Pollutant Load Reduction Credit for Tree Planting

Overview

Urban trees and forests improve stream quality and watershed health primarily by decreasing the amount of stormwater runoff and pollutants that reach our local waters. The processes of rainfall interception, evapotranspiration, infiltration, and nutrient uptake are important for providing these benefits and are well-accepted in the scientific community. However, it is difficult to quantify the services provided by individual trees because they vary with tree species and age, storm characteristics, climatic conditions, soils, and other factors. It is this uncertainty on how to "credit" trees for runoff and pollutant load reduction that has limited its use as a stormwater BMP for meeting water quality requirements.

The Center for Watershed Protection developed a national Pollutant Load Reduction Credit for tree planting that can be adopted by regulatory entities who wish to offer a scientifically defensible credit that encourages greater use of trees for meeting total maximum daily load (TMDL) requirements. The credit quantifies an annual reduction in nutrient and sediment loads relative to the pollutant loading rate of the underlying land cover. The credit applies to trees planted in the urban environment, but does not apply to planted riparian buffers, large-scale reforestation projects or trees planted in engineered soils, such as bioretention or structural soils.

The Pollutant Load Reduction Credit was developed using a water balance model to estimate the mean annual runoff for a single tree at maturity planted over turf or impervious cover, compared to runoff from those same sites without trees. The model was run for the four hydrologic soil groups (HSG) for five tree types at 31 locations in 11 climate zones (Figure 1). Metrics derived from i-Tree Forecast were used to parameterize the water balance model. The modeling results were used to calculate reductions of total nitrogen (TN), total phosphorus (TP) and total suspended sediment (TSS). Documentation of the model is provided in Hynicka and Caraco (2017).

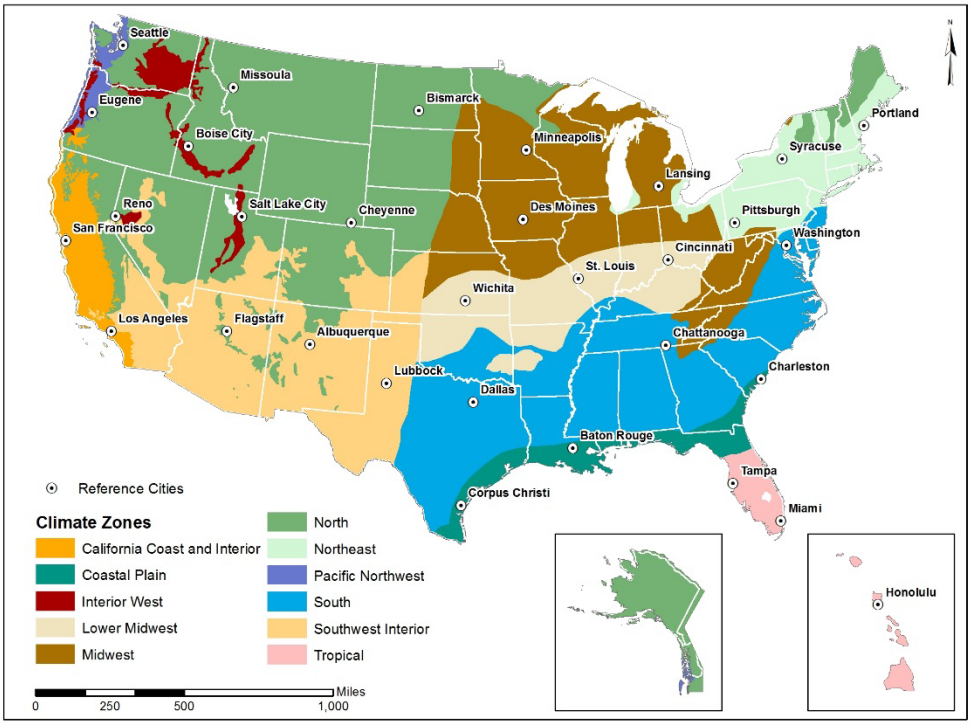

Figure 1. Climate Zones for Crediting Framework (modified from McPherson 2010)

How to Use the Credit

The Pollutant Load Reduction Credit is presented in a series of lookup tables for each of the 11 climate zones. These tables can be accessed using the Pollutant Load Reduction Credit Tool by selecting your climate zone from a dropdown menu using the map in Figure 1. The lookup tables present the annual per-tree TN, TP and TSS load reductions for broadleaf deciduous large, medium and small trees, and coniferous evergreen large and small trees. Within each lookup table, values are provided for the four HSG types and for trees planted over turf and impervious cover. Table 1 provides an example of results for a broadleaf deciduous medium sized tree planted in the Midwest.

Table 1. CREDIT FOR A BROADLEAF DECIDUOUS MEDIUM TREE IN THE MIDWEST

Soil Type/Land Cover	Load Reduction (lb/year)		
	TN	TP	TSS
HSG-A, pervious	0.0030	0.0005	0.29
HSG-B, pervious	0.014	0.0025	1.4
HSG-C, pervious	0.026	0.0044	2.5
HSG-D, pervious	0.034	0.0059	3.3
Unknown Soil Type, pervious	0.026	0.0044	2.5
Impervious cover	0.016	0.0027	1.5

The values in the lookup tables represent the potential benefits provided under optimal conditions (i.e., healthy trees at maturity). Agencies adopting this credit as part of the TMDL regulatory framework may wish to specify qualifying conditions to obtain the full credit, and offer a reduced credit (70% of the optimal credit, derived from i-Tree Forecast simulations of reduced growth conditions) where these conditions are not met. Another option is to include a credit 'roll out' schedule to account for early growth stages of a tree, relative to the tree at maturity. If the former option is chosen, the following minimum set of qualifying conditions are recommended. These can be modified to account for localized conditions in consultation with a professional arborist or urban forester.

1. Maintenance Agreement and Plan: Periodic maintenance is required to ensure long-term survival and health of urban trees, particularly during the establishment period. To receive full credit, a maintenance agreement and plan should be in place for the planting project. A maintenance agreement should specify the party responsible for maintenance, stipulate the length of time which the agreement is valid, and identify minimum standards for care and any required submittals. A maintenance plan will prescribe the specific maintenance activities and their frequency and will often include a checklist. The key maintenance activities for urban tree planting include regular watering for the first few growing seasons, weeding and mulch replacement, removing staking and tree protection as needed, pruning, and fertilization. Maintenance can also include periodic inspection and tree replacement.

2. Consultation with an Urban Tree Professional: Choosing tree species that are appropriate for the site conditions and determining where to plant them are decisions that determine the ultimate success of an urban planting project. For a project to receive full credit, these decisions should be make in consultation with an urban tree professional (i.e., a licensed arborist or urban forester) so that the project can be designed to work with rather than against the many site constraints found in the urban landscape (e.g., utilities, poor soils, extreme heat). At a minimum, an urban tree professional should be consulted on species selection but these experts can also assist with selecting planting stock, identifying planting locations that provide sufficient soil volume for trees and adequate setbacks from infrastructure, recommending soil amendments, and demonstrating proper planting techniques. The latter is particularly important for projects implemented by volunteer groups.
3. Curbside Leaf Pickup Program (for trees planted over impervious cover only): Emerging studies demonstrate the significance of nutrient leaching from leaf litter, which collects in curbs and gutters in urban areas and is flushed through the storm drain system, ultimately contributing to the nutrient load in local streams. Therefore, for trees planted over impervious cover (i.e., street and parking lot trees), the nutrient reduction credit provided by the trees is likely to be outweighed by the nutrient load contributed by leaf litter, unless the leaves are removed through a curbside leaf pickup program. Therefore, a qualifying condition to receive credit for trees planted over impervious cover is that a leaf pickup program be in place that serves the planting site. In the future, the credit may be able to be modified to better account for the nutrient load from leaf litter as more studies become available to help quantify the average load for a tree planted in the urban environment.

The Design Specifications for Urban Tree Planting provided in CWP (2017b) can also be incorporated as guidance into the crediting framework to ensure that trees planted can reach their full potential benefits.

Needed Inputs

To apply the credits in the lookup tables, the following inputs are needed:

- Climate region
- Tree type (broadleaf deciduous medium is the default if unknown)
- Soil type (HSG-C is the default if unknown)
- Underlying land cover (grass or impervious cover – grass if unknown)
- Number of trees planted
- Information to determine if qualifying conditions have been met (e.g., minimum soil volume provided, maintenance plan in place)
- Pollutant event mean concentrations (optional), if local values are available to replace the default provided

The Pollutant Load Reduction Credit Tool includes a Credit Calculator worksheet that calculates estimated annual reduction in TN, TP and TSS associated with a tree planting project based on these user inputs.

Calculations

To estimate the pollutant load reductions associated with tree planting, the following equation is used[1]:

*Runoff Reduction (gallons/year) * pollutant concentration (mg/l) * number of trees *8.33x10^{-6}= annual pollutant load reduction associated with tree planting (lbs/yr)*

Results

Results are provided in Table 2 for the following example: 100 broadleaf deciduous medium trees planted over turf with C soils in the Midwest climate zone. The table shows both the optimal and reduced credit for this planting scenario. The optimal credit is only given when qualifying conditions (e.g., minimum soil volume provided, maintenance plan in place) are met.

Table 2. POLLUTANT LOAD REDUCTIONS FOR 100 BDM TREES PLANTED IN THE MIDWEST

	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	TSS Reduction (lbs/yr)
Optimal (100%)	3.4	0.59	330
Reduced (70%)	2.4	0.41	231

Assumptions and Limitations

This national credit framework provides a template for a first approximation of benefits provided by urban tree planting for TMDL credit. Site specific conditions for individual planting scenarios may deviate from these average values where more detailed monitoring or site characteristics are considered. Assumptions and limitations include:

- Values represent average annual results. Results for a representative number of native tree species were averaged to produce results for five generic tree types, and results from selected locations in each climate zone were averaged as well.
- Credit only accounts for rain falling on the canopy (e.g., assumes that runoff is not being directed to the tree from an upstream drainage area)
- Applies to annual pollutant load reduction rather than event-specific calculations (i.e., state-specific performance standards)
- Credits assume that pollutant load reductions are directly proportional to runoff reduction. For TP and TSS, the runoff reduction values are multiplied by typical urban runoff concentrations. For TN, however, the urban runoff concentration is multiplied by a "flux factor" (approximately 0.65). This is a conservative assumption that accounts for the fact that soluble forms of nitrogen that are infiltrated beneath the soil surface may eventually reach a stream or other water body.
- Credit should not be applied in areas with a high water table since the underlying model assumed that flow beneath the root zone was not restricted
- The model results are considered 'optimal' as the growing conditions for the trees does not account for stresses in the urban environment that may affect tree growth or mortality and account for the runoff reduction based on a mature tree.
- However, the results are conservative as the output provided is shown for runoff reduction only and does not account for losses due to leachate, below the shallow

[1] The constant in this equation (8.33x10^{-6}) converts gal*mg/l to pounds.

groundwater or rooting zone. Further simplifications of the model framework were made to quantify the runoff volume from trees planted over impervious cover.

References

Hynicka, J. and D. Caraco. 2017. *Relative and Absolute Reductions in Annual Water Yields and Non-Point Source Pollutant Loads of Urban Trees*. Crediting Framework Product #2 for the project Making Urban Trees Count: A Project to Demonstrate the Role of Urban Trees in Achieving Regulatory Compliance for Clean Water. Center for Watershed Protection, Ellicott City, MD.

McPherson, E.G. 2010. Selecting reference cities for i-Tree Streets. *Arboriculture & Urban Forestry*, 26(5): 230-240.