

Biodiversity in Managed vs. Unmanaged Sites

A Comparison of Species Richness and Abundance in the Upland Forest of
Kleinstuck Preserve

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Introduction

Invasion involves the movement of something into a place, and the negative effects that occur thereafter. Biological invasions by non-native species have been the basis for much ecological research, because it causes many environmental problems. Invasive species out-compete native species by depleting common resources, thus reducing the native species' ability to survive. This can result in the loss of biodiversity as a single invasive organism can displace or out-compete multiple native organisms. In extreme cases, this can result in extinction of a species. Habitats are invaded by foreign species and scientists are eager to measure the impacts these introduced species have on native communities, such as an upland forest habitat. Introduced species threaten local biodiversity in two ways—by either direct competition with native plant species, or by altering their ecosystem (Vitousek, 1986). Plants that are introduced to the community by humans can become invasive species.

Many studies aim to better understand the effects new species have on habitats that contain established species and ecological processes (Alpert *et al.*, 2000). The answers to this inquiry are utilized to best manage the habitat. For example, identifying the most affected species can lead to concentrated efforts on protecting the most vulnerable species. Land management is the leading strategy to remedy the impacts of invasive species. The most effective land management strategy considers the characteristics of the habitat and how the habitat will respond to different land-use patterns (Mooney *et al.*, 2000). Although the task of managing land can often be an overwhelming one, stewards everywhere are working towards developing the most effective strategies of land management (Mooney *et al.*, 2000). Strategies of land management include manually removing the invasive species, chemical treatments, and the introduction of other species to help control the invasive species.

Owned by Western Michigan University, the 48-acres of Kleinstuck Preserve is located in the Kalamazoo-Portage area. At Kleinstuck, the pond has been filled by invasive plants and active land management is needed to keep the Preserve from declining. Invasive species of the area do not have natural predators so they are able to out-compete the natives, which creates vulnerable areas that only have very few native plants. The Stewards of Kleinstuck is a group that has formed in an effort to protect the Kleinstuck Preserve under the “Kleinstuck Management Plan”. They aim to remove the invasive species and allow the natives to “restore as much biological diversity and ecosystem health as possible to the natural areas of the preserve and surrounding landscape”. They predict that this management will help the habitats and water quality in and around Kleinstuck. Their methods of land management include cutting shrubs, pulling out invasive species, and hauling brush. (Jorth, 2009)

In order to see if there is a difference in biodiversity in managed versus unmanaged areas, we measured the species abundance and richness of both sites in the upland forest of the Kleinstuck Preserve. Management practices should affect smaller plant species with short generation times and younger individuals (such as woody seedlings) more than larger tree species with longer generation times. Because of these increased generation times, it will take longer to see the affects of management practices on populations of larger tree species (Ryan and Yoder, 1997). For these reasons, we hypothesize that there will be no difference in the abundance and richness of larger woody species. Because of the efforts being made by the stewards, we predict management will have an effect on the smaller plants identified in our 0.5x0.5 m plots. Within these smaller species, the native species abundance and richness will be higher in managed sites than in unmanaged sites. Conversely, we hypothesize that introduced species richness and abundance will be lower in managed sites. The results of our study may be

used by the Stewards as guidance, as it will gauge the effectiveness of their management plan to date.

Results

Overall we surveyed 972 plants (Table 1). In the underbrush of both managed and unmanaged sites, garlic mustard occurred in very dense patches consisting of both small and medium sized plants. Also, the abundance of garlic mustard was higher in managed than in unmanaged sites. Honeysuckle grew thickly and dominated the underbrush in the unmanaged sites, while its presence was reduced within the managed plots. The canopy in all the plots was dominated by native Red Maple and Sassafras (27 and 13 individuals, respectively) and was dotted with introduced Norway maples and an occasional Hawthorne (5 and 1 individuals respectively).

The Shannon Index was calculated for each treatment type and managed sites had a lower overall diversity, $H' = 1.37$, than unmanaged sites $H' = 1.44$. In the 10 x 10m and 5 x 5m plots there was no significant difference in the abundance or species richness of introduced and native plants between the managed and unmanaged plots (Figure 1). In 0.5 x 0.5m abundance and species richness of introduced species was lower in managed plots and native species richness was higher in managed plots. However, there was no significant difference in the abundance of native plants between site types (Figure 1). The difference in introduced species richness and abundance between sites was only significant after the removal of garlic mustard from analysis. A summary of the statistical analyses for these data are provided in Table 2.

Table 1. Species richness and abundance of plants observed in 3 managed and 3 unmanaged sites in the Kleinstuck Preserve during the spring of 2009.

Species	Unmanaged	Managed	Total
<i>Introduced 10 x 10m</i>			
Hawthorne	1	1	2
Norway Maple	5	3	8
<i>Introduced 5 x 5m</i>			
Elm	1	0	1
Honey Suckle	Too dense to count*	0	0
Winged Wahoo	0	1	1
<i>Introduced 0.05 x 0.05m</i>			
Elm	1	0	1
Garlic Mustard	29	199	228
Honey Suckle	341	6	347
Norway Maple	0	2	2
Winged Wahoo	0	0	0
<i>Total introduced species richness</i>	5	5	10
<i>Total introduced abundance</i>	378	212	590
<i>Native 10 x 10m</i>			
Ash	1	0	1
Black Cherry	2	3	5
Crab Apple	1	0	1
Red Maple	27	24	51
Red Oak	2	0	2
Sassafras	13	7	20
<i>Native 5 x 5m</i>			
Black Cherry	0	1	1
Red Maple	1	11	12
Wild Sarsaparilla	1	0	1
<i>Native 0.05 x 0.05m</i>			
Black Cherry	1	36	37
Grape Vine	2	1	3
Grass	1	3	4
Jack in the pulpit	4	0	4
May apple	26	35	61
Pitcher Plant	0	7	7
Red Maple	0	2	2
Red Oak	0	1	1
Virginia Creeper	15	0	15
Wild Sarsaparilla	82	72	154
<i>Total native species richness</i>	12	9	21
<i>Total native abundance</i>	179	203	382
<i>Total abundance</i>	557	415	972
<i>Total species richness</i>	18	14	32

*Honeysuckle represented more than 50% of the understory ground cover.

Note: Abundance is used instead of mean and standard deviation because many species had a small sample size and a mean and standard deviation might not be a good representation of the population.

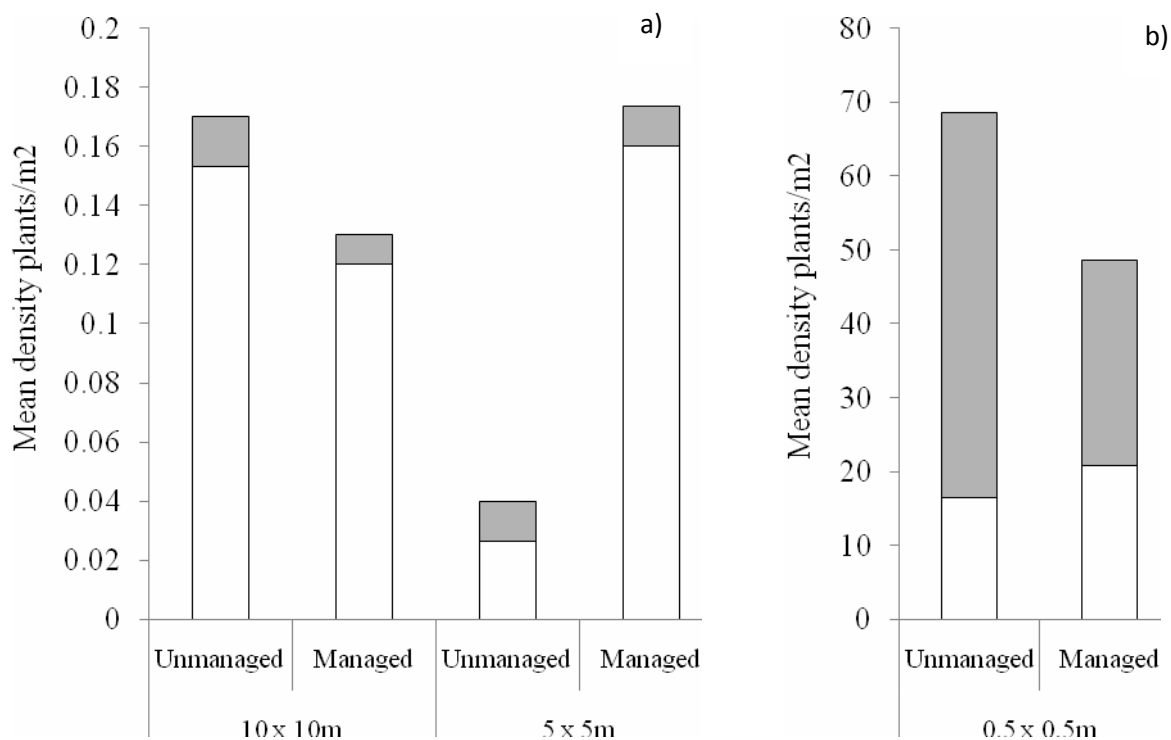


Figure 1. Mean density of plants by treatment groups (managed and unmanaged) and plot size (a) sizes 10 x10m and 5 x 5m and (b) 0.5 x 0.5. Native species are represented by white bars and introduced species are represented by dark bars. Garlic mustard data has not been included in this figure.

Table 2. Comparisons of significant differences in plant abundance and species richness between managed and unmanaged sites. Comparisons were made for native and introduced species observed in large plots (10 x10m and 5x5m) as well as quadrats (0.25m x 0.25m). Significance is denoted by an * and p-value less than 0.05. The corresponding t values (t) and degrees of freedom (df) are depicted as well. 95% confidence intervals are presented to quantify the difference in abundance and species richness between site types. Confidence intervals corresponding to significant differences between sites are denoted by an *.

Comparison	t	df	p value	CI
<i>Large plots</i>				
Native Abundance	0.43	3.2	0.692	(-14.24, 18.90)
Native Species Richness	-0.54	2.3	0.640	(-5.41, 4.07)
Introduced Abundance	-0.74	2.6	0.518	(-7.54, 4.87)
Introduced Species Richness	-0.50	3.2	0.649	(-2.38, 1.72)
<i>Quadrats</i>				
Native Abundance	1	54.9	0.322	(-1.04, 3.11)
Native Species Richness	4.69	55.3	0.000*	(0.46, 1.14)*
Introduced Abundance	-5.63	30.2	0.000*	(7.65, 16.34)*
Introduced Species Richness	-2.24	58	0.029*	(0.04, 0.69)*

Populations of woody plants within managed and unmanaged plots had an approximately J-shaped curve; a higher proportion of individuals comprising the smaller (younger) size classes than larger (older) size classes. Within seedlings, small tree, and large tree size classes, unmanaged sites had a higher average number of individuals than managed sites. However, within the sapling size class, managed sites had a significantly higher average number of individuals than in unmanaged sites ($t = 2.56$, $d.f. = 5.52$, $p = 0.046$). Data was transformed on a log scale and displayed on a log scale (Figure 2) but, significance was calculated on non logged data (graph not shown).

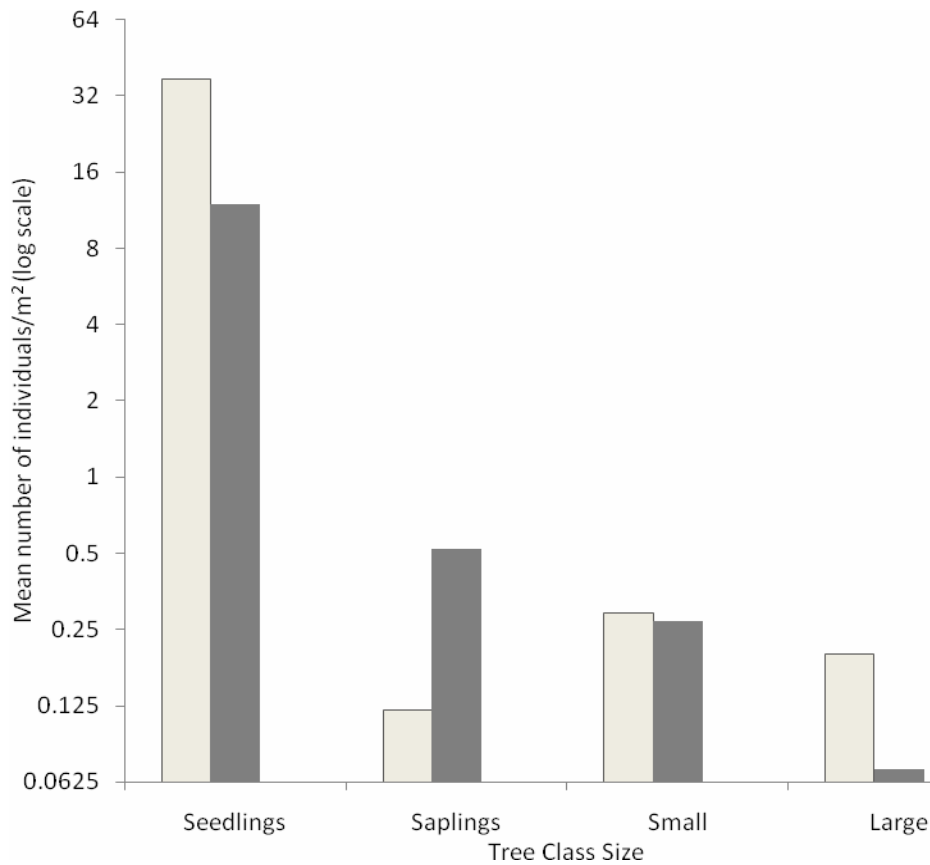


Figure 2. Mean number of woody native and introduced individuals per m^2 in 10 x 10m and 5 x 5m plots on a log scale. Individuals are divided by managed (gray) and unmanaged sites (white) as well as size class. Standard error not shown in order to improve clarity of the figure.

Discussion

Potential weaknesses of our analysis include the fact that all our data for abundance and the native plant richness in unmanaged plots do not have a normal distribution. This is evidenced by visual inspection of the associated histograms and the normal probability plots. The Kleinstuck Preserve is relatively small and so we were limited in the number of plots we could sample. Our sample size was thirty for each treatment, which we assumed would be a reasonable sample of the population. Because our statistical analyses were based on normality of data, sampling a larger number of plots would give our inferences more credibility. Even when the population distribution is nonnormal, which may be the case in our study site; with a large enough sample size the sampling distribution will be approximately normal.

In this study we limited our data collection to abundance and richness of plant species found in upland forest areas. Our assumption was that by limiting our sampling to similar areas, our study would be influenced to a lesser degree by confounding factors such as light availability or soil quality. That being said, it may be interesting to do a similar study of diversity between treatment types as well as different habitats. Within the preserve there are marsh and swamp forests with similar problems in terms of the presence of introduced species. The Stewards also employ similar management strategies to these areas including the physical and chemical removal of introduced species. In future studies, we could compare plant diversity in different habitat types that use similar management strategies to determine whether the effectiveness of management strategies is dependent on the type of habitat. For instance, marsh forests may be more heavily impacted by the use of fertilizers from nearby houses as the fertilizer tends to drain directly into the swamp (Jorth, 2009). In previous studies, it has been shown that a higher concentration of resources such as the nitrogen found in fertilizer may actually favor introduced species. With high levels of nitrogen, some introduced species can grow so much faster than

native species that they quickly outcompete and exclude these native plants (Brooks, 2003). Strategies used in upland forests, such as the physical removal of introduced species, may not be intense enough in some habitats where introduced species have such an advantage over native species. This information could help the Stewards to adapt their management practices to specific habitats.

Also, the results of our study could be time-dependent. That is, the management efforts provided by the Kleinstuck Stewards are relatively recent, and there may not have been enough time to see the effects of their plan. Although it appeared that management was having a positive effect on the diversity of native species, it did not appear to be decreasing the number of introduced species. If the management continues, we may see a shift in the dynamics of the introduced/native plant community in later years. It would be helpful and interesting to make this a long-term study, and repeat the data collection annually for the next five to ten years.

References

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