Experimental tests of community assembly rules in a tallgrass prairie restoration

by

Andrea Margaret Blong

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Program of Study Committee:
Brian J. Wilsey, Major Professor
Heidi Asbjornsen
Tom Jurik

Iowa State University

Ames, Iowa

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ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

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CHAPTER 1. OVERVIEW

General Introduction

Plants can be categorized by their traits into functional groups (Fox 1999). Another approach is to determine how strongly they affect community composition; plants that are strong drivers of composition are called ecological engineers (Jones et al. 1997; Lockwood and Samuels 2004; Crain and Bertness 2005). While both functional groups and ecological engineers can affect community composition through assembly rules (Fox 1999), the difference between the two would be one of degree. Examples of ecological engineers would include the keystone predator (Paine 1969) of animal ecology, or a nexus species (Lockwood and Samuels 2004)–a species which does not persist in the community, but which has long-lasting effects upon its composition. The nurse plant effect (Nuñez et al. 1999; Padillia and Pugnaire 2006) is an example of an ecological engineer in plant ecology, where the presence of an adult plant facilitates seedling establishment and growth through abiotic site amelioration. This in turn leads to a significantly different community composition. Examples of nurse plant effects include tussock grasses in salt marshes, which decrease soil salinity and allow less salt-tolerant species to establish (Crain and Bertness 2005), and shrubs that provide shade for cactus seedlings (Valiente-Banuet and Ezcurra 1991).

The study of ecological engineers and their potential effects on developing communities may be important to the study of alternative stable states. Alternative stable states are two or more possible stable, persisting communities that can form under similar preliminary abiotic conditions, and all species in the regional pool have equal access to the community. Thus, alternative stable state theory has practical implications in restoration ecology. Suding et al.

(2004) theorized that one reason native species fail to establish in restorations may be due to resistance to change by the currently established, non-native dominated community. The non-native community may exist as an alternative stable state (Lockwood et al. 1997, Didham and Watts 2005, Schroder, Persson and De Roos 2005; see also multiple stable equilibria in Chase 2003) of the site. One possible way to improve restoration success is to exploit particular plant traits, such as those of an ecological engineer, and cause a stable, non-native plant based community to diverge into a stable, native plant based community. There is experimental evidence that plants do differ in a number of traits, including physiology (Fargione and Tilman 2005), rooting depth (Fargione and Tilman 2005), and period of peak growth (Hooper and Vitousek 1997; Hooper 1998; Polley et al. 2006). What is not well understood is how these traits affect the entire community, which traits are the most important drivers of community composition, and if species are functionally redundant. Once we understand how each species contributes to a community, we may be able to utilize these traits to achieve better restoration success.

Thesis Organization

The first objective of this research was to determine if plant species in tallgrass prairies were functionally different. A second objective was to determine if the study species affected the early community composition of experimental tallgrass prairie restorations. If these species do cause early compositional divergences, another objective was to determine which traits caused such differences. The final objective was to use my data to help recommend appropriate nurse (cover) crops for use in various restoration settings.

CHAPTER 2. EXPERIMENTAL TESTS OF COMMUNITY ASSEMBLY RULES IN A TALLGRASS PRAIRIE RESTORATION

Abstract

Community assembly theory predicts that community members regulate the identity of invaders based on the traits of the recipient community. A hypothesized rule for community assembly is Fox's assembly rule, which states that a member of a functional group currently in community will tend to exclude other members from that group. In order to test this assembly rule, we experimentally varied the functional identity of the dominant early-emerging species in tallgrass prairie restoration plots at each of two sites differing in productivity level. Within each of the main plots, we established weeded, late-emerging prairie transplant sub-plots in order to test how early-emerging species identity directly affected the late-emerging species community over two years. Seedling establishment by both native and non-native species in the main plots showed evidence for the presence of assembly rules during the initial 2 years of establishment; however, compositional differences did not follow Fox's assembly rule. In the transplant study, we found that early-emerging species did not cause transplant community divergence at either site, suggesting that assembly rules operate at the seedling establishment stage in tallgrass prairies.

Introduction

Assembly rule theory predicts that communities form through deterministic processes such that community members regulate the identity of future colonists. Diamond (1975) first proposed that assembly rules exist after observing the distribution of bird species on a series of islands. He discovered that certain species never occurred together on the same island, in what he termed "forbidden combinations." Gotelli and McCabe (2002) conducted a meta-analysis of 96 species presence-absence matrices across several taxonomic groups. They found that in most communities, species co-occurred less than expected by chance, supporting Diamond's findings. However, they did not suggest any specific assembly rule to account for such patterns of co-occurrence.

One rule that may be applied to multiple taxa is the guild (or functional group) assembly rule proposed by Fox (1983). The guild assembly rule predicts that the presence of guild members can prevent colonization by other species of that guild. Presence of guild members would lead to the greater colonization of a species from the other guilds. Although some consider abiotic filtration of species to be an assembly rule (Weiher and Keddy 1999), for the purposes of this paper only plant-plant interactions that have the potential to alter community composition (e.g., competition or facilitation) shall be considered for possible community assembly rules.

Although the guild assembly rule was developed for mammals (Fox 1983), efforts have been made to test it with plant functional groups (plant species that perform similar functions in the community, e.g. fix nitrogen). Wilson and Whittaker (1995) found evidence for functional groups in a salt marsh community that was correlated with leaf morphology. Fargione et al.

(2003) found evidence for the functional group assembly rule using the perennial grassland functional groups of C_3 graminoid, C_4 graminoid, leguminous forb, and non-leguminous forb in a sand prairie system. However, they tested this assembly rule using the biomass of only one species from each functional group, not the total biomass of all the members of each group. Fargione and Tilman (2005) found that plots containing higher proportions of a dominant, shallow-rooted C_4 prairie grass contained fewer non-planted species possessing shallow roots and mid-season phenology, again supporting the assembly rule proposed by Fox (1983).

An early-emerging species is one that is among the first to germinate during secondary succession or restoration. Early-emerging plant species can potentially have large effects on later colonists, such as by limiting water or nutrient availability. Assuming that species do vary in important functional traits, one can test for the presence of assembly rules by experimentally controlling the functional group identity of the dominant early-emerging species in a developing community. Important traits could include longevity, phenology, and differences in productivity.

Annual species often dominate early successions/restorations, and may prevent invasion of perennial species. Polley et al. (2006) showed in Texas that winter annual invaders significantly decreased soil moisture early in the growing season, thus significantly lowering the growth of perennial prairie species later in the year. Biennial species and C_3 graminoids grow primarily during the cooler parts of the growing season, which could prevent other cool-season species from invading the community. A C_4 graminoid, *Schizachyrium scoparium*, was shown to exclude other species possessing a mid-season phenology (Tilman and Fargione 2005). Grasses tend to produce large quantities of long-lasting litter (Facelli and Facelli 1993), which would lead to invasion by shade-tolerant species. Leguminous forbs could increase soil nitrogen content, allowing nitrophilic species a competitive edge over other species.

Chase (2003) predicts that high productivity sites are more likely to experience the effects of assembly rules than low productivity sites, thus leading to diverging community compositions. Low productivity sites are predicted to attain a single community composition, as abiotic forces more strongly structure the community than plant-plant interactions. Furthermore, plant interactions, and therefore assembly rules, may also be contingent upon the abiotic environment. Bertness and Callaway (1994) demonstrated increasing positive plant interactions as abiotic stress increased, and increasing negative plant interactions at less abiotically taxing sites. By replicating an early-emerging species experiment at two sites that differ in productivity, we can investigate the interactions of abiotic conditions with assembly rules.

Assembly rule theory also has practical applications, especially in restoration projects. A cover or nurse crop (Shirley 1994; Perry and Galatowitsch 2003; Pywell et al. 2002) is a plant species that, as used in restorations, is hypothesized to improve recruitment and establishment of desirable species in one of two ways: directly, through the amelioration of the relatively harsh abiotic conditions (e.g., high light, high evaporation) associated with newly planted restorations; or indirectly, by suppressing competitive weeds (Figure 1), which is where assembly rule theory would be useful. Assembly rule theory could assist in choosing a cover crop whose traits would exclude weeds while simultaneously allowing establishment by desirable species. While Shirley (1994) provides anecdotal evidence for the efficacy of cover crops, experimental evidence has shown little to no support for their use (Pywell et al. 2002; Perry and Galatowitsch 2003). Even if cover crops do not prevent weed invasion, however, their utility may lie in other areas. If cover crops regulate invader identity according to assembly rules, they could be utilized to increase β diversity in prairie restorations. By creating a patchy mosaic of various cover crops, restorations could attain high β diversity similar to that found in unplowed prairie remnants (Martin et al. 2005, Wilsey et al. 2005).

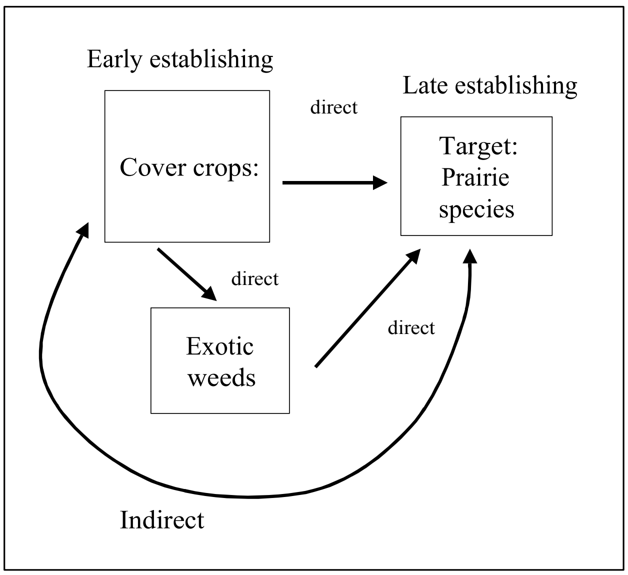

Figure 1. Model for early-emerging species effect. Cover crops of early-emerging species are predicted to facilitate late-emerging prairie establishment through an indirect pathway by reducing invaders. This is predicted to occur only if the indirect effect is larger than any direct negative effect of native early-emerging species on late-emerging species.

With these factors in mind, we addressed the following questions. Firstly, how does productivity affect competition amongst species? Evidence shows that species are more likely to compete at high community productivity levels (Bertness and Callaway 1994; Callaway et al. 2002); competition-driven communities may therefore feel the effects of assembly rules more strongly. Conversely, are the abiotic conditions so harsh at low productivity sites such that we find evidence for facilitation? Second, do early-emerging species differ significantly in important traits such as period of peak growth and aboveground biomass? Third, do differences among early-emerging species result in divergent communities of invaders? Additionally, if communities do diverge, are the colonists from a different or the same functional group as the early-emerging species? Answers to these questions will help us determine if early-emerging species would be an appropriate cover crop.

Materials and Methods

Study sites

Experimental plots were established in 2004 at each of two locations differing in tallgrass prairie productivity. The high productivity site (August average biomass 424 g/m^2; see main plot experimental design) is located at the Iowa State University Horticulture Farm, north of Ames, Iowa, USA. The low productivity site (August average biomass 187 g/m^2) is on the Iowa State University Western Research Farm, near Castana, Iowa, USA. The plots are located in abandoned pastures on west- to southwest-facing hillsides previously dominated by the non-native C_3 grass, smooth brome (*Bromus inermis*). The Ames site had not been grazed since the establishment of the Horticulture Farm in the 1960's; the Castana site was grazed by cattle until 2001.

Experimental Design

Main Plots–early-emerging species effects on invading invader composition

At each of the two sites, replicated 5 x 5 m plots were disked to remove the brome and then either seeded with one of five, functionally different, early-emerging species at the rate of 11 kg/ha or kept as non-vegetated controls (Table 1).

Table 1: Early-emerging species treatments and their characteristics.

Treatments	Functional Group	Longevity	Average Seed Mass (mg)
Bouteloua curtipendula	C_4 grass	perennial	0.9
Elymus canadensis	C_3 grass	perennial	5.5
Desmanthus illinoensis	N-fixing legume	perennial	6.4
Chamaecrista fasciculata	N-fixing legume	annual	10.6
Rudbeckia hirta	forb	biennial	0.3
Non-vegetated control	-	-	-

Each treatment had 6 replicate plots for a total of 36 plots at each site. Treatments were assigned to plots using a completely randomized design. Corridors of 3 m between the plots were periodically mowed to maintain the vegetation below 6 cm in height. For our treatments, we chose species that are among the first to germinate and become established in tallgrass prairie restorations, and included some which have been suggested as possible cover crop species (Packard and Mutel 1997). Dornbush and Wilsey (unpublished data) found in a prairie restoration experiment started from seed that *Chamaecrista fasciculata, Desmanthus illinoensis*, and *Rudbeckia hirta* had the most numerous seedlings in the first year. *Bouteloua curtipendula* was the earliest emerging C_4 grass and *Elymus canadensis* the earliest emerging C_3 grass in several previous experiments (Wilsey unpublished data, Dickson and Wilsey, unpublished data). The C_3 grass *E. canadensis* has also been previously suggested as a cover crop (Packard and Mutel 1997, Martin et al. 2005).

Each treatment was applied by adding seeds on bare ground a week after disking occurred in April 2004. Plots were then cultipacked to prevent seed movement and provide good contact between the seeds and the soil. *Rhizobium* species commonly associated with native legumes were added in equal amounts to each plot, in the form of live *Rhizobia* in peat moss mixed with local soil. This was done to ensure that specific *Rhizobium* were available to the native legumes. Non-planted species (invaders) were removed for two months to ensure the full establishment of treatment species, by spot-treating with herbicide (Roundup) prior to germination of treatment species, or by hand or mowing after germination. Once treatment species achieved canopy heights of 15-30 cm in late June 2004, we discontinued invader management measures. Invaders were allowed to enter the plots freely thereafter. In control plots, invaders were clipped to the soil surface twice during the first growing season (in June and October), and large, persistent biennial plants were spot-treated with herbicide (Roundup) once at the end of the first growing season at the Ames site. Invader management in control plots was also discontinued when the late-emerging prairie seed mix was added in November 2004.

Since late-emerging prairie species were our target for an ongoing test of assembly rules, we added a seed mix of 28 late-emerging species (Table 2) to each plot in November 2004, using an equal number of seeds per species.

Table 2: Seed mix of prairie species that were added after early-emerging species established in 2004.

Species	Family
Warm season grasses	
1. Little bluestem, *Schizachyrium scoparium*	Poaceae
2. Big bluestem, *Andropogon gerardii*	Poaceae
3. Indian grass, *Sorghastrum nutans*	Poaceae
4. Switch grass, *Panicum virgatum*	Poaceae
5. Side-oats gramma, *Bouteloua curtipendula*	Poaceae
6. Tall dropseed, *Sporobolus asper*	Poaceae
Cool season grasses	
7. June Grass, *Koeleria macrantha*	Poaceae
8. Porcupine Grass, *Stipa spartea*	Poaceae
Forbs	
9. Wild Bergamot, *Monarda fistulosa*	Lamiaceae
10. Bottle Gentian, *Gentiana andrewsii*	Gentianaceae
11. Butterfly Milkweed, *Asclepias tuberosa*	Asclepiadaceae
12. Dotted[1] or Rough[2] Blazing Star, *Liatris aspera* and *L. punctata*	Asteraceae
13. Ground Plum, *Astragalus crassicarpus*	Fabaceae
14. Hoary Vervain, *Verbena stricta*	Verbenaceae
15. Lead Plant, *Amorpha canescens*	Fabaceae
16. Pale purple[1] or Narrow Leaved[2] Coneflower, *Echinacea pallida* and *E. angustifolia*	Asteraceae
17. New Jersey Tea, *Ceanothus americanus*	Rhamnaceae
18. Ox-eye, *Heliopsis helianthoides*	Asteraceae
19. Prairie Phlox, *Phlox pilosa*	Polemoniaceae
20. Prairie Larkspur, *Delphinium virescens*	Ranunculaceae
21. Prairie Rose, *Rosa arkansana*	Rosaceae
22. Purple Prairie Clover, *Dalea purpurea*	Fabaceae
23. Red Root, *Ceanothus herbaceus*	Rhamnaceae
24. Round-headed Bush Clover, *Lespedeza capitata*	Fabaceae
25. Smooth Aster, *Aster laevis*	Asteraceae
26. Stiff Goldenrod, *Solidago rigida*	Asteraceae
27. White Prairie Clover, *Dalea candidum*	Fabaceae
28. Compass plant, *Silphium laciniatum*	Asteraceae
29. Pasque flower, *Anemone patens*	Ranunculaceae

[1] Castana site [2] Ames site

Although late-emerging native species are important to our long-term study, equally important are the possibilities of early community divergences due to the invasion of non-planted species. These can hinder native species establishment (Pywell et al. 2002) by quickly dominating open ground, and limiting light, water, or nutrients. By measuring invader composition in the initial year of community establishment, we had an early test of whether the treatment species can lead to divergent invader species compositions. In July 2004, we estimated relative cover of all species in two 30 x 30 cm quadrats in each plot in order to compare species compositions among treatments.

At the Ames site, we decided to investigate community development more thoroughly. In September 2004, we sampled aboveground biomass within two 50 x 50 cm quadrats randomly placed in each treatment plot. We clipped the biomass at approximately 1 cm above ground, and also collected litter. Control plots were not sampled, since they had been clipped for invader control during the growing season. We sorted the biomass by species using taxonomic guides (Eilers and Roosa 1994) and dichotomous keys (Barkley et al. 1986, Pohl 1954). Biomass was then oven-dried for 48 hours at 60°C and weighed.

In 2005, we similarly collected biomass in one 50 x 50 cm quadrat in each plot twice in the growing season, once each in June and August. All biomass samples were sorted to species using taxonomic guides (Eilers and Roosa 1994) and dichotomous keys (Pohl1954; Barkley et al. 1986), oven-dried at 60°C for 48 hours, and weighed.

Tests of Fox's assembly rule in invader communities using functional group sets

We chose two'functional group sets' to test Fox's assembly rule. All species were assigned to functional groups using taxonomic guides (Eilers and Roosa 1994) and dichotomous keys (Pohl 1954; Barkley et al. 1986). We investigated two functional group sets, in order to best ascertain which characteristic of an early-emerging species was the most important determinant of species composition. One set defined a species according to its grass-forb-legume status, which employs the functional groups used in perennial grassland studies, based on mode of photosynthesis, grass-forb status, and the ability to fix nitrogen. These groups were C_3 graminoids, C_4 graminoids, non-leguminous forbs, and leguminous forbs functional groups. The second functional group set was defined by the longevity of a species. Annuals and biennials were combined into one group, and perennial species into another. This functional group set is commonly used in annual and disturbed grasslands. Early successional systems are typically dominated by annual/biennial species for a number of years (Bazzaz 1996). Their dominance in early successional sites may be due to the wide seed dispersal ability of annual and biennial species (Fargione et al. 2003) or due to their superior competitive ability in the harsh conditions of early succession (Pacala and Rees 1998).

Transplant Sub-Plot Treatments-- early-emerging species effects on late-emerging native seedlings

To study the direct effects of an early-emerging species on late-emergent native prairie species, we established weeded sub-plots within the main plots and planted seedlings of eight, functionally different species. While early-emerging species may directly compete with late-emerging species, they may also have an indirect positive effect on establishment through invader suppression (Figure 1). By removing the weed component from the community, we could study only the direct effects of the early-emerging species treatments.

We chose native prairie species to represent the grassland functional groups (C_3 graminoids, C_4 graminoids, leguminous forbs, and non-leguminous forbs) that had functionally similar counterparts among the early-emerging species treatments (Table 1). To avoid misrepresenting a species-specific response as being characteristic to its entire functional group, we used two representative species from each functional group. All transplant species are ones commonly used in prairie restorations.

Transplant Species:

1) *Dalea purpurea*, a perennial N-fixing legume
1) *Lespedeza capitata*, a perennial N-fixing legume
2) *Dicanthelium oligosanthes*, a perennial C_3 grass
3) *Stipa spartea*, a perennial C_3 grass
4) *Schizachyrium scoparium*, a perennial C_4 grass
5) *Andropogon gerardii*, a perennial C_4 grass
6) *Monarda fistulosa*, a perennial C_3 forb
7) *Ratibida pinnata*, a perennial C_3 forb

D. purpurea, L. capitata, S. scoparium, A. gerardii, and *M. fistulosa* were started from seed in a greenhouse in March 2004. Due to lack of seed availability, we purchased seedlings of

R. pinnata and *S. spartea* from a supplier in May 2004, and trimmed them to a similar size as those species started from seed. Only one seedling of *S. spartea* was planted in each sub-plot due to restricted supplies. *D. oligosanthes* was unavailable in either seed or seedling form; plants of this species were dug from each study site in May 2004 and trimmed to a similar size as the other transplant species. All trimmed species were allowed to recover from trimming before being transplanted outdoors.

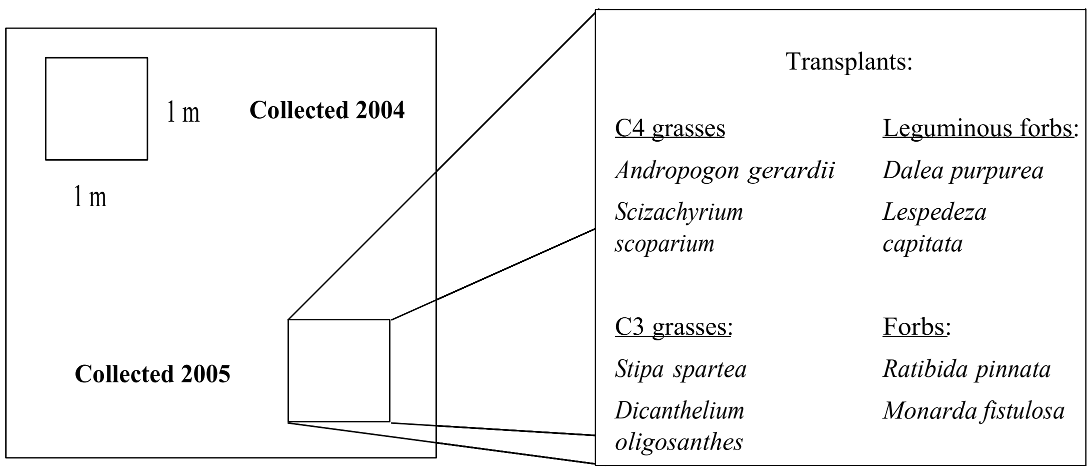

Figure 2: Diagram of main and subplots for an experiment conducted in Iowa. Seeds of a single early-emerging species (*Bouteloua curtipendula, Chamaecrista fasciculata, Desmanthus illinoensis, Elymus canadensis,* and *Rudbeckia hirta*) were added to the main plots. Transplants of eight prairie species were added to each of the two weeded subplots.

In June 2004, two 1 x 1 m subplots, at least 20 cm from the main plot edge, were cleared of all invaders (Figure 2). Two months after the the early-emerging species had been sown, two seedlings of each study species (except *S. spartea*) were added into each subplot in late June/early July 2004. Seedling transplants were placed in each subplot in random locations, with the restriction of having at least 10 cm between transplants. When the random location landed upon an early-emerging species plant, transplants were placed directly to the side of the plant. Subplots were weeded monthly throughout each growing season, so that plant-plant interactions would only occur between the early-emerging species and transplants.

At the end of each growing season (2004 and 2005), a random subplot was harvested from each plot before the first killing frost of the season. This was done at the Ames site in October 2004 and September 2005, and at the Castana site in November 2004 and October 2005. At the Ames site, roots of one transplant of each species were excavated to a depth of 15 cm with a 5 cm diameter coring tool, and the aboveground biomass of each transplant species and the early-emerging species were collected. At the Castana site, due to its longer distance from Ames, only aboveground biomass and crowns of the target and early-emerging species were harvested.

Statistical Analysis

Main Plots

For the 2004 relative cover data, we averaged the two sub-samples within each plot due to their lack of independence. This average was then *ln*(y+1) transformed in order to improve normality. A two-way ANOVA (site x treatment) was performed on the transformed relative cover of the early-emerging species. In order to interpret the site x treatment interaction, we performed a 'slice' procedure on the results. This procedure independently tests the strength of the interactions among the multiple levels of a class (such as site) and a treatment without physically separating the data by class level, which would reduce the degrees of freedom for the treatment effects, and thus the power of the analysis (Littel et al. 2002).

To analyze the 2004 Ames site biomass data, we averaged the treatment species biomass of the two sub-samples of each plot. For the 2004 Ames data and 2005 data for both sites, we ln(y+1) transformed the biomass of the treatment species to improve normality. We then performed a one-way repeated measures ANOVA on the Ames site data (2004, June 2005, August 2005), and a two-way (site x treatment) repeated measures ANOVA on the 2005 biomass data for both sites. In the two-way analysis, we again sliced the data by site.

Invader species composition Year 1

For the Ames site investigation, species biomass per quadrat was ln(y+1) transformed to improve normality. We then averaged the two sub-samples of each plot, and performed a one-way (treatment) ANOVA analysis for each guild set, using contrasts appropriate to the functional group set we tested.

Invader species composition Year 2

To test if significant differences existed among the treatments, we utilized the multi-response permutation procedure (MRPP), a non-parametric test (McCune and Grace, 2002). Each site and collection time were analyzed individually, using the relative biomass of the harvested invader species.

When the MRPP indicated that differences in invader composition existed amongst the treatments, we performed a nonmetric multidimensional scaling (NMDS) (McCune and Grace, 2002) ordination, using the relative invader biomass of each species. This was done to determine which invader species were driving differences amongst treatments. Each site was ordinated separately, using both harvest times in each ordination.

Transplant Sub-Plots

Aboveground biomass

Because we collected the aboveground biomass of the transplants at both sites, we could compare the effects of site upon the seedlings. Aboveground biomass (aboveground biomass of all surviving transplants of one species) of each species was *ln*(y+1)-transformed to improve normality. We then performed two-way (site x treatment) repeated measures ANOVA on the *ln*-transformed aboveground seedling biomass. Also using aboveground biomass, we analyzed species diversity (Simpson's Diversity = $1/\Sigma p_i^2$) of the transplant communities using transplant biomass. In 2004, two subplots from the Ames site were lost (an *E. canadensis* and a *B. curtipendula* subplot), while in 2005 a control plot at the Castana site was lost; both sub-plots from these plots were therefore dropped from all transplant analyses.

Tests for species composition differences

We used several measurements for differences in species composition among transplants. We first used a multi-response permutation procedure (MRPP) to test for differences in species composition among treatments using relative total biomass of the transplants. Total transplant species biomass per sub-plot was calculated using the following formula:

Total Biomass = (Aboveground biomass) + [(# surviving transplants) * (belowground biomass of transplant)]

Because the belowground biomass of seedlings was collected differently at each site, we analyzed the sites separately.

Second, we analyzed the functional group community composition and how it changed over time. We found the relative biomass of each transplant species, separated the species into grassland functional groups, and rank-transformed the functional groups to maintain normality. We then performed repeated measures ANOVA on the rank-transformed grassland functional group BIOMASS for each site separately, as root biomass was collected differently at each site.

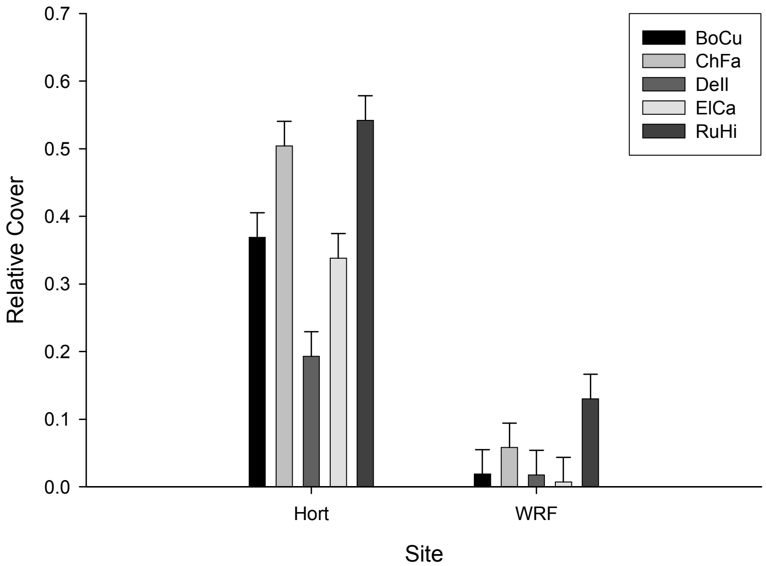

Figure 3: Relative cover of early-emerging species in 2004 at Ames, Iowa (high productivity) and Castana, Iowa (low productivity). BoCu = *Bouteloua curtipendula*, ChFa = *Chamaecrista fasciculata*, DeIl = *Desmanthus illinoensis*, ElCa = *Elymus canadensis*, and RuHi = *Rudbeckia hirta.*

Results

Main Plots—Effect of early emerging species on invaders

Early-emerging species establishment and biomass

We found differences between sites in early-emergings species relative cover (Figure 3). In the July 2004 relative cover sample, relative cover of treatment species was significantly higher at the Ames site (Figure 3, $p < 0.05$). There were also significant differences in the relative cover among the early-emerging species at the Ames site (Table 3). The two annual/biennial treatments, *C. fasciculata* and *R. hirta*, possessed higher relative covers than the three perennial treatments in Ames (Figure 3). *C. fasciculata* had an average relative cover of 66%, while *R. hirta* had an average of 72%. Average cover of the other three treatment species ranged from 23-46%

Table 3: Results of two-way (site x treatment) ANOVAs (F values) of relative cover and biomass of early-emerging treatment species. "df" is degrees of freedom for each class.

	df	Relative Cover 2004		df	Relative Biomass 2005
Site	1	224.30***	Site	1	4.40*
Treatment	4	12.68***	Treatment	4	11.38**
Site x Treatment	4	4.16**	Site x Treatment	4	2.74*
Slice			Error	50	
Ames	4	14.88***	Time	1	0.05
Castana	4	0.12	Time x Site	1	0.16
Error	59		Time x Treatment	4	13.10***
			Time x Site x Treatment	4	2.25
			Error	50	

* = $p < 0.05$
** = $p < 0.01$
*** = $p < 0.001$

In 2005, relative biomass of the early-emerging species significantly differed between sites and among treatments, with a significant site x treatment interaction (Table 3). *R. hirta* showed marked decreases in relative biomass from June to August at both sites. The relative biomass of this species peaked early in the growing season, with average relative biomasses of 43% and 53% at Ames and Castana, respectively. At the Castana site, the other treatment species showed increases in relative biomass over time. The treatment *B. curtipendula* showed the greatest increases in relative biomass, from 5% in June to 37% in August.

At the Ames site, *B. curtipendula* and *C. fasciculata* significantly (Table 4) decreased in relative biomass from September 2004 (55% and 77%, respectively) to August 2005 (28% and 3%, respectively), while the other treatments showed no significant changes over time.

Table 4: Results of a one-way repeated measures ANOVA (F values) of the relative biomass of the early-emerging species treatments at the Ames site, from September 2004, June 2005, and August 2005 biomass clips. "df" is degrees of freedom for each class.

	df	Treatment Biomass
Treatment	4	1.70
Error	25	
Contrasts		
Legume vs others	1	4.29*
Forb vs others	1	0.05
C_3 grass vs others	1	0.00
C_4 grass vs others	1	5.11*
Time	1	73.27***
Time x Treatment	4	9.10***
Time x Contrasts		
Legume vs others	2	3.95*
Forb vs others	2	2.96
C_3 grass vs others	2	0.64
C_4 grass vs others	2	10.97***
Error	50	

* = $p < 0.05$
** = $p < 0.01$
*** = $p < 0.001$

Composition of invaders at the Ames site, 2004

Species treatments varied in their amount of invader biomass accumulation, but trends were not always consistent with Fox's assembly rule. We found that C_3 graminoids were significantly higher within the C_3 treatment, *E. canadensis* (contrast $p < 0.05$). C_3 graminoid invaders were also significantly lower within the forb treatment, *R. hirta* (contrast $p < 0.001$). *E.*

canadensis also contained more C_4 graminoids than than other treatments (contrast $p < 0.05$). No other contrasts were found to be significant.

Within the annual/biennial and perennial functional group sets, perennial treatments contained significantly higher amounts of perennial invaders (contrast $p < 0.001$) than annual/biennial treatments. Annual/biennial invasion was not significantly different among treatments. Additionally, perennial treatments contained more invader biomass than annual/biennial treatments (Figure 4).

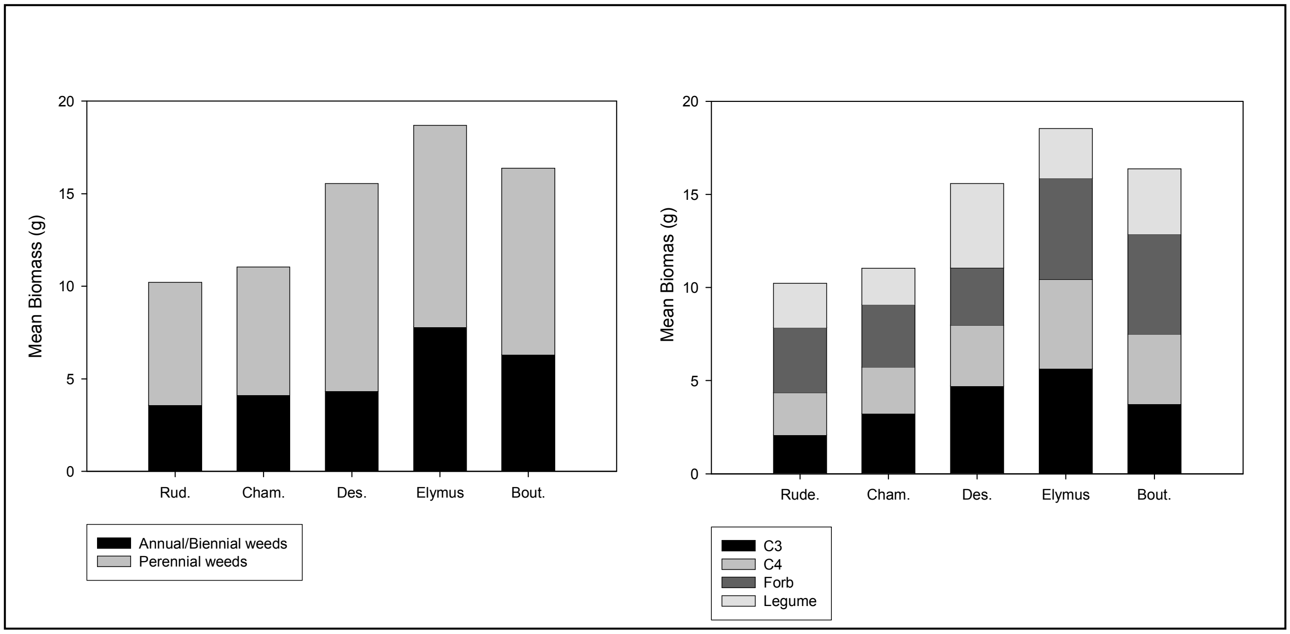

Figure 4: Invader biomass in plots at the Ames site in 2004. *Rudbeckia hirta* (Rude) and *Chamaecrista fasciculata* (Cham) had fewer invaders than did the other cover crop species (Des = *Desmanthus illinoensis*, Elymus = *Elymus canadensis*, Bout = *Bouteloua curtipendula*). Invaders were categorized based on their functional grouping (annuals-biennials vs. perennials in the left panel, and cool season (C3), warm season (C4) grasses, forbs and legumes in the right panel).

The biomass of the early-emerging species was an important predictor of invader biomass. Because biomass is correlated with light, water, and nutrient uptake, we performed an ANCOVA that included the biomass of the early-emerging species treatment. Biomass of invaders decreased as early-emerging species biomass increased (Figure 5). After we accounted for biomass of the early-emerging species, there was no other effect of early-emerging species.

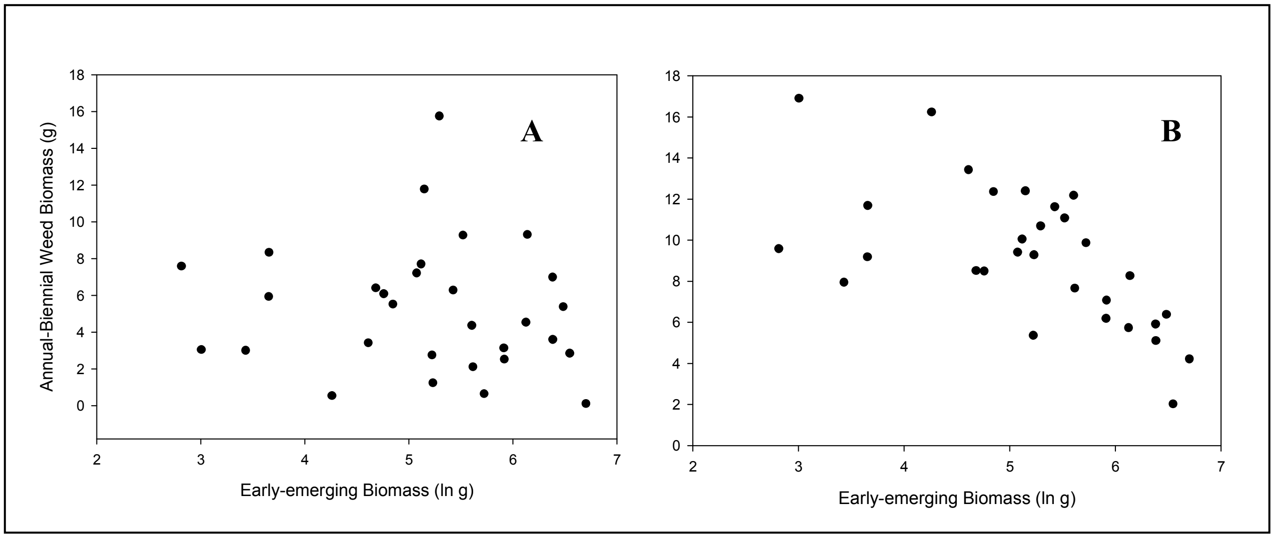

Figure 5: Early-emerging species biomass versus (A) annual-biennial invaders ($r^2 = 0.22$, $p < 0.55$) and (B) perennial invaders ($r^2 = 0.50$, $p < 0.01$) at the Ames site in 2004. Perennial invader biomass was negatively correlated with early-emerging species biomass, while annual-biennial invader biomass was not significantly correlated.

Composition of invaders at Ames and Castana, 2005

The MRPP analysis of the Ames site 2005 relative invader biomass indicated significant differences in composition among treatments for both collection periods (June A = 0.08, $p <$ 0.02; August A = 0.10, $p < 0.01$). Treatments at the Castana site were not significantly different for either collection time (June A = -0.07, $p < 0.94$; August A = -0.03, $p < 0.93$).

The NMDS ordination of the Ames 2005 biomass data showed that differences in community compositions were strongly driven by *B. inermis*, an exotic perennial C_3 grass, and *Coronilla varia*, an exotic perennial legume (Figure 6). The ordination graph indicates that *B.*

inermis and *C. varia* tend to be negatively correlated, such that treatments with high *B. inermis* content tend to have low *C. varia* biomass, and vice versa. *E. canadensis* treatments tended towards high *B. inermis* biomass and low *C. varia* biomass, whereas *C. fasciculata* treatments tended otherwise (Figure 6). Where neither species were abundant, the ordination indicated that treatment plots contained higher amounts of the native annual forb *Artemisia artemisiifolia*, the exotic annual C4 grass *Setaria glauca*, and the native annual forb *Polygonum ramosissimum* (Figure 6). Control plots tended to have low relative biomasses of both *B. inermis* and *C. varia*.

At the Castana site, the biomasses of *B. inermis* and the exotic perennial legumes *Trifolium pratense* and *T. repens* were negatively correlated (Figure 7). Plots containing lower relative biomasses of the above species either contained more of the exotic legume *Melilotus spp*, or the native annual forb, *Conyza canadensis*. However, none of the treatments appeared to group strongly along the above species' axises. (Figure 7).

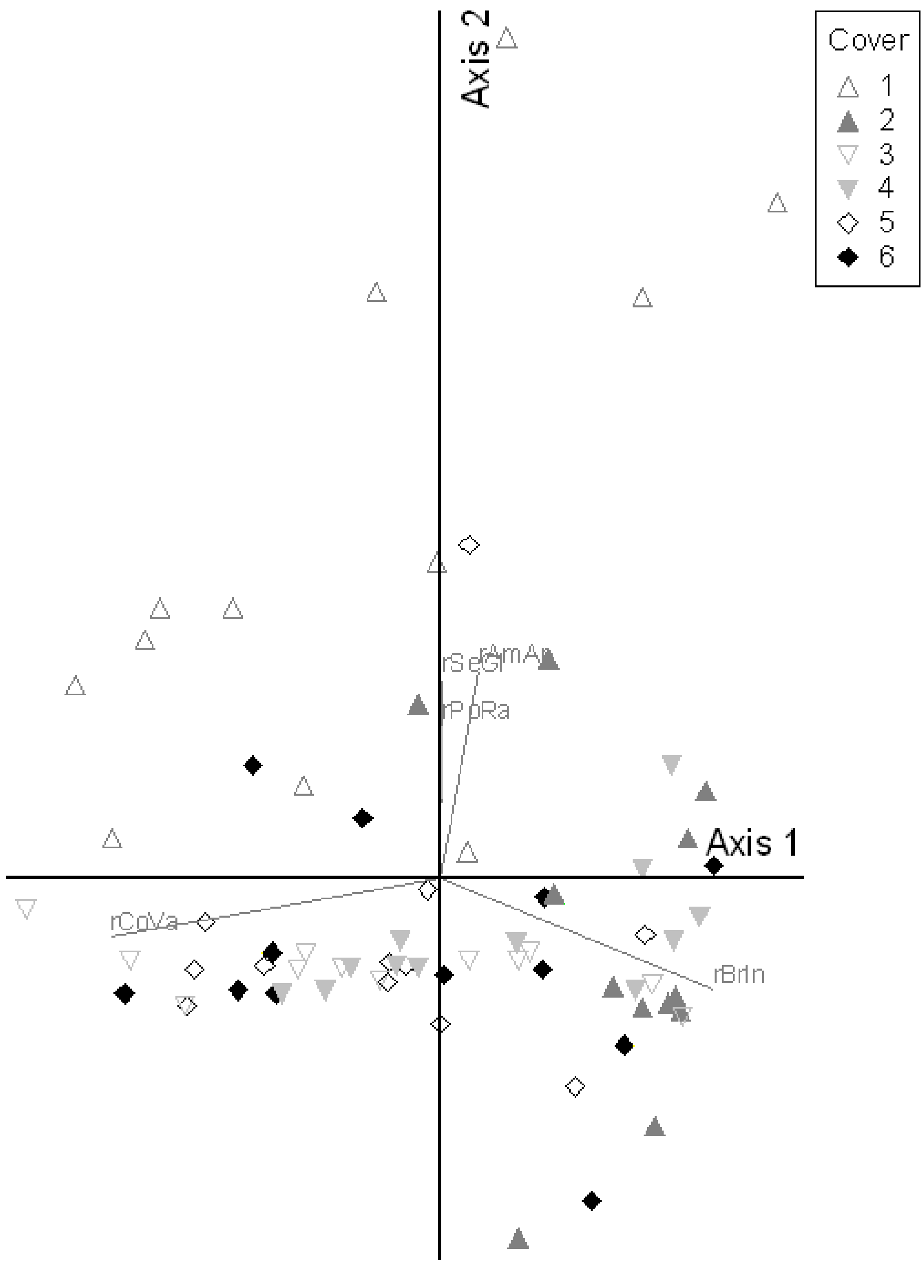

Figure 6: NMDS ordination of relative invader biomass of the Ames site June and August 2005 biomass clips. Open triangles (1) are Control plots; closed triangles (2) are *E. canadensis*; open upside-down triangles (3) are *C. fasciculata*; closed upside-down triangles (4) are *D. illinoensis*; open diamonds (5) are *R. hirta*; and closed diamonds (6) are *B. curtipendula*. The species on the ordination axises are: BrIn = *Bromus inermis*, CoVa = *Coronilla varia*, AmAr = *Ambrosia artemsiifolia*, SeGl = *Setaria glauca*, and PoRa = *Polygonum ramosissium*.

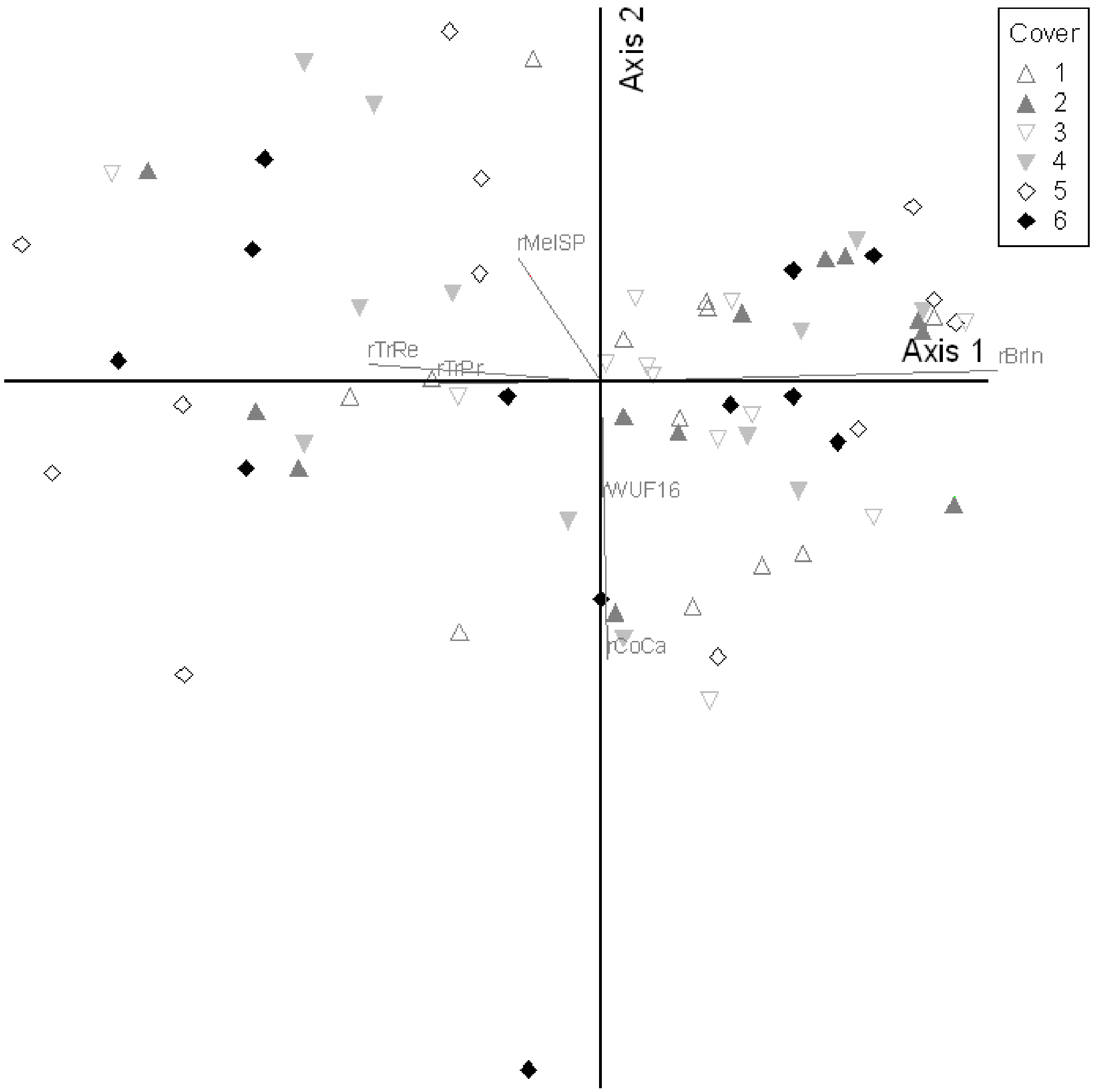

Figure 7: NMDS ordination of relative invader biomass of the Castana site June and August 2005 biomass clips. Open triangles (1) are Control plots; closed triangles (2) are *E. canadensis*; open upside-down triangles (3) are *C. fasciculata*; closed upside-down triangles (4) are *D. illinoensis*; open diamonds (5) are *R. hirta*; and closed diamonds (6) are *B. curtipendula*. The species on the ordination axises are: BrIn = *Bromus inermis*, CoCa = *Conyza canadensis*, TrPr = *Trifolium pratense*, TrRe = *Trifolium repens*, MelSP = *Melilotus spp*, and WUF16 = Unknown Castana forb.

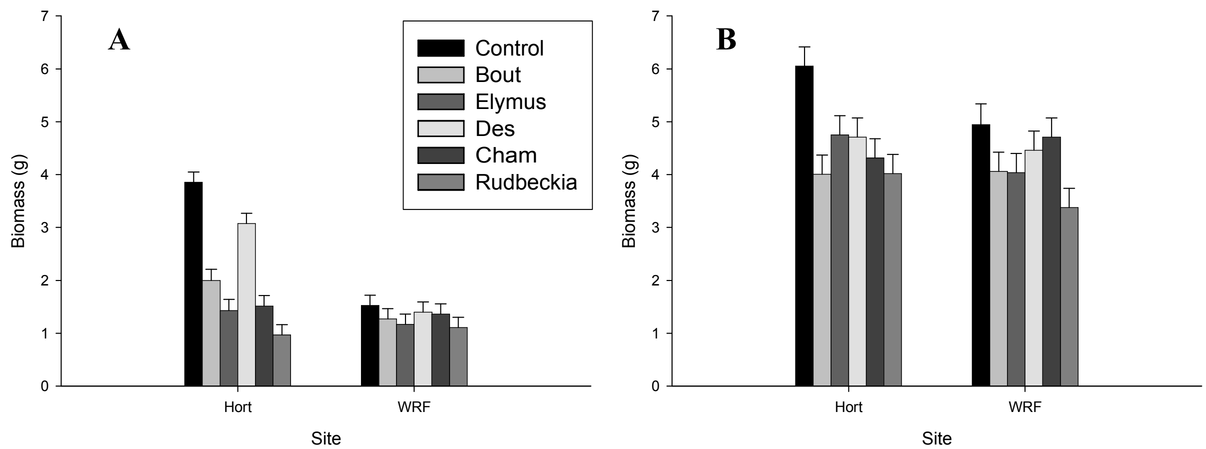

Figure 8: Mean *ln*(y+1) aboveground biomass of prairie transplants, collected October 2004 (A) and September 2005 (B) at Ames, Iowa (Hort), and November 2004 (A) and October 2005 (B) at Castana, Iowa (WRF).

Transplant Sub-Plots

Aboveground biomass of target seedlings

Aboveground biomass of the transplants (Fig. 8) increased significantly (Table 5) from year 1 to year 2 as plants fully established. Transplant aboveground biomass differed significantly between sites, with the Ames site possessing higher aboveground transplant biomass (Figure 8). At the Ames site there was a significant effect of early-emerging species presence ($p < 0.001$ for both years), indicating that early-emerging species were competing with the late-emerging target species. Control and Leguminous forb treatments had significantly higher aboveground transplant biomasses, while the Forb (*R. hirta*) treatment had significantly lower aboveground transplant biomass in Ames (Table 5). There was no effect of early-emergings species presence at the Castana site, indicating that early-emerging species were neither competing with or facilitating late-emerging species at this site.

Table 5: Results of two-way (site x treatment) repeated measures ANOVAs (F values) using *ln*+1 transformed total transplant aboveground biomass, and Simpson's diversity using *ln*+1 transformed transplant biomass. "df" is degrees of freedom for each class.

	df	Total Aboveground Biomas	Diversity
Site	1	33.84***	42.61***
Treatment	5	12.65***	4.69***
Contrasts			
Legumes vs others	1	14.37***	4.86*
Forbs vs others	1	14.82***	3.60
C_3 grass vs others	1	0.21	3.99
C_4 grass vs others	1	0.12	1.44
Control vs others	1	38.88***	10.44**
Site x Treatment	5	5.27***	3.42**
Error	57		
Time	1	584.19***	294.64***
Time x Site	1	4.13*	39.89***
Time x Treatment	5	1.02	2.62*
Time x Contrasts			
Legumes vs others	1	0.00	3.23
Forbs vs others	1	0.07	3.67
C_3 grass vs others	1	1.49	3.76
C_4 grass vs others	1	0.84	2.72
Control vs others	1	0.07	0.50
Time x Site x Treatment	5	2.78*	2.77*
Error	57		

* = $p < 0.05$
** = $p < 0.01$
*** = $p < 0.001$

Transplant species diversity also showed a site x treatment interaction (Table 5). This treatment effect was significant at only the Ames site for both years ($p < 0.001$). Ames Control and *D. illinoensis* plots resulted in significantly higher transplant diversity (Figure 9); however, this effect did not persist in the *D. illinoensis* plots. Transplant diversity generally increased between years among the other treatments.

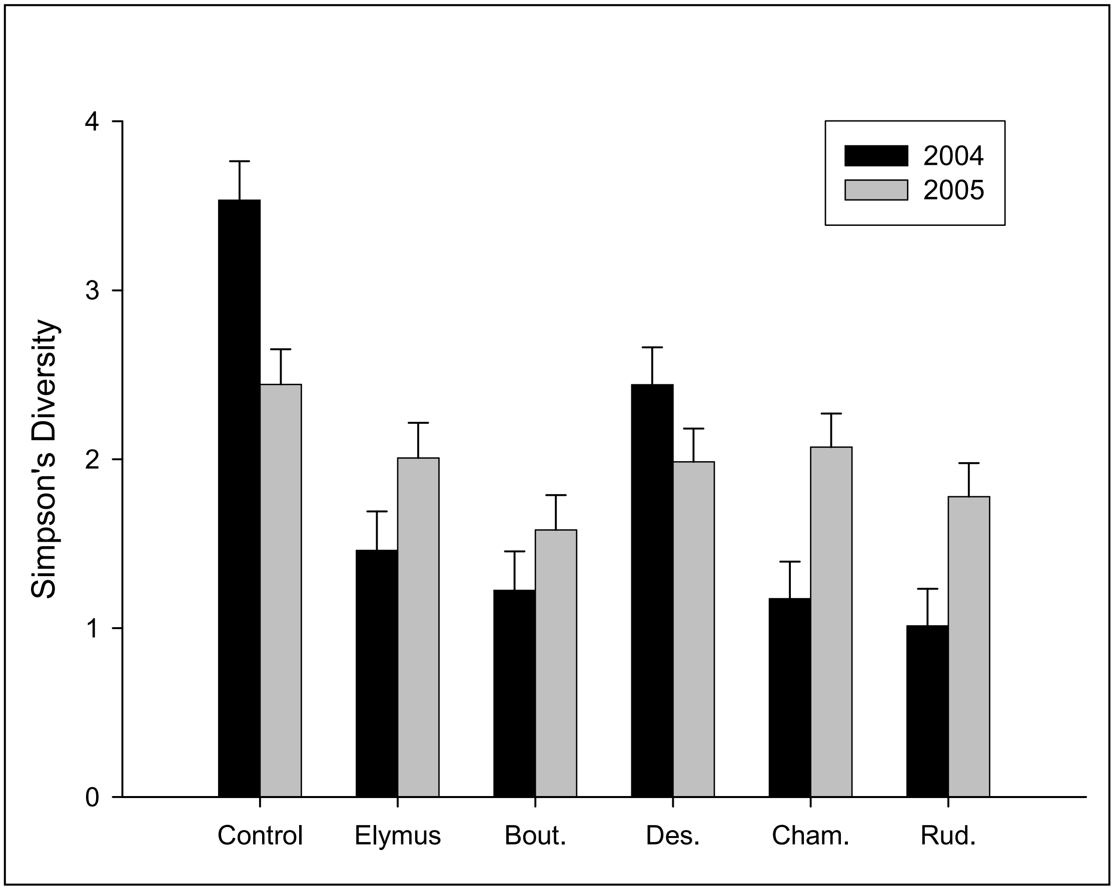

Figure 9: The effect of early-emerging species on transplant diversity (Simpson's Index) at the Ames site in 2004 (black bars) and 2005 (gray bars). Elymus = *Elymus canadensis*, Bout. = *Bouteloua curtipendula*, Des. = *Desmanthus illinoensis*, Cham. = *Chamaecrista fascicultata*, Rud. = *Rudbeckia hirta*.

Transplant species composition

There were no differences in species composition among treatments (MRPP, $p > 0.05$) The MRPP analyses of the relative total transplant biomass by site and time showed no significant differences in species composition (Figure 10).

Rankings of the functional group biomasses at the Ames site showed significant differences among all functional groups amongst treatments (Table 6). Except for the Forb transplants however, these differences were driven solely by the Control treatments, where all functional groups had the highest rankings. The Forb transplants had significantly higher rankings in the Leguminous Forb treatments (particularily *D. illinoensis*), and significantly lower rankings in the Forb treatment. At the Castana site, we found no significant differences among treatments for any of the functional groups (Table 7).

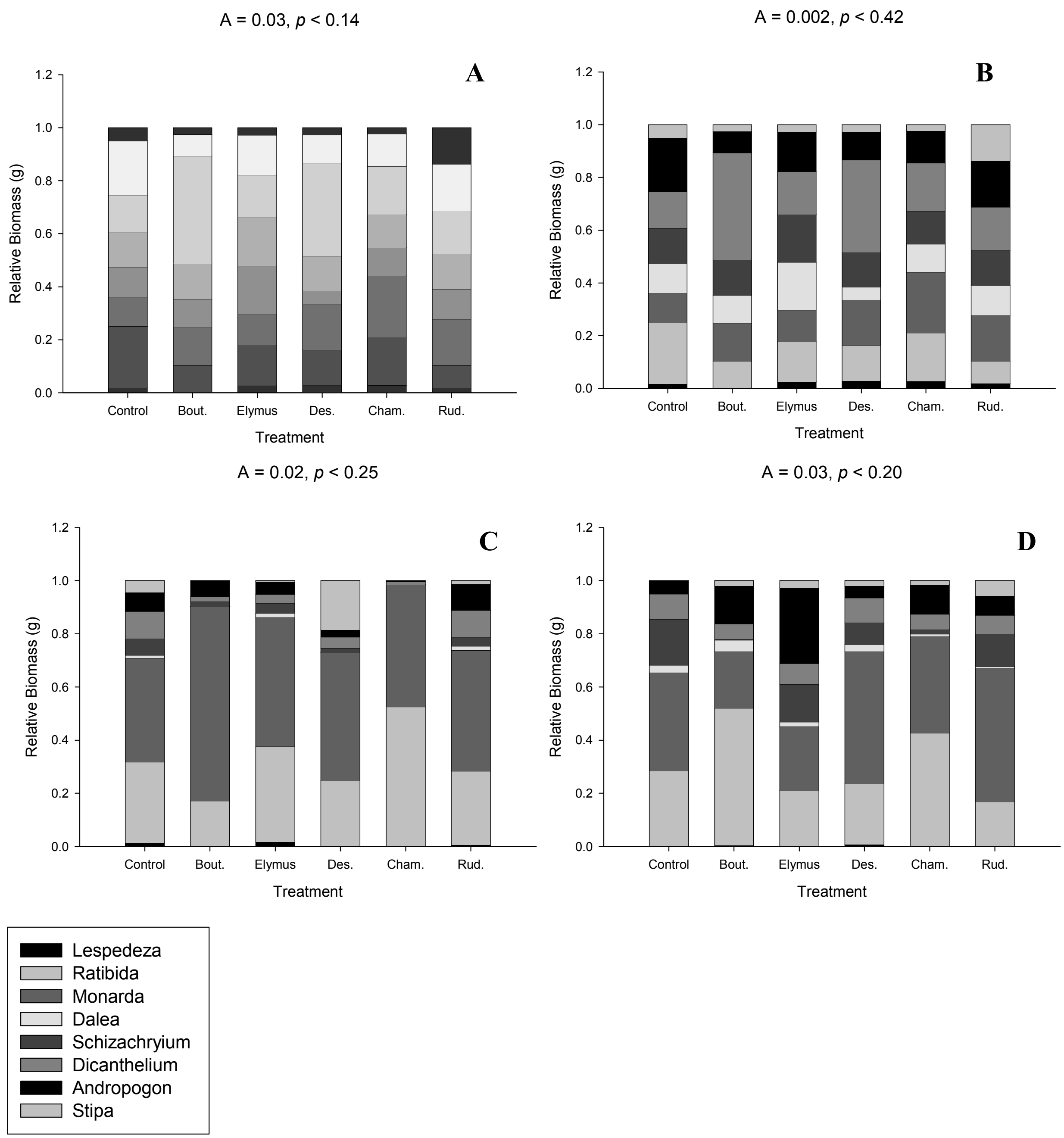

Figure 10: Results of multi-response permutation procedures on the relative total biomass of transplants by species, in Ames 2004 (A), Castana 2004 (B), Ames 2005 (C), and Castana 2005 (D). Treatments are Control, Bout. = *Bouteloua curtipendula*, Elymus = *Elymus canadensis*, Des. = *Desmanthus illinoensis*, Cham. = *Chamaecrista fasciculata*, and Rud. = *Rudbeckia hirta*.

Table 6: Results of a one-way repeated measures ANOVA (F values) using ranked total (above and belowground) biomass of transplant functional groups at the Ames site (high productivity site). "df" is degrees of freedom for each class.

	df	C_4 grass *B.curtipendula*	C_3 grass *E.canadensis*	Legume *C.fasciculata* *D.illinoensis*	Forb *R.hirta*
Treatment	5	13.28***	10.53***	5.42**	9.42**
Contrasts					
Legumes vs others	1	0.92	1.97	0.92	6.98*
Forbs vs others	1	0.41	0.77	0.35	13.10**
C_3 grass vs others	1	1.98	0.98	0.36	0.00
C_4 grass vs others	1	0.09	3.25	0.00	0.09
Control vs others	1	43.03***	31.25***	20.43***	27.86***
Error	29				
Time	1	0.07	0.03	0.16	0.06
Time x Treatment	5	2.62*	1.64	4.13**	2.77*
Time x Contrasts					
Legumes vs others	1	4.04	2.33	10.61**	3.76
Forbs vs others	1	5.57*	5.28*	10.60**	1.13
C_3 grass vs others	1	3.04	0.31	4.30*	7.13*
C_4 grass vs others	1	2.60	0.34	1.76	1.99
Control vs others	1	0.01	1.09	0.00	0.20
Error	29				

* = $p < 0.05$
** = $p < 0.01$
*** = $p < 0.001$

Table 7: Results of a one-way repeated measures ANOVA (F values) using ranked total (above and belowground) biomass of transplant functional groups at the Castana site (low productivity site). "df" is degrees of freedom for each class.

	df	C_4 grass *B.curtipendula*	C_3 grass *E.canadensis*	Legume *C.fasciculata* *D.illinoensis*	Forb *R.hirta*
Treatment	5	2.30	0.77	1.79	1.35
Contrasts					
Legumes vs others	1	1.62	3.38	0.64	3.46
Forbs vs others	1	2.60	1.12	5.11*	0.92
C_3 grass vs others	1	1.26	0.58	4.50*	0.92
C_4 grass vs others	1	1.14	0.18	0.70	0.26
Control vs others	1	5.31*	0.11	0.14	2.93
Error 29					
Time 1	0.16	0.04	0.00	0.04	
Time x Treatment	5	0.40	0.42	0.74	0.17
Time x Contrasts					
Legumes vs others	1	0.06	0.07	0.68	0.37
Forbs vs others	1	0.34	0.15	0.10	0.53
C_3 grass vs others	1	0.74	0.83	0.54	0.10
C_4 grass vs others	1	0.00	0.72	0.00`	0.09
Control vs others	1	0.88	0.08	1.59	0.06
Error 29					

* = $p < 0.05$
** = $p < 0.01$
*** = $p < 0.001$

Discussion

The results of the transplant experiment show that competition did take place between prairie plants, and that competition was strongest at the high productivity site. Moreover, the interactions at the low productivity site tended to be more neutral.

Early-emerging species also competed more strongly at the seedling stage of the transplants, with differences largely disappearing by the end of the second growing season. This suggests that once an invading species survives the seedling establishment phase, early-emerging species have few long-term effects on the survival and growth of the invader. Although our experiment studied the invasion of native species into a native-dominated community, our data are similar to those of Yurkonis et al. (2005), who found that exotic species extirpated native species by limiting their seedling recruitment and not by out-competing adult native plants. In both cases, invasion appears to be limited by seedling recruitment, prevented by adult plants in the communities.

While neutral theory (Hubbell 2005) predicts that plant species are equivalent in traits such as biomass or resource capture, our findings show that plant species are not equivalent. Using biomass as a surrogate for resource capture and timing of growth, we found significant differences among the early-emerging species in relation to peak biomass and timing of the peak growth period in 2005. Similarly, Hooper and Vitousek (1997) and Hooper (1998) demonstrated that California serpentine grassland species differed greatly in their germination, period of peak growth, and seed set. Fargione and Tilman (2005) showed that a prairie C_4 grass, *S. scoparium,* differed from other grassland species in rooting depth and phenology. Zavaleta and Hulvey

(2004) and Losure et al. (2006) have shown that timing of growth matters greatly to invader suppression.

The identity of the early-emerging species also affected invader colonization and composition, but this occurred only at the high productivity site. This implies that highly productive communities are structured more by competition than by the abiotic environment, as described in the theoretical paper by Chase (2003). Highly productive communities are predicted to be more strongly shaped by community assembly rules, suggesting that assembly rules could be found operating at the Ames site.

The transplant and biomass data show mixed support for Fox's assembly rule. Although at the Ames site the forb transplants did support this assembly rule to some extent, the other transplants did not conform to the rule. Analysis of the 2004 Ames invader biomass data using the grassland functional group set revealed that both C_3 and C_4 graminoid invaders preferentially invaded the *E. canadensis* (C_3 grass) treatment. One reason that the graminoids were able to invade may be due a combination of their relative tolerance for shade in comparison to other functional groups, and the high litter production of *E. canadensis*. This combination of traits would tend to favor invasion by graminoids.

Results from the 2004 invader analysis using the longevity functional groups showed no support for Fox's assembly rule. Annual-biennial early-emerging species had greater suppression of perennial invaders than did perennial treatments. Our data support the niche theory of succession put forth by Pacala and Rees (1998), where annual and biennial species dominate early successional communities due to their specialization for the abiotic conditions of early succession. The high biomasses of the annual-biennial treatment species show that they were better competitors for resources than their perennial invaders. Conversely, the lower biomasses typical of the perennial treatments indicate that more resources were available to invaders in these communities, allowing for more invasion by the less competitive (in comparison to annual-biennial species) perennial invaders.

Although community members did regulate the identity of colonizing species, our results do not fully conform to Fox's assembly rule. Von Holle and Simberloff (2003) also found mixed support for Fox's assembly rule in an experimental riparian forest restoration. Although Fargione et al. (2003) found evidence for Fox's assembly rule in a prairie restoration, disagreements in our findings may stem from several major differences between their experiment and ours, such as age of the restoration at sampling period (10+ years in the Fargione study, 1-2 years for our study), timing of seed addition (mid-season versus spring), and soil types (sand versus clay loams and loess).

Use of early-emerging species as cover crops

A successful cover crop should either directly facilitate native species growth through the amelioration of the harsh abiotic conditions of bare ground or have the ability to suppress non-planted species invasion, thereby indirectly encouraging native species recruitment (Figure 1). The seedling transplant study found that early-emerging species do not facilitate the growth of established late-emerging prairie species. Competitive interactions were strong at the Ames (high productivity) site during the initial year of establishment. However, once transplants were fully established in the plots (year 2), differences in transplant biomass between the controls and treatments were smaller. These data suggest that at high productivity sites, the presence of an early-emerging species cover crop would not have long-term negative effects on adult later-emerging species once they became established. At the Castana (low productivity) site, early- and late-emerging species experienced little to no competition or facilitation, suggesting that communities at that site are structured more strongly by the abiotic environment (Chase 2003).

Unwanted species invasion can be a serious problem in restorations, as the invaders out-compete the target species and dominate the restoration. Some of the early-emerging species tested suppress invasion more than others. The annual and biennial treatments, *C. fasciculata* and *R. hirta*, respectively, had lower total invader biomass than the perennial treatments. If a reduction in invader biomass is all that is desired, planting an annual or biennial cover crop is suggested. However, because the tested annual and biennial species did not persist over time (personal observations), the native perennial species would have to invade early for the restoration to be successful. Therefore, the ability to regulate the identity of the invading species, and the timing of their invasion, are more useful than mere invader biomass suppression.

As noted above, the most dramatic patterns of suppression were found using the longevity-based functional group set. In addition to suppressing perennial invaders, the annual and biennial cover crops could also impede invasion by native perennial species, thus slowing down the restoration. Perennial crops could have the opposite effect and allow native perennial invasions. Because annual and biennial invader biomass was not influenced by treatment identity, it may be impractical to use cover crops to prevent annual and biennial species invasion.

Furthermore, our data suggest that perennial invaders, and not annual-biennial invaders, may pose the greatest threats to restorations in a perennial grassland system. At the Ames site, the restoration communites tended to contain high relative biomass of either one of the exotic perennials, *C. varia*, a legume, or the C_3 grass *B. inermis*. At the Castana site, communities were strongly associated with *B. inermis*, and the exotic perennial legumes *Medicago lupulina*, *Trifolium pratense*, and *T. repens*. Although *Melilotus spp.* does not make up a significant proportion of the biomass, the other species attain average relative biomasses (including the treatment species) of 10-57 %. Such community dominance by exotic species could prevent native seedlings from invading the community, as demonstrated by Yurkonis et al. (2005).

Although native cover crops do suppress invasion, and do compete to some extent with established later-emerging native species, whether they negatively affect native perennial seedling establishment remains an important unanswered question. This can be tested with longer-term data.

Conclusions

Our study of the invader species composition yielded several important results. First, early divergences in community composition appear to depend on the productivity of the site. However, plots at the high productivity site may eventually converge on one community composition as the early-emerging species disappear; this will be tested with longer-term data. If they do eventually converge, we would learn that periodic disturbances could be important to the maintenance of high β-diversity in the tallgrass prairie ecosystem. Prescribed fires are commonly used in prairie restorations, and it is not quite known how fire will affect the early-emerging species dominance for either productivity level. Regular disturbance regimes may even counteract the tendencies of low productivity sites to converge upon a single community.

Secondly, the main plot study revealed that while plant traits do regulate invader identity, such regulation does not explicitly follow Fox's assembly rule, and some traits appear to be stronger community regulators than others. Longevity of a species and time of peak growth (Losure 2006, Polley et al. 2006, Fargione and Tilman 2005) may be the coarsest trait 'filters' of tallgrass community regulation, while other traits act as finer filters.

The overall implications of our experiments for tallgrass prairie restorations would be that high productivity sites may be easier and faster to restore than low productivity sites. Also, perennial species are more likely to cause problems in the long run than annual-biennial species, particularly the perennial exotics *B. inermis* and *C. varia*. Evidence from Losure (2006) suggests that *C. varia* is exceptionally difficult to eradicate once it has become established in a community.

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APPENDIX. LIST OF ALL SPECIES, RELATIVE BIOMASSES, RELATIVE FREQUENCY IN PLOTS, AND TOTAL MEAN BIOMASS (50 x 50 cm quadrat)

Appendix.

Ames Site, September 2004		*Bouteloua*		*Elymus*		*Desmanthus*		*Chamaecrista*	
Species Name	Abbreviation	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency
Ambrosia artemsiifolia	AmAr	0	0.0	0.035	0.5	0.0003	0.2	0	0.0
Andropogon gerardii	AnGe	0.0005	0.2	0	0.0	0	0.0	0	0.0
Aster pilosus	AsPi	0	0.0	0.004	0.2	0	0.0	0	0.0
Bromus inermis	BrIn	0.12	1.0	0.149	1.0	0.166	1.0	0.069	1.0
Carex spp	CarexSP	0	0.0	0.002	0.3	<0.0001	0.2	0	0.0
Chenopodium alba	ChAl	0.003	0.2	0.0007	0.2	0.0003	0.2	0	0.0
Cirsium arvense	CiAr	0	0.0	0.0001	0.2	0	0.0	0	0.0
Cirsium vulgare	CiVu	0	0.0	0.011	0.2	0	0.0	0	0.0
Convolvulus arvensis	CoAr	0.01	0.2	0.001	0.2	0	0.0	0.002	0.3
Conyza canadensis	CoCa	0.0002	0.2	0	0.0	0.018	0.3	0	0.0
Coronilla varia	CoVa	0.042	0.8	0.007	0.5	0.097	0.7	0.032	0.7
Dicanthelium oligosanthes	DiOl	0	0.0	0.02	0.2	0	0.0	0	0.0
Digitaria ischaemum	DiIs	0.004	0.2	0.035	0.5	0.0009	0.2	0.003	0.2
Elymus repens	ElRe	0	0.0	0.012	0.2	0.0005	0.2	0	0.0
Euphorbia dentata	EuDe	0	0.0	0.0002	0.2	0	0.0	0	0.0
Euphorbia supina	EuSu	0.0003	0.3	0.0001	0.2	0.002	0.3	0	0.0
Lactuca ludoviciana	LaLu	0	0.0	0	0.0	0	0.0	0.001	0.2
Lactuca sp.	LactucaSP	0	0.0	0	0.0	0	0.0	0.0002	0.2
Medicago lupulina	MeLu	0.011	0.5	0.024	0.8	0.002	0.3	0.001	0.3
Melilotus spp.	MelilotusSP	0	0.0	0	0.0	0	0.0	0.004	0.2
Muhlenbergia schreberi	MuSc	0	0.0	0	0.0	0.0007	0.3	0.0001	0.2
Oxalis stricta	OxSt	0.004	0.8	0.007	0.8	0.006	0.7	0.001	0.7
Panicum capillare	PaCa	0.09	0.8	0.077	0.8	0.186	0.8	0.032	0.8
Parthenocissus quinquefolia	PaQu	0.004	0.2	0	0.0	0	0.0	0	0.0
Phalaris arundinacea	PhAr	0.012	0.2	0	0.0	0.022	0.3	0.011	0.2
Physalis heterophylla	PhHe	0	0.0	0.003	0.2	0	0.0	0	0.0
Physalis virginiana	PhVi	0.004	0.5	0.005	0.3	0.007	0.2	0.007	0.7
Plantago major	PlMa	0.001	0.2	0.009	0.3	0.037	0.5	0.0009	0.3
Poa pratensis	PoPr	0.002	0.2	0.007	0.3	0.002	0.8	0.001	0.5
Polygonum convolvulus	PoCo	0	0.0	0	0.0	0.002	0.2	0	0.0
Polygonum pensylvanicum	PoPe	0	0.0	0.015	0.2	0	0.0	0	0.0
Portulaca olecera	PoOl	0	0.0	0.0008	0.2	0.01	0.2	0	0.0
Setaria glauca	SeGl	0.029	0.5	0.059	0.7	0.073	0.3	0.061	0.5

Appendix. (continued)

Ames Site, September 2004

Species Name	Abbreviation	Bouteloua Relative Biomass	Bouteloua Relative Frequency	Elymus Relative Biomass	Elymus Relative Frequency	Desmanthus Relative Biomass	Desmanthus Relative Frequency	Chamaecrista Relative Biomass	Chamaecrista Relative Frequency
Solanum nigrum	SoNi	0	0.0	0.0008	0.2	0	0.0	0.003	0.2
Solidago rigida	SoRi	0	0.0	0.002	0.2	0	0.0	0	0.0
Taraxacum officinale	TaOf	0.001	0.2	0.0004	0.2	0.001	0.3	<0.0001	0.2
Trifolium pratense	TrPr	0	0.0	0	0.0	0.012	0.2	0	0.0
Trifolium repens	TrRe	0.041	0.5	0.04	0.5	0.094	0.5	0.004	0.5
Verbascum thapsus	VeTh	0.048	0.5	0	0.0	0.0001	0.2	0.014	0.3
Viola pratincola	ViPr	0.001	0.2	0	0.0	0.003	0.2	0.001	0.2
Unknown Grass	UnG22	0	0.0	0	0.0	0	0.0	<0.0001	0.2
Unknown Forb	UnF18	0	0.0	0	0.0	0.0001	0.2	0	0.0
Unknown Forb	UnF27	0	0.0	0	0.0	0	0.0	0	0.0
Early-Emerging Species									
Elymus canadensis	ElCa	0	0.0	0.456	1.0	0	0.0	0	0.0
Bouteloua curtipendula	BoCu	0.55	1.0	0	0.0	0	0.0	0	0.0
Desmanthus illinoensis	DeIl	0	0.0	0	0.0	0.258	1.0	0	0.0
Chamaecrista fasciculata	ChFa	0	0.0	0	0.0	0	0.0	0.77	1.0
Rudbeckia hirta	RuHi	0	0.0	0	0.0	0	0.0	0	0.0
Prairie Mix Species									
Verbena stricta	VeSt	0.025	0.7	0.016	0.2	0	0.0	0	0.2
Total Mean Biomass (g)		102.96		106.64		94.15		167.74	

Appendix. (continued)

Ames Site, September 2004

Species Name	Abbreviation	*Rudbeckia* Relative Biomass	*Rudbeckia* Relative Frequency
Ambrosia artemsiifolia	AmAr	0	0.0
Andropogon gerardii	AnGe	0	0.0
Aster pilosus	AsPi	0	0.0
Bromus inermis	BrIn	0.021	1.0
Carex spp	CarexSP	0.0001	0.2
Chenopodium alba	ChAl	0	0.0
Cirsium arvense	CiAr	0	0.0
Cirsium vulgare	CiVu	0	0.0
Convolvulus arvensis	CoAr	0	0.0
Conyza canadensis	CoCa	0	0.0
Coronilla varia	CoVa	0.027	0.8
Dicanthelium oligosanthes	DiOl	0.013	0.3
Digitaria ischaemum	DiIs	0	0.0
Elymus repens	ElRe	0	0.0
Euphorbia dentata	EuDe	0	0.0
Euphorbia supina	EuSu	0	0.0
Lactuca ludoviciana	LaLu	0.001	0.2
Lactuca sp.	LactucaSP	0	0.0
Medicago lupulina	MeLu	0	0.0
Melilotus spp.	MelilotusSP	0	0.0
Muhlenbergia schreberi	MuSc	0	0.0
Oxalis stricta	OxSt	0.001	0.7
Panicum capillare	PaCa	0.067	1.0
Parthenocissus quinquefolia	PaQu	0	0.0
Phalaris arundinacea	PhAr	0	0.0
Physalis heterophylla	PhHe	0	0.0
Physalis virginiana	PhVi	0.002	0.5
Plantago major	PlMa	0.0001	0.2
Poa pratensis	PoPr	<0.0001	0.2
Polygonum convolvulus	PoCo	0	0.0
Polygonum pensylvanicum	PoPe	0	0.0
Portulaca olecera	PoOl	0	0.0
Setaria glauca	SeGl	0.005	0.2

Appendix. (continued)

Ames Site, September 2004		*Rudbeckia*	
Species Name	Abbreviation	Relative Biomass	Relative Frequency
Solanum nigrum	SoNi	0.0004	0.3
Solidago rigida	SoRi	0	0.0
Taraxacum officinale	TaOf	0	0.0
Trifolium pratense	TrPr	0.005	0.3
Trifolium repens	TrRe	0.001	0.7
Verbascum thapsus	VeTh	0.009	0.5
Viola pratincola	ViPr	0.0007	0.3
Unknown Grass	UnG22	0	0.0
Unknown Forb	UnF18	0	0.0
Unknown Forb	UnF27	0.0001	0.2
			0.0
Early-Emerging Species			
Elymus canadensis	ElCa	0	0.0
Bouteloua curtipendula	BoCu	0	0.0
Desmanthus illinoensis	DeIl	0	0.0
Chamaecrista fasciculata	ChFa	0	0.0
Rudbeckia hirta	RuHi	0.835	1.0
Prairie Mix Species			
Verbena stricta	VeSt	0.012	1.0
Total Mean Biomass (g)		125.56	

Appendix. (continued)

Ames site, June 2005 Species Name	Abbreviation	Control Relative Biomass	 Relative Frequency	*Bouteloua* Relative Biomass	 Relative Frequency	*Elymus* Relative Biomass	 Relative Frequency	*Desmanthus* Relative Biomass	 Relative Frequency
Ambrosia artemsiifolia	AmAr	0.107	0.2	0	0.0	0.0007	0.3	0	0.0
Andropogon gerardii	AnGe	0	0.0	0	0.0	0	0.0	0	0.0
Asclepias verticilliata	AsVe	0.019	0.2	0	0.0	0.0006	0.2	0	0.0
Aster pilosus	AsPi	0	0.0	0	0.0	0	0.0	0	0.0
Aster spp	AsterSP	0	0.0	0	0.0	0	0.0	0	0.0
Bromus inermis	BrIn	0.082	1.0	0.385	1.0	0.416	1.0	0.43	1.0
Carex spp	CarexSP	0.0004	0.2	0	0.0	0.006	0.2	0.0004	0.2
Capsella bursa-pastoris	CapBP	0.1	0.2	0	0.0	0	0.0	0	0.0
Chenopodium alba	ChAl	0.0001	0.2	0	0.0	0	0.0	0	0.0
Cirsium spp	Thistle	0	0.0	0	0.0	0	0.0	0	0.0
Cirsium arvense	CiAr	0	0.0	0	0.0	0	0.0	0	0.0
Cirsium vulgare	CiVu	0	0.0	0	0.0	0	0.0	0	0.0
Convolvulus arvensis	CoAr	0	0.0	0.015	0.2	0.005	0.2	0.0005	0.2
Conyza canadensis	CoCa	0.0002	0.2	0	0.0	0.0002	0.2	0.0001	0.3
Coronilla varia	CoVa	0.116	0.7	0.233	0.8	0.028	0.3	0.263	0.8
Dicanthelium oligosanthes	DiOl	0.086	0.2	0	0.0	0.097	0.2	0	0.0
Digitaria ischaemum	DiIs	0	0.0	0	0.0	0	0.0	0	0.0
Elymus repens	ElRe	0	0.0	0	0.0	0.011	0.2	0	0.0
Euphorbia dentata	EuDe	0	0.0	0	0.0	0	0.0	0	0.0
Euphorbia supina	EuSu	0	0.0	0	0.0	0	0.0	0	0.0
Euphorbia corollata	EuphSP	0	0.0	0	0.0	0	0.0	0	0.0
Festuca sp.	Fescue	0	0.0	0	0.0	0	0.0	0	0.0
Lactuca ludoviciana	LaLu	0	0.0	0	0.0	0	0.0	0	0.0
Lactuca sp.	LactucaSP	0	0.0	0	0.0	0	0.0	0	0.0
Medicago lupulina	MeLu	0.16	0.8	0.002	0.3	0.005	0.3	0.0002	0.2
Melilotus spp.	MelilotusSP	0	0.0	0	0.0	0	0.0	0	0.0
Muhlenbergia schreberi	MuSc	0	0.0	0	0.0	0.0001	0.2	0	0.0
Oxalis stricta	OxSt	0.046	0.7	0.0001	0.2	0	0.0	0	0.0
Panicum capillare	PaCa	0.0005	0.2	0	0.0	0	0.0	0	0.0
Parthenocissus quinquefolia	PaQu	0	0.0	0.005	0.2	0	0.0	0	0.0
Phalaris arundinacea	PhAr	0	0.0	0	0.0	0	0.0	0	0.0
Physalis heterophylla	PhHe	0	0.0	0	0.0	0	0.0	0.0001	0.2
Physalis virginiana	PhVi	0.006	0.3	0	0.0	0.002	0.2	0	0.0

Appendix. (continued)

Ames site, June 2005

Species Name	Abbreviation	Control		*Bouteloua*		*Elymus*		*Desmanthus*	
		Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency
Plantago major	PlMa	0.001	0.2	0	0.0	0.006	0.3	0.0008	0.2
Poa pratensis	PoPr	< 0.0001	0.2	0.008	0.3	0.014	0.7	0.008	0.5
Polygonum convolvulus	PoCo	0	0.0	0	0.0	0	0.0	0	0.0
Polygonum pensylvanicum	PoPe	0.0006	0.2	0	0.0	0	0.0	0	0.0
Polygonum ramosissimum	PoRa	0	0.0	0	0.0	0	0.0	0	0.0
Portulaca olecera	PoOl	0	0.0	0	0.0	0	0.0	0	0.0
Potentilla spp	Potent	0	0.0	0	0.0	0	0.0	0.001	0.2
Rumex crispus	RuCr	0	0.0	0	0.0	0	0.0	0.009	0.2
Setaria glauca	SeGl	0.026	0.5	0	0.0	0	0.0	0	0.0
Solanum carolinense	SoCa	0	0.0	0	0.0	0	0.0	0	0.0
Solanum nigrum	SoNi	0	0.0	0	0.0	0	0.0	0	0.0
Solidago rigida	SoRi	0	0.0	0	0.0	0	0.0	0	0.0
Sporobolus vaginiflorus	SpVa	0	0.0	0	0.0	0	0.0	0	0.0
Taraxacum officinale	TaOf	0.022	0.3	0.0001	0.2	0.002	0.5	0	0.0
Trifolium pratense	TrPr	0.003	0.2	0	0.0	0.0003	0.2	0.01	0.2
Trifolium repens	TrRe	0.032	0.2	0.096	0.3	0.147	0.3	0.172	0.5
Verbascum thapsus	VeTh	0.054	0.2	0.102	0.3	0	0.0	0	0.0
Viola pratincola	ViPr	0.023	0.5	0	0.0	0	0.0	0.007	0.2
Verbena alba	VeAl	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Forb	HUF35	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Grass	HUG12	0.013	0.2	0	0.0	0	0.0	0	0.0
Unknown Forb	HUF15	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Forb	HUF23	0	0.0	0	0.0	<0.0001	0.2	0	0.0
Unknown Grass	HUG27	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Grass	HUG14	0	0.0	0.001	0.2	0	0.0	0	0.0

Appendix. (continued)

Ames site, June 2005		Control		*Bouteloua*		*Elymus*		*Desmanthus*	
Species Name	Abbreviation	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency
Early-emerging Species									
Elymus canadensis	ElCa	0	0.0	0	0.0	0.239	1.0	0	0.0
Bouteloua curtipendula	BoCu	0	0.0	0.14	1.0	0	0.0	0	0.0
Desmanthus illinoensis	DeIl	0	0.0	0	0.0	0	0.0	0.092	0.8
Chamaecrista fasciculata	ChFa	0	0.0	0	0.0	0	0.0	0	0.0
Rudbeckia hirta	RuHi	0	0.0	0	0.0	0	0.0	0	0.0
Prairie Mix Species									
Verbena stricta	VeSt	0.101	0.7	0.011	0.3	0	0.0	0.006	0.2
Ratibida pinnata	RaPi	0.0008	0.2	0	0.0	0	0.0	0	0.0
Rosa arkansana	Rosa	0	0.0	0	0.0	0.019	0.2	0	0.0
		46.7		114.19		92.46		110.98	

Appendix. (continued)

Ames site, June 2005

Species Name	Abbreviation	*Chamaecrista* Relative Biomass	*Chamaecrista* Relative Frequency	*Rudbeckia* Relative Biomass	*Rudbeckia* Relative Frequency
Ambrosia artemsiifolia	AmAr	0	0.0	0	0.0
Andropogon gerardii	AnGe	0	0.0	0	0.0
Asclepias verticilliata	AsVe	0	0.0	0	0.0
Aster pilosus	AsPi	0	0.0	0	0.0
Aster spp	AsterSP	0	0.0	0	0.0
Bromus inermis	BrIn	0.523	1.0	0.228	1.0
Carex spp	CarexSP	0	0.0	0.002	0.2
Capsella bursa-pastoris	CapBP	0	0.0	0	0.0
Chenopodium alba	ChAl	0	0.0	0	0.0
Cirsium spp	Thistle	0	0.0	0	0.0
Cirsium arvense	CiAr	0	0.0	0	0.0
Cirsium vulgare	CiVu	0	0.0	0	0.0
Convolvulus arvensis	CoAr	0.016	0.2	0	0.0
Conyza canadensis	CoCa	0.0001	0.2	0	0.0
Coronilla varia	CoVa	0.404	0.8	0.26	0.8
Dicanthelium oligosanthes	DiOl	0	0.0	0	0.0
Digitaria ischaemum	DiIs	0	0.0	0	0.0
Elymus repens	ElRe	0	0.0	0	0.0
Euphorbia dentata	EuDe	0	0.0	0	0.0
Euphorbia supina	EuSu	0	0.0	0	0.0
Euphorbia corollata	EuphSP	0	0.0	0	0.0
Festuca sp.	Fescue	0	0.0	0	0.0
Lactuca ludoviciana	LaLu	0	0.0	0	0.0
Lactuca sp.	LactucaSP	0	0.0	0.042	0.2
Medicago lupulina	MeLu	0.001	0.3	0.0002	0.2
Melilotus spp.	MelilotusSP	0	0.0	0.0002	0.2
Muhlenbergia schreberi	MuSc	0	0.0	0	0.0
Oxalis stricta	OxSt	<0.0001	0.2	0.001	0.3
Panicum capillare	PaCa	0	0.0	0	0.0
Parthenocissus quinquefolia	PaQu	0	0.0	0	0.0
Phalaris arundinacea	PhAr	0	0.0	0	0.0
Physalis heterophylla	PhHe	<0.0001	0.2	0	0.0
Physalis virginiana	PhVi	0.0006	0.2	0	0.0

Appendix. (continued)

Ames site, June 2005

Species Name	Abbreviation	*Chamaecrista* Relative Biomass	*Chamaecrista* Relative Frequency	*Rudbeckia* Relative Biomass	*Rudbeckia* Relative Frequency
Plantago major	PlMa	0	0.0	0	0.0
Poa pratensis	PoPr	0.003	0.5	0	0.0
Polygonum convolvulus	PoCo	0	0.0	0	0.0
Polygonum pensylvanicum	PoPe	0	0.0	0	0.0
Polygonum ramosissimum	PoRa	0	0.0	0	0.0
Portulaca olecera	PoOl	0	0.0	0	0.0
Potentilla spp	Potent	0	0.0	0	0.0
Rumex crispus	RuCr	0	0.0	0	0.0
Setaria glauca	SeGl	0	0.0	<0.0001	0.2
Solanum carolinense	SoCa	0	0.0	0	0.0
Solanum nigrum	SoNi	0	0.0	0	0.0
Solidago rigida	SoRi	0	0.0	0	0.0
Sporobolus vaginiflorus	SpVa	0	0.0	0	0.0
Taraxacum officinale	TaOf	0.003	0.3	0.001	0.2
Trifolium pratense	TrPr	0	0.0	0.012	0.3
Trifolium repens	TrRe	0.002	0.5	0.0007	0.3
Verbascum thapsus	VeTh	0.028	0.2	0.004	0.2
Viola pratincola	ViPr	<0.0008	0.2	0.003	0.2
Verbena alba	VeAl	0.017	0.2	0	0.0
Unknown Forb	HUF35	<0.0001	0.2	0	0.0
Unknown Grass	HUG12	0	0.0	0	0.0
Unknown Forb	HUF15	0	0.0	0	0.0
Unknown Forb	HUF23	0	0.0	0	0.0
Unknown Grass	HUG27	0	0.0	0.004	0.2
Unknown Grass	HUG14	0	0.0	0	0.0

Appendix. (continued)

Ames site, June 2005

Species Name	Abbreviation	*Chamaecrista* Relative Biomass	*Chamaecrista* Relative Frequency	*Rudbeckia* Relative Biomass	*Rudbeckia* Relative Frequency
Early-emerging Species					
Elymus canadensis	ElCa	0	0.0	0	0.0
Bouteloua curtipendula	BoCu	0	0.0	0	0.0
Desmanthus illinoensis	DeIl	0	0.0	0	0.0
Chamaecrista fasciculata	ChFa	0.001	0.3	0	0.0
Rudbeckia hirta	RuHi	0	0.0	0.431	1.0
Prairie Mix Species					
Verbena stricta	VeSt	0	0.0	0.012	0.3
Ratibida pinnata	RaPi	0	0.0	0	0.0
Rosa arkansana	Rosa	0	0.0	0	0.0
		166.81		70.37	

Appendix. (continued)

Ames site, August 2005		Control		*Bouteloua*		*Elymus*		*Desmanthus*	
		Relative	Relative	Relative	Relative	Relative	Relative	Relative	Relative
Species Name	Abbreviation	Biomass	Frequency	Biomass	Frequency	Biomass	Frequency	Biomass	Frequency
Ambrosia artemsiifolia	AmAr	0.203	0.3	0	0.0	0	0.0	0	0.0
Andropogon gerardii	AnGe	0	0.0	0	0.0	0	0.0	0	0.0
Asclepias verticilliata	AsVe	0	0.0	0	0.0	0	0.0	0	0.0
Aster pilosus	AsPi	0	0.0	0.01	0.2	0.042	0.2	0	0.0
Aster spp	AsterSP	0.002	0.2	<0.0001	0.2	0	0.0	0	0.0
Bromus inermis	BrIn	0.02	0.5	0.082	1.0	0.413	1.0	0.338	1.0
Carex spp	CarexSP	<0.0001	0.2	0	0.0	0.0005	0.2	0	0.0
Capsella bursa-pastoris	CapBP	0	0.0	0	0.0	0	0.0	0	0.0
Chenopodium alba	ChAl	0.007	0.2	0	0.0	0.0001	0.2	0	0.0
Cirsium spp	Thistle	0.009	0.2	0	0.0	0	0.0	0	0.0
Cirsium arvense	CiAr	0	0.0	0	0.0	0	0.0	0	0.0
Cirsium vulgare	CiVu	0	0.0	0	0.0	0	0.0	0	0.0
Convolvulus arvensis	CoAr	0	0.0	0.0002	0.3	0.005	0.2	0	0.0
Conyza canadensis	CoCa	0.068	0.3	0	0.0	0	0.0	0.011	0.5
Coronilla varia	CoVa	0.126	0.7	0.434	0.8	0.018	0.5	0.266	0.7
Dicanthelium oligosanthes	DiOl	0.012	0.2	0	0.0	0.065	0.2	0.01	0.2
Digitaria ischaemum	DiIs	0.002	0.3	0	0.0	0.0007	0.2	0	0.0
Elymus repens	ElRe	0	0.0	0	0.0	0.105	0.2	0.008	0.2
Euphorbia dentata	EuDe	0	0.0	0	0.0	0	0.0	0	0.0
Euphorbia supina	EuSu	0	0.0	0	0.0	0	0.0	0	0.0
Euphorbia corollata	EuphSP	0	0.0	0	0.0	<0.0001	0.2	0	0.0
Festuca sp.	Fescue	0.001	0.2	0	0.0	0	0.0	0	0.0
Lactuca ludoviciana	LaLu	0	0.0	0	0.0	0	0.0	0	0.0
Lactuca sp.	LactucaSP	0	0.0	0	0.0	0	0.0	0	0.0
Medicago lupulina	MeLu	0.003	0.7	0.0001	0.2	0	0.0	0	0.0
Melilotus spp.	MelilotusSP	0.0006	0.2	0	0.0	0	0.0	0	0.0
Muhlenbergia schreberi	MuSc	0	0.0	0	0.0	0	0.0	0	0.0
Oxalis stricta	OxSt	0.218	0.7	0	0.0	0	0.0	0	0.0
Panicum capillare	PaCa	0.023	0.8	0	0.0	0	0.0	0.0004	0.5
Parthenocissus quinquefolia	PaQu	0	0.0	0.01	0.2	0	0.0	0	0.0
Phalaris arundinacea	PhAr	0	0.0	0.141	0.2	0.095	0.2	0	0.0
Physalis heterophylla	PhHe	0.028	0.5	0	0.0	0.001	0.2	0	0.0
Physalis virginiana	PhVi	0.035	0.5	0.037	0.5	0.002	0.2	0.01	0.7

Appendix. (continued)

Ames site, August 2005		Control		*Bouteloua*		*Elymus*		*Desmanthus*	
Species Name	Abbreviation	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency
Plantago major	PlMa	0.0001	0.2	0	0.0	0.0005	0.2	0	0.0
Poa pratensis	PoPr	0	0.0	0.014	0.3	0.001	0.5	0.061	0.3
Polygonum convolvulus	PoCo	0	0.0	0	0.0	0	0.0	0	0.0
Polygonum pensylvanicum	PoPe	0	0.0	0	0.0	0	0.0	0	0.0
Polygonum ramosissimum	PoRa	0.003	0.3	0	0.0	0	0.0	0	0.0
Portulaca olecera	PoOl	0	0.0	0	0.0	0	0.0	0	0.0
Potentilla spp	Potent	0	0.0	0	0.0	0	0.0	0	0.0
Rumex crispus	RuCr	0	0.0	0	0.0	0	0.0	0	0.0
Setaria glauca	SeGl	0.008	0.7	0	0.0	0.001	0.3	0.008	0.3
Solanum carolinense	SoCa	0.15	0.2	0	0.0	0	0.0	0	0.0
Solanum nigrum	SoNi	0	0.0	0	0.0	0	0.0	0	0.0
Solidago rigida	SoRi	0	0.0	0	0.0	0	0.0	0	0.0
Sporobolus vaginiflorus	SpVa	0	0.0	0	0.0	0.0003	0.2	0	0.0
Taraxacum officinale	TaOf	0.002	0.3	0.0009	0.5	0.0001	0.3	0.0002	0.3
Trifolium pratense	TrPr	0	0.0	0	0.0	0.0005	0.2	0	0.0
Trifolium repens	TrRe	0.0003	0.5	0	0.0	0.0003	0.7	0	0.3
Verbascum thapsus	VeTh	0.019	0.3	0	0.0	0	0.0	0	0.0
Viola pratincola	ViPr	0.005	0.5	0.0008	0.2	0	0.0	0	0.0
Verbena alba	VeAl	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Forb	HUF35	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Grass	HUG12	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Forb	HUF15	0.0009	0.2	0	0.0	0	0.0	0	0.0
Unknown Forb	HUF23	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Grass	HUG27	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Grass	HUG14	0	0.0	0	0.0	0	0.0	0	0.0

Appendix. (continued)

Ames site, August 2005		Control		*Bouteloua*		*Elymus*		*Desmanthus*	
Species Name	Abbreviation	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency
Early-emerging Species									
Elymus canadensis	ElCa	0	0.0	0	0.0	0.212	1.0	0	0.0
Bouteloua curtipendula	BoCu	0	0.0	0.238	0.8	0	0.0	0	0.0
Desmanthus illinoensis	DeIl	0	0.0	0	0.0	0	0.0	0.287	0.8
Chamaecrista fasciculata	ChFa	0	0.0	0	0.0	0	0.0	0	0.0
Rudbeckia hirta	RuHi	0	0.0	0	0.0	0	0.0	0	0.0
Prairie Mix Species									
Verbena stricta	VeSt	0.119	0.5	0.032	0.2	0.038	0.3	0	0.0
Ratibida pinnata	RaPi	0	0.0	0	0.0	0	0.0	0	0.0
Rosa arkansana	Rosa	0	0.0	0	0.0	0	0.0	0	0.0
Total Mean Biomass (g)		96.09		119.16		101.37		94.69	

Appendix. (continued)

Ames site, August 2005

Species Name	Abbreviation	*Chamaecrista* Relative Biomass	*Chamaecrista* Relative Frequency	*Rudbeckia* Relative Biomass	*Rudbeckia* Relative Frequency
Ambrosia artemsiifolia	AmAr	0	0.0	0.0005	0.2
Andropogon gerardii	AnGe	0	0.0	0	0.0
Asclepias verticilliata	AsVe	0	0.0	0	0.0
Aster pilosus	AsPi	0.062	0.2	0	0.0
Aster spp	AsterSP	0	0.0	0	0.0
Bromus inermis	BrIn	0.29	1.0	0.151	1.0
Carex spp	CarexSP	0	0.0	0.0001	0.2
Capsella bursa-pastoris	CapBP	0	0.0	0	0.0
Chenopodium alba	ChAl	0	0.0	0	0.0
Cirsium spp	Thistle	0	0.0	0	0.0
Cirsium arvense	CiAr	0	0.0	0	0.0
Cirsium vulgare	CiVu	0	0.0	0	0.0
Convolvulus arvensis	CoAr	0.007	0.3	0	0.0
Conyza canadensis	CoCa	0.05	0.2	0	0.0
Coronilla varia	CoVa	0.507	0.8	0.497	0.8
Dicanthelium oligosanthes	DiOl	0	0.0	0.108	0.3
Digitaria ischaemum	DiIs	0	0.0	0	0.0
Elymus repens	ElRe	0	0.0	0	0.0
Euphorbia dentata	EuDe	0	0.0	0	0.0
Euphorbia supina	EuSu	0	0.0	0	0.0
Euphorbia corollata	EuphSP	0	0.0	0	0.0
Festuca sp.	Fescue	0	0.0	0	0.0
Lactuca ludoviciana	LaLu	0	0.0	0	0.0
Lactuca sp.	LactucaSP	0	0.0	0	0.0
Medicago lupulina	MeLu	0	0.0	0.006	0.5
Melilotus spp.	MelilotusSP	0	0.0	0	0.0
Muhlenbergia schreberi	MuSc	0	0.0	0	0.0
Oxalis stricta	OxSt	0	0.0	0.0003	0.2
Panicum capillare	PaCa	0.001	0.2	0.003	0.7
Parthenocissus quinquefolia	PaQu	0	0.0	0	0.0
Phalaris arundinacea	PhAr	0	0.0	0	0.0
Physalis heterophylla	PhHe	0.0003	0.2	0.004	0.2
Physalis virginiana	PhVi	0.011	0.3	0.0003	0.2

Appendix. (continued)

Ames site, August 2005

Species Name	Abbreviation	*Chamaecrista* Relative Biomass	*Chamaecrista* Relative Frequency	*Rudbeckia* Relative Biomass	*Rudbeckia* Relative Frequency
Plantago major	PlMa	0	0.0	0	0.0
Poa pratensis	PoPr	0.013	0.3	0.006	0.3
Polygonum convolvulus	PoCo	0	0.0	0	0.0
Polygonum pensylvanicum	PoPe	0	0.0	0	0.0
Polygonum ramosissimum	PoRa	0	0.0	0	0.0
Portulaca olecera	PoOl	0	0.0	0	0.0
Potentilla spp	Potent	0	0.0	0	0.0
Rumex crispus	RuCr	0	0.0	0	0.0
Setaria glauca	SeGl	<0.0001	0.2	0	0.0
Solanum carolinense	SoCa	0	0.0	0	0.0
Solanum nigrum	SoNi	0	0.0	0	0.0
Solidago rigida	SoRi	0	0.0	0	0.0
Sporobolus vaginiflorus	SpVa	0	0.0	0	0.0
Taraxacum officinale	TaOf	0.0003	0.2	0.0003	0.2
Trifolium pratense	TrPr	0	0.0	0.001	0.2
Trifolium repens	TrRe	0.0008	0.2	0.001	0.5
Verbascum thapsus	VeTh	0.008	0.2	0.001	0.2
Viola pratincola	ViPr	0	0.0	0.001	0.3
Verbena alba	VeAl	0	0.0	0	0.0
Unknown Forb	HUF35	0	0.0	0	0.0
Unknown Grass	HUG12	0	0.0	0	0.0
Unknown Forb	HUF15	0	0.0	0	0.0
Unknown Forb	HUF23	0	0.0	0	0.0
Unknown Grass	HUG27	0	0.0	0	0.0
Unknown Grass	HUG14	0	0.0	0	0.0

Appendix. (continued)

Ames site, August 2005		*Chamaecrista*		*Rudbeckia*	
Species Name	Abbreviation	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency
Early-emerging Species					
Elymus canadensis	ElCa	0	0.0	0	0.0
Bouteloua curtipendula	BoCu	0	0.0	0	0.0
Desmanthus illinoensis	DeIl	0	0.0	0	0.0
Chamaecrista fasciculata	ChFa	0.031	0.2	0	0.0
Rudbeckia hirta	RuHi	0	0.0	0.128	0.8
Prairie Mix Species					
Verbena stricta	VeSt	0.019	0.3	0.086	0.5
Ratibida pinnata	RaPi	0	0.0	0	0.0
Rosa arkansana	Rosa	0	0.0	0	0.0
		161.72		66.56	

Appendix. (continued)

Castana Site, June 2005		Control		*Bouteloua*		*Elymus*		*Desmanthus*	
Species Name	Abbreviation	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency
Ambrosia artemsiifolia	AmAr	0.004	1.0	0.002	0.5	0.006	0.5	0.005	3.0
Asclepias verticilliata	AsVe	0	0.0	0.0004	0.2	0.001	0.2	0	0.0
Aster pilosus	AsPi	0	0.0	0.0003	0.2	0.002	0.3	0	0.0
Bromus inermis	BrIn	0.571	1.0	0.321	1.0	0.368	1.0	0.476	6.0
Carduus nutans	CaNu	0	0.0	0.01	0.3	0.045	0.2	0	0.0
Chenopodium alba	ChAl	0	0.0	0	0.0	0	0.0	0	0.0
Cirsium sp	Thistle	0	0.0	0	0.0	0	0.0	0.006	1.0
Cirsium vulgare	CiVu	0.003	0.2	0	0.0	0	0.0	0	0.0
Conyza canadensis	CoCa	0.009	0.2	0.005	0.2	0.001	0.2	0.006	5.0
Dicanthelium oligosanthes	DiOl	0	0.0	0	0.0	0	0.0	0.0008	1.0
Digitaria ischaemum	DiIs	0	0.0	0	0.0	0	0.0	0	0.0
Equinus arvense	EqAr	0	0.0	0	0.0	0.011	0.2	0	0.0
Euphorbia supina	EuSu	0	0.0	0	0.0	0	0.0	0	0.0
Euphorbia spp	EuphSP	0	0.0	0	0.0	0	0.0	0	0.0
Medicago lupulina	MeLu	0.016	0.8	0.035	1.0	0.022	0.8	0.099	5.0
Melilotus spp.	MelSP	0.009	0.2	0.057	0.2	0.0005	0.2	0.079	1.0
Oxalis stricta	OxSt	0.004	0.2	0.0005	0.3	0	0.0	0	0.0
Paspalum spp	Pasp	0.0005	0.2	0	0.0	0	0.0	0	0.0
Phleum pratense	PhPr	0.029	0.2	0	0.0	0	0.0	0	0.0
Poa pratensis	PoPr	0.01	0.8	0.003	0.5	0.004	0.3	0.003	3.0
Polygonum ramosissimum	PoRa	0	0.0	0	0.0	0	0.0	0	0.0
Rumex crispus	RuCr	0.001	0.2	0	0.0	0	0.0	0	0.0
Setaria glauca	SeGl	0.0005	0.5	0.0003	0.5	0.001	0.5	0	0.0
Sporobolous vaginiflorus	SpVa	0.0007	0.2	0	0.0	0	0.0	0.0001	1.0
Taraxacum officinale	TaOf	0.002	0.5	0.008	0.3	0.003	0.3	0.005	2.0
Trifolium pratense	TrPr	0.137	0.7	0.144	0.7	0.104	0.5	0.075	4.0
Trifolium repens	TrRe	0.207	1.0	0.364	1.0	0.264	1.0	0.239	6.0
Unknown Forb	WUF23	0	0.0	0.0001	0.2	0	0.0	0	0.0
Unknown Grass	WUG12	0	0.0	0	0.0	0	0.2	0	0.0
Unknown Forb	WUF16	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Grass	WUG20	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Grass	WUG32	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Forb	WUF 25	0	0.0	0	0.0	0	0.0	0	0.0

Appendix. (continued)

Castana Site, June 2005		Control		*Bouteloua*		*Elymus*		*Desmanthus*	
Species Name	Abbreviation	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency
Unknown Forb	WUF14	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Forb	WUF15	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Forb	WUF1	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Forb	WUF21	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Grass	WUG21	0	0.0	0	0.0	0	0.0	0	0.0
Early-Emerging Species									
Elymus canadensis	ElCa	0	0.0	0	0.0	0.158	1.0	0	0.0
Bouteloua curtipendula	BoCu	0	0.0	0.046	1.0	0	0.0	0	0.0
Desmanthus illinoensis	DeIl	0	0.0	0	0.0	0	0.0	0.002	1.0
Chamaecrista fasciculata	ChFa	0	0.0	0	0.0	0	0.0	0	0.0
Rudbeckia hirta	RuHi	0	0.0	0	0.0	0	0.0	0	0.0
Prairie Mix Species									
Verbena stricta	VeSt	0.0001	1.0	0.004	0.3	0	0.5	0.004	3.0
Silphium lanceolata	SiLa	0	0.0	0	0.0	0	0.0	0	0.0
Total Mean Biomass (g)		70.86		64.3		68.55		64.69	

Appendix. (continued)

Castana Site, June 2005

Species Name	Abbreviation	*Chamaecrista* Relative Biomass	*Chamaecrista* Relative Frequency	*Rudbeckia* Relative Biomass	*Rudbeckia* Relative Frequency
Ambrosia artemsiifolia	AmAr	0.002	0.8	0	0.0
Asclepias verticilliata	AsVe	0	0.0	0	0.0
Aster pilosus	AsPi	0	0.0	0	0.0
Bromus inermis	BrIn	0.478	1.0	0.17	1.0
Carduus nutans	CaNu	0	0.0	0	0.0
Chenopodium alba	ChAl	0	0.0	0	0.0
Cirsium sp	Thistle	0.0002	0.2	0.01	0.3
Cirsium vulgare	CiVu	0	0.0	0	0.0
Conyza canadensis	CoCa	0.005	0.8	0	0.0
Dicanthelium oligosanthes	DiOl	0	0.0	0.0007	0.2
Digitaria ischaemum	DiIs	0	0.0	0	0.0
Equinus arvense	EqAr	0	0.0	0	0.0
Euphorbia supina	EuSu	0	0.0	0	0.0
Euphorbia spp	EuphSP	0	0.0	0	0.0
Medicago lupulina	MeLu	0.12	1.0	0.023	1.0
Melilotus spp.	MelSP	0.079	0.3	0.044	0.3
Oxalis stricta	OxSt	0.003	0.2	0.0004	0.2
Paspalum spp	Pasp	0	0.0	0	0.0
Phleum pratense	PhPr	0.003	0.2	0.011	0.2
Poa pratensis	PoPr	0.006	0.7	<0.0001	0.2
Polygonum ramosissimum	PoRa	0	0.0	0	0.0
Rumex crispus	RuCr	0	0.0	0	0.0
Setaria glauca	SeGl	0.0006	0.3	0	0.0
Sporobolous vaginiflorus	SpVa	0	0.0	0	0.0
Taraxacum officinale	TaOf	0.01	0.7	0.0001	0.2
Trifolium pratense	TrPr	0.102	0.8	0.085	0.5
Trifolium repens	TrRe	0.188	1.0	0.12	0.8
Unknown Forb	WUF23	0	0.0	0	0.0
Unknown Grass	WUG12	0	0.0	0	0.0
Unknown Forb	WUF16	0	0.0	0	0.0
Unknown Grass	WUG20	0	0.0	0	0.0
Unknown Grass	WUG32	0	0.0	0	0.0
Unknown Forb	WUF 25	0	0.0	0	0.0

Appendix. (continued)

Castana Site, June 2005

Species Name	Abbreviation	*Chamaecrista* Relative Biomass	*Chamaecrista* Relative Frequency	*Rudbeckia* Relative Biomass	*Rudbeckia* Relative Frequency
Unknown Forb	WUF14	0	0.0	0	0.0
Unknown Forb	WUF15	0	0.0	0	0.0
Unknown Forb	WUF1	0	0.0	0	0.0
Unknown Forb	WUF21	0	0.0	0	0.0
Unknown Grass	WUG21	0	0.0	0	0.0
Early-Emerging Species					
Elymus canadensis	ElCa	0	0.0	0	0.0
Bouteloua curtipendula	BoCu	0	0.0	0	0.0
Desmanthus illinoensis	DeIl	0	0.0	0	0.0
Chamaecrista fasciculata	ChFa	0.0004	0.8	0	0.0
Rudbeckia hirta	RuHi	0	0.0	0.534	1.0
Prairie Mix Species					
Verbena stricta	VeSt	0.0009	0.3	0.003	0.3
Silphium lanceolata	SiLa	0	0.0	0.0004	0.2
Total Mean Biomass (g)		72.25		65.81	

Appendix. (continued)

Castana Site, August 2005		Control		*Bouteloua*		*Elymus*		*Desmanthus*	
Species Name	Abbreviation	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency
Ambrosia artemsiifolia	AmAr	0.109	0.8	0.063	1.0	0.108	0.8	0.054	0.8
Asclepias verticilliata	AsVe	0	0.0	0	0.0	0	0.0	0	0.0
Aster pilosus	AsPi	0	0.0	0	0.0	0	0.0	0	0.0
Bromus inermis	BrIn	0.483	1.0	0.309	1.0	0.447	1.0	0.489	1.0
Carduus nutans	CaNu	0	0.0	0	0.0	0	0.0	0	0.0
Chenopodium alba	ChAl	0	0.0	0.0003	0.2	0	0.0	0	0.0
Cirsium sp	Thistle	0	0.0	0	0.0	0.011	0.3	0.003	0.5
Cirsium vulgare	CiVu	0	0.0	0	0.0	0	0.0	0	0.0
Conyza canadensis	CoCa	0.147	0.5	0.123	0.7	0.068	0.7	0.145	1.0
Dicanthelium oligosanthes	DiOl	0.003	0.2	0	0.0	0	0.0	0.002	0.2
Digitaria ischaemum	DiIs	0.044	0.7	0.015	1.0	0.031	0.7	0.038	0.8
Equinus arvense	EqAr	0	0.0	0	0.0	0	0.0	0	0.0
Euphorbia supina	EuSu	0.006	0.3	<0.0001	0.2	0.002	0.5	0.003	0.7
Euphorbia spp	EuphSP	0.007	0.2	0	0.0	0.001	0.2	0	0.0
Medicago lupulina	MeLu	0.012	0.8	0.005	0.8	0.013	0.8	0.019	0.8
Melilotus spp.	MelSP	0	0.0	0.01	0.3	0.004	0.2	0.104	0.2
Oxalis stricta	OxSt	0.001	0.3	0.001	0.3	0	0.2	<0.0001	0.2
Paspalum spp	Pasp	0	0.0	0	0.0	0.002	0.3	0	0.0
Phleum pratense	PhPr	0.036	0.2	0.024	0.3	0	0.0	0	0.0
Poa pratensis	PoPr	0.003	0.7	0.003	0.5	0.005	0.3	0.013	0.7
Polygonum ramosissimum	PoRa	0	0.0	0	0.0	0	0.0	0	0.0
Rumex crispus	RuCr	0	0.0	0	0.0	0	0.0	0	0.0
Setaria glauca	SeGl	0.003	0.3	0.0006	0.5	0.026	0.7	0.0003	0.5
Sporobolous vaginiflorus	SpVa	0.002	0.5	0.0004	0.3	0.006	0.5	0.007	0.5
Taraxacum officinale	TaOf	0.0002	0.2	0.0001	0.2	0.0002	0.2	0.0006	0.3
Trifolium pratense	TrPr	0.092	0.7	0.038	0.8	0.018	0.5	0.036	0.5
Trifolium repens	TrRe	0.026	0.8	0.0012	1.0	0.027	0.7	0.045	0.7
Unknown Forb	WUF23	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Grass	WUG12	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Forb	WUF16	0	0.0	0.0002	0.2	0	0.0	0	0.0
Unknown Grass	WUG20	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Grass	WUG32	0.002	0.2	0	0.0	0	0.0	0	0.0
Unknown Forb	WUF 25	0	0.0	0	0.0	0	0.0	<0.0001	0.2

Appendix. (continued)

Castana Site, August 2005

Species Name	Abbreviation	Control Relative Biomass	Control Relative Frequency	*Bouteloua* Relative Biomass	*Bouteloua* Relative Frequency	*Elymus* Relative Biomass	*Elymus* Relative Frequency	*Desmanthus* Relative Biomass	*Desmanthus* Relative Frequency
Unknown Forb	WUF14	0.006	0.2	0	0.0	0	0.0	0	0.0
Unknown Forb	WUF15	0	0.0	0	0.0	0.003	0.2	0	0.0
Unknown Forb	WUF1	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Forb	WUF21	0	0.0	0	0.0	0	0.0	0	0.0
Unknown Grass	WUG21	0	0.0	0	0.0	0	0.0	0	0.0
Early-Emerging Species									
Elymus canadensis	ElCa	0	0.0	0	0.0	0.17	1.0	0	0.0
Bouteloua curtipendula	BoCu	0	0.0	0.366	0.8	0	0.0	0	0.0
Desmanthus illinoensis	DeIl	0	0.0	0	0.0	0	0.0	0.007	0.3
Chamaecrista fasciculata	ChFa	0	0.0	0	0.0	0	0.0	0	0.0
Rudbeckia hirta	RuHi	0	0.0	0	0.0	0	0.0	0	0.0
		0	0.0	0	0.0	0	0.0	0	0.0
Prairie Mix Species									
Verbena stricta	VeSt	0.016	0.8	0.03	0.5	0.059	0.7	0.032	1.0
Silphium lanceolata	SiLa	0	0.0	0	0.0	0	0.0	0	0.0
Total Mean Biomass (g)		42.87		55.58		54.17		40.75	

Appendix. (continued)

Castana Site, August 2005		*Chamaecrista*		*Rudbeckia*	
Species Name	Abbreviation	Relative Biomass	Relative Frequency	Relative Biomass	Relative Frequency
Ambrosia artemsiifolia	AmAr	0.036	0.8	0.044	0.8
Asclepias verticilliata	AsVe	0	0.0	0.001	0.2
Aster pilosus	AsPi	0	0.0	0	0.0
Bromus inermis	BrIn	0.571	1.0	0.474	1.0
Carduus nutans	CaNu	0	0.0	0	0.0
Chenopodium alba	ChAl	0	0.0	0	0.0
Cirsium sp	Thistle	0.001	0.2	0.001	0.2
Cirsium vulgare	CiVu	0	0.0	0	0.0
Conyza canadensis	CoCa	0.086	0.5	0.076	0.5
Dicanthelium oligosanthes	DiOl	0.0009	0.2	0	0.0
Digitaria ischaemum	DiIs	0.01	0.8	0	0.5
Equinus arvense	EqAr	0	0.0	0	0.0
Euphorbia supina	EuSu	0.005	0.2	0.001	0.3
Euphorbia spp	EuphSP	0.007	0.2	0	0.0
Medicago lupulina	MeLu	0.014	1.0	0.003	0.7
Melilotus spp.	MelSP	0	0.0	0.165	0.3
Oxalis stricta	OxSt	0.002	0.2	0.002	0.2
Paspalum spp	Pasp	0	0.0	0.0002	0.2
Phleum pratense	PhPr	0	0.0	0	0.0
Poa pratensis	PoPr	0.008	0.8	0.003	0.8
Polygonum ramosissimum	PoRa	0.0007	0.2	0	0.0
Rumex crispus	RuCr	0	0.0	0	0.0
Setaria glauca	SeGl	0.02	0.2	0.004	0.3
Sporobolous vaginiflorus	SpVa	0.002	0.3	0.003	0.3
Taraxacum officinale	TaOf	0.0005	0.3	0.0007	0.5
Trifolium pratense	TrPr	0.059	0.7	0.032	0.3
Trifolium repens	TrRe	0.063	0.5	0.009	1.0
Unknown Forb	WUF23	0	0.0	0	0.0
Unknown Grass	WUG12	0	0.0	0	0.0
Unknown Forb	WUF16	0	0.0	0	0.0
Unknown Grass	WUG20	0.0006	0.2	0	0.0
Unknown Grass	WUG32	0	0.0	0	0.0
Unknown Forb	WUF 25	0	0.0	0	0.0

Appendix. (continued)

Castana Site, August 2005

Species Name	Abbreviation	*Chamaecrista* Relative Biomass	*Chamaecrista* Relative Frequency	*Rudbeckia* Relative Biomass	*Rudbeckia* Relative Frequency
Unknown Forb	WUF14	0	0.0	0	0.0
Unknown Forb	WUF15	0	0.0	0	0.0
Unknown Forb	WUF1	0	0.0	<0.0001	0.2
Unknown Forb	WUF21	0	0.0	0.002	0.2
Unknown Grass	WUG21	0	0.0	0.0005	0.2
Early-Emerging Species					
Elymus canadensis	ElCa	0	0.0	0	0.0
Bouteloua curtipendula	BoCu	0	0.0	0	0.0
Desmanthus illinoensis	DeIl	0	0.0	0	0.0
Chamaecrista fasciculata	ChFa	0.079	0.8	0	0.0
Rudbeckia hirta	RuHi	0	0.0	0.094	0.7
		0	0.0	0	0.0
Prairie Mix Species					
Verbena stricta	VeSt	0.033	0.5	0	0.7
Silphium lanceolata	SiLa	0	0.0	0	0.0
Total Mean Biomass (g)		46.06		41.29	