Suitability of Eight Northeastern U.S. Native Shrubs as Replacements for Invasive Plants in a Difficult Landscape Site with White-tailed Deer Pressure

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SUMMARY. Nursery and landscape professionals are interested in white-tailed deer (*Odocoileus virginianus*)–resistant native plants to replace invasive species used in difficult landscape sites, such as parking lot islands, which are dry, nutrient-poor, and exposed to sun and heat. Eight native shrubs [creeping sand cherry (*Prunus pumila* var. *depressa*), elderberry (*Sambucus canadensis*), gray dogwood (*Cornus racemosa*), highbush blueberry (*Vaccinium corymbosum*), round leaf dogwood (*Cornus rugosa*), northern spicebush (*Lindera benzoin*), sweetbells (*Eubotrys racemosa*), and virginia rose (*Rosa virginiana*)] were planted in a large commuter parking lot on the University of Connecticut campus to evaluate their suitability for use in difficult landscapes. The non-native, invasive shrubs ‘Compactus’ winged euonymus (*Euonymus alatus*) and ‘Crimson Pygmy’ japanese barberry (*Berberis thunbergii*) were also planted as controls representing non-native species typically planted in such sites. Aesthetic quality ratings for sweetbells matched the controls (rating of 4.5 out of 5.0) and plants exhibited a high level of white-tailed deer resistance. Virginia rose and creeping sand cherry had similar aesthetic quality to controls, despite light grazing of plants by white-tailed deer. Elderberry was damaged by moderate white-tailed deer grazing and snow load, but plants regenerated to 485% of initial size in one growing season with white-tailed deer exclusion. Gray dogwood, round leaf dogwood, and northern spicebush exhibited the least resistance to white-tailed deer grazing. Both dogwood species had lower aesthetic quality than the controls, and round leaf dogwood had the lowest survival rate (68%) after 2 years. However, several individuals of gray dogwood, round leaf dogwood, and northern spicebush that were less heavily damaged by white-tailed deer grew into attractive shrubs after white-tailed deer exclusion. Highbush blueberry had significantly lower aesthetic quality than controls and only 75% survival after 2 years, indicating that this species is an unsuitable replacement for invasives in difficult landscape sites. This study identified the underused native shrubs sweetbells, virginia rose, and creeping sand cherry as suitable replacements for invasives in difficult landscape sites with white-tailed deer pressure.

The sustainable landscape featuring native plants is a rapidly expanding trend in horticulture. Native plants support wildlife, including pollinators, and are not invasive (Tallamy, 2007). Some of the most popular and widely used plants for landscaping have been found to be invasive, and sales of these plants have declined dramatically in recent years (McCoy 2011). Two such invasive

shrubs are japanese barberry and winged euonymus. Ironically, some of the same traits that brought japanese barberry and winged euonymus horticultural prominence are also what makes them invasive (Lehrer et al., 2006). The most obvious and important of these traits is

their ability to perform well in variable environmental conditions, including difficult landscape sites. Furthermore, high white-tailed deer pressure on many landscapes necessitates the need for white-tailed deer-resistant ornamental plants.

The replacement of invasive plants with native plants is a desirable solution to the invasive plant problem (Gagliardi and Brand, 2007). Not all native plants will tolerate difficult landscape conditions, that include dry, nutrient-poor soils, and exposure to high sunlight, heat and wind, and damage from pedestrians, as well as japanese barberry and winged euonymus (Lubell, 2013). The direct replacement of japanese barberry and winged euonymus with native shrubs requires research to identify species that are suitable for difficult landscape conditions. Based on observations of diverse natural habitats, we identified the following eight underused native shrubs as potential candidates for use as invasive plant alternatives: creeping sand cherry, elderberry, gray dogwood, highbush blueberry, round leaf dogwood, northern spicebush, sweetbells, and virginia rose. The objective of this study was to determine whether these eight native shrubs are well adapted to landscape use. The identification of well-adapted native shrubs will enable the nursery industry to offer a broader palette of native plants for use in landscaping that will be profitable over time.

Materials and methods

Eight Northeastern U.S. native shrub species (creeping sand cherry, elderberry, gray dogwood, highbush blueberry, round leaf dogwood, northern spicebush, sweetbells, and virginia rose; Table 1) were selected for this study. Elderberry, gray dogwood, round leaf dogwood, northern spicebush, and virginia rose were sexually propagated and creeping sand cherry, highbush blueberry, and sweetbells were asexually propagated from individual stock plants.

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.3048	ft	m	3.2808
3.7854	gal	L	0.2642
2.54	inch(es)	cm	0.3937
16.3871	inch ³	cm ³	0.0610
28.3495	oz	g	0.0353
0.9464	qt	L	1.0567

Table 1. Nomenclature and plant description of eight Connecticut native shrub species. Plant descriptions are based on observations in Connecticut and literature sources.

Common name	Source of plant	Plant description ^a
Creeping sand cherry	Cutting	Groundcover, less than 1 ft tall. White flowers in early spring as the foliage emerges. Slender, 1 to 3 inches long, simple alternate leaves are lime green with silver undersides and turn orange-red in fall. Small black fruit ripen in fall.
Elderberry	Seed	Multistemmed, upright spreading habit (5 to 10 ft tall). Coarse-textured plant with stout stems and large opposite compound leaves with 5 to 11 serrate leaflets. Large flat-topped inflorescences of small white star-shaped flowers. Edible purple-black berries in late summer.
Gray dogwood	Seed	Upright with suckering shoots that grow vertically at first and then arch over and branch profusely. Connecticut plants reach 6 ft tall. Plants have smaller leaves than other shrubby dogwoods and finer texture. Also, flower clusters are more upright and panicle shaped (2-inch diameter). White fruit on uniquely colored coral red pedicels in late summer. Red-orange to purple fall color.
Highbush blueberry	Cutting	Upright, spreading habit (6 to 12 ft tall). Alternate, simple leaves are dark green to dark blue-green in summer and turn red in fall. Small, white urn-shaped flowers in early spring. Edible berries ripen blue-black in summer.
Northern spicebush	Seed	Stems grow upright at first and then horizontally. Open grown plants are dense and are round to oval in outline. Alternate, simple leaves are light green in summer and turn yellow in fall. Foliage is aromatic when crushed. Small yellow flowers in early spring are also scented. Oval shaped fruit are a glossy scarlet red.
Round leaf dogwood	Seed	Upright, spreading habit (6 to 10 ft tall) with stout stems. Large, rounded opposite leaves. Stems develop coral red coloration in winter and feature interesting lenticels. Small white flowers in dense, flat-topped, 2-inch diameter clusters. Fruit transition from green to white to robin's egg blue to amethyst in summer.
Sweetbells	Cutting	Upright shoots end in arching twigs. Open-grown plants are multistemmed and reach 3 to 6 ft tall. Alternate, simple leaves are 1 to 3 inches long. Glossy foliage emerges with reddish cast, turns dark green in summer, and scarlet red in fall. Small, white urn-shaped, flowers emerge on one-sided racemes and give off light fragrance. In winter, twigs and naked flower buds develop reddish coloration.
Virginia rose	Seed	Low growing (2 to 4 ft tall) with upright shoots and a dense, rounded habit. Alternate, compound leaves with 5 to 9 coarsely toothed leaflets. Glossy dark green foliage turns orange-red in fall. Fragrant, five-petal pink flowers (2-inch to 3-inch diameter), solitary or in small groups, bloom in summer. Numerous fruit (1/2-inch to 1-inch diameter) ripen red-orange in fall and persist through winter.

^aInformation adapted from Cullina (2002), Dirr (2011), and Hightshoe (1988); 1 inch = 2.54 cm, 1 ft = 0.3048 m.

Elderberry, gray dogwood, and virginia rose were obtained in #1 containers (3 qt) from New England Wetland Plants Inc. (Amherst, MA). Spicebush was obtained in #1 containers from Planter's Choice Nursery (Newtown, CT). Highbush blueberry was obtained in #2 containers (7 qt) from Prides Corner Farms (Lebanon, CT). Creeping sand cherry, round leaf dogwood, and sweetbells were propagated and grown by the authors and finished in #1 containers at the University of Connecticut (UConn) Plant Science Research and Education Facility (Storrs, CT). Plants were installed in parking lot islands in a commuter parking lot on the UConn campus (Storrs, CT) in USDA hardiness zone 6a on 1 June 2012. Two non-native, invasive species, 'Crimson Pygmy' japanese barberry and 'Compactus' winged euonymus, were also planted and used as controls. These species were asexually propagated and were

obtained in #2 containers from Prides Corner Farms.

The experimental design was a randomized complete block design with five replications and the experimental unit consisted of five individual plants. A block consisted of a planting row, which was divided into ten equal experimental units each containing five plants of a species. Each block contained 50 plants and 250 plants in total were installed for the study. Three blocks were installed in a single parking lot island and two blocks in a separate parking lot island. Each block was within 5 ft of asphalt parking lot or concrete sidewalk. One week before planting, block perimeters were marked and the grassy vegetation was sprayed with glyphosate herbicide. Shrubs were installed with the top of the root ball at or slightly higher than the surrounding landscape soil. Plants were arranged in two staggered rows with 4-ft centers within row and 3 ft

between rows. The five individual plants per experimental unit were arranged so that three plants occupied one row and two plants occupied the other row in adjacent positions. Blocks were mulched with shredded softwood bark to a depth of 3 inches. Plants were irrigated by hand with a watering wand immediately after planting, three times weekly for the first 4 weeks and twice weekly for the next 6 weeks. Each shrub was irrigated with ≈ 3 L of water at each irrigation event. After the 10 weeks following planting, shrubs did not receive supplemental irrigation for the remainder of the study. Plants did not display visible signs of drought stress for the duration of the study. Plants were fertilized on 22 Apr. 2013 and 24 Apr. 2014 with 30 g of granular 10N-4.4P-8.3K in the area 12 to 24 inches from the crown. Blocks were mulched a second time on 22 May 2013 with shredded softwood bark to a depth of 2 inches. The soil at the parking lot site

had sandy loam texture, pH 6.1, and 3.5% organic matter.

Plant height and width were measured at time of planting in June 2012 and at 106 weeks after planting (WAP) on 26 June 2014. Plant width was measured twice, at right angles to each measurement, and averaged. Plant size was calculated as the product of the height and two perpendicular widths. Percent change in plant size was calculated using the formula: $(\text{size at 106 WAP} - \text{initial size}) / \text{initial size} \times 100\%$. Plant survival was evaluated during the third week of June 2013 and 2014.

Since damage from white-tailed deer browse was so prevalent for several study species during the 2013 growing season, the severity of white-tailed deer damage was evaluated using a visual rating. On 19 June 2013, plants were rated for severity of white-tailed deer damage using a scale of 1 to 5, where 1 represented no damage, 2 represented slight damage (some shoot tips browsed), 3 represented moderate damage (majority of shoot tips browsed), 4 represented moderate to heavy damage (shoot tip browse and some shoots browsed to half original length or more), and 5 represented heavy damage (most shoots browsed to half original length or more).

On 25 Apr. 2014, a fence was erected around each of the study blocks to prevent white-tailed deer browsing during the 2014 growing season so that the plants could be evaluated in 2014 for aesthetic quality without the impact of white-tailed deer browse. On 26 June 2014, all plants were visually rated for aesthetic quality based on uniformity of shape and density of foliage using a scale of 1 to 5 where 1 represented a sparse, asymmetrical plant, 2 represented an asymmetrical plant with some sparse sections, 3 represented a dense, asymmetrical plant, 4 represented a dense, slightly asymmetrical plant, and 5 represented a dense, uniformly proportional plant. For elderberry, round leaf dogwood, and northern spicebush, there was one experimental unit in 2014 that had zero or only one surviving plant, and these were not evaluated for aesthetic quality. Therefore, aesthetic quality ratings for elderberry, round leaf dogwood, and northern spicebush were based on four replications instead of five.

For the white-tailed deer damage severity rating and the aesthetic

quality rating, three independent observers rated each plant and the three observations were averaged. Percent survival data were transformed using arcsine for mean separation analysis. Data were subjected to analysis of variance using the PROC MIXED procedure and mean separation using Fisher's least significant difference test ($P \leq 0.05$) using SAS (version 9.2 for Windows; SAS Institute, Cary, NC).

Results and discussion

All of the native species, except for northern spicebush, survived the first winter as well as the non-native controls 'Crimson Pygmy' japanese barberry and 'Compactus' winged euonymus, which had 100% survival (Table 2). Survival of northern spicebush (88%) may have been reduced by the full sun conditions at the parking lot sites since this plant grows naturally in partly to mostly shade of the forest understory. The plants that did survive grew well in full sun. First-year survival rates for the other native species ranged from 92% to 100% (Table 2).

The parking lot sites on the UConn campus were frequently visited by white-tailed deer, and white-tailed deer browse was observed on many species. Native sweetbells and highbush blueberry never had white-tailed deer damage [rating of 1 Table 2)] and exhibited a high level of white-tailed deer resistance. The non-native 'Crimson Pygmy' japanese barberry was also undamaged by white-tailed deer during this study. Native virginia rose and creeping sand cherry had slight white-tailed deer damage, where some shoot tips were browsed, which was similar to the ratings of non-native control 'Compactus' winged euonymus (1.8). Significantly more white-tailed deer damage was found on elderberry, round leaf dogwood, gray dogwood, and northern spicebush, which had ratings of 2.9, 3.0, 3.4, and 4.0, respectively. These plants had most of their shoot tips browsed with substantial leaf removal for some species and occasional shoots were browsed to half their original height. Our findings about the degree of white-tailed deer damage for japanese barberry, winged euonymus, and elderberry generally support the deer-resistance ratings by Perdomo et al. (2004), in their extension bulletin for the state of New Jersey. However, our results for highbush blueberry and northern

spicebush contradict the New Jersey ratings for these plants. We found that highbush blueberry was substantially more white-tailed deer-resistant than northern spicebush.

After the second winter, there was plant attrition for all of the native species except for virginia rose (Table 2). Northern spicebush had similar plant attrition in both the first and second years, with 76% of plants surviving after 2 years. Attrition of highbush blueberry doubled in year two, resulting in 75% survival after 2 years. Creeping sand cherry and elderberry had 100% survival in year one, but after the second winter, survival was 88% and 80%, respectively. Round leaf dogwood also had 100% survival in year one, but losses during the second winter were substantial, with only 68% of plants surviving after 2 winters. Plant attrition after the second winter for sweetbells and gray dogwood was slight at 4%. After 2 years, survival for all of the native species was similar to the non-native control 'Crimson Pygmy' japanese barberry, and survival for round leaf dogwood was less than that for the non-native control 'Compactus' winged euonymus.

Plant attrition, growth, and aesthetic quality were impacted by factors including: 1) the inherent suitability of the species to the difficult parking lot landscape, 2) varying amounts of white-tailed deer browse and the species ability to recover from white-tailed deer browse, and 3) substantial impacts from heavy snowfalls and snow removal practices over Winter 2013–14. The town of Storrs, CT, had 54 inches of snow during the months of Jan. and Feb. 2014 (U.S. Department of Commerce, 2009a, 2009b), and its removal from parking lots required extraordinary measures and large equipment, which resulted in heavy amounts of snow being piled on the study plantings and snow plow blades hitting plants.

Over the course of the study, most native plants increased in size, while a few decreased in size (Table 3). Both of the non-native controls increased in size. Elderberry exhibited substantial percent increase in plant size (485%), which is primarily due to this species fast growth rate (Dirr, 2011), but is also indicative of an ability to overcome white-tailed deer browsing and snow load impacts. Sweetbells, virginia rose, round leaf dogwood, and northern spicebush also showed increases in plant size. Creeping sand

Table 2. One-year survival and severity of white-tailed deer damage in 2013 and 2-year survival and aesthetic quality in 2014 of eight Connecticut native and two non-native shrub species planted in a commuter parking lot on the University of Connecticut campus (Storrs, CT).

Species	1-yr Survival (%)	2-yr Survival (%)	White-tailed deer damage (1–5 scale) ^z	Aesthetic quality (1–5 scale) ^y
	2013	2014	2013	2014
Native species				
Creeping sand cherry	100 a ^x	88 ab	2.3 cd	3.6 abc
Elderberry	100 a	80 ab	2.9 bc	3.7 abc
Gray dogwood	96 ab	92 ab	3.4 ab	2.9 bc
Highbush blueberry	92 ab	75 ab	1.0 e	2.4 c
Northern spicebush	88 b	76 ab	4.0 a	3.7 abc
Round leaf dogwood	100 a	68 b	3.0 bc	2.9 bc
Virginia rose	96 ab	96 ab	1.8 d	3.9 ab
Sweetbells	96 ab	92 ab	1.0 e	4.5 a
Non-native species				
‘Compactus’ winged euonymus	100 a	100 a	1.8 d	4.5 a
‘Crimson Pygmy’ japanese barberry	100 a	84 ab	1.0 e	4.5 a

^aAll five plants per experimental unit (n = 5) were rated by three people; 1 = no damage, 2 = slight damage, 3 = moderate damage, 4 = moderate to heavy damage, 5 = heavy damage.

^yAll five plants per experimental unit (n = 5); except for elderberry, round leaf dogwood, and northern spicebush (n = 4) were rated by three people; 1 = sparse asymmetrical plant, 2 = asymmetrical plant with some sparse sections, 3 = dense, asymmetrical plant, 4 = dense, slightly asymmetrical plant, 5 = dense, uniformly proportional plant.

^zMean separation within columns (lowercase letters) by Fisher's least significant difference test ($P \leq 0.05$). Percent survival data were transformed using arcsine, and reported table values for after 1-year survival and after 2-year survival represent original means and transformed letters.

Table 3. Height, width, and size at time of planting (initial) and 106 weeks after planting (WAP) and percent change in plant size over three growing seasons (2012 to 2014) for eight Connecticut native and two non-native shrub species planted in a commuter parking lot on the University of Connecticut campus (Storrs, CT).

Species	Initial			106 WAP			Change in plant size (%) ^w
	Ht (inches) ^z	Width (inches) ^y	Size (1000 inch ³) ^x	Ht (inches)	Width (inches)	Size (1000 inch ³)	
Native species							
Creeping sand cherry	12.2	28.1	96.8	9.5	29.7	90.5	−6
Elderberry	26.7	25.1	162.2	42.1	34.9	949.6	485
Gray dogwood	21.4	16.7	64.1	17.6	16.4	59.4	−7
Highbush blueberry	52.2	30.4	483.9	20.8	18.1	88.6	−82
Northern spicebush	34.0	18.2	119.7	30.2	20.9	144.9	21
Round leaf dogwood	27.2	19.2	100.0	23.8	21.3	146.1	46
Virginia rose	20.5	26.2	140.5	25.0	28.1	216.9	54
Sweetbells	25.6	22.8	133.5	27.6	25.0	183.5	38
Non-native species							
‘Compactus’ winged euonymus	25.1	25.6	171.5	28.1	33.2	354.5	107
‘Crimson Pvgmv’ japanese barberry	16.4	21.8	79.6	16.6	29.1	142.7	79

^x1 inch = 2.54 cm.

^yPlant width was measured twice, at right angles to each measurement, and averaged.

^zPlant size was the product of the height and two perpendicular widths; 1 inch³ = 16.3871 cm³.

^wPercent change in plant size was calculated using the formula: (size at 106 WAP – initial size/initial size) × 100%.

cherry, gray dogwood, and highbush blueberry showed decreases in plant size, which were slight for sand cherry (–6%) and gray dogwood (–7%). Reduction in plant size of creeping sand cherry was attributed to white-tailed deer browse, which removed long vigorous shoots that extended the width of the plant, and produced more interior branching. Gray dogwood suffered moderate to heavy white-tailed deer browse and demonstrated little ability to regenerate. Highbush blueberry

exhibited dramatic decreases in plant size (–82%) because the upper parts of plants had extensive dieback, which had to be pruned out.

The two non-native controls had the highest aesthetic quality rating at 4.5, which was matched exactly by the native sweetbells (Table 2). Aesthetic quality for virginia rose, northern spicebush, elderberry, and creeping sand cherry were statistically similar to the non-native controls. Gray dogwood, round leaf dogwood, and

highbush blueberry had significantly lower aesthetic quality than the non-native controls.

Sweetbells exhibited high resistance to white-tailed deer browse and was able to tolerate snow load because of its slender flexible stems and its propensity to produce copious suckers from its base. Despite repeated light white-tailed deer browse, virginia rose plants were able to break new buds and retain dense habit and healthy appearance (Fig. 1). Its branches are supple

Fig. 1. Photographs of eight Connecticut native species and two non-native species planted in a commuter parking lot on the University of Connecticut campus (Storrs, CT) 2 years after transplanting: (A) ‘Compactus’ winged euonymus (non-native), (B) creeping sand cherry, (C) ‘Crimson Pygmy’ japanese barberry (non-native), (D) elderberry, (E) gray dogwood, (F) highbush blueberry, (G) northern spicebush, (H) round leaf dogwood, (I) sweetbells, and (J) virginia rose.

enough to withstand snow loads and its rhizomatous, suckering nature helped in recovery from white-tailed deer browse and snow impacts. Round leaf dogwood has rigid stems that did suffer light damage from snow load. Many round leaf dogwood plants were so damaged by white-tailed deer that they were unable to recover dense habit even after white-tailed deer exclusion. However, several individuals that had less severe white-tailed deer damage, recovered to produce attractive, dense plants (Fig. 1). Northern spicebush appeared to struggle initially in the full sun parking lot conditions and was not tolerant of white-tailed deer browse. Several individuals of northern spicebush that were less heavily damaged by white-tailed deer grew into attractive shrubs after white-tailed deer exclusion. Highbush blueberry was unable to establish in the difficult parking lot conditions and its brittle stems were broken by snow load. This plant is often touted as an alternative to invasive 'Compactus' winged euonymus because of its red fall color (Abbey, 2004; Burrell, 2006; Cullina, 2003); however, our findings indicate that highbush blueberry is not a suitable replacement for use in difficult landscape conditions where 'Compactus' winged euonymus is frequently used. Gray dogwood naturally grows in dry, infertile and often, exposed sites and is thought of as a tough plant. However, the plants used in this study lacked the vigor necessary to regenerate healthy specimens in a single growing season with white-tailed deer exclusion. After damage from white-tailed deer and snow load, elderberry was quickly able to recover and produced healthy looking

plants in one growing season with white-tailed deer exclusion (Fig. 1). Creeping sand cherry performed well overall; however, because of its prostrate growing habit, specimens in one end block were mowed over by landscape crews that did not recognize the plants. Both non-native control species performed well and exhibited all of the traits that have made them popular landscape ornamentals. 'Compactus' winged euonymus plants were grazed by white-tailed deer more heavily than was expected; however, they were able to recover to produce dense, symmetrical specimens. 'Crimson Pygmy' Japanese barberry did exhibit damage from snow plows and snow load because plants are low growing and have brittle shoots.

Sweetbells performed exceedingly well in the challenging parking lot conditions and can directly replace invasives in difficult landscape sites. Virginia rose and creeping sand cherry are also suitable replacements for invasives in difficult landscape situations with minimal white-tailed deer presence. Round leaf dogwood, gray dogwood, and northern spicebush may be suitable replacements for invasives in difficult situations if white-tailed deer can be excluded and plants be provided additional care during the first couple of establishment years. Highbush blueberry is not a suitable replacement for invasives in difficult landscape conditions.

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