Effects of IRRIGATION AND MOWING on species diversity of grass and wildflower mixtures for the Intermountain West

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ABSTRACT

Grass and wildflower mixtures can be aesthetically appealing, water-conserving, low-maintenance alternatives to conventional turfgrass. One problem with these mixtures is loss of species diversity over time. We examined the effects of irrigation and mowing on the species diversity of 3 grass and wildflower mixtures. The nonirrigated and non-mowed treatment combination maintained diversity most effectively whereas the irrigated and mowed treatment combination was least effective. Generally, when the irrigation treatment was significant ($P < 0.05$), irrigated plots contained more wildflowers. When the mowing treatment was significant ($P < 0.05$), mowed plots contained more common yarrow (*Achillea millefolium* L. [Asteraceae]) and strawberry clover (*Trifolium fragiferum* L. [Fabaceae]) and fewer Pacific aster (*Symphyotrichum chilense* (Nees) Nesom [Asteraceae]). Height measurements on non-mowed plots showed that irrigated plots had taller canopies than nonirrigated plots. Common yarrow was the most competitive wildflower, followed by strawberry clover and Pacific aster. Mixture 3 containing crested wheatgrass (*Agropyron cristatum* (L.) Gaertn. [Poaceae]) and thickspike wheatgrass (*Elymus lanceolatus* (Scribn. & J.G. Sm.) Gould ssp. *lanceolatus* [Poaceae]) maintained species diversity for the longest duration under nonirrigated and non-mowed conditions.

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KEY WORDS

competition (biology), arid region plants, prairie, forbs

NOMENCLATURE

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Turfgrass is highly valued for aesthetic appeal, as a surface for recreational activities, and for 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 for many years. One method is to use drought-tolerant grass and wildflower mixtures that may require no mowing or fertilization and therefore decrease the cost of irrigation and maintenance. These mixtures would be used in areas where activity is low but turf is desired, and they would provide many of the benefits of turf, such as soil stabilization and aesthetic appeal (Meyer and Pedersen 1999).

In addition to the potential for reduced management inputs, grass and wildflower mixtures can introduce native species into landscape settings. Many of these native species have been overlooked for ornamental value, but these are the same species that naturalists praise when describing native plant communities. Mixtures of grasses and wildflowers are one way to bring more of these species to urban landscapes.

Although native species can be planted in urban sites, natural plant communities will not necessarily develop. Soils can be quite different, sites may be irrigated to promote growth of other species, and mowing may be utilized. In these situations, it is not clear how well many of the native species will compete with nonnatives.

One challenge in developing and using these mixtures is maintaining species diversity over time. When grass and wildflower mixtures are used to create a naturalized look, visual complexity or diversity is usually preferred (Calvin and others 1972; Kaplan and Kaplan 1978), even though that diversity may not be how the plants occur naturally. In our study, we define *species* *diversity* as the contribution of individual species to the total number of wildflowers (or total percentage of grass cover). We define *competitiveness* in terms of number of individuals. Those species with more individuals are considered more competitive. A mixture that maintains species diversity will have the least number of changes in the contribution by each species to the total number of wildflowers (or percentage of grass cover) over time. In some ecological literature, this is referred to as *evenness* (Hayek and Buzas 1997). Understanding the effects of environmental factors on competitiveness of species within a mixture is essential for maintaining species diversity.

Private companies and universities have developed and tested low-maintenance grass and wildflower mixtures and marketed them by the names of Ecolawn, Fleur de Lawn, Ecology Lawn Mix, and No Mow (Cook 1996; Meyer and Pedersen 1999). Meyer and Pedersen (1999) found that mixtures performed as well as conventional low-maintenance, cool-season grasses when evaluated for color, cover, and overall appearance. Some of the grass and wildflower mixtures developed in Oregon, however, have performed unsatisfactorily in Utah (Kjelgren 2002), and very little research has been reported on species composition of grass and wildflower mixtures in semiarid regions.

Maintaining species diversity in grass and wildflower mixtures is difficult. One commonly used method is to overseed these mixtures with wildflowers every 2 to 3 y (Garriga 2000). Another method is to plant species that are relatively equally competitive for the given environment. Before mixtures containing equally competitive species can be developed, information on the effects of irrigation, mowing, and competition of various species is needed. The objectives of our study were to evaluate the effects of irrigation and mowing on the species composition of 3 grass and wildflower mixtures.

MATERIALS AND METHODS

Study Site

Our study was conducted at the Utah State University Greenville Research Farm (Millville silt loam soil) in North Logan, Utah. The plot area, which had not been cropped for at least 2 y, was tilled twice and hand-raked immediately before sowing. The mean growing season temperature for the study period was slightly higher (18 °C [64 °F]) than the 30-y mean (17 °C [62 °F]) for the same site (Utah Climate Center 2003). The mean growing season precipitation for the study period was lower (2.2 cm/mo [0.9 in/mo]) than the 30-y mean (3.9 cm/mo [1.5 in/mo]) for the same site (Utah Climate Center 2003).

Grass and Wildflower Mixtures

Three grass and wildflower mixtures were established from seeds (Table 1). The mixtures varied in grass species but all contained the same wildflower species (Table 1). Blue grama (*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths [Poaceae]) is a weakly rhizomatous warm-season grass with grayish-green leaves (Turgeon 1999). Field fescue (*Festuca arvernensis* Auquier, Kerguélen & Markgr.-Dannenb. [Poaceae]), Sandberg bluegrass (*Poa secunda* J. Presl [Poaceae]), and crested wheatgrass (*Agropyron cristatum* (L.) Gaertn. [Poaceae]) are bunch type cool-season grasses, and thickspike wheatgrass (*Elymus lanceolatus* (Scribn. & J.G. Sm.) Gould ssp. *lanceolatus* [Poaceae]) is a sod-forming cool-season grass (Anderson and Sharp 1995; Turgeon 1999). The 4 cool-season varieties used in our study varied in color from blue-green to green. Pacific aster (*Symphyotrichum chilense* (Nees) Nesom [Asteraceae]) is a rhizomatous perennial that grows 0.1 m (3.9 in) to 1 m (39.4 in) tall and produces purplish to violet or pink flowers (Welsch and others 1987). Common yarrow

TABLE 1

Percentage of seed composition by species in each mixture.

Species	Grass type	Mix 1	Mix 2	Mix 3
			%	
Blue grama	Warm	36.9	36.9	
Field fescue	Cool	36.9		
Sandberg bluegrass	Cool		36.9	
Crested wheatgrass	Cool			36.9
Thickspike wheatgrass	Cool			36.9
Pacific aster		6.3	6.3	6.3
Common yarrow		6.3	6.3	6.3
Small leaf pussytoe		6.3	6.3	6.3
Trailing fleabane		1.0	1.0	1.0
Strawberry clover		6.3	6.3	6.3
Pure live seed/m^2		12 000	12 000	12 000

Conversion: m^2 = 10.8 ft^2

(*Achillea millefolium* L. [Asteraceae]) is also rhizomatous, grows 0.1 m (3.9 in) to 1 m (39.4 in) tall, and produces white to pink flowers (Welsch and others 1987). Small leaf pussytoe (*Antennaria parvifolia* Nutt. [Asteraceae]) is a stoloniferous, mat-forming perennial that grows 3 cm (1.2 in) to 15 cm (5.9 in) tall with white to pink bracts (Welsch and others 1987). Trailing fleabane (*Erigeron flagellaris* Gray [Asteraceae]) is a biennial or short-lived perennial that grows 3 cm (1.2 in) to 25 cm (9.8 in) tall with white, pink, or blue flowers (Welsch and others 1987). Strawberry clover (*Trifolium fragiferum* L. [Fabaceae]) is a rhizomatous and stoloniferous perennial that grows 5 cm (2 in) to 30 cm (11.8 in) long and produces purplish flowers (Welsch and others 1987).

Varieties were selected based on drought tolerance, uniform competitiveness, and low height (less than 38 cm [15 in]). Germination percentage for each species was obtained from the respective seed labels, except for trailing fleabane, which could not be found. Instead 80% was used as a conservative estimate given that germination percentages of the other wildflowers were 85% to 95%. Germination tests were not done on trailing fleabane because seed was extremely limited.

Experimental Design

A split block experimental design was used with 3 factors (irrigation, mowing, and mixtures). Irrigation (no irrigation and approximately 5 cm [2 in] once every 2 wk) and mowing (no mowing and mowing once a week at a height of 10 cm [4 in]) were whole-plot factors. Mixtures were randomized within the irrigation treatment but were not randomized across the mowing treatment to facilitate maintenance logistics. Both irrigation and mowing treatments were considered randomized for statistical analysis, however. The experiment was replicated 4 times. Each replicate consisted of 12 plots (each plot being 1 m^2 [11 ft^2]). A 1-m (3.3-ft) buffer was planted between the irrigated and nonirrigated treatments, and a 0.5-m (1.6-ft) buffer was planted between replicates. Buffers were planted to red fescue (*Festuca rubra* L. [Poaceae]) at 293 kg/ha (6 lb/1000 ft^2). To facilitate uniform seed distribution and provide fertilizer, 1090 g (2.4 lb) of Milorganite™ (6N:2P:0K, Milwaukee Sewage Division, Milwaukee, Wisconsin) was added to each seed mixture (439 kg N/ha [9 lb N/1000 ft^2]). Mixtures were sown on 4 May 2000. All plots were well irrigated through establishment, after which irrigation frequency was gradually reduced to once per week (17 July 2000). All plots were irrigated on 25 July 2000, at which time the irrigation treatment began. The irrigation treatment was applied from August 2000 through September 2001, although during this time frame, all plots received only natural precipitation from October through April.

Evaluations and Analysis

Number of each wildflower species, percentage of cover of each grass species, canopy height, flower height, and aboveground biomass of each species were recorded. Numbers of wildflowers were recorded about the 15th of each month from within a random transect (10 cm x 1 m [4 in x 3.3 ft]) of each plot. Data were recorded from August through October 2000 and April through October 2001. Percentage of cover of each grass species, canopy height, and flower height were recorded during October 2000 and 3 times between April and October 2001. Percentage of cover was determined by estimating cover of each grass species in a random transect within each plot. Canopy and flower height, which in this article refer to individual flowers or inflorescences, were measured at 3 locations in the plot. The mowed treatment was not analyzed for canopy height. Aboveground biomass was measured at the end of the experiment (October 2001). A randomly selected transect from each plot was clipped of all vegetation, separated into grass and the 3 wildflower species, and dried at 59 °C (138 °F). Unidentifiable biomass (pieces too small to identify) was the largest component of total biomass; however, the amount of unidentified biomass was not significantly different between the treatments.

Statistical analyses were performed using PROC MIXED of SAS (SAS Institute 2001). All factors were considered fixed effects. Data that did not satisfy the tests for normality were transformed by inverse, square root, or log (Table 2). Each month was analyzed separately.

RESULTS AND DISCUSSION

Only 3 of the 5 wildflower species germinated in sufficient numbers to evaluate. Trailing fleabane was not found and less than 1 small leaf pussytoe plant per transect was found throughout the study. As a result, these species were not considered in the experimental analysis.

Species Numbers

Some significant 2- and 3-way interactions among Pacific aster, common yarrow, and strawberry clover were observed, but none were consistent or appeared meaningful and will not be discussed further.

In our study, species diversity was best maintained under the nonirrigated and non-mowed treatments as measured by the least number of differences between species (Figure 1). These conditions suppressed the most vigorous species, common yarrow and strawberry clover, to the point that Pacific aster could compete although it was suppressed to some extent as well. When irrigation was supplied and (or) mowing practiced, common yarrow and strawberry clover dominated (Figures 1, 2, and 3). Irrigation allowed for significantly more growth as indicated by canopy height and biomass, while mowing encouraged the species with vigorous asexual reproduction. Common yarrow and strawberry clover were similar in all treatments except the nonirrigated and non-mowed treatment in which common yarrow was more numerous.

Common Yarrow

Common yarrow was not negatively affected by any of the treatments. It capitalized on available water and dealt with the drought conditions (Warwick and Black 1982). Common yarrow also thrived under mowing because of vigorous asexual reproduction through rhizomes (Kannangara 1985; Henskens and others 1992). Dominance also occurred in the non-mowed treatment, similar to that observed by Kirkham and others (1999). Common yarrow appeared more competitive than strawberry clover (Figure 1), which is supported by Bourdot and Butler (1981) who found that yarrow was more competitive than white clover. Common yarrow was so competitive that it visually dominated the mixtures. Common yarrow may be appropriate only on non-mowed and nonirrigated sites in the semiarid West, and then only with other species that are more competitive than those evaluated here.

Strawberry Clover

Strawberry clover was also a good competitor as it was not negatively affected by the mowing or irrigation treatments. Unlike common yarrow, strawberry clover did not dominate by visual observation. Using a less competitive variety of clover and maintaining it under nonirrigated and non-mowed conditions may be most appropriate in a mixture of grasses and wildflowers. Strawberry clover appeared to be slightly more sensitive to drought than common yarrow (Figure 2), which is similar to results from other studies of white clover (Thomas 1984; Hart 1987). Strawberry clover was especially influenced by mowing (Figure 3). It was less competitive in the non-mowed treatment, which concurs with studies of infrequently cut white clover/grass swards (Acuna and Wilman 1993). Asexual reproduction through stolons was observed in both mowed and non-mowed treatments, with more occurring in the mowed treatments. This same response to mowing or grazing was observed by Evans and others (1998). Strawberry clover was positively affected by the grasses in mixture 3 (crested wheatgrass and thickspike wheatgrass; Table 3). As both grasses are cool-season species, strawberry clover may have been able to take advantage of decreased grass activity during the summer, which may not have occurred with grass mixtures containing a warm-season grass.

Pacific Aster

In all treatment combinations, except the nonirrigated and non-mowed treatment, there were fewer Pacific aster than common yarrow and strawberry clover. Pacific aster was fairly insensitive to irrigation but negatively affected by mowing,

TABLE 2

Data transformations used in statistical analysis. Each month was evaluated separately. Transformations were only done when the raw data did not satisfy the tests of normality (normal quantile plots, tests for normality, and residual plots).

Evaluation	Measurement	Date	Transformation
Number of individuals			
	Pacific aster	Apr 2001	square root
		Jul 2001	square root
		Aug 2001	square root
		Oct 2001	square root
	Common yarrow	Apr 2001	log
		Jul 2001	square root
		Oct 2001	square root
	Strawberry clover	Aug 2000	5 outliers deleted
		Oct 2000	log with 1 outlier deleted
		Jul 2001	square root
		Aug 2001	4 outliers deleted
		Sep 2001	square root
Height (cm)			
	Canopy	fall 2000	square root
		summer 2001	square root
	Pacific aster	fall 2000	log
		fall 2001	square root
	Common yarrow	spring 2001	log with 3 outlier deleted
		summer 2001	1 outlier deleted
	Thickspike wheatgrass	summer 2001	square root
	Crested wheatgrass	fall 2000	log
		spring 2001	log
Grass cover (%)			
	Mixture 1	summer 2001	square root
	Mixture 2	summer 2001	square root with 1 deletion
		fall 2001	square root with 1 deletion
	Mixture 3	fall 2000	1 outlier deleted
		spring 2001	log
		fall 2001	square root
Biomass (g)			
	Grass	fall 2001	square root
	Pacific aster	fall 2001	log
	Common yarrow	fall 2001	square root with 1 deletion

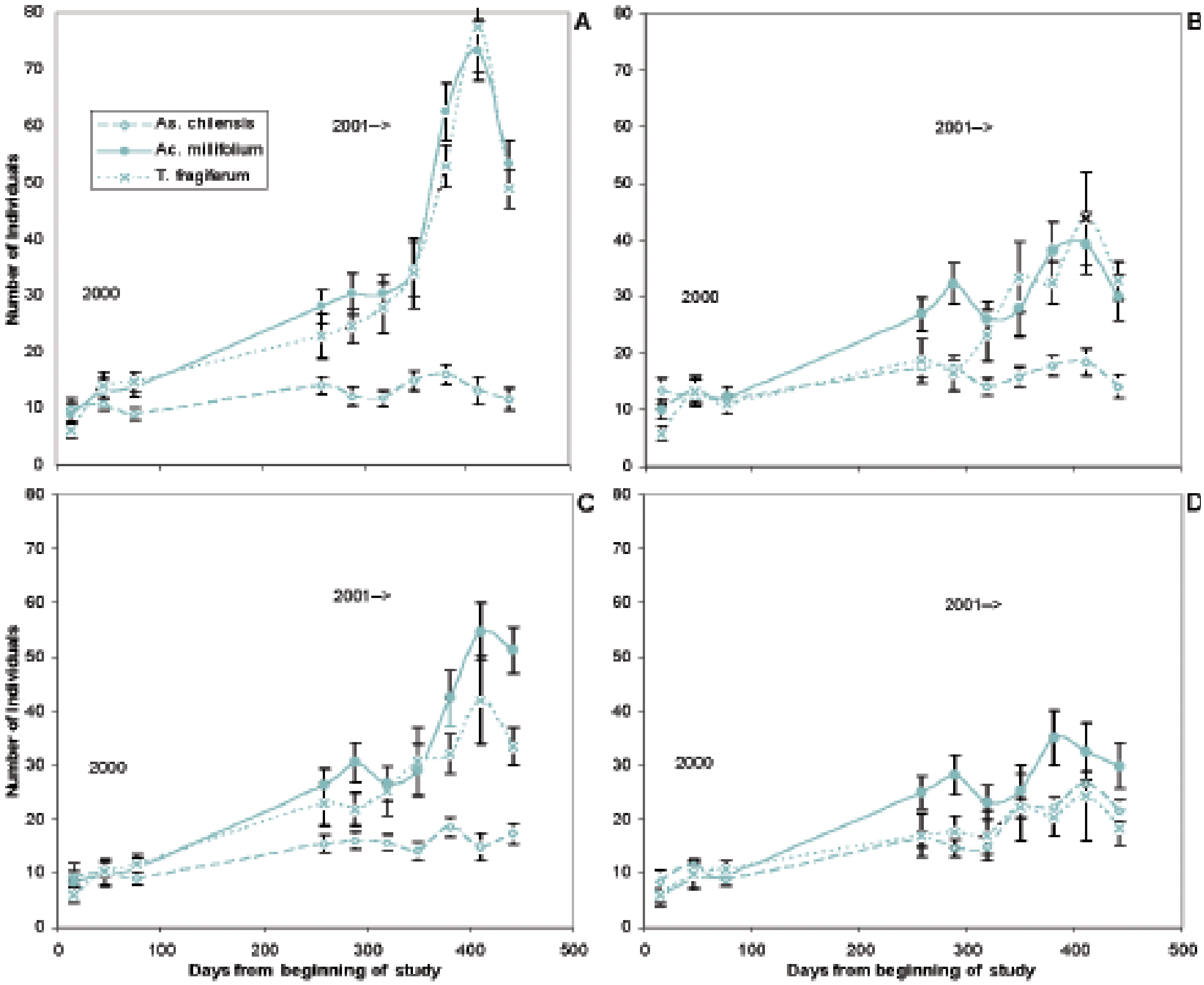

Figure 1. Number of wildflowers per species per transect for the (A) irrigated and mowed treatment, (B) irrigated and non-mowed treatment, (C) nonirrigated and mowed treatment, and (D) nonirrigated and non-mowed treatment. Evaluations were made from August 2000 through October 2001. Each month was analyzed separately.

whereas common yarrow and strawberry clover tended to increase under irrigation and mowing (Figures 2 and 3). Pacific asters do reproduce asexually (Welsch and others 1987) but little asexual reproduction was observed in our study. Mowing reduced Pacific aster numbers possibly because of the lack of asexual reproduction combined with the lack of sexual reproduction due to flower removal by the mowing treatment. Zimmerman and Neuenschwander (1984) and Hickman and Hartnett (2002) also found that asters were negatively affected by grazing. Unlike common yarrow and strawberry clover, Pacific aster did not appear to respond to irrigation (Figures 1 and 2). Plant numbers were similar in both irrigation treatments and did not dominate visually. This trait, combined with better performance in the non-mowed treatment, makes Pacific aster most appropriate for nonirrigated and non-mowed sites.

Percentage of Cover of Grass Species in Each Mixture

Although there was one 3-way interaction and eight 2-way interactions involving individual grass species, percentage of coverage of the grasses was similar across the irrigation and (or) mowing treatment(s) in all of the interaction plots. Because these interactions were infrequent and trends were spurious rather than consistent, we will focus on the main effects for the 3 mixtures.

Field fescue was more competitive than blue grama in mixture 1; however, blue grama was more competitive than Sandberg bluegrass in mixture 2 (Table 4). Mowing had no effect on total grass cover of mixture 2 and only affected mixture 1 in fall 2001 (negative effect; Table 5). In mixtures 1 and 2, one of the two grass species dominated from the beginning of the study, indicating differences in actual seed germination percentages. Better estimation of seed germination is essential for future

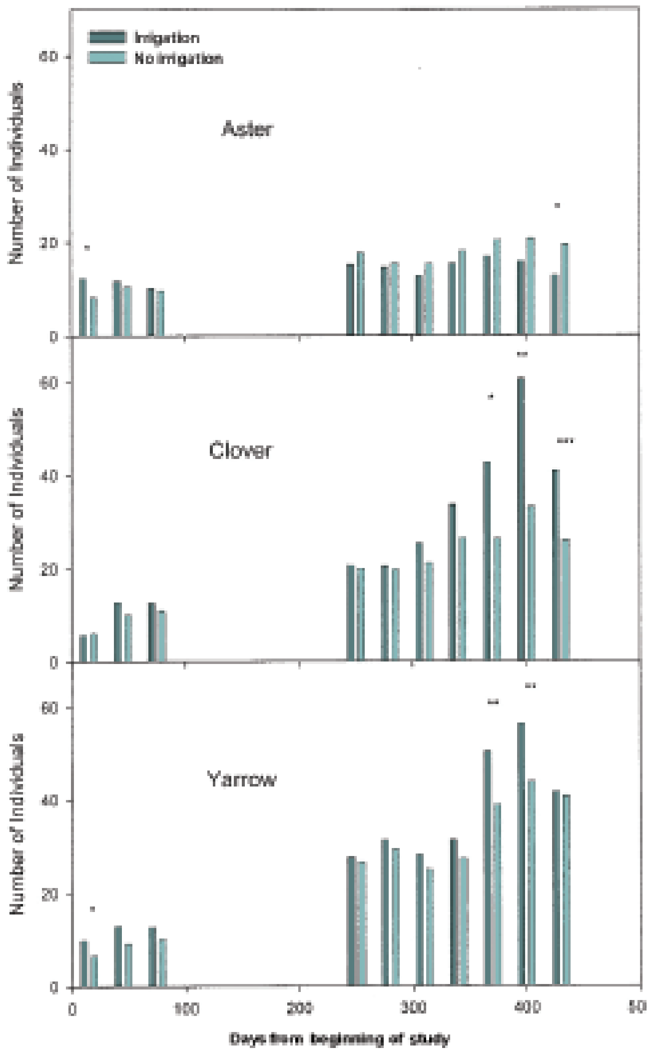

Figure 2. Differences in wildflower numbers per transect due to irrigation treatment from August 2000 through October 2001. Each month was evaluated separately. *, **, and *** indicate significant differences with *P* values less than 0.05, 0.01, and 0.001, respectively.

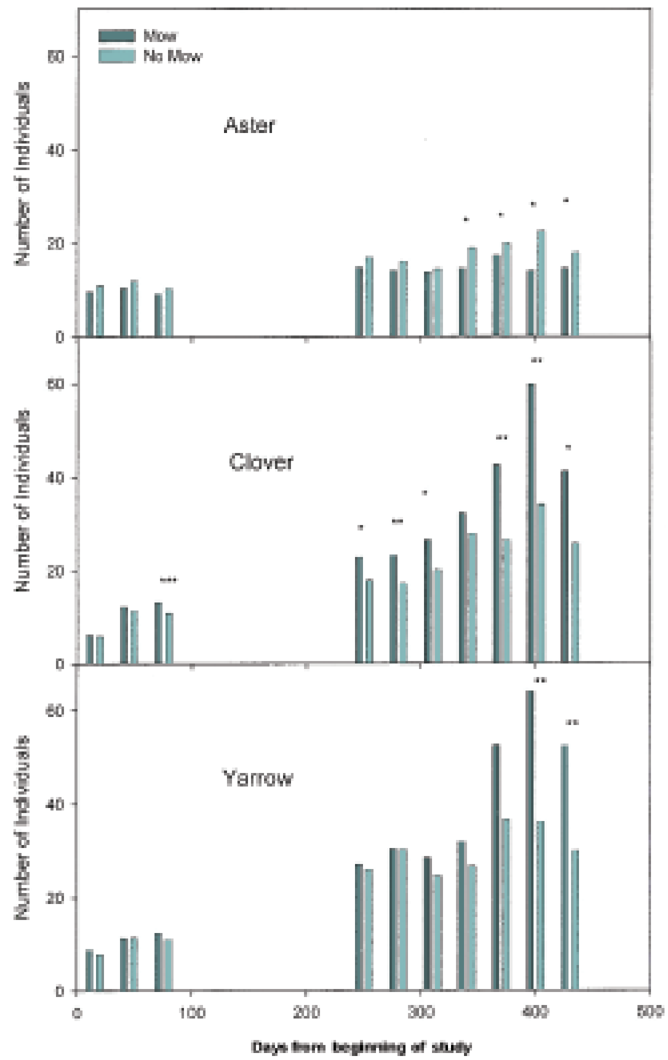

Figure 3. Differences in wildflower numbers per transect due to mowing treatment from August 2000 through October 2001. Each month was evaluated separately. *, **, and *** indicate significant differences with *P* values less than 0.05, 0.01, and 0.001, respectively.

studies. Percentage of cover of each grass species in mixture 3 (crested and thickspike wheatgrass) did not differ throughout the study, with the exception of fall 2000 (Table 4). This may be due to correct germination rates and (or) relatively equal competitiveness of the two species, as crested and thickspike wheatgrass are more closely related than the grasses in the other two mixtures (Watson and Dallwitz 1992). Mowing negatively affected the total grass cover of mixture 3 in summer and fall 2001. This may indicate that crested and thickspike wheatgrass are less adapted to intense mowing than the other 3 grass species. Interestingly, irrigation had no significant effect on the total grass cover of any of the mixtures (Table 6).

Canopy, Flower Height

All height differences showed that irrigated plants were taller than nonirrigated plants. Canopy height was greater in the irrigated treatment than the nonirrigated treatment in every evaluation except spring 2001 (Table 7). Canopy height measured grass and strawberry clover. Height measurements (growth) are more sensitive to differences due to the irrigation treatment than are plant number measurements (Taiz and Zeiger 2002). Irrigated Pacific aster, crested wheatgrass, and thickspike wheatgrass were taller only in fall 2001, which may indicate that differences in flower height may not be seen unless several hot, dry months precede the evaluation. Canopy and common yarrow heights were positively affected by irrigation at each evaluation in 2001 except the spring evaluation, which makes sense as winter and spring precipitation supplied

TABLE 3

Significant differences in wildflower number due to mixture treatment between August 2000 and October 2001. Each month was evaluated separately and nonsignificant data are not shown.

Species	Date	Mixture	Number of plants per transect[Z]
Common yarrow			
	Sep 2000 *	1	13.6 a
		3	8.9 b
Strawberry clover			
	Aug 2000 **	2	4.4 b
		3	6.6 a
	Aug 2001 **	1	33.8 b
		2	32.0 b
		3	41.3 a
	Oct 2001 *	1	29.8 b
		3	40.4 a

*, ** Significant at $P < 0.05$ and 0.01 levels, respectively.

[Z] Means with the same letter, within a species and date, are not significantly different.

TABLE 4

Percentage of grass cover by species for mixtures 1 through 3.

		Vegetative cover (%)			
Mix	Species	Fall 2000	Spring 2001	Summer 2001	Fall 2001
1	Blue grama	10.1 **	6.4 ***	3.8 ***	6.9 ***
	Field fescue	19.3	15.7	17.1	16.7
2	Blue grama	13.2 **	8.4 ***	7.7 ***	7.4 ***
	Sandberg bluegrass	3.9	0.4	0.1	0.0
3	Crested wheatgrass	13.5 *	7.8	5.9	10.9
	Thickspike wheatgrass	6.5	12.2	7.5	8.2

*, **, *** Significant at $P < 0.05$, 0.01, and 0.001 levels, respectively.

ample water to all plots. The data on the remaining species in the mixtures were insufficient to analyze because of lack of flowers. No height differences were found between any of the 3 mixtures (unpublished data).

Comparing Biomass with Number of Individuals

Number of individuals or percentage of cover was used in our study to evaluate competitiveness. Biomass was also recorded at the end of the experiment. Whenever biomass was significant for a treatment effect, number of individuals was also significant. However, some effects that were not significant for biomass were significant in number of individuals (Tables 8 and 9). It is unlikely that, by chance, all significant biomass evaluations were also significant species count evaluations, which lends validity to both methods. Differences between the 2 methods may be due to insensitivity of the biomass method, hypersensitivity of the species count method, or the species count method may be an early indicator of plant fitness that subsequent biomass evaluations would reflect.

When choosing an evaluation method, researchers should consider that the biomass evaluation is destructive while the species count method is not, and that the species count method only indicates growth with increases in numbers, so growth in the size of individuals within a population is not seen. The appearance of mixtures was better measured by individuals than biomass in our study. In one case, biomass yield was the opposite of what was apparent (Table 8). This, combined with the time consuming, destructive process and loss of information due to unidentifiable material, made species counts more appropriate and informative in our study.

CONCLUSIONS

Understanding how grass and wildflower species react to different stresses and to each other will be essential for future studies of grass and wildflower mixtures. Our study has shown that species diversity was best maintained under nonirrigated and non-mowed conditions and that irrigating and mowing decreased species diversity. Species able to capitalize on irrigation or to reproduce asexually under mowed conditions will compete more effectively than species with no or reduced adaptation abilities. In our study, Pacific aster was the least competitive, while strawberry clover and common yarrow were very competitive. Common yarrow appeared slightly more competitive than strawberry clover and appeared to be more abundant than did the strawberry clover. Future studies should consider: 1) not using common yarrow because of its dominance in the mixtures; 2) including a higher percentage of grasses in the mixtures, possibly as high as 90%; 3) using more wildflower species to avoid visual domination by one or two species; 4) using a shorter variety of Pacific aster and a slightly less competitive variety of

TABLE 5

Effects of mowing on total grass cover (%) of mixtures 1 through 3.

		Total grass cover (%)			
Mixture	**Treatment**	**Fall 2000**	**Spring 2001**	**Summer 2001**	**Fall 2001**
1	mowed	14.6	10.4	11.1	9.6 **
	non-mowed	14.8	11.8	11.4	13.9
2	mowed	8.5	4.1	3.4	2.9
	non-mowed	8.6	4.8	4.8	5.3
3	mowed	9.8	8.4	5.3 *	5.9 *
	non-mowed	10.2	11.6	8.1	13.2

*, ** Significant at $P < 0.05$ and 0.01 levels, respectively.

TABLE 6

Effects of irrigation on total grass cover (%) of mixtures 1 through 3.

		Total grass cover (%)			
Mixture	**Treatment**	**Fall 2000**	**Spring 2001**	**Summer 2001**	**Fall 2001**
1	irrigated	14.6	11.1	10.7	11.9
	nonirrigated	14.8	11.1	11.8	11.6
2	irrigated	9.9	4.3	3.8	3.1
	nonirrigated	7.2	4.6	4.3	5.0
3	irrigated	10.1	10.0	6.5	8.0
	nonirrigated	9.9	10.0	6.9	11.1

strawberry clover; and 5) conducting field germination tests on all species to ensure the desired species composition.

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TABLE 7

Canopy (grass and strawberry clover) and flower height measurements.

		Height (cm)			
Species	**Treatment**	**Fall 2000**	**Spring 2001**	**Summer 2001**	**Fall 2001**
Canopy	irrigated	11.9 *	16.7	27.0 **	29.5 **
	nonirrigated	7.3	17.1	15.4	14.4
Thickspike wheatgrass	irrigated	0.0	0.0	61.5	65.2 *
	nonirrigated	0.0	0.0	48.0	43.0
Crested wheatgrass	irrigated	25.6	30.6	57.8	58.4 *
	nonirrigated	26.3	30.2	50.0	47.1
Common yarrow	irrigated	29.2	24.7	55.7 *	54.8 ***
	nonirrigated	23.9	24.8	47.9	48.5
Pacific aster	irrigated	24.8	0.0	62.8	63.1 *
	nonirrigated	22.3	0.0	57.2	53.2

*, **, *** Significant at $P < 0.05$, 0.01, and 0.001 levels, respectively.

TABLE 8

Biomass and number of individuals of each wildflower species as influenced by mowing, irrigation, or mixture treatments. Mixtures were nonsignificant unless shown.

		Mean of evaluation methods[z]	
Species	**Treatment**	**Biomass (g)**	**Number of individuals**
Pacific aster			
	mowed	5.2 b	13.8 b
	non-mowed	21.0 a	16.9 a
	irrigated	15.9	12.1 b
	nonirrigated	19.2	18.9 a
Common yarrow			
	mowed	23.4 b	51.2 a
	non-mowed	40.3 a	29.3 b
	irrigated	30.9	41.5
	nonirrigated	35.0	40.6
Strawberry clover			
	mowed	13.5	41.2 a
	non-mowed	13.5	25.6 b
	irrigated	20.2 a	40.8 a
	nonirrigated	6.8 b	26.0 b
	mix 1	12.2	29.8 a
	mix 3	15.9	40.4 b

[z] Means with the same letter, within a species and treatment, are not significantly different.

TABLE 9

Total grass biomass and percentage of cover as influenced by mowing, irrigation, or mixture treatments.

	Mean of evaluation method[z]	
Treatment	**Biomass (g)**	**Cover (% area)**
mowed	10.5	10.6 b
non-mowed	10.3	16.7 a
irrigated	10.6	12.1
nonirrigated	10.3	15.1
mix 1	15.6 a	23.5 a
mix 2	7.5 b	8.1 b
mix 3	8.2 b	13.5 b

[z] Means with the same letter, within a treatment, are not significantly different.

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