Reproductive Trait Variation in Northern Red Oak, *Quercus rubra*

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Abstract:

Northern Red Oak, *Quercus rubra*, is a common dominant species in hardwood forest ecosystems in the Eastern United States. This report comprises the first two years of an extended multi-year project that examines reproductive and offspring traits in three age classes of red oaks at Black Rock Forest in Cornwall, NY. Results show that catkin abundance was highest in the middle age class in both 2006 and 2007. Seed mass from the young age class were significantly larger than that from the old age class. However, the seedlings from those of the young age class were significantly smaller than seedlings from the old tree class creating a negative correlation between seed mass and seedling growth. When analyzing specific seedling traits, the difference in seedling size arose from root biomass, which showed a significant difference between old and young age classes. The results do not support the accepted idea that larger seed mass leads to better quality of seedlings but suggests that other factors influence this relationship. In addition, carbon/nitrogen composition analyses reveal nearly double the amount of carbon and nitrogen percentages in the old age class compared to young and middle age classes.

Background:

Understanding the carbon cycle and carbon storage is a critical part of comprehending the global climate system. Variation between tree species, including differences in canopy structure and fungal communities, can affect population dynamics within an ecosystem. Within one species, there can also be variation within a population due to microsite habitat (altitude, availability of nutrients, shade etc.), age of the trees or individual genetic variation. Our study examines reproductive traits, consisting of catkins and acorn rain, and offspring traits of seedlings including emergence time, seedling biomass, specific leaf area and nitrogen content, according to the age of the parent tree. Our null hypothesis is that tree age will not affect the reproductive and offspring traits in the Northern Red Oak, *Quercus rubra*.

Red Oak Life Cycle:

The Northern Red Oak, *Quercus rubra*, is a hardwood, monoecious species common in the United States. The male flowers are borne in catkins that emerge in spring and are wind pollinated (Sander, 1990). After fertilization in spring, the female flower matures into an acorn in two years. In forests, Northern Red Oak start bearing acorns at around age 25 but do not produce abundantly until around age 50 (Sander, 1990). The Northern Red Oak is a masting species, in which there is a significantly larger than normal acorn crop at irregular intervals, usually every 2-5 years (Sander, 1990).

References:

Sander, I. L. (1990). Quercus rubra L. . *In* "Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654" (R. M. Burns and B. H. Honkala, eds.), Vol. 2. U.S. Department of Agriculture, Forest Service, Washington D.C.

Sork, V. L., Bramble, J., and Sexton, O. (1993). Ecology of mast-fruiting in 3 species of North-American deciduous oaks. *Ecology* **74**, 528-541.

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Results:

- Middle age class produced the most catkins in both 2006 and 2007
- Catkin abundance was 22% higher in 2006 than 2007

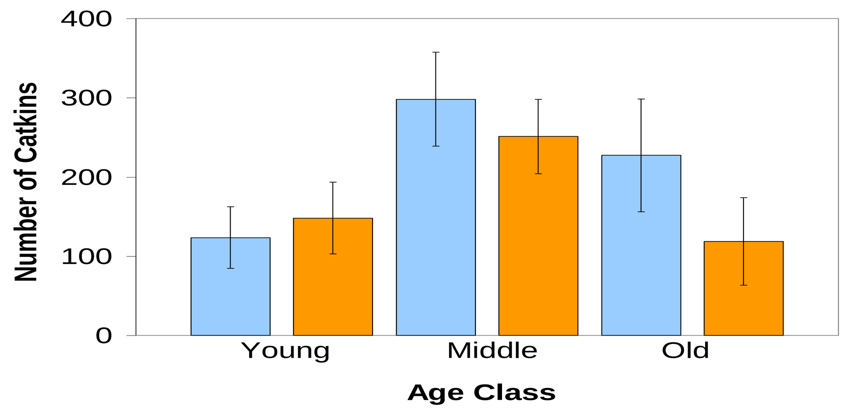

Figure 1: Average number of catkins collected per tree by age class in 2006 and 2007. The blue bars represent data from 2006 and the orange bars represent data from 2007. The error bars represent two standard errors from the mean in each category.

- Acorn weight varied significantly between old and young age classes during mast year 2006 but not during post-mast year 2007 (figure 2).

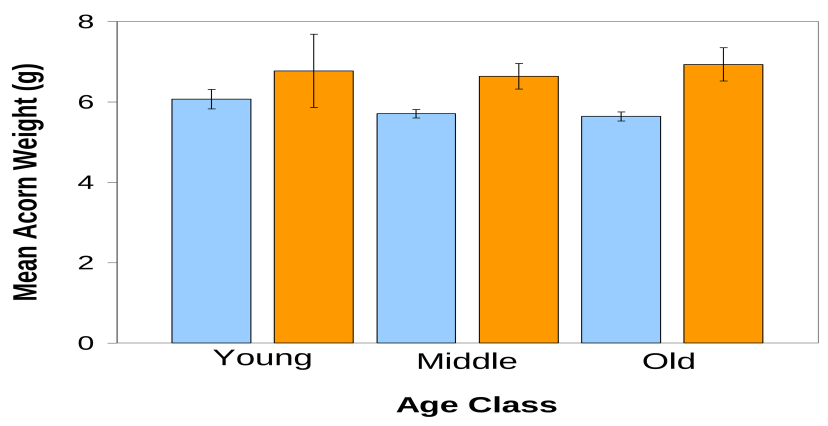

Figure 2: Mean acorn weight of mature viable acorns by age class of the parent tree. The blue bars represent data from 2006 and the orange bars represent data from 2007. The error bars represent two standard errors from the mean in each category.

- Negative correlation between acorn weight and seedling dry weight
- Larger seed mass not connected with survival advantage
- Variation in seedling dry weight related to belowground traits rather than aboveground traits (figure 4).

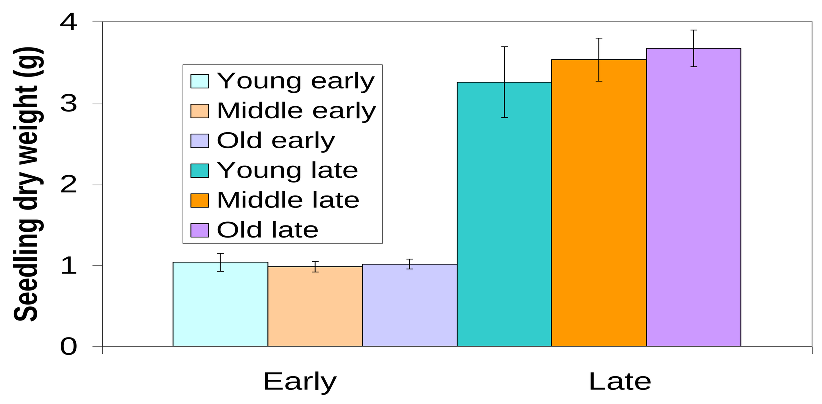

Figure 3: Mean seedling dry weight, separated into harvest time and age class of the parent tree. The error bars represent two standard errors from the mean in each category.

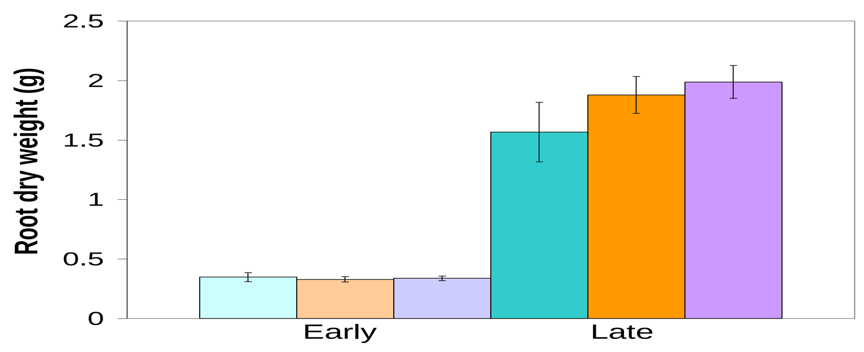

Figure 4: Mean root dry weight, separated into harvest time and age class of the parent tree. The error bars represent two standard errors from the mean in each category.

- Microsite differences in carbon and nitrogen percentage evident between old and other age classes (table 1)

	Percent nitrogen	Percent carbon	Carbon/Nitrogen ratio
Young	0.28	7.22	26
Middle	0.28	7.38	26
Old	0.59	14.26	24

Table 1: Soil nutrient composition for the stands of each age class at BRF.

Conclusion:

Although the young age class produced the heaviest acorns in 2006, these seedlings were generally smaller suggesting that factors other than seed mass has an influence on seedling establishment in a controlled environment. The disparity between age classes is shown more clearly in belowground traits than aboveground traits, which may indicate a stronger influence from root establishment on seedling survival.

The seedlings were not tested in a forest ecosystem. It is assumed that further factors such as soil composition or fungal interactions would influence the success of their establishment in forests.

The variation in seed mass and seedling size might be related to phenotypic variation such that some individuals have greater reproductive capacity than others, regardless of age. Additionally, certain stands could have advantageous genes derived from a strongly competitive parent plant.

The complex reproductive patterns of the Northern Red Oaks should be further studied in order to formulate better predictions in changes to forest ecosystems in the eastern United States.

Methods:

<u>Sampling.</u>

In fall of 2006, acorns were sampled from three *Quercus rubra* dominated stands at BRF, aged 35-, 90-, and 135-years. The acorns, from 12 trees in each stand, were collected from the forest floor in a standard area of 0.64 m^2 plots. In spring of 2006, catkins were collected from the same stands. In early spring, all confirmed viable acorns were potted and randomized into blocks to ensure equal distribution of acorns according to stand age and left to grow in the Barnard Greenhouse. The early harvest was after 1 month of seedling growth and consisted of destructively collecting seedling traits. The late harvest took place after 4 months of seedling growth.

<u>Nitrogen:</u>

6 seedlings from each of the 3 age class from the early harvest were chosen for nitrogen analysis. One leaf from each of the 18 seedlings was prepared and sent out for nitrogen analysis.

<u>Soil Analysis</u>

In October of 2007, soil from each age class were collected to be analyzed for nitrogen and carbon content.

Acknowledgements:

I thank the Hughes Science Pipeline Project for financial support and the helpful staff at Black Rock Forest. Thanks to Dr. Hilary Callahan for mentoring and Dr. Martin Stute for advising. I am grateful to Angelica Patterson, Mei-Ho Lee and my fellow interns Samantha Roberts, Lu Gomezdelat and Christine Chang. Also, thanks to previous interns, Mia Mattioli, Sarah Tepler and Naomi Weiner.