ATLANTIC WHITE CEDAR REGENERATION IN THE GREAT DISMAL SWAMP FOLLOWING HURRICANE ISABEL: 2006 BLACKWATER CUT RESULTS

Robert T. Belcher[1], Travis R. Comer[1,] and Robert B. Atkinson[2]

[1]*Robert T. Belcher and Travis R. Comer, Project Scientist, Malcolm Pirnie, Inc., Newport News, Virginia, 23606*

[2]*Robert B. Atkinson, Associate Professor, Christopher Newport University, Newport News, Virginia, 23606*

Abstract: The Great Dismal Swamp National Wildlife Refuge began a large-scale salvage logging and cedar restoration project in response to the considerable damage caused by Hurricane Isabel in September 2003. The objectives of this study were to quantify and compare cedar regeneration associated with salvage logged areas and skidder trails in the Blackwater Cut, and adjacent areas not salvaged logged to help guide future site management and additional restoration work. In 2006, permanent plots were established on a 28-ha site within the Great Dismal Swamp National Wildlife Refuge. Cedar regeneration was quantified within 25-m^2 plots and the height of each seedling was measured. Seedling height ranged from 5 to 75 cm, however 93 percent of all seedlings surveyed were less than 20 cm tall. The number of seedlings within plots varied greatly, from 0 to 77. Mean seedling density in the salvage logged areas, skidder trails and un-salvaged plots were 14,533; 4,400; and 0 stems/ha respectively, compared to 1,006 stems/ha in the pre-Isabel mature forest. These results suggest conditions within the Blackwater Cut have been suitable for the establishment, survival and growth of cedar, but regeneration failed in the un-salvaged areas.

Keywords: Atlantic white cedar, Great Dismal Swamp, Hurricane Isabel, establishment, *Chamaecyparis thyoides*

INTRODUCTION

Chamaecyparis thyoides, Atlantic white-cedar populations have declined dramatically throughout its range (Korstian and Brush 1931, Little 1950). Nowhere has the decline been as significant as in the historic limits of the Great Dismal Swamp (GDS). The pre-colonial extent of cedar within the GDS is not precisely know; however, Shaler (1890) estimated the original extent of the swamp as 569,804 ha and pollen analysis conducted by Whitehead and Oaks (1979) suggested that cedar was a significant component of the GDS for the past 3,000 years. In 1907, a forestry trade publication, the American Lumberman, estimated the cedar holdings of the John L. Roper Lumber Company within the GDS at 24,281 ha, and Akerman (1923) estimated that 45,527 ha of cedar swamps occurred within the Virginia portion of the GDS. Carter (1987) estimated that pure cedar populations, i.e. stands where cedar comprised at least 80 percent of total basal area, had dwindled to a mere 1,000 ha in Great Dismal Swamp National Wildlife Refuge (GDSNWR).

The dramatic decline of the cedar population is thought to have been caused by poor silvicultural practices and anthropogenic degradation at a landscape level (Akerman 1923, Little 1950, Laderman 1989, Belcher 2005). As a result, species composition and functions were altered which comprised self-maintenance potential. Between the 1870s and 1970s, anthropogenic degradation had become progressively more destructive. The alteration included changes in wildfire frequency and intensity, conversion to agriculture or silvicultural plantations, and extensive hydrologic modifications (Akerman 1923, Little 1950, Phillips and others 1998).

In September 2003, Hurricane Isabel inflicted considerable damage to the forest throughout North Carolina and Virginia. Some of the worst damage occurred within the remaining 1,000 ha of mature cedar in the GDSNWR. Storm damage included snapping and uprooting trees, which left the forest floor littered with a thick layer of debris that would prohibit the natural regeneration of cedar. Without salvage and restoration, these damaged cedar stands would likely convert to a maple-gum swamp. Therefore, the GDSNWR began a large-scale salvage logging and cedar restoration project (Belcher and Poovey, These Proceedings).

The objectives of this study were to quantify and compare cedar regeneration associated with salvage logged areas and skidder trails in the Blackwater Cut, and adjacent areas not salvaged logged.

METHODS

Site Description

The Blackwater Cut is approximately 28 ha in size and is located on the south side of Corapeake Ditch Road approximately 5.5 km from the western border of the GDSNWR (figures 1 and 2). The site was salvage logged between spring 2004 and spring 2005 with the use of an excavator mounted with a grapple saw and a rubber tire skidder (figure 3). Cedar seedlings were released from woody competition by an aerial application of Habitat® in September 2004. Habitat was applied at a concentration of 32-fluid ounces per acre. Mentholated seed oil was used a surfactant.

Prior to Hurricane Isabel, the site was dominated by approximately 65 - 75 year old cedar (Merry 2005) and was part of a multiyear study funded by the USEPA. The structural attributes of the stand were previously described by DeBerry and others (2003, table 1). Loomis and others (2003) and Shacochis and others (2003) described the floristic composition. Thompson and others (2003) and Atkinson and others (2003) characterized soil physical and biochemistry characteristics and site hydrologic signatures, respectively. The Blackwater Cut was referred to as "Dismal Swamp-Mature" in each of the above referenced publications.

Cedar regeneration associated with salvage logged areas and skidder trails in the Blackwater Cut, and adjacent areas not salvaged logged were quantified by assigning cedar seedlings to 10-cm height classes within 25-m^2 (5 m x 5 m) plots between January and February 2006. Nine permanently marked plots established in the USEPA study described above, were re-established and used as salvage logged plots, and three additional salvage logged plots were established at 100 m intervals along a fourth transect. Ten skidder trails plots were randomly established within the site's network of skidder trails. Ten un-salvaged plots were established in a nearby cedar stand that was damaged by Hurricane Isabel but not salvage logged. Examples of salvage logged, skidder trail, and un-salvaged plots are shown figure 4.

RESULTS

A total of 546 cedar seedlings were located and measured during this study. Seedling height ranged from 5 to 75 cm and 93 percent of seedlings were less than 20 cm in height. The remaining 7 percent of cedar seedlings ranged in size from 20 cm to 87 cm. The number of seedlings within each plot varied greatly, from 0 to 77.

Salvage logged plots contained a total of 436 seedlings, which represented 79.9 percent of all seedlings found, and Skidder trail plots contained a total of 110 seedlings (20.1 percent of all seedlings found). No seedlings were found in the un-salvaged plots. For the 0 to 10-cm, 10 to 20-cm, and 20 to 30-cm size classes, the mean number of trees per size class was greatest in the salvage logged and lowest in the un-salvaged plots (table 2).

Mean cedar density in salvage logged plots was 14,533 seedlings/ha, much greater than the 4,400 seedlings/ha in the skidder trail plots. Cedar seedlings occurred within a fairly narrow elevation range throughout the site. No cedar seedlings were observed in inundated swales or on the tops of hummocks.

DISCUSSION

Cedar regeneration within the Blackwater Cut appears to be sufficient to restock the site, excluding some unforeseen catastrophic event. Only 7 and 23 percent of the existing cedar seedlings in the salvage logged and skidder trails, respectively, would need to reach maturity to exceed the pre-Isabel stocking levels reported in DeBerry and others (2003). However, the restocking densities reported here are unlikely to limit invasion by cedar competitors, i.e., red maple, and continued herbicidal treatment may be required.

Overall, conditions within the Blackwater Cut have been suitable for the establishment, survival and growth of cedar, but regeneration failed in the un-salvaged areas. These findings support earlier observations and findings. USFWS (2004) stated that salvage logging would facilitate cedar regeneration as opposed to taking no action, which would likely result in the establishment of red maple. Laderman (1989) illustrated a similar result when mature cedars were toppled in a violent storm and when other seed sources were plentiful.

Akerman (1923) and Little (1950) consider light, moisture, and microrelief as critical factors affecting cedar regeneration. These factors appear to explain much of the variability in cedar regeneration in the current study. Shading caused by storm debris and accelerated growth of understory species prevented cedar germination in un-salvaged plots in the same manner as dense logging slash. In salvage logged plots, the removal of the timber and competition control, allowed cedar germination to occur in suitable microsites. The variability between skidder trails and salvage logged plots may be associated with moisture differences. Soil disturbance caused by multiple passes of the skidder included compaction, lateral displacement and incorporation of large amounts of peat, all of which appeared to cause many portions of skidder trail to be either too wet or too dry for cedar regeneration.

Additional monitoring is recommended in order to quantify seedling mortality and recruitment, assess invasion by red maple, evaluate the effect of heart rot on cedar with age, and to determine the conditions that favor reestablishment of cedar.

ACKNOWLEDGEMENTS

We gratefully acknowledge the logistical support and assistance of Bryan Poovey of the Great Dismal Swamp National Wildlife Refuge. We would like to thank Erin Bradshaw, Amber Bradshaw, Wes Hudson and Ben Salter for their assistance in gathering field data. We also wish to thank two anonymous reviewers for their helpful comments and suggestions.

LITERATURE CITED

American Lumberman. April 27, 1907. A trip through the varied and extensive operations of the John L. Roper Lumber Company in eastern North Carolina and Virginia. Pp. 51-114.

Akerman, A. 1923. The white cedar of the Dismal Swamp. Virginia Forestry Publication 30: 1-21.

Atkinson, R.B.; DeBerry, J.W.; Loomis, D.T.; Crawford, E.C.; Belcher, R.T. 2003. Water tables in Atlantic white cedar swamps: Implications for restoration. In: Atkinson, R.B.;. Belcher, R.T; Brown, D.A.; Perry, J.E., eds. Atlantic white cedar restoration ecology and management symposium. Newport News, VA: Christopher Newport University: 137-150.

Belcher, R.T. 2005 .Atlantic white cedar management: the perpetuation of a globally threatened ecosystem. Dare County Bombing Range Stake Holders Meeting in Manteo, NC.

Belcher, R.T.; Poovey, B. (These Proceedings). Atlantic White Cedar Salvage efforts in the Great Dismal Swamp following Hurricane Isabel.

Carter, A.R.. (1987) Cedar restoration in the Dismal Swamp of Virginia and North Carolina. In: Laderman, A. D. ed. Atlantic White Cedar Wetlands. Boulder, CO. Westview Press. 323-325

DeBerry, J.W.; Belcher, R.T.; Loomis, D.T.; Atkinson, R.B. 2003. Comparison of aboveground structure of four Atlantic white cedar swamps. In: Atkinson, R.B.; Belcher, R.T; Brown, D.A.; Perry, J.E., eds. Atlantic white cedar restoration ecology and management symposium. Newport News, VA: Christopher Newport University: 67-80.

Korstian, C.F.; Brush,W.D. 1931. Southern white cedar. U.S. Dept. of Agriculture. Tech. Bull. 251. 75p.

Laderman, A.D. 1989. The ecology of Atlantic white cedar wetlands: a community profile. U.S. Fish and Wildlife Service Biological Report (85(7.21).

Little, S. 1950. Ecology and Silviculture of white cedar and associated hardwoods in southern New Jersey. Yale University School of Forestry Bull. 56.

Loomis, D.T.; DeBerry, J.W.; Belcher, R.T.; Shacochis, K.M.; Atkinson, R.B. 2003. Floristic diversity of eight Atlantic white cedar sites in southeastern Virginia and northeastern North Carolina. In: Atkinson, R.B.; Belcher, R.T; Brown, D.A.; Perry, J.E., eds. Atlantic white cedar restoration ecology and management symposium. Newport News, VA: Christopher Newport University: 91-100.

Merry, S.D. 2005. Factors affecting tree ring width in Atlantic White Cedar, Chamaecyparis thyoides (L.)B.S.P., within Great Dismal Swamp National Wildlife Refuge and Alligator River National Wildlife Refuge. MS Thesis at Christopher Newport University, Newport News, VA 23606

Phillips, R.W.; Hughes, J.H.; Buford, M.A.; Gardner, W.E.; White, F.M.; Williams, C.G. 1998. Atlantic white cedar in North Carolina, USA. In: Laderman, A.D. ed. Coastally restricted Forests. New York: Oxford University Press. 156-170.

Shacochis, K.M.; DeBerry, J.W.; Loomis, D.T.; Belcher, R.T.; Atkinson, R.B. 2003. Vegetation importance values and prevalence index values of Atlantic white cedar stands in the Great Dismal Swamp and Alligator River National Wildlife Refuges. In: Atkinson, R.B.;. Belcher, R.T; Brown, D.A.; Perry, J.E., eds. Atlantic white cedar restoration ecology and management symposium. Newport News, VA: Christopher Newport University: 227-233.

Shaler, N.S. 1890. General Account of the Fresh-water Morasses of the United States, with a description of Virginia and North Carolina. U.S.G.S. 10th annual Report for 1888-1889, USGS. 253-339.

Thompson, G.S.; Belcher, R.T.; Atkinson, R.B. 2003. Soil Biochemistry in Virginia and North Carolina Atlantic white cedar swamps. In: Atkinson, R.B.;. Belcher, R.T; Brown, D.A.; Perry, J.E., eds. Atlantic white cedar restoration ecology and management symposium. Newport News, VA: Christopher Newport University: 113-124.

USFWS 2004. Environmental Assessment for the Atlantic white cedar salvage and restoration at the Great Dismal Swamp National Wildlife Refuge. Hadley, MA:USFWS

Whitehead, D.R.; Oaks, Jr. R.Q. 1979. Developmental history of the Dismal Swamp. In: Kirk Jr., P.W. ed. The Great Dismal Swamp. Charlottesville, VA: University Press of Virginia: 25-43.

Table 1--Pre-Isabel structural attribute table ranked in order of aboveground biomass contribution for tree (≥ 2.54 cm dbh, >305 cm) and shrub (< 2.54 cm, but ≥ 33.0 cm tall) strata for Blackwater Cut (Source: DeBerry and others 2003)

Tree Species	Basal Area (m^2 / ha)	Relative Percent Basal Area	Number (stems/ ha)	Biomass (kg/ha)	Relative Percent Biomass	Mean dbh (cm)
Cedar	55.08	90.82	1,006	179,886	86.63	25.36
Acer rubrum	3.88	6.39	211	18,136	8.73	13.35
Pinus serotina	0.61	1.00	17	3,534	1.70	13.57
Persea borbonia	0.40	0.65	156	1,723	0.83	3.60
Magnolia virginiana	0.27	0.45	67	949	0.46	6.43
Pinus taeda	0.18	0.30	6	854	0.41	20.40
Vaccinium corymbosum	0.13	0.21	150	323	0.16	3.19
Nyssa biflora	0.04	0.06	22	106	0.05	4.60
Other tree species	0.07	0.12	117	90	0.04	
Tree Stratum Total	60.64	100.00	1,750	205,602	99.01	
Shrub Stratum Total			19,965	2,047	0.99	
Total Aboveground			21,715	207,649	100.00	

Table 2--Cedar seedlings by size class

Treatment	# of 25-m^2 plots	Total Seedlings	Mean (total) number of seedlings per size class [percent of total size class] 0-10 cm	10-20 cm	20-30 cm	30+ cm
Salvage logged	12	436	24.2 (290) [66.5]	9.3 (111) [25.4]	2.3 (28) [6.4]	0.6 (7) [1.6]
Skidder trails	10	110	8.5 (85) [77.3]	2.2 (22) [20]	0.1 (1) [0.01]	0.2 (2) [0.02]
Un-salvaged	10	0	0 (0) [N/A]	0 (0) [N/A]	0 (0) [N/A]	0 (0) [N/A]
Total	32	546	(375) [68.7]	(133) [24.4]	(29) [5.3]	(9) [1.6]

Figure 1--Great Dismal Swamp National Wildlife Refuge Vicinity Map

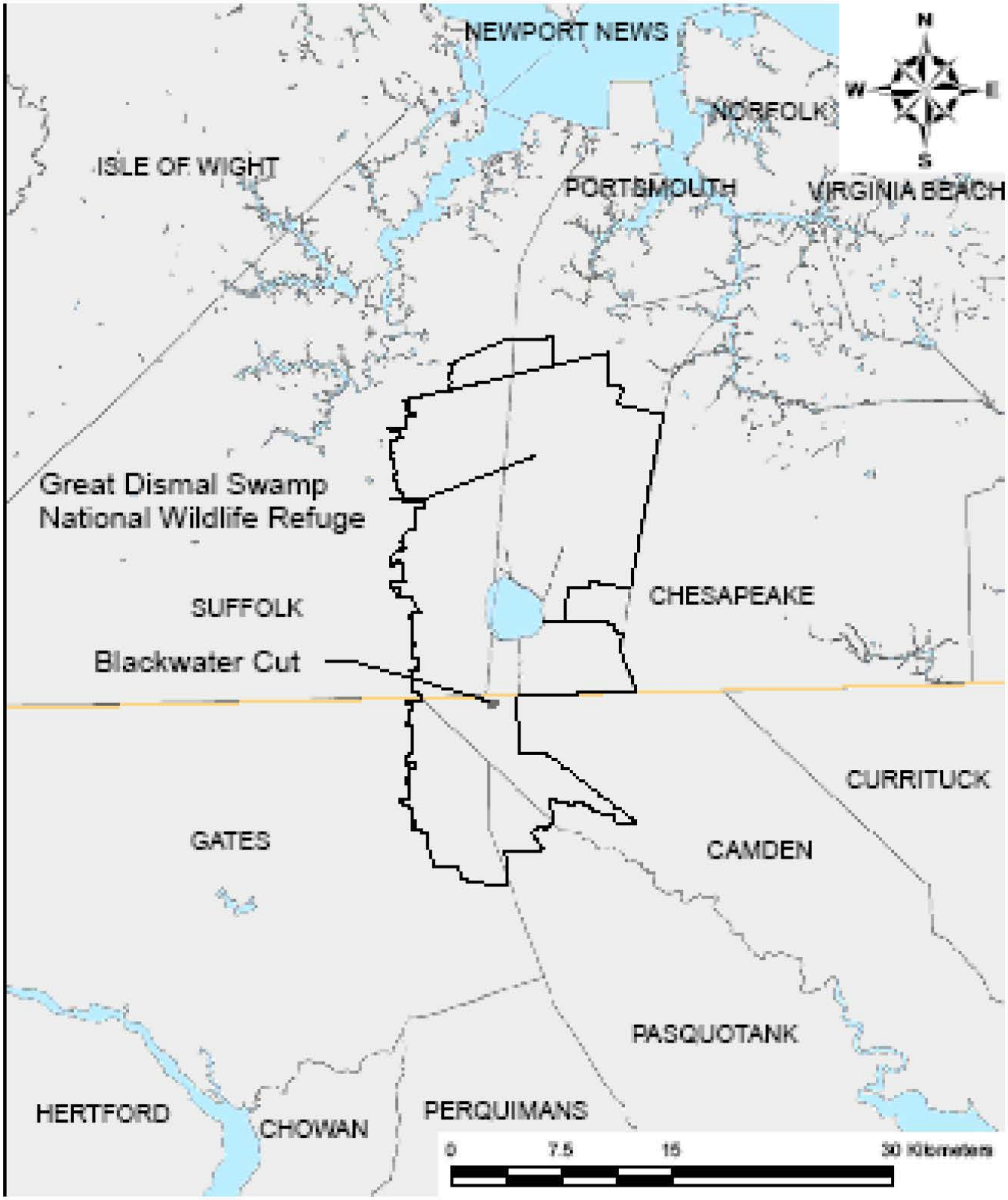

Figure 2--Aerial photograph of Blackwater Cut, courtesy of Brian Martin.

Figure 3–Hydraulic Grapple skidder used to salvage log the Blackwater Cut, courtesy of Brian Martin

Figure 4--Example of: (a) salvage logged plot, (b) skidder trail plot, (c) un-salvaged plots

a.

b.

c.