HERBIVORY, TISSUE NUTRIENT CONCENTRATION, AND MORPHOMETRIC COMPARISON OF TWO STOCK TYPES OF ATLANTIC WHITE CEDAR IN CHESAPEAKE, VA

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Abstract: Herbivory by white-tailed deer in afforestation and reforestation projects is an ongoing concern for resource managers as it increases tree mortality and decreases growth. The purpose of this study is to compare herbivory intensity on three parameters of growth, and tissue nutrients for Atlantic white cedar (cedar) seedlings from two nursery stocks planted in the Cavalier Wildlife Management Area (CWMA) in Chesapeake, Virginia. In the summer of 2010, 180 cedar from two stock types, rooted cuttings and seedlings, were planted in ten plots. In summer 2011, morphometric parameters including height, canopy diameter and stem diameter were measured for each tree. Intensity of herbivory and carbon and nitrogen content of cedar leaves were measured in leaf tissue samples. Seedlings were more heavily browsed than rooted cuttings ($p < 0.001$), however the total nitrogen content of rooted cuttings and seedlings were similar ($p > 0.05$). Rooted cuttings exhibited greater increases in height, canopy, and basal diameter than seedlings ($p < 0.001$); however, when herbivory effects were eliminated, height, canopy, and basal diameter of rooted cutting and seedlings did not differ ($p > 0.05$). Total nitrogen content did not play a role in herbivory preference; however stock type of cedar may play a role in herbivory and should be considered in restoration plans.

Key Words: Atlantic white cedar, herbivory, tissue nutrients

INTRODUCTION

Atlantic White Cedar, *Chamaecyparis thyoides* (L.) B.S.P., (cedar) is a medium-sized tree that grows in scattered stands along the eastern and southeastern coast of the United States. Cedar, an obligate wetland species (USDA Plants Database 2011), is adapted to saturated areas on peat deposits. Since European colonization, 98% of the area once populated by this ecosystem type has disappeared and it is now considered globally threatened ecosystem (Noss et al. 1995). The Great Dismal Swamp and Cavalier Wildlife Management Area (CWMA) are part of the historic range of this cedar species, and restoration projects are currently underway.

Reestablishment of cedar can be difficult because seedlings cannot tolerate low-light conditions (Belcher et al. 2003). Various aspects of hydrology also effect the growth of the seedlings, particularly during the first year when seedlings may be killed by either prolonged inundation or by drought (Akerman 1923, Brown and Atkinson 2003). If possible, natural regeneration is the preferred method of establishing cedar (Laderman 1989); however, a natural seed source was not available at CWMA and managers planted both rooted cuttings and seedlings.

Factors that may affect cedar reestablishment include hydrology (Atkinson et al. 2003), shade (Belcher et al. 2003, Laderman 1989), and herbivory by white-tailed deer (*Odocoileus virginianus*) (Tripler et al. 2002). White-tailed deer populations have risen over the past century due to game laws and reduced hunting pressure; in Virginia, abundance of white-tailed deer increased from about 25,000 to about 900,000 animals between 1931 and the 1990s (Knox 1997). Selective browsing by white-tailed deer can alter plant communities in swamps (Webb et al. 1956, Van Deelen et al. 1996), has been found to impact cedar grown as an ornamental species (Fargione et al. 1991), and has had detrimental effects on cedar restoration projects (Little and Somes 1958). Predation by deer has hindered successful reestablishment in New Jersey (Zimmermann 1995) and in North Carolina (Hinesley et al. 2003). Browsed cedar trees have lower height and canopy growth (Mylecraine et al. 2003), which can effect cedar tolerance of inundation (Cook et al., This Volume).

Factors such as plant quantity, accessibility, nutrient content, and digestibility play a role in white-tailed deer browsing habits (Richardson 1990). The amount of energy, protein and vitamins in a particular plant may influence browsing (Richardson 1990). Potential variation in nutrient concentrations associated with various planting types (e.g. rooted cuttings and seedlings) and propagation conditions may affect deer browse frequency and intensity. Tripler et al. (2002) found that saplings of tree species that were fertilized with nitrogen were associated with higher tissue nitrogen concentrations and that fertilized saplings had higher deer browse frequency than unfertilized saplings. The purpose of this study is to evaluate the effect of cedar stock type (rooted cuttings and seedlings) and tissue nitrogen content on herbivory intensity in a restored cedar swamp.

METHODS

Site Description and Study Design

The Cavalier Wildlife Management Area (CWMA) is located in southeastern Virginia, in the City of Chesapeake. CWMA is approximately 8 km east of the Great Dismal Swamp, and is

in the historic range of the swamp. CWMA is owned and maintained by the Virginia Department of Game and Inland Fisheries.

Ten plots each containing 36 trees of both rooted cuttings and seedlings were planted in May 2009. Each plot contained six rows of six cedar trees, were planted on 1.6-m spacing with alternating planting type.

Morphometric parameters of height, canopy diameter, and basal diameter were collected in fall 2011. Height was measured from ground level to tip of longest terminal branch. Canopy diameter was calculated as the mean of three subsamples measured at the height where maximum canopy width occurred. Basal diameter was measured 1 cm above the ground.

Evidence of deer browse can be detected by the presence of ragged or broken ends on browsed branches (Craven and Hygnstrom 1994). Browse intensity on each tree was estimated using a semi-quantitative scale modified from Mylecraine et al. (2003) and included 0 (no browse), 1 (slight browse), 2 (moderately severe browse), and 3 (severe browse).

Tree samples for tissue nutrient analysis were obtained in the summer of 2011. Five samples were taken from the outer 2 cm of branches from each of 18 trees for each planting type. Samples were composited to create one sample of each planting type per plot for each of the ten plots in the study. Tree samples of ~2 mg were placed in an 80 °C drying oven for at least 24 hours before being ground and passed through a 20-μm sieve. Nitrogen content in each sample was measured using a Thermo Scientific FLASH 2000 CHNS/0 analyzer. Data were arranged and graphed using Microsoft Excel (2007) and statistical analysis was performed using SigmaPlot (2012).

RESULTS AND DISCUSSION

Rooted cuttings were larger than seedlings at the time of sampling. Height of rooted cuttings (68.6 cm) was greater than seedlings (63.3 cm, $p < 0.001$)(figure 2A). Canopy diameter of rooted cuttings (29.3 cm) was larger than for seedlings (20.6 cm, $p < 0.001$)(figure 2B). Rooted cuttings had a larger basal diameter (8.5 mm) than seedlings (6.9 mm, $p = 0.002$)(figure 2C). Some of these differences may be attributed to differential growth rates, although rooted cuttings appeared larger at the time of planting.

Figure 2A. Height of rooted cuttings and seedlings.

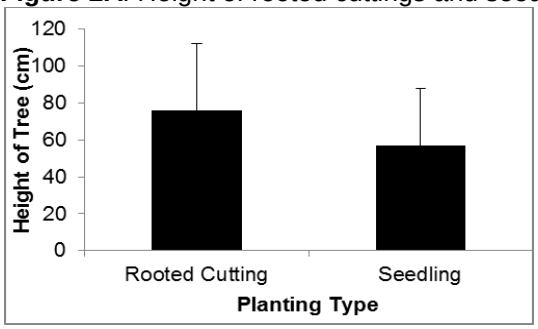


Figure 2B. Canopy diameter of rooted cuttings and seedlings.

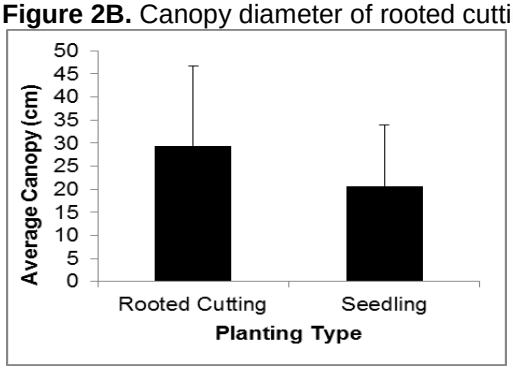
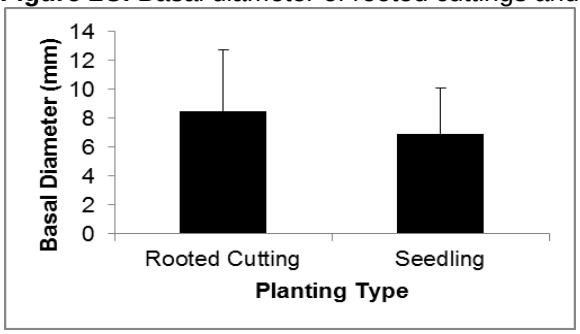


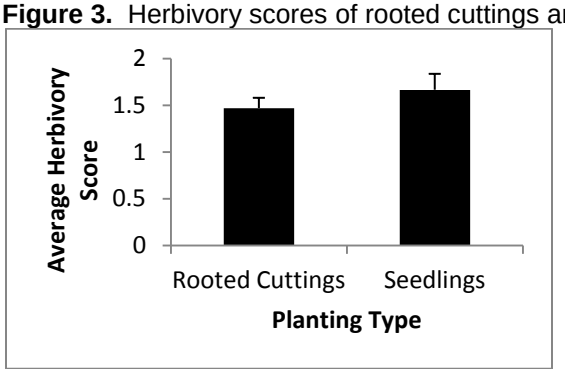
Figure 2C. Basal diameter of rooted cuttings and seedlings.



Deer preferentially browsed seedlings compared to rooted cuttings in this study. Scores of herbivory upon seedlings (1.67, S.E. $\pm$ 0.17) were higher than the herbivory on rooted cuttings (1.46, S.E. $\pm$ 0.11, $p < 0.001$)(figure 3). In addition, frequency of browsing on cedar seedlings (84.2%) was numerically greater than on rooted cuttings (80.9%). In contrast to our findings, a study of Monterey pine, *Pinus radiata*, in Australia reported more browsing damage on rooted cuttings than seedlings (Fielding 1968).

Deer herbivory has been shown to cause a reduction in plant survival and growth rates (Russell et al. 2001), but differs among sites. Browse rate at CWMA was much higher than that in a concurrent study in which maximum herbivory frequency among seven management units in GDSNWR was 27.8%. Where there is potential for herbivory, rooted cuttings may be a better choice for restoration given the lower browse rates in spite of the greater size.

Figure 3. Herbivory scores of rooted cuttings and seedlings.



In general, higher herbivory scores were associated with reduced height (figure 4A), canopy diameter (figure 4B), and stem diameter (figure 4C).

Figure 4A. Height and herbivory intensity.

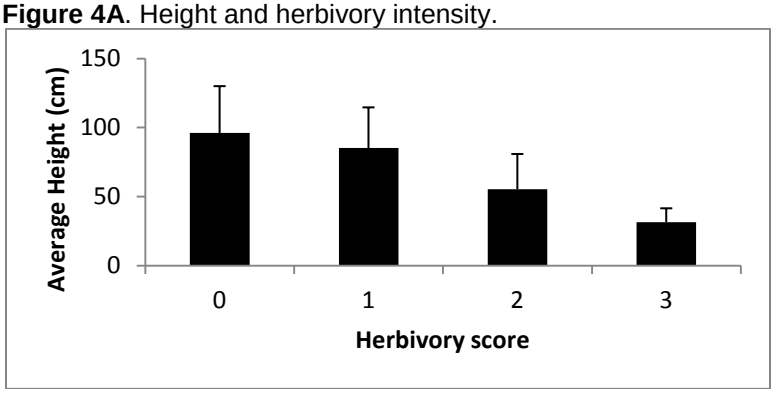


Figure 4B. Canopy diameter and herbivory intensity.

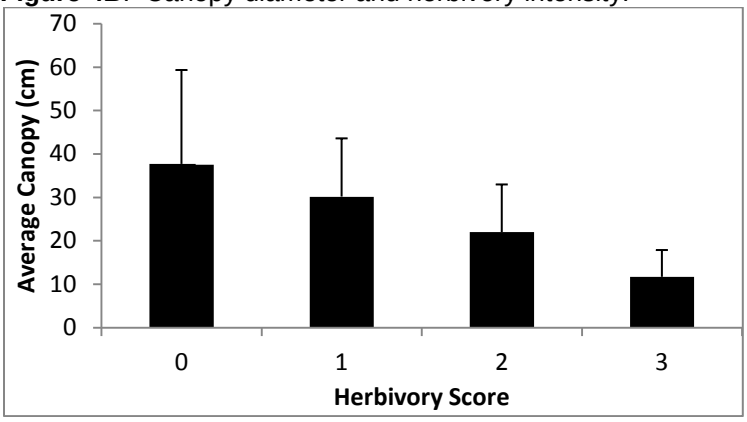
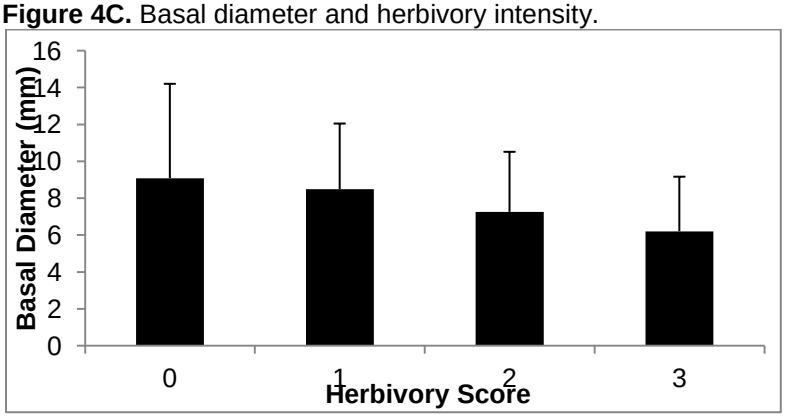


Figure 4C. Basal diameter and herbivory intensity.



When moderately and heavily browsed trees were excluded from calculations, stock types did not differ for height (figure 5A), canopy diameter (figure 5B), or stem diameter (figure 5C). These findings suggest that if herbivory were eliminated, the two planting types would have similar growth. Furthermore, if performance is similar among stock types, less expensive materials could be planted at higher density, addressing the effects of herbivory at no additional cost.

Figure 5A. Height of trees receiving a 0 or 1 herbivory score.

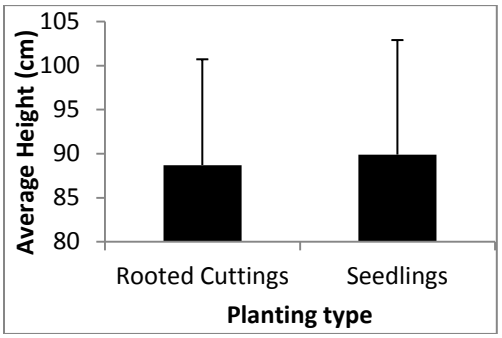


Figure 5B. Canopy diameter of trees receiving a 0 or 1 herbivory score.

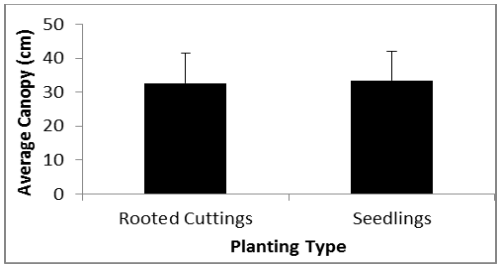
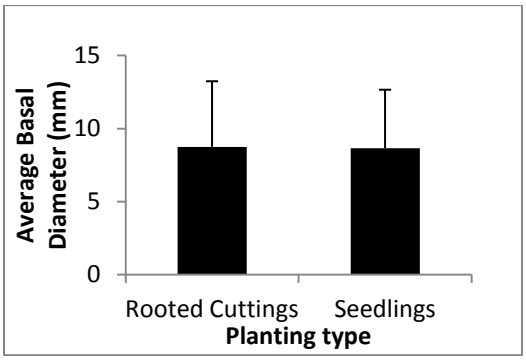


Figure 5C. Basal diameter of trees receiving a 0 or 1 herbivory score.

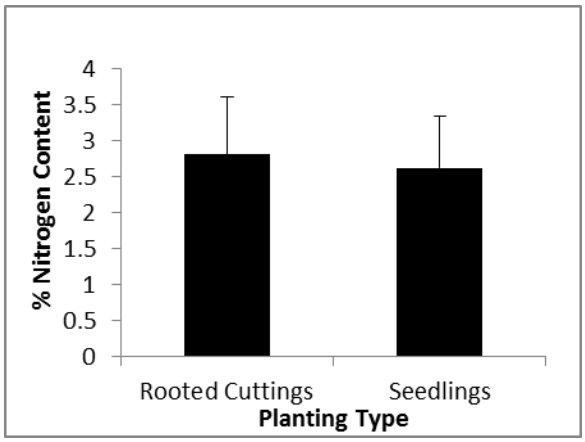


Overall, nitrogen content was relatively high in cedar at CWMA (grand mean = 2.7%). Previous work in GDSNWR by Gomez and Day (1982) reported lower tissue nitrogen content for cedar (1.03%). Whigham and Richardson (1988) reported cedar tissue nitrogen concentration of 1.20% in a stand on the eastern shore of Maryland, which was lower than in the current study. Total nitrogen in rooted cuttings (2.8, S.E. ± 0.80) did not differ from seedlings (2.6, S.E. ± 0.72, $p > 0.05$)(figure 6).

In a concurrent study in GDSNWR that employed the same planting materials and sources as at CWMA; however, cedar needle tissue nitrogen content in burned stands (2.02%) and unburned stands (1.58%) was much lower than in the present study. While no soil nutrient data was available for the CWMA site, differences in soil nutrient availability may affect tissue concentrations (Brady and Weil 2008) and appears likely in this study.

Total nitrogen content and herbivory intensity were not related ($R^2 = 0.116$, $p > 0.05$); therefore, differences in observed tissue nitrogen content within CWMA does not appear to play a role in deer browsing preference. However, the high nitrogen tissue concentrations at CWMA may be contributing to overall browsing intensity at the site.

Figure 6. Tissue total nitrogen content in rooted cuttings and seedlings.



Additional measures may be required in order to achieve desired stocking levels at CWMA. A study conducted in the Pocosin Lakes National Wildlife Refuge assessed the effectiveness of protecting newly planted cedar using electric fences, tree shelter tubes, wire mesh cages, and tall fences (Hinesley et al. 2003). Studies have shown that such protective devices are effective but may be too expensive to be feasible (Hinesley et al. 2003, Zimmermann 1997). Capsaicin, the active ingredient in pepper spray, has been shown to decrease herbivory (Kochenderfer and Ford 2008). Aerial spraying of capsaicin has been used at CWMA, and while herbivory rates were high, rates were likely lower than if spraying had not occurred.

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