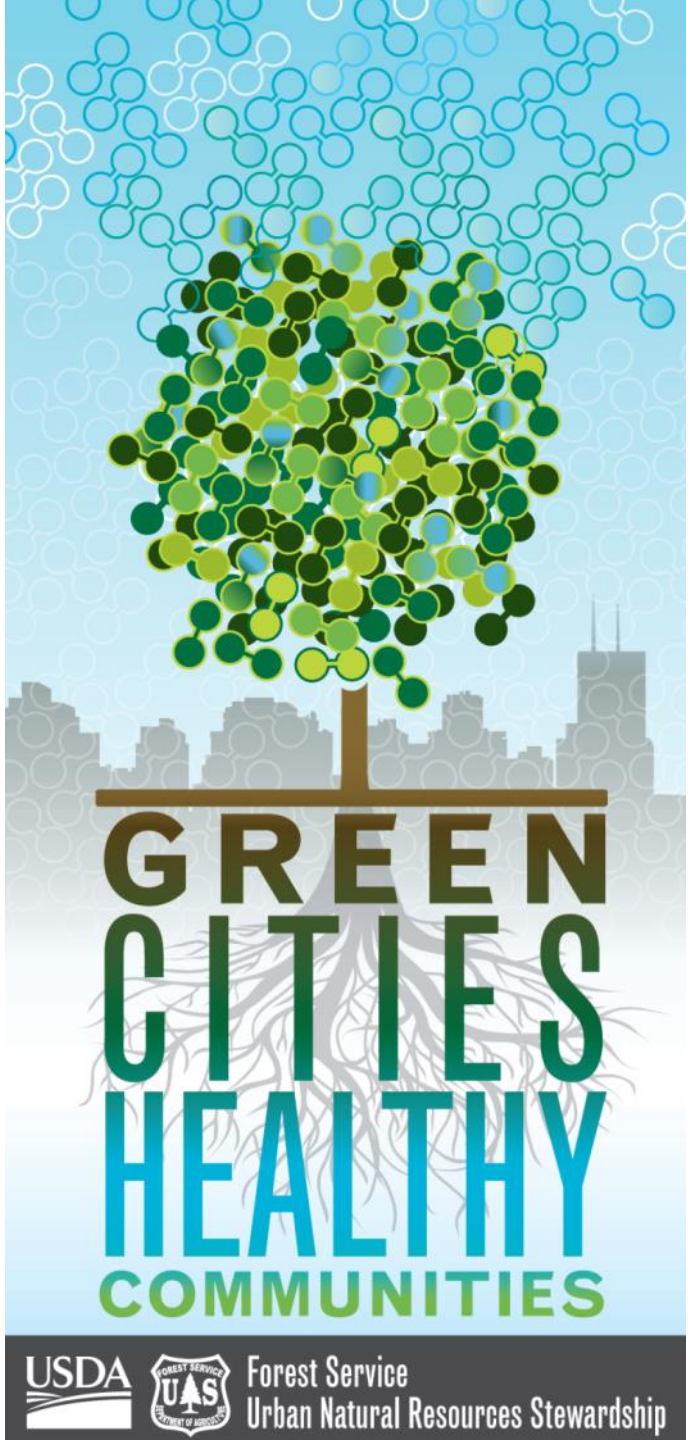

USDA Forest Service

URBAN FOREST CONNECTIONS

webinar series

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www.fs.fed.us/research/urban-webinars

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Making Urban Trees Count: Quantifying and Crediting Stormwater Benefits

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Making Urban Trees Count: Quantifying and Crediting Stormwater Benefits

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January 10, 2018
Urban Forest Connections Webinar Series

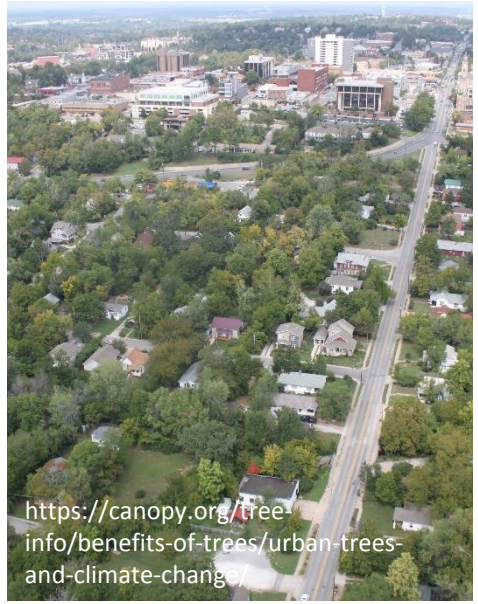
About the Center for Watershed Protection

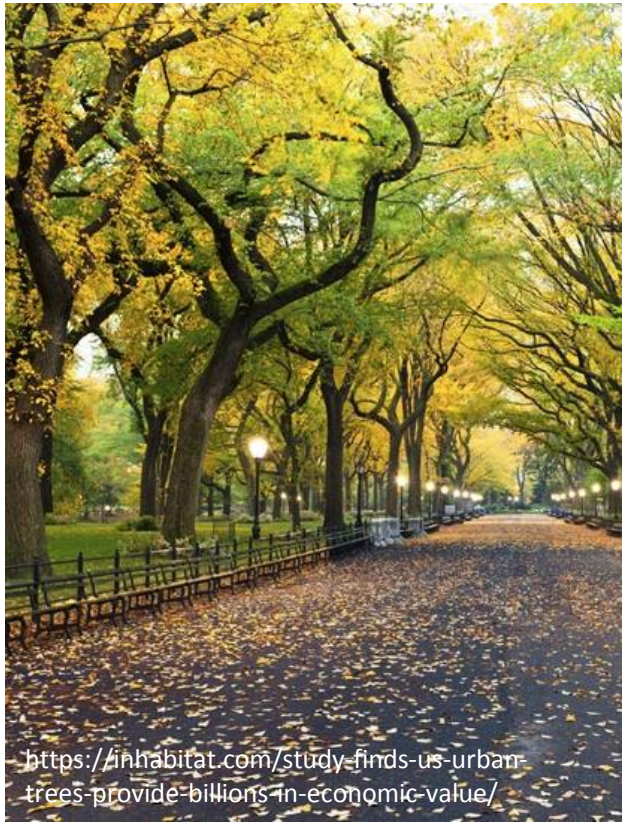
www.cwp.org

- Founded in 1992 – celebrating 25 years!
- 501 (c) 3 nonprofit; works to protect, restore and enhance our waterways
- Diverse client base of government agencies, foundations, watershed organizations and firms across the country
- Headquartered in Ellicott City, MD with offices in VA, PA, NY and SC.

Outline

- Project overview
- Stormwater & trees
  - What do we know? What are the gaps?
- Existing crediting methods
- New crediting framework
- Water Balance Model development
- Chesapeake Bay Program urban tree canopy credit case study


https://canopy.org/tree-info/benefits-of-trees/urban-trees-and-climate-change/


https://inhabitat.com/study-finds-us-urban-trees-provide-billions-in-economic-value/

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Stormwater BMPs

The Urban Tree Canopy

Urban Trees are Different

- No defined drainage area
- Difficult to quantify benefits
- Benefits INCREASE over time
- Urban conditions
- Concerns about maintenance
- Consequently, lack of incentive to use them unless there are available ‘credits’

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“Making Urban Trees Count”: A stormwater credit framework for urban tree planting

- To provide science-based credit to encourage use of trees to meet stormwater management requirements
- Components of project:
  - Literature review and synthesis
  - Review of existing credit systems
  - Credit development
    - Expert Panel
    - Water Balance Model
  - Pilot study

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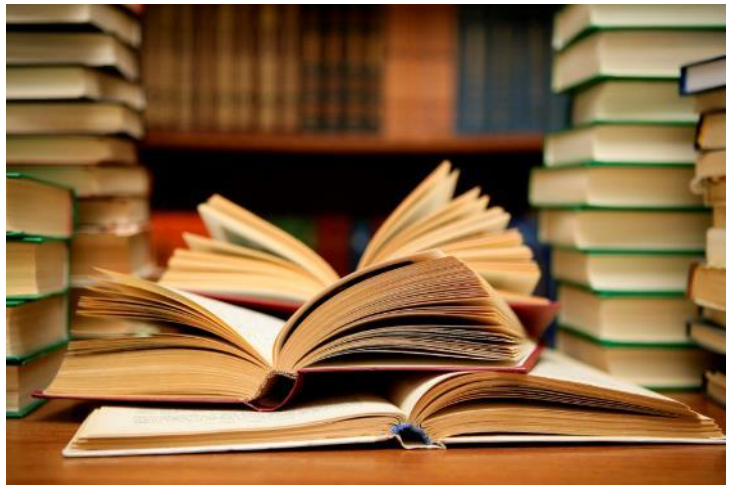
National Urban and Community Forestry Advisory Council Grant Program

USDA

Forest Service U S Department Agriculture

Urban Trees: What Do We Know?

- Literature review of **159** studies to address questions:
  1. What is the effectiveness of urban tree canopy on reducing runoff, nutrient and sediment loads?
  2. How does effectiveness vary by species, over time, with differences in planting sites (e.g., distance from impervious cover or other trees, soil conditions, geographic location) and with different maintenance strategies?
- Review included studies on the benefits of non-urban trees/forests
- Download at: https://www.cwp.org/making-urban-trees-count/



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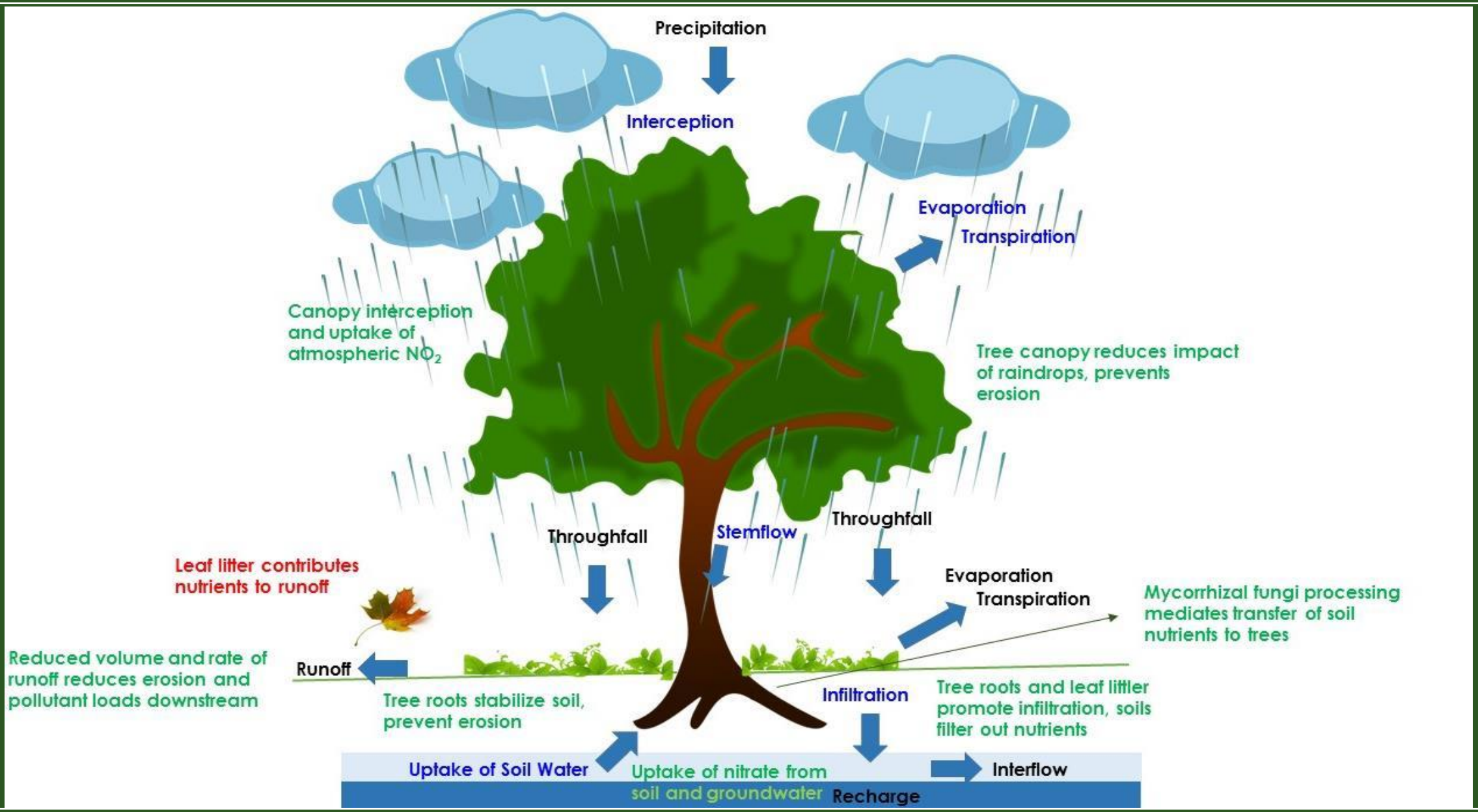
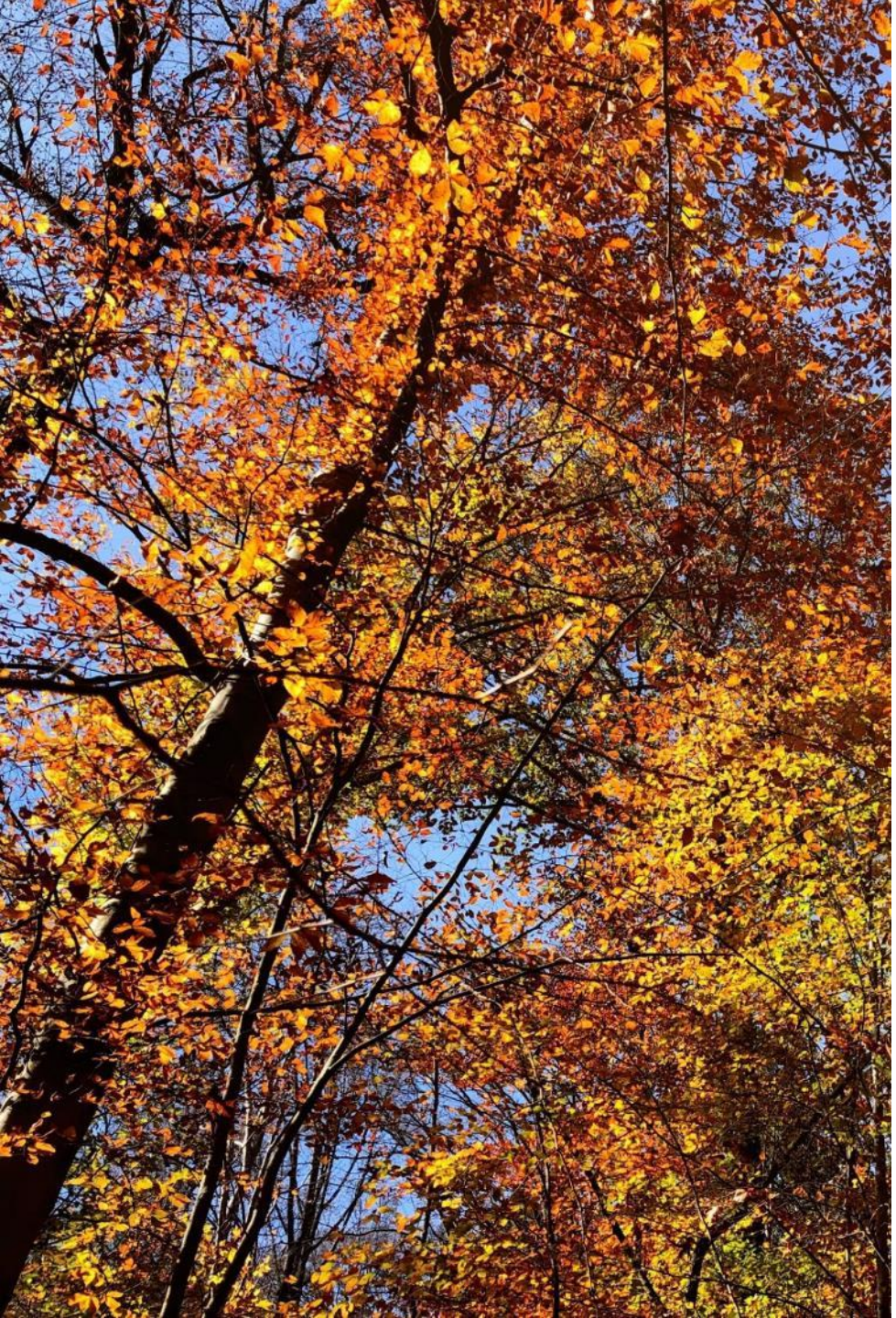

Precipitation
Interception
Evaporation
Transpiration
Canopy interception and uptake of atmospheric NO_2
Tree canopy reduces impact of raindrops, prevents erosion
Throughfall
Stemflow
Throughfall
Leaf litter contributes nutrients to runoff
Evaporation
Transpiration
Mycorrhizal fungi processing mediates transfer of soil nutrients to trees
Reduced volume and rate of runoff reduces erosion and pollutant loads downstream
Runoff
Tree roots stabilize soil, prevent erosion
Infiltration
Tree roots and leaf littler promote infiltration, soils filter out nutrients
Uptake of Soil Water
Uptake of nitrate from soil and groundwater
Interflow
Recharge



Variability

Interception alone is impacted by:

- Rainfall intensity
- Duration and frequency of rainfall
- Leaf area
- Leaf angle distribution
- Leaf surface characteristics
- Meteorological factors (wind speed, vapor pressure, etc.)
- Tree type (evergreen versus deciduous)
- Season/time of year

Review of Existing Credit Systems

- Common Variables:
  - Regulatory context (TMDLs, stormwater)
  - Type of BMP (conservation, planting, forests, individual trees)
  - Tree type (evergreen, deciduous)
  - Metric (IC, runoff, pollutants)
- Qualifying conditions

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Tree Planting Credit Summary

Community	Type of Credit	Credit for a Deciduous Tree
Sacramento, San Jose and Santa Clara Valley, CA; Portland, OR; Indianapolis, IN; Philadelphia, PA	IC	$100ft^2$
Seattle, WA	IC	$20ft^2$
Pine Lake, GA	Volume	<12” DBH: 10 gallons/in; >12” DBH: 20 gallons/in
Washington, DC	Volume	$10ft^3$
Vermont	Volume	$5ft^3$
Minnesota	Volume and P load	Depends on soil volume and other factors
Chesapeake Bay Program	N, P and S load	Pollutant load reduction associated with conversion of $144ft^2$ to tree canopy land use

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Adapted from Stone Environmental (2014)

Challenges and Gaps

- Limited number of studies directly addressing the water quality benefits of urban trees
- Each component of the cycle is affected by numerous factors, leading to high variability
- Individual studies not directly comparable due to different scales/methods
- Emerging issue of leaf litter contribution to nutrient loads
- Managers need crediting systems that are simple, allow for comparison to other BMPs, and work within the currency and timescale of the compliance program

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New Crediting Framework

Summary of Tree Planting Credits Developed from Water Balance Model Results		
Characteristic	**Pollutant Load Reduction Credit**	**Stormwater Performance-Based Credit**
Use of Credit	· Compliance with nutrient and sediment TMDLs	· Compliance with site-based stormwater management requirements (volume-based and pollutant-based)
Required Inputs	· Climate region · Number of trees planted	· Nearest city (from drop-down list) · Tree type · Surface over which the tree will be planted · Number of trees planted · A breakdown of HSG soil type/land cover combinations for the entire site · The design storm, in inches
Optional Inputs	· Tree type · Soil type · Surface over which the tree will be planted · TN, TP and TSS event mean concentrations	· Tree size (DBH) · Tree canopy area · TN, TP and TSS event mean concentrations
Outputs	· Annual reduction in TN, TP and TSS loads (lbs/yr) for an individual tree and for a tree planting scenario	· Runoff (cubic feet), TN (lbs), TP (lbs) and TSS (lbs) reduction for user-defined tree planting scenario for a specific storm event (e.g., design storm)

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Available at: https://www.cwp.org/making-urban-trees-count/

Chesapeake Bay Program Case Study

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Chesapeake Bay TMDL

- TMDL established in 2010 by EPA
- Largest ever established: 64,000 square mile watershed
- Reduce TN by 25%, TP by 24%, and TSS by 20% by 2025
- Jurisdictions submit plans outlining how they will achieve these reductions through implementation of BMPs
- Chesapeake Bay Watershed Model is part of rigorous accounting framework that incorporates “crediting” protocols for each BMP

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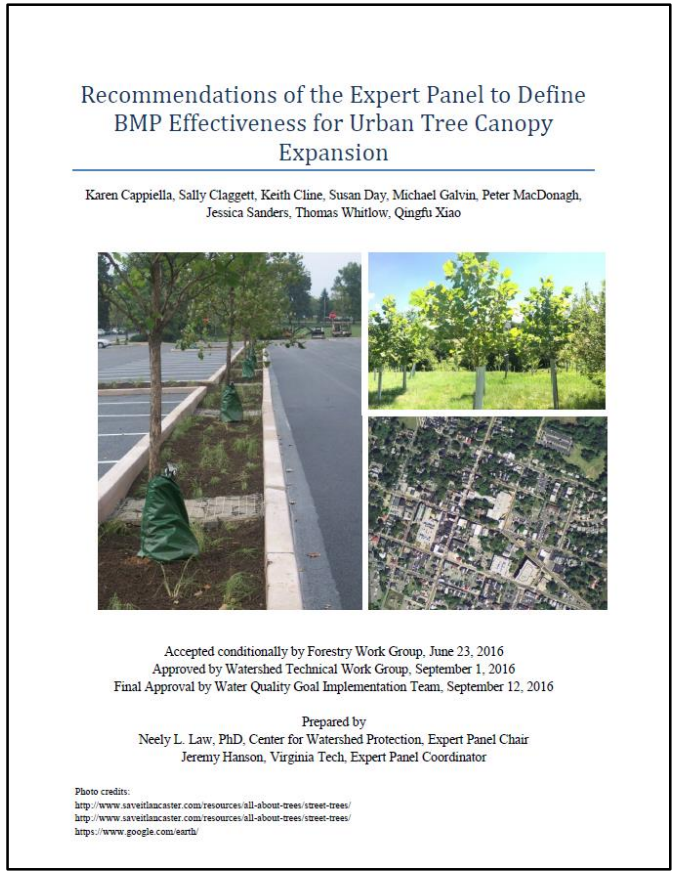
Urban Tree Canopy Expert Panel

- Convened by Chesapeake Bay Program in 2015
- Composed of 15 experts and panel support
- Charge was to determine pollution reduction estimates for the urban tree canopy BMP to be represented in the Chesapeake Bay Watershed Model
- Recommendations based on review and synthesis of the literature, best professional judgment and Water Balance Model developed by Hynicka and Divers (2016)
- Final approval by CBP in 2016



Recommendations of the Expert Panel to Define BMP Effectiveness for Urban Tree Canopy Expansion

Karen Cappiella, Sally Claggett, Keith Cline, Susan Day, Michael Galvin, Peter MacDonagh, Jessica Sanders, Thomas Whitlow, Qingfu Xiao

Accepted conditionally by Forestry Work Group, June 23, 2016
Approved by Watershed Technical Work Group, September 1, 2016
Final Approval by Water Quality Goal Implementation Team, September 12, 2016

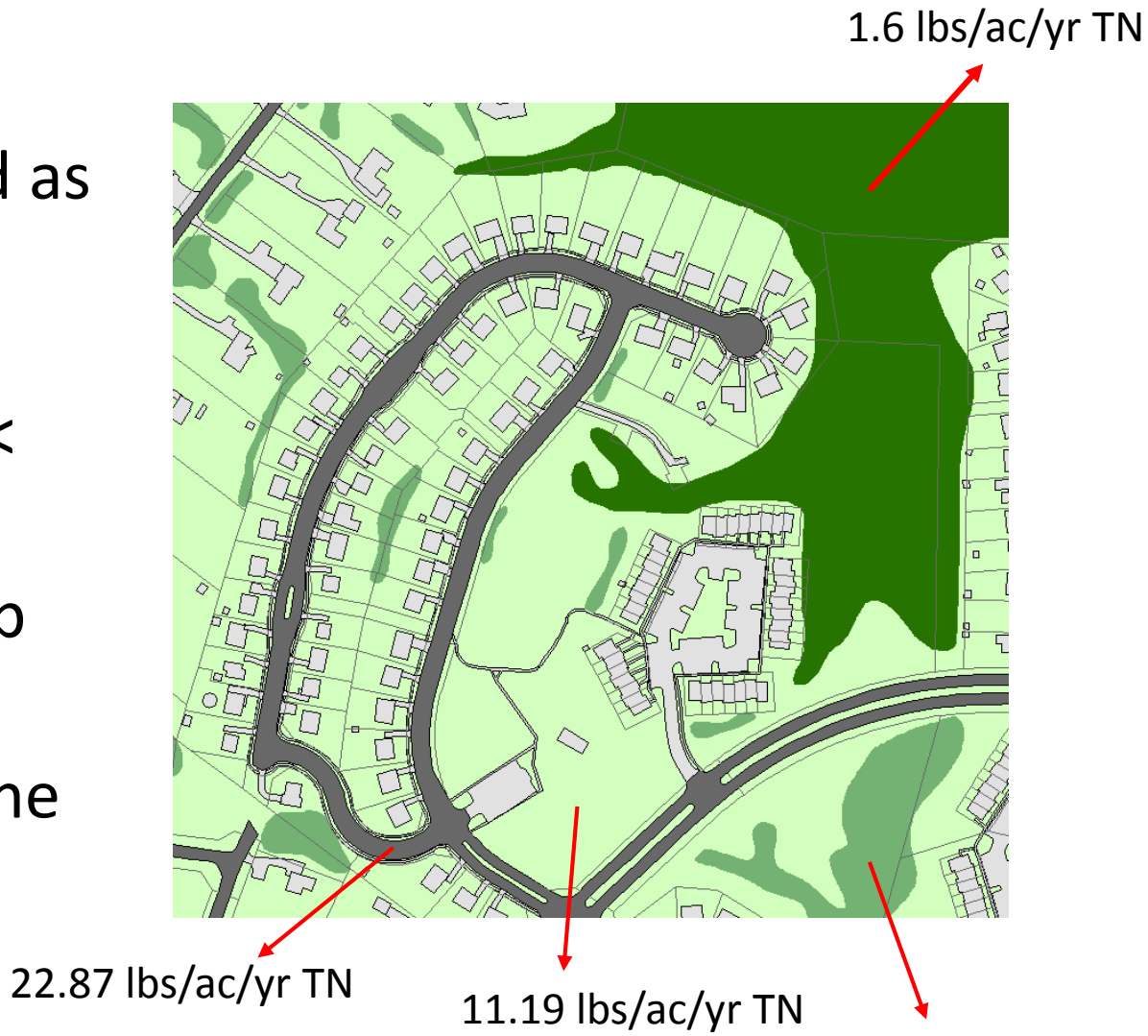
Prepared by
Neely L. Law, PhD, Center for Watershed Protection, Expert Panel Chair
Jeremy Hanson, Virginia Tech, Expert Panel Coordinator

Photo credits:
http://www.saveitlancaster.com/resources/all-about-trees/street-trees/
http://www.saveitlancaster.com/resources/all-about-trees/street-trees/
https://www.google.com/earth/

Report available at: http://chesapeakestormwater.net/2016/09/webcast-urban-tree-canopy/

Urban Tree Canopy in the Chesapeake Bay Watershed Model

- EXISTING tree canopy is represented as a land use in the model
- Tree canopy land use is assigned its own unique pollutant loading rate (< turf but > forest)
- High resolution imagery used to map canopy Bay-wide
- NEW tree canopy is credited using the Expert Panel protocols



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Urban Tree Canopy BMP Definitions

Urban Tree Canopy Expansion
Trees planted in an urban area that are not part of a riparian forest buffer, structural BMP, or Urban Forest Planting BMP. Includes all individually planted trees such as street trees and small-scale residential plantings.

Urban Forest Planting
Trees planted to establish forest-like conditions and meet state planting density and understory management requirements

Report available at: http://chesapeakestormwater.net/2016/09/webcast-urban-tree-canopy/

Basis of Urban Tree Canopy Expansion Credit

- Trees reduce runoff and pollutant loads relative to loads from turf or impervious cover without tree canopy
- Water Balance Model quantifies this reduction
- Credit is applied as a relative % reduction of pollutant load of underlying land cover (turf or impervious)

Tree canopy relative land use loading rates based on the underlying land use land cover (Source: Hynicka and Divers 2016)

Land Use	Total Nitrogen Reduction (%)	Total Phosphorus Reduction (%)	Total Sediment Reduction (%)
Canopy over Turfgrass	23.8	23.8	5.8
Canopy over Impervious	8.5	11.0	7.0

Report available at: http://chesapeakestormwater.net/2016/09/webcast-urban-tree-canopy/

Application of Urban Tree Canopy Expansion Credit

- Required information: # of trees planted; land cover (turf or impervious), planting location, year planted
- Conversion factor used to convert # of trees planted to acres of tree canopy land use (derived from i-Tree Forecast)
- Reflects projected canopy size 10 years after planting
- 1 acre of tree canopy coverage = 300 trees ($144ft^2$/tree)
- Outputs: TN, TP and TSS reductions (lbs/yr)

Report available at: http://chesapeakestormwater.net/2016/09/webcast-urban-tree-canopy/

Verification of the Urban Tree Canopy Expansion BMP

- Pollution reduction credits expire after 10 years
- Assumption is that after 10 years, trees are large enough to be captured by high resolution imagery
- Replacement of lost trees recommended but not required as method accounts for mortality, 2.5 - 5%

Image source: https://environment.arlingtonva.us/trees/plant-trees/recommended-trees/

Report available at: http://chesapeakestormwater.net/2016/09/webcast-urban-tree-canopy/

Tree Crediting Resources

- National Crediting Framework products:
  - Annual Pollutant Load Reduction Credit for Tree Planting (TMDL)
  - Stormwater Performance-Based Credit for Tree Planting (event or design-storm)
  - Literature Synthesis
  - Water Balance Model Documentation
  - Design Specifications for Urban Tree Planting
  - https://www.cwp.org/making-urban-trees-count/
- www.treesandstormwater.org
- Tree Credit Systems and Incentives at the Site Scale: https://vtcommunityforestry.org
- Urban Tree Canopy Expansion BMP Report: http://chesapeakestormwater.net/2016/09/webcast-urban-tree-canopy/

Making Urban Trees Count: A Stormwater Credit Framework for Urban Tree Planting

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