A Novel Research Framework to Assess Water Quality Impacts of Urban Trees

Question B7, Water Quality of an Urban Tree

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Key Research Questions

1. Do urban forest characteristics that influence ecohydrology occur in common configurations and can these configurations be captured through the development of an urban forest typology?
2. Will more complex urban forest types (e.g., those having more canopy layers, greater density, more understory plants or shrubs, litter layers, etc.) reduce runoff volume to a greater extent than simpler configurations?
3. How do different tree species affect runoff response?

H1: Urban Tree Typology

Urban forest characteristics that influence ecohydrology occur in common configurations and these configurations can be captured through the development of an urban forest typology.

- Use Available Ground-Based Data and Lidar to develop a classification scheme.
- Expected to find that data could be used to classify trees into meaningful typologies.

An Ecohydrological Typology

We recognize that trees will perform differently in terms of stormwater mitigation based on their immediate surroundings. We used ecohydrological landscape characteristics to develop a typology, grouping trees with others that have similar ecohydrological benefits. Qualitatively rank categories by benefit potential.

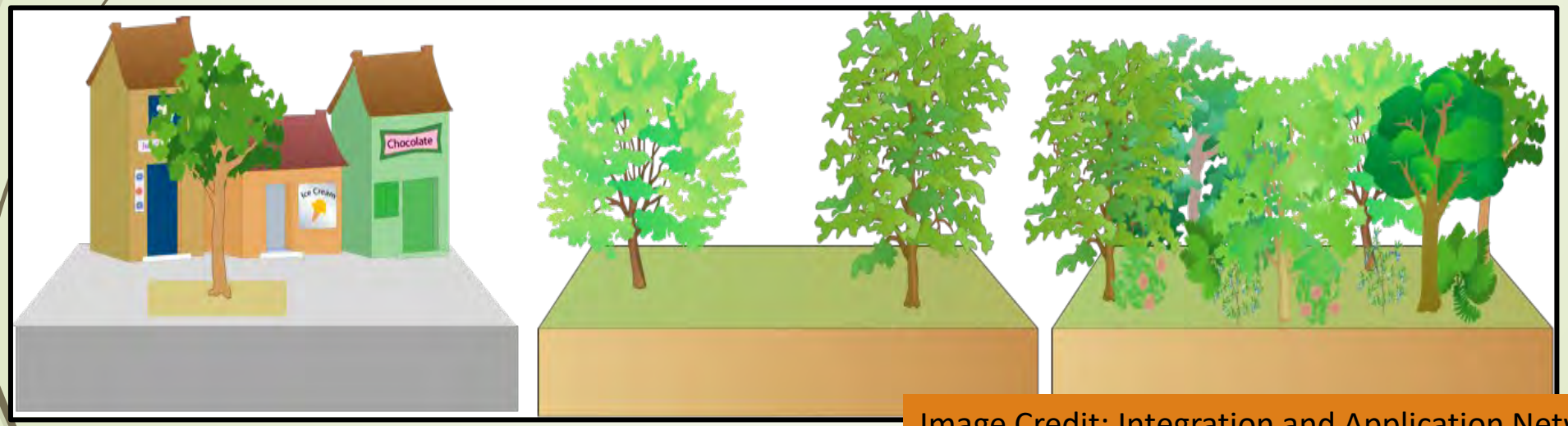
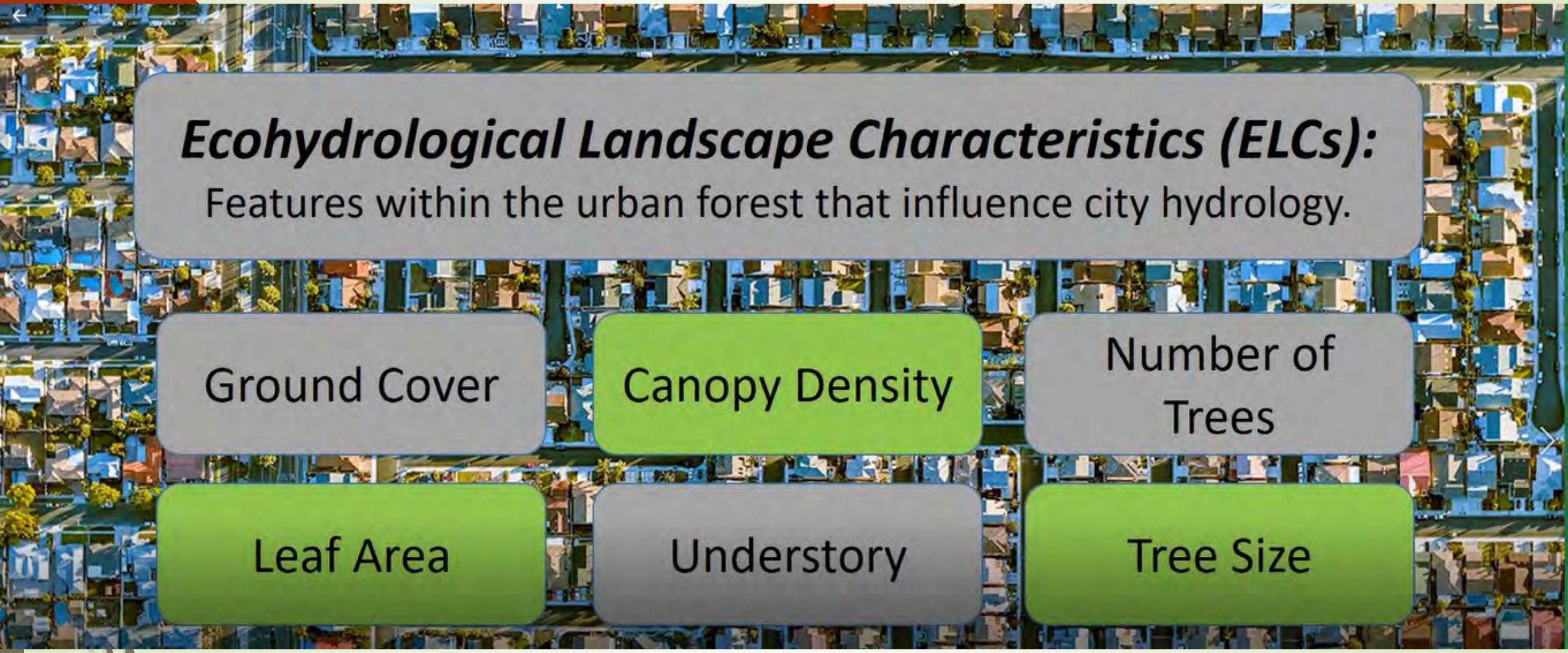
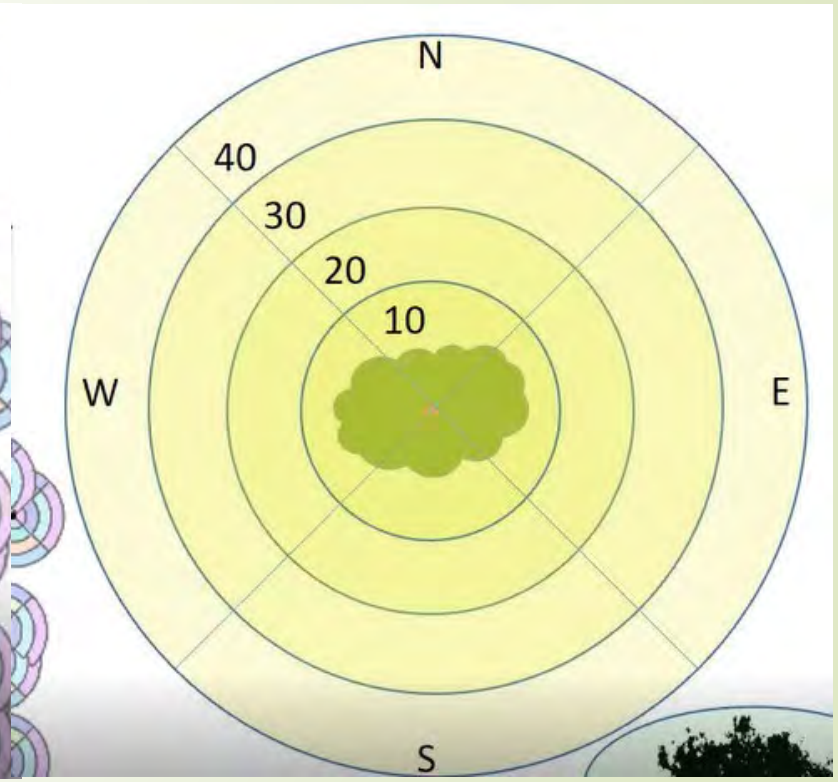


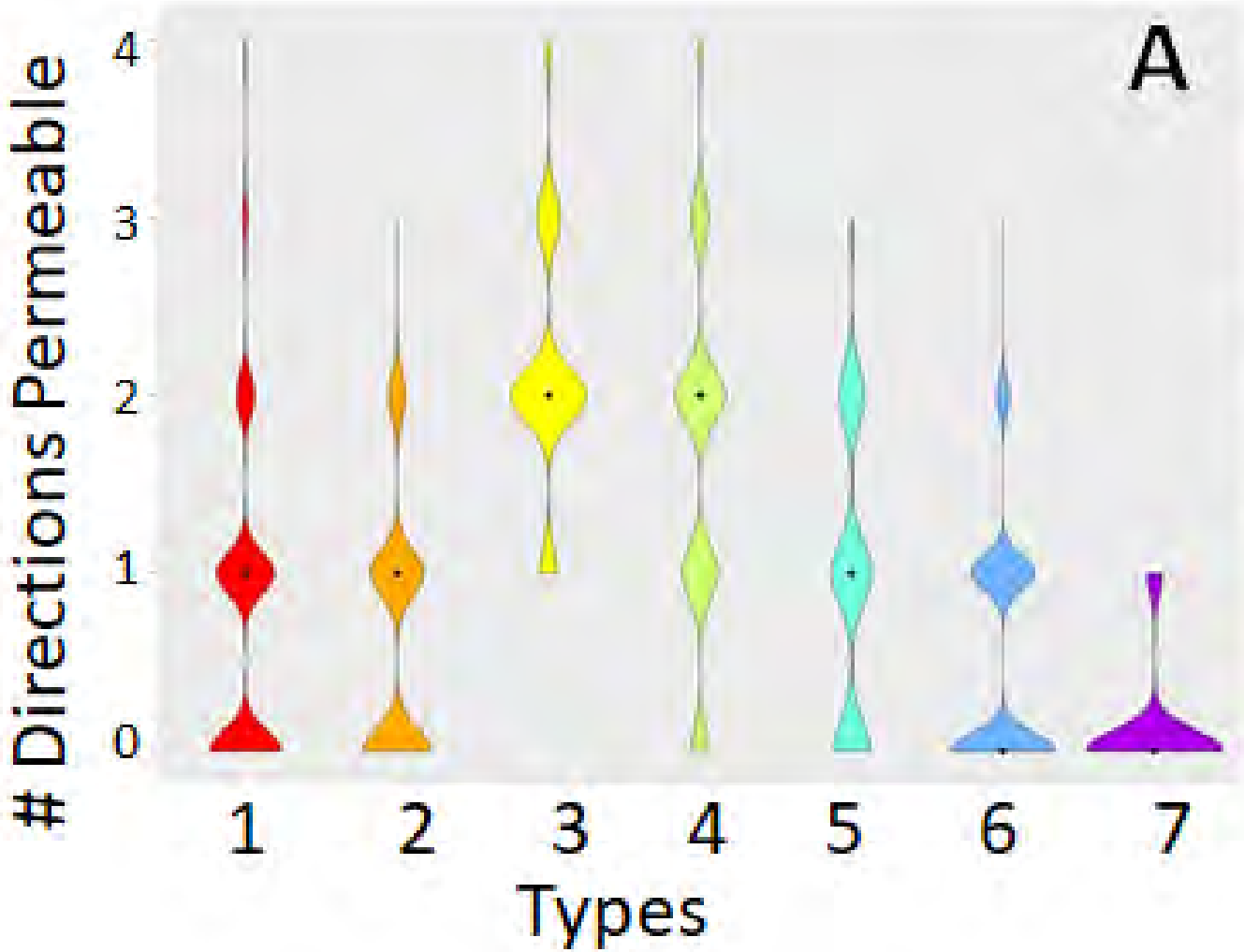
Image Credit: Integration and Application Network, UMD Center for Environmental Science

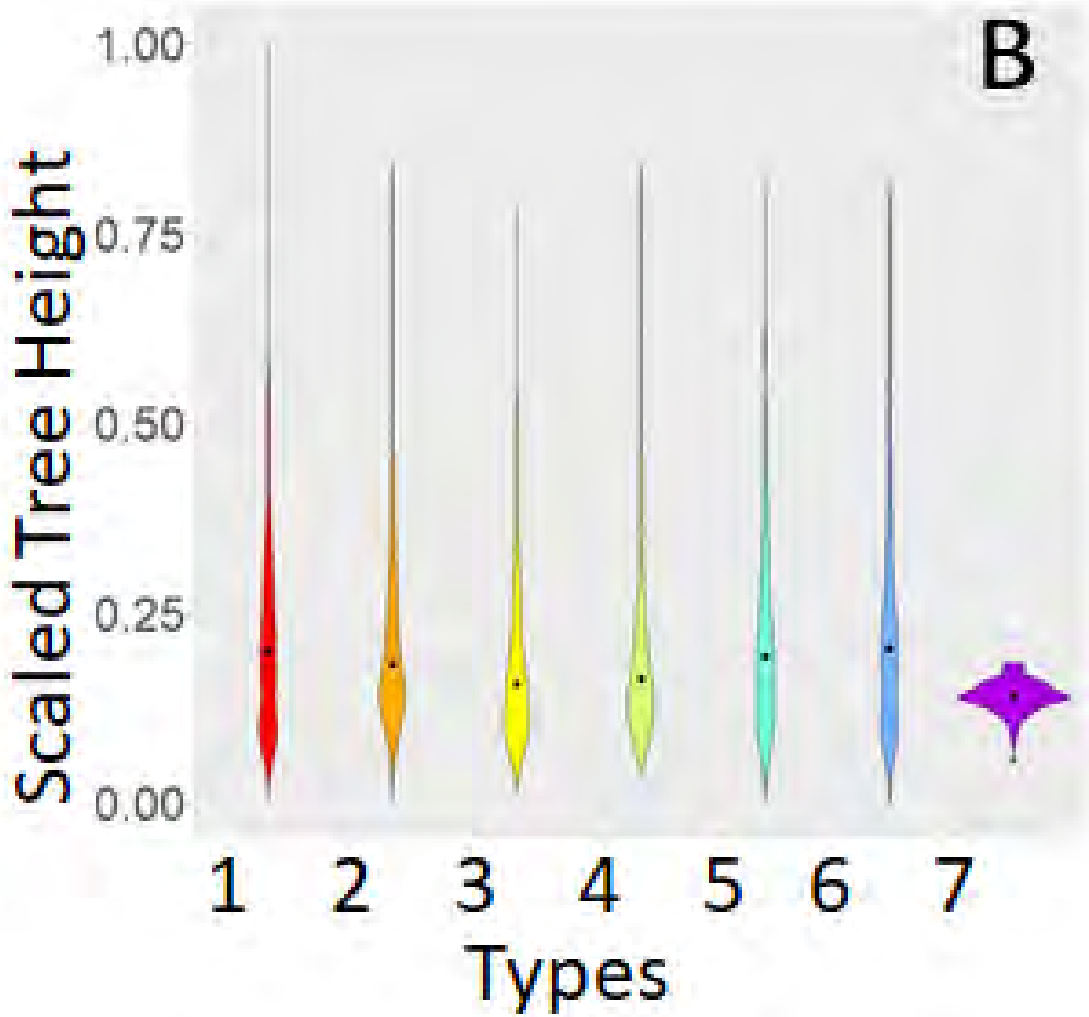

Ecohydrological Landscape Characteristics (ELCs):
Features within the urban forest that influence city hydrology.
Ground Cover
Canopy Density
Number of Trees
Leaf Area
Understory
Tree Size

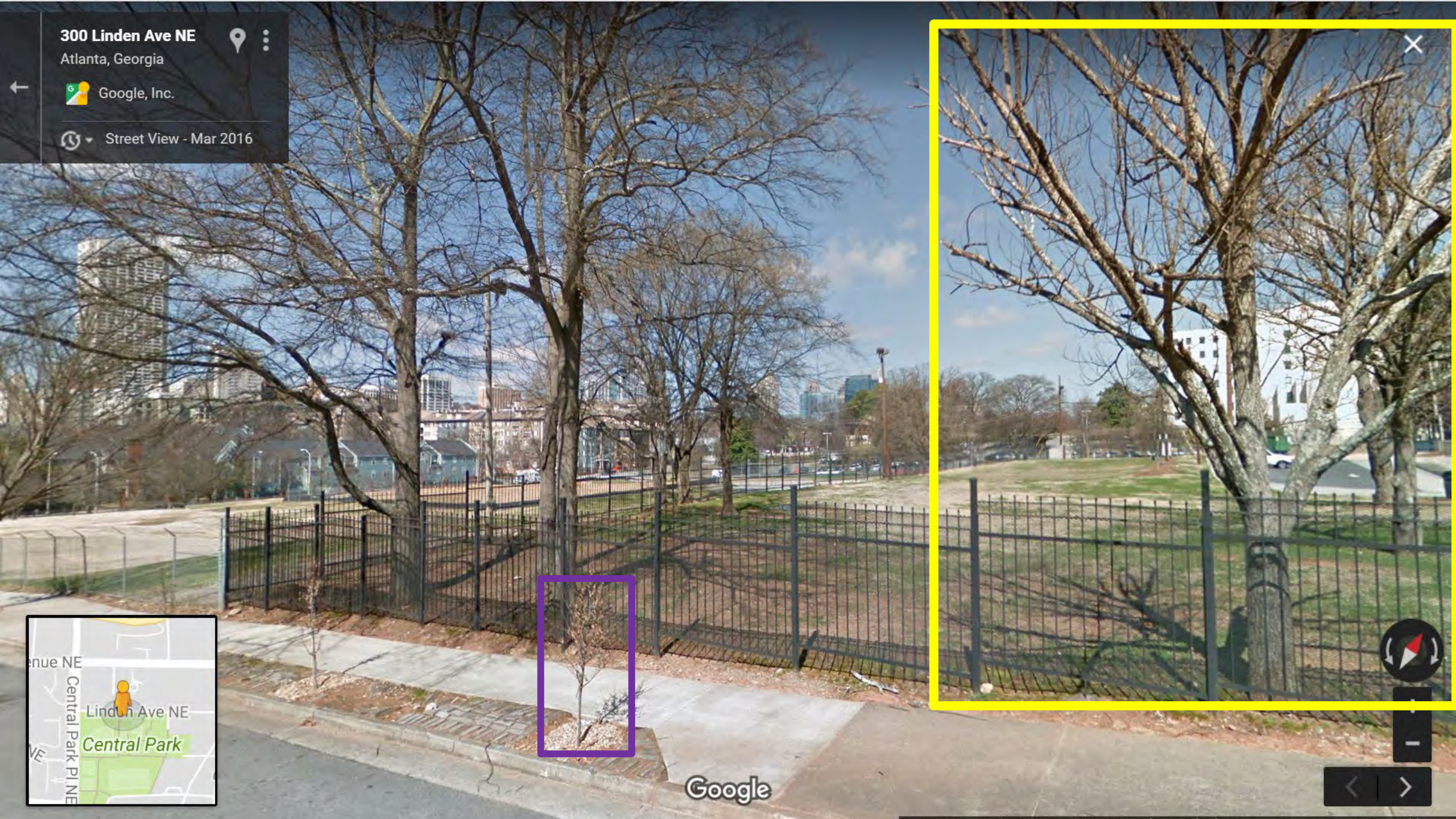
Method Takes into Account the Tree And Its Surroundings



Example Characteristics by Type (Distribution among Trees in Each Type)



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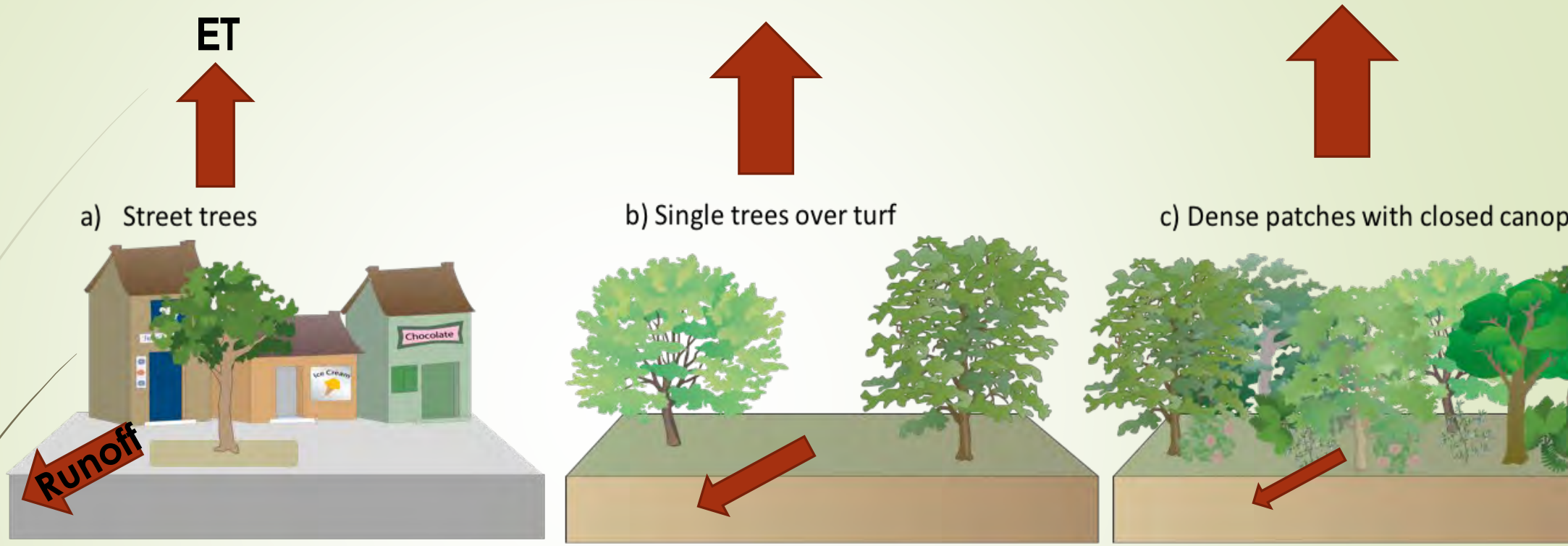
Method Potentially Allows Planners to Understand Differences Among Tree Canopy Types

H2: Effects of Forest Types on Runoff Reduction

H2: More complex urban forest types (e.g., those having more canopy layers, greater density, more understory plants or shrubs, litter layers, etc.) will result in greater runoff volume reduction.

- Effects on Transpiration:
  - Expected: Closed Canopy types will have greater transpiration than Open Type
  - Expected: Evapotranspiration will be impacted by Vapor Pressure Deficit and Soil Moisture
- Effects on Interception and Runoff Volume
  - Expected: Closed Canopy Types will have Greater Interception
  - Expected: Closed Canopy Types will have Lower Runoff Volumes

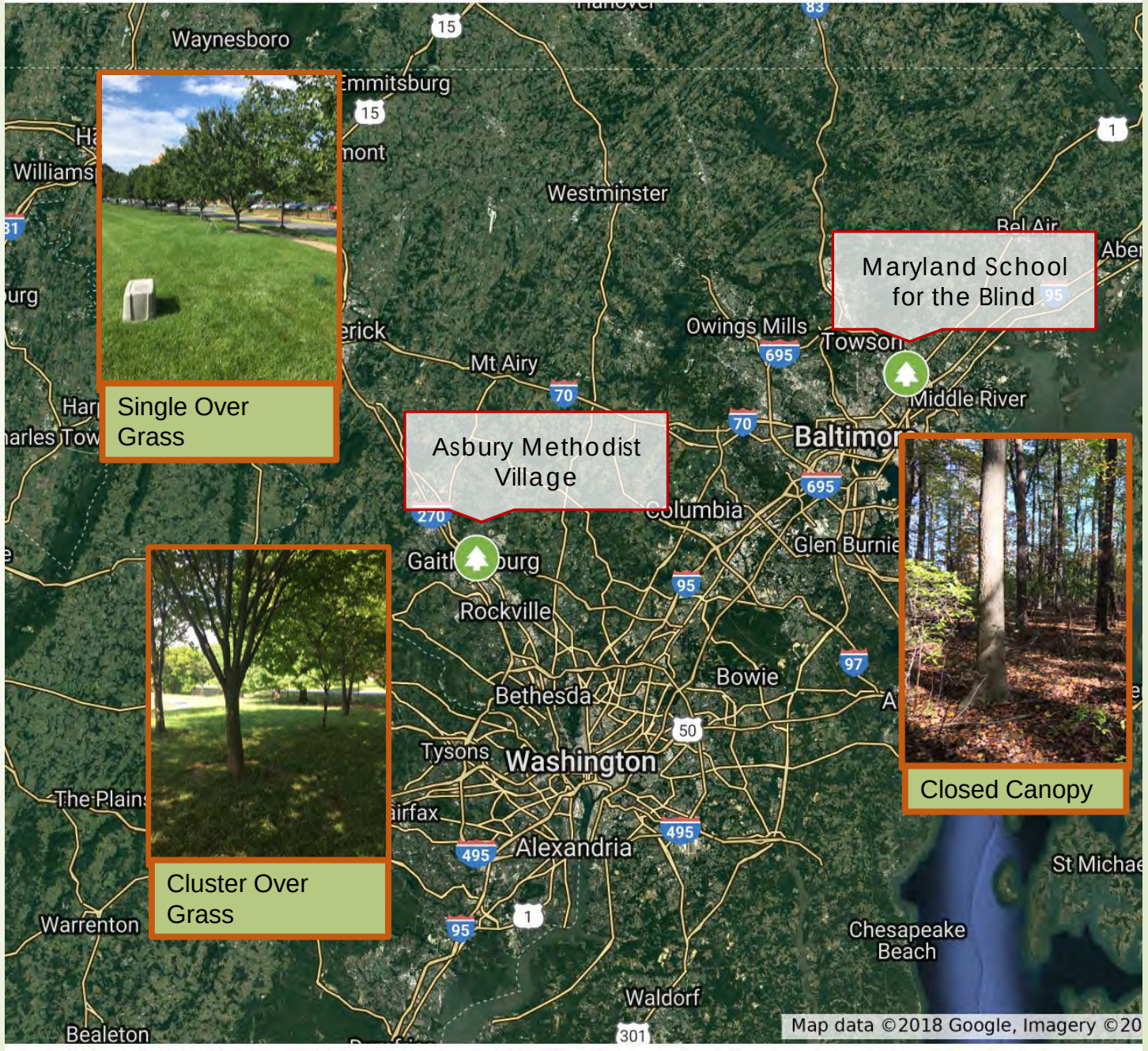


Examples of different urban tree typologies. (Images courtesy of the Integration and Application Network, UMD Center for Environmental Science)

Study Area

Criteria:

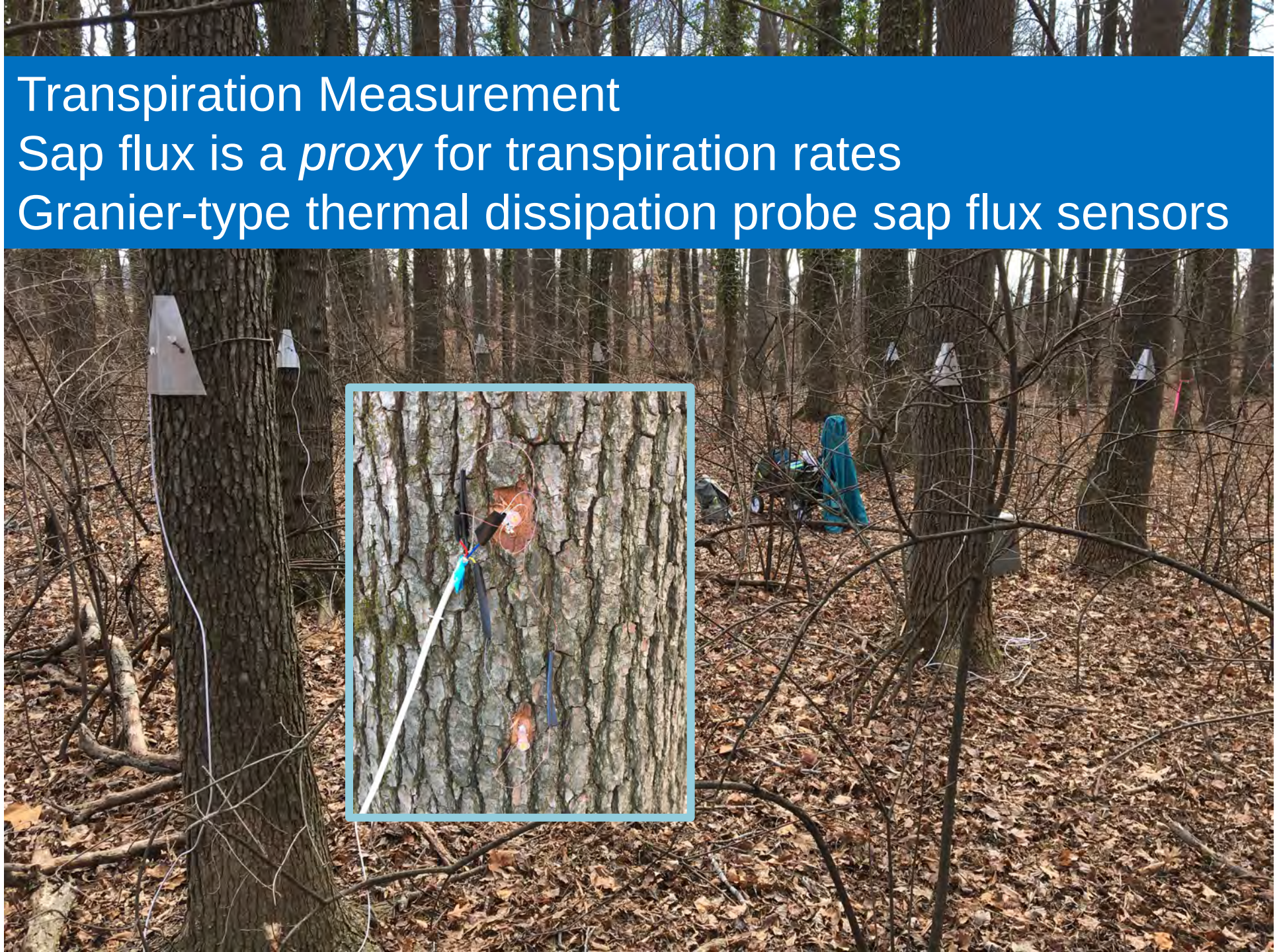
- Site accessibility
- Safety for the research equipment
- Recommended by the Montgomery County



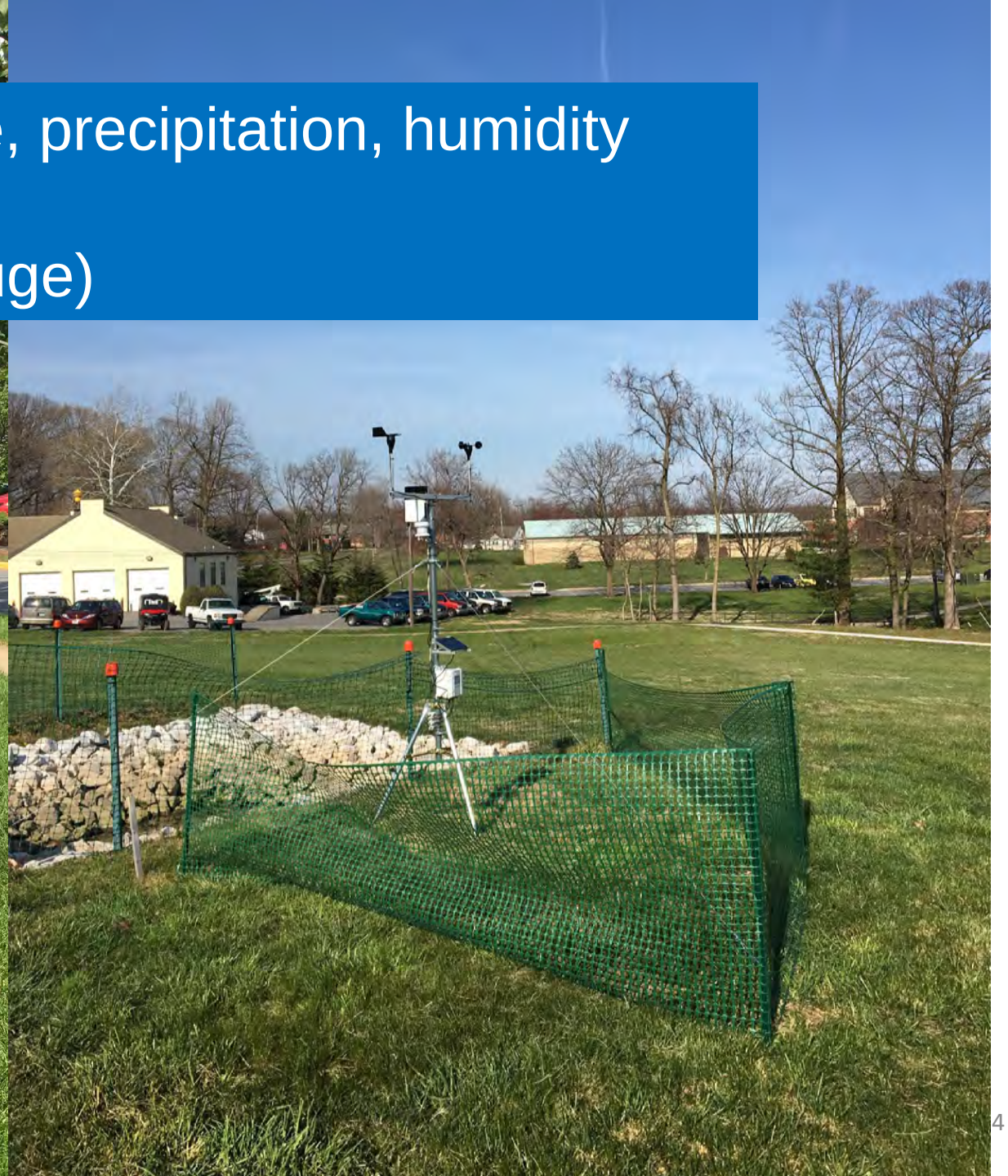
Transpiration Measurement

Sap flux is a *proxy* for transpiration rates

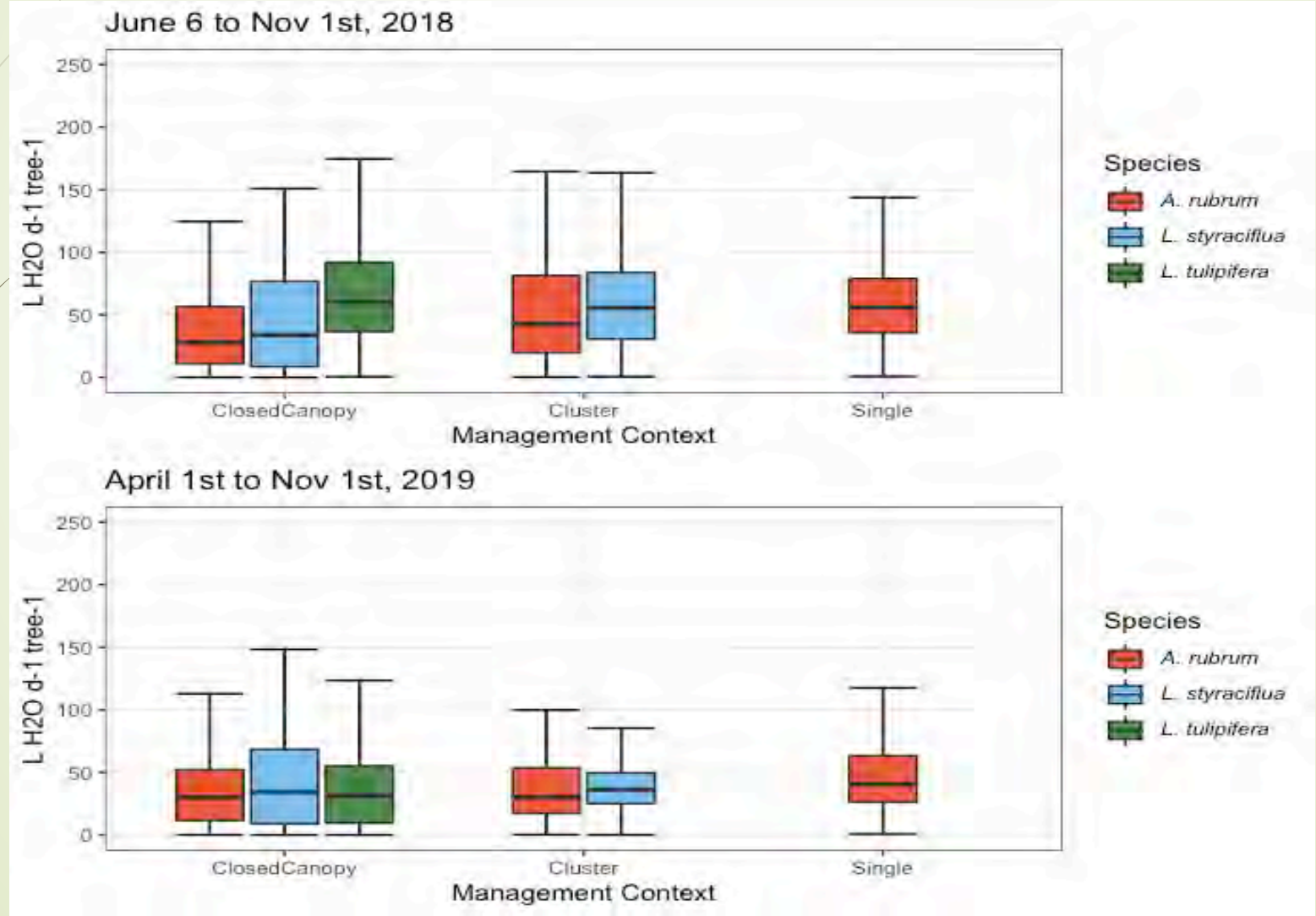
Granier-type thermal dissipation probe sap flux sensors



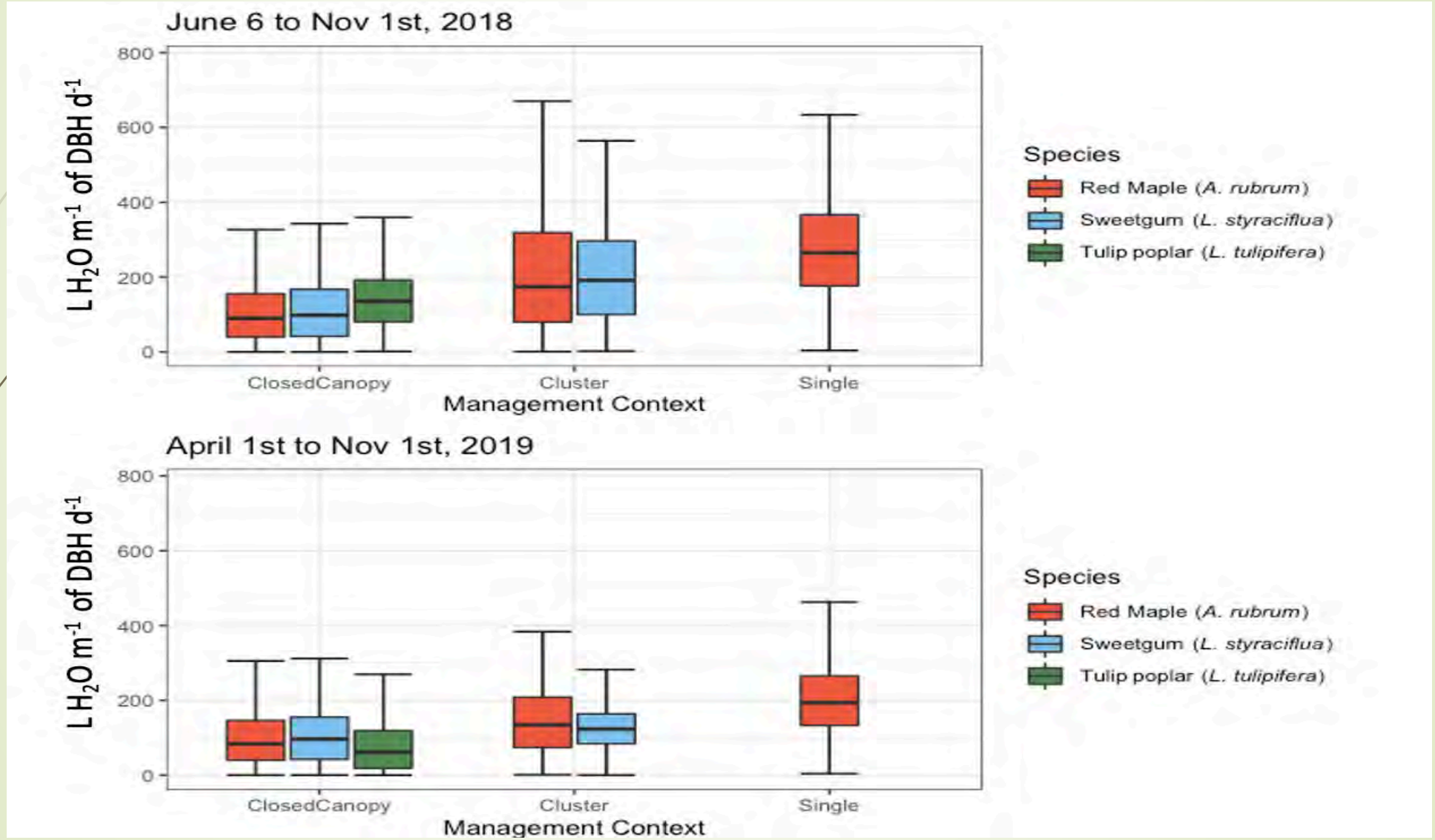
Weather Station: temperature, precipitation, humidity
Soil moisture sensors
Canopy interception (rain gauge)



On a Per-Tree Basis, Trees in the "Single" Setting had the Greatest Transpiration.

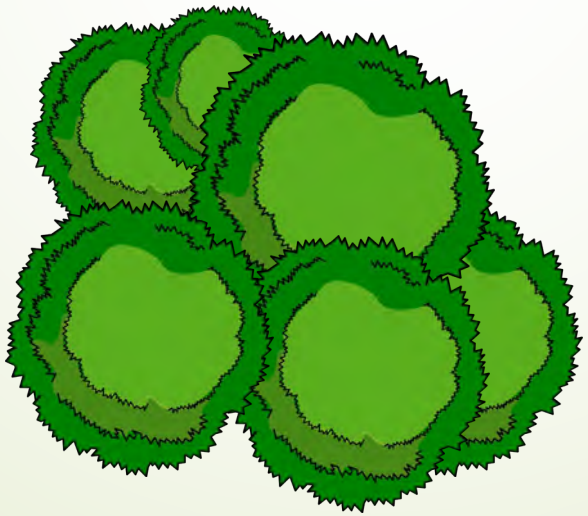


Results are Similar on a Per-DBH Unit

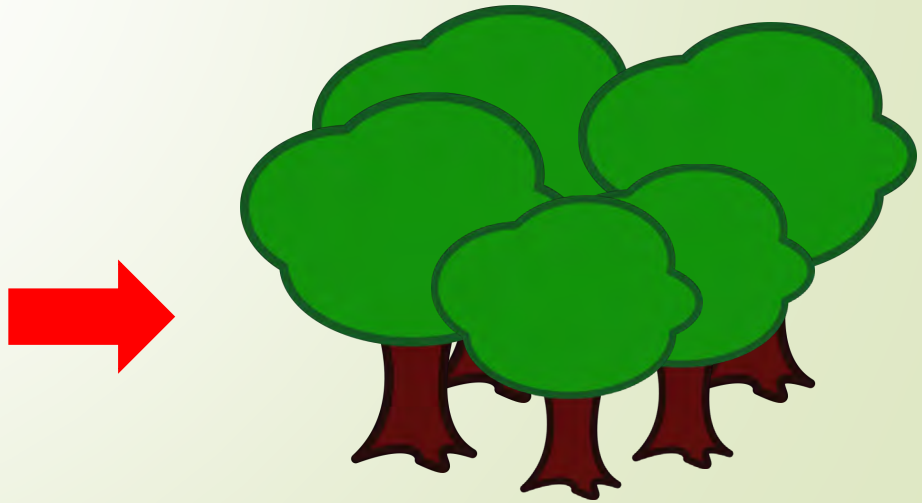


Why Do Individual Trees Have the Highest Per-Tree Transpiration Rates?

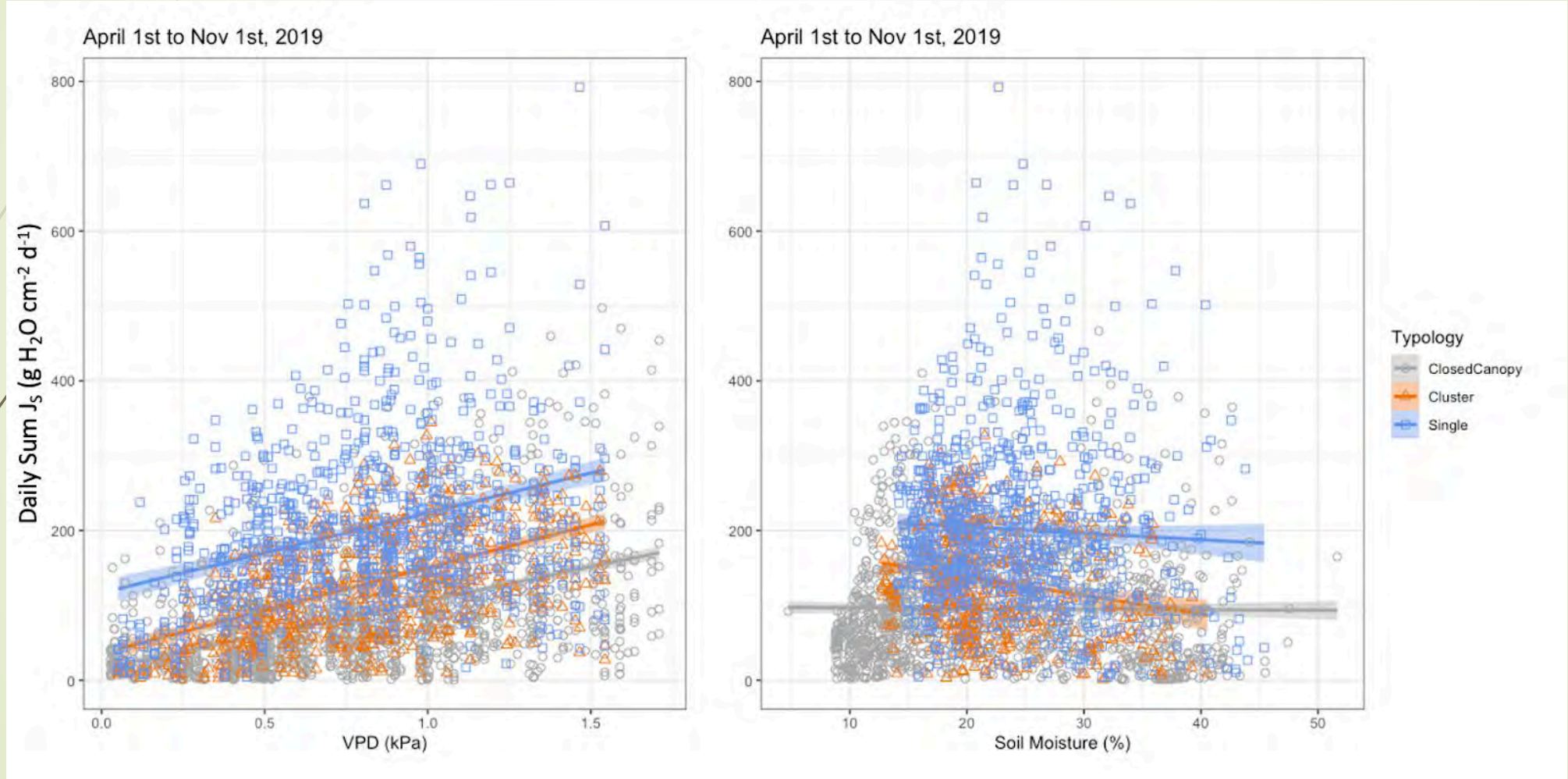
- Tree Density (Per-Tree or Per-DBH has different results than Per-Area)
- Exposure to Wind and Sun
- Greater Leaf Area for Single Trees



Birds Eye View of Tree Canopy



What Drivers Influence Transpiration?

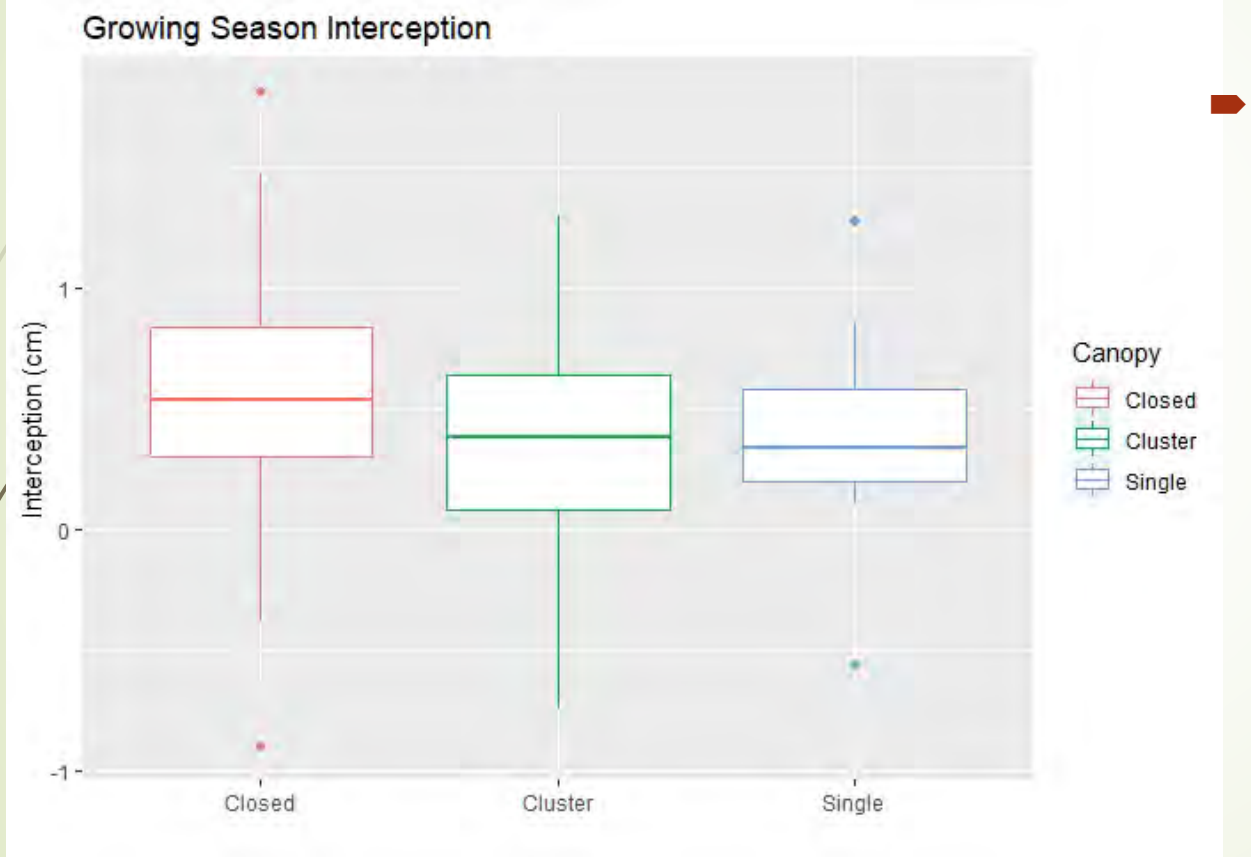


Interception: How Much Rainfall Is Intercepted by the Tree Canopy?

Penn State Extension

- We assume that a more complex canopy will provide more interception.
- We're measure interception as the difference between "Throughfall" (measured below the tree canopy and "Rainfall" measured outside the tree canopy.

Closed Canopy Has the Greatest Interception



- Interception (Rainfall Captured by Leaves)
  - Is greatest in the closed canopy
  - Median values range from about 0.3 cm for single trees to 0.6 cm for closed canopy.
  - Values are variable (especially depending on storm depth)

Interception Differences between Cluster and Closed Canopy Is Different but Not “Dramatic”

Cluster Over Grass

Closed Canopy

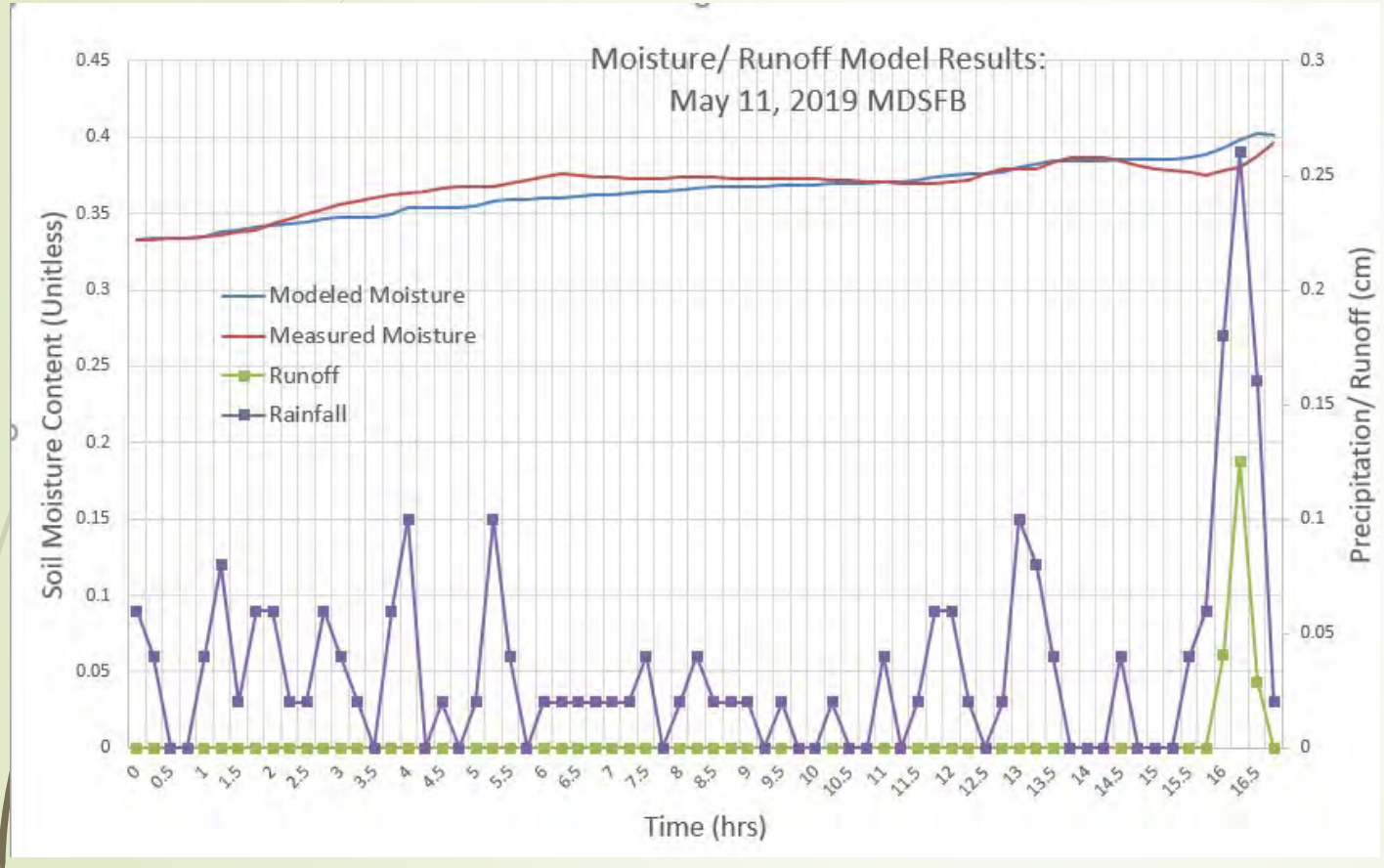
- This Closed Canopy Patch Does not have a complex understory
  - Missing Mid-Story
  - Missing the Shrub Layer
  - Missing the Herbaceous Layer
  - Little to no natural regeneration

How Do the Soils Compare at Each Site?

	Soil Type	Bulk Density (g/cc)	Organic Matter (%)
Closed - (NW)	Loam-Clay Loam	1.31	4.6
Closed - (SE)	Loam	1.22	2.6
Single	Loam	1.22	2.0
Cluster	Loam	1.33	2.7

- Soil types were mostly similar.
- The “Northwest” site at the Maryland School for the Blind (closed canopy) had high organic matter, and was also often saturated
- Single Tree setting had the lowest organic matter.
- The cluster setting had the highest bulk density (a measure of soil compaction)

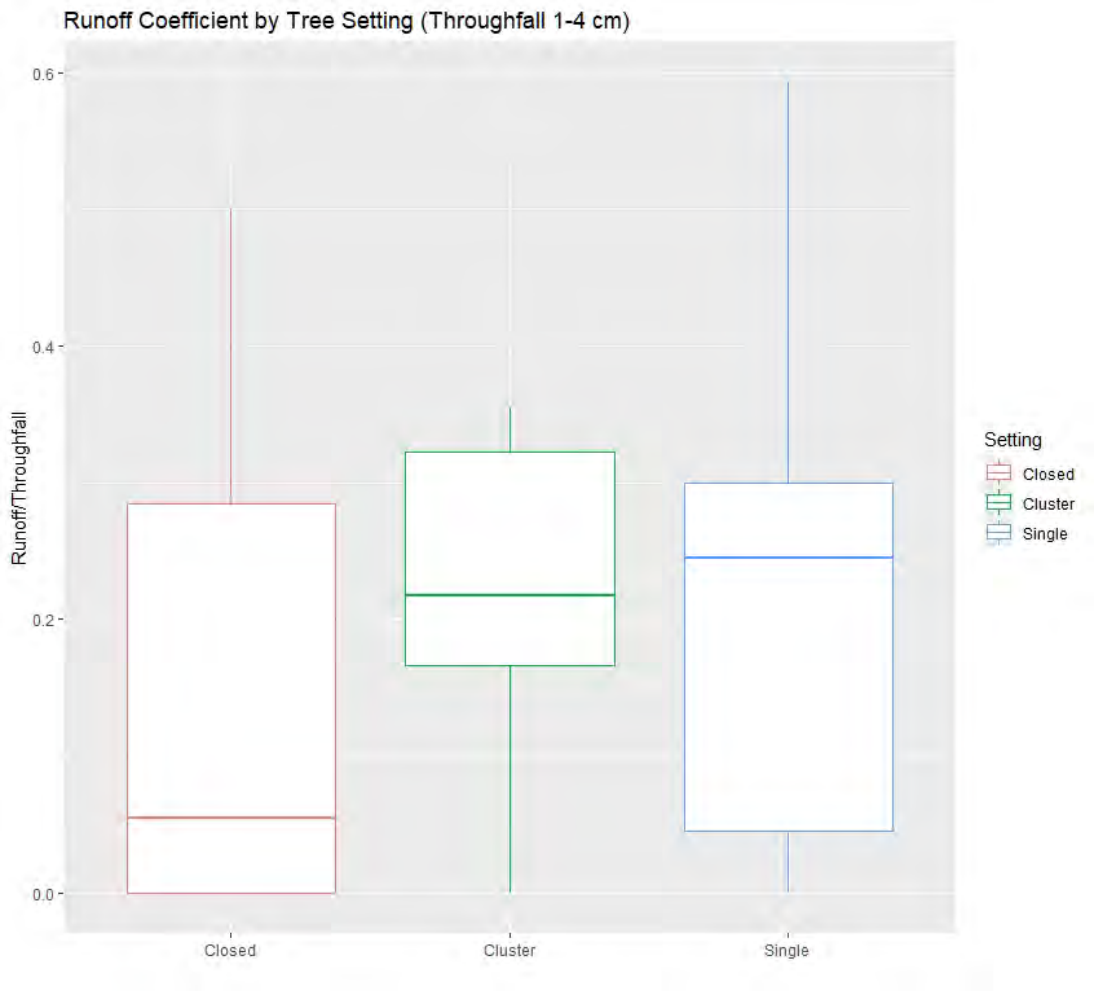
Runoff Computed Using the Green-Ampt Infiltration Model



Runoff *when rainfall intensity exceeds infiltration rate*

Calibrate to reproduce monitored soil moisture

Runoff Results



- Evaluated runoff from individual storm events with at least 1” but less than 4” of throughfall.
- The results suggest that the “Closed Canopy” setting produces the least runoff (similar to forest).
- Coefficients for Cluster and Single sites more similar to Turf on average.
- Results are highly variable, depending on initial soil moisture and storm (throughfall) depth.

Acknowledgment Slide

- The Research Team gratefully acknowledges the Montgomery County Department of Environmental Protection for funding this work.

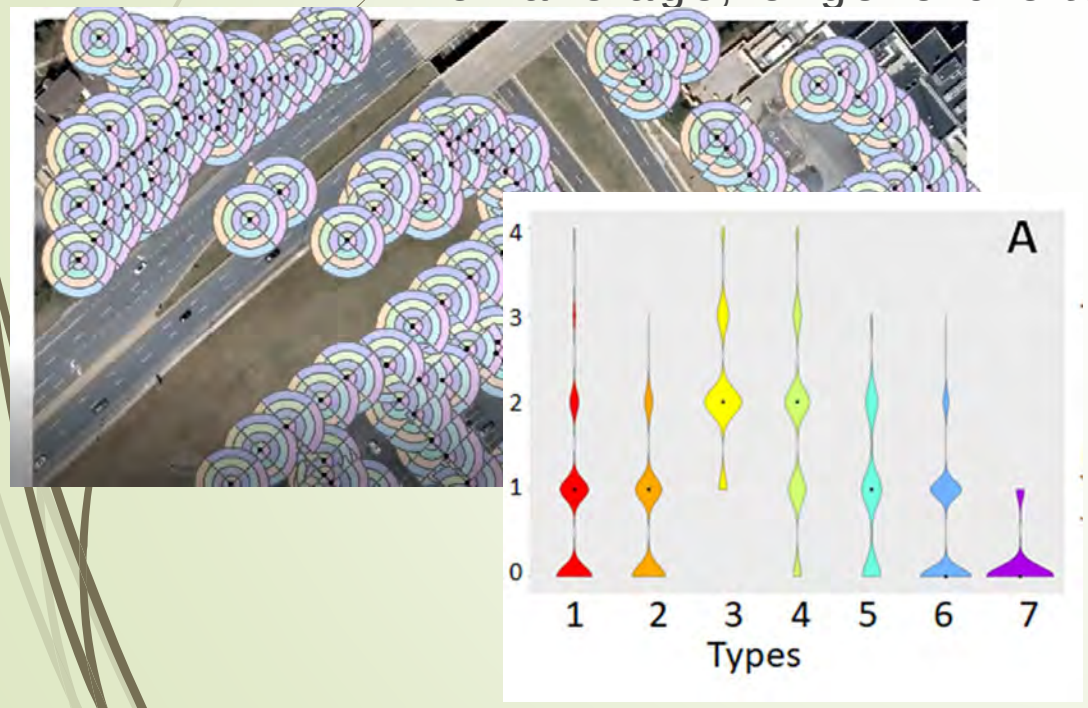
Translation Slides by:

Laura Miller,
Montgomery County Department of Environmental Protection

What does this mean for me?

What do I take from this if I am a practitioner:

- Big leafy crowns really do make a difference. This adds to the growing body of evidence about the benefits of trees.
- Mapping can now be used to predict where life-spans of trees would be, on average, longer or shorter. This is a fabulous planning tool.



What does this mean for me?

What do I take from this if I am a regulator:

- Forests and trees must be actively managed for overall health and sustainability to continue to provide optimal levels of benefits such as water quality and stormwater management.
- Provide support and funding for a variety of planting and maintenance programs and provide incentives to retain forests and trees.

Thank You!

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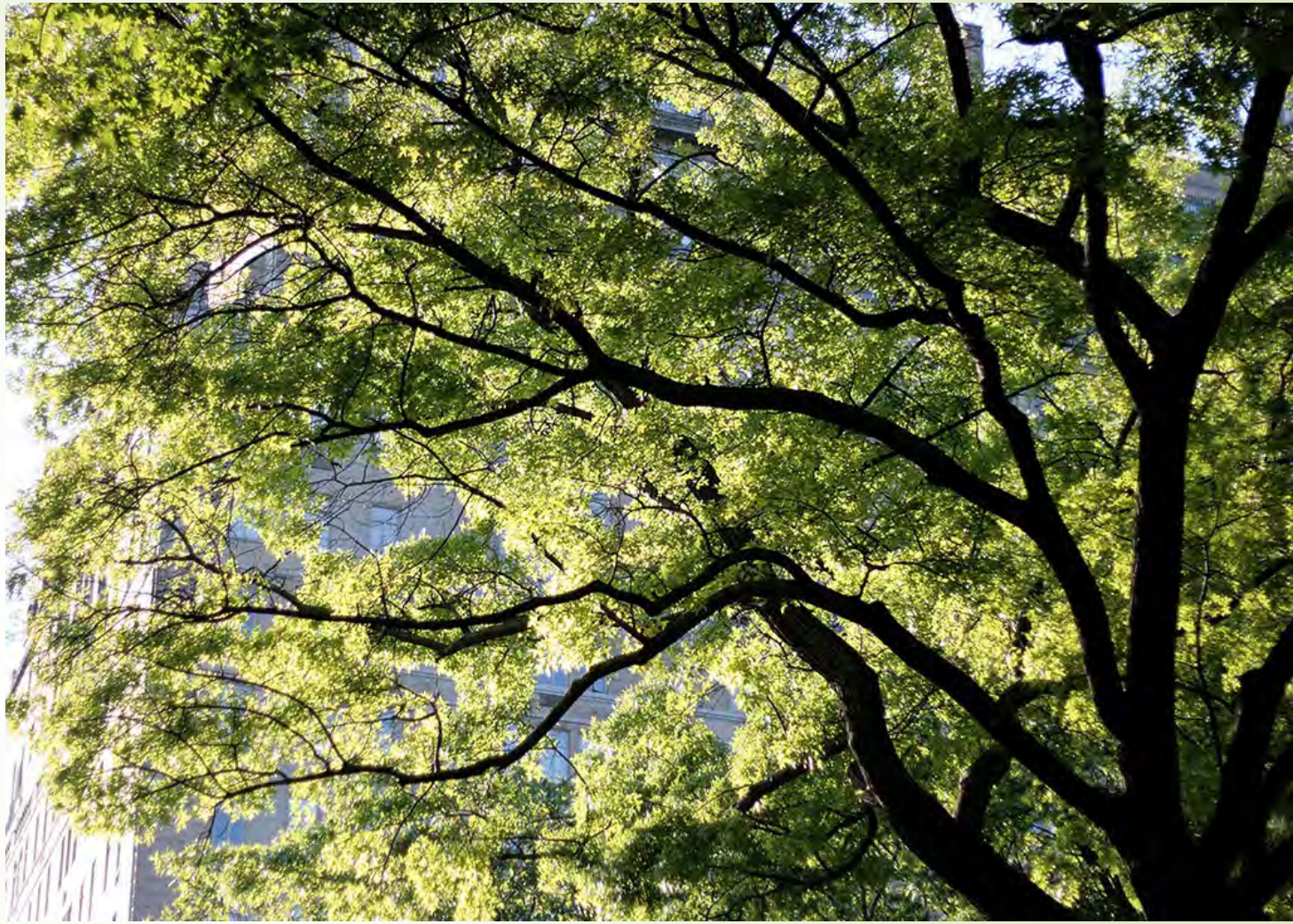

Photo Source: American Forests