Reducing Phosphorus in Urban Stormwater: Understanding the Importance of Technology versus Frequency


LEACH

Nine study catchments were monitored in three Wisconsin cities

Study Objectives

- Determine if removal of leaf litter results in a detectable change in end-of-pipe nutrient load
- Evaluate common methods of leaf collection and street cleaning technologies and frequencies used by Wisconsin MS4s

April

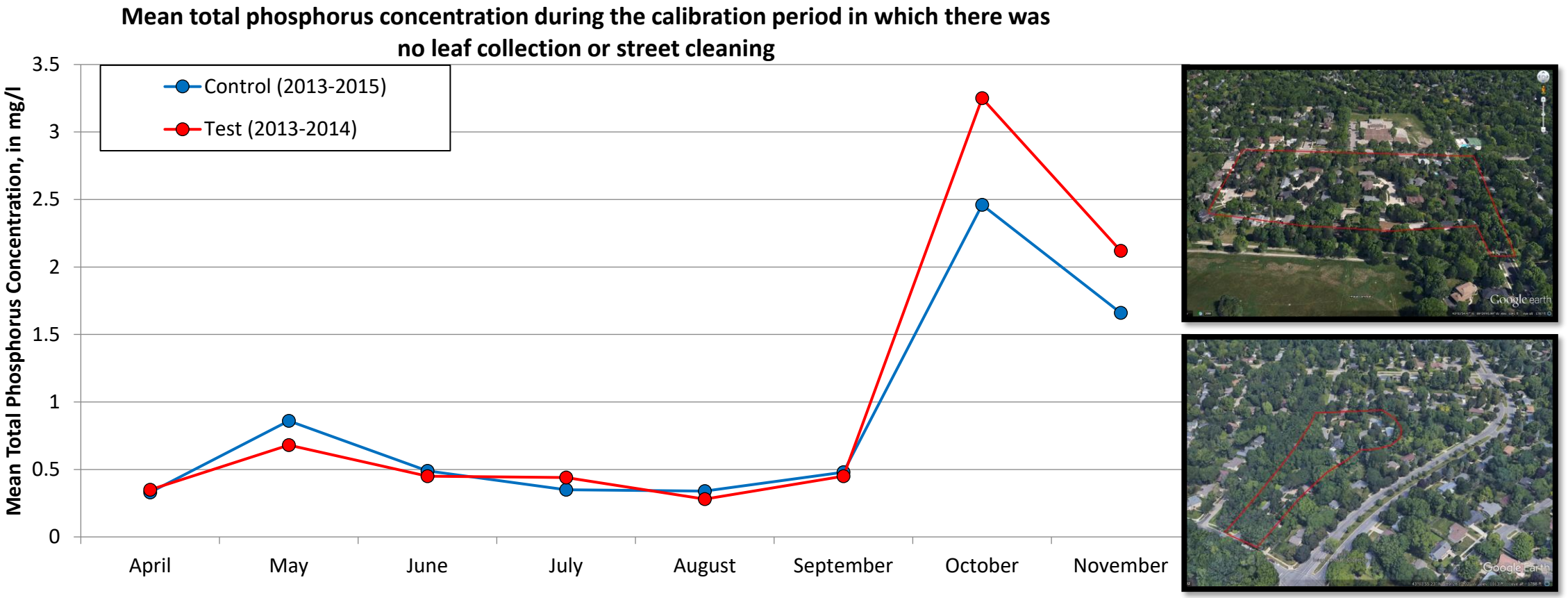
May

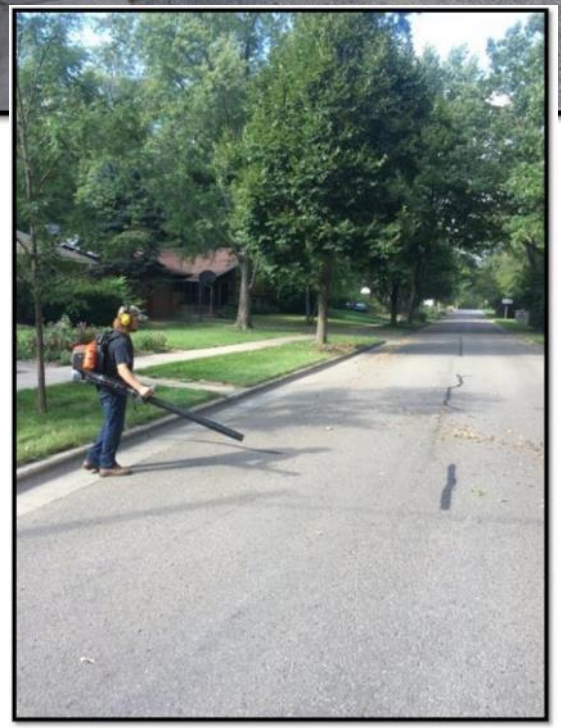
June-Aug

Sept

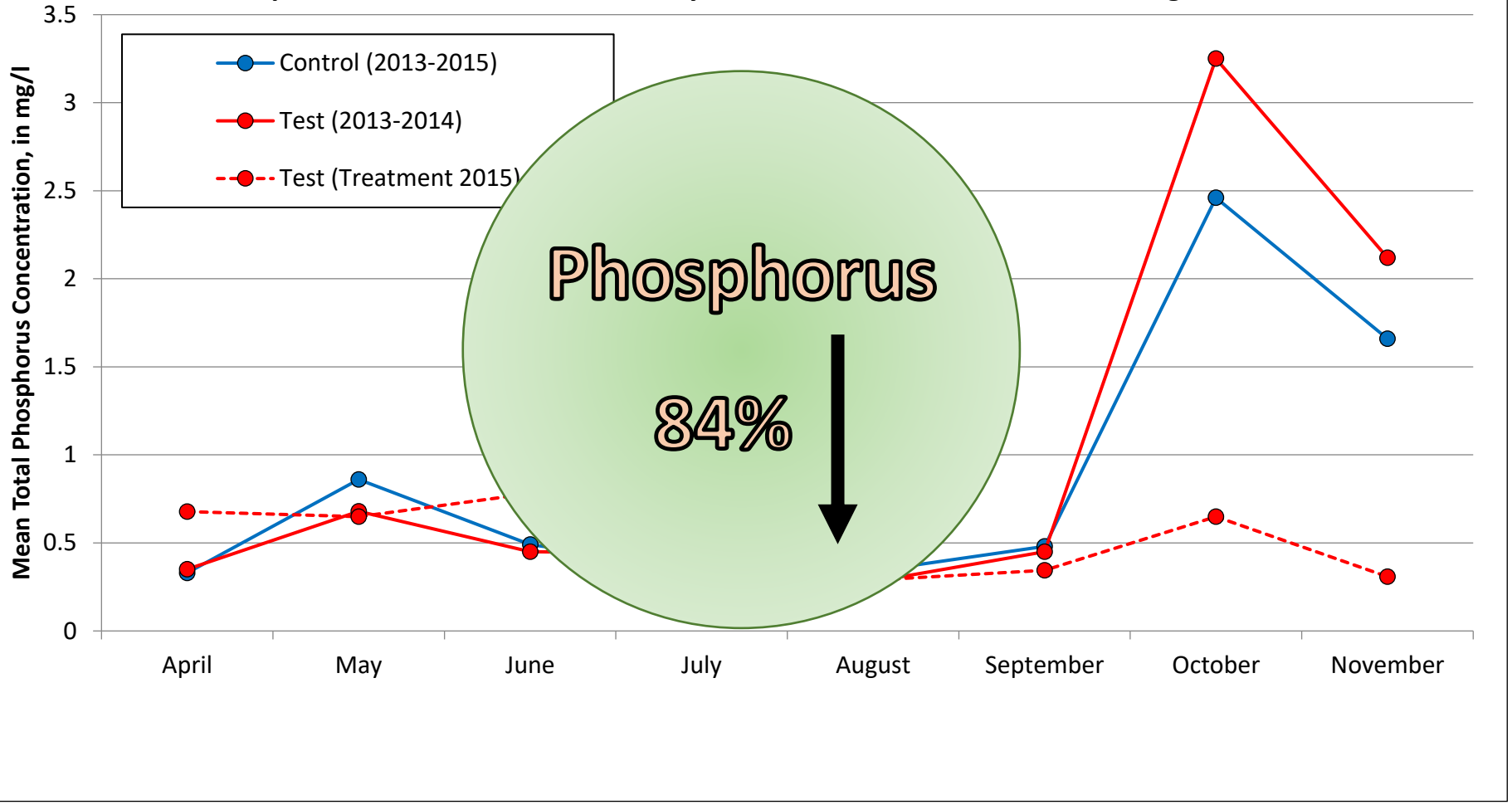
Oct

Nov





Mean total phosphorus concentration during the calibration period compared to the treatment period in which there was weekly leaf collection and/or street cleaning



Evaluation of Leaf Collection and Street Cleaning Technology and Frequency

“T2-R1”

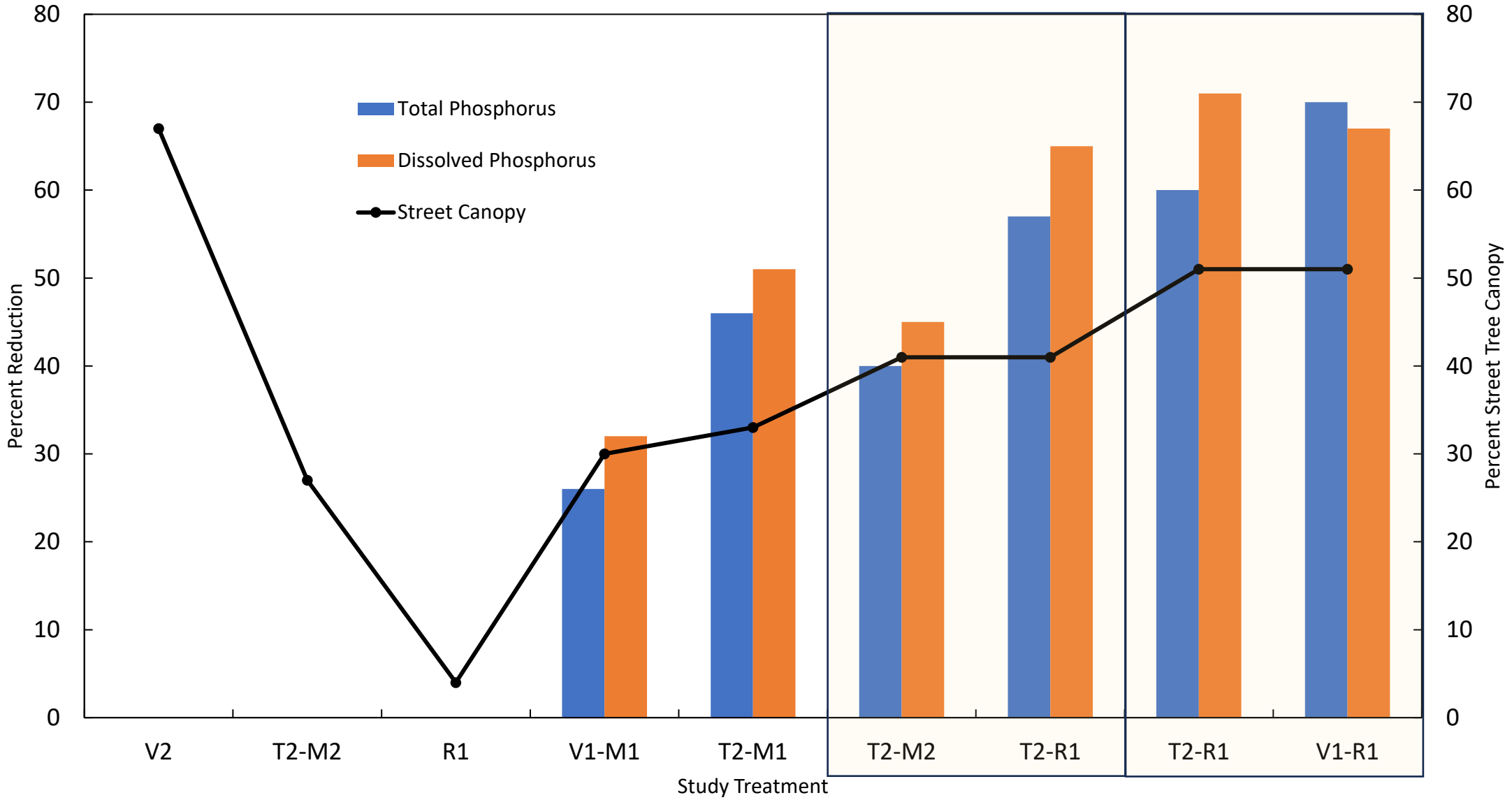
Leaf Collection Method and Frequency

T = Transfer
V = Vacuum-mulch
1 = Weekly
2 = Bi-weekly

Street Cleaning Method and Frequency

R = Regenerative-air
M = Mechanical Broom
1 = Weekly
2 = Bi-weekly

How Well Do Municipal Leaf Collection and Street Cleaning Programs Work?



Take Home Message…

Important Factors For Phosphorus Reduction

Sweeper Technology

- Regenerative-air sweepers are more efficient at removing leaf litter in street

Sweeper Frequency

- Greater frequency means less accumulation of leaf litter

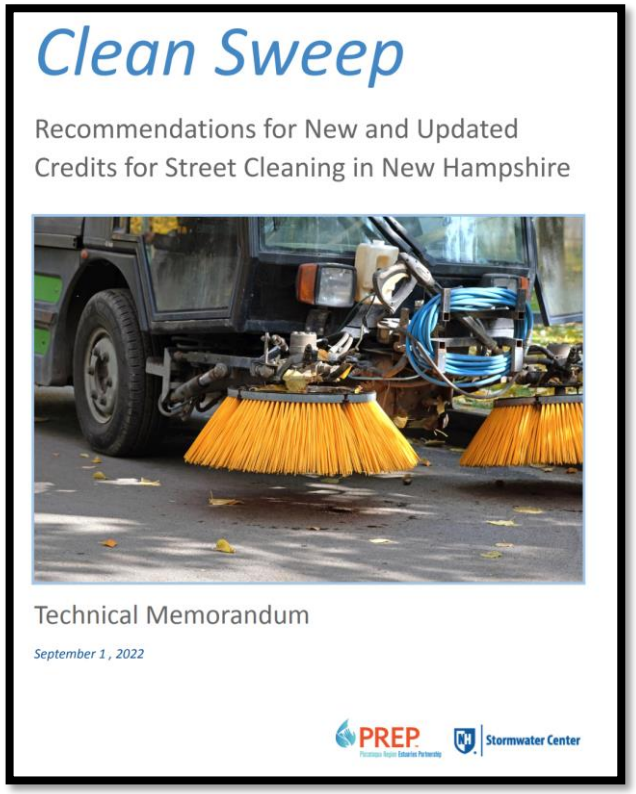
Street Tree Canopy

- More canopy = more leaf litter that can be removed

Relative importance for phosphorus reduction

MS4 Phosphorus Reduction Credit for Leaf Collection and Street Cleaning

- Wisconsin, Minnesota, and New Hampshire have developed phosphorus reduction credits to MS4s with qualifying street cleaning programs



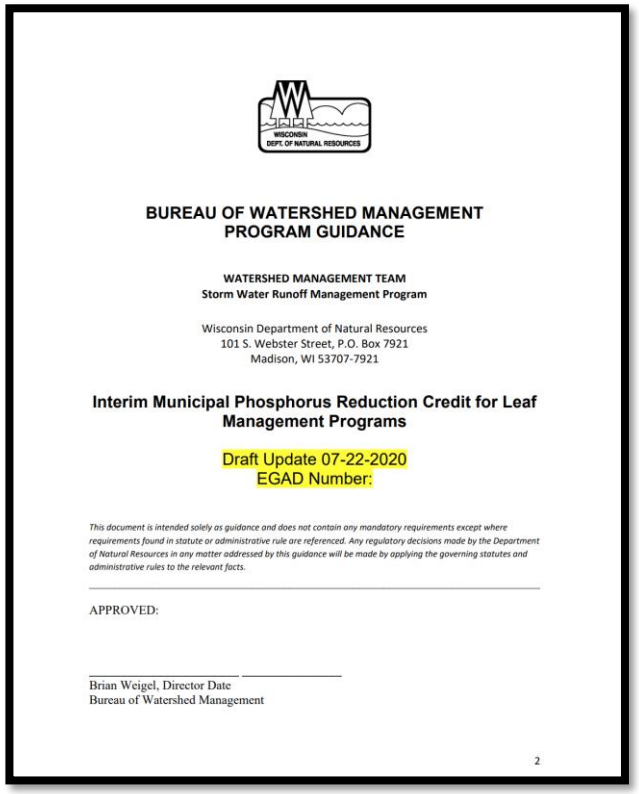
Clean Sweep

Recommendations for New and Updated Credits for Street Cleaning in New Hampshire

Technical Memorandum

September 1 , 2022

PREP Stormwater Center



WISCONSIN DEPT. OF NATURAL RESOURCES

BUREAU OF WATERSHED MANAGEMENT PROGRAM GUIDANCE

WATERSHED MANAGEMENT TEAM
Storm Water Runoff Management Program

Wisconsin Department of Natural Resources
101 S. Webster Street, P.O. Box 7921
Madison, WI 53707-7921

Interim Municipal Phosphorus Reduction Credit for Leaf Management Programs

Draft Update 07-22-2020
EGAD Number:

This document is intended solely as guidance and does not contain any mandatory requirements except where requirements found in statute or administrative rule are referenced. Any regulatory decisions made by the Department of Natural Resources in any matter addressed by this guidance will be made by applying the governing statutes and administrative rules to the relevant facts.

APPROVED:

Brian Weigel, Director Date
Bureau of Watershed Management

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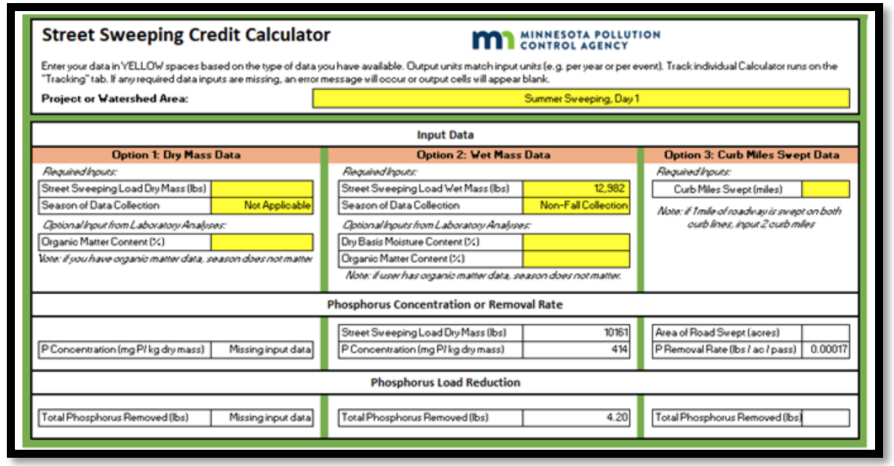


Street Sweeping Credit Calculator

MINNESOTA POLLUTION CONTROL AGENCY

Enter your data in YELLOW spaces based on the type of data you have available. Output units match input units (e.g. per year or per event). Track individual Calculator runs on the "Tracking" tab. If any required data inputs are missing, an error message will occur or output cells will appear blank.

Project or Watershed Area: Summer Sweeping, Day 1

Input Data

Option 1: Dry Mass Data		Option 2: Wet Mass Data		Option 3: Curb Miles Swept Data	
Required Inputs:		*Required Inputs:*		*Required Inputs:*	
Street Sweeping Load Dry Mass (lbs)		Street Sweeping Load Wet Mass (lbs)	12,982	Curb Miles Swept (miles)	
Season of Data Collection	Not Applicable	Season of Data Collection	Non-Fall Collection	*Note: if 1 mile of roadway is swept on both curb lines, input 2 curb miles*	
Optional Input from Laboratory Analyses:		*Optional Input from Laboratory Analyses:*			
Organic Matter Content (%)		Dry Basis Moisture Content (%)			
Note: if you have organic matter data, season does not matter		Organic Matter Content (%)			
		Note: if user has organic matter data, season does not matter.			

Phosphorus Concentration or Removal Rate

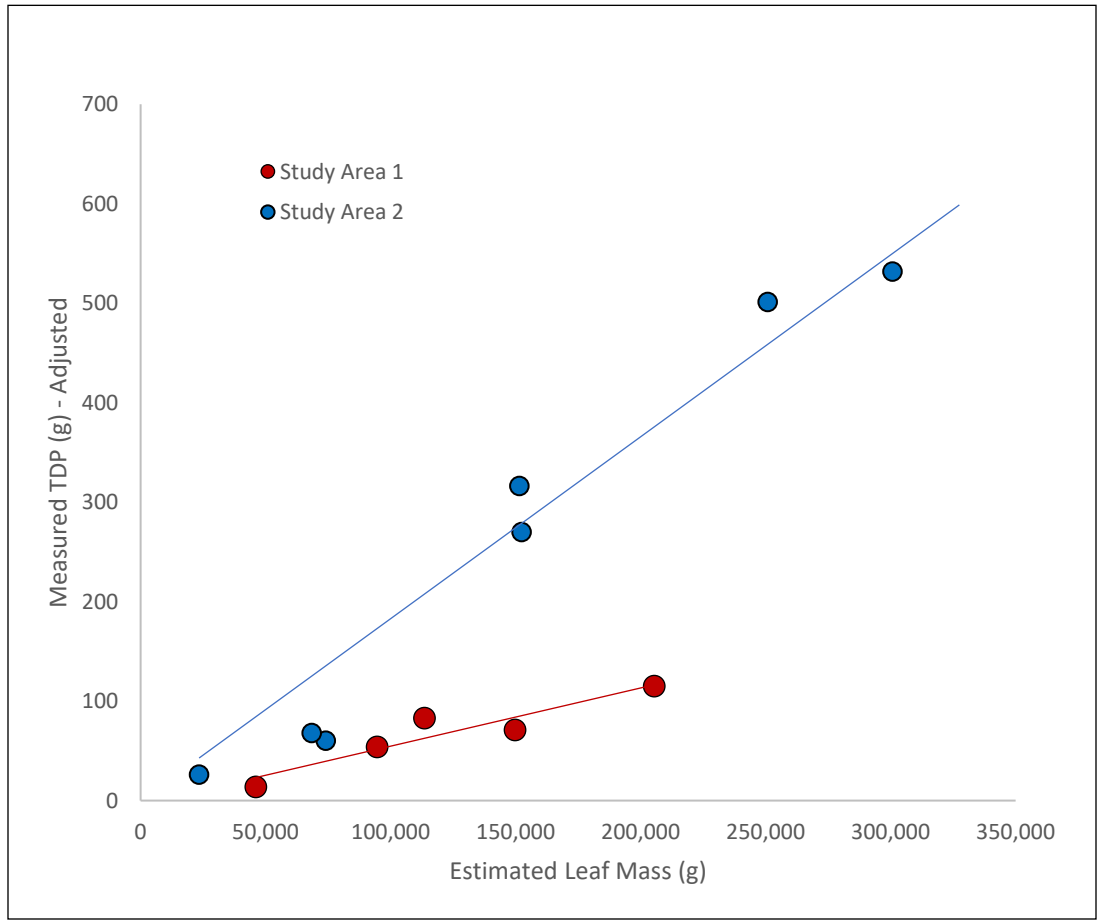
P Concentration (mg P/kg dry mass)	Missing input data	Street Sweeping Load Dry Mass (lbs)	10161	Area of Road Swept (acres)	
		P Concentration (mg P/kg dry mass)	414	P Removal Rate (lbs / ac / pass)	0.00017

Phosphorus Load Reduction

Total Phosphorus Removed (lbs)	Missing input data	Total Phosphorus Removed (lbs)	4.20	Total Phosphorus Removed (lbs)	

How best to incorporate into models?

Regression models



Journal of Environmental Management 315 (2022) 115171

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Predictive models of phosphorus concentration and load in stormwater runoff from small urban residential watersheds in fall season

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ARTICLE INFO

Keywords:
Phosphorus
Multiple linear regression
Stormwater management
Urban street trees
Leaf management

ABSTRACT

Urban street trees are a key part of public green infrastructure in many cities, however, leaf litter on streets is a critical biogenic source of phosphorus (P) in urban stormwater runoff during Fall. This study identified mass of street leaf litter (M_{leaf}) and antecedent dry days (ADD) as the top two explanatory parameters that have significant predictive power of event end-of-pipe P concentrations through multiple linear regression (MLR) analysis. M_{leaf} and volume of runoff (Vol) were the top two key explanatory parameters of event end-of-pipe P loads. Two-predictor MLR models were developed with these explanatory parameters using a 40-storm dataset derived from six small urban residential watersheds in Wisconsin, USA, and evaluated using storms specific to each study basin. The MLR model validation results indicated sensitivity to storm composition in the datasets. Our analysis shows selected parameters can be used by environmental managers to facilitate end-of-pipe P prediction in urban areas. This information can be used to reduce the amount of P in stormwater runoff by adjusting the timing and frequency of municipal leaf collection and street cleaning programs in urban areas.

1. Introduction

Urban stormwater runoff with excessive amounts of nutrients has significant potential to cause water quality degradation, such as eutrophication, in receiving waters (Novotny et al., 1985; Brezonik et al., 2002; Francey et al., 2010; May et al., 2013; Melcher and Horsburgh, 2017). To mitigate adverse impacts and meet water quality targets and standards set by regulatory authorities (e.g., Total Maximum Daily Load determined by U.S. Environmental Protection Agency under the U.S. Clean Water Act), an effective stormwater quality management plan is needed (Settle et al., 2007; Yang and Lusk, 2018). A best management practice is stormwater source control, or managing stormwater runoff as its source and preventing nutrients from entering the stormwater drainage system (Clar et al., 2004; Martin et al., 2007; Landsman and Davis, 2018).

A key nutrient affecting stormwater quality is phosphorus (P), which is a major contributor to eutrophication in freshwaters (Settle et al., 2007). In urban residential watersheds, multiple P sources that vary temporally and spatially contribute to end-of-pipe P in stormwater (Smil, 2000; Yang and Toor, 2017). Potential P sources in stormwater runoff include street leaf litter, pet/animal wastes, atmospheric deposition, near-street open lawns/turfgrass, and soil fertilizer (Jassby et al., 1994; Migon and Sandroni, 1999; Brezonik and Stadelmann, 2002; Némery et al., 2005; Hobbie et al., 2017).

Street leaf litter has been identified as an important P source, especially in fall seasons, in urban residential watersheds (Dorney, 1986; Schreeg et al., 2013; Selbig, 2016; Janke et al., 2017). During a storm event, soluble P from leaf litter is extracted and transported by stormwater to the watershed outlet through the drainage system, thereby contributing to end-of-pipe P concentration and load (Allison et al., 1998; Schreeg et al., 2013; Janke et al., 2017). Because of the paucity of in-depth knowledge on the complex generation and transport mechanisms underlying P in stormwater runoff and the influence of rainfall, as well as various watershed characteristics (Brezonik and Stadelmann, 2002; May et al., 2013; Li et al., 2015), statistical approaches have shown advantages for quantifying end-of-pipe P concentration and load (Adams and Papa, 2001; Li et al., 2015). The data needed for establishing statistical models can be collected through stormwater quality monitoring programs. Compiling and analyzing monitored data to develop statistical regression models that predict end-of-pipe P

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Leachable phosphorus from senesced green ash and Norway maple leaves in urban watersheds

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[b] U.S. Geological Survey, Upper Midwest Water Science Center, Middleton, WI 53562, United States

HIGHLIGHTS

- Tree leaf litter is a source of phosphorus (P) in urban stormwater runoff.
- Leaf litter P release varies with species, degree of fragmentation and age.
- Norway Maple leaf litter released more dissolved P than Green Ash.
- Equations were developed to predict time-variable P release from leaf litter.

GRAPHICAL ABSTRACT

ARTICLE INFO

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Editor: Jay Gan

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Street trees
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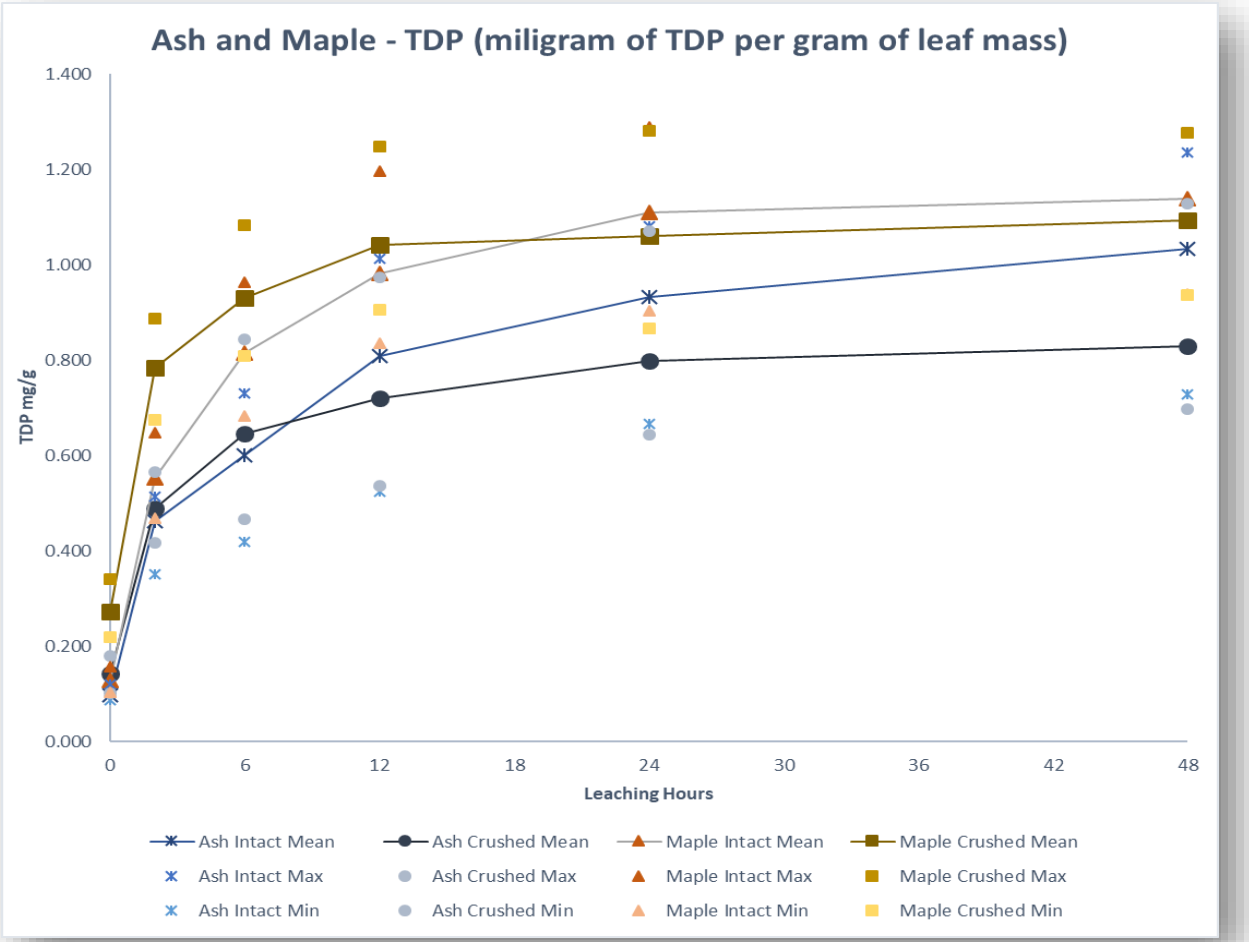
Nutrient leaching dynamics
Species-effects
Environmental conditions

ABSTRACT

In urban watersheds, street tree leaf litter is a critical biogenic source of phosphorus (P) in stormwater runoff. Stormwater extracts P from leaf litter and transports it, through the storm sewer network, to a receiving waterbody potentially causing downstream eutrophication. The goal of this study is to understand P leaching dynamics of two prevalent tree species (Norway maple (*Acer platanoides*) and green ash (*Fraxinus pennsylvanica*)) in three urban residential watersheds in Madison, Wisconsin, USA. Leaf litter was collected from the three basins during Fall 2017 and 2018. Laboratory experiments showed an initial rapid total dissolved phosphorus (TDP) release that gradually plateaued over a 48-hour period. The total TDP released from Norway maple (2.10 mg g^{-1}) was greater than from green ash (1.60 mg g^{-1}). Within the same species, increased fragmentation of leaves led to more rapid initial TDP release, but not greater total TDP release. Increased aging of senescent leaves decreased total TDP release. Incubation temperature and volume of water in contact with leaves may not be critical factors affecting TDP leaching dynamics. Predictive equations were derived to characterize time-variable TDP release of both Norway maple and green ash leaves. Potential TDP release from leaf litter estimated using these equations was compared with field-measured end-of-pipe TDP loads in one of the study watersheds. Our results indicate that preventing leaf litter from accumulating in streets is an important stormwater quality control measure.



Urban Forestry & Urban Greening 56 (2020) 126826

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Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug

An Assessment of Street Tree Diversity: Findings and Implications in the United States

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ARTICLE INFO

Handling Editor: Wendy Chen

Keywords:
Management
Plant Selection
Resilience
Tree Diversity
Urban Forestry

ABSTRACT

Integrating tree species diversity into urban forest management can help create resilient tree populations. In this study, the abundance of trees within families, genera, and species levels was determined through a system

Midwest Region

Species	Places[1] (N)	Mean[2] (%)	SEM[3]
Acer platanoides	34	4.9	0.6
Acer saccharinum	37	4.7	0.7
Fraxinus pennsylvanica	31	4.3	0.5
Gleditsia triacanthos	48	4.2	0.3
Acer rubrum	25	2.5	0.3
Acer saccharum	17	1.1	0.1
Tilia cordata	11	0.7	0.1
Celtis occidentalis	12	0.7	0.1
Quercus palustris	7	0.7	0.1
Fraxinus americana	9	0.6	0.1

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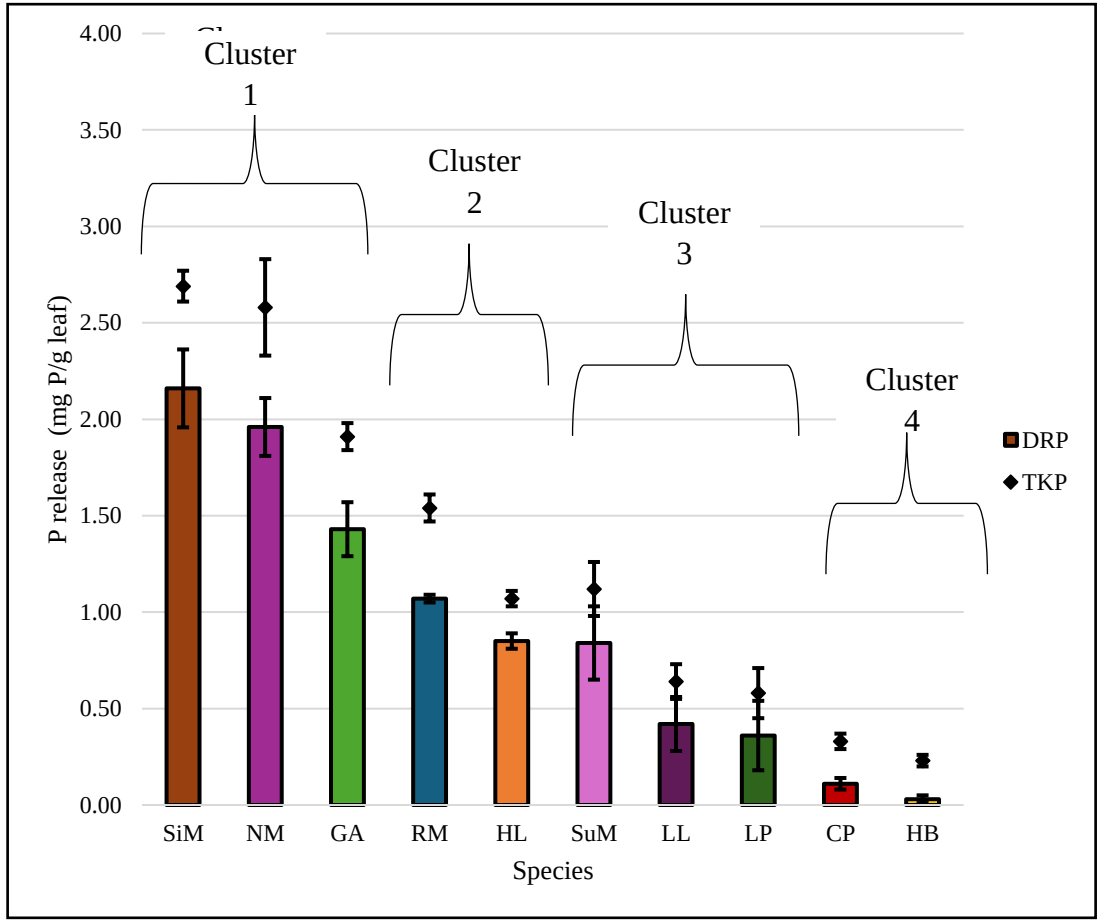
UNIVERSITY OF WISCONSIN–MADISON



TreeKeeper

Welcome, Guest

search

City of Madison, WI

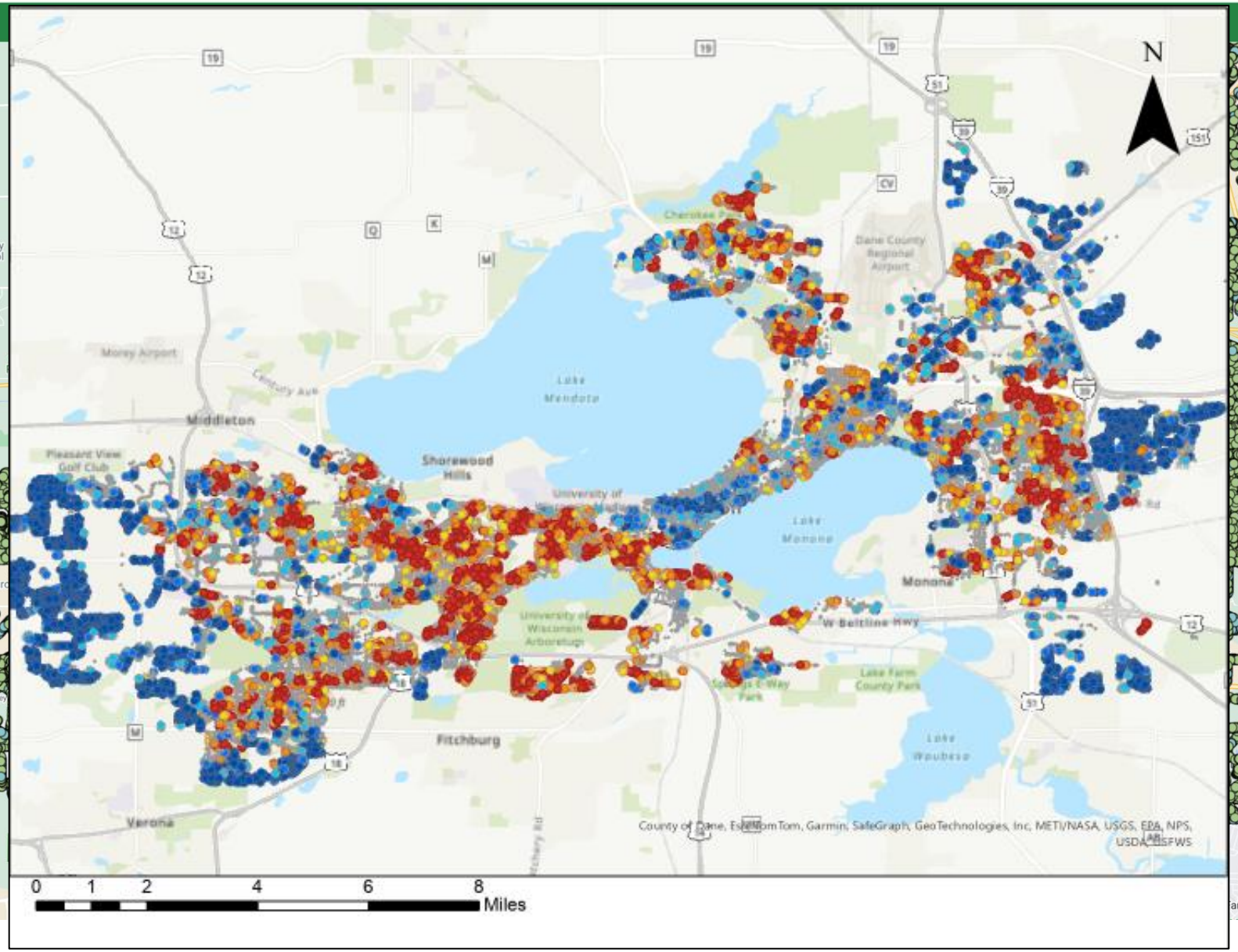
Active Layers

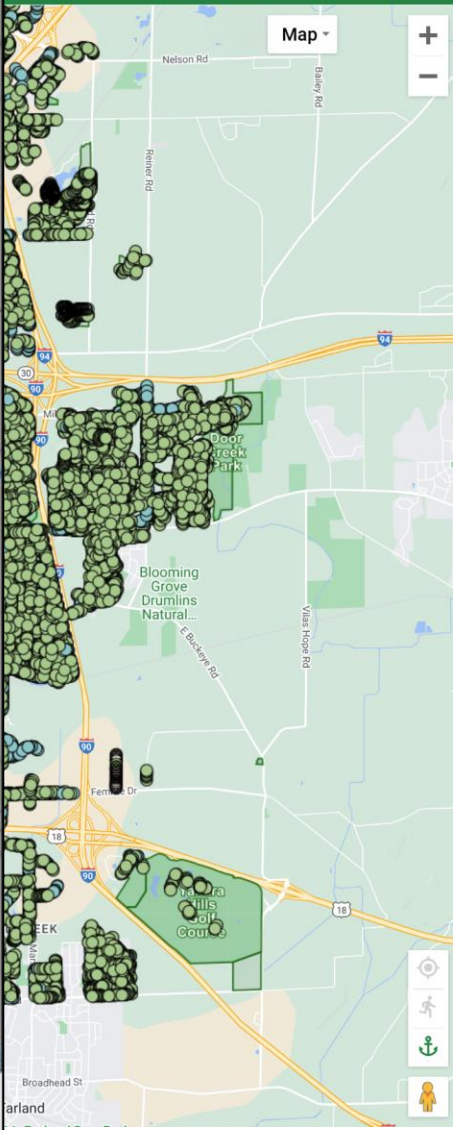
Hide All

- Selected
- Selected Park Trees
- ROW Trees
  - Trees
  - Stump
  - Vacant
  - TBD
- Park Trees
- ~Parks [shapefile]

Inactive Layers

- Selected Layers (0)
- Layers (0)
- Reference Layers (0)





i-Tree Stormwater Credits | Home | Project | Menu | i-Tree | Status | Feedback

Welcome to the i-Tree Stormwater Credit Calculator!

The i-Tree Stormwater Credit Calculator is designed to help you estimate the reduced pollutant loading and stormwater runoff from a tree planting project. The goal of this calculator is to provide an accessible, accurate, and consistent basis to inform stormwater credits for trees.

Users enter the following information:

- Species
- Diameter at breast height (in)
- Impervious cover (%)
- Soil type
- Land use
- Number of years to project tree growth
- The number of trees with each configuration

The following information is calculated for all trees in the project:

- Annual and average daily reduction in pollutant loading
- Annual and average daily reduction in stormwater runoff volume
- Nutrient (P) content in annual leaf drop

i-Tree™

Stormwater Credits

Get Started

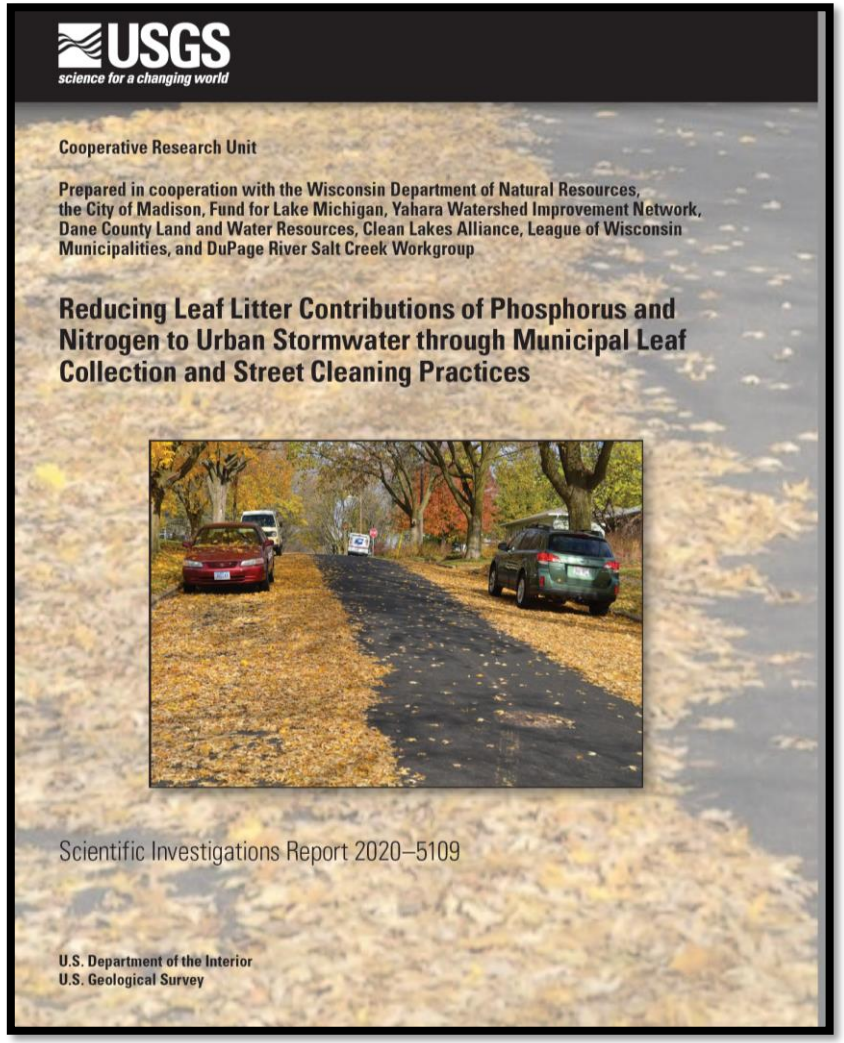
Use of this tool indicates acceptance of the EULA.

How does leaf management influence downstream BMP performance?

By reducing phosphorus at its source, do other BMPs gain or lose efficiency?

- Wet ponds
- Are models “double-dipping”?

https://images.app.goo.gl/tk68gkJxcPYCKe2x5



Bill Selbig
USGS – Upper Midwest Water Science Center
wrselbig@usgs.gov

Publications:

Evaluation of leaf removal as a means to reduce nutrient concentrations and loads in urban stormwater, *Science of the Total Environment* 571, pp. 124 – 133. http://dx.doi.org/10.1016/j.scitotenv.2016.07.003

Selbig, W.R., Buer, N., Bannerman, R.T., and Gaebler, P. 2020, Reducing Leaf Litter Contributions of Phosphorus and Nitrogen to Urban Stormwater through Municipal Leaf Collection and Street Cleaning Practices, USGS Scientific Investigations Report 5109, 17 p., https://doi.org/10.3133/sir20205109

Cooperators:

- Wisconsin DNR
- U.S. Geological Survey
- Dane County, WI
- DuPage County, IL
- City of Madison
- City of Fond du Lac
- City of Oshkosh
- League of Wisconsin Municipalities
- Fund for Lake Michigan
- Clean Lakes Alliance
- Madison Metropolitan Sewerage District