Growth and Establishment of Managed Grasslands and Ornamental Grasses in the WSU Puyallup Research Rain Gardens

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Low impact development is an emerging concept for managing urban stormwater. A critical tool in the low impact development approach and one of importance to the green industry is bioretention (Dietz, 2007). Bioretention cells, commonly known as rain gardens, are shallow depressions in the landscape filled with soil media and plants. They can be implemented on various scales from small residential lots to large commercial properties. Rain gardens use the biological, physical, and chemical properties of plants, soil media, and microorganisms to infiltrate water and filter pollutants and are intended to be long-term installations.

Plants are an essential component of rain gardens; they absorb nutrients, transpire water and help maintain favorable soil infiltration and microbiological activity. The moisture status of plants within a rain garden can vary with season and location. In the Pacific Northwest, plants must tolerate wet winters as well as dry summers, preferably without supplemental irrigation. During wet seasons, rain gardens will have different hydrologic zones, varying from temporarily saturated, oxygen-deprived conditions in low areas to dry conditions in upper areas that merge with the existing landscape. For long-term success, identifying plants that will be healthy and viable under these widely varying conditions is crucial.

Most rain garden research has been done in the eastern U.S., which has substantial rainfall in the summer, when evapotranspiration is high. The heavy winter rainfall and summer drought typical of the Northwest provide challenges for survival of rain garden plants, and research is needed to evaluate the suitability of different plant species for use in different moisture zones within rain gardens. In order to expand the list of plants recommended for rain gardens in the Pacific Northwest, replicated rain garden research to evaluate 30 different plant species and cultivars was initiated in late summer 2010 at the Washington State University Research and Extension Center in Puyallup. In this paper we will report on the growth and survival of the grass species included in our research.

Sixteen research rain gardens were installed as part of a Low Impact Development stormwater research program partly funded by a Washington Department of Ecology grant (http://www.wastormwatercenter.org/low-impact/). The rain gardens include 4 replications each of an unplanted control and three different landscape designs: a tree and shrub planting; a mixed landscape planting with trees, shrubs, ornamental grasses, sedges and rushes; and a managed grassland planting of turf-type grasses. Figure 1 shows the rain gardens in October 2012 and June 2015.

Figure 1: Rain Gardens in the Low Impact Development Research Area of the Washington State University Puyallup Research and Extension Center. Top photo taken October 11, 2012, bottom photo taken June 3, 2015.

Each rain garden cell has approximately 256 ft^2 of surface area. A bioretention soil mix of 60 percent sand and 40 percent recycled yard-waste compost (by volume) was spread to a depth of 18 inches. The cells have a flat bottom area (approximately 10ft x 10ft) and sloping edges. This creates hydrologic zones of varying soil moisture (the wetter bottom, the dryer top and the sloped zone that transitions between the top and bottom zone).

Managed Grassland. Grasses for the managed grassland were seeded in late summer 2010. Each rain garden was divided into 4 quadrants, with a different perennial cool-season turfgrass species or species mixture in each. The 4 quadrants are: tall fescue, a coarser-textured species typically regarded as more drought-tolerant because of its deep fibrous root system; fine fescues (chewings and creeping red), fine textured species considered low-maintenance due to their slow growth; colonial bentgrass, a fine-textured stoloniferous species adapted to the Puget Sound area; and a fine fescue/colonial bentgrass mixture. Seed was manually watered as needed to insure germination.

Ornamental Grasses. Ornamental grasses for the rain gardens were selected based on aesthetic characteristics and their considered potential for survival in the different rain garden hydrozones. The species, container size at transplant, and number of individuals included in the rain gardens as-well-as the hydrologic zone (dryer on the top, wetter in the bottom and transitional on the slopes) where they were planted are listed in Table 1. Ornamental grasses were obtained from

Table 1. Survival of ornamental grasses under evaluation in the WSU Puyallup LID research rain gardens. Plants were placed in different hydrozones in the rain gardens based on their potential adaptation. All plants were transplanted from containers in fall 2010 and irrigated as needed with overhead sprinkler irrigation during the summer of 2011. Plants were not irrigated after the summer of 2011.

Rain Garden Hydrozone	Scientific Name	Common Name	Container Size at Planting	Number Planted	Survival Percent (%) for Plants in Spring 2011	2013	2015
Dry	*Deschampsia cespitosa* 'Northern Lights'	Tufted hairgrass	4-inch	8	100%	75%	38%
Transition	*Deschampsia cespitosa* 'Northern Lights'	Tufted hairgrass	4-inch	12	100	17	8
Wet	*Deschampsia cespitosa* 'Northern Lights'	Tufted hairgrass	4-inch	8	100	50	12
Dry	*Festuca glauca* 'Boulder Blue'	Blue oat grass	3-inch	12	100	100	83
Transition	*Festuca glauca* 'Boulder Blue'	Blue oat grass	3-inch	8	100	100	50
Dry	*Miscanthus sinensis* 'Little Kitten'	Japanese silvergrass	1-gallon	12	100	100	100
Transition	*Miscanthus sinensis* 'Little Kitten'	Japanese silvergrass	1-gallon	4	100	100	100
Wet	*Miscanthus sinensis* 'Little Kitten'	Japanese silvergrass	1-gallon	4	100	100	100
Dry	*Molinia caerulea* 'Skyracer'	Moor grass	1-gallon	8	100	100	100
Transition	*Molinia caerulea* 'Skyracer'	Moor grass	1-gallon	8	100	88	88
Wet	*Molinia caerulea* 'Skyracer'	Moor grass	1-gallon	8	100	88	75

local nurseries, selected for uniformity and transplanted to the rain gardens in fall 2010. Plants were mulched to a depth of 3.5 to 4 inches with arborists' wood chips.

All plants were manually irrigated at planting in the fall of 2010 and then relied on natural rainfall until the summer of 2011. Drainage of the rain gardens in this study was excellent and no standing water was observed during the winter months. An overhead sprinkler irrigation system was installed, and from June to September 2011 all rain gardens were irrigated as needed to prevent plant water stress. After September 2011, no supplemental irrigation was applied to the rain gardens. Table 2 shows the precipitation during the time of this experiment measured by a WSU AgWeatherNet station (http://weather.wsu.edu/awn.php) located about one-half mile from the rain gardens.

Table 2. Monthly precipitation in inches recorded at Washington State University Puyallup Research and Extension Center during the rain garden study.

Month	2010	2011	2012	2013	2014
January	6.44	4.36	5.03	2.78	4.12
February	3.35	3.20	3.09	1.51	6.71
March	3.83	6.68	6.14	2.58	8.45
April	2.75	4.77	3.07	4.39	4.02
May	3.83	4.40	2.54	3.39	2.57
June	3.09	1.60	2.08	1.54	0.70
July	0.50	0.78	1.23	0.00	0.90
August	0.40	0.34	0.00	1.46	1.55
September	2.88	1.14	0.01	7.56	1.93
October	4.04	3.79	5.60	1.60	5.03
November	4.43	5.46	6.35	3.45	5.21
December	4.59	2.63	6.40	1.42	4.58

Once established, the managed grassland rain gardens were treated as minimally mowed turf. Maintenance typically consisted of cutting all grasses back to a height of 3 inches two or three times during the growing season. Maintenance of the ornamental grasses was limited to cutting all grasses back in late winter.

Data on survival, growth, and quality of rain garden plants is being collected. A grant from the WSDA Nursery License Surcharge Fund was awarded in fiscal year 2013 to help fund plant data collection. Ornamental grass survival data from spring 2011, spring 2013 and spring 2015 are presented in Table 1. When considering plant growth and survival results it is important to consider how the environment in the rain gardens has changed over time as plants have grown. Figure 2 shows rain gardens the first growing season when plants were small and all plants were exposed to full sun. Figure 3 shows mixed landscape rain gardens after 2 growing seasons (fall 2012) and Figure 4 shows rain gardens in June 2015. In rain gardens with trees and shrubs, many of the ornamental grasses that were in full sun are now in dense shade.

Figure 2. Appearance of the WSU Puyallup rain gardens the first spring after planting. The mixed landscape rain garden with ornamental grasses is in the foreground. Top photo was taken April 2011, bottom photo was taken June 2011 during a WALP Tour.

Figure 3: Appearance of ornamental grasses the WSU Puyallup rain gardens on October 11, 2012. Top photo from left to right the grasses are *Miscanthus* 'Little Kitten', *Molinia* 'Skyracer' and *Deschampsia* 'Northern Lights'. Bottom photo from left to right grasses are *Miscanthus* 'Little Kitten' (background), *Festuca* 'Boulder Blue' (forground), and *Molinia* 'Skyracer'.

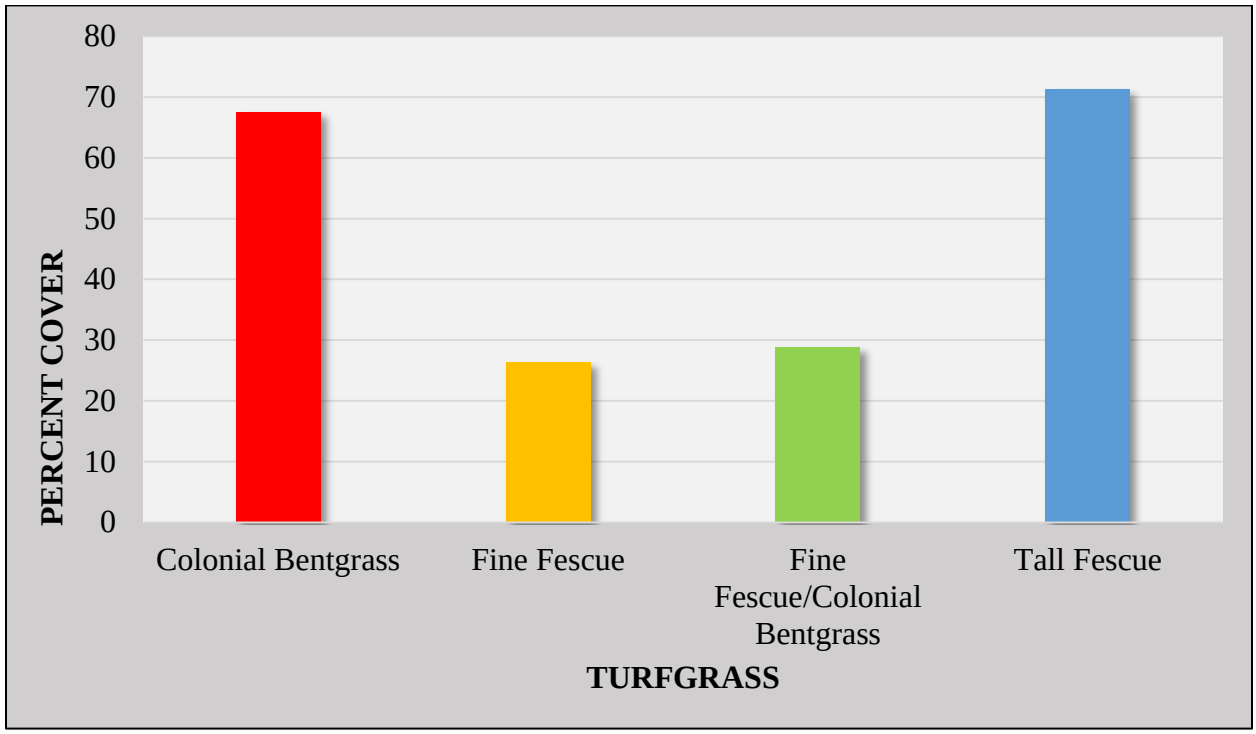
Figure 4. Appearance of the mixed landscape and the managed grassland rain garden in June 2015. Top photo shows the ornamental grasses from left to right: *Miscanthus* 'Little Kitten', *Festuca* 'Boulder Blue', and *Molinia* 'Skyracer'. Bottom photo shows the managed grassland.

Results of visual evaluations the spring following transplant (Spring 2011) indicated survival was 100% for all 4 ornamental grass species. In the summer of 2012, August and September were extremely dry with no rainfall and 0.01 inches, respectively (Table 2), and some plants exhibited water stress symptoms. Figure 3 shows the ornamental grasses on October 11, 2012, the pictures were taken the day before it started to rain. All 'Boulder Blue' oat grass and 'Little Kitten' miscanthus were alive and growing in spring 2013 and only 1 of the 8 'Skyracer' moor grass plants in both the transition and wet rain garden zones was dead (88% survival rate). Survival was much lower for 'Northern Lights', a variegated tufted hairgrass cultivar with only 17% survival of plants in the transition zone. This cultivar is considered "one of the few ornamental grasses that grows well in shade" (Missouri Botanical Garden) and it did not do well in the full sun environment characteristic of the rain gardens when they were first planted.

Growth of grasses in the managed meadow rain gardens is shown in Figure 5. Percent cover of the turf-forming grasses in the managed grassland rain gardens was determined in June of 2015 using digital image analysis (Richardson et. al., 2001). To reduce variation, all plots were photographed on one individual morning when light conditions were similar. Images were then analyzed using software that accounts for variation in green tissue. The results are shown in Figure 6. Due to space constraints, not all quadrants collected the same amount of sunlight. Therefore, trends must be carefully interpreted. The data does suggest that certain turfgrass types are more vigorous than others, under these particular conditions.

Figure 5: Mixed meadow rain garden treatment showing the four grasses used. Top photo was taken December 2011. Bottom photo was taken May 2013

Figure 6. Percent of cover in the managed grassland rain gardens measured in spring 2015 using digital image analysis. Each rain garden was divided into quadrants and quadrants were seeded with the turf grasses indicated. Data represents the average of four replications.



Results after four growing seasons indicate all turf and ornamental grasses except the 'Northern Lights' deschampsia grew well in the WSU Puyallup rain gardens. As the trees and shrubs continue to grow, shade will increase and this competition for light will likely influence growth and survival of those grasses that require full sun.

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