Flood and Drought Tolerance Trials of Select Shrub Species
&
Woody Shrubs for Stormwater Retention Practices Northeast and Mid-Atlantic Regions

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by
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Abstract

Stormwater runoff creates many issues particularly in our urban areas. Decreasing the initial volume of stormwater entering our existing catchment systems can help to alleviate some of the issues associated with stormwater. One method for retaining and assisting in the gradual infiltration of stormwater runoff is to create planted catchment practices. The current planting suggestions for these practices tend to focus on wetland shrubs, the thinking being that this is a wet environment therefore we should use wet soil adapted shrubs here. The flaw in this thinking is that often these catchment practices remain dry for long periods of time making them less ideal spaces for many wetland species. By putting plants through rigorous flood and drought trials to test their plasticity in this regard can help us to select successful species for stormwater catchment practices.

In part one of this work I outline the methods and outcomes of an experiment in which the flood and drought tolerance of six shrubs species (*Amorpha fruticosa, Hippophae rhamnoides, Salix arenaria, Salix purpurea Shepherdia argentea*, and *Spiraea tomentosa*) were tested. The goal of the experiment was to determine whether these species had potential for use in the aforementioned planted stormwater retention and infiltration practices.

In the second section of this work I explore the issues associated with stormwater and some of the benefits of controlling stormwater runoff using planted stormwater catchment practices. In addition I generally outline site requirements and appropriate plant selections for creating successful, sustainable planted stormwater retention and infiltration practices.

Biographical Sketch

Ethan M. Dropkin began his higher academic career at the University of Vermont where he received a Bachelor of Science in Secondary Education (English). After graduation he worked as an Environmental Educator, Camp Counselor, Canvasser for the Democratic National Committee and a tutor.

After about a year he got the opportunity to work as a gardener for the New York City Department of Parks and Recreation. He worked as both a Neighborhood Parks Initiative (NPI) Gardener and as a District Gardener in Bay Ridge, Brooklyn. In these roles he: mediated the relationship between the privately funded Shore Road Garden Council and the NYC Parks Department, designed and installed all new plantings in the Shore Road Garden utilizing largely native or suitable sustainable plants, created and installed informative labels for a selection of popular specimens in the garden, instituted a composting system,designed and installed a 3 block long erosion control shade garden at Owls Head Park. He was responsible for the horticultural management of over 13 parks and greenstreets, including: pruning, fertilization, watering, IPM, garden expansion, and weed eradication. He supervised over 100 volunteers, of all ages, twice a year at one of the most attended “It’s My Parks Day” sites in the city, smaller volunteer groups throughout the year, and mentored a High School summer intern; teaching horticultural practice.

Following this work he was accepted into the Masters of Landscape Architecture program at Cornell University which he completed in May, 2013. Subsequently he was accepted in to the Maters of Professional Studies in Horticultre program at also Cornell, of which this project is the outcome.

To Liz, the love of my life. Your constant support has helped me stay true to myself and my process. You are my greatest cheerleader, my best friend, and the reason I made it through graduate school. All my thanks and all my love.

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Testing Flood and Drought Tolerance of Selected Shrub Species for use in Bioswale Installations

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ADDITIONAL INDEX WORDS: stormwater, *Amorpha fruticosa* L., *Hippophae rhamnoides* L., *Salix arenaria* L., *Salix purpurea* L., *Shepherdia argentea* (Pursh) Nutt., *Spiraea tomentosa* L., bioswale, rain garden

Summary. Six shrubs: *Amorpha fruticosa, Hippophae rhamnoides, Salix arenaria, Salix purpurea, Shepherdia argentea*, and *Spiraea tomentosa*; were tested for their ability to grow in flooded and dry conditions, mimicking the conditions that may be found in planted stormwater catchment installations. The four conditions tested were seven days flooded, three days flooded, moist well-drained, and drought. While some statistical plant growth differences were found between treatments, these were not horticulturally important. All six shrubs showed good growth and survival and are potentially successful candidates for use in planted stormwater catchment installations.

Stormwater is rain or snowmelt which flows over the ground and does not directly infiltrate into the soil. Historically stormwater only occurred during large storm events when the rate of rainfall or snowmelt was greater than the rate at which water could be absorbed into the soil. With the advent of wide-scale development and urbanization the amount of impervious surface in the US is approximately 43,000 sq. mi. with an additional quarter of a million acres being added each year (Schueler and Holland, 1994). In addition to an increase in impervious surfaces, soils which become compacted due to human impacts, also experience a significant drop in their ability to absorb runoff during storm events (Gregory, 2006). Increases in stormwater tax our sewage treatment systems, especially in cities that have combined stormwater and sanitary sewers.

This can create a host of other stormwater related issues including: sedimentation, erosion, nutrient loading, pollution, etc. (Karimipour, 2010). Generally some or all of these problems can be found in the watersheds of urban and suburban areas and anywhere downstream of these areas. Capturing stormwater in retention/infiltration installations during a storm event and allowing it to slowly infiltrate, rather than rush directly into sewers can help mitigate many of these issues.

Planting these catchment sites can assist in the success of these practices as plant roots providing infiltration channels for water to move through (Bartens, 2008). In conjunction with soil microorganisms, plants can help remove pollutants like heavy metals from retained stormwater (Jurries, 2003) and help to hold soils together, reducing erosion by stormwater (Caltrans, 2008). Plants help to slow stormwater runoff, which in turn causes some suspended solids and sediment, to settle out of the runoff (Jurries, 2008). Moreover, plants add aesthetic and educational value (Echols and Pennypacker, 2008), increase biodiversity, and create habitat (Wise, 2010). To promote plantings with reduced maintenance costs, the value of woody plants should be considered. While herbaceous plants are potentially quicker to establish and fill a site, post-establishment they require at least yearly pruning to remove thatch and seasonal die-back. Woody plants however due to their generally slower growth rate and more permanent growth habit require far less pruning, potentially only once every three years, reducing the overall amount of maintenance significantly (Russ and Polomski, 1999).

Given all of these benefits it is critical to include plants in stormwater practices whenever possible. When selecting plants for stormwater infiltration, common sense would seem to dictate the use of wetland plants. However, due to the rapid rate at which most of these practices allow water to infiltrate, the majority of planted stormwater practices will be inundated from a few minutes after a storm event, to a day or two. Unlike most permanent or semi-permanent wetlands these areas remain relatively dry a majority of the time. As a result plants that can handle both temporary inundation and relatively protracted drought are the best choices for a low-maintenance planting. Many lists of suggested plant species exist, however they are largely based on observation rather than replicated experiments. Some of these lists include: “Wetland Indicator Status List” (USDA, 2013), “Landscaping Guidance for Stormwater BMPs” (Maryland Department Environmental Resources, 2007), and Recommended Plant List for

Bioretention Facilities (Fairfax County Public Works and Environmental Services, 2007), etc. These and other plant lists like them tend to be gleaned exclusively from native wetland species and rarely take into account the extended dry periods most stormwater installations experience.

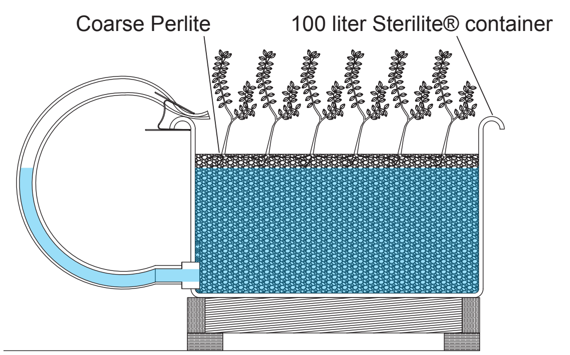
One literature review looked at the flood, drought and shade tolerance of 806 species on three continents (Niinemets and Valladares, 2007). While this study was expansive, it used accumulated data from many varied methods and created flood and drought rankings based on a long time scale.

Other than the aforementioned study, most of the existing experiments in this area of study only looked at the flood tolerance of species and not at their drought tolerance (Dylewski, Wright, Tilt, LeBleu; 2011)(Glenz, Schlaepfer, Iorgulescu, Kienast; 2006). Since stormwater infiltration practices experience both flooding and drought, the goal of this study was to discover the adaptability of plants at both ends of the hydrologic spectrum.

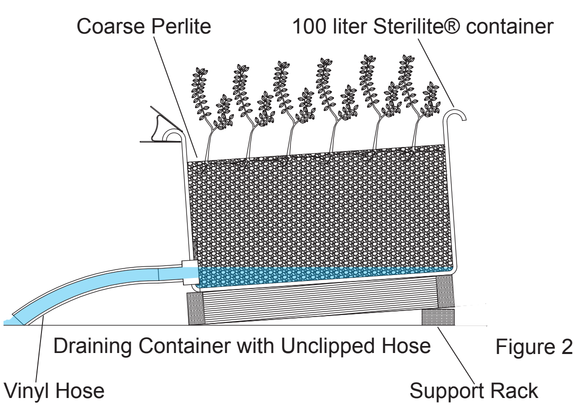
Materials and Methods

Six species of shrubs were tested for their ability to grow in media that was either saturated or allowed to dry down. The species used were: *Amorpha fruticosa*, *Hippophae rhamnoides* ‘Sprite’, *Salix arenaria*, *Salix purpurea* ‘Nana’, *Shepherdia argentea*, and *Spiraea tomentosa*. *A. fruticosa*, *S. argentea*, and *S. tomentosa* were grown from seed in March 2011 in a greenhouse and then were transferred to the field in May 2011 where they were grown on until they were transferred to the containers in June 2013. *S. arenaria* and *S. purpurea* were 10 in. rooted cuttings collected in May of 2013 from shrubs on the Cornell campus, in Ithaca NY. They were rooted in pots of Whitmore Company Inc. Super Coarse Horticultural Grade Perlite in a greenhouse until their transfer to #1 containers. *H. rhamnoides* were 3 year old landscape shrubs cut back to approximately 24 inches and were also rooted in pots of perlite in a greenhouse until their transfer to the treatment containers. These species were chosen for different reasons. In the case of *S. purpurea* we had observed a strong flood tolerance and wanted to test its tolerance to drought. In the case of *S. arenaria* and *H. rhamnoides*, both had proved very drought tolerant and we were interested in their ability to handle saturated conditions. *A. fruticosa*, *S. tomentosa*, and *S. argentea* have all been observed to grow in saturated and droughty soils in the wild and we wanted to scientifically test their response to varying soil moisture levels.

A support rack was constructed from 5.08 cm. x 10.16 cm. planks and plywood, to facilitate container drainage (see Figure 1). The rear rail of the rack was elevated by placing a 5.08 cm. x 10.16 cm. plank underneath it. As a result, the rack sloped 11.5° from front to back. On top of each of the 50 cm. x 36 cm. plywood sections a 100 liter (85.7 cm x 49.2 cm. x 34cm.), clear plastic Sterilite® container was placed. Each of these containers had a hole drilled into the center of the short wall, 1 cm. above the base of the container. The hole was plugged with a 1 cm. plastic hose barb connected to a 1.905 cm. MNPT (Male National Pipe Thread) with a 1 cm. PVC FNPT coupler. The open end of the drain on the inside of the container was then covered with a piece of 8 Mesh .028 Steel 91.44 cm. wide screen. A 46 cm. piece of 1.58 cm. OD by 1.905 cm. ID vinyl hose was attached to the barb end of the drain to facilitate drainage. Each container was then filled with approximately 25.4 cm. coarse perlite. Into the approximate center of the container, a 45.72 cm. length of 2.54 cm. diameter PVC piping was inserted until it reached the bottom of the container. When removed, this facilitated reaching



Flooded Container with Clipped Hose Figure 1



Draining Container with Unclipped Hose Figure 2 the bottom of the container with the theta moisture meter probe. Moisture levels for all treatments were recorded twice a week using a HH1 Delta T Devices Theta Meter (Delta-T Devices Ltd, Cambridge, and UK). Levels were recorded using the direct probe output/volts units.

On May 9, 2013, 20 containers, had one each of the six shrub species planted into perlite medium. Plants were placed approximately 15 cm apart and watered in. Once the plant material was transferred to the container media they were allowed to establish from May 9th to July 23rd, 2013. At this time they were fertilized twice weekly with a 1:100 solution of Jack's Professional LX 21-5-20 All Purpose Water-Soluble fertilizer (J.R. Peters Inc., Allentown, PA) mixed with water. The shrubs were cut back by approximately half on June 17th. On July 23 they were severely pruned again (See Table x [Data from July 23rd]). At this point plant heights and branch numbers were standardized by species. After standardization, measurement of height, from the base to tip were taken for all species except *H. rhamnoides*. In addition, the number of branches and combined branch lengths were also measured for all species barring *H. rhamnoides*. For *H. rhamnoides* total height, crown height and crown volume was recorded. These same measurements were recorded twice more over the growing period, once on September 18-19 and finally at the end of the experiment on Oct. 24, 2013. Also measured on the final date was overall root length and how far above the original rooting zone adventitious roots could be found.

Five replicate containers were randomly assigned to one of 4 treatments.

- Treatment 1: containers were flooded for seven days with 25 liters of water and allowed to drain for 4 days after which they were flooded for another seven days. This flooding and draining sequence was repeated until the end of the experiment.

- Treatment 2: Containers were flooded for three days with 25 liters of water and then allowed to drain for 4 days. This sequence was repeated for the entire experiment.

- Treatment 3: Containers were kept well-watered but allowed to drain continuously. Moisture levels were kept between 0.4 and 0.6 units

- Treatment 4: Containers were allowed to dry down until the moisture meter registered 0.1 unit and then re-watered with 25 liters of water and allowed to drain freely.

On August 2, 2013 the experiment began. Containers for treatments 1 and 2 were flooded with 25 liters of water. Moisture readings at the surface of each container confirmed saturated conditions (1.0 approximately). Moisture readings in the treatments 3 and 4 registered at approximately 0.7 units.

For all data analysis, JMP Pro 10.0.2 was used. Standard least square means were used to make comparisons of growth parameters for the various treatments. Each species was handled separately; comparisons across species were not made. Student's t-tests were conducted to determine statistically significant differences among treatments, with differences being considered significant when $P<0.05$.

Results

Hippophae rhamnoides 'Sprite'

There were no significant differences in height, crown volume, or creation of adventitious roots above the original rooting zone in all four treatments. Root length for the 7-day flood, 3-day flood, and moist well-drained treatments were not significantly different. However, root length for the drought treatment had significantly longer roots than those of the 7-day or 3-day flood treatments, a difference of 10.6 cm. and 8.8 cm. respectively. See Table 1.

Treatment	Height	Length of Side Branches	Number of Side Branches	Root Length	Number of Adventitious Roots
Seven Day Flood	45^{A}	175.8^{A}	13.8^{A}	53.4^{A}	4.4^{A}
Three Day Flood	49.6^{A}	194.2^{A}	9.6^{A}	60.4^{A}	4.4^{A}
Moist Well-drained	43^{A}	84^{A}	9.8^{A}	52.6^{A}	2.4^{B}
Dry	45.6^{A}	164^{A}	13^{A}	53.4^{A}	4.8^{A}

Table 1

Salix arenaria

There were no significant differences in height, root length, or creation of adventitious roots above the original rooting zone found in four treatments. Combined length of side branches for 7-day flood and moist well-drained treatments were significantly different from one another (93 cm. and 35.8 cm. respectively). Length of side branches for 3-day flood and drought treatments were not significantly different from any of the other treatments. There were no significant differences in the number of side branches for the 7-day flood or moist well-drained treatments. Neither was there a significant difference between the numbers of side branches for the 3-day flood or drought treatments. There was a significant difference between the branch lengths of these two pairs, namely that the 3-day flood and moist well-drained treatments had significantly fewer side branches on average than the 7-day flood or drought treatments (93 cm. and 62.8 cm. respectively). See Table 2.

Treatment	Height	Crown Volume	Root Length	Number of Adventitious Roots
Seven Day Flood	4.2^{A}	11411.4^{A}	24^{B}	4^{A}
Three Day Flood	18.4^{A}	12044^{A}	22.8^{B}	3.2^{A}
Moist Well-drained	20.4^{A}	12335.6^{A}	$31.4^{A\,B}$	4^{A}
Dry	10.4^{A}	6300.2^{A}	43^{A}	3.6^{A}

Table 2

Salix purpurea

There were no significant differences in length of side branches, number of side branches, root length, or creation of adventitious roots above the original rooting zone found across all four treatments. Height for the 7-day flood, moist well-drained, and drought treatments were not significantly different from one another, however; height for the 3-day flooded treatment was found to be significantly taller than the other 3 treatments. It was 10.5 cm. taller than the 7-day flood treatment, 7.3 cm. taller than the moist well-drained treatment, and 11.1 cm. taller than the drought treatment. See Table 3.

Treatment	Height	Length of Side Branches	Number of Side Branches	Root Length	Number of Adventitious Roots
Seven Day Flood	46.8^{A}	93^{A}	8.6^{A}	39.6^{A}	6.4^{A}
Three Day Flood	47.4^{A}	$50.6^{A\,B}$	$4.2^{A\,B}$	40.2^{A}	6.6^{A}
Moist Well-drained	35.8^{A}	34^{B}	$4.4^{A\,B}$	29^{A}	9^{A}
Dry	37.4^{A}	$62.8^{A\,B}$	9.2^{A}	45.4^{A}	7^{A}

Table 3

Spiraea tomentosa

There were no significant differences in height, length of side branches, or root length found in four treatments. Number of side branches for the 7-day flood, 3-day flood, and moist well-drained treatments were not significantly different from one another however, the number of side branches for the drought treatment (15.6) was found to be significantly greater than for the other 3 treatments (11.8, 7.8, and 13.6 respectively). The creation of adventitious roots above the original rooting zone was not significantly different between the 7-day flood and moist well-drained treatments. Nor was the creation of adventitious roots above the original rooting zone significantly different between the 3-day flood and drought treatments. There was a significant difference recorded between the creation of adventitious roots above the original rooting zone of these two pairs, namely that the 7-day flood and moist well-drained treatments had significantly higher development of adventitious roots above the original rooting zone on average (4.4 cm. and 4 cm. respectively) than did the 3-day flood or drought treatments (3 cm. and 1.6 cm. respectively). See Table 4.

Treatment	Height	Length of Side Branches	Number of Side Branches	Root Length	Number of Adventitious Roots
Seven Day Flood	36^{B}	302.2^{A}	33.2^{A}	36.2^{B}	10.8^{A}
Three Day Flood	46.5^{A}	283.2^{A}	24.8^{A}	38^{B}	10^{A}
Moist Well-drained	$39.2^{A\,B}$	337.2^{A}	38.2^{A}	$50.4^{A\,B}$	10.4^{A}
Dry	35.4^{B}	252.4^{A}	22.6^{A}	46.8^{A}	12.4^{A}

Table 4

Amorpha fruticosa

There were no significant differences in height, length of side branches, number of side branches, or root length found across all four treatments. There were no significant differences in the creation of adventitious roots above the original rooting zone found between the 7-day flood, 3-day flood, and drought treatments but there was a significant difference between the creation of adventitious roots above the original rooting zone for these three treatments and the moist well-drained treatment. The moist well-drained treatment developed adventitious roots 2.4 cm. above the original rooting zone compared to 4.4 cm. in the case of the 7-day flood and 3-day flood treatments and 4.8 cm. in the case of the drought treatment. See Table 5.

Treatment	Height	Length of Side Branches	Number of Side Branches	Root Length	Number of Adventitious Roots
Seven Day Flood	24.6^{B}	14.2^{A}	5.2^{A}	22^{A}	4.8^{A}
Three Day Flood	$30.8^{A\,B}$	20.8^{A}	7.6^{A}	24.2^{A}	$3.8^{A\,B}$
Moist Well-drained	$28.75^{A\,B}$	16.4^{A}	7.8^{A}	30.5^{A}	1.75^{B}
Dry	33.25^{A}	20.6^{A}	8^{A}	22.75^{A}	$4.25^{A\,B}$

Table 5

Shepherdia argentea

There were no significant differences in length of side branches, number of side branches, or root length found in four treatments. The 7-day flood, 3-day flood and moist well-drained treatments showed no significant difference in height, however the drought treatment was significantly taller (33.25 cm.) than the other three treatments (24.6 cm, 30.8 cm, and 28.75 cm. respectively). Creation of adventitious roots above the original rooting zone was significantly more in the 7-day flood treatment (4.8 cm.) than in any of the other three treatments (3.8cm, 1.75 cm, and 4.25 cm. respectively). See Table 6.

Treatment	Height	Length of Side Branches	Number of Side Branches	Root Length	Number of Adventitious Roots
Seven Day Flood	44.25^{A}	123.4^{A}	$11.8^{A\,B}$	26^{A}	4.4^{A}
Three Day Flood	36.8^{A}	76.4^{A}	7.8^{B}	27.8^{A}	$3^{A\,B}$
Moist Well-drained	42.6^{A}	174^{A}	$13.6A^{B}$	30^{A}	4^{A}
Dry	45.4^{A}	187.8^{A}	15.6^{A}	27^{A}	1.6^{B}

Table 6

Discussion

Although we found many significant differences in growth within tested species, the differences were generally only those of a few centimeters for any of the plants tested. While this difference in centimeters may have been statistically notable, from a horticultural standpoint it was unimportant..

There were a few findings worth noting however. *S. arenaria* had the greatest combined side branch length (93 cm.) in the 3-day flood treatment and the greatest height (46.8 cm.) in the 7 day-flood treatment. Conversely though, *S. arenaria* had the greatest number of side branches and longest roots in the drought treatment (9.2 and 45.4 cm. respectively). This implies that drought conditions caused it to put on long stem growth, but that drought conditions stimulated it to root deeper and produce denser branch growth. *S. tomentosa* displayed the greatest height (45.4 cm.), greatest side branch length (187.8 cm.), and greatest number of side branches (15.6) in drought conditions implying that drought stimulated increased growth from this species. *S. argentea* displayed greatest height (33.25 cm.) and number of side branches (8) in the drought treatment condition implying that drought stimulated increased growth from this species as well. It is important to note that our evaluation of the functionality of these plants was more important than their optimal growth potential. Since stormwater infiltration practices often are stressful areas for plants to succeed in, their survival and any continued growth was an indicator of success rather than their growth rate matching plants of the same species under ideal conditions.

In their 2007 study Niinemets and Valladares created flood and drought rankings by reviewing studies of environmental stresses at a long time scale. For example, a flood rating of 5 on their scale represented tolerance to waterlogging of over a year or more, while a ranking of 1 represented an intolerance to water-saturated soils for more than a few days during the growing season (Niinemets and Valladares, 2007). This is too extensive a flood period for us to reasonably look at since stormwater infiltration practices generally drain within 24 hours, although we did test flood tolerance for up to a week. In addition, although this study did produce flood and drought tolerance data for three of the species we studied, it did not include data for *Amorpha fruticosa*, *Salix arenaria*, or *Spiraea tomentosa*.

H. rhamnoides had previously been ranked with a drought tolerance of 3.46 and a flood tolerance of 1.88 at the high end of both of their ranges (Niinemets and Valladares, 2007). This puts *H. rhamnoides* somewhere between "tolerates one to two weeks of waterlogging during the growing season" and "does not tolerate water-saturated soils for more than a few days during the growing season" a ranking which corroborates our data. However while our seven-day flood trial did received a three-day drain between flooding, those plants were essentially flooded for nearly three months, which implies the potential for greater flood tolerance on the part of *H. rhamnoides* than this study reported. The drought tolerance of 3.46 (equivalent of about one month of drought) was also consistent with our findings (Niinemets and Valladares, 2007).

Previous findings for *S. purpurea* put its drought tolerance at 1.37 and its flood tolerance at 3.55 (Niinemets and Valladares, 2007). While the flood data is consistent with our findings, our finding for drought tolerance show that it has a much higher tolerance than the previous study found. A drought tolerance of 1.37 is equal to "a few days of drought", whereas our findings show that it can actually tolerate droughts of several weeks and possibly longer.

The previous data on *S. argentea* gave it a drought tolerance rating of 4 and a flood tolerance rating of 1. The drought data we collected was consistent with the findings of the previous study. Our flood data however showed *S. argentea* to be tolerant of at least a full week of flooding (possibly longer) whereas the previous study only ranked it as tolerant of only a few days of saturated soils (Niinemets and Valladares, 2007).

There are some considerations for future experiments. Firstly, it might be helpful to study the tolerances of a larger array of species to increase to potential diversity. For example: *Cephalanthus occidentalis*, *Diervilla spp.*, *Hypericum spp.*, *Iva frutescens*, *Lonicera oblongifolia*, *Myrica gale*, *Salix candida* ‘Silver Fox’ are good candidates for testing based on anecdotal observations. Moreover, we built an establishment period into our experiment which likely had an impact on overall growth and survival rates. Future iterations of this experiment might benefit from using non-established plants as a comparison.

Overall this study proved the flood tolerance of these species but more importantly it also displayed their drought tolerance. Since all species displayed tolerance to both flood and drought they all should be considered for use in planted stormwater retention and infiltration practices.

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Appendix

Woody Shrubs for Stormwater Retention Practices

Woody Shrubs for Stormwater Retention Practices

Northeast and Mid-Atlantic Regions

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Cornell University
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Woody shrubs provide low-maintenance, attractive cover for stormwater retention and infiltration practices.

Planted stormwater retention and infiltration practices are important for reducing runoff and maximizing green space in urban areas. While a wide variety of herbaceous plants such as Soft Rush (*Juncus effusus*), Swamp Milkweed (*Asclepias incarnata*), and Joe-Pye Weed (*Eutrochium spp.*, formerly *Eupatorium spp.*) are often successfully used in these spaces, they can present maintenance issues because of the need to annually cut back dead foliage and stems. Utilizing woody plants decreases the need for additional seasonal maintenance while successfully adding aesthetic and functional vegetation to stormwater retention practices.

What is Stormwater?

Stormwater is rain or snowmelt which flows over the ground and does not directly infiltrate into the soil. Historically stormwater runoff only occurred during large storm events when the rate of rainfall or snowmelt was greater than the rate at which water could be absorbed into the soil. With the advent of wide-scale development and urbanization, the area of impervious surface in the US is approximately 43,000 sq. mi. with an additional 400 sq. mi. being added each year (Schueler and Holland,1994). Increases in artificial impervious surfaces like roads, roofs, sidewalks and parking lots have created a corresponding increase in stormwater runoff. In addition to an increase in impervious surfaces, soils, which can become compacted due to

The Study

A portion of the information here is based on a three-month study in Ithaca, N.Y. conducted by Horticulture Masters of Professional Studies student Ethan M. Dropkin under the guidance of Cornell University's Urban Horticulture Institute director, Dr. Nina Bassuk.

The study focused on testing the flood and drought tolerances of six shrub species, all included in this pamphlet. The species (*Amorpha fruticosa, Hippophae rhamnoides, Salix arenaria, Salix purpurea, Shepherdia argentea, Spiraea tomentosa)* showed tolerance of both human impacts, also experience a significant drop in their ability to absorb runoff during storm events (Gregory, 2006). Increases in stormwater tax the capacity of our sewage treatment systems, especially in cities that have combined stormwater and sanitary sewers. This can create a host of other stormwater related issues.

Stormwater Issues

Increased volumes of stormwater runoff caused by an increase in impervious surface area and compacted soils, have resulted in a variety of issues including:

- Sedimentation of water sources, which reduces light penetration of the water column, warms water by reflecting solar radiation, and negatively homogenizes stream bottom habitats
- Streambank erosion
- Excess nutrient and organic carbon loading resulting in anoxic (low-oxygen) water conditions, which is detrimental to aquatic life
- Bacterial contamination of water sources especially in conditions where sanitary sewer is combined with stormwater
- Hydrocarbon pollution of rivers, lakes and oceans
- Pesticide poisoning of aquatic habitats when excess pesticides are washed into water systems
- Chloride contamination of freshwater systems from de-icing salts used in winter
- Thermal impacts from warmer stormwater heating aquatic habitats of cool water species
- Terrestrial trash and debris collecting in aquatic systems

Generally some or all of these problems can be found in the watersheds of urban and suburban areas, and anywhere downstream of these areas. Usually these issues and contaminants result in poor water quality for human use, degradation of wetland habitats and extirpation of aquatic species (Karimipour, 2010).

long-term flooding and drought which makes them good candidates for use in stormwater retention/infiltration plantings.

These species were chosen for their hardiness and known or suspected tolerances to flood, drought, and urban conditions.

More information, publications and other resources can be found at: http://www.hort.cornell.edu/uhi/

Urban Horticulture Institute


Water Column sedimentation of an Urban Stream

Combined Sewer Overflow

Of particular concern in large cities like New York, Chicago, and Washington D.C. is the issue of bacterial contamination. These cities and many other municipalities across the country operate combined sewer systems. These systems were designed to collect stormwater runoff, sewage, industrial wastewater, etc. in one system which would ideally all go to a treatment plant to be cleaned. However, during large storm events the stormwater load often becomes too much for the system to process and combined sewer overflow (CSO) is released into the nearest convenient water body to avoid a back up in the system (Billah, 2012). In New York City for example, over 27 billion gallons of contaminated stormwater are emptied into New York Harbor each year and only one-twentieth of an inch of rain is needed to overtax this system and cause a CSO event (Grumbles, 2010).

Municipal, State and Federal Stormwater Regulation

Although many of the systems and practices which contribute to this problem are outdated, the regulations in place to mitigate them are increasingly concerned with the future health of our aquatic systems. At all levels of government the impacts of past mishandling of stormwater management have resulted in broad scale initiatives to improve our practices, and as a result, improve water quality.

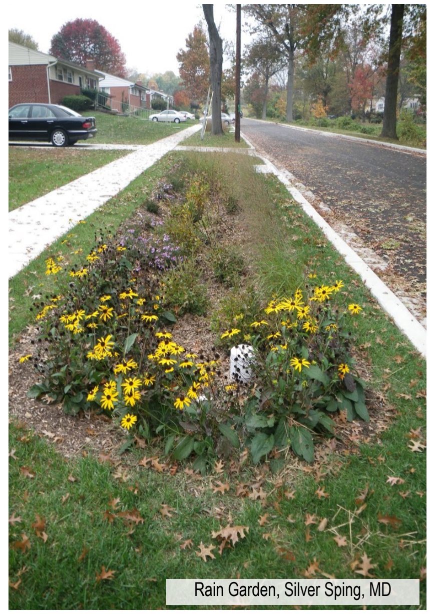
At the federal level, the Environmental Protection Agency (EPA) has created the National Pollutant Discharge Elimination System (NPDES), which includes requirements for Best Management Practices (BMPs) for stormwater. Their program is targeted at everyone from states and municipalities to contractors and individuals (EPA-NPDES, 2012).

In New York State, the Department of Environmental Conservation (DEC) has created the New York Stormwater Management Design Manual which dovetails with the EPA requirements and provides regionally specific information to help create BMPs for New York State (Karimipour, 2010).

At the municipal and watershed levels, stormwater infiltration issues are also being addressed. Two of the best examples are in New York City and Syracuse. In New York City, a comprehensive Sustainable Stormwater Management Plan has been created, nested within the larger plaNYC sustainability initiative (Strickland, 2009). In the Onondaga Lake watershed, efforts to mitigate the severe pollution of Onondaga Lake have resulted in the Save the Rain program (savetherain, 2013). This set of combined initiatives, which includes broad scale creation of green infrastructure; rain barrel programs and increases urban canopy, are all targeted at the reduction of contaminated stormwater runoff entering aquatic systems.


Vegetated Swale

Stormwater Infiltration Practices


Rain Garden, Silver Sping, MD

A large part of each of the previously mentioned regulatory plans, and essentially any stormwater runoff reduction plan, is the creation of stormwater infiltration practices. Stormwater infiltration practices come in a variety of forms but their overall goal is to slow, retain and in certain cases detain stormwater during and after a storm event. In some cases this is used to reduce the occurrence of CSOs but often the goal is to capture pollutants before they enter the larger watershed, and to improve water quality overall. Of particular interest are a number of the planted stormwater infiltration practices that have developed recently. Below are some specific terms currently used to describe these practices.

(**Vegetated) Filter Strip**
Vegetated strips (usually of mown lawn grass) are used to slow and treat sheet (surface) water runoff and direct it towards riparian buffers or other undisturbed natural areas where the water can be absorbed into the soil. Filter strips are generally used in conjunction with existing or restored riparian buffers.

Vegetated Swale
Maintained (mowed) turf-lined swales are designed to slow stormwater and assist with treatment and infiltration, while keeping runoff flowing towards existing drainage systems. Generally these are used as an alternative to conventional subsurface stormwater pipes or artificial hard-sided channels.

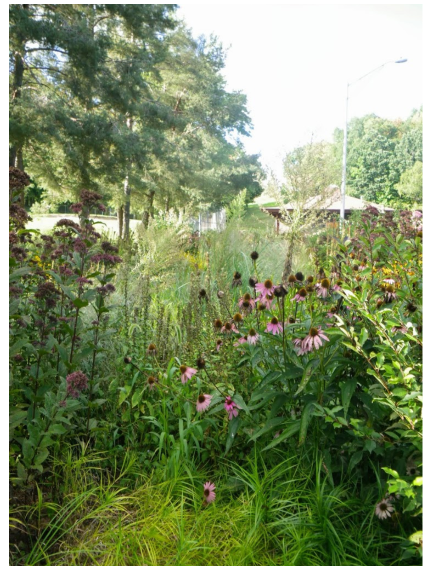
Tree planting/Tree pit
Designated tree planting areas which can reduce runoff and erosion by channeling water into the soil surrounding planted trees. Tree canopies temporarily catch and slow or stop water from reaching the ground. In addition, trees will uptake some of the water in this area through their roots.

Rain Garden
A constructed vegetated depression used to temporarily retain stormwater runoff from impervious surfaces during storm events typically of 1-inch or less. Using plants and distinct engineered substrates, pollutants are filtered and water infiltrates into the soil over the period of 1 to 2 days.

Stormwater Planters
Surface or subsurface planters designed to slow, filter, and possibly retain stormwater runoff. There are generally three types of stormwater planters: contained planters, infiltration


Harrison St. Bioswale, Syracuse NY

planters, and flow-through planters. Contained planters are impervious boxes designed to hold a finite amount of water which is then slowly released through evaporation and transpiration. Infiltration planters have open bottoms and allow runoff to slowly infiltrate into the soil below the planter. Flow-through planters have built-in drains that allow water to move out of the planters after it has been slowed and cleaned by the planting media in the planter (Karimipour, 2010).


Sunnycrest Golf Course Bioswale, Syracuse NY

Bioswale

This is a term used by many municipalities and government bodies. Filter strips, vegetated swales, and rain gardens could all be considered bioswales if constructed correctly. Bioswales are essentially stormwater runoff conveyance and infiltration systems which slow, direct, clean and help infiltrate runoff. Plants assist with stormwater infiltration and provide ecological value such as creating habitat and reducing urban heat island effects (USDA-NRCS, 2007).

All of the above practices can be used to reduce, clean and slow stormwater runoff. Used in conjunction with each other and with a variety of additional practices not covered here (such as green roofs, parking area reduction, stream daylighting, etc.) stormwater runoff can be significantly reduced in urbanized watersheds.

Why Use Plants?

Plants are an integral part of all of the stormwater infiltration practices listed above. They play a variety of important roles in the success of these practices. Plants:

- provide infiltration channels for water to move through via their roots (Bartens, 2008)
- assist in the removal of pollutants like heavy metals from retained stormwater, in conjunction with soil microorganisms (Jurries, 2003)
- help to hold soils together, reducing erosion by stormwater (Caltrans, 2008)
- slow runoff which in turn may cause some suspended solids, sediment, etc. to settle out of the water (Jurries, 2008)
- add aesthetic value and educational potential (Echols and Pennypacker, 2008)
- improve air quality through uptake of gaseous pollutants
- reduce the urban heat island effect through evaporative cooling and shading
- can sequester atmospheric carbon
- increase biodiversity and create wildlife habitat (Wise, 2010)

Given all of these benefits, it is critical to include plants in stormwater practices whenever possible.

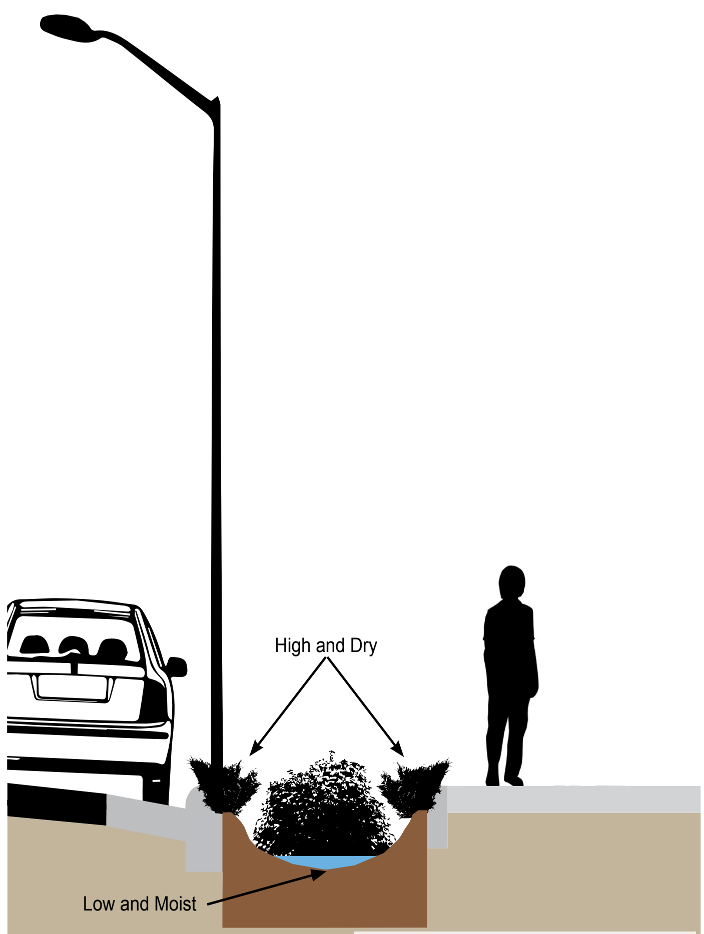
What Plants are Best?

When selecting plants for stormwater infiltration, common sense would seem to dictate the use of wetland plants. However, due to the rate at which most of these practices allow water to infiltrate, the majority of planted stormwater practices will likely only be inundated for a few minutes after a small storm event, and up to a day or two for a larger event. Unlike most permanent or semi-permanent wetlands, these areas remain relatively dry most of the time. Because of this charateristic, plants that can handle both temporary inundation and relatively protracted drought are the best choices for a low-maintenance planting.

The location within the stormwater practice that plants are installed is also significant. Generally these practices will have high points around their edges, which are relatively level to the surrounding topography, and low points towards their center which will be several inches or feet (depending on the size of the practice and its intended water holding capacity) lower than the rim. As a result, the wettest parts of these plantings will be their lowest point. This report deals exclusively with plants appropriate for these low lying, periodically saturated areas. Soil moisture levels at the upper edge of retention and infiltration practices are generally average to dry. Therefore many plants which are appropriate for average to dry soils can be used there. Appropriate plant selections for these drier areas include (but are not limited to): *Juniperus spp., Rosa spp., Cotinus spp., Callicarpa spp.*, etc. However, many of these plants might be unlikely to thrive in the periodically saturated conditions found at the lower elevations of these practices.

Most stormwater treatment planting guidelines suggest the use of native plants exclusively. However due to the unique moisture/drought tolerances required for successful growth in these sorts of practices, it would be imprudent to exclude non-native plants. Because of the growth limitations associated with these planting areas, as long as a plant can succeed on site, and is not invasive, any plant that can grow here should be considered.

To promote plantings with reduced maintenance costs, the value of woody plants, specifically shrubs,



Conditions of Swale edge vs. Swale bottom should be considered. While herbaceous plants may establish more quickly and fill a site, they require at least yearly pruning post-establishment to remove dead foliage and seasonal die-back. Woody plants however—due to their generally slower growth rate and more permanent growth habit—require far less pruning, potentially only once every three years, reducing the overall amount of maintenance significantly (Russ and Polomski, 1999).

Site Assessment

Assessing your site and its surroundings is important for a successful stormwater landscape installation. In the case of most stormwater retention/infiltration practices, significant engineering below ground will be necessary to control the amount and rate of stormwater retention/infiltration. While these considerations are important when preparing the site for stormwater practices, plant have factors which are specific to their success. These include:

Exposure - All plants require some amount of sun to thrive. It is important to understand your site's light conditions. Take into account both the shadows cast by surrounding structures as well as any nearby trees or trees used in your installation. It is important to consider the shade produced by growing vegetation over time. Have the mature size of all plants in mind during the planning stages.

Hardiness - Make sure the chosen plants are appropriate to the USDA Hardiness Zone of the site. Hardiness Zone is a measure of the average minimum winter temperature your area is likely to receive (USDA, 2012).

Microclimates - These are highly localized areas which have growing conditions different from the larger area surrounding them. Cities are often warmer than surrounding areas (in summer and winter) because of the prevalence of absorptive and reflective construction materials used there.

Importance of Soil pH

The pH of a soil is a measure of how acidic or basic (alkaline) the chemistry of that soil is. pH is expressed as a scale from 0-14, with 7 being neutral. Soil with a pH below 7 is considered acidic. Likewise soil with a pH above 7 is considered basic. Most nutrients are at their greatest availability in soils with a pH of around 6.0-7.0. However, many plants can tolerate a wide range of acidity or alkalinity while some are specialists that will only grow successfully in soils of very low (acid) or high (basic) pH. Acid soils have a higher concentration of hydrogen ions, while basic soils have more hydroxide ions. The concentrations of these respective ions help to determine the type of chemical reactions that can occur in the soil. In particular, they can control soil nutrient availability for plants.
If plant nutrients are limited, some types of plants will either grow poorly or die. For example, plants in the family Ericaceae (Rhododendrons, Blueberries, Heaths) exhibit **chlorosis** (a yellowing of their leaves) and will grow weakly and even die if

Chlorosis on *Rhododendron spp.*

Additionally, particularly in urban areas with large-scale buildings and narrow streets, wind patterns may be calm or turbulent due to the channelization of air currents. Almost by definition, stormwater plantings are microclimates. Since they are designed to capture stormwater, the bottoms of these installations will likely be wetter than their surroundings, at least for short periods of time following storm events. In addition, the sides of stormwater infiltration/retention practices will generally be drier than their lowest points which creates a subtle moisture gradient.

Soil Fertility and pH- Test the soil on site to determine its pH levels, nutrient concentration, and salt content. All of these factors will help determine which plants are most appropriate for the site and indicate necessary additives for a future planting mix. Soil testing should reveal any potential nutrient deficiencies which will likely be addressed at installation. In addition, using nitrogen-fixing plants could help mitigate many long term nutrient replacement issues. Sometimes additional fertilization may become necessary as plants mature. Never fertilize newly planted materials to avoid nutrient burn to roots and foliage. If soil and foliar tests at any point show that nutrient deficiencies are developing, it is best to use a time-released granular fertilizer with slow-release water-insoluble nitrogen (WIN), or an appropriate micronutrient fertilizer as directed.

Soil Conditions - Although soil texture, compaction, and drainage rates will likely change based on the site design, knowing the initial soil conditions will be important in creating the specification of what should be installed on site. In addition understanding the final conditions will be of utmost importance in selecting and siting plants.

Salt Inputs - This can be an important factor in determining appropriate plants for any urban planting, but is particularly important for stormwater plantings. In areas of the country that receive ice and snow in the winter, large amounts of de-icing salts may be used to keep roads and

grown in alkaline soils.

Importance of Iron in Soils

One of the main reasons that acid loving plants become chlorotic in basic soils is because of the limited availability of accessible iron, an important plant nutrient. Iron is found in two forms in the soil: ferric and ferrous. Ferric iron is insoluble and therefore impossible for plants to take up unless they have mechanisms for solubilizing the iron near their root zone. Fortunately many plants are able to do this. In high pH soils, iron is present in the ferric form. As pH lowers (below 6.2), iron converts into its ferrous form and is more readily available for uptake by plants. In addition, in anaerobic (oxygen limited) soils ferric iron also converts to its ferrous form. This is one of the reasons why many wetland plants require acidic soils, even when planted in well drained sites.

Urban Soils

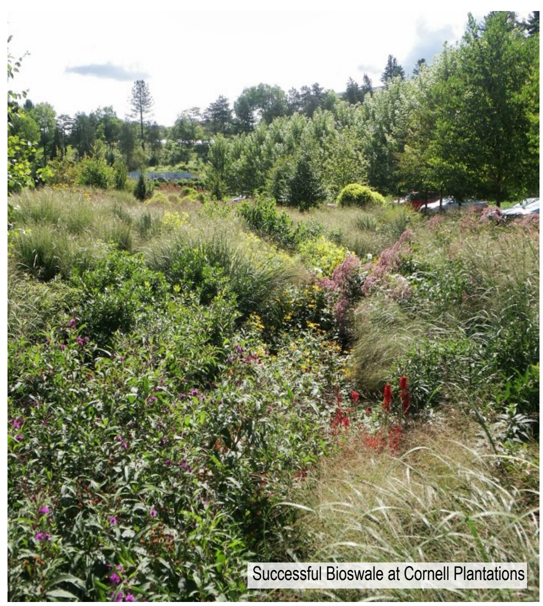
In urban environments the soils are almost always heavily disturbed. In addition, they tend to be fairly alkaline due to the leaching of basic elements from concrete-based construction materials. Basic leachate comes not only from building and sidewalks but often high pH rubble is turned into the soil during demolition and construction. As a result, most urban landscapes have high pH soils, even in areas where the parent soil may be acidic or sidewalks clear and safe. It is possible that for three to six monthes of the year, much of the runoff entering stormwater practices will be highly saline. In addition to saline runoff, roadside plants often have to deal with salt spray from cars. While this may not be an issue for some plants, for others it can be highly detrimental. It is therefore very important to determine how much salt will be entering your planting, how quickly it will leach out of the root zone and what plants can withstand salt spray and/or salt soils.

Irrigation Access - Despite the fact that these plants will receive water throughout the year in the form of runoff, they will need supplemental watering to keep them growing and thriving until their roots are established. Even after initial establishment these plants may need irrigation during periods of prolonged drought, as is the case with any planting.

Site Assessment Checklist

The following is a checklist for use during a typical site assessment. The information from this checklist acts as a basic guide for the selection of sub-structural layers, soil mix, planting selections, and drainage regime necessary for creating a successful and sustainable stormwater retention/ infiltration practice. This checklist is by no means exhaustive and there may be other factors worth recording at specific sites.

neutral. When selecting plants for urban areas, it is generally wisest to focus on those that can tolerate soils in the range of 7.0 and up. However, when dealing with stormwater plantings, wetland plants which are often acid soil dependent are often used. It is important to remember that most stormwater infiltration and retention plantings will likely be dry fairly regularly. Therefore they will not provide wetland plants with the anaerobic, ferrous iron-rich soils they require to grow with vigor and longevity. Thus knowing the soil pH is one of the most important factors for choosing plants that will flourish on a particular site and help a new installation succeed in the long term. Fortunately, there are many plants that tolerate a wide soil moisture gradient and a wide pH gradient.


Successful Bioswale at Cornell Plantations

1. Site Location ____

2. Site Description ____

3. Climate

a. ***USDA Hardiness Zone***

__7b __6b __5b __4b __3b
__7a __6a __5a __4a __3a

b. ***Microclimate Factors***

__Re-reflected heat load
__Frost pocket
__Wind
Other ____________

c. ***Sunlight Levels***

__Full sun (6 hrs. or more)
__Partial sun or filtered light
__Shade

d. ***Irrigation Levels***

__No supplemental irrigation
__Automatic irrigation system
Irrigation amount and rate:

____

4. Soil Factors

a. ***Range of pH Levels*** _______
(Note actual readings on sketch)

b. ***Texture***

__Clayey
__Loamy
__Sandy

c. ***Compaction Levels***

__Severely compacted
__Moderately compacted
__Somewhat compacted
__Uncompacted

d. ***Drainage Characteristics***

___Presence of mottled soil
___Low-lying topography
Indicator plants suggest site drainage:
___wet ___well-drained ___dry
Percolation test results (in./hr.)
___poorly drained (< 4"/hr.)
___moderately drained (4"- 8"/hr.)
___excessively drained (> 8"/hr.)

e. Other Soil Considerations

__Indications of soil layer disturbance
__Evidence of recent construction
__Presence of construction debris
__Noxious weeds present:

____
____
____
____

__Evidence of excessive salt usage
__Erosion of soil evident
__Evidence of soil contamination
__Usage that compacts soil

f. ***Specific Soil Problems***

____
____
____
____
____
____
____

5. Structural Factors

a. ***Limitations to above-ground space***

___Overhead wires (height:________)
Proximity to buildings/structures:
Other_________________________

b. ***Limitations to below-ground space***

__Utilities marked and noted on sketch
Approximate rooting volume for site
Length:__ Width: __ Depth: __

6. Visual Assessment of Exisiting Plants

a. Species ***b. Size*** ***c. Growth Rate*** ***d. Visual Assessment***

Sketch of Site

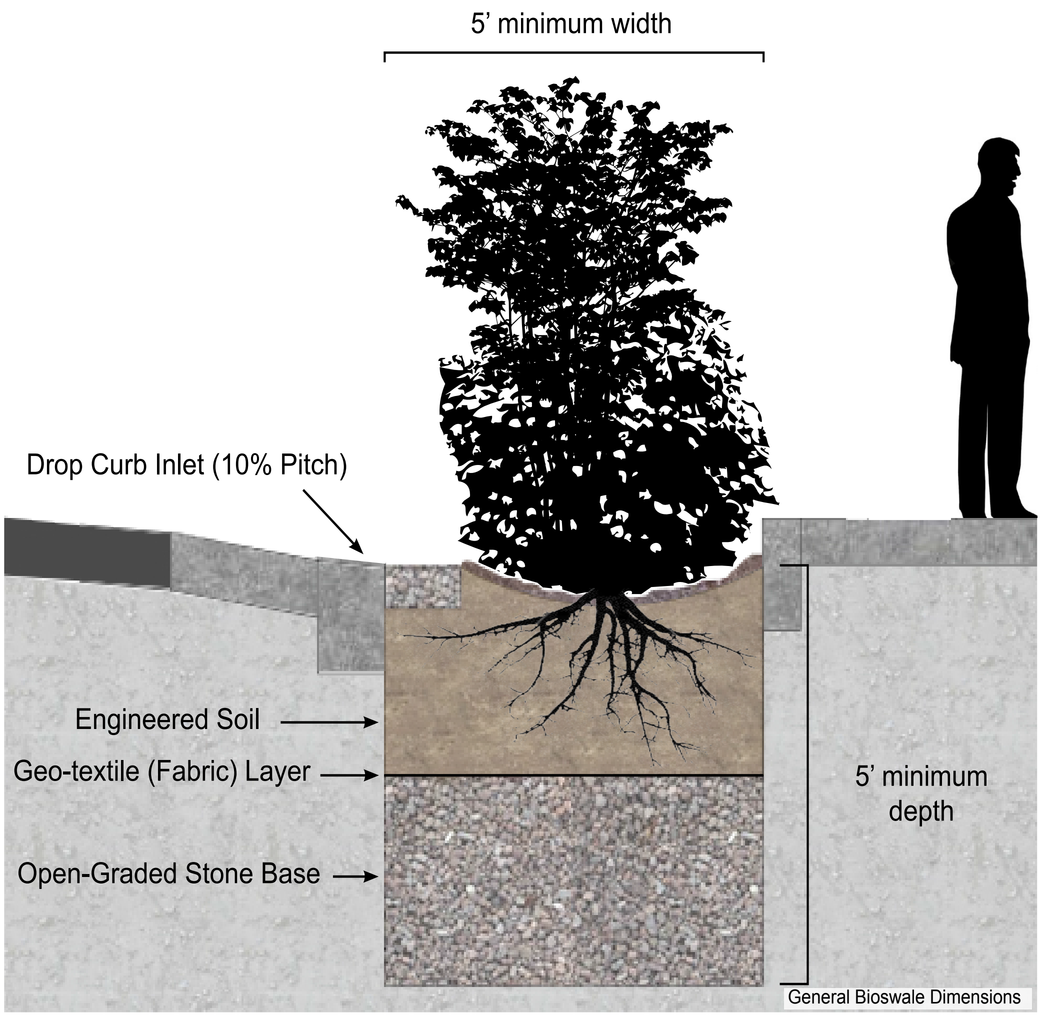
Note north arrow; circulation patterns; pH readings; location of overhead wires; underground utilities, buildings and pavement, as well as problem drainage areas.

Design Considerations Prior to Plant Selection

Site design requirements will vary greatly depending on the type of stormwater collection practice intended for the site. However, some factors will be a part of any design, including:

- regrading of the surrounding site to direct stormwater into the collection basin
- creation of a basin sized large enough to handle the volume of water it is intended to hold
- installation of planting substrate and sub-surface soil layers which may include but are not limited to mulch, an engineered soil mix, geotextile fabric, and an open-graded stone base course
- selection of of hi-hat drains, perforated piping, stone filled drainage columns, and/or conventional storm sewer connections to assists with drainage/remove excess water from the site during severe storm events
- installation of fencing or tree-pit guards depending on the drop from sidewalk/street level which is created

These and other site design criteria may impact plant selection, location, installation, and



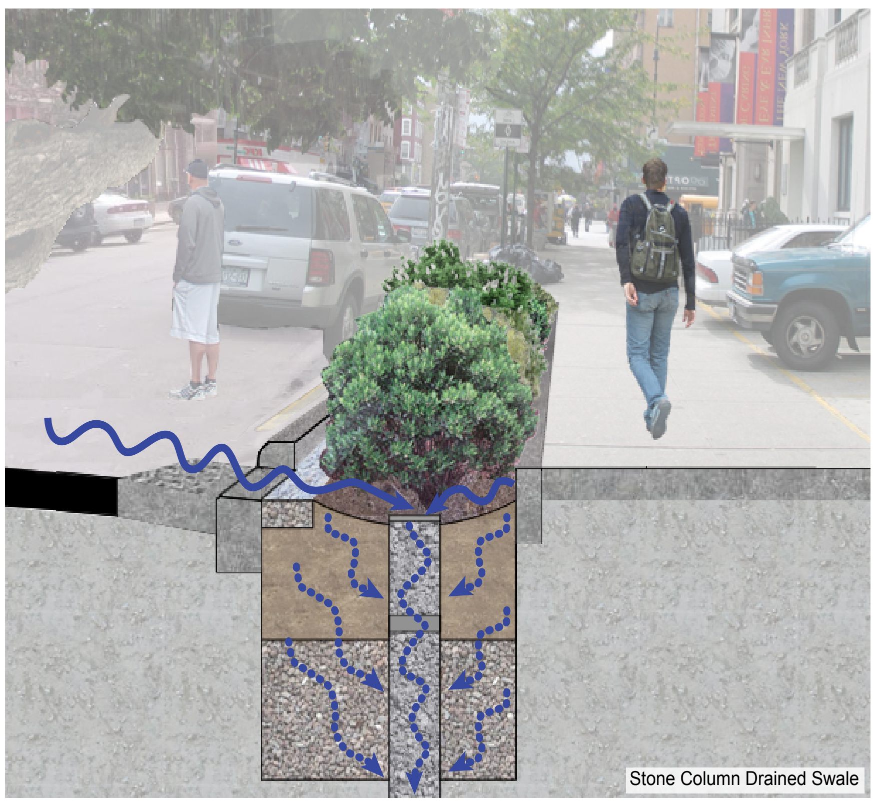
maintenance requirements. Early stage planning to create plantings which assist rather than impair the long-term function of stormwater practices are integral in the success of a project.

The accompanying images of the Open-Drained Swale, Stone Column Drained Swale, and Hi-Hat Drained Swale while typical are not to scale and all requisite site features may not be idetified or located on them. Always check local regulations for specific design and construction requirements.

Maintenance

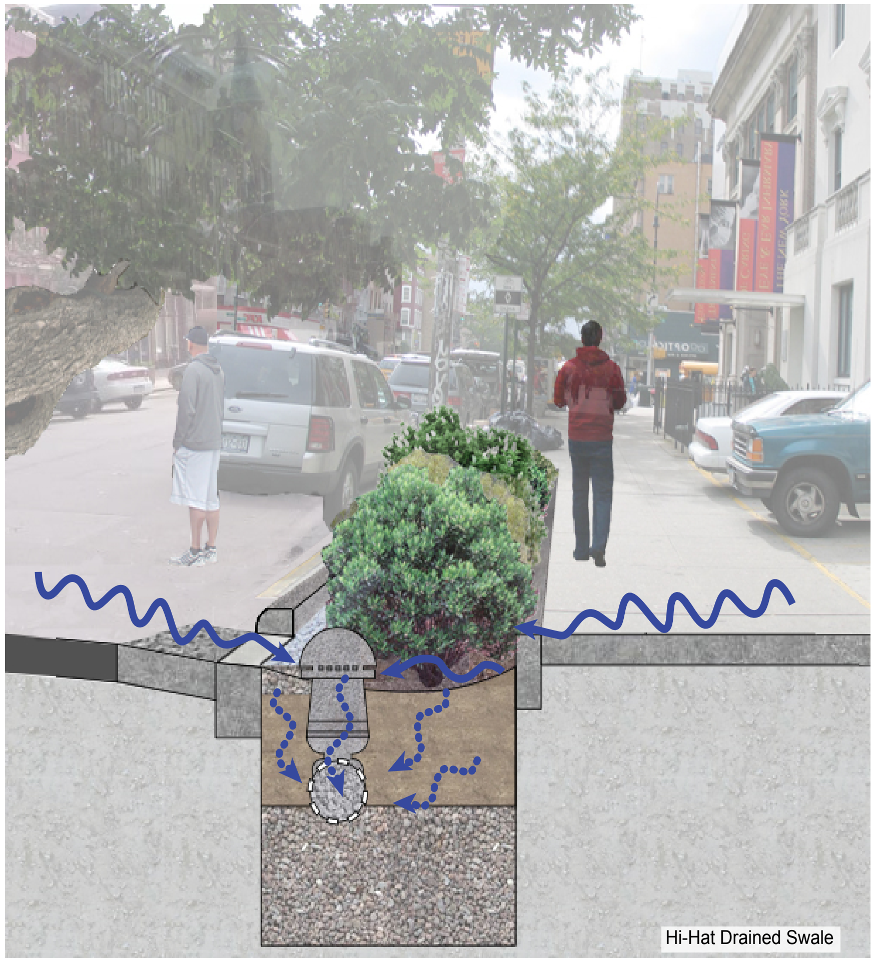
Maintenance requirements for stormwater infiltration/retention vary depending on whether the desired aesthetic is formal or more naturalistic. As mentioned previously, one way to decrease overall maintenance is to use woody plants, which generally require less annual maintenance than herbaceous

Open-Drained Swale



Stone Column Drained Swale

plants. Regardless, it is important to create a regular maintenance plan for these sites so that they do not become unsightly, unsafe, or non-functional.


Hi-Hat Drained Swale

Regular maintenance tasks will likely include:

- regular weeding throughout the establishment period, with a likely reduction in weeding frequency once shrubs establish and form a closed canopy
- yearly mulching of established plantings
- watering during dry periods, especially during the first two years of establishment
- pruning and thinning on a rolling three-year cycle; this will be important for some plants to improve ornamental characteristics, encourage new growth, and to control form and size
- pruning of dead, damaged, diseased, and hazard branches/foliage
- periodic flushing of trapped sediments from catch basins, pipes, or gravel to maintain drainage and remove flow obstructions
- replacement of dead plants

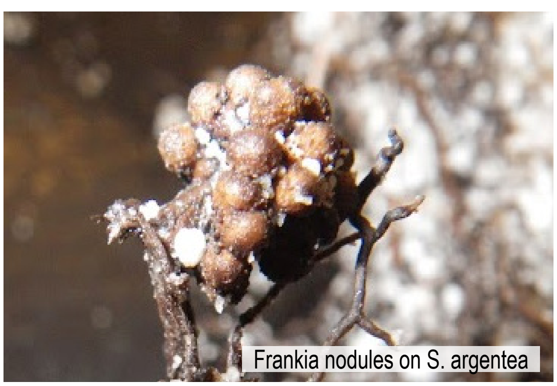
Soil Nitrogen

Of the many nutrients important for healthy plant growth, none is more important than nitrogen. Nitrogen is one of the essential cellular building-blocks for all life, plants included. Most nitrogen on the planet is found in its gaseous form. In fact, the earth's atmosphere is approximately 79% nitrogen. However this form of nitrogen is largely inaccessible to plants. Atmospheric nitrogen (N_2) is made available for plant use by converting it to either ammonium (NH_4^+) or nitrate (NO_3^-). This process of converting nitrogen from its

(Vincentz, 2007)

Rhizobium nodules

Frankia nodules on H. rhamnoides



Frankia nodules on S. argentea

inert form to a usable form is called nitrogen fixation. Some fixed nitrogen is also added to the soil when the extreme energy of a lightning strike causes atmospheric nitrogen and oxygen to bond forming nitrous oxides. When these oxides come in contact with rain they create nitrates which are carried to the soil by precipitation. Other than man-made fertilizers, another way nitrogen becomes available to plants is through bacterial nitrogen fixation. When bacteria digest surface organic matter, animal droppings or slowly decomposing soil organic matter (humus), the byproduct is ammonium or nitrate, which becomes available to plants.

Nitrogen Fixation

Many types of microorganisms in the soil can fix nitrogen, however of particular interest are rhizobia and frankia. These groups of soil bacteria have formed symbiotic relationships with certain plant species; the plants provide the bacteria with food created during photosynthesis and the bacteria provide the plants with ammonium. These bacteria, in concert with the plants, help create nodules on roots of a host of species and genera in the family of Fabaceae (the Pea Family). Frankia has associations with many disparate plant families, genera, and species. Frankia associates of particular interest in the northeast include:

- plants in the genus *Alnus* (Alders)
- all species in Elaeagnaceae: *Elaeagnus* (Silverberries),

Plant Selection

The following list identifies a variety of evergreen and deciduous shrubs for use in planted stormwater retention and infiltration practices. These plants have been selected because of their performance in our experimental trials, their proven use in New York City and/or Syracuse's stormwater planted practices, or their documented cultural tolerances. All have been proven hardy in the Northeast. This list is by no means comprehensive. Rather, it is a tested or observed sample of the large array of shrubs suited for use in the periodically saturated locations often encountered at the bottom of stormwater practices.

Personal aesthetics and specific site conditions will vary but the plant characteristics provided will help to select viable plants for any site. Keep in mind that any listed cultural tolerances—soil texture, pH, flood, drought and salinity—have rarely been empirically quantified for many species. Likewise, native range and distribution notes are contested for many plants. They are merely offered here to suggest the likelihood of where a plant may be successfully grown. These caveats aside, sticking to the guidelines below should result in largely successful plantings.

Shepherdia (Buffaloberries), and *Hippophae* (Sea Buckthorns)

- three genera in the family of Myricaceae: *Myrica* (Sweet Gales), *Morella* (Bayberries), and *Comptonia* (Sweetfern)
- plants in the genus *Ceanothus* (New Jersey Tea)

Luckily, many of these species are suitable for use in planted stormwater practices.

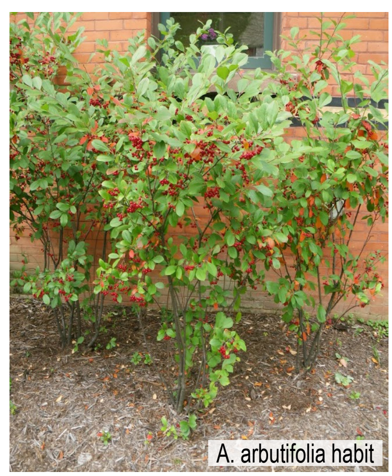
Nitrogen Importance in Stormwater Management Plantings

One of the ways nitrogen can be lost from soils is by leaching. This is a physical process whereby usable forms of nitrogen can be washed out of the root zone by excessive drainage. This can be particularly problematic in coarse soils. As coarse materials like sand and crushed stone are sometimes used in planted stormwater practices, it is important to consider ways to reduce the impact of nitrogen leaching. One of the easiest ways to combat this phenomenon is to utilize nitrogen-fixing plants in your palette which can replace leached nitrogen.

Pass Arboretum Rain Garden, Syracuse NY

Stormwater Shrubs Suggested Species List

- Scientific Name: ***Amorpha fruticosa***
- Common Name: **Desert False Indigo**
- Family: Fabaceae
- Native Range:Southeastern North America
- Hardiness Zone: 2-9
- Sun/Shade: Full Sun
- Cultural Tolerances: Flood and drought tolerant; grows in sand to clay
- Height: 6 to 15 feet
- Spread: 5 to 15 feet
- Growth Habit: Large, leggy shrub; deciduous, compound leaves, can fix its own nitrogen
- Ornamental Characteristics: Flowers are generally purple or white with golden anthers; yellow fall foliage; foliage, bark, and fruits have a citrus-like or spicy scent
- Pests and Diseases: No serious pests or diseases. Occasionally susceptible to leaf spot, powdery mildew, twig canker and rust.
- Cultivars/Relatives:
- **'Albiflora' -** a white flowering form
- **'Crispa'** - curley-leaved form
- **'Lewisii'** - narrow leaved variety



- Scientific Name: ***Aronia arbutifolia***
- Common Name: **Red Chokeberry**
- Family: Rosaceae
- Native Range: Northeastern North America
- Hardiness Zone: 4-9
- Sun/Shade: Full sun to Part Shade
- Cultural Tolerances: Prefers acid soils but can handle pH levels up to 8.0; tolerates flood and drought conditions
- Height: 6 to 10 feet
- Spread: 3 to 5 feet


A. arbutifolia fruit

- Growth Habit: Stiff, vase shaped, upright, leggy shrub; spreads by suckers
- Ornamental Characteristics: Clusters of white flowers, bright red edible berries, spectacular red fall foliage
- Pests and Diseases: No serious pests or diseases. Occasionally susceptible to leaf spot and twig/fruit blight.
- Cultivars/Relatives:
- ***A. x prunifolia*** **-** a naturally occuring hybrid between A. arbutifolia and A. melanocarpa
- **'Brilliantissima' -** probably more commonly found in nurseries than the straight species. Improved flowering, fruiting, and foliage luster and color.


A. melanocarpa habit

- Scientific name: ***Aronia melanocarpa***
- Common Name: **Black Chokeberry**
- Family: Rosaceae
- Native Range: Eastern North America
- Hardiness Zone: 3 to 8
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Prefers acid soils but can handle pH levels up to 8.0; tolerates flood and drought conditions
- Height: 3 to 6 feet
- Spread: 3 to 6 feet
- Growth Habit: Round topped, Multi-stemmed, suckering, deciduous shrub
- Ornamental Characteristics: Clusters of white flowers, bright black edible berries, spectacular red fall foliage
- Pests and Diseases: No serious pests or diseases. Occasionally susceptible to leaf spot and blight.
- Cultivars/Relatives:
- ***var. elata*** **-** a larger plant overall and with larger individual parts (leaves, flowers, fruits).
- **'Autumn Magic' -** more compact than the species (3'-5' tall) with improved fruit set and bright red-purple fall color.
- **'Morton' (Iroquois Beauty™) -** dwarf form (2' to 3' tall)
- **'Viking' -** like 'Autumn Magic' mid-sized cultivar (3' - 6' tall).


A. melanocarpa fruit

- Scientific Name: ***Baccharis halimifolia***
- Common names: **Groundseltree, Eastern Baccharis**
- Family: Asteraceae
- Native Range: Northeastern North America
- Hardiness Zone: 5 to 9
- Sun/Shade: Full Sun to Partial Shade
- Cultural Tolerances: Flood and drought tolerant; grows in sand to clay; salt spray and soil tolerant
- Height: 5 to 12 feet
- Spread: 5 to 7 feet
- Growth Habit: Sprawling, multistemmed, open shrub; Dioecious
- Ornamental Characteristics: Cottony white, persistent fruits on female plants
- Pests and Diseases: No serious pests or diseases.
- Cultivars/Relatives:
- ***B. glomeruliflora*** - a more southern relative, hardy from Zone 8 -10
- **'White Caps'** - compact, upright form; bluish foliage; heavier fruit production


B. halimifolia habit


B. halimifolia fruit

- Scientific Name: ***Ceanothus americanus***
- Common Name: **New Jersey Tea**
- Family: Rhamnaceae
- Native Range: Eastern North America
- Hardiness Zone: 4 - 8
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Drought and high pH


C. americanus flower

- Height: 3 to 4 feet
- Spread: 3 to 5 feet
- Growth Habit: Low, mounding, deciduous shrub, capable of nitrogen fixation
- Ornamental Characteristics: Racemes of white flowers
- Pests and Disease: No serious pests or diseases.
- Cultivars/Relatives:
- ***C. herbaceus*** **-** A more inland species almost identical to C. americanus.
- ***Ceanothus x pallidus*** **'Marie Simon' -** pink flowers, hardy from Zones 6-11


C. americanus habit

- Scientific Name: ***Clethra alnifolia***
- Common Name: **Sweet Pepperbush, Summersweet**
- Family: Clethraceae
- Native Range: Eastern North America
- Hardiness Zone: 3 to 9
- Sun/Shade: Full Sun to Partial Shade
- Cultural Tolerances: Tolerant of flooding and salt spray; requires acid soil
- Height: 4 to 8 feet
- Spread: 4 to 6 feet
- Growth Habit: Dense oval to upright deciduous shrub spreads slowly by stolons
- Ornamental Characteristics: Spicily fragrant racemes of white or pink flowers, glossy green leaves that turn to bright yellow in autumn, cinnamon colored bark
- Pests and Diseases: No serious pests or diseases; may contract mites under extreme drought; may become chlorotic in high pH soils
- Cultivars/Relatives:
- **'Hummingbird'** - low spreading variety with large, white flowers
- **'Pink Spires'** - rose pink buds that fade to white


C. alnifolia flowers


C. alnifolia 'Ruby Spice' flower

as they bloom

- **'Rosea' -** Pink buds and light pink flowers
- **'Ruby Spice' -** rose pink flowers that do not lose color
- **'September Beauty' -** Slightly more compact than species; late white flowers
- **'Sixteen Candles' -** particularly fragrant flowers, golden fall color


C. alnifolia habit

- Scientific Name: ***Cornus amomum***
- Common Name: **Silky Dogwood**
- Family: Cornaceae
- Native Range: Eastern North America
- Hardiness Zone: 4 to 8
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Tolerant of nearly full shade; tolerates prolonged inundation
- Height: 6-12 feet
- Spread: 6-12 feet
- Growth Habit: Large, irregular shrub, branches will layer where they touch the ground, may form small colonies
- Ornamental Characteristics: White flowers in early summer that mature from white to blue
- Pests and Diseases: No serious pests or diseases; occasionally suceptible to scale, borers, leaf miners, leaf spot, crown canker, blights, root rot, and powdery midew.
- Cultivars/Relatives:
- ***C. rugosa* -** native to the Northeastern US; large, rough, oval leaves; difficult to find in the trade, but recognized for its tolerance of high pH soils.


C. amomum fruit


C. amomum habit

(SB Form, 2007)

- **'Blue Cloud' -** bluish floiage; particularly blue fruit
- **'Cinderella' -** ivory variegated foliage

C. amomum flowers

(SB Flowers, 2007)

- Scientific Name: ***Cornus racemosa***
- Common Name: **Grey Dogwood**
- Family: Cornaceae
- Native Range: Northeastern North America
- Hardiness Zone: 4 - 8
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Tolerant of a wide range of soil moisture, pH, and texture
- Height: 4 to 15 feet
- Spread: 10 to 15 feet
- Growth Habit: deciduous, upright suckering shrub; readily forms spreading clonal colonies
- Ornamental Characteristics: Clusters of white flowers maturing to white fruit borne on red peduncles; good fall color running from yellow through orange, red, maroon, to purple
- Pests and Diseases: No serious pests or diseases. Dogwood bud gall very occasionally a problem.
- Cultivars/Relatives:
- **'Emerald' -** Glossy green leaves, superior form, pinkish fruits

C. racemosa foliage

C. racemosa in fruit

- **‘Cuyahoga’ -** Pyramidal tree form
- **‘Geauga’ -** A dense multi-stemmed with dark-green foliage and reddish new growth
- **‘Huron’ -** rounded, globular form; 4’ tall and wide; notable red fall color
- **‘Mahoning’ -** a stoloniferous spreader to 10’ tall; notable grey winter stem color
- **‘Muskingum’ -** a dwarf form; 2’ tall and 4’ wide
- **‘Ottawa’ -** Fastigiate tree form; 12’ tall and 6’ wide


C. racemosa flowers

- Scientific Name: ***Cornus sanguinea***
- Common Name: **Bloodtwig Dogwood**
- Family: Cornaceae
- Native Range: Northern Eurasia
- Hardiness Zone: 5 to 7
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Can tolerate moist soils
- Height: 5 to 8 feet
- Spread: 5 to 6 feet
- Growth Habit: Rounded, high mounding shrub; may sucker to form colonies. Rejuvenative pruning of older stems every three years will help keep stem color vibrant.
- Ornamental Characteristics: Clusters of creamy white flowers that mature to midnight blue fruits; unique pale greenish yellow fall color; spectacular gradient of red, yellow, and orange colored bark on an individual plant.
- Pests and Diseases: No serious pests or diseases
- Cultivars/Relatives:


C. sanguinea fall foliage


C. sanguinea stem color

- **‘Arctic Sun’** - dwarf; 3-4 feet high and wide
- **‘Compressa’** - Fastigiate; dark green, deeply veined leaves; short internodes; few branches
- **‘Midwinter Fire’** - improved winter stem color
- **‘Winter Flame’** - improved winter color and smaller than species (3 to 4 feet)
- **‘Viridissima’** - yellow-green bark

C. sanguinea fruit

- Scientific Name: ***Cornus sericea/alba***
- Common Name: **Red-Osier Dogwood, Red-twig Dogwood**
- Family: Cornaceae
- Native Range: Northeastern North America and Northeastern Asia respectively
- Hardiness Zone: 3 to 8
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Tolerant of a wide range of soils, including very saturated;
- Height: 6 to 9 feet
- Spread: 8 to 12 feet
- Growth Habit: A large spreading deciduous shrub; will form stoloniferous colonies; rejuvenative pruning of older stems every three years will help keep stem color vibrant
- Ornamental Characteristics: White flowers maturing to white fruits, spectacular bright red (sometimes yellow) bark.
- Pests and Diseases: Susceptible to leaf

C. sericea/alba habit

C. sericea/alba fruit

and twig blights. Scale, leaf miners and bagworms are occasional insect pests. Deer browse can be problematic

- *C. sericea* Cultivars/Relatives:
- **'Baileyi'** - good stem color, superior flowering and fruiting to species
- **'Cardinal'** - superior stem color
- **'Flaviramea'** - Bright yellow bark, susceptible to canker
- **'Isanti'** - relatively dwarf form, 5-6 feet tall, low, dense, mounding; heavy fruiting
- **'Kelseyi'** - dwarf form, to 3 feet
- **'Silver and Gold'** - yellow bark form with variegated leaves
- *C. alba* Cultivars/Relatives:
- **'Alleman's Compact'** - relatively dwarf form, to 6' tall
- **'Elegantissima'** - white variegated foliage
- **'Ivory Halo'** - white variegated foliage with more dense, compact habit than 'Elegantissima'
- **'Bloodgood'** - markedly showy red stems
- **'Bud's Yellow'** - bright yellow stems, a good substitute for the disease-prone C. sericea 'Flaviramea'
- **'Gouchaultii'** - yellow, pink, and white varigated leaves
- **'Siberian Pearls'** - superior flowers and fruits; white fruits mature to blue
- **'Sibirica'** - superior coral-red stems and bluish fruits
- **'Spaethii'** - yellow variegated leaves


C. sericea/alba stems


C. sericea/alba buds


C. sericea/alba foliage

- Scientific Name: ***Dasiphora (Potentilla) fruticosa***
- Common Name: **Shrubby Cinquefoil**
- Family: Rosaceae
- Native Range: Two sub-species, scattered across the Northern Hemisphere
- Hardiness Zone: 2 to 7
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Tolerant of drought and high pH; reputedly tolerant of flooding; very winter hardy
- Height: 2 to 4 feet
- Spread: 3 to 5 feet
- Growth Habit: Dense, low-mounding shrub; dioecious
- Ornamental Characteristics: extremely cultivar dependent; pale green to bluish foliage color; bloom color: white, pink, peach, yellow, orange
- Pests and Diseases: No serious pests or diseases. Powdery mildew may occur in humid climates. Susceptible to fungal leaf spots and spider mites, aphids, Japanese beetles, etc.
- Cultivars/Relatives:
- Over 130 named cultivars; below are a few of the most noteworthy.
- **'Abbotswood' -** prolific white flowers; bluish foliage
- **'Abbotswood Silver' -** same as above but with white variegated leaves
- **'Gold Drop' -** rounded plant to 3 feet; yellow flowers; long-blooming
- **'Pink Beauty' -** clear pink blossoms, semi-dwarf to 2 feet
- **'Snowbird' -** white blossoms; double-flowering; lustrous foliage
- **'Mango Tango' -** bicolor flowers; orange-red radiating to yellow


D. fruticosa habit


D. fruticosa flowers

- **'Red Robin' -** red flowers that fade slightly to orange
- **'Sundance' -** double, yellow flowers
- **'Yellow Gem' -** yellow flowers with ruffled petals


D. fruticosa flower

- Scientific Name: ***Hippophae rhamnoides 'Sprite'***
- Common Name: **Dwarf Sea Buckthorn**
- Family: Elaeagnaceae
- Native Range: North and Central Eurasia
- Hardiness Zone: 3 to 8
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Tolerates sandy soils, extreme flood and drought tolerance, tolerant of salt
- Height: 2 to 5 feet
- Spread: 2 to 4 feet
- Growth Habit: Dense and compact, male cultivar that produces no fruit; although fruits have great edible and medicinal properties, *Hippophae* has invasive potential and fruiting varieties should be avoided; can fix its own nitrogen; dioecious
- Ornamental Characteristics: Silvery-bluish foliage
- Pests and Diseases: No serious pests or diseases.
- Cultivars/Relatives: N/A


H. rhamnoides habit


H. rhamnoides habit

- Scientific Name: ***Hypericum kalmianum*** (see other Hypericum spp. on pgs. 47-48)
- Common Name: **Kalm's St. Johnswort**
- Family: Clusiaceae
- Native Range: Northeastern North America
- Hardiness Zone: 4 to 9
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Tolerant of drought and flooding, flowers best in full sun
- Height: 2 to 3 feet
- Spread: 2 to 3 feet
- Growth Habit: Dense, mounding, semievergreen to evergreen shrub
- Ornamental Characteristics: Bluish foliage, clusters of relatively large, golden flowers
- Pests and Diseases: No serious pests or diseases
- Cultivars/Relatives:
- **'Ames'** - hardier than species
- **'Blue Velvet' -** superior blue foliage
- **'Gemo' -** prolonged bloom period
- **'Sunny Boulevard'** - compact, mounding form with dark green leaves


H. kalmianum habit


H. kalmianum flowers

- Scientific Name: ***Ilex glabra***
- Common Name: **Inkberry Holly**
- Family: Aquifoliaceae
- Native Range: Southeastern North America
- Hardiness Zone: 4 to 9
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Tolerant of a variety of soil textures and moistures;


I. glabra habit

prefers acid to neutral soil pH

- Height: 5 to 8 feet
- Spread: 5 to 8 feet
- Growth Habit: Dense to loose evergreen shrub; suckers to form colonies; dioecious
- Ornamental Characteristics: Glossy evergreen foliage, white flowers that mature to black berries; dioecious
- Pests and Diseases: No serious pests or diseases. Occasionally susceptible to spider mites in dry conditions; may become chlorotic in high pH conditions; leaf spot can occasionally be problematic
- Cultivars/Relatives:
- **'Compacta'** - dense, oval habit
- **'Ivory Queen'** - white fruited instead of black fruited
- **'Nordic'** - extremely cold hardy form; notable for its broad growth habit and dark green lustrous foliage, a male selection
- **'Shamrock'** - best dwarf form with glossy deep green, rounded, 3 to 5 feet high.


I. glabra habit


I. glabra fruit

- Scientific Name: ***Ilex verticillata***
- Common Name: **Winterberry**
- Family: Aquifoliaceae
- Native Range: Northeastern North America
- Hardiness Zone: 3 to 9
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Prefers wet, acid soil but can handle relatively dry soils as well


I. verticillata habit

- Height: 3 to 12 feet
- Spread: 3 to 12 feet
- Growth Habit: Upright, rounded, deciduous shrub
- Ornamental Characteristics: White flowers mature to dense crops of bright red or orange berries; dark grey-brown bark covered with white lenticels; dioecious, needs pollinator the flowers simultaniously to set fruit
- Pests and Diseases: No serious pests or diseases. Occasionally contracts leaf spot or powdery mildew. Plants become chlorotic and sometimes die in high pH soils.
- Cultivars/Relatives:
- **'Afterglow' -** reddish orange fruits; very glossy leaves; compact habit
- **'Aurantiaca' -** slightly dwarf to 5 feet; orange-red fruit that fades to orange-yellow; early flowering
- **'Cacapon' -** slightly dwarf to 5 feet; heavy fruiting; glossy green leaves
- **'Chrysocarpa' -** yellow-fruited form
- **'Jim Dandy' -** slightly dwarf to 5 feet; early flowering male clone for pollinating early flowering female cultivars ('Afterglow', 'Aurantiaca', 'Red Sprite', etc.)
- **'Red Sprite' -** dwarf female clone to 4' tall; low, mounding habit; early bloomer; very large, persistent red fruits
- **'Shaver' -** an early-flowering form, slightly dwarf to 5 feet; produces orange-red fruit and glossy leaves
- **'Southern Gentlemen' -** late flowering male clone for pollinating late flowering female cultivars ('Cacapon', 'Sparkleberry', 'Shaver', 'Winter Gold', 'Winter Red', etc.)
- **'Stoplight' -** newer late flowering selection with large, deep red fruit and


I. verticillata habit


I. verticillata flower


I. verticillata fruit

glossy foliage; to 8 feet

- **‘Sunsplash’ -** female selection with splotchy yellow variegated leaves
- **‘Winter Gold’ -** late flowering female selection; pinkish or golden-orange fruit; light green leaves
- **‘Winter Red’** - one of the most popular cultivars; profuse bright red fruits; rounded; to 8 feet
- *Ilex verticillata x serrata* hybrids:
- **‘Apollo’** - late flowering male clone with new growth emerging red
- **‘Autumn Glow’** - dense growth to 10’
- **‘Bonfire’** - profusion of early season fruits; fruit at an early age; mounding habit to 10 feet
- **‘Raritan Chief’ -** male clone useful for its long flowering period; to 12 feet; glossy green foliage
- **‘Sparkleberry’** - popular cultivar; to 12 feet; long-persisting medium-sized fruit


I. verticillata habit

- Scientific Name: ***Itea virginica***
- Common Name: **Virginia Sweetspire**
- Family: Iteaceae
- Native Range: Southeastern North America
- Hardiness Zone: 5 to 9
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Generally requires acid to neutral soil; tolerates a wide variety of soil texture and moisture; forms colonies by sucking
- Height: 3 to 4 feet
- Spread: 4 to 6 feet
- Growth Habit: Low to medium, deciduous, rounded shrub


I. virginica fall foliage

- Ornamental Characteristics: Long, drooping, fragrant racemes of white flower; spectacular red fall color; red to red-brown bark
- Pests and Diseases: No serious pests or diseases. May become chlorotic in high pH soil.
- Cultivars/Relatives:
- **'Henry's Garnet'** - more cold-tolerant with flowers and fall color superior to species
- **'Little Henry'** - dwarf form to 4 feet
- **'Long Spire'** - notably long racemes
- **'Merlot'** - compact habit with red fall foliage
- **'Morton'** - best high pH tolerance, to 7.0 approximately
- **'Sara Eve'** - pale pink flowering
- **'Saturnalia'** - matures to a smaller size than species, comparable to 'Henry's Garnet


I. virginica flowers


I. virginica habit

- Scientific Name: ***Morella (Myrica) pensylvanica***
- Common Name: **Northern Bayberry**
- Family: Myricaceae
- Native Range: Northeastern North America
- Hardiness Zone: 2 to 9
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Extremely tolerant of a variety of soils especially sandy soils; tolerant of salt spray/soils; tolerant of flooding and drought
- Height: 5 to 10 feet
- Spread: 5 to 10 feet
- Growth Habit: Medium to large rounded


M. pensylvanica habit

shrub; deciduous to semi-evergreen; suckers readily to form colonies; capable of nitrogen fixation; dioecious

- Ornamental Characteristics: Glossy green leaves; persistent gray-blue fruits
- Pests and Diseases: No serious pests or diseases.
- Cultivars/Relatives:
- **'Bobbee'** - female clone; dense growth; 6 to 8 feet high and wide
- **'Silver Sprite' -** female clone; broadly mounding; silvery-grey leaves; semi-dwarf to 5 feet


M. pensylvanica fruit

- Scientific Name: ***Physocarpus opulifolius***
- Common Name: **Common Ninebark**
- Family: Rosaceae
- Native Range: Eastern and Central North America
- Hardiness Zone: 2 to 8
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Tolerant of a variety of soil types; tolerates flooding and drought
- Height: 5 to 8 feet
- Spread: 4 to 6 feet
- Growth Habit: Medium to large, multi-stem, arching, deciduous shrub
- Ornamental Characteristics: Clusters of pale pink or white flowers; foliage color and size varies by cultivar; exfoliating bark
- Pests and Diseases: No serious insect or disease problems. Fireblight, leaf spots, and powdery mildew occasionally an issue.


P. opulifolius habit


P. opulifolius flower

- Cultivars/Relatives:
- **'Center Glow' -** foliage emerges green and gold and slowly fades to burgundy as they mature
- **'Dart's Gold' -** semi-dwarf to 5 feet; chartreuse foliage turns orange in fall
- **'Diablo'** - deep purple foliage
- **'Lady in Red' -** compact habit; burgundy foliage; pink flowers
- **'Little Devil'** - semi-dwarf to 4 feet; compact habit; white-pink flowers, deep burgundy foliage
- **'Nugget'** - chartreuse foliage; dense habit; 6 feet tall and wide; superior to 'Dart's Gold'
- **'Snowfall'** - green foliage; dense habit to 7 feet; showier flowers and foliage than species
- **'Summer Wine'** - deeply cut, wine-red foliage; dense, mounding growth habit


P. opulifolius habit

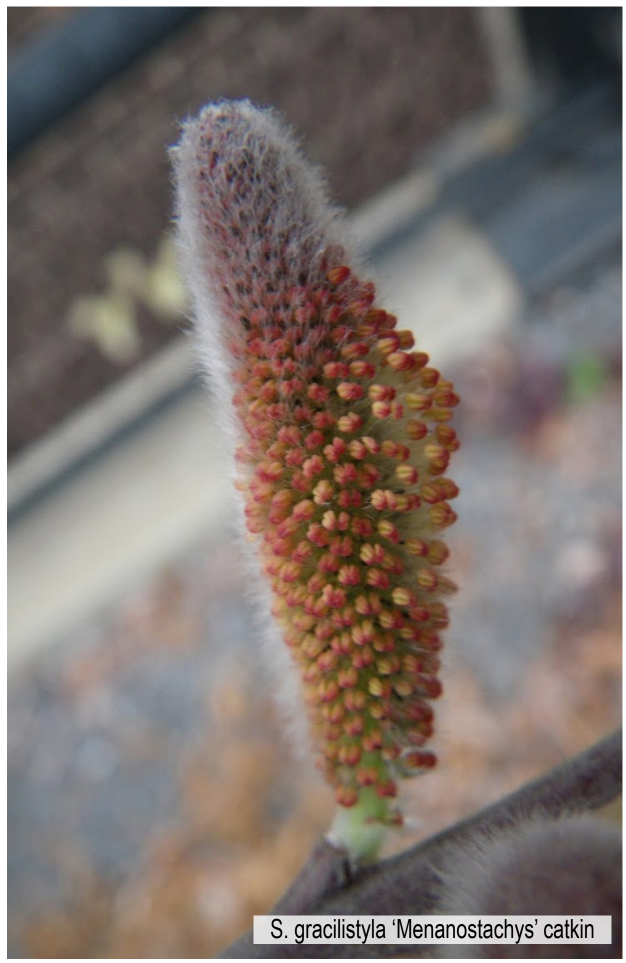
- Scientific Name: ***Salix (repens var.) arenaria***
- Common Name: **Creeping Silver Willow**
- Family: Salicaceae
- Native Range: Coastal Northwestern Europe
- Hardiness Zone: 4 to 6
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Extreme drought tolerance for a willow, flood tolerant as well; tolerant of a variety of soils especially sand, tolerant of salt spray
- Height: 2 to 3 feet
- Spread: 5 to 6 feet
- Growth Habit: Low, mounding canes


S. arenaria habit

- Ornamental Characteristics: Small, downy, silvery leaves; forms a dense groundcover with regular pruning
- Pests and Diseases: No serious pests or diseases. Potentially suceptible to aphids, rust, and scale
- Cultivars/Relatives:
- ***S. repens*** - more prostrate than S. arenaria


S. arenaria habit

- Scientific Name: ***Salix discolor***
- Common Name: **Pussy Willow**
- Family: Salicaceae
- Native Range: Northern North America
- Hardiness Zone: 2 to 7
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Prefers full sun and moist soils but can tolerate some drought
- Height: 6 to 15 feet
- Spread: 4 to 12 feet
- Growth Habit: Large deciduous multi-stem shrub; dioecious
- Ornamental Characteristics: Silky, pearl-grey then yellow-green catkins emerge in early spring
- Pests and Diseases: Susceptible to numerous pests and diseases including: blights, powdery mildew, leaf spots, gray scab, cankers, aphids, scale, borers, lacebugs and caterpillars.
- Cultivars/Relatives:
- **'Rosea'** - pale rosy catkins
- ***S. caprea*** - northern European species; larger catkins, several cultivars, including 'Pendula' with a


S. gracilistyla 'Menanostachys' catkin

weeping habit.

- ***Salix gracilistyla* 'Melanostachys' -** native to China, Korea and Japan; 6 to 10 feet tall; showy black catkins with red anthers


S. discolor catkins

- Scientific Name: ***Salix purpurea***
- Common Name: **Purple Willow, Purple Osier Willow**
- Family: Salicaceae
- Native Range: Europe and Western Asia
- Hardiness Zone: 4 to 8
- Sun/Shade: Full Sun
- Cultural Tolerances: Prefers moist soils but can handle drought as well; tolerant of clay soils and high pH
- Height: 3 to 10 feet
- Spread: 4 to 10 feet
- Growth Habit: Deciduous; full, multi-stem shrub; upright to mounding (cultivar dependent), dioecious
- Ornamental Characteristics: Attractive leathery, bluish foliage on handsome purple stems
- Pests and Diseases: No serious insect or disease problems. Occasionally susceptible to numerous foliar diseases, blights and cankers and many insect pests including aphids, scale and borers.
- Cultivars/Relatives:


S. purpurea catkins


S. purpurea habit

- **'Canyon Blue'** - semi-dwarf to 5 feet; steely blue-gray foliage; low and rounded
- **'Gracilis'** - medium height to 6 feet; slender upright stems
- **'Pendula'** - spreading, pendant growth habit
- **'Nana'** - semi-dwarf to 6 feet; striking blue-green foliage
- **'Nancy Saunders'** - female clone; silvery-grey leaves on glossy, maroon-red stems
- **'Streamco'** - very vigorous growth; readily suckers and self layers; selected


S. purpurea habit

- Scientific Name: ***Rhus copallina***
- Common Name: **Shining Sumac, Winged Sumac, Flameleaf Sumac**
- Family: Anacardiaceae
- Native Range: Eastern North America
- Hardiness Zone: 4 to 9
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Tolerant of drought and salt; relatively flood tolerant; tolerant of a wide range of soil textures and poor soils
- Height: 7 to 15 feet
- Spread: 7 to 20 feet
- Growth Habit: Deciduous shrub to small tree; root suckers to form large colonies, sometimes aggressively
- Ornamental Characteristics: Spectacular red and orange fall color; yellow-green flower spikes that mature to persistent red fruits
- Pests and Diseases: No serious pest


R. copallina habit


R. copallina fall foliage

or disease problems. Occasionally susceptibility to leaf spot, rusts, scale, aphids and mites.

- Cultivars/Relatives:
- **'Prairie Flame'** - semi-dwarf to 7 feet; glossy green foliage; even better fall color than species.
- **'Lanham's Purple'** - bright purple emergent foliage that fades to glossy red-green through the growing season; more colorful flowers than species; excellent fall color


R. copallina habit

- Scientific Name: ***Rosa palustris***
- Common Name: **Swamp Rose**
- Family: Rosaceae
- Native Range: Eastern and Central North America
- Hardiness Zone: 4 to 9
- Sun/Shade: Full Sun
- Cultural Tolerances: Prefers acid soil but tolerates neutral pH; very tolerant of flooding; tolerant of drought
- Height: 3 to 6 feet
- Spread: 3 to 6 feet
- Growth Habit: Deciduous, thorny, multi-stem shrub; spreads slowly by suckers
- Ornamental Characteristics: Glossy green foliage; large, fragrant pink flowers throughout summer; glossy, red, persistent hips
- Pests and Diseases: Not generally susceptible to the diseases and pests that attack many of the hybrid roses. Pest and disease problems associated with other roses which might rarely affect this species could include: black spot, powdery mildew, rust, aphids, beetles, borers, scale, thrips, rose


R. palustris habit


R. palustris flower

midges and leafhoppers.

- Cultivars/Relatives:
- ***var. scandens*** **-** more graceful and arching than species

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- Scientific Name: ***Sambucus canadensis/nigra***
- Common Name: **American Elderberry/ Black Elderberry**
- Family: Adoxaceae
- Native Range: Eastern North and Central America (from Canada to Panama) and Europe respectively
- Hardiness Zone: 3 to 11
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Prefers moist soils but tolerates some drought; tolerates a variety of soil types
- Height: 5 to 12 feet
- Spread: 5 to 12 feet
- Growth Habit: Large multi-stem shrub; suckers and layers to form colonies
- Ornamental Characteristics: Large umbels of small white to pink flowers; dark purple fruits; foliage color of green, yellow, and purple by cultivar
- Pests and Diseases: Some susceptibility to canker, powdery mildew, leaf spot, borers, spider mites and aphids.
- Cultivars/Relatives:
- **'Adams' -** larger, more numerous fruits than species
- **'Aurea' -** large (to 10 feet), golden leaved variety
- **'Laciniata' -** deeply incised green leaves


S. nigra 'Black Lace flowers


S. canadensis habit


S. canadensis flowers

- **'Variegata'** - narrow leaflets with creamy white-yellow variegation; prefers semi-shade for best foliage color
- **'York'** - larger, more numerous fruits than species; similar to 'Adams'
- S. nigra Cultivars:
- **'Black Beauty'** - dark purple foliage; lemon-scented, pink flowers
- **'Black Lace'** - deeply incised dark purple foliage; lemon-scented, pink flowers; dark blackish-red fruits


S. canadensis fruit

- Scientific Name: ***Sambucus racemosa/pubens***
- Common Name: **Red Elderberry**
- Family: Adoxaceae
- Native Range: Temperate Eurasia and Northern North America respectively
- Hardiness Zone: 4 to 9
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Tolerant of moist to relatively dry soils
- Height: 6 to 15 ft.
- Spread: 6 to 15 feet
- Growth Habit: Large multi-stem shrub; suckers and layers to form colonies
- Ornamental Characteristics: Large racemes of small white to pink flowers; glossy red fruits; foliage color of green, yellow, and purple by cultivar
- Pests and Diseases: Some susceptibility to canker, powdery mildew, leaf spot, borers, spider mites and aphids.
- Cultivars/Relatives:
- **'Sutherland Gold'** - deeply incised, golden leaved variety


S. racemosa fruit

(Jerzy, 2006)


S. racemosa 'Sutherland Gold' foliage

(Ramsey, 2006)

- **'Plumosa Aurea'** - slighty incised, golden leaved variety; new foliage emerges burgundy and fades to gold

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- Scientific Name: ***Spiraea tomentosa***
- Common Name: **Steeplebush**
- Family: Rosaceae
- Native Range: Eastern North America
- Hardiness Zone: 3 to 8
- Sun/Shade: Full Sun
- Cultural Tolerances: Tolerant of a variety of soil types; prefers acid soils; tolerant of flooding and drought
- Height: 2 to 4 feet
- Spread: 3 to 5 feet
- Growth Habit: Deciduous, upright, multi-stem shrub; suckering
- Ornamental Characteristics: Tall, dense racemes of small pink to rose-purple flowers; textured green leaves covered in orange hairs beneath
- Pests and Diseases: No serious pest or disease problems. Susceptible to many of the diseases that attack other rose family members, including leaf spot, fire blight and powdery mildew, aphids, leaf roller, caterpillars and scale.
- Cultivars/Relatives:
- ***S. alba*** - Native to Eastern and Central North America; white to pink racemes of flower; with thin narrow leaves


S. tomentosa flowers


S. tomentosa habit

- Scientific Name: ***Symphoricarpos albus***
- Common Name: **Common Snowberry**
- Family: Caprifoliaceae
- Native Range: Northern North America
- Hardiness Zone: 2 to 7
- Sun/Shade: Sun to Medium Shade
- Cultural Tolerances: Tolerant of a variety of soils; high pH tolerant; drought tolerant and reputedly flood tolerant
- Height: 3 to 6 feet
- Spread: 3 to 6 feet
- Growth Habit: Dense, rounded habit; spreads by suckers
- Ornamental Characteristics: Small bell shaped rose-pink and white flowers that mature into large white “marshmallow-like” fruits
- Pests and Diseases: No serious pest or disease problems. Anthracnose, leaf spot, powdery mildew, rust, berry rot, and spider mites may occur.
- Cultivars/Relatives:
- ***var. laevigatus*** **-** more vigorous than species; larger in all parts, particularly the fruits; grows to taller than 6 feet
- **‘Variegata’** - variegated white-edged leaves


S. alba flowers

(Vincentz, 2007)


S. alba fruits

- Scientific Name: ***Viburnum lentago***
- Common Name: **Nannyberry Viburnum**
- Family: Adoxaceae
- Native Range: Northeastern and Central North America
- Hardiness Zone: 2 to 8
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Prefers full sun, is tolerant of a variety of soils and flood/ relative drought
- Height: 14 to 16 feet
- Spread: 6 to 12 feet
- Growth Habit: Deciduous, upright, multi-stem shrub; suckers to form colonies
- Ornamental Characteristics: Glossy green leaves; umbels of white to pink flowers that mature to dark blue, edible fruits; attractive reddish-purple fall foliage
- Pests and Diseases: No serious pests or diseases. Occasionally susceptible to powdery mildew in humid climates.
- Cultivars/Relatives:
- **'Deep Green'** - large to 20 feet; lustrous dark gren leaves
- **'Pink Beauty'** - pink fruits that turn purple with age.


V. lentago flowers


V. lentago habit

- Scientific Name: ***Viburnum nudum***
- Common Name: **Possumhaw Viburnum**
- Family: Adoxaceae
- Native Range: Eastern North America
- Hardiness Zone: 3 to 8
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Requires low pH soils; prefers moist to wet soils, but can handle


V. nudum habit

some drought

- Height: 5 to 12 feet
- Spread: 5 to 12 feet
- Growth Habit: Dense, rounded, upright, multistem, deciduous shrub; plant at least two varieties to get good fruit set
- Ornamental Characteristics: Glossy green leaves; umbels of white flowers that mature to colorful fruits; fruits start out green and color through pink to purple-blue; excellent orange and red fall foliage
- Pests and Diseases: No serious pests or diseases. Occasional pests and diseases might include: aphids, borers, nematodes, scale, thrips, anthracnose, leaf spots and powdery mildew.
- Cultivars/Relatives:
- ***V. cassinoides*** **-** more northern species; V. nudum is sometimes recognized as a sub-species of V. cassinoides
- **'Brandywine' -** glossy leaves, better fruit color than species; wine-red fall foliage
- **'Count Pulaski' -** large glossy leaves, better fruit color than species
- **'Deep Pink' -** is a V. cassinoides cultivar with deep pink fruits
- **'Pink Beauty' -** relatively compact, to 6 feet; leaves, fruit, and fall color attractive as with species
- **'Winterthur' -** glossy leaves, excellent fruit color


V. nudum fruits


V. cassinoides habit

- Scientific Name: ***Viburnum prunifolium***
- Common Name: **Blackhaw Viburnum**
- Family: Adoxaceae
- Native Range: Eastern North America
- Hardiness Zone: 3 to 9


V. prunifolium fruit

- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Tolerant of flooding and drought; tolerates fairly deep shade, however flowers best in full sun
- Height: 12 to 15 feet
- Spread: 6 to 12 feet
- Growth Habit: Deciduous multi-stem shrub or single-stem small tree
- Ornamental Characteristics: Glossy dark green leaves; umbels of white flowers that mature to blue-black fruit; excellent fall color; “alligator” bark when mature
- Pests and Diseases: No serious pest or disease problems. Occasionally susceptible to powdery mildew.
- Cultivars/Relatives:
- **‘Early Red’ -** emerging leaves are tinged red; fall foliage is deep red
- **‘Knighthood’ -** dark purple fall color; mildew resistant
- **‘Ovation’ -** upright, columnar habit to 10 feet tall; emerging leaves are reddish; mildew resistant
- **‘Summer Magic’** - more rounded, tight habit than species; beautiful yellow and red fall foliage


V. prunifolium habit


V. prunifolium flowers

Potential Species List

The following species have some of the tolerances or characteristics necessary to make them successful species in planted stormwater practices. However they may be untested for use in these practices. They have potential and should be considered and even used in stormwater retention/infiltration practices but with the knowledge that more experimentation is needed to understand their suitability.

- Scientific Name: ***Cephalanthus occidentalis***
- Common Name: **Buttonbush**
- Family: Rubiaceae
- Native Range: North America except for the Northwest
- Hardiness Zone: 3 to 9
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Drought tolerance untested; can handle extreme flooding to average moisture soils; tolerant of a variety of soil textures
- Height: 5 to 12 feet
- Spread: 4 to 8 feet
- Growth Habit: Deciduous, open, rounded shrub; fairly coarse but not unattractive
- Ornamental Characteristics: Very glossy green leaves; unique round clusters of buds that bloom white to pinkish-white
- Pests and Diseases: No serious pests or diseases.
- Cultivars/Relatives:
- **'Sputnik'** - larger blooms and longer bloom period than species; pinkish flowers
- **'Sugar Shack'** - semi-dwarf to 4 feet; bright red fruits


C. occidentalis habit


C. occidentalis flowers

- Scientific Name: ***Diervilla lonicera/ sessilifolia***
- Common Name: **Bush Honeysuckle**
- Family: Caprifoliaceae
- Native Range: Northeastern North America and Southeastern North America respectively
- Hardiness Zone: 3 to 10
- Sun/Shade: Full Sun to Full Shade
- Cultural Tolerances: Flood tolerance untested; tolerates soil textures from sand to clay; particularly tolerant of dry soils; tolerates low and high pH
- Height: 3 to 4 feet
- Spread: 3 to 4 feet
- Growth Habit: Low mounding, deciduous shrub; suckers to form broad clonal thickets
- Ornamental Characteristics: Exfoliating bark; glossy green leaves; new grow may have attractive pale red stems; clusters of yellow flowers; red to purple fall foliage
- Pests and Diseases: No serious pests or diseases. May occasionally get powdery mildew.
- Cultivars/Relatives:
- ***D. lonicera* 'Copper'** - emerging leaves copper-red; superior fall color to species
- ***D. sessilifolia* 'Butterfly'** - excellent red fall color
- ***D. sessilifolia* 'Cool Splash'** - white variegated foliage


D. sessilifolia habit


D. sessilifolia flowers


D. sessilifolia mass planting

- Scientific Name: ***Hypericum spp.***
- Common Name: **St. Johnswort spp.**
- Family: Hypericaceae (formerly Clusiaceae)
- Native Range: Northern Hemisphere
- Hardiness Zone: varies, (5) 6- 9
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Varies; flood tolerance untested; generally tolerant of sandy and dry soils; generally tolerant of drought
- Height: 2 to 4 feet
- Spread: 2 to 4 feet
- Growth Habit: Small, dense, mounding shhrub
- Ornamental Characteristics: Profuse, large to small bright yellow flowers; exfoliating bark; bright green to bluish leaves
- Pests and Diseases: Generally pest and disease free. Root rot and wilt can be significant problems in hot and humid climates, nematodes can occassionally problematic.
- Cultivars/Relatives: Many species and cultivars; below are some of the most likely to work in stormwater practices.
- ***Hypericum densiflorum*** **-** Bushy St. Johnswort; native to the east coast of North America; dense rounded growth; bright clusters of small flowers; thick, glossy foliage
- ***Hypericum frondosum*** **-** Cedarglade St. Johnswort; native to southeastern North America
- ***H. frondusum*** **'Sunburst' -** medium-sized showy yellow flowers; attractive blue-green foliage
- ***Hypericum*** **'Hidcote'** - marginally hardy in Zone 5; very large bright yellow flowers; blooms throughout the season;


H. 'Hidcote' habit


H. 'Hidcote' habit

reddish stems; orange fall color

- ***Hypericum prolificum* -** Shrubby St. Johnswort; native to eastern North America; dense rounded growth; covered in clustered of bright yellow flowers with showy bushy stamens; exfoliating bark

H. prolificum flowers

- Scientific Name: ***Iva frutescens***
- Common Name: **Marsh-elder, High Tide Bush**
- Family: Asteraceae
- Native Range: Atlantic and Gulf Coast of North America
- Hardiness Zone: 5 to 10
- Sun/Shade: Full Sun
- Cultural Tolerances: Drought tolerance untested; tolerates growing in seawater, the most salt tolerant native plant; tolerates sandy soil and other soil types
- Height: 2 to 10 feet
- Spread: 6 to 12 feet
- Growth Habit: Dense upright rounded habit
- Ornamental Characteristics: Succulent green foliage; racemes of inconspicuous greenish flowers
- Pests and Diseases: No serious pests or diseases.
- Cultivars/Relatives: N/A

I. frutescens habit

I. frutescens flowers

- Scientific Name: ***Lonicera oblongifolia***
- Common Name: **Swamp Fly Honeysuckle**
- Family: Caprifoliaceae
- Native Range: Northeastern North America
- Hardiness Zone: 3 to 6
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Drought tolerance untested; stongly flood and high pH tolerant; prefers a cool, moist habitat
- Height: 2-3 feet
- Spread: 2-3 feet
- Growth Habit: Low, upright shrub
- Ornamental Characteristics: Creamy white flowers that turn to yellow as they age; bright red to red-purple fruits
- Pests and Diseases: No serious pests or diseases. Aphids can occasionally problematic.
- Cultivars/Relatives: N/A

L. oblongifolia fruits

(Moran [ref. DOL14729], 2005)

L. oblongifolia fruits

(Moran [ref. DOL15337], 2005)

- Scientific Name: ***Myrica gale***
- Common Name: **Sweetgale**
- Family: Myricaceae
- Native Range: Northern and Eastern mountainous North America, Northern Europe, coastal East Asia
- Hardiness Zone: 1 to 6
- Sun/Shade: Full Sun to part Shade
- Cultural Tolerances: Drought and high pH tolerance untested; extremely flood tolerant; tolerant of a wide varity of soil textures; relatively salt tolerant
- Height: 2 to 5 feet
- Spread: 1 to 5 feet
- Growth Habit: Low mounding deciduous

M. gale catkins

(Porse, 2008)

shrub; capable of nitrogen fixation

- Ornamental Characteristics: Leathery dark green leaves; small yellow to maroon flowers; sweetly-spicy fragant foliage
- Pests and Diseases: No serious pests or diseases. Occasionally susceptible to root rots, stem rots, rusts, and leaf spot.
- Cultivars/Relatives: N/A

M. gale habit

(Peters, 2007)

- Scientific Name: ***Salix candida***
- Common Name: **Sageleaf Willow, Hoary Willow**
- Family: Salicaceae
- Native Range: Northern North America
- Hardiness Zone: 1 to 6
- Sun/Shade: Full Sun to Part Shade
- Cultural Tolerances: Drought tolerance untested; tolerant of flood and high pH
- Height: 2 to 13 feet
- Spread: 4 to 13 feet
- Growth Habit: Small to medium sized upright shrub; deciduous; dioeceous
- Ornamental Characteristics: Foliage can be leathery and glossy green on top and felted silver-grey beneath or silvery-grey and pubescent on top and bottom; yellow catkins
- Pests and Diseases: No serious known pests or diseases.
- Cultivars/Relatives:
- **'Silver Fox'** - dwarf to 3 feet; felted silvery leaves

S. candida foliage

(Mohlenbrock, 1989)

- Scientific Name: ***Shepherdia argentea***
- Common Name: **Silver Buffaloberry**
- Family: Elaeagnaceae
- Native Range: Northern and Western North America
- Hardiness Zone: 3 to 9
- Sun/Shade: Full Sun
- Cultural Tolerances: Tolerant of flood and drought; tolerant of high pH; relatively high salt tolerance
- Height: 3 to 20 feet
- Spread: 3 to 20 feet
- Growth Habit: Irregular shrub to small tree; slow growing; thorny; deciduous; weak suckering habit; cabable of nitrogen fixation; dioeceous
- Ornamental Characteristics: Silvery-grey foliage; yellow flowers which mature to bright red berries
- Pests and Diseases: No serious pests or diseases. White heart rot sometimes a problem in older plants.
- Cultivars/Relatives:
- ***S. canadensis*** **-** shares the range of S. argentea but with a larger eastern distribution; less silvery foliage than s. argentea
- **'Sakakawea'** - yellow fruiting variety

S. argentea fruits

(Lavin 009, 2012)

S. argentea habit

(Lavin 004, 2012)

Plant Qualities at a Glance

Below are some simplified lists of the plants described previously which can further help in selecting the right plant for a site.

Plants that prefer or require Low pH Soils:

- *Aronia melanocarpa*
- *Clethra alnifolia*
- *Ilex glabra*
- *Ilex verticillata*
- *Itea virginica*
- *Spiraea tomentosa*
- *Viburnum nudum*

Plants that fix nitrogen:

- *Amorpha fruticosa*
- *Ceanothus americanus*
- *Hippophae rhamnoides*
- *Morella pensylvanica*
- *Myrica gale*
- *Shepherdia argentea*

Plants that tolerate Saline Water/Soil:

- *Amorpha fruticosa* *
- *Aronia arbutifolia* *
- *Aronia melanocarpa* *
- *Baccharis halimifolia* ***
- *Cephalanthus occidentalis* *
- *Clethra alnifolia* *
- *Hippophae rhamnoides* * (Qin, He, Tan, Wang, Chen, 2009)
- *Ilex glabra* *
- *Itea virginica* *
- *Iva frutescens* ***
- *Myrica gale* *
- *Morella (Myrica) pensylvanica* **
- *Rhus copallina* **

- *Salix arenaria* *
- *Sambucus canadensis* *
- *Shepherdia argentea* ** (Qin, He, Tan, Wang, Chen, 2009)

* Tolerates infrequent flooding by water with low salinity
** Tolerant of infrequent flooding by brackish water
*** Tolerant of infrequent to prolonged flooding by brakish to saline water

reference for above unless otherwise noted (Thunhorst, 1993)

Additional Information

For Cultural and Distribution information of the plants:

- **Missouri Botanical Garden's Plant Finder Database**
  http://www.missouribotanicalgarden.org/plantfinder/plantfindersearch.aspx
- **University of Connecticut Plant Database of Trees, Shrubs and Vines**
  http://www.hort.uconn.edu/plants/
- **USDA Plant Database**
  http://plants.usda.gov/java/
- **Cornell University Woody Plants Database**
  http://woodyplants.cals.cornell.edu/search.php
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For Stormwater Retention/Infiltration Practice Construction and Standards information:

- **Save the Rain - Green Projects List**
  http://savetherain.us/green-projects-list/
- **NYC - DEP Standards for Green Infrastructure**
  http://www.nyc.gov/html/dep/pdf/green_infrastructure/bioswales-standard-designs.pdf
- **New York State Stormwater Management Design Manual**
  http://www.dec.ny.gov/chemical/29072.html

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