Laurel Brigham

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**The Effect of Phosphorus and Nitrogen Addition**

 **on Red Maple (*Acer rubrum*) Seed Production**

**Introduction**

The northeastern United States is experiencing high levels of acid rain as a result of human activity (Driscoll et al. 2001), which may be contributing to the changing vegetative composition of temperate forests. Before European settlement, the forests of the northeastern United States were primarily composed of oaks (*Quercus alba, Quercus velutina*), spruce (*Picea*), pines (*Pinus*), beech (*Fagus*), fir (*Abies*), birch (*Betula*), hemlock (*Tsuga*), cedar (*Thuja*), and sugar maple (*A. saccharum*) (Abram 1998). Red maple (*A. rubrum*) was not a dominant tree species at this time, but its numbers have increased dramatically in recent times (Abram 1998). *A. rubrum* may have been able to become a dominant competitor in this system as a result of suppressed fire regimes (Abram 1998), but it may be thriving as a result of the nutrient levels altered by acid rain.

Acid rain is a significant concern in the northeastern United States as a result of air pollution (Driscoll et al. 2001). It is composed of sulfuric and nitric acid from anthropogenically derived sources; it acidifies and varies the nutrient content in soil (Driscoll et al. 2001). More acidic soil can cause phosphorus (P) to become occluded, meaning that it is unavailable for uptake by plants (Chapin et al. 215; DeForest et al. 2012). Aluminum (Al) and iron (Fe) become more mobile in more acidic soils and bind to the P, thereby leading to P occlusion and potentially P limitation (Chapin et al. 215). While most trees in the northeastern forests of the United States may be at a disadvantage of a result of this nutrient limitiation, *A. rubrum* thrives in low nutrient conditions.

You decided not to bring in the idea that red maple can change the proportion of male and female branches, and that high P is associated with more female flowers? We have a good experimental design for testing this hypothesis.

*A. rubrum* has tolerances and a reproductive strategy that enable it to thrive under many conditions. The species has low nutrient requirements (Abrams 1998) and can flourish under a greater variety of pH and soil types than other forest species in North America (Burns and Barbara 60), thereby giving it the title of “super–generalist”. red maple produces a large number of seeds each year, around 12,000 to 91,000 (Burns and Barbara 60). The fruits are small, lightweight, and in the shape of double samaras, making it efficient at wind travel (Burns and Barbara 60). These characteristics contribute to the current widespread distribution and large number of red maple trees.

**Objectives and Hypotheses**

 Changing the composition of the forests of the northeastern United States may alter nutrient cycling or affect animals that rely on the out-competed trees, thus it is important to understand the reasons behind the unusually high numbers of *A. rubrum*. For this reason, this study seeks to investigate the potential impact of phosphorus levels on the mass and number of *Acer rubrum* seeds. It is hypothesized that *A. rubrum* grown under higher phosphorus conditions would have lower seed mass and count than trees grown under lower P conditions because the species thrives in nutrient-poor soils. In this soil fertilization experiment, P, N, and a combination of the two have been added to stands of trees since 2011 and litter baskets are placed to collect plant material, including seeds.

**Methods**

*Data Collection and Processing*

The contents of the litter baskets were collected 5-15 June 2016 from all plots within the 11 stands containing litter baskets. For the C1, C2, C4, and C6-C9 plots, there are 9 subplots and a litter basket in the four corner subplots and the center. Plots C3 and C5 do not have litter baskets. For the Jeffers Brook and Hubbard Brook plots, there are 4 subplots that all contain a litter basket with a fifth litter basket at center point. Litter had not been collected since November 2015 and as red maples drop their seeds for a 1-2 week period April through July, it is expected that the bulk of the seeds were collected.

The litter was stored in paper bags and placed in a drying oven overnight at 60C. The sticks were removed from the litter and the contents of the bag were weighed. The red maple seeds were picked out of the litter and weighed separately. Seedless samaras were counted to help account for seed predation and double samaras were treated as two seeds.

*Statistical Testing*

R programming (R Core Development Team, 3.1.2) will be used for the statistical testing. I plan on performing ANOVA tests to measure the difference between mean seed weights and counts and their potential interactions with nutrient treatments. In the past, litter collections had been separated by species and so the average number of red maple leaves in a litter basket will be used as a covariate to account for differing numbers of red maples in a subplot or distance from the litter basket.

**Expected results**

There have been two fertilization studies regarding red maple seed production and they have produced opposing results. Peters (2014) found that P addition resulted in lower seed production than control plots while Bjorkbom et al. (1979) found that NPK addition increased seed production. The former also increased the pH, but did not see a significant difference in the number of seeds across treatments. However, the difference in results may be due to an interaction between the N and P in the Bjorkbom et al. study, which could be teased apart by looking at N, P, and N and P addition in this study. Perhaps red maples are more N-limited than P-limited and thus adding excess P showed little effect (Peters 2014) while adding N was beneficial (Bjorkbom 1979). Thus, I expect to see a higher seed count and seed mass from red maples growing in the N and N and P addition plots, while seeing little effect in the P addition and control plots.

**Implications**

 Acid rain may be increasing the amount of N in the soils of the northeastern US, which may provide red maple additional nutrients that enable greater seed production. With increasing N comes decreased P, but red maples may not be significantly limited by this nutrient. Hence, the red maple may have a competitive advantage over trees that experience P limitation as a result of the acid rain. This may facilitate the expansion of the red maple at the expense of other species.

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