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Green Roof Plant Trials for the Central Great Plains

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ABSTRACT

Forty-three taxa representing native and adaptable plants were trialed for 4 years on an irrigated (as needed) 15 cm (6 inch) deep extensive green roof in Lincoln, NE. Twenty-three of the taxa showed good performance with minimal maintenance. At the end of the trial in fall 2014, 32 of the taxa still had at least one specimen surviving. Drought impacts in the trial's second year eliminated several taxa. Presented here are results and the positive findings of four new extensive green roof taxa, *Festuca cinerea*, *Carex glauca*, *Eragrostis trichodes*, and *Distichilis spicata*.

Key words: green roof, plant evaluation, Great Plains, *Bouteloua hirsuta*, *Carex bicknellii*, *Distichilis spicata*, *Muhlenbergia cuspidata*,

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INTRODUCTION

Interest and necessity for expanding the palette of native and adaptable plants for extensive green roofs continues in many locales across North America (Monterusso et al 2005, Bousset et al 2009, Lambrinos 2011, MacIvor and Lundholm, 2011, Dvorak et al 2013, Sutton 2013, Skabelund 2014, Schneider 2014). Additionally, Lundholm et al (2010) have suggested that a palette that mixes plant life-forms improves ecological function and diversifies green roof plant assemblage structure. Many of those palettes are of local interest and plant trials provide unbiased information for use by green roof designers.

The goal of this trial was to study 43 taxa for a several year period starting in 2011, observe the plants' growth habits, and report on their potential for central Great Plains' green roof use. Unfortunately the intention of gathering at least 10 years of observations was truncated to 4 when the structure supporting green roof site was scheduled to be expanded and reconstructed in 2015.

MATERIALS AND METHODS

Located in Lincoln, NE, the 185.8 m² (2000-foot²) Sandhills Publishing (SHP) green roof was created in 2010 atop a parking structure. The green roof has a 2% slope, 15 cm (6 in) of a custom blended proprietary substrate, Type V Soil (Table1), and contacts the ground surface on two sides. It faces west, southwest receiving full summer sun and prevailing southwesterly summer winds. No fertilizer was used at planting time or thereafter. During first year establishment, weekly irrigation of 2.5 cm (0.5 in) regardless of rainfall was applied. Thereafter it received, as needed, at least 0.50-inches (1.26 cm) to 0.75-inches (1.9 cm) of water per 10 days either in rainfall or irrigation.

The suite of plants for trial included forbs, sub-shrubs, geophytes (*Allium* spp.) and grasses selected from a careful review of the Bluebird Nursery Catalog (Bluebird Nursery, Clarkson, NE). Additional taxa were grown from seed or plants collected in the Central Great Plains. All plants were in 32's (32 containers per flat) 5.7 cm (2.25 in) by 5.7 cm (2.25 in) and 7.6 cm (3 in) deep. Plants obtained from the nursery were in a standard organic mix and those

Table 1. Substrate Constituents

TYPE IV SOIL – Semi-Intensive Rootzone (agronomic on structure)

A blend of the following components:

1. 70% Processed Sand
2. 15% Compost
3. 15% Black Castings

TYPE V SOIL – Extensive Rootzone (agronomic on structure)

A blend of the following components:

1. 55% Lightweight Aggregate (either Expanded Shale or Expanded Slate)
2. 45% Type IV Soil

grown from collected seed or propagules were greenhouse grown in a rooflite extensive substrate™ (Manufacturer, Skyland USA, P.O. Box 159 Landenberg, PA). In late May 2011, four specimens of each taxon were planted in three randomly located replications in a square pattern 20 cm (8 in) apart on the green roof at SHP. Each replication was marked with a pressure sensitive metal tag located next to the specimen in the northeast corner of the 4-plant suite. In

several instances for some of those plants grown from seed or cuttings, twelve plants were not available, so 6 (two replications of 3 plants) or 8 individuals (two replications of 4 plants) were planted instead. For replications of 3 plants the southwesterly replication corner was left empty. This pattern and plant size allowed individual plants to be located quickly re-examined each year and to be distinguished from volunteer seedlings. A total of 45 different taxa and 530 individual plants were trialed. Four taxa, *Aster oblongifolia*, *Bouteloua gracilis*, *Juncus tenuis*, and *Schizachyrium scoparium* consisted of two different cultivars or came from two different seed provenance and were analyzed separately bringing the total trial groups to 47. All replications were mowed to a height of 6.4 cm (2.5 in) in March of 2013, and 2014 and clippings removed.

During the falls of 2011, 2012, 2013, and 2014 in the last week of September or first week of October, observations were made consisting of individual plant height, plant spread (in two directions), a growth rating, and the number/location of each plant (Tables 2 and 3). Similar to Schneider et al (2014), height and spread were collapsed into a volume called “size” (i.e., $(\text{height} + \text{spread1} + \text{spread2})/3$). The rating scheme based on visual condition was as follows: Visual condition: 0 = dead; 1 = stressed w/ wilting and browning, and reduced from initial size; 2 = little change; 3 = slow growth; 4 = healthy with good growth.

Tables 2 and 3 show three measured variables: size (volume), rating, and survival. Of these, size should not be used to compare across taxa because each has inherently size differences; rating and survival thus become more important. At minimum, a good performer should exhibit slow growth (rating 3) or healthy, good growth (rating 4). According to Schneider et al (2014), a plant with good performance should have 75% survival. In this trial since a gap in survival existed between 67% and the next lowest at 33%, the cut off was set at 67% survival after 4 years. Doing this only brought three taxa’s rating and survival into consideration: *Aster oblongifolius* (4, 67%), *Amorpha nana* (4, 67%) and *Artemisia frigida* (3, 73%).

RESULTS

As shown in Table 2, only one taxa, *Iris cristata*, failed to grow the first year (2011). Three additional taxa, *Lotus corniculatus*, *Antennaria dioica rosea*, and *Liatris punctata*, did not survive through the second growing season into 2012. Eight taxa did not survive until fall 2013, *Allium caeruleum*, *Allium cernuum*, *Artemisia filifolia*, *Oryzopsis hymenoides*, *Ephedra minuta*, *Hymenoxys scaposa*, *Juncus tenuis*, and *Ephedra regeliana*. Two taxa failed to survive until fall 2014, *Thermopsis rhombifolia*, and *Engelmannia pinnatifida*. An additional 9 taxa were still on the roof in fall 2014, but had survival rates below 67%. The remaining 23 taxa (three include cultivars or differing provenances) were growing well and, except for four species, had survival rates above 82%.

DISCUSSION

Sutton et al (2012) reviewed nearly two-dozen North American green roofs that featured prairie species and Schneider et al (2014) reviewed an additional 101 native and adapted taxa. Excepting these taxa: *Festuca cinerea*, *Penstemon*, *pinifolius*, *Carex glauca*, all others in this trial with good performance are native prairie plants (Table 3). However, native plant species can vary as noted by the difference in size of plantings that came from different provenances for *J. tenuis*, *B. gracilis* and *S. scoparium*. In this trial, 14 of the taxa with poor performance had not been reported on for green roof use and 4 taxa (*Festuca cinerea*, *Carex glauca*, *Eragrostis trichodes*, and *Distichilis spicata*) have not been reported for green roof use.

No attempt was made to statistically analyze the variance of size, survival, or survival, but simple ratings and survival numbers tell an incomplete story about individual plants. For example, the large number of taxa losses observed in the fall 2013 were actually gone in the spring of 2013, their demise most likely a direct result of very bad growing conditions in the summer of 2012 (Figures 1 & 2). Even though the plots were irrigated every ten days, the heat, drought and wind desiccation of July 2012 was severe and damaging; many did not survive the winter. July 2012 was the second driest and hottest on record for Lincoln. Since the plantings were only in their second full growing season, they did not have extensive root systems to support the severe stress of the 2012 growing season.

Furthermore, completely mowing the plots in the springs of 2013 and 2014 also led to lower survival for some taxa. For example, the woody to suffrutescent taxa (Table 2 asterisked), *Artemisia filifolia*, *Eriogonum umbellatum*, *Ericameria nauseous*, and *Hypericum sphaerocarpum*, saw lower survival rates after being mowed to 6.5 cm (2.5 in). While mowing generally helped native grasses and forbs by removing dead tops and reducing thatch, it impacted those shrub and sub-shrubs disproportionately and thus those taxa should be avoided if mowing is used as a part of the maintenance regime.

Since the observations were recorded in late September or early October, cool season plants may have been recorded as missing when they were dormant or smaller in size when they were not actively growing. For example, *Penstemon hirsutus* and *Rueillia humilis* were anecdotally observed earlier in the growing seasons 2012- 2014.

Platt and Weis (1977, 1985) studied what they called fugitive species those, which remained in a prairie plant community by moving between openings such as disturbance patches. These fugitives, while perennial, were prolific seeders, remained in the seed bank and readily germinated under proper conditions. Four taxa (Table 2, boldface): *Dichanthelium oligosanthos scribneriana*, *Sporobolus, cryptandrus*, *Artemisia, ludoviciana*, and *Phemeranthus parviflorus* 'Wyo' showed lower survival but could be considered fugitives because they had many more remaining plants at different locations on the green roof because of reseeding. Interestingly, *A. ludoviciana* died out in the original planting locations but spread widely by underground stolons, not seeds. The fugitives will most likely remain on the green roof until all openings have become filled. While lower in survival these fugitives are an infilling resource available in case of disturbance gaps. Six of the good performing taxa (Table 3, boldface) also produced substantial numbers of volunteer plants: *Bouteloua hirsuta*, *Schizachyrium scoparium*, *Eragrotis trichodes*, *Bouteloua gracilis*, *Aster fendleri*, and *Aster oblongifolius*. *E. trichodes* easily became the most abundant plant on the green roof.

While not part of the original focus of the plant observations and by the luck of random juxtaposition, it became apparent that several of the shrubby taxa acted like nurse specimens and provided structure, wind and sun protection. The implication for green roof planting designers would be to arrange such shrubby species in such a way, for example on the roof's windward side, to provide establishment and seedling sites for other more delicate species.

Table 2. Taxa with poor performance in central Great Plains (Lincoln, NE) green roof plant trials (2011-2014)

Genus	Species	In ³ Size	Rating	2011 % Living	In ³ Size	Rating	2012 % Living	In ³ Size	Rating	2013 % Living	In ³ Size	Rating	2014 % Living
<i>Iris</i>	<i>cristata</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lotus</i>	<i>corniculatus</i>	4	1	67	0	0	0	0	0	0	0	0	0
<i>Antennaria</i>	<i>dioica rosea</i>	6	3	100	0	0	0	0	0	0	0	0	0
<i>Liatris</i>	<i>punctata</i>	3	2	100	0	0	0	0	0	0	0	0	0
<i>Allium</i>	<i>caeruleum</i>	2	2	100	16	4	33	0	0	0	0	0	0
<i>Allium</i>	<i>cernuum</i>	12	3	100	19	4	56	0	0	0	0	0	0
<i>Artemisia</i>	<i>filifolia*</i>	10	3	100	21	4	83	0	0	0	0	0	0
<i>Oryzopsis</i>	<i>hymenoides</i>	11	2	100	17	4	10	0	0	0	0	0	0
<i>Ephedra</i>	<i>minuta</i>	7	3	100	4	3	50	0	0	0	0	0	0
<i>Hymenoxys</i>	<i>scaposa</i>	10	4	100	7	4	8	0	0	0	0	0	0
<i>Juncus</i>	<i>tenuis</i>	14	4	100	16	3	67	0	0	0	0	0	0
<i>Ephedra</i>	<i>regeliana</i>	4	2	100	2	2	17	0	0	0	0	0	0
<i>Thermopsis</i>	<i>rhombifolia</i>	17	4	100	13	4	42	7	3	8	0	0	0
<i>Engelmannia</i>	<i>pinnatifida</i>	14	3	100	5	3	33	3	2	17	0	0	0
<i>Dichanthelium</i>	<i>oligosanthes scribneriana</i>	13	4	100	14	4	100	13	4	100	0	0	0
<i>Ruellia</i>	<i>humilis</i>	14	4	100	5	2	8	7	2	8	7	2	8
<i>Penstemon</i>	<i>hirsutus</i>	11	4	100	8	3	33	9	3	8	9	3	8
<i>Eriogonum</i>	<i>umbellatum*</i>	7	3	100	7	3	82	8	3	45	7	2	9
<i>Ericameria</i>	<i>nauseous*</i>	14	3	100	19	4	83	20	3	67	16	3	25
<i>Allium</i>	<i>flavum</i>	7	3	100	19	4	29	19	4	29	15	4	29
<i>Sporobolus</i>	<i>cryptandrus</i>	20	4	100	23	4	100	37	4	33	37	4	33
<i>Artemisia</i>	<i>ludoviciana</i>	23	4	100	32	4	67	48	4	33	35	4	33
<i>Phemeranthus</i>	<i>parviflorus</i> 'Wyo'	8	4	100	8	4	100	8	4	100	8	4	33
<i>Hypericum</i>	<i>sphaerocarpum*</i>	21	4	100	23	4	100	32	4	100	27	4	33

* = shrubs and sub-shrubs **Boldface** = present on the roof and from volunteering from seed

Table 3. Taxa with good performance in central Great Plains (Lincoln, NE) green roof plant trials (2011-2014)

Genus	Species/Cultivar/Source)	In ³ Size	Rating	2011 % Living	In ³ Size	Rating	2012 % Living	In ³ Size	Rating	2013 % Living	In ³ Size	Rating	2014 % Living
Aster	oblongifolius	13	3	100	13	4	100	19	4	67	24	4	67
<i>Amorpha</i>	<i>nana</i>	13	3	100	10	3	67	22	4	67	22	4	67
Artemisia	frigida	22	4	100	22	4	82	14	3	73	14	3	73
<i>Allium</i>	<i>stellatum</i>	10	3	100	18	4	75	24	4	67	23	4	75
<i>Bouteloua</i>	<i>gracilis</i> 'Connard'	23	4	83	28	4	83	29	4	83	30	4	83
<i>Festuca</i>	<i>cinerea</i>	8	2	100	10	4	100	18	3	100	14	3	91
Liatris	aspera	11	2	100	20	4	83	36	4	83	32	4	91
Aster	oblongifolius 'Bluebird'	25	4	100	30	4	100	33	4	92	31	4	92
<i>Penstemon</i>	<i>pinifolius</i>	18	4	100	26	4	100	30	4	100	19	4	92
Aster	fendleri 'My Antonia'	14	3	100	15	4	100	21	4	100	19	4	92
Bouteloua	gracilis 'N 1st'	26	4	100	28	4	100	20	4	100	20	4	92
Schizachyrium	scoparium 'Blaze'	20	4	100	26	4	92	33	4	92	38	4	92
<i>Carex</i>	<i>glauca</i>	14	4	100	17	4	92	22	4	92	25	4	92
Eragrotis	trichodes	33	4	100	42	4	100	31	4	100	35	4	92
<i>Bouteloua</i>	<i>dactyloides</i>	18	4	100	18	4	100	41	3	100	44	3	100
<i>Carex</i>	<i>inops heterophila</i> 'SDSU'	16	4	100	12	4	100	25	3	100	29	3	100
<i>Juncus</i>	<i>tenuis</i> 'N 1st'	7	3	100	17	3	100	18	3	100	16	3	100
Schizachyrium	scoparium 'NCIA'	26	4	100	19	4	100	25	4	100	28	4	100
<i>Allium</i>	<i>schoenoprasum scenescens</i>	13	3	100	17	4	100	21	4	100	20	4	100
<i>Distichilis</i>	<i>spicata</i>	20	4	100	16	4	100	24	4	100	24	4	100
<i>Carex</i>	<i>bicknellii</i>	18	4	100	19	4	100	25	4	100	24	4	100
<i>Muhlenbergia</i>	<i>cuspidata</i>	24	4	100	21	4	100	28	4	100	28	4	100
Bouteloua	hirsuta	19	4	100	17	4	100	24	4	100	40	4	100

Boldface = volunteering from seed. Good performance = Survival > 67% and Rating of 3 or 4

Figure 1. Monthly normals and precipitation for Lincoln, NE during June, July, and August of years 2011, 2012, 2013, and 2014

Figure 2. Monthly average normals and temperatures for Lincoln, NE during June, July, and August of years 2011, 2012, 2013, and 2014

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