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The Effects of an Early Season Clipping on Several Grassland Species

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Abstract. In one year, the Proposed 100-Acres Quarry Park, Stearns County, Minnesota, USA, will be undergoing development. One aspect of the development is the management (i.e. burning, seeding, clipping) of an old grassland within the park. I studied clipping as a management scheme and expected the species richness (number of species) to increase after clipping and the prostrate species to respond better than the erect species. I estimated the initial coverage in early June 1994, and then the experimental plots were clipped to a height of approximately 6 cm. After I estimated the final coverage in September 1994, I compared the experimental plots to the undisturbed control plots. The species richness showed no significant change in response to clipping. However, individual species responded differently to clipping. Of the dominant erect species, *Achillea millefolium* showed little change in coverage, while *Castelleja coccinea* decreased, and *Solidago missouriensis* increased. The dominant prostrate species *Antennaria neglecta* and *Poa pratensis* increased in coverage, *Fragaria virginiana* showed little change, and *Trifolium repens* decreased. Contrary to the expected result, the species richness of the community showed no significant change mainly due to the timing of the clipping treatment. However, as expected, the data suggest that erect species suffered a coverage loss due to clipping as compared to prostrate species. A possibility is that the resources (i.e. space and light) previously exhausted by erect species were made available to the prostrate species, allowing the prostrate species to increase their coverage.

INTRODUCTION

Disturbances play a significant role in determining the shape and structure of a plant community (Armesto and Pickett 1985). A vague definition of disturbances states that they interrupt the normal course of events for a community (Begon, Harper and Townsend 1990). However, it is difficult to determine what is normal for an entire plant community. Therefore, for this study, a disturbance is a force originating outside the plant community that physically alters the community (i.e. fire, herbivory, clipping, or flooding). This physical alteration can change the resource availability for plants within the disturbed area, allowing competitively inferior species to invade (Carson and Pickett 1990). For example, disturbances can create gaps in plant communities which provide space for other plants (Armesto and Pickett 1985). Also, disturbances often reduce the dominant competitors, simply because they are the most abundant. Consequently, inferior competitors are given the chance to exploit resources that were previously exhausted by the dominant species.

Grubb (1977), Connell (1978), and Grime (1979) have found that species richness (number of different species) can be influenced by disturbances. Grime (1979) predicted that the peak of species richness due to a disturbance seems to appear at intermediate levels of frequency (the number of disturbances over time) and intensity (percent of living biomass removed). Many studies have tested this hypothesis, but according to Pickett and Armesto (1985), a system of defining the level of frequency and intensity has not been made. Consequently, it is difficult to determine at what level a disturbance should be applied to initiate a desired response in species richness.

Herbivory can be a form of disturbance because it can originate outside the plant community (i.e. a cow, an insect) and physically alter plants. Many experiments in the past have used clipping (mechanical removal of aboveground biomass) to simulate herbivory (Painter et al. 1989, Jameson 1963, Dyer et al. 1991). However, clipping may not perfectly simulate herbivory. For example, grazing animals may prefer certain species, select specific parts of the plant, or trample the area; clipping does not mimic these subtleties (Jameson 1963). Also, clipping cannot simulate underground herbivory. But, despite these limitations, clipping has been used to gather information about plants and their responses to disturbances, because clipping can be controlled, repeated, and focused on certain areas.

Past clipping experiments show that as the frequency of clippings increase when over the intermediate level, the number of inferior competitors (species that are out-competed under normal conditions) decrease along with their dry matter yield (Aldous 1930, Jameson 1963, Breymeyer 1980). However, the frequency of clipping may not play as important a role as the intensity of the clipping. For example, varying the height of clipping can remove different essential parts of the plant. Depending upon the plant species, a clipping height of 10 cm may or may not remove all of the flowers, thereby affecting the plant's likelihood of reproducing.

The timing of clipping influences the response. Clipping early in the season tends to increase growth rate, while late-season clipping often reduces growth rate (Breymeyer 1980). An early-season clipping on immature plants would not affect their growth as much as it would affect that of adult plants (Maschinski and Whitham 1989). Generally, immature plants are allocating most of their resources to growth; adult plants are usually allocating resources to storage or reproduction. As a result, the immature plants may rebound quickly after a disturbance, while the adult plants might struggle.

Species composition of grasslands seems to play an important role in their responses to clipping. According to Dyer et al. (1991), there are insufficient data in scientific literature to make adequate predictions of the overall response of grasslands to grazing. When Jameson (1963) clipped a monoculture of plants, the result was usually the reduction of plant dry matter yield. But, when a mixture of species were clipped, some species exhibited a dry yield increase. Albertson et al. (1953) and Robocker and Miller (1955) found that prostrate species such as *Schizacharium scoparium* experienced a delayed response in which yield was not affected or increased after a year of clipping. Graber (1933) found similar results specifically with the weedy species *Poa pratensis*. Short-statured or more prostrate plants seem to respond positively to grazing, while taller, more erect plants respond negatively (Gregor and Sansome 1926). Robocker and Miller (1955) supported that conclusion further by showing that clipping had an adverse effect on erect species such as *Andropogon gerardii, Sorghastrum nutans,* and *Panicum virgatum.* Overall, the response of a grassland plant community to a clipping is complicated. Many factors such as the frequency, intensity, and timing of clipping and the species composition of the grassland interact to determine the overall outcome of clipping.

As part of an inventory of the natural history of the Proposed 100-Acres Quarry Park, I explored the effects of an early season clipping treatment on several grassland species. I asked two questions: 1) does plant species richness change after clipping; and 2) does growth habit alter the ability to grow after clipping? Based on past studies, I would expect the species richness to increase after clipping and the prostrate species to respond better than the erect species.

MATERIALS AND METHODS

Study site

This study was performed with the cooperation of Chuck Wocken, a Stearns County, Minnesota official. The study was intended to provide data to officials who will assist in the development of the Proposed 100-Acres Quarry Park in Waite Park, Stearns County, Minnesota, USA. My study site was located in a grassland within the Proposed 100-Acres Quarry Park, approximately 110 km NW of Minneapolis. The grassland was about 4 ha and was surrounded by an oak/aspen forest on the northern, southern, and eastern border, and a wetland on the western border. A dirt road through the center of the grassland was originally an access road to the granite quarries for large machinery when the area was quarried by the Cold Spring Granite Company. The grassland itself was hayed until the 1950's and has been relatively untouched since (Chuck Wocken *personal communication*). I located an area 30 m x 50 m in the south-central portion of the prairie, approximately 10 m from the dirt road and the forest (See Fig 1). This area was selected due to the observable diversity. The dominant erect species were *Achillea millefolium, Castelleja coccinea*, and *Solidago missouriensis;* the dominant prostrate species were *Antennaria neglecta, Fragaria virginiana, Poa pratensis,* and *Trifolium repens*.

Experimental Design

In early June 1994, I randomly selected 25 1 m x 1 m meter plots within the study site. Using a 1 m x 1 m frame divided into 4 sections (25%), I estimated the initial coverage based on the Daubenmire Canopy-Coverage Method (See Table 1) (Knight

1978). Using a gasoline-powered string trimmer, I clipped 12 randomly selected plots (experimental plots) to a height of approximately 6 cm. The remaining 13 plots served as the control. Every week, I made trips to the site, searching the control and treatment plots for species appearing after my initial coverage estimation. In early September 1994, I estimated the final coverage.

The species identification was verified using resources from the botanical survey that was being conducted simultaneously by the St. John's University/College of St. Benedict Biology Department.

Statistical analyses

I performed a two-sample t-test and a mixed-model ANOVA on MINITAB Version 7 within St. John's University's VAX system.

RESULTS

Species richness

There was no significant variation (t=-.63, df=23, p=.537) in the initial species richness between the clipped (mean=13.4 +/- 2.6 [s.d.]) and unclipped plots (mean=12.7 +/- 3.1) and the final species richness (t=-.20, df=23, p=.845) between the clipped (mean=12.3 +/- 1.6) and unclipped plots (mean=12.1 +/- 2.8). The clipped plots experienced a greater negative change in species richness as compared to the unclipped plots (See Fig 2), but this result was not significant (t=.49, df=23, p=.631).

Measured individual plant responses

I focused my attention upon species that had initial coverages of >1% and/or are late successional species in mature grasslands (i.e. *Andropogon gerardii, Schizacharium scoparium*, and *Lespedeza sp.*). These species were then divided into categories of erect (approx. >6cm tall) and prostrate (approx. <6cm tall) species according to their heights at the adult stage of their life cycle.

Analysis of variance revealed that species responded differently to clipping due to the clipping/species interaction (f=4.65, df=23,552, p<.001). The erect species *Achillea millefolium, Erigeron philadelphicus, A. gerardii*, and *Lespedeza sp.* showed little change (final coverage - initial coverage) in coverage, while *Agropyron repens, Rudbeckia hirta*, and *Solidago missouriensis* experienced minor positive changes in coverage. The erect species *Agrostis hyemalis, Castelleja coccinea, Solidago altissima*, and *Solidago rigida* experienced minor negative changes in coverage while *Bromus inermis* and *Solidago nemoralis* experienced major negative changes in coverage (See Fig 3).

The prostrate species *Convovulus sepium, Fragaria virginiana, Rumex sp., S. scoparium*, and *Vicia americana* showed little change in coverage, while *Antennaria neglecta* and *Trifolium hybridum* experienced minor positive changes in coverage. *Poa pratensis* experienced a major positive change in coverage. Only one prostrate species, *Trifolium repens*, experienced a minor negative change in coverage (See Fig 4).

Individual plant responses

Clipped *A. gerardii* experienced stunted growth and was approximately one third the height of the unclipped *A. gerardii*, yet it still flowered simultaneously with the unclipped plants. There were no observable differences in the flowers. *R. hirta* and *S. missouriensis* experienced severe stunted growth due to clipping in which its height decreased by 90%, but basal leaves grew after the clipping, giving the plants a rosette type appearance. *C. coccinea* was completely eradicated from the unclipped plots, but appeared in late August in some of the clipped plots.

DISCUSSION

Species richness

The species richness was unaffected by clipping. Any combination of the three factors (frequency, intensity, and timing) may have attributed to the insignificant species richness response. One possibility is that the single clipping height of 6 cm may have been ineffective, in that it did not alter the conditions of the plant community enough to cause an invasion of other plants (i.e. an increase in species richness). I think a study that explored a range of repeated clippings and clipping heights would show a point at which the plant community exhibits a maximum species richness. Another possibility is that the early-season clipping did not affect the immature plants, which were generally the most predominant compared to mature plants during the early-season. The clipping may have been just a temporary setback to the immature plants because resources were already being allocated to growth. If the majority of plants would have been adult plants which were not allocating resources to growth, the species richness may have changed significantly.

Individual species response

The results of this study showed that some individual species responded to clipping differently than others. Based on past studies, clipping seems to have more adverse effects on erect species as compared to prostrate species (Albertson et al. 1953, Robocker and Miller 1955, Graber 1933, Gregor and Sansome 1926). Erect species showed a decrease in yield and frequency in response to clipping while prostrate species showed no response or increase in yield. Most erect species of this study showed no appreciable response. However, three erect species showed a relatively dramatic decrease in coverage in response to clipping. *Solidago nemoralis* exhibited a 14.8% decrease, *Bromus inermis* a 10.2% decrease, and *Castelleja coccinea* a 7.8% decrease in coverage. It is a characteristic response for *S. nemoralis* and *C. coccinea*, as erect species, to show a negative response to clipping (Gregor and Sansome 1926, Robocker and Miller 1955). However, a decrease in coverage is relatively uncharacteristic for *B. inermis*. When *B. inermis* was clipped at a height of 5 cm, it showed a +34% *increase* in above-ground biomass (Dyer et al. 1991). The above-ground biomass is a different measurement than the coverage, but there is a positive correlation between the two. Therefore, an increase in above-ground biomass can indicate an increase in coverage. However, in this study, *B. inermis* decreased in coverage. The difference may be in the fact that while the clipping height of Dyer's study was similar to this study, the clipping was repeated 5 times over a single growing season. *B. inermis* may respond differently to repeated clippings as opposed to a single clipping.

The prostrate species of this study basically responded as predicted by past experiments (Albertson et al. 1953, Robocker and Miller 1955, Graber 1933, Gregor and Sansome, 1926). With the exception of *Trifolium repens* showing the negligible decrease in coverage of 4.7%, the rest of the prostrate species were either unaffected or increased as a result of clipping. The weedy species *Poa pratensis* showed the major characteristic response to clipping by increasing 20.9% in coverage. This increase in coverage is consistent with Graber's finding that the yield of *P. pratensis* increases in response to clipping (1933). In response to clipping, *P. pratensis* may be able to exploit the release of resources and invade the disturbed area. However, by no means is this response the rule for all types of disturbances. Fire has a tremendous adverse effect on *P. pratensis.* Curtis et al. found that an early spring burn of a prairie cut the frequency of *P. pratensis* in half (1948). Consequently, the nature of the disturbance also plays an important role in determining the content of a grassland community.

As stated above, *C. coccinea* responded predictably to the clipping treatment. However, it responded uncharacteristically in the observational analysis of this study. *C. coccinea* had an initial coverage of over 9%, the fourth highest, but in the final coverage, it was completely eradicated from the control plots. Interestingly, multiple plants appeared in late August in three different clipped plots. Based on its initial coverage in June, *C. coccinea* could be considered an early seasonal species, but after a clipping treatment, it appeared in the late season. This phenomenon indicates that the clipping released resources that *C. coccinea* could exploit and invade an area. Exactly what resources were made available can only be speculated. As discussed before, disturbances create gaps in a community, providing space for competitively inferior species (Armesto and Pickett 1985). Consequently, the clipping may have created enough space and light for *C. coccinea* to invade. However, this may not be the only contributing factor. *C. coccinea* is a parasitic plant; hence, the mulching action of the weed-whacker may have released nutrients that *C. coccinea* could exploit or the clipping may have weakened other species enough so that *C. coccinea* could take advantage of its parasitic abilities.

In conclusion, the single clipping over one season at a height of approximately 6 cm did not affect species richness, decreased erect species coverage, and did not affect or increased prostrate species coverage. *B. inermis* responded unpredictably by decreasing in coverage, while *P. pratensis* responded predictably by increasing in coverage. *C. coccinea* elicited the predicted decrease in coverage in response to clipping, but unpredictably appeared in clipped plots while it was eradicated from the unclipped plots in the late growing season.

The results of this study produced some interesting questions and ideas about future research. Because species richness was not affected, I would recommend a study that would attempt to determine the level of frequency and intensity of clipping at which the maximum species richness is observed. This could be effectively done by exploring a range of repeated clippings as well as a range of clipping heights. More pertinent data would be attained if the study was carried over several seasons instead of just one and more measuring schemes were used (i.e. biomass, growth rate, root growth, etc.). Another interesting route would be to measure the effects of several types of disturbances, especially burning. As stated above, fire adversely effected *P. pratensis* which thrived under the clipping conditions. With *P. pratensis* significantly reduced, it would be interesting to see if another species began to dominate or appear.

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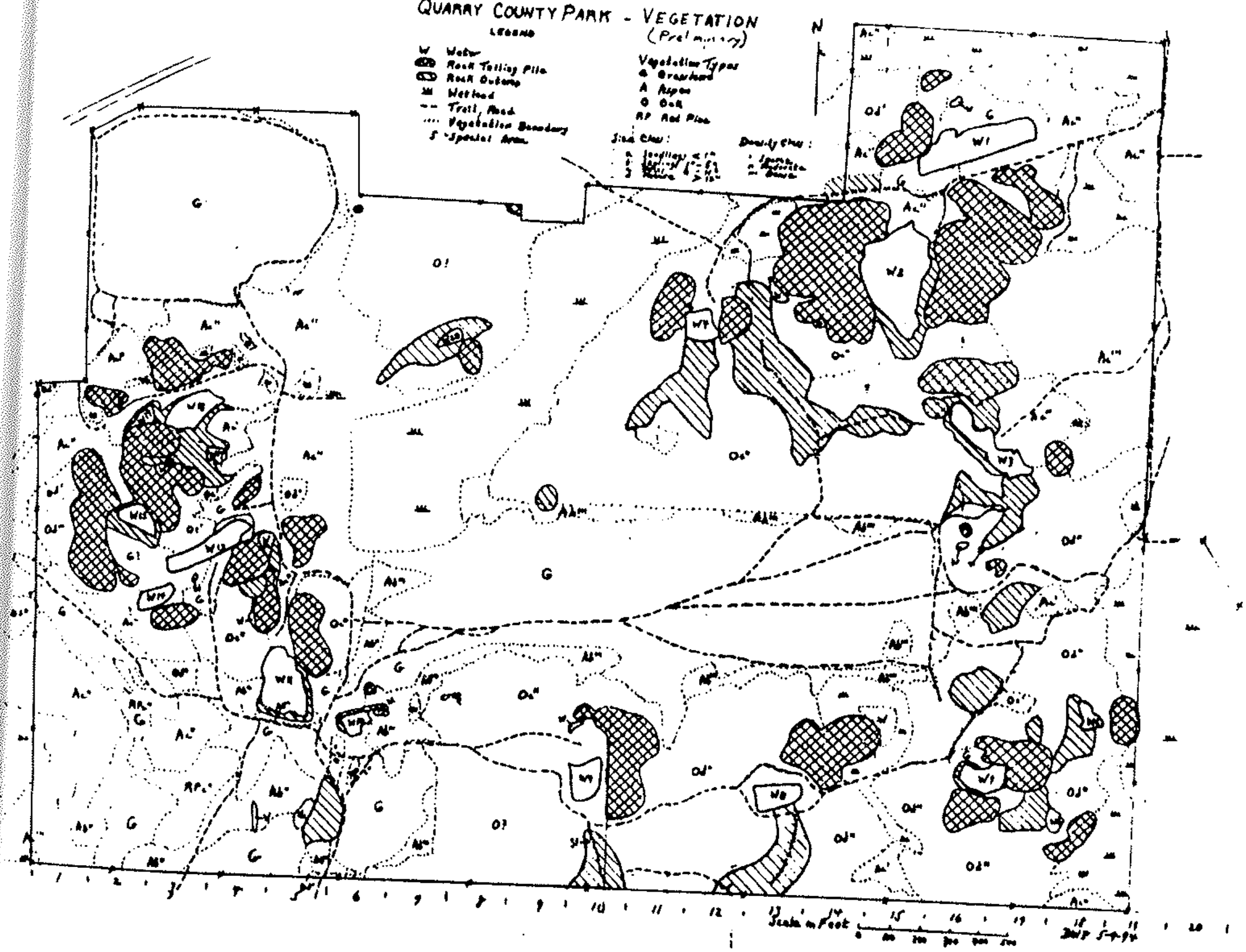

Fig 1. Generalized map of the Proposed 100-Acres Quarry Park, Waite Park, Stearns County, Minnesota, USA. The study site was in the south-central portion of the central grassland (marked with "G").

TABLE 1: The Daubenmire Canopy-Coverage Scale used to estimate coverages.

COVERAGE CLASS	RANGE
1	0% to 5%
2	5% to 25%
3	25% to 50%
4	50% to 75%
5	75% to 95%
6	95% to 100%

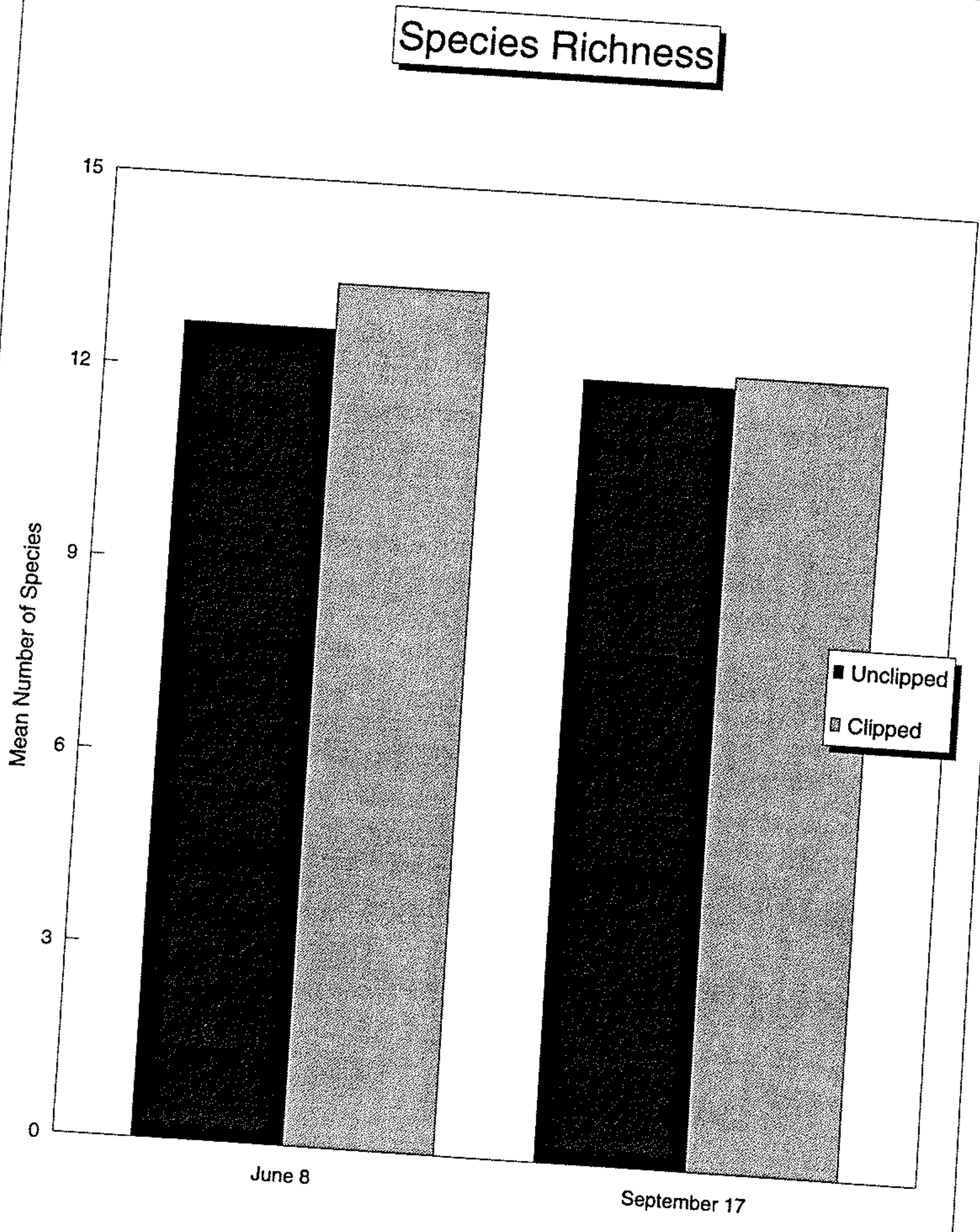

Fig 2. Mean species richness of the unclipped and clipped plots before clipping (June 8) and after clipping (Sept. 17).

ERECT SPECIES

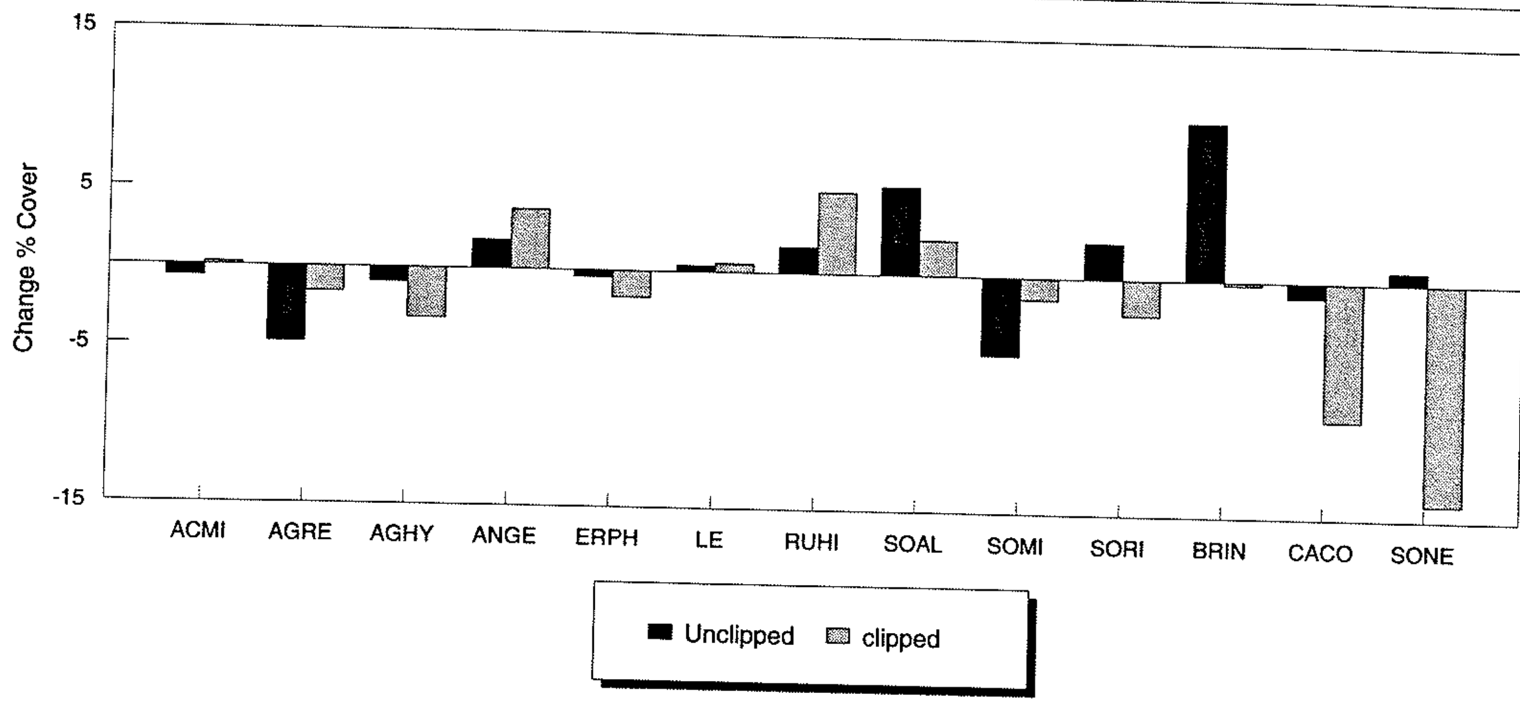

Fig 3. The change (final coverage - initial coverage) in coverage for erect species in unclipped and clipped plots.

[ACMI=A. millefolium, AGRE=A. repens, AGHY=A. hyemalis, ANGE=A. gerardii, ERPH=E. philadelphicus, LE=Lespedeza sp., RUHI=R. hirta, SOAL=S. altissima, SOMI=S. missouriensis, BRIN=B. inermis, CACO=C. coccinea, SONE=S. nemoralis]

PROSTRATE SPECIES

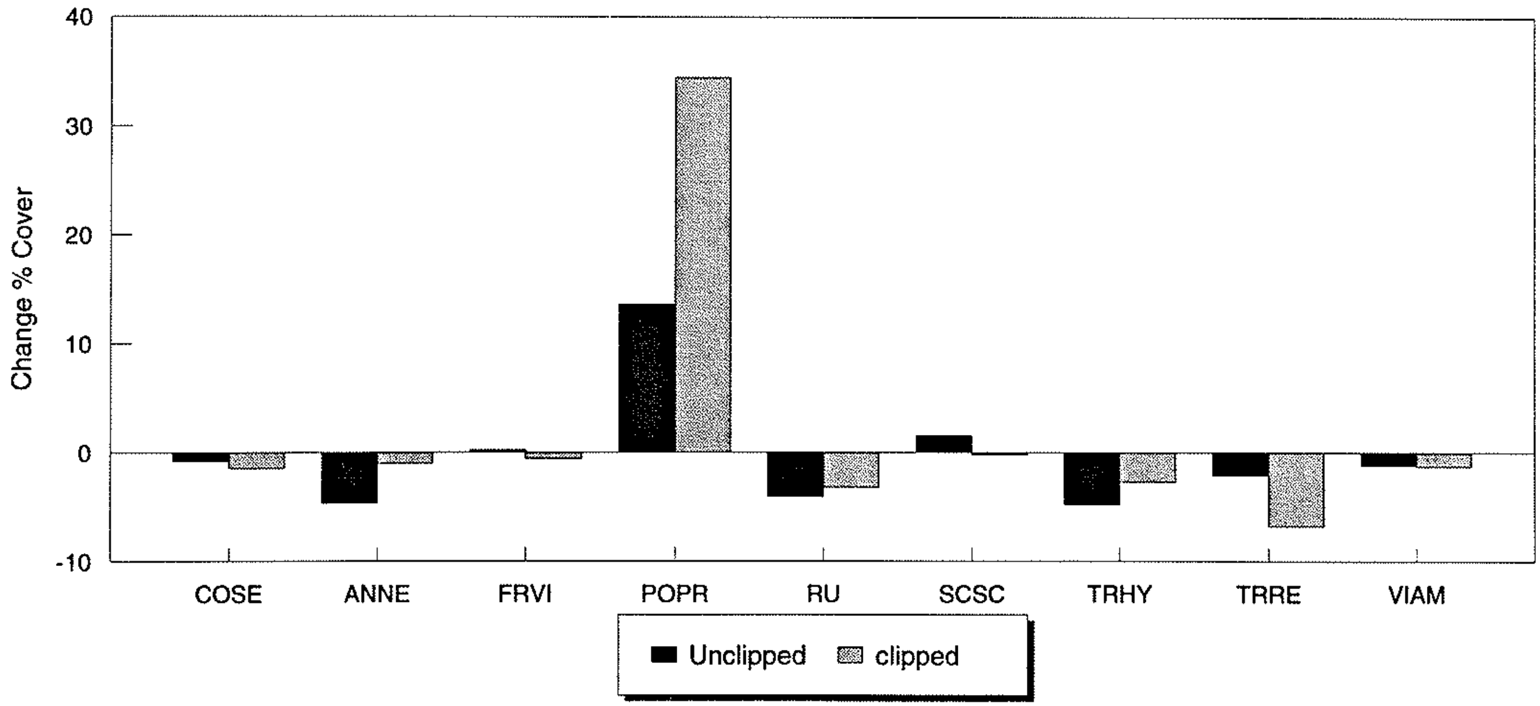

Fig 4. The change (final coverage - initial coverage) in coverage for prostrate species in unclipped and clipped plots.

[COSE=C. sepium, ANNE=A. neglecta, FRVI=F. virginiana, POPR=P. pratensis, RU=Rumex sp., SCSC=S. scoparium, TRHY=T. hybridum, TRRE=T. repens, VIAM=V. americana]

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