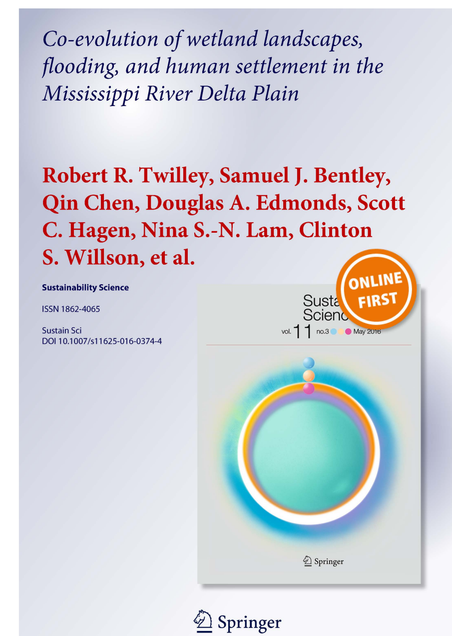
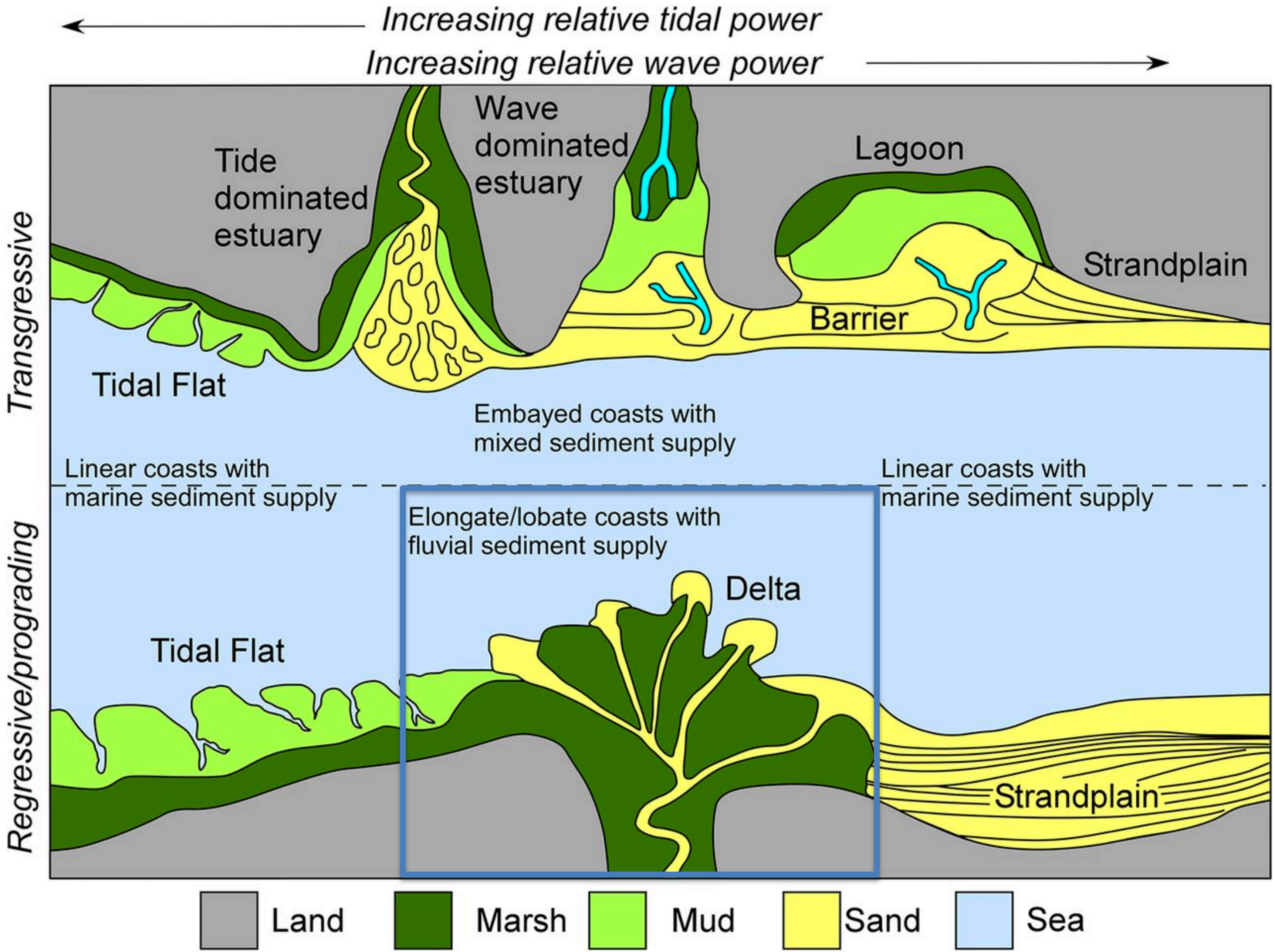
"Co-evolution of wetland landscapes, flooding and human settlement in the Mississippi River Deltaic Plain: An update"

Robert R. Twilley
Department of Oceanography and Coastal Sciences, LSU
Director of Louisiana Sea Grant College Program

Vertical Land Motion in the Chesapeake Bay
February 28, 2020

Visualizing the Complexity of Edges: Gulf

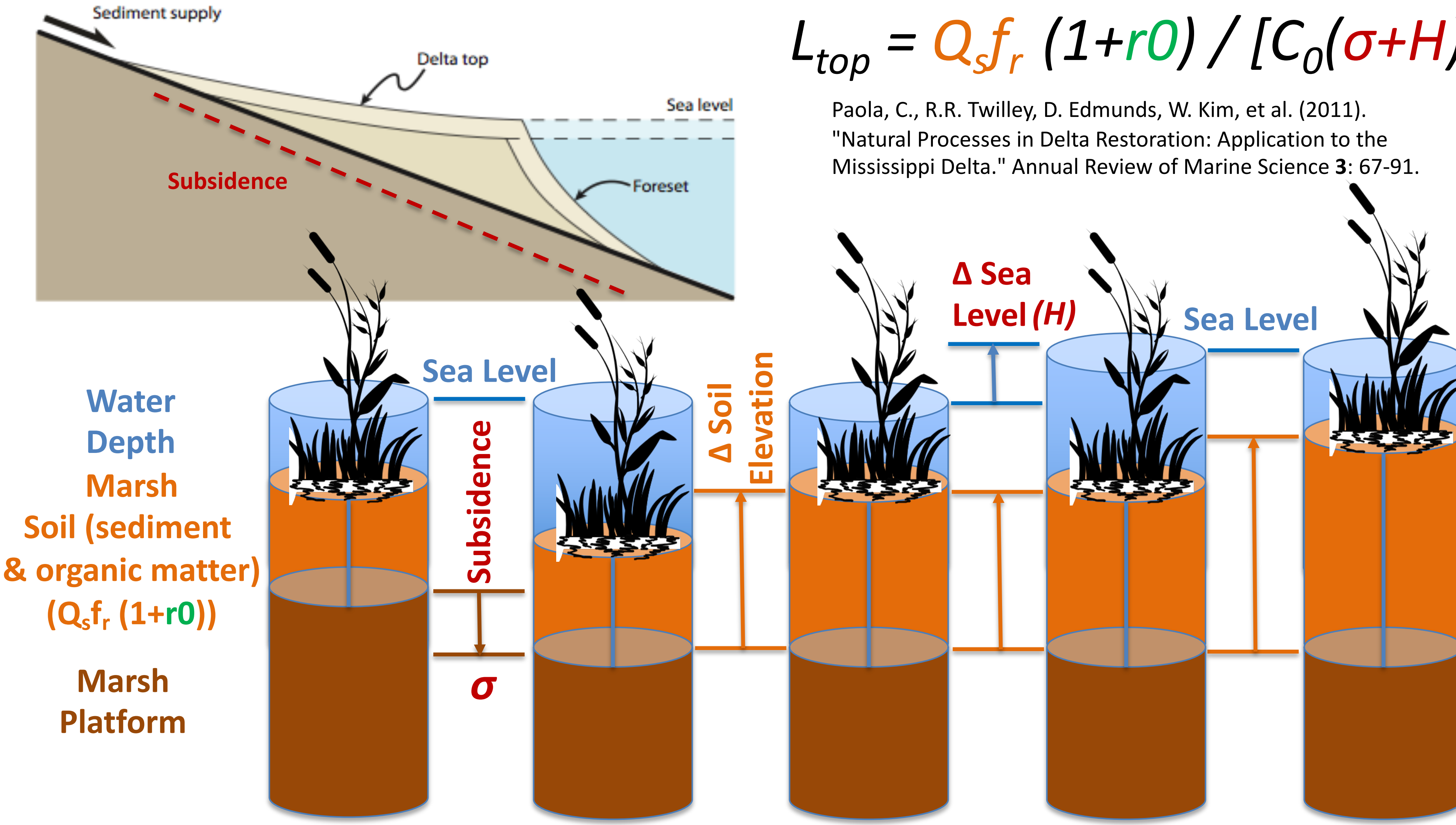


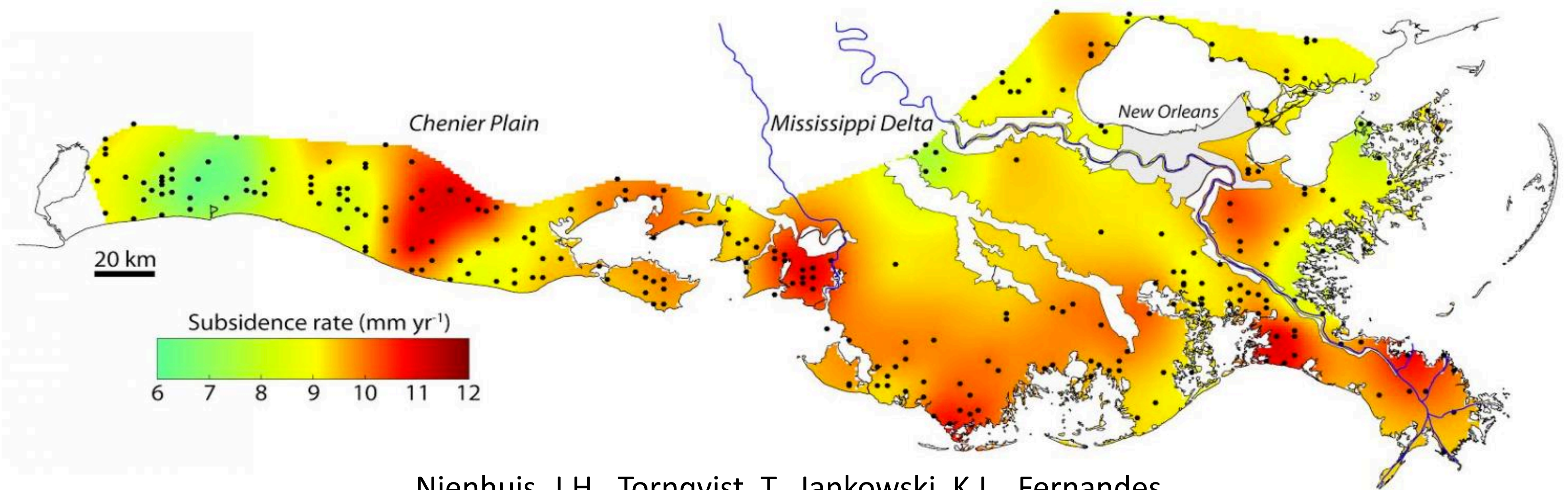

Increasing relative tidal power
Increasing relative wave power
Transgressive
Regressive/prograding
Tide dominated estuary
Wave dominated estuary
Lagoon
Strandplain
Barrier
Tidal Flat
Embayed coasts with mixed sediment supply
Linear coasts with marine sediment supply
Linear coasts with marine sediment supply
Elongate/lobate coasts with fluvial sediment supply
Delta
Tidal Flat
Strandplain
Land
Marsh
Mud
Sand
Sea

Delta Mass Balance Model = balance between sea-level rise + subsidence vs deposition of sediment and organic matter sequestration:

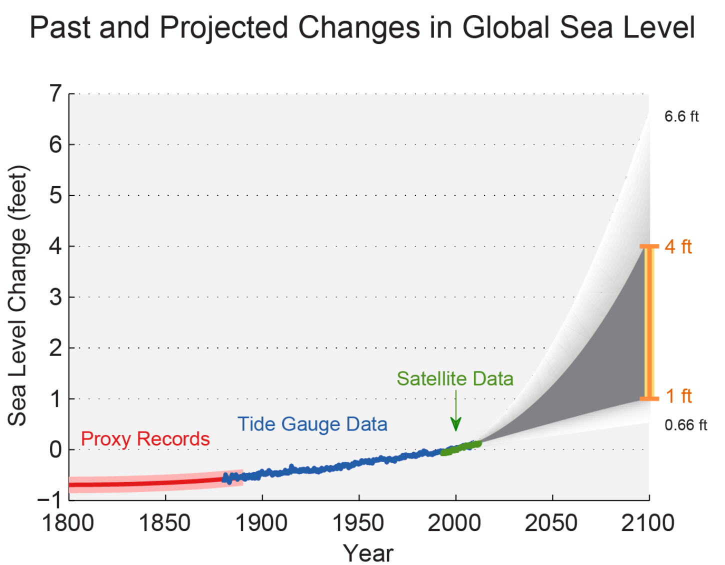
$$L_{top} = Q_s f_r \,(1+r0) \,/\, [C_0(\sigma+H)]$$

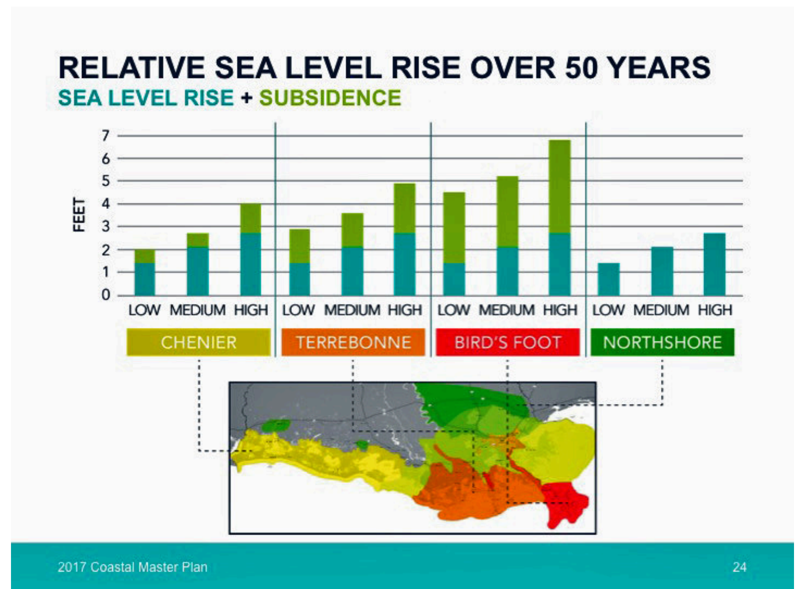
Paola, C., R.R. Twilley, D. Edmunds, W. Kim, et al. (2011). "Natural Processes in Delta Restoration: Application to the Mississippi Delta." Annual Review of Marine Science **3**: 67-91.



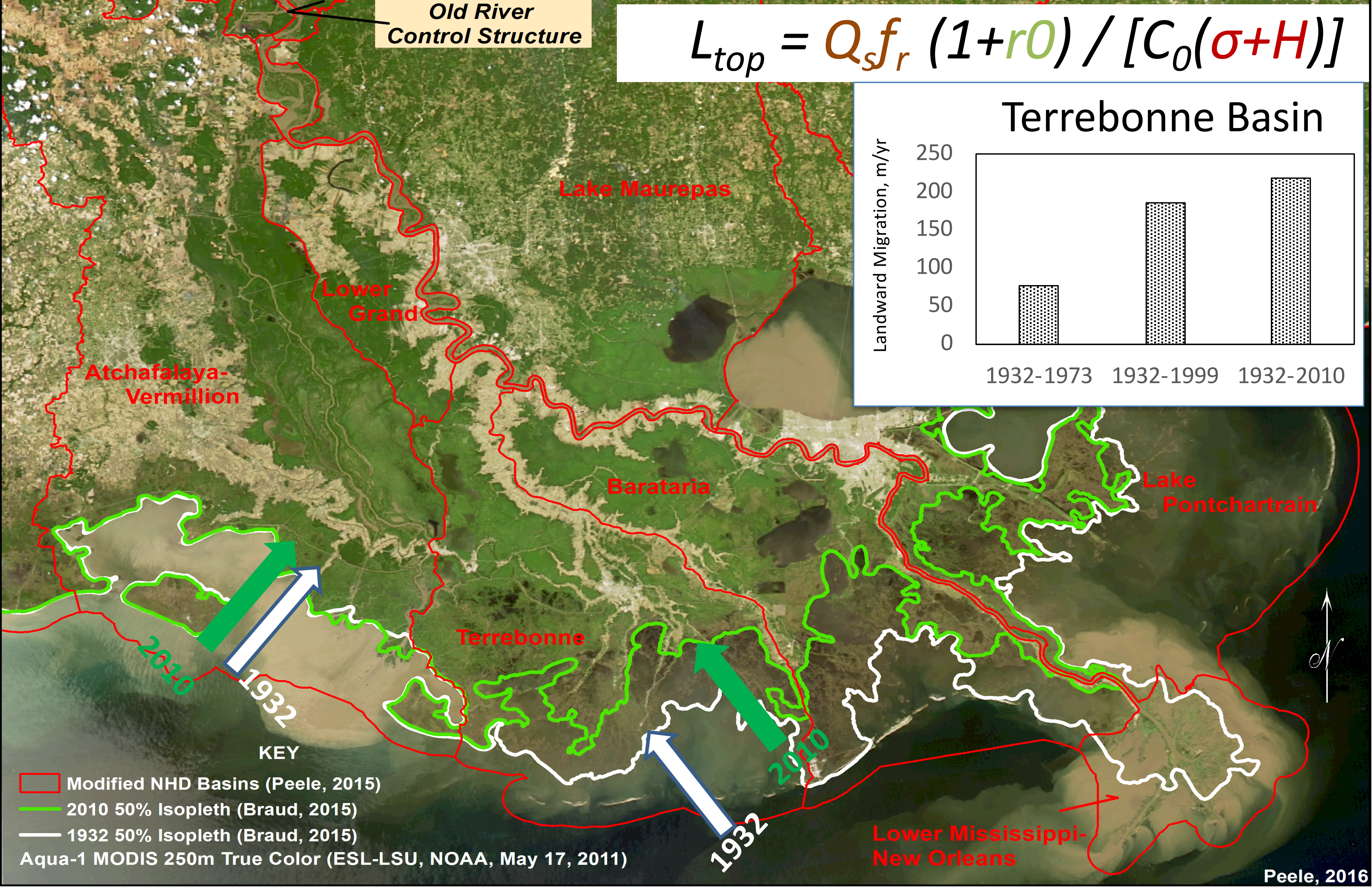


Nienhuis, J.H., Tornqvist, T., Jankowski, K.L., Fernandes, A.M., Keogh, M.E., 2017. A new subsidence map for coastal Louisiana. GSA Today 27.





$$L_{top} = Q_s f_r\,(1+r0)\,/\,[C_0(\sigma+H)]$$



state took it over and it was supposed to be a model community with a community center with child care, elderly care. A lot of activities so kids can play in a safe environment. But all that kind of got shoved in a hole and we can't get it out. It's very disappointing, actually. I'm very depressed."

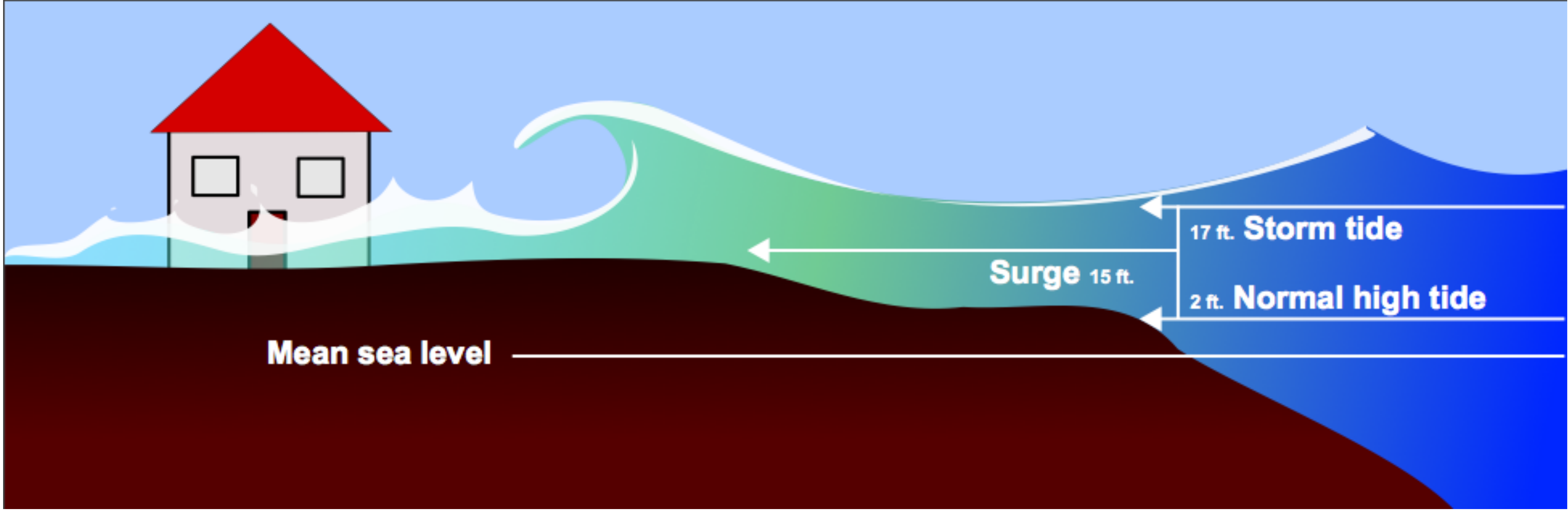
Rumors of outsiders offering to buy Isle de Jean Charles camps has prompted some to put up signs such as this. Climate change and rising sea levels are the biggest threats to Isle de Jean Charles. A sign in one resident's front yard offers their thoughts on the matter.

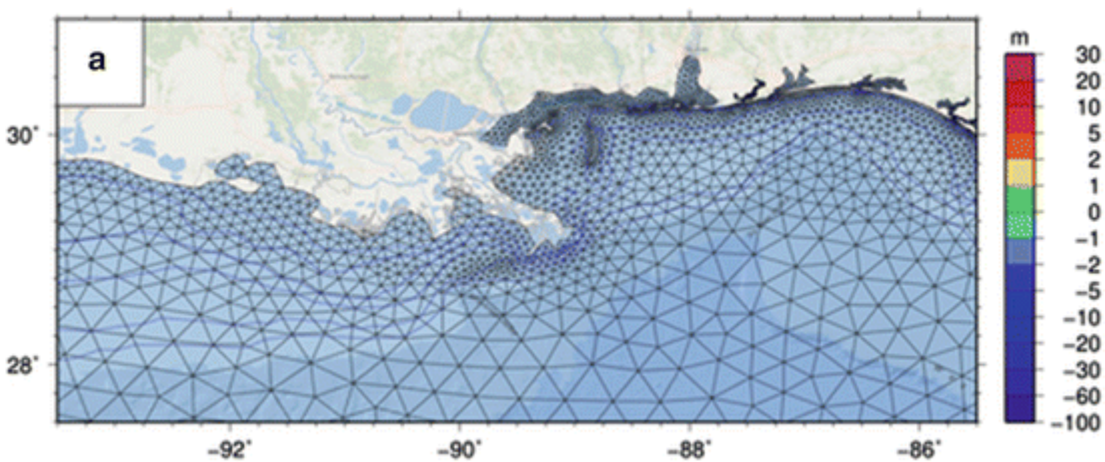
SCOTT CLAUSE/USA TODAY NETWORK

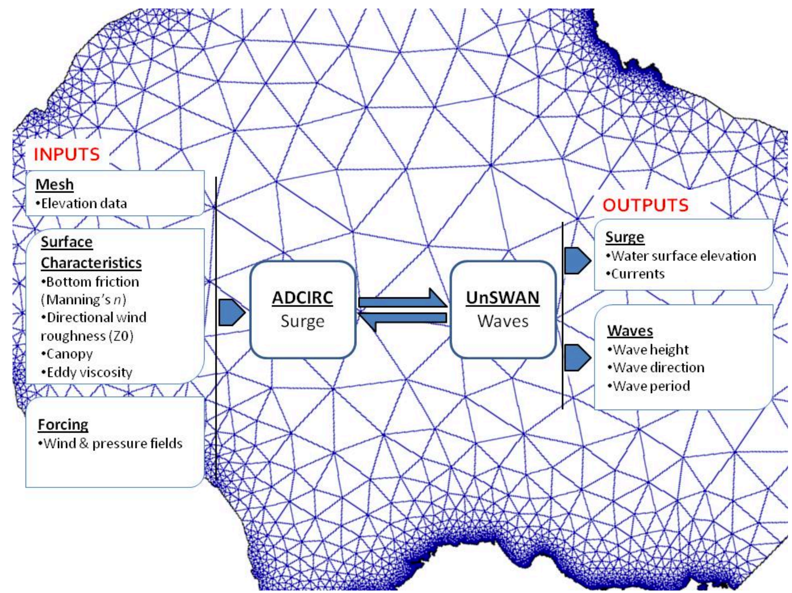
CLIMATE COLLISION

As Gulf swallows Louisiana island, displaced tribe fears the future

Andrew J. Yawn, The American South
Updated 9:35 a.m. CST Feb. 27, 2020







LSU
Center for Coastal Resiliency

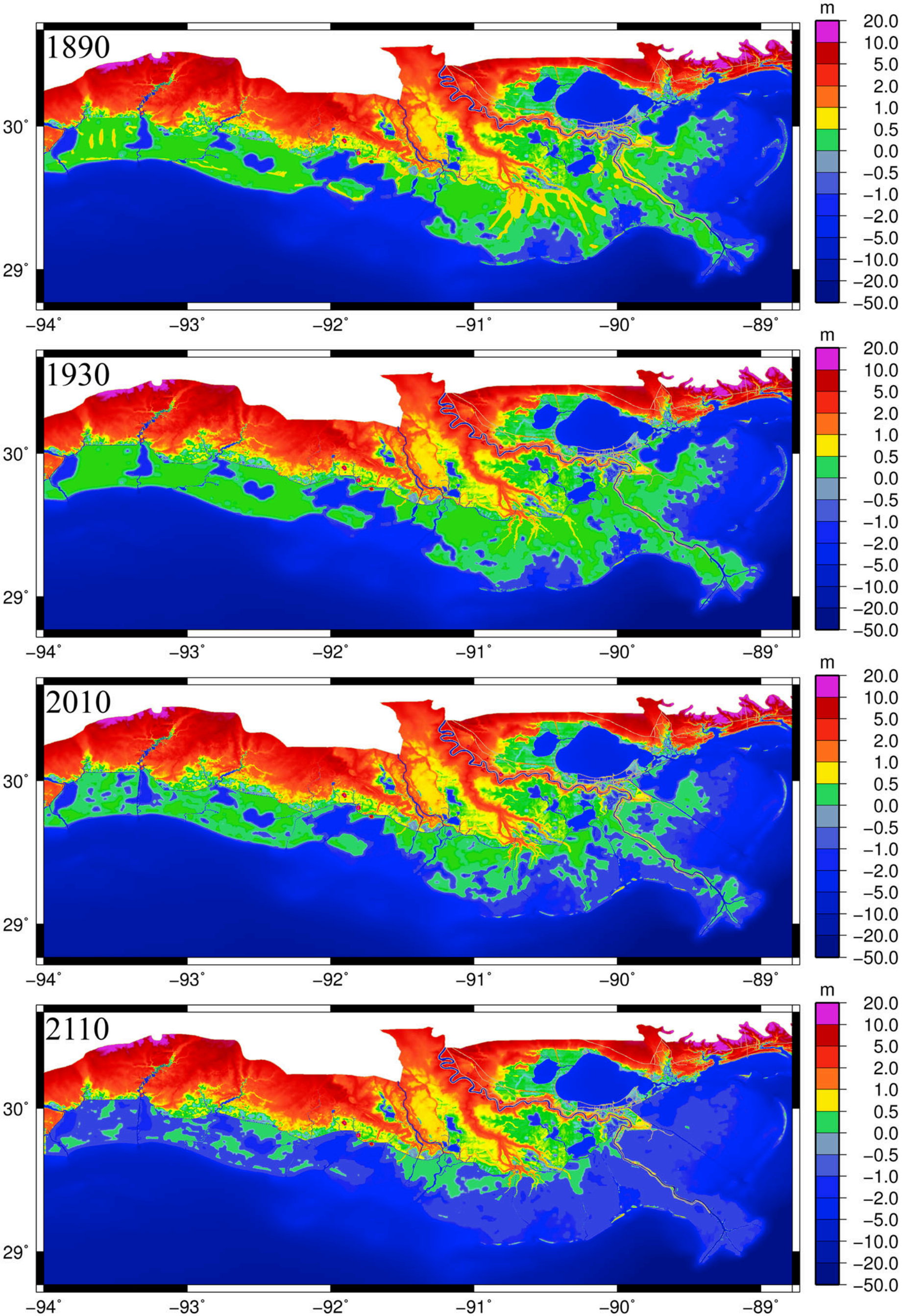


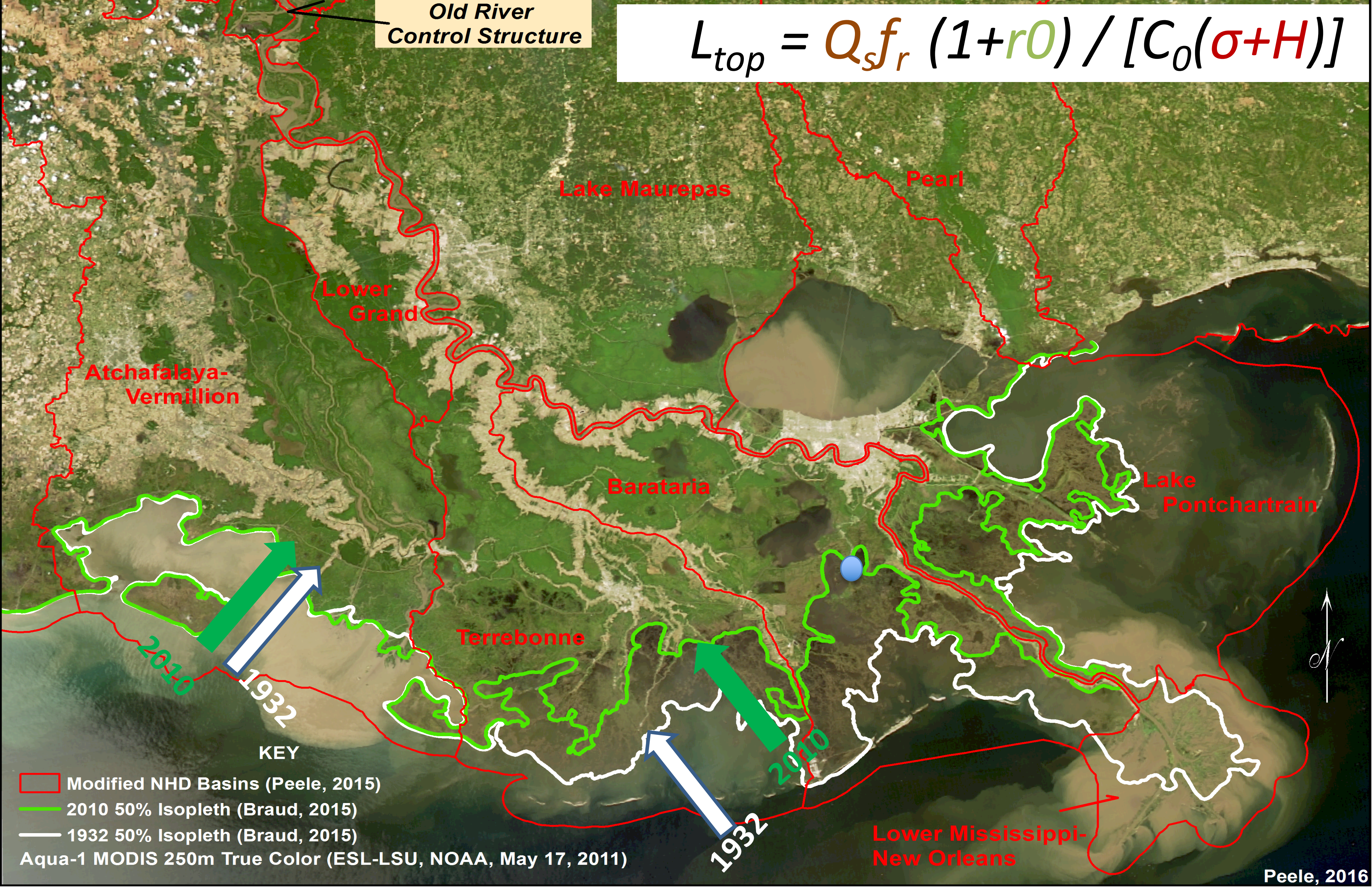
Fig. 2 Topography and bathymetry: 1890, 1930, 2010, and 2110

Siverd, C. G., S. C. Hagen, M. V. Bilskie, D. H. Braud and R. R. Twilley **2020**. "Quantifying storm surge and risk reduction costs: a case study for Lafitte, Louisiana." Climatic Change: 157(3), 445-468

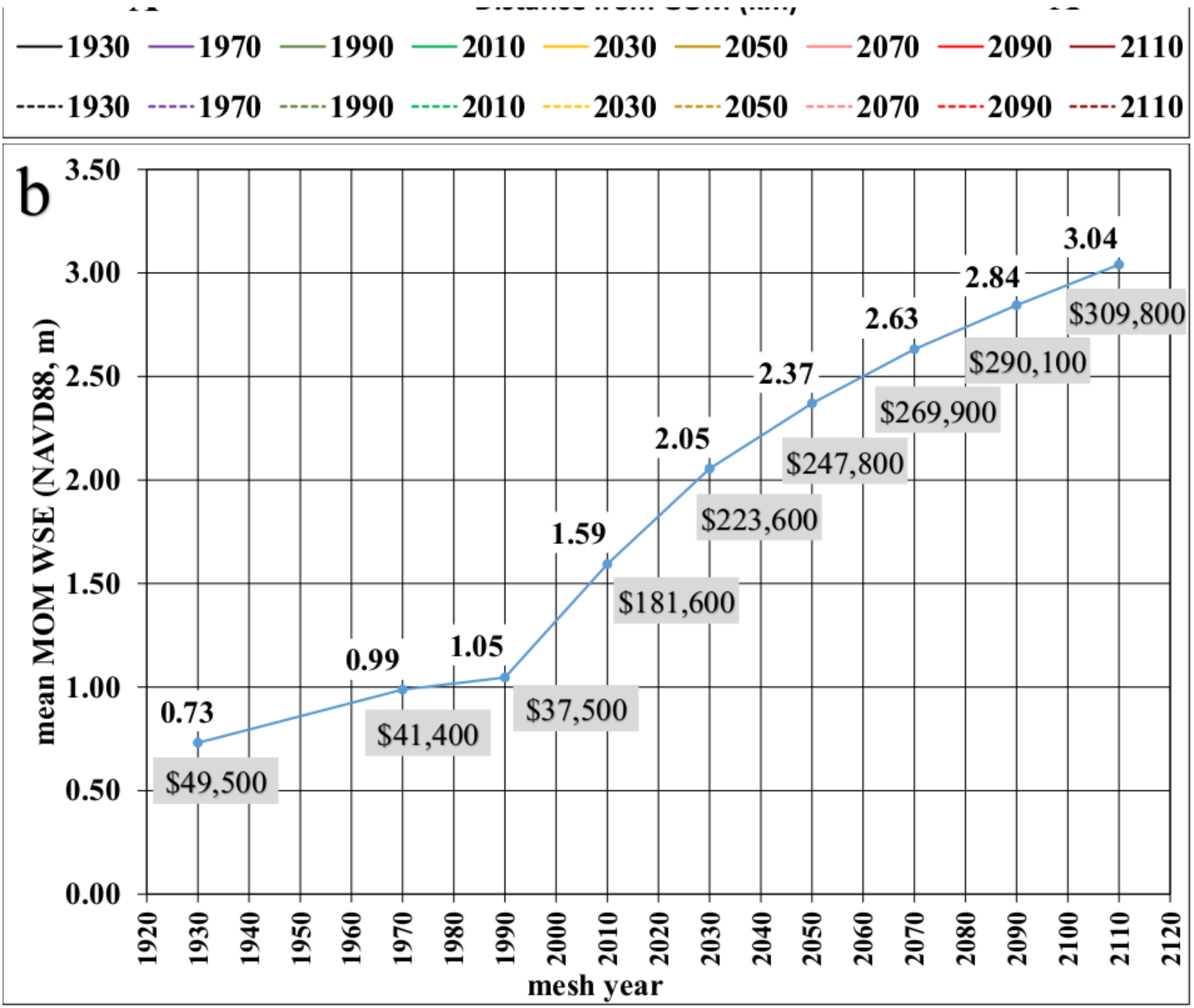
Siverd, C. G., S. C. Hagen, M. V. Bilskie, D. H. Braud, R. H. Peele, M. R. Foster-Martinez and R. R. Twilley **2019**. "Coastal Louisiana landscape and storm surge evolution: 1850–2110." Climatic Change. *157*(3), 445-468

Siverd, C. G., S. C. Hagen, M. V. Bilskie, D. H. Braud, S. Gao, R. H. Peele and R. R. Twilley **2019**. Assessment of the temporal evolution of storm surge across coastal Louisiana. Coastal Engineering 150: 59-78.

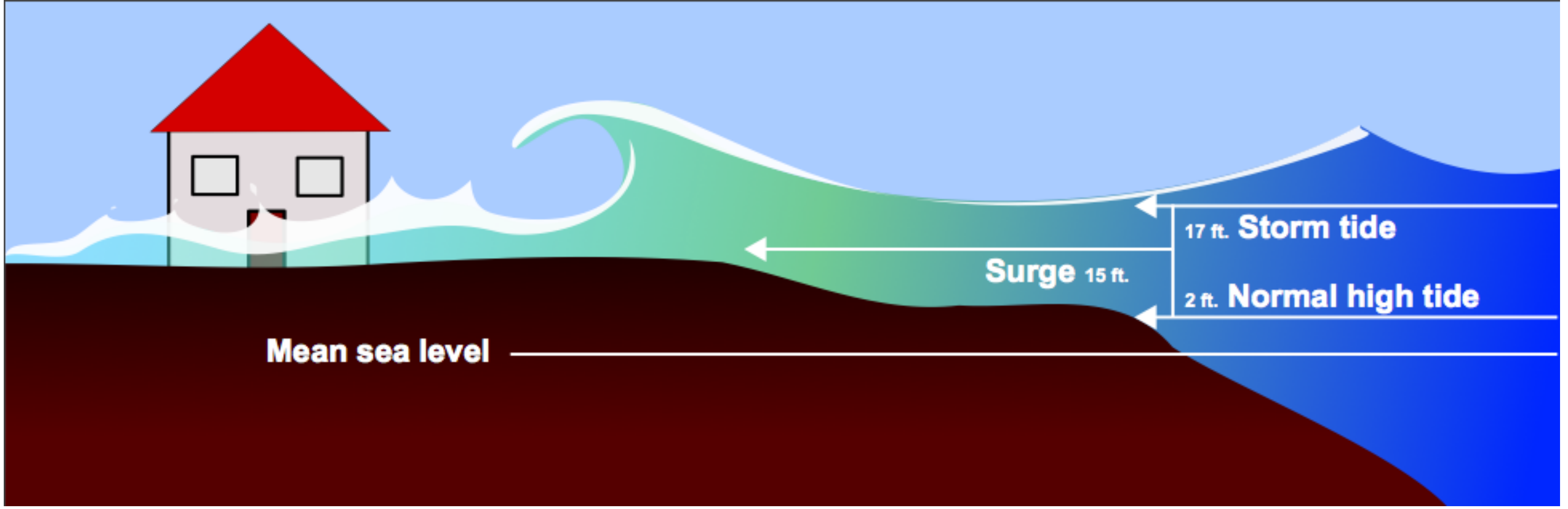
Siverd, C. G., Hagen, SC, Bilskie, MV, Braud, DH, Peele, RH, Twilley, RR. **2018**. Hydrodynamic storm surge model simplification via application of land to water isopleths in coastal Louisiana. Coastal Engineering 137: 28-42.



Old River
Control Structure
$L_{top} = Q_s f_r (1+r0) / [C_0(\sigma+H)]$
Lake Maurepas
Pearl
Lower
Grand
Atchafalaya-
Vermillion
Barataria
Lake
Pontchartrain
Terrebonne
2010
1932
2010
1932
KEY
Modified NHD Basins (Peele, 2015)
2010 50% Isopleth (Braud, 2015)
1932 50% Isopleth (Braud, 2015)
Aqua-1 MODIS 250m True Color (ESL-LSU, NOAA, May 17, 2011)
Lower Mississippi-
New Orleans
N
Peele, 2016



Maximum of maximum (MOM) water surface elevations at Lafitte, Louisiana. Gray boxes: average cost per person in 2010 USD for protection from Hurricane Isaac storm surge for each storm surge model mesh year 1930-2110. GMSL rise of 2 mm/year 1930-2010 and GMSL rise of 5.1 mm/year 2010-2110 included

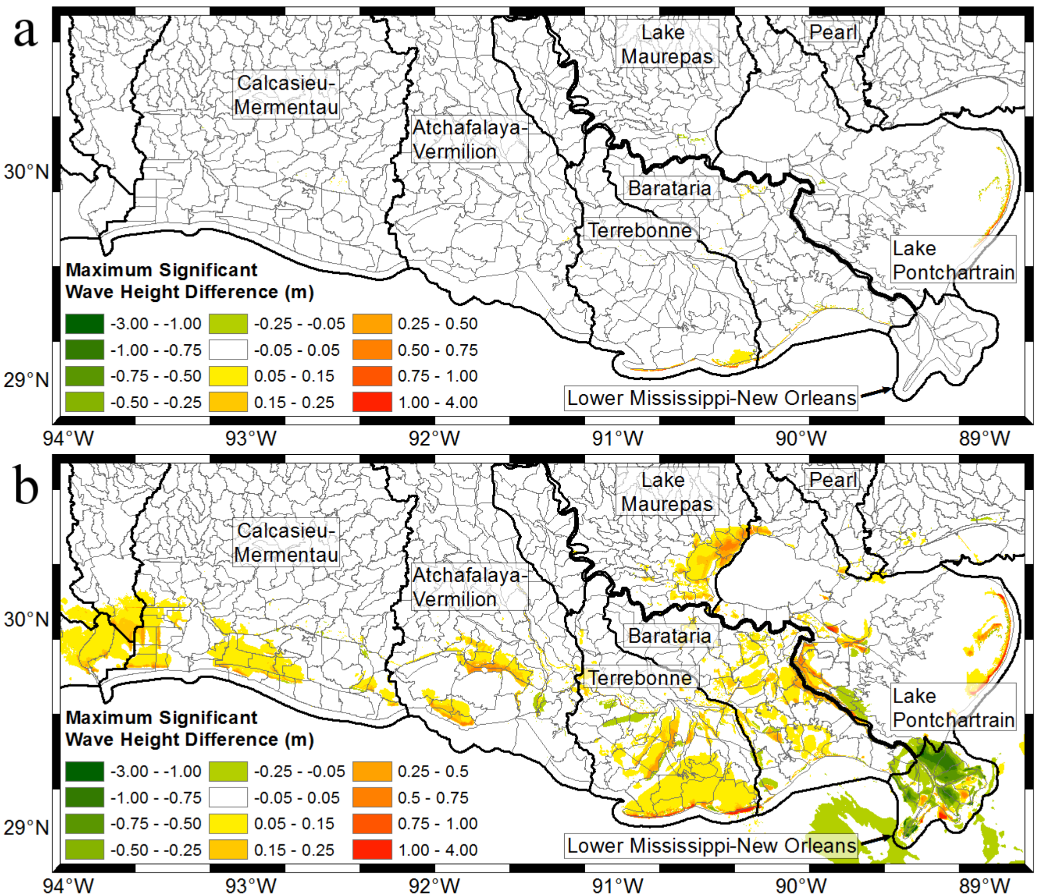


Approximate costs per person are also calculated (2010 USD):
$49,500 (1930),
$41,400 (1970),
$37,500 (1990),
$181,600 (2010),
$223,600 (2030),
$247,800 (2050),
$269,900 (2070),
$290,100 (2090), and
$309,800 (2110).

The Gulf of Mexico (GOM) migrated 7.4 km inland within the Louisiana Barataria coastal basin between 1973 and 2010.

For each person in Lafitte, flood defense costs increased approximately (2010 USD) $19,000 per person per kilometer inland migration of the GOM from 1973 to 2010.

The methodology developed in this case study effectively connects wetland loss with increased flood defense costs and can be applied to communities with similar challenges.



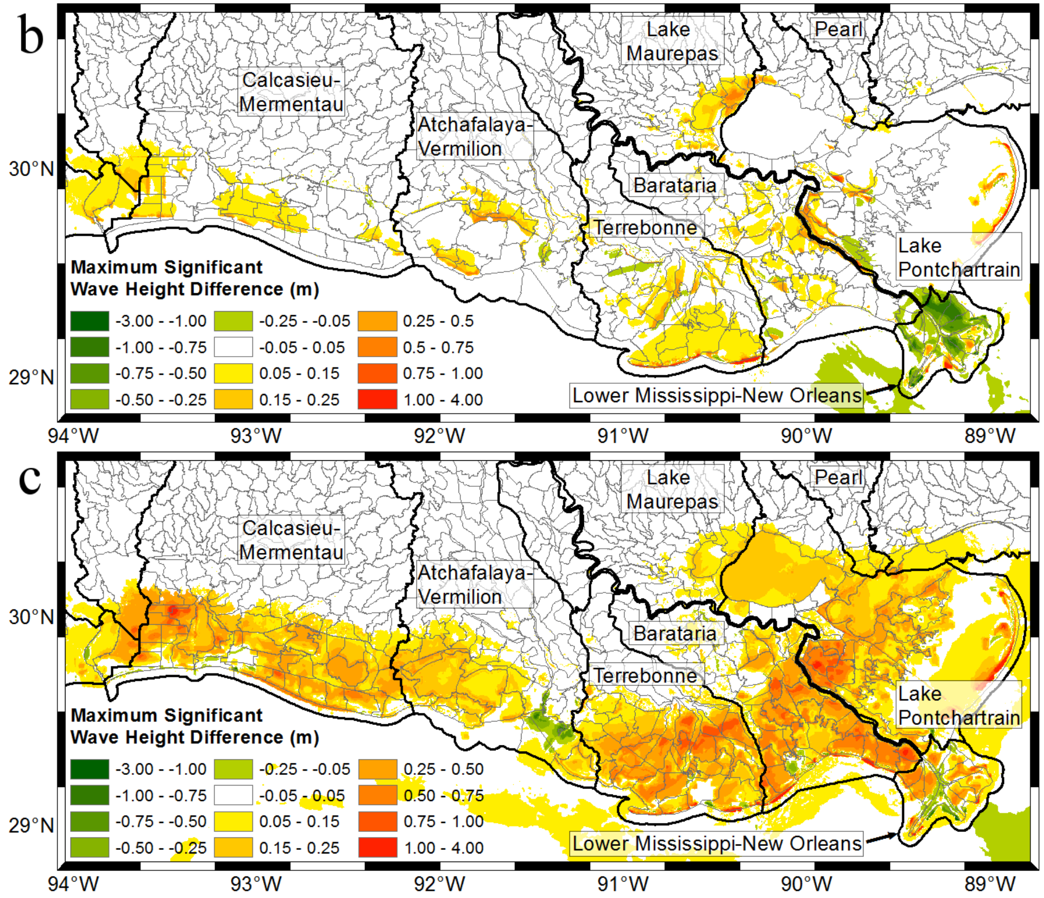
Simulation results for 1850 and 1890 demonstrate minimal change in storm surge characteristics along the Louisiana coast.

Mean maximums of maximums (MOM) water surface elevations difference (m, NAVD88) for 14 hurricanes simulated as follows:

YEARS	Sea Level Rise
a) 1850-1890,	0.5 mm/yr
b) 1890-1930,	1.0 mm/yr
c) 1930-2010,	2.0 mm/yr
d) 2010-2110,	5.1 mm/yr
e) 1850-2110.	

b

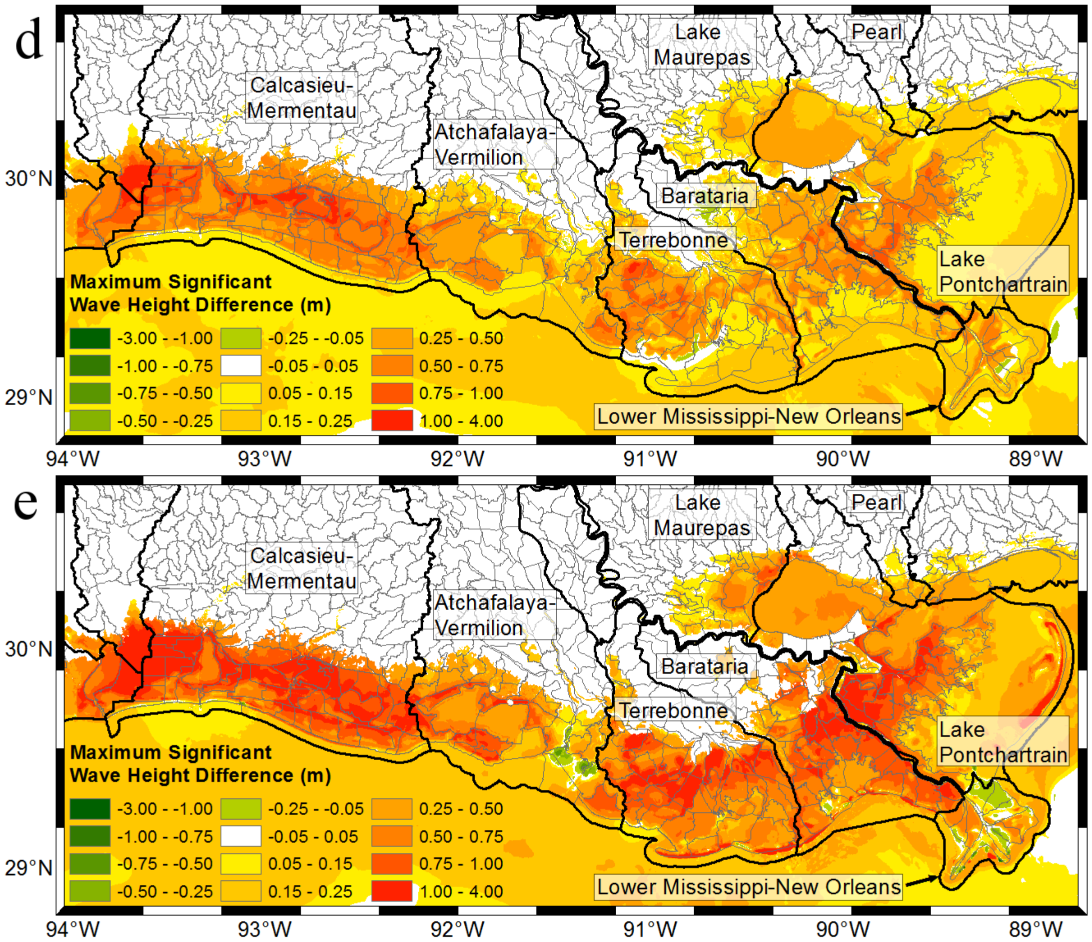
c



A mean maximum storm surge height increase of 0.26 m from 1930 to 2010 is quantified within the sediment-abundant Atchafalaya-Vermilion coastal basin, while increases of 0.34 m and 0.41 m are quantified within sediment-starved Terrebonne and Barataria, respectively.

Mean maximums of maximums (MOM) water surface elevations difference (m, NAVD88) for 14 hurricanes simulated as follows:

	YEARS	Sea Level Rise
a)	1850-1890,	0.5 mm/yr
b)	1890-1930,	1.0 mm/yr
c)	1930-2010,	2.0 mm/yr
d)	2010-2110,	5.1 mm/yr
e)	1850-2110.	



Future mean maximum storm surge heights increase across these three coastal basins by 0.67 m, 0.55 m, and 0.75 m, indicating negligible differences from 2010 to 2110, regardless of sediment availability.

Mean maximums of maximums (MOM) water surface elevations difference (m, NAVD88) for 14 hurricanes simulated as follows:

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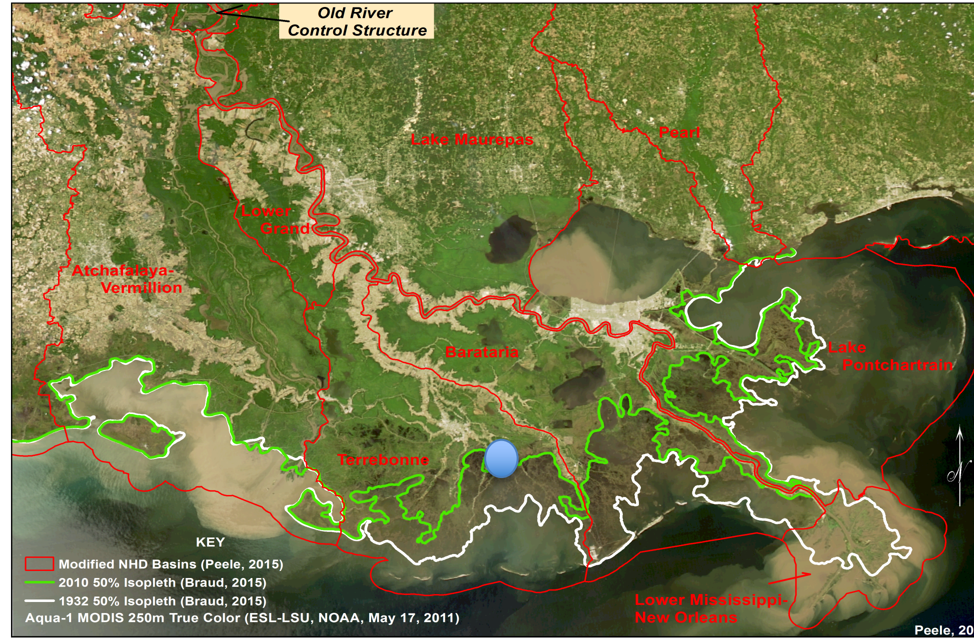
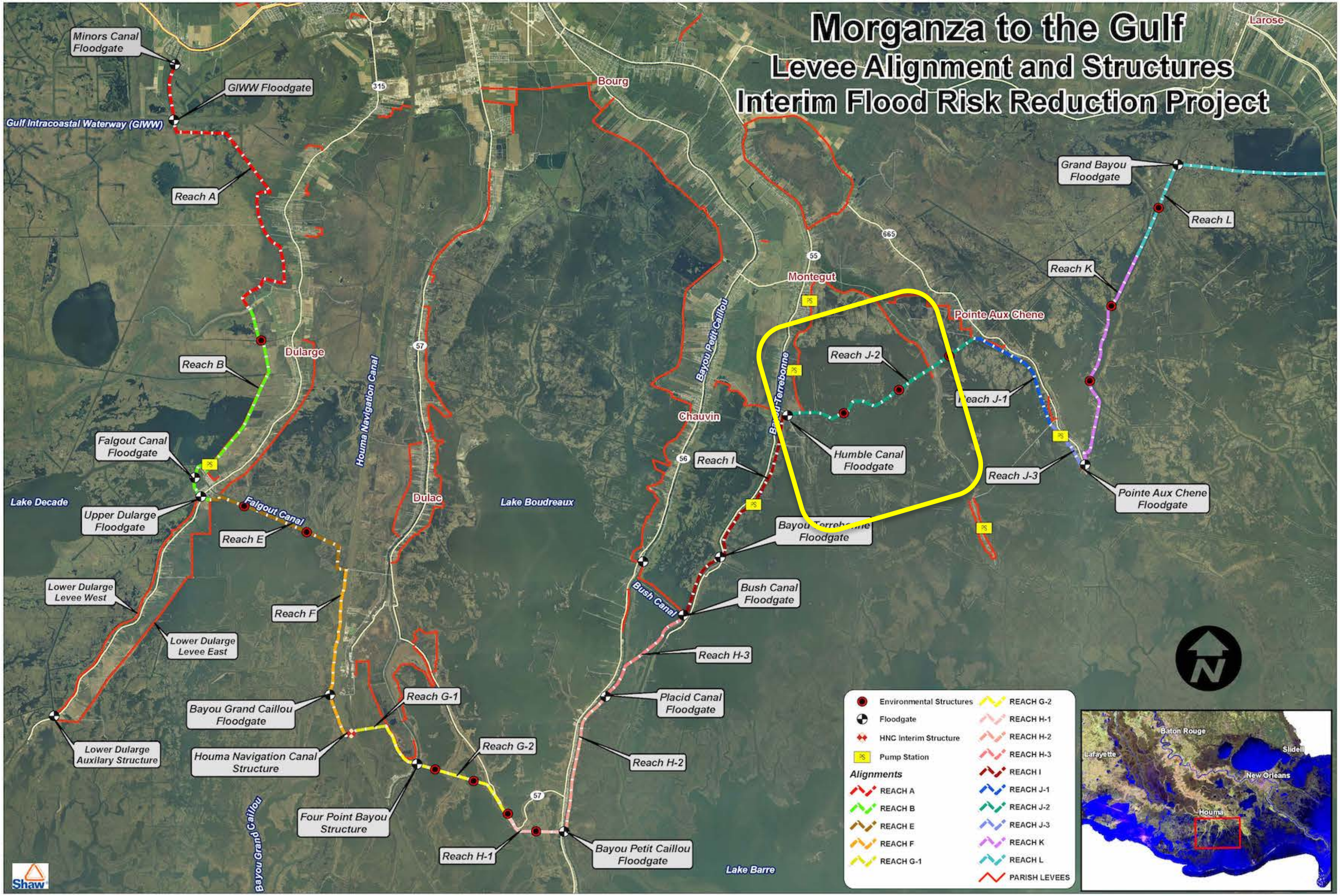
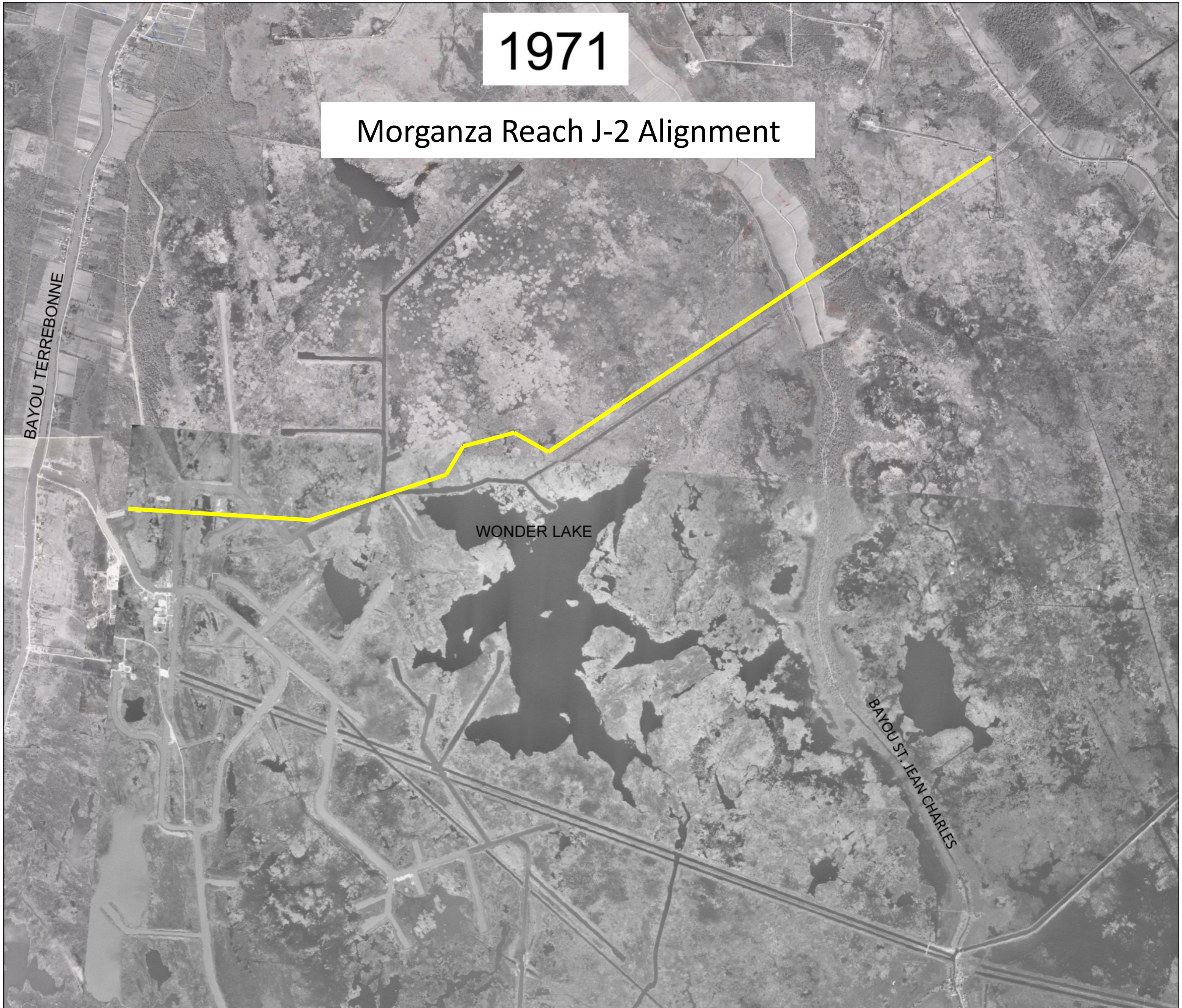


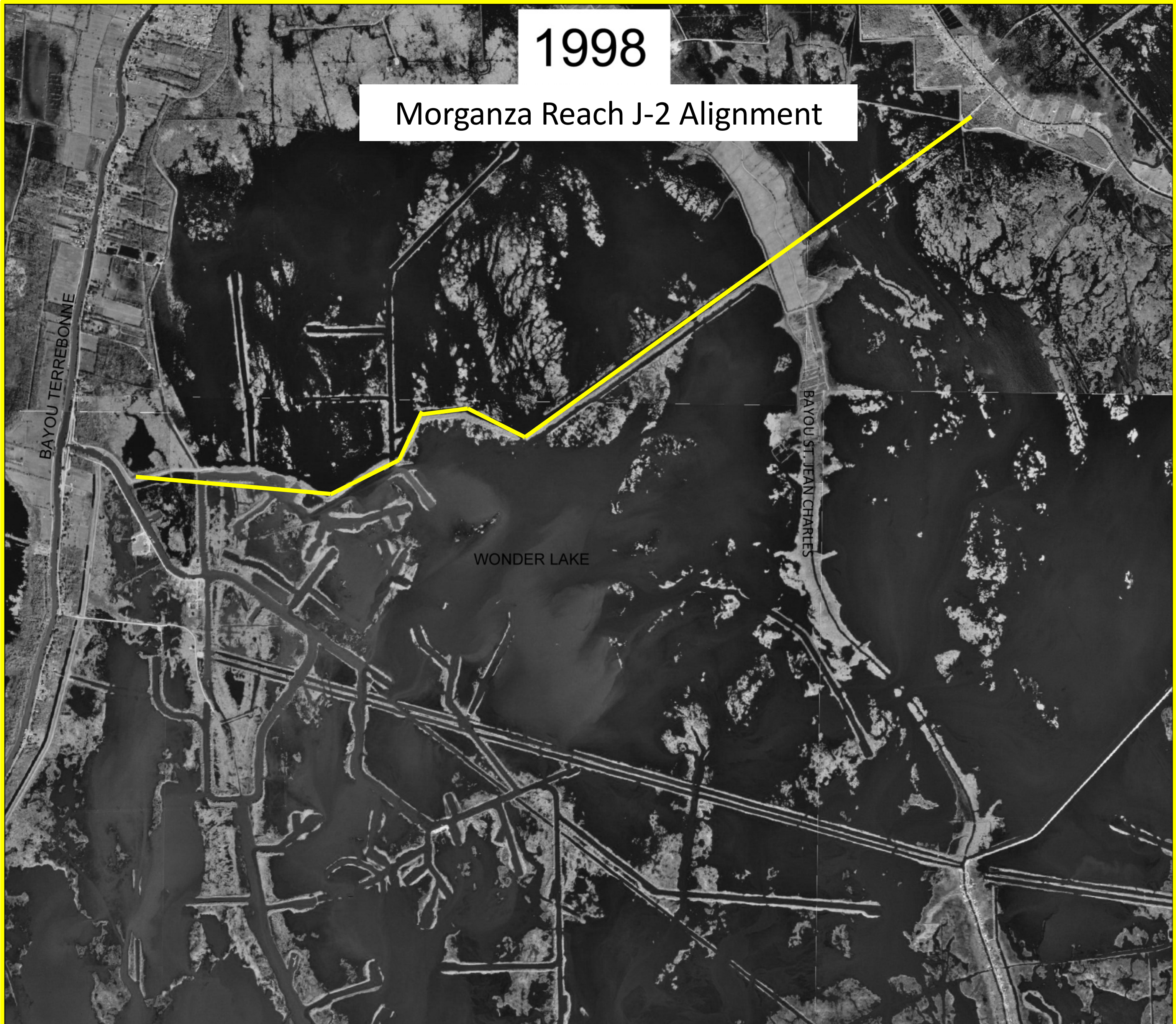
1. A mean maximum storm surge height increase of 0.26 m from 1930 to 2010 is quantified within the sediment-abundant Atchafalaya-Vermilion coastal basin, while increases of 0.34 m and 0.41 m are quantified within sediment-starved Terrebonne and Barataria, respectively.
2. Future mean maximum storm surge heights increase across these three coastal basins by 0.67 m, 0.55 m, and 0.75 m, indicating negligible differences from 2010 to 2110, regardless of sediment availability.
3. Results indicate that past changes in the Louisiana coastal landscape and storm surge were a consequence of local land and river management decisions while future changes are dominated by relative (subsidence and eustatic) sea level rise.

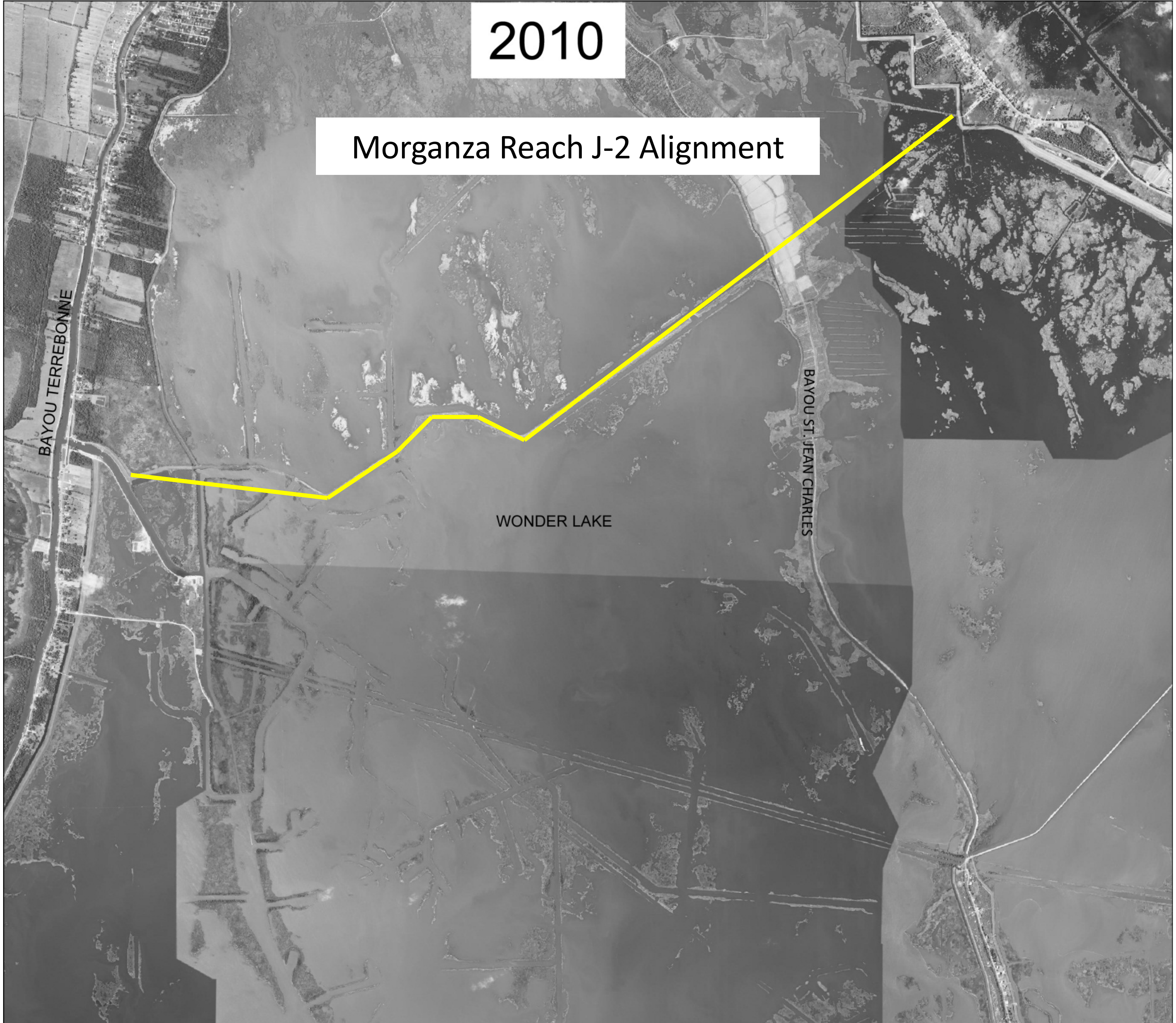


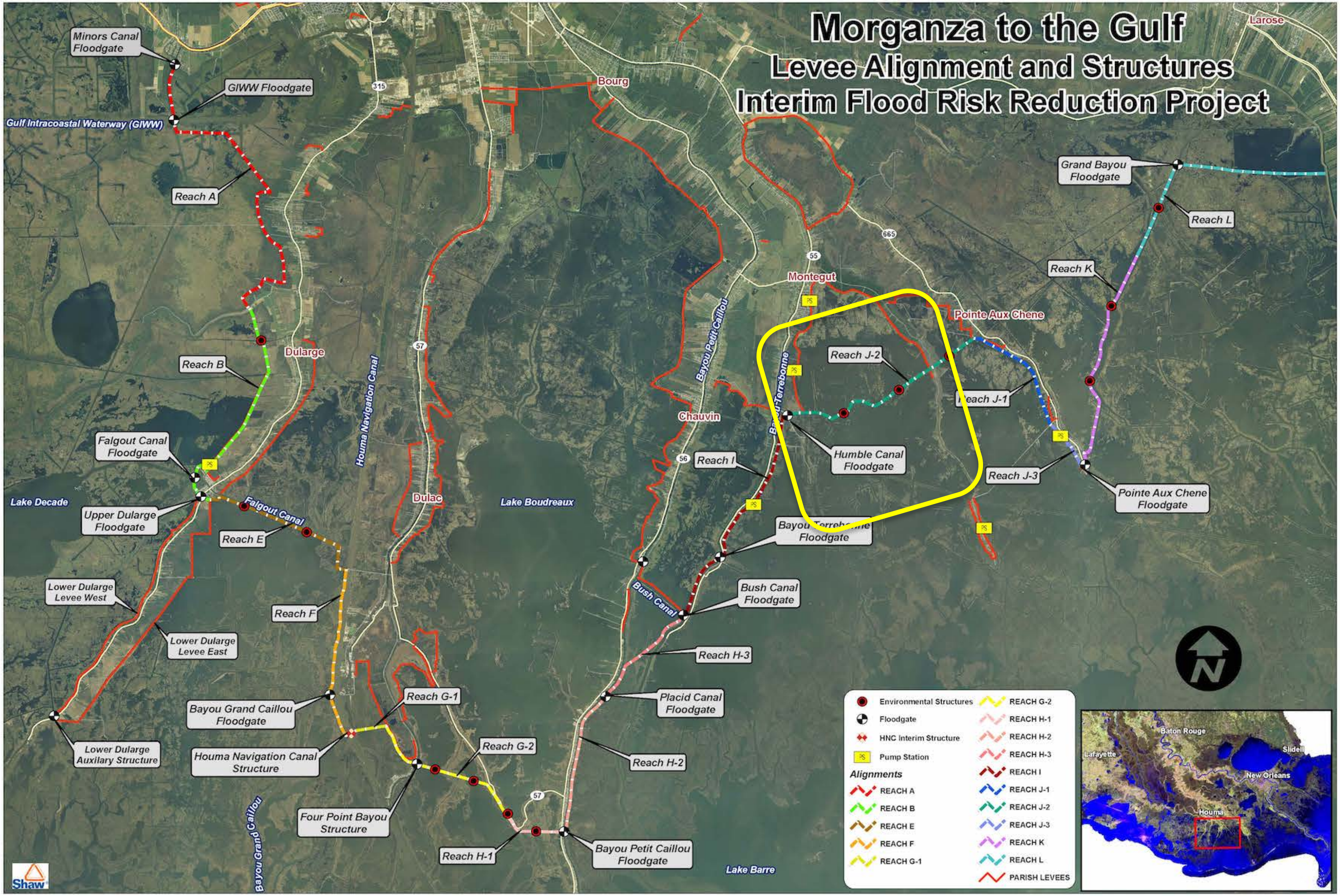
Morganza to the Gulf
Levee Alignment and Structures
Interim Flood Risk Reduction Project
Minors Canal Floodgate
GIWW Floodgate
Gulf Intracoastal Waterway (GIWW)
Reach A
Reach B
Dularge
Falgout Canal Floodgate
Upper Dularge Floodgate
Lake Decade
Falgout Canal
Reach E
Reach F
Lower Dularge Levee West
Lower Dularge Levee East
Lower Dularge Auxilary Structure
Bayou Grand Caillou Floodgate
Houma Navigation Canal Structure
Four Point Bayou Structure
Bayou Grand Caillou
Houma Navigation Canal
Reach G-1
Reach G-2
Reach H-1
Dulac
Lake Boudreaux
Bourg
Bayou Petit Caillou
Chauvin
Reach I
Bush Canal
Bush Canal Floodgate
Reach H-3
Placid Canal Floodgate
Reach H-2
Bayou Petit Caillou Floodgate
Lake Barre
Montegut
Bayou Terrebonne
Reach J-2
Humble Canal Floodgate
Bayou Terrebonne Floodgate
Pointe Aux Chene
Reach J-1
Reach J-3
Pointe Aux Chene Floodgate
Reach K
Reach L
Grand Bayou Floodgate
Larose
Environmental Structures
Floodgate
HNC Interim Structure
Pump Station
Alignments
REACH A
REACH B
REACH E
REACH F
REACH G-1
REACH G-2
REACH H-1
REACH H-2
REACH H-3
REACH I
REACH J-1
REACH J-2
REACH J-3
REACH K
REACH L
PARISH LEVEES
Baton Rouge
Lafayette
Slidell
New Orleans
Houma
Shaw



1971
Morganza Reach J-2 Alignment
BAYOU TERREBONNE
WONDER LAKE
BAYOU ST. JEAN CHARLES


1998
Morganza Reach J-2 Alignment
BAYOU TERREBONNE
BAYOU ST. JEAN CHARLES
WONDER LAKE


2010
Morganza Reach J-2 Alignment
BAYOU TERREBONNE
WONDER LAKE
BAYOU ST. JEAN CHARLES



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Baton Rouge
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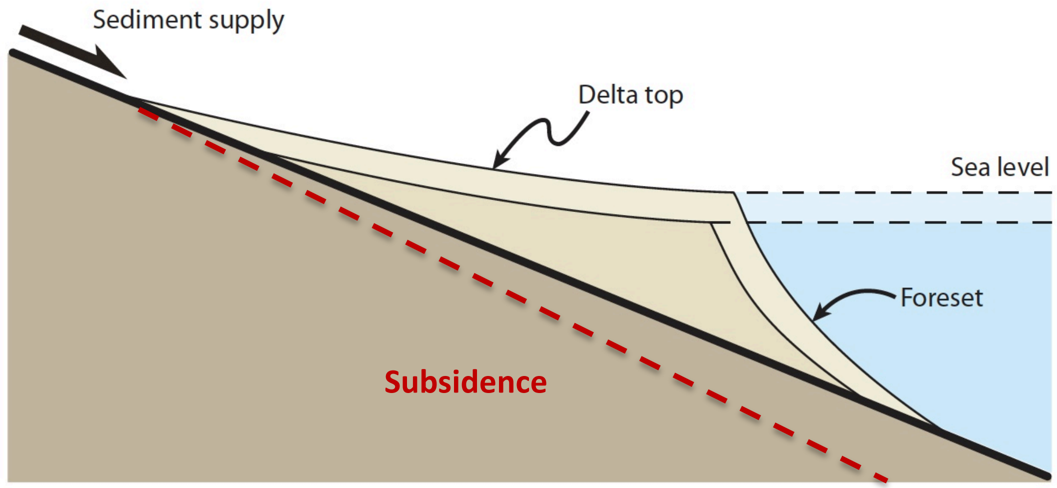
Slidell
New Orleans
Houma
Shaw

Questions?



$$L_{top} = Q_s f_r\ (1+r0)\ /\ [C_0(\sigma+H)]$$

L_{top} the area of the delta top where :

Q_s total volumetric sediment supply,

f_r the fraction retained in the delta top, and

r_{org} the rate of storage of organic matter in soil of delta top,

H is eustatic sea level,

σ spatially averaged subsidence rate

Delta Mass Balance Model = balance between sea-level rise + subsidence vs deposition of sediment and organic matter sequestration

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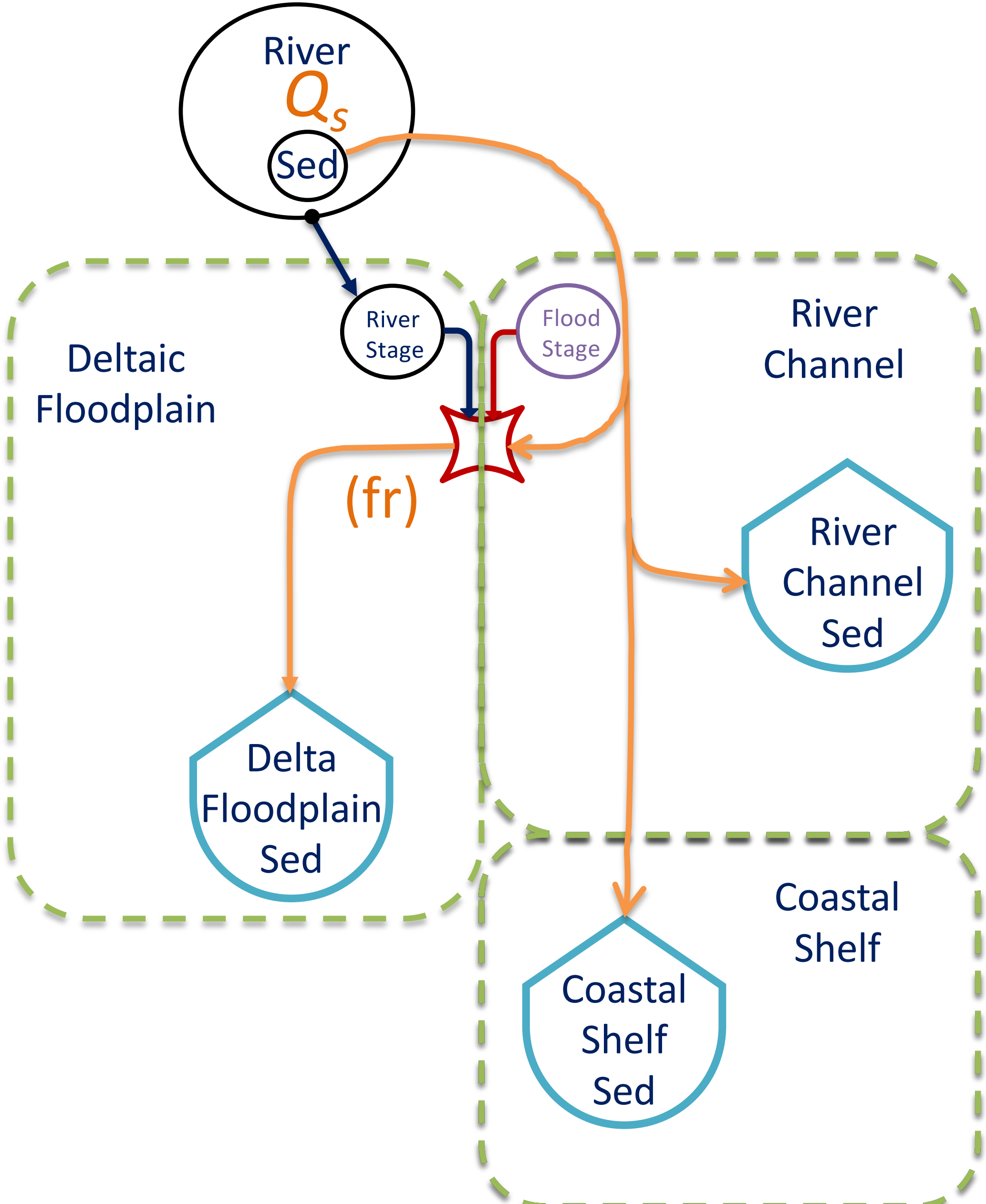

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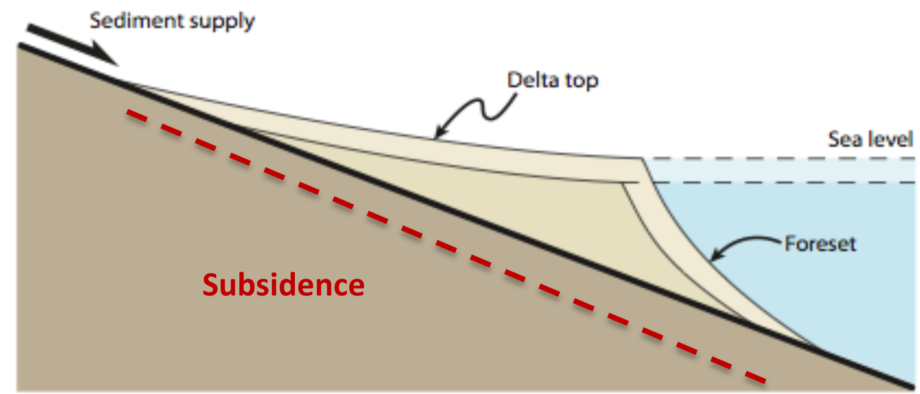
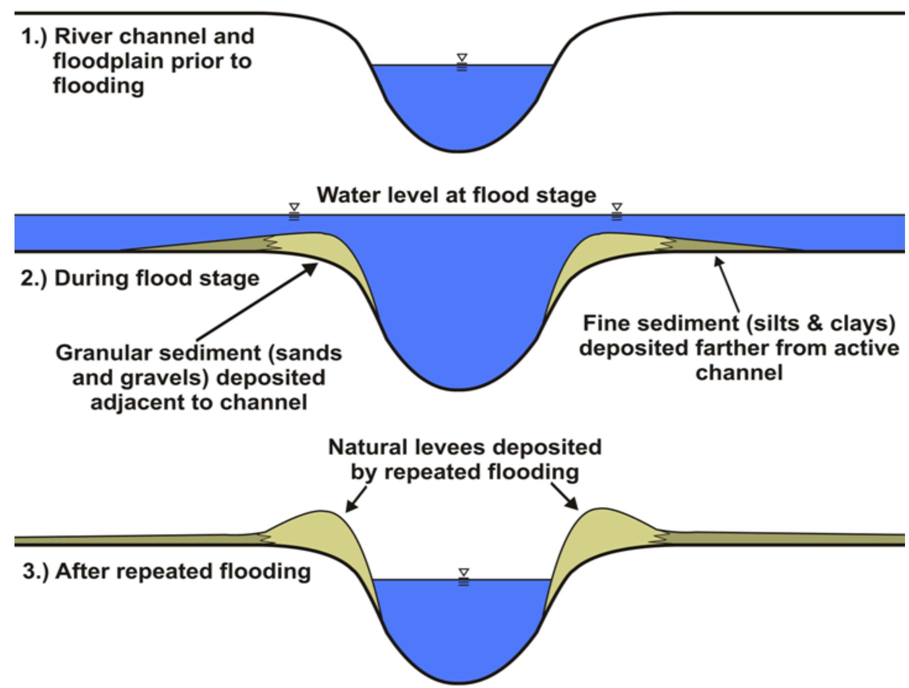
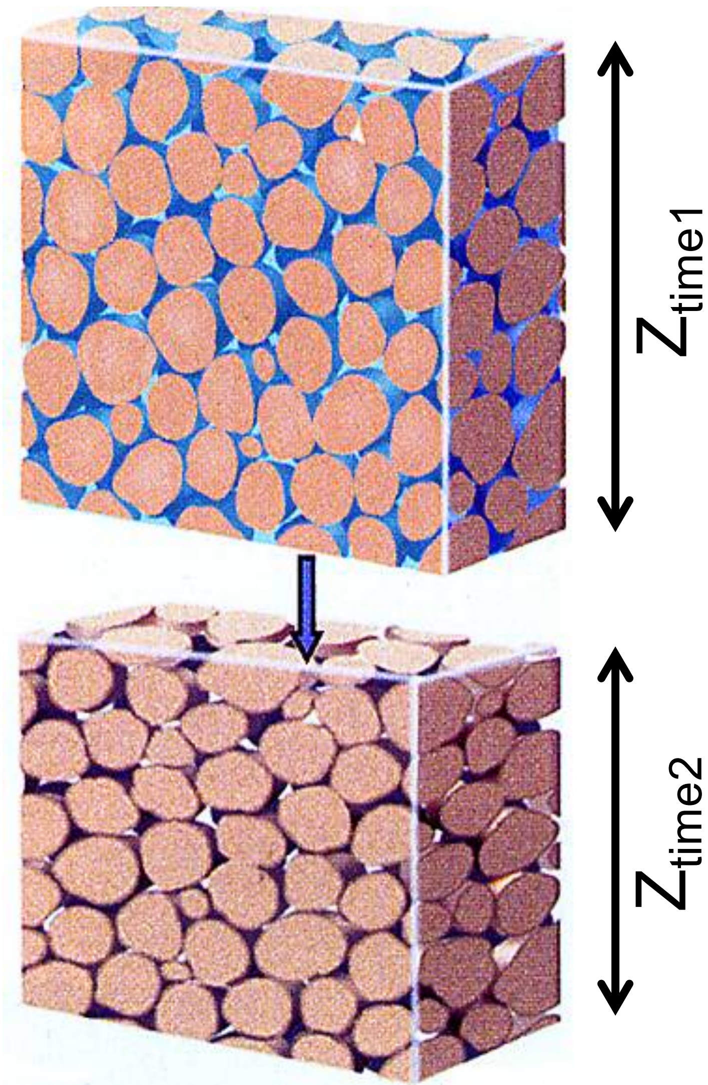
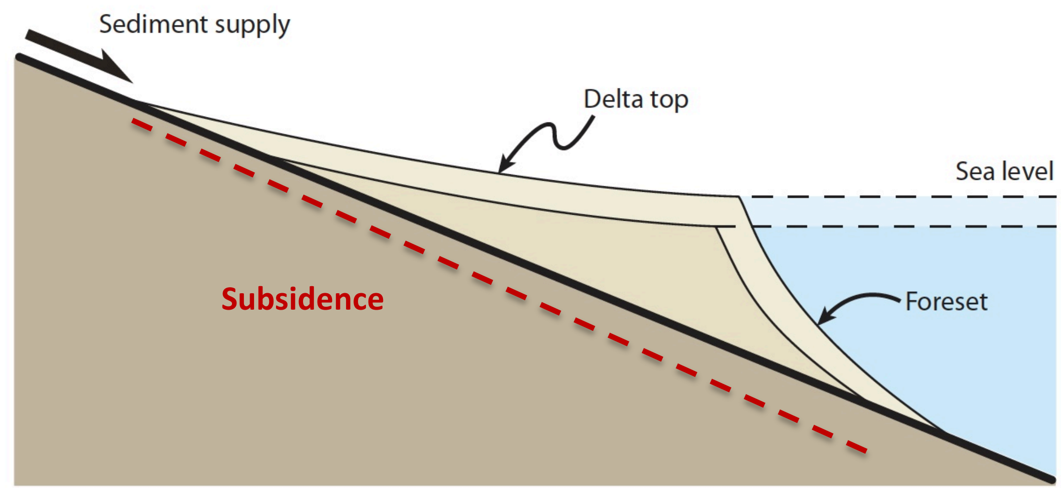


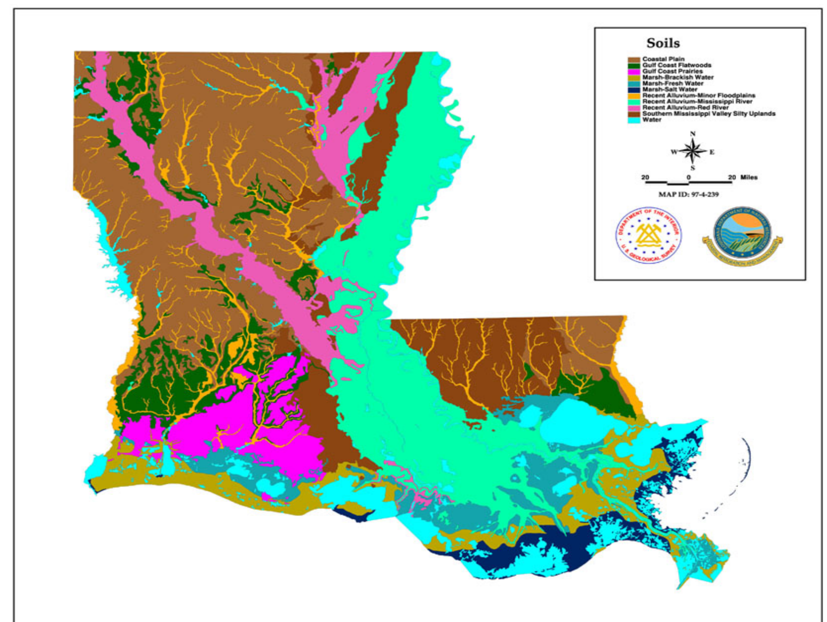


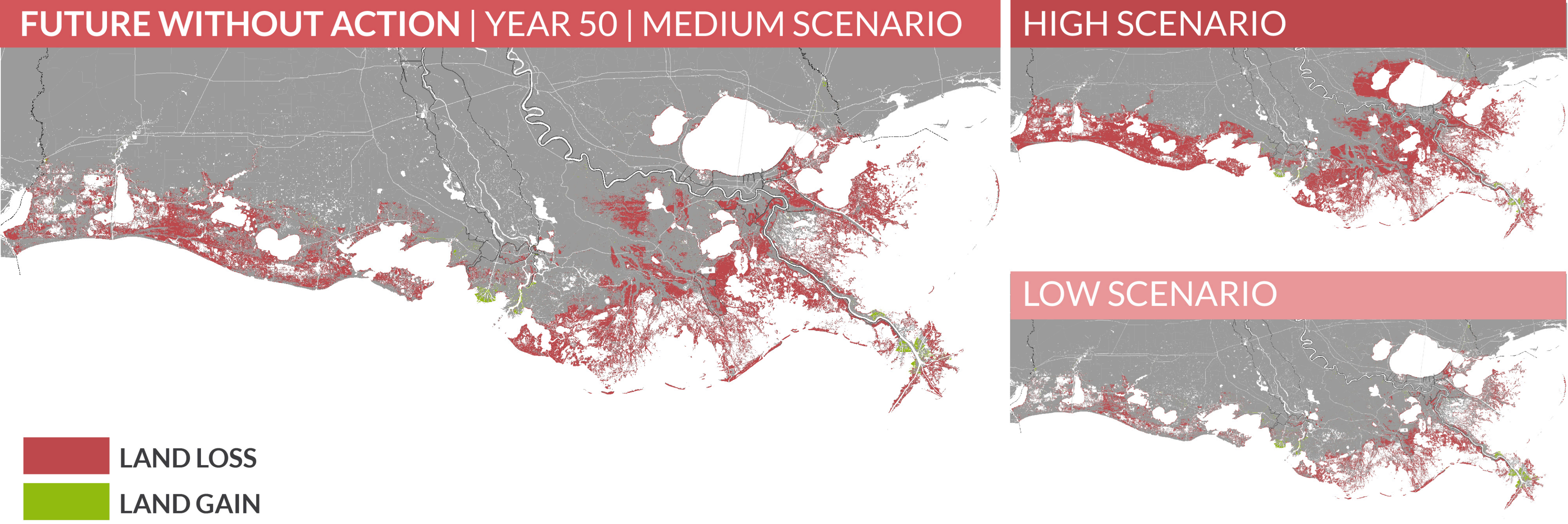
$$L_{top} = Q_s f_r (1+r0) / [C_0(\sigma+H)]$$

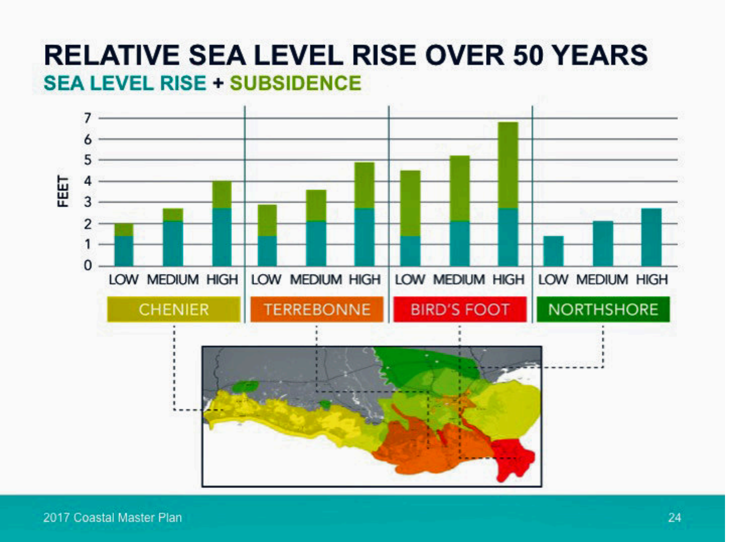
Subsidence (σ).

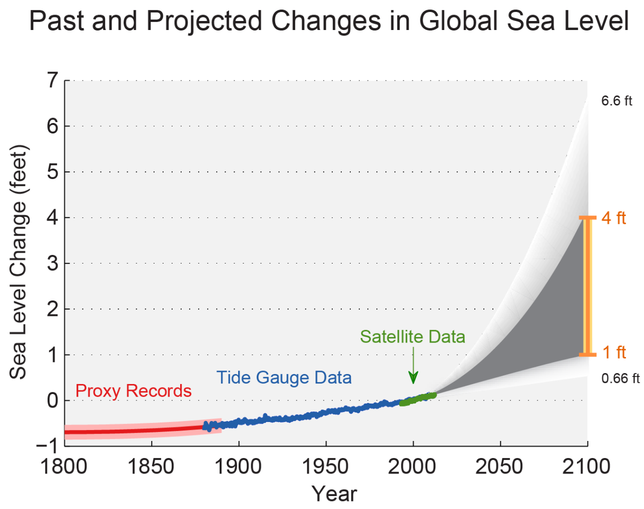






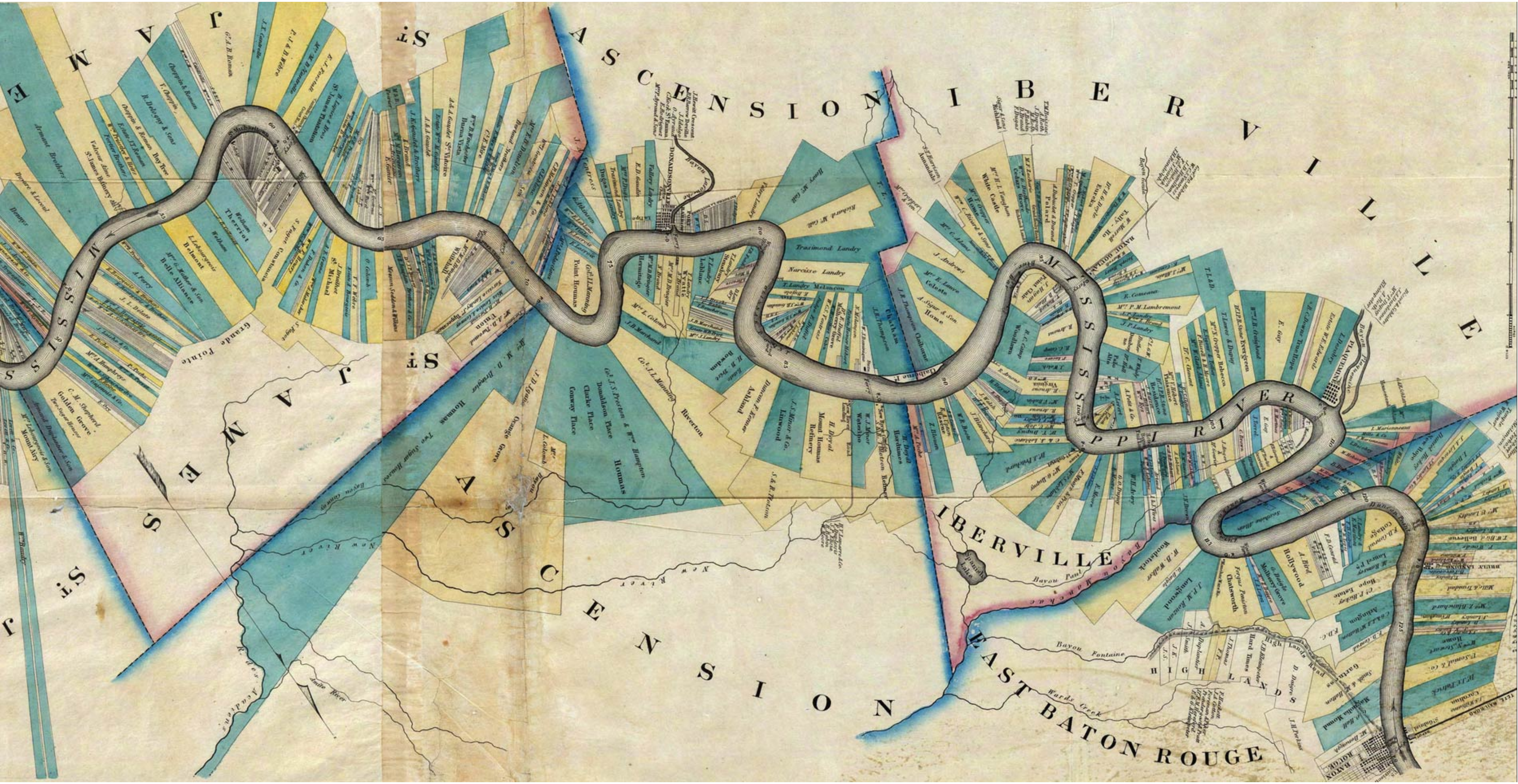




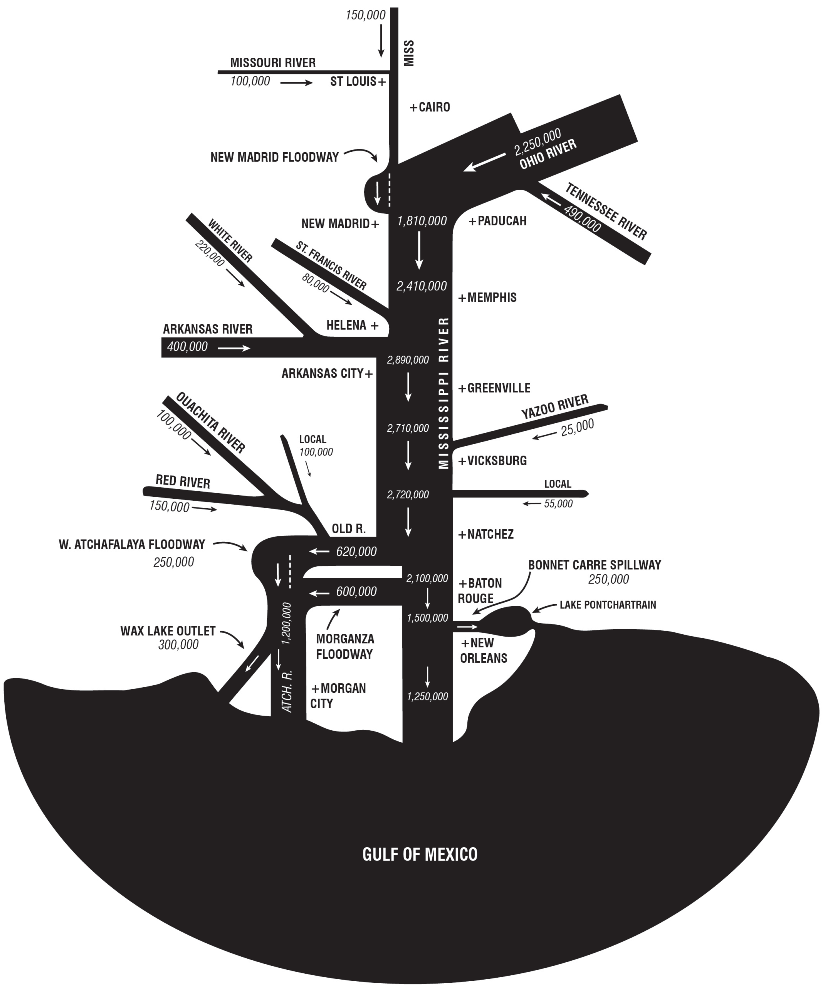


Louisiana 2017 Coastal Master Plan
Coastal Protection and Restoration Authority

Donaldsonville
Grand Lake
New Orleans
Bayou Lafourche
Atchafalaya Bay
Fort Jackson
LAKE PONTCHARTRAIN
LAKE MAUREPAS
ASCENSION
ST JAMES C.H.
ASSUMPTION
THIBODEAUX
ST CHARLES
PLAQUEMINE C.H.
LAKE BORGNE
TERRE BONNE
CAILLOU BAY
TIMBALIER BAY
WEST BAY
OYSTER BAY
Isle Dernière
LAKE CAILLOU
LAKE WASHA
LAKE PALOURDE


ST. JAMES
ASCENSION
IBERVILLE
EAST BATON ROUGE
MISSISSIPPI RIVER
DONALDSONVILLE
PLAQUEMINE
BATON ROUGE
Grande Pointe
New River
Amite River
Bayou Paul
Bayou Fontaine
Bayou Manchac
Wards Creek
HIGH LANDS
High Lands Road
Trasimond Landry
Narcisse Landry
Richard McCall
Belmont
Belle Alliance
Golden Grove
Mount Airy
St. Michael
Point Houmas
Riverton
Ashland
Linwood
Mount Houmas
Bocage
Chatham
White Castle
Celeste
Evergreen
Woodstock
Longwood
Chatsworth
Hollywood
Hope Estate
Magnolia Mound
Cottage
Bella Bellevue
Hard Times

MR&T Flood Control Act of 1928 (1941)



Project Design Flood