

Differing effects on dicots and monocots by *Centaurea maculosa*

Abstract

The purpose of our study was to test the effects of the invasive species spotted knapweed (*Centaurea maculosa*) on plant community. Being efficient at competing for nutrients and water, and for producing offspring, *C. maculosa* is an aggressive invader of dry pastures and native rangelands. We predicted that knapweed would more negatively affect dicots than monocots in terms of plant abundance, species richness, and height. Our study site was located in a field in Harbor Springs, MI. We set up plots with and without knapweed and measured species richness, abundance, and height for the plants within the plots. We found a marginally significant effect on total and dicot species richness between the two treatments, with lower species richness in plots with knapweed, while monocot species richness did not vary in plots with and without knapweed. There was not a significant difference in total plant abundance between the two treatments. We also did not find significant differences between dicot or monocot abundance or height in plots with and without knapweed. We could not conclude that knapweed impacted dicot species more than monocot species, or had an impact on the plant community. It is possible that *C. maculosa* must be at higher densities in order to have a large impact on plant communities.

Introduction

Invasive species are non-native organisms that are introduced into ecosystems and compete strongly with native species, sometimes causing their extinction. Invasives tend to spread more quickly and grow more rapidly in their invasive range than in their native range. Gordon (1998) states that invasive species capable of displacing native species tend to have

characteristics such as effective reproductive and dispersal mechanisms, and higher competitive ability than that of the native species, which can be seen in amur honeysuckle (*Lonicera maackii*) and purple loosestrife (*Lythrum salicaria*). Amur honeysuckle is a Eurasian invasive shrub that, over the last few decades, has become abundant in southwestern Ohio and adjacent states. Collier et al. (2002) showed that there were lower species richness and abundance under crowns of amur honeysuckle plants because it reduced light levels and availability of nutrients and water for its competitors. Purple loosestrife, similarly, is an invasive Eurasian wetland plant shown to have competitive superiority to native wetland plants because it outnumbers native species in seedbanks, its seeds germinate faster and the seeds also have higher germination rates (Blossey et al. 2001). Hejda (2009) found that many invasive species decrease species diversity and abundance in invaded areas. Among these invasive species is garlic mustard (*Alliaria petiolata*), which displaces native species with competition and allelopathy (Meekins and McCarthy, 1999).

The novel weapons hypothesis states that invasives are superior competitors in regions where they are not native because they possess physical and/or chemical defenses and weapons that species in their non-native ranges have not evolved defenses to (He et al. 2009). Allelopathy refers to the negative effect of chemicals, which are released by one plant species, on the growth or reproduction of another plant species (Bais et al. 2003, Inderjit and Callaway 2003). An example of allelopathy is observed in spotted knapweed (*Centaurea maculosa*) (He et al. 2009). *C. maculosa*, a plant native to Eurasia, was introduced into the Pacific Northwest roughly at the turn of the century and has, in abundance, spread throughout multiple countries (Kelsey and Locken 1986). *C. maculosa* has many characteristics which have contributed to its invasive ability, such as a high seed count and a taproot, capable of better accessing water resources than native species. *C. maculosa* also possesses the chemicals catechin and cnicin which inhibit plant

growth (Perry et al. 2007). However there is still debate as to which of these chemicals truly inhibit plant growth (Kelsey and Locken 1986, Perry et al. 2005).

To date, studies of the effects of *C. maculosa* phytochemicals on grassland species have all occurred in a laboratory setting, such as the study where Bais et al. (2003) found that catechin can trigger cell death. Kelsey and Locken (1986) found that cnicin reduced growth in five of seven species tested. The tendency of *C. maculosa* to co-occur with certain species while eliminating others remains unexplained. An experiment done by Perry et al. (2005) showed that catechin caused mortality of six species that they tested, all of which were dicots. Sensitivity to catechin, too, varies among plant species (Perry et al. 2005), but it is unknown whether monocots and dicots have differing degrees of sensitivity.

The purpose of our study was to examine plant species richness and abundance, as well as to further examine dicot and monocot sensitivity to the invasive plant species *C. maculosa*. We expected fewer plant species and fewer individuals growing near knapweed plants compared to areas without knapweed plants. We also expected to see lower dicot and monocot species richness and abundance in areas with knapweed than without. Lastly, we hypothesized that the height of dicots would be more suppressed than that of monocots when growing near knapweed plants than in areas without knapweed. To test these hypotheses we looked at the species richness, plant abundance and heights of individual plants in areas with and without knapweed in northern Michigan.

Methods

Our site was located in a meadow in Harbor Springs, Michigan. The site consisted of many acres of monocot plants, such as wheatgrass and cattail grass, with some dicot plants such

as lamb's quarters and strawberry. Knapweed covered almost all of the area. To test our hypotheses we made 10 plots, 0.6 m in diameter, using a knapweed plant as the center, and 9 plots, 0.6 m in diameter, without knapweed. In the knapweed sites we chose plots with only a single large knapweed plant. In sites without knapweed, we randomly chose plots, making sure to avoid areas with knapweed. All plots had the same relative altitude, distance from tree line, sunlight, and slope.

In each of the plots, we recorded what plant species occurred in each plot, the number of plants in the plot for each species, and the height of each plant. When there was a large abundance of a plant species, we counted the abundance of that species in one fourth of the plot, and then multiplied it by four to get an estimate of the number of individuals for that species. We also measured the height of up to 10 individual plants for each species, selecting at random when the abundance for the species was more than 10. We used t-tests to compare total, dicot, and monocot species richness between the two treatments; to compare the total, dicot, and monocot plant abundances between the two treatments; and to compare the dicot plant heights and monocot plant heights between the two treatments.

Results

The mean number of monocot plants was about eight times higher in plots than that of dicot plants. Many of the monocot plants were grasses, like wheatgrass and cattail grass, and some of the dicot plants seen included strawberry and lamb's quarters. The total abundance of plants in non-knapweed plots was not significantly different from plots with knapweed ($t=-0.25$, $df=17$, $p>0.05$; Figure 1). Total abundance of plants was almost identical in both types of plots. Abundance of monocot plants in non-knapweed plots was not significantly different from plots

with knapweed ($t=-0.15$, $df=17$, $p>0.05$; Figure 1). Likewise, the abundance of dicot plants in non-knapweed plots was not significantly different from plots with knapweed ($t=-0.51$, $df=17$, $p>0.05$; Figure 1).

The species richness in non-knapweed plots was about 30% higher than richness in knapweed plots. The total species richness in non-knapweed plots was not significantly different from plots with knapweed, however there was a marginally significant trend toward higher species richness in non-knapweed plots ($t=-1.72$, $df=17$, $p=0.1$; Figure 2). Dicot species richness showed a similar trend ($t=-1.59$, $df=17$, $p=0.13$; Figure 2). The mean dicot species richness in non-knapweed plots was about 60% higher than dicot species richness in knapweed plots. Monocot species richness in non-knapweed plots was not significantly different from plots with knapweed ($t=-0.55$, $df=17$, $p=0.59$; Figure 2).

The mean heights of monocot plants were about twice the size of the mean heights of dicot plants in the plots. The heights of dicot plants were not significantly different between knapweed and non-knapweed plots ($t=0.68$, $df=17$, $p>0.05$; Figure 3). The heights of monocot plants were not significantly different between knapweed and non-knapweed plots ($t=0.196$, $df=17$, $p>0.05$; Figure 3).

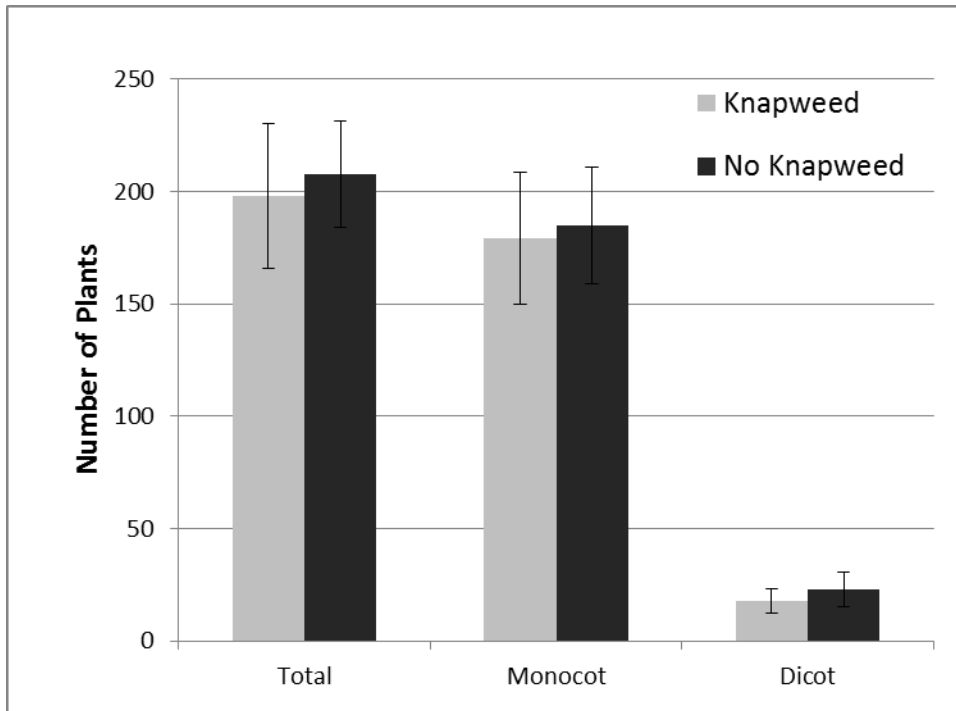


Figure 1. Mean plant abundance (\pm SE) between knapweed and non-knapweed areas ($p > 0.05$ for all comparisons)

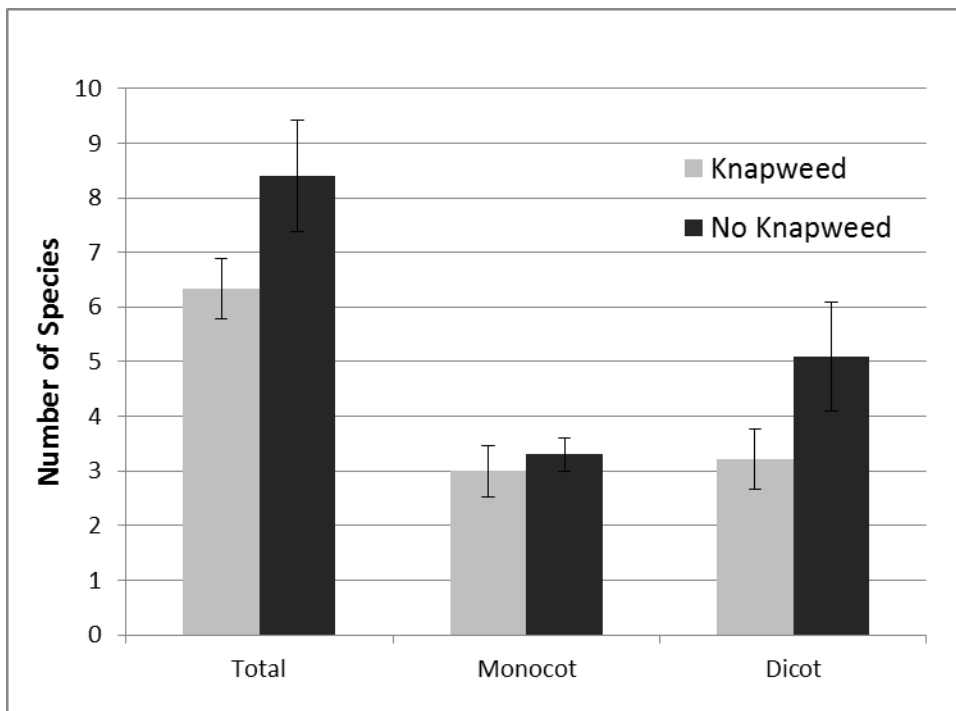


Figure 2. Comparison between number of species in knapweed and non-knapweed areas ($p > 0.05$ for all comparisons)

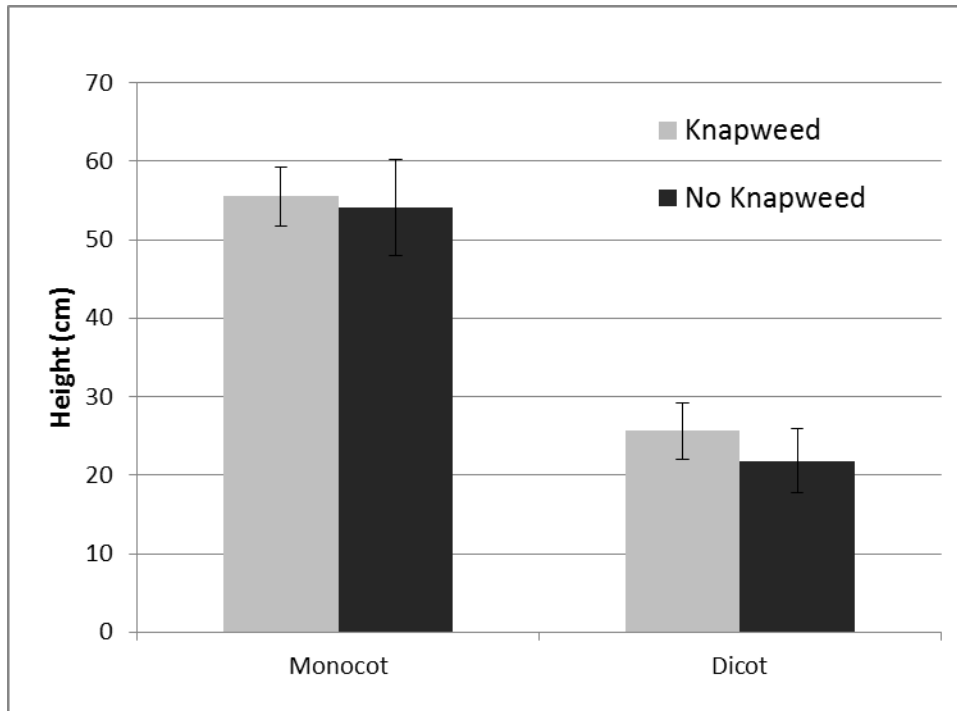


Figure 3. Comparison of heights of plants between knapweed and non-knapweed areas ($p > 0.05$ for both comparisons)

Discussion

While we found that there was a trend toward higher total species richness and dicot species richness between the two treatments, there was not a significant difference in species richness, abundance, or height between the two treatments, overall or for dicots or monocots. Plant species richness has been shown to be lowered in environments infested with non-indigenous plants such as amur honeysuckle and garlic mustard (Collier et al. 2002, Meekins and McCarthy 1999). However, our results for total plant species richness and dicot species richness were only marginally significant. It appeared that knapweed may have more negatively affect dicot species richness than monocot species richness, because of the greater difference in dicot species richness between the treatments. Although we found some marginally significant results, we must refute our hypotheses that there would be lower species richness in plots with knapweed

than without, and that knapweed would more negatively affect dicot species richness than monocot species richness. Blossey et al. (2001) found that at low abundance, non-indigenous plants may have no or only minor ecosystem impacts. It is possible that with more knapweeds in an area, it may increase detectable impacts on plant species richness.

Abundance of individual plants has also been shown to be lower in plant communities invaded by non-native plant species (Hejda et al. 2009). However, we found that knapweed did not negatively affect total plant abundance, dicot plant abundance, or monocot abundance. It also did not negatively impact dicot plant abundance more than monocot abundance. From these results we must refute our hypotheses that there would be lower plant abundance in plots with knapweed than without, and that knapweed would more negatively affect dicot abundance than monocot abundance. He et al. (2009) found that all *C. maculosa* was a stronger competitor against North American native plants than against European native plants. They theorized that the difference in competitive advantage was due to differing catechin sensitivity among plants from the two regions, because North American natives evolved without exposure to the allelopathic chemical, and did not evolve defenses. The lack of difference in plant abundance between treatments may be because the plant species in the sites have evolved similar traits as European native plants. It is again possible that the difference we saw was a result in the low density of knapweed.

The mean height of dicot plants and monocot plants was not significantly different between treatments; therefore we reject our hypothesis that knapweeds would affect dicot plant height more than monocot plant height. This may also be because of the low abundance of knapweed in the plots. The amount of competition and allelopathic chemicals may be directly correlated with the abundance of knapweed plants. There are some studies that do not support the

idea of knapweed being allelotoxic, such as Perry et al. (2007), who found that catechin was detected infrequently with *C. maculosa* soils. However Inderjit and Callaway found that chemical effects can vary along with the biotic and abiotic factors in natural soils. This may also be the cause of differences in catechin effects on plants between lab results and field results.

In conclusion, we found no significant effect of *C. maculosa* on species richness, abundance, or height overall or between monocot and dicot plants. This may be due to the low abundance of knapweed in our knapweed plots. Catechin has been found to be abundant in soil extracts from spotted knapweed invaded ecosystems (Bais et al. 2003), and there may be a direct correlation between abundance of knapweed and catechin abundance in the soil. With greater abundance of knapweed in plots, and possibly more abundance of allelopathic chemicals, we may see more differences in not only total plant abundance and species richness between plots with and without knapweed, but differences in negative impacts between monocots and dicots.

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