Examination of Factors Contributing to the Growth and Loss of Wetlands in Louisiana*

Ricardo A. Olea[1] and James L. Coleman[2]

Search and Discovery Article #80622 (2017)**
Posted December 4, 2017

*Adapted from oral presentation given at AAPG 2017 Annual Convention and Exhibition, Houston, Texas, April 2-5, 2017

[1]U. S. Geological Survey, Reston, Virginia, United States (rolea@usgs.gov)
[2]U. S. Geological Survey, Reston, Virginia, United States (jlcoleman@usgs.gov)

Abstract

The main growth factor of present-day southern Louisiana wetlands is the deposition of sediments from the Mississippi River delta. Concurrently, three natural forms of subsidence have been leading to wetland loss: (1) downward flexure of the lithosphere from the accumulation of up to 20,000 m of post-Triassic sediments deposited on the northern margin of the Gulf of Mexico sedimentary basin; (2) basin ward sliding of this sediment accumulation and associated normal faulting of the sediments; and (3) compaction of this accumulation by simultaneous compression of sediments and expulsion of fluids. Prior to the 1900s, coastal wetlands were being constructed at an average rate of 250 km^2 per century. By the 1930s, there was quantitative evidence of reversal in wetland expansion, by which time new basin wide factors of anthropogenic origin had appeared. After the Mississippi River flood of 1927, engineering modifications to control flooding and improve navigation reduced the amount of sediments reaching the coast by eventually channeling their discharge onto the continental platform away from the wetlands. Since about the beginning of the Industrial Revolution there has been an accelerated worldwide sea level rise. Other influences have been: (1) production of sulfur, oil, gas, and groundwater; (2) construction of navigational channels; (3) digging of oil and gas production pipelines; and (4) changes in river water chemistry contributing to soil biodegradation. Since the 1930s, wetland land loss has been at an annual average rate of 61 km^2 per year. By using Monte Carlo simulation, we compared actual total subsidence rates against the combined effect of all regional forms of subsidence in coastal Louisiana. In doing so, we clarified the magnitude and relative importance of those processes. Among the anthropogenic causes, our study indicates that subsidence associated with historic oil and gas production has an average contribution of 5% relative to the natural causes of subsidence. Canal construction has been brought to an essential minimum after contributing about 20% of the wetland

areal losses. This leaves sediment supply and sea level rise as the factors of main concern for the future. Controlled diversion of Mississippi River sediments into adjacent wetlands may help offset diminished sediment supply and associated subsidence in local areas.

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EXAMINATION OF FACTORS CONTRIBUTING TO THE GROWTH AND LOSS OF WETLANDS IN LOUISIANA

Ricardo A. Olea
James L. Coleman

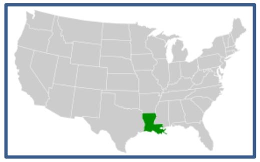
100th Anniversary Meeting AAPG
Houston, 2-5 April 2017

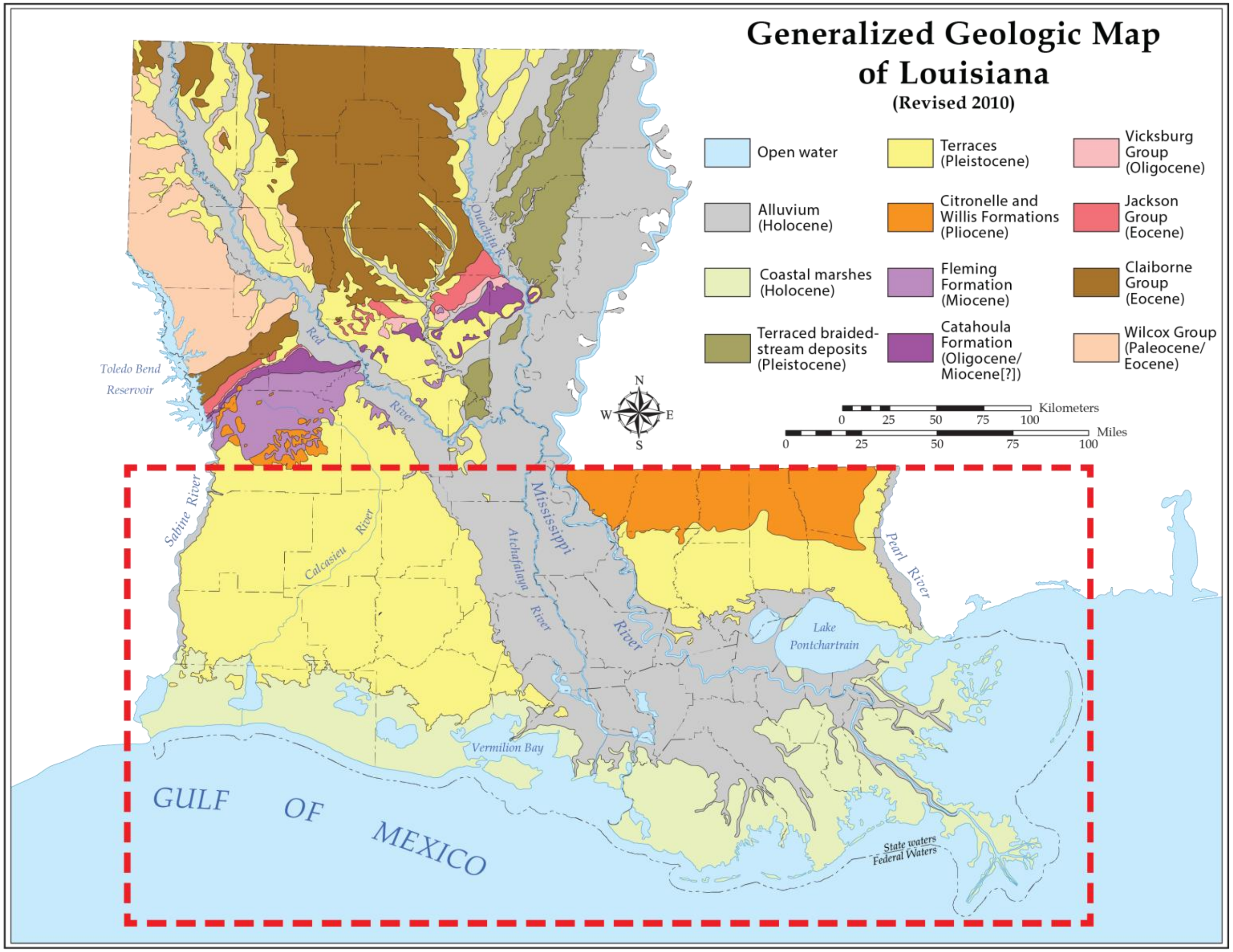
U.S. Department of the Interior
U.S. Geological Survey

Outline

- Study area
- Geology
- Growth contributing factors
- Holocene areal extension through time
- Causes behind losses
- Conclusions

Study area

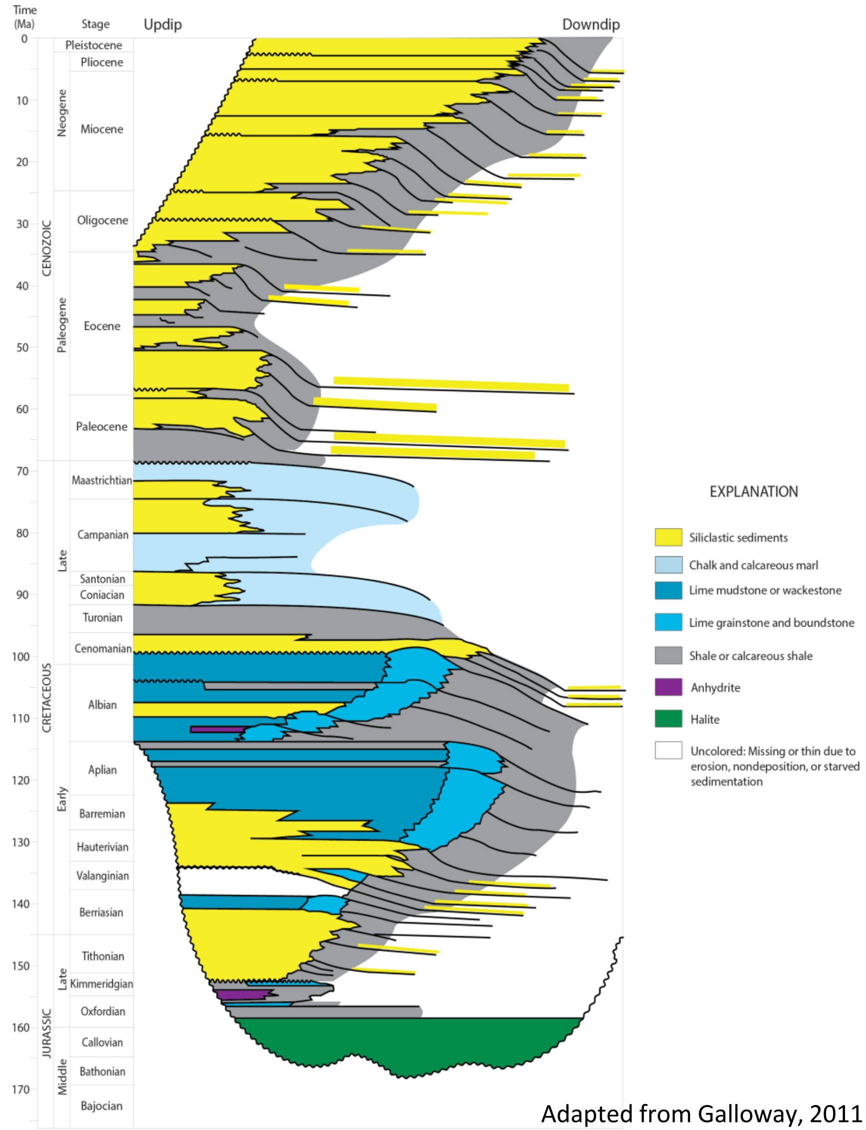




Modified from Louisiana Geological Survey, 2010

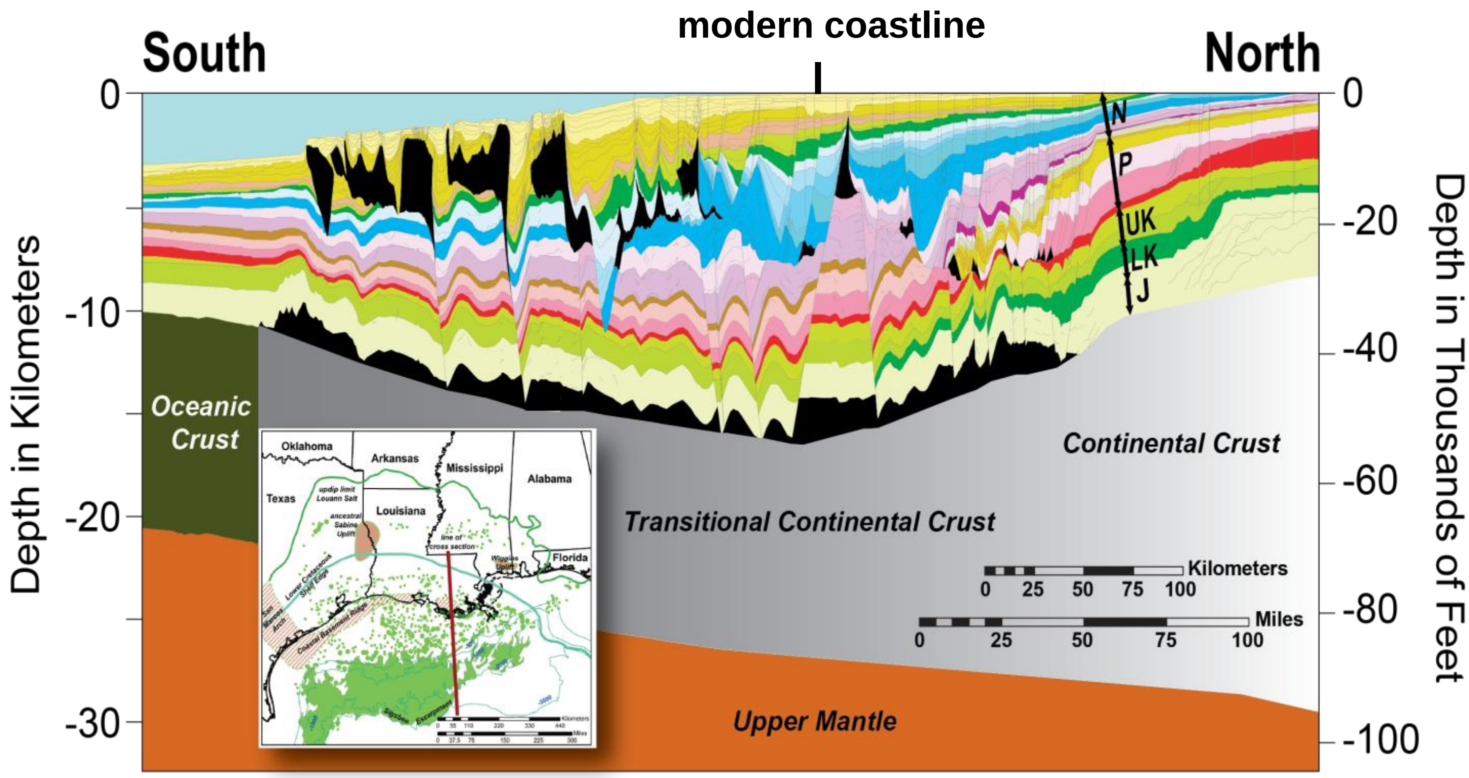
Generalized stratigraphic column (Geology)

Cenozoic formations are deltaic, slope, and basinal deposits of sediments transported and deposited by the Mississippi and other Gulf Coastal Plain rivers and submarine channels



Adapted from Galloway, 2011

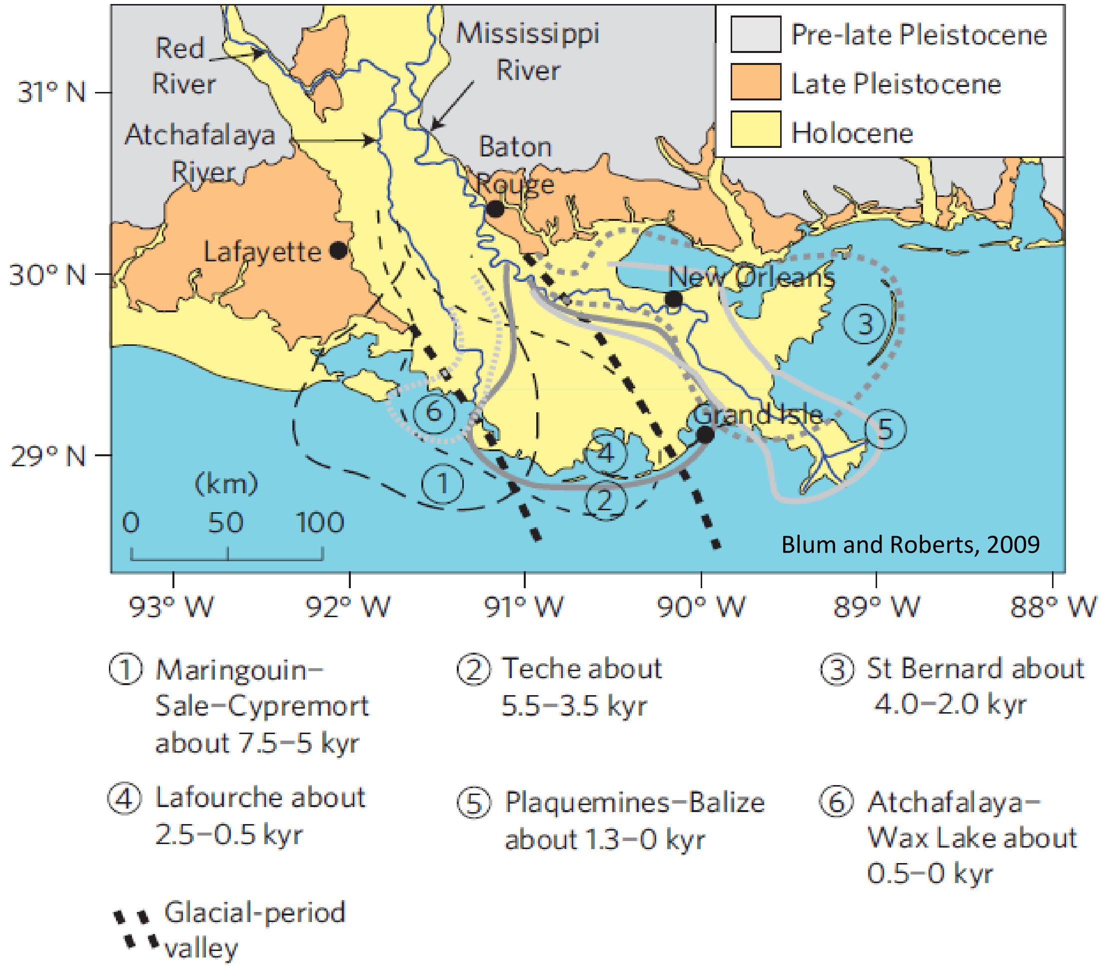
Generalized cross section (Geology)



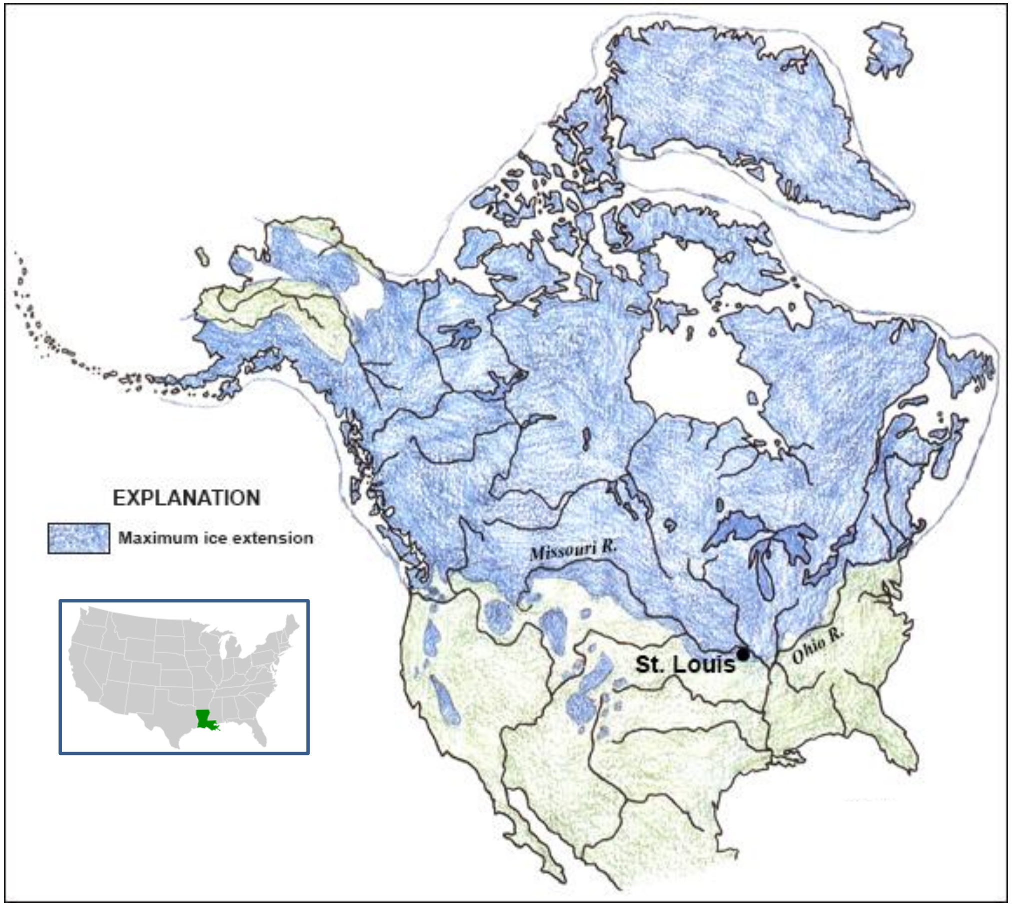
Modified from Nelson et al., 2000

The Mississippi delta (Main growth factor)

Build-up of Mississippi type deltas is highly dynamic: increase in main channel length results in avulsion, which leads to depocenter switches and partial erosion of sediments already consolidated.



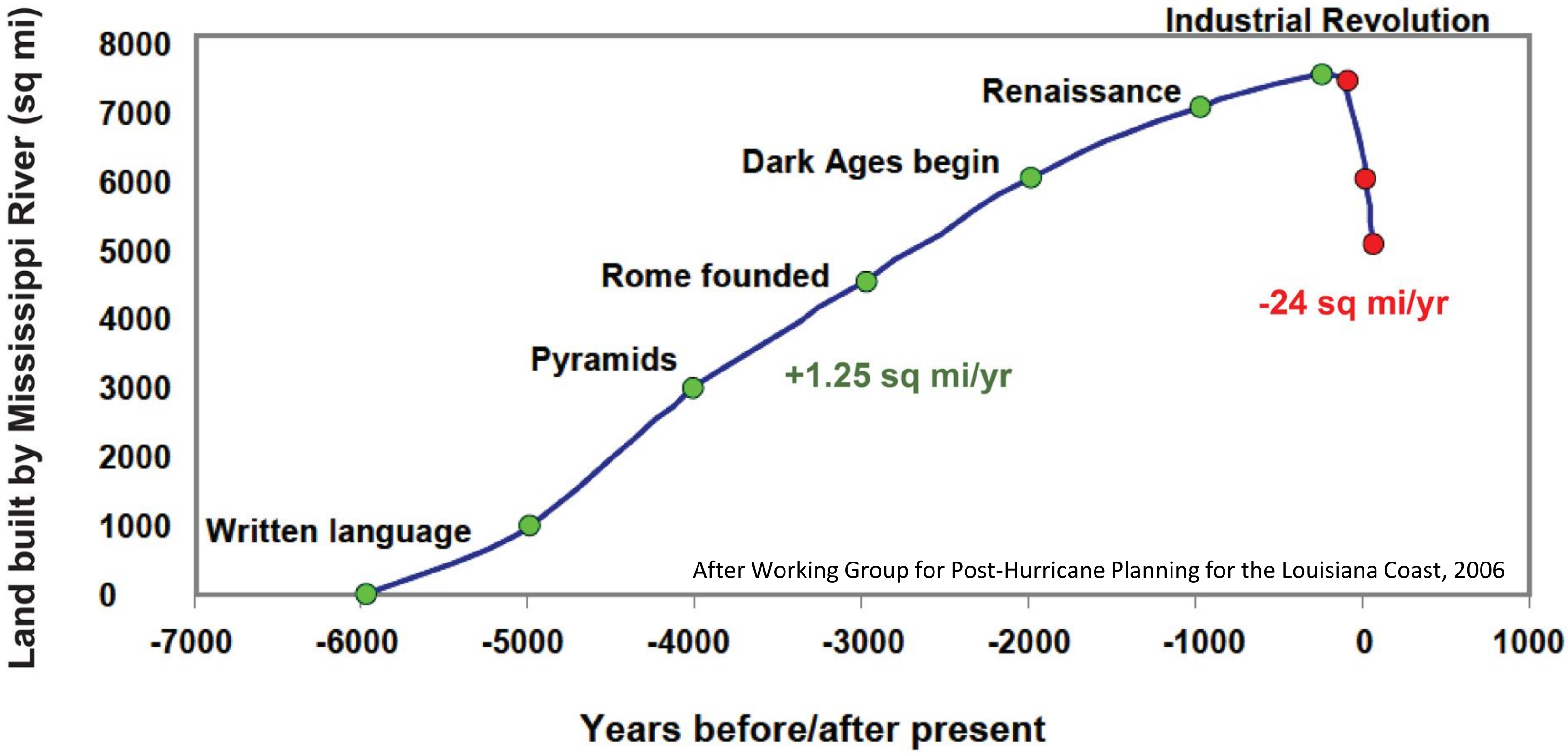
Glacial isostasy (Minor growth factor)



After Menzies, 2002

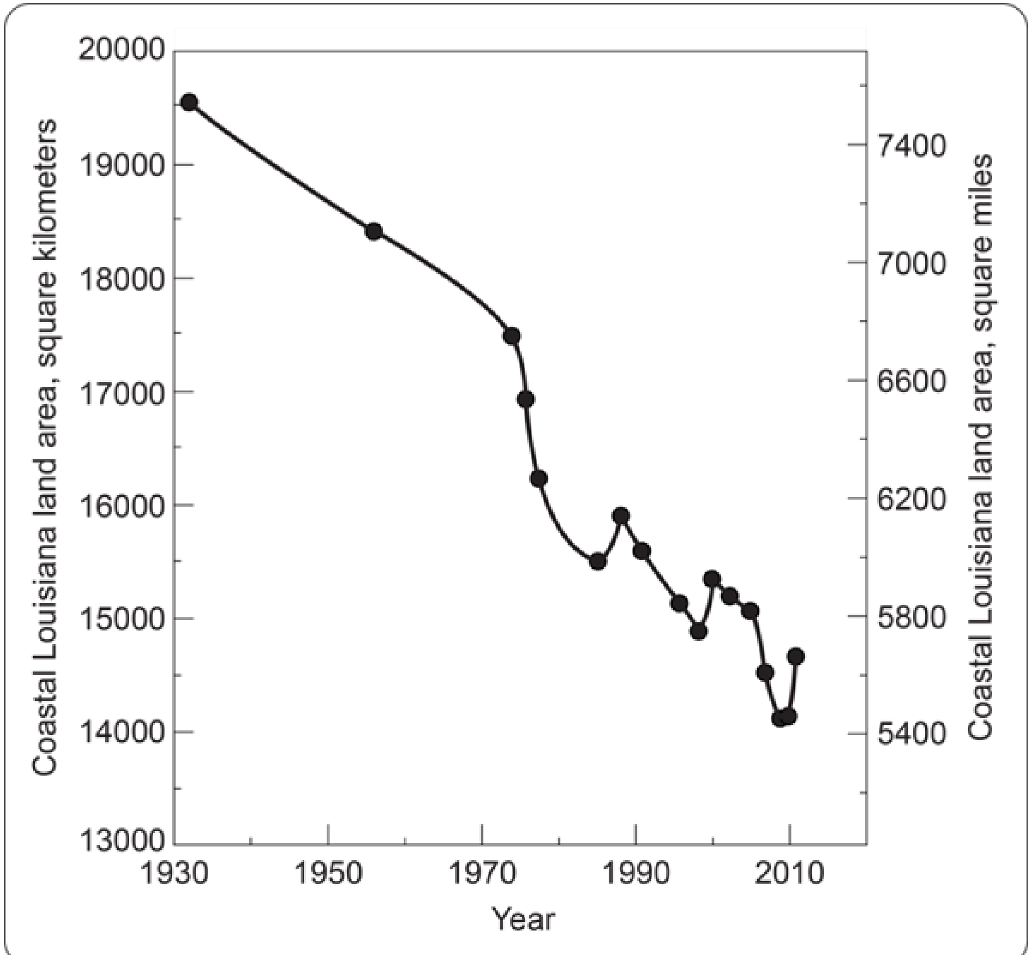
Last glaciation resulted in crust subsidence underneath and close to the ice fields. Conversely, by isostatic compensation, land elevation increased in the periphery of the glaciated area as far south as Louisiana. Today, with the disappearance of that continental ice, the process has been reversed.

Postulated coastal area during the Holocene



Coastal areas in Louisiana expanded for millennia primarily because of the deposition of Mississippi delta sediments.

Measured areal extension during the last 80 years



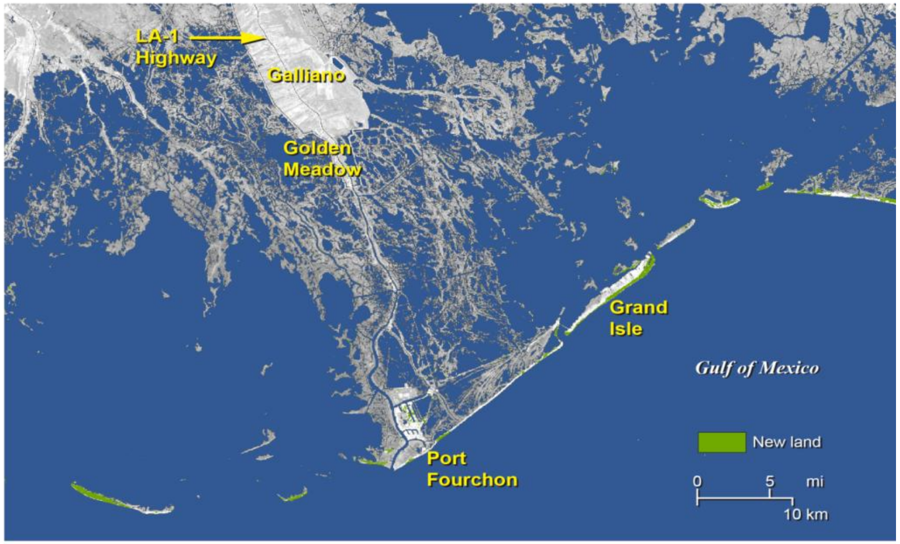
Couvillion, 2011

By the 1930s, obvious coastal losses prompted surveying and search on causes. The losses have been fairly persistent and systematic.

Partial areal testimony

1932

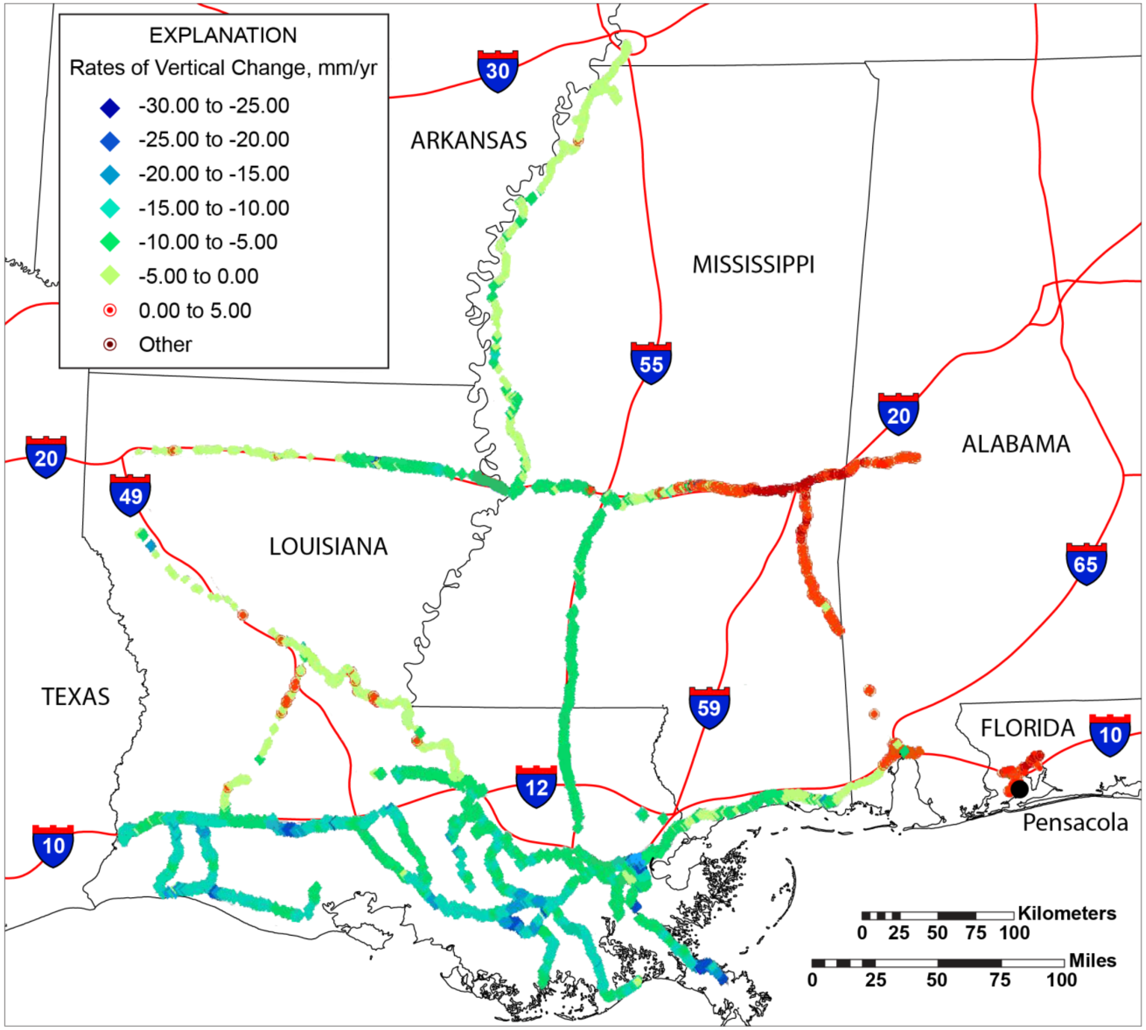
2011



Gill, 2013

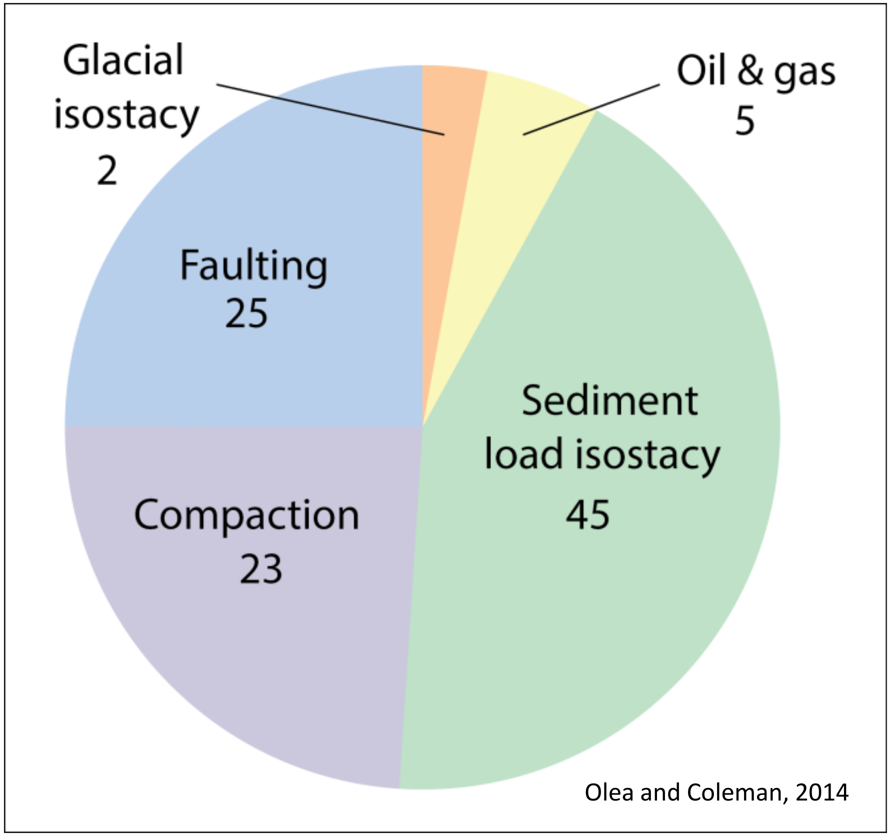
Subsidence survey (Loss causes)

High precision geodetic surveys allowed putting numbers on the rate of subsidence, which is quite ubiquitous throughout most of the state of Louisiana; not solely a process along the coast.



Modified from Shinkle and Dokka, 2004

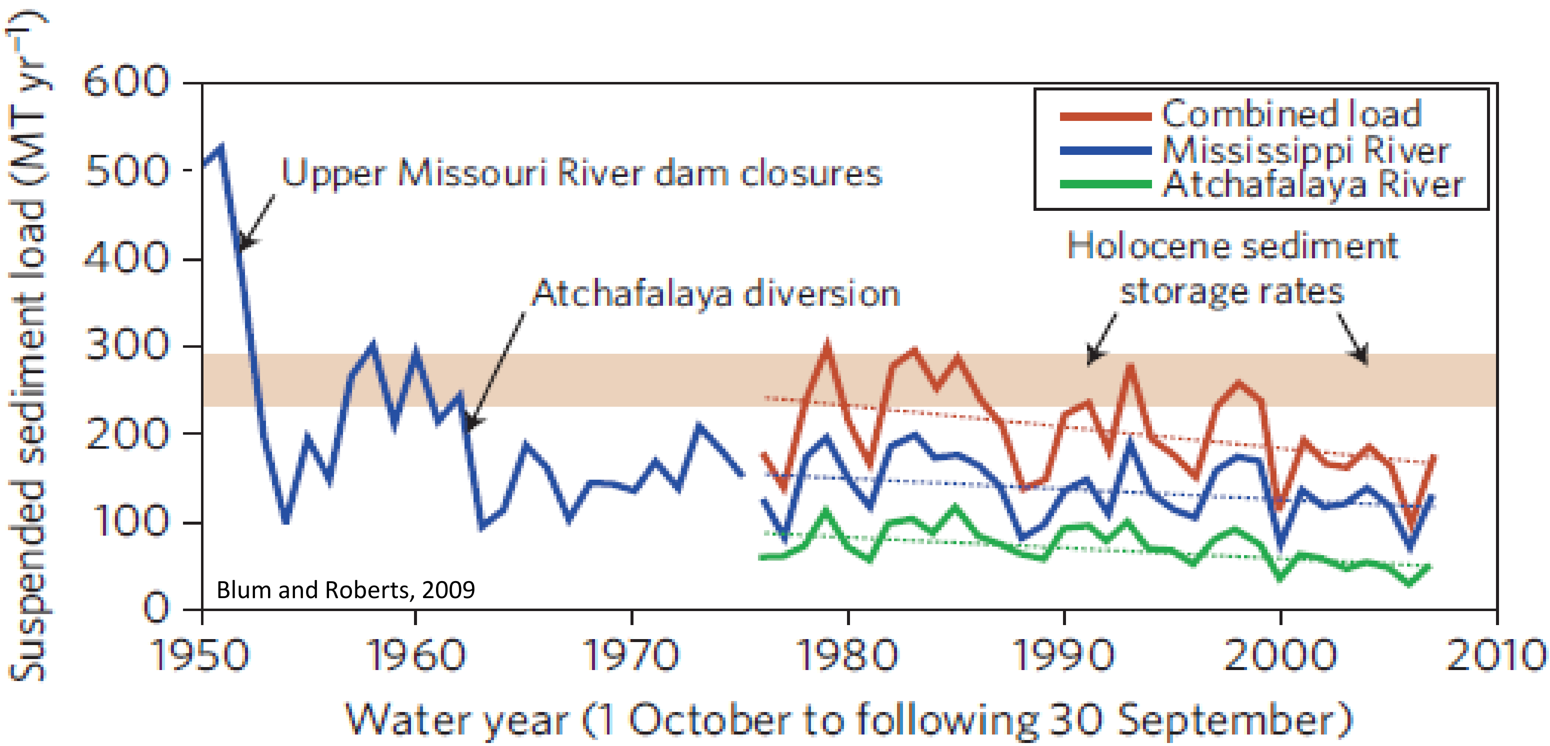
Ranking of subsidence causes



Values denote relative contribution, in percent

There are multiple forms of subsidence, all natural except for oil and gas extraction. Individual subsidence rates and the geodetic surveys allowed us to prepare and validate a ranking of relative importance for those forms of subsidence acting regionally using the Monte Carlo method.

A critical negative factor: sediment load (Loss causes)



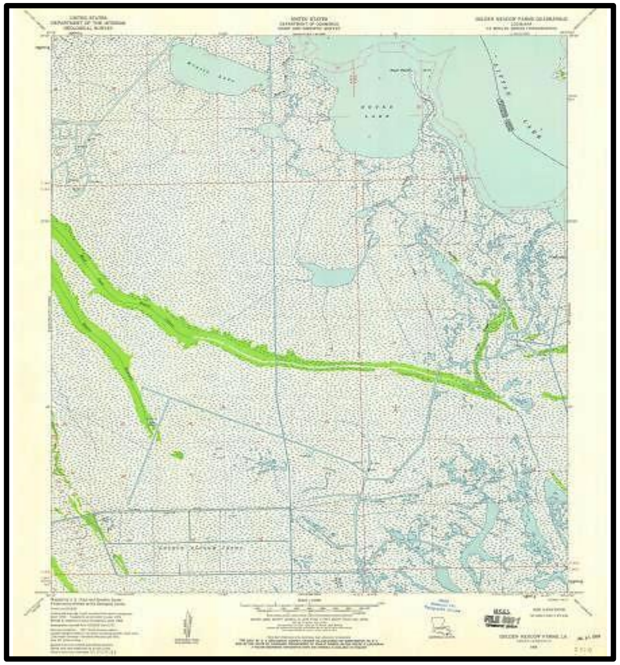
Reduction in the load of sediments transported by the Mississippi river and interference in their form of dispersion are important factors contributing to the modern coastal land losses.

Other coastal loss factors: canal constructions

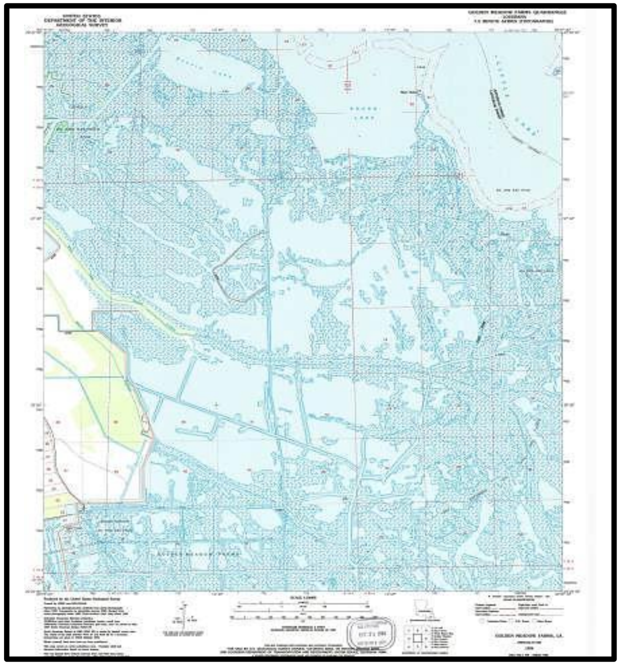
Golden Meadow Farms, Louisiana
USGS 7½ minute topographic quadrangle

Canals not only turned land into open waters, but over the years, open waters expanded beyond the original canal margins.

1956

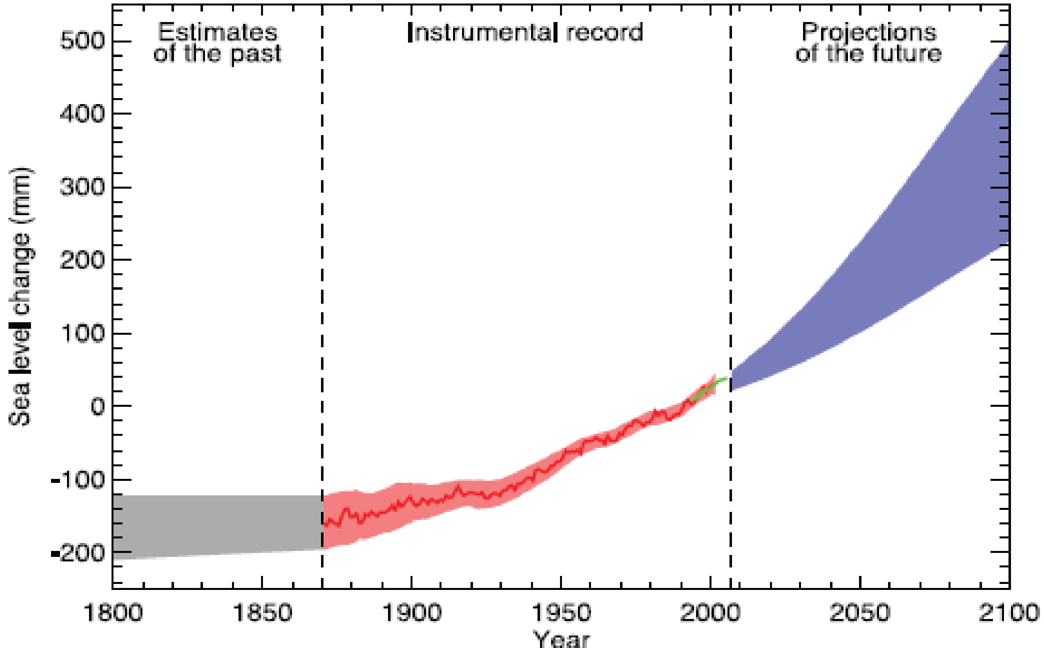


1994



We have estimated that canal constructions are the cause of about 20% of land losses since the 1930s.

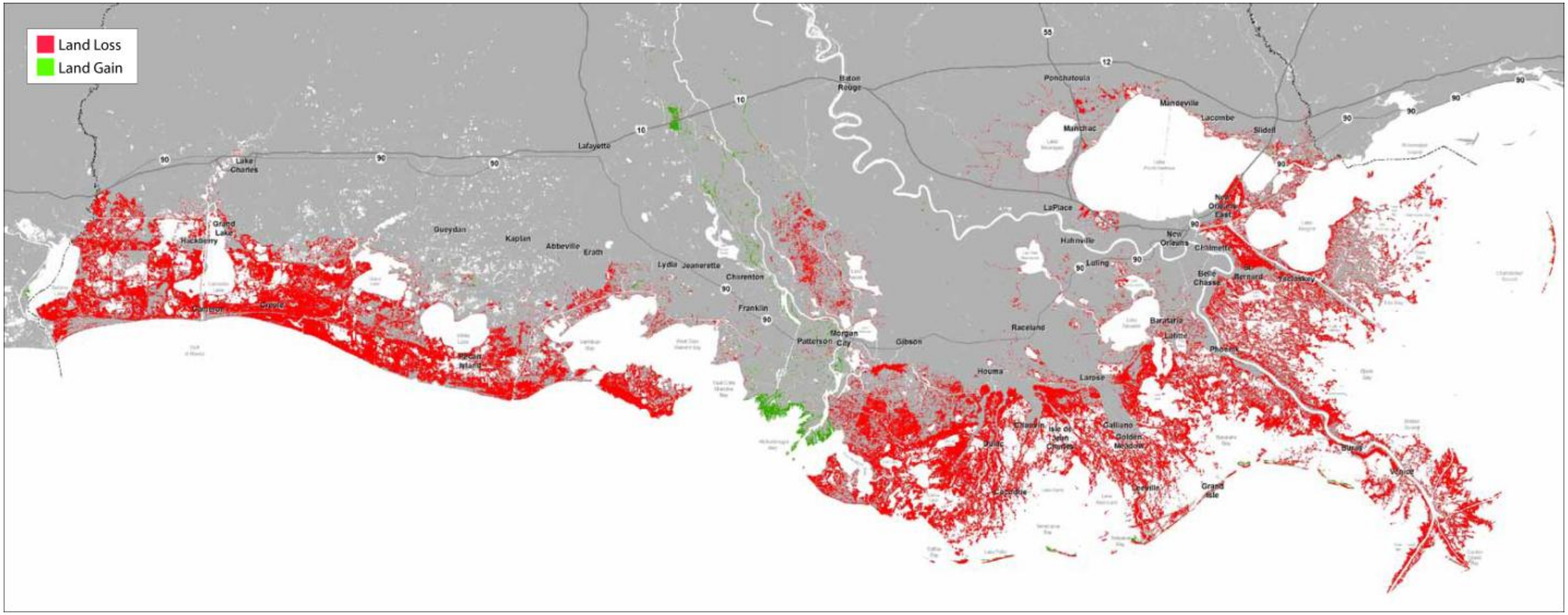
An increasing negative factor: sea level rise



Bindoff et al., 2007

From being a non-factor, exponential sea level rise is turning into the dominant cause of land loss here and in most coastal areas around the world.

One scenario land extension and losses by 2064



Modified from Coastal Protection and Restoration Authority, 2012

Conclusions

- Dynamics of coastal Louisiana geology are complex and constantly evolving.
- Several forms of subsidence are natural and contribute to coastal land losses in Louisiana.
- There is no technology to manage these negative causes.
- The natural antidote to geologic subsidence in the geologic and historic past was overcompensation by deposition of Mississippi river sediments.
- Such effective overcompensation has been neutralized by starvation created by a substantial upstream sediment load retention, a clear anthropogenic cause.
- Land loss will further deteriorate if sea-level rise accelerates.

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