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Prescribed burns and targeted mowing as a Means of Pest Control: synthetic grazing and prescribed burning of reed canary grass monocultures (*Phalaris arundinacea*)

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Abstract

Reed canary grass, *Phalaris arundinacea*, poses an intense threat to native biodiversity across the American Midwest. Its prolific vegetative growth allows it to outcompete local ecotypes, forming monocultures that alter the entire microclimate from soil properties to hydrology. Many management techniques have been proposed, including burning, water table management, clipping, and herbicide application. Here, the effect of bloomtime mowing in tandem with occasional prescribed burning on growth is studied in a restored prairie of Southeastern Minnesota. I randomly sampled three half meter plots in four sites each: two mowed and two unmowed sites. Clipping samples were also collected and separated between forb and graminoid masses. Basic species richness was higher at mowed sites (n=11,9) than unmowed sites (n=3,5). The Shannon index followed this trend of higher diversity at mowed sites (H =.28, .37) than at unmowed sites (.23, .17). The Simpson index showed less difference in diversity, with only one significant variant (mowed diversity of .30 and .33, unmowed of .31 and .18). There was no significant difference between forb or graminoid biomass between mowed and unmowed sites. Recently burned sites had a higher percentage of forbs (mean 26.5%) than not recently burned sites (mean 12.4%). These results suggest that both burning and mowing may have a positive impact on the diversity and forb to graminoid ratios of RCG monotypes. However, further study should examine the long-term effects of repeated bloomtime mowing as well as the future trends of forb and graminoid biomass.

Keywords:

Reed canary grass, *Phalaris arundinacea*, prairie restoration, mowing, prescribed burns.

Introduction

Reed canary grass (*Phalaris arundinacea)* poses a serious threat to biodiversity in the American Midwest. It is an invasive perennial with an aggressive nature that makes it a problem species for land management in many ecosystems, particularly wetlands and wetland prairies. First planted in the early 1900's for livestock grazing, reed canary grass (RCG) has become relatively ubiquitous in the midwestern landscape. For instance, Bernthal and Hatch (2008) found that it is present in one in seven acres of all wetlands in Wisconsin. Nonetheless, RCG is still intentionally introduced for erosion control, seed source, and soil stabilization across Wisconsin and Minnesota (Wi DNR 2009).

P. arundinacea effectively outcompetes native species for a few reasons. High seed vitality and prolific rhizome structures are its greatest asset for high fitness. It overpopulates the seed bank and creates thick subsurface turf that prohibits other plants from sprouting roots. RCG also sends up shoots earlier in the spring than most local plants do, shading them out and decreasing their germination rates (Shaw 2000). These two factors contribute to its ability to form monocultures, or large areas hosting a single species. Large stands of reed canary then constrict the soil, causing a number of ecosystem changes such as shifts in hydrology and nutrient levels (Wi DNR 2009).

Of the many proposed methods for RCG management and removal, burning and bloomtime mowing may be both effective and relatively simple. Both methods allow the prairie to essentially 'reset'. The above ground biomass is removed, bringing them all to the same level. In prescribed burns, increased phosphorus and other key nutrients promote sped-up growth of native plants while having little to no effect on reed canary (Larson 2009). Likewise, mowing simulates grazing which native plants are more adapted to than *P. arundinacea.* Both techniques have been shown to promote forb growth more than graminoid (Shaw 2000).

This study attempted to evaluate the effect of mowing and grazing on species diversity and forb biomass in a restored prairie of southeastern Minnesota. I hypothesized that if reed canary grass fitness was influenced by bloomtime mowing and prescribed burns, then there would be a greater species richness and proportion of forbs in mowed plots than unmowed plots. Likewise, recently burned plots would follow the same trend. The specific objectives of this study were to:

1. Evaluate the total plant species richness and diversity of reed canary grass monotypes in mowed and unmowed sites, as well as recently burned sites and not recently burned sites.
2. Evaluate the forb to graminoid ratios of reed canary monotypes that were mowed, unmowed, recently burned, and not recently burned.

Methods

I conducted my research at four sites within the St. Olaf Natural Lands in southeastern Minnesota. Two of the sites had been flat-mowed in June while two had not. Two of the sites were also burned in 2017, while the most recent burning on the other two sites occurred in 2014 and 2015. Each site had at least a 10x10 area of reed canary monotype. I used a random stratified sampling system to mark three plots at each site for a total of 12 plots. I then hand counted and identified species within each half-meter plot. I also took clippings of half of the area of each plot for biomass analysis.

In the lab, I sorted graminoid and forb biomass from the clippings and dried them in a drying oven at 60 degrees Celsius for 48 hours. I then weighed the samples. I entered the data into an excel spreadsheet where I made graphs and figures. Excel is a powerful tool for visual representation of data. I performed statistical tests using R studio and R commander, which provides a graphics interface for important R functions. Namely, I used R to perform one-way (t-test) and multiway ANoVAs.

Results

Raw data counts present 12 plots that vary widely in composition and density (table 1). Reed canary grass is present in all plots. Seedlings (measuring less than 25cm) were counted separately in order to obtain a picture of age structure. Other species' seedlings were not present. Aside from RCG, canada goldenrod (*Salidago altissima*) was the most present species. Simply from the raw data, it is apparent that mowed areas are higher in species richness, though there is a high level of unevenness.

These trends are shown in figure 1, which presents the compiled count data as a stacked column chart. Here, age structure of the communities is apparent through the distribution of RCG and RCG seedlings as percentages. Mowed sites had a higher occurrence of mature *P. arundinacea* (73%) than unmowed sites (64%), but unmowed plots had a greater number of seedlings. Overall, there is a higher percentage of reed canary at unmowed sites (85% versus 83%), suggesting a younger population with more prolific reproduction. Likewise, increased species richness at mowed sites is apparent, as is the uneven distribution of species.

Diversity indices (table 2) further shows this trend. Species richness is higher at mowed sites (9, 11) than at unmowed sites (3, 5). The Shannon index also is higher in mowed plots (.28, .37) than unmowed plots (.23, .18). The Simpson index does not differ between mowed and unmowed types. Piecewise variance assessments of these numbers found that only site 4 (unmowed) is different than the others (p-value $<.05$), suggesting that the Simpson index is not a conclusive method of diversity analysis in this case. This is likely because of the relatively small sample size and low species evenness.

Forb and graminoid biomass ratios were significantly different (p-value 4.23E-6) at recently burned sites (mean forbs 26.5%) compared to unburned sites (mean forbs 12.4%). Biomass data was not significantly different between mowed and unmowed sites. Figure 2 presents ratio data in a stacked column chart as a means of comparing sites that will inherently have different biomasses due to the process of mowing.

Discussion

Diversity and species richness

Although reed canary grass was present in all plots, a higher species richness and Shannon index at both mowed plots suggests that mowing is effective for equalizing the fitness of native plants in RCG monotypes. The Simpson index, which weighs evenness higher than the Shannon index, did not come to this conclusion. Although indices are useful for understanding diversity from a number of perspectives, ecologist Lou Jost (2009) states that direct species richness counts are more useful than indices in areas of low diversity.

Investigating RCG seedling counts gives a snapshot of the age structure of the community. One of reed canary's most valuable assets is its ability to sprout new growth quickly, creating a subsurface turf that blocks other species from breaking through (Shaw 2000). Low growth counts suggest that its ability to reproduce quickly is weakened. Mowed sites had a significantly smaller proportion of seedlings than unmowed plots. Waller and Dyer (1995) propose that this may due to reed canary grass lacking the adaptation to grazing that native forbs and graminoids have. Particularly, grazing during seed production lowers the energy and nutrients available to the plant for resprouting.

Forb and graminoid biomass

A study of oak savanna in Michigan by Reinhart et al. (2017) showed that prescribed burning can increase forb production at a higher rate than graminoid production. Likewise, the Wisconsin DNR (2009) suggests that mowing during bloomtime has a positive effect on late season inflorescence production. Surprisingly, this study supported Reinhart et al. but refuted the conclusions of the Wisconsin DNR. Future studies should attempt to consolidate biomass data over multiple years in order to better understand the effect of both control methods.

The results of this study mostly supported my hypotheses. Sites were significantly different in richness, with a higher diversity at both mowed sites than unmowed. Likewise, a greater forb to graminoid ratio was found at recently burned sites. On the other hand, burning had no significant effect on diversity. Although conclusions are not fully supported, there were observed benefits to both prescribed burning and bloomtime mowing. Future studies in the Natural Lands should attempt to create a controlled experiment where more sites are purposefully left unmanaged for comparison.

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Figures/Tables

Table 1. Raw count data of number of individuals for all 12 plots with common and taxonomic names.

Common name	**Site 1 (mowed)**			**Site 3 (mowed)**			**Site 2 (unmowed)**			**Site 4 (unmowed)**		
	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii
RCG *P. arundinacea*	33	226	161	69	130	95	44	79	118	90	77	85
RCG (seedlings)	3		2	26	34	24	36	48	26	31	21	
canada goldenrod *S. Altissima*	42	11	5	2	7	7	20	23	29		6	7
Sedges *Carex sp.*	1			16	3			7		1		
bush clover *L. leptostachya*				1	1							
little blue stem *S. scoparium*				2								
turf grass				8	3							
Beebalm *M. fistulosa*				1								
red clover *T. pratense*	3			5								
Yarro *A. millifolium*	14			1								
big blue stem *A. gerardii*	1		3		18							
unknown 1	2					12						
canada thistle *C. arvense*	1									3		
black-eyed susan *R. hirta*	1		3									
unknown 2										15	1	
Totals	**101**	**237**	**174**	**100**	**157**	**173**	**131**	**196**	**138**	**140**	**105**	**92**

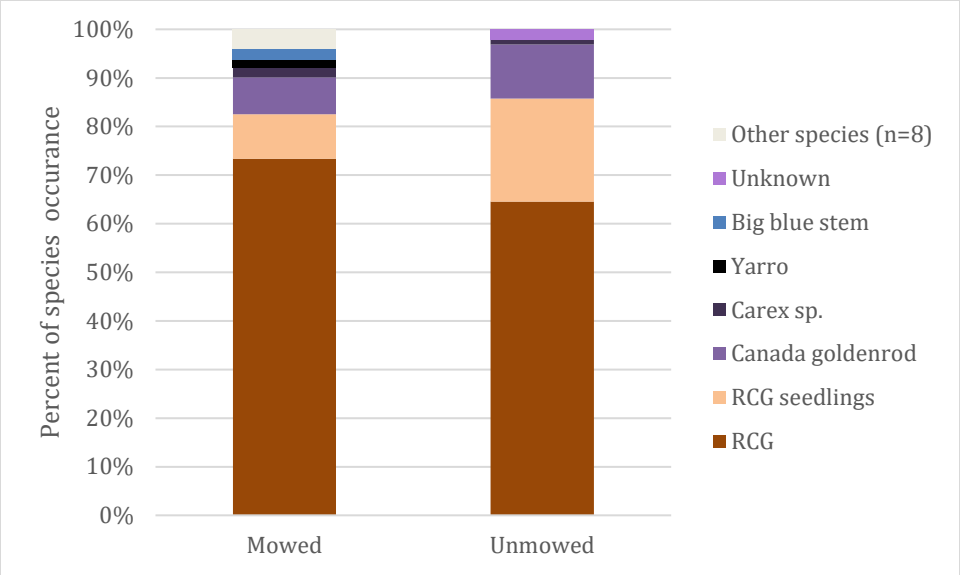

Figure 1. Stacked column chart of species as percentages. Mowed sites show higher diversity and a smaller overall occurrence of reed canary grass.

Table 2. Diversity indices for mowed and unmowed sites. Mowed sites show a higher diversity than unmowed sites in both their richness and Shannon index. Simpson indices are less conclusive, likely because of a higher emphasis on evenness, which is lowered due to high counts of RCG.

	Mowed		**Unmowed**	
	Site 1	Site 3	Site 2	Site 4
Richness	9*	11*	3*	5*
Shannon (H')	0.28*	0.37*	0.23*	0.18*
Simpson (Ds)	0.30	0.33	0.31	0.18

* = Significant difference between sites

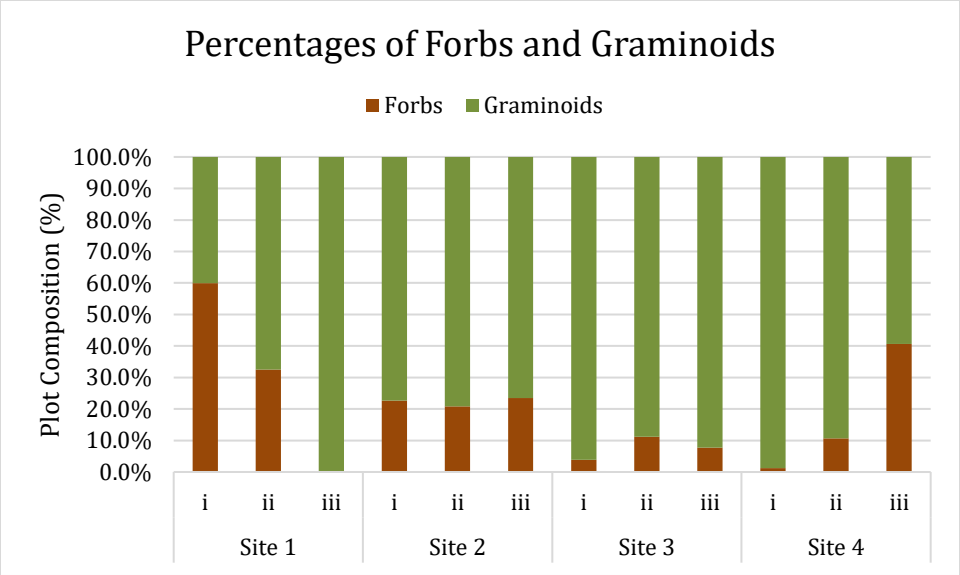

Figure 2. Stacked column chart showing ratios of forbs to biomass at each plot. Sites 1 and 3 (mowed) are relatively inconsistent, however sites 2 and 4 (recently burned, mean 26.5% forbs) suggest a higher forb production (p-value 4.23E-6) than non-recently burned sites (mean 12.4% forbs).

Table 3. Occurrence of forb and graminoids at each site. Data is in reference to above graph, which gives the percentage of either plant type at each site.

		FORBS (G)	GRAMINOIDS (G)
SITE 1	**i**	11.33	7.58
	ii	8.63	17.87
	iii	0	57.34
SITE 2	**i**	10.11	34.44
	ii	19.13	72.87
	iii	14.94	48.68
SITE 3	**i**	1.87	45.88
	ii	6.88	54.66
	iii	4.35	52.14
SITE 4	**i**	0.99	80.15
	ii	10.04	83.64
	iii	32.18	46.96