Update on Potential Occurrence of Natural Swamp Regeneration on the Maurepas Land Bridge, Southeast Louisiana: 2017 Data Collection

Theryn Henkel
Eva Hillmann
Kristen Butcher
David Baker

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Introduction

The Lake Pontchartrain Basin Foundation (LPBF) began documenting the potential occurrence of natural swamp regeneration on the Maurepas Land Bridge in 2016 (Figure 1) (Henkel et al. 2017). In 2017, study plots were revisited and trees re-measured. This update will serve as a supplement to the first report published describing this data collection effort called “Potential occurrence of natural swamp regeneration on the Maurepas Land Bridge, Southeast Louisiana.” The citation and hyperlink to this report can be found in the literature cited section of this document.

Figure 1: Location of the natural swamp regeneration study area on the Maurepas Land Bridge.

The background information presented in the previous report remains valid. It appears that conditions on the Maurepas Land Bridge continue to improve for natural swamp regeneration. Soil salinities have been decreasing of the land bridge since the closure of the Mississippi River Gulf Outlet (MRGO), and continued to decrease through 2017 according to the Coastwide Reference Monitoring System (CRMS) (Figure 2). While there is a risk that soil salinity could spike during a drought year, killing many trees naturally recruited since the closure of the MRGO, there is a chance that conditions have changed enough to protect the region from devastating impacts from drought. The baseline salinities are much lower than what was experienced during the most recent drought (1999-2000) when surface salinities spiked to 16 ppt. Additionally, since the MRGO was closed, a large conduit for saltwater intrusion into Lake Pontchartrain has been eliminated, re-establishing the Rigolets and Chef Menteur Passes as the dominant pathways for salinity exchange up and down the estuary. Lastly, there are three river diversions proposed in the Louisiana State Master Plan which would provide freshwater, nutrients, and sediment to this region (CPRA 2017a). Given these factors, there is a possibility that natural swamp regeneration may continue into the future.
Figure 2: Soil salinity over time at two Coastwide Reference Monitoring System (CRMS) stations on the Maurepas Land Bridge. These CRMS stations are located on the north and south side of Pass Manchac. Soil salinity continued to decrease on the Maurepas Land Bridge through 2017.

Methods

Data Collection

The methods for data collection in 2017 were the same as in 2016; with the exception of herbaceous vegetation, which was not surveyed in 2017. In the same eight plots previously established in 2016 (Figure 3), all tagged trees were re-measured, or recorded as dead. Any new trees located in the plots were tagged, identified, measured, and a GPS location was recorded. Soil salinity was measured at the center of each plot; and elevation measured at each of the four corners and at the center of each plot (see Henkel et al. 2017).

Analysis

Differences in all parameters (DBH, soil salinity, elevation) were assessed between 2016 and 2017 using repeated measures ANOVA. Mortality rates were also calculated across all plots and within plots. Due to the fact that there were a small number of new trees in the plots and low mortality (described in the results section), Shannon’s Diversity Index (Hill 1973) and the Floristic Quality Index (Cretini et al. 2012) were not re-calculated for the 2017 data. Biomass was calculated using the same allometric equations presented in Henkel et al. 2017 (Chojnacky et al. 2014) (Table 1). Density distributions of DBH by plot and species were created.

Table 1: Allometric equations used to calculated tree biomass.

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Allometric Biomass Equation*</th>
<th>Diameter range (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acer rubrum</td>
<td>Red Maple</td>
<td>Y = -2.0470 + 2.3852ln(dbh)</td>
<td>3-109</td>
</tr>
<tr>
<td>Fraxinus pennsylvanica</td>
<td>Green Ash</td>
<td>Y = -2.0314 + 2.3524ln(dbh)</td>
<td>3-43</td>
</tr>
<tr>
<td>Nyssa aquatica</td>
<td>Water Tupelo</td>
<td>Y = -2.2118 + 2.4133ln(dbh)</td>
<td>3-64</td>
</tr>
<tr>
<td>Nyssa sylvatica</td>
<td>Blackgum</td>
<td>Y = -2.2118 + 2.4133ln(dbh)</td>
<td>3-64</td>
</tr>
<tr>
<td>Quercus virginiana</td>
<td>Live Oak</td>
<td>Y = -3.0304 + 2.4982ln(dbh)</td>
<td>3-74</td>
</tr>
<tr>
<td>Salix nigra</td>
<td>Black Willow</td>
<td>Y = -2.4441 + 2.4561ln(dbh)</td>
<td>3-70</td>
</tr>
<tr>
<td>Taxodium distichum</td>
<td>Bald Cypress</td>
<td>Y = -2.6327 + 2.4757ln(dbh)</td>
<td>3-109</td>
</tr>
<tr>
<td>Triadica sebifera</td>
<td>Chinese Tallow</td>
<td>Y = -2.5095 + 2.5433ln(dbh)</td>
<td>4-42</td>
</tr>
<tr>
<td>Ulmus americana</td>
<td>American Elm</td>
<td>Y = -2.2118 + 2.4133ln(dbh)</td>
<td>3-64</td>
</tr>
</tbody>
</table>

*Equations from Chojnacky et al.

Y = Biomass (kg); dbh = diameter at breast height (cm)
Results

Elevation

Elevation was not significantly different by plot over time (p=0.93). Mean elevation in 2017 across all plots (all 40 measurements taken) was 0.09 m ± 0.13 (0.33 ft ± 0.44). Elevation ranged from -0.21m to 0.31m (-0.71 ft to 1.0 ft). In 2016 elevation ranged from -0.26 to 0.26 meters (-0.88 to 0.88 ft.) across all plots.

Figure 3: Location of the eight study plots on the Maurepas Land Bridge.
Soil Salinity
Soil salinity was not significantly different by plot over time (p=0.11), but did decrease slightly. Mean soil salinity across all plots in 2016 was 1.7 ppt ± 0.61 and in 2017 was 1.5 ppt ± 0.7 (Figure 4).

![Soil Salinity in 2016 and 2017 by Plot](image)

Figure 4: Soil salinity in 2016 and 2017 in each plot. Six of the eight plots decreased in soil salinity while two (5 and 6) increased.

Woody Vegetation

Species Composition
In 2016, there were 647 trees located in the eight plots. In 2017, 16 new trees were found in five of the plots. Of the 16 trees, six were likely already in the plots but missed the previous year. This was determined by the size of the trees, which indicated they were older than 1-year old saplings. Swamp red maple (*Acer rubrum var. drummondi*) had the most new trees (7), although three were most likely already in the plot (DBH over 7.0 cm). Chinese tallow (*Triadica sebifera*) had the second highest number of new trees (4). Two new green ash (*Fraxinus pennsylvanica*) trees were located (one likely present in 2016), and water tupelo (*Nyssa aquatica*), black willow (*Salix nigra*), and bald cypress (*Taxodium distichum*) each had one new individual, but the water tupelo and black willow trees were likely present in 2016. New trees were found in plots 2, 4, 5, 6, and 8. The pattern of richness increasing while soil salinity decreased remained similar to the previous year and no new species were detected in any of the plots.

Tree Size
In 2017, DBH ranged from 0.2 to 97.8 with a mean of 17.4 cm ± 14.3. The density distribution across all plots and species remained similar between 2016 and 2017 (Figure 5). DBH was not significantly different by year (p=0.729) or by the interaction of species and year (p=0.998). DBH was significantly different by species in 2017 (similar to 2016; p<0.001) and can be explained by the density
distribution by species in both years (Figure 6). Red maple, Chinese tallow, and green ash tended to have smaller individuals (10 cm or less), bald cypress had individuals of all sizes (small to over 70 cm), and water tupelo, black gum and black willow had trees of intermediate size (around 25 cm). These patterns were the same in both years. The mean growth rate across all plots and species was 0.35 cm ± 0.81. The species with the largest mean growth rate was black willow (0.92 cm ± 0.93), followed by bald cypress (0.79 cm ± 0.99) and water tupelo (0.5 cm ± 0.92). The species with the lowest growth rates were green ash (-0.03 cm ± 0.8), Chinese tallow (0.14 cm ± 0.47) and swamp red maple (0.17 cm ± 0.32). Blackgum had an intermediate growth rate (0.31 cm ± 0.42).

Figure 5: Density distribution plot of DBH (cm) across all species and plots for 2016 (left) and 2017 (right). The DBH distribution is very similar for both years.

Figure 6: Density distribution plot of DBH by species. The plots are similar for 2016 (left) and 2017 (right). Common names (left) and scientific names (right) are both shown.

Biomass

Biomass increase was calculated for each tree between 2016 and 2017. Although the growth rates reported above may seem low, it is important to calculate the biomass increase because larger
trees may only show small diameter growth but this incremental growth along the trunk of a tall tree can translate to a large amount of biomass that a tree produces. Mean biomass in 2017 was 248 kg ± 449 (546 lbs ± 989) (Table 2). This is an average increase of 10.2 kg (22.5 lbs) of biomass from 2016 (this calculation includes loss of biomass due to mortality). Total biomass in all plots in 2017 was 146,427 kg (322,816 lbs) an increase of 4,146 kg (9,140 lbs). Tree biomass increased on average by 6.8 kg, or 15 lbs (605 trees used; trees too small for allometric equations were eliminated). The species with the largest increase in both total and mean biomass was bald cypress (despite only having the second highest mean growth rate) (Table 2). Bald cypress had more and larger individuals, translating to higher biomass increases with lower growth rates. Water tupelo had the second largest total biomass increase, but black willow had the second largest mean biomass increase. Blackgum had the largest decrease in biomass. This is most likely due to the mortality of one individual that was 34.0 cm or 543 kg in 2016. This was the largest blackgum individual in the study plots. When the loss of this individual is eliminated, the mean biomass increases 4.98 kg between 2016 and 2017. The biomass of Chinese tallow also decreased, likely due to the loss of one larger individual (11.4 cm, 39.68 kg). Using the biomass and plot size, it was determined that the biomass increase was 207 g/m²/yr across all plots.

Table 2: Biomass changes between 2016 and 2017 by species. Biomass was calculated using the equations in table 1.

<table>
<thead>
<tr>
<th>Species</th>
<th>Total Biomass 2016 (kg)</th>
<th>Total Biomass 2017 (kg)</th>
<th>Increase/Decrease in Total Biomass 2016-2017 (kg)</th>
<th>Mean Biomass 2016 (kg)</th>
<th>Mean Biomass 2017 (kg)</th>
<th>Increase/Decrease in Mean Biomass 2016-2017 (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swamp Red Maple</td>
<td>1,818.71</td>
<td>1,916.88</td>
<td>98.17</td>
<td>16.09 ± 13.91</td>
<td>16.96 ± 14.29</td>
<td>0.83 ± 6.07</td>
</tr>
<tr>
<td>Green Ash</td>
<td>1,234.54</td>
<td>1,248.38</td>
<td>13.84</td>
<td>14.87 ± 19.34</td>
<td>15.04 ± 20.16</td>
<td>0.16 ± 2.79</td>
</tr>
<tr>
<td>Water Tupelo</td>
<td>87,391.84</td>
<td>89,454.99</td>
<td>2,063.16</td>
<td>365.66 ± 245.97</td>
<td>385.58 ± 255.68</td>
<td>8.63 ± 63.9</td>
</tr>
<tr>
<td>Blackgum</td>
<td>2,817.71</td>
<td>2,393.72</td>
<td>-424.00</td>
<td>112.71 ± 114.03</td>
<td>99.74 ± 77.68</td>
<td>-16.96 ± 110.07</td>
</tr>
<tr>
<td>Live Oak</td>
<td>17.59</td>
<td>18.01</td>
<td>0.42</td>
<td>Only One Individual</td>
<td>Only One Individual</td>
<td>Only One Individual</td>
</tr>
<tr>
<td>Black Willow</td>
<td>1,389.86</td>
<td>1,579.10</td>
<td>189.24</td>
<td>115.82 ± 104.88</td>
<td>131.59 ± 122.79</td>
<td>14.56 ± 23.62</td>
</tr>
<tr>
<td>Bald Cypress</td>
<td>46,843.82</td>
<td>49,053.24</td>
<td>2,209.43</td>
<td>650.61 ± 925.88</td>
<td>671.96 ± 998.23</td>
<td>30.27 ± 121.30</td>
</tr>
<tr>
<td>Chinese Tallow</td>
<td>734.18</td>
<td>728.55</td>
<td>-5.63</td>
<td>14.39 ± 12.15</td>
<td>14.57 ± 12.01</td>
<td>-0.11 ± 5.87</td>
</tr>
<tr>
<td>American Elm</td>
<td>32.64</td>
<td>34.15</td>
<td>1.51</td>
<td>Only One Individual</td>
<td>Only One Individual</td>
<td>Only One Individual</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>142,280.89</strong></td>
<td><strong>146,427.02</strong></td>
<td><strong>4,146.13</strong></td>
<td>238.33</td>
<td>248.60</td>
<td>10.28</td>
</tr>
</tbody>
</table>

**Mortality**

Of the 647 trees measured and tagged in 2016, 17 were found dead in 2017 (2.6%). The mean DBH of the dead trees was 14.9 cm ± 10.8, with a maximum DBH of 34.0 cm (blackgum) and minimum DBH of 0.8 cm (bald cypress). Mortality was experienced in four of the eight plots (Figure 7). Plots 1, 2, 3, and 7 did not experience any mortality. The plot with the highest mortality rate was plot 5 (4.7%), followed by Plot 4 (4.3%) (Figure 7). Plot 6 had 3.1% mortality and Plot 8 had 2.6 % mortality. Mortality was not correlated with soil salinity ($r^2 = 0.14$) as the plots with the highest and lowest soil salinity did not experience mortality. When the four plots with no mortality are removed there is a strong correlation of mortality with soil salinity ($r^2 = 0.95$); higher soil salinity resulted in higher mortality (Figure 8). However, this removes half of the plots from the data set, so there is caution in asserting elevated soil salinity is currently the prevailing mechanism for mortality in the region. Lastly, mortality differed by species. There was only one individual of live oak (*Quercus virginiana*) and American elm (*Ulmus americana*) and they both survived. The species with the highest mortality was black willow at 7.7 % (1 of 13 individuals died). Swamp red maple had the second highest mortality at 4.1% (5 of 121 individuals died), followed by blackgum at 3.6% (1 of 28 individuals died). Water tupelo had the most individuals
die, but had a mortality rate of only 2.9% (7 of 237 individuals died). Chinese tallow, bald cypress and green ash all had one individual die for mortality rates of 1.5%, 1.4%, and 1.2%, respectively. There was no trend of mortality with elevation.

Figure 7: Percent mortality by plot from 2016 to 2017 (orange bars) and overall mortality across all plots (blue line).

Figure 8: Percent mortality versus soil salinity. The correlation is not strong when all plots are considered (left; $r^2 = 0.14$) but become much stronger when plots with no mortality are removed (right; $r^2 = 0.95$). Half of the plots did not experience mortality so there is caution in asserting that elevated soil salinity is currently the prevailing mechanism for mortality in the region.
Discussion

The results of the 2017 re-sampling of the eight regeneration plots did not reveal many changes over the one-year time period. There were 16 new trees found in the plots and 17 trees that died. Ten trees possibly germinated since 2016, which indicates two possible means of natural regeneration: (1) natural regeneration is a slow, methodical process with a few new trees germinating every year, which results in a mixed age forest; or (2) natural regeneration is episodic, with many trees germinating in one or two year periods when conditions are ideal. Seeds then lie in wait for the next “germination episode,” resulting in a forest with many trees of the same age or a “cohort,” with gaps between the age classes. All species require some period of dry down to germinate but differ in preferred timing of dry down and ability to germinate (Burns and Honkala 1990). More data are needed to determine the basis of natural swamp regeneration in this region.

The mortality rates seen in this study are slightly higher than typical background mortality rates in this type of forest. Generally, background mortality, or “natural” annual mortality in swamp forests is between 1% to 2% (Chapman et al. 2008). Background mortality does not include mortality due to major climate events such as a hurricane or drought. In this study, overall mortality across all plots was 2.6%, or slightly higher than background mortality. All of the species in the plots experienced mortality (except for the one live oak and American elm individual) and it did not seem that any one species experienced high mortality. The species with the highest mortality (black willow) only had one individual die but resulted in a higher percent mortality because there were only 13 individuals to begin with. Overall, mortality rates were not high and were close to what would be expected in normal years. The low mortality is a good sign for the smaller (younger) trees, indicating that these new trees are thriving in the region.

The second year of data collection did not change any of the conclusions reached after the first year. New mortality and growth rate data provided useful information to further understand forest dynamics and indicators of forest health. Compared to other studies, mortality rates on the Maurepas Land Bridge were average, and growth rates ranged from average to low (Mitsch and Ewel 1979, Ewel and Wickenheiser 1988). The mean increase in biomass per tree was also comparable or towards the higher end to those found in other studies (Mitsch and Ewel 1979, Shaffer et al. 2009). The mean g/m²/yr across all plots was slightly lower than what has been categorized as healthy swamp in the region but slightly higher than relict swamp (swamp that is not reproducing) (Shaffer et al. 2009, Shaffer et al. 2016).

This limited data set suggests that the swamp forest on the Maurepas Land Bridge is in the beginning stages of natural regeneration. Pioneer species have colonized and climax species are present in lower numbers. The future of natural regeneration in the region is uncertain but there are a few factors that increase the chance of successful regional swamp regeneration. The closure of the MRGO has decreased both surface and soil salinity in the region and also may have decreased large fluctuations in salinity common when the MRGO was open (CPRA 2017b). Whether or not salinity spikes will be less severe during drought than previously experienced in the region (during 1999-2000) remains to be seen. Further, the freshwater and sediment diversions proposed for the region would also help maintain fresh salinities. There are 3 regional diversions proposed in the 2017 Louisiana State Master Plan, including the East Maurepas, Manchac Land Bridge and Union Diversions, all proposed for implementation within the next 10 years (CPRA 2017a). The East Maurepas Diversion has received funding to complete engineering and design and overall it appears there is an emphasis on salinity control in the region, which would promote natural regeneration and guard against future salinity spikes.

This study may be conducted less frequently in the future since only a small number of new trees recruited into the study plots between the first and second year of data collection. Re-measuring
existing trees and locating newly recruited trees every three years may be sufficient to determine the extent (in area and time) of natural swamp regeneration on the Maurepas Land Bridge. However, if regeneration is episodic rather than constant, not surveying the plots every year could cause researchers to miss a mass recruitment event, making it difficult to narrow down the conditions that were favorable for seedling recruitment, growth, and survival. Whatever the sampling regime, LPBF will continue to investigate natural swamp regeneration in this region.

References


