The Relationship Between Percent Soil Moisture and Gender Ratios of the Box Elder (*Acer negundo*)

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Abstract: It has been found that male and female dioecious trees often display different growth patterns in which the females grow larger than the males. In box elder trees, females are found to have a higher growth rate in vegetative shoots than reproductive shoots while males are found to have an equal growth rate for both shoot types. Also, although they typically are found to have a 1:1 sex ratio overall, they are generally unevenly distributed with females growing primarily in dry regions and males being found in very moist areas.

It is the object of this study to examine the distribution of box elder trees in relation to sources of water, as well as landscape type. To achieve these objectives, a fifty meter line was laid down and ten transects of five by five meters were examined for trees, diameter and gender were noted. Soil cores were taken at each location and dried in the oven to provide data on soil moisture content. This process was repeated at three different locations at varying distances from water sources. The data collected was then entered into Stat view and analyzed to determine the relationship between gender and diameter, gender and soil moisture, and soil moisture and diameter. It was found that the there was a significant difference between tree size and location as well as between location and soil moisture. There was not a significant difference between soil moisture and tree gender or tree gender and diameter. Although soil moisture did not affect gender distribution, each site was found to have differently sized trees depending on the landscape type.

Introduction:

Dioecious trees are those that possess both male and female trees. It is often thought that this type of situation might be disadvantages from an evolutionary standpoint due to the fact that it cuts the population in half, making only half of the total plant numbers reproductive (Heslop-Harrison, 1972). Sexual reproduction also has a very high energy cost due to have to exert energy to create gametes and then to nurture the resulting zygotes. Having two genders does however have a large advantage, in that it enforces outcrossing (Bawa and Opler, 1975). This forced out crossing promotes genetic diversity, which in turn make the plant more successful and more adaptable. This is especially true of species that live in unstable environments. This also enables the plant to adapt if a sudden change were to occur. For example, imagine a tropical plant that has been living at 90 degrees Fahrenheit for a thousand years, it is perfectly adapted to existing under those conditions, but were the temperature to drop suddenly, if the tree did not have mechanisms for dealing with the cold, it would cease to exist. However, if that same tree undergoes sexual reproduction and possesses genetic diversity, it may well possess the variability needed to keep it alive in the cold.

Because of the importance of females in sexual reproduction it is often common that females would grow at a greater rate. A study performed on aspen clones found that females had a different size class distribution when compared to males; they also had a larger number of ramets and a greater basal area (Sakai and Burris, 1985). Also in a study looking at staghorn sumac, females were found to have a greater mean height than males, a result that correlates with other studies done on staghorn sumacs (Vlasak, 1990). There is an idea that female dioecious trees can either allocate energy towards growth or reproduction, a hypothesis that persists due to the fact that trees only have so much quantitative energy and so must make a choice as to what they put it towards. However, a study of box elder trees found that females had a greater growth rate in the first fifteen years of their life and exceeded males in both reproductive mass expenditure and seasonal wood production. The data found contradicts the idea that a female plant can put energy towards either reproduction or growth, as the female box elder is found to excel at both (Ramp and Stephenson, 1988).

The box elder is a dioecious tree, possessing a female tree that bears seeds and a male tree. The seeds ripen from August to October and are shed through spring. Seedlings can grow for one to two years in the understory waiting for a gap to open that they can grow into, but die off if a gap doesn't open by the end of that time period. Once they get a foothold, box elders grow quickly and are very successful because they can tolerate poor conditions, existing in flood conditions for up to a month while also possessing the ability to survive under exceedingly dry, drought conditions. However, their strength to survive extremes is tested by the fact that they are brittle trees and posses thin bark which makes them susceptible to fire, wind, and ice damage. Its unique combination of hardiness and weakness make it a fairly short-lived tree averaging sixty years of age and a height of around fifteen meters. These characteristics make it perfect to fill its niche of being an early succession tree species that is frequently found in grasslands and on the edges of forests.

As mentioned above, box elders follow the trend of females growing more quickly than males. Despite the difference in growth rates, female and male box elders exist in approximately 1:1 ratio. It should be noted however, that box elders are often found in an uneven distribution of the two genders. While females grow in great numbers in potentially dry regions, males are found to be more abundant in regions that are prone to being very moist. This is due to a number of things, including the fact that females posses: lower stomatal conductance to water vapor and transpiration, greater stomatal sensitivity to declining soil water content and increased leaf to air vapor pressure gradients, as well as possessing less stomata in general (Dawson and Ehleringer, 1993).

This study endeavors to further examine the ratio of male to female boxelder trees and their distribution. It will look at their proximity to water and the prevalent landscape that they are growing on and how that affects the genders found in particular regions. This study hopes to further prove the relationship of water and boxelder gender, as well as the size difference between genders, meaning that I expect to find more males nearer to the water and more females farther away, as well as greater diameters for the females found.

Methods:

Sampling: Three sites were selected for their proximity to water as well as their distinct landscape characteristics. The first site was an old forest with many fallen trees and a community structure that was markedly skewed to the side of older trees, it was not near any sources of water and appeared to be fairly dry. The second site was also not near water sources and appeared to have a relatively low moisture content, it was a predominently recent growth of trees on a patch of prairie. The third and final site began within ten meters of a pond and so was presumed to have a higher water content than either of the other two sites. It was a medium aged growth that was in a forest setting but did not have an entirely closed canopy.

At each site a fifty meter transect line was laid out, it then was divided into ten-five by two meter sections. In each section the genders of trees and saplings present as well as their diameter was noted. Three soil samples were also taken from each site, these were then dried in an oven and analysed for percent moisture content.

Once data was collected from all sites, it was entered into statview and analysed. ANOVA tests were run to determine a number of things:

-if gender and diameter were related
-if site, gender, and diameter were related
-if site and soil moisture were related
and
-if gender was related to site one, site two, or site three

A contingency test was also run to determine if there was a correlation between all the sites data together and gender.

Results:

The ANOVA comparing tree gender to tree diameter (Fig. 1) showed no significant results (p-value=0.82). The two-way ANOVA looking at site, gender, and diameter (Fig. 2) showed no significant differences when all three factors were involved (p-value= 0.83). However, when just looking at site and diameter there is a significant differences between the sites (p-value= 0.0104). The ANOVA test looking at site compared to soil moisture (Fig. 3) was significant (p-value=0.0426). In the three ANOVA tests run to see if gender was related to site, there was no significant relationship at any of the sites (site one p-value=0.79, site two p-value=0.29, and site three p-value=0.61). Finally the contingency test showed no significant correlation between all the data grouped together and gender (p-value=0.80).

Discussion:

Although there was a significant difference between percent soil moisture, there were very few other correlations. Specifically, there were no correlations involving sites and gender, meaning that at least on St. Olaf campus there wasn't a relationship between water and gender. It should be noted that site three which I anticipated as having the highest percent moisture, actually had the lowest. Regardless of this difference, there was still no relationship either way. The only other significant difference was a correlation between site and diameter, this showed that the trees at site one were largest, site two were smallest, and site three were medium. These values did not correlate with percent moisture found and can be attributed to the age of the stand, rather than the proximity to water. Site one where the trees were largest was by all appearances the oldest stand with the oldest tree, thus largest diameters. In contrast, site two, which had the smallest trees, was a very young stand which was reflected by the prairie landscape around it (indicating that the trees were saplings that had not been affected by prairie fires yet).

One reason for the reversed moisture data might be that this year was a drought year, quite a bit of vegatation turned brown and the ground was fairly dry and hard. I expected this to not impact soil moisture too much due to the fact that I sampled next to a pond, but evidently it might have had a greater impact than I anticipated. As far as finding no results to support female box elder trees growing faster than males, I think that there are a few things to consider. First, tree cores of the trees would give a better indication of their true age and allow for correlating age with diameter, this might give a more accurate picture of size differences. Also, this study looked at thirty-six total trees, eighteen female and eighteen males, perhaps if the sample sizes had been larger, there would have been more of a difference found. In addition to taking a larger sample size, sampling at more extreme locations might reveal more of a correlation to proximity to water. For example, if a sample was taken in the middle of a prairie at a great distance from water and then in a swampy region, then perhaps females would be found in the prairie site and males at the swamp site. Were I to repeat this exeriment or do future studies, I would look at taking a larger sample and looking for greater extremes in my sites.

Regardless of the fact that my results did not turn out to be significant, my results could still be useful because they illustrate the fact that drastic differences are not always present, despite what seem like large differences in sites. This result is exceedingly intreging and more study is definitely necessary to prove how different conditions need to be in order to experience differences in gender ratios.

<u>Literature Cited</u>:

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Figures and Tables:

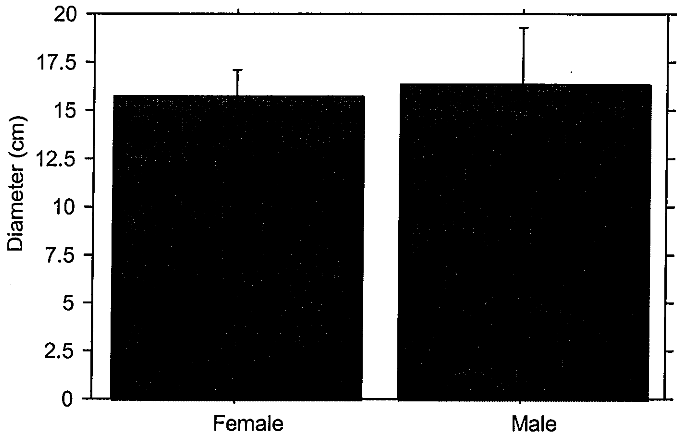

Fig. 1 ANOVA Diameter compared to gender (P-value=0.82)

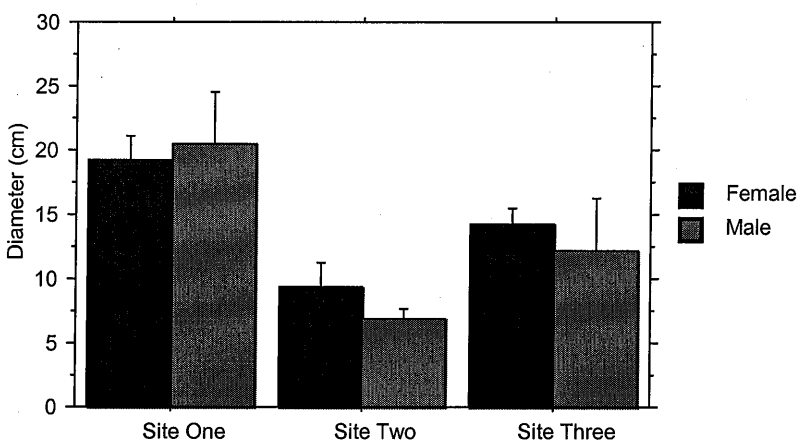

Fig. 2 Two-way ANOVA of site, gender and diameter.

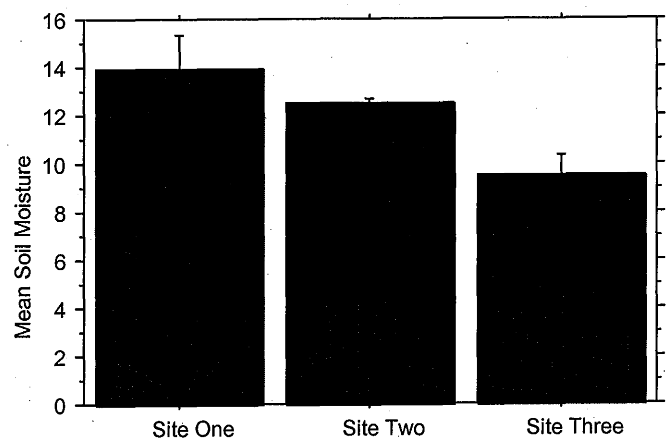

Fig. 3 Site as related to percent soil moisture (p-value=0.0426)