PLANT SURVIVAL IN THE FLOODPLAIN RESTORATION OF CRABTREE SWAMP, HORRY COUNTY, SC

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ABSTRACT. Crabtree swamp is located in the Kingston Lake Watershed (HUC 03040206-08-03) in northeastern SC. The swamp flows around the City of Conway and discharges into the Waccamaw River. Since the 1960's, the US Army Corps of Engineers have dredged an eight-mile canal through the swamp to prevent and control flooding. The dredge materials were piled onto the adjacent banks, creating a very steep, unstable levee system that isolated the remaining floodplain, increased water velocities, and eliminated habitat and fish spawning grounds. Horry County and the City of Conway, with assistance from federal agencies and two universities, are restoring the natural floodplain to stabilize the canal and improve water quality. In April 2009, a half-mile stretch along one streambank was restored by removing dredge materials, regrading the bank slopes and revegetating with native trees, shrubs and wetland plants. Their health status has been assessed periodically and data archived in GIS datalayers. By restoring the natural floodplain, the energy of the floodwater is dissipated, permitting deposition of sediment and improved water quality.

Partners learned important lessons such as the need for 1) strong partner commitment; 2) overall coordination; 3) maintenance guidelines; 4) project assessment and sharing results; and 5) enabling natural processes. Future restoration work is needed to address continuing erosion and water quality problems in unrestored stream reaches. A second segment of the canal is being restored in 2012.

INTRODUCTION

The Waccamaw River is a blackwater river that flows from Lake Waccamaw, NC, and winds through Conway on its way to the mouth of Winyah Bay in Georgetown, SC. Crabtree canal, a channelized tributary, and the adjacent swamp are part of the Kingston Lake watershed that is approximately 20 sq. mi. in area and represents a major conduit for water through Conway before discharging into the Waccamaw. The canal runs approximately eight miles through Conway, in northeastern Horry County, SC (see Figure 1.)

Crabtree Canal, as it is now known, was the solution to major flooding in Conway after a storm event that dropped 10.38 inches of rain in a 14 hour period on June 6th, 1964. The rising water caused major transportation corridors in Conway (U.S. highways 701, 501, and 378) to be closed or impassable. Approximately $4,000,000 in tobacco crops were destroyed by flooding, as well as small businesses and homes suffering severe damage. Farmers and residents declared Crabtree swamp was harmful to their livelihood.

Farmers and land owners petitioned the state to establish the Crabtree Watershed Conservation District for the purposes of funding. Mayor Huckabee, George Jenkins Sr. and Col. S. Y. Coker of the US Army Corps of Engineers (USACOE) spearheaded the flood control project. Through this effort, the swamp was dredged and channelized, in an effort to prevent future flooding from destroying residential, commercial, and agricultural areas.

In 1965-66, the USACOE excavated a 6.5-mile canal through Crabtree Swamp to improve drainage, piling the dredged materials along the bank, effectively cutting off the floodplain. Another 1.5 miles was channelized in the 1980’s. Over time, the canal banks have steepened due to the increased water flow through the canal (Figure 2a), causing bank instability and increased erosion rates. Channelization of the formerly winding swamp has significantly impacted the hydrology of the ecosystem, affecting the frequency, degree and duration of flooding. Water quality has also declined.

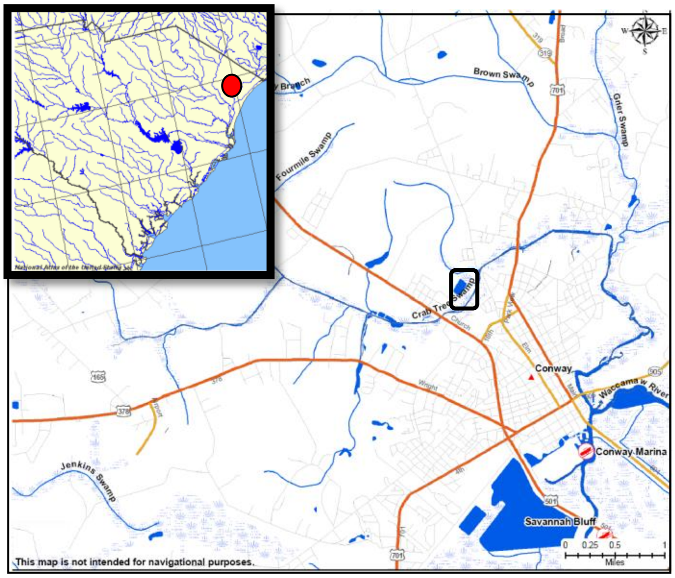

Figure 1. Map showing Crabtree Canal flowing through Conway, SC. Location of the restoration work is shown by the black box and the red dot on the inset state map.

The area around Conway has experienced a change in land use over the past 50 years, shifting from an agricultural to an urban landscape. The increase in the impervious surfaces within the watershed causes the water flow in Crabtree Canal to be flashy during rain events. Currently, Crabtree Canal is listed on South Carolina's 303(d) list of impaired waters for dissolved oxygen and fecal coliforms. The waters also experience high suspended sediment concentration after rain events. The net effect of these impairments has been to diminish the quality of aquatic habitat in the Crabtree Canal.

OBJECTIVES

A watershed management plan was developed for the Kingston Lake Watershed in 2010 (Libes and Fuss 2010). The restoration of Crabtree Canal was included as an action item. To implement this component of the watershed management plan, Horry County, the City of Conway, and Coastal Carolina University devised a restoration plan to improve conditions in Crabtree Canal that was based on findings from a hydrological and pollution source tracking study completed in 2008 and a floral survey of adjacent swamps performed in 2009.

In May 2009, construction began at the chosen demonstration site to reconnect the floodplain along a ½-mile segment of one bank of Crabtree Canal (Figures 1 and 2b). A second ½-mile segment is undergoing restoration, 0.3 miles upstream of the first site on the opposite bank.

The three main objectives of the floodplain restoration are to: 1) slow the flow of water; 2) increase water storage; and 3) reduce erosion (Fuss et al. 2010.) The restoration was designed by Coastal Carolina and Clemson Universities, in collaboration with the City of Conway and Horry County. Expert advice in selection of suitable indigenous plants was provided by Dr. Will Conner (Professor of Forestry and Natural Resources, Clemson University). Species were selected to encompass a broad range of plants indigenous to southeastern bottomland hardwood swamps.

Permission to engage in this work was obtained from the property owners in the Crabtree Watershed Conservation District who signed a Memorandum of Understanding in 2008 with Horry County and the City of Conway to partner on restoration efforts (Fuss et al. 2010). The main objective was to restore a more natural bank slope and revegetate the project site with indigenous trees and shrubs. Restoring a site's hydrology is the most important factor to consider in a bottomland hardwood restoration (Allen et al 2001; Clewell and Lee 1990).

The goals of the plantings were to stabilize the soils on

Figure 2. (a) Left hand photograph shows steepened banks of Crabtree Canal prior to restoration. (b) Right-hand photograph shows restored floodplain during planting. Erosion control logs are located at top of bank in the aquatic zone.

the newly exposed floodplain; intercept suspended sediments being transported downstream; uptake pollutants, including nutrients and bacteria; provide nesting, foraging and perching habitat for wildlife. An additional objective of the project was to provide accessible recreation for the community, to help them reconnect with this important resource.

METHODS

The first phase of the restoration began in 2009, when ½-mi along one streambank was restored by removing the original dredge materials and re-grading the bank slopes. The restored floodplain was re-vegetated with indigenous trees, shrubs and wetland plants.

In May 2009, 251 trees (11 species) and 297 shrubs (7 species) were planted across an 18'-wide aquatic zone and a 42'-wide upland zone. Species indigenous to local hardwood floodplain swamps were obtained from local nurseries in sizes ranging from 3 to 50 gallons. Several 100-ft long segments of pre-planted wetland carpets, with about 12 species of native emergent vegetation were installed at elevations above, at, and below the mean water line. These carpets were constructed using 5 foot wide coir mats and were made by Charleston Aquatics, Inc. The plantings had been grown out to a height of about 1 foot prior to planting.

The planting plan was designed to test which species were best suited to the aquatic and upland zones. To track survival rates, the plants were tagged with a unique identification number and locations recorded with a Real Time Kinematic (RTK) GPS. Their health status has been assessed periodically and data archived in GIS datalayers. The trees have been retagged over the years as

		Count of Green + Mixed				
Species	***Trees Received in 2009***	**May-10**	**Oct-10**	**May-11**	**Jul-12**	***% Survival to 2012***
Atlantic White Cedar (*Chamaecyparis thyoides*)	**2**	**0**	**0**	**0**	**0**	**0%**
Beauty Berry (*Callicarpa americana*)	**27**	**14**	**10**	**20**	**13**	**48%**
Button Bush (*Cephalanthus occidentalis*)	**166**	**131**	**138**	**156**	**136**	**82%**
Bald Cypress (*Taxodium distichum*)	**38**	**37**	**36**	**35**	**33**	**87%**
Black Gum (*Nyssa sylvatica*)	**55**	**16**	**22**	**34**	**21**	**38%**
Swamp titi *(Cyrilla racemiflora)*	**22**	**6**	**6**	**4**	**5**	**23%**
Dahoon Holly (*Ilex cassine*)	**15**	**9**	**11**	**13**	**12**	**80%**
Eastern Red Cedar (*Juniperus virginiana*)	**20**	**7**	**7**	**9**	**8**	**40%**
Green Ash (*Fraxinus pennsylvanica*)	**20**	**13**	**14**	**12**	**15**	**75%**
Persimmon (*Diospyros virginiana*)	**10**	**8**	**3**	**10**	**11**	**110%**
River Birch (*Betula nigra*)	**20**	**15**	**14**	**16**	**16**	**80%**
Red Mulberry (*Morus rubra*)	**15**	**12**	**9**	**3**	**10**	**67%**
Sycamore (*Platanus occidentalis*)	**20**	**16**	**12**	**15**	**11**	**55%**
Southern Red Oak (*Quercus falcata*)	**7**	**1**	**0**	**2**	**0**	**0%**
Swamp Tupelo (*Nyssa biflora*)	**44**	**50**	**31**	**28**	**30**	**68%**
Poplar Tree (*Liriodendron tulipifera*)	**10**	**3**	**5**	**3**	**5**	**50%**
Wax Myrtle (*Morella cerifera*)	**55**	**39**	**41**	**38**	**35**	**64%**
Sugar berry (*Celtis laevigata*)	**2**	**0**	**0**	**1**	**0**	**0%**
Unidentified	**NA**	**2**	**7**	**0**	**0**	
Green+ Mixed	***548***	***380***	***366***	***399***	***361***	
% Green + Mixed	**100%**	**69%**	**67%**	**73%**	**66%**	
Total counted (all categories)	**548**	**414**	**418**	**439**	**419**	
% Recounted	**100%**	**76%**	**76%**	**80%**	**76%**	

Table 1. Tree counts based on surveys conducted periodically since planting and survival rate to date. Survival rates ≥ 75% are highlighted in red. Trees with low planting numbers are highlighted in yellow. See text for an explanation of the persimmon survival rate that exceeds 100%.

the original tags have weathered or gone missing.

Tree and shrub conditions were classified as either: 1) Green; 2) Mixed (brown and green); 3) Brown; 4) Dead; and 5) Mixed with New Growth. "Green" surviving trees were regarded as 100% green, whereas "Dead" trees were considered 0% green. For a tree to be considered "Mixed", at least 50% of the tree had to be brown and to be considered "Brown", less than 20% of the tree would be green. "Mixed/ new growth" meant that there was evidence of new growth.

RESULTS

Since the planting of 548 trees and shrubs in May 2009, tree status has been assessed at least once a year. The results are presented in Table 1. In July 2012, the overall survival rate was found to be 66% with 361 of the planted flora being observed as either "green", "mixed" or "mixed with new growth". High mortality rates (<50% survival) were exhibited by seven species: Atlantic white cedar, beauty berry, black gum, swamp ti ti , eastern red cedar, southern red oak, and sugarberry. Note that three of these species had low planting numbers (Atlantic white cedar, sugarberry, and southern red oak). Six species had very high survival rates (≥75%), i.e., button bush, bald cypress, dahoon holly, river birch, persimmon and green ash. Note that the tree counts performed in May and October 2010 were likely incomplete as more of the trees tagged in 2009 were counted in May 2011. The total trees counted over time should decline as dead trees fall to the ground and are potentially washed downstream.

DISCUSSION

As shown in Figure 3, plant mortality was highest in areas subject to high-energy floodwater regimes, i.e. the aquatic zone. This area also had a higher percentage of plants categorized as mixed, a sign of stress. Data are available to infer flood inundation frequencies and hence how species survival relates to floodplain function. Since species were deliberately planted to test tolerance to challenging environmental conditions, individual species survival rates reflect effects of less than optimal plantings.

Native plants that have volunteered at the restoration site include blue vervain (*Verbena hastate)* and groundsel bush (*Baccharis halimifolia*), both of which have colonized the section closest to the channel. Along the upper border, long leaf pine (*Pinus palustris*) and sweet gum (*Liquidambar styraciflua*) have re-populated open spaces. The original stand of persimmon (*Diospyros virginiana*) has multiplied, leading to a survival rate >100% as some recruits were tagged during the 2011 monitoring effort.

A site maintenance plan has been implemented to manage invasive species and to guide brush trimming. Invasive species include Johnsongrass (*Sorghum halepense*) in the aquatic zone and Alligator weed (*Alternanthera philoxeroides*) in the channel. Chinese tallow (*Triadica spp.*), rattlebox (*Crotalaria spp*), and Chinese/Japanese privet (*Ligustrum spp*) are found in the in the upland border.

A second segment of floodplain is being restored with planting scheduled for winter 2012. This site is located 0.3-mile upstream of the first segment on the opposite streambank. Based on the survival results from the first restoration, which was designed as a pilot to guide future efforts, this second segment will be planted with a lower density of trees and shrubs. A test plot will also be seeded with native grasses.

It will be important to continue to monitor plant status at the site, not only to watch for early detection of invasive or nuisance species, but to monitor natural revegetation to be sure that desired species are colonizing the site. Some plant species may have limited dispersion mechanisms that won't be mimicked in the newly restored site. Due to extensive development and channelizing of the former swamp upstream of the project site, there may

Figure 3. GIS datalayer showing status of planted trees following a survey conducted in July 2012.

be limited opportunity for some species to recolonize the site. Natural regeneration has been found to be effective when the desired bottomland hardwood ecosystem is found in close proximity to the restoration site (Allen et al. 2001). Efforts to restore hydrologic conditions at a site in the Savannah River watershed have resulted in colonization of plants that in the future will provide a similar canopy to pre-disturbance conditions, likely due to the project site being directly adjacent to the targeted ecosystem (Nelson et al. 2000).

One lesson learned is the importance of establishing a written maintenance plan that all stakeholders have agreed to. In 2009, herbicide spraying in a utility right of way killed several hundred willows that are not included in Table 1. In 2010, mowing led to the death of several trees. As a result, a maintenance plan was formulated and adopted by all the project partners. Nevertheless, in the 2012 survey, tree damage was observed that could be tied to a recent over application of herbicide intended to control invasive species in a utility right of way.

ACKNOWLEDGEMENTS

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