LOUISIANA COASTAL ZONE EROSION: 100+ YEARS OF LANDUSE AND LAND LOSS USING GIS AND REMOTE SENSING

By
Dr. Lionel D. Lyles and Dr. Fulbert Namwamba
Southern University
Baton Rouge Campus

This paper intends to focus attention on the idea that land loss and vegetation change are not random occurrences, but their disappearance seems to parallel oil and gas production in the Louisiana coastal wetlands. ." GIS and remote sensing data will be used to demonstrate the extent to which annual spring flooding no longer deposit "…invaluable sediments and nutrients to wetlands." There are 160,000 or more oil and gas wells located in an area in South Louisiana commonly known as the Louisiana coastal wetlands. This vast number has come to dominate this region since the Heywood well was dug in 1901. Moreover, 18 percent of U.S. oil production originates in, is transported through, or processed in the Louisiana coastal wetlands with a value of $6.3 billion a year." In addition, 24 percent of U.S. natural gas production originates in, and is processed in, the Louisiana coastal wetlands; at a value of $10.3 billion per year. This level of production has altered the Louisiana coastal wetlands' over the past 100+ years. The following factors have collectively created an increasing problem of land loss and vegetation change: (1) Levees (2) Channeling and (3) Saltwater Intrusion. As it is, "Louisiana loses 1 acre of land every 24 minutes

INTRODUCTION

Since 1950, the Louisiana coast, an area that stretches from New Orleans, LA to Lake Charles located immediately south of the Intracoastal Canal, has been experiencing increasing land loss and land cover (vegetation) change. The purpose of this study is to explore the impact that the major landuse-oil and gas production-has had on the historical disappearance of thousands of acres of land. Specifically, GIS techniques will be used to establish a link between oil and gas well production and land loss in the Louisiana wetlands. In addition, in the course of this study it will be demonstrated how oil and gas production in the wetlands has systematically decreased the sheet flow of freshwater over the land, thereby generating a condition of vegetation dieback, which over time, has stimulated the erosion of land along the Louisiana coast. When freshwater vegetation is exposed to prolonged saltwater intrusion, it perishes, leaving the land vulnerable to erosion.

The study examines one hypothesis within the context of land loss and vegetation change along the Louisiana coast. That is, due to oil and gas companies' need to build an infrastructure in the wetlands to gain access to these resources, thousands of canals have been dug across the Louisiana coast through a process called *channeling.* The latter is necessary to create pathways, or waterways, through the wetlands to move drilling and other equipment to sites where potential oil and gas resources exist. At the outset, we will focus some attention on the physical geography of the Louisiana coast.

GEOGRAPHY OF COASTAL LOUISIANA

According to the Coast 2050: Toward a Sustainable Coastal Louisiana, 1998, a report of the Louisiana coastal Wetlands Conservation and Restoration Task force and the Wetlands Conservation and Restoration Authority, "coastal Louisiana is made up of two wetland-dominated ecosystems, the Deltaic Plain of the Mississippi River…and the closely linked Chenier Plain…"[1] "The LCZ [Louisiana Coastal Zone] includes 3,815 square miles of coastal marshes and swamps divided among four sub-regions of the Mississippi Deltaic Plain and the Chenier Plain ecosystems."[2]This geography took over 5,000 years to build up through natural delta-building processes. During this time, the Mississippi delta was active in creating the Deltaic Plain, and, since 1950, the Atchafalaya Delta has been active forming deltas at the mouth of the Lower Atchafalaya River. *Map 1.0* shows the geo-spatial location of the Deltaic Plain and the Chenier Plain. In short, when sediments-clay, sand, and silt-are diverted from the Mississippi River to a coastal bay or lake, the water velocity slows down, and these deposits form bars, lobes, and shoals. Overtime, landmass is gradually built up. If the Mississippi River is unable to divert sediments through a distributary system, then the sediments are deposited far out on the continental shelf, thereby having little or no affect on coastal landmass buildup.

Overtime, the Deltaic Plain was created through deposition of sediments near the coast. The buildup of land moves from east to west. As a result, sediments deposited near the coast are carried westward by mudstreams, which created the Chenier Plain over thousands of years. According to the Coast 2050 report, "the dominant longshore drift along the Louisiana coast is from east to west, and as a result, during intervals when the Mississippi is active along the western side of the Deltaic Plain, the mudstream moves fine-grained sediments toward the Chenier Plain and mudflats form. These are colonized by marsh grass and have added new wetlands to the coast. Under the influence of this natural process for more than 5,000 years, the Louisiana coast continuously built itself up. However, in less than half a century the coast, which took this long to be created, is currently experiencing rapid land loss and vegetation change to an extent that it now borders on collapse.

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[1] ___________ Coast 2050: Toward a Sustainable Coastal Louisiana, Louisiana Department of Natural Resources, Baton Rouge, LA, 1998, p. 19.

[2] ___________ Coastal Louisiana and South Florida: A comparative Wetland Inventory, America's Wetland, 2003, p. 3.

METHODOLOGY

To conduct this study, we made use of the most recent 1998 DOQQs. A DOQQ is a remote sensing image taken from an airplane, which covers a specific area of land on the ground. We obtained all of the 1998 DOQQs for the Louisiana Coastal Wetlands. Once we decided to use the Atchafalaya region as our test area, we proceeded to import the selected Atchafalaya region images into a Geographical Information System (GIS) environment. At this point, we used the Louisiana State University *Atlas database*, which contains data for oil and gas wells in Louisiana. Then, we opened a selected DOQQ image and afterwards, we overlaid it with GIS data related to oil and gas wells. Observations from these GIS layers have been incorporated in the subsequent discussion.

100+ YEARS OF LAND LOSS

The Coast 2050 report stated "the balance of Louisiana's coastal systems has been upset by [mostly] human activities."[3] In just a matter of a century serious land loss and vegetation has occurred. For example, "massive coastal erosion, which began around 1890 and peaked during the 1950's and 1960's, has resulted in loss and deterioration of wetlands, barrier islands, and ridges…During a period of little more than 100 years, more than one million acres, or about 20% of the coastal lowlands (mostly wetlands), have eroded. Because it took about 5,000 years for the coastal lowlands to form, it follows that 1,000 years of natural land building was eroded in about one century. As a result, both the Deltaic and Chenier Plain systems are badly degraded. The Deltaic Plain has lost and continues to lose subsystem components and is approaching a condition of system collapse."[4] Within the Deltaic Plain, most land loss has occurred in the lower Terrebonne and Barataria Basins and the Mississippi Basin; the majority of land loss in the Chenier Plain occurred near the Calcasieu and Sabine Lakes region.

More recently, it is pointed-out in the Coast 2050 report that "the rate of coastal land loss in Louisiana has reached catastrophic proportions. Within the last 50 years, land loss rates have exceeded 40 square miles per year, and in the 1990's the rate has been estimated to be between 25 and 35 square miles each year. This loss represents 80% of the coastal wetland loss in the entire continental United States…If recent loss rates continue into the future, even taking into account current restoration efforts, then by 2050 coastal Louisiana will lose more than 630,000 additional acres of coastal marshes,

[3] Ibid., p. 31.
[4] Ibid., p. 31.

swamps, and islands…in some places there is nothing left to lose."[5] According to the USGS Open File Report OFR 03-334, "within the last 70 years, Louisiana has lost more than 1.22 million acres of coastal wetlands, and a new USGS model predicts that 448,000 acres will vanish into the Gulf of Mexico in another 50 years…This 120-year loss exceeds the combined land area of Delaware, the District of Columbia, and the Baltimore, MD, metropolitan areas."[6]

In addition, after taking a helicopter ride over coastal Louisiana to assess the current land loss situation, Gov. Kathleen Blanco, and a group of national policymakers, concluded that "…coastal erosion…claims about 25 miles of coastline a year."[7] Most of this land loss is due to the disruption of the coastal ecosystem by the large concentration of oil and gas wells located throughout the wetlands.

DISTRIBUTION OF OIL AND GAS WELLS IN THE LOUISIANA COASTAL WETLANDS

By 2000, there were 160,000 or more oil and gas wells operating in the Louisiana Coastal Wetlands. These wells are heavily concentrated in both the Deltaic and Chenier Plains. ***Map 1.1*** shows the spatial distribution of oil and gas wells that are located in this region. Because a vast majority of the oil and gas wells are inaccessible by highways due to swamp and marshes, oil exploration, production, and distribution is made possible by digging canals throughout the wetlands. According to a LAcoast report, *"eighteen percent of U.S. oil production originates in, is transported through, or is processed in the Louisiana coastal wetlands with a value of $6.3 billion a year. Almost 24 percent of U.S. gas production originates in or is processed in Louisiana's coastal wetlands with a value of $10.3 billion a year."*[8] These figures suggest that a large volume of activity takes place in the wetlands, and, more importantly, they also point to the fact that a canal infrastructure has been built to support the more than 160,000 oil and gas wells located throughout the wetlands. The canal infrastructure was formed based on a process called channeling.

Burdeau stated "since the 1950s, more than 8,000 miles of canals have been dug for oil exploration and shipping and scientists believe the canals caused 36 percent of the land loss in coastal Louisiana. The state has lost 1,900 square miles since 1932…Until the late 1980s and early 1990s, coastal land loss in Louisiana was not widely recognized as a problem and canal digging went on unabated."[9] The *Lacoast* report added "over the last 200 years, industry [has]…cut numerous channels and canals through the wetlands for transportation and oil exploration. These channels [have created]…the movement of unnatural water patterns, ultimately increasing erosion and wetland demise."[10] Moreover,

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[5] Ibid., p. 1.

[6] USGS Open File Report OFR 03-334, 2000, p. 4.

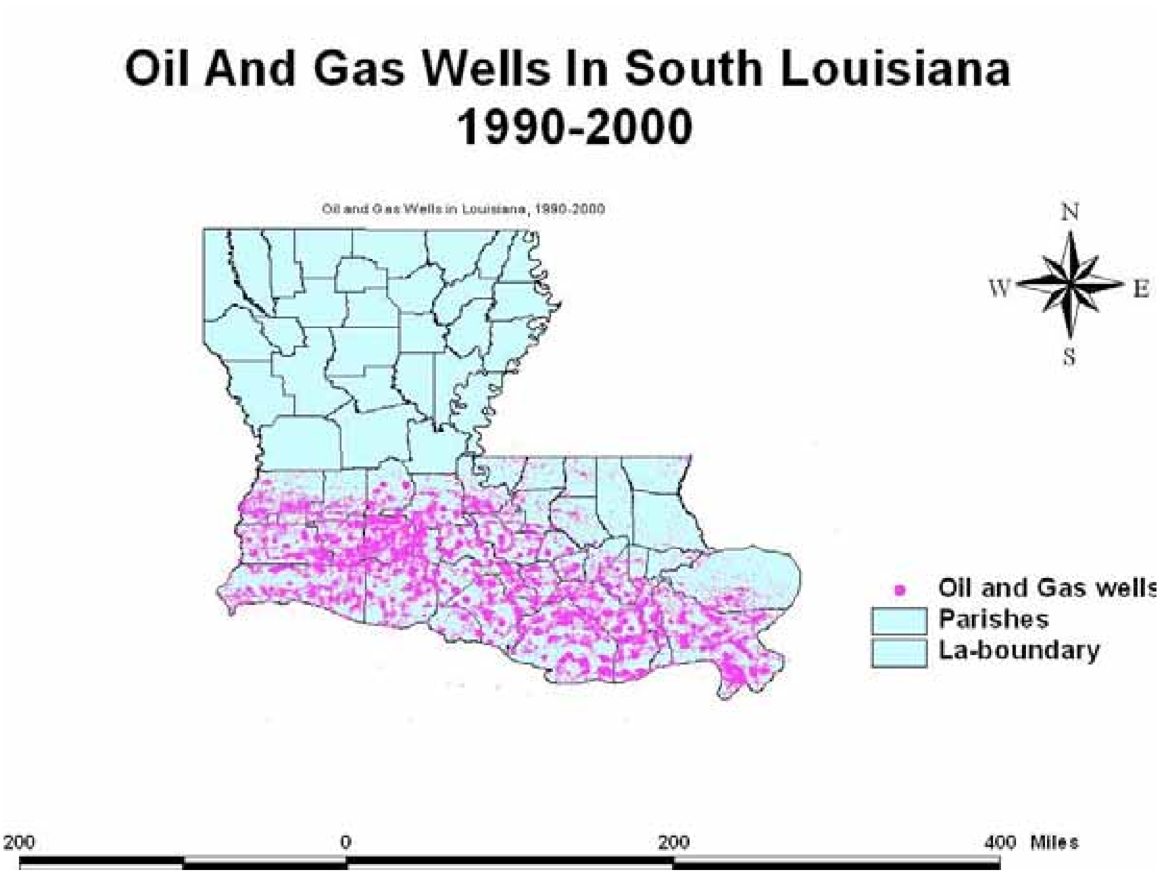
[7] Burgess, Richard, "Blanco pushes for coastal help," The Daily Advertiser, October 23, 2004, p. 1A.

[8] ____________ "Louisiana Offshore Oil and Gas Activity," www.lacoast.gov/watermarks/1999c, March 16, 2004, p. 1.

[9] Burdeauu, Cain, "Companies win lawsuit on marsh canals," The Advocate, January 24, 2005, p. 5B.

[10] ___________ "Louisiana Offshore Oil and Gas Activity," www.lacoast.gov/watermarks/1999c, March 16, 2004, p. 2.

Dunne stated "navigation and oil exploration canals enable saltwater to move in and kill the vegetation necessary for healthy marshes. "Spoil banks," created from the marsh and muck dug for canals and channels and then tossed aside, disrupt the natural flow of water across the marsh. And levees…prevent the flooding that once replenished the marsh."[11]



Map 1.1 Oil and Gas Wells Distribution in South Louisiana

Canals and channels dug to reach oil and gas wells in the wetlands allow saltwater to intrude inland. The saline in the water has caused the dieback of freshwater vegetation, which ultimately leads to wetland erosion. According to the Lacoast report, "the result of …channeling is saltwater intrusion…The intrusion …like too much salt water, can offset the balance and rapidly destroy wetlands."[12] Map 1.2 shows how saltwater intrudes inland once a canal or channel has been dug, which often results in ponding, leading to the death of freshwater vegetation. Using Digital Orthorectified Quarter Quadrangles (DOQQ) for the Atchafalaya coastal region located within the Mississippi Deltaic Plain, evidence of the impact channeling has had on the wetlands can be observed. Before we

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[11] Dunne, Mike, "The Vanishing State," The Sunday Advocate, November 7, 1999, p. 3K.

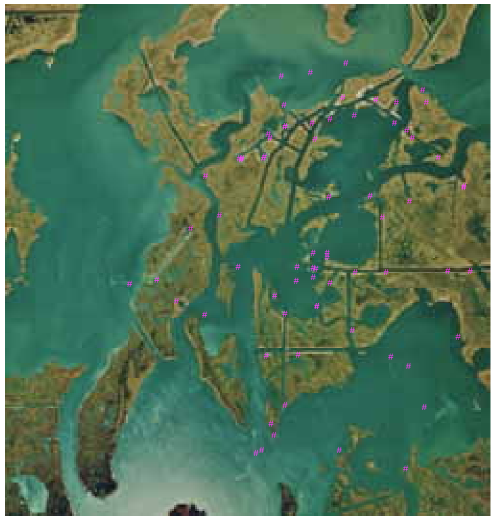
[12] __________ "Louisiana Offshore Oil and Gas Activity," www.lacoast.gov/watermarks/1999c, March 16, 2004, p. 3.

show the impact of canals and channeling on the wetlands, a brief word about the methodology used in this study follows.

MISSISSIPPI DELTAIC PLAIN: ATCHAFALAYA REGION

Map 1.2 shows an aerial view of the Atchafalaya region near the Gulf of Mexico. Close observation of this image reveals a clear pattern of canals and channels that have been dug into the wetlands for transportation purposes. When we overlaid another on top of this one showing oil and gas wells, we discovered a one-to-one correlation between canals and channels and where the oil and gas wells are actually located. ***Map 1.3*** demonstrates this result. ***Map 1.4*** shows the geographical location of both the canals and channels simultaneously. What is interesting is no matter what DOQQ we used to compare oil and gas wells with canals and channels, and regardless if it is located in the Chenier Plain or Deltaic Plain, the one-to-one correlation between the two variables remained unchanged. Canals and channels were dug to gain access to oil and gas wells; thus, as the images indicates, all oil and gas wells are located at some point along a dug canal or channel in the wetlands.

Map 1.2 Sample of Atchafalaya Region Channeling



Map 1.3 Sample of Atchafalaya Region Channeling in Relation to Oil and Gas Wells

Map 1.4 Sample of Atchafalaya Region Channeling in Relation to Oil and Gas Wells.

CONCLUSION

The central conclusion we were able to reach, after examining the selected DOQQ and GIS data, is a majority of the land loss and vegetation change that has occurred in the Louisiana coastal wetlands over the past 100 years is a result of canals and channels that were dug to provide transportation for oil and gas exploration. No other factor, whether it is weather or urban sprawl, has had a more adverse affect on the wetlands. Moreover, the hypothesis we set out to test related to channeling and canals seems to have merit. Further research will be done throughout the wetlands to see if our initial findings remain consistent. If so, then we will be in a position to identify channeling and canals as the two main forces contributing to land loss and vegetation change in the Louisiana wetlands today.