

# TREES AS BMPS

Using Tree Canopy for Stormwater Runoff Reduction



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# Overview

- ▣ Runoff reduction benefits of tree canopy
  - Why consider tree canopy?
  - Can we quantify the benefit?
  - Sustainability
- ▣ Tree Canopy & the MS4 Program
  - New development/redevelopment credits
  - Community tree programs
- ▣ Other considerations
  - Safety
  - Nutrient Management



# Ecological Services of Trees

Municipal Forest Resource Analysis: New York City  
(Center for Urban Forest Research, 2007)

- ▣ Tree inventory & benefit analysis quantified:
  - Energy savings
  - CO2 reduction
  - Other air pollutant reduction
  - Enhanced property value
  - **Stormwater runoff reduction**



Source: CUFR 2007



# Ecological Services of Trees

## CUFR: Municipal Forest Resource Analysis - NYC

- ▣ Annually, trees provide \$121.9 million in ecological services for NYC.
  - \$209 per tree
  - \$5.60 in benefits for every \$1.00 for tree planting and care
- ▣ Trees provide \$35.6 million annual savings in treating stormwater, because of rainfall interception
  - Average reduction of 1432 gallons per tree per year



# Stormwater Benefits of Trees

The *Tree Benefit Calculator* indicates a 12-inch Red Maple in the Northeast intercepts 1353 gallons of water per year (~3.8" over the area of its crown).

The screenshot shows the 'National Tree Benefit Calculator' interface. At the top, it says 'Arbor Day Foundation' and 'We inspire people to plant, sustain, and celebrate trees.' Below the navigation bar, the main heading is 'National Tree Benefit Calculator Beta'. A prominent green button says 'Calculate a New Tree'. Below this, there are tabs for 'Overall Benefit', 'Stormwater', 'Property Value', 'Energy', 'Air Quality', and 'CO2 About'. The 'Stormwater' tab is selected. On the left, a diagram illustrates 'Canopy Interception and Evaporation' with labels for 'Precipitation', 'Interception', 'Evaporation', 'Throughfall', and 'Ponding Surface'. The main text reads: 'Your 12 inch Red maple will intercept 1,353 gallons of stormwater runoff this year.' It explains that urban stormwater runoff washes chemicals and litter into streams, wetlands, rivers, and oceans. It also notes that trees act as mini-reservoirs, controlling runoff at the source. A list of benefits includes: intercepting and holding rain on leaves, branches and bark; increasing infiltration and storage of rainwater through the tree's root system; and reducing soil erosion by slowing rainfall before it strikes the soil. At the bottom, it credits 'DAVEY' and 'Casey Trees' as the developers of the calculator.



National Tree Benefit Calculator  
<https://www.arborday.org/calculator/index.cfm>

<http://www.publicdomainpictures.net/>





Presented at CEI's Navigating the New Stormwater Permit on March 30, 2017 in Marlborough, MA  
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# Stormwater Benefits of Trees

- ▣ CEI Project:  
“Tree Canopy Stormwater Implementation & Outreach Program”
  - Quantify stormwater benefits of trees
  - Explore use of tree canopy for stormwater management under Federal and State programs
  - Develop implementation and outreach tools to promote tree canopy management as a BMP
- ▣ Financed with Federal Funds from the EPA under § 319 (MassDEP Project 14-07/319)







# i-Tree Tools

<http://www.itreetools.org/index.php>

## ▣ Developed by USDA Forest Service & partners

Arbor Day Foundation

Davey Tree Expert Company

Society of Municipal Arborists

Casey Trees

International Society of Arboriculture

## ▣ Suite of Software Applications & Utilities

- i-Tree Design

- **i-Tree Hydro**

- i-Tree Species

- Other “urban forest management” applications



# Stormwater Benefits of Trees

- ▣ Apply *i-Tree Hydro* to prototype scenarios:
  - Subdivision roads
  - Urban streets
  - Parking lots



(Alex92287 – Flickr.com)




(Using Trees to Reduce Stormwater Runoff -  
Center for Watershed Protection/USDA Forest Service)



# i-Tree Hydro Hydrologic Model

**i-Tree Hydro Executive Summary**  
 Project Location: Marlborough, Massachusetts  
 Project Time Span: 01/01/2011 - 12/31/2012



**Model Parameters**

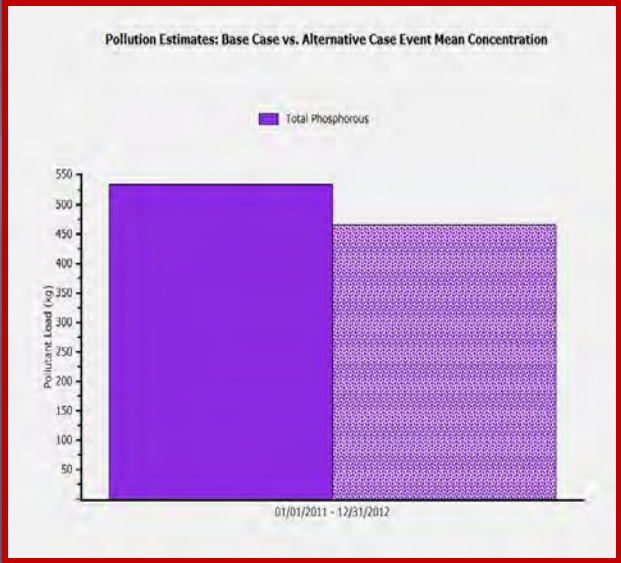
Watershed Area square kilometers	Rainfall millimeters	Total Runoff cubic meters
1.00	2,574.29	1,757,435.78

**Land Cover**

	Base	Alternative
Tree Cover %	1.0	81.2
Shrub Cover %	0.0	0.0
Herbaceous Cover %	27.2	0.4
Water Cover %	0.0	0.0
Impervious Cover %	71.8	18.4
Soil Cover %	0.0	0.0

**Streamflow Predictions**

	Total Runoff		Baseflow		Pervious Flow		Impervious Flow	
	Base	Alternative	Base	Alternative	Base	Alternative	Base	Alternative
Total Flow (cubic meters)	1,757,435.8	1,529,121.9	65,604.7	54,514.7	83,632.7	63,122.4	1,608,198.6	1,411,484.6
Highest Flow (cubic meters / hour)	27,913.8	27,643.3	5.0	5.0	5,293.3	5,256.6	22,617.5	22,384.2
Lowest Flow (cubic meters / hour)	1.3	0.9	1.3	0.9	0.0	0.0	0.0	0.0
Highest Flow Date	07/28/12	07/28/12	10/31/11	11/09/12	07/28/12	07/28/12	07/28/12	07/28/12
Lowest Flow Date	06/11/11	08/15/11	06/12/11	08/15/11	01/01/11	01/01/11	01/01/11	01/01/11
Average Flow (cubic meters/h)	100.3	87.3	3.7	3.1	4.8	3.6	91.8	80.6
Number of flow events ABOVE average flow	258.0	219.0	9.0	6.0	11.0	9.0	260.0	220.0
Average length of flow events ABOVE average (hours)	5.8	6.1	1,244.1	1,382.8	9.8	8.6	5.8	6.1
High Flow: Number of flow events ABOVE 1 standard deviation	165.0	149.0	45.0	14.0	11.0	10.0	171.0	153.0
Average length of flow events ABOVE 1 standard deviation (hours)	3.6	3.5	46.3	314.4	6.6	4.6	3.8	3.6
Number of flow events BELOW average flow	259.0	220.0	8.0	5.0	12.0	10.0	261.0	221.0
Average length of events BELOW average (hours)	62.0	73.5	877.9	1,755.8	1,358.6	1,664.0	61.5	73.2

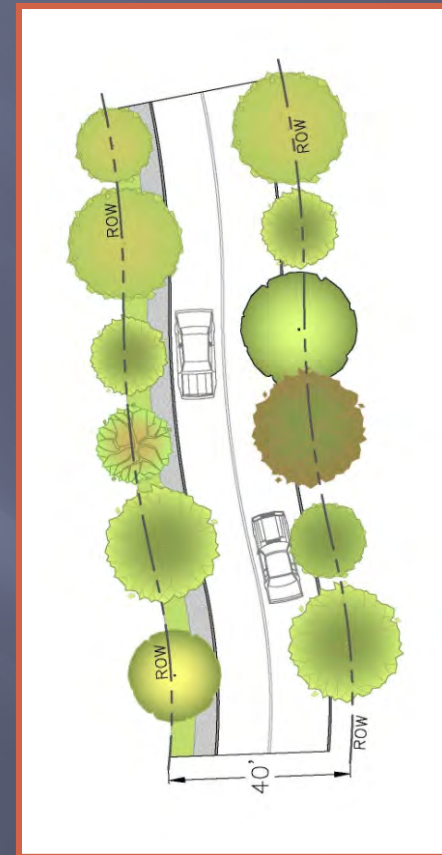
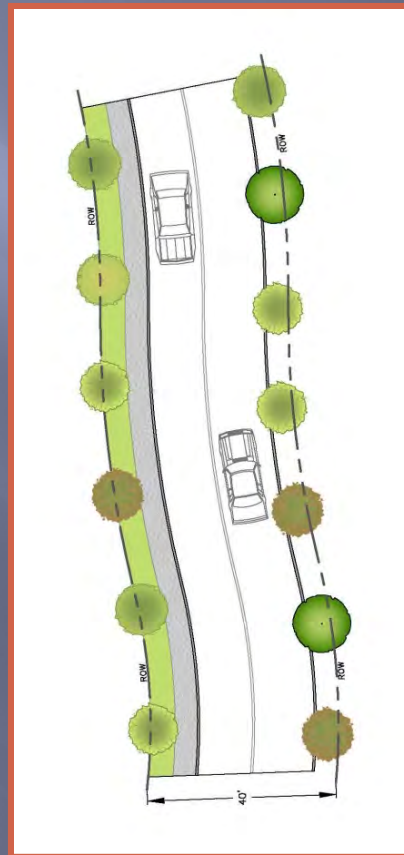
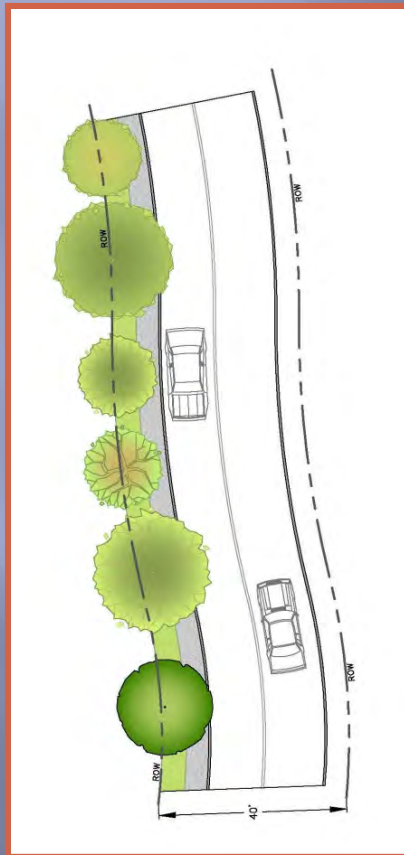


Runoff reduction

Phosphorus reduction



# Subdivision Road Alternatives



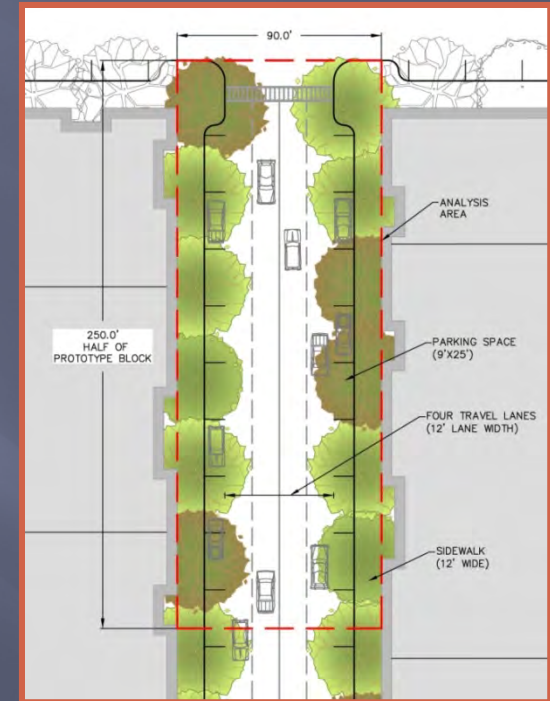
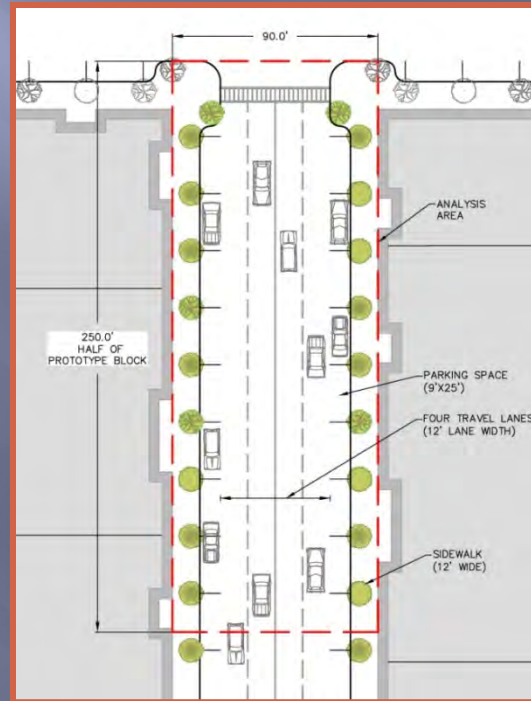
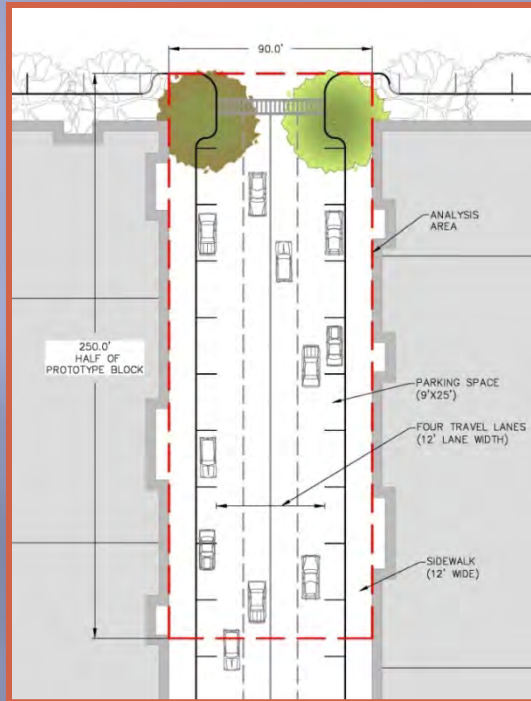
Total area under canopy 41%  
 Impervious under canopy 31%

57%  
 41%

81%  
 74%



# Urban Street Alternatives



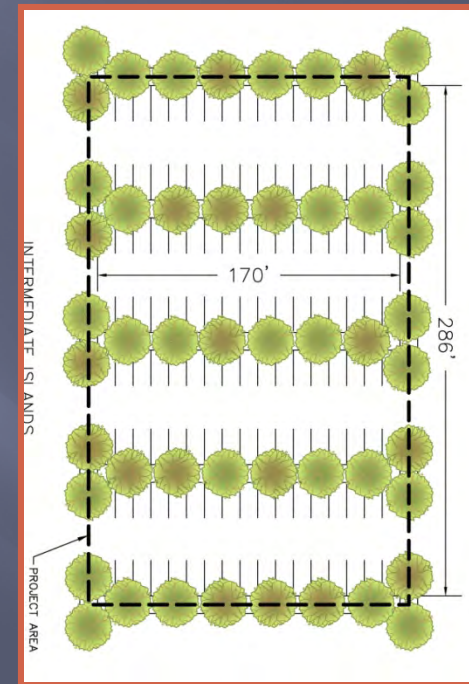
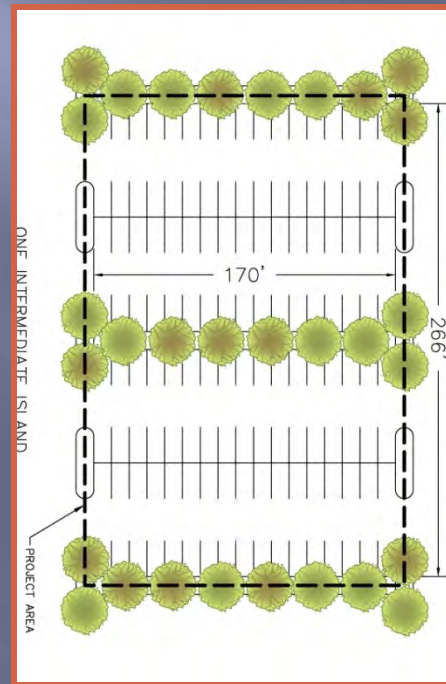
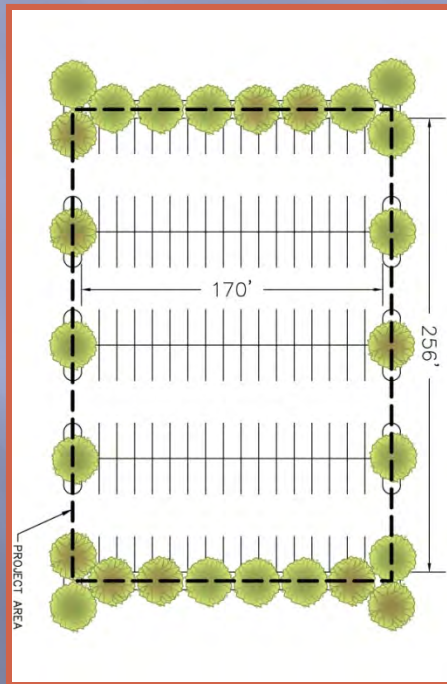
Total area under canopy      11%  
 Impervious under canopy      11%

41%  
 41%

53%  
 53%



# Parking Lot Alternatives



Total area under canopy 11%  
 Impervious under canopy 7%

25%  
 18%

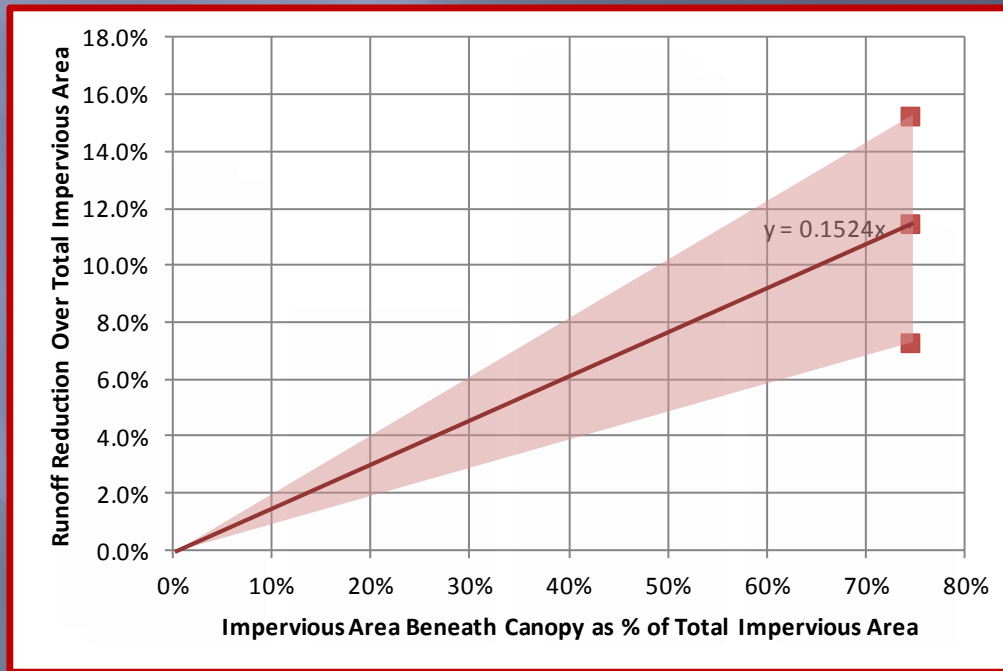
38%  
 26%



# Results of i-Tree Hydro Analysis

Runoff reduction ~ 15% for impervious surface located beneath tree canopy

Range for scenarios analyzed = 1.1 to 12.4%

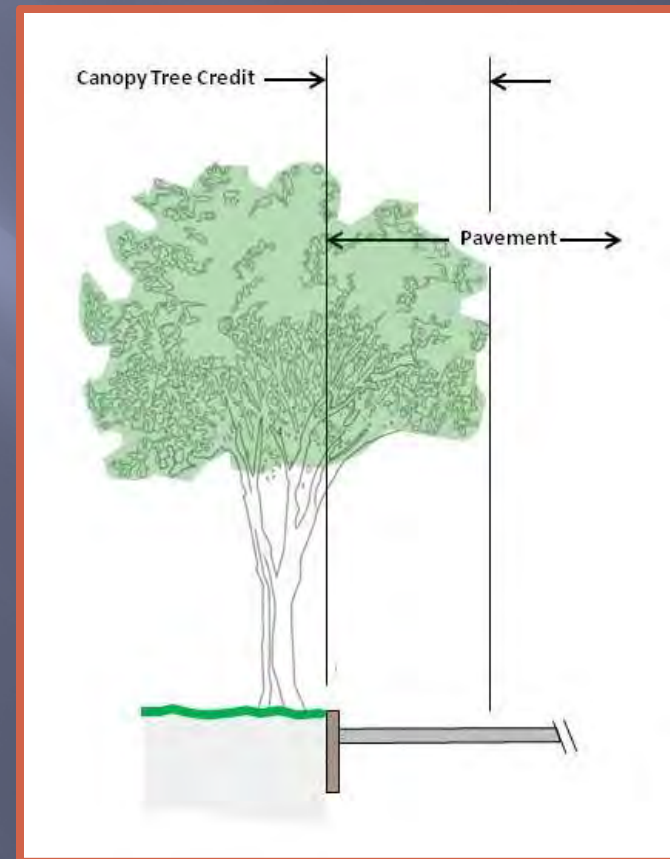


Range for scenarios analyzed = 7 to 74%



# Runoff Reduction WQV Credit

- ▣ Shaded Impervious Surface Only





# US EPA NPDES MS4 Permit

Section 2.3.6. of Permit issued in 2016 requires:

- ▣ MS4's must have a program to address post construction stormwater management
- ▣ New development and redevelopment projects must retain runoff and/or treat for specified removals of TSS (and other pollutants)

New development	Retain <u>1.0-inch</u> runoff volume from <i>total post-development impervious surface</i>
Redevelopment	Retain <u>0.80-inch</u> runoff volume from <i>total post-development impervious surface</i>



# US EPA NPDES MS4 Permit

- ▣ Regulatory language for credits for tree canopy:
  - Preserve existing trees overhanging pavement
  - Provide new trees that will grow to overhang pavement
  - Provide for long term viability
- ▣ Credits designed to allow a reduction in volume of runoff retained and/or treated for either new or redevelopment projects



# Runoff Reduction Credit

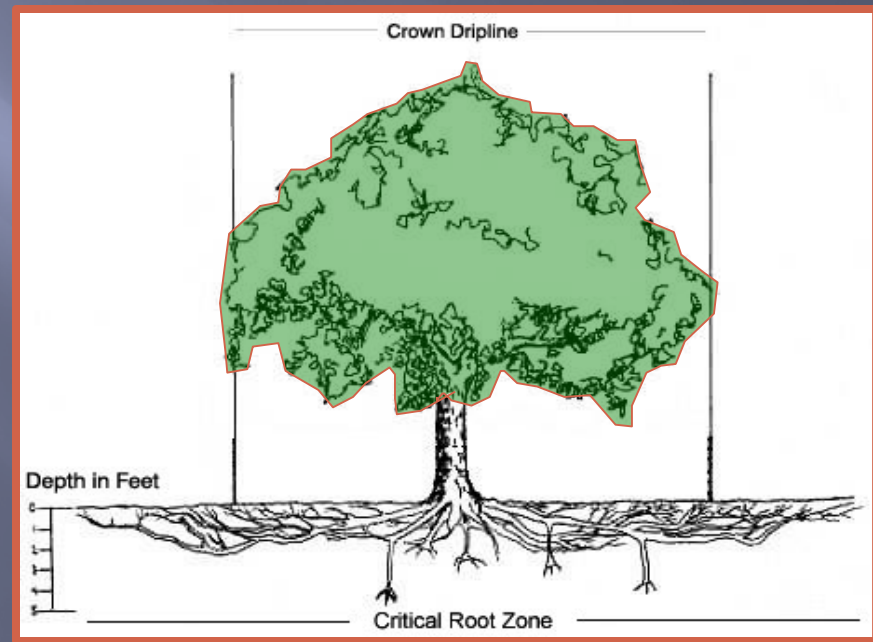
- ▣ Limits on disturbance around existing an existing trees

How close can new pavement encroach without damaging tree?

Recommend requiring assessment by a qualified tree professional

Tree species vary in sensitivity:

<http://www.extension.umn.edu/garden/yard-garden/trees-shrubs/protecting-trees-from-construction-damage/#pavement>

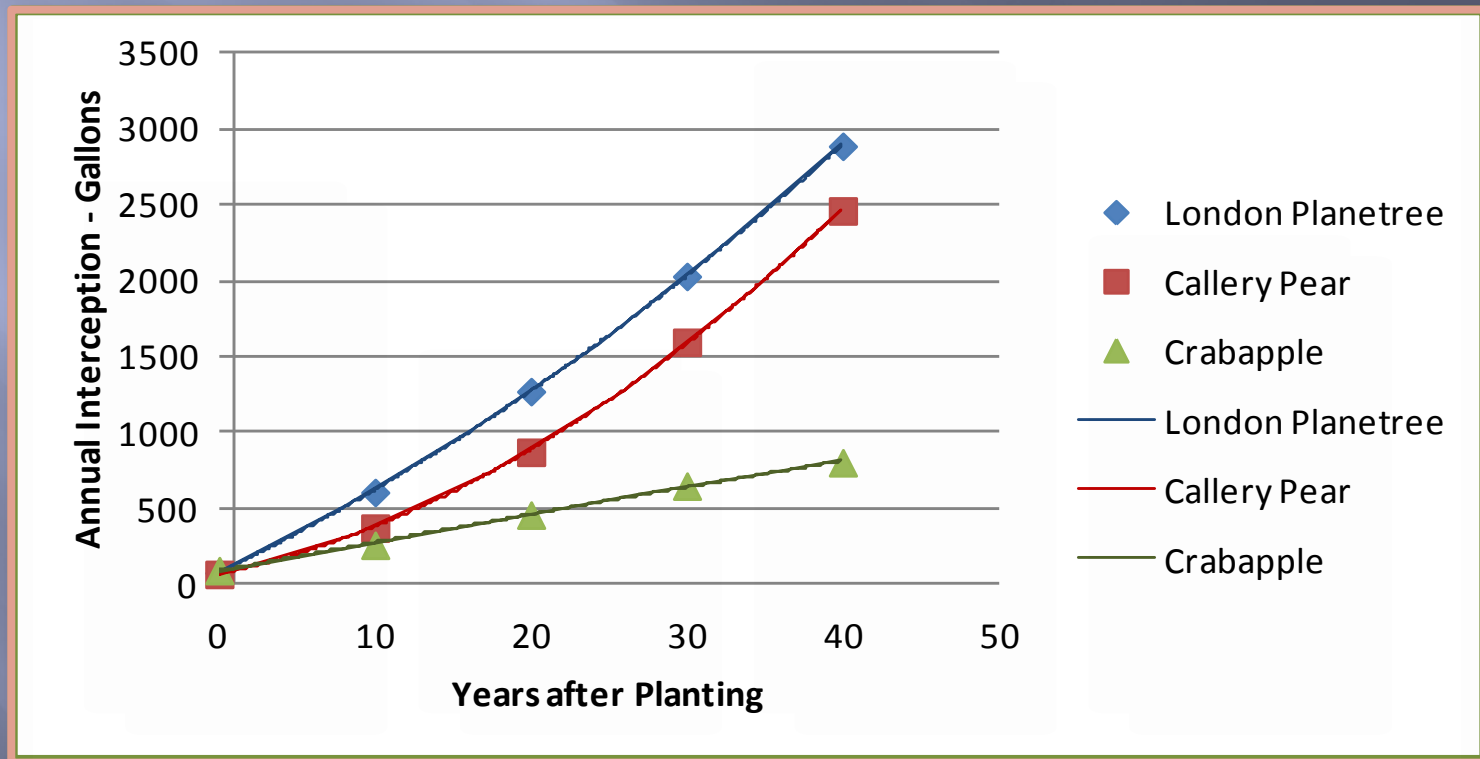


<http://www.seattle.gov/trees/treeCare.htm>



# Runoff Reduction Credit

- New tree plantings – need to account for variation over the lifetime of the tree.



# Runoff Reduction Credit



- ▣ Applies to pavement with overhanging canopy
- ▣ Existing trees:
  - 15% volume reduction for qualifying trees
  - Protection of trees during construction
  - Limits on new pavement beneath the tree
- ▣ New tree plantings
  - 7.5% volume reduction for qualifying trees
  - Provision of adequate soils volume for long term viability
- ▣ Requires maintenance and replacement



# Canopy Tree/Pavement Relationship

Will the tree destroy the pavement...



(MassDOT)

...or will the pavement  
kill the tree ?



(Using Trees to Reduce Stormwater Runoff-  
Center for Watershed Protection/USDA Forest Service)



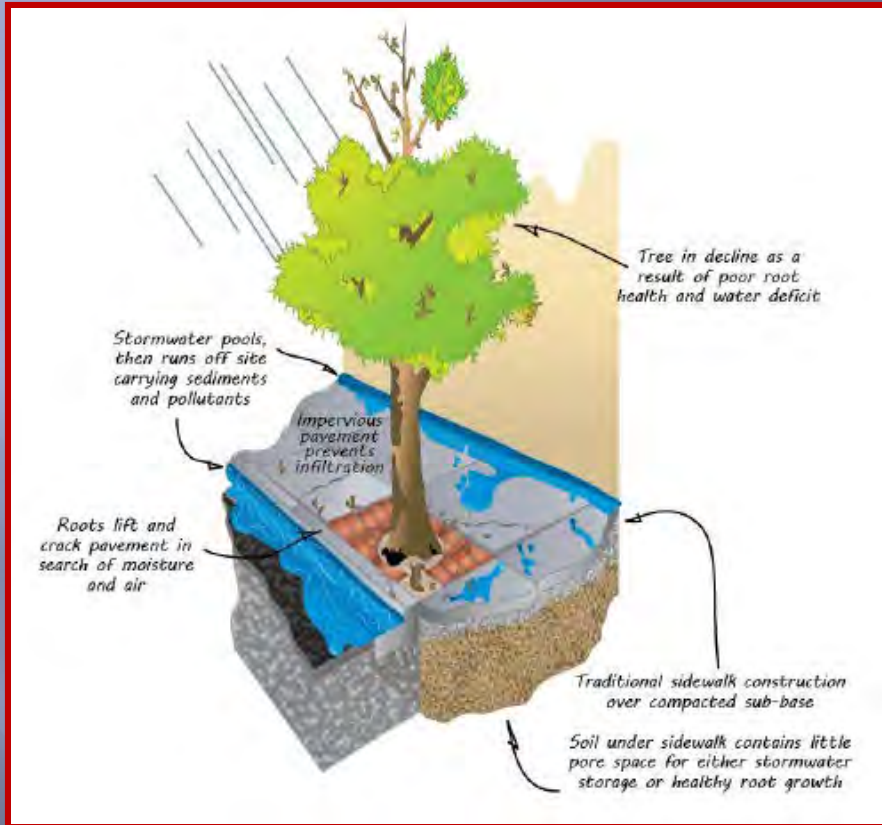
# Tree versus pavement...



Source: McPherson & McDonagh, 2012



# Tree versus Pavement



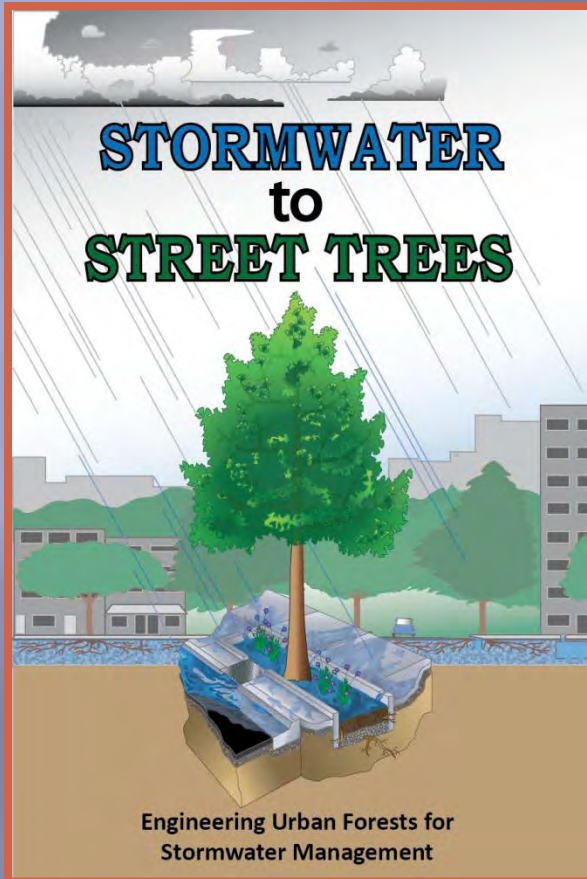
- Average life expectancy of urban tree = 7 to 10 years
- Limited by soil water and nutrient storage
- Solution = ~ 2 cu. ft. of soil volume per sq. ft. of crown

(US EPA. 2013. Stormwater to Trees: Engineering Urban Forests for Stormwater Management. EPA 841-B-13-001)





# Tree versus pavement...



Properly sized planting beds -  
assist where needed using:

- ❑ Suspended pavement/  
structural cells
- ❑ Structural soil material



[http://www.davey.com/media/183712/  
Stormwater\\_to\\_Street\\_Trees.pdf](http://www.davey.com/media/183712/Stormwater_to_Street_Trees.pdf)

# Long term management considerations

- ▣ Prevention of future removal
- ▣ Provision for replacement
- ▣ Provision for tree maintenance
- ▣ Provision for pavement sweeping

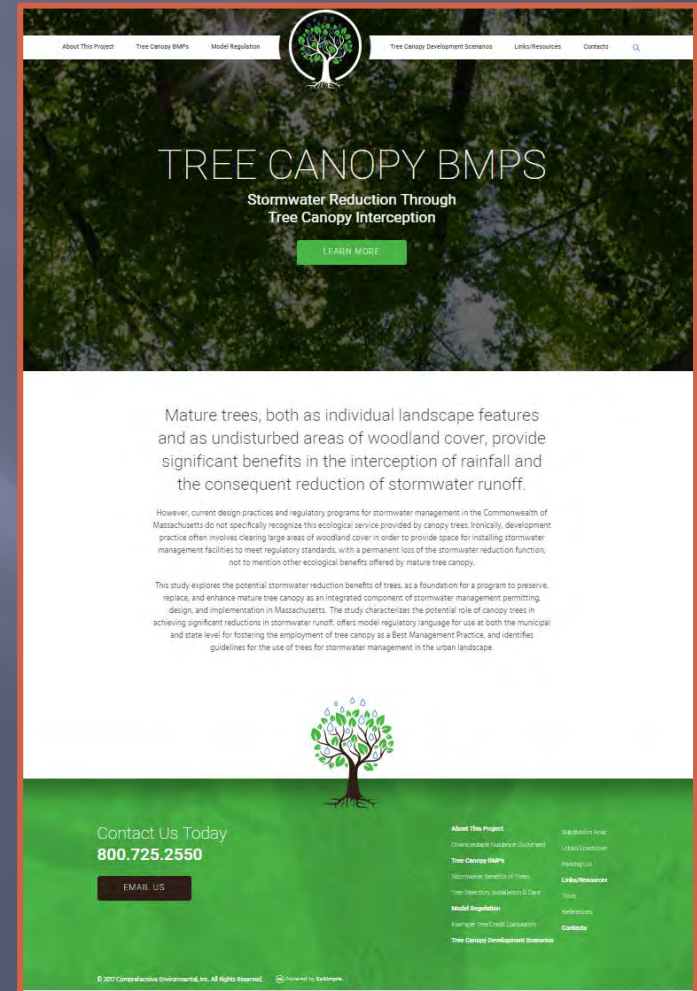




# Tree Canopy BMP Website

www.treecanopybmp.org

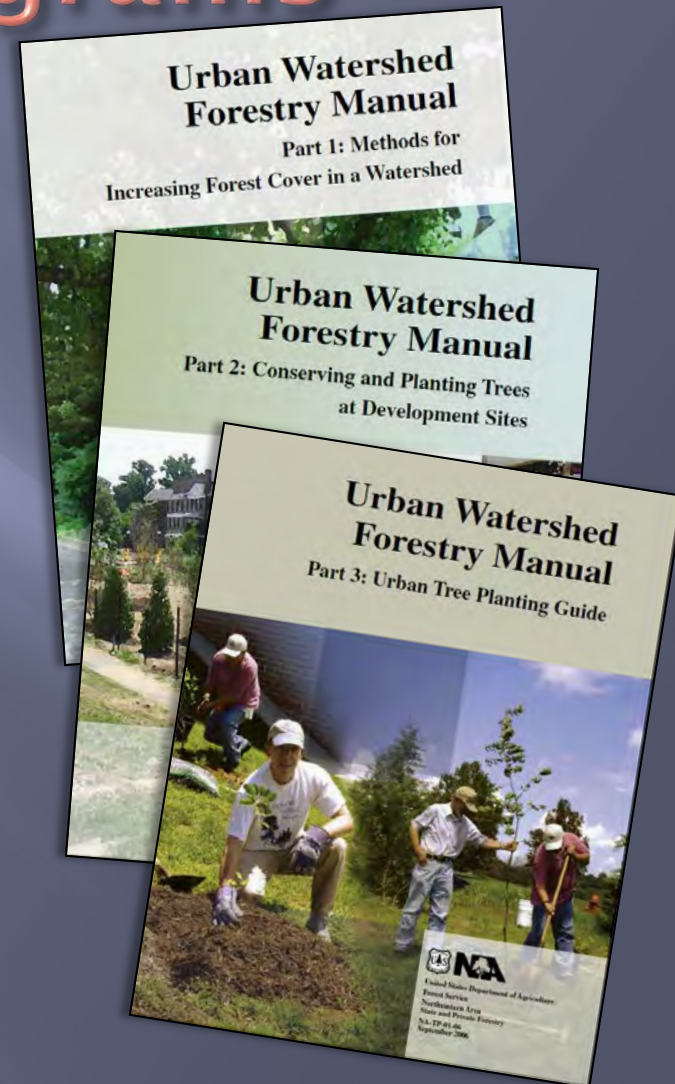
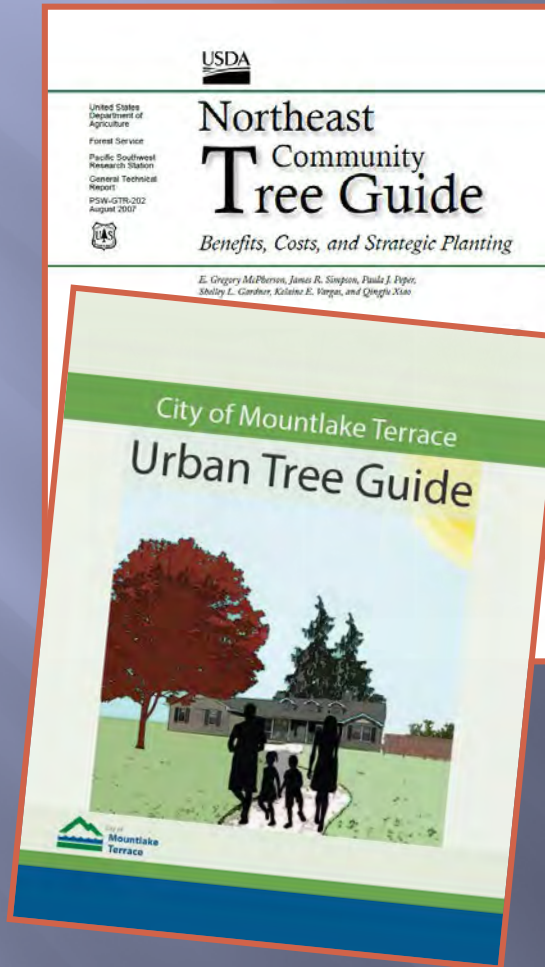
- Information about the study
- Links to resources
- Model regulatory language
- Outreach materials



Presented at CEI's Navigating the New Stormwater Permit on March 30, 2017 in Marlborough, MA  
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# Community Programs

Links to resources



Model Regulation | Tree x

treecanopybmp.sosimplecms.com/model-regulation

Apps Dropbox i-Tree Streets BMP Review | Water Imported From IE Outlook Web Access

About This Project Tree Canopy BMPs **Model Regulation** Tree Canopy Development Scenarios Links/Resources Contacts

# MODEL REGULATION

Example Tree Credit Calculation

## Model Regulation \*

Municipalities that elect to adopt this recommended language should note the following:

- The language offered below may need to be modified to be consistent with the format of the municipality's particular bylaw and regulations.
- The proposed language may require further modification to comply with the final USEPA Massachusetts MS4 General Permit when it is formally issued.
- The municipality should consult with its legal counsel to review proposed new or modified Bylaws and Regulations, as well as the procedural requirements for adopting these instruments, for consistency with applicable laws and regulations of the Commonwealth of Massachusetts.

Section [*insert #*] Administrative Land Disturbance Review Procedure and Standards

[*Subsection #*] Application Requirements and Performance Standards

(Paragraph #) Performance Standards.


11:41 AM 3/21/2017

\* We anticipate this language will be compatible with model bylaw & regulations under development by MAPC/Neponset Stormwater Partnership, to be available mid-2017




# Community Programs

## Map/Inventory Public Trees and Benefits




- With i-Tree Canopy, you review Google Maps aerial photography at random points to conduct a cover assessment within a defined project area.
- You draw your project area boundaries right onto Google Maps or you load an ESRI polygon shapefile in [latitude/longitude coordinates](#).
- i-Tree Canopy randomly generates sample points and zooms to each one so you can choose from your pre-defined list of cover types for that spot.
- 500-1000 survey points are suggested; the more points you complete, the better your cover estimate for your study area.
- If estimating tree cover, tree benefits can also be estimated.
- Recommended web browsers: [Mozilla Firefox](#)<sup>1</sup> or [Google Chrome](#)<sup>2</sup>
- [Learn how i-Tree Canopy works.](#)<sup>3</sup>

**i-Tree Canopy** v8.1  
Estimate tree cover and tree benefits for a given area with a random sampling process that lets you easily classify ground cover types.



GIS-based canopy mapping utility



### i-Tree Streets

#### Overview

Within the i-Tree software suite, street tree populations are assessed using i-Tree Streets, which is an analysis tool for urban forest managers that uses tree inventory data to quantify the dollar value of annual environmental and aesthetic benefits: energy conservation, air quality improvement, CO2 reduction, stormwater control, and property value increase.

It's an easy-to-use, computer-based program that allows any community to conduct and analyze a street tree inventory. Baseline data can be used to effectively manage the resource, develop policy and set priorities. Using a sample or an existing inventory of street trees, this software allows managers to evaluate current benefits, costs, and management needs.

[Learn more](#) ><sup>3</sup>

#### Initial Decisions

The first steps in creating a Streets project are:

1. Define the street tree population for the project you wish to conduct. The population can range from a single planting site on a block of interest to a particular neighborhood, but it is more commonly the entire city street tree population. Users have the option of analyzing an existing street tree inventory or completing a new Streets-compatible inventory.
2. If an existing street tree inventory is not available, users must decide whether a complete or sample inventory of their community's street trees will be conducted. A complete inventory provides a much more comprehensive picture of your urban forest and a great foundation for daily work activities as well as future planning. A sample inventory, on the other hand, is quicker, less expensive, and can provide baseline data for decision making, but typically cannot be used for day-to-day management activities. You should balance the needs and resources of your community to decide which inventory method is appropriate.

#### Working with Existing Inventories

Whether you have a small or large population of street trees, setting up a Streets project with an existing complete inventory is relatively straight forward. Streets is not GIS-based and requires only basic inventory data. Designed to be flexible and adaptive, Streets can accept and analyze data from any existing street tree inventory provided species and trunk diameter data are present and that Streets inventory formatting protocols are correctly followed.

Tree inventory protocol & supporting analysis software

# Community Programs

## Map/Inventory Public Trees and Benefits



sUAV mapping & analysis



# Safety Considerations

How much “clear zone” is enough?  
(context sensitive)



MassDOT





# Nutrient Loading Considerations



*Tree Canopy Stormwater  
Implementation &  
Outreach Program*

Financed with Federal  
Funds from the EPA under  
§ 319 (MassDEP Project 14-  
07/319)



Questions?

