Central Wetlands Study:
Soil and Surface Salinity and Vegetative Communities,
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Introduction

The Central Wetlands (CW) are 30,000 acres of wetlands that are bordered by the Mississippi River Gulf Outlet (MRGO) to the east and the 40 Arpent Canal, also known as the Florida Canal, and levee to the west. The CW are located mostly in St. Bernard Parish (the triangle in the northern most corner is in Orleans Parish), positioned between the waters and marshes of Lake Borgne and greater New Orleans. Historically, the CW was a dynamic environment with a combination of bald cypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*) swamp, fresh and brackish marsh, as well as some bottomland hardwood forest (USACE 1999). This provided natural storm surge protection for the people of New Orleans until the mid 20th century.

In the early part of the 20th century there was extensive logging in the CW. A second generation of bald cypress did grow, however, construction of the MRGO in 1968, as well as the dredging of many oil and gas canals, changed the natural hydrology of the CW so much so that the second generation of swamp almost completely died off (Barras et al. 2008). At the same time, fresh marsh in the CW began converting to brackish marsh and open water, mainly attributed to hurricane scouring and saltwater intrusion (Morton and Barras 2011). The canals associated with the MRGO, oil and gas infrastructure, and logging, became conduits into the CW for salt water. Interstitial water salinity (also referred to as soil salinity) is one of the major limiting factors of plant community composition in wetlands (Odum 1988; Earle and Kershaw 1989; Mitsch and Gosselink 1993; Howard and Mendelssohn 1999). Further, the spoil banks associated with the construction and maintenance of canals impound wetlands, hinder sheet flow, and dissected the Central Wetlands into several impoundments. Spoil banks cause impoundments to remain flooded and stagnant, which affects seed germination (Middleton 2009), and prevent water exchange that would naturally “freshen” an area impacted by salt water intrusion from storm surges. These cumulative impacts have prevented the CWU from functioning as a natural storm surge buffer for the city of New Orleans. Currently, the CW is a mosaic of wetlands habitats that range from realtively healthy with stable soil and dense vegetation to open water and ghost swamps (Figure 1).

![Figure 1: Different habitats present in the Central Wetlands today from densely vegetated *Spartina patens* marsh to remnant cypress-tupelo swamps to open water and ghost swamps.](image-url)
There has been great interest and much conversation about the restoration and effective management of the CW since Hurricane Katrina devastated much of the Ninth Ward community and surrounding area. The closure of the MRGO in 2007 was a first step. Currently there are several restoration plans and experimental pilot projects in consideration that would impact the CW and would attempt to restore some of the natural habitat while strengthening ecosystem services. These plans and proposals include a river diversion at the Violet Siphon, marsh creation and stabilization with dedicated dredge material, and cypress-tupelo and marsh plantings. Planting projects are a part of nearly all restoration plans in southeast Louisiana and their success depends largely on the suitability of the planting location, including the interstitial soil salinity and hydrological conditions, to the vegetation being planted. To this end, LPBF investigated the soil salinity across the CW to ascertain the suitability of the area for swamp restoration and to gain a general understanding of the soil salinity dynamics in the area, including the effect of the numerous spoil banks and impoundments. An in-depth understanding of the environmental parameters found across these sub-units will allow for more informed planning of restoration activities, which will increase the success and effectiveness of those restoration activities and their impact on the surrounding communities.

Methods

LPBF began collecting salinity data beginning January through March of 2013. We initially set out to collect samples at thirty sites, but quickly expanded the number of sites to fifty. Thirty-seven of the sites are situated within the CW. The remaining thirteen are located in the marshes between the MRGO and Lake Borgne, including the Golden Triangle and Proctor Point. We used the LPBF 14’ flat-bottom boat to navigate and sample within the CW and the 19’ Cape Horn to reach the marsh sites along the MRGO. Some of the sites located on the west side could be accessed by road. To sample the soil pore water, soil sipper technology was used (Folse et al. 2008)(Figure 2). The soil sipper is a rigid plastic tube that is inserted 30cm into the ground with small holes drilled at the tip. The rigid plastic tube is connected to other soft plastic tubing and then a syringe. The syringe is used to create suction which draws the water out of the soil. The syringe is filled with water that is then discarded three times before sample collection begins. A number of samples are drawn and collected into a sample jar until there is enough water to measure salinity. Before salinity is measured the sample is homogenized. The soil sipper technique was chosen over installing permanent PVC wells which requires landowner permission, is time consuming and expensive to install and are at risk for vandalism in the field. At of the 50 sites, a soil porewater was collected and salinity was determined, surface water salinity was determined (if possible, standing water was needed) and a meter square randomly assigned plot near the soil salinity extraction point was measured for percent total plant cover and percent cover by species. In addition, as part of our Hydrocoast Map data collection process, surface salinity was measured every two weeks in the triangle and periodically throughout the CW.
Figure 2: Soil sipper used to extract soil pore water to measure soil salinity.

Results

The data show a slight west to east salinity gradient inside the CWU and a north to south gradient outside the CW. Within the CW, the gradient is likely influenced by pump stations for storm water and treated wastewater runoff into the CW at several sites along the 40 Arpent Canal. Further, some freshwater input from the Mississippi River through the Violet Siphon likely also impacts the salinity gradient in the CW (Figure 3). Outside the CW, the gradient is likely influenced by the rock dam closure across the MRGO. While the west to east salinity gradient is present in the CW on a large scale, there is variability based on the impoundments that are present. In the southeast corner of the CW, below the Violet Canal. There are several impoundments evident from aerial photography. There appears to be a minimum of six impoundments but more are less could be present depending on how disconnected these areas are from regular water exchange with waterways and the ability of rainwater to flush out saltwater that is introduced during storms. If some cases, the soil salinity was very different with taken on either side of a canal which indicates that these impounded areas are different hydrologically and have varying connections to water bodies (Figure 4). At one site, the soil salinity was 4.7 on one side of the canal and 6.9 on the other side. It was clear visually that the soil bank on the side with the higher soil salinity has a higher and more intact spoil bank while the soil bank on the other side was lower and degraded. The degraded soil bank me have allowed for more flushing and water exchange between the marsh and the canal during high water. In the section of the CW between Paris Road and the Violet Canal, there are less impoundments and a strong west to east salinity gradient is evident (Figure 5). In the triangle area at the northern end to the CW and in the next unit to the south (both north of Paris Road) there is also in strong salinity gradient from the 40 arpent canal, where salinity is lowest to Bayou Bienvenue, where salinity is highest (Figure 6).
Figure 3: Soil salinity in the winter of 2013 in the Central Wetlands and at the reference sites along the MRGO. Soil salinity tended to be lower near the 40 Arpent Levee and Canal and higher towards the MRGO, most likely due to influence from rainwater runoff and pump station discharge during rain events.

Figure 4: The existence of impoundments in the southeast corner of the Central Wetlands are evident and supported by the different soil salinities that were measured in the impoundments, even when in close proximity, on either side of a canal.
Figure 5: Soil salinity in the Central Wetlands between Paris Road and the Violet Canal. A strong soil salinity gradient is evident with low salinities near the 40 Arpent Levee and Canal and higher salinities near the MRGO.

Figure 6: Soil salinity in the Central Wetlands north of Paris Road.
The surface salinity was measured at or near each soil salinity point if possible. Surface salinity was measured if there was standing water on top of the marsh deep enough for a measurement or if there was water nearby (a pond, bayou, etc.). The surface salinity was measured to ensure that the soil salinity measurements were accurate. If the soil salinity and the surface salinity were the same then this was an indication that the soil salinity sample was contaminated with surface salinity. In almost all cases, the surface salinity was lower than the soil salinity both in and outside the CW (Figures 7-10). Sometimes the difference between soil and surface salinity was greater than 5ppt. In the area south of Violet Canal, where there are the most impoundments, the surface salinity was fresher than the soil salinity, even in areas where the soil salinity was fresh because of the influence of the storm water pump stations (Figure 7). In the section between Paris Road and Violet Canal surface salinities did not exceed 4 ppt while soil salinities up to 7.8 were measured (Figure 8). In the area north of Paris Road surface salinities were below 2.5 ppt while soil salinities of 6.5 were found (Figure 9). Outside the CW, in the Golden Triangle, the difference between the surface salinity and the soil salinity was variable (Figure 10). In some cases there were larger differences, (surface = 3.3 ppt), soil = 7.5 ppt) and in some cases the difference was small (surface = 5.6ppt, soil = 5.7 ppt). Alternatively, in some cases, the surface salinity was higher than the soil salinity.

Figure 7: Soil and surface salinity in the Central Wetlands south of Violet Canal. Notice the impact of impoundments on both surface and soil salinity.
Figure 8: Surface and soils salinity in the Central Wetlands between Paris Road and the Violet Canal. Surface salinities are fresh near the 40 Arpent Levee and Canal.

Figure 9: Surface and soil salinity in the Central Wetlands north of Paris Road. The surface salinities remained fresh across the area while the soil salinity was more variable.
Surface and soil salinity in the Golden Triangle, outside of the Central Wetlands. The marshes in this area are less impounded and have a more natural hydrologic connection to nearby water bodies when compared to the Central Wetlands.

Surface salinity was measured in canals periodically throughout the CW for our Hydrocoast Map products. These data were used over time to track salinity fluctuations at six locations within the CW (Figure 11). The salinity was freshest over time in the triangle at the north end of the CW. Fresh conditions were also found in the Violet Canal during the spring, coinciding with openings of the Violet Siphon. Generally, however, the surface salinity in the CW was similar across five of the locations (the triangle site demonstrated a different pattern) with higher salinities in the late summer to early winter and lower salinities in the spring. The highest salinity measured was 8.0 ppt in January, 2013. These data indicate that the surface salinity in the canals in much of the CW fluctuates in unison and is similar across the region.

Figure 10: Surface and soil salinity in the Golden Triangle, outside of the Central Wetlands. The marshes in this area are less impounded and have a more natural hydrologic connection to nearby water bodies when compared to the Central Wetlands.

Figure 11: Surface salinity at six locations across the Central Wetlands. Salinity was measured in canals except at the Triangle location where it was measured in open water.
Total percent plant cover and percent cover by species was measured near each soil salinity extraction site. In total, there were twelve terrestrial plant species found (submerged aquatic vegetation in open water sites was excluded from this analysis) in the CW and the reference sites to the east. Of the twelve species, four are found in fresher habitats and eight are found in brackish or salt marsh habitats. The four fresh species found were alligator weed (*Alternanthera philoxeroides*), floating marsh pennypwort (*Hydrocotyle ranunculoides*), Jesuit’s bark (*Iva frutescens*), and dotted smartweed (*Polygonum punctatum*). The brackish and salt marsh species found were flatsedge (*Cyperus* sp.), saltgrass (*Distichlis spicata*), fimbry (*Fimbristylis* sp.), wand lythrum (*Lythrum lineare*), smooth cordgrass (*Spartina alterniflora*), three-square bulrush (*Schoenoplectus americanus*), saltmeadow cordgrass (*Spartina alterniflora*) and southern annual saltmarsh aster (*Symphytichum divaricatum*). No clear pattern of plant distribution was detected except that near the E.J. Gore Pumping Station in the southwest corner, where soil salinity is low (1.4 ppt), there is a fresh marsh community whereas the rest of the sites had brackish or saltmarsh communities. It was also found that plant communities located in close proximity but in different impoundments (located on either side of a canal) had different species composition and percent cover.

**Discussion**

There are many restoration projects that are proposed for the CW, including marsh creation, the Violet Diversion and wastewater assimilation. Some of these projects propose restoring some of the CW to swamp forest. The desire to restore the area to swamp forest was what precipitated this research. There was little data on whether the soils of the CW were suitable for swamp, mostly bald cypress, restoration. In general, bald cypress does not tolerate extended periods of flooding with salinities greater than 2 ppt or saturated soils higher than 2 ppt. While bald cypress can survive extended periods of flooding (not seedlings) and can survive pulses of salinities up to 10 ppt, the combination of flooding with saline water proves detrimental to growth and survival (Allen et al. 1996), especially if encountered during the growing season (Iwanaga et al. 2011). Currently, there are few places that bald cypress could be restored in the CW, using the 2 ppt salinity cutoff, as indicated by the soil salinity data. Areas near the E.J. Gore Pumping Station and near the Meraux Pumping Station, located north of Gore, have soil salinities below 2 ppt. However, the plant community found near the Meraux station was not indicative of a fresh plant community, being dominated by saltmeadow cordgrass. This could indicate that the area is in transition, that the soils could support fresh vegetation but the plant community has not yet responded. On the contrary, the soils could experience salt pulses at other times of the year, making the area unsuitable for plant communities associated with fresh conditions. While fresh marsh plant species have low tolerance for salt marsh conditions, experiencing decreased growth rates and increased mortality (Spalding and Hester 2007), the same is not true for salt marsh plants exposed to freshwater. In general, plants that are tolerant of high salinity can tolerate or thrive under fresh conditions, but are usually outcompeted in fresh environments and are relegated to saltier environments where competition is reduced (Crain et al. 2004; Castillo et al. 2005). Therefore, there is often a lag time for vegetation change when soils freshen. In general, the CW is not currently suitable for swamp forest restoration.

The data collection for this project was funded for two years (by other sources) and data has already been collected (but not analyzed) in the summer of 2013 and the winter of 2014 and the final round of data collection will be in summer of 2014. There is potential for soil salinity and vegetation changes to occur over time in CW. With the closure of the MRGO there is less potential for saltwater intrusion into the CW so the region could freshen over time. Over the two year data collection period, seasonal fluctuations in soil salinity and vegetation cover will be detected as well as any long-term trend for changes in soil salinity or plant community composition. At the end of the data collection and analysis, recommendations will be made on the future of restoration projects in the CW and on what
types of projects should be implemented in different regions of the CW. Restoration of the CW to its previous density of swamp and marsh habitats is most likely impossible. However, the potential is high for strategic restoration to swamp habitat where soils are suitable or can be pumped in and restoration or enhancement of other marsh types through hydrologic restoration and marsh nourishment. The CW can be converted into a healthy wetland complex supporting a variety of marsh habitats and wildlife. The continued monitoring of the CW will provide guidance to the most effective restoration plan for the area.

References