Geomorphology and Baldcypress Restoration of the Caernarvon Delta near the Caernarvon Diversion, Southeast Louisiana

2011 Report

by

Andy Baker, Theryn Henkel, John Lopez and Ezra Boyd
Lake Pontchartrain Basin Foundation

A Project of the Lake Pontchartrain Basin Foundation and the Coalition to Restore Coastal Louisiana

Contents

Introduction

This is the first report of a series that will document monitoring of the Big Mar Pond area near the Caernarvon Diversion from 2010 to 2013 where two significant developments are occurring. First is the occurrence of new significant wetland growth on the Caernarvon Delta and second is the implementation of a baldcypress re-forestation project within the same area. This report documents these aspects separately, but also the synergy and challenges of planting on an actively growing delta. The lessons-learned will benefit this area and other future re-forestation projects of similar character. Additional significance to the project is that the nearby levees and floodwalls to protect St. Bernard and Plaquemines Parishes should benefit from the additional storm buffering effects of the new wetlands and coastal forest (**Figure 1**).

The Caernarvon Diversion is located 15 miles downriver from New Orleans in Plaquemines Parish near the Plaquemines/St. Bernard Parish line (**Figure 1**) and was constructed in 1991. The structure was designed to divert up to 8,000 cfs from the Mississippi River into the local estuary, but has rarely flowed at this capacity (LPBF CHMP 2006; http://waterdata.usgs.gov/usa/nwis/uv?site_no=295124089542100). Big Mar Pond is part of the receiving area for waters diverted 1.5 miles from the Mississippi River through the Caernarvon Diversion. Although the Caernarvon conveyance canal is directly connected to Big Mar Pond, it is estimated to receive less than half of the Caernarvon Diversion discharge due to the hydrologic efficiency to flow toward Bayou Mandeville and Lake Lery. From 2001 to the present, the structure has been occasionally operated under a pulsing regimen to mimic historical spring floods. The structure was also opened to maximum discharge during the BP oil spill in an attempt to prevent oil from moving inland. In spring 2011, during the historic flood that occurred on the Mississippi River, the discharge was generally less than 1000 cfs. The Caernarvon diversion has a complex and controversial history, and some suggest it may have had a role in weakening the already-eroding marsh (Kearney et al. 2011). For more information on the Caernarvon diversion, go to the Lake Pontchartrain Basin Foundation (LPBF) technical reports webpage at saveourlake.org

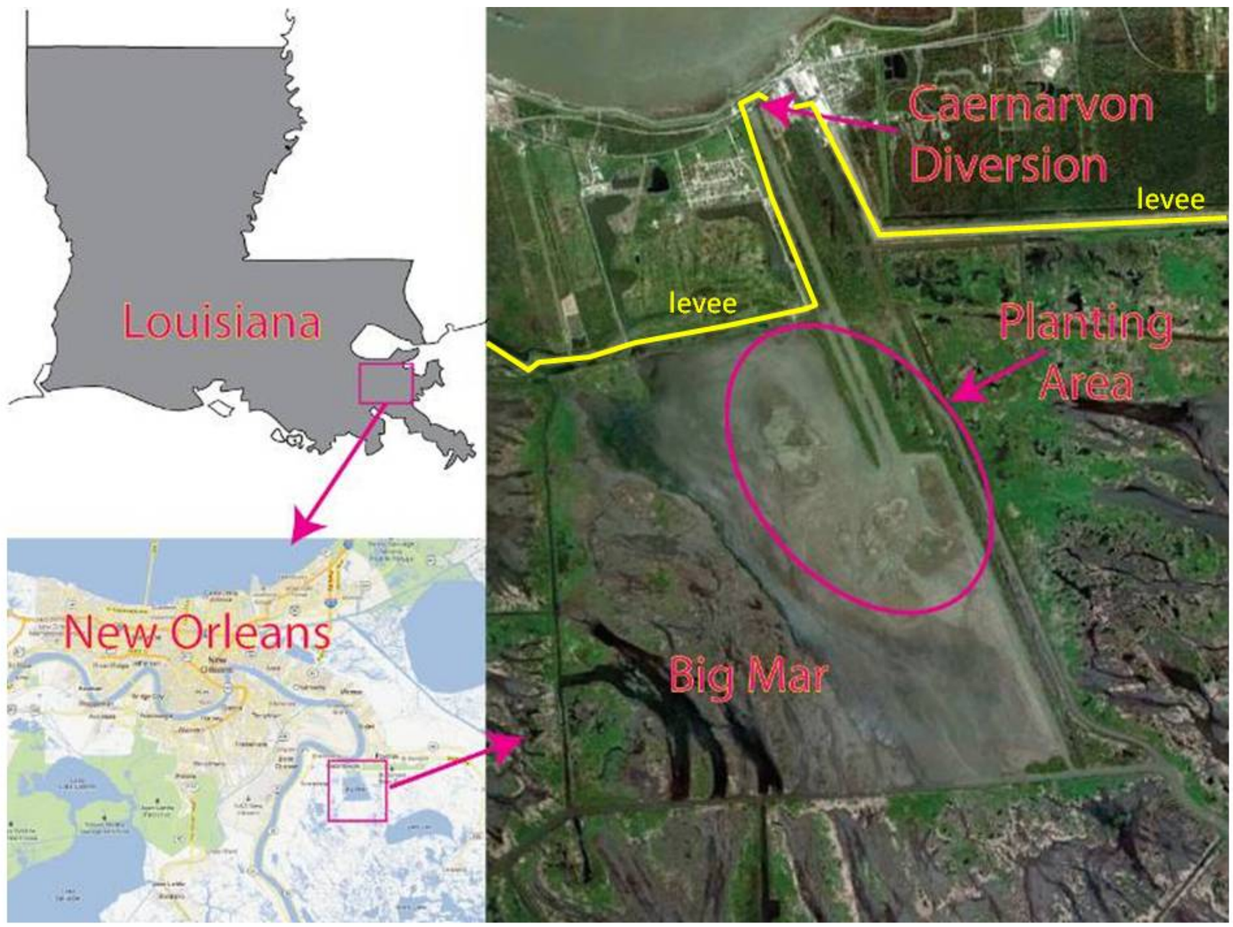

Figure 1: The location of the Caernarvon Diversion and Big Mar Pond in southeast Louisiana.

Big Mar Pond is a large, shallow pond formed by a failed agricultural impoundment in the early 20th century. Since the construction of the diversion, sediment has been deposited in Big Mar Pond. Over time, there has been enough accumulation in some areas to permanently support emergent wetland plant life. Two studies conducted just south of Big Mar Pond, one from 1996 to 2000 (Lane et al. 2006) and another in 1998 (DeLaune et al. 2003), found significant sediment accumulation in the area, both mineral and organic. Since 2005, a delta has formed at the end of the outfall canal. In this area, cattail (*Typha* sp.), bulltongue (*Sagittaria* *lancifolia*), maidencane (*Panicum hemitomon*) and *Sesbania macrocarpa* have been replacing brackish marsh vegetation. There has also been establishment of some black willow (*Salix nigra*) trees. The area is currently thriving with different kinds of birds, water fowl, numerous alligators and diverse insect life.

From 2010 to 2011, the Lake Pontchartrain Basin Foundation (LPBF) and the Coalition to Restore Coastal Louisiana (CRCL) planted baldcypress (*Taxodium distichum*) trees in Big Mar Pond on the newly formed delta. This project's goal is to establish baldcypress swamp in newly-emerged wetlands deposited by the Caernarvon diversion.

This is not the first attempt to re-establish a cypress swamp in the Pontchartrain Basin, but it is the first to be done in an area under influence of an artificial river diversion. Extensive baldcypress planting has been done along Pass Manchac starting around the 1980's. Most of these trees were killed by high salinity in a drought in the late 1990's (Gary Shaffer Pers. Comm., 2011). Another intense local baldcypress planting was at the Hammond Wastewater Assimilation project (also in the Lake Maurepas area). These trees have suffered from severe nutria herbivory, in part due to the enhanced nutria activity associated with the assimilation project (Day et. al, 2011). Both these projects indicate the potential importance of a riverine source of freshwater and nutrients for baldcypress re-forestation. The recent emergence of the Caernarvon delta associated with the nearby Caernarvon Diversion is an unprecedented opportunity in the Pontchartrain Basin to pursue baldcypress reforestation under the more natural condition of riverine flow and delta formation from the Mississippi River.

Caernarvon Delta Growth

Prior to 2004, wetland growth (defined as persistent emergent wetland vegetation in formerly open water) within Big Mar Pond was negligible (**Figure 2**). Since 2004, wetland growth is significant and appears to be accreting annually. This wetland growth is a result of an active delta that has two distinct zones and, therefore, is referred to as the Caernarvon Delta Complex. The total area of Big Mar Pond is 1,720 acres. The emergent portion of the Caernarvon Delta Complex now occupies 35% to 50% of Big Mar Pond.

In the northeast quadrant of Big Mar Pond near the terminus of the Caernarvon conveyance canal, a mineral platform of radiating bars and shallow inter-bars (i.e. the delta platform) has become vegetated. This has the typical delta geomorphology of bars and small bifurcating distributary channels. In 2005, Hurricane Katrina pushed marsh balls from the surrounding marsh into the southwest portion of Big Mar Pond (**Figure 3**). The hurricane deposition in this zone became nucleation points in which wetland extent expanded since 2005. This expansion was initially floatant marsh, but appears to be acting as a sediment trap for fine sediment from Carnarvon Diversion discharge, thus comprising a proto-delta. This proto-delta area was not significantly impacted by Hurricane Gustav in 2008. Further, the appearance of some black willow indicates the marsh is not entirely floatant and has become more stable.

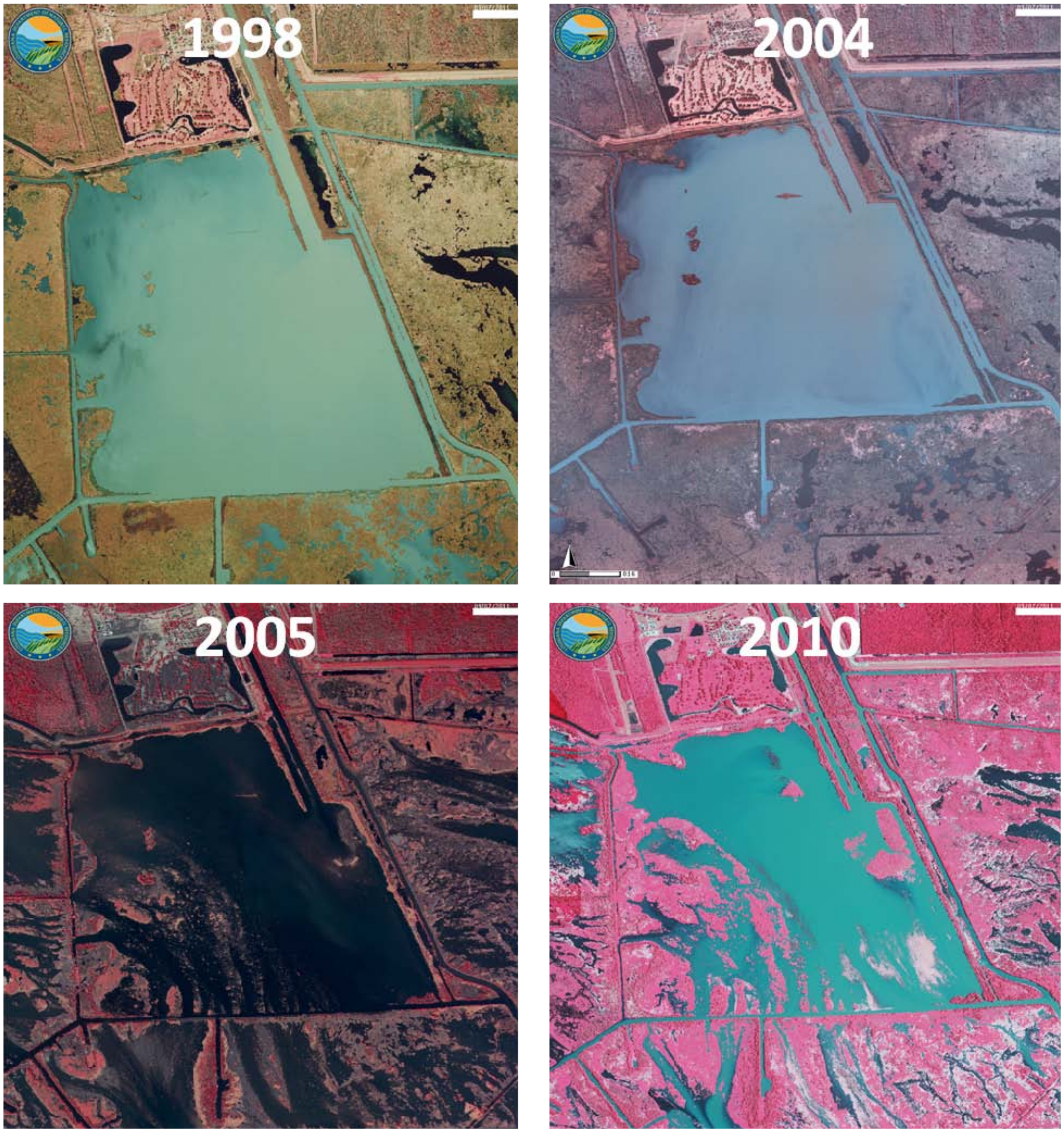

Figure 1: Land change in Big Mar Pond from 1998 to 2010. Notice the wrack and marsh balls deposited by Hurricane Katrina in 2005 and significant delta growth by 2010.

In the summer of 2010, the Caernarvon diversion was opened for 15 weeks at full capacity in response to the BP oil spill. LPBF has estimated that over 125,000 cubic yards of sediment entered the marsh during this time (Baker and Lopez 2011).

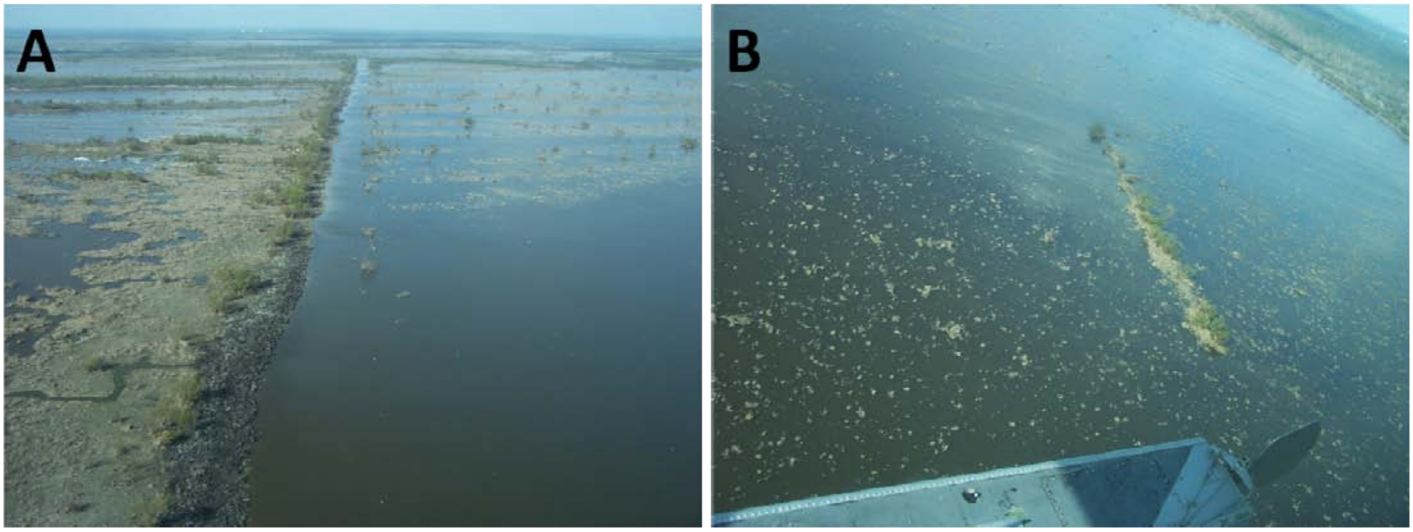

Figure 3: Marsh balls deposited into the Big Mar Pond area by Hurricane Katrina. View looking west with the south on the right side (A) and view looking down on the marsh balls in Big Mar Pond (B).

From 2010 to 2011 there was significant growth of the delta in the northwest quadrant in Big Mar Pond. In March of 2011, a flyover of the area revealed exposed mudflats with little vegetative cover, which was some expansion from 2010. By August of 2011, there had been more expansion of the delta and the formerly exposed mud was almost 100% vegetated (**Figures 4, 5 and 6**).

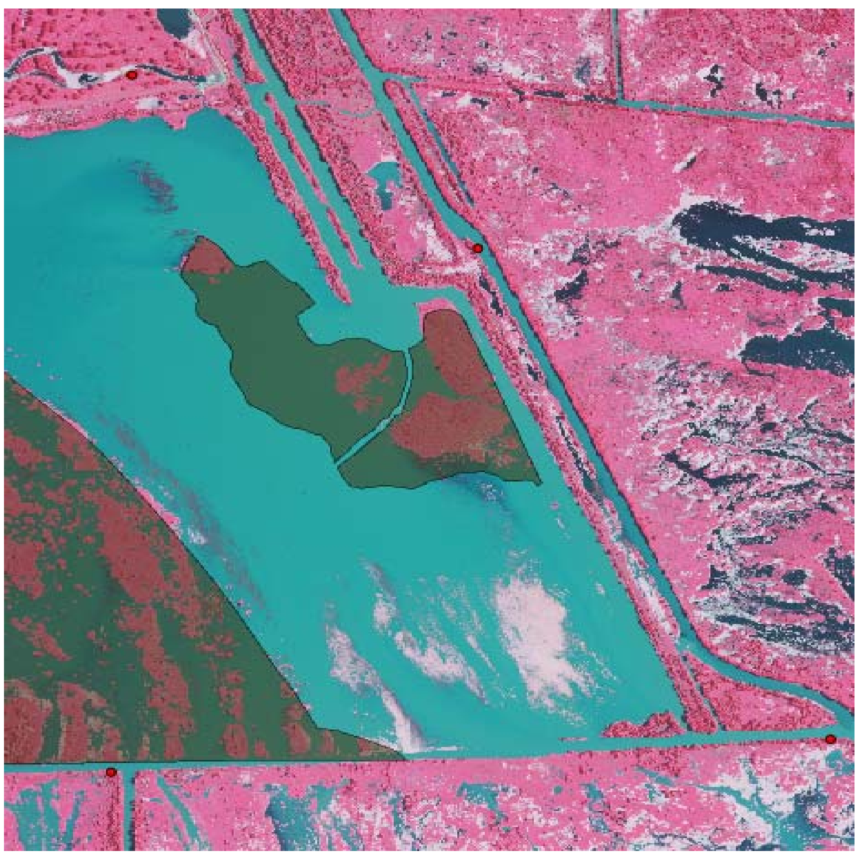

Figure 4: Outline of delta extent in 2011 laid over the color infrared imagery from 2010. Notice the significa**nt** growth in the delta area in one year.

Figure 5: Picture of exposed mudflats in Big Mar Pond in March of 2011 and the nearly 100% vegetated delta in August 29, 2011.

Figure 6: On the ground view of the vegetated delta on August 24, 2011. This area was bare mud flats six months prior.

LPBF estimates that there was 19 acres of wetland growth from 1998 to 2004, and that the total wetland growth in Big Mar Pond from 1998 to 2011 is 600 acres. Of this total, 581 acres are new growth since 2004. The USGS data set indicates 23 acres growth from 1998 to

2004, and 321 acres of growth from 2004 to 2010. The delta growth from 2010 to 2011 is estimated to be approximately 104 acres, which is significant growth in one growing season. LPBF data indicate that the wetland growth rate in Big Mar Pond from 1998 to 2004 is 3 acres per year. The rate of growth from 2004 to 2011 is 83 acres per year (Henkel et al. 2011). Both LPBF and USGS data clearly indicate an increase in rate of wetland growth after 2004 (**Figure 7**).

The rate of wetland expansion after 2004 is 14 times (1400%) greater than before. Big Mar Pond in 2011 is at least 40% emergent wetlands, but the remaining open water areas are all less than a foot deep under normal marsh water levels. Based on the observed trends of wetland emergence, LPBF projects the annual rate of wetland growth to be approximately 80 acres per year in Big Mar Pond. As Big Mar Pond becomes filled with sediment, it will reach a threshold for capacity to retain sediment. Most likely, the entire area will not become emergent wetland as water will continue to flow from the Caernarvon Diversion through the area. Because of this, there is future potential for wetland accretion or emergence outside Big Mar Pond as the ability to retain sediment within the pond diminishes.

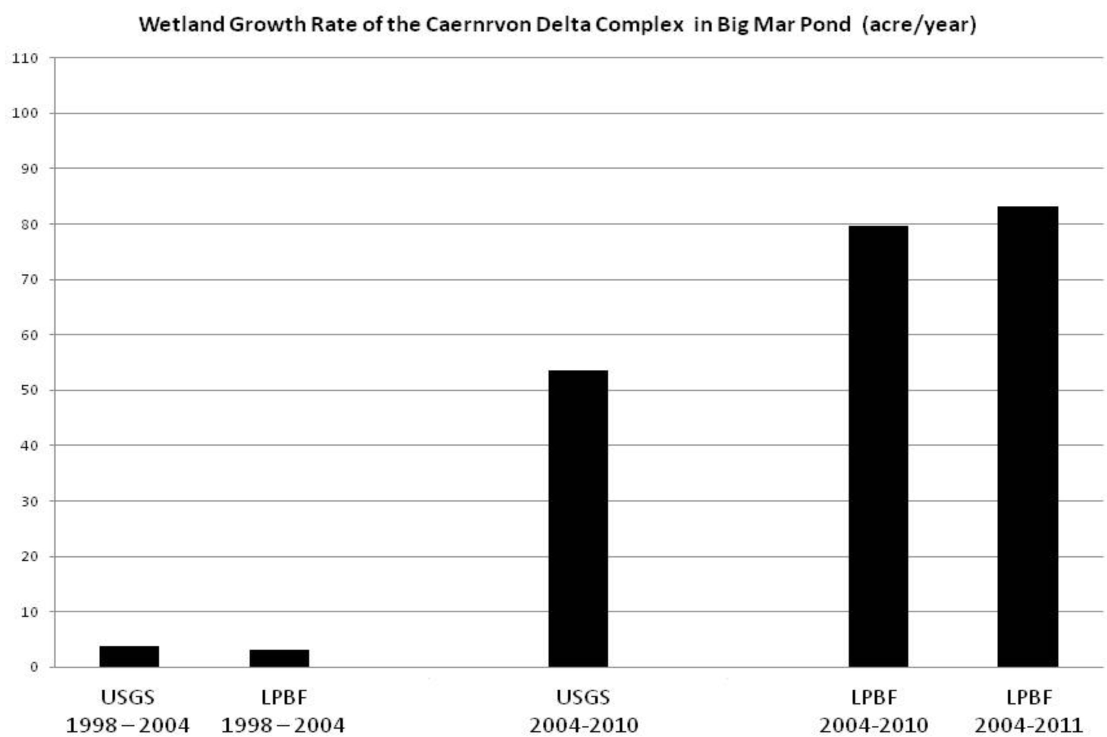

Figure 7: Bar graph showing wetland growth rates in Big Mar Pond calculated by LPBF and the USGS, from 1998 to 2011

This pattern of dramatic increase in the rate of wetland growth is similar to that documented for other larger diverted flows, such as the Wax Lake Delta and the Atchafalaya Delta (Roberts et al. 1997; Roberts et al. 1980). In similar cases of introduced river flow, there is an initial delay in wetland growth as mineral soil platforms vertically accrete to a threshold on which emergent vegetation can survive. Once this occurs, a much higher rate of wetland growth occurs. Nevertheless, the current higher growth rate in Big Mar Pond was not expected considering that: (i) the diversion was designed to minimize sediment delivery, (ii) the maximum discharge capacity is small, (iii) the diversion has been under-operated, (iv) the diversion has not been operated to efficiently deliver sediment, and (v) most of the discharge does not flow into Big Mar Pond. Beyond Big Mar Pond, there is undoubtedly a much larger area of mineral accretion, that is, the submerged, pro-delta extends beyond Big Mar Pond. Although to date only isolated sites of land building occurred outside of Big Mar Pond, it is likely that, within a few years, new wetland creation will begin occurring outside of it. This is more likely if the Caernarvon Freshwater Diversion is operated in a manner that effectively delivers sediment to the receiving basin. It is likely that the rate of growth could be increased by a different operation scheme to increase efficiency of sediment delivery.

Baldcypress Re-forestation Project

Swamp forests of giant baldcypress trees once covered much of the area around New Orleans. Clear-cut logging destroyed the pre-European forests over much of their former range, and salt water intrusion killed much of what was left. Baldcypress regeneration is precluded by to nutria herbivory, salinity, and slow germination rates (especially in areas with high rates of subsidence or rising water). Under existing conditions and without management, seedling mortality is high. Because of man-made changes in the habitat, reestablishing baldcypress often requires human intervention in the form of manually planting saplings. (See Holm et. al., 2011 for a recent review of nutria herbivory in Louisiana.)

In 2009, the Coalition to Restore Coastal Louisiana (CRCL) received a donation of 10,000 baldcypress trees from the Restore the Earth Foundation (REF). As a result, the CRCL created the "10,000 Trees for Louisiana" project with a goal of plating the trees in various locations across the coast. The trees that were provided by REF are from native Louisiana seed stock. LPBF and CRCL chose Big Mar Pond as one of the planting sites. The two groups made plans to plant approximately 1,000 trees in the area over three years with the assistance of volunteers. The emergence of new land in 2010 provided a larger area for tree planting, thus enhancing the Big Mar Pond planting project.

Initially, for the first two plantings, trees were grown in greenhouses in South Carolina (still with local seed stock) then transported to Louisiana for planting. For the most recent planting in November 2011, REF began to partner with a local grower and received the trees from local grower Aaron Peirce with Resource Environmental Solutions. In general, the trees were in three gallon pots and were three to five feet tall (see **Figures 13, 14 and 17**).

2010 Planting

LPBF planted a single baldcypress tree without nutria protection in March 2010 in Big Mar Pond. In August, the tree was still alive and thriving (**Figure 8**). Further reconnaissance indicated that water levels and salinity were suitable for a baldcypress reforestation project. Thus began planning for the fall planting of 2010.

Figure 8: The first baldcypress planted without nutria protection in March 2010 in Big Mar Pond survived for several months indicating that habitat was suitable for a large scale re-forestation. Howard Callahan, driving the airboat, is the land manager who has been very helpful with the re-forestation project. (August 27, 2010)

On the morning of October 15th, five LPBF staff, four CRCL staff and eight volunteers met at the Delacroix Corporation boat launch. Planting crews set off in canoes as LPBF's 19’ Cape Horn moved plants one mile to the end of the Caernarvon canal (**Figure 10**). The canoes then ferried people and 200 trees through very shallow water to the planting sites. Some of the newly deposited sediment was firm sand, while nearby areas were soft, silty mud **(Figure 9**). In order to ascertain if baldcypress trees could survive on newly formed sandbars and exposed mud, the team planted 170 trees on the bare mud flats of the emerging delta **(Figure 9)**. At the same time, 30 trees were planted on an established island just outside the main diversion outflow. The trees were planted without nutria protection tubes **(Figure 11).** Normally these protective covers are required because the non-native nutria (*Myocastor coypus*) quickly eat the root crown of newly planted trees. Though these larger rodents do not eat the entire plant, nutria often completely destroy unprotected plantings within weeks. It was thought that the nutria protection would not be necessary because the initial planting in March 2010 of a single tree survived without protection (**Figure 8**) and because hunters and land managers had commented that the area had lots of large alligators, which are known to prey on nutria (Keddy et al. 2009). If this was true, the entire planting might be able to proceed without the added expense and trouble of nutria protection.

Figure 9: Upper picture - Volunteers plant cypress on newly emerged islands in October 2010. Nutria protection tubes were not used. There was 100% mortality of the first planting due to nutria and the instability of the un-vegetated bars. (Ezra Boyd, Blaise Pezold, and JoAnn Burke)
Lower picture – One of the few trees found that were previously planted on bare mud flats. Most trees were entirely missing. April 1, 2011

Figure 10: Trees and staff being shuttled to the planting site in October 2011 (Linda Delaney, Chelsea Core, and JoAnn Burke (LPBF), and Natalie Snider (formerly CRCL).

When the planting site was surveyed in March, almost none of the trees were found. The 170 trees on the exposed sandbars were completely gone except for a couple of dead trees. Apparently the sandbars themselves had shifted, due to either winter storms or flow from the diversion. Nutria were also likely part of the high mortality.

The 100% mortality rate of the October planting led to a change of strategy for the next planting, scheduled in March 2011. Nutria protection tubes would be used on half the trees, and they would be planted on more vegetated sites that were less subjected to the direct outflow of the diversion and the storm-generated waves (**Figures 11 and 13**).

March 2011 Planting

Just prior to the planned March 11, 2011 planting, the Caernarvon Diversion was flowing at nearly 5000 cfs, creating a dangerous condition for planting in Big Mar Pond due to the water velocity and higher water levels. A request was made by LPBF to reduce the discharge over the weekend of the planting. The State agreed to reduce the discharge on Saturday of the planting and indicated that the structure would be re-opened on Sunday. Unknown to everyone was that the river was moving into a record flood, and that turbidity in the river was very high. The discharge was reduced dramatically just before the planting. However, the discharge remained very low for the next few months during the record 2011 flood when at times sediment load was high. It seems the diversion closure was precipitated by the request for the planting, but it is uncertain why the structure remained closed for a prolonged period. The unfortunate result was that an opportunity to introduce a significant volume of sediment into the wetlands was lost.

On March 11th, 2011, 175 trees were delivered to the Big Mar Pond area for planting the next day. On March 12th, four CRCL staff, six LPBF staff and sixteen volunteers convened to plant the trees. It was discovered that, overnight, approximately 20 trees had been stripped of the bark at the base. Gnaw marks suggested that rabbits were responsible. Unfortunately, due to a logistical mix-up, no nutria protection tubes were brought for the planting that day. With a volunteer crew assembled and ready to go, it was decided to continue planting and return with protective tubes as soon as possible.

On April 1st, (merely 18 days after the planting), two LPBF staff returned to the planting site to check on the trees. They found heavy mortality from nutria damage; only 44 of 175 trees remained (24%) (**Figures 11 and 12**). Planting sites in open, freshly deposited ground were hardest hit. (Due to an oversight during the planting process, the locations of approximately 50 trees were not recorded.). Despite dozens of alligators swimming nearby, nutria were evident and active.

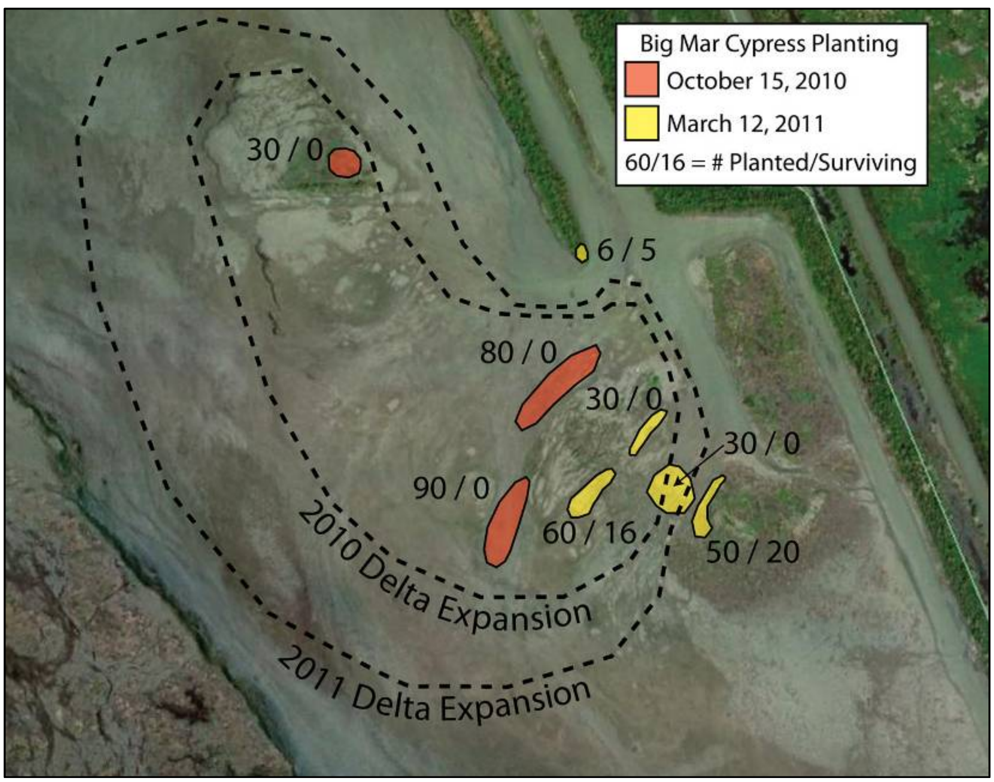

Figure 11: Locations survival rate of trees planted in the October, 2010 and March, 2011 planting, in Big Mar Pond. (Delta outlines are highly schematic)

On April 4th, an LPBF biologist and one volunteer canoed to the site with nutria protection tubes for all the remaining trees. The tubes used were a solid cylindrical tube of stiff, biodegradable plastic. Tubes were slipped over the trees to the base. Follow-up monitoring in

May, July and September showed that almost all the trees with protection tubes were still alive and most were thriving. Only three trees had died, all of which had sustained damage before being protected. **Figure 17** shows the nutria protection tubes used in March 2011.

Figure 12: Examples of nutria herbivory damage to baldcypress planted in March 2011 without nutria protection tubes. Pictures taken April 1, 2011 just three weeks after planting.

November 2011 Planting

On November 1-3, 2011, 650 trees were planted over three days involving ten staff from LPBF and CRCL along with almost fifty volunteers, ten canoes, three airboats and two powerboats. The first day was spent moving trees one mile to a staging area at the end of the diversion canal. On the second and third days, volunteers moved trees from the staging area to planting sites by canoe and airboat (**Figure 13**).

Figure 13: Staff and volunteers load baldcypress trees into canoes with nutria protection tubes. Andy Baker LPBF and Nathan Arthur (volunteer) – on land.

Volunteers assembled nutria protection tubes which were placed around each tree before it was moved. These nutria protection tubes were different than those used in March 2011. The material was flat sheets of biodegradable plastic. The sheets were rolled into a cylinder around the tree and plastic cable ties were used to hold it in place (**Figures 14 and 15**). Because the plastic was light and weak without additional support, the tubes could be easily blown over by the wind and completely blown off the tree. Therefore, a bamboo stick was placed inside the tube and pressed into the ground after the tree was planted. As discovered later, this was generally successful, but in areas of very weak soil, the bamboo was not adequate to hold the tube in place, and trees were exposed to herbivory.

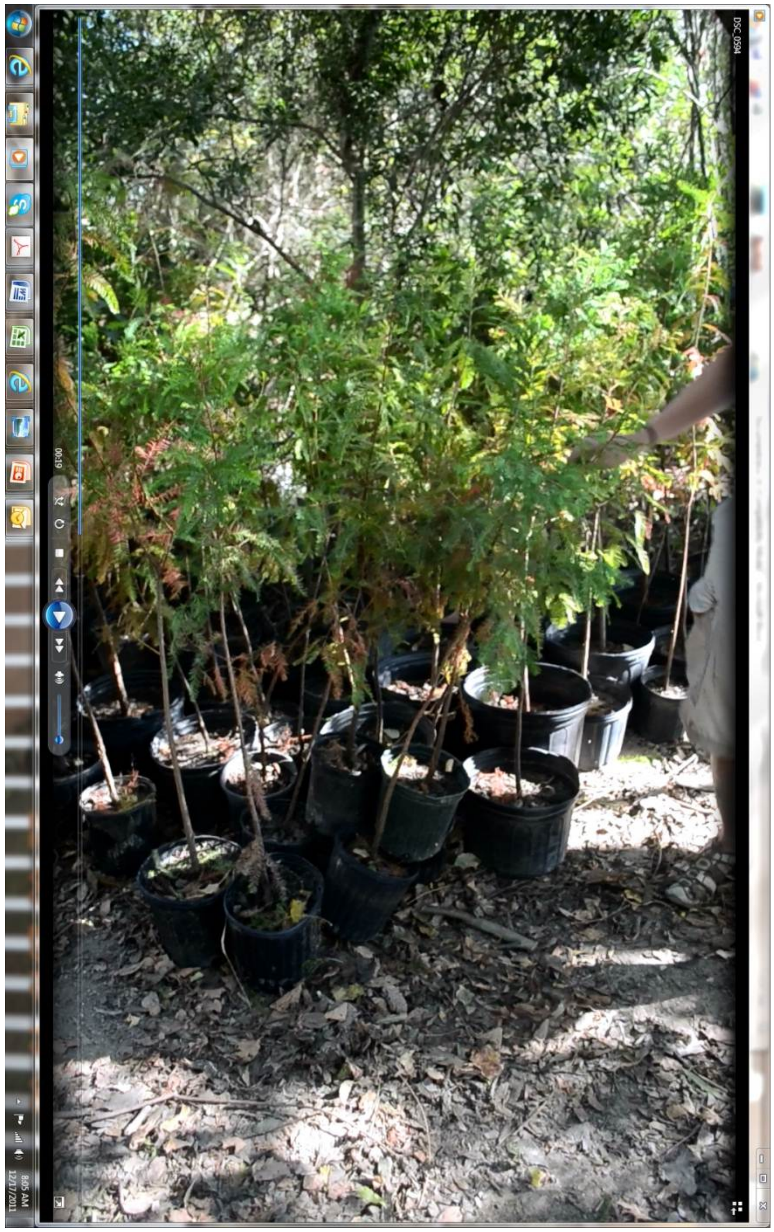

Figure 14: Representative trees planted November 2011.

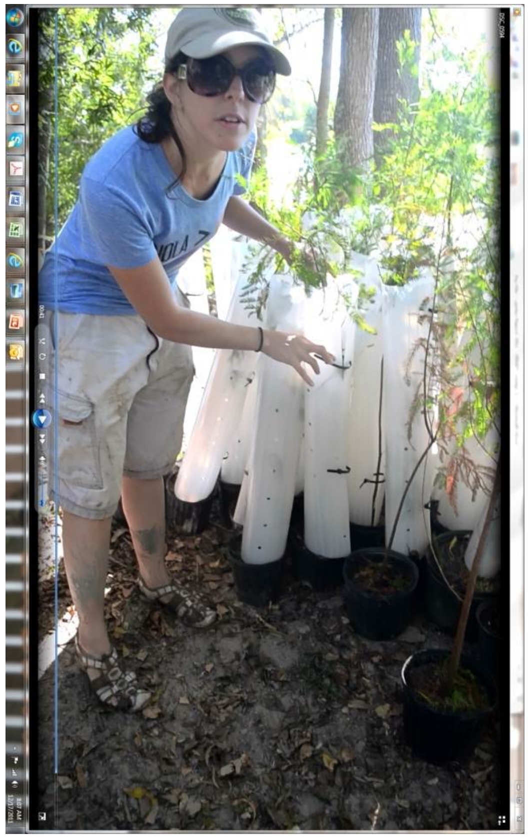

Figure 15: Representative tree planted November 2011 with nutria protection tubes. These were flat sheets rolled into a tube and held with cable ties. These also required bamboo poles to hold the tubes in place once the trees were planted. (Morgan Crutcher CRCL staff)

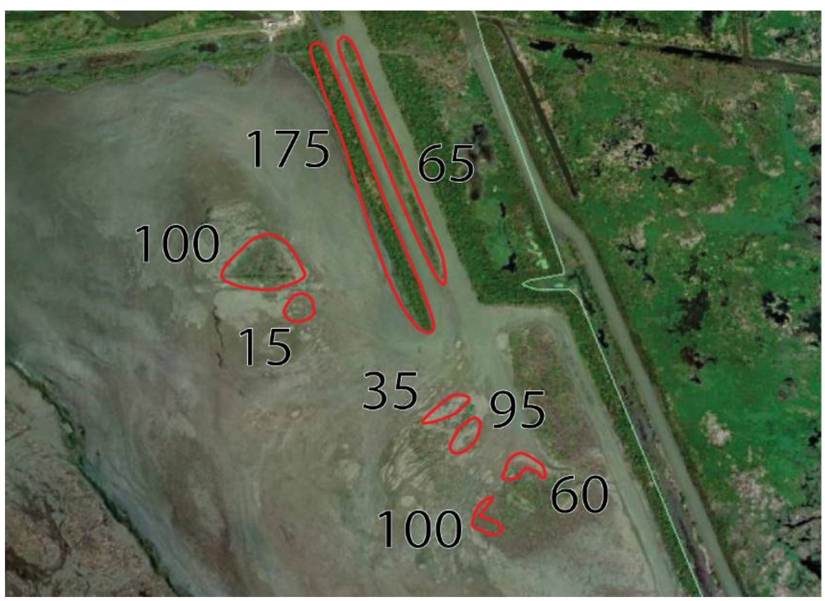

Figure 16: November 2011 planting locations in Big Mar Pond.

During the November planting, it was noted that the trees planted in March (8 months prior) which had nutria protection tubes had grown significantly. Tree heights seemed to have roughly doubled, and the tree circumference had more than doubled. (No systematic measurements were taken.)

The monitoring visit on December 8, 2011 showed that almost all of the trees planted in the prior month had survived their first three weeks in the ground. A few had died of shock, but the only nutria damage was on trees whose protections had come loose. Longer stakes are needed to secure the nutria protections in soft mud. Trees that had been planted in prior plantings and had survived were thriving.

Figure 17: November 2011 - LPBF staff (Dr. Ezra Boyd) with an unplanted baldcypress tree, next to a tree that had been planted in March of 2011. The larger tree was roughly the same size as the smaller tree when planted, showing good growth over eight months. Note the nutria protection tube type used in March was a solid plastic cylindrical tube.

December 2011 Status of Project area and Re-forestation

Figures 18 and 19 are oblique plane photographs taken over Big Mar Pond on December 8, 2011. They indicate some senescence and submergence of the delta area. The pro-delta area seems to have additional wetland area and to have consolidated into larger continuous areas of wetlands. This is further indication of this area's viability for future cypress planting. It is expected that continued wetland expansion will occur in Big Mar Pond and nearby areas.

A total of 1,025 baldcypress trees have been planted in three plantings, starting in October 2010 (**See Table 1 below**). Monitoring suggests that 656 of these trees are currently alive, so the current overall survival rate is 64%. However, it is clear that survival is distinctly different for trees with and without nutria protection tubes. For those 330 trees without tubes, we suspect survival is virtually 0%. Trees with nutria protection tubes have a much higher survival rate, which, at this early stage (less than one year since planting), appears to be more than 90%. The trees planted in March 2011 with nutria protection tubes have approximately doubled in height and girth, indicating that the need for the nutria protection tubes will diminish quickly. Therefore, the long-term prognosis for the baldcypress re-forestation appears to be feasible with initial application nutria protection tubes, and other lessons learned from this project (see table below).

Figure 18: Photograph taken December 8, 2011 showing the Caernarvon Delta area in Big Mar Pond (Courtesy of Frank Cole -LA DNR-CMD).

Figure 19: Photograph taken December 8, showing the pro-delta area **in** Big Mar Pond. 2011 (Courtesy of Frank Cole -LA DNR-CMD)

Activity	Date	Discharge cfs	Water level ft	# trees planted	Estimated Survival
Reconnaissance	March 24, 2010	1,000	0.9		
Reconnaissance	August 27, 2010	0	1.0		
Planting	October 15, 2010	600	0.9	200	0
Planting	March 11, 2011	2,000	1.8	175	
Monitoring & nutria protection	April 1, 2011	1,200	1.5		44
Completed nutria protection	April 4, 2011	1,200	0.9		
Monitoring	June 8, 2011	600	0.8		
Monitoring	August 24, 2011	3,000	1.7		38
Over flight LPBF	August 29, 2011	2,800	1.7		
Mapping of new delta & veg ID	September 16, 2011	1,100	0.9		
Planting	November 1-3, 2011	1,500	1.4	650	618
Monitoring & Planting	November 8, 2011	2,200	1.7		
Over flight pictures DNR	December 8, 2011	2,100	1.6		
Monitoring	December 12, 2011	3,300	1.6		
TOTAL				**1025**	**656**
% overall survival					**64%**
% survival w/nutria protection					**95%**

Table 1: Summary of Activities and tree survival rates

Future Planning and Lessons-Learned

The final 600 trees of this planting project are scheduled to be planted in March 2012. However, field reconnaissance in 2011 indicates that there are suitable sites for thousands more trees to be planted in Big Mar Pond (pro-delta) and the adjacent wetlands that receive fresh water from the Caernarvon diversion. With application of the lessons-learned and with continued operation of the diversion, this could be the beginning of a large-scale cypress swamp restoration effort in upper Breton Sound. Monitoring of the Caernarvon Delta re-forestation will continue through at least July 2013, when a final report will be completed.

Coastal restoration is gaining momentum in Louisiana, and applied research projects like this one make an important contribution to the growing body of knowledge on how to conduct restoration projects effectively. The planned restoration of the Central Wetlands (north and west of Caernarvon) will involve planting hundreds of thousands of trees and lessons learned from this planting can be incorporated into the planning process for that large restoration effort.

Lessons-Learned:

1. Monitoring did not begin until after the second planting. Monitoring should start immediately after each planting.
2. Planning must consider that soil conditions on the Caernarvon Delta vary dramatically (very soft to firm) in the planting areas and can be difficult or impossible to walk on for planting.
3. Tree planting with volunteers in canoes and with airboat support is adequate for planting.
4. Planting within Big Mar Pond may be hazardous or challenging if the discharge through the Caernarvon Diversion exceeds 3,500 cfs.
5. Requests to reduce the Caernarvon discharge for planting should consider the full possible impacts of altering the discharge.
6. The long-term success of the baldcypress re-forestation and continued land growth is dependent on the continued operation of the Caernarvon Diversion.
7. Nutria protection tubes used in the March 2010 planting are stiffer and may be preferable to those used in November 2011. The tubes used in November required bamboo poles which, in some cases, were still inadequate to keep the tubes in place.
8. Since an expanding delta has inherent geomorphic changes and a dynamic evolution, baldcypress trees should be planted on stable ground indicated by the presence of some emergent vegetation for optimal results.
9. Nutria protection tubes should be used on all baldcypress trees and installed at the time of planting, regardless of local alligator populations or the visible presence of the invasive rodents.
10. Better documentation of tree characteristics (girth & height)should be acquired prior to planting.
11. Future monitoring should include representative sampling of tree height and girth.
12. Accurate location and counting of the planted trees is essential during the work process, preferably using GPS and photography.
13. Monitored trees should be clearly marked with fluorescent tape or flags, because finding a particular plant in the marsh is difficult once the dense native vegetation has grown up around it.
14. Using different colored tags or nutria protection tubes to track trees planted at different times would be useful.

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- The numerous volunteers who came out to plant trees in sometimes not favorable conditions
- Coalition to Restore Coastal Louisiana for partnering with LPBF and providing the trees through their "10,000 Trees for Louisiana" project
- The Delacroix Corporation for use of their boat launch.