Introduction of Native Species Diversity into Exotic Lovegrass Infestations: Year 2

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Introduction

Much of Southern Arizona's biologically diverse grasslands are increasingly threatened by the invasion of exotic lovegrasses, but little is known about their management or control, or the economic return from such efforts. In fall 2005, the Tucson PMC harvested seed from the abundant grasslands of the Appleton-Whittell Research Ranch of the Audubon Society in Elgin, Arizona, to answer some of these questions. Using seed from that harvest, a replicated study was initiated in 2006 by the PMC and the Research Ranch near the harvest site to investigate the potential for patch establishment of native species into an invasive-dominated site of Boer lovegrass (*Eragrostis curvula*). Boer lovegrass, and to an even greater extent, lehmann lovegrass (*E. lehmanianna*), have been present in relatively small quantities on the Ranch for years, but have become dominant over much of the range following the catastrophic Ryan fire in 2002.

Methods

Seed harvested from the ranch was minimally processed (once through the hammermill) for use in this project. Multiple species of grasses and forb seed, including *Eragrostis intermedia, Bouteloua gracilis, B. hirsuta, B. eriopoda, B. curtipendula, B. chondrosioides, Bothriochloa barbinodis, Digitaria californica, Lycurus phleoides, Leptochloa dubia, Aristida spp., Sida filicaulis, Ipomoea coccinea, Viguiera annua, Convolvulus equitans* were identified in the seed mix. The harvest site was selected based on its low density of exotic grasses. Because the few Lehmann lovegrass patches encountered at the site were avoided while harvesting, very little Lehmann lovegrass should have entered into the seed mix.

The purpose of this study was to investigate the potential for the removal of patches of Boer lovegrass within a large infestation and to increase native diversity within those patches with the use of several cultural practices:

Mowing- with diesel tractor and rotary mower
Broad-spectrum herbicide- Roundup Ultra 5% rate and blue dye
Growth suppressant- Embark 2-S at 4 pints/ac and blue dye
Seeding- Native seed planted with FLXII Truax No-Till Grass Drill (1" depth)

Four replications of the following treatments were equal in size and arranged randomly in replicated complete block grid pattern (Figure 1):

- mow & herbicide & seed
- mow & growth suppressant & seed
- mow & seed
- seed only
- control

All 20 plots were 50 ft by 8 ft, with a 5 ft buffer around each plot to prevent overlap of treatments. The equipment was passed through each block to ensure uniformity of the treatments. Plots were delineated by colored rebar stakes.

The plots were set up and treated during the month of July. Four of the five treatments (16 plots) were mowed. Seven days later, four of the mowed plots were sprayed with herbicide, and another four of those plots were sprayed with a growth suppressant hormone. Three days following the spraying, four of the five treatments (all but the control plots) were seeded with a drill. Approximately 40 seed/sq ft were seeded in the plots, double the recommended range seeding rate to increase the opportunity of germination. Approximately 14.46 lb/ac was used in each of the drill's boxes (fluffy seed and small seed) for all plots combined. The growth suppressant hormone treatment was rendered ineffective due to multiple rainfall events following application, and this treatment was dropped from the study.

Plot pattern following mowing and spraying

Seedlings began to emerge following the summer rains July through September. On October 19 the four active treatments in the Boer treatments were evaluated. Data were collected from within a 1 m x 0.5 m frame placed randomly twice in each plot. Seedlings of perennial species and mature perennial species were identified in each frame. The four treatments were evaluated according to the following variables:

- Mean frequency of native grass seedlings
- Mean frequency of exotic grass seedlings
- Mean frequency of native forb seedlings

- Mean frequency of mature native grasses
- Mean frequency of mature exotic grasses
- Mean frequency of mature native forbs

- Mean species composition of seedlings
- Mean species composition of mature plants

- Vegetation cover in frame (Daubbenmeier cover class score)

Plants that were established in the plots previous to treatment (mature native grasses, forbs and exotic grasses) were recorded in each frame. Seedlings of native grasses, forbs and exotic grasses were identified using a seedling identification guide and recorded in each frame. Species composition was listed for mature plants and seedlings; these totals number represent the overall species composition variable. Species composition for native grasses, native forbs and exotic grasses were also recorded. Cover was estimated in each frame using Daubbenmeier scores.

Results

Following treatment the first year

The plots sprayed with herbicide had significantly lower cover scores (p=0.0053, Table 1) and significantly lower species composition of mature plants (p<0.0005, Tables 5, 7, 9 and 11) than the plots that were not sprayed. However, there was no difference in mean frequency of mature native grasses (p=0.147), mature exotic grasses (p=0.203) or mature forbs (p=0.75) between treatments.

Jennifer Arnold (NRCS Tucson Field Office), Linda Kennedy (Research Ranch) and Leslie Wood (PMC) examine seedlings in the frame.

Table 1. Cover and Mature Plant Composition following Treatment

Treatment	N	Vegetation Cover (%)	Species composition of mature plants (#)
Mow & Herbicide & Seed	8	11.63 b	0.25 b
Mow & Seed	8	45.25 a	6.28 a
Seed only	8	42.50 a	4.25 a
Control	8	53.13 a	5.38 a

Values follwed by different letters are significantly different (α=0.05)
Randomized complete block AOV and LSD All-Pairwise Tukey Test were conducted.

In terms of plant establishment, a significantly greater number of native grass seedlings germinated in the sprayed plots than the control plots (p=0.023, Table 2). A greater number of exotic grass seedlings germinated in the sprayed plots than the mowed plots, although this difference was not statistically significant (p=0.084). Of the 32 total plots examined, 3 plots had Boer lovegrass seedlings, and 8 plots had Lehmann lovegrass seedlings. Three of the eight plots containing Lehmann lovegrass seedlings were in the plots sprayed with herbicide. Slightly greater numbers of forb seedlings came up in sprayed plots than the control plots and the seeded only plots (p=0.183).

Seedlings emerging from drill rows in a plot mowed, sprayed and seeded.

Species composition of seedlings was significantly greater in the sprayed plots than the other treatments (p=0.0003, Table 2 and Tables 5, 7, 9 and 11).

Table 2. Frequency and Composition of Seedlings Following Treatment

Treatment	N	Native grass seedlings (#)	Exotic grass seedlings (#)	Species composition of seedlings (#)
Mow & Herbicide & Seed	8	70.72 a	18.28	8.13 a
Mow & Seed	8	43.00 ab	0.75	4.35 b
Seed only	8	45.50 ab	5.38	2.75 b
Control	8	11.00 ab	5.88	2.87 b

Values follwed by different letters are significantly different (α=0.05)
Randomized complete block AOV and LSD All-Pairwise Tukey Test were conducted.

Plant establishment and maintenance in the second year

The results in 2007, the year following the treatment year, is closely linked to the plants that established in the planting the previous year. In contrast to 2006, few seedlings germinated in any of the plots in 2007; on average, zero to three were observed in each plot. No significant differences were observed between treatments in numbers of native grass seedlings (p=0.222), exotic grass seedlings (p=0.351), or native forb seedlings (p=0.318), although for all three types slightly more seedlings germinated in the sprayed plots. Of the few seedlings that did germinate, no difference (p=0.7389) and overall low species composition was observed in all treatments - the lowest, the control, had a mean of 1 species of seedling per plot, the greatest, the sprayed plots, had a mean 1.8 species of seedling per plot (Tables 6, 8, 10 and 12).

Greater numbers of mature plants (those in the plot prior to treatment as well as those established the previous year) were observed in the plots where vegetation was removed the previous year. Although the difference was not significant, a greater number of mature native grasses were found in the sprayed plots and the mowed plots than the plots were no vegetation was removed (p=0.184, Table 3). More mature exotic grasses were also observed in the sprayed plots, although this difference was not significant (p=0.341). A greater number of mature forbs were also recorded in the sprayed plots than the other treatments (p=0.054). Despite the greater numbers of mature plants in the sprayed plots, the cover score was significantly lower in those plots than the sprayed plots (p=0.029).

Table 3. Frequency of Mature Plants and Vegetation Cover

Treatment	N	Native grasses (#)	Exotic grasses (#)	Forbs (#)	Veg. Cover (%)
Mow & Herbicide & Seed	8	16.8	14.38	7.9	29.75 b
Mow & Seed	8	16.1	4.75	4.3	59.38 a
Seed only	8	9.6	4.63	2.0	53.50 a
Control	8	3.3	5.63	2.5	63.75 a

Values followed by different letters are significantly different (α=0.05)
Randomized complete block AOV and LSD All-Pairwise Tukey Test were conducted.

There was a significantly greater overall species composition of mature plants in the sprayed plots than the control plots (p=0.020, Table 4) in this second year following

treatment. A significantly greater diversity of mature native grasses were recorded in the sprayed plots than the control plots (p=0.006), and although not significant, a greater variety of mature native forbs were found in the sprayed plots than the controlled or seeded only plots (p=0.099). No significant differences in species composition of mature exotic grasses were found between treatments (p=0.502); on average, most plots had at least one of the two *Eragrostis* species (Tables 6, 8, 10 and 12).

Table 4. Species Composition of Mature Plants

Treatment	N	Native grasses (#)	Native forbs (#)	Overall Composition (#)
Mow & Herbicide & Seed	8	5.0 a	3.4	9.1 a
Mow & Seed	8	3.1 ab	2.6	6.9 ab
Seed only	8	2.4 ab	1.3	4.8 ab
Control	8	1.3 b	1.5	4.0 b

Values followed by different letters are significantly different (α=0.05)
Randomized complete block AOV and LSD All-Pairwise Tukey Test were conducted.

Discussion

The Boer lovegrass study demonstrated several interesting findings over the two years of data collection. The fact that numbers of plants prior to treatment in 2006 – both native and exotic— did not differ between treatments suggests that the plots had low vegetative density initially. Hence, even a relatively sparse lovegrass infestation can have a large effect on the potential for establishing native species. The preliminary year of the study also demonstrated that no two weeds are alike. Although the dominant species at the site, and presumably in the seed bank, was Boer lovegrass, Lehmann lovegrass germinated even more readily. Both species are cause of concern, but Lehmann lovegrass appears to be the more aggressive of the two.

In the treatment year of 2006, plots that were mowed, sprayed and seeded had the least vegetation cover, experienced the greatest grass seedling increase, and had the highest species composition of seedlings. These results appear to point in favor of native plant establishment. However, use of herbicide followed by the drill's minor disturbance to the soil surface also provided optimum conditions for germination of exotic seed present in the soil. Due to the fact that care was taken to avoid the patches of invasive species in the seed harvest, the exotic seedlings had to have emerged from the seed bank, not from the seed mix. Spraying with herbicide removed preexisting plants at the site, providing space and resources for the germination of a greater number and diversity of seedlings- both native and exotic. This fact may be a cause of concern because any effort to establish native species in an invasive-dominated site will simultaneously increase the invasive species in the seed bank. Restoration efforts to increase native species diversity using chemical control and seeding will require follow-up of weed control.

On the other hand, the results of mowing in the treatment year may potentially provide options for the restorationist. Fewer exotic seedlings established in the plots that were mowed and seeded than those that were mowed, sprayed and seeded. Cut biomass left on the ground in the mowing process shades the soil surface. This shading effect may prevent the establishment of exotic grass seedlings, which require light to germinate. By

increasing the open canopy through herbicide application, the greatest number of exotic seedlings germinated, and by increasing shade by mowing, the fewest number of exotic seedlings established. Providing shade through mulch may decrease the prevalence of exotic seedling establishment, and hence may be an additional tool for increasing native diversity with fewer exotics.

The year following the treatment year, 2007, further demonstrates that removal of exotic vegetation allows for establishment of native diversity. The seedlings from the treatment year of 2006 persisted into the following year as mature plants. This was demonstrated by the fact that the greatest number of mature plants was recorded in the sprayed plots and mowed plots in 2007, not the seeded only and control plots, where plants were already growing. The preexisting plants in those plots were larger, however, which explains the greater cover value in the frame. In addition, few seedlings established in the second year, as little open ground was available for germination.

Not only did more mature native grasses and forbs persisted into the second year in the sprayed plots, but mature exotic grasses did as well, perhaps making questionable the issue of success in a restoration effort such as this one. However, the fact that species composition of mature plants was greatest in the sprayed plots – particularly for native grasses and forbs – gives weight to the use of chemical control in efforts of increasing patch establishment of native diversity into an invasive-dominated site.

Conclusion

The establishment of native species in stands of exotic grasses may be possible through the removal of existing vegetation. However, due to the fact that patch establishment of native vegetation through herbicide application simultaneously establishes the exotic vegetation in the area, additional long-term information on species composition, and requirements of follow-up weed control efforts, are required to determine feasibility of these types of restoration efforts. In addition, more comprehensive studies are needed to establish a methodology for vegetation removal and seeding into exotic-dominated sites. For instance, studies involving additional weed treatment methods and those that control for each additional treatment or combination of treatments, will provide a clearer explanation for the processes taking place. Finally, studies involving the use of hay bales harboring native seed will provide information on the shading effect, and the potential for preventing germination of exotic seed in the seed bank while providing resources for the germination of native plants.

Table 5. Species Composition in *Mow + Herbicide + Seed* Treatment, 2006 (Year 1)

Block	Frame	Species- seedlings	Species- mature plants
A	1	*Grasses*- ERLE[1],ERIN,BOGR,LEDU,ARTE,LYPH *Forbs*- Croton, Sida NM, Dychariste, Evolvulus, Chaetopappa, Portulaca suffrutescens, Falls witchgrass (Digitaria cognata)	None
A	2	*Grasses*- ERLE[1],BOCU,ERIN,ARTE,DICA,BOHI	None
B	1	*Grasses*- DICA,ARHA,ERIN,BOGR,LEDU *Forbs*- Dychariste, Sida, Cudweed, daisy	None
B	2	*Grasses*- ERCU[1],ERIN,ARTE,BOCU *Forbs*- Dychoriste,Daisy, Cercium (thistle)	None
C	1	*Grasses*- ERIN,BOCU,LEDU,ARTE,DICA	*Grasses*- ERCU[1] *Forbs*- Dychariste gnaphalium
C	2	*Grasses*- ERLE[1],ERIN,LEDU,DICA,BOCH *Forbs*- Sida, Dychoriste, Evolvulus, bundleflower	None
D	1	*Grasses*- DICA,LEDU,BOGR *Forbs*- Cudweed, bundle flower, Mtn. caliandra, ragweed,evolvulus, dychoriste	None
D	2	*Grasses*- DICA,ARTE,ERIN,BOGR,LYPH *Forbs*- Daisy,Cudweed,Desert marigold, Conyzia	None

[1]Exotic grasses consisted of ERLE (Lehmann lovegrass) and ERCU (Boer lovegrass)

Native grass species consisted of ERIN (Plains lovegrass), LEDU (Green sprangletop), ARTE (Purple threeawn), ARHA (Spidergrass), LYPH (Common wolftail), DICA (Arizona cottontop), HIBE (Curly mesquite), BOBA (Cane beardgrass), BOGR (Blue grama), BOCU (Sideoats grama), BOCH (Sprucetop grama), BOER (Black grama).

Table 6. Species Composition in *Mow + Herbicide + Seed* Treatment, 2007 (Year 2)

Block	Frame	Species- seedlings	Species- mature plants
A	1	*Grasses*- ERLE[1], BOGR, ERIN *Forbs*- none	*Grasses*- ERCU[1], ERLE[1], DICO, LYPH, BOGR, BOCU, ERIN, DICA, ARDI *Forbs*- Evolvulus, Ragweed
A	2	*Grasses*- ERLE[1], BOGR Forbs- Dychoriste	*Grasses*- ERLE[1], BOGR, BOCU, ERIN, ARDI Forbs- Evolvulus
B	1	*Grasses*- ERLE[1], BOGR, BOCU, ERIN, ARDI *Forbs*- Evolvulus	*Grasses*- ERLE[1], BOGR, DICA, ARTE, LEDU, ERIN, BOCU, BOHI *Forbs*- Cudweed, Sida Abutifdia, Ragweed, Erigeron, Dischoriste, Evolvulus
B	2	None	*Grasses*- BOGR, DICA, ARTE, BOCU *Forbs*- Erigeron, Conyzia (SP)
C	1	None	*Grasses*- ERLE[1], BOGR, DICA, ERIN, ARTE, BOHI *Forbs*- Cudweed, Sida, Dischoriste
C	2	*Grasses*- ERLE[1]	*Grasses*- ERLE[1], Grama sp Forbs- Evolvulus, Bundleflower
D	1	*Grasses*- ERIN	*Grasses*- DICA, BOCU, BOGR, BOBA, ARTE *Forbs*- Conyzia, Ragweed, Chaetopappa, Erigeron, Cudweed, Calliandra humulis
D	2	*Forbs*- Cudweed	*Grasses*- ARTE, DICA, LYPH, ARDI, BOCU, BOGR, HIBE *Forbs*- Cudweed, Conyzia, Ragweed, Chaetopappa, Erigeron

[1]Exotic grasses consisted of ERLE (Lehmann lovegrass) and ERCU (Boer lovegrass)

Native grass species consisted of ERIN (Plains lovegrass), LEDU (Green sprangletop), ARTE (Purple threeawn), ARHA (Spidergrass), LYPH (Common wolftail), DICA (Arizona cottontop), HIBE (Curly mesquite), BOBA (Cane beardgrass), BOGR (Blue grama), BOCU (Sideoats grama), BOCH (Sprucetop grama), BOER (Black grama).

Table 7. Species Composition in *Mow + Seed* Treatment in 2006 (Year 1)

Block	Frame	Species- seedlings	Species- mature plants
A	1	*Grasses*- ARTE *Forbs*- Sida, Dyschariste	*Grasses*- ERCU[1],BOCU *Forbs*- Hierba de pasmo, convolvulus, sida, evolvulus, ragweed, chaetopappa, mimosa
A	2	*Grasses*- ERLE[1],BOGR,ATRE,ERIN *Forbs*- Ragweed, Evolvulus, Dychoriste	*Grasses*- ERLE[1],HIBE,BOCU,BOGR,ERIN,ARTE, DICA,BOHI
B	1	*Grasses*- BOGR	*Grasses*- ERCU[1],BOGR *Forbs*- Dychoriste, Ragweed
B	2	*Grasses*- BOCU,ERIN, *Forbs*- Dychoriste,Mtn. Caliandra	*Grasses*- ERCU[1],BOGR *Forbs*- Evolvulus,Prostrate sida,Upright sida
C	1	No data	No data
C	2	*Grasses*- BOGR,ATRE,DICA,LEDU *Forbs*- Dychoriste, Portulaca, Daisy, Evolvulus,Hybanthus	*Grasses*- BOGR *Forbs*- Sida, Evolvulus, bundle flower, flame flower
D	1	*Forbs*- Ragweed, Dychoriste	*Grasses*- ERCU[1],BOER *Forbs*- Evolvulus, Dychoriste
D	2	*Forbs*- Dalea, bundleflower, Dychoriste	*Grasses*- ERCU[1],BOBA,BOCU,BOCH,ERIN *Forbs*- Dychoriste, Bundle flower, Upright sida, Portulaca suffrutescens

[1]Exotic grasses consisted of ERLE (Lehmann lovegrass) and ERCU (Boer lovegrass)

Native grass species consisted of ERIN (Plains lovegrass), LEDU (Green sprangletop), ARTE (Purple threeawn), ARHA (Spidergrass), LYPH (Common wolftail), DICA (Arizona cottontop), HIBE (Curly mesquite), BOBA (Cane beardgrass), BOGR (Blue grama), BOCU (Sideoats grama), BOCH (Sprucetop grama), BOER (Black grama).

Table 8. Species Composition in *Mow + Seed* Treatment in 2007 (Year 2)

Block	Frame	Species- seedlings	Species- mature plants
A	1	*Grasses*- BOGR, Aristida spp	*Grasses*- ERCU[1], BOGR, BOCU, ERIN *Forbs*- Evolvulus, Chaetopappa, Hierba de pasma, Ragweed, Talinum, Mimosa
A	2	*Grasses*- ERLE[1], BOGR, Aristida spp *Forbs*- Dyschoriste	*Grasses*- ERLE[1],ERCU[1], BOGR, ERIN, ARDI, BOCU, HIBE *Forbs*- Ragweed, Evolvulus, Talinum, Desmanthus
B	1	*Grasses*- Grama sp	*Grasses*- ERCU[1], BOGR *Forbs*- Sida abutifolia
B	2	*Grasses*- ERLE[1]	*Grasses*- ERLE[1], ERCU[1], BOGR *Forbs*- Portulaca suffrutescens
C	1	*Forbs*- Erigeron (daisy)	*Grasses*- ERLE[1], BOGR *Forbs*- Ragweed
C	2	*Grasses*- BOGR, DICA, BOHI	*Grasses*- BOER, BOCU, DICA, ERIN, LEDU, LYPH, ARTE, BOHI *Forbs*- Evolvulus, Talinum, Ragweed, Desmanthus, Erigeron (daisy)
D	1	None	*Grasses*- HIBE, BOGR, LYPH *Forbs*- Bundleflower, Ragweed
D	2	None	*Grasses*- ERCU[1], ERLE[1], BOBA, ERIN, BOCU *Forbs*- Hierba de Pasmo

[1]Exotic grasses consisted of ERLE (Lehmann lovegrass) and ERCU (Boer lovegrass)

Native grass species consisted of ERIN (Plains lovegrass), LEDU (Green sprangletop), ARTE (Purple threeawn), ARHA (Spidergrass), LYPH (Common wolftail), DICA (Arizona cottontop), HIBE (Curly mesquite), BOBA (Cane beardgrass), BOGR (Blue grama), BOCU (Sideoats grama), BOCH (Sprucetop grama), BOER (Black grama).

Table 9. Species Composition in *Seed Only* Treatment in 2006 (Year 1)

Block	Frame	Species- seedlings	Species- mature plants
A	1	*Grasses*- ERIN,ARTE,BOGR,DICA	*Grasses*- ERCU[1],BOGR
A	2	*Grasses*- ERIN,ARTE,BOGR	*Grasses*- ERCU[1],BOCU,BOGR *Forbs*- Dychoriste, Chaetopappa
B	1	*Forbs*- Dychoriste	*Grasses*- ERCU[1],ERLE[1],ERIN,BOCU,BOGR *Forbs*- Dychoriste, Evolvulus, bundleflower
B	2	*Grasses*- ERLE[1],ARTE	*Grasses*- ERLE[1], Panic grass *Forbs*- Evolvulus, Prostrate sida, bundle flower, Dalea
C	1	*Grasses*- ERLE[1],BOGR,LEDU,ERIN *Forbs*- Portulaca, Dychariste, Calliandra hymulus	*Grasses*- ERCU[1],BOGR *Forbs*- Dychariste, Evolvulus, Poinsetta radiens
C	2	*Grasses*- BOCU,BOGR *Forbs*- Sida, Portulaca, Dychoriste	*Grasses*- BOGR,BOCU *Forbs*- Sida
D	1	*Grasses*- BOGR	*Grasses*- ERCU[1]
D	2	*Grasses*- LYPH *Forbs*- Dychoriste	*Grasses*- ERCU[1],BOBA *Forbs*- Evolvulus, Chaetopappa

[1]Exotic grasses consisted of ERLE (Lehmann lovegrass) and ERCU (Boer lovegrass)

Native grass species consisted of ERIN (Plains lovegrass), LEDU (Green sprangletop), ARTE (Purple threeawn), ARHA (Spidergrass), LYPH (Common wolftail), DICA (Arizona cottontop), HIBE (Curly mesquite), BOBA (Cane beardgrass), BOGR (Blue grama), BOCU (Sideoats grama), BOCH (Sprucetop grama), BOER (Black grama).

Table 10. Species Composition in *Seed Only* Treatment in 2007 (Year 2)

Block	Frame	Species- seedlings	Species- mature plants
A	1	*Grasses*- BOGR, Aristida sp *Forbs*- Talinum	*Grasses*- ERCU[1], ARTE, DICA, BOGR
A	2	*Grasses*- ERCU[1]	*Grasses*- ERCU[1], BOGR, DICA *Forbs*- Chaetopappa, Dyschoriste
B	1	None	*Grasses*- ERLE[1], ERCU[1], BOCU *Forbs*- Dischoriste, Bundleflower, Evolvulus, Sida decumbens
B	2	*Grasses*- ERLE[1], Grama sp., ARTE	*Grasses*- Halls panic, DICO, BOHI, BOGR *Forbs*- Sida abutifolia
C	1	*Grasses*- BOGR, BOCU, Aristida sp	*Grasses*- ERLE[1], ERCU[1], BOCU, ERIN, BOGR, ARTE, LEDU *Forbs*- Dischoriste, Sida
C	2	*Grasses*- BOGR	*Grasses*- ERCU[1], BOGR, BOCU, DICA *Forbs*- Sida
D	1	None	*Grasses*- ERCU[1]
D	2	None	*Grasses*- ERCU[1], BOBA

[1]Exotic grasses consisted of ERLE (Lehmann lovegrass) and ERCU (Boer lovegrass)

Native grass species consisted of ERIN (Plains lovegrass), LEDU (Green sprangletop), ARTE (Purple threeawn), ARHA (Spidergrass), LYPH (Common wolftail), DICA (Arizona cottontop), HIBE (Curly mesquite), BOBA (Cane beardgrass), BOGR (Blue grama), BOCU (Sideoats grama), BOCH (Sprucetop grama), BOER (Black grama).

Table 11. Species Composition in *Control* in 2006 (Year 1)

Block	Frame	Species- seedlings	Species- mature plants
A	1	*Grasses*- BOGR	*Grasses*- ERCU[1],BOCU,BOGR
A	2	None	*Grasses*- ERCU[1],BOGR *Forbs*- Day Flower, Bundle flower, chaetopappa
B	1	*Forbs*- Cudweed, prostrate sida	*Grasses*- ERCU[1],BOCU *Forbs*- Daisy, Evolvulus, bundleflower, Prostrate sida
B	2	*Grasses*- ERLE[1] *Forbs*- Bundle flower, Mtn. Calliandra	*Grasses*- ERCU[1],ERLE[1],ERIN *Forbs*- Evolvulus, prostrate sida
C	1	*Grasses*- ERLE[1],ERCU[1],HIBE *Forbs*-Dychariste, Bundleflower, Sida NM	*Grasses*- ERCU[1],BOCU,HIBE,BOCH *Forbs*- Portulaca, Bundleflower, Sida
C	2	*Grasses*- ERCU[1], Unk. grama species *Forbs*- Dychoriste, Sida NM	*Grasses*- ERCU[1],BOGR *Forbs*- Unknown forb
D	1	*Forbs*- Dychoriste	*Grasses*- ERCU[1],BOGR,HIBE,BOCH,LYPH *Forbs*- Chaetopappa, Red maids, Bundleflower
D	2	*Forbs*- Portulaca suffrutescens, Dychoriste, Mtn. Caliandra, falls witchgrass, hybanthus	*Grasses*- ERCU[1],BOGR,BOER *Forbs*- Ragweed, Evolvulus

[1]Exotic grasses consisted of ERLE (Lehmann lovegrass) and ERCU (Boer lovegrass)

Native grass species consisted of ERIN (Plains lovegrass), LEDU (Green sprangletop), ARTE (Purple threeawn), ARHA (Spidergrass), LYPH (Common wolftail), DICA (Arizona cottontop), HIBE (Curly mesquite), BOBA (Cane beardgrass), BOGR (Blue grama), BOCU (Sideoats grama), BOCH (Sprucetop grama), BOER (Black grama).

Table 12. Species Composition in *Control* in 2006 (Year 2)

Block	Frame	Species- seedlings	Species- mature plants
A	1	*Grasses*- BOGR, BOCU	*Grasses*- ERCU[1],BOCU,BOGR *Forbs*- Solanum (silverleaf nightshade)
A	2	None	*Grasses*- ERCU[1],BOGR *Forbs*- Talinum
B	1	*Grasses* - LYPH *Forbs*- Erigeron	*Grasses*- ERCU[1],BOCU *Forbs*- Sida abutifolia
B	2	None	*Grasses*- ERCU[1],ERLE[1],ERIN *Forbs*- Evolvulus, Sida abutifolia
C	1	None	*Grasses*- ERCU[1],ERLE[1],BOCU *Forbs*- Bundleflower (desmanthes cooleyii), Sida
C	2	None	*Grasses*- ERCU[1]
D	1	None	*Grasses*- ERCU[1],BOER
D	2	None	*Grasses*- ERCU[1],BOGR,BOER, DICO Forbs- Ambrosia, Bundleflower, Dischoriste, Evolvulus

[1]Exotic grasses consisted of ERLE (Lehmann lovegrass) and ERCU (Boer lovegrass)

Native grass species consisted of ERIN (Plains lovegrass), LEDU (Green sprangletop), ARTE (Purple threeawn), ARHA (Spidergrass), LYPH (Common wolftail), DICA (Arizona cottontop), HIBE (Curly mesquite), BOBA (Cane beardgrass), BOGR (Blue grama), BOCU (Sideoats grama), BOCH (Sprucetop grama), BOER (Black grama).

Figure 1. Plot Plan of Treatments