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Ecological response of forested wetlands with and without Large-Scale Mississippi River input: Implications for management

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ABSTRACT

We investigated two adjacent wetlands in the Lake Pontchartrain basin, one of which receives periodic input of Mississippi River water and one which does not, to gain insight into how isolation from river input impacts wetland loss in the Mississippi delta. The LaBranche (LB) wetlands bordering Lake Pontchartrain are severely degraded due to saltwater intrusion, subsidence, leveeing of the river, and hydrologic alterations including partial impoundment. Directly adjacent is the Bonnet Carré (BC) spillway, a geomorphically similar area that contains healthy baldcypress swamp. The spillway carries river water to the lake during high discharge years and has been opened eleven times in 80 years, with flows as high as 9000 $m^3\ s^{-1}$. The primary hydrologic difference between the two areas is the regular input of River water to the BC wetlands while the LB wetlands are isolated from the river. The interior of the LB wetlands is also isolated from sediment originating from Lake Pontchartrain. Long-term accretion, tree growth, and elevation were measured in these two wetland areas to determine impacts of riverine input. ^{137}Cs accretion rates in the BC wetlands were 2.6–2.7 cm yr^{-1}, compared to 0.43 and 1.4 cm yr^{-1}, respectively, in the LB wetlands in areas without and with sediment input from Lake Pontchartrain. Baldypress growth in the BC averaged about 2.3 mm ring width yr^{-1}, compared to 1.4 mm yr^{-1} in LB. Trees are of relatively the same age due to lack of recruitment and widespread logging. Tree height, an indicator of site quality, is about 20% less at the LB sites compared to BC, even though the trees are approximately the same ages. The average wetland elevation in the BC wetlands was about one meter with some areas higher than two meters, and was significantly higher than elevations in the LB (average sea level and 0.3 m, respectively, in areas with and without input from Lake Pontchartrain).

1. Introduction

Freshwater, sediments and nutrients from the Mississippi River formed the expansive network of deltaic wetlands in coastal Louisiana, including forested wetlands such as those that are the focus of this study (Roberts, 1997; Day et al., 2007; Törnqvist et al., 2006; Shaffer et al., 2009a). In the 20th century, there was a dramatic loss of about 25% of these coastal wetlands. This loss was due to a variety of factors such as pervasive hydrological alteration and enhanced subsidence, but there is broad consensus that isolation of the deltaic plain from riverine input is one of the primary factors contributing to this loss (Kesel, 1988, 1989; Mossa, 1996; Day et al., 2000, 2007). In an effort to restore marshes and freshwater swamps, water from the Mississippi River is being diverted into coastal wetlands, primarily in small-scale diversions less than 200 $m^3\ s^{-1}$ such as the Caernarvon diversion (Day et al., 2009).

Previous research has shown that these small river diversions can increase marsh primary production, wetland surface elevation, and vertical accretion (DeLaune et al., 2003; Lane et al., 2006; Day et al., 2007, 2009). However, there is concern that these diversions are so small compared to pre-levee flooding of the Mississippi River that they are not making a significant contribution to coastal restoration and that they may make wetlands susceptible to hurricane damage (Turner, 2010; Howes et al., 2010). In the past, large

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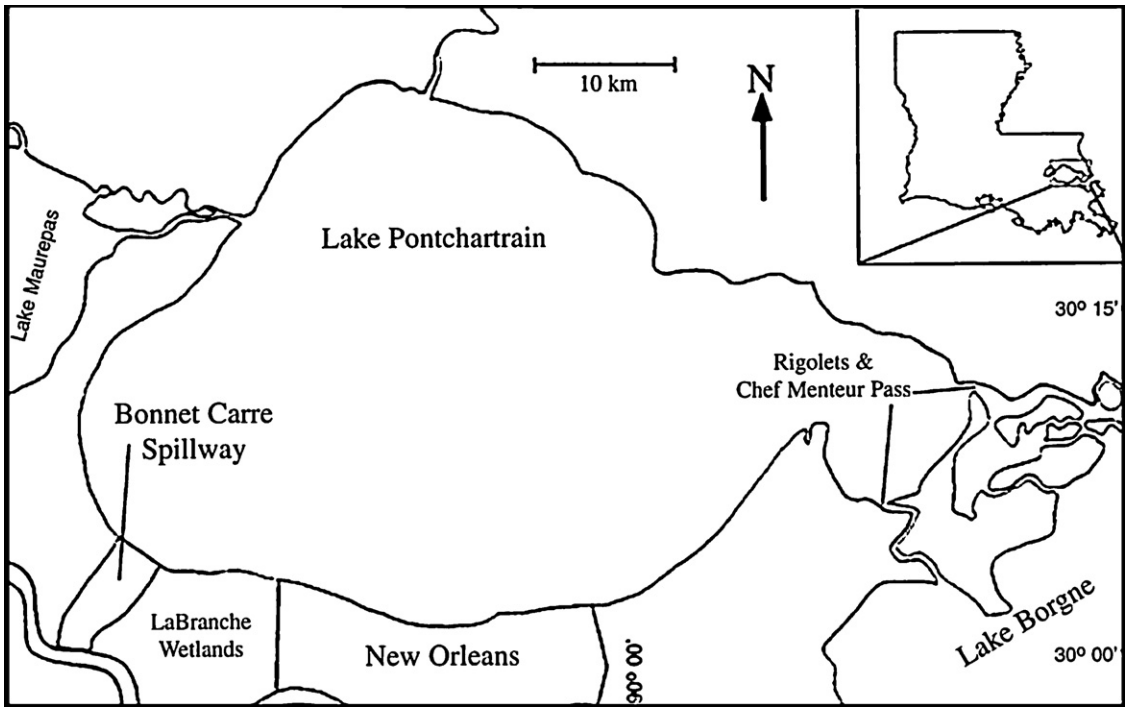

Fig. 1. Location of the Bonnet Carré Spillway and LaBranche wetlands within the Pontchartrain Basin, Louisiana. Figure reprinted with permission from author Lane et al. (2001).

crevasses on the Mississippi River were fairly common and they delivered large quantities of freshwater (generally with peak discharge between 5000 and 10,000 $m^3 s^{-1}$) and sediment to adjacent wetlands (Davis, 2000; Day et al., 2009). With larger river diversions planned for future restoration projects, it is important to understand how discharges of large volumes of water will impact wetlands.

One example of an area with large-scale riverine input is the Bonnet Carré spillway, which carries floodwaters from the river to Lake Pontchartrain Basin when high river levels threaten New Orleans (Fig. 1). The LB wetlands, located adjacent to the BC spillway and separated from it by an earthen levee, are an example of wetlands that have been isolated from the river by levees for more than a century. In this paper we compare baldcypress growth, sediment accretion, elevation in wetlands and other information in the BC wetlands with adjacent LB wetlands to determine impacts of an infrequent, large-scale diversion on forested coastal wetlands.

2. Objectives of research

We hypothesized that previous openings of the BC spillway have led to higher elevation, increased accretion, and increased cypress growth rates than in the LB wetlands that have been isolated from flooding from the Mississippi River for over a century. We also hypothesized that accretion rates in the BC wetlands are sufficient to offset current and projected increases in the rate of sea-level rise. To test our hypotheses, the objectives of this research were to:

1) Utilize LIDAR data to determine and compare elevations between the two study sites;
2) Determine long-term patterns of sediment accretion in the BC and LB wetlands using ^{137}Cs;
3) Determine long-term patterns of baldcypress growth in the study sites and relate patterns to environmental conditions such as precipitation, drought, and storms; and
4) Synthesize available information on the area to determine factors responsible for change over time.

3. Methods

3.1. Site description

3.1.1. Bonnet Carré Spillway

The BC Spillway was completed in 1931 in response to the great flood of 1927 (Barry, 1997). The purpose of the spillway is to decrease river stage to reduce flooding threat to New Orleans. The 3.4 km wide spillway is confined by two 8.6 km levees, and connects the Mississippi River to Lake Pontchartrain. A water flow regulation structure, consisting of 350 floodgates (each with twenty 20 cm × 30 cm creosoted wooden timbers 3.1–3.6 m in length), is located at the Mississippi River inlet. The structure is opened and closed by removing or replacing the timbers one at a time. Thus, it can take a week or more to completely open or close the structure. The spillway is located just downstream of the Bonnet Carré crevasse, one of the many natural crevasses that occurred in the 1800s, introducing up to 10,000 $m^3 s^{-1}$ of river water into Lake Pontchartrain during high flow events (Kesel, 1989; Davis, 1993). The spillway has 1300 ha of forested wetlands; approximately 50% of the total spillway area (Lane et al., 2001). Although the spillway was designed for flood control, its use as a freshwater diversion to manage salinity levels for oyster production and to provide sediments and nutrients for wetland restoration has been considered (Lane et al., 2001).

Since 1931, the spillway has been opened eleven times during high water events of the Mississippi River, with flows ranging from 3100 to 9000 $m^3 s^{-1}$ (Table 1; Sikora and Kjerfve, 1985; Day et al., 1999; Lane et al., 2001). Spillway openings generally correspond to the peak hydrograph of the Mississippi River when snowmelt and rainfall in the upper basin increase flow and stage in the lower river. When open, water flows through the spillway into Lake