





## SPECIES COMPOSITION CHANGES IN A

## ROOFTOP

## GRASS AND WILDFLOWER MEADOW

*Implications for designing  
successful mixtures*

| Daniel W Dewey, Paul G Johnson, and Roger K Kjølgren |

## ABSTRACT

Based on our observations of a grass and wildflower meadow growing in 7 radiation zones on the roof of The Church of Jesus Christ of Latter-day Saints Conference Center in Salt Lake City, Utah, we identified 21 species that should be considered for future grass/wildflower mixture studies. We also found a single wildflower species and 1 grass species that were too aggressive for mixtures, and 4 wildflower species and 3 species of grass that were not aggressive enough. Mixtures of grasses and wildflowers can be aesthetically appealing, water-conserving, low-maintenance alternatives to conventional turfgrass.

## KEYWORDS

competition, weeds, prairie, Asteraceae, Campanulaceae, Fabaceae, Geraniaceae, Iridaceae, Poaceae, Ranunculaceae, Rosaceae, Scrophulariaceae

## NOMENCLATURE

ITIS (2002)

Native plant meadow growing atop the roof of The Church of Jesus Christ of Latter-day Saints Conference Center in Salt Lake City, Utah.

Photo by Daniel W Dewey

Turfgrass is highly valued for aesthetic appeal, recreational activities, and environmental modification in urban landscapes (Turgeon 1999). Significant costs, however, are associated with maintaining turfgrass, including fertilization, pest control, mowing, and irrigation (Beard and Green 1994). Scientists have addressed methods of decreasing these costs and use of resources for many years. One method is the use of drought-tolerant grasses and wildflowers in mixtures that may require no mowing or fertilization, and decrease the cost of irrigation and maintenance. These mixtures of grasses and wildflowers can still provide many of the benefits of turf, such as soil stabilization and aesthetic appeal (Meyer and Pedersen 1999).

One challenge in developing grass and wildflower mixtures is balancing relative competition among species in a mixture. An overly competitive species can result in the loss of species diversity within a mixture over time. Many people consider grass and wildflower mixtures that have a diversity of flowers to be more aesthetically pleasing than those with only 1 or 2 different wildflower species (Garriga 2000). A related challenge in developing grass and wildflower mixtures is the lack of long-term data on interspecific competition for many drought tolerant species found in the western US. Prior studies have examined competition among a limited number of species (Cook 2001; Dewey 2002), but conducting these studies on a large number of species is difficult, expensive, and time consuming. Evaluations of large numbers of species would provide a basis for species selection in future grass and wildflower studies. Our study objective was to observe relative competitiveness of grass and wildflower species in a range of different temperature environments.

## MATERIALS AND METHODS

## Evaluation Meadow

The experiment was conducted on the rooftop meadow of the Conference

Center in Salt Lake City, Utah, of The Church of Jesus Christ of Latter-day Saints. The meadow, which is approximately 1 ha (2.5 ac) in area, was designed as a western US grassland. The meadow was divided into 7 zones by landscape architects (Wilde 2000) according to the perceived amount of direct, reflected, and infrared radiation (Figures 1 and 2). The species composition within each zone was designed based on these perceived radiation loads (Tables 2 through 7). The rootzone substrate was comprised of a 1-m-deep (3.3-ft) profile of Utelite (Coalville, Utah), a sterile expanded shale medium, which provided a uniform growing medium that was free of weeds and pathogens. All species in the meadow were planted as plugs in early summer 2000 by several hundred volunteers with minimal training. The meadow was over-seeded by hand on 19 April 2001 with a mixture containing the same grass and wildflower species used in the summer 2000 planting. Some additional wildflower species were planted in the over-seeding that were absent in the summer 2000 planting (all species are shown in Table 1). The meadow was irrigated twice weekly with less than 2.54 cm (1 in) of water at each application (Wilde 2000).

Species Evaluations

We evaluated the grass and wildflower species in fall 2000, and in spring, summer, and fall 2001 by counting the number of plants of each species present in sample areas. In each zone, 2 to 4 sample areas were evaluated with each sample area being 4.65 m<sup>2</sup> (50 ft<sup>2</sup>). (Zone 5 was found to be so similar to Zone 4 that we eliminated it from this study.) Percent vegetative cover was used to evaluate Canada bluegrass in Zone 4 during 2001 due to its aggressive rhizomatous growth, which made accurate counting impossible. The other 3 bluegrasses (alpine bluegrass, big bluegrass, and mutton bluegrass) were counted as a group and will be referred to as the bluegrasses (Table 1). Bluebunch wheatgrass, slender wheatgrass, thickspike wheatgrass, and western wheatgrass were also counted



Photo by Daniel W Dewey

Figure 1. Zone 1. South or west side of taller walls (> 0.6 m [2 ft]).

as a group and will be referred to as the wheatgrasses (Table 1). Idaho fescue and ovina (sheep) fescue were also counted as a group and will be referred to as the fescues (Table 1). Our study was observational because the meadow was not designed for statistical analysis; species were not planted randomly within a zone and we were unable to replicate within each zone because each sample area had a unique species composition.

OBSERVATIONS

The roof meadow studied provides a unique opportunity to study plant

species in a partially controlled environment where plant competition is not influenced by weed competition or non-uniform soil conditions. This allows for the comparison of many species across a range of temperature gradients. Tables 2 through 7 show the number of plugs that were supposedly planted in each zone and the numbers of individuals counted at the beginning and end of the study. As the meadow was planted by several hundred volunteers, the numbers in the “scheduled for planting” column in the tables may only approximate the number of plugs actually planted.

TABLE 1

Species evaluated.

GRASSES (POACEAE)		
Bluegrasses		
	Canada bluegrass	<i>Poa compressa</i> L.
	Other bluegrasses	
	Alpine bluegrass	<i>Poa alpina</i> L.
	Big bluegrass	<i>Poa secunda</i> J. Presl
	Mutton bluegrass	<i>Poa fendleriana</i> (Steud.) Vasey
Fescues		
	Idaho fescue	<i>Festuca idahoensis</i> Elmer
	Ovina fescue	<i>Festuca ovina</i> var. <i>ovina</i> L.
Wheatgrasses		
	Bluebunch wheatgrass	<i>Pseudoroegneria spicata</i> ssp. <i>spicata</i> (Pursh) A. Love
	Slender wheatgrass	<i>Elymus trachycaulus</i> ssp. <i>trachycaulus</i> (Link) Gould ex Shinnery
	Thickspike wheatgrass	<i>Elymus lanceolatus</i> ssp. <i>lanceolatus</i> (Scribn. & J.G. Sm.) Gould
	Western wheatgrass	<i>Pascopyrum smithii</i> (Rydb.) A. Löve
Junegrass		
Mountain brome		<i>Koeleria</i> spp. Pers.
Ricegrass		<i>Bromus carinatus</i> Hook. & Arn.
Sand dropseed		<i>Oryzopsis</i> spp. Michx.
Tufted hairgrass		<i>Sporobolus cryptandrus</i> (Torr.) Gray
Wildrye		<i>Deschampsia caespitosa</i> (L.) Beauv
		<i>Elymus</i> spp. L.
WILDFLOWERS		
Ashy sunflower		<i>Helianthus mollis</i> Lam. (Asteraceae)
Aster		<i>Aster</i> spp. L. (Asteraceae)
Bluebell bellflower		<i>Campanula rotundifolia</i> L. (Campanulaceae)
Blue wild indigo		<i>Baptisia australis</i> (L.) R. Br. Ex Ait. F. (Fabaceae)
Columbine		<i>Aquilegia</i> spp. L. (Ranunculaceae)
Culver's root		<i>Veronicastrum virginicum</i> (L.) Farw. (Scrophulariaceae)
Dense blazing star		<i>Liatris spicata</i> (L.) Willd. (Asteraceae)
Geranium		<i>Geranium</i> spp. L. (Geraneaceae)
Goldenrod		<i>Solidago</i> spp. L. (Asteraceae)
Lupine		<i>Lupinus</i> spp. L. (Fabaceae)
Oregon daisy		<i>Erigeron speciosus</i> (Lindl.) DC. (Asteraceae)
Penstemon		<i>Penstemon</i> spp. Schmidl. (Scrophulariaceae)
Purple coneflower		<i>Echinacea purpurea</i> (L.) Moench (Asteraceae)
Purple meadowrue		<i>Thalictrum dasycarpum</i> Fisch. & Avé-Lall. (Ranunculaceae)
Queen of the prairie		<i>Filipendula rubra</i> (Hill) B.L. Robins. (Rosaceae)
Rocky Mountain iris		<i>Iris missouriensis</i> Nutt. (Iridaceae)
Spotted joepyeweed		<i>Eupatorium maculatum</i> L. (Asteraceae)
Tickseed		<i>Coreopsis</i> spp. L. (Asteraceae)
White sage		<i>Artemisia ludoviciana</i> Nutt. (Asteraceae)

TABLE 2

Number of individuals of each species per 4.56 m<sup>2</sup> (50 ft<sup>2</sup>) in Zone 1.

Species	Scheduled for Planting <sup>a</sup>	Summer 2000	Fall 2001
<i>Grasses</i>			
Canada bluegrass	0	0	< 1
Fescues	17	14	14
Junegrass	17	19	19
Sand dropseed	15	14	23
Wheatgrasses	48	92	66
Wildrye	0	0	1
<i>Wildflowers</i>			
Ashy sunflower	0	1	0
Bluebell bellflower	0	2	0
Blue wild indigo	0	3	2
Dense blazing star	< 1	< 1	< 1
Geranium	0	4	0
Goldenrod	< 1	0	2
Lupine	0	1	0
Penstemon	< 1	0	3
Purple meadowrue	0	1	0
Tickseed	< 1	2	0
White sage	< 1	6	56

<sup>a</sup> Number of plants scheduled to be planted. No data on actual numbers planted.

TABLE 3

Number of individuals of each species per 4.56 m<sup>2</sup> (50 ft<sup>2</sup>) in Zone 2.

Species	Scheduled for Planting <sup>a</sup>	Summer 2000	Fall 2001
<i>Grasses</i>			
Bluegrasses	18	14	0
Canada bluegrass	0	0	22
Fescues	6	3	0
Ricegrass	12	0	< 1
Wheatgrasses	39	49	35
Wildrye	6	0	30
Unknown grasses		46	0
<i>Wildflowers</i>			
Blue wild indigo	< 1	1	0
Columbine	6	2	0
Culver's root	3	4	0
Geranium	0	1	< 1
Goldenrod	< 1	2	2
Lupine	0	1	< 1
Penstemon	< 1	0	10
Spotted joepyeweed	0	< 1	7
Tickseed	< 1	2	0

<sup>a</sup> Number of plants scheduled to be planted. No data on actual numbers planted.

**Zone 1 – Maximum Sunlight,  
Maximum Reflection/Radiation**

Areas considered to be in Zone 1 were on the south or west side of walls that were greater than 0.6 m (2 ft) tall. Zone 1 was the only zone where Canada bluegrass did not proliferate or invade, indicating that Canada bluegrass may be suitable for extremely dry conditions only (Table 2). Ashy sunflower, bluebell bellflower, geranium, lupine, purple meadowrue, tickseed, and the wheatgrasses were less competitive (numbers decreased). Goldenrod, penstemon, sand dropseed, and white sage were more competitive (numbers increased). Numbers of blue wild indigo, dense blazing star, the fescues, and Junegrass remained constant indicating moderate competitiveness.

**Zone 2 – Maximum Sunlight,  
Moderate Reflection/Radiation**

Areas considered to be in Zone 2 were on the south or west side of walls that were less than 0.6 m. The bluegrasses, blue wild indigo, columbine, Culver's root, fescues, tickseed, and wheatgrasses were less competitive (Table 3). Canada bluegrass, penstemon, spotted joepyeweed, and wildrye were more competitive. Numbers of geranium, goldenrod, and lupine remained constant indicating moderate competitiveness.



TABLE 4

Number of individuals of each species per 4.56 m<sup>2</sup> (50 ft<sup>2</sup>) in Zone 3.

Species	Scheduled for Planting <sup>a</sup>	Summer 2000	Fall 2001
<i>Grasses</i>			
Bluegrasses	24	0	6
Canada bluegrass	24	27	60
Junegrass	0	0	< 1
Mountain brome	14	1	8
Ricegrass	1	0	2
Tufted hairgrass	0	0	1
Wheatgrasses	38	54	42
Wildrye	16	0	6
Unknown grasses		18	0
<i>Wildflowers</i>			
Ashy sunflower	< 1	< 1	3
Aster	< 1	2	< 1
Blue wild indigo	< 1	2	2
Columbine	< 1	2	0
Dense blazing star	< 1	2	< 1
Geranium	< 1	4	< 1
Goldenrod	< 1	2	2
Penstemon	< 1	2	5
Purple coneflower	< 1	2	1
Queen of the prairie	0	1	< 1
Rocky Mountain iris	< 1	2	2
Tickseed	< 1	3	0

<sup>a</sup> Number of plants scheduled to be planted. No data on actual numbers planted.

**Zone 3 – Maximum Sunlight Only**

Areas considered to be in Zone 3 were not adjacent to any walls or trees where they would receive additional or reduced sunlight, or radiation or reflectance. Aster, columbine, dense blazing star, geranium, queen of the prairie, tickseed, and the wheatgrasses were less competitive (Table 4). Ashy sunflower, the bluegrasses, Canada bluegrass, mountain brome, penstemon, ricegrass, tufted hairgrass, and wildrye were more competitive. Numbers of blue wild indigo, goldenrod, purple coneflower, and Rocky Mountain iris remained constant indicating moderate competitiveness.



Photo by Daniel W Dewey

Figure 2. Zone 3. No additional or reduced radiation.

TABLE 5

Number of individuals of each species per 4.56 m<sup>2</sup> (50 ft<sup>2</sup>) in Zone 4.

Species	Scheduled for Planting <sup>a</sup>	Summer 2000	Fall 2001
<b>Grasses</b>			
Bluegrasses	27	0	2
Canada bluegrass	26	30	35
Mountain brome	0	0	6
Tufted hairgrass	19	20	11
Wheatgrasses	0	9	14
Wildrye	16	58	14
<b>Wildflowers</b>			
Aster	2	1	0
Blue wild indigo	0	1	3
Columbine	< 1	2	0
Culver's root	0	2	0
Geranium	6	6	2
Goldenrod	0	2	0
Lupine	< 1	< 1	0
Penstemon	0	2	2
Purple coneflower	< 1	1	0
Purple meadowrue	0	1	2
Queen of the prairie	2	4	< 1
Spotted joepyeweed	< 1	2	2
Tickseed	2	1	0

<sup>a</sup> Number of plants scheduled to be planted. No data on actual numbers planted.

TABLE 6

Number of individuals of each species per 4.56 m<sup>2</sup> (50 ft<sup>2</sup>) in Zone 6.

Species	Scheduled for Planting <sup>a</sup>	Summer 2000	Fall 2001
<b>Grasses</b>			
Bluegrasses	9	24	2
Canada bluegrass	0	0	48
Fescues	0	0	1
Mountain brome	31	2	5
Tufted hairgrass	4	1	0
Wheatgrasses	31	32	18
Wildrye	0	0	6
<b>Wildflowers</b>			
Blue wild indigo	0	2	0
Columbine	0	2	0
Culver's root	0	1	1
Dense blazing star	0	2	< 1
Geranium	7	6	2
Goldenrod	0	2	0
Lupine	0	1	0
Penstemon	0	2	1
Purple meadowrue	12	6	1
Queen of the prairie	2	1	1
Spotted joepyeweed	0	2	4

<sup>a</sup> Number of plants scheduled to be planted. No data on actual numbers planted.

### Zone 4 – Minimal Shading

Areas considered to be in Zone 4 were on the north or east side of walls less than 0.3 m (1 ft) tall. Aster, columbine, Culver's root, geranium, goldenrod, purple cone-flower, queen of the prairie, tickseed, tufted hairgrass, and wildrye were less competitive (Table 5). Blue wild indigo, Canada bluegrass, mountain brome, and the wheatgrasses were more competitive. Numbers of penstemon, purple meadowrue, and spotted joepyeweed remained constant indicating moderate competitiveness.

### Zone 6 – Moderate Shading

Areas considered to be in Zone 6 were on the north or east side of walls less than 0.6 m (2 ft) tall. The bluegrasses, blue wild indigo, columbine, dense blazing star, geranium, lupine, penstemon, purple meadowrue, and the wheatgrasses were less competitive (Table 6). Canada bluegrass, mountain brome, spotted joepyeweed, and wildrye were more competitive. Numbers of Culver's root and queen of the prairie remained constant indicating moderate competitiveness.

TABLE 7

Number of individuals of each species per 4.56 m<sup>2</sup> (50 ft<sup>2</sup>) in Zone 7.

Species Scheduled for Planting <sup>a</sup>	Summer 2000	Fall 2001	
<b>Grasses</b>			
Bluegrasses	25	8	0
Canada bluegrass	25	40	49
Mountain brome	0	0	10
Ricegrass	0	0	4
Tufted hairgrass	17	13	0
Wheatgrasses	0	44	36
Unknown grasses		5	0
<b>Wildflowers</b>			
Geranium	0	8	12
Goldenrod	0	4	4
Oregon daisy	0	1	0
Penstemon	0	1	5
Purple meadowrue	12	2	1

<sup>a</sup> Number of plants scheduled to be planted. No data on actual numbers planted.

**Zone 7 – Maximum Shading**

Areas considered to be in Zone 7 were on the north or east side of walls more than 0.6 m (2 ft) tall. The bluegrasses, Oregon daisy, purple meadowrue, tufted hairgrass, and the wheatgrasses were less competitive (Table 7). Canada bluegrass, geranium, mountain brome, penstemon, and ricegrass were more competitive. Numbers of goldenrod remained constant indicating moderate competitiveness.

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## SUMMARY

The grass and wildflower species that performed well under the conditions on this experimental garden can be used in developing drought-tolerant, low-maintenance grass and wildflower mixtures. Equal competitiveness or stable plant populations promote a mixture that maintains species diversity. Canada bluegrass and white sage appeared too competitive if planted with other grasses and wildflowers in a mixture. Vigorous asexual reproduction made these species extremely competitive under these meadow conditions, dominating many of the other species. In contrast, the bluegrasses, bluebell bellflower, columbine, purple meadowrue, and tickseed may not be competitive enough with the plants in this meadow. Low growing, drought-tolerant varieties of ashy sunflower, aster, blue wild indigo, dense blazing star, the fescues, geranium, goldenrod, Junegrass, lupine, mountain brome, Oregon daisy, penstemon, purple coneflower, queen of the prairie, ricegrass, Rocky Mountain iris, sand dropseed, spotted joepyeweed, tufted hairgrass, the wheatgrasses, and wildrye competed well but did not dominate plant populations in the meadow.

Species that compete well in the meadow will be the most likely to compete well in typical landscape situations because the environments are very similar. Most landscapes are irrigated, and consist of a diversity of species grown in environments that can range from extremely hot (sunny side of buildings) to extremely cool (shaded side of buildings). Likewise, the meadow is irrigated, consists of a diversity of species, and has environmental conditions ranging from hot (Zone 1) to cool (Zone 7). Weed competition was not an issue in the meadow because no weed seeds were present in the soil and any weeds that germinated were removed by hand. Weed control is also done in typical landscape situations but may be more difficult because of soil seed banks and

labor costs. The presence of weeds increases resource competition so it is likely that the least competitive species from the meadow will probably not compete well in a landscape situation where weed competition is of concern.

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