The Effects Varying Seeding Rates of Prairie Grasses and Forbs on Native Plant Establishment in a Prairie Reconstruction

Final Report

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Executive Summary

The Iowa DOT is seeking ways to improve practices associated with revegetation projects to increase establishment of native grasses and forbs. Iowa DOT has developed various seed mixes for re-vegetation projects (Iowa DOT 2005). Each seed mix has the potential to result in a different plant community. Results from this research project will provide information on the seeding rates for species needed for optimal establishment of grasses and wildflowers in future Iowa DOT prairie plantings as well as determine if current seeding practices are adequate. This information can be used to revise or develop seeding rate recommendations for re-vegetation projects.

In 2004, experimental plots were established in the right-of-way along Interstate 20 in Black Hawk County, Iowa. The experiment replicated a typical Iowa DOT re-vegetation prairie planting. All Iowa DOT specifications for a re-vegetation planting (site preparation, seeding, and mowing) were followed in the experiment. Prairie plant establishment, biomass, and richness and weed biomass and richness were compared in plots seeded with the same species but at different seeding rates: 1:1 (A seed mix with an equal amount of grass and forb seed), 1:5 (A forb rich seed mix with five times more forb seed than grass seed), 5:1(A grass rich seed mix with five times more grass seed than forb seed). The grass and forb seeding rates (seeds planted/ft^2) of the treatments included: 1:1 (26 grass seeds, 26 forb seeds), 1:5 (10 grass seeds, 51 forb seeds), and 5:1 (51 grass seeds, 10 forb seeds). Data was collected in 2004 and 2005. A summary of the results of the experiment are as follows.

Prairie Plant Establishment: An increase in the seeding rate increased prairie plant establishment. However, plant establishment was not proportional to the addition of seed. Planting five times more grass seed resulted in a doubling of established grass plants. Planting five times more forb seed resulted in seven times more forb plants.

Prairie Plant Mortality: Increasing the seeding rate of either grasses or forbs did not significantly change plant mortality. Competition from non-native plants may have contributed to native plant mortality. In the second year, tall fescue (*Festuca arundinacea*) and bird's foot trefoil (*Lotus corniculatus*) was present in over 70% and 32% of all quadrat samples.

Species Richness: An increase in the seeding rate increased species richness of the natives. The increase in species richness was not proportional to the addition of seed. Planting five times more grass seed resulted in an increase in species richness by 21%. However, planting five times more forb seed resulted in an increase in species richness by 191%. Species richness of weeds was similar across all seeding treatments.

Plant Biomass: An increase in the seeding rate increased prairie plant biomass. An increase in seeding rate of grasses appeared to have a greater effect reducing weed biomass than increasing the seeding rate of forbs.

The recommendations from this report are to plant more seeds per square foot and seed equal numbers of forbs and grasses. Seeding grasses at a rate of less than 26 seeds/ft^2 may not result in adequate grass establishment in a re-vegetation prairie planting. To achieve the minimum grass establishment of 1 grass plant/ft^2, prairie grasses should to be seeded at a rate between 26 and 50 seeds/ft^2. In addition, seeding grasses at a rate between 26 and 50 seeds/ft^2 should also reduce weed growth. To increase species richness of the planting, forbs should be seeded at a rate at least equal to the seeding rate of the grasses.

INTRODUCTION

The Iowa Department of Transportation (DOT) is currently planting native prairie grasses and forbs into interstate and highway rights-of-ways. Some of these plantings include "re-vegetation" projects. Re-vegetation plantings involve converting established non-native grass stands in the rights-of-ways to prairie plantings consisting of native grasses and forbs. The goal of this program is to create diverse native prairie plantings resistant to soil erosion and weedy invasion, improve water quality, enhance the landscape aesthetics, and reduce the long-term roadside vegetation maintenance costs. In re-vegetation projects, the non-native vegetation is killed with a herbicide and the prairie seed is planted into the killed sod with a no-till drill. The site is periodically mowed in the first two growing seasons to reduce weeds and stimulate the natives.

The seeding rate can have a significant impact on species composition of a prairie planting. Planting too many seeds of one species or a small group of species can dominate the stand. Many prairie plantings in Iowa are dominated by warm-season prairie grasses because too few forb seeds were included in the seed mix (Smith 2007). Iowa DOT has been using various seed mixes for re-vegetation and other seeding projects (Iowa DOT 2005). Each seed mix has the potential to result in a different plant community.

There are some problems associated with inadequate prairie seed mixes. First, planting too few seeds can result in low prairie plant establishment. In a re-vegetation seeding, there is the potential for non-native plants to recover and dominate the planting if prairie plant establishment is too low. Second, planting too many grass seeds can result in a stand dominated by grasses with few to no forbs. One problem of particular concern in right-of-way prairie plantings is weed invasion. Tilman (1997) found that grasslands with few forbs are more

susceptible to plant invasion. An example of an invasive plant species that is of concern in prairie re-vegetation plantings in right-of-ways is Canada thistle (*Cirsium arvense*). Eradicating Canada thistle can be costly as well as harmful to native species. Some herbicides that kill Canada thistle also can kill prairie grass and forb seedlings (Crop Data Management Systems 2007). There is the increased risk of health problems due to exposure of maintenance personnel to pesticides. In addition, contamination of groundwater and other impacts on the environment are a concern.

The objectives of this study were to 1) assess and compare native plant emergence, mortality, and richness among three seeding treatments and 2) assess and compare native plant and weed biomass among three seeding treatments. The seeding treatments were: 1:1 (equal amount of grass and forb seed), 1:5 (five times more forb seed than grass seed), 5:1 (five times more grass seed than forb seed). All plots were seeded in 2004 with the same species but at different seeding rates.

Results from this research project will provide information on the quantities of seed by species needed for optimal establishment of grasses and wildflowers in future Iowa DOT prairie plantings as well as determine if current seeding practices are adequate. This information can be used to revise or develop seed quantity recommendations for re-vegetation projects.

METHODS AND MATERIALS

Site Description

Research plots were established in 2004 in the north and south right-of-way (ROW) of highway 20 between the Grundy County line and the Hwy 63 exit in Black Hawk County, Cedar Falls Iowa. The experiment used a randomized block design for treatments. Four blocks were located in the north and two in the south ROW. Each block consisted of four 0.07 ha. plots. There were three seeding treatments in the experiment: 1:1 (280 grass seeds:282 forb seeds/m^2 or 26 grass seeds:26 forb seeds/ft^2), 1:5 (108 grass seeds:558 forb seeds/m^2 or 10 grass seeds:51 forb seeds/ft^2), 5:1 (539 grass seeds:112 forb seeds/m^2 or 51 grass seeds:10 forb seeds/ft^2). There were six replicates for each treatment.

Site Preparation and Seeding

The existing vegetation on the research sites consisted of stands of cool-season Eurasian pasture grasses that included smooth brome (*Bromus inermis*), tall fescue (*Festuca arundinacea*), Kentucky bluegrass (*Poa pratensis*), and orchardgrass (*Dactylis glomerata*). In 2004, the vegetation was mowed in mid-April (4" high) and sprayed with a non-selective herbicide (glyphosate) in early May.

The seed mixes for the experiment included 63 prairie species (Table 2). All seed was tested for viability by an independent seed-testing lab. Seeding rate for each species was calculated based upon by pure live seed (PLS) and seed weight estimates of Henderson and Kern (1999). Seed was mixed and bagged for each plot. Equal amounts of clay chips were also added to each bag and mixed thoroughly to improve the flow of seed through the no-till drill.

The plots were seeded in early June of 2004 with a no-till seed drill and mowed in early July and August in both 2004 and 2005. Every attempt was made to follow Iowa DOT seeding specifications for re-vegetation projects.

Vegetation Sampling

The vegetation was sampled in mid September of 2004 and 2005. Two random 15 meter transects were established in each plot. Each transect extended from the delineator post to the fence line near the back of the ROW. This was done to sample the entire ROW profile (foreslope, bottom, and backslope). At 1 meter intervals, the vegetation was sampled using a 0.10 m^2 quadrat frame. Within the quadrat frame, all native seedlings were identified and counted and all weed species were identified. In addition, five quadrats from each transect were chosen at random for biomass sampling in 2006. Native grasses, forbs, and weeds were clipped at ground level and bagged by plant group. Bags were oven dried (60^oc) for three days and weighed.

Data Analysis

The data were analyzed using a analysis of variance (ANOVA) with two factors: block and seeding rate. The model included six blocks, and three (grass:forb) seed ratio factors (1:5, 1:1, 5:1). Skewness (g1) and kurtosis (g2) were calculated for all data sets. A student's t-test (alpha = 0.05, with infinite degrees of freedom) was conducted to determine if the data had significant skew or kurtosis from zero (Wilkinson 1989). The data was square-root transformed to run the ANOVA. A Tukey's protected test for pairwise comparisons was used to compare means among the seeding rate treatments.

RESULTS and DISCUSSION

Effects on Native Plant Emergence

Increasing in the seeding rate of either grasses or forbs increased the number of plants that established. The 5:1 treatment plots had significantly more grass plants than all other seeding treatments (Table 1). Grass establishment increased as the seeding rate of the grasses increased (Table 6). However, the increase of the grass establishment was not proportional to the increase in seeding rate. In 5:1 treatment plots, seeding 539 grass seeds/m^2 (50 grass

seeds/ft^2) resulted in 12 grass plants/m^2 (1.1 grass plants/ft^2), whereas, 108 seeds/m^2 (10 grass seeds/ft^2) planted in 1:5 plots resulted in 6 grass plants/m^2 (0.6 grass plants/ft^2) (Table 6). Planting five times more grass seed resulted in only a doubling of established plants. Establishment of the forbs also increased as seeding rate of the forbs increased (Table 1). The 1:5 treatment plots had significantly more forbs than the other seed ratio treatments (Table 1). The proportion of forb plants to the amount of forb seed planted differed from the grasses. In the 1:5 treatment plots, seeding 558 forb seeds/m^2 (51 forb seeds/ft^2) resulted in 8 forb plants/m^2 (0.7 forb plants/ft^2), whereas, 112 forb seeds/m^2 (10 forb seeds/ft^2) planted in 5:1 plots resulted in only 1 forb plant/m^2 (0.1 forb plant/ft^2) (Table 6). Planting five times more forb seed in the 1:5 seeding treatment resulted in 7 times more plants than the 5:1 seeding rate.

The difference in grass and forb establishment measured in this experiment may have implications when developing seed mixes for prairie re-vegetation projects. It appears that forb establishment is more sensitive to changes in seeding rates than the grasses. This may help project coordinators customize seeding rates according to the type of re-vegetation planting. For example, if the planting site is susceptible to erosion, large increases in grass seeding rates may be needed for adequate grass establishment to protect the soil. A successful prairie planting should have a minimum of 11 grass plants/m^2 (1 prairie grass plant/ft^2) (Morgan 1995). In this experiment, grass establishment in 1:1 and 1:5 plots were below the 1 grass plant/ft^2 minimum (Table 1). It appears that prairie grasses need to be seeded at a rate between 280 and 539 seeds/m^2 (26 and 50 seeds/ft^2) to achieve the minimum grass establishment in a prairie re-vegetation planting.

Effects on Native Plant Mortality

Plant mortality was evident across all seeding treatments (Table 1A). However, increasing the seeding rate of either grasses or forbs did not significantly change plant mortality (Table 1A). Competition from non-native plants may have contributed to prairie plant mortality. In 2005, Tall fescue (*Festuca arundinacea*) and bird's foot trefoil (*Lotus corniculatus*) had re-invaded the plots. Tall fescue and bird's foot trefoil was present in over 70% and 32% of all quadrat samples (Table 5).

Effects on Species Richness

Seeding rate had an effect on species richness. An increase in seeding rate for both grasses and forbs increased species richness (Table 2). Species richness of forbs was significantly highest in 1:5 plots among seeding rate treatments (Table 2). Species richness increased much more dramatically when the seeding rate of forbs increased. Species richness of forbs increased by 191% when five times more forb seed was planted (Table 2). However,

species richness of forbs was similar in 1:1 and 1:5 plots even though there was 2 times more forb seed planted in 1:1 plots (Table 2). It appears that seeding forbs above 282 seeds/m^2 (26 forb seeds/ft^2) is needed to significantly increase forb richness of a re-vegetation planting (Table 2, Table 4). The increase in species richness of grasses with the addition of grass seed was much lower than with the addition of forb seed. Species richness of grasses increased by only 21% in 5:1 plots but had five times more seed planted than in 1:5 plots (Table 2). Species richness of grasses was similar in 1:1 and 1:5 plots even though there was 2.6 times more grass seed planted in 1:1 plots (Table 2). It appears that seeding grasses above 280 grass seeds/m^2 (26 grass seeds/ft^2) is needed to significantly increase grass richness of a re-vegetation planting (Table 2, Table 4).

Species richness of weeds was similar among seeding rate treatments (Table 2). The suppression of weed species by increasing grass and forb establishment was not observed in this experiment. This may be a function of poor weed control prior to planting. The abundance of perennial non-native grasses and broad-leaved plants throughout all the plots clearly demonstrated that one application of glyphosate did not adequately control these plants (Table 5).

Plant Biomass

An increase in the seeding rate increased plant biomass. Native grass biomass was greatest in 5:1 plots seeded with the highest amount of grass seeds (Table 3). Likewise, the greatest amount of forb biomass was measured in 1:5 plots seeded with the highest amount of forb seed (Table 3). Weed biomass was significantly lower in 5:1 plots among seeding rate treatments (Table 3). This suggests that native grasses may have a greater effect of reducing weed growth than the forbs. However, it appears that an increase greater than a doubling in the seeding rate of grasses is needed to reduce weed growth.

CONCLUSION

Seeding rate played a critical role in prairie plant establishment. As the seeding rate increased prairie plant establishment increased. However, some plots had poor grass establishment. In this experiment, seeding 108-270 grass seeds/m^2 (10-25 grass seeds/ft^2) produced about half 5.4 plants/m^2 (0.5 plants/ft^2) of the minimum grass establishment needed for a successful prairie planting. Severe weed competition may have contributed to low grass establishment. One spring application of glyphosate did not control perennial non-native grasses and weeds by the end of the experiment.

Species richness was also affected by seeding rates. Increasing the seeding rate of grasses and forbs will result in increased richness of the planting. However, to significantly increase species richness in the planting, grass seed should be seeded between 280 and 539 seeds/m^2 (26 to 50 seeds/ft^2) and forbs should be seeded between 282 and 558 seeds/m^2 (26 to 51 seeds/ft^2).

Seeding rate affected weed growth. In this experiment only the highest seeding rate of grasses 539 grass seeds/m^2 (50 grass seeds/ft^2) reduced weed growth. However, it could not be determined which weed species or group of weeds were affected.

Based upon results from this experiment, seeding grasses at a rate between 280 and 539 seeds/m^2 (26 to 50 seeds/ft^2) and seeding forbs at a rate between 282 and 558 seeds/m^2 (26 to 51 seeds/ft^2) will ensure adequate establishment of the grasses and result in a species rich prairie re-vegetation planting. Prairie establishment may differ under different temperature and precipitation conditions.

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Table 1. Mean number of plants per m^2 and standard deviations of native plants sampled in September 2004 and 2005. Means were square root transformed and the plant groups analyzed separately with a one-way ANOVA. Different letters are significantly ($p<0.05$) different based on a Tukey HSD test for each group. Reported means were not back-transformed.

	--------Grass:Forb Seeding Treatments-------			
Plant Group (Year)	1:1 (s.d.)	1:5 (s.d.)	5:1 (s.d.)	p-value
Total Natives (2004)	4.17 (0.910)	4.04 (0.881)	4.45 (0.917)	0.538
Total Natives (2005)	3.47 (1.097)	3.55 (1.002)	4.06 (1.110)	0.359
Native Grasses (2004)	3.25 (0.716)^{a}	2.45 (0.688)^{b}	4.20 (0.816)^{c}	0.001
Native Grasses (2005)	2.74 (1.147)^{a}	2.30 (0.673)^{a}	3.87 (1.040)^{b}	0.001
Native Forbs (2004)	2.60 (0.675)^{a}	3.20 (0.650)^{a}	1.36 (0.687)^{b}	0.001
Native Forbs (2005)	1.93 (0.881)^{a}	2.68 (0.833)^{b}	1.08 (0.738)^{c}	0.001

Table 1A. Mean mortality (%) of native plant groups. Mortality was calculated from the end of the growing season in 2004 to the end of the growing season in 2005. Plant groups were analyzed separately with a one-way ANOVA. Different letters are significantly ($p<0.05$) different based on a Tukey HSD test for each group. Reported means were not back-transformed.

	--------Grass:Forb Seeding Treatments-------			
Plant Group	1:1 (s.d.)	1:5 (s.d.)	5:1 (s.d.)	p-value
Native Grasses	28.5 (30.3)	15.5 (23.1)	21.4 (22.1)	0.462
Native Forbs	38.4 (34.6)	30.6 (28.9)	34.6 (40.3)	0.863

Table 2. Mean number of species per m^2 and standard deviations of plant groups sampled in September 2004 and 2005. . Means were square root transformed and the plant groups analyzed separately with a one-way ANOVA. Different letters are significantly ($p<0.05$) different based on a Tukey HSD test for each group. Reported means were not back-transformed.

	-------Grass:Forb Seeding Treatments-------			
Plant Group (Year)	1:1 (s.d.)	1:5 (s.d.)	5:1 (s.d.)	p-value
Total Native Species (2004)	3.01 (0.561)[a]	3.33 (0.499)[a]	2.45 (0.508)[b]	0.001
Total Native Species (2005)	2.23 (0.486)	2.44 (0.523)	2.18 (0.373)	0.347
Forb Species (2004)	2.32 (0.543)[a]	2.81 (0.409)[a]	1.28 (0.639)[b]	0.001
Forb Species (2005)	1.93 (0.589)[a]	1.89 (0.397)[a]	0.99 (0.670)[b]	0.003
Grass Species (2004)	1.89 (0.304)	1.77 (0.396)	2.04 (0.254)	0.138
Grass Species (2005)	1.54 (0.362)[a]	1.48 (0.222)[a]	1.88 (0.241)[b]	0.004
Total Weed Species (2004)	2.63 (0.258)	2.58 (0.183)	2.45 (0.227)	0.141
Total Weed Species (2005)	2.56 (0.261)	2.63 (0.207)	2.58 (0.331)	0.822

Table 3. Mean biomass (grams-dry weight per $0.1m^2$) and standard deviations of plant groups sampled in September of 2005. Means were square root transformed and the plant groups analyzed separately with a one-way ANOVA. Different letters are significantly ($p<0.05$) different based on a Tukey HSD test for each group. Reported means were not back-transformed.

	-------Grass:Forb Seeding Treatments-------			
Plant Group	1:1 (s.d.)	1:5 (s.d.)	5:1 (s.d.)	p-value
Total Natives	3.20 (2.233)	3.09 (1.945)	2.76 (1.487)	0.839
Native Grass	2.54 (2.526)	2.14 (1.884)	2.71 (1.486)	0.782
Native Forbs	1.12 (1.192)[ab]	1.76 (1.504)[a]	0.24 (0.494)[b]	0.010
Total Weeds	5.21 (0.479)[ab]	5.71 (1.225)[a]	4.69 (0.753)[b]	0.026

Table 4. Prairie species and seeding rates per m^2 used in the experiment.

			Seeding Treatments (seeds planted/sq. meter)		
Grasses	**Common Name**	**live seeds/oz**	**1:1**	**1:5**	**5:1**
Andropogon gerardii	Big Bluestem	10000	22	11	54
Bouteloua curtipendula	Side-Oats Grama	8650	32	11	54
Calamagrostis canadensis	Blue Joint Grass	248880	11	11	54
Elymus canadensis	Canada Wildrye	6200	22	11	54
Koeleria macrantha	June Grass	400000	8	5	27
Panicum virgatum	Switchgrass	16000	32	11	54
Schizachyrium scoparius	Little Bluestem	15300	22	11	54
Sorghastrum nutans	Indian Grass	11500	43	11	54
Spartina pectinata	Prairie Cordgrass	6040	11	11	54
Sporobolis asper	Tall Dropseed	30000	54	5	27
Sporobolis heterolepis	Prairie Dropseed	15000	22	8	40
Stipa spartea	Porcupine Grass	2132	3	3	13
		TOTAL	**280**	**108**	**539**
Forbs					
Allium canadense	Wild Garlic	8398	3	5	1
Amorpha canescens	Leadplant	17884	5	11	2
Anemone cylindrica	Thimbleweed	16485	5	11	2
Artemisia ludoviciana	Prairie Sage	250000	5	11	2
Asclepias incarnata	Swamp Milkweed	4800	5	11	2
Asclepias tuberosa	Butterfly Milkweed	3350	1	3	1
Aster ericoides	Heath Aster	200000	5	11	2
Aster laevis	Smooth Blue Aster	52670	5	11	2
Aster novae-angliae	New England Aster	67500	5	11	2
Aster sericeus	Silky Aster	476000	5	11	2
Astragalus canadensis	Milk Vetch	18662	5	11	2
Baptisia leucantha	White Wild Indigo	1700	1	1	0
Cassia fasiculata	Partridge Pea	2700	5	11	2
Coreopsis palmata	Prairie Coreopsis	11000	1	1	0
Dalea candida	White Prairie Clover	18230	5	11	2
Dalea purpurea	Purple Prairie Clover	18950	5	11	2
Desmodium canadense	Showy Tick Trefoil	5500	1	1	0
Echinacea pallida	Pale Purple Coneflower	5300	5	11	2
Erynigium yuccifolium	Rattlesnake Master	7500	5	11	2
Eupatorium altissimum	Tall Boneset	50000	11	22	4
Helenium autumnale	Sneezeweed	130000	22	43	9
Helianthus grosseserratus	Bigtooth Sunflower	13440	1	1	0
Helianthus laetiflorus	Prairie Sunflower	4480	1	3	1
Heliopsis helianthoides	Ox-eye Sunflower	6300	5	11	2
Lespedeza capitata	Round-Headed Bush Clover	9000	5	11	2
Liatris aspera	Rough Blazingstar	15500	5	11	2
Liatris ligulistylis	Meadow Blazingstar	11760	3	5	1
Liatris pycnostachya	Prairie Blazingstar	11000	5	11	2
Lobelia siphilitica	Great Blue Lobelia	500000	5	11	2
Monarda fistulosa	Wild Bergamot	75000	11	22	4
Parthenium integrifolium	Wild Quinine	7000	5	5	1
Penstemon digitalis	Foxglove Beardtongue	130000	5	11	2
Penstemon grandiflorus	Large Fl. Beardtongue	14000	5	11	2
Phlox pilosa	Prairie Phlox	19000	1	2	0

Pycnanthemum virginianum	Common Mt. Mint	220000	27	54	11
Ratibida pinnata	Yellow Coneflower	30000	5	11	2
Rosa spp.	Wild Rose	500	1	1	0
Rudbeckia hirta	Black-eyed Susan	92000	5	11	2
Rudbeckia subtomentosa	Sweet Coneflower	43000	5	11	2
Silphium integrifolium	Rosinweed	1200	1	1	0
Silphium laciniatum	Compass Plant	660	0	0	0
Solidago graminifolia	Grass Leaved Goldenrod	200000	5	11	2
Solidago nemoralis	Old Field Goldenrod	300000	5	11	2
Solidago rigida	Stiff Goldenrod	41000	5	11	2
Solidago speciosa	Showy Goldenrod	103600	5	11	2
Tradescantia ohiensis	Ohio Spiderwort	8000	5	11	2
Verbena hastata	Blue Vervain	93000	16	32	6
Verbina stricta	Hoary Vervain	28000	5	11	2
Vernonia fasciculata	Ironweed	24000	5	11	2
Veronicastrum virginicum	Culver's Root	800000	5	11	2
Zizia aurea	Golden Alexanders	11000	5	11	2
		TOTAL	**282**	**558**	**112**

Table 5. Mean frequency (%) of weed species present in quadrat (n=180) samples in 2005.

			Grass:Forb Seeding Treatments (% freq.)		
Genus-Species	**Common Name**	**Origin**	**1:1**	**1:5**	**5:1**
Ambrosia artemisiifolia	Common Ragweed	Native	9.4	13.9	12.8
Apocynum cannabinum	Indian Hemp	Native	2.8	0.0	0.0
Asclepias syriaca	Common Milkweed	Native	0.0	1.7	0.0
Bromus inermis	Smooth Brome	Exotic	9.9	13.3	23.9
Cirsium arvense	Canada Thistle	Exotic	37.8	29.4	18.9
Cirsium vulgare	Bull Thistle	Exotic	5.0	11.1	1.1
Convolvulus arvensis	European Bindweed	Exotic	0.6	6.1	1.7
Dactylis glomerata	Orchard Grass	Exotic	1.7	6.7	5.6
Elytrigia repens	Quackgrass	Exotic	0.0	1.7	1.1
Festuca arundinacea	Tall Fescue	Exotic	76.1	72.8	74.4
Lotus corniculatus	Bird's-Foot Trefoil	Exotic	32.8	36.7	38.9
Melilotus spp.	Sweet Clover	Exotic	27.8	28.3	15.6
Pastinaca sativa	Wild Parsnip	Exotic	5.6	6.1	0.5
Phalaris arundinacea	Reed Canary Grass	Exotic	7.2	5.0	6.7
Physalis virginiana	Virginia Ground Cherry	Native	6.7	7.8	12.8
Plantago rugelii	Common Plantain	Exotic	2.2	0.6	0.6
Poa pratensis	Kentucky Bluegrass	Exotic	10.6	4.4	10.6
Polygonum spp.	Smartweed sp.	Native	0.0	1.1	0.0
Setaria spp.	Foxtail sp.	Exotic	10.0	14.4	10.6
Sonchus oleraceus	Common Sow Thistle	Exotic	0.6	10.0	7.2
Taraxacum officinale	Common Dandylion	Exotic	10.0	2.8	7.2
Trifolium pratense	Red Clover	Exotic	0.6	1.7	2.2

Table 6. Total plants per m^2 detected in quadrat samples in 2005.

		Grass:Forb Seeding Treatments (per square meter)					
		1:1		1:5		5:1	
Grasses	**Common Name**	Seeds Sowed	Total Plants	Seeds Sowed	Total Plants	Seeds Sowed	Total Plants
Andropogon gerardii	Big Bluestem	22	1.9	10.8	1.1	53.9	2.9
Bouteloua curtipendula	Side-Oats Grama	32	0.9	10.8	0.4	53.9	1.2
Calamagrostis canadensis	Blue Joint Grass	11	0.0	10.8	0.0	53.9	0.0
Elymus canadensis	Canada Wildrye	22	3.6	10.8	3.1	53.9	5.1
Koeleria macrantha	June Grass	8	0.0	5.4	0.0	27.0	0.0
Panicum virgatum	Switchgrass	32	0.7	10.8	0.4	53.9	0.4
Schizachyrium scoparius	Little Bluestem	22	0.1	10.8	0.1	53.9	1.0
Sorghastrum nutans	Indian Grass	43	0.8	10.8	0.3	53.9	0.6
Spartina pectinata	Prairie Cordgrass	11	0.0	10.8	0.0	53.9	0.1
Sporobolis asper	Tall Dropseed	54	0.7	5.4	0.2	27.0	0.3
Sporobolis heterolepis	Prairie Dropseed	22	0.1	8.1	0.0	40.4	0.0
Stipa spartea	Porcupine Grass	3	0.0	2.7	0.0	13.5	0.0
	Total	**280**	**9**	**108**	**6**	**539**	**12**
Forbs							
Allium canadense	Wild Garlic	3	0.0	5.4	0.0	1.1	0.0
Amorpha canescens	Leadplant	5	0.1	10.8	0.0	2.2	0.0
Anemone cylindrica	Thimbleweed	5	0.0	10.8	0.0	2.2	0.0
Artemisia ludoviciana	Prairie Sage	5	0.0	10.8	0.1	2.2	0.0
Asclepias incarnata	Swamp Milkweed	5	0.4	10.8	0.3	2.2	0.1
Asclepias tuberosa	Butterfly Milkweed	1	0.0	2.7	0.3	0.5	0.0
Aster ericoides	Heath Aster	5	1.1	10.8	0.3	2.2	0.2
Aster laevis	Smooth Blue Aster	5	0.0	10.8	0.1	2.2	0.0
Aster novae-angliae	New England Aster	5	0.0	10.8	0.0	2.2	0.0
Aster sericeus	Silky Aster	5	0.0	10.8	0.0	2.2	0.0
Astragalus canadensis	Milk Vetch	5	0.0	10.8	0.2	2.2	0.0
Baptisia leucantha	White Wild Indigo	1	0.0	1.1	0.0	0.2	0.0
Cassia fasiculata	Partridge Pea	5	0.4	10.8	0.6	2.2	0.0
Coreopsis palmata	Prairie Coreopsis	1	0.0	1.1	0.0	0.2	0.0
Dalea candida	White Prairie Clover	5	0.1	10.8	0.1	2.2	0.0
Dalea purpurea	Purple Prairie Clover	5	0.1	10.8	0.2	2.2	0.1
Desmodium canadense	Showy Tick Trefoil	1	0.1	1.1	0.0	0.2	0.1
Echinacea pallida	Pale Purple Coneflower	5	0.0	10.8	0.2	2.2	0.0
Erynigium yuccifolium	Rattlesnake Master	5	0.0	10.8	0.0	2.2	0.0
Eupatorium altissimum	Tall Boneset	11	0.0	21.6	0.1	4.3	0.0
Helenium autumnale	Sneezeweed	22	0.0	43.1	0.0	8.6	0.0
Helianthus grosseserratus	Bigtooth Sunflower	1	0.2	1.1	0.5	0.2	0.0
Helianthus laetiflorus	Prairie Sunflower	1	0.1	2.7	0.2	0.5	0.1
Heliopsis helianthoides	Ox-eye Sunflower	5	0.4	10.8	1.2	2.2	0.2
Lespedeza capitata	Round-Headed Bush Clover	5	0.1	10.8	0.1	2.2	0.0
Liatris aspera	Rough Blazingstar	5	0.1	10.8	0.1	2.2	0.0
Liatris ligulistylis	Meadow Blazingstar	3	0.0	5.4	0.0	1.1	0.0
Liatris pycnostachya	Prairie Blazingstar	5	0.0	10.8	0.0	2.2	0.0
Lobelia siphilitica	Great Blue Lobelia	5	0.0	10.8	0.0	2.2	0.0
Monarda fistulosa	Wild Bergamot	11	0.3	21.6	0.4	4.3	0.1
Parthenium integrifolium	Wild Quinine	5	0.1	5.4	0.0	1.1	0.0
Penstemon digitalis	Foxglove Beardtongue	5	0.0	10.8	0.0	2.2	0.0
Penstemon grandiflorus	Large Fl. Beardtongue	5	0.0	10.8	0.0	2.2	0.0

Phlox pilosa	Prairie Phlox	1	0.0		2.2	0.0	0.4	0.0
Pycnanthemum virginianum	Common Mt. Mint	27	0.1		53.9	0.1	10.8	0.0
Ratibida pinnata	Yellow Coneflower	5	0.1		10.8	0.4	2.2	0.1
Rosa spp.	Wild Rose	1	0.0		0.5	0.0	0.1	0.0
Rudbeckia hirta	Black-eyed Susan	5	0.7		10.8	1.9	2.2	0.3
Rudbeckia subtomentosa	Sweet Coneflower	5	0.0		10.8	0.1	2.2	0.0
Silphium integrifolium	Rosinweed	1	0.0		1.1	0.0	0.2	0.0
Silphium laciniatum	Compass Plant	0	0.0		0.1	0.0	0.0	0.0
Solidago graminifolia	Grass Leaved Goldenrod	5	0.0		10.8	0.0	2.2	0.0
Solidago nemoralis	Old Field Goldenrod	5	0.0		10.8	0.0	2.2	0.0
Solidago rigida	Stiff Goldenrod	5	0.3		10.8	0.2	2.2	0.1
Solidago speciosa	Showy Goldenrod	5	0.0		10.8	0.0	2.2	0.0
Tradescantia ohiensis	Ohio Spiderwort	5	0.0		10.8	0.0	2.2	0.0
Verbena hastata	Blue Vervain	16	0.0		32.3	0.0	6.5	0.0
Verbina stricta	Hoary Vervain	5	0.0		10.8	0.0	2.2	0.0
Vernonia fasciculata	Ironweed	5	0.0		10.8	0.2	2.2	0.0
Veronicastrum virginicum	Culver's Root	5	0.0		10.8	0.0	2.2	0.0
Zizia aurea	Golden Alexanders	5	0.1		10.8	0.1	2.2	0.0
	Total	**282**	**4**		**558**	**8**	**112**	**1**