INFLUENCE OF FLOODING, FREEZING, AND AMERICAN BEAVER HERBIVORY ON SURVIVAL OF PLANTED OAK SEEDLINGS

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Abstract—Good seedlings, proper planting, and competition control normally result in successful hardwood planting. However, other factors can have serious impact on planting success, such as the impact of flooding, freezing, and the American beaver (*Castor canadensis*). In 2014, three planting stocks of Nuttall oak (*Quercus nuttallii*) and Shumard oak (*Quercus shumardii*) were planted on two sites in southern Mississippi and survival checks were conducted monthly. The first check revealed that only three seedlings of the containerized stock had survived. Subsequent nursery inquiries revealed that many containerized seedlings died from freezing over the unusually cold winter. During the second check, it was discovered that beavers had uprooted many seedlings and consumed the roots at one site. Rain gauge data confirmed that excessive rainfall had resulted in site flooding and seedlings remained underwater for a portion of the month of May. After the immediate loss from beaver damage, Shumard oak seedlings suffered an additional loss over both remaining planting stocks due to the extended period of inundation. Most of the loss caused by inundation was large potted seedlings. Overall, 99.8 percent mortality occurred in one planting stock due to freezing, 22 percent of mortality was due to beaver damage, and 33 percent of mortality was due to inundation in the remaining planting stocks.

INTRODUCTION

Oak (*Quercus spp.*) seedlings were planted in the spring of 2014 to evaluate and compare survival and growth of different planting stocks of oaks as part of ongoing research focusing on oak restoration on Hurricane Katrina damaged lands throughout southern Mississippi and Louisiana. Planting stock survival is the most important factor in seedling establishment of any species, and it was immediately apparent that the 2014 planting would experience exceptionally low survival rates. Survival was so abnormally low that a separate study was implemented to quantify and identify the sources of seedling loss. With artificial regeneration using high quality seedlings, proper planting, and competition control, mortality is normally low (Self and others 2010). These variables can be controlled when implementing reforestation/afforestation processes. Uncontrollable and out-of-the-ordinary circumstances affecting seedling survival may also arise, particularly in the first growing season. Factors impacting this research were documented as flooding, freezing, and American beaver (*Castor Canadensis*) herbivory.

OBJECTIVES

1. To evaluate survival of different planting stocks of oak seedlings.
2. To identify causes of seedling loss and quantify results for each cause.

MATERIALS AND METHODS

Site Description/ Site Preparation

The two sites utilized in this study are separated by approximately 60 miles. Site one (Odom Site) is located in the northeastern corner of Perry County, MS, approximately six miles north-northeast of Richton, MS. It is a bottomland site surrounded by small streams, but little to no flooding occurs. The Odom Site was previously used for pasture land containing an extensive herbaceous layer growing on soil types Savannah and Stough fine sandy loams (WSS 2015). Site preparation included subsoiling to break the hardpan from livestock compaction. Site two (Welford Site) is located in eastern George County, MS, near the Alabama state line on the Escatawpa River approximately 14 miles southeast of Lucedale, MS. It experiences periodic flooding but usually on a very small scale. The Welford Site was previously a mixed hardwood stand on mostly Lenoir silt loam with a small amount of Harleston fine sandy loam (WSS 2015) near the river. Site preparation consisted of using a bulldozer to clear debris.

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Seedlings

Two oak species were evaluated in this study: Shumard oak (*Quercus shumardii*) and Nuttall oak (*Quercus nuttallii*). Three planting stocks of each species were used including high-quality 1-0 bareroot, conventional 240ml containerized, and 3.8L large potted seedlings. The bareroot stock was produced by Rayonier nursery in Elberta, AL. Mossy oak Native Nursery in Osborn, MS, produced the conventional containerized stock. Resource Environmental Solutions (RES) native tree and coastal marsh grass nursery in Montegut, LA, was contracted by Restore the Earth Foundation to grow and plant the large potted stock. Mississippi State University (MSU) personnel planted both bareroot and conventional containerized stocks in the middle of February. The commercial planting crew planted the large potted seedlings on April 1, with a MSU researcher on site for supervision.

Plot Establishment

A complete randomized block design comprised of three replicates of 100 tree units for each planting stock/species combination (treatment) was used. The Odom Site was planted on a 10'x10' spacing, while the Welford site had to be condensed into an 8'x8' spacing. HWC (herbaceous weed control) was applied to bareroot and containerized stock. No HWC was applied for the large potted stock type, because they are marketed for a plant and walk away approach.

Survival

Survival checks were taken monthly for the first growing season. Trees were not recorded as dead until no green was present on any leaf or in the cambium. Freeze damage was determined by a combination of deduction methods. American beaver herbivory was determined by missing seedlings that were previously healthy before the flood event, and shoots that were left on site with teeth marks that were cut by the animal. Inundation deaths were determined by trees that were weakened then died within two survival checks post flood event.

RESULTS AND DISCUSSION

Freezing

During the first survival check, 99.8 percent or 1,197 out of 1,200 of the conventional containerized stock were discovered dead, a total loss for the purpose of this research. No other planting stock was affected indicating that site conditions could be ruled out as the cause. Slight sub-freezing temperatures do not usually affect seedlings because the roots are not exposed due to the growing medium acting as an insulator. In north Mississippi, January temperatures were recorded below freezing (32 °F) for 25 days, with 4 days (two, 2 day periods) temperature never rising above freezing. During that month 10 days were below 20°F, 6 days below 15 °F, and 3 days below 10 °F. This is unusually low as the 30-year average low is 37 °F. The conclusion of the involved parties was that such deep freezes at night, many days not warming enough to thaw the soil, and small container size allowed the roots to freeze in the nursery containers. Evidence of freezing is not noticeable until seedlings try to break dormancy, and it should be noted that all seedlings appeared normal and healthy at time of planting.

Flooding

Eighteen inches of rain were recorded on the Welford site in April, with eight inches occurring in two days. The Escatawpa River runs approximately 350 feet from the planting area with an elevation change of 11.5 feet to the lowest seedlings and 14 feet to the highest seedlings. The average depth of the river is 4 feet, but during April it rose to over 18 feet according to NOAA flood data (AHPS 2014). Some local residents unofficially measured the water depth at 21 feet during the flooding period. With the proximity to the river and slight elevation change of the site, the rising river water reached the seedlings quickly. The seedlings were inundated to depths ranging from 4 feet-6.5 feet during this period. The flood contributed to mortality by soil displacement, allowing easy access to American beaver, and preventing gas exchange.

Soil displacement—Water covered the site allowing soil particles to break apart more easily and be displaced. In turn, the displaced soil contributed to the root system not being able to support the above ground portion of the seedling. Large potted seedlings have a low root to shoot ratio that already allows the seedling to be overturned easily. The flow of water along with debris pushed approximately 50 of these seedlings over and uprooted 32 others, which were all Nuttall oak. Nuttall oak had a much larger above ground mass and were, therefore, more susceptible to the flooding damage. The loose soil also allowed the American beaver to more easily pull the bareroot stock roots out of the ground.

American beaver—When planting oak seedlings, the normal rodent concern is small rodents girdling the seedlings at or below ground level (Schreiber and Swihart 2009, Tyler and others 2008). American beavers can be a greater concern planting if certain conditions are present. American beaver herbivory seems to be specific to age, time of year, and water level for oak seedlings. They prefer first-year seedlings in late winter/early spring when water is shallow in the area (Krinard and Johnson 1981). It appears that American beaver prefer first-year bareroot seedlings because they are newly planted and have softer roots. The roots have not had time to become well established, flooding reduces any bond with the soil thereby leaving them vulnerable to being pulled out. The preferred time of year is when alternative food sources are scarce, and there is a short

growth period from planting date. American beavers also chewed off large potted seedlings but evidence of root consumption could not be found. Thirty-three percent of all bareroot mortality on the Welford site was directly related to beaver, while only 11 percent of large potted mortality could be attributed to them.

Gas exchange—Inundating plants with water restricts atmospheric exchange of gases. Plants rely on roots and leaves to exchange carbon dioxide and oxygen needed for photosynthesis (Anderson and Pezeshki 1999). Some species can slow respiration while flooded for periods of time then resume once water has receded, some species growth will be greatly reduced even after the water has receded, and others will never resume respiration once flooded. Oaks can function for different periods with their roots covered in water, but not under full inundation. In their first year, seedlings that are overtopped by floodwaters for more than three weeks during growing season will die (Walker and Oswald 2000). However, tolerance to flooding varies among species of oaks. Nuttall oak has shown only about 2 percent mortality that can be directly linked to complete inundation in this study while Shumard oak had greater than 40 percent.

Overall Survival

On the Odom site where no flooding occurred, overall survival was 84 percent excluding containerized stock and 56 percent including containerized stock. On the Welford site where flooding occurred, overall survival was 28 percent excluding containerized stock and 19 percent including containerized stock. Table 1 provides details of survival by species and planting stock for each site. A complete loss of containerized stock from freezing occurred on both sites, totaling 33 percent of all mortality. Twenty-two percent of mortality on the Welford site was directly caused by American beavers. Table 2 presents mortality for the Welford site by cause, species, and planting stock.

CONCLUSION

Nuttall oak has proven to be more resilient than Shumard oak on the bottomland sites in this study.

Table 1—Survival percentages of seedlings by site, species, and planting stock for 2014 growing season (excluding containerized stock)

	Odom Site (no flood)	Welford Site (with flood)
Bareroot overall	84 %	31 %
Shumard oak	69 %	34 %
Nuttall oak	99 %	28 %
Large potted overall	83 %	25 %
Shumard oak	75 %	6 %
Nuttall oak	91 %	43 %

Table 2—Mortality percentages of seedlings on Welford Site by cause, species, and planting stock for 2014 growing season (excluding containerized stock)

	Soil displacement	American beaver	Inundation
Bareroot overall	—	33 %	11 %
Shumard oak	—	21 %	22 %
Nuttall oak	—	45 %	1 %
Large potted overall	5 %	11 %	38 %
Shumard oak	—	16 %	77 %
Nuttall oak	5 %	6 %	3 %

Overall Nuttall oak growth exceeded that of Shumard oak on both sites whether flooded or not flooded. The most likely reason is that Nuttall oak has adapted to growing in wet areas by allocating growth to height while young thus allowing their tops to exceed flood levels as fast as possible. Flooding can contribute to seedling mortality in other ways than just inundation to seedling mortality. American beaver can be detrimental to seedling survival in the first growing season if flooding occurs in late winter to early spring. Study results also underscore the importance of nursery management when overwintering containerized seedlings during sub-freezing temperatures. Nurseries should take precautions to keep roots from freezing. Consideration should be taken of as many of these extraordinary conditions as possible that affect survival and growth while planning successful artificial oak regeneration.

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