Spotted Knapweed Abundance and Species Richness in Restored and Unrestored Ecosystems

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Abstract

Spotted knapweed (Centaurea maculosa or Centaurea Stoebe), is an invasive perennial that is becoming widespread across Northern Michigan. A highly successful competitor in open habitats, spotted knapweed is quickly dominating abandoned farm fields in Northern Michigan. This study examines spotted knapweed abundance and species richness, comparing these factors on restored and unrestored land belonging to the Little Traverse Conservancy. No significant difference was found between species richness or spotted knapweed abundance at restored versus unrestored sites. A slight positive correlation between species richness and spotted knapweed abundance was found, though the sample size of this study was insufficient for drawing reliable conclusions. Further research into the relationship between spotted knapweed abundance and species richness, as well as the effectiveness of different management techniques should be considered

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Introduction

Spotted knapweed (*Centaurea maculosa* or *Centaurea Stoebe*) is a plant native to Europe which was introduced to North America around the end of the nineteenth century (Watson and Renney, 1974). It is a perennial with purple flowers that lives for 3 to 5 years (Story, 2002). In Europe, it is most aggressive in the forest steppe zone (Harris and Cranston 1978), and in North America is an invasive species often found in open habitats such as fields and roadsides (Watson and Renney, 1974). Spotted knapweed has been successful at dominating landscapes in the United States and Canada, where it has invaded millions of hectares of land (LeJeune and Seastedt 2001), causing significant economic and ecological damage by reducing herbivore forage (Story, 2002).

Spotted knapweed reproduces through seeds only, and seeds can last for 8 years before germinating (Story, 2002; Goodwin and Burch, 2007). A strong pioneer species, spotted knapweed is able to germinate in a broad range of conditions (Watson and Renney, 1974). In addition, spotted knapweed produces an allelopathic compound that is a phytotoxin released by plant roots (Bais et al., 2003). This trait of spotted knapweed reduces germination of nearby grasses (Story, 2002), and could result in a reduction in species diversity where spotted knapweed is present. It was previously thought that spotted knapweed secreted catechin as an allelopathic chemical, however more recent research questions the role of catechin in this mechanism (Blair et al., 2005).

We conducted our research on four nature preserves belonging to the Little Traverse Conservancy (LTC) in Emmet County, Michigan. LTC has tried different strategies for controlling spotted knapweed on some of their land. Some areas have had management in the form of hand-pulling spotted knapweed by LTC staff and volunteers. Another strategy they have tried is treating a field with herbicide to kill all plant life, tilling in the soil, and replanting the land with native grasses.

In this study we compare abundance of spotted knapweed in restored and unrestored areas in Northern Lower Michigan and examine its relationship to the presence of other plant species in the area. The restored areas had received invasive species control, either hand pulling of invasive species or herbicide treatment and subsequent replanting of native species, while the unrestored areas had no treatment done at all. We hypothesize that in areas that have not been restored, spotted knapweed will be more abundant and species richness will be lower than at restored sites. We predict that with restoration work that attempts to control its population, spotted knapweed will be less successful at dominating a landscape. Due to the increased abundance of spotted knapweed in unrestored landscapes, we expect there to be lower species richness as a result of competition, due in part to its allelopathic effects.

Methods

Spotted knapweed abundance was studied in two “restored” sites and two “unrestored” sites on public nature preserves managed by the Little Traverse Conservancy in Emmet County, Michigan. The unrestored sites were the Goodhart Preserve and the Kuebler preserve and received no management activities in any way. The restored sites were the Kalman Preserve and the Waldron Fen. At the Kalman preserve, a crew of volunteers had hand-pulled spotted knapweed about a week before our sampling occurred. At the Waldron Fen site, the sampled field had been treated with herbicide and then replanted with native grasses four years before this study.

At each site, we sampled three 50 meter by 1 meter transects. Within these transects the number of spotted knapweed stems was counted. The presence of all other plant species in the transect was recorded as well, though frequency of these species was not recorded. Dead plants were excluded from our data collection.

We ran ANOVA tests to compare spotted knapweed abundance at restored versus unrestored sites, as well as species richness at the different sites. We also created a species collection curve for each site to compare species richness. Finally, we looked at the correlation between spotted knapweed abundance and species diversity in the study. All data were analyzed in R.

Results

We found that there were not significant differences in spotted knapweed abundance between restored and unrestored sites ($p = 0.0981$; Table 1), or in species richness between restored and unrestored sites ($p = 0.219$; Figures 1 & 2). We found a slight positive correlation between spotted knapweed abundance and species diversity (Fig. 3).

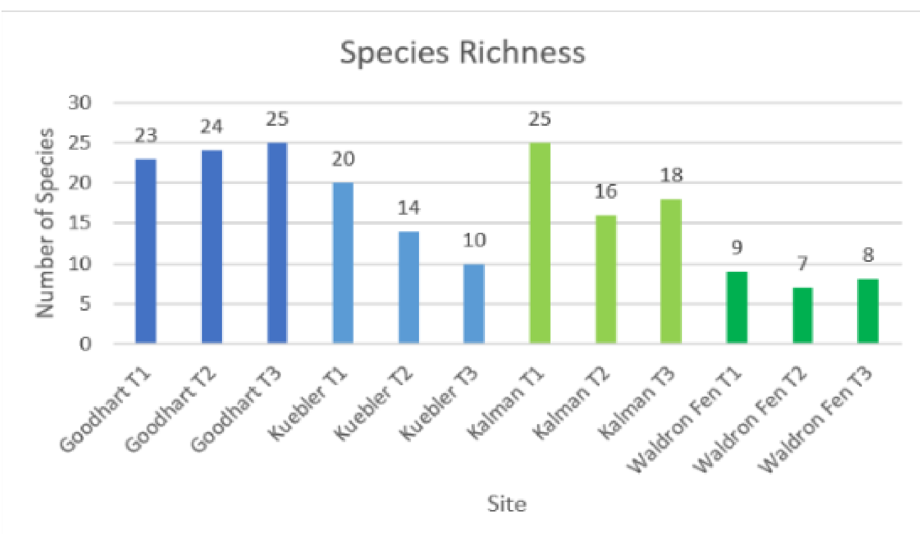

Figure 1: Species Richness at each site. Restored sites are in green and unrestored sites are in blue. We did not find a significant difference in species richness in restored versus unrestored sites ($p = 0.219$).

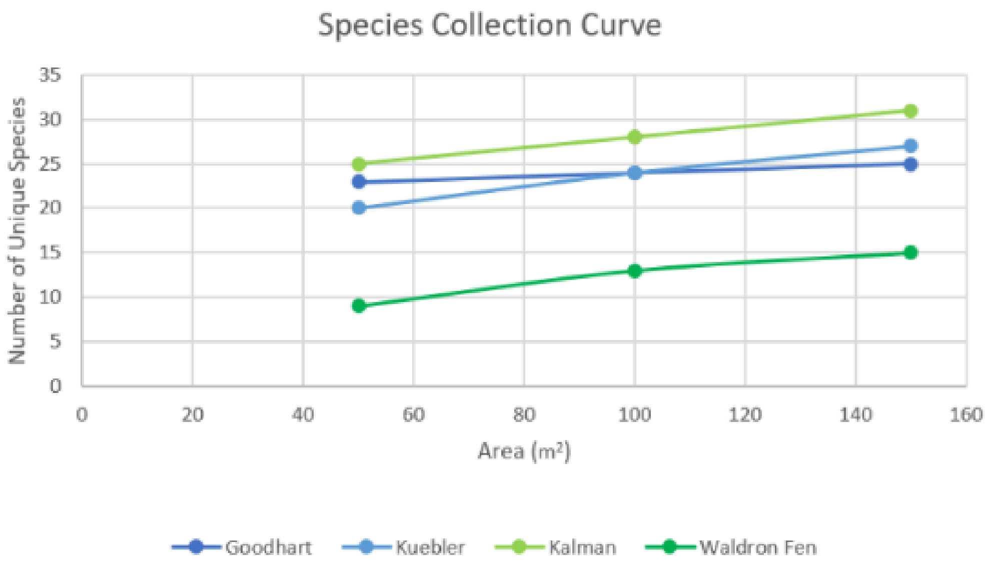

Figure 2: Species Collection Curve showing the number of unique species found at 50m2, 100m2, and 150m2 for each site. Restored sites are in green, unrestored sites are in blue.

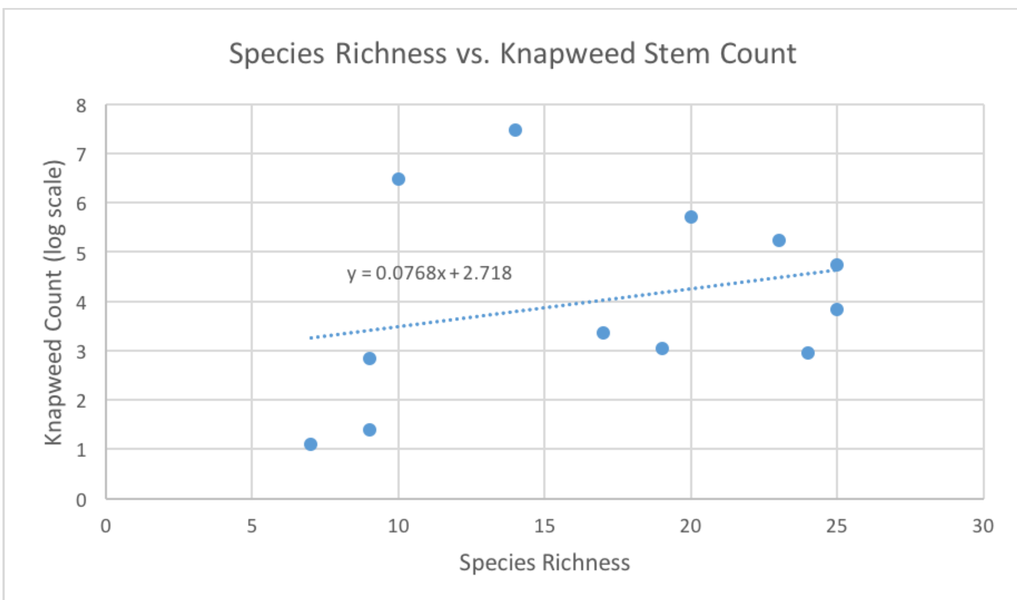

Figure 3: Species richness plotted against spotted knapweed abundance on a log scale for each transect at each site. There is a slight positive correlation between spotted knapweed abundance and species diversity.

Table 1: Spotted knapweed abundance at each site. We found no significant difference between spotted knapweed abundance at restored versus unrestored sites (p = 0.0981).

Site	Average Number Of Knapweed Stems Counted	Standard Deviation
Goodhart	107	84.285
Kuebler	903	760.007
Kalman	32	12.767
Waldron Fen	8	7.810

Discussion

We found no significant differences in spotted knapweed abundance or species richness between unrestored and restored sites, nor did we find the predicted negative correlation between spotted knapweed abundance and species richness. This means that we cannot conclude that spotted knapweed abundance is different in restored and unrestored areas, nor can we conclude that species richness differed between restored and unrestored sites. Furthermore, contrary to our hypothesis, we found a slight positive correlation between spotted knapweed abundance and species richness (Fig. 3), suggesting that spotted knapweed could enhance species richness, or that a diverse plant community helps promote spotted knapweed proliferation.

These results are not supported by existing literature about spotted knapweed. This is likely due to an inadequate sample size in our study. When we first planned our study we were intending to survey two additional sites in Wilderness State Park (one restored, one unrestored), however we were not able to get the required permits in time for this study. Having that additional data may have helped to increase our sample size enough to make our data significant, but it may have also confounded our data because of differences in the landscapes of the Wilderness sites (dunes vs. old fields in the LTC sites). The differences in sites may have affected the data we did collect as well. Three of the sites we surveyed were old farm fields (Goodhart, Kuebler, Waldron Fen), while the Kalman preserve was not a field.

Additionally, the two restored sites that we visited had received different types of restoration and at different times (one was a week before data collection and one was four years before). Though it was not initially a point of interest in this study, it might have been beneficial to compare the different management methods practiced on the Kalman and Waldron Fen preserves. Given the differences in time of restoration for the two sites studied, it is difficult to compare the two restoration efforts we studied to each other and determine which method is more effective in eradicating spotted knapweed. The Waldron Fen restoration work, which involved applying herbicides to kill all plant life, tilling in the soil, and re-seeding with native grass, resulted in a noticeable (though statistically insignificant) lack of spotted knapweed compared to other sites, but also resulted in lower species richness because only a few types of plants were replanted.

If we were to do this study again, we would survey a larger sample of sites that are of a more uniform ecosystem type, for example old farm fields in Emmet County, Michigan. We would still study spotted knapweed abundance in restored and unrestored habitats. Ideally, we would also study species evenness as well as richness of other plant species so that overall diversity could be compared between sites. A future long-term study exploring the effectiveness of different management strategies would also be of interest. Such a study would explore the same elements as previously discussed and compare results in areas with different management strategies.

There are several possible management strategies for controlling the spread of spotted knapweed. In this study we saw hand-pulling and herbicide treatment plus replanting. In addition, there are weevils that have been released in an attempt to control spotted knapweed populations (Carson and Landis, 2014). These weevils are present in Michigan, but have only recently begun entering the area where this study was conducted, so their populations are not yet established in this region. One concern with the weevils is that they may also target native species, so further research on their behavior and effects would be beneficial.

Conducting further research on the effects of spotted knapweed on its surrounding environment and the success of different management strategies will be important as spotted knapweed causes significant ecological and economic damage, as well as being so widespread and difficult to get rid of. The presence of spotted knapweed reduces forage for domesticated livestock as well as wildlife (Story, 2002). It also increases soil surface runoff and erosion and changes native plant habitats by monopolizing nutrients available and releasing allelopathic compounds (Bedeian et al., 2013). Finding out if and how spotted knapweed affects local species diversity is an important step in developing management plans for this invasive species. Because it is so difficult to get rid of, due to long-lasting seeds and lack of herbivory from livestock, learning to what extent it actually damages habitats will be valuable in making decisions about management. Further research about spotted knapweed in Michigan will also be important, since much of the existing literature focuses on Western North America.

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