Advancing Statewide Phosphorus Reduction Credits for Municipal Leaf Collection

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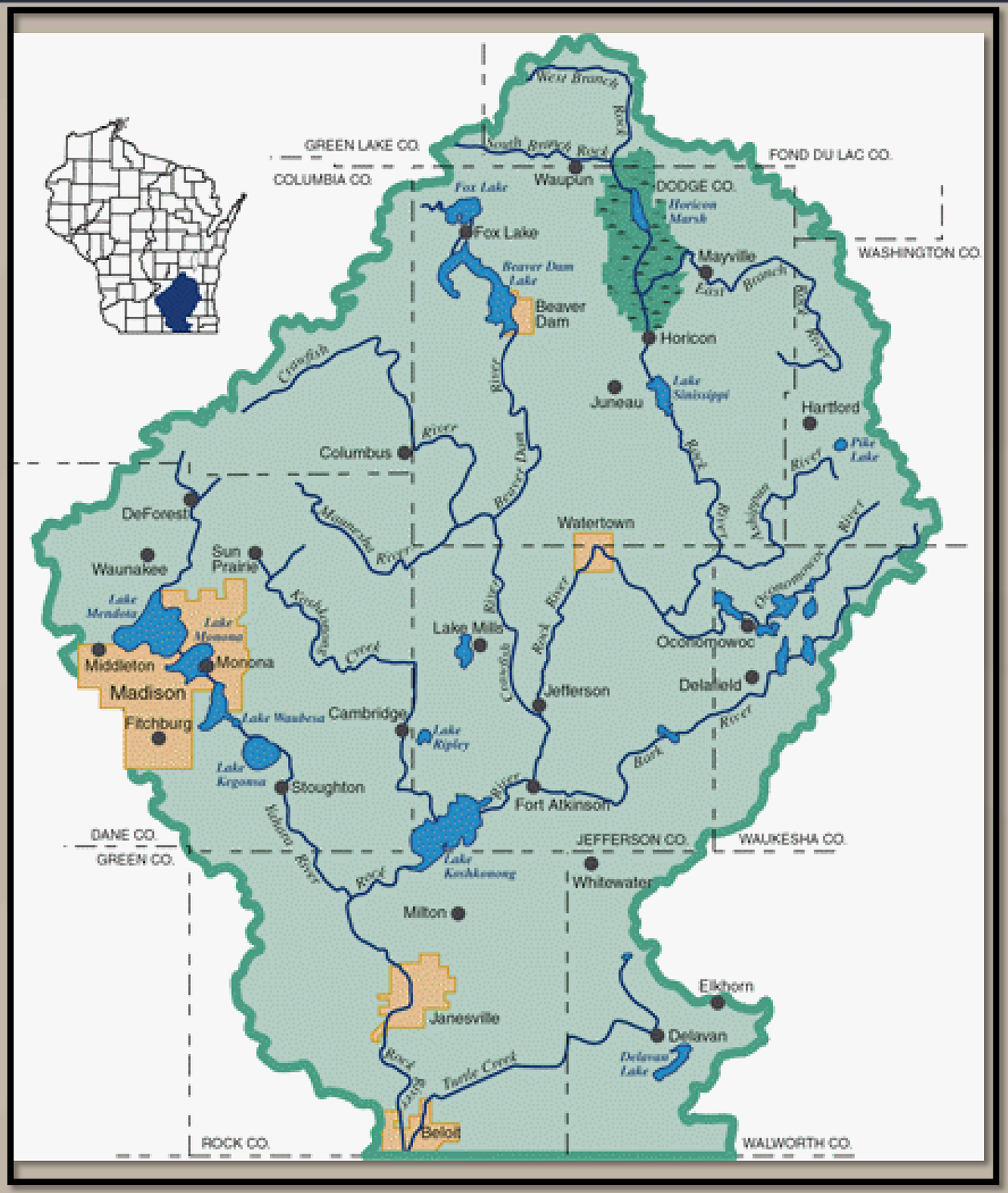
Leaf Collection to Reduce Phosphorus - Pilot Study



Source: Rock River Coalition

- Agricultural and urban sources of phosphorus are targeted in the Adaptive Management plan for Rock River TMDL
- Leaf collection identified as reasonable measure to reduce Total P delivered to lakes
- What percent reduction in nutrients can municipal separate storm sewer systems (MS4) expect by collecting leaves?
- Are some leaf collection practices better than others?

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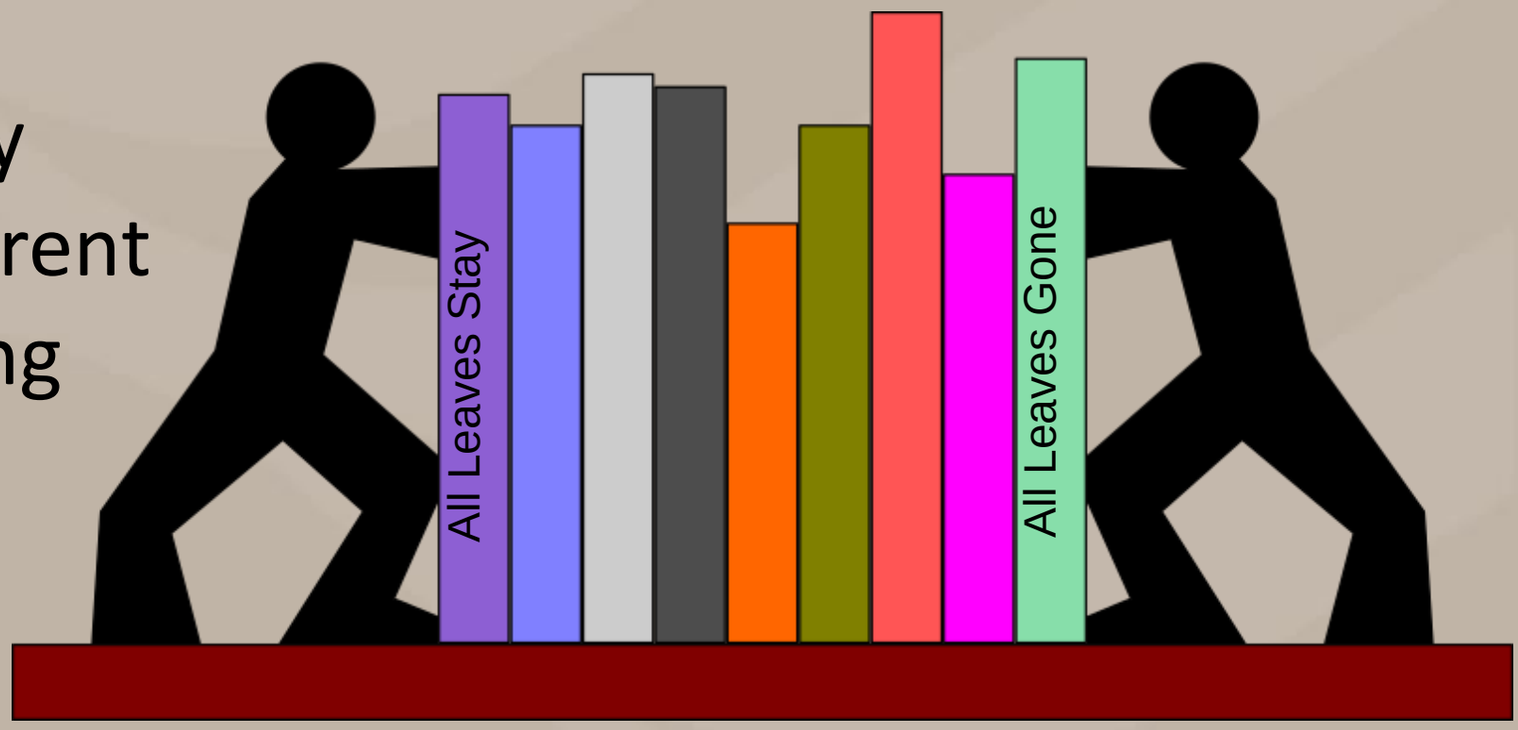
Study Objectives

1. Collect water-quality samples from a control and test basin to determine if removing leaves will result in *detectable* changes in phosphorus [“book end approach”]

2. Develop criteria to rapidly assess effectiveness of different leaf collection practices using field survey techniques



Study Timeline and Progress

- 2013 – 2017: Quantified P reduction from four different leaf collection practices
- 2016 – 2017: Added leaf mass surveys
- 2017: UW graduate student to complement study
- 2017: WDNR writes draft guidance for leaf collection credits
- 2018 – 2019: Continue quantifying P reduction for more leaf collection practices

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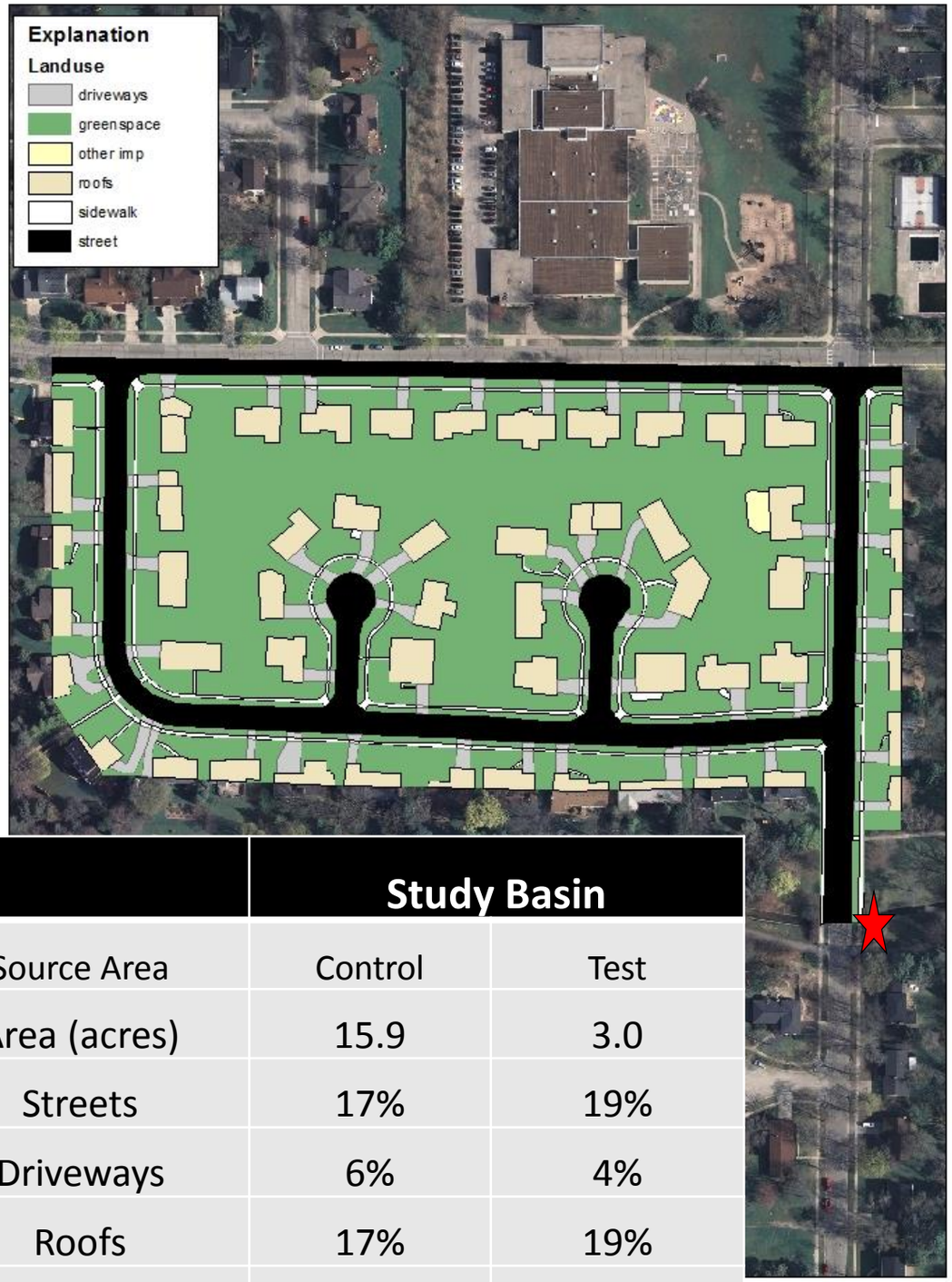
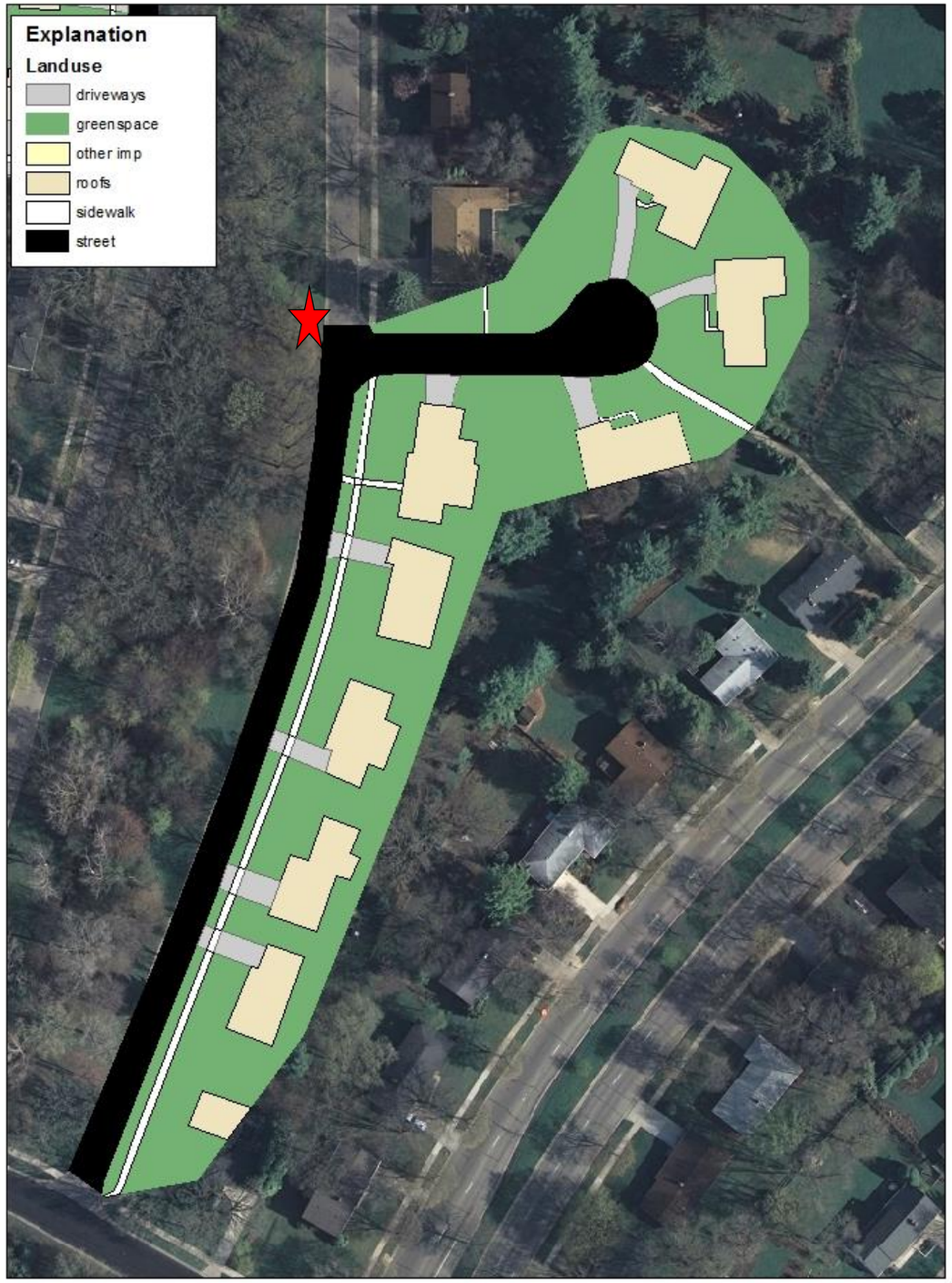
Paired Basin Study Design

Control



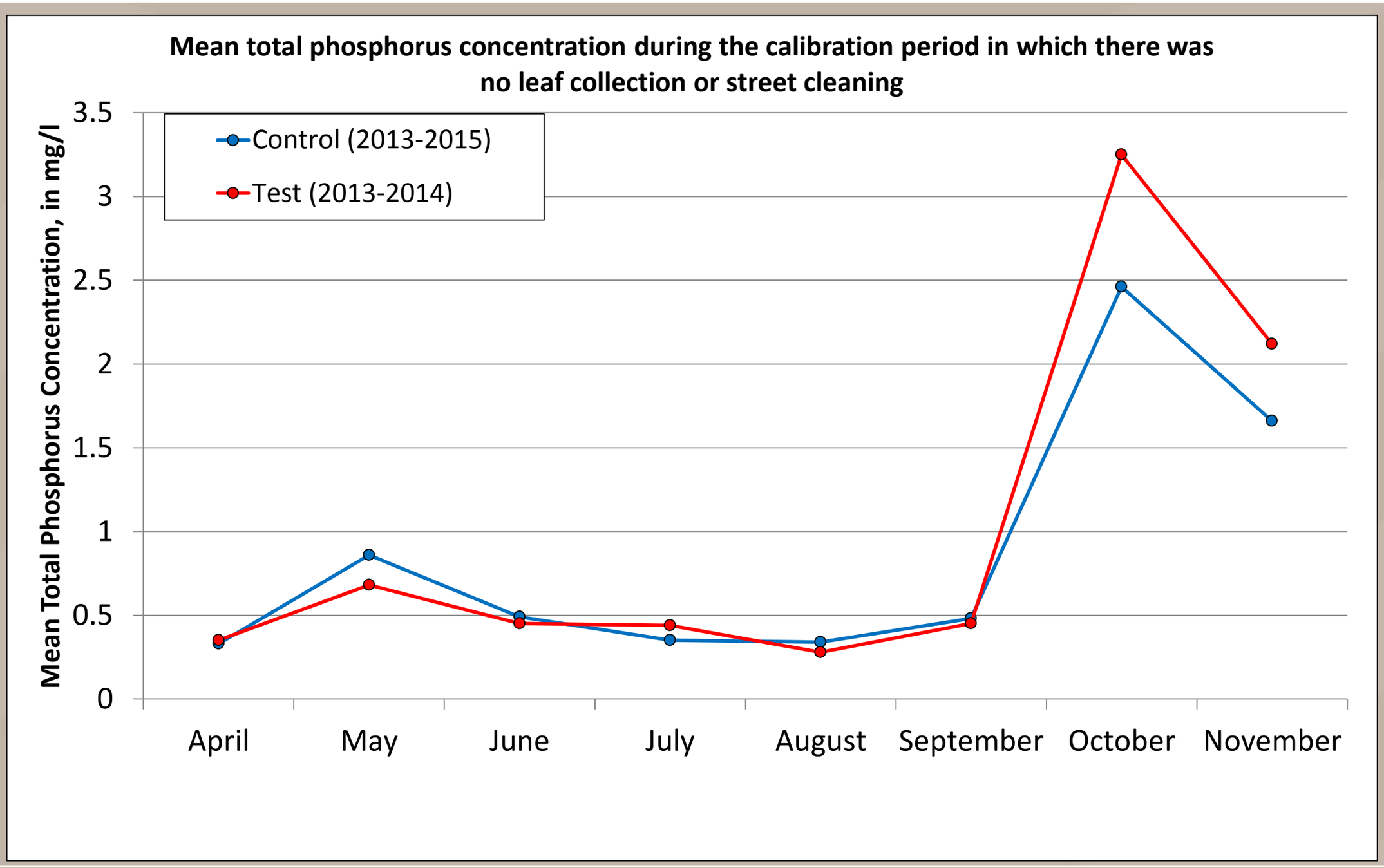
	Study Basin	
Source Area	Control	Test
Area (acres)	15.9	3.0
Streets	17%	19%
Driveways	6%	4%
Roofs	17%	19%
Sidewalks	5%	3%
Lawns/Open	55%	54%
Other Impervious	<1%	0%
Tree Cover	45%	68%

Test



USGS Monitoring Location

Photo Credit: USGS



“Escalated” Leaf Management in Test Basin

1. Weekly street cleaning in spring and summer
2. Weekly collection of leaf piles followed by street cleaning in fall

Photo Credit: USGS

Photo Credit: USGS

Plus…

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“Escalated” Leaf Management

In addition to municipal efforts, USGS field crews would clear all organic debris from street surface prior to rain event

Photo Credit: USGS

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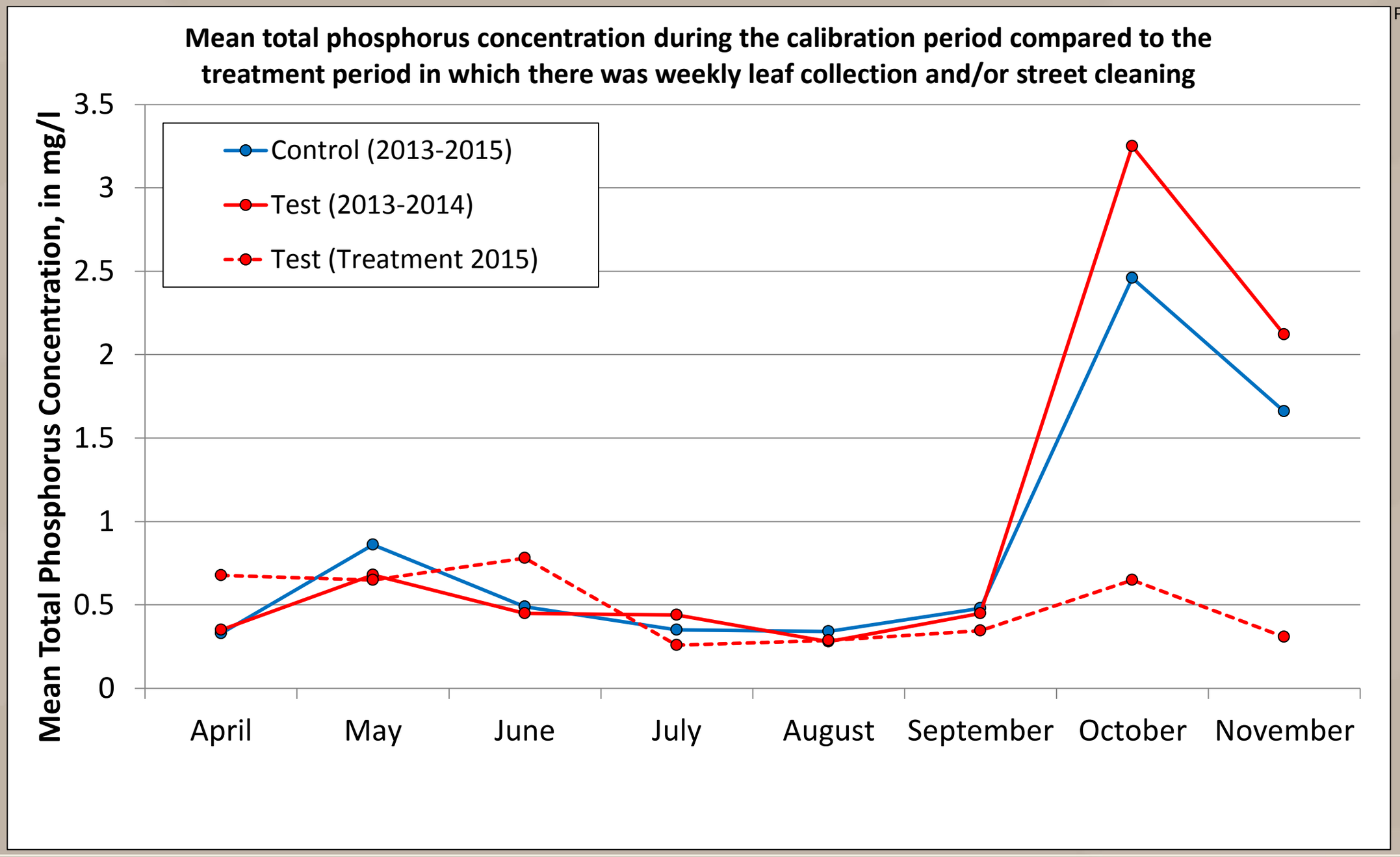
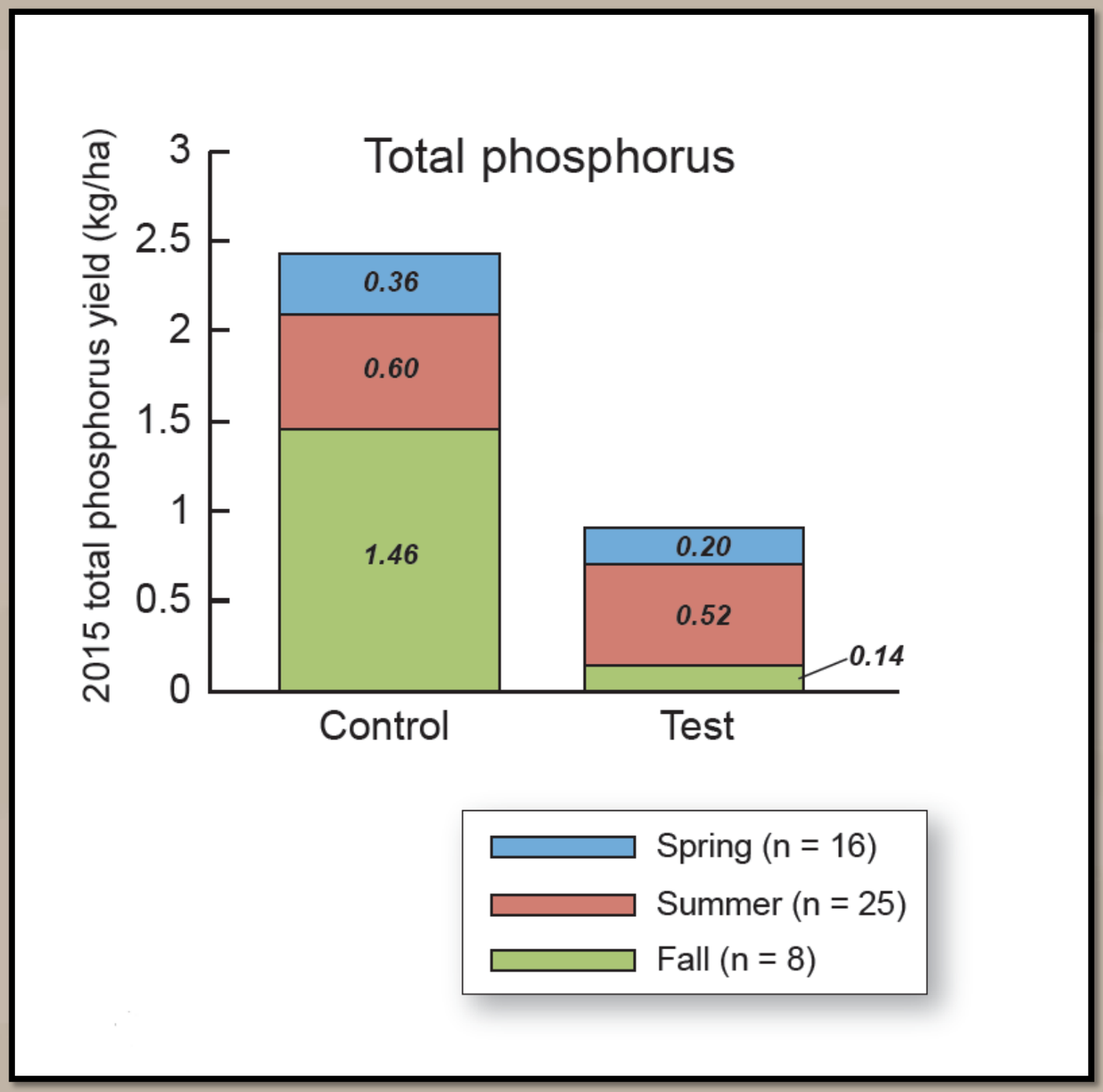
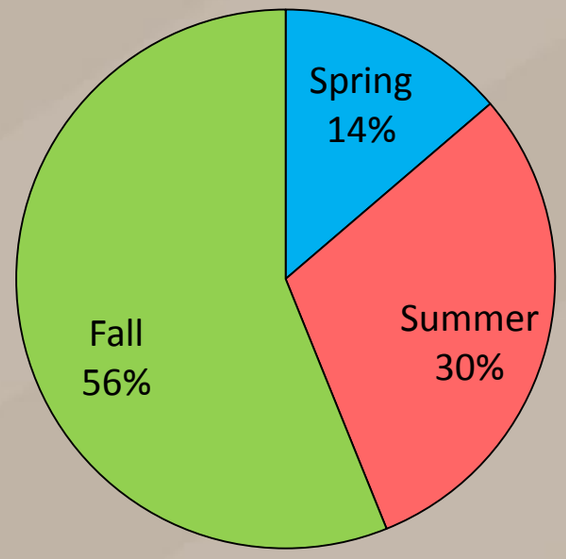


Seasonal Total Phosphorus Yield as a Percent of the 2015 Annual Yield (winter excluded)



Control



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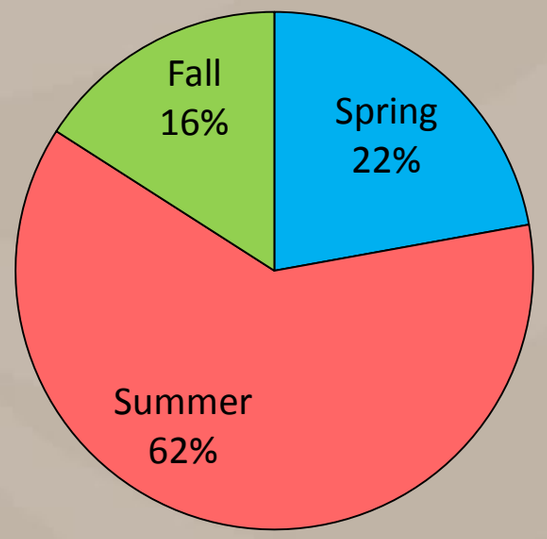
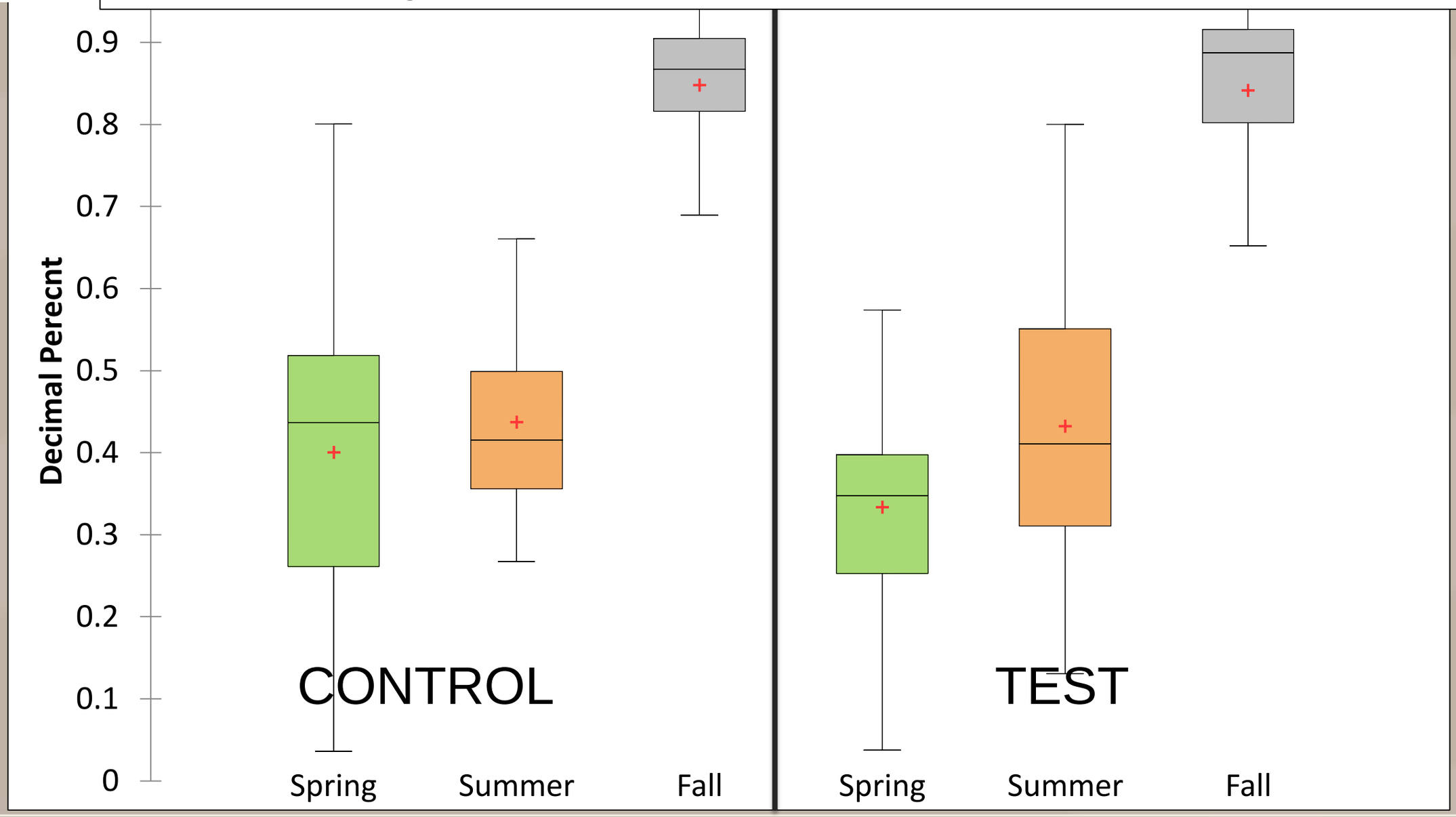
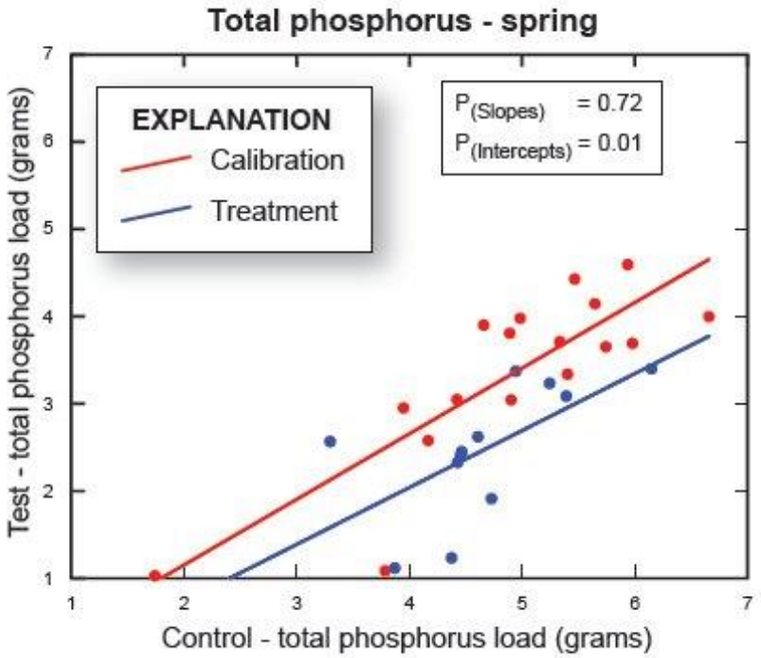


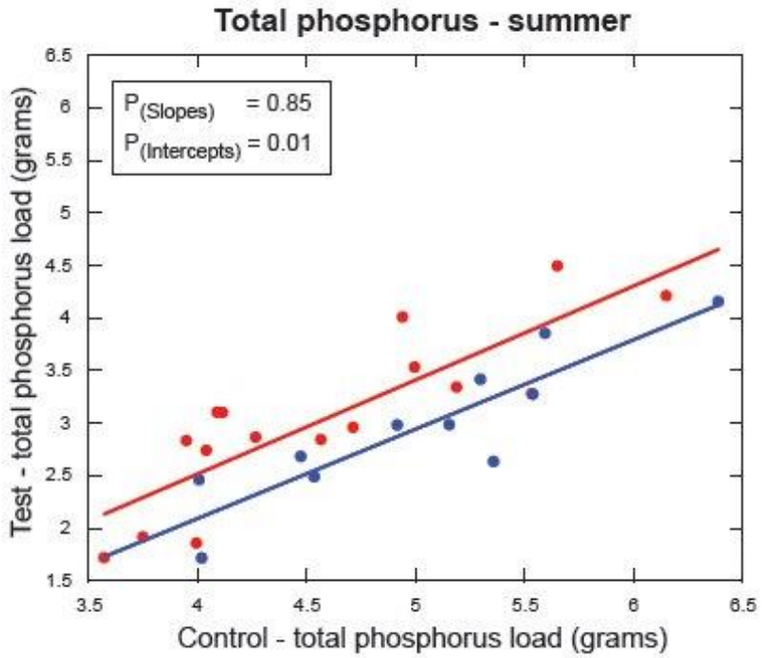
Leaf Collection One of few Options to Reduce Dissolved Phosphorus

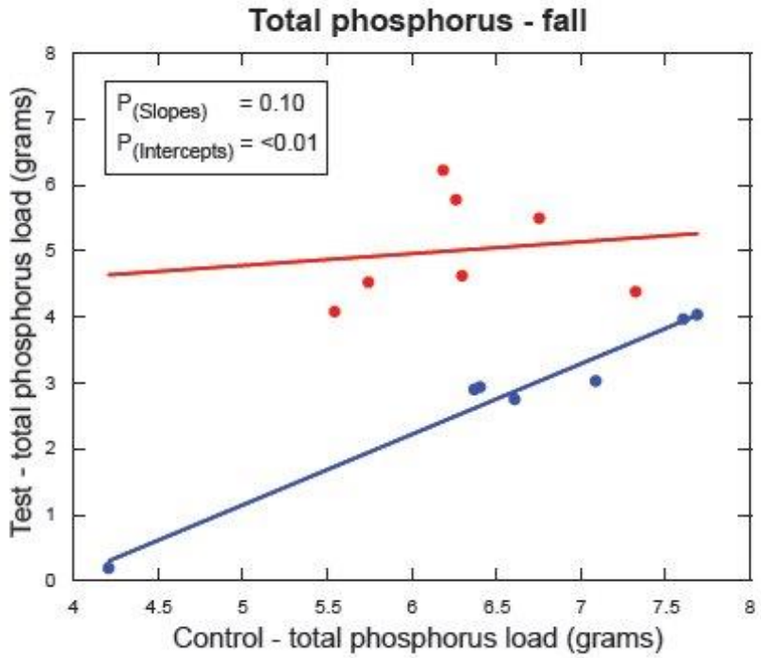
Leaf collection may be one of only a few options to reduce dissolved phosphorus since structural controls do not effectively remove the dissolved fraction.

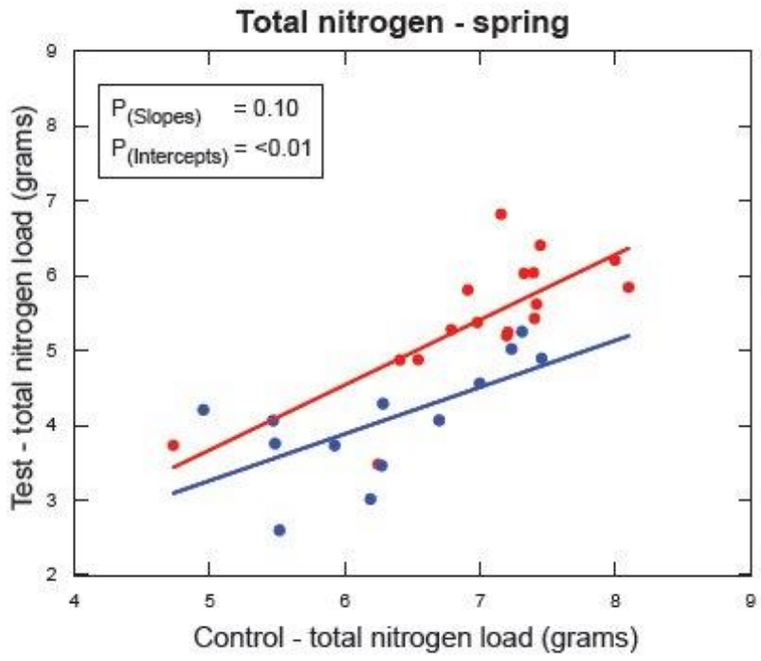


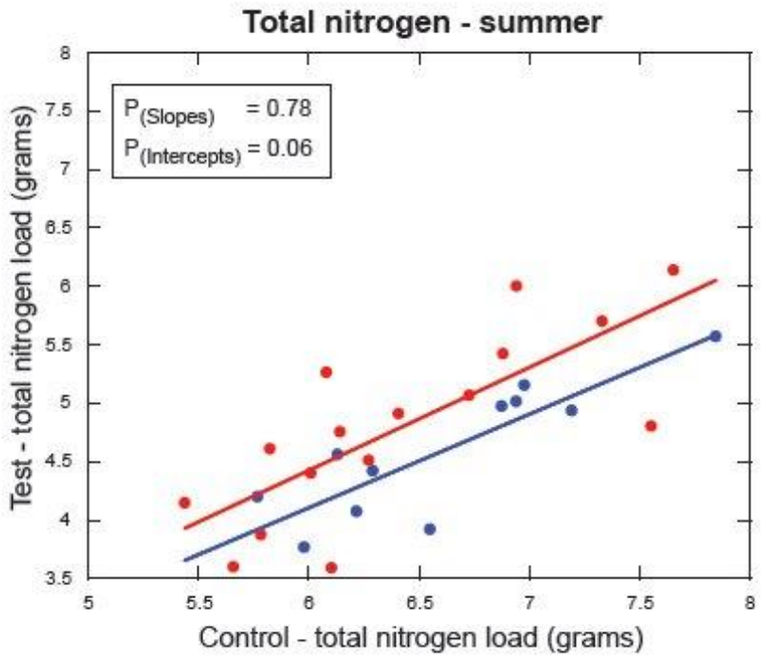
Paired Basin Results for Nutrient Load (Log), in grams

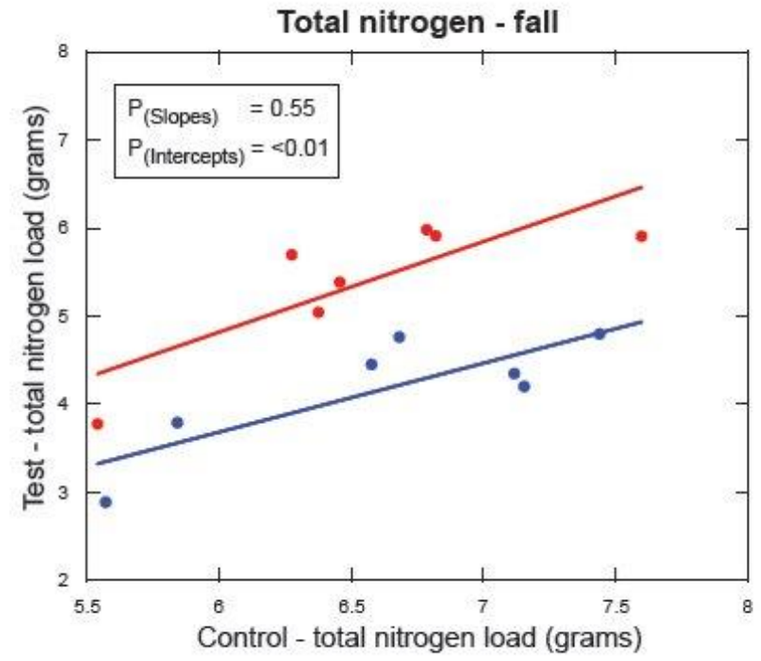












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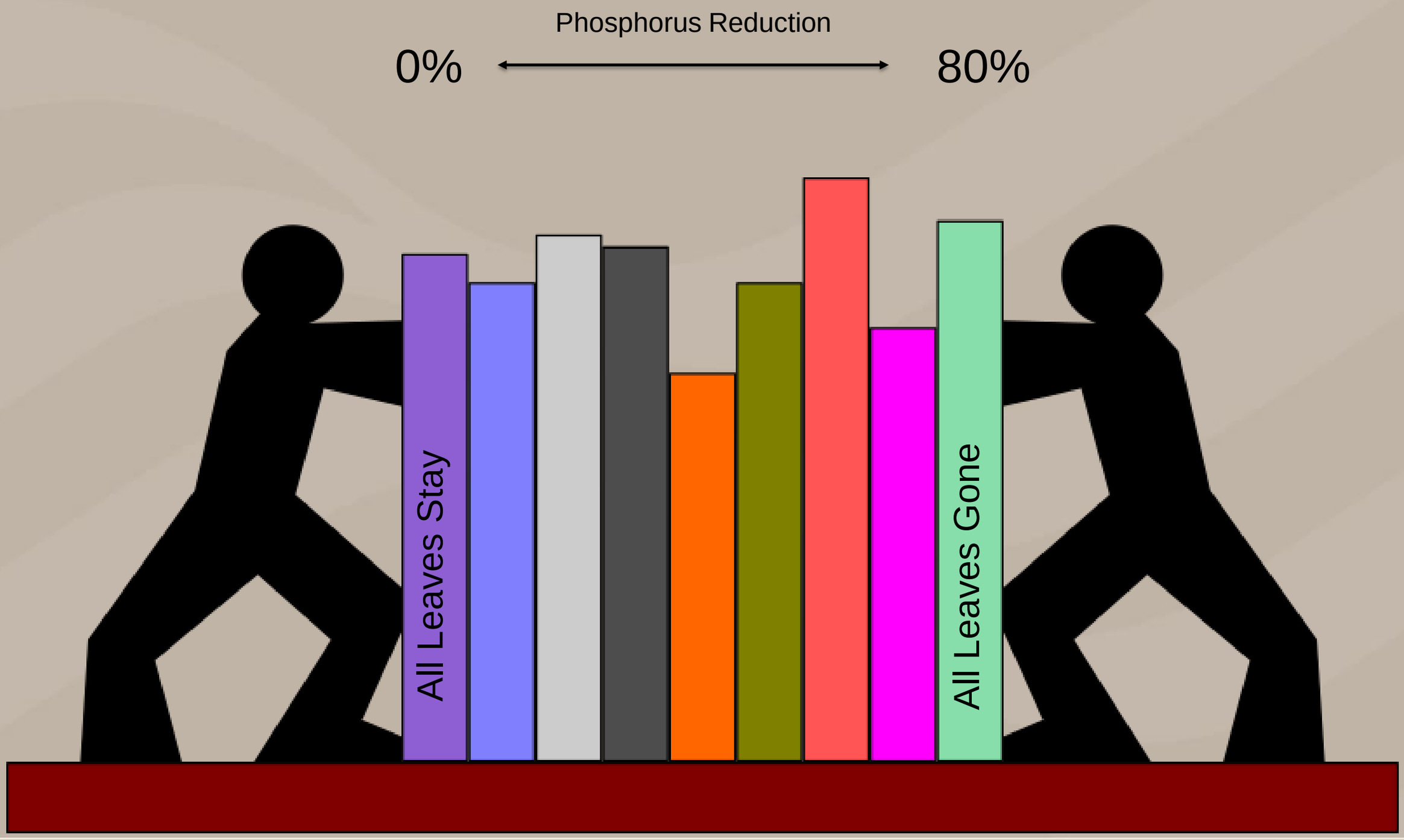
Percent Reduction in Nutrient Load - 2015

--, no statistical change

Parameter	Spring	Summer	Fall
Total Phosphorus	-45	-36	-84
Total Nitrogen	-52	--	-74
Dissolved Phosphorus	-51	--	-83
Dissolved Nitrogen	-44	--	-71

Photo Credit: USGS

How Does Your City Collect Leaves?



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Leaf Collection and Street Sweeping Practices

Leaf Collection		Street Cleaning		
Method	**Frequency**	**Method**	**Frequency**	**Year Completed**
Transfer	Weekly	Mechanical/blower	Pre-event	2015
Transfer	Biweekly	Mechanical	Biweekly	2016
Transfer	Biweekly	Regenerative Air	Weekly	2017
Vacuum	Weekly	Regenerative Air	Weekly	2017
Transfer[1]	Biweekly	Regenerative Air	Weekly	2018

[1] Medium density canopy

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Leaf Collection and Street Sweeping Practices RESULTS

Leaf Collection		Street Cleaning		
Method	**Frequency**	**Method**	**Frequency**	**Year Completed**
Transfer	Weekly	Mechanical/blower	Pre-event	2015
Transfer	Biweekly	Mechanical	Biweekly	2016
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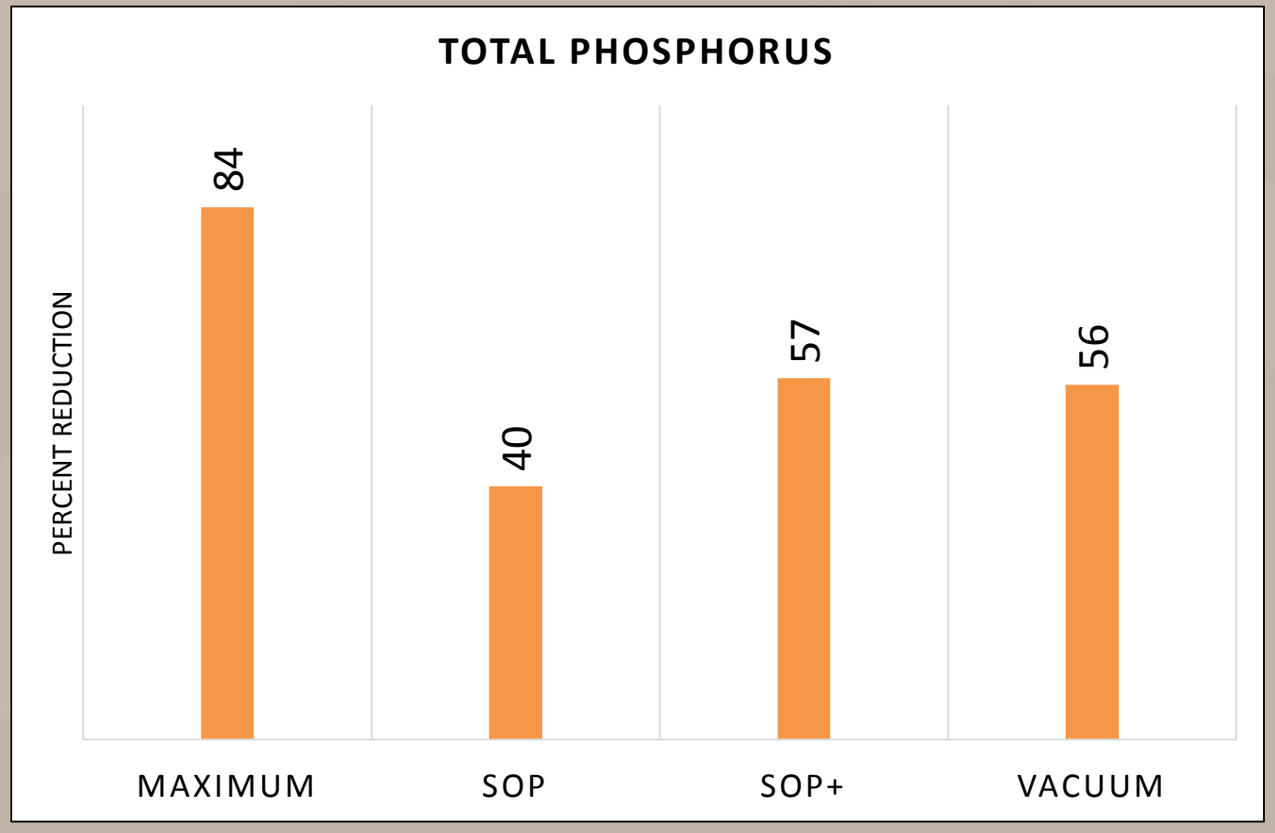
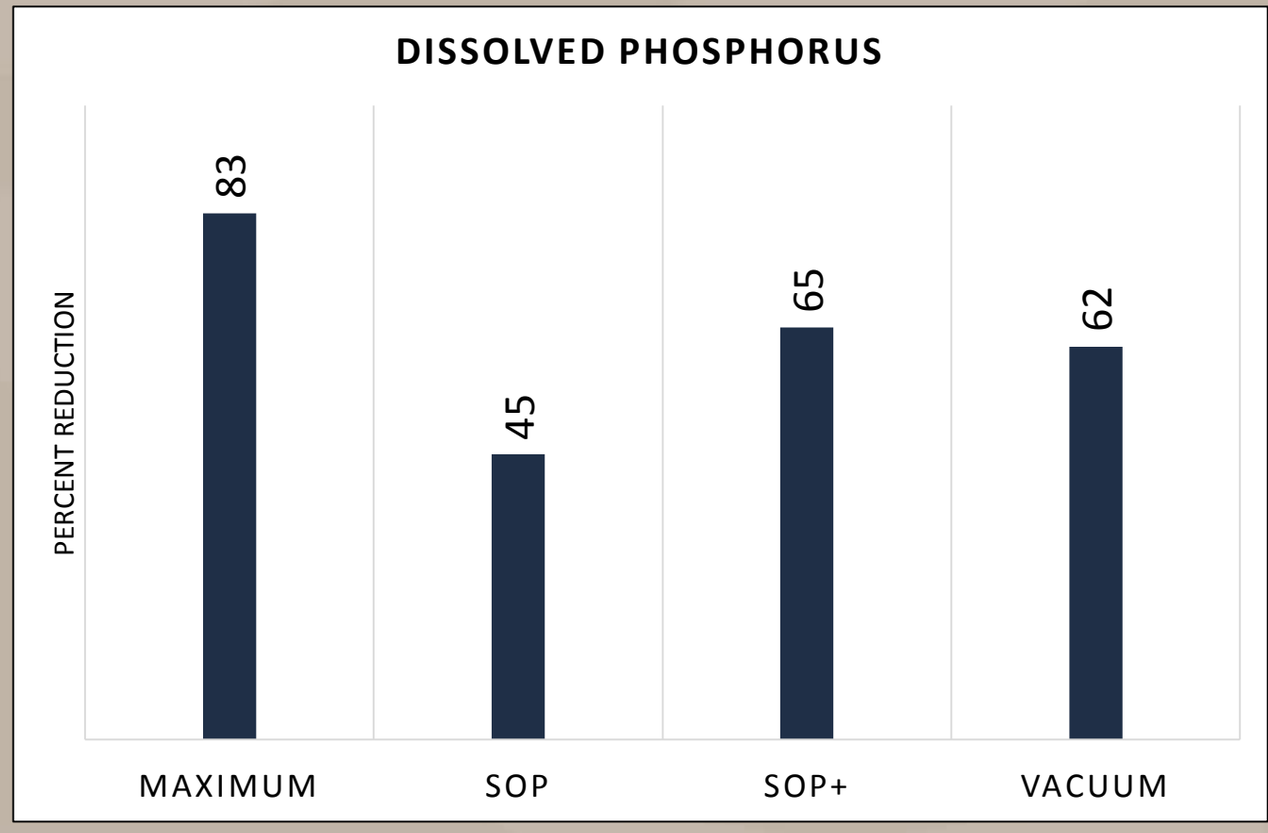
Vacuum	Weekly	Regenerative Air	Weekly	2017
Transfer[1]	Biweekly	Regenerative Air	Weekly	2018

[1] Medium density canopy





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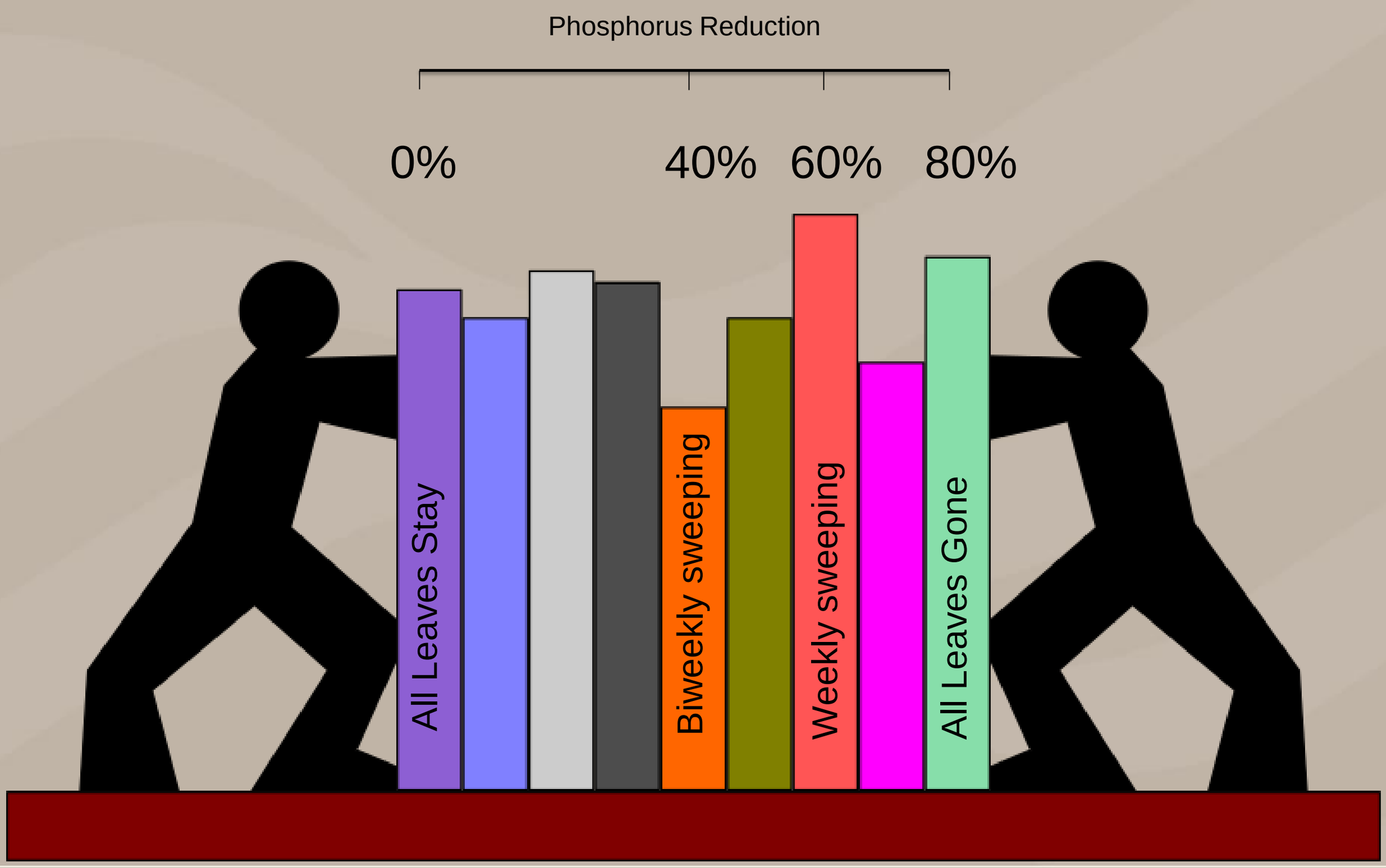
How Does Your City Collect Leaves?



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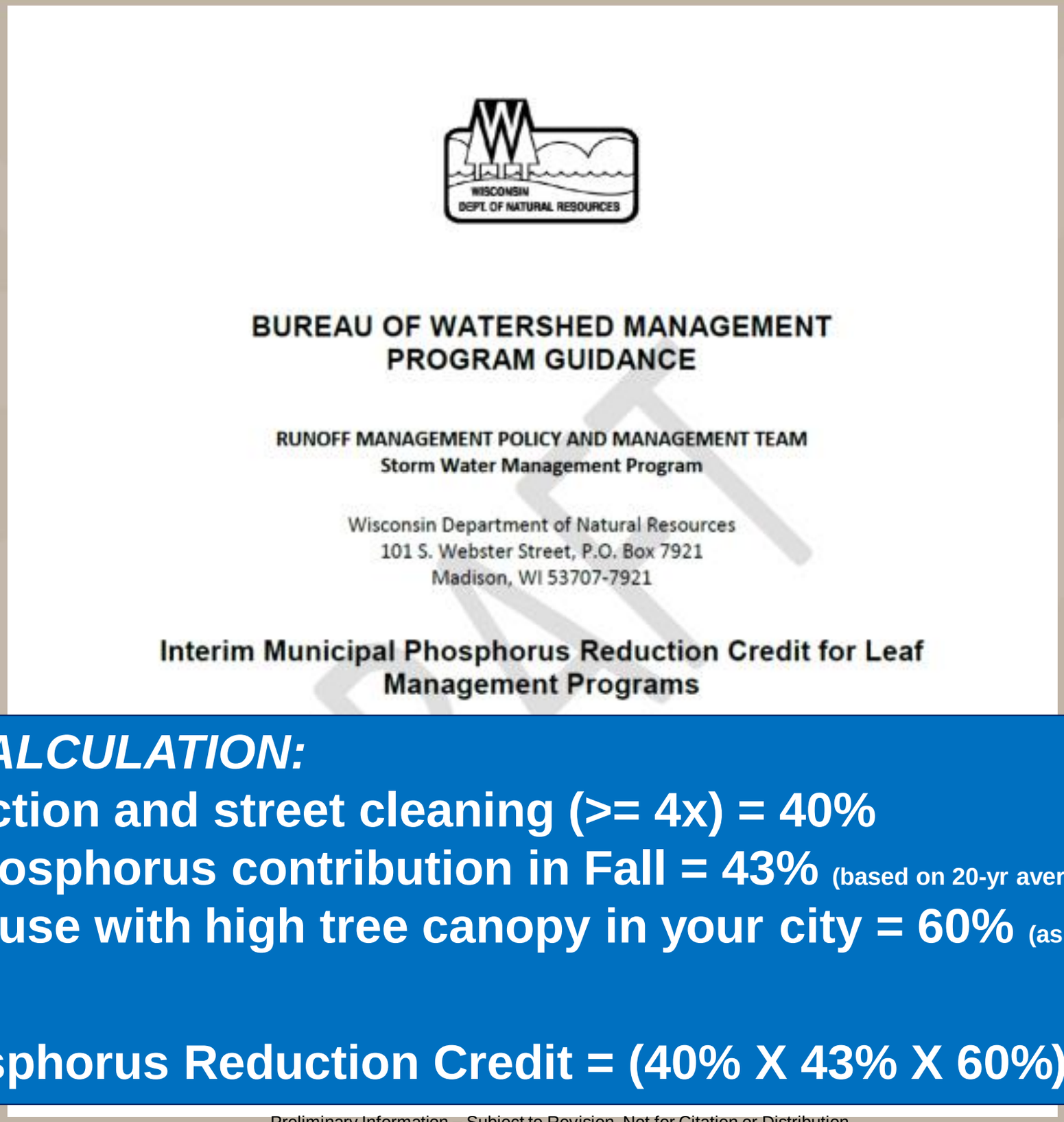
How Could a Leaf Collection Program Relate to Phosphorus Reduction Credits for Your City?



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DEPT. OF NATURAL RESOURCES

BUREAU OF WATERSHED MANAGEMENT
PROGRAM GUIDANCE

RUNOFF MANAGEMENT POLICY AND MANAGEMENT TEAM
Storm Water 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

EXAMPLE CALCULATION:

- **Leaf collection and street cleaning (>= 4x) = 40%**
- **Annual phosphorus contribution in Fall = 43%** (based on 20-yr average)
- **MDR land use with high tree canopy in your city = 60%** (as an example)

Annual Phosphorus Reduction Credit = (40% X 43% X 60%) = *10 %*

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Estimating Unit Cost of P Removal

KNOWN

- 15,774 tons of leaves collected in 2016
- $147 per ton
- Amount of P in leaves varies (0.27 – 0.95 g/lb)
- Existing Madison collection method gets 40% reduction in P

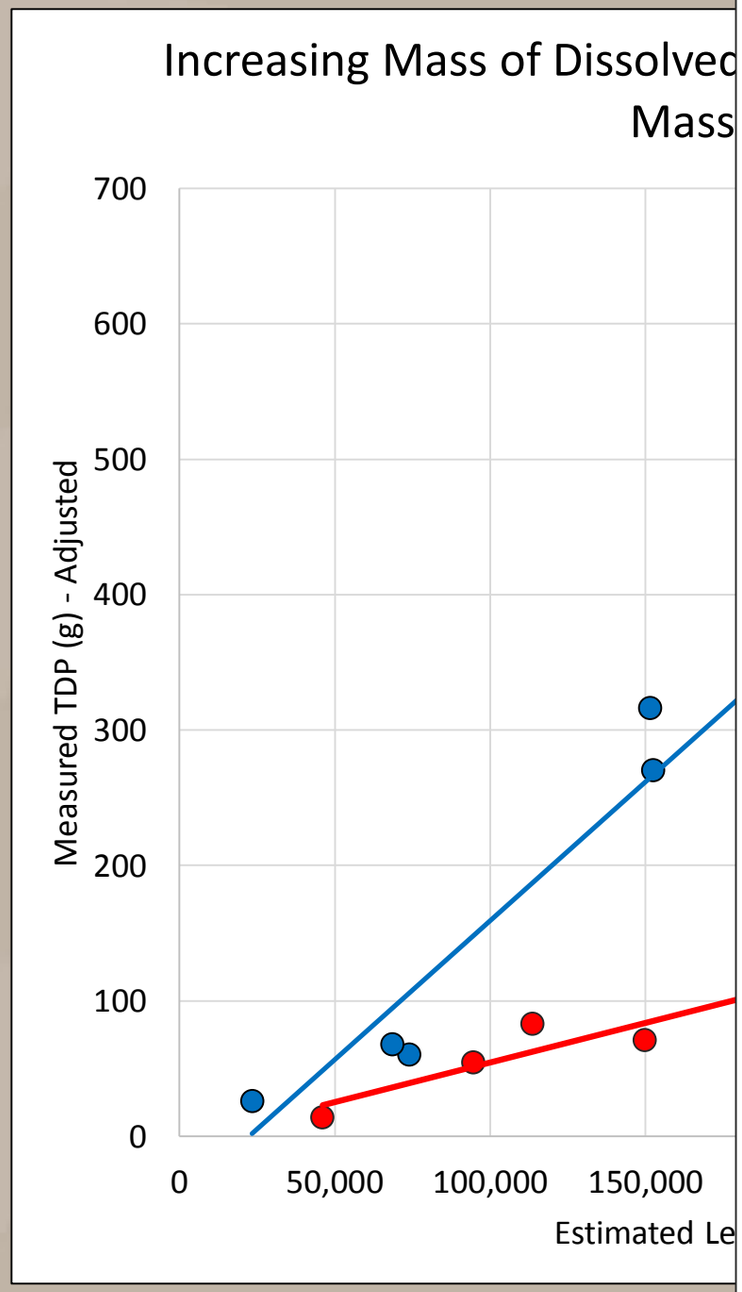
ASSUMED

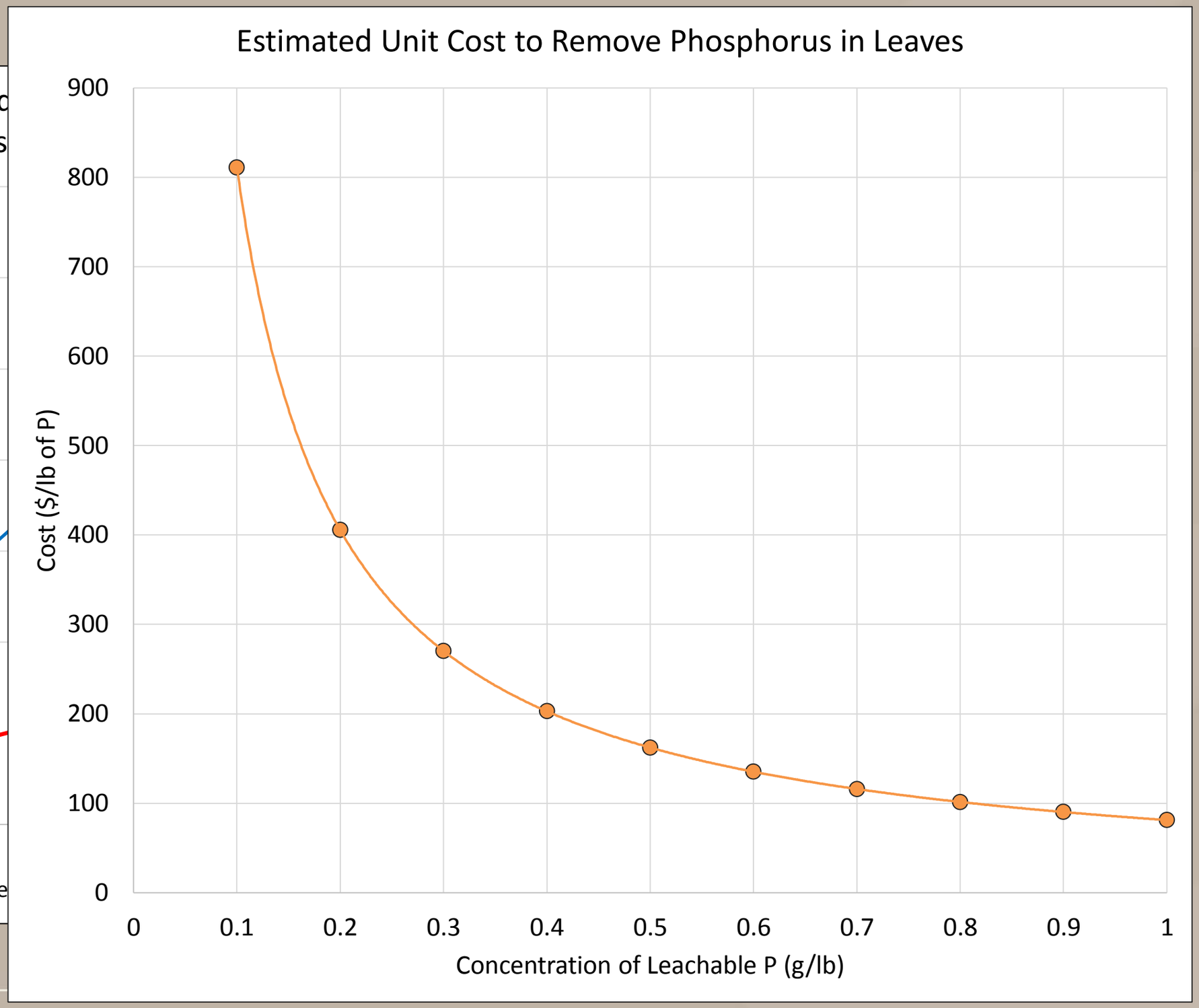
- 70% of leaves collected are from MDR
- 15-25% of MDR leaves are in street

Estimating Unit Cost of P Removal

1. 15,774 tons x 70% = 11,042 tons of leaves in MDR
2. 11,042 tons x 25% in street = 2,761 tons of leaves in street
3. 2,761 tons x $147/ton = $405,795 to collect leaves in street
4. 2,761 tons x 0.27 g/lb = 3,286 lbs. of leachable P
5. 3,286 lbs. of P x 40% efficiency = 1,315 lbs. of P removed
6. $405,795 ÷ 1,315 lbs. = $309/lb. of P

Amount of Leachable P in Leaves can Vary





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Next Steps…

- Evaluate other commonly used municipal leaf collection programs
- Develop semi-quantitative method to predict phosphorus load in stormwater based on estimate of leaf mass on streets
- Develop algorithms to predict phosphorus in stormwater
  - Can be used in models

Photo Credit: USGS

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Questions

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Evaluation of leaf removal as a means to reduce nutrient concentrations and loads in urban stormwater

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HIGHLIGHTS

- Leaves are a significant source of phosphorus to urban stormwater.
- Phosphorus and nitrogen were measured in basins with and without leaf removal.
- Nearly 60 percent of the annual phosphorus yield comes from leaf litter in the fall.
- Timely removal of leaf litter can reduce phosphorus concentrations by 80%.
- Leaf removal is one of a few options available to reduce dissolved phosphorus.

GRAPHICAL ABSTRACT

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ABSTRACT

While the sources of nutrients to urban stormwater are many, the primary contributor is often organic detritus, especially in areas with dense overhead tree canopy. One way to remove organic detritus before it becomes entrained in runoff is to implement a city-wide leaf collection and street cleaning program. Improving our knowledge of the potential reduction of nutrients to stormwater through removal of leaves and other organic detritus on streets could help tailor more targeted municipal leaf collection programs. This study characterized an upper ideal limit in reductions of total and dissolved forms of phosphorus and nitrogen in stormwater through implementation of a municipal leaf collection and street cleaning program in Madison, WI, USA. Additional measures were taken to remove leaf litter from street surfaces prior to precipitation events.
Loads of total and dissolved phosphorus were reduced by 84 and 83% ($p < 0.05$), and total and dissolved nitrogen by 74 and 71% ($p < 0.05$) with an active leaf removal program. Without leaf removal, 56% of the annual total phosphorus yield (winter excluded) was due to leaf litter in the fall compared to 16% with leaf removal. Despite significant reductions in load, total nitrogen showed only minor changes in fall yields without and with leaf removal at 19 and 16%, respectively. The majority of nutrient concentrations were in the dissolved fraction making source control through leaf removal one of the few treatment options available to environmental managers when reducing the amount of dissolved nutrients in stormwater runoff. Subsequently, the efficiency, frequency, and timing of leaf removal and street cleaning are the primary factors to consider when developing a leaf management program.

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0048-9697/

References Cited:

Dorney, J.R., 1986. Leachable and total phosphorus in urban street tree leaves. Water Air Soil Poll. 28, 439-443.

Selbig, W.R., 2016, 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.

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