Planting Trees for Urban Stormwater Management

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Trees are known to provide many benefits for mission sustainment, including but not limited to flood and stormwater management through volume control and runoff pollution treatment, shade to reduce heat island effects and health impacts, and carbon sequestration to mitigate future climate impacts. Tree planting BMPs can not only be used for TMDL and MS4 credit but can also be leveraged to help meet INRMP goals and maximize the efficiency of existing BMPs, as described below. Understanding how trees' benefits are quantified and how they can be managed to maximize stormwater mitigation can help installation staff optimize their return on investment when planting trees to meet multiple objectives.

How trees provide stormwater management benefits and how they can be optimized is not commonly considered. To answer these questions, the U.S. Department of Agriculture (USDA) hosted a presentation by Dr. Trisha Moore and Eric Kuehler on "Urban Trees and Stormwater Management: Quantifying Impacts, Maximizing Benefits" in October 2021 (see link in "For More Information"). The following information summarizes their presentation.

How Does Tree Planting Provide Stormwater Management?

Trees facilitate several processes that provide stormwater quantity and quality regulation (Figure 1). Table 2 describes these processes.

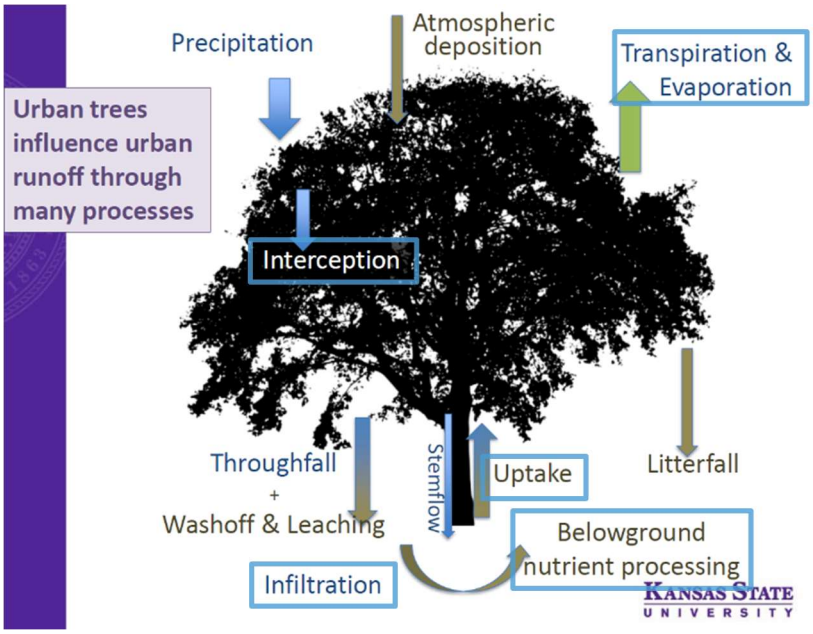
Table 2. Stormwater Management Processes Associated with Trees

Process	Description	Water Quantity or Quality Control
Interception	Water is intercepted by the leaves of trees rather than falling to the ground, increasing the amount of precipitation that is evaporated	Quantity
Infiltration	Tree roots condition soils to increase the rate at which water enters soil and the soil's water storage capacity	Quantity
Uptake	Absorption of water and nutrients (including nitrogen and phosphorus) from the soil	Both
Nutrient Processing	In addition to nutrient absorption (uptake), root systems enhance microbial processing in soil systems, reducing the amount of nutrients released	Quality
Evapotranspiration	Water removed from the ground by the tree is released in the air as water vapor	Quantity

According to Dr. Moore's presentation on urban tree research, the combination of the water quantity control processes described above result in 17% to 30% reduction of runoff underneath a tree's canopy. This research also supports trees as providing greater control over nutrient release or runoff than turf grass.

Can Trees Increase BMP Performance?

If trees are planted in the drainage area of a stormwater control system (e.g., bioretention cell or treatment wetland), they can potentially increase that system's performance. This is a result of the decreased volume of stormwater and corresponding quantity of pollutants (nutrients) that would drain to the stormwater control system. Therefore, with added tree canopy, the chances of BMPs being bypassed, with a loss of stormwater treatment or flood control is reduced.



OORE'S PRESENTATION

Figure 1: Urban tree process to regulate urban stormwater runoff.

What Factors Influence the Stormwater Management Capabilities of Trees?

Characteristics of the tree itself and where it is located influence how the tree mitigates stormwater runoff. These characteristics include:

- **Species type:** some trees have greater rainfall retention capabilities than others. For example, a University of Tennessee study found that pine can prevent the runoff of 50% of rainfall within its canopy, while deciduous trees prevent the runoff by 24-32%. This is a result of several factors such as leaf size, shape, and density and if the tree seasonally loses its leaves.
- **Age/size:** larger, older trees tend to be able to retain, uptake, and transpire more rainfall than smaller, younger trees due to increased tree canopy and water/nutrient demand. Therefore, extending a tree's lifespan by considering climate adaptation and maintenance needs increases the stormwater mitigation capabilities of an installation's overall tree canopy.
- **Soil conditions:** high soil aeration increases infiltration and tree uptake. Care should be taken so that soils are not compacted within the tree planting area as this would hinder stormwater's ability to infiltrate into the soil.
- **Location:** stormwater benefits are influenced by tree species and where the trees are planted to meet the desired outcomes. To reduce stormwater runoff into a retention structure, the installation should plant trees within the structure's drainage area. Tree species also influence optimal planting location. For example, species such as sycamore, yellow birch, and sugar maple should be planted in open areas with wet conditions, while oaks, elms, and mulberries should be planted in upland sites or surrounding bioretention practices that use high infiltration media.

What Management Strategies Optimize the Benefits of Urban Trees?

Thoughtfully selecting and planting resilient species and properly maintaining trees helps sustain mission requirements, meets multiple goals, and provides the greatest return on investment of an installation's urban tree canopy. Some practices that help urban trees most effectively perform their natural processes (Table 2) related to stormwater mitigation include:

- Encouraging crown growth over impervious surfaces (see image)
- Conducting routine tree litter (leaf and branch) cleaning practices for trees over impervious surfaces or near stormwater drains to reduce excess nutrient runoff
- Promoting soil aeration (e.g., through mulching or with spike aerators) so infiltration and uptake are not hindered
- Retaining tree canopy near stormwater infrastructure catchment basins.
- Preventing soil surface exposure (prevent erosion) through mulching or vegetation
- Retaining and planting a diversity of trees including species that do not seasonally shed leaves
- Prioritizing trees with a high leaf area index (total leaf surface area relative to canopy)
- Maintaining larger trees, where appropriate

IMAGE FROM ERICK KUEHLER'S PRESENTATION

Tree canopy extending over a sidewalk to reduce rainfall intensity on impervious surfaces.

Takeaways for DoD Installations

Careful selection, planting and maintaining urban tree canopy at an installation not only provides valuable water quality and quantity benefits but also supports Chesapeake Bay TMDL Federal Planning Goals, maximizes the performance of existing BMPs, helps meet INRMP goals, and contributes to climate resiliency. To optimize tree planting practices to meet multiple goals, installation staff should understand how trees affect stormwater management and what methods enhance their stormwater mitigation benefits. This knowledge can be leveraged during the installation's planning processes to maximize the return on investment of tree planting activities.

For More Information:

USDA, "Urban Trees and Stormwater Management: Quantifying Impacts, Maximizing Benefits" webinar recording: https://www.fs.fed.us/research/urban-webinars/urban-trees-stormwater-management.php

USDA, "Urban Forest Systems and Green Stormwater Infrastructure" paper: https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/Urban-Forest-Systems-GSI-FS-1146.pdf

Water Research Foundation (WRF), "Predicting Urban Tree Contributions to Urban Runoff Budgets with Statistical Models" fact sheet: https://www.waterrf.org/system/files/resource/2020-01/PROJECTPAPER-4837-2.pdf

WRF, "Incorporating Forestry into Stormwater Management Program" paper: https://www.waterrf.org/system/files/resource/2020-01/DRPT-4837.pdf