Treating Stormwater with a Tree Box Filter in a Coastal New England City

A Field Study of Effectiveness and Community Guidance for Installations

Acknowledgements:

The adoption of innovative stormwater technologies is challenging for many communities, yet their diffusion is dependent on having ready and relevant examples. This project would not have been possible without the participation and cooperation of many individuals and organizations who were willing to give it a try. Thanks to all who contributed to the project in some way, including the city of Portsmouth, CMA Engineers, Inc., Gove Construction, Filterra Bioretention Systems, Ironwood Engineering, Salmon Falls Nursery, and the businesses and residents of State Street. Thanks to the project partners, University of New Hampshire Stormwater Center, New Hampshire Division of Forests and Lands – Urban Forestry Center, New Hampshire Sea Grant and UNH Cooperative Extension for conducting the research and helping to tell the story. Deep gratitude is extended to the project funders – USDA Forest Service Northeastern Area State and Private Forestry Competitive Grant Program – for supporting this integrated research and outreach project. The photographs are credited to N.H. Sea Grant, UNH Cooperative Extension and Urban Forestry Center staff, A. Dupere, A. Hammond, J. Peterson, R. Zeiber.

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Submitted to

USDA Forest Service

2010 Northeastern Area State and Private Forestry
Competitive Grant Initiative

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Background:

Many communities across the nation are trying to reduce the polluted runoff draining from their streets, walkways, parking lots and roofs. Suburban and urbanizing towns, in particular, are looking for new ways to protect the health of the streams, rivers, wetlands, lakes and bays that often provide identity and character to their communities. Portsmouth, N.H. is among them. It's a small city on the Atlantic coast midway between Boston, Mass. and Portland, Maine, that is home to just over 21,000 people. It's considered one of the nation's oldest cities and has many attractive historic, cultural, economic and ecological features.

Portsmouth is located at the mouth of the Piscataqua River. The Piscataqua borders the states of New Hampshire and Maine along its shorelines and links the ocean waters of the Gulf of Maine to fresh water from inland rivers in the Great Bay Estuary, located about 10 miles inland. As a Municipal Separate Storm Sewer System (MS4) community, Portsmouth is required by the U.S. Environmental Protection Agency to try to reduce the amount of pollutants that enter adjacent waterbodies through its stormwater pipes. The MS4 program is intended to prevent harmful pollutants from entering the nation's waterbodies from municipal sources. Common threats to water quality in New England include excessive sediments (sand and silt), nutrients (nitrogen and phosphorus), pathogens (bacteria and viruses), chloride (road salt) and toxic contaminants (often petroleum-based chemicals that come from land-based origins).

Introduction to Project:

Managing stormwater to prevent flooding in urban or urbanizing areas is not new; however, reducing the amount of pollutants carried in stormwater is a relatively new focus for communities. Communities are sometimes reluctant to adopt new techniques and technologies because of uncertainty with how the new techniques might perform, be maintained or cost. In 2010, Portsmouth took advantage of an opportunity to try some innovative stormwater management techniques. State Street, a two-lane road in the historic downtown section, was undergoing a renovation that included digging up some of the paved street and sidewalk. The renovation had several purposes, including updating utilities, separating stormwater and wastewater systems, and beautification.

This renovation allowed the city to replace several traditional storm drains with **tree box filters**, devices that shuttle stormwater from the street into a concrete box filled with a special soil mix and planted with a street tree. These devices treat stormwater by filtering out pollutants contained in the street runoff as water flows from the street, through the device, and out into underground stormwater pipes. Additionally, the UNH Stormwater Center (UNHSC), a stormwater treatment evaluation center, was interested in monitoring the performance of tree box filters in the field. UNHSC regularly monitors tree box filter performance on campus, and the State Street project offered an additional site to continue tests in a high profile urban setting. The general ability of trees to provide stormwater management benefits is well established. These include interception – the process of tree leaves, branches and trunk reducing the amount and velocity of rain drops reaching the ground, transpiration – the movement on water through the tree and gaseous release from the leaves and stems, and infiltration – the movement of surface water through the soil (US EPA, 2013). Tree box filters differ from conventional street trees in that runoff from a designated drainage area is collected and delivered to the tree where it infiltrates and is filtered by the tree roots and soils.

For a more general discussion of how trees provide stormwater management benefits, see *Stormwater Management Benefits of Trees Final Report* by Stone Environmental Project ID 12-161, March 11, 2014. (Prepared for Vermont Department of Forests, Parks and Recreation with funding provided by the U.S. Forest Service Northeastern Area State and Private Forestry Competitive Allocation.) http://www.vtwaterquality.org/stormwater/docs/manualrevision/sw_White_Paper_tree_benefits_2014_01_08_draft.pdf

For a comparison of conventional street trees and tree box filters in an ultra urban area and some discussion of different types of tree box filters, see a report from the Charles River Watershed Association titled *Stormwater, Trees and the Urban Environment*, (2009). http://www.crwa.org/hs-fs/hub/311892/file-642201447-pdf/Our_Work_/Blue_Cities_Initiative/Resources/CRWA_Stormwater_Trees_Urban_Environment.pdf

In addition to having a "research-ready" site, local monitoring expertise and a motivated and tree-friendly municipality, the project benefitted from other partnerships. Portsmouth is the host city for the Urban Forestry Center and both the city and the center are frequent University partners. The engineering and construction contractors were also willing to participate in the pilot project. Grant funding from the N.H. Division of Forests and Lands through the FY2010 Northeastern Area State and Private Forestry Competitive Grant Initiative got the project off the ground. CMA, the participating engineering firm was recognized with the Outstanding Civil Engineering Achievement Award for 2010 by the N.H. Section of the American Society of Civil Engineers for their work on the State Street renovation.

Project Details:

The renovation included the installation of 12 additional street trees. Among those were three tree box filters where street trees had previously been located, specifically at 136, 222 and 278 State Street. One of the tree box filters was monitored for stormwater treatment performance (figure 1). The tree boxes were installed along State Street, a busy downtown street with curbside parking traveled mainly by passenger vehicles and delivery trucks targeting restaurants, shops and offices in the area. Each tree box drains an area of impervious cover approximately 13,000 square feet in size (about 1/3 acre). The ratio of the drainage (watershed) area to filter area is 311:1.

Figure 1: Location of the two monitoring equipment sites which include the reference sample (influent – blue dot) and the post-treatment water leaving the tree box filter (effluent – red dot) (UNHSC Performance Evaluation Report, 2012).

The climate in the area is characterized as coastal, cool temperate forest with a monthly average precipitation rate of about four inches. The mean annual temperature is 48°F, with an average low in January of 15.8°F and an average high in July of 82°F.

The tree boxes, made by Filterra Bioretention Systems, are precast concrete, six feet deep by eight feet long and nine feet wide (photo 1). A cross sectional view (figure 3) of the box shows a layer of a foot of crushed stone bedding just over the floor, three feet of soil mix and six inches of triple shredded bark mulch. This box can hold a five-inch caliper tree. A red maple was selected for this particular site. A 12-inch perforated pipe embedded in the bottom layer of crushed stone collects and channels treated stormwater into the existing drainage system. Two six-inch diameter overflow bypasses are installed on either side of the system and tie directly into the perforated underdrain to handle rain events that exceed the design storm event (photo 2). The design storm event is typically a one-inch rainfall over a 24-hour period. When it rains in Portsmouth, the rainfall depth is one inch or less more than 90% of the time.

The Filterra tree boxes are filled with a proprietary soil mix. It is critical that tree box filters have soil mixes that have particular properties. The soils must be able to support the growth of the tree, drain adequately and achieve a high level of water quality treatment results. Slow percolation of stormwater through the soil helps with the removal or transformation of some pollutants. At the same time, percolation has to occur quickly enough so that the stormwater doesn't pond for long periods of time. Soil characteristics for the Portsmouth tree box filter as compared to non-proprietary systems researched at UNH are provided in table 1.

Table 1: Soil characteristics for the tree box filter compared to non-proprietary reference characteristics

System	Date Installed	Soil Mix				Vegetation Cover	Organic Content	% Passing 200 um Sieve	Hydraulic Loading		
		Sand	Compost	Soil	Woodchips				Drainage Area (acre)	Filter Surface Area (ft^2)	WQV (ft^3)
UNHSC Tree Filter	2005	80%	20%	-	-	Green Ash	2.1	5%	0.1	28	425
Portsmouth Tree Filter	2011			`		Red Maple	2.9	2%	0.3	72	Not Disclosed

Photo 1: The concrete box is transferred from the truck to the installation site.

Photo 2: A high flow bypass pipe helps divert water from the box into the stormwater system when stormwater volumes are especially high.

Photo 3: This shows how the influent was collected via a deep sump catch basin and drawn into a sampler. The location is represented by the blue dot in figure 1.

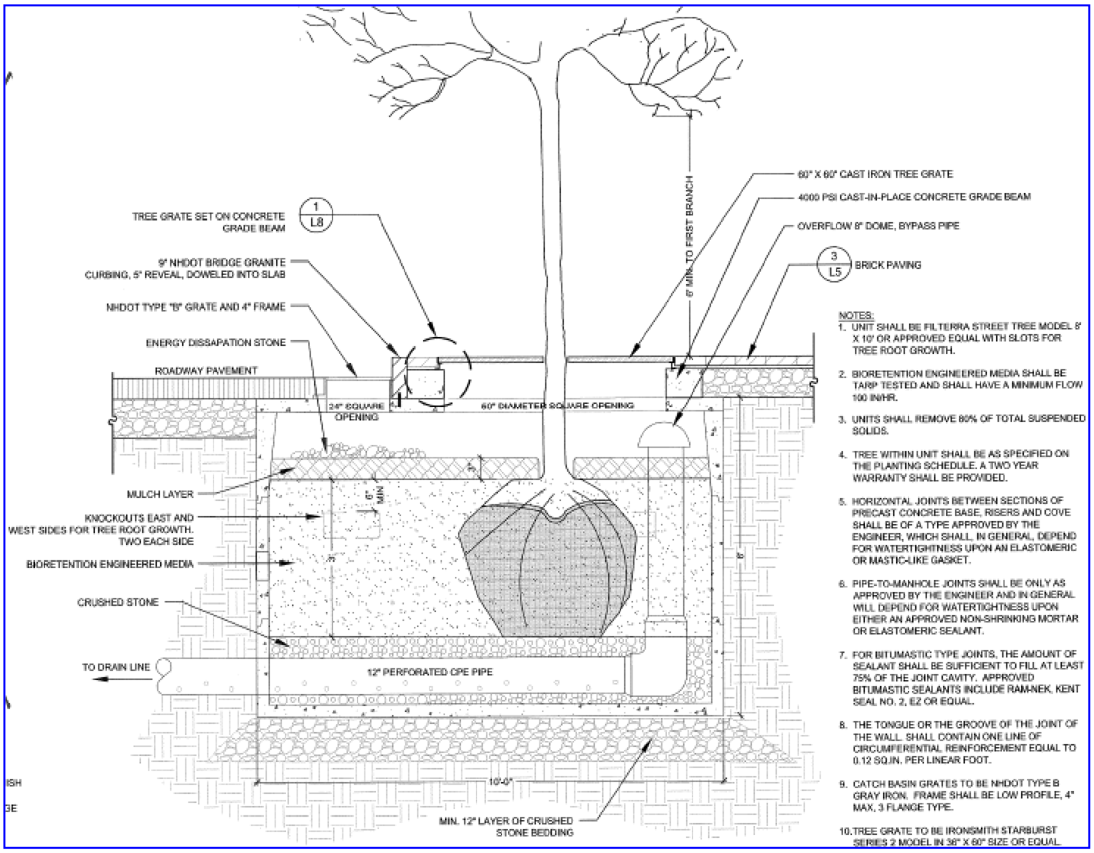


Figure 2: Cross-section view of tree box filter design

Photo 4: This shows the effluent sampler installed inside the tree box during the monitoring phase. The location is represented by the red dot in figure 1.

Monitored Pollutants:

In order to test the performance of the tree box filter as a stormwater treatment, one of the three boxes installed on State Street was monitored. Water was captured and collected in automated samplers, both coming into the system (influent) prior to treatment (photo 3) and leaving the tree box filter system (effluent) (photo 4). See figure 1 for locations. Water samples from both sources were sent to a lab to test for specific pollutant levels. Then the influent and effluent measurements were compared in order to gauge the effectiveness of the tree box filter as a treatment for each pollutant tested. The following pollutants were monitored.

- **Sediment** – as measured by Total Suspended Solids (TSS) and Suspended Sediment Concentrations (SSC)

Excess sediment is a runoff pollutant because it clouds water and tends to carry other pollutants with it. Fine sediments float in the water column and restrict how far light can penetrate water. Fine sediments can clog the gills of aquatic and marine animals and sediments that sink to the bottom can smother marine and aquatic animal habitats and nesting areas. Sediments also attract hydrophobic materials (those that don't chemically mix well in water), some of which are considered pollutants. These materials include phosphorus, nitrogen, some metals and bacteria that attach to sediment contained in stormwater. TSS is currently the most widely used metric for assessing water quality performance of stormwater treatment systems nationally (UNH Stormwater Center, 2009). Sediments get into stormwater from vegetation loss, soil erosion, construction, land disturbance and similar activities.

- **Metals** – as measured by Total Zinc (Zn)

Metals are pollutants that, above certain levels, are toxic to living organisms. Heavy metals contained in stormwater might include copper, zinc, lead, chromium, iron, aluminum and manganese. Total zinc test was used for this study because it is the metal of highest concentration in this study area. Zinc enters stormwater from tire wear and galvanized metal like that used in guard rails. (UNH Stormwater Center, 2009)

- **Hydrocarbons** – as measured by Total Petroleum Hydrocarbons Diesel Range (TPH-D)

Total petroleum hydrocarbons (TPH) is a term used to describe a large family of several hundred chemical compounds that originally come from crude oil (Agency for Toxic Substance and Disease Registry at Center for Disease Control, 1999). Crude oil is used to make petroleum products, which can pollute the environment. Total petroleum hydrocarbons in the semi-volatile (diesel) range (TPH-D) are the ones most likely to be measurable above detection limits in the test area (UNH Stormwater Center, 2009). Petroleum hydrocarbons enter the environment through automobiles and spills, from industrial releases, or as byproducts from commercial or private uses of petroleum-based products, including some fuels, solvents, penetrating oils and pesticides.

- **Nutrients**

Two main types of nutrients were assessed – nitrogen and phosphorus. Nitrogen is measured as Dissolved Inorganic Nitrogen (DIN) comprised of nitrate (NO3), nitrite (NO2) and ammonia (NH4). Phosphorus is measured as Total Phosphorus (TP). Nutrients are critical contributors to the growth of living things, but can create ecological problems when amounts are excessive within a marine or aquatic system. In excess, nitrogen can lead to harmful algal blooms and low oxygen conditions in estuarine and coastal waters. Excess phosphorus can result in the same for freshwater systems. Dissolved inorganic forms of nitrogen are considered the bio-available (and therefore, troublesome) type for saltwater ecosystems. Nitrogen is found in different forms within an ecosystem, and those forms change as a result of biochemical processes. Total phosphorus measurements are typically used for water quality testing. Nutrients are ubiquitous in the environment and enter waterbodies through point sources (directly in pipes) as well as through atmospheric deposition and stormwater runoff from agricultural, residential and commercial sources. Common sources of nutrients include fertilizer, wastewater and those that are attached to sediment.

Research Activities:

The primary study question was to determine whether or not the treatment unit was able to produce observable improvements in quality and reduction in volume of stormwater runoff. Details of the study are included in a technical report by UNH Stormwater Center staff and associated with this project, *Performance Evaluation Report of the Portsmouth Tree Box Filter Treatment Unit*. The testing occurred from June 2011 through September 2011 during which 13 storm events were monitored. The storms ranged from low intensity to high intensity and small volume to large volume. During the study period, there were five rain events where greater than one inch of rain fell in a 24-hour period. Previous studies by the UNHSC (Roseen, et al, 2006) have shown that most of the pollutant mass is carried in stormwater during the first inch of rainfall. The State Street test site showed the same first flush effect (UNHSC Performance Evaluation Report, 2012).

The relative “amount” of each pollutant before and after treatment was represented by its Event Mean Concentration (EMC) or a flow weighted average concentration. From there a Removal Efficiency (RE) was calculated. The removal efficiencies were calculated as both average and median for all storms, however, median values are considered more reliable for studies such as storm water treatment unit performance investigations (UNHSC Performance Evaluation Report, 2012).

Summary of Water Quality Monitoring Results:

After monitoring for over six months and 13 storms, the tree box filter demonstrated an ability to remove most of the tested pollutants in stormwater runoff, with removal efficiencies ranging from excellent to modest depending on the pollutant (figure 3). Details about the test results can be found in the project's technical report, *Performance Evaluation Report of the Portsmouth Tree Box Filter Treatment Unit.* In summary, the test tree box filter performed very well (>85%) in removing sediment and sediment associated pollutants (as measured by SSC and TSS) and exceptionally well at removing metals and hydrocarbons (as measured by TZn and TPH-D respectively).

The system was not able to remove dissolved inorganic nitrogen (DIN), although it demonstrated modest removal (14%) of total nitrogen indicating an ability to temporarily capture organic and particulate forms of nitrogen. Tree filters in urban areas require soils that drain easily (in order to avoid flooding), which prevents dissolved forms of nitrogen from staying in contact with soil microbes long enough to transform into less bio-available forms. Nitrogen removal could potentially improve with alteration of the soils, installation of internal storage reservoirs, enhancement of groundwater recharge, or other innovative design approaches (UNHSC Performance Evaluation Report, 2012).

The system did show promising potential (52%) for phosphorus removal, at least initially. It would be important to maintain the soil mix over time in order to retain the sorptive capacity of the treatment system.

It may be noteworthy that the State Street tree box filter performed very similarly to the tree box filter located at the University of New Hampshire's stormwater treatment field evaluation site.

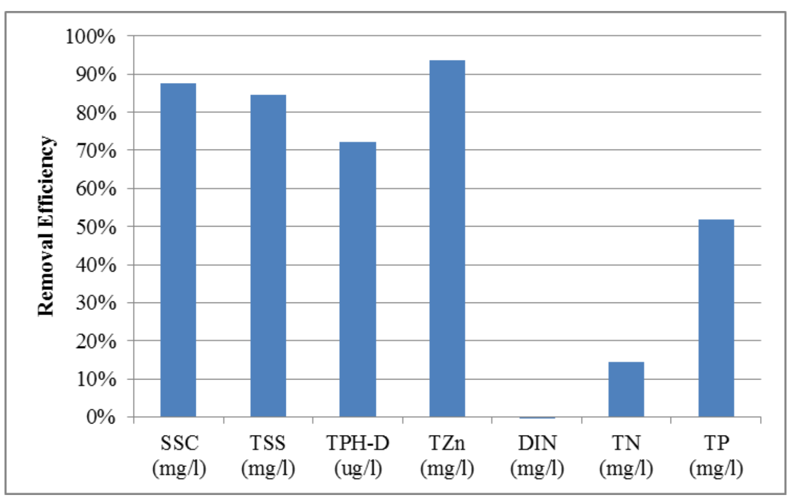


Figure 3: Median Removal Efficiencies – a comparison chart for monitored storm events at State Street site. (UNHSC Performance Evaluation Report, 2012)

Design Considerations for State Street Site:

This demonstration site had some unique considerations related to its function as both a research site and as part of a greater municipal renovation project. For example, newly planted street trees often require extra watering and fertilization as they become established; however, extra watering and fertilization would disturb the experimental monitoring regime. As such, larger caliper trees were planted that were already well established (>3" in diameter) and any additional watering done was communicated with the monitoring team in order to avoid triggering the sampling equipment.

A larger caliper tree was also necessary because the large catch basin and inflow pipes required that the box be set well below grade. Having several small inlet pipes may have allowed the box to be set a bit higher and the tree to be smaller in size.

Another consideration for this particular project was that it was located in an historical district with narrow sidewalks, fairly narrow roadway and old foundations. This meant that excavation had to be carried out extremely carefully in order not to damage the historic buildings that house tightly packed residences and businesses in a pedestrian friendly area.

The narrow roadways, characteristic of historic, downtown Portsmouth and part of what makes it an appealing pedestrian area, prompted the use of large concrete tree boxes with very thick walls. With little existing road shoulder, cars and trucks traveling the road would necessarily be driving over the underground box, which needed to be able to withstand those loads. The road had to be partially closed to traffic during installation.

Although the limited downtown space, older utilities and streetscape posed challenges from the city's perspective, the use of tree box filters to help reduce urban pollution entering the Piscataqua River was considered a major accomplishment. Portsmouth is now home to a number of tree box filters.

Recommendations for Urban Tree Box Filter Installations:

- Prepare for some differences from planting typical street trees. Depending on the inlet configuration, some trees may need to be planted more deeply than typical street trees because they must fit into a box located below the storm grate or stormwater inlet. Select trees whose lowest branches will not interfere with pedestrians and whose highest boughs will not interfere with utility wires in densely developed settings. Portsmouth had to trim lowest branches for public safety (photo 5).

Photo 5: This is a view of the completed installation. The storm drain allows stormwater into the tree box. Sidewalk grates help prevent soil compaction. The newly installed tree had to have its lowest branches trimmed, not ideal for a newly planted street tree but necessary in this case.

- Work with experienced and motivated partners if possible. There are bound to be some unforeseen challenges and rewards as with any new project. This project benefitted from the engagement, willingness and enthusiasm of the municipality, a tree-friendly community, an urban forestry center, a university, the engineering firm, the contractor and the tree nursery. The engineering firm involved in this street renovation won an award for their work on the project.

- Include adjacent property owners among the project partners. Although affected business owners may favor trees, they don't want their business access or signage to be obscured. Bringing affected parties in on the planning early to help avoid potential conflicts later on.

- Select tree varieties that are appropriate street trees for the growing zone and conditions. In addition, consider that trees in a box filter will typically receive large volumes of water during a storm from the street into a well-drained soil mix, so the trees need to tolerate both very wet and dry conditions. In cold climates where street de-icing regularly occurs, make sure species also have high salt tolerances. For specific recommendations for the northeastern U.S., see the **Tree Selection Guide** pages.

- To mulch or not to mulch is a constant debate in the field. Some prefer the weed deterrent offered by the layer of mulch, others feel that mulch floats particularly in urban environments like the Portsmouth tree box installation and has the potential to clog outlet structures and high flow bypasses. If mulch is selected, careful attention to the type of mulch is necessary. In this situation, the mulch was a three-inch layer of triple shredded bark mulch designed to be replaced periodically as needed.

- Tree box filter trees may suffer less compaction than typical street trees if the box is large and if other techniques and devices (e.g., grates, Silva Cells, etc.) designed to prevent soil compaction from foot and vehicle traffic are used.

- When considering costs, plan for tree box filter installations to initially cost more than conventional street trees depending on the situation. Keep in mind, however, that tree box filters provide additional benefits by reducing demand on existing stormwater infrastructure and are designed to reduce pollution of receiving waters. In situations requiring heavier duty components and more sophisticated engineering, costs are likely to be higher. In cases with simpler conditions, costs for the installation of tree box filters will be closer to that of conventional installations.

- Both conventional street trees and stormwater tree filters require maintenance. Portsmouth added a drop inlet debris catcher to help make maintenance easier (photo 6). Some proprietary systems come with maintenance agreements for the first several years.

Maintenance is often a challenge with street trees. “Tree pits are being used as garbage cans and ashtrays,” according to a city employee.

Photo 6: Drop inlet debris catcher is installed in catch basin.

- Work with professionals who can help design a system for contaminants of highest concern at a site. Climate, likely contaminants, soil mixes, maintenance regimes, size constraints, urbanization level and other factors should influence how any particular tree box filter system is designed or selected for a particular location.

Crabapple

Scientific Name: ***Malus spp***

Common Cultivars: **"Adams", "Donald Wyman", "Prairifire", many others; choose for disease resistance, persistent fruit**

Lowest Hardiness Zone: **4**

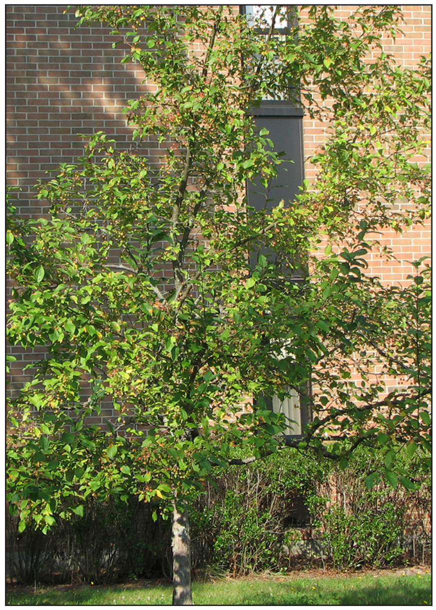
Light Requirements: **full sun**

Soil Preferences: **well drained**

Mature Size: **small, 10' to 30' tall, 10' to 35' wide**

Growth Rate: **medium**

Mature Crown Shape: **rounded, oval or vase shaped depending on cultivar**



Flowers: **single or double; white, pink or red; spring**

Foliage: **simple 1-2" long, green to reddish green**

Fruit: **1/4-2" apples, various shades of red, orange or yellow**

Bark/Branch: **variable depending on cultivar**

Uses: **depends on cultivar; under utility lines, confined spaces, street tree, specimen, lawn; check cultivar to see if native**

Urban Stress Tolerance: **depending on cultivar, can be good; tolerant of salt, heat, drought**

Significant Health Issues: **some susceptible to apple scab, fireblight, cedar-apple rust**

Possible Negative Qualities: **fruit can be messy**

Hawthorne

Scientific Name: ***Crataegus*** **species**

Common Cultivars: ***Crataegus viridis*****, "Winter King";** ***Crataegus laevigata*****, "Crimson Cloud";** ***Crataegus crusgalli var. inermis***

Lowest Hardiness Zone: **4**

Light Requirements: **full sun**

Soil Preferences: **tolerant of most soils and pH**

Mature Size: **small, 15-30' tall, 10-35' wide**

Growth Rate: **medium**

Mature Crown Shape: **oval to rounded**

Flowers: **white or pink, some smell foul**

Foliage: **simple, 1-4" long, fall yellow, orange, red or purple**

Fruit: **1/4-1" red, apple like**

Bark/Branch: **can have long thorns**

Uses: **native*, see Comments, street tree, possibly under utility lines, specimen, lawn**

Urban Stress Tolerance: **toughest of small flowering trees, relatively long lived on urban sites**

Significant Health Issues: **select disease resistant cultivars**

Possible Negative Qualities: **long thorns, not all have "tree form"**

Comments: ***native species include:** ***Crataegus crusgalli, Crataegus mollis, Crataegus nitida, Crataegus phaenopyrum, Crataegus succulenta, Crataegus viridis***

Honeylocust

Scientific Name: ***Gleditsia triacanthos var. inermis***

Common Cultivars: **"Imperial", "Shademaster", "Skyline"**

Lowest Hardiness Zone: **4**

Light Requirements: **full sun**

Soil Preferences: **deep, moist, neutral pH**

Mature Size: **large, 50-60' tall, 50-60' wide**

Growth Rate: **fast**

Mature Crown Shape: **broad oval**

Flowers: **subtle**

Foliage: **compound leaves, bright green, lacy; fall showy, clear yellow**

Fruit: **long brown pods, usually few on clutivars**

Bark/Branch: **attractive bark, gray-brown, long flat strips separated by furrows**

Uses: **native, lawn tree, street tree if space, allows filtered light to reach ground beneath**

Urban Stress Tolerance: **tolerant of pollution, salt**

Significant Health Issues: **bagworm, spider mites, webworm, pod gall midge, cankers**

Possible Negative Qualities: ***var inermis*** **should be thorn free, overused in past**

Comments: **select from northern seed sources**

Japanese Tree Lilac

Scientific Name: ***Syringa retculata***

Common Cultivars: **"Ivory Silk", "Summer Snow"**

Lowest Hardiness Zone: **3**

Light Requirements: **full sun**

Soil Preferences: **well drained, slightly acidic**

Mature Size: **small, 20-30' tall, 15-25' wide**

Growth Rate: **medium**

Mature Crown Shape: **rounded**

Flowers: **showy, fragrant, white in early summer**

Foliage: **simple, 2-4" long**

Fruit: **tan capsules in clusters**

Bark/Branch: **gray-brown with horizontal lines; twigs stout, shiny**

Uses: **under utility lines, confined spaces, street tree, specimen, lawn**

Urban Stress Tolerance: **tolerant of salt**

Significant Health Issues: **some resistance to mildew, scales, and borers**

Comments: **prefers cool summers**

Red Maple

Scientific Name: ***Acer rubrum***

Common Cultivars: **several**

Lowest Hardiness Zone: **3**

Soil Preferences: **tolerant of most soils**

Mature Size: **medium to large, 40-70' tall and wide**

Growth Rate: **fast**

Mature Crown Shape: **rounded**

Flowers: **showy, orange red in early spring**

Foliage: **simple, green; fall yellow to red depending on individual**

Fruit: **2-3" samaras**

Bark/Branch: **ash gray**
Uses: **native, lawn tree, shade tree**

Urban Stress Tolerance: **intolerant of heavily polluted areas**

Significant Health Issues: **possible leaf hoppers and borers**

Possible Negative Qualities: **fruit can be a litter problem**

Sargent Cherry

Scientific Name: ***Prunus sargentii***

Common Cultivars: **"Accolade", "Columnaris", "Rancho"**

Lowest Hardiness Zone: **5**

Light Requirements: **full sun to partial shade**

Soil Preferences: **moist, acidic, well drained**

Mature Size: **small to medium, 25-40' tall, 25-40' wide**

Growth Rate: **fast**

Mature Crown Shape: **broad, spreading**

Flowers: **Showy, 2" single pink in May**

Foliage: **simple, 3-5" long, oval, dark green; fall showy yellow, orange or red**

Fruit: **1/2" red to black drupe, birds like**

Bark/Branch: **reddish shiny bark, looks polished**

Uses: **under utility lines, most grow to 30', specimen, lawn, shade, parking lot**

Urban Stress Tolerance: **salt tolerant, some tolerance of drought**

Significant Health Issues: **caterpillars, black knot disease**

Photos 7-12 from Tree Box Filter A (near 136 State Street)

Site Excavation:

Photo 7: Note historic buildings and foundations.

Photo 8: Note the historic neighborhood, pedestrian-friendly walkways, compact commercial and residential development. The Piscataqua River is in the distance.

Base Layer Installation:

Photo 9: This is a view of the base layer of crushed stone right after installation.

Box Installation:

Photo 10: Note round hole for drain pipe to municipal stormdrain system and rectangular hole for tree root expansion.

Photo 11: The cover is placed on the box.

Photo 12: This is view of box and cover installed. Note cutouts in box cover for tree (larger one) and stormdrain (smaller one).

Photos 13 - 19 from Tree Box Filter B (near 222 State Street)

Finish Work at the Box Installation Site:

Photo 13: Note paving, curbing and brick sidewalk installed in preparation for soil and tree installation.

Tree Installation:

Photo 14: A red maple cultivar was selected and delivered for this project.

Photo 15: This is a view of the balled and burlapped tree roots.

Photo 16: The red maple is being delivered to tree box filter site.

Photo 17: Note depth of planting required to fit this box and installation.

Photo 18: Soil mix is being added to box.

Photo 19: The tree box filter undergoes a final inspection.

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