ESTABLISHMENT PATTERNS OF WATER-ELM AT CATAHOULA LAKE, LOUISIANA

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Abstract--At Catahoula Lake in central Louisiana, an internationally important lake for water fowl, hydrologic alterations to the surrounding rivers and the lake itself have led to an expansion of water-elm (*Planera aquatic* J.F. Gmel.) into the lake bed. In this study, we used dendrochronology and aerial photography to quantify the expansion of water-elm in the lake and identify patterns of expansion. Our data suggest woody vegetation encroached into Catahoula Lake by about 10.4 km^2 (30 percent of the lake area) between 1940 and 2007. Encroachment has been concentrated in the northeast near the connection to Dry River, in the southwest at the input of Little River, and to a lesser extent south of the Diversion Canal on the eastern side of the lake. Woody vegetation is encroaching on the lake in three patterns. The first is a pattern of continuous encroachment, which occurred in 50 percent of our transects. The second pattern is a long-term stable pattern (no encroachment; younger and older trees intermingling), which occurred in 25 percent of our transects. The third pattern is complex with no discernable trend and is complicated by attempts to manage the woody expansion. The reasons for expansion are not well understood, and recently, increased rates have been manifest in multiple modes of establishment.

INTRODUCTION

Catahoula Lake is a backswamp lake in the floodplain of the Black River that is seasonally inundated and palustrine. Lake levels fluctuate about 6 m each year, going almost completely dry beginning in July to about November (USGS 2002). This annual variation promotes growth of wetland plants like sprangletop [*Leptochloa fusca* (L.) Kunth ssp. *fascicularis* (Lam.) N. Snow], Walter's millet [*Echinochloa walteri* (Pursh) A. Heller], and yellow nutsedge (*Cyperus esculentus* L.) which are sources of carbohydrates for wintering waterfowl and migratory birds using the lake as a stop along their route (Bruser 1995). The variability of Catahoula Lake water levels has been long known. Tedford (2009) found that lake water levels have been fluctuating at least since 4,000 years BP.

Hydrologic alterations to Catahoula Lake and the surrounding rivers have been occurring since at least the early 1920s. Catahoula Lake receives inputs from the headwaters of the Little River and backwater flooding from the Mississippi, Ouachita, Black, and Red rivers and drains through a diversion canal that runs from near French Fork to the Black River (Fig. 1) (Tedford 2009). Before the canal was built, the lake drained through the French Fork of Little River. A series of locks and dams were built first in 1926 and again in 1972 on the Black River to allow for navigation. These adjustments raised the level of the Black River and would have flooded Catahoula Lake permanently (Sessums 1954). The sole drainage through French Fork of the Little River was no longer adequate. To allow the natural, seasonal drawdown, the Corps of Engineers built a diversion canal which runs from near French Fork to the Black River. Today water is managed through opening and closing the water control structure on the diversion canal (Saucier 1998).

There has been great concern over the last few decades that Catahoula Lake is experiencing a shift from wetland vegetation toward woody plants on the lake bed which outcompete the herbaceous vegetation. We do not have complete information about historic management of the lake, but historic aerial imagery suggests woody expansion has been occurring since 1952. Today managers mow, burn, and herbicide to eliminate young water-elm (*Planera aquatic* J.F. Gmel.) and swamp privet [*Foresteria acuminata* (Michx.) Poir.] on the bed of the lake. These techniques are both costly and time consuming. Our goal is to quantify the amount and rate of woody expansion into the lake and better understand patterns of

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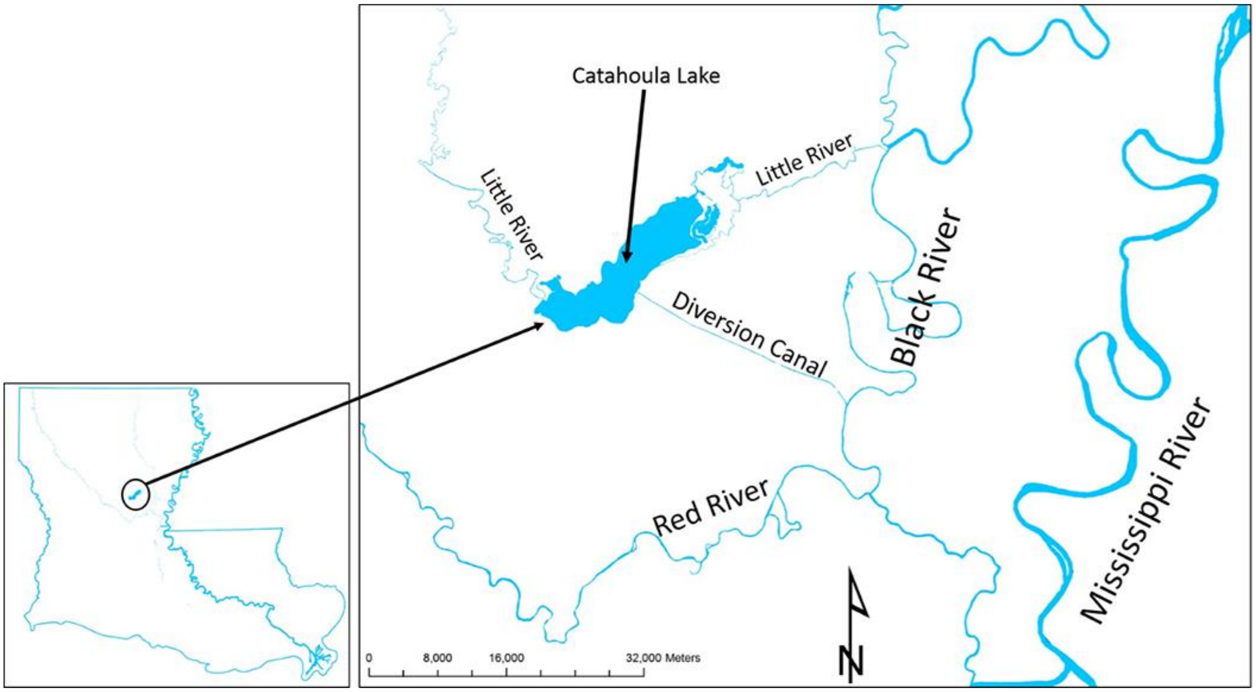

Figure 1—Location of Catahoula Lake in relation to its inputs and outputs: the Little, Red, Black, and Mississippi rivers and the diversion canal.

expansion. We compared aerial imagery to tree ages obtained from tree rings.

METHODS

Aerial Photo Interpretation

We examined USDA aerial imagery from 1940, 1966, and 2007 and Wills' (1963) map of plant types to quantify the extent and amount of expansion of woody vegetation. Imagery was selected by considering time of year, age, resolution, and water level. We scanned the 1940 and 1966 imagery and imported it into ARCMap 9.3.1 where it was georeferenced to the 2007 USDA imagery from the National Agriculture Imagery Program (NAIP). The imagery was then rectified to the Universal Transverse Mercator (UTM) coordinate system and georeferenced in ARCMap. We also scanned and georeferenced Wills' (1963) vegetation map. We analyzed the aerial imagery from 1940, 1966, and 2007 using air photo interpretation and ARCMap. We used Paine's (1981) density classifications to delineate polygons of existing woody vegetation from 20 to 100 percent cover. The resulting polygons were evaluated for expansion and removal of woody vegetation between years.

Tree Ring Data

We established 7 transect lines across the study area to determine tree ages. Five of these transects were approximately the same as those of Wills (1963). The remaining two transects had nearly the same location and azimuth as those of Bruser (1995). Transects varied in length and the number of points. Sampling points were established at intervals along each transect line in the water-elm zone to determine tree ages. We used the point-quarter sampling method to sample trees, selecting the closest tree ≥ 5 cm in diameter at breast height (d.b.h.) in each quadrant within 10 m from the origin. If no trees ≥ 5 cm d.b.h. were present within 10 m, a sample was not taken in that quadrant. We collected cross-sections from the largest stem of the tree as close to the base as possible with a chain saw. For trees > 30 cm d.b.h., we collected two increment cores per tree instead. Cores and cross-sections were dried at 50 ºC and sanded to 600 grit until cells were clearly visible under the microscope. Age of some partially-decayed trees was calculated by estimating the number of rings in the decayed section.

RESULTS

Aerial imagery indicated woody vegetation is expanding into the lakebed, and the rate of expansion has increased since 1966. Between 1940 and 1966, about 1.6 km^2 of woody expansion occurred. We calculated a rate of expansion of 0.17 percent per year from 1940-1966. Between 1966 and 2007, we found that the rate of expansion increased to 0.44 percent per year. Between 1940 and 2007, the lake experienced expansion of 10.4 km^2 or 30 percent (Fig. 2).

Using the tree ring data, we found 35 pre-modification trees and 160 post-modification trees. About 73 percent of the trees sampled were established after the canal was built. However, the oldest trees were 131-years-old, pre-dating any hydrologic changes to the lake.

We observed three patterns of expansion. In the first pattern, younger trees were found at the encroaching margin and older trees behind. This pattern was evident in half of the transects. This indicates a pattern of continuous encroachment (Fig. 3). The second pattern we observed was one of long-term stability (Fig. 4). This represented 25 percent of transects. Here we found young trees along the edge and filling in behind. The final scenario, accounting for 25 percent of transects, was less predictable. We found younger trees filling in behind an advancing front and sites that were complex with no discernible pattern (Fig. 5).

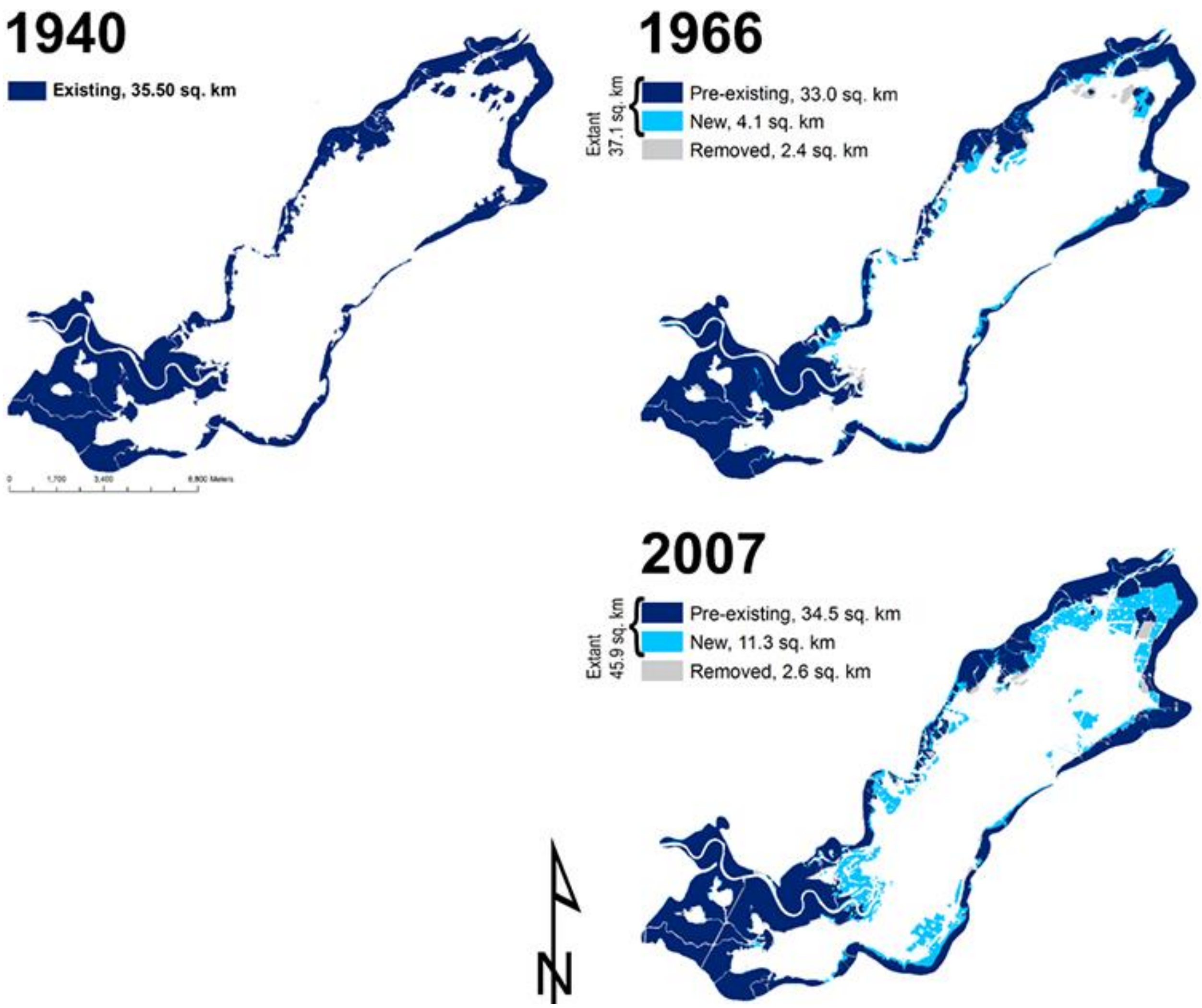

Figure 2—Expansion of woody vegetation at Cathoula Lake from 1940 to 2007.

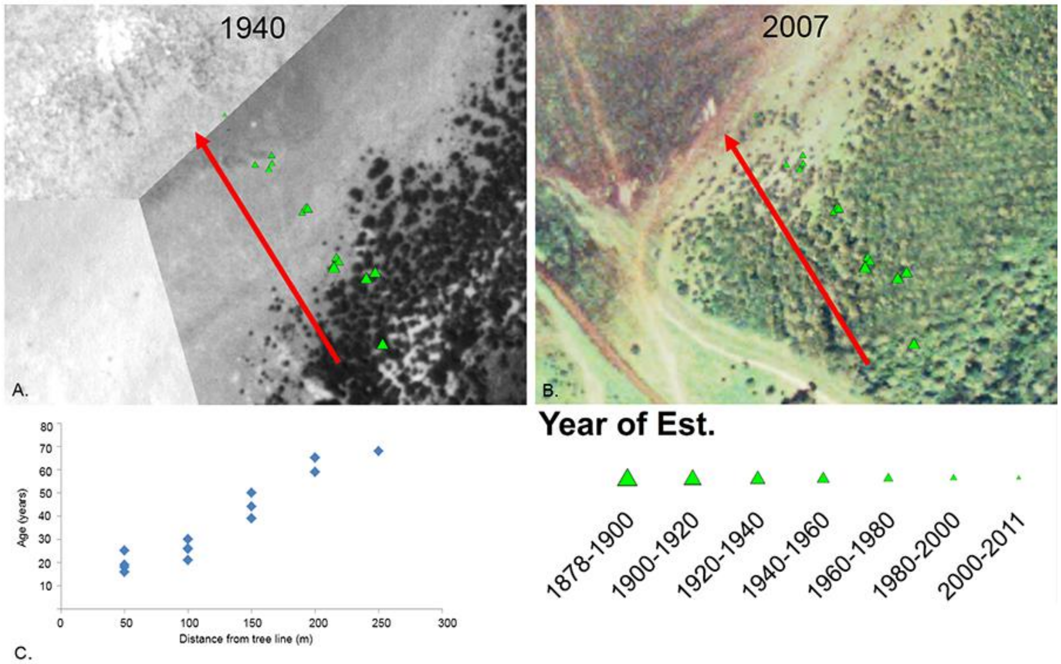

Figure 3—Example of continuous encroachment of woody vegetation. Triangles show location of sampled trees. Red arrows denote lake center. (A) USDA aerial imagery from 1940, (B) USDA aerial imagery from 2007, and (C) age of trees in relation to distance from tree line.

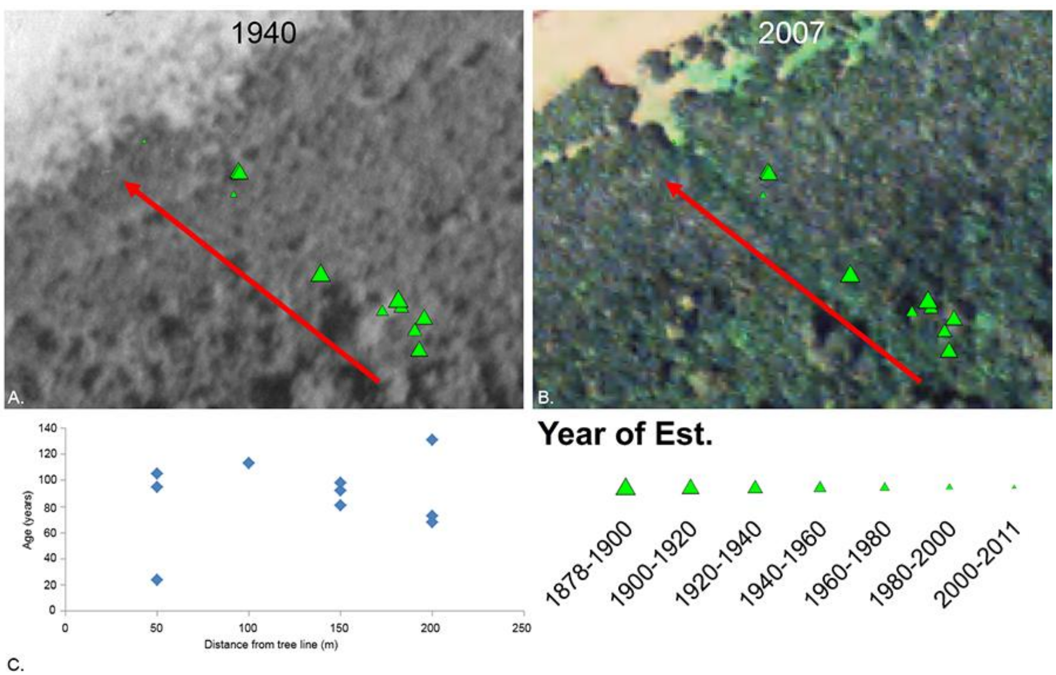

Figure 4—Example of long-term stability of woody vegetation extent. Triangles show location of sampled trees. Red arrows denote lake center. (A) USDA aerial imagery from 1940, (B) USDA aerial imagery from 2007, and (C) age of trees in relation to distance from tree line.

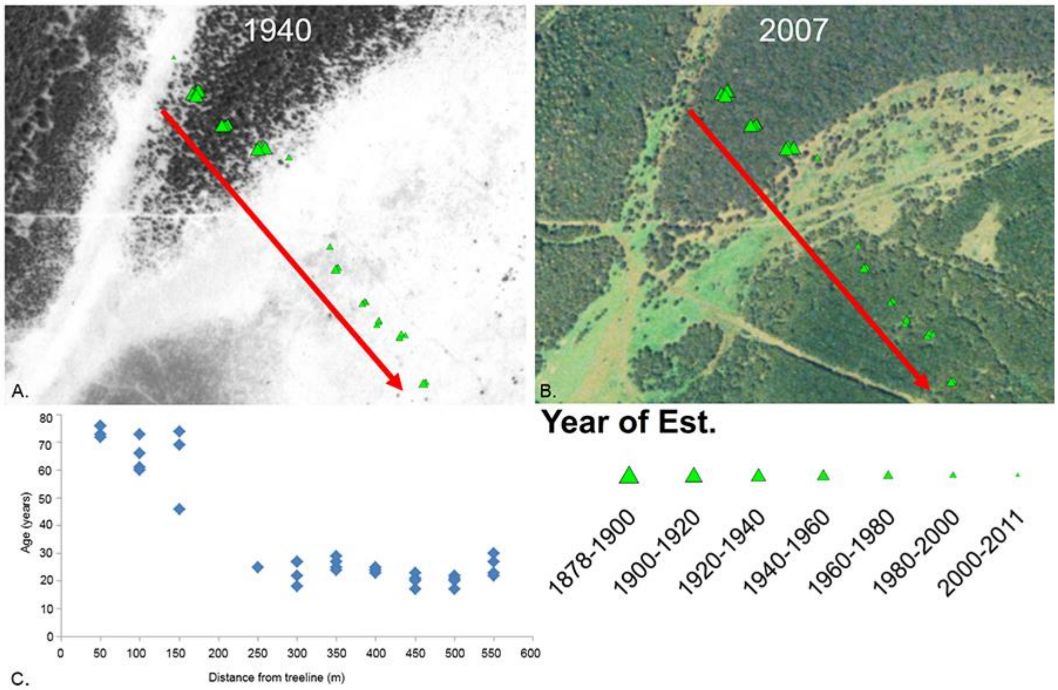

Figure 5—Example of complex pattern of encroachment of woody vegetation. Triangles show location of sampled trees. Red arrows denote lake center. (A) USDA aerial imagery from 1940, (B) USDA aerial imagery from 2007, and (C) age of trees in relation to distance from tree line.

DISCUSSION

We did not investigate soil conditions or possible changes caused by any sediment deposition. If there is substantial sedimentation, it is possible that location and amount of sediment correlates to locations of expansion. It is also possible that sediment composition varies spatially within the lake and helps control establishment of woody species. One complicating factor is that wave action is important for maintaining lake bottom morphology (Brown 1943) which would mute spatial patterns of lake-bottom sediments.

Historic variability in lake chemistry is not well understood. However, there was extensive salt-water pollution from petroleum extraction in the lake itself and upstream in the watershed of the Little River, such that Wills (1963) reported salinity at times of low water approaching that of sea water. Salinity stress would obviously affect plant species composition and may have disrupted normal successsional pathways and edaphic relationships for some period of time.

It remains generally poorly understood why Catahoua Lake is an open body of water and not a forested wetland. Some theories suggest that human disturbance is at least partially responsible for this condition. For example, grazing by cattle and feral hogs has sometimes been cited as a reason Catahoula Lake has remained unforested (Willis 2009). However, Tedford (2009) showed that ecologic conditions (caused by fluctuating water levels) have been similar for the past 4,000 years. Thus, there has likely been a recent change in some main natural process causing the ecosystem to cross a threshold toward forest occupation.

CONCLUSIONS

Woody vegetation has been encroaching into the formerly herbaceous lake bottom at Catahoula Lake. The rate of expansion is apparently faster now than prior to major hydrologic modifications at the lake, which are dominated by the establishment of deeper water on the Black River and establishment of the diversion canal to manage hydrology of the lake. Patterns of establishment do not allow for clear interpretation of the major processes controlling extent of water-elm, so further work is needed to understand the linkage between hydrologic modifications and the ecosystem at the lake margin.

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