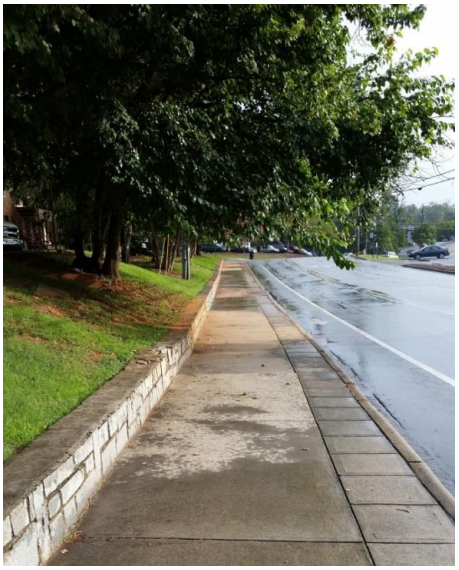
Trees and Stormwater Runoff

By Eric Kuehler, Science Delivery / Technology Specialist
US Forest Service
Urban Forestry South



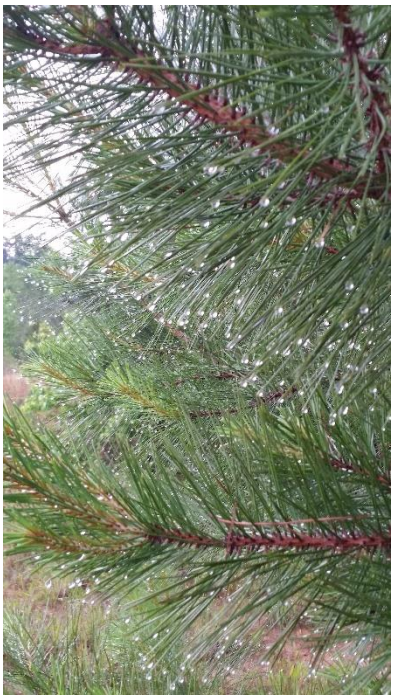
April showers bring May flowers…and a lot of urban stormwater runoff. There is plenty of published research that shows that with increased urban development comes increased stormwater runoff. Trees and urban forest systems (trees, groundcover, and soil) are natural "green" infrastructure that help to manage stormwater runoff at its source. The parts of this system work together as a "treatment train" or series of practices designed to mitigate stormwater runoff to provide considerable stormwater volume and pollution control through rainfall interception and intensity reduction, stormwater infiltration, and nutrient uptake.

The canopy formed by urban trees intercepts rain as soon as it starts to fall. That rainfall remains in the canopy where it eventually evaporates back into the atmosphere. Analysis of all research looking at urban tree canopy interception shows that deciduous trees retain about 20% of the rain falling on its crown while conifers retain close to 30%. The rest of the rain either falls through the crown to the surface below or trickles down the stem where it infiltrates into the soil around the tree. With these numbers stormwater engineers can begin to calculate stormwater benefits of existing tree cover.

When the leaf and branch surface area in the upper part of the tree canopy is filled and cannot hold additional rainfall, excess water drips from these surfaces to those lower in the canopy. This reduces rainfall intensity by the time it drips from the canopy and delays runoff to storm drains or other stormwater control measures. This, in effect, allows the stormwater drainage system to work more efficiently and reduces the chances of it becoming overwhelmed thus helping to reduce surface flooding.
Soils provide the bulk of stormwater volume control. Macro- and micro-pores within the soil allow for temporary water storage from which trees acquire water and nutrients. Tree roots condition the soil through mechanical, biological, and chemical means, increasing its ability to store greater volumes of water. Stormwater runoff not intercepted in the canopy is directed to the soil at the base of a tree. Stemflow, or excess water traveling down the stem of the tree to the soil at its base, can penetrate deep into the soil profile as water moves along the root surfaces.

Once in the soil, water becomes accessible to tree roots. Through the process of transpiration, water is essentially pulled from the soil pore space and used by the tree.

This process allows for greater water storage capacity in the soil as water is transpired most days during the growing season.



Soils also filter nutrients from stormwater runoff. Trees need many of the nutrients found in runoff for growth and survival, especially nitrogen and phosphorus. The uptake of these nutrients from the soil by trees reduces the amount leaching into groundwater, helping to retain and improve water quality. However, trees also store many of these nutrients in their leaves. At the end of the growing season, a large amount of these nutrients remain in leaves. When the tree sheds these leaves in autumn, significant amounts of nutrients can find their way to ponds, lakes, and eventually the ocean.

Precisely quantifying the stormwater benefits of trees is difficult because of species differences in attributes that affect rainfall storage such as crown architecture, leaf structure, and surface texture. For example, needle-leafed trees generally store more rainfall than broadleaf trees, and evergreens intercept more rainfall than deciduous trees over the course of a year. Natural systems also vary in relation to regional climate differences (arid vs. tropical) and microclimates, not to mention the average frequency, intensity, and volume of local rainfall events.

Urban forest systems can help us better manage stormwater runoff by reducing stormwater volume, slowing rainfall intensity, delaying runoff, improving infiltration into soil, and increasing water storage capacity in soils. Larger, mature trees provide greater benefits, and healthy trees appreciate in terms of benefits over time, so managing the entire urban forest to increase leaf surface area is a good strategy to help manage stormwater runoff city-wide. Trees increase the quality of life in our cities for residents, visitors, and business owners. Using them purposefully can help to reduce some of the disservices that come with development and improve the long-term sustainability of urban ecosystems.