Evaluation of Leaf Collection as a Means to Reduce Nutrient Loads from Urban Basins

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Background

Isthmus Newspaper, April 19, 2013, vol. 38, no. 16

- Strong public interest to keep lakes fishable and swimmable
  - Beach closures (algal blooms)
  - Invasives
- Federal/State pollutant restrictions
  - Rock River TMDL for Total P

Adaptive Management Approach To Reduce Phosphorus to Area Lakes

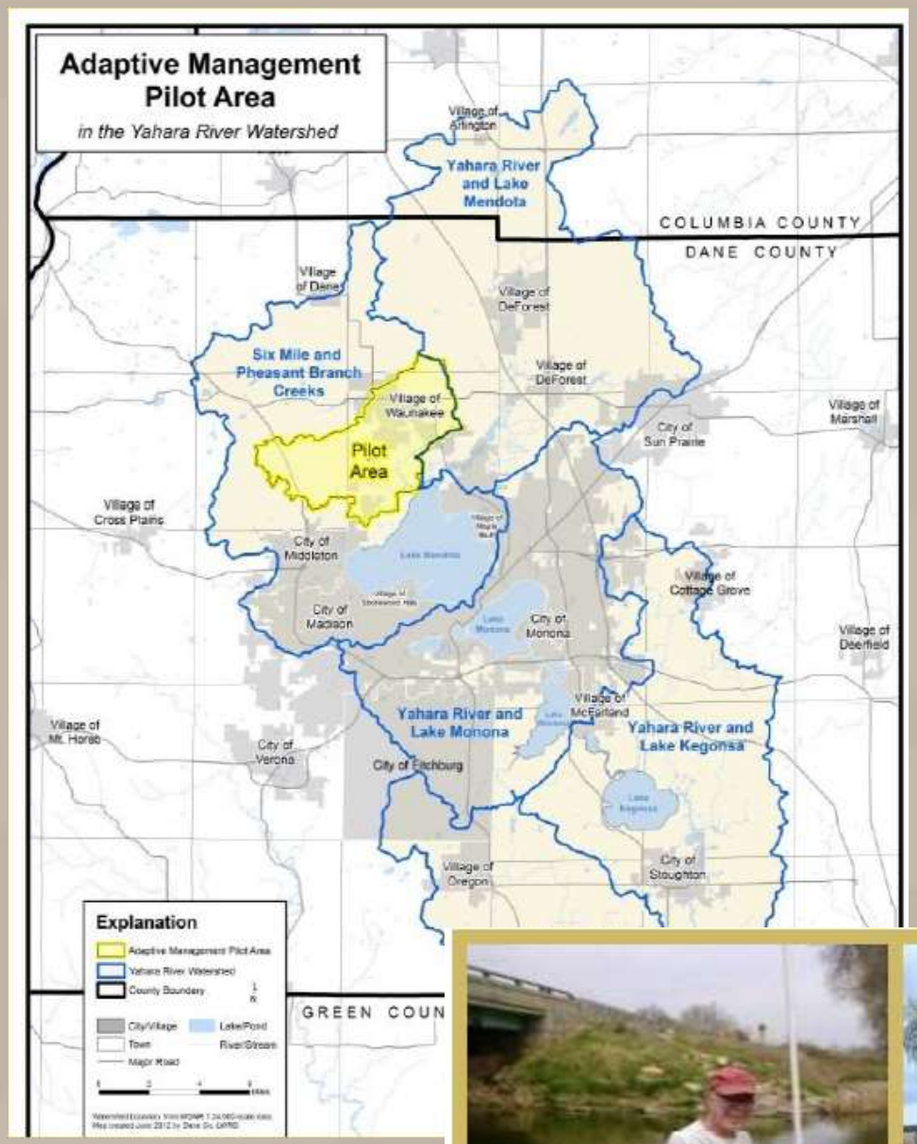

Photo credit: Yahara WINS

- Approximately 30 partners
- Addresses municipal/industrial wastewater plants, municipal stormwater, and agricultural runoff
- Evaluates wide range of practices, both agricultural and urban

Photo credit: Yahara WINS

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Pilot Study: Urban Phosphorus Reduction through Leaf Collection

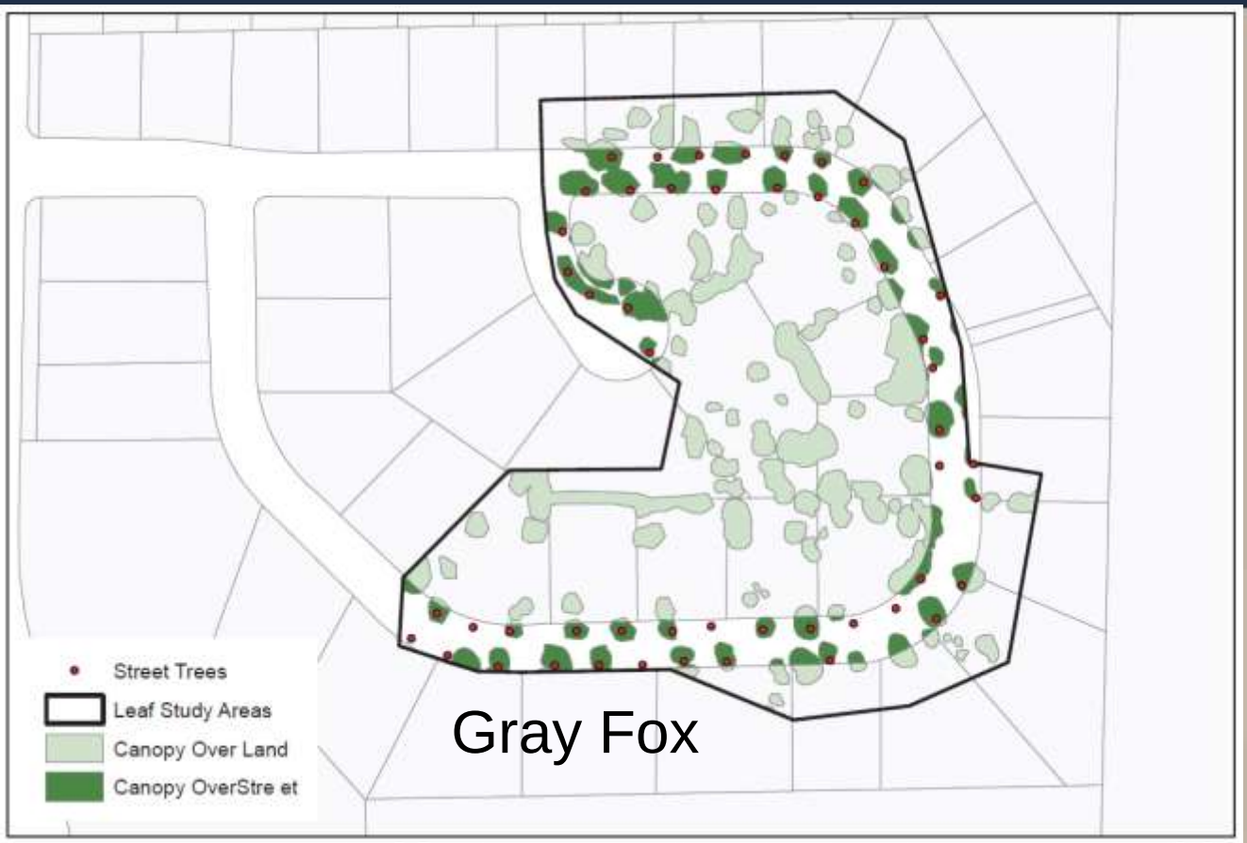
Photo credit: City of Woodstock, IL

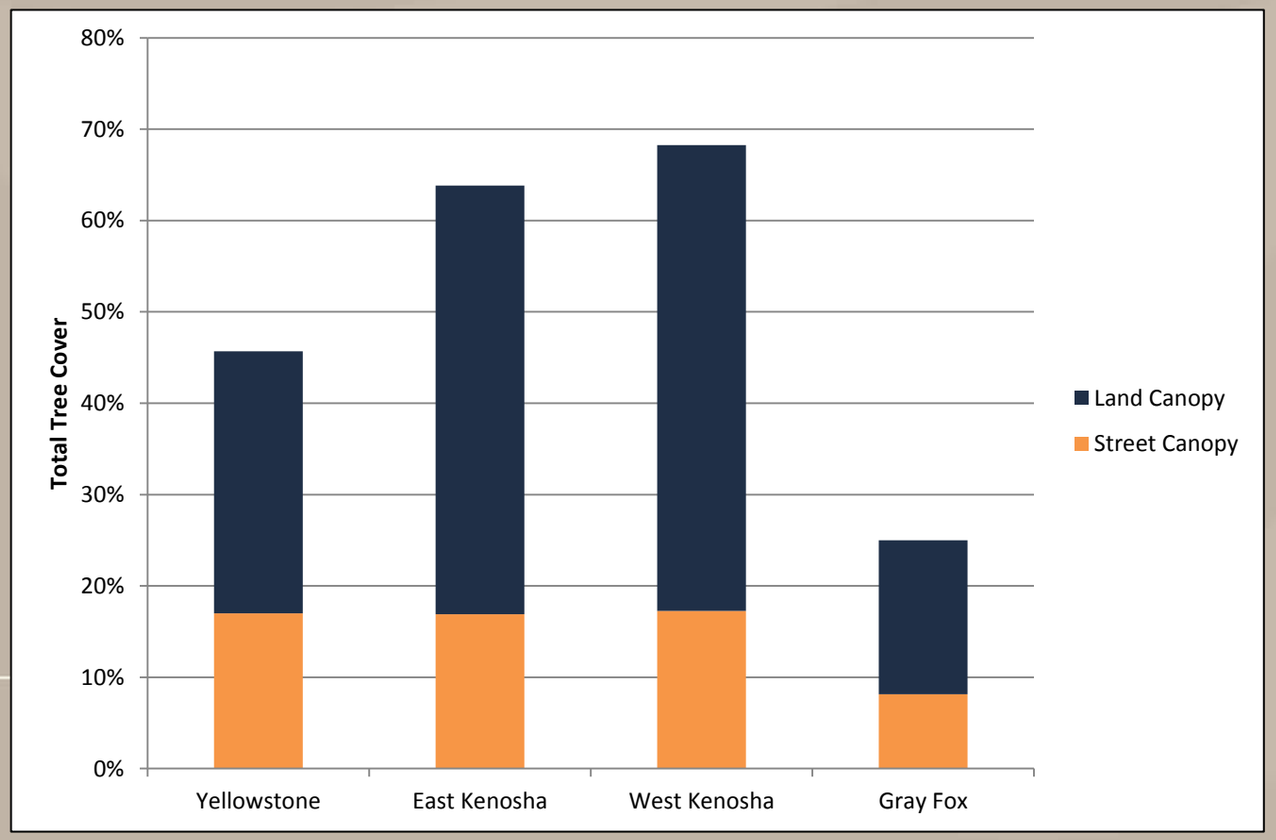
- Leaf collection identified as reasonable measure to reduce total phosphorus delivered to lakes
- What percent phosphorus reduction can MS4s expect by collecting leaves?
- Are some leaf collection practices better than others?

Four Study Basins in Madison, WI

	Study Basin			
Source Area	Yellowstone	East Kenosha	West Kenosha	Gray Fox
Area (ac.)	15.9	3.0	2.5	9.1
Streets	17%	19%	17%	14%
Driveways	6%	4%	5%	8%
Roofs	17%	19%	16%	13%
Sidewalks	5%	3%	4%	1%
Lawns/Open	55%	54%	58%	63%
Other Impervious	<1%	0%	0%	1%
Tree Cover	45%	68%	57%	26%

Percent Tree Cover





Measurement of Phosphorus in Water

Photo credit: USGS

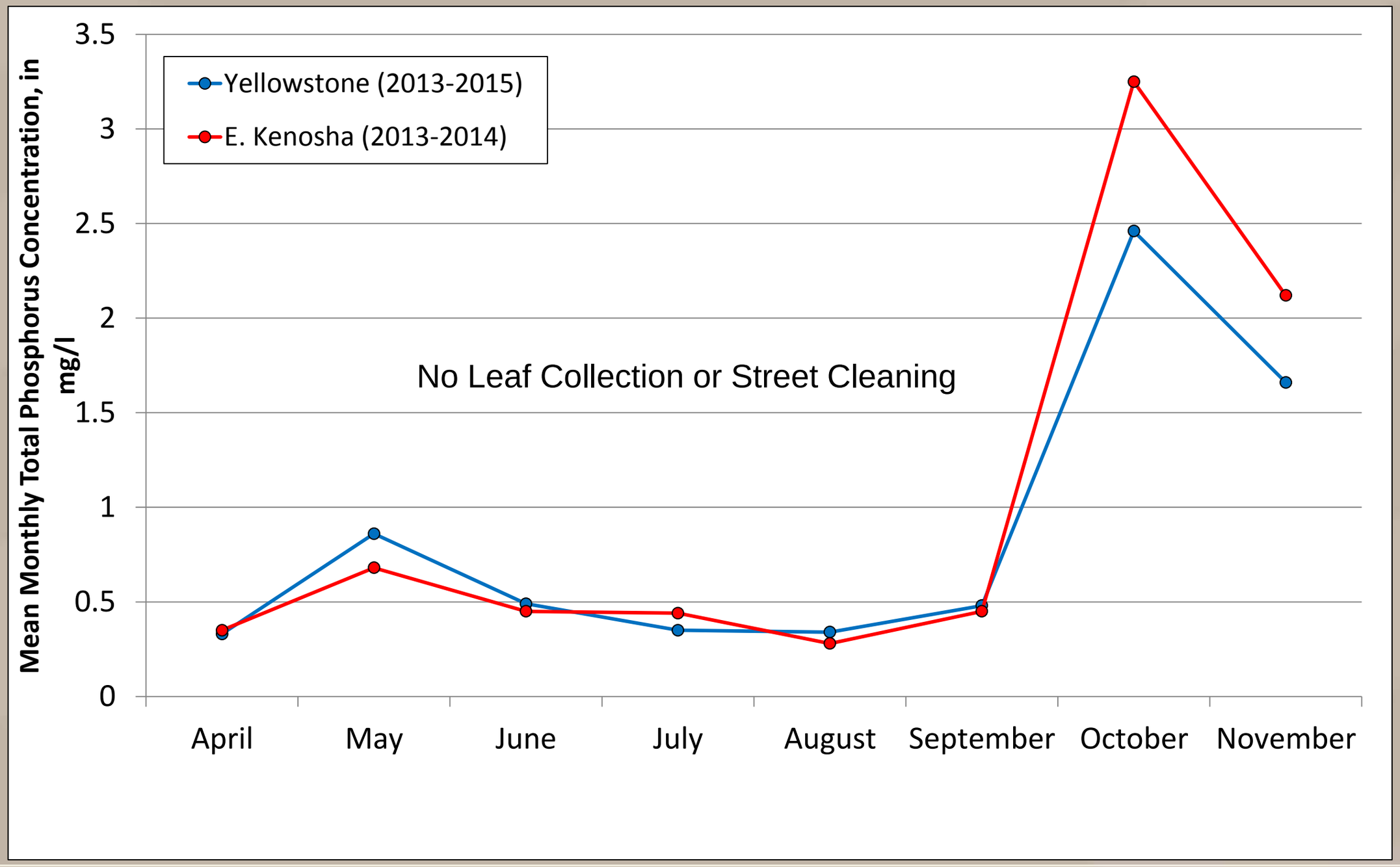
Photo credit: USGS

Measurement of Phosphorus in Gross Solids (leaves)

Photo credit: USGS

Photo credit: USGS

Photo credit: USGS



Municipal Leaf Collection in Test Basins

Municipal efforts included weekly collection of leaf piles followed by high-efficiency street cleaning
October – November 2015

Photo credit: USGS

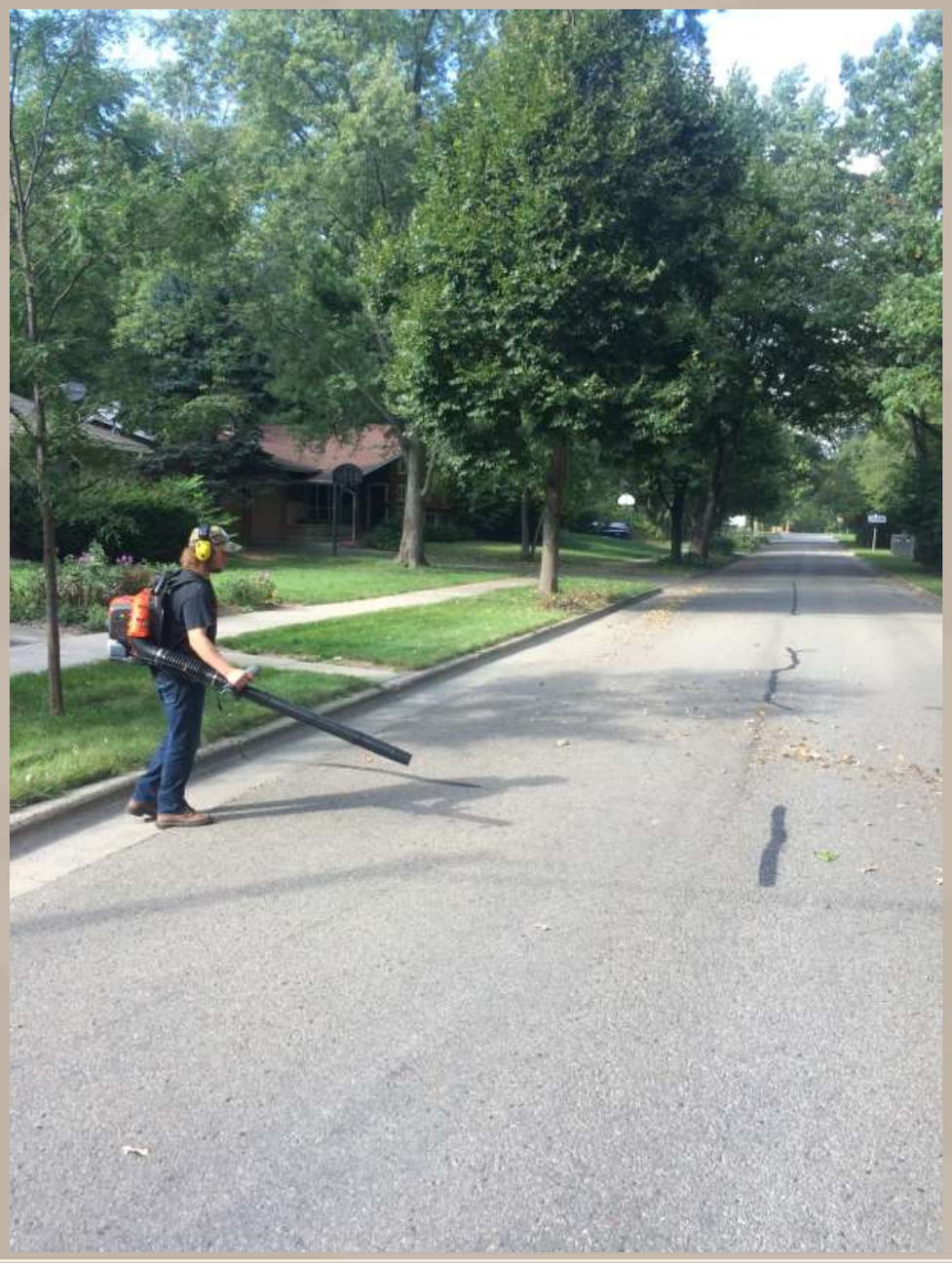
Photo credit: USGS

Plus…

Maximum Leaf Removal

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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Before Leaf Blowing

Photo credit: USGS

After Leaf Blowing

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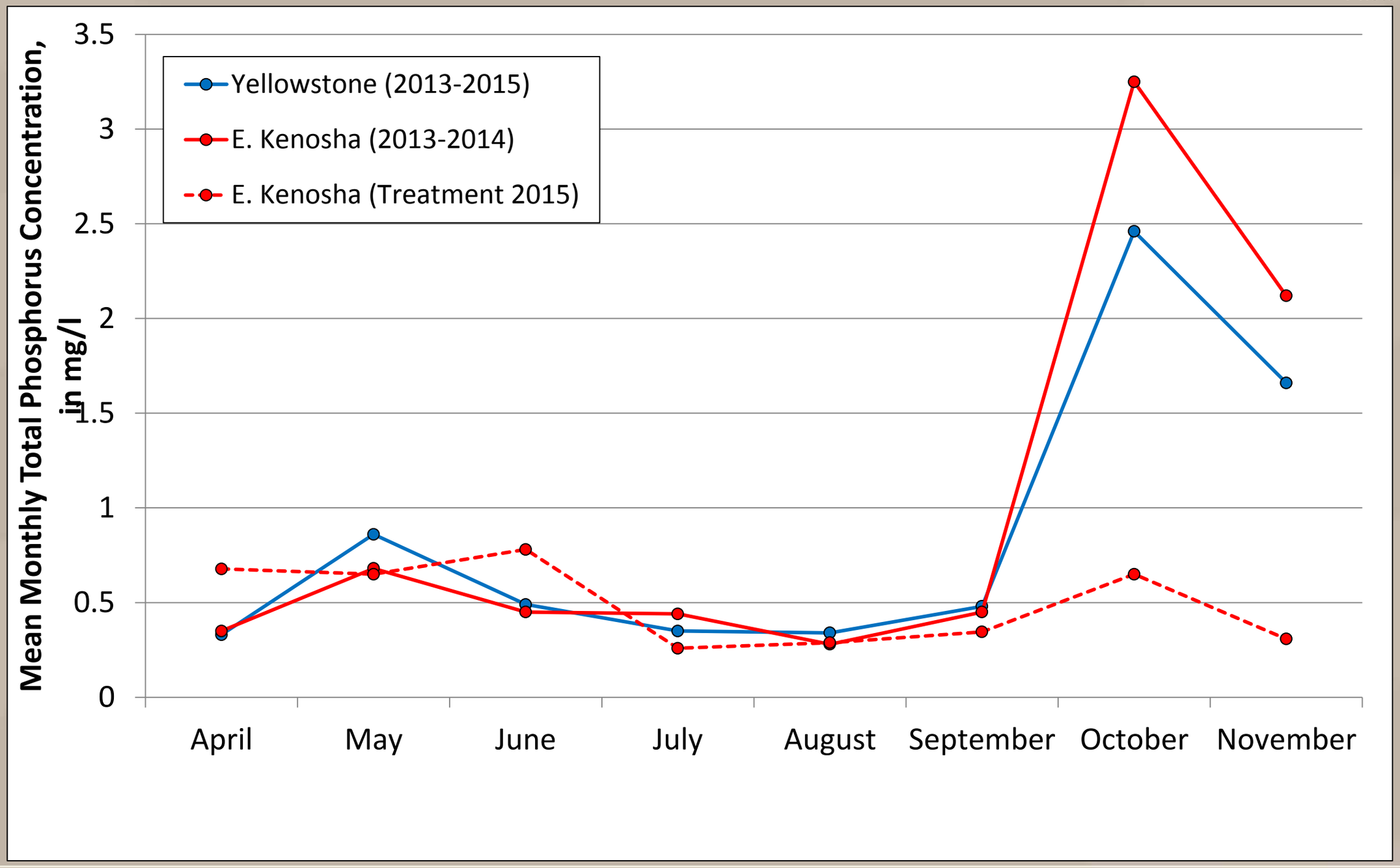
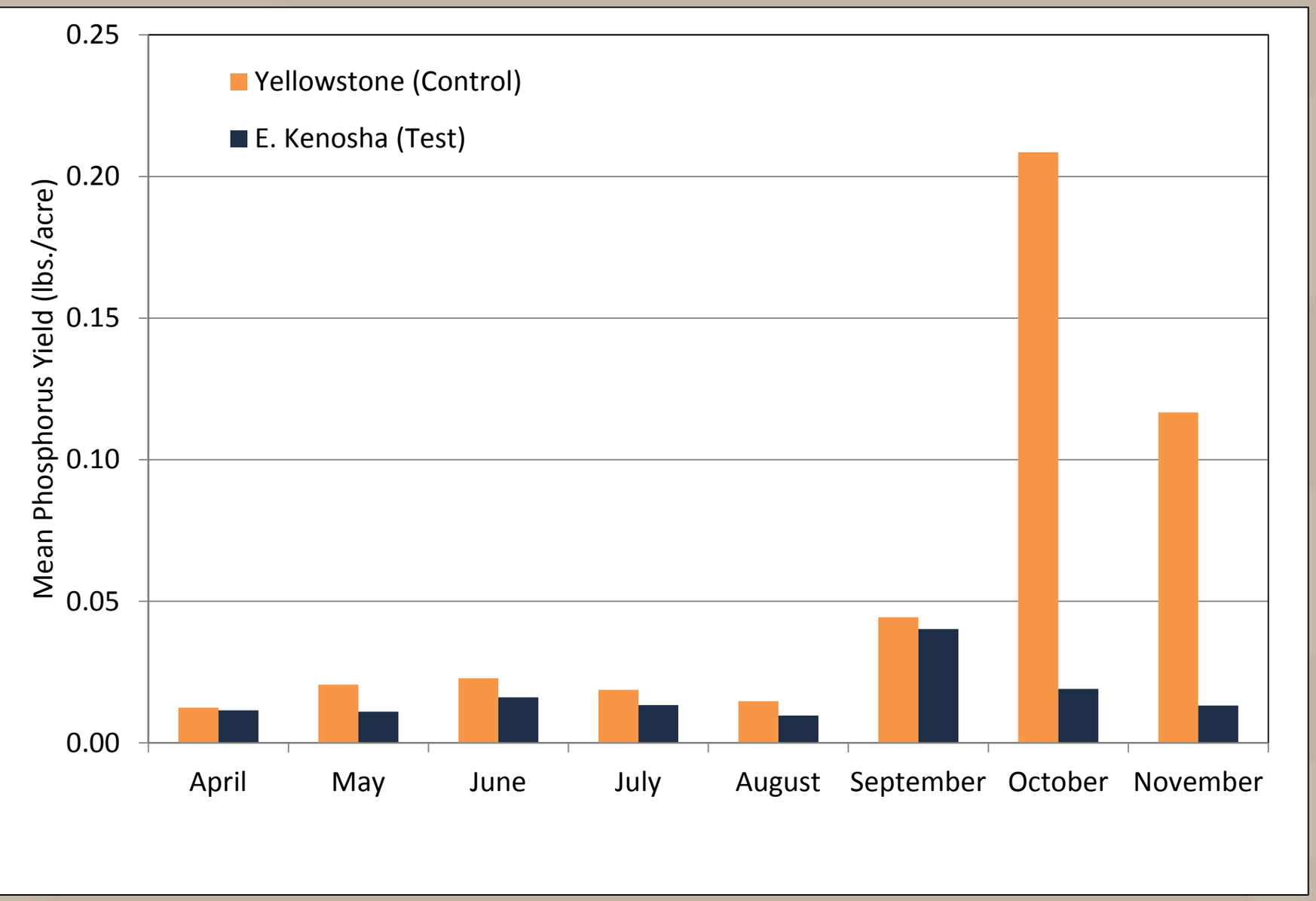


2015 Mean Monthly Phosphorus Yield



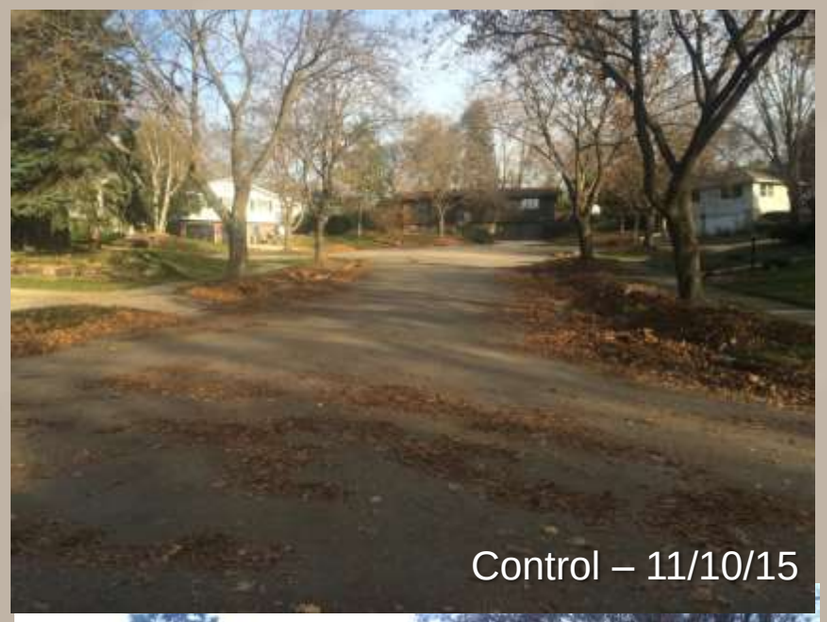
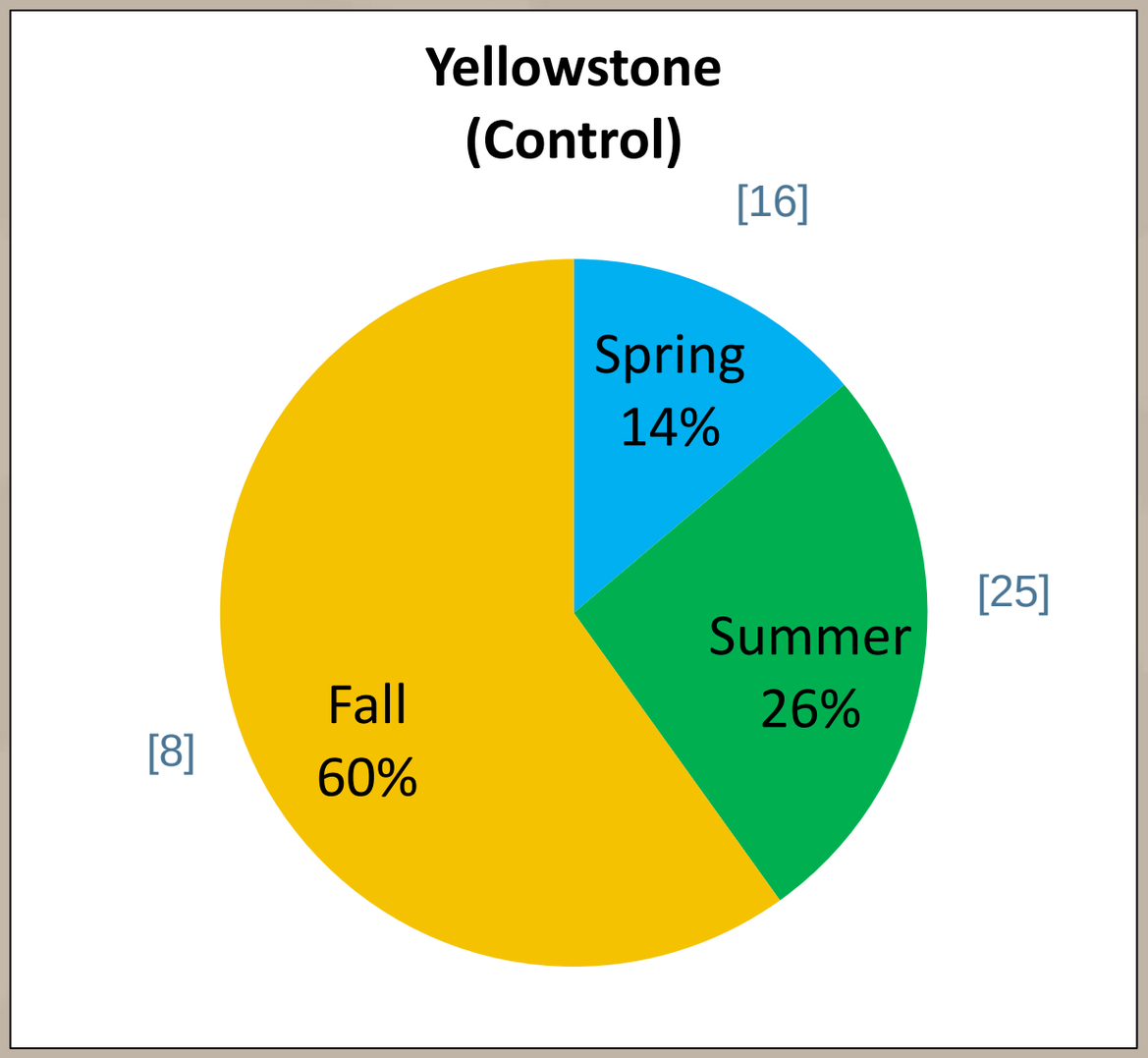
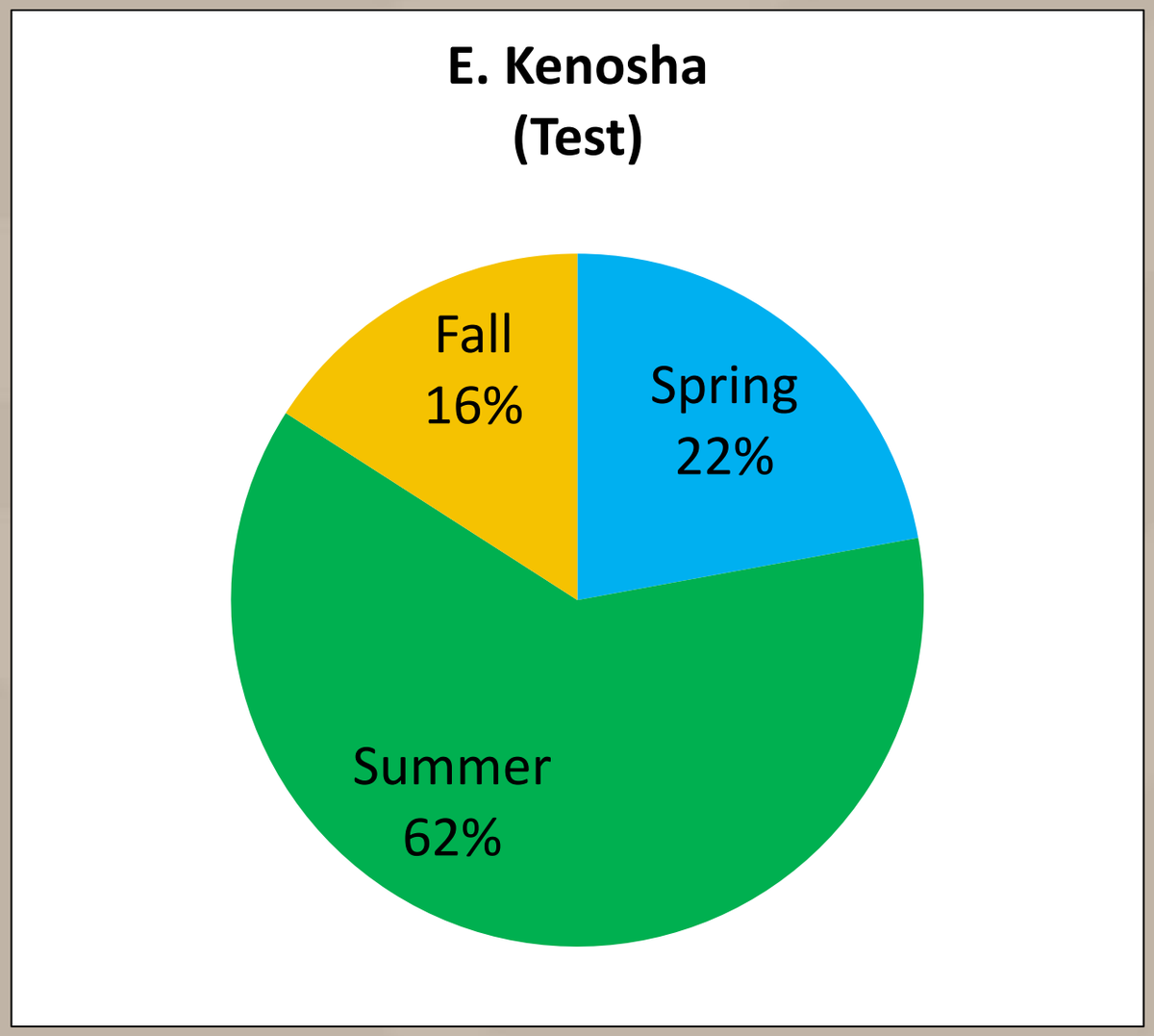


Photo credit: USGS

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

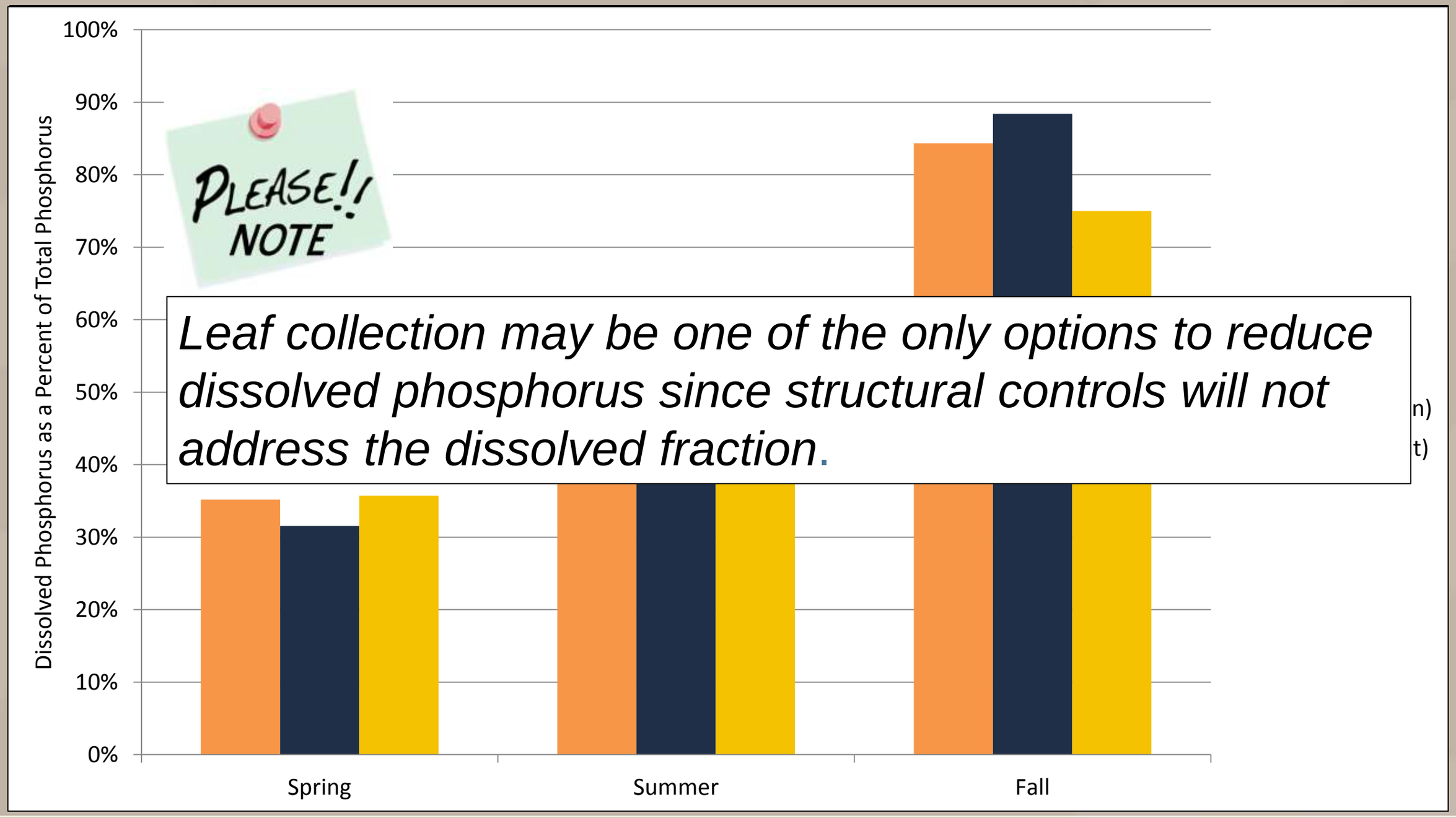




[3] = Number of events

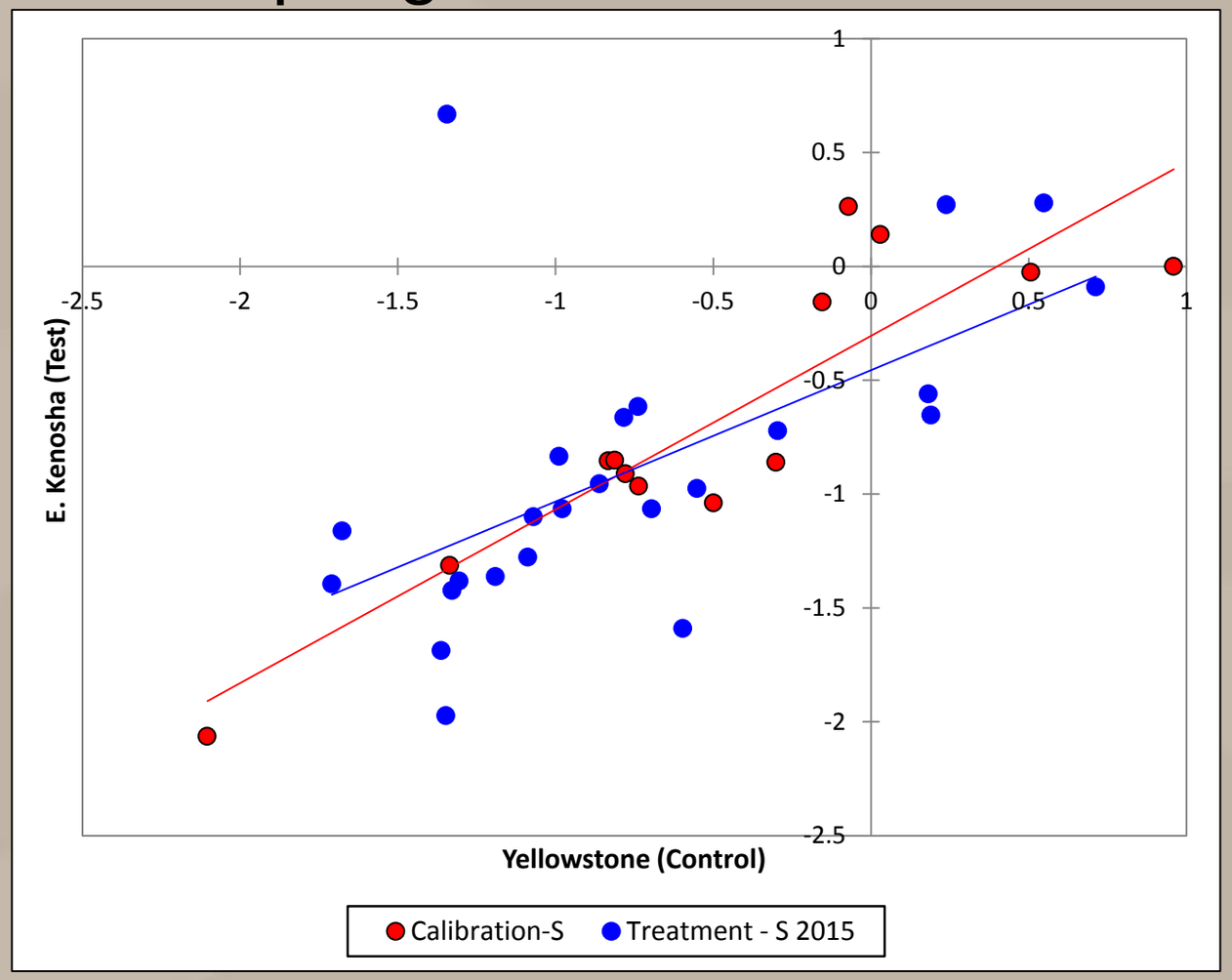
Seasonal Phosphorus Speciation

Most of the phosphorus measured in the fall is dissolved

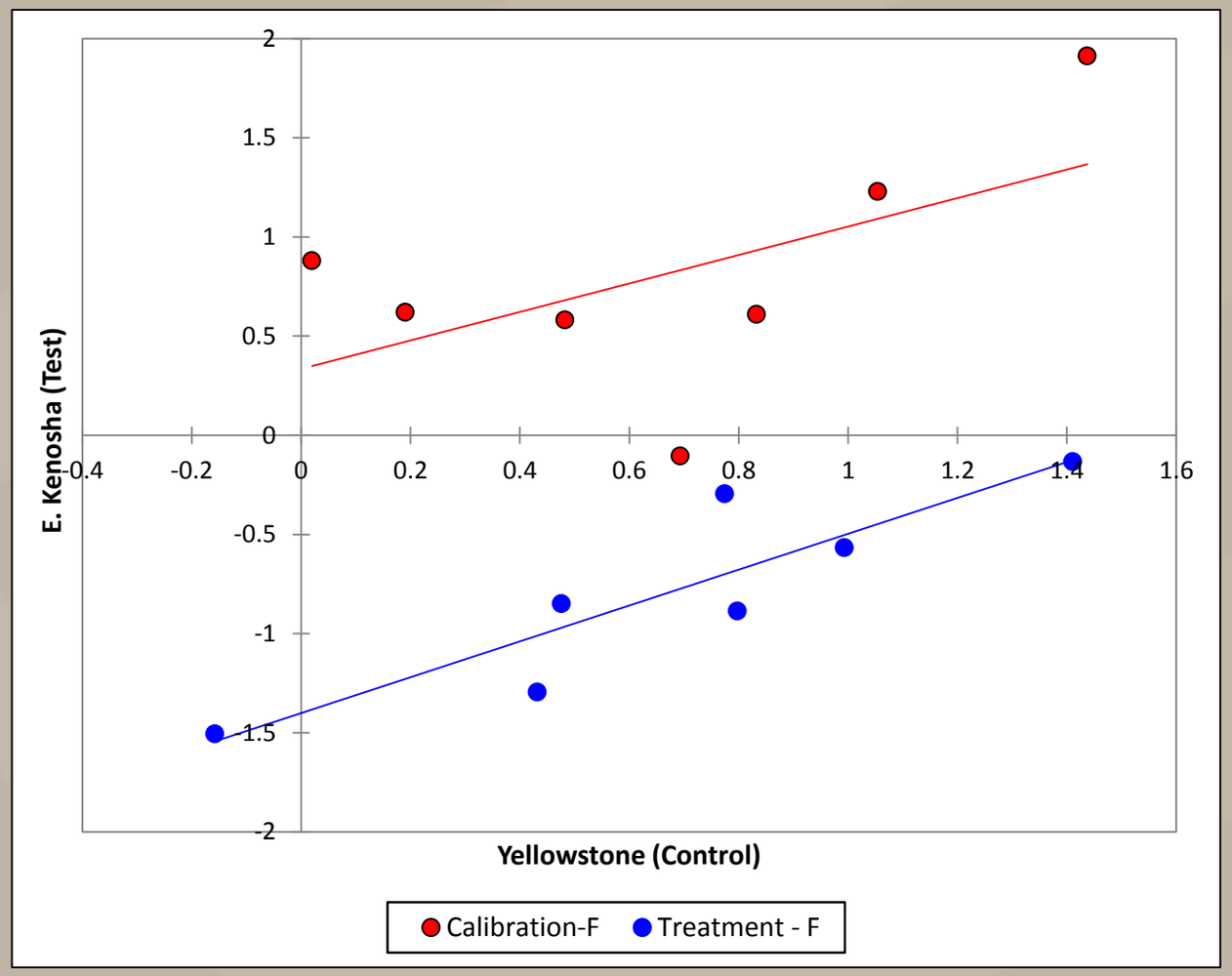


Paired Basin Status
Total Phosphorus Concentration (Log), in mg/L

Spring/Summer 2015



Fall 2015



Percent Reduction in Nutrient Concentrations 2015

Parameter	Spring/Summer	Fall
Total Suspended Solids	--(1)	--
Total Phosphorus	--	-80(2)
Total Nitrogen	--	-31
Total Organic Carbon	--	-76
Dissolved Phosphorus	--	-84
Dissolved Nitrogen	--	-39
Dissolved Organic Carbon	--	-77

(1), no statistical change
(2), A negative value indicates percent reduction

Cumulative Mass of Leaves on Streets

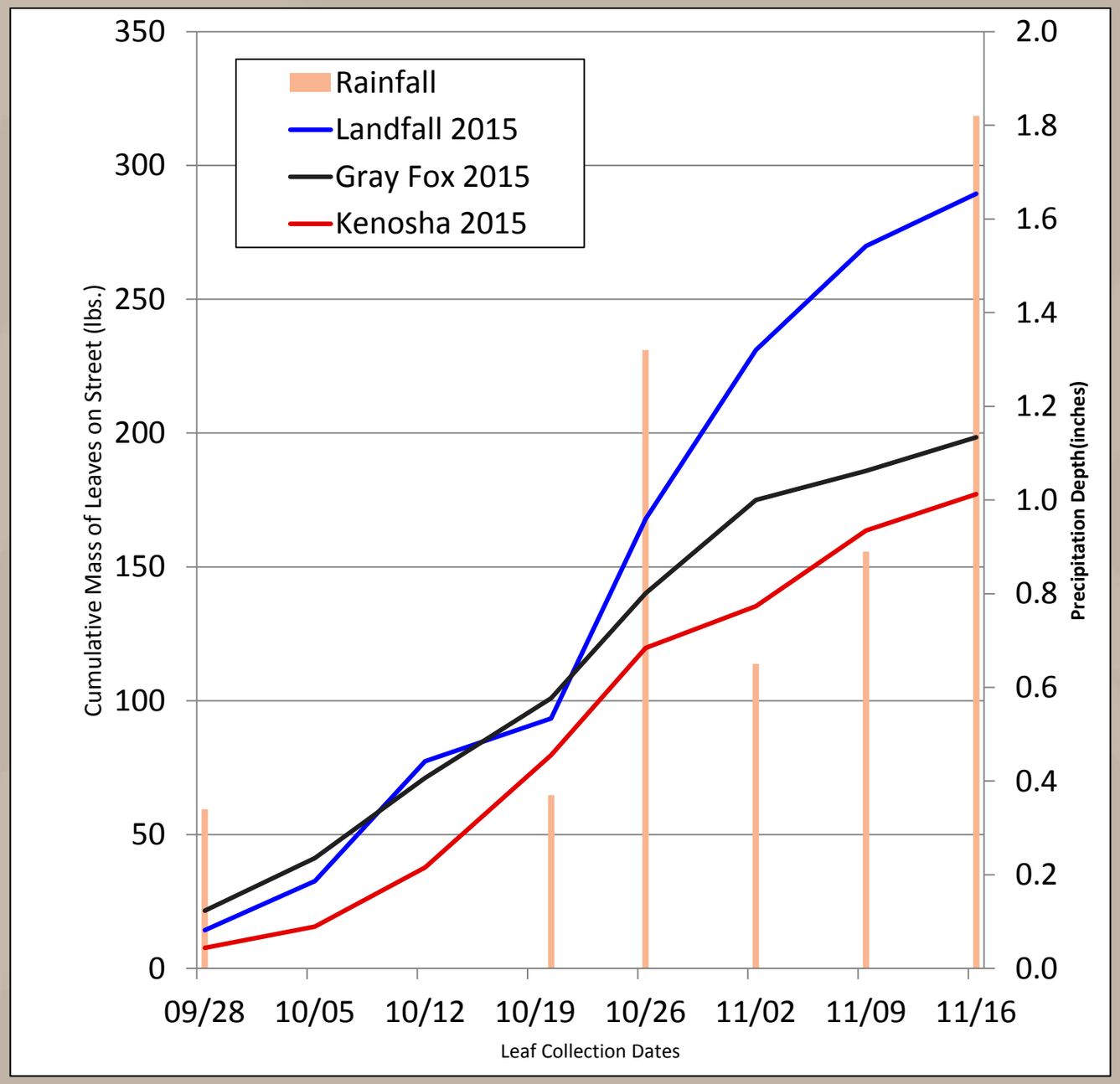
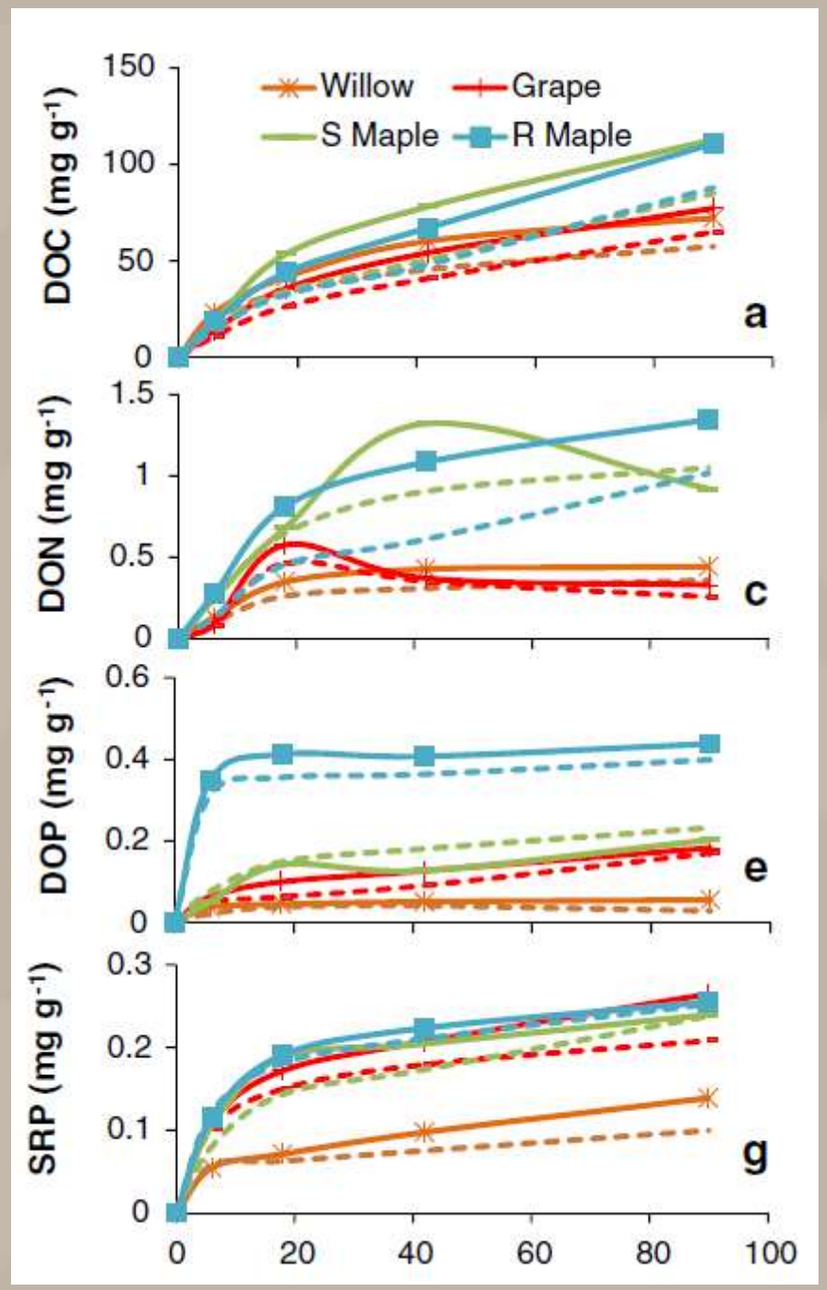


Photo credit: USGS

Estimating Phosphorus Load in Runoff from Leaf Mass on Streets

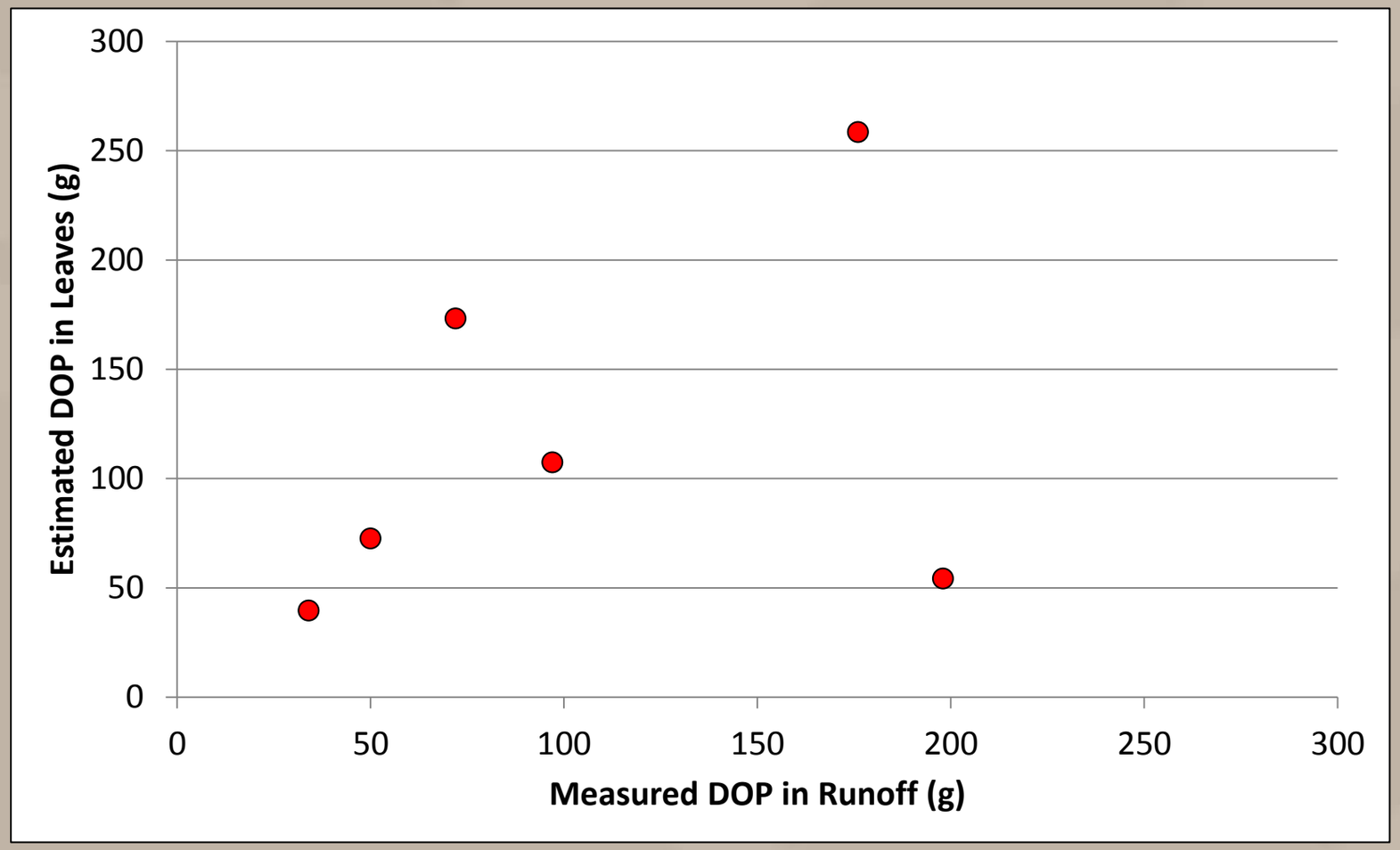


Duan et al. (2014)

Incubation Time (hrs)

$y = a(1-\exp(-bt))$

Red Maple:
$a = 0.40$
$b = 1.44$



Solid and dashed lines represent leaching at 20° and 4° Celsius, respectively

What we know…

- Up to 60% of the annual phosphorus load can occur from leaf litter in the fall
- Phosphorus is primarily dissolved in Fall. Leaf collection may be one of only a few management options
- Removal of leaves from streets can reduce nutrient concentrations by 80%, BUT….

  - Timing of leaf collection is critical to significant phosphorus reduction

Photo credit: USGS

What we're still learning…

- What factors control phosphorus leaching from leaves over time?
- Will municipal leaf collection strategies have any measurable benefit?
  - Vacuum mulching
  - Bagging
  - Transfer
  - Other
- Are certain geographic areas in a city more prone to high phosphorus loading?
  - Tree density
  - Species
  - Land use

Photo credit: USGS

Cited References

- Duan, S., Delaney-Newcomb, K., Kaushal, S.S., Findlay, S.E.G., Belt, K., 2014. Potential effects of leaf litter on water quality in urban watersheds, Biogeochemistry, 121, pp. 61 – 80. doi:10.1007/s10533-014-0016-9.