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Understanding green roof spatial dynamics: results from a scale based hydrologic study and introduction of a low-cost method for wide-range monitoring

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Green roofs have the potential, if implemented on a wide scale and with proper foresight, to become an important supplement to traditional urban water management infrastructure, while also helping to change the face of cities from concrete draped, highly modified environments, to hybrid places where nature is more closely integrated into designs rather than pushed out of them. The ability of these systems to act as a decentralized rainwater handling network has been the topic of many recent studies. While these studies have attempted to quantify the hydrologic performance of green roofs, it's clear that they are dynamic systems whose responses are difficult to generalize. What also seems to be lacking from many studies is a discussion on the effects of green roof scale, spatial planning and configuration. This research aims to understand how rainfall characteristics and green roof scale impact its hydrologic performance. Three extensive green roof systems in New York City, with the same engineered components, age and regional climatic conditions, but different drainage areas, are analyzed. We find that rainfall volume and event duration are two of the parameters that most affect green roof performance, while rainfall intensity and antecedent dry weather period are less significant. We also find that green roof scale does in fact affect hydrologic performance, but mainly in reducing runoff peaks, with rainfall retention and lag time being much less affected by drainage area.

We also introduce a low-cost monitoring method, termed the Soil Water Apportioning (SWA) method, which uses a water balance approach to analytically link precipitation to substrate moisture, and enable inference of green runoff and evapotranspiration from information on substrate moisture changes over time. Twelve months of in situ rainfall and soil moisture observations from three different green roof systems – extensive vegetated mat, semi-intensive vegetated mat, and semi-intensive tray – are used to test the reliability of the proposed approach using two different low-cost soil moisture probes. The estimates of runoff are compared with observed runoff data for durations ranging between 6 months to 1 year. Preliminary results indicate that this can be an effective low-cost and low-maintenance alternative to the custom made weir and lysimeter systems frequently used to quantify runoff during green roof studies. By significantly reducing the cost and labor associated with typical monitoring efforts, the SWA method makes large scale studies of green roof hydrologic performance more feasible.