The Effect of Slope Position and Gap Size on Chestnut Hybrid Performance Relative to Tulip Poplar and Chestnut Oak: Implications for Reintroduction

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Abstract

Optimal sites in the forest environment must be identified for successful reintroduction of chestnut hybrids. Understory light levels, slope position, aspect, soil type, and competition may all affect chestnut performance with some factors having a more pronounced effect. We focused on understory light levels and slope position effects on growth and survival of tree seedlings. The experimental study was conducted in an oak-hickory secondary forest in the Ridge and Valley province of Virginia. In 2008, pure and hybrid chestnut, tulip, and chestnut-oak seedlings were planted in two gap sizes, 200 m² (30-45% of full sunlight) and 800 m² (20-35% of full sunlight) and on two slope positions (upper slope and mid-slope) for a 3 x 2 factorial design. Percent ground cover of Rubus spp. was estimated as low, medium or high for each plot. Height (cm) and diameter (mm) were recorded at the end of every growing season to identify relative growth rate and survival after 5 years. Treatment (a combination of gap size and slope position) had a significant effect on diameter (p<0.0001) and survival (p<0.0001) but not on height (p=0.016). Chestnut establishment was most successful in small gaps on upper slopes because of lower rodent predation (by girdling) and less competition or crushing from Rubus spp. In addition, tulip poplar had significantly greater growth than chestnut in both large and small, mid-slope plots suggesting that chestnut seedlings would not be able to compete well at these sites. The recommended locations for chestnut reintroduction within oak-hickory forests in Virginia are small gaps on upper slopes due to a combination of greater ability to compete with tulip poplar, less rodent predation and less competition from Rubus spp.

Introduction

- Castanea dentata was once a keystone species throughout Appalachia, providing habitat and food resources for wildlife.
- The fungal blight, C. parasitica, infects the above ground tree shoots usually after five growing seasons. Infected trees can reemerge and survive in forest understories with more open canopies (less productive systems).
- The Chinese chestnut, C. mollissima, exhibits blight resistance characteristics and has been hybridized with C. dentata (TACF). Sequential backcrossing has retained the blight resistance, while maximizing C. dentata morphology.
- Greenhouse experiments have found the American chestnut has the ability to adapt to various light and soil conditions (Lathem, 1990), suggesting that it is a generalist species.
- In order to successfully reintroduce Castanea hybrids in the forest understory, optimal conditions for establishment and survival must be determined with field experiments.

Methods

- 12 experimental plots were assigned a treatment combination of two levels of light (large gap and small gap) and two soil conditions (mid-slope and upper slope), enclosed with deer fencing.
- One-year-old seedlings of pure chestnut, hybrid chestnut (C. dentata/hybrids), tulip (L. tulipifera), and chestnut were planted in the plots, spaced 1 meter apart.
- Height (cm), diameter (mm), and survival was measured at the end of each growing season for 5 years.
- Herbaceous vegetation within the plots was quantified by estimating percent ground cover. ANOVA tests were performed to determine significant differences in growth between species and treatments. Post-hoc Tukey's tests were run to indicate differences between treatments and between species.
- A binomial regression analysis was carried out to determine significance between survival and treatment, as well as, survival and species.

Results

Conceptual Model for Survival and Growth Relative to Slope Position

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Species</th>
<th>Height (cm)</th>
<th>Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Slope (SM)</td>
<td>C. dentata/hybrids</td>
<td>120 cm</td>
<td>12 cm</td>
</tr>
<tr>
<td>Upper Slope (SM)</td>
<td>C. tulipifera</td>
<td>150 cm</td>
<td>15 cm</td>
</tr>
<tr>
<td>Upper Slope (SM)</td>
<td>Q. prinus</td>
<td>120 cm</td>
<td>12 cm</td>
</tr>
<tr>
<td>Lower Slope (LM)</td>
<td>C. dentata/hybrids</td>
<td>90 cm</td>
<td>9 cm</td>
</tr>
<tr>
<td>Lower Slope (LM)</td>
<td>C. tulipifera</td>
<td>120 cm</td>
<td>12 cm</td>
</tr>
<tr>
<td>Lower Slope (LM)</td>
<td>Q. prinus</td>
<td>90 cm</td>
<td>9 cm</td>
</tr>
</tbody>
</table>

Discussion

- L. tulipifera had significantly greater relative growth rate than Castanea hybrids in all three treatments except small, xeric (upper slope) plots.
- Castanea hybrids had the greatest height and diameter in large, mesic (lower slope) plots but survival was poor.
- Castanea hybrids had significantly greater survival in small, xeric (upper slope) plots.
- Rodent predation by girdling occurred in mesic plots during the first 2-3 years of growth.
- Larger gap plots had higher ground cover (Rubus spp) while small gap plots correlated with lower ground cover. Large gaps permit more light allowing Rubus spp. to thrive.
- When abiotic (light, soil moisture) and biotic factors (predation, competition) are considered, smaller gaps on upper slope sites are the best location for Castanea hybrids.

Conclusion

- We recommend that Castanea hybrids be planted in small gaps on upper slopes within the oak-hickory forests of the Shenandoah Ridge and Valley Province.
- In these conditions, seedlings have a much higher chance of survival due to a combination of low competition from herbaceous vegetation (and potentially tulip poplar) and less rodent predation (if protection with tree shelters is not used).
- A parallel study beginning next Spring (2015) will test the manipulation of light on growth and survival of Castanea hybrids within the highly productive Appalachian cove system.

Acknowledgements

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Figure 1. Experimental plot design. Each plot was assigned one of the following treatments: combination of large, mesic (LM), large, xeric (SX), small, mesic (SM), and small, xeric (SX) with mesic plots located on lower slopes and xeric plots located on upper slopes. All plots were 6 x 6 m square.