THE EFFECTS OF *AILANTHUS ALTISSIMA*

ON GROUND LEVEL VEGETATION

IN CUMBERLAND, MARYLAND

BY

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ABSTRACT

Ailanthus altissima is an invasive tree species from China that is believed to be allelopathic. Because of this we wished to determine whether or not *A. altissima* affects ground level vegetation. Our first hypothesis was that species richness, species diversity and percent ground cover will increase with increasing distance from an adult *A. altissima.* Our second hypothesis was that species richness, species diversity and percent ground cover around *A. altissima* will differ from that around *Prunus serotina.* We conducted our experiment by using five *A. altissima* and five *P. serotina*. Around each of these study trees we set up three ten meter transects, with ten 1 x 1m plots along each. Inside each plot we counted the number of species as well as the number of individuals per species and estimated the percent ground cover around each individual tree. These data were used to calculate mean species richness, species diversity and percent ground cover at each distance for both study species. Regression analysis found no significant relationship between any of the dependent variables and distance for either study species. Student's t- test showed no significant difference in any of the dependent variables between the study species. Our null hypotheses were accepted and we found no evidence for allelopathy. We can conclude that *A. altissima* does not affect ground level vegetation at our study site, therefore it may not be a very damaging invasive there. Any removal or restoration efforts may be better spent on other invasive species.

INTRODUCTION

An exotic species is a species existing outside of its natural habitat. An invasive species is a species that exists out of its natural habitat and causes environmental or economic damage. The United States has approximately 50,000 invasive species that cause major environmental damage and economic losses totaling approximately $137 billion per year (Pimentel et al. 2000). Invasive species can be pathogens or predators of native species in an ecosystem. Too many invasive species can be destructive to an ecosystem because resources are limited, and invasive species often out-compete native species for resources (Bright 1995).

The zebra mussel is an example of an invasive species. The native habitat of zebra mussels is Eurasia. They were first discovered in Lake St. Clair in June of 1988 and are now well established in North America (Gulf of Maine Aquarium 2003). Zebra mussels are a threat to the ecosystem and are considered an invasive species because of their annoyance to society. Zebra mussels clog wells and pipes. They also reproduce rapidly, causing overpopulation. This species is costing the U.S. millions of dollars each year. Aside from economic impacts, zebra mussels have biological impacts. Native plankton populations are severely reduced by zebra mussels because of the superior filtering abilities of large zebra mussel colonies compared to native mussel colonies. This problem reduces food availability for native organisms and damages food web dynamics (Gulf of Maine Aquarium 2003).

The glassy-winged sharpshooter is an example of an invasive insect species (California Department of Food and Agriculture 2005). It is a native of the southern United States and northern Mexico. The glassy-winged sharpshooter was first discovered outside of its native range in California in 1990. This insect can adapt to lush agricultural areas and has chosen orchards and vineyards as its habitat. The glassy-winged sharpshooter causes a threat to California's viticulture regions because it injects the plants with Pierce's disease. This disease results in a rapid decrease in foliage and eventually the death of the plants. Presently, the glassy-winged sharpshooter is threatening San Joaquin valley's $ 2.8 billion raisin, table wine and grape industries (California Department of Food and Agriculture 2005).

Ailanthus altissima, known as "the tree of heaven" or "God's tree" is an exotic and invasive species of plant in the United States (Shah 1997). *Ailanthus altissima* was introduced to North America in 1784 by a man named William Hamilton. He brought *A. altissima* here by mistake, thinking it was the Chinese varnish tree. *Ailanthus altissima* was pushed out of society and was left on its own to escape into the wild. *Ailanthus altissima* roots and pollen were believed to cause medical problems. The pollen was believed to have caused hay fever-like symptoms which lasted for weeks. The roots were believed to have caused chronic sore throats, disturbed stomachs, nausea and, over time, tuberculosis. Later, many of these beliefs were disproved. He roots of A. altissima can cause damage to sewers and foundations, and can taint well water (Shah 1997). Because of these undesirable effects *A. altissima* is no longer planted purposely. Existing trees have been neglected and the species rapidly escaped into the wild (Shah 1997).

Allelopathy refers to the effects of one plant on another plant through the release of chemicals known as allelochemicals (Ferguson and Rathinasabapathi 2003). *Ailanthus altissima* is believed to be allelopathic by some scientists. Heisey (1997) was not sure if *A. altissima* was really allelopathic in nature because its toxins are short-lived in the soil and might not last long enough to affect other plant life. Heisey (1997) thought that *A. altissima* might produce these toxins as a deterrent to herbivores because of *A. altissima's* bitter taste and because few animals feed on it. However, Mergen (1959) found that *A. altissima* is toxic to 46 species of plants. The difference between these two experiments was that Mergen (1959) conducted his in a greenhouse and parts of Heisey's (1997) experiments were conducted outside. In a pot the toxin could be concentrated and more powerful than in the wild where the toxin is spread out (Inderjit 1996).

The purpose of this study is to discover whether or not *A. altissima* affects ground level vegetation. We need to know this information so that we can decide whether or not we need to be concerned about *A. altissima* in our natural areas. Studies like this may also lead to ideas about *A. altissima* control and restoration of affected areas and may help to settle the debate over the allelopathic abilities of *A. altissima*. We hypothesize that ground cover, species richness and species diversity will increase with increasing distance from *A. altissima*. Our hypothesis was based on results from Buck and Mann's (2002) findings from their study on the impact of *A. altissima* on ground cover diversity in a disturbed Virginia forest. They found that *A. altissima* reduced species richness, species diversity and percentage of native plant species (Buck and Mann 2002). We also hypothesized there will be a significant difference in our dependent variables, species richness, percent ground cover, and species diversity between *A. altissima* and *Prunus serotina*. This hypothesis was chosen in order to compare *A. altissima* to a native, non-allelopathic plant.

METHODS

A*ilanthus altissima*, our experimental species, was introduced to Philadelphia around 1784 and is classified as an invasive species in the U.S (Shah 1997). The plant became popular because of its beautiful foliage and fast growth, even though the male plant emits a foul smelling odor. *Ailanthus altissima* has the ability to grow in a multitude of climates that would seem unfit for healthy plant growth. *Ailanthus altissima* is also able to grow in a multitude of different soil types. The tree reproduces asexually by cloning itself from its roots and also sexually through its prolific seeding. *Ailanthus altissima* can mature to up to sixty feet (Shah 1997).

Prunus serotina or black cherry is native to the United States. The range of the plant is from Nova Scotia and New Brunswick to Southern Quebec and Ontario into Michigan and eastern Minnesota; south to Iowa, extreme eastern Nebraska, Oklahoma and Texas, then east to central Florida (Marquis 1990). *Prunus serotina* grows best under cool, moist and temperate conditions. The soils that *P. serotina* grows best in are acidic soils like the soils of the Allegany plateau. Some of these plants produce seeds every year, but good seed crops occur only at one to five year intervals. Asexual reproduction occurs through stump sprouting. We chose *P. serotina* as a control species because it was found in the same geographic area as *A. altissima* and because it has a similar root structure (Marquis 1990).

We did our study at the campus woodlot at Allegany College of Maryland in Cumberland. The location of Cumberland is 39˚N latitude and 78˚W longitude. The elevation in this area is about 688 feet above sea level. The climate in this region is temperate (City-data.com 2005). The woodlot is a mixed deciduous hardwood stand on an alfisol soil (University of Wisconsin 2005). We chose the campus as our study area because it has both *P. serotina* and *A. altissima* in the same area which allowed us to control factors such as soil, climate, and light.

Five of each tree species were chosen for our study. For each tree we set up three 10 meter transects to the left, the right and the back of the tree. The transects were ten meters because *A. altissima* roots only extend out about eight meters (Davies 1944) and we wanted to be sure to include the entire root system. The reason we only used the back, the left and the right of each tree is because each tree faced a pathway along the woodlot edge, where the vegetation had been altered by humans. This area was too unlike the areas along the transects to include in our study.

Using meter sticks, we set up ten plots that measured one by one meter each along each transect (see Figure 1).

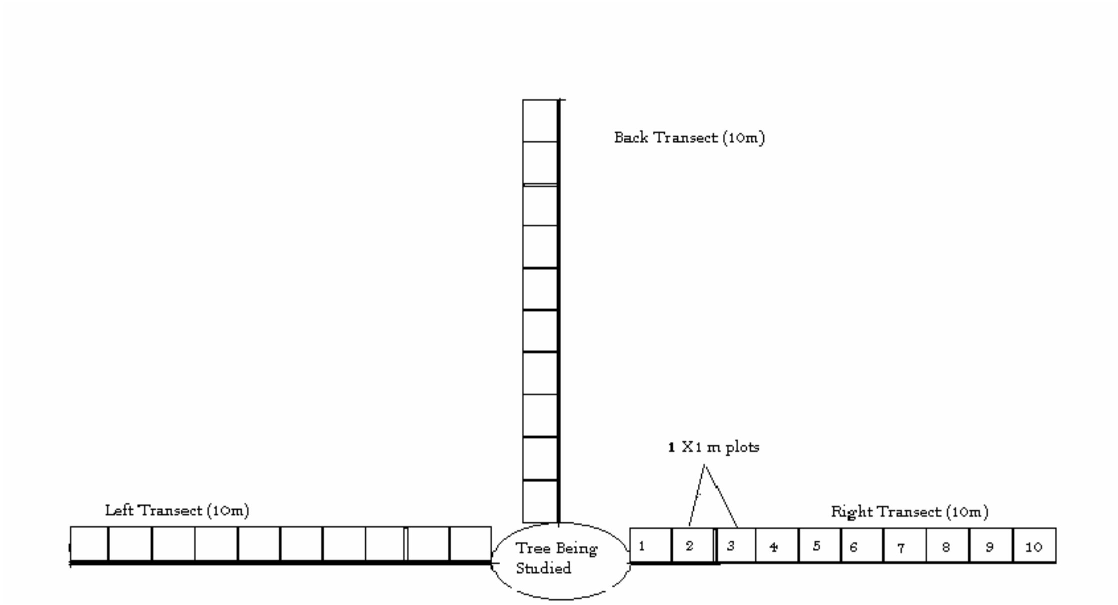

Figure 1: This figure shows our set up for retrieving data to help test our hypotheses.

Once each plot was set up, we estimated the percentage of ground cover. To do this we created a rectangular shaped box with our pointer fingers and thumbs which was about 20x25cm, the equivalent to 5% of each plot. By holding the guide over all living plants 136cm or lower, we were able to estimate ground cover. After estimating the percent of ground cover we counted the number of species of plants, and then we counted the number of individuals in each species.

Once we finished recording all of our information onto our data sheets, we calculated species richness and species diversity. These in addition to the percent ground cover are our dependent variables. The dependent variables were chosen because they are similar to the variables used by Buck and Mann (2002). We used the Shannon Wiener Diversity Index as a measure of species diversity. The equation is: H= sum (P_i [ln] P_i), where P_i= n_i/N, n_i= number of individual in species and N= number of individuals in all species. This equation gives us a number from 0 , which represents low diversity, and 7, which represents high diversity. We calculated species richness by adding up the number of species in each plot (Nowark 2005).

We calculated the mean of each dependent variable at each distance for both study species. Regression analysis was used to determine the relationship between distance and the dependent variables. Pearson's Product Moment Correlation Coefficient shows the strength of the relationship of each regression. We used Student's t-test to determine the difference in the dependent variables between each species. For all t-tests performed, our degree of confidence was 90%, α = .10, and degrees of freedom = 18. Furthermore, we used two tailed t-tests.

RESULTS

There was no statistically significant relationship between mean species richness and distance for either study species (see Figure 2). The r-value for *A. altissima* was 0.354, and the r-value for *P. serotina* was -0.309. Our calculated p-value was 0.162 for mean species richness. Therefore, there was no significant difference in mean species richness between *A. altissima* and *P. serotina*.

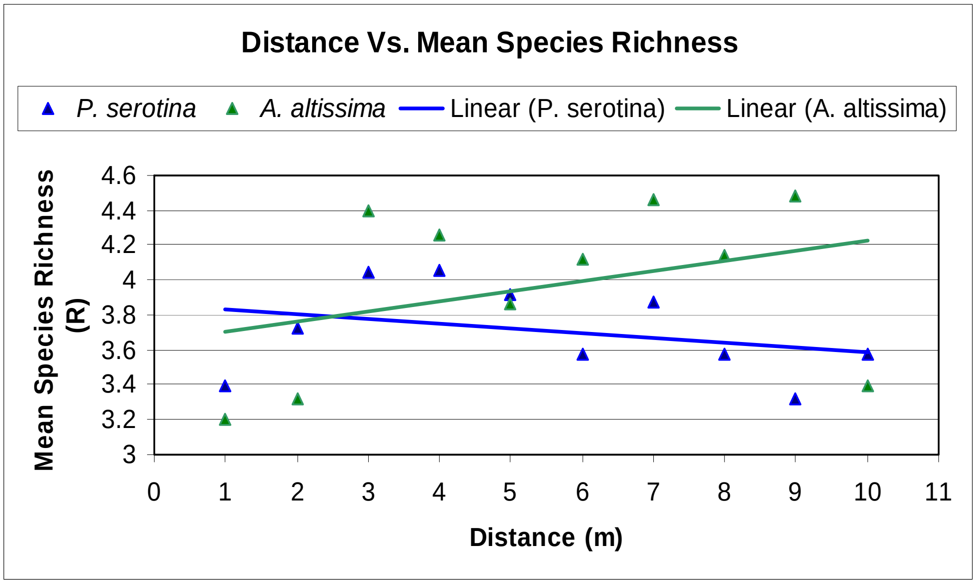

Fig. 2. – This figure shows the regression analysis of species richness.

There was no statistically significant relationship between mean percent ground cover and distance for either tree species (see Figure 3). The r-value for *A. altissima* was 0.715, and the r-value for *P. serotina* was 0.552.Our calculated p-value for mean percent ground cover was 0.873. Therefore, there was no significant difference in mean percent ground cover between *A. altissima* and *P. serotina*.

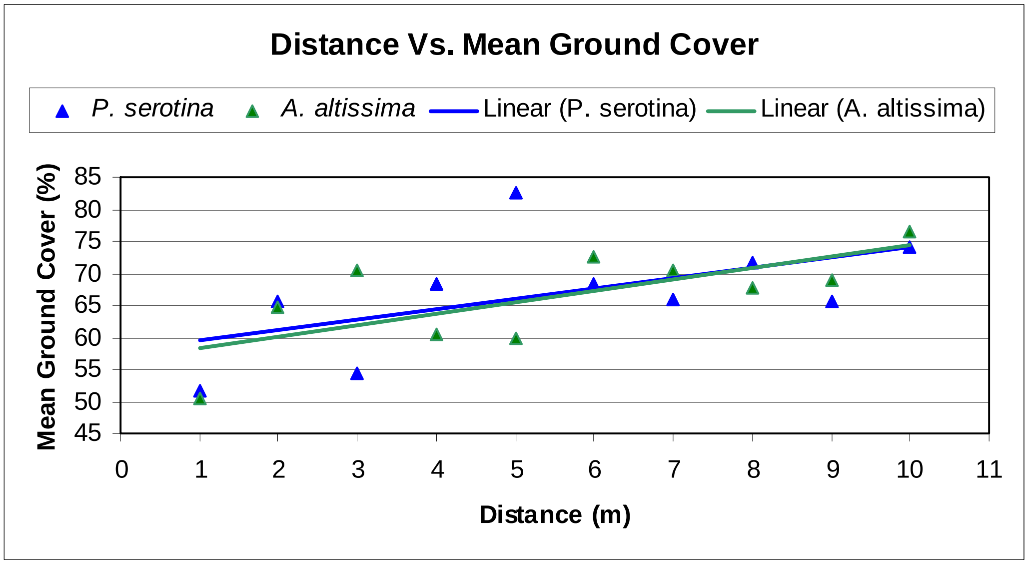

Fig. 3. – This figure shows the regression analysis of % ground cover.

There was no statistically significant relationship between the mean Shannon-Wiener Diversity Index and distance for either study species (see Figure 4). The r-value for *A. altissima* was 0.559 and the r-value for *P. serotina* was -0.339. Also, our calculated p-value was 0.326 for mean Shannon-Wiener Diversity Index. Therefore, there was no significant difference in mean Shannon-Wiener Diversity Index between *A. altissima* and *P. serotina*.

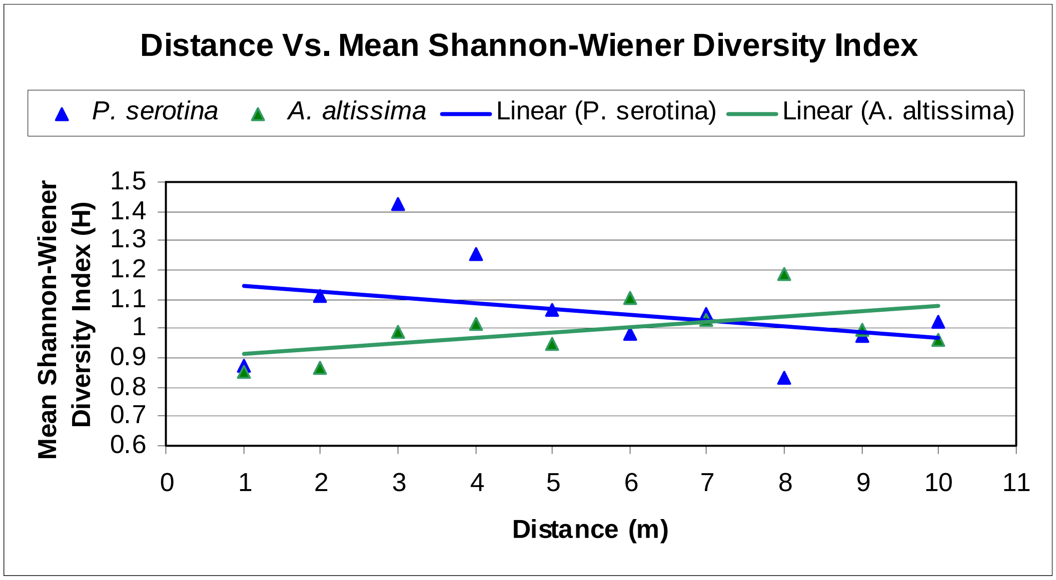

Fig. 4. – This figure shows the regression analysis of species diversity.

Discussion and Conclusion

The purpose of our study was to determine if *A. altissima* affected ground level vegetation. Based on our results, *A. altissima* does not affect the ground level vegetation in our study area. Our hypotheses in this experiment were percent ground cover, species richness and species diversity will increase with increasing distance from an adult *Ailanthus altissima;* and percent ground cover, species richness and species diversity of ground level vegetation around *A. altissima* will differ from that around *P. serotina.* Both of our hypotheses were rejected after completing a full analysis of our data. The hypotheses were rejected because there was not a statistically significant difference in any dependent variable between A. *altissima* and *P. serotina*. There also was not a statistically significant relationship between the dependent variables and distance for either study species. This finding is important because it allows us to conclude that A. *altissima* is not causing the community harm economically or ecologically in this area. This means that if we were going to concentrate on invasive species removal in this area we might spend our time and money on another more harmful species.

Our study does not agree with Buck and Mann's (2002) findings which were that species richness, species diversity and percent of native species decrease closer to *A. altissima*. We found no significant relationship between our dependent variables and distance at our study site. This may be due to differences between our study sites. Buck and Mann (2002) did their study within a disturbed Virginia forest. Our study site was along the edge of a fragmented forest, which was highly disturbed by humans. A study done by Ross et al. (2002) found that human disturbance coupled with fragmentation has a stronger and more immediate effect in reducing species richness and species diversity. This has led us to believe that species richness and species diversity were probably already lowered in our study area. This reduction altered our chances of finding a difference because there were other factors that were lowering species richness and diversity. This reduction may have masked any effect that *A. altissima* may have had on the vegetation at our site.

Our study did not find support for *A. altissima* using allelopathy in nature because we found no difference in our dependent variables between species or any relationship with distance. Our study agreed with a study done by Heisey and Heisey (2003), which found that the herbicidal effects of an extract of *A. altissima* bark declined within the first few weeks of application. This finding supports evidence that ailanthone, the secondary metabolite produced by *A. altissima,* is rapidly degraded under field conditions. From this Heisey and Heisey (2003) concluded that ailanthone was not produced for allelopathy.

There were many limitations to our experiment. We did not test for ailanthone and the site was a forest fragment disturbed by humans. The experiment is only pseudoreplicated, meaning that we studied only one site, but multiple trees within that site. The fact that we did not test for toxins is important because we do not know if there were even toxins in the soil or where the toxins were located along the transects. If we knew that, we may have been able to determine whether or not the toxins are actually strong enough to have an effect that is harmful to other plant species. This limitation could be corrected by extracting toxins from the soil if they are present. Since we were not able to test the toxins, we are not sure what their actual purpose is. Because the site is a fragmented edge it affects the experiment because of the reasons discussed above. Looking at more study sites would give us a better sample of the population of interest and allow us to make conclusions about more than one area. All of these limitations have an impact on our study because they can alter the data or the results and impact our conclusions. Upon determining if the toxins actually exist in the soil, we could apply the toxins to the roots of other plants and see if the toxins affect them. We can also fix these limitations by testing a forest that is not anthropogenically disturbed and going to more than one site.

Because we found no evidence for allelopathy, but Buck and Mann (2002) did, we were left with three questions pertaining to the allelopathic abilities of A. *altissima*. If the toxins are supposed to be in the roots, why does the aroma accumulate around the leaves of the tree? This question can be tested by taking a sample of the toxins from both the roots and the leaves of the tree, and determining whether they are the same or different toxins, and if one is more deadly than the other. Studying the leaves of *A. altissima* rather than the roots may indicate what is really causing a grave effect in the environment. Another question we have for this study is does *A. altissima* effect ground level vegetation if it is in a forest with a high percent of exotic species? We can test this by going to a site that is known for exotic species and testing the level of species richness, species diversity and the percent of ground cover. This question is important because we want to see if *A. altissima* is harmful to both native and exotic species. One more question that we are left with is whether or not *A. altissima's* toxin can only be used for defense against predators since it is not long lasting in the soil. This question could be answered by doing testing with insects, testing *A. altissima* toxin against different fungi, looking up previous research in science journals, and researching different internet sources. This question is important because if A. *altissima* is not toxic to other plants, it may be harmful to other species in nature.

Ultimately, our results found that there is not a statistically significant difference in mean percent ground cover, species richness and species diversity between A. *altissima* and *P. serotina*. Also there were no significant relationships between distance and any dependent variable for either A. *altissima* or *P. serotina*. Based on our study, we conclude that we can not classify *A. altissima* as an allelopathic plant because it does not seem to be harming ground level vegetation. This allows us to conclude that the *A. altissima* may not be an important invasive in this area.

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