2002

Baldcypress Restoration in a Saltwater Damaged Area of South Carolina

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BALDCYPRESS RESTORATION IN A SALTWATER DAMAGED AREA OF SOUTH CAROLINA

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Abstract-Baldcypress (*Taxodium distichum* (L.) Rich.) seed was collected in 1992 from nine different estuarine areas in the southeastern United States (Winyah Bay, SC, Ogeechee and Altmaha Rivers in GA, Loftin Creek, FL, Ochlockonee River FL, Mobile Bay, AL, West Pearl River, LA, Bayou LaBranche, LA, and Lake Chicot, LA) and planted in Clemson University's Hobcaw nursery in the spring of 1993. Germination ranged from a low of 16 percent for seed from FL to 58 percent for seed from NC. Seedlings were grown in the nursery for two growing seasons, lifted, and planted in an area killed by saltwater introduced by Hurricane Hugo's (1989) storm surge. Half of the seedlings were protected with tree shelters. Seedlings averaged 122 cm tall upon planting. Survival after 6 years was 99 percent. Height growth of seedlings in tree shelters was significantly higher than those not in tree shelters for each year except during year 3. Among the seed sources, seedlings from the Loftin Creek, FL source have shown greatest growth, with and without protection, for all growing seasons except the first year. After 6 years, average height of tree-shelter protected seedlings was 393 cm while the average height of non-protected seedlings was 281 cm. Tree-shelters increased early growth of seedlings, but once they emerged from the tree-shelter, growth differences between shelter and no-shelter treatments decreased and seems to be more related to the degree of deer herbivory experienced by unprotected seedlings.

INTRODUCTION

Low-lying coastal forested wetlands are particularly vulnerable to saltwater intrusion. Subsidence and sea level rise along the Northern Gulf of Mexico coast are causing increased flooding and saltwater intrusion into freshwater areas (Guntenspergen and others 1998). As a result, baldcypress (*Taxodium distichum* (L.) Rich.) and water tupelo (*Nyssa aquatica* L.) forests are being killed (Allen 1992, Krauss and others 2000, Pezeshki and others 1990). In addition, saltwater flooding caused by storm surges can significantly alter forest communities (Conner 1993, Gresham 1993, Williams 1993), and it may take years before the forest recovers (Conner 1995). Hurricanes are recognized as a normal part of the climatic regime, and natural ecosystems have developed morphologically and ecologically to aperiodic disturbances (Conner and others 1989, Pimm and others 1994). Hurricane wind damage is related to storm intensity, duration, forest structure, and soil conditions (Gresham and others 1991, Loope and others 1994). Forests generally recover quickly from wind damage. However, areas impacted by saltwater intrusion may require artificial regeneration in order to ensure adequate stocking. For example, when Hurricane Hugo came ashore north of Charleston, South Carolina on September 21, 1989, its storm surge was estimated to be as high as 3 m at Georgetown (Williams 1993). High winds and saltwater intrusion damaged an estimated 1.8 million ha (about $1 billion worth of timber) of South Carolina's forests (Hook and others 1991, Marsinko and others 1993).

Previous studies have shown some promising results indicating that baldcypress may tolerate some degree of salinity (O-8 ppt). Studies in Louisiana have shown that substantial intraspecific variation in salt tolerance exists within baldcypress populations (Allen 1994, Allen and others 1994, Krauss and others 1998, Pezeshki and others 1995). These studies were conducted under greenhouse conditions. The only field study that could be found was that of Krauss and others (2000), who planted baldcypress seedlings grown from seed collected in Louisiana, Mississippi, and Alabama. Survival and growth of baldcypress seedlings varied significantly among different salinity, hydrologic, and vegetative combinations in areas impacted by saltwater intrusion, and certain genotypes of baldcypress maintained greater height growth when planted in degraded wetlands.The major objective of this project was to determine if there are baldcypress populations in the southeastern United States that can survive and grow in saltwater damaged areas. A secondary objective was to determine whether or not using tree-shelters would increase survival and height growth of planted baldcypress seedlings.

MATERIALS AND METHODS

Hobcaw Forest is located 7 km southeast of Georgetown, SC (figure 1). A portion of the forest on the western edge of the property was damaged by saltwater intrusion when Hurricane Hugo's storm surge flooded the forest in September 1989. The impacted forest was originally dominated by baldcypress. The soil is a Hobcaw soil (fine-loamy, siliceous, thermic, Typic umraquults), very poorly drained, and moderately permeable with less than 2 percent slopes. Although high concentrations of salinity were found in the site up to 30 months after the hurricane (Williams 1993), there was no detectable salinity at the time of planting.

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Citation for proceedings: Outcalt, Kenneth W., ed. 2002. Proceedings of the eleventh biennial southern silvicultural research conference Gen. Tech. Rep. SRS-48. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station, 622 p.

Table l-Height (cm) of baldcypress seedlings from 9 seed sources after 6 growing seasons in a South Carolina wetland forest damaged by Hurricane Hugo's storm surge. See text for explanation of seed source code names. Values in a row with unlike lower case letters are statistically different at an alpha level of 0.05

	Seed source								
Year	SC	ELA	SGA	WFL	SLA	EFL	CLA	NGA	AL
1995	142bc	147bc	150ab	137c	155a	151ab	142bc	144bc	142bc
1996	157c	164bc	168bc	164bc	175ab	181a	160bc	160bc	159bc
1997	172c	178bc	184bc	181bc	195ab	206a	181bc	182bc	176bc
1998	213c	227bc	229bc	228bc	251ab	273a	226bc	231 bc	213c
1999	257c	290bc	277bc	288bc	316ab	345a	280bc	291 bc	266c
2000	292c	330bc	323bc	347bc	369ab	407a	321 bc	346bc	313bc

Baldcypress seeds were collected in November 1992 from seven estuarine areas subject to tidal influence (Winyah Bay, SC=SC; Ogeechee River, GA=NGA; Altamaha River, GA=SGA; Flint River, FL=EFL; Ochlockonee River FL=WFL; Mobile Bay, AL=AL; Bayou LaBranche, LA=SLA) and two freshwater areas (West Pearl River, LA=ELA; Lake Chicot, LA=CLA) (figure 1). Cones were collected from five trees at each site, air-dried, crushed to separate the seed, mixed with wet sand, and stored in plastic bags between 4 and 8 degrees C for 90 days.

After stratification, the seeds were planted in the Hobcaw nursery in the spring of 1993. After two growing seasons, the seedlings were lifted and prepared for planting by cutting all lateral roots off and cutting the tap root to approximately 23 cm (Conner and others 1999). The root-pruned seedlings were wrapped in moist peat and transported to the field where they were planted in an area killed by saltwater from Hurricane Hugo's storm surge. Tree shelters were placed on one half of the seedlings. Height growth was measured each year from 1995 to 2000. Statistical analyses of the data were done using a completely randomized design for repeated measurements with factorial arrangement between nine seed sources, two tree-shelter treatments, and six growing seasons.

RESULTS

Survival rates for all seed sources was high. After six growing seasons, survival for all trees was 99 percent. Only four trees died during the study and all of them were non-sheltered trees.

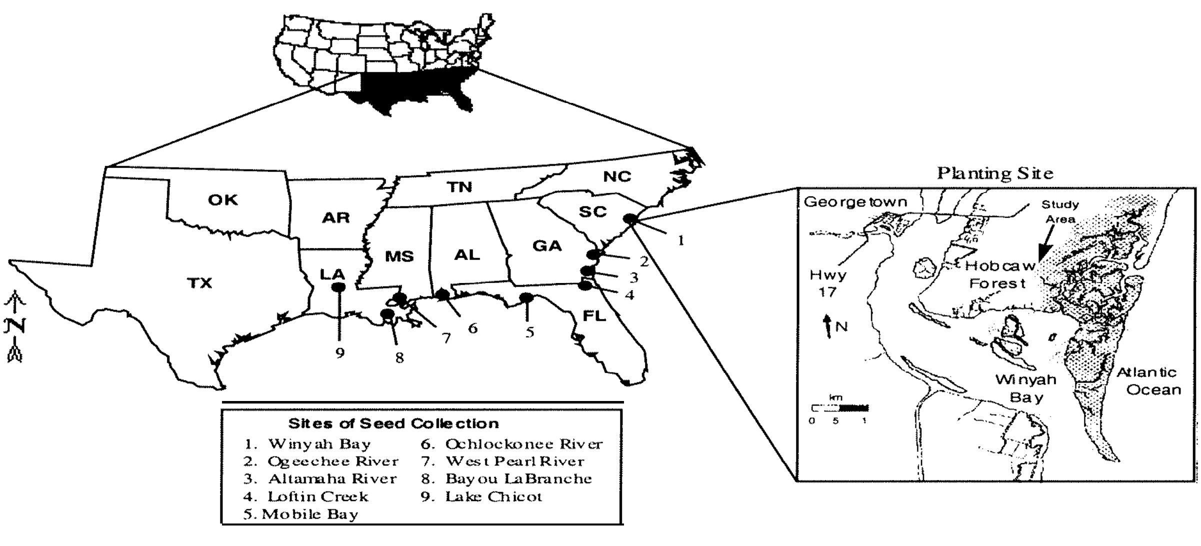

Figure l-Map of the southern United States showing baldcypress seed collection sites and the South Carolina planting site.

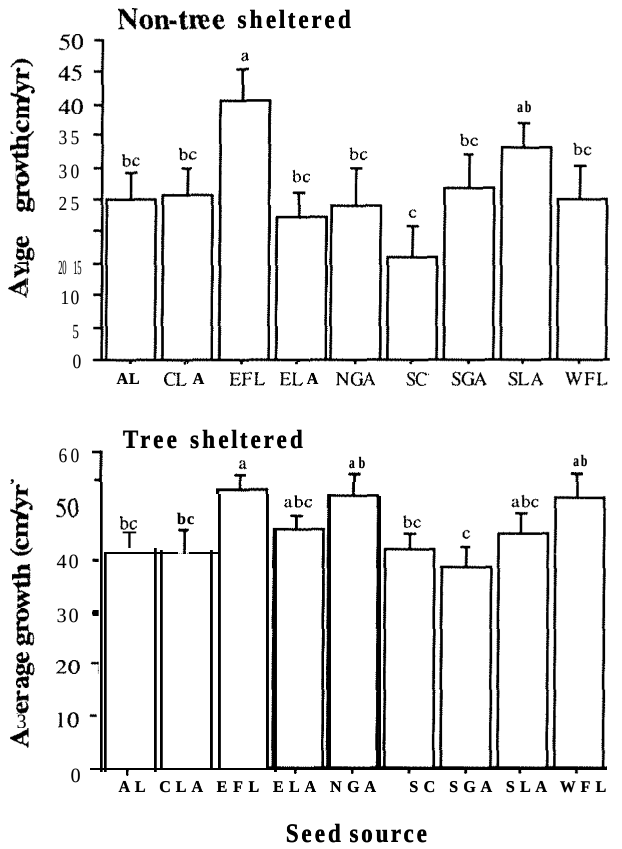

Figure 2-Average annual height growth (cm) of baidcypress seedlings planted in South Carolina with and without tree shelters. Error bars represent ±1 S.E.

After six growing seasons, average height of tree-shelter protected seedlings was 393 cm while the average height of non-protected seedlings was 281 cm. Growth of seedlings in tree shelters was significantly greater than for non-shelter seedlings except during the third growing season when both sheltered and non-sheltered seedlings increased by an average of about 17.8 cm/yr in height (figure 2). Overall, sheltered seedlings grew an average of 44.7 cm/yr while non-sheltered seedlings grew 25.4 cm/yr. All seedlings grew better after the third growing season. During the first three growing seasons, seedlings average growth was 20 cm/yr, but growth more than doubled for growing seasons 4 through 6.

Among seed sources, seedlings from east Florida (EFL) and south Louisiana (SLA) have shown the greatest growth by an average of 44.1 and 38.9 cm/yr, respectively. However, only EFL seedlings grew significantly better than all other seed sources (except those from SLA). The rest of the seed sources exhibited similar growth rates, and they were not significantly different from each other.

Growth differences were more readily noticeable in non-sheltered trees than in sheltered ones (figure 3). Growth of the non-sheltered EFL seedlings was significantly greater than all others sources otherthan SLA. In the sheltered seedlings, however, growth differences were less distinct. Although EFL seedlings had the highest average annual growth rate, they were not significantly greater than seedlings from ELA, NGA, SLA, or WFL.

Final heights of seedlings after six growing seasons in the field varied from a low of 292 cm for SC seedlings to a high of 407 cm for EFL seedlings (table 1). The EFL seedlings have grown the best in the planted site for five of the six years measured. During the first year, SLA seedlings were the tallest (155 cm), but not significantly so.

DISCUSSION

Coastal forests are increasingly being subjected to increased flooding and salinity levels. The impact is widespread and can be detrimental to these forests (Allen 1992, Conner 1994, Pezeshki and others 1990). Previous studies have examined species-level responses to salinity increases (Conner 1994, Conner and Askew 1994, Conner and others 1997, McLeod and others 1996) as well as family-level variations (Allen 1994, Allen and others 1994, Krauss and others 1998, Pezeshki and others 1995). Current research is aimed at finding and/or improving the tolerance of baldcypress for use in restoration projects in swamp forests damaged by saltwater intrusion (Allen and others 1994, Krauss and others 2000).

Baldcypress has demonstrated significant intraspecific variation in treatments as high as 8 ppt (Allen and others 1994), but beyond that, mortality is likely (Conner and others 1997). Interestingly, genotypes of baldcypress with the greatest amount of tolerance to salinity are not always found in brackish water seed sources. Krauss and others (2000) found that freshwater seed sources in their study were among the top performers under saline conditions in terms of height growth. The best performers in this study were from the more brackish areas, even though the site retained no measurable salinity.

Overall, all baldcypress seedlings from the nine sources in this study had high survival rate and good height growth in the saltwater damaged area. After six growing seasons, the area

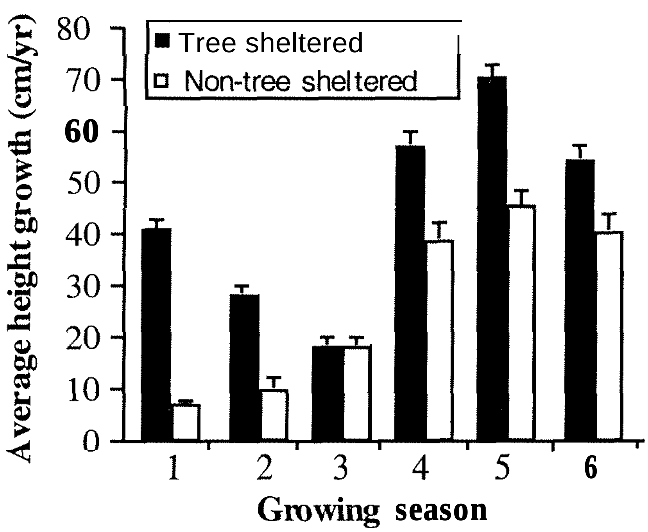

Figure 3-Average height growth of baldcypress seedlings with and without tree shelters by seed source. Error bars are ±1 S.E. and different lower case letters represent a significantly significant difference with an alpha level of 0.05

shows signs of success with respect to restoration efforts (i.e. planted seedlings are beginning to produce seed and young seedlings were observed in the area around the planted seedlings). These findings suggest that an adequate stocking of baldcypress in this saltwater storm surge damaged area has been accomplished through planting. In addition, protecting young seedlings with tree shelters improves early survival and growth and are recommended in areas where herbivory might be a problem.

ACKNOWLEDGMENTS

Funding was provibed by the Mclntire-Stennis Cooperative Forestry Research Program through Clemson University. In any such program of this duration, many people have helped with the field work. We especially want to thank Wayne lnabinette for his help in collecting seed, growing the seedlings, and assisting in planting and measuring the seedlings each year. We also thank Jeffery Vernon and Mike Gibson for field assistance. Belle W. Baruch Institute of Coastal Ecology and Forest Science Technical Contribution: 01-01.

REFERENCES

Allen, J.A. 1992. Cypress-tupelo swamp restoration in southern Louisiana. Restoration and Management Notes. 10: 188-l 89.

Allen, J.A. 1994. Intraspecific variation in the response of baldcypress (*Taxodium disfichum)* to salinity. Baton Rouge, LA: Louisiana State University. Ph.D. dissertation. 183 p.

Allen, J.A.; Chambers, J.L.; McKinney, D. 1994. Intraspecific variation in the response of *Taxodium disfichum* seedlings to salinity. Forest Ecology and Management. **70:** 203-214.

Allen, J.A.; Pereshki, S.R.; Chambers, J.L. 1996. Interaction of flooding and salinity stress on baldcypress (*Taxodium disfichum).* Tree Physiology. 16: 307-313.

Conner, W.H. 1993. Artificial regeneration of baldcypress in three South Carolina forested wetland areas after Hurricane Hugo. In Brissette, John C., ed. Proceedings of the seventh biennial southern silvicultural research conference. Gen. Tech. Rep. SO-93. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 185188.

Conner, W.H. 1994. The effect of salinity and waterlogging on growth and survival of baldcypress and Chinese tallow seedlings. Journal of Coastal Research. 1 O(4): 1045-l 049.

Conner, W.H. 1995. Woody plant regeneration in three South Carolina *Taxodium/Nyssa* stands following Hurricane Hugo. Ecological Engineering. 4: 277-287.

Conner, W.H. 1998. Impact of hurricanes on forests of the Atlantic and Gulf coasts. In Laderman, A.D., ed. Coastally restricted forests. New York, NY: Oxford University Press: 271-277.

Conner, W.H.; Askew, G.R. 1992. Response of baldcypress and loblolly pine seedlings to short-term saltwater flooding. Wetlands. 12(3): 230-233.

Conner, W.H.; Day, J.W., Jr.; Baumann, R.H.; Randall,J. 1989. Influence of hurricanes on coastal ecosystems along the northern Gulf of Mexico. Wetlands Ecology and Management. l(1): 45-56.

Conner, W.H.; McLeod, K.W.; Carron, J.K. 1997. Flooding and salinity effects on growth and survival of four common forested wetland species. Wetlands Ecology and Management. 5: 99-109.

Conner, W. H.; K. W. McLeod; L. W. lnabinette [and others]. 1999. Successful planting of tree seedlings in wet areas, In Haywood, James D., ed. Proceedings of the tenth biennial southern silviculture research conference. Gen. Tech. Rep. SRS-30. Asheville, NC: US. Department of Agriculture, Forest Service, Southern Research Station: 201-204

Gresham, CA. 1993. Changes in baldcypress-swamp tupelo wetland soil chemistry caused by Hurricane Hugo induced saltwater inundation. In: Brissette, J.C., ed. Proceedings of the Seventh biennial southern silvicultural research conference; 1992 November 17-19, Mobile, AL. Gen. Tech. Rep. SO-93. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 171-t 75.

Gresham, CA.; Williams, T.M.; Lipscomb, D.J. 1991. Hurricane Hugo wind damage to southeastern U.S. coastal forest tree species. Biotropica. 23: 420-426.

Guntenspergen, G.R.; Vairin, B.A.; Burkett, V. 1998. Overview of coastal wetland global climate change research. In Gutenspergen, G.R.; Vairin, BA., eds. Vulnerability of coastal wetlands in the Southeastern United States: climate change research results, 1992-1997. Rep. USGS/BRD/BSR-1998-0002.089-97. Lafayette, LA: U.S. Department of Interior, U.S. Geological Survey, National Wetlands Research Center: l-6.

Hook, D.D.; Buford, M.A.; Williams, T.M. 1991. Impact of Hurricane Hugo on the South Carolina coastal plain forest. Journal of Coastal Research. Sl8: 291-300.

Krauss, K.W.; Chambers, J.L.; Allen, J.A. 1998. Salinity effects and differential germination of several half-sib families of baldcypress from different seed sources. New Forests. 15: 53-68.

Krauss, K.W.; Chambers, J.L.; Allen, J.A. [and others]. 2000. Growth and nutrition of baldcypress families planted under varying salinity regimes in Louisiana, USA. Journal of Coastal Research. 16(1): 153-163.

Loope, L.; Duever, M.; Herndon, A. [and others]. 1994. Hurricane impact on uplands and freshwater swamp forest. Bioscience. 44: **238-246.**

Marsinko, A.P.C.; Straka, T.J.; Baumann, J.L. 1993. Hurricane Hugo: a South Carolina update. Journal of Forestry. 91(9): 9-17.

McLeod, K.W.; McCarron, J.K.; Conner, W.H. 1996. Effects of inundation and salinity on photosynthesis and water relations of four southeastern coastal plain forest species. Wetlands Ecology and Management. 4(1): 31-42.

Pezeshki, S.R.; DeLaune, R.D.; Choi, H.S. 1995. Gas exchange and growth of baldcypress seedlings from selected U.S. Gulf coast populations: responses to elevated salinities. Canadian Journal of Forest Research. 25: 1409-1415.

Pezeshki, S.R.; DeLaune, R.D.; Patrick, W.H., JR. 1990. Flooding and saltwater intrusion: potential effects on survival and productivity of wetland forests along the U.S. Gulf Coast. Forest Ecology and Management. 33/34: 287-301.

Pimm, S.L.; Davis, G.E.; Loope, L. [and others]. 1994. Hurricane Andrew. Bioscience. 44: 224-229.

Williams, T.M. 1993. Salt water movement within the water table aquifer following Hurricane Hugo. In: Brissette, J.C., ed. Proceedings of the Seventh biennial southern silvicultural research conference; 1992 November 17-19, Mobile, AL. Gen. Tech. Rep. SO-93. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 177-l 84.