Neighborhood-Scale Green Infrastructure Performance Informed by Field Monitoring and Social Interactions

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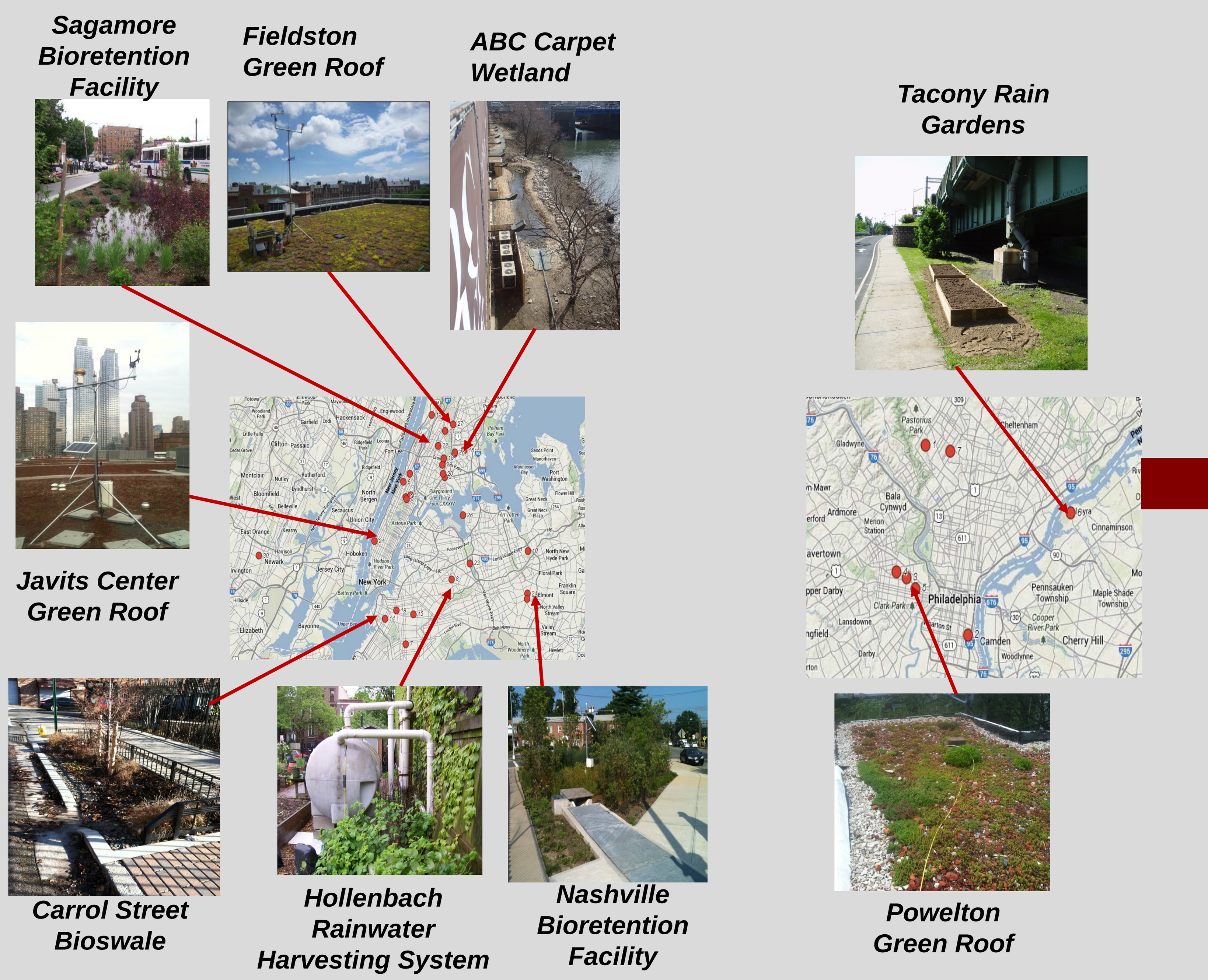
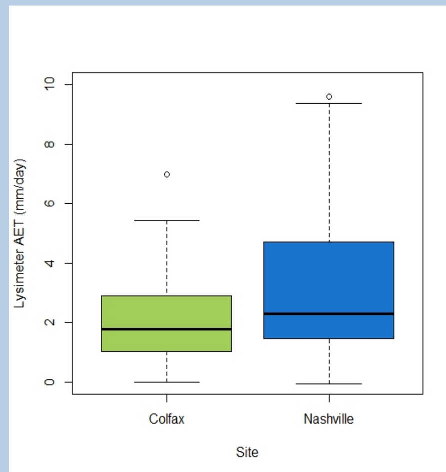
I. Green Infrastructure Observatory



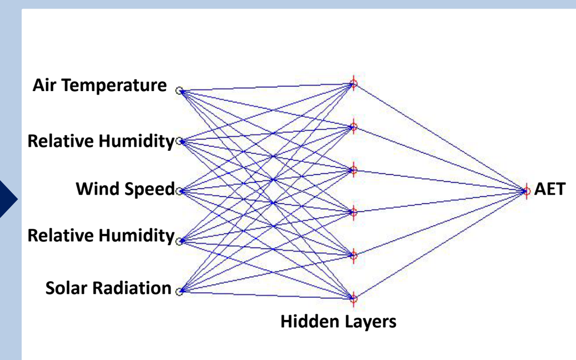
II a. Performance Rules Based on Field Observations

Effect of hydraulic loading ratio on actual evapotranspiration (by weighing lysimeter)

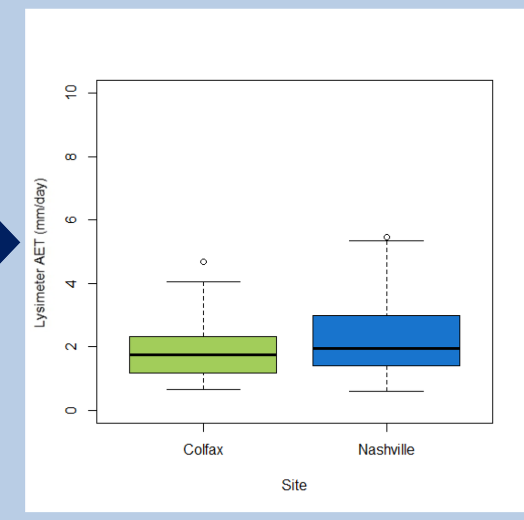
Observed



Artificial Neural Network



Predicted



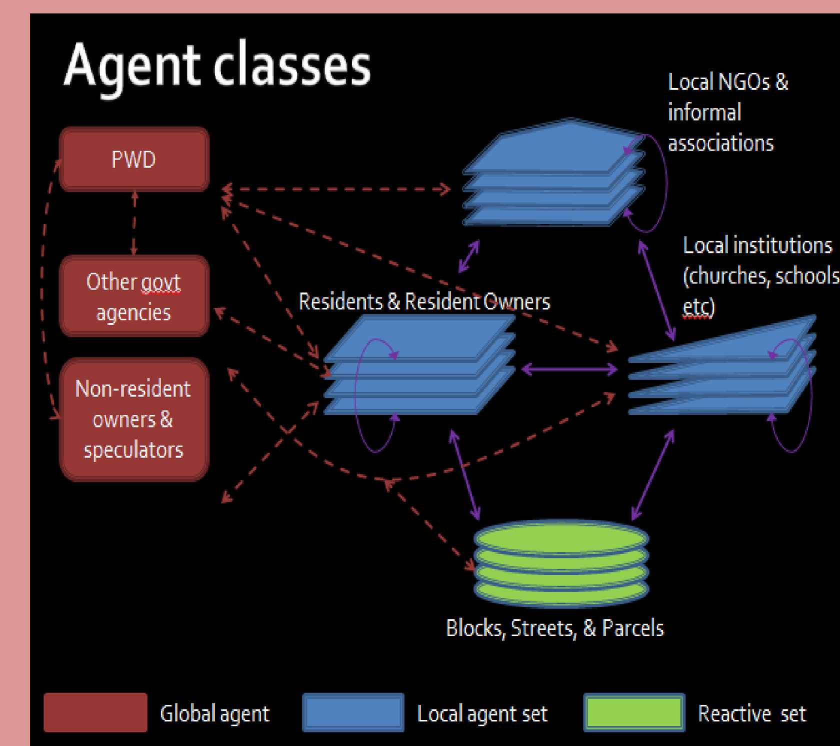
The box plots above demonstrate that over the course of a 1 year period, actual evapotranspiration (AET) rates experienced at the hydraulically isolated Colfax bioretention area are lower than those measured at the Nashville bioretention area, which receives runoff from a street catchment approximately three times its size through a curbcut. The measurements were made by weighing lysimeters installed in the bioretention facilities at significant cost.

Conventional approaches to predicting AET requires detailed descriptions of onsite weather conditions (temperature, net radiation, wind speed, and relative humidity), soil moisture, and vegetation type. Also required are crop coefficients (not currently available) that would be appropriate for the unique diversity of species represented in municipal green infrastructure plant pallets. Our long term monitoring of onsite weather conditions, and AET in NYC bioretention facilities allow us to develop artificial neural networks (ANN) that can predict AET from readily available climate data and hydraulic loading ratios, for use in watershed models.

Without the expensive field monitoring apparatus, the neural network can be used to reasonably predict actual field AET, bypassing the need to develop crop coefficients and attenuating factors. If trained on a sufficient number of sites with different hydraulic loading ratios to represent the diversity of conditions encountered in NYC streets, this ANN can be incorporated into highly discretized representations of the greened urban watershed

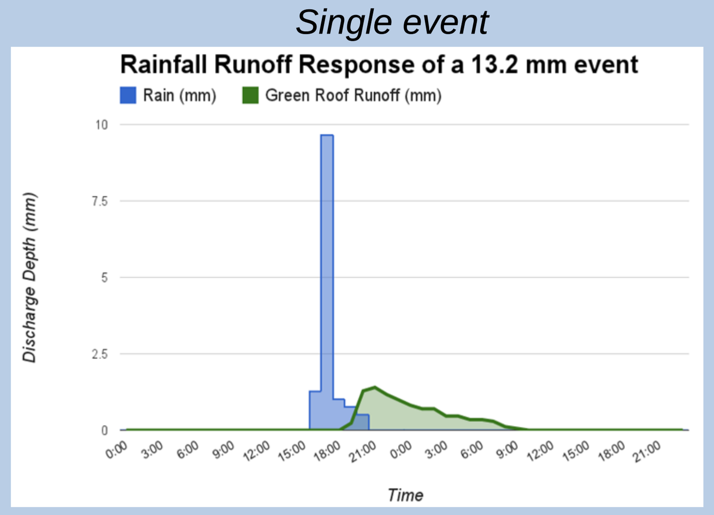
II b. Relevant Social Interactions

Mediated modeling activities, for example using the Low Impact Development Rapid Assessment (LIDRA) model developed by our group, help us to convert social, institutional, and other "on the ground" realities into rules constraining where and when we can expect certain types of GI to appear as urban watersheds are gradually restored/greened in the decades to come. These are converted into spatially, and temporally explicit sets of dynamic rules programmed into agent-based models that represent the key physical, economic, institutional, and socioeconomic actors in urban watersheds



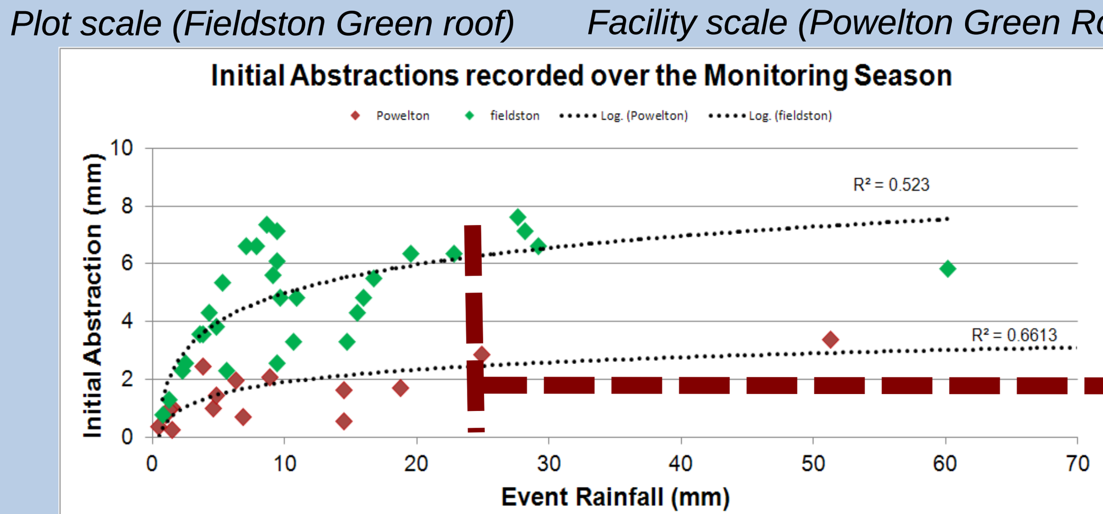
Same GI typology, different scales of observation

Single event



Multiple events

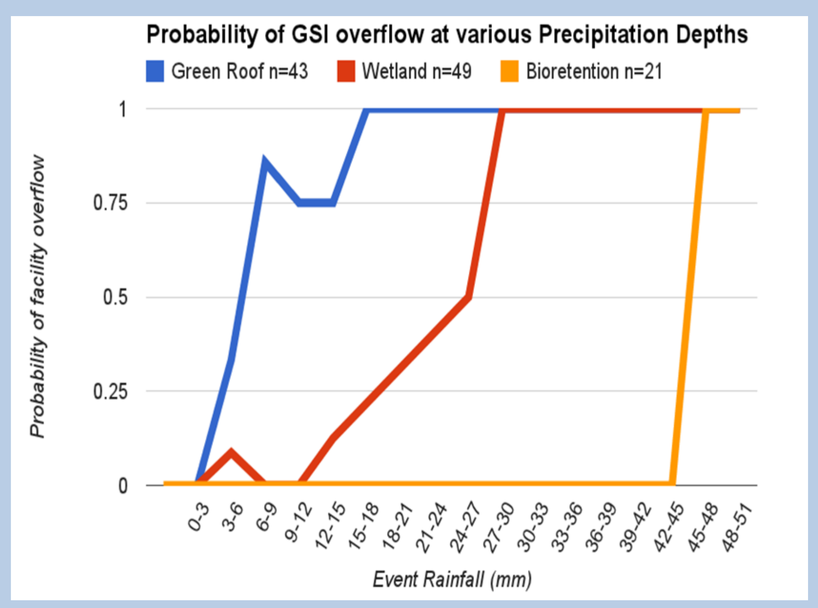
Plot scale (Fieldston Green roof) *Facility scale (Powelton Green Roof)*



Time series data collected throughout the observatory is discretized into discrete events for statistical analysis purposes. A key research question is how GI performance scales spatially, and what the optimal measurement scale is if the goal is to develop rules to incorporate into watershed models

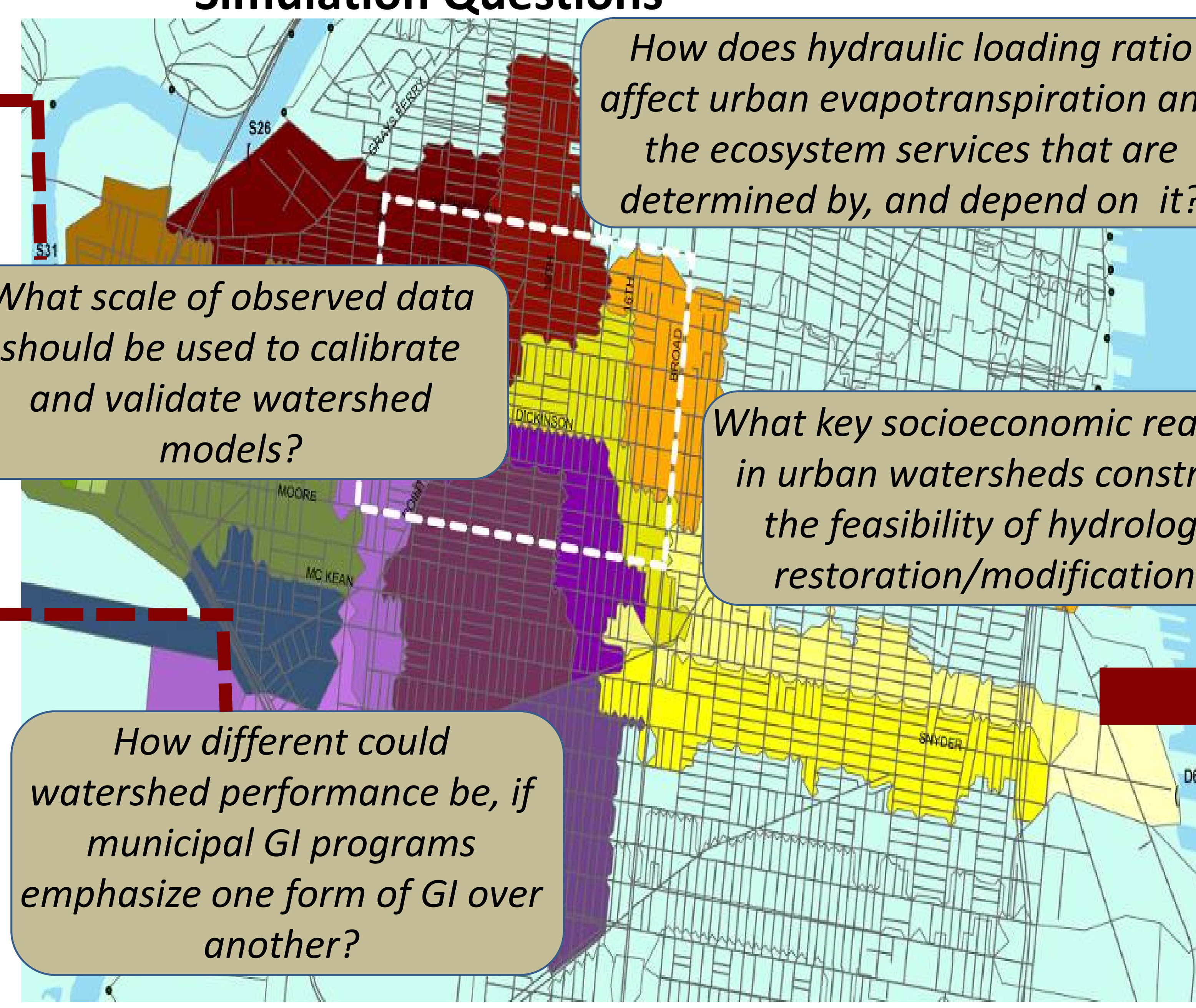
The trends shown in the two graphs shown above, depicting the initial abstraction as a function of rainfall depth, are identical. At both observation scales, the trend line fit to the initial abstraction values plateaus above a saturating rainfall depth. However, the initial abstraction associated with a 25.4 mm (1 inch) storm differs at the two sites. More work is necessary to determine whether this difference is due to the scale of observation, or to differences in the design of the two green roofs.

Different GI typology, identical scale of observation



Shown to the left is an analysis of multiple events at three different GI sites: the Fieldston Green Roof , the ABC Carpet stormwater wetland, and the Nashville bioretention facility. The vertical axis depicts the probability that storms binned by total rain depth are 100 % retained in the facility. As is evident from the three series, these three facilities have very different abilities to capture stormwater. Nashville, a bioretention area connected to an impervious street at a hydraulic loading ratio of 3:1 shows the best performance, followed by the ABC Carpet stormwater treatment wetland (lined and designed with a permanent pool to support emergent vegetation, while receiving runoff from a 0.3 hectare parking lot), and the Fieldston Green roof, which can only completely retain (relatively) small storms., and receives only direct precipitation. The (cost) effectiveness of municipal green infrastructure programs featuring each of these different GI typologies will vary significantly.

III. Up-scaled Watershed Simulation Questions



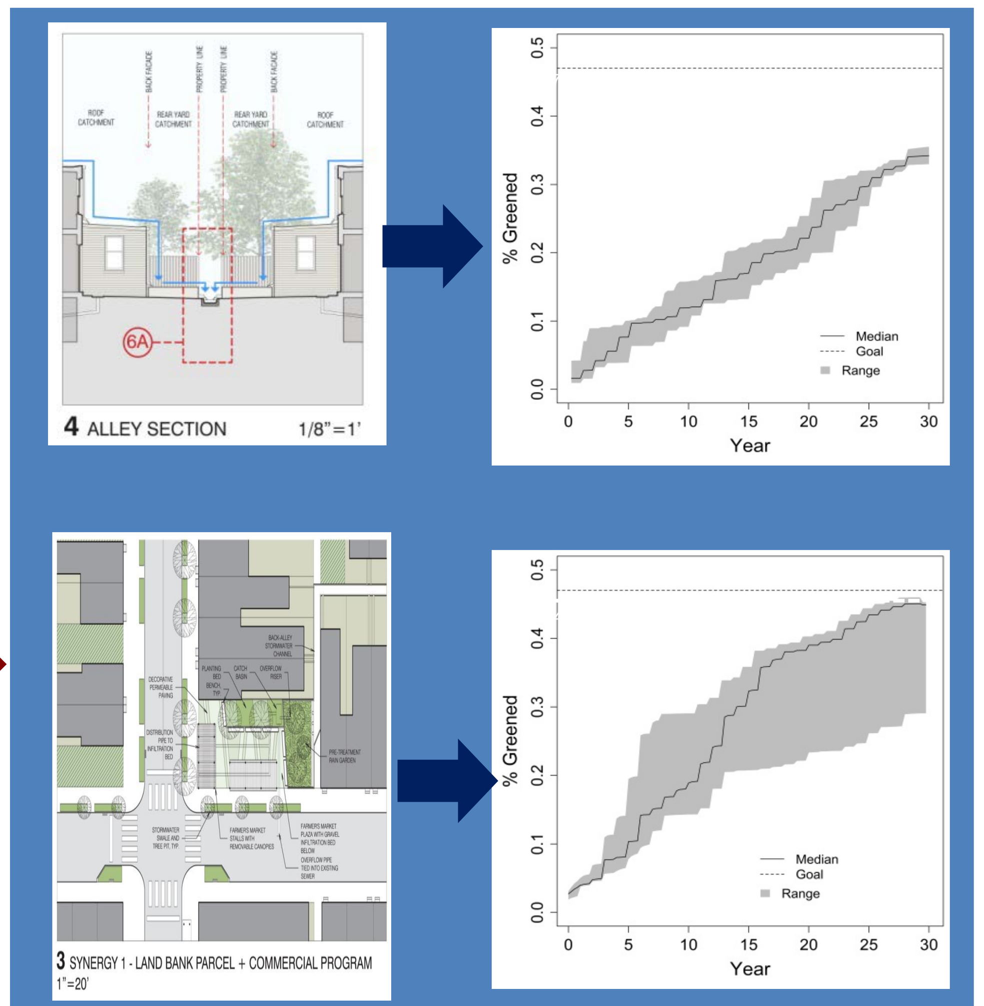
How does hydraulic loading ratio affect urban evapotranspiration and the ecosystem services that are determined by, and depend on it?

What scale of observed data should be used to calibrate and validate watershed models?

What key socioeconomic realities in urban watersheds constrain the feasibility of hydrologic restoration/modification?

How different could watershed performance be, if municipal GI programs emphasize one form of GI over another?

IV. Coupled socio-ecological models of future urban watershed functionality



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