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Evolution of the oxbow morphology of the Caloosahatchee River in South Florida

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A B S T R A C T

The Caloosahatchee River, located in Southern Florida, was originally a meandering and relatively shallow river. During the 1920s, the Caloosahatchee River was channelized and became the C-43 canal. The channelization has significantly impacted the river ecosystem, particularly the oxbows. The oxbows are the U-shaped water bodies on each side of the river channel, which are the remnant bends of the original river. To understand how anthropogenic influence affects hydrologic systems, the study was designed to assess the geomorphic changes of 37 oxbows of the Caloosahatchee River, Florida. The study presented trends in the evolution of oxbow morphology by comparing the data collected in 2011 with a cross-sectional survey collected by the South Florida Water Management District in 1978. In both 1978 and 2011, oxbows in Lee County were significantly larger, wider and deeper than in Hendry County. Exterior limb cross-sections were significantly larger, wider and deeper than interior cross-sections in both 1978 and 2011. Finally, an attempt to determine trends in the evolution of the morphology of the oxbows demonstrated that the overall maximum depth is significantly decreasing in the interior of the oxbow and that the mean depth is significantly increasing in the exterior cross-sections. This analysis also showed that the width is significantly increasing throughout the oxbow. Factors responsible for such differences may include natural geomorphic processes, pattern changes due to channelization, land use and anthropogenic activities.

Introduction

The Caloosahatchee River is a South Florida river greatly impacted by the Central and Southern Florida Flood Control Project (CSFFCP). The river was dredged and channelized after disastrous floods following major hurricanes during the 1920s. The channelization and installation of lock and dam structures created opportunities for population and economic growth (SFWMD et al., 2009). Today, the C-43 channelized flood control and waterway is far from resembling the original narrow and meandering Caloosahatchee River. The health of the river has declined over the last decades, affecting the water quality and quantity (Doering & Chamberlain, 1999; Doering, Chamberlain, & Haunert, 2002; Liu et al., 2009), ecosystem (Merritt et al., 2002) and morphology (Antonini, Fann, & Roat, 2002; Milleson, 1979). As a result of channelization, the meanders of the Caloosahatchee River have been disconnected, and their conditions are degrading.

Although previous studies revealed the degraded conditions of the oxbows, there is no comprehensive geomorphological study that discusses a specific trend in their degradation. The purpose of this study is to assess the geomorphic changes of the oxbows of the Caloosahatchee River, Florida and to determine if these remnant meanders are gradually degrading over time and if so, by what mechanism(s) – sediment accumulation and/or bank erosion.

Oxbow lakes and channelization

Channelization is the manmade version of meander cutoff creation. Naturally, a meander cutoff experiences four phases: bend preparation, short circuit, oxbow lake, and infill (Erskine, Melville, Page, & Mowbray, 1982). A short circuit may be caused by two types of natural cutoff: a chute cutoff or a neck cutoff (Julien, Shah-Fairbank, & Kim, 2008). A chute cutoff usually forms when water flow creates a chute across the inside of a point bar, which decreases the sinuosity. The channel forms an interior bar. A neck cutoff occurs when river sediment is deposited continuously on the

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convex bank, and sediment is eroded from the concave bank. Consequently, the sinuosity of the meander increases until the two parts join. Eventually the neck will disappear and a straight channel is formed, thus creating an abandoned channel or cutoff. An oxbow lake is formed when the cutoff is isolated from the main channel by sediment deposition (Julien et al., 2008). Overtime, oxbow lakes tend to dry out (Julien et al., 2008) or become filled with sediments (Rasmussen & Mossa, 2011).

Water quality is an important component in trying to understand the dynamics of oxbow lakes and it is impacted by land use practices (Cullum, Knight, Cooper, & Smith, 2005; Glinska-Lewczuk, 2009; Zablotowicz et al., 2010). Toonen, Kleinhans, and Cohen (2012) studied sediment fills in oxbow lakes and they categorized the type of sediment in these lakes. Overbank sedimentation rates were studied in the upstream and downstream reaches, and the major findings were sedimentation rates were "slower in the narrow and straight channels" and "faster in large and sinuous channels" (Citterio & Piegay, 2009). Other studies have addressed hydrologic connectivity between the oxbow lakes and its floodplains (Hudson, Heitmuller, & Leitch, 2011; Phillips, 2011). The understanding of natural river path is complex due to human alteration of the environment (Citterio & Piegay, 2009; Slowik, 2011, 2012). In addition to anthropogenic factors, natural occurrences could also degrade oxbow lakes (Koc, Kobus, & Glinska-Lewczuk, 2009). In his study of the anthropogenic impacts on Obra River in Western Poland, Slowik (2011) found that natural river patterns were preserved in the sediment deposit. Even though in the current study sediment samples were not taken from the sites, this study is similar to Caloosahatchee River oxbow because the Obra River was channelized and its morphology was changed overtime. In another study, Large and Petts (1996) used aerial photography to determine channel changes over time on the Trent River. They reported on the need to protect the floodplains and natural habitat. Aerial photography have been used to document the changes to the river systems in the past (Beechie, Liermann, Pollock, Baker, Davies, 2006; Hooke, 2007; Kiss & Sipos, 2007; Kleinhans & van den Berg, 2011; Micheli & Larsen, 2011; Slowik, 2012; Zanoni, Gurnel, Drake, & Surian, 2008).

The first comprehensive study that focused on the Caloosahatchee River oxbows was the 1978 environmental inventory by Milleson for the South Florida Water Management District. This study first reported the degraded conditions of the oxbows. Subsequent studies to document oxbow conditions were initiated for the Caloosahatchee River Citizen Association (CRCA-Riverwatch) in 1996 and 2001 as documented by Capece, Wessel, and Gallant (2012, 177 pp) and Wessel, Capece, and Cham (2001). Merritt et al. completed a more comprehensive bio-assessment study in 2002. A limited bio-assessment on a single oxbow was completed by Southern DataStream (2006) prior to a restoration project funded by South Florida Water Management District and implemented by Hendry County. Vegetation in the river surroundings and floodplain pools are important in restoring the river ecosystem conditions (Gore & Shields, 1995).

Study area

The Caloosahatchee River watershed is located in southwest Florida, USA between Lake Okeechobee and the San Carlos Bay, Gulf of Mexico (Fig. 1). The watershed has an area of 1408 square miles and is spread among four counties: Charlotte, Lee, Hendry, and Glades (FDEP, 2011). The population within those counties is estimated at 830,000 inhabitants (BEBR, 2011). The study area is located between Franklin Lock (Lee County) and the City of LaBelle (Hendry County).

Originally, the narrow and meandering Caloosahatchee River had Lake Flirt, located approximately two miles east of LaBelle, as its source. A waterfall at Fort Thompson separated the Caloosahatchee from the marsh and lake systems that extended to Lake Okeechobee. During the rainy season, Lake Okeechobee would overflow and fill the sawgrass marshes flowing westward to Lake Hicpochee, Lake Bonnet, and finally to Lake Flirt up to the waterfall (Antonini et al., 2002). Today, the remnant bottom of Lake Flirt is a low-lying pasture in Glades County, north of Port LaBelle. East of S-79 (Franklin Lock) very little remains of the original Caloosahatchee. The excavated, straight channel that has replaced it is known as C-43 and serves as a flood control, water supply, and navigation waterway maintained by the U.S. Army Corps of Engineers (FDEP, 2005).

Prior to channelization, the river was surrounded by shrub, brushland, rangeland, upland forest and wetlands (Antonini et al., 2002). The channelization of the Caloosahatchee River provided opportunities for agricultural and urban development (SFWMD et al., 2009), which is today the dominant land use.

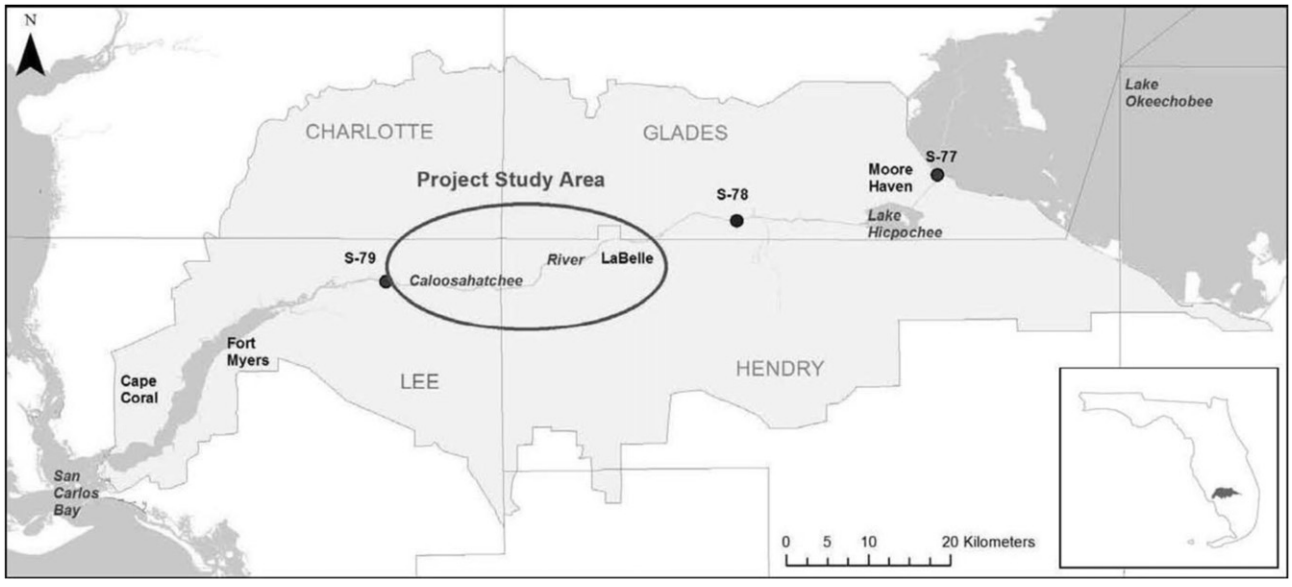

Fig. 1. Map of the Caloosahatchee River watershed (Data source: USGS & SFWMD).