
- These results are key to "counting" green infrastructure toward Clean Water Act consent orders, and overall effective waste/storm water management

Conclusions, soil water

- If we apply evapotranspiration losses, then profiles may “dry out” differently
- Wilting point was not typically an issue, as soil water retention was uniformly high
- Urban soil profiles tend to be overall wetter than reference
- This simulation data is a starting point to better understand plant-soil water relationships
- This perspective will better inform selection of plants for intentional GI, or tell us more about why the extant plant community is there
- We are running more than 300 paired simulations from 12 different cities to see if there are more generalizable patterns in urban soil hydrologic response

Thank you, and any questions?

Thanks to: our consulting USDA-NRCS Soil Scientists to identify pre-urban reference soil series: Carl Fuller, Eric Gano, Jeff Glanville, Manuel Matos, Maxine Levin, Rich Shaw
Stephon Thomas, Steve Baker; Ryan Stewart (Virginia Tech), and to all of the citizens and agencies in the cities that we worked in.

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