Invasibility of different forest types at UNDERC-East

BIOS 35502: Practicum in Environmental Field Biology

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Abstract

The process on invasion can be seen from the point of view of the non-native species, as well as that of the habitat. The invasibility, how likely it is to be the subject of an invasion, of a habitat can be determined by understanding the characteristics of the location and is a very important measure for ecological communities. By comparing the non-natives in different habitats, the invasibility of a habitat can be determined relative to the other, especially if the comparison is between canopy gaps as they have more resources and provide the opportunity for new species to thrive. The purpose of this study is to find if there is a difference in the non-native population of herbaceous species found in canopy gaps in coniferous and maple forests. Our predications were that coniferous forest would have less non-natives as the dominant species in the area tend to prefer more acidic soils. To test this hypothesis we surveyed the herbaceous plant species in 7 gaps in each forest type, for a total of 14, and compared the number of species, as well as the frequency of individuals using a Mann-Whitney test. Our results indicated no difference between the non-native herbaceous populations, indicating that both of them have the same level of invasibility.

Introduction

Understanding the process by which non-native species colonize new locations is important because of the effect non-native species may have on ecological communities. Colonization processes are complex and non-native species can cause ecological and economic damage (Pimentel 2005). These non-native species that cause considerable ecological and economic damage are considered to be invasive species. As studies show that the costs incurred

by invasive species are predicted to increase (Vitousek et al. 1996), it is a crucial time to gain a deeper understanding of invasion processes and what makes some habitats more likely to be colonized by non-native species. Understanding these mechanisms can provide land managers important strategies for how to reduce invasion events and rates for at-risk communities.

There are two way of studying the invasion process, focusing on the non-native species, and focusing on the habitat. An example of a study focused on the non-native species was performed by Baker (1974) who showed how invasive weeds adapted to new locations and affected agriculture. The other approach was taken by a large study in the Czech Republic, which showed that the resources of a particular environment affected the colonization of a non-native species, where the success of exotic species was different according to the characteristics of the different habitat types it was present in (Pysˇek 1995). This study showed that invasibility can be assessed for a given location by examining both its biotic and abiotic conditions, such as moisture and nitrogen availability, planting history, and pollinators.

In forests, canopy gaps play an important role in resource availability as they present an opportunity for understory species to receive more light, which in turn affects growth rate(Canham 1988). The formation of these gaps is typically caused by disturbances, specially wind (Nowaki 1998). These canopy gaps also present an opportunity for shade intolerant species to establish (Schnitzer and Carson 2001), and studies have shown that gaps have higher species richness per unit area than non-gap areas(Hubbell 1999). Given this availability of resources, as well as the disturbance from the gap formation process, gaps could provide the opportunity for non-natives to have the ability to compete with native species. However, resource availability is not the only factor to consider when determining invasibility. The success of exotics species is

also dependent on the native species of the location, and different plant communities may be more being more likely to experience invasions than others (Lonsdale 1999).

In this study, we examine non-native herbaceous species located in forests of the Great Lakes region. We assess two main forest types: sugar maple-dominated northern hardwood and coniferous forests. The hardwood forests are deciduous and dominated by sugar maple(*Acer saccharum)* and quaking aspen (*Populus tremuloides*), while the coniferous forest are evergreen and are dominated by white spruce (*Picea glauca),* balsam fir *(Abies balsamea)* and Eastern Hemlock (*Tsuga canadensis)*. An important difference between these forest types is the soil pH; species found in coniferous forests are associated with more acidic soils(Ste-Marie and Pare 1999) than those in maple forests (Londo et al 2006). As soil pH is an important factor in plant growth, it may play an important role in shaping plant communities.

Finding if a difference in non-native populations between these communities exists could be an indication that one community is less receptive to the process of invasion. This is extremely crucial in areas affected by deer browsing, as deer prefer to browse coniferous trees(White 2012). This preference, as well as sugar maple's higher shade tolerance, are contributing to changing the understory in northern forests (Long 2007). Finding if one of these two forests types is more recipient to non-native species would be a very important factor in evaluating the severity of deer browse. Deer could possibly be changing the understory of forests towards a type that is more receptive to invasions.

In this study, we assess patterns in herbaceous plant establishment between gaps of conifer and maples forests. Specifically we expect that:

1. There will be both fewer non-native herbaceous species and they will occur at lower relative frequencies in coniferous relative to maple gaps because fewer species are adapted to growing in acidic soil. While the soil acidity may reduce the number of non-natives that can grow in the soil, natives with adaptations may have an advantage.

2. There will be lower herbaceous plant diversity, density and species richness in coniferous relative to maple gaps because fewer plants have adapted to the soil conditions in coniferous forest.

Methods

Study site and sampling methedology

To better understand the distribution of non-native species between maple and coniferous forests gaps, we conducted field surveys between June 13th and July 13th 2016 at the University of Notre Dame Environmental Research Center in the upper peninsula of Michigan. Seven pairs of gap and canopy plots were surveyed in each forest type, for a total of 14 gap and 14 canopy plots. Gaps were only selected if they had an area of at least 20 m^2. Once a site was identified, a 4 x 4 m grid was placed in the center of the canopy gap, and every herbaceous plant species was counted, identified, and then categorized as “non-native or “native.” Once a gap was located, a paired non-gap, or canopy, plot was selected by getting a random compass bearing and walking 30 meters in the direction of the compass bearing (Heatwole 2007). If this process designated a canopy plot in an area which was not the right forest type, the process was be repeated.

Statistics

In order to calculate the relative frequency of non-native species per plot, we divided he total number of non-native individuals by all herbaceous plants surveyed in the plot. We

calculated density by dividing the number of herbaceous individuals by 16 m^2, the area of the sampled area. We also calculated the Shannon diversity index of each plot, as well as species richness.

To assess the differences between gaps and canopy plots, I first subtracted the relative frequency of non-native species, density, diversity and richness of canopy plots from their paired gap plot. This means that values above zero indicated that gaps had a positive difference compared to the canopy, values below zero indicated gaps had a negative difference compared to the canopy. Then I tested whether these differences in species, individuals frequencies, density and diversity varied significantly between maple and conifer forests using t-tests or Mann-Whitney U-tests, when data was not normally distributed.

Results

Descriptive Statistics

The number of herbaceous species per plot ranged from 0 to 4, with individuals from a species ranging from 1, to 147. There were 11 species in total, with 10 found in coniferous forests, and 6 in maple forests. The most abundant species was Canada mayflower (*Maianthemum canadense*), which was found at more than half of the locations. There were 4 non-native species present in the plots, 3 of them in coniferous plots, and only one in maple plots.

Non-natives in gaps between forest type

The Mann-Whitney test between non-native species in gaps differentiated by forest types indicated that there was no significance difference between them (p-value: 0.2328, U = 16, df = 8.1595, STDerror: 0.123). The Mann-Whitney test between non-native frequencies in gaps

differentiated by forest types indicated that there was no significance difference between them (p-value = 0.2335, U = 16, df = 10.855, STDerror: 0.123).

Species density, diversity and richness

The t-test between the species diversity in gaps differentiated by forest types indicated that there was no significance difference between them (t = 1.2612, df = 10.043, p-value = 0.2358, STDerror: 1.367). The t-test between the species density in gaps differentiated by forest types indicated that there was no significance difference between them (t = 1.3091, df = 10.98, p-value = 0.2172, STDerror: 0.163). The t-test between the species richness in gaps differentiated by forest types indicated that there was no significance difference between them (t = 0.85934, df = 11.666, p-value = 0.4075, STDerror: 0.465).

Discussion

No difference between gaps - One of the most startling results of this paper is the lack of support for the hypothesis by the results. The results indicated that there is no difference between non-native species(Figure 1) and their frequency in gaps(Figure 2) in either forest type. What is even more striking is that there was also no significance difference in species diversity(Figure 3), individual density(Figure 4) or species richness(Figure 5) between the two groups. This was surprising because of the differences in the forest types, which would indicate a difference in the herbaceous plants found in the area.

Herbaceous species - One of the important aspects to consider when looking at the results of this paper is its focus on the herbaceous species found in the plots. The plots surveyed had multiple species that were not herbaceous, and in some occasions there were no herbaceous species found(Figure 6). This is especially important because it means that the results are not necessarily

the opposite of what past studies found, but that the result are from a section of the whole plant community. Taking into account the other different species for further studies would give a more complete view of the effects of gaps and forest types. There were multiple woody species found in the plots I surveyed, and not only where they saplings of the dominant forest species, but there were multiple individuals of the genus *rubus* that were not included in this study as they are not herbaceous.

New gaps - The process of gap creation is a constant one, and during surveying the same area at a different time I was able to see new gaps that had been recently formed. Given that I only analyzed 14 gaps, it is possible that surveying a gap which was newly formed and had not being the subject of increased plant activity would greatly affect my results. The fourth and fifth gaps could be in this category of new gaps, as there were no herbaceous species in either of them. Without time for their effect to be apparent, new gaps have the same communities and canopies, and might even have a fractured community caused by the disturbance of gap creation.

Other Tests - With all the data collected we were able to run different tests to evaluate different questions, for example to see if there is a difference in species diversity between maple canopy and maple gaps. The problem with this test, and many others that we tried to run was that there was very little data, as the necessary data for that test is half of the total collected. For this reason as well as the aforementioned problem with only using herbaceous species, most of the other test we run showed no significant difference.

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Tables

Table 1: Includes name, coordinates, area, , # of non-native species, # of non-native individuals, diversity index, species density for all gaps

Forest Type	Gap Name	Coordinates		Gap Area(m^2)	# of Non-Native Species	# of Non-Native Individuals	Diversity Index	Species Density
Conifer	Plum #1	N 46 13 39.0	W 089 31 28.0	86.87	0	0	0.617	7.313
	Plum #2	N 46 13 04.1	W 089 29 29.7	24.45	0	0	0.000	0.750
	Plum #3	N 46 13 00.8	W 089 29 29.2	32.88	1	2	0.536	1.625
	Firestone #1	N 46 14 56.9	W 089 31 08.4	30.97	1	11	0.000	0.688
	Naked Kitty #1	N 46 12 58.1	W 089 31 16.2	37.50	0	0	0.000	4.938
	Naked Kitty #2	N 46 13 00.1	W 089 31 16.1	49.89	0	0	0.000	4.438
	Naked Kitty #3	N 46 12 59.8	W 089 31 16.1	49.89	1	35	1.091	5.813
Maple	West Tenderfoot #1	N 46 13 49.0	W 089 31 56.2	53.03	0	0	0.844	1.688
	West Tenderfoot #2	N 46 13 49.9	W 089 31 57.8	199.14	1	31	0.575	2.625
	West Tenderfoot #3	N 46 13 49.7	W 089 31 58.5	71.43	0	0	0.000	0.000
	West Tenderfoot #4	N 46 13 50.1	W 089 31 58.0	76.98	0	0	0.000	0.000
	West Tenderfoot #5	N 46 13 48.9	W 089 32 02.1	117.67	0	0	0.685	1.438
	West Tenderfoot #6	N 46 13 40.3	W 089 32 12.0	59.22	0	0	0.317	3.250
	West Tenderfoot #7	N 46 13 38.9	W 089 32 15.0	34.98	0	0	0.000	0.625

Figures

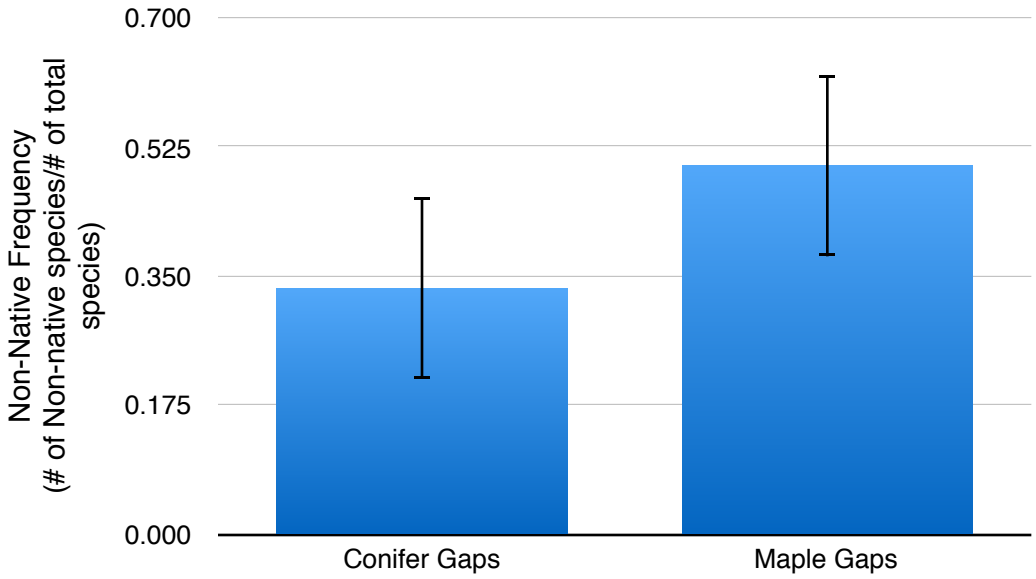

Figure 1: The frequency of non-native species found in conifer gaps and maples gaps.

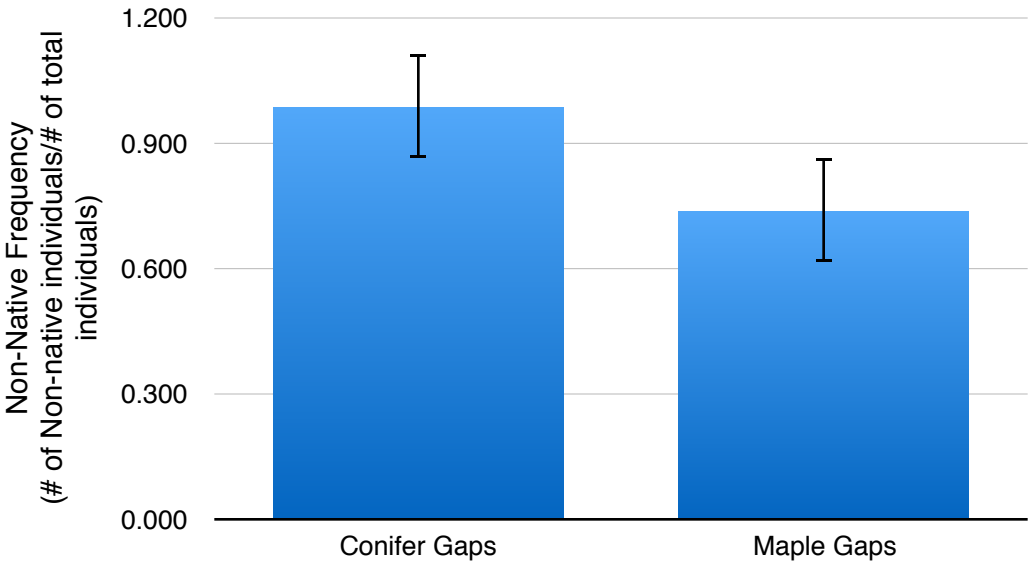

Figure 2: The frequency of non-native individuals found in conifer gaps and maples gaps.

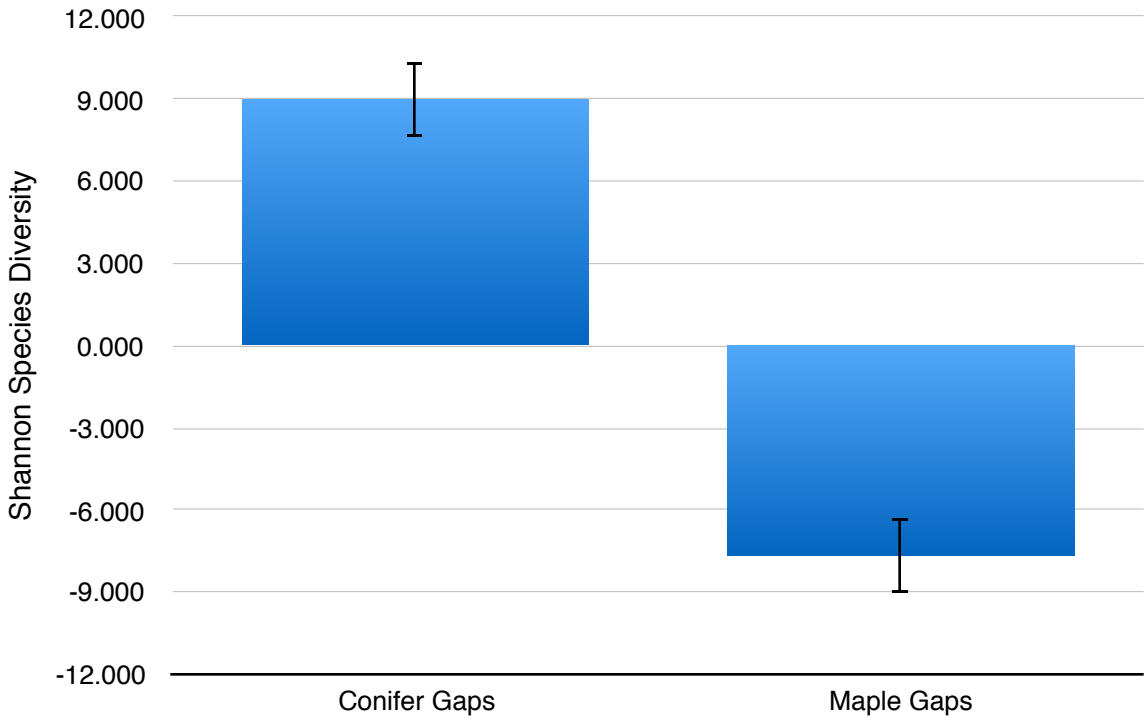

Figure 3: Shannon diversity index found in conifer gaps and maples gaps.

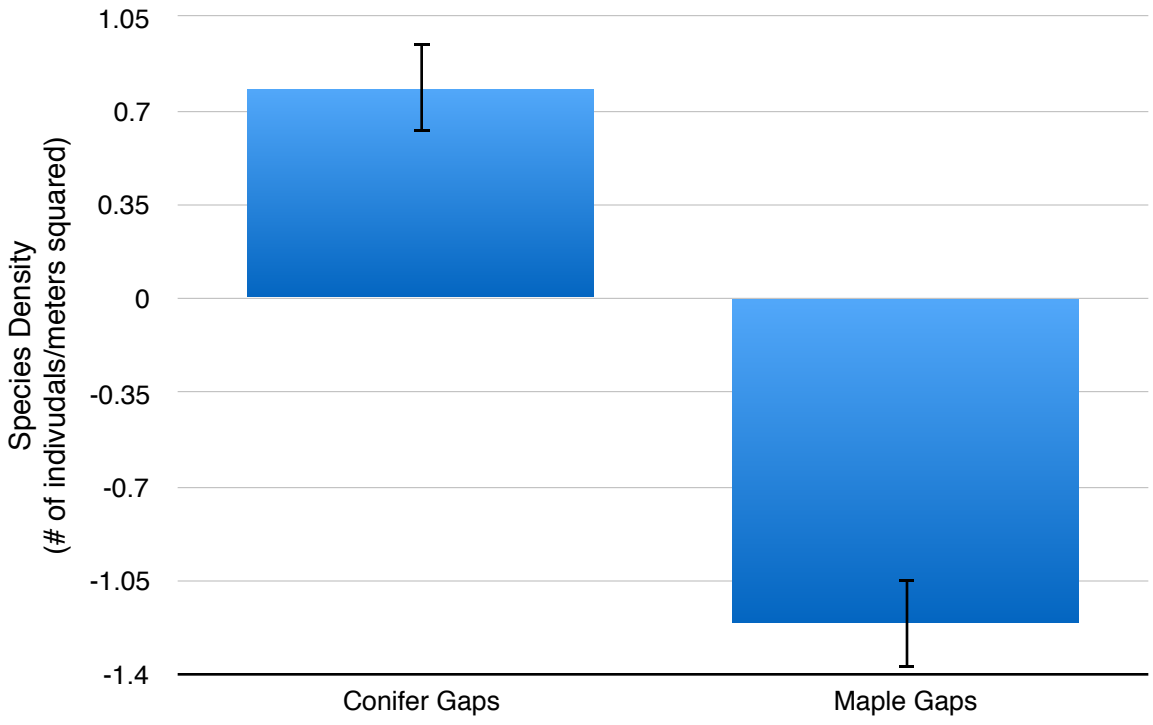

Figure 4: Species Density found in conifer and maples gaps