Cost Efficiency and Other Factors in Urban Stormwater BMP Selection

WIP Local Technical Meeting Series
November 2013

Greg Busch
Maryland Department of the Environment
gbusch@mde.state.md.us

Which BMPs to choose?

- Cost efficient BMPs
  - Ones that remove the greatest quantity of nitrogen, phosphorus or sediment for the least cost
- BMPs that provide benefits beyond nutrient & sediment removal
  - Removal of other pollutants
  - Public health
  - Neighborhood beautification
  - Heat island reduction

Measuring the cost effectiveness of a BMP

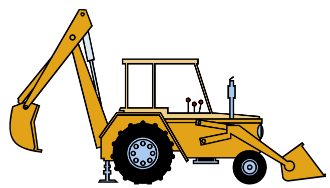
- How much nitrogen does an acre of forest buffer remove in a given year?

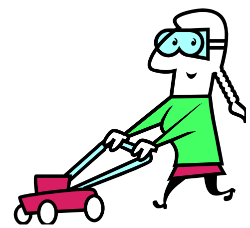
1 acre of forest buffer removes about 6 pounds of nitrogen from the Bay each year

- How much does an acre of forest buffer cost per year?

1 acre of forest buffer costs about $530 per year

Annualizing the cost of a BMP





Land Acquisition Cost / Lifespan + Design & Construction Costs / Lifespan + Annual O&M Costs = Annualized BMP Costs

Among urban stormwater BMPs, we have generally chosen a lifespan of 20 years. Although many of the BMPs – including forest buffers – would be expected to last much longer than this, 20 years provides a good horizon for stormwater planning.

Cost of nutrient removal

Cost of BMP

$530 per acre per year

Effectiveness of BMP

6 pounds of nitrogen removed per acre per year

=

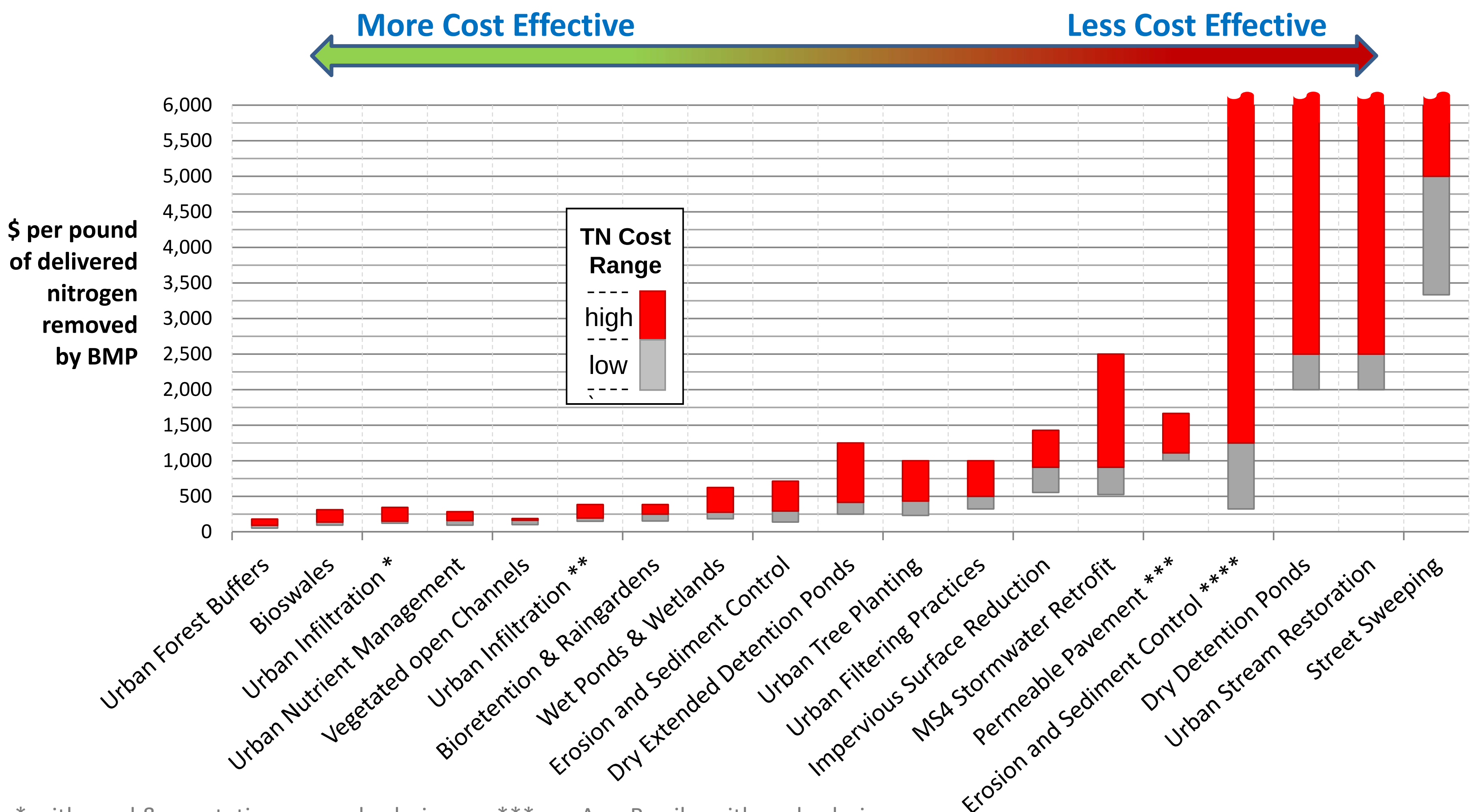
Cost of nutrient removal

$88 per pound of nitrogen

Note that over the life of this BMP (say, 20 years) the cost of this BMP to remove 1 pound of nitrogen each year will be: *20 years × $88 per pound = $1,760*

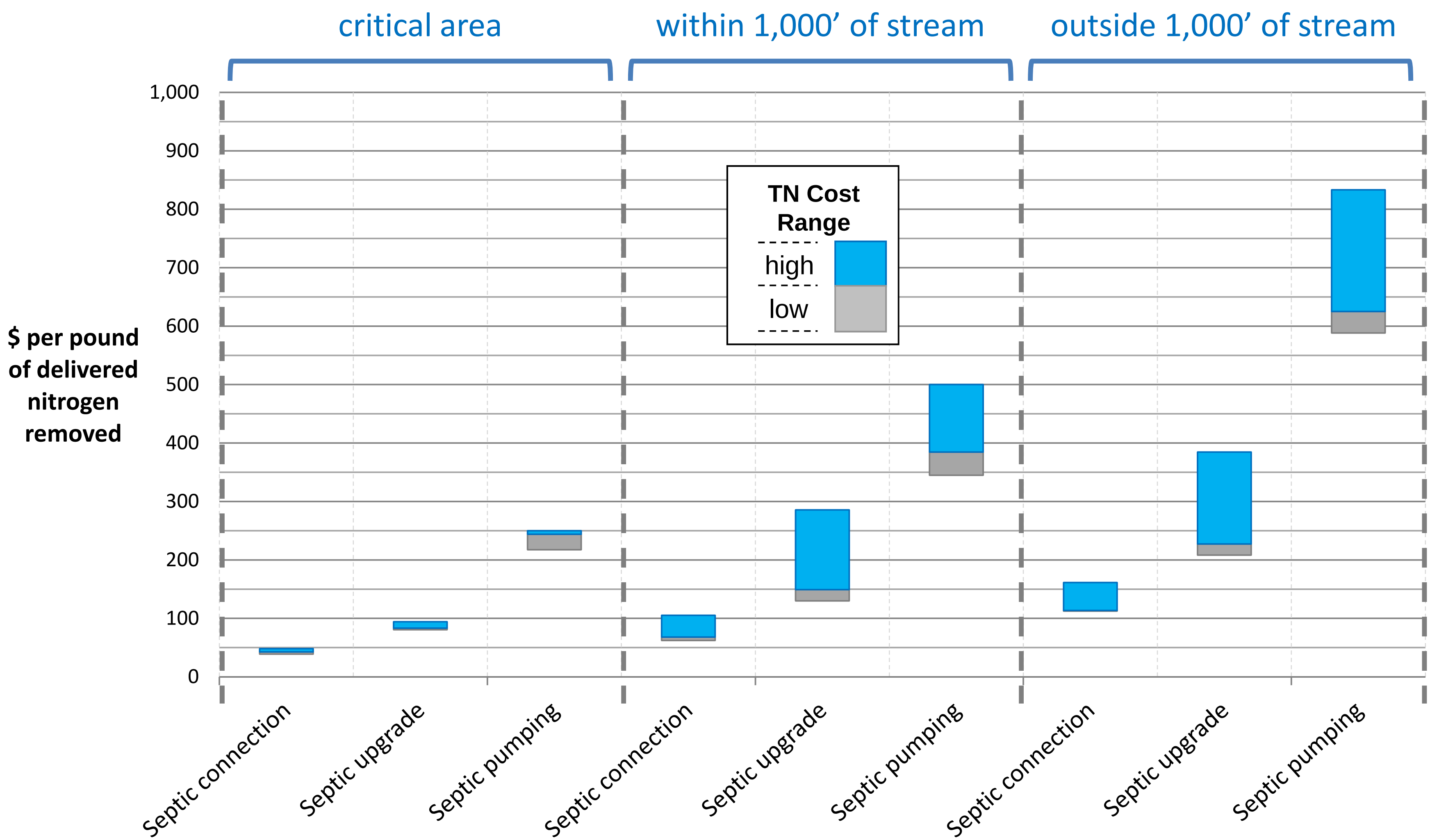
Another way to look at this is a in terms of cost efficiency. How many pounds of a nutrient can be removed for $1,000? In this example, an investment of $1,000 will result in a 11.4 pound reduction of nitrogen.

Comparing urban stormwater BMPs by cost effectiveness



* with sand & vegetation, no underdrain
** with sand & vegetation, no underdrain
*** on A or B soils, with underdrain
**** on extractive land use

Comparing septic & wastewater BMPs based on cost efficiency



Example Spreadsheet

CALVERT COUNTY Stormwater BMP Effectiveness BMP Name	Land Use	Unit	Acres of BMP Applied in 2025 WIP	Pollutant Removal Effectiveness TN delivered [lbs removed per acre per year]	TP delivered [lbs removed per acre per year]	TSS delivered [lbs removed per acre per year]	Cost of BMP Design and Construction Costs [$/unit]	Land Acquisition Cost [$/unit]	O&M Costs [$/unit]	Project Life [$/unit]	Annual Cost [$/unit]	Cost per pound Cost of delivered TN removal [$/pound removed]	Cost of delivered TP removal [$/pound removed]	Cost of delivered TSS removal [$/pound removed]
Bioretention & raingardens	all urban	acre treated	5,626.8	4.0	0.3	95.9	$9,469	$3,000	$383	20	$1,006	$254	$2,980	$10
Bioretention & raingardens	impervious urban	acre treated	736.1	6.0	1.1	391.5								
Bioretention & raingardens	pervious urban	acre treated	4,890.7	3.7	0.2	51.4								
Impervious Urban Surface Reduction	impervious urban	acre	0.0	8.4	2.0	715.9	$96,250	$50,000	$885	20	$8,198	$972	$4,118	$11
Permeable Pavement with Sand and Veg	pervious urban	acre	0.0	3.8	0.5	135.4	$83,853	$0	$765	20	$4,958	$1,288	$9,351	$37
Street Sweeping	impervious urban	acre	0.0	0.2	0.0	33.7	$6,049	$0	$451	20	$753	$4,737	$22,006	$22
Urban Filtering Practices	all urban	acre treated	122.2	2.4	0.3	129.8	$8,750	$5,000	$383	20	$1,071	$447	$3,136	$8
Urban Filtering Practices	impervious urban	acre treated	28.2	3.4	0.9	391.4								
Urban Filtering Practices	pervious urban	acre treated	94.0	2.1	0.2	51.4								
Urban Forest Buffers	pervious urban	acre	2.5	5.0	0.7	140.4	$6,507	$0	$206	20	$531	$106	$759	$4
Urban Nutrient Management	pervious urban	acre	6,078.4	0.8	0.1	0.0	$0	$0	$53	1	$53	$67	$982	n/a
Urban Tree Planting	pervious urban	acre	22.0	3.8	0.3	46.6	$6,506	$28,409	$229	20	$1,975	$523	$7,377	$42
Wet Ponds and Wetlands	all urban	acre treated	4,404.4	1.2	0.2	81.2	$4,529	$2,000	$191	20	$517	$448	$2,330	$6
Wet Ponds and Wetlands	impervious urban	acre treated	736.2	1.7	0.7	293.6								
Wet Ponds and Wetlands	pervious urban	acre treated	3,668.2	1.0	0.1	38.5								

How loading rate affects BMP performance

BMPs installed on segments with higher loading rates will remove more pollution.

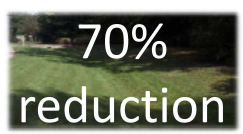
Example:

- A Bioswale is expected to reduce an urban nitrogen load by 70%

- If it is placed on an impervious acre with a loading rate of 10 lbs per year, it will remove 7 lbs of nitrogen per year.

7 lbs/year

- But if it is placed on an acre of urban impervious land with a loading rate of 15 lbs per year, it will remove 10.5 lbs of nitrogen per year.



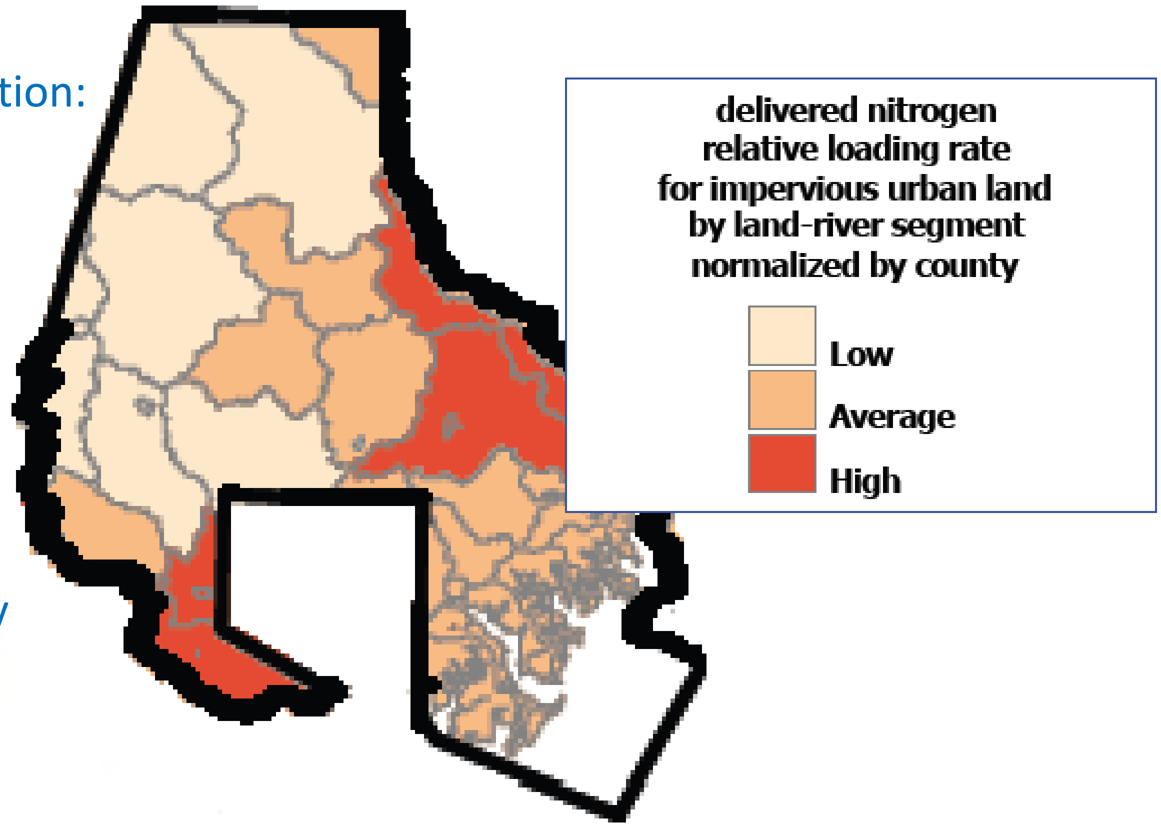
10.5 lbs/year

Geographic Factors

How much geographic variation is there between delivered urban loading rates within a county?

9 counties show variation:

- Allegany County
- Baltimore City
- Baltimore County
- Carroll County
- Frederick County
- Garrett County
- Harford County
- Howard County
- Montgomery County



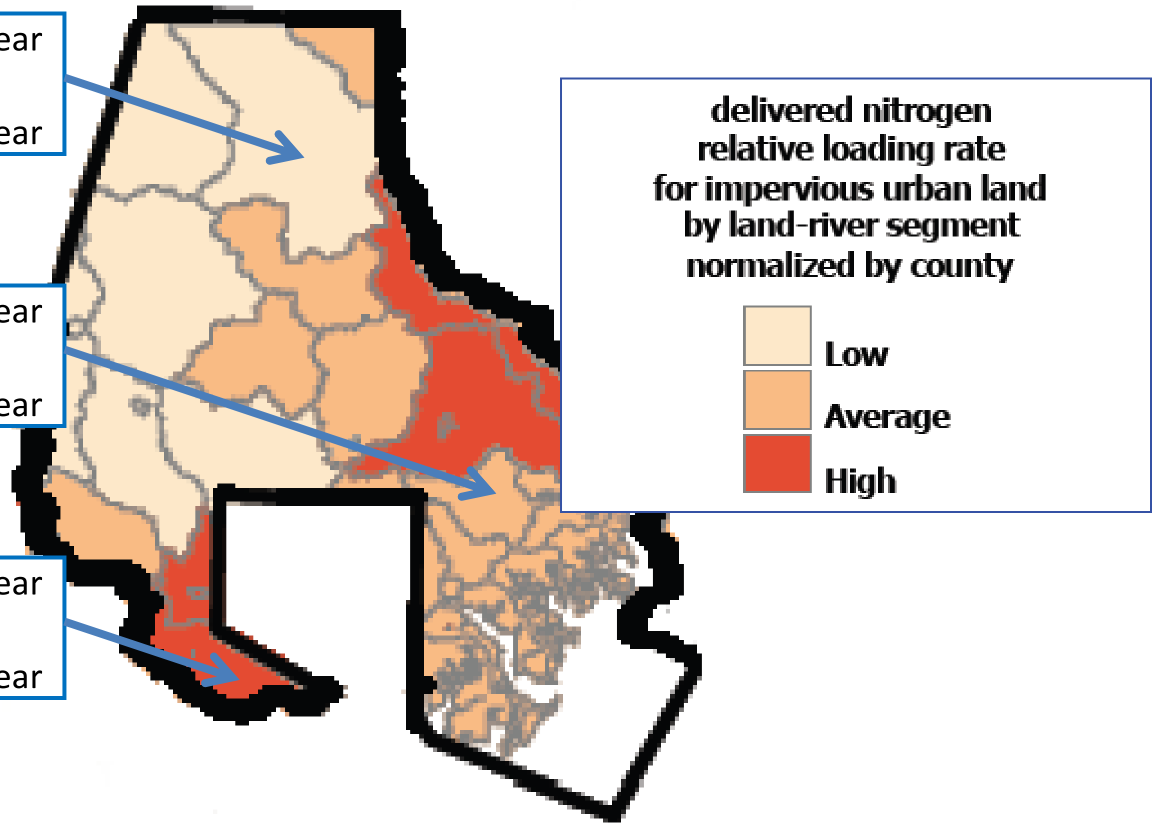
Example

Treating one acre of impervious urban land with a rain garden can reduce the delivered nitrogen loads to the Bay by:

loading rate: **4.44** lbs/acre/year
reduction: **70** %
removal: **3.11** lbs/acre/year

loading rate: **7.32** lbs/acre/year
reduction: **70** %
removal: **5.12** lbs/acre/year

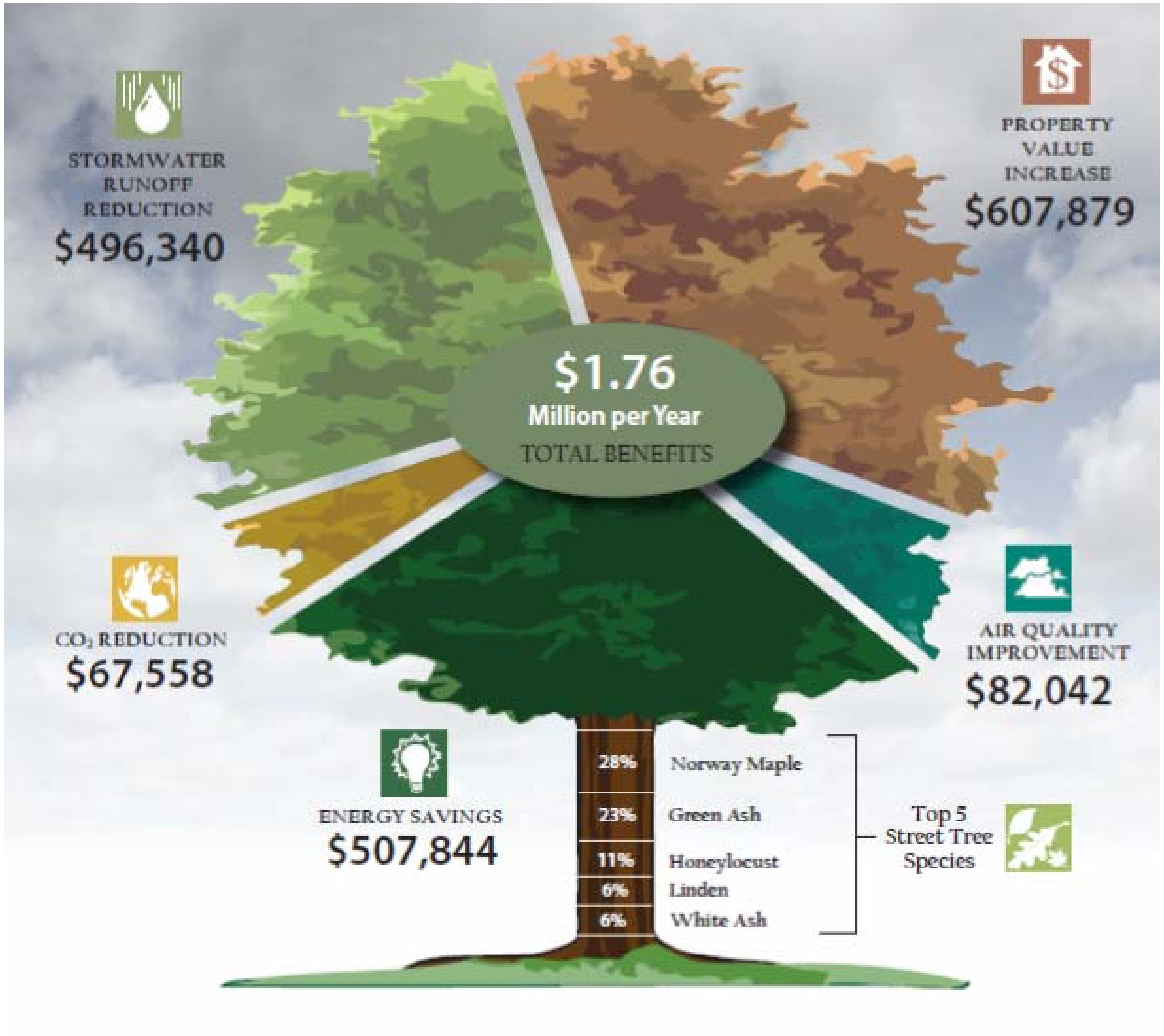
loading rate: **11.56** lbs/acre/year
reduction: **70** %
removal: **8.09** lbs/acre/year



Benefits Beyond Nutrient Removal

- Other benefits of Urban Stormwater BMPs
  - public health benefits
    - air quality
    - bacteria reduction
  - local water quality
    - other TMDLs
  - quality of life benefits
    - neighborhood beautification
    - recreation
    - wildlife habitat
  - urban heat island
    - ozone formation
    - stream temperature
  - carbon sequestration
  - flood control

The Value of Street Trees to the City of Fond du Lac, WI



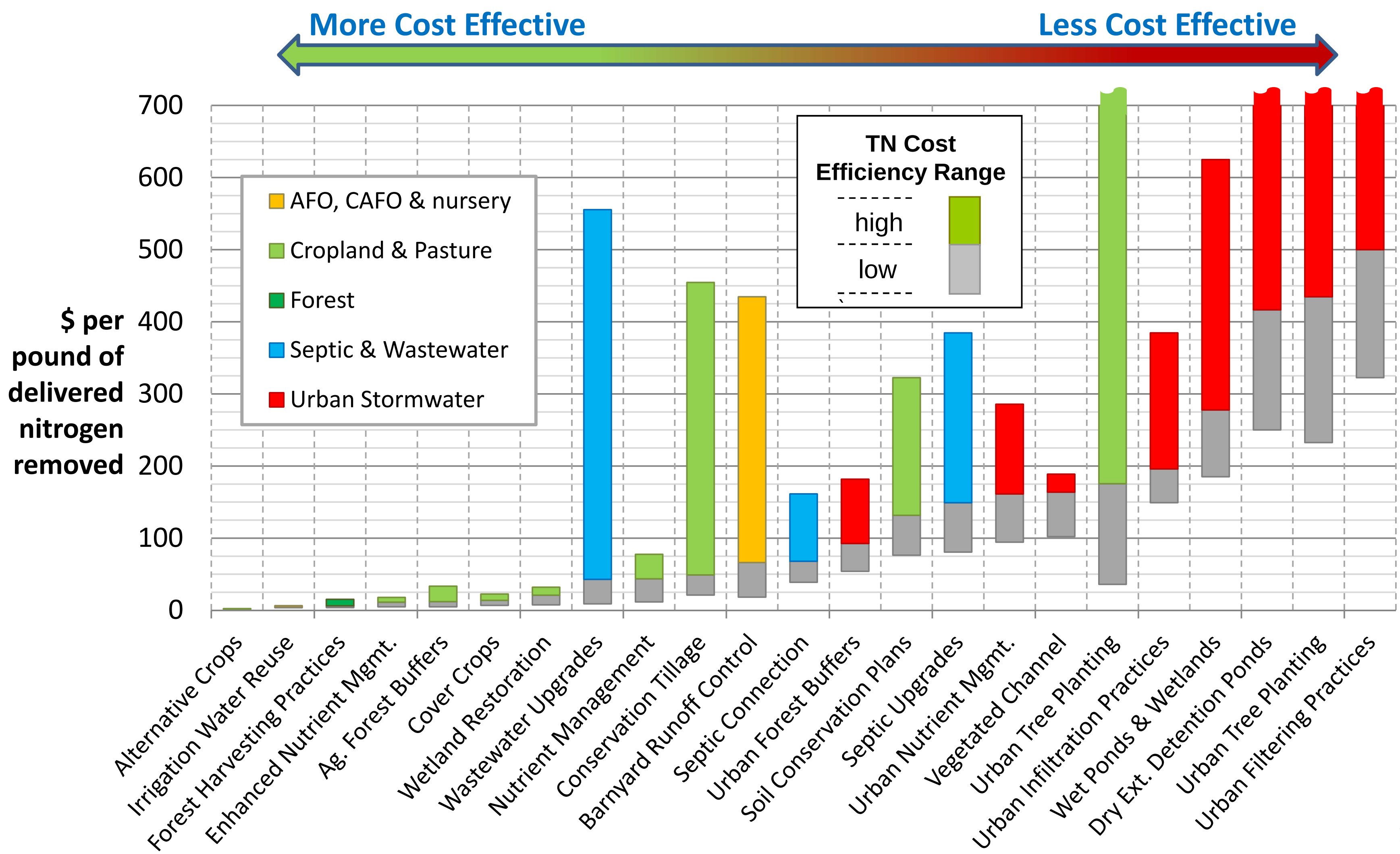
http://www.itreetools.org/resources/reports/WDNR_Fond_du_Lac_reports.pdf

Gray vs. Green Practices

	Public Health	Recreation	Neighborhood Beautification	Urban Heat Island	Wildlife Habitat	Carbon Sequestration	Flood Control
Gray Options							
Dry Detention Ponds	Low	Low	Low	Low	Low	Low	High
Hydrodynamic Structures	Low	Low	Low	Low	Low	Low	Low
Permeable Pavement	Mid	Low	Mid	Mid	Low	Low	High
Street Sweeping	Mid	Low	High	Low	Low	Low	Low
Green Options							
Bioretention	Mid	Low	High	Mid	Mid	Low	Mid
Forest Buffers	Mid	High	High	High	High	High	High
Urban Impervious Surface Reduction	Low	Mid	High	High	Mid	Mid	High
Tree Planting	Mid	Mid	High	High	High	High	Mid

source: Center for Watershed Protection, Cost-Effectiveness Study of Urban Stormwater BMPs in the James River Basin, Ellicott City, MD 2013

Comparing BMPs Across Sectors by Cost Effectiveness



Future Steps

- County-Level Data to be Provided
- MAST is being upgraded in 2014 to include cost estimates
  - The updated version will incorporate a user-defined BMP cost option