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Local Ecology Research Papers

Comparison of two prairie restoration sites to examine density, maturity, and species diversity

Anne K. Okerman
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Anne K. Okerman
Field Ecology
Dr. Kathleen Shea
St. Olaf College
Northfield, Mn

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OKERMAN, ANNE. St. Olaf College, Northfield, Mn. 55087, U.S.A.
Comparison of two prairie restoration sites to examine density, maturity, and species diversity.

Restorations of native vegetation to an area is a means to increase the biological diversity of an area. Prairie restorations using an array of native species is valuable to the midwest area as it preserves native plants that are accustomed to the soil and invaluable to the ecosystem. This study examines two prairie restoration sites on the St. Olaf campus that were planted four years apart from each other. Planting methods varied from site to site which might effect the biodiversity, density, coverage and height of the prairie plant species. The Shannon-Simpson diversity indices determined that there was a significant difference in diversity between the sites. Big Bluestem was an important grass for both sites as well as the forb Rubeckia. Coverage and density is also shown to be dependent on the site for most species. Grasseswere more dense with fewer forb diversity suggesting the need for a burn. Both prairies are relatively new and over time native species will continue to establish themselves in more substantial ways if management of prairies is continued.

Introduction

Biological diversity is perhaps an absolute necessity for the functioning and sustainability of ecosystems (Tilman, Wedin & Knops, 1996). Native prairies of the Midwest region in the United States support one of the most diverse and interrelated communities known. In this study, restored prairies will be examined to determine the progress of the native plant establishment in terms of biodiversity and maturity.

Restoration to native prairies is an expanding idea in conservation biology and is an effort to replace the grasslands that have diminished. The land that we inhabit was once comprised of thousands of hectares of vast grassland where bison roamed and grasses prevailed. Today, less than 0.1% of these native landscapes are left due to European settlement, advances in technology, and urban development.

> The prairie appears almost monotonous in the general uniformity of its plant cover. Its main features are the absence of trees, scarcity of shrubs, the dominance of grasses, and a characteristic xeric flora. (Sampson & Knopf,1994).

Historically, public thought has not recognized the extreme diversity and intraspecific relationships that are hidden within the sea of grasses which have great effect on the sustainability of the earth. With the loss of these prairies, so also have the numbers of animals, plants, and birds diminished that once thrived in the harsh environment of prairie lands. Native prairie conservation and restoration has been largely neglected in growing efforts to support and sustain biological diversity (CEQ 1991), however, gradually the value and importance of restored prairies is taking hold and efforts are being made to reestablish this natural landscape of the Midwest region.

The St. Olaf Campus has taken on a mission to restore previous agricultural land into native grasslands creating natural habitats on the outskirts of campus. Though the areas are small and may be considered "remnant prairies," they are important in supporting a diversity of plants and small animals native to grassland environments (Shafer 1995). The process of restoration for prairies can be done in a variety of ways depending upon how extreme the restoration will be. Soil preparation using herbicides may be necessary to get rid of seed banks from previous vegetation, however, prairie grass will adapt to nutrient-poor soil. As prairie grasses establish over time, they add substantial amounts of organic matter from deep decaying roots (Packard& Mutel, 1997) therefore enriching the soil for themselves and other forbs. Prairie grasses and forbs need to be suited, though, to the soil moisture levels and should come from seeds banks that originate in a 50-200mi radius of the restoration site (Dunnette, 1997). This will ensure that the restored prairie will be close to the original vegetation of a site.

The biodiversity of a restored prairie is essential for its success, though the main goal is to restore a community on a site to its most original vegetation. Studies have shown that plant diversity has a significant effect on productivity, nutrient use, and nutrient loss (Tilman, Wedin, and Knops, 1996). Many prairie plant species inhabit close spaces sharing resources so that they bloom and reproduce at different times. The individuals of a species differ slightly from each other in their abilities to adjust and respond to a range of environmental conditions (Packard & Mutel, 1997). The slight differences represent the diversity within the species and, importantly, ensure that the integrity of a prairie will be preserved in the event of a disturbance or change such as the extreme case of global warming.

The management of a prairie is most important in the first three years of its establishment yet requires minimal effort afterwards if it is well-established. It is during this time that the prairie grasses establish their roots that eventually become 75% of the prairie biomass (Packard & Mutel, 1997). There is little above-ground growth that may allow weeds to invade so mowing may be necessary to reduce unwanted seeds and allow light to prairie plants. Once the prairie is well-established, occasional burning is essential for the prairies' productivity and survival of native plants. Fires are an essential part for the plant community structure and composition of tallgrass prairie. Historically, prairie fires swept across the land which burned back invading woodland species and allowed the prairie plants to regrow from the roots up. The deep root system of prairie grasses allow them to thrive following a burning. Studies have shown that late spring burning favors warm-season perennial grasses but reduces species diversity and heterogeneity. In contrast, the diversity and abundance of forbs is favored during the first few years after a fire but them decrease (Abrams and Hulbert, 1987 as sited by Towne and

Knapp, 1996). Studies have also examined the response of prairie forbs to nitrogen-deficient soil after burning to determine that most legumes are affected in biomass and density though they have shown adaptability to a frequent-fire habitat (Towne & Knapp, 1996).

The purpose of this investigation was to compare two different areas of restored prairies planted four years apart from each other. The investigation assess differences in the diversity and maturity of the sites which vary in age, size, planting technique, and timed burnings. Both sites are located on the St. Olaf campus in Southern Minnesota. This study will assess the restoration process of two remnant prairies by examining the characteristics of individual species.

Methods

The restored prairie sites were located on the St. Olaf campus and had been converted from conventional agricultural land (figure 1.). The newest site was planted by Prairie Restoration, Inc. by plowing rows and inserting seeds of prairie grasses and forbs; it was last burned in 1996. The older site was planted by hand and then raked over to push the seeds into the ground. It's last burning occurred in 1991.

The line-intercept sampling method was used as discussed in Brower et. Zar, (1991). Two transects at each site measuring 30m for the older site and 20m for the newer site were used to collect data to determine density, coverage, frequency, and importance value. The height of the predominant grass species Big Bluestem was them measured in height.

Data were collected and collated for results. Using the methods described in Chapter 3: Field and Laboratory Methods for General Ecology, the **relative density, relative frequency, relative coverage,** and **importance value**

were determined from the data (Brower et. al.,
study can be referred to in the lab manual.

Statistical analysis was performed using
the Shannon and Simpson indices of diversity. ANOVA tests compare the density and coverage of a species in relation to the site where it was found. The ANOVA analysis studied the effect of independent variables on a continuous dependent variable when the independent variables are divided into groups rather than a range of values (Abacus Concepts, 1992). Each table summarizes the test by giving the number of individuals, the mean height of the stem, the standard error, and the P-value.

ANOVA tests were used to examine various relationships. Six species found on both sites, consisting of three grasses and three forbs were compared to determine how density and coverage related to site. The height of the big bluestem was also tested as compared to sites. The density of grasses and density of forbs were compared within each site.

Results

As seen in Table 1 the results of this study show that the number of individuals was higher at the newer prairie, site one, compared to the older prairie, site two. Species Richness was also slightly higher at site one than at site two. Shannon Index states that site one had greater diversity in relation to site two. The biodiversity is a significant difference between sites as shown by the p-value of the Simpson Index. Individual numbers and species richness are slightly different between transects within each plot though the Shannon and Simpson indices determine the difference in diversity as not significant.

Relative density, relative frequency, and relative coverage compare the various species within each site to determine the importance values. Table 2. examines site one to determine that Rubeckia had the highest importance value followed by reed grass, big bluestem, canada wild rye, and little bluestem. Table 3. describes that dried grasses had the highest importance value at site two followed by big bluestem, Indian grass, little bluestem, milkweed and asters. The importance values of the species on each site are compared in figure 1.

ANOVA tests of six plants was conducted to determine significant relationships of density and coverage according to site. As seen in table 4, Big bluestem and dandelion species density and coverage show that they are not related to site as determined by the p-value. Canada wild rye and Rubeckia show that their density and coverage is significantly different between sites. The mean density of little bluestem is greater at site one which is shown as a significant difference though coverage is not. Coneflowers, however, have a significantly greater coverage at site one though density does not vary as much between sites.

Big bluestem height is greater at site one than at site two as seen in figure 2. The height of this species has a significant relationship to site as determined by ANOVA tests shown in table 5.

Density of grass species and forb species as a factor of site is tested using ANOVA. Grasses are more dense than forbs for both prairie restoration sites as seen in figure 3 and 4. However, site two shows that grasses are significantly more dense though it is not significant for site one as summarized in table 6.

Discussion

The progress and success of the native vegetation in restored prairie areas is important to assess for maintaining its biodiversity. From this evaluation, maintenance techniques can be determined to ensure a close replication of the the original ecosystem. The tallgrass prairie of the midwest is a biologically diverse, fire-dependent ecosystem whose native grasses and forbs interact in complex ways and are adapted to frequent fires. Plant response is extremely sensitive to the timing of the burning within as much as four days (Benning, 1993). Therefore, it is important to pay careful attention to specific burning and plant growth status.

Planting techniques may be a direct relation to the variation of the prairie sites. The prairie restored in 1993 by Prairie Restorations, Inc. was conducted using a plow that create rows in which to insert the seeds. During the prairie's establishment, plants grow in rows leaving spaces to expand. Results from the study have shown that the most recently restored prairie site had a greater species diversity and species richness than the older restored prairie (table 1.) The forb ıbeckia was the most influential species at this site which may be due to its aggressive nature as stated by Runkel & Roosa (1989). However, grass species, reed grass, big bluestem, Canada wild rye, and little bluestem were predominant in this site (table 2.) which suggests that the grass species are establishing themselves after a four year time period. The height of the big bluestem, a predominant tallgrass prairie species was proven to be greater at the newer prairie site thus supporting the idea that species are becoming more mature. Though the spaces between plant rows would lead one to believe that invaders could easily succeed and take over, it appears that this is not affecting the native plant establishment in terms of density, diversity, and height.

The plant composition of the older prairie site, however, shows that grass species are more dense and are more influential (table 3 & 6.). Dried grass, big bluestem, Indian grass, and Little Bluestem are predominant grasses. Forbs which are accustomed to moist soils, milkweed, asters, and goldenrod, are important forbs at this site. Though there appeared to be less biodiversity and species richness at the older prairie site, it may be due to the seed content that was originally planted. Restoring prairies require planting species in percentages as determined by the planter.

The issue of human selection of prairie content is raised in this study. According to Gene Bakko, the newer prairie restoration site was planted with many flowering annuals so that in the first year, it would be a colorful display. However, these species died out which was "disappointing". It is easy to choose species that will create the most aesthetically pleasing place, however, prairies may not consist of the most original vegetation. In this respect, it is important to develop an overall appreciation of all plant species of the tallgrass prairie and the intricate web of interspecific relationships.

The dominance of grasses at the older prairie site may be an indication that burning is needed. There are few forbs and less diversity which is characteristic of the process that forbs increase in diversity and abundance during the first years after burning but then decrease. Fire suppression can cause a loss of species (Leach & Gimish, 1996) as prairies are dependent on fires. The big bluestem, for example, has shown to be more efficient photosynthetically in burned than unburned prairie (Benning, 1993). Burning will destroy invasive species who are not adapted to the process and will also replenish the soil.

Biodiversity has been determined to increase productivity and sustainability of ecosystems though a complete understanding has not been attained. However, a diversity-productivity hypothesis is based on the idea that the interspecific differences in the use of resources by plants allow more diverse plant communities to utilize resources more fully and attain greater productivity (Naeem, et. al.,1994 as stated by Tilman et. al., 1996). A further study by Tilman et. al. (1996) combines the hypothesis that nutrient leaching losses from ecosystems will decrease plant diversity because of greater nutrient capture in more diverse ecosystem to develop a diversity-sustainability hypothesis. This hypothesis states that the sustainability of soil nutrient cycles and fertility is dependent on biodiversity. A species-rich grassland is more resistant to ravages of drought and recover more quickly than species-poor prairies (Kareiva, 1996). Another important aspect of restoring biodiversity to prairies is that it preserves a natural history of our land. Many prairie plant species have invaluable worth as medicine or foods and are rich in cultural history.

Overall, the restoration sites appear to be doing well though further investigation might examine soil, effects of bordering agricultural land, invading species, etc. It would be interesting to compare species composition of these sites after burning to determine the changes. The effects of the surrounding environments such as the wetlands, forests, and agriculture are possibilities for the inhibited growth of the prairies and might also be examined.

In conclusion, prairie restorations require extensive knowledge of the original vegetative composition of a site. This study has examined the progress of two prairie sites to determine that restorations have been successful though management is a continuing process. By examining the biodiversity and species composition, an assessment of the prairie can be gathered which give insight for management procedures.

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Table 1. The number of species, species richness, and the Shannon and Simpson diversity indices are compared between sites and transect lines within each site. Site one is the newer prairie planted in 1993; Site two is the older prairie, planted in 1989.

	Sites:		*Site One:*		*Site Two:*	
	Site 1	Site 2	Transect 1	Transect 2	Transect 1	Transect 2
# of individuals	675	625	343	332	342	284
Species Richness	28	25	19	24	23	21
Shannon Index	2.63	2.31	2.33	2.65	2.79	2.59
Simpson Index	0.89	0.92	0.88	0.89	0.92	0.91
t-value	4.61		1.4		1.51	
p-value	0.01		NS		NS	

Table 2. Line-Intercept sampling methods were used to determine relative density, relative frequency, relative coverage and importance values of each species in site one, the younger prairie restoration planted in 1989.

Site one					
Species	# of Individuals	Relative Density	Relative Frequency	Relative Coverage	Importance Value
Reed grass	88	0.13	0.085	0.122	0.337
Little Bluestem	47	0.07	0.057	0.105	0.232
Big Bluestem	70	0.104	0.085	0.119	0.308
Switchgrass	12	0.018	0.035	0.02	0.073
Canada Wild Rye	74	0.11	0.078	0.119	0.307
Wire grass	2	0.003	0.014	0.003	0.02
Unknown grass	9	0.013	0.035	0.02	0.068
June grass	10	0.015	0.028	0.018	0.061
Side Oats Gama	6	0.009	0.014	0.014	0.037
Rubeckia	143	0.212	0.085	0.15	0.447
Yarrow	53	0.079	0.064	0.037	0.18
Hoary Vervain	6	0.009	0.021	0.003	0.033
Moss	14	0.021	0.043	0.023	0.087
Dandelion	33	0.049	0.05	0.083	0.182
Milkweed	7	0.01	0.035	0.016	0.061
Clover	4	0.006	0.014	0.006	0.026
Coneflower	29	0.043	0.071	0.056	0.17
Goat's Rue	2	0.003	0.007	0.003	0.013
Unknown 1	18	0.027	0.021	0.006	0.054
Ragweed	3	0.004	0.007	0.003	0.031
Speedwell	14	0.021	0.057	0.033	0.111
Foxtail	4	0.006	0.021	0.006	0.033
Unknown 2	5	0.007	0.028	0.008	0.043
Thistle	3	0.004	0.007	0.004	0.015
Blue Vervain	1	0.001	0.007	0.002	0.01
Golden Alexander	11	0.016	0.007	0.005	0.028
Ox-eye Helopsis	1	0.001	0.007	0.002	0.01
Goldenrod	5	0.007	0.014	0.015	0.036
TOTAL #	675				

Table 3. Line-Intercept sampling methods were used to determine relative density, relative frequency, relative coverage, and importance values of site two, the older prairie restoration site planted in 1989.

Site two					
Species	# of Individuals	Relative Density	Relative Frequency	Relative Coverage	Importance Value
Big Bluestem	66	0.106	0.077	0.146	0.329
Indian grass	74	0.118	0.077	0.132	0.327
Little Bluestem	70	0.112	0.077	0.129	0.318
Side Oats Gama	7	0.011	0.01	0.033	0.054
Switch grass	6	0.01	0.019	0.009	0.038
June Grass	11	0.018	0.029	0.015	0.062
Canada Wild Rye	10	0.016	0.029	0.008	0.053
Unknown Grass	4	0.006	0.01	0.003	0.019
Dried Grass	61	0.098	0.077	0.161	0.336
Rubeckia	31	0.05	0.058	0.041	0.149
Dandelion	31	0.05	0.067	0.029	0.146
Clover	12	0.019	0.029	0.005	0.053
Yarrow	20	0.032	0.048	0.032	0.112
tree	4	0.006	0.019	0.009	0.034
Goldenrod	36	0.058	0.048	0.041	0.137
Moss	12	0.019	0.048	0.015	0.082
Asters	37	0.059	0.067	0.058	0.184
Liatris	1	0.002	0.01	0.001	0.013
Leadplant	2	0.003	0.01	0.004	0.017
Unkown 2	5	0.008	0.029	0.006	0.041
Milkweed	51	0.082	0.048	0.059	0.189
Golden Alexander	19	0.03	0.038	0.024	0.092
Blue Vervain	27	0.043	0.029	0.024	0.096
Field Thistle	8	0.013	0.038	0.014	0.065
Yellow Coneflower	3	0.005	0.01	0.003	0.018
TOTAL #	625				

Table 4. ANOVA Statistical tests compare six species common in both sites examining their density and coverage as a factor of site.

Big Bluestem	# Intervals	Mean Density	Standard Error	**P-value**	Mean Coverage	Standard Error	**P-Value**
Site One	12	5.833	0.824		33	6.068	
Site Two	8	8.25	2.541	0.3042	53.625	20.443	0.2286
Little Bluestem							
Site One	12	3.917	1.138		29.083	8.701	
Site Two	8	8.75	1.13	0.0098	48.875	7.657	0.1278
Canada Wild Rye							
Site One	12	6.167	1.167		33	6.582	
Site Two	7	1	0.655	0.0054	3.5	1.946	0.0022
Rubeckia							
Site One	12	12.333	1.499		41.65	5.964	
Site Two	8	3.875	1.274	0.0009	15.475	5.735	0.0075
Dandelion							
Site One	12	2	0.835		19.125	10.933	
Site Two	7	3.286	0.865	0.329	8.083	2.234	0.494
Coneflower							
Site One	12	1.417	0.358		11.25	3.025	
Site Two	7	0.375	0.375	0.0676	1.286	1.286	0.0272

Table 5. ANOVA statistical tests examine the height of the Big Bluestem as a factor of location.

Big Bluestem Height				
	# of Individuals	Mean Height	Standard Error	**P-value**
Site 1	44	162.589	2.835	
Site 2	59	150.051	1.734	0.0001

Table 6. The density of grass species and forb species were compared in relation to site using ANOVA statistical tests.

Site 1	# of Individuals	Mean Density	Standard error	**P-value**
Grasses	70	5.629	0.863	
Forbs	70	4.5	0.566	0.276
Site 2				
Grasses	42	7.333	0.705	
Forbs	63	4.476	0.477	0.0007

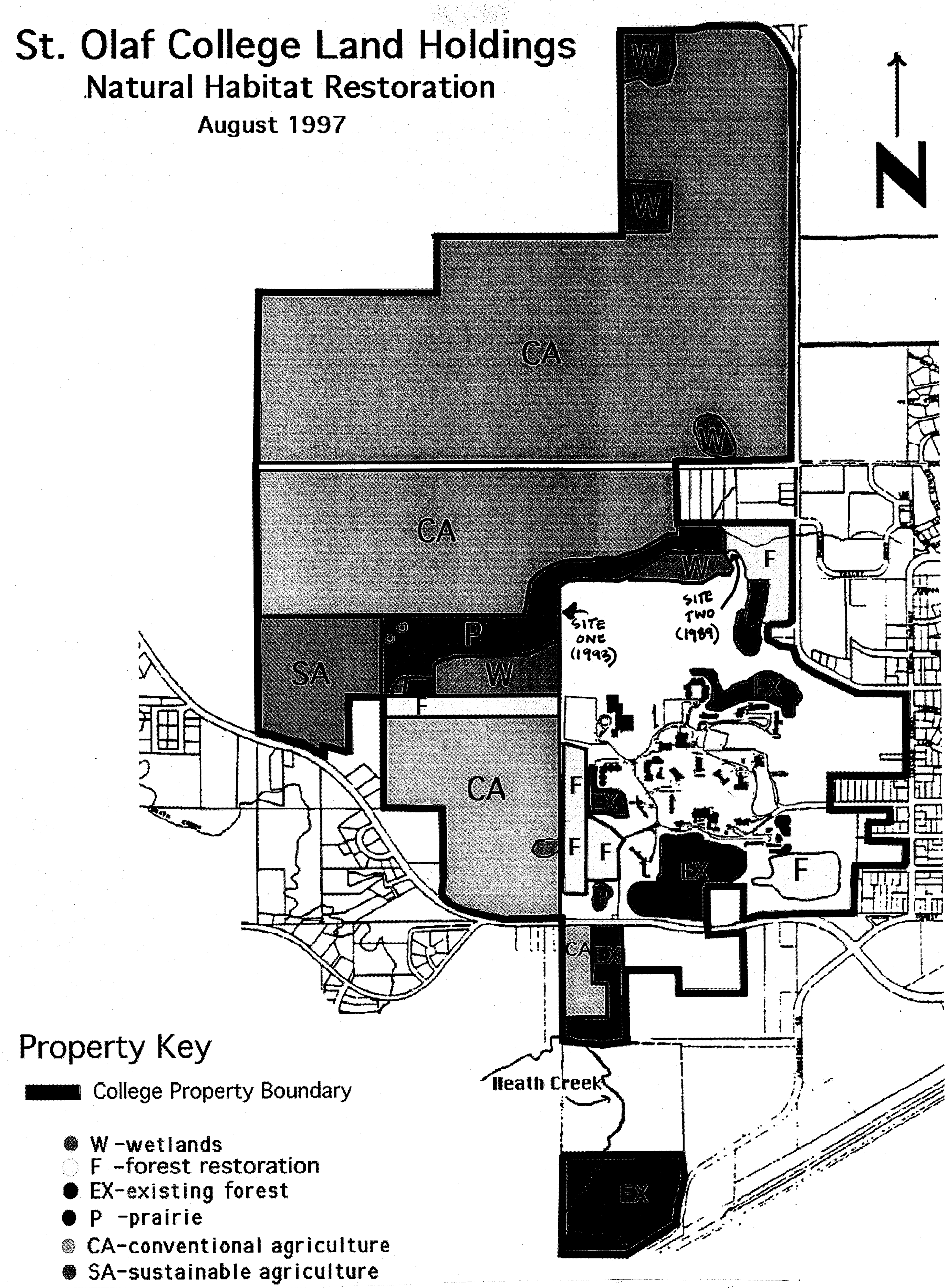


Figure 1. A map of the St. Olaf College campus and land holding show the range of land use as of August, 1997. This displays the prairie restorations where this study was carried out and the land bordering the

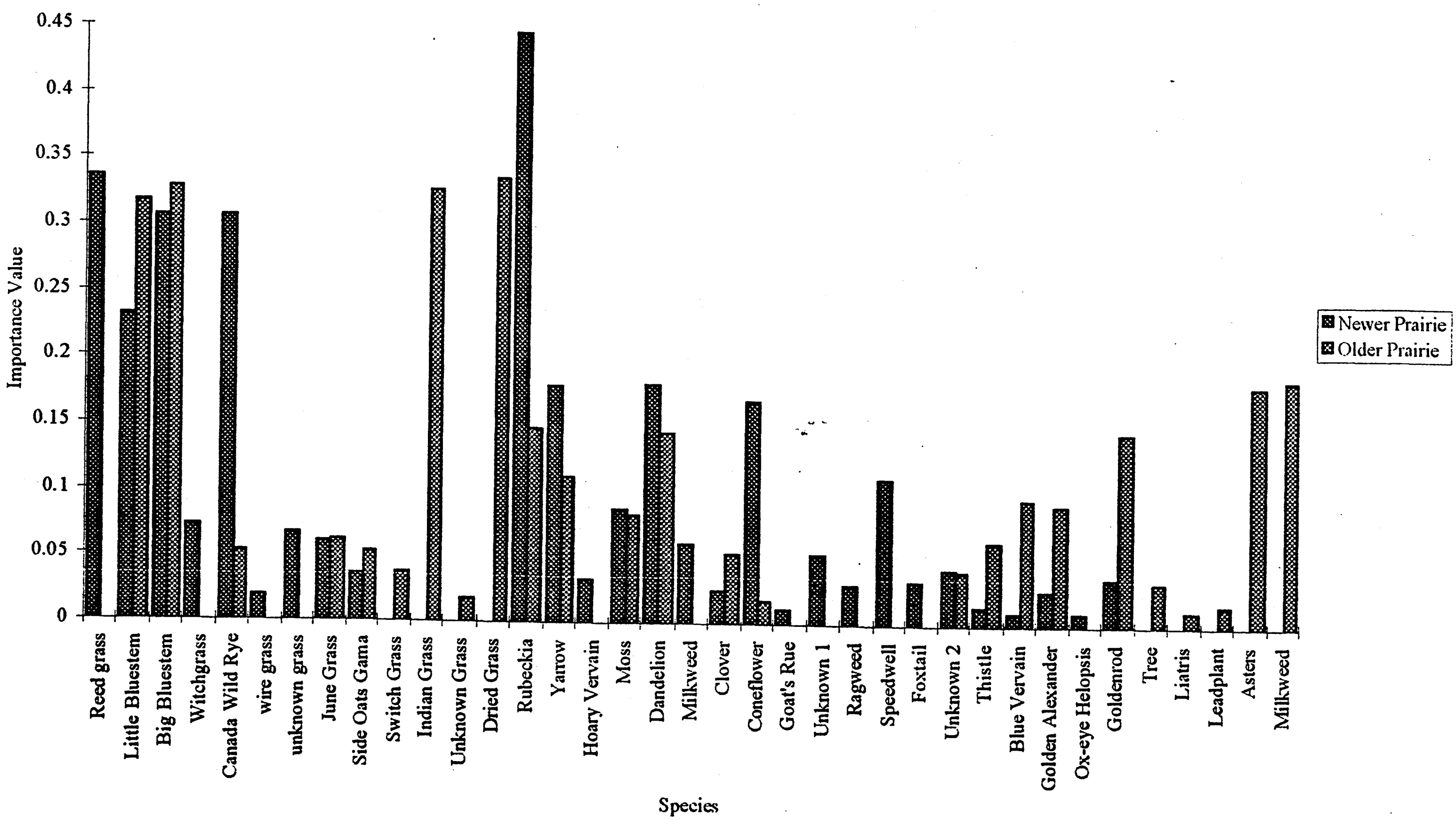


Figure 2. The importance values of all species found in the older and newer prairie sites are compared in this graph.

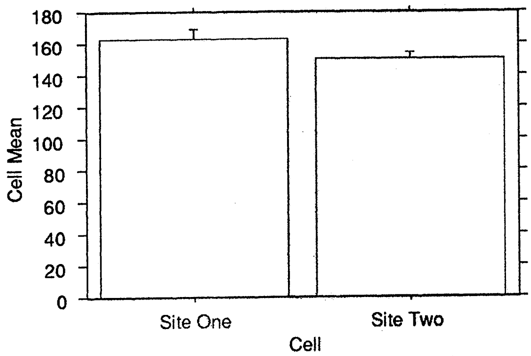


Figure 3. ANOVA test results show the height of the Big Bluestem for site one- the newer restored prairie compared to site two- the older restored prairie.

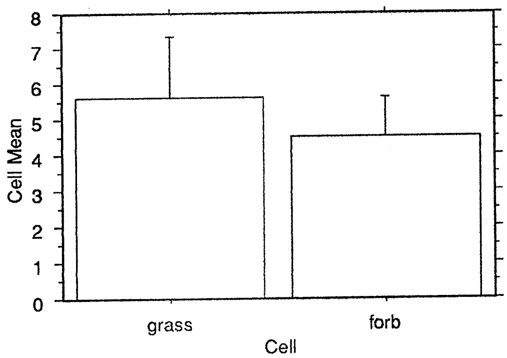


Figure 4. Density of grasses and forbs of the newer priarie restoration site are compared using ANOVA tests.

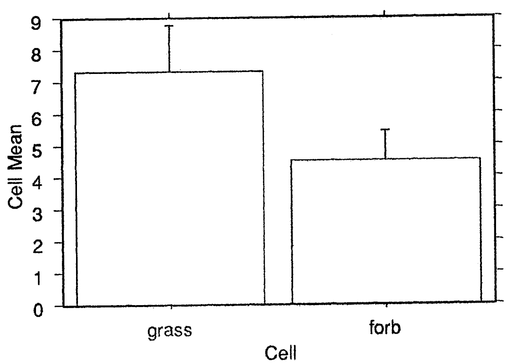
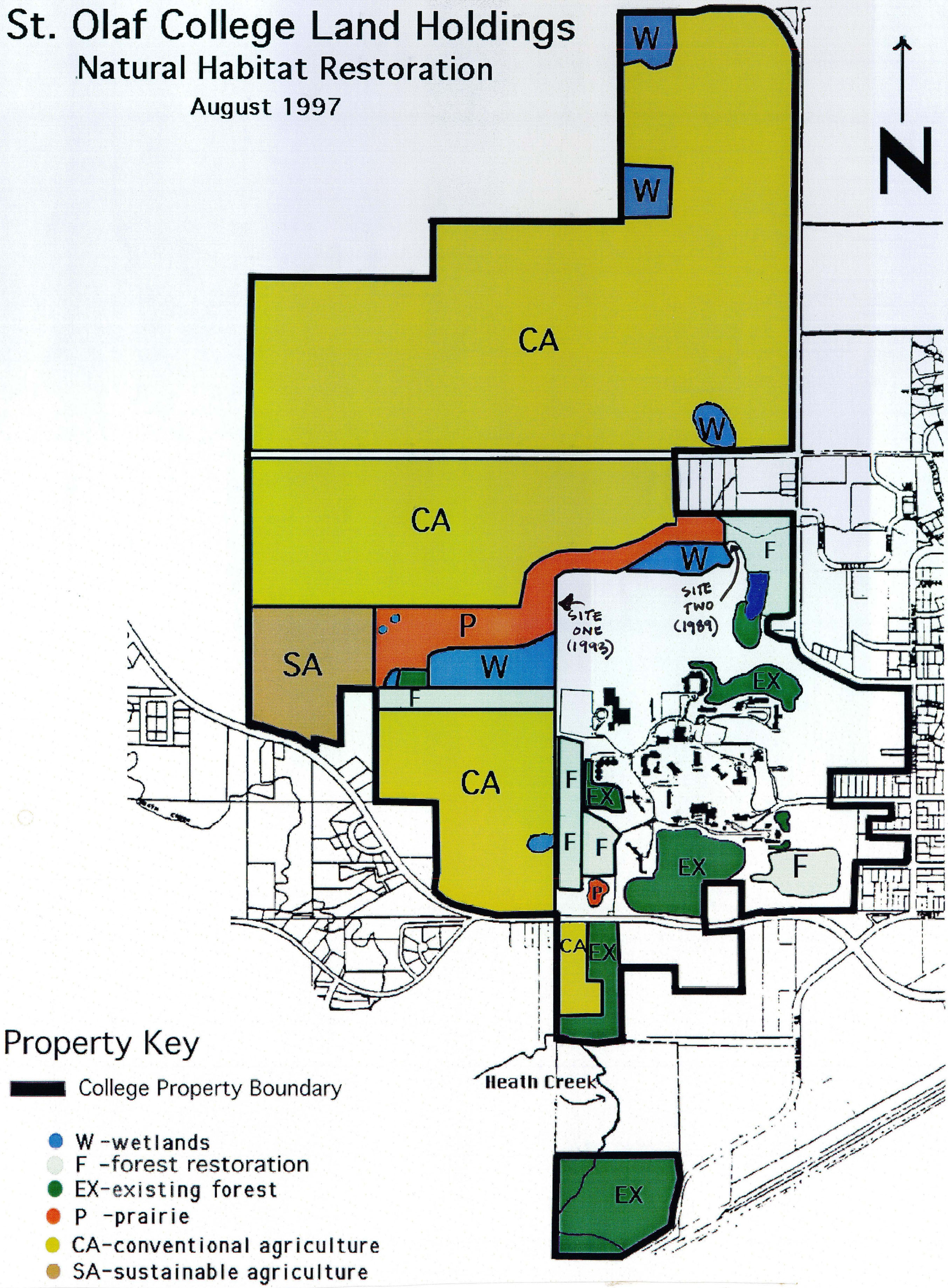


Figure 5. Density of prairie grasses and fobs of the older prairie site are compared using ANOVA statistical tests.



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