ARTIFICIAL REGENERATION OF BALDCYPRESS IN THREE SOUTH CAROLINA FORESTED WETLAND AREAS AFTER HURRICANE HUGO [1]

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Abstract. Permanent plots were established in three forested wetlands on Hobcaw Barony, South Carolina, during the spring of 1990 to monitor recovery of the wetlands following Hurricane Hugo. Plots were located in (1) an area that retained saltwater for several days following the hurricane storm surge, (2) an area flushed with saltwater, and (3) an area that received no saltwater. Because of the lack of natural regeneration occurring in the three areas, baldcypress seedlings were planted to help restock the stands. Tubex treeshelters were placed on one-half of the seedlings to determine if they improved survival and height growth. After two growing seasons, survival was greatest in the area that received no saltwater. The treeshelters seemed to increase survival of seedlings in the two storm surge areas. Height growth was greatest in the area that retained saltwater, and seedlings averaged over 10 inches taller than seedlings in the other two areas. Whereas the treeshelters seemed to have a beneficial effect on height growth during the first growing season, growth differences were not as pronounced during year two. Available light and salinity levels may be the two most important factors controlling survival and growth in the stands. More detailed research needs to be conducted to develop sound silvicultural plans.

Introduction

Hurricanes are an episodic, but normal, part of the climatic regime of the southeastern United States. Current evidence indicates that between 160,000 and 320,000 hurricanes have occurred in the Florida Keys during the past 2 million years (Ball et al. 1967). What coastal ecosystems would be like without hurricanes is unknown, but they would probably be different, both morphologically and ecologically (Conner et al. 1989). Hurricane disturbance can result from both wind and flooding effects. High winds can defoliate, break, or topple trees, with the severity of damage related to storm intensity, forest structure, species, and soil conditions (Weaver 1989, Gresham et al. 1991). Little attention has been given to storm surge effects since heavy rains accompanying the hurricane usually saturate soils to protect them from saltwater intrusion (Gardner et al. 1991, Hook et al. 1991).

Hurricane Hugo struck the South Carolina coast in September 1989 causing timber damage on nearly 4.5 million acres (Hook et al. 1991). Hobcaw Forest, 4 miles east of Georgetown and 56 miles northeast of where the eye of the hurricane came ashore, was hit with winds estimated to be 54 mi/hr gusting to 86 mi/hr (Purvis et al. 1990). Although heavy damage was sustained in pine forests and poorly drained bottomland forests, baldcypress (*Taxodium distichum* (L.) Rich.) forests suffered little wind damage (Gresham et al. 1991, Hook et al. 1991). The greatest damage to forested wetlands on Hobcaw was caused by saltwater flooding from the 10 ft storm surge.

Objectives

The objectives of this research were to initially document the effects of Hurricane Hugo on Hobcaw forested wetlands and natural recovery of the forest. However, the lack of natural regeneration during the first growing season after Hugo necessitated the establishment of long-term study plots to monitor regeneration patterns and to examine the feasibility of planting seedlings in the affected stands. This paper describes the damage done to three forested wetland stands, the lack of natural regeneration, and the initial success of underplanting baldcypress seedlings.

Methods

Study plots were established during March 1991, 18 months after Hurricane Hugo, in three forested wetland stands on Hobcaw Forest. The first stand (hereafter referred to as Marsh Road) was a

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baldcypress/swamp blackgum (*Nyssa sylvatica* var. *biflora* (Walt.) Sarg.) forest that lies between two old beach ridges on the eastern edge of Hobcaw Forest. Saltwater from the storm surge was retained in the forest for several days. The second area (Boardwalk) was flushed by saltwater, and the third area (Crabhaul) received no saltwater but did receive minor wind damage.

Within each stand, five 0.12 acre plots were installed during the spring of 1990 to inventory trees larger than 4.0 inches diameter at breast height (dbh). Each tree was tagged, dbh measured, and condition or cause of death recorded. Natural regeneration was monitored in ten 3.3 ft X 3.3 ft subplots within each of the larger plots. Regeneration was inventoried in June and September 1990 and in January and May 1991. Seed banks were sampled by randomly collecting twenty 12 in X 12 in X 2 in sections of forest floor from each stand in July 1990. The soil samples were mixed, placed in trays, put in a greenhouse, kept moist, and inventoried weekly for three months. After three months, tree seeds were collected by sieving and tested for viability using Tetrazolium (Shuel 1948).

When it became evident that little natural regeneration was occurring in the stands, 80 one-year-old baldcypress seedlings (obtained from the South Carolina Forestry Commission) were planted adjacent to each tree measurement plot in March 1991. The planting design consisted of 20 equally spaced planting spokes radiating from a center point. Four seedlings were planted on each spoke at a 6.6 ft spacing. Two foot tall Tubex treeshelters were used on seedlings in every other row to determine if they increased survival and growth of newly planted seedlings in wetland conditions.

Results and Discussion

Tree Damage

Very few tops were broken out of trees in the wetland stands (Table 1), although 84% of baldcypress trees and 88% of swamp blackgum trees did suffer some limb breakage (Gresham et al. 1991). Major damage was caused by the 10 foot storm surge that struck the eastern edge of the forest. Runoff was impeded in the Marsh Road stand by old logging roads at each end of the low-lying area that the forest is in. Saltwater was retained for several days until water levels stabilized at prestorm heights. Salinity levels of 2 ppt were still being measured two years after the hurricane. Over one-half of the canopy trees were killed during the first few weeks following flooding. Saltwater also flooded the Boardwalk area, killing the mainly waxmyrtle (*Myrica cerifera* L.) understory. Only 28% of the canopy trees died immediately after the saltwater surge. Additional mortality occurred, however, during the summer following the storm surge. It is unknown why this delay in mortality occurred in the Boardwalk area. Canopy trees are still dying in the two saltwater areas, indicating that there are still residual effects of the salt.

Table 1. *Variation in Hurricane Hugo damage to three forested wetland stands in South Carolina. All values are given as percentages.*

Area	Top Breakage	Dead 1990	Dead 1991
Crabhaul	2.7	0	0
Boardwalk	3.8	28.0	40.8
Marsh Road	1.8	57.1	65.5

Natural Regeneration

There was very little natural regeneration of woody species during the two growing seasons following Hurricane Hugo. The greatest number of baldcypress and water tupelo seedlings came up in the Crabhaul stand, but they failed to grow tall enough to survive subsequent flooding. In the Marsh Road and Boardwalk stands, some redbay (*Persea borbonia* (l.) Spreng.), waxmyrtle, fetterbush (*Lyonia lucida* (Lam.) Koch), and red maple (*Acer rubrum* L.) became established on old stumps, cypress knees and buttresses, and other raised areas that kept them out of the water. Overall, only 3 water tupelo seedlings survived in the Crabhaul stand, along with 5 baldcypress in the Boardwalk stand and 2 baldcypress in the Marsh Road stand.

The soil seed banks were surprisingly devoid of seeds from the canopy species. A total of 7 baldcypress and 13 swamp blackgum seeds germinated from the soil sections taken from Crabhaul. This was much better than the Boardwalk stand (no germination) or the Marsh Road stand (3 baldcypress). Although a number of seeds were sieved from the soil samples at the end of three months, none tested viable with Tetrazolium. This pool of dead seeds is similar to that observed by Schneider and Sharitz (1986) for another forested wetland site in South

Carolina. They suggested that too much flooding may result in nonviable seeds. Saltwater may have also had an impact in this study. Additional work needs to be done examining the seed longevity and viability in relation to flooding and salinity.

Planted Seedlings

Survival of baldcypress seedlings during the first growing season was greatest in the Crabhaul stand and least in the Boardwalk stand (Table 2). Tubex treeshelters seemed to greatly increase survival in the Boardwalk area, while there were no differences in survival of Tubex and non-Tubex seedlings in the Crabhaul stand. Survival was greater with treeshelters in the Marsh Road stand, but not significantly. Survival percentages after two growing seasons were similar to first year survival in the Crabhaul and Marsh Road stands, but the Boardwalk stand continued to lose seedlings. Saltwater in the Marsh Road and Boardwalk areas may still be affecting survival. Examination of Cl^- levels in seedling leaves revealed 71 ppm in the Boardwalk area and 57 ppm in the Marsh Road area compared to 17 ppm in the Marsh Road area. Whereas chloride is an essential micronutrient, excess chloride can be detrimental (Ghosh and Drew 1991). Pezeshki et al. (1988) found that salinity causes accumulation of several ions in baldcypress leaf tissue significantly decreasing photosynthesis levels.

Table 2. *Survival of planted baldcypress seedlings in three South Carolina wetland stands.*

Area	First-year survival		Second-year survival	
	Tubex	non-Tubex	Tubex	non-Tubex
Crabhaul	100	100	100	99
Boardwalk	79	48	72	38
Marsh Road	94	82	92	80

Height growth was best in the Marsh Road area during both growing seasons (Table 3). Average height of seedlings in the Marsh Road stand were 3 inches greater than seedlings in the other two areas after one growing season and 10 inches greater after two growing seasons. The Tubex treeshelters seemed to have a beneficial effect on height growth during the first growing season but not as clear an effect during the second year. Non-Tubex seedlings grew slightly more than Tubex seedlings in Crabhaul during the second growing season and slightly less than Tubex seedlings in Marsh Road. The Boardwalk was the only area that exhibited significantly greater height growth of Tubex seedlings during the second growing season. Most of the seedlings grew out of the 2-foot treeshelters during the first year. Therefore, the treeshelters did not offer much of an advantage over non-Tubex seedlings during the second year. Taller treeshelters should be tested to see if they remain beneficial for longer than one growing season.

Table 3. *Average height growth (inches) of planted baldcypress seedlings in three South Carolina wetland stands.*

Area	First-year growth		Second-year growth	
	Tubex	non-Tubex	Tubex	non-Tubex
Crabhaul	3.5	3.0	4.6	5.0
Boardwalk	3.4	1.3	5.0	0.9
Marsh Road	7.0	4.2	11.6	10.7

One factor that probably influenced growth rates at the Crabhaul and Boardwalk stands was the amount of sunlight reaching the forest floor. Only 4% of available light reached the Crabhaul forest floor during the summer months. Even though 38% of available light reached the floor at Boardwalk, this may not have been sufficient for maximum growth. Baldcypress tends to be intermediately tolerant to shade and grows best in full sunlight conditions (Wenger 1984, Wilhite and Toliver 1990). The Marsh Road stand has the most open canopy and 58% of available light reached the forest floor. Conner and Flynn (1989) found similar results in a Louisiana wetland forest where baldcypress seedlings planted in more open areas grew better than those planted in shaded areas (9 inches versus 3 inches).

Conclusions

Natural regeneration in hurricane impacted forested wetland stands is very erratic. To ensure adequate stocking of the stand after disturbance, planting may be necessary. However, there is much to learn before we can recommend large-scale reforestation of baldcypress stands. More detailed, long-term studies need to be conducted to ensure that sound silvicultural practices be formulated.

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