

Life Cycle of Oil and Gas Fields in the Louisiana Coastal Zone

Impacts on the Mississippi Delta

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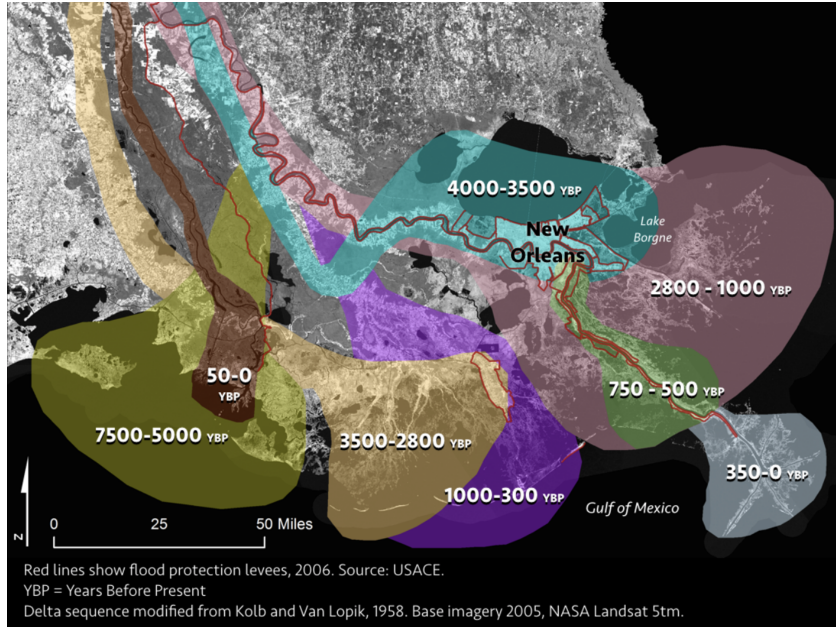
Louisiana State University

Baton Rouge, LA

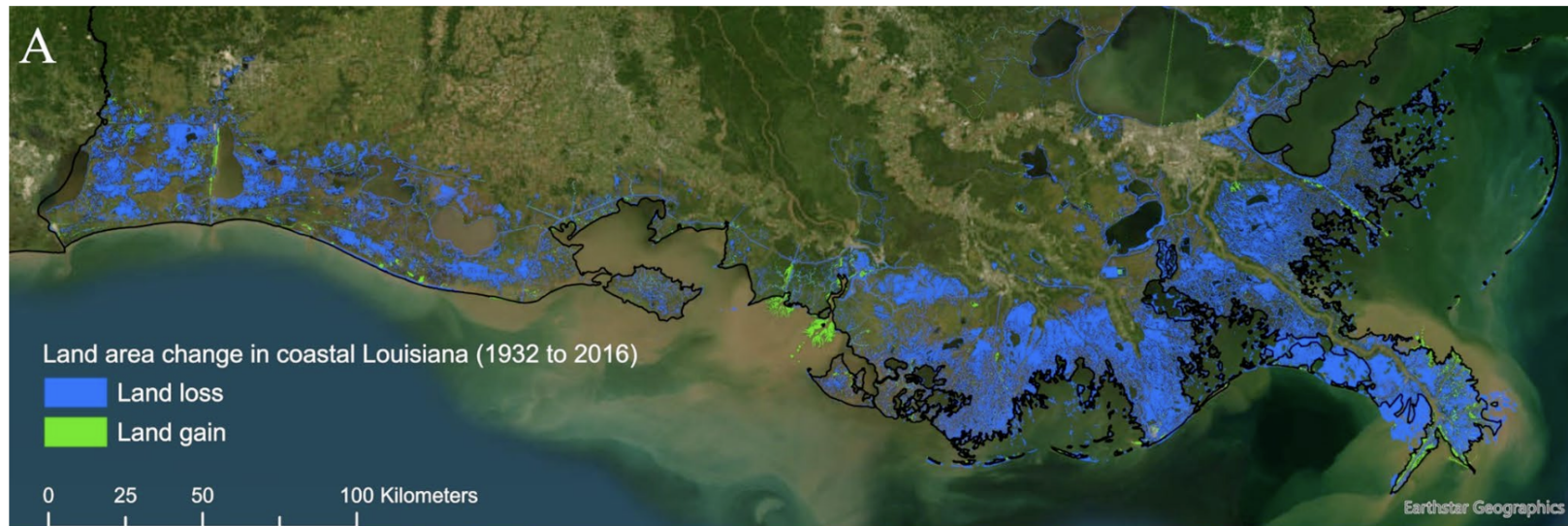
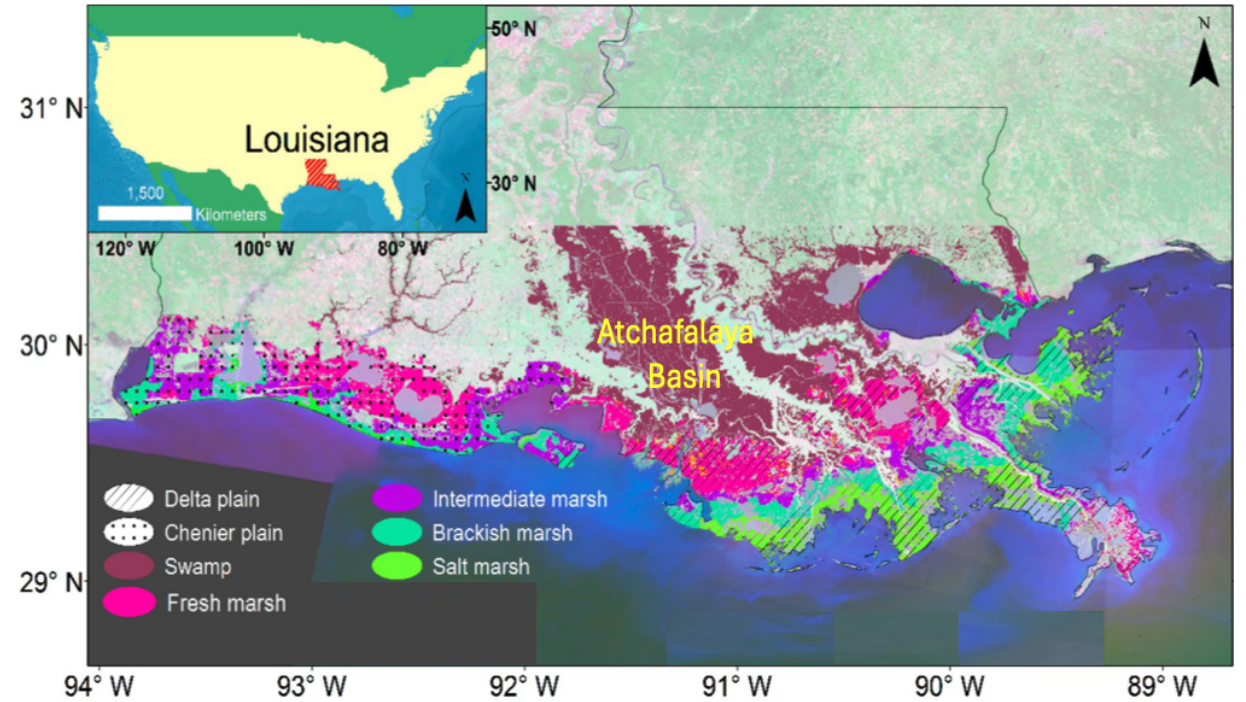
Outline

- Overview of the Mississippi Delta
- Pervasive alteration of surface hydrology and ecology
- Induced subsidence and wetland loss
- Pervasive contamination
- Infrastructure left in place
- Governmental and Societal Impacts

The Mississippi Delta

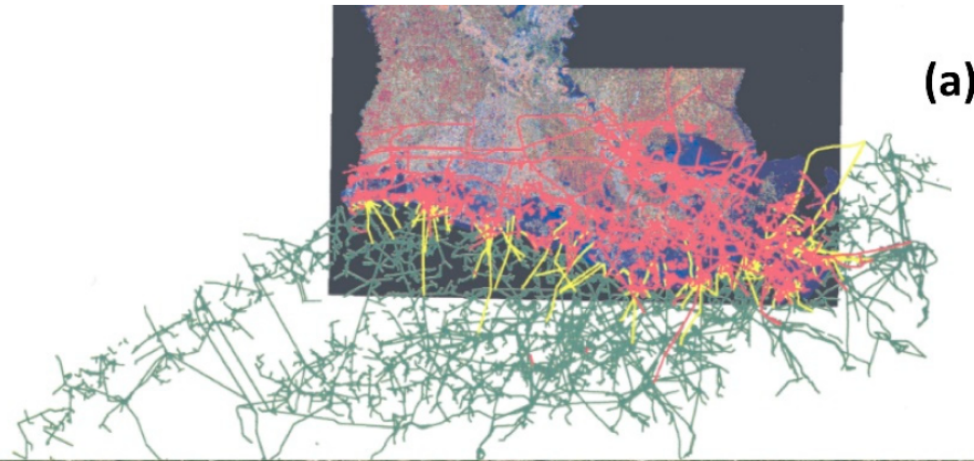


Delta Lobes

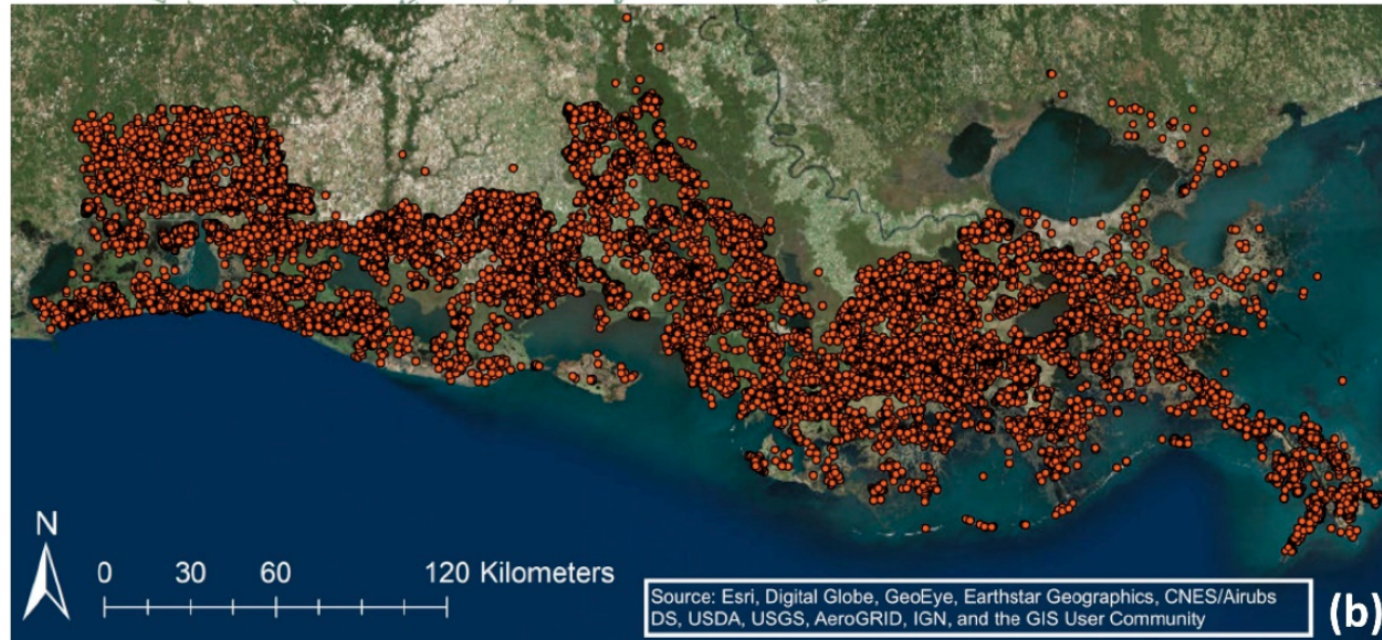


Interdistributary Basins and Vegetation Zones

Wetland Loss in the Mississippi Delta



Oil and Gas Pipelines

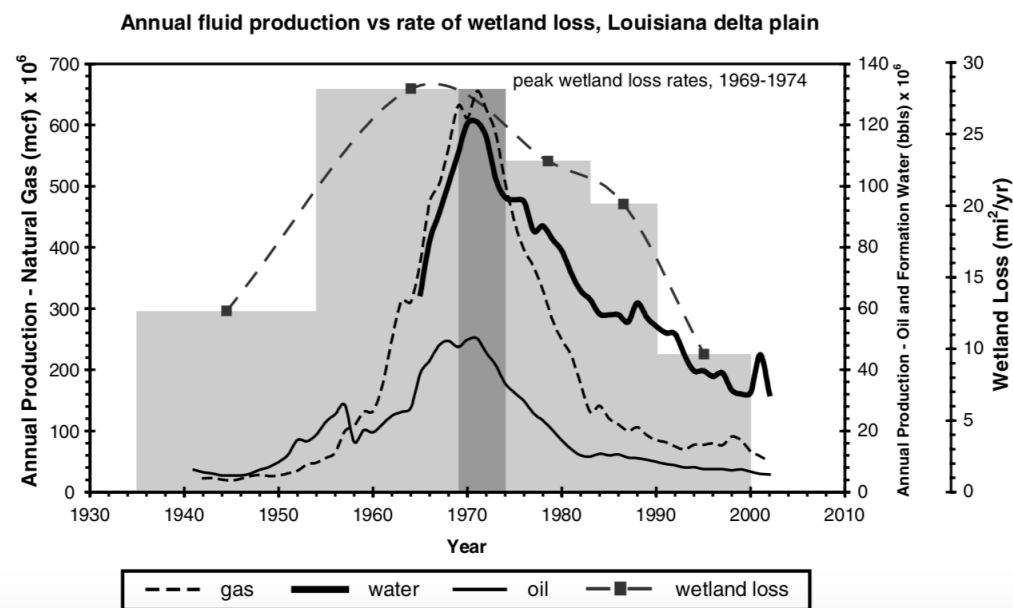
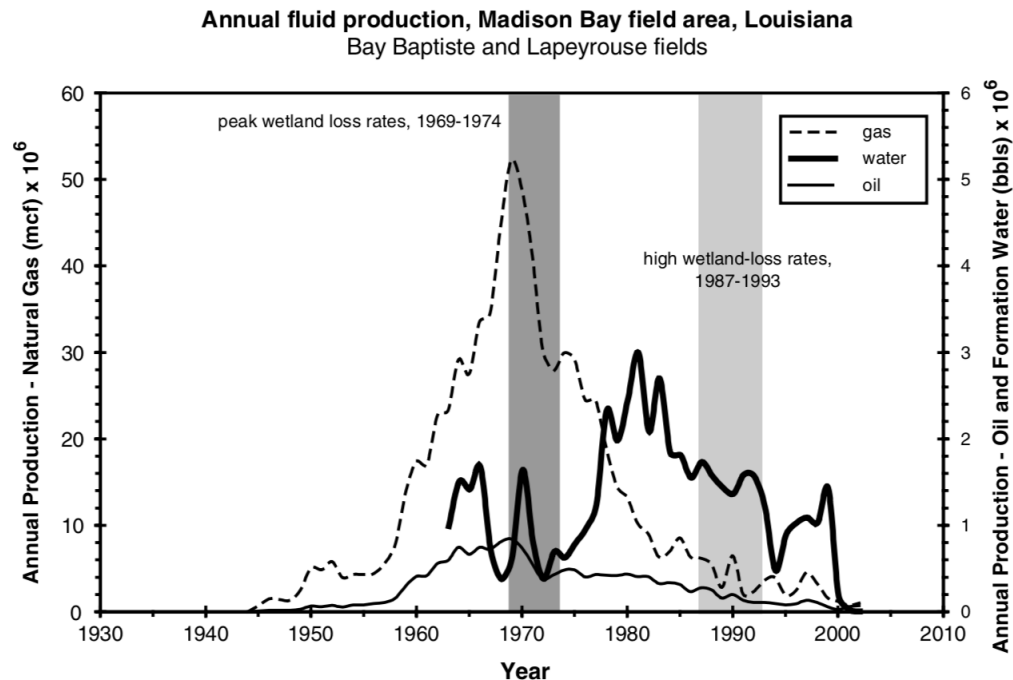


Oil and Gas Well Permits
Issued Between 1900 and
2017 That Were Plugged
or Abandoned as of 2017

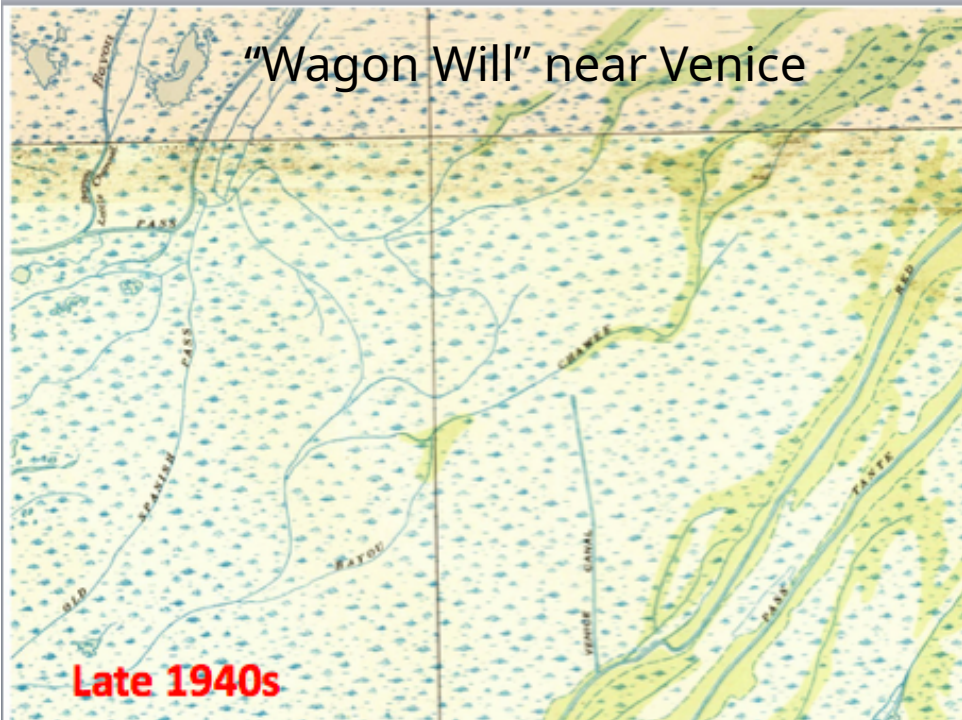
Turner and McClenachan
2018

Production History and Wetland Loss

Morton et al. 2006



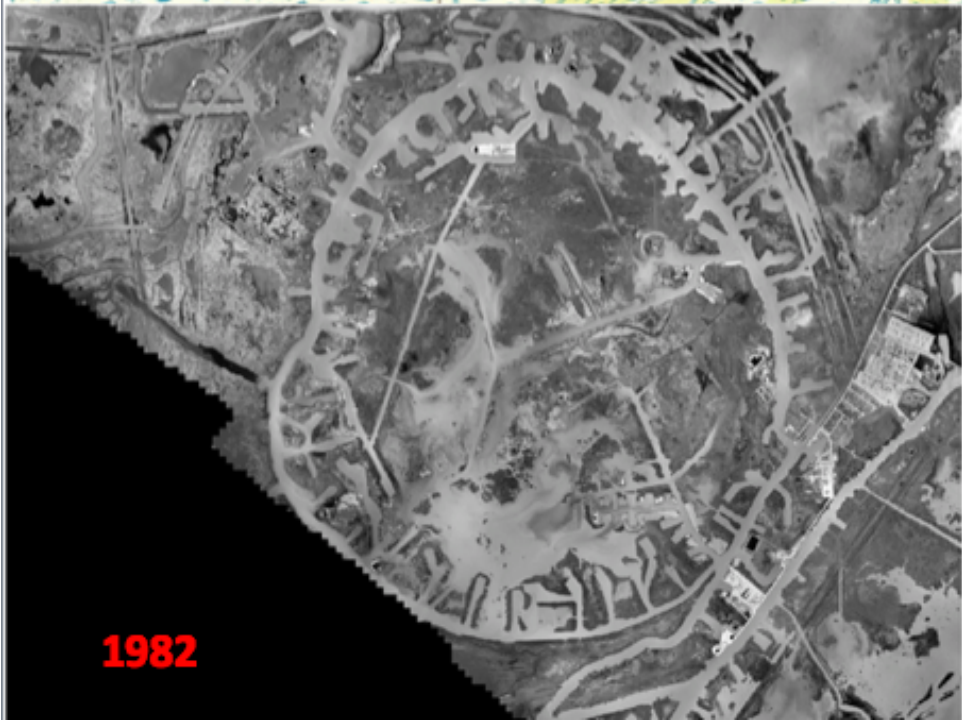
"Wagon Will" near Venice



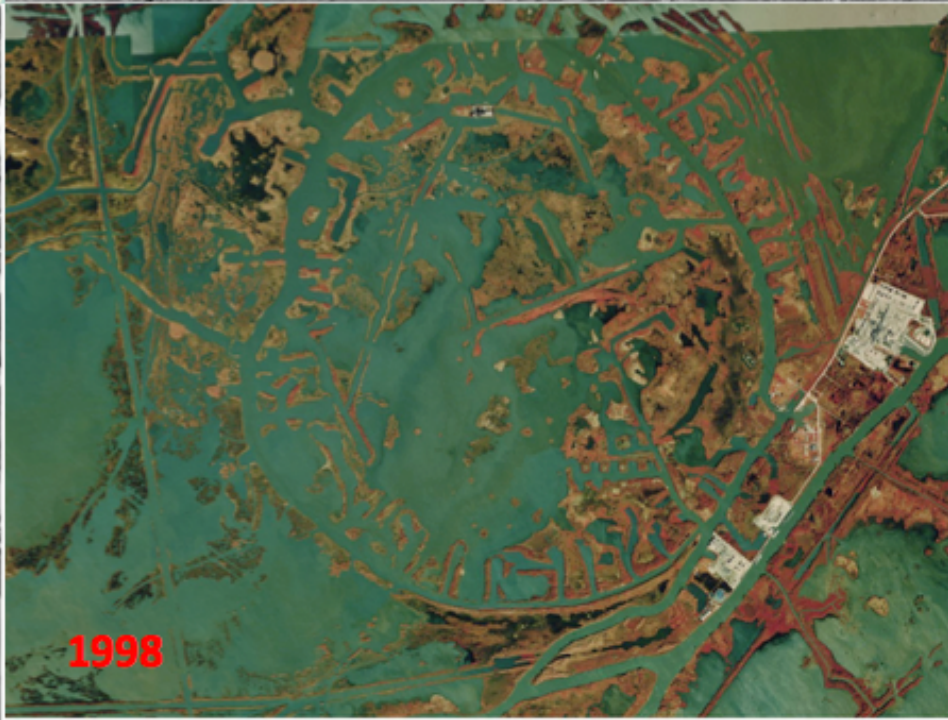
Late 1940s



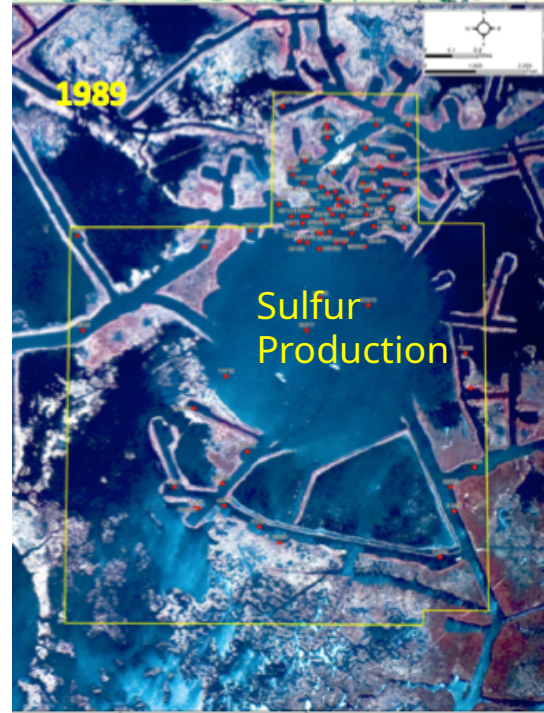
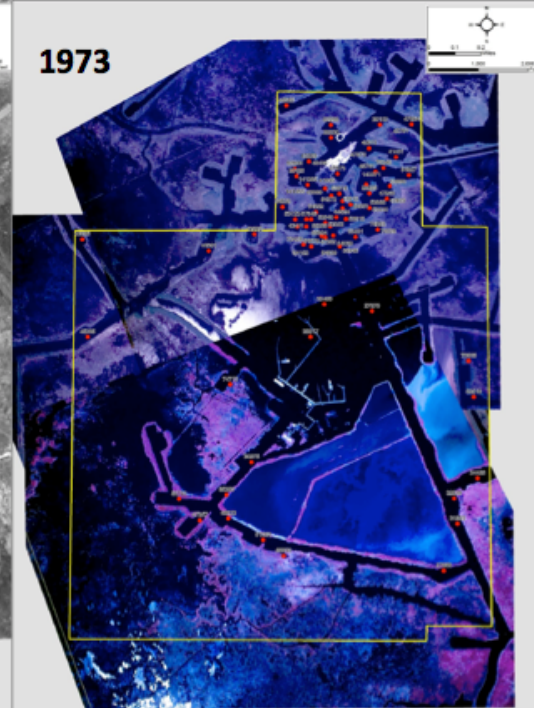
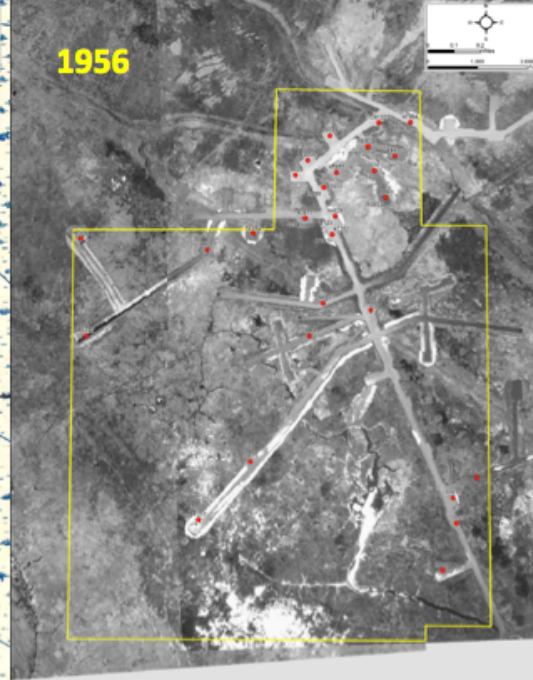
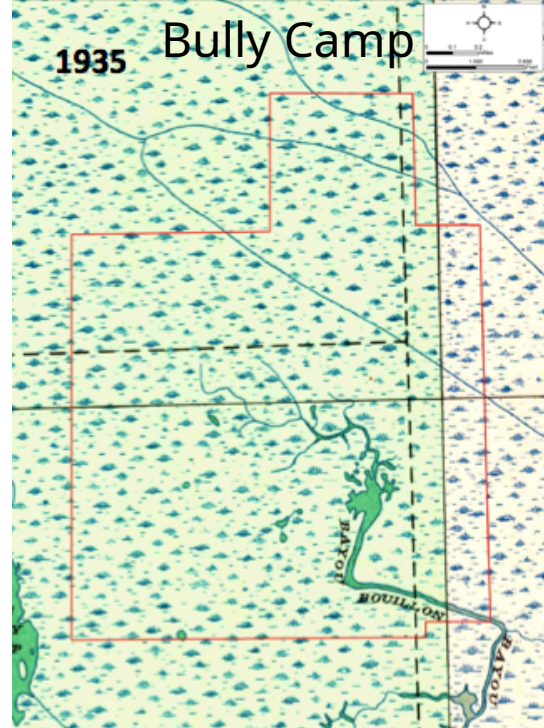
1956



1982



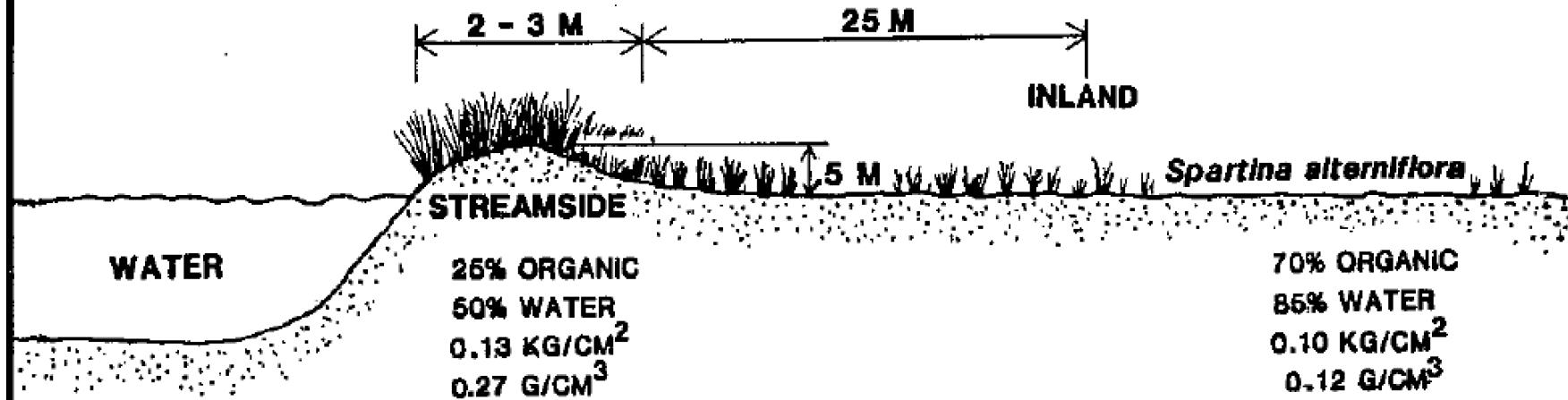
1998



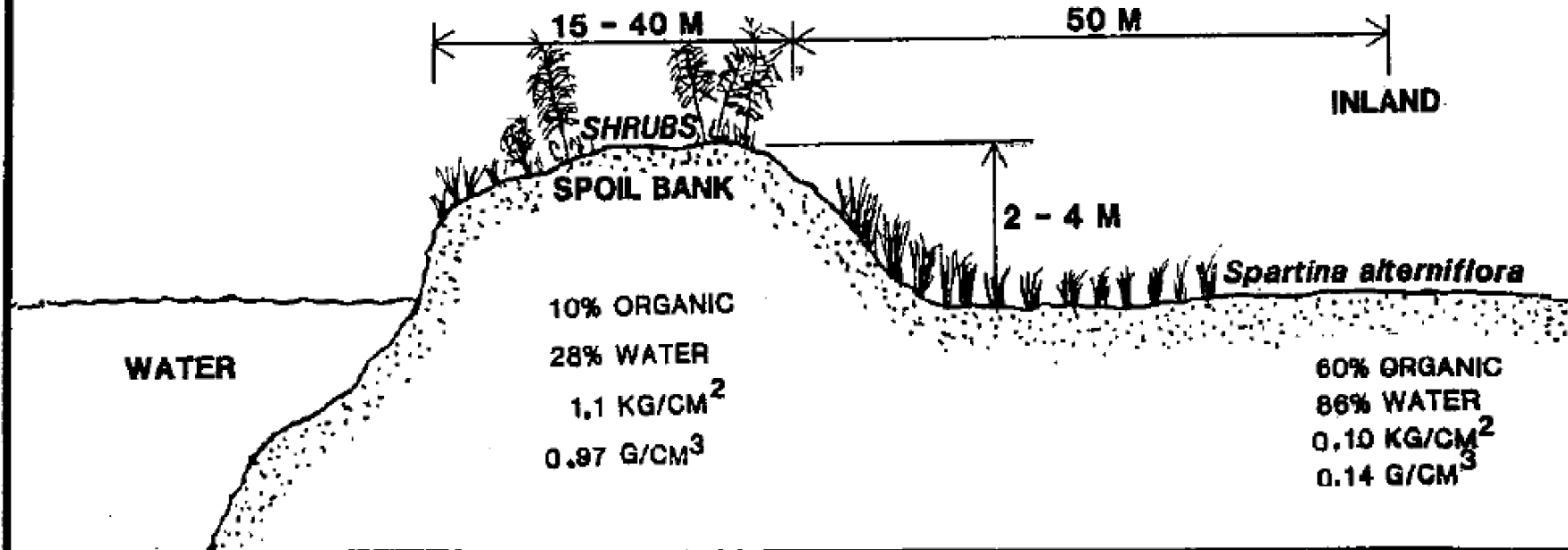
ALTERATIONS TO SURFACE HYDROLOGY

A. NATURAL MARSH

Turner 1987



B. CANALED MARSH



Adding Sediment Increases Productivity and Organic Soil Formation

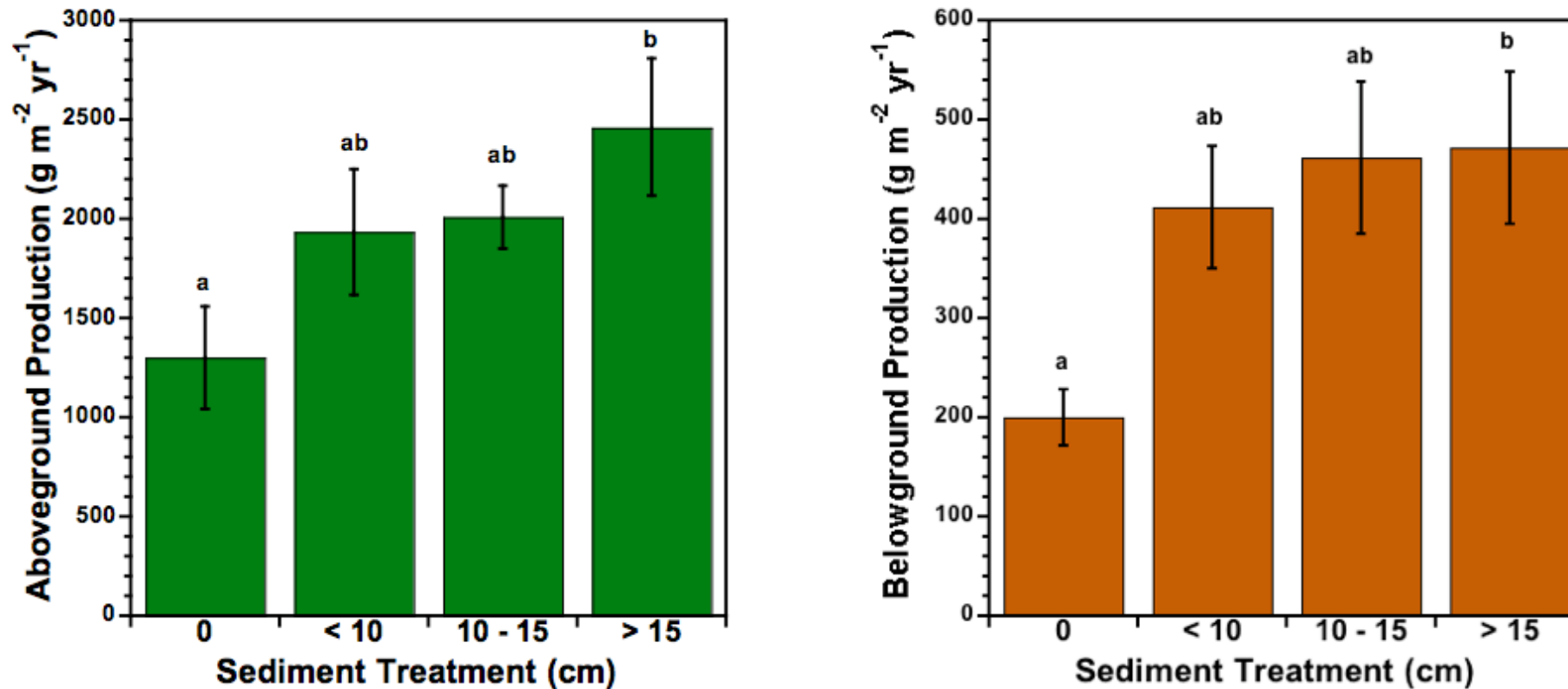


Figure IV. Effects of sediment-slurry amendments on aboveground and belowground production in a brackish marsh dominated by *Spartina patens* (data from Graham and Mendelssohn 2013)

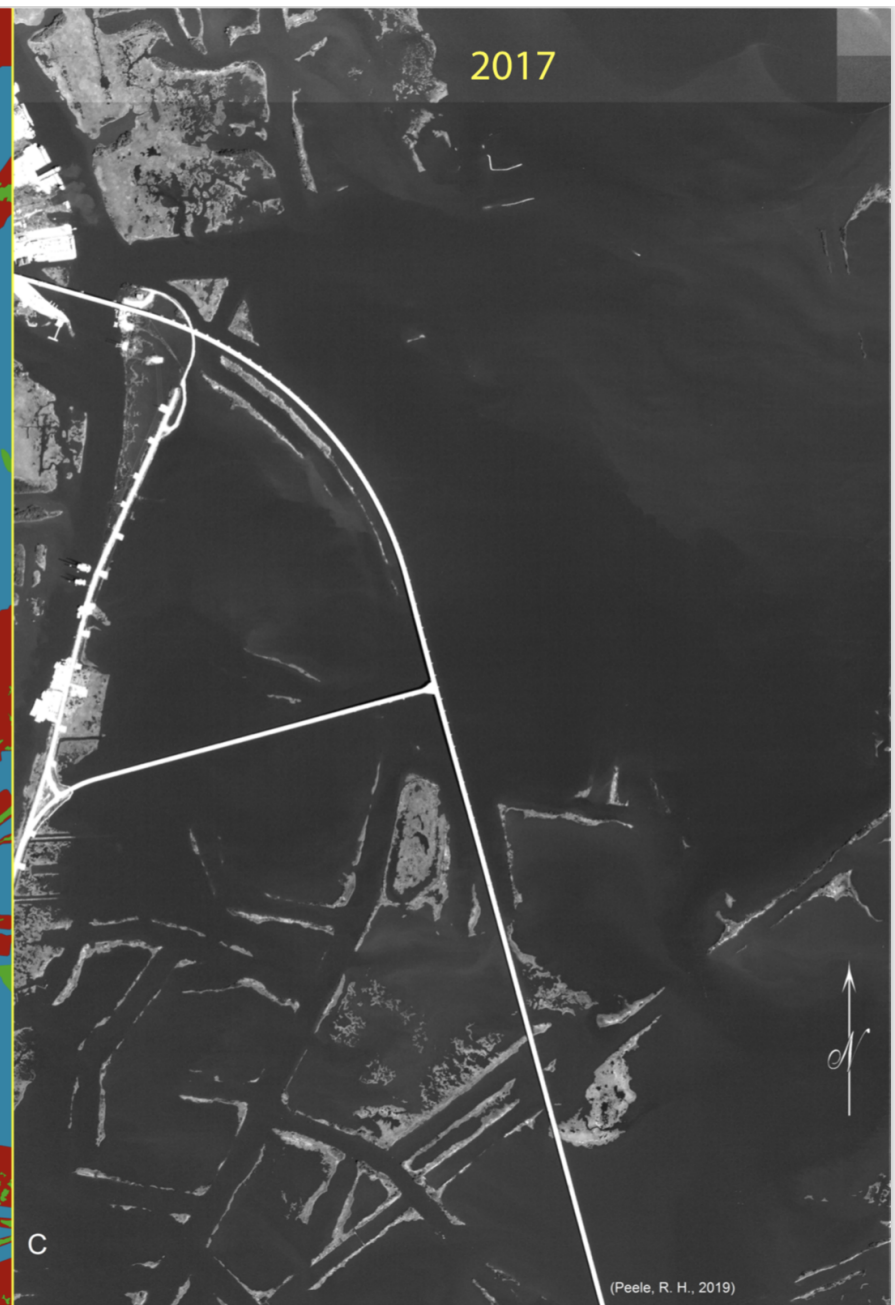
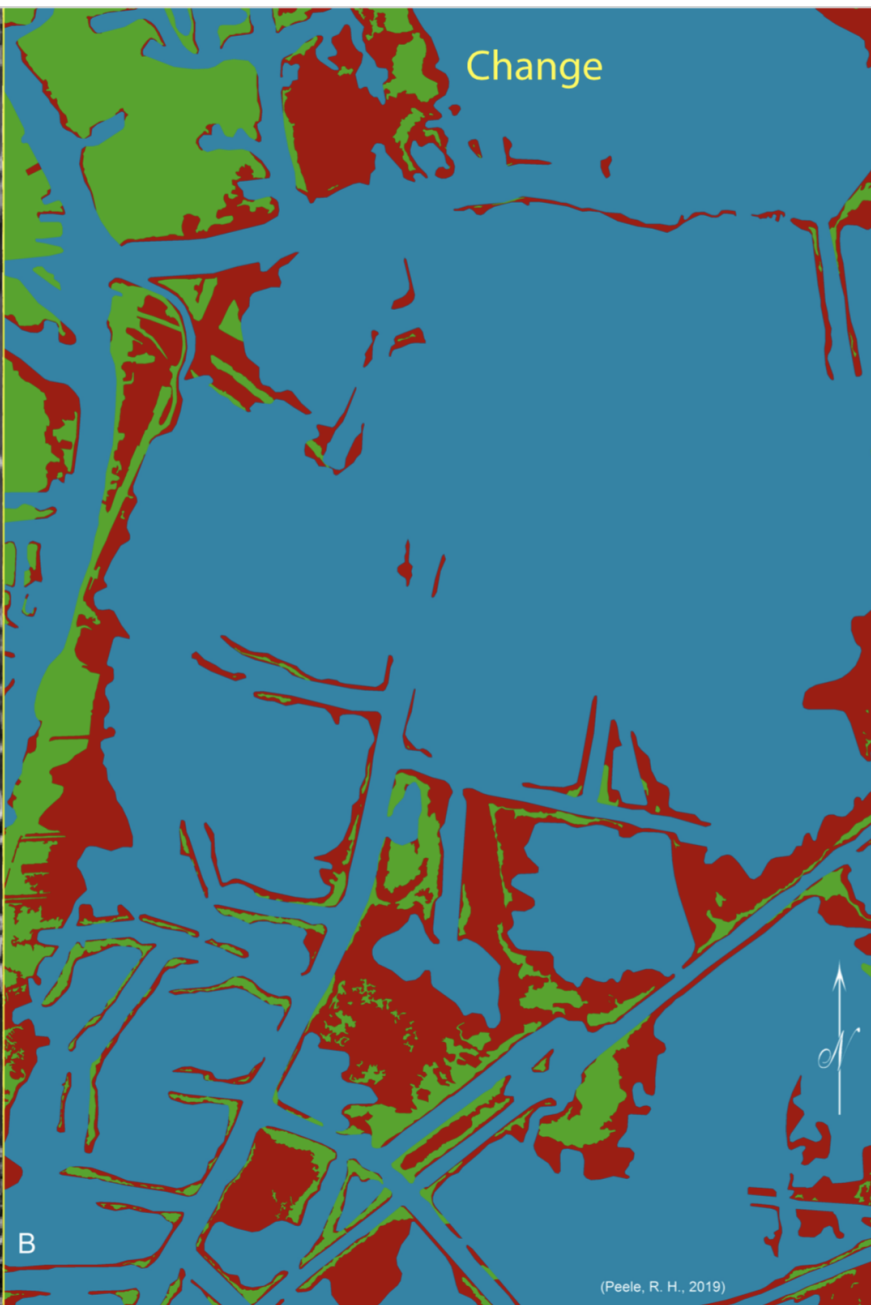


Table 1. Estimates of the percentage of wetland loss caused by all oil and gas activities (overall) or by direct or indirect impacts of oil and gas activities.

Location	Time Period	Overall Impacts (% wetland loss)	Direct Impacts (% wetland loss)	Indirect Impacts (% wetland loss)	Source
Coastal Louisiana	1931-1967		69		Gagliano and van Beek 1970
Coastal Louisiana		45			Gagliano 1973
Coastal Louisiana			10-69		Craig et al. 1979
Coastal Louisiana		33-67			Deegan et al. 1979
Coastal Louisiana			10	up to 80	Turner et al. 1982
Coastal Louisiana	1955-1978		10	48-97	Scaife et al. 1983
Mississippi River Deltaic Plain	1955/56-1978		25-39		Deegan et al. 1984
Coastal Louisiana	1932-1990	Majority of losses			Turner 1987, 1997 Turner and McClenachan 2018
Coastal Louisiana	1955-1978	20-60	14-16	20-60	Turner and Cahoon 1987
Coastal Louisiana	1955-1978		16		Turner 1990
Coastal Louisiana	1955-1978		6.6		Baumann and Turner 1990
Coastal Louisiana	1955-1978		16	30-59	Boesch et al. 1994
Breton Sound,	1933-1990	68			Day et al. 2000
Barataria Basin	1933-1990	72			Day et al. 2000
Mermentau Basin	1933-1990	35			Day et al. 2000
Mississippi River Deltaic Plain	1930-1990	33.2	10.8	22.4	Penland et al. 2001 a,b

As Canal Density
Increases, the Density
of Natural Channels
Decreases

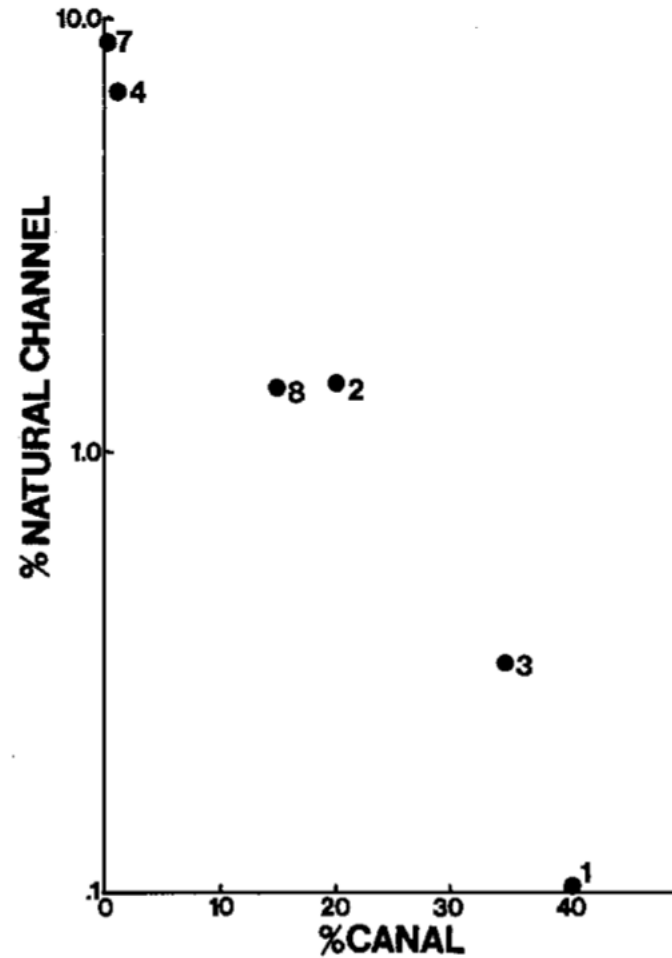
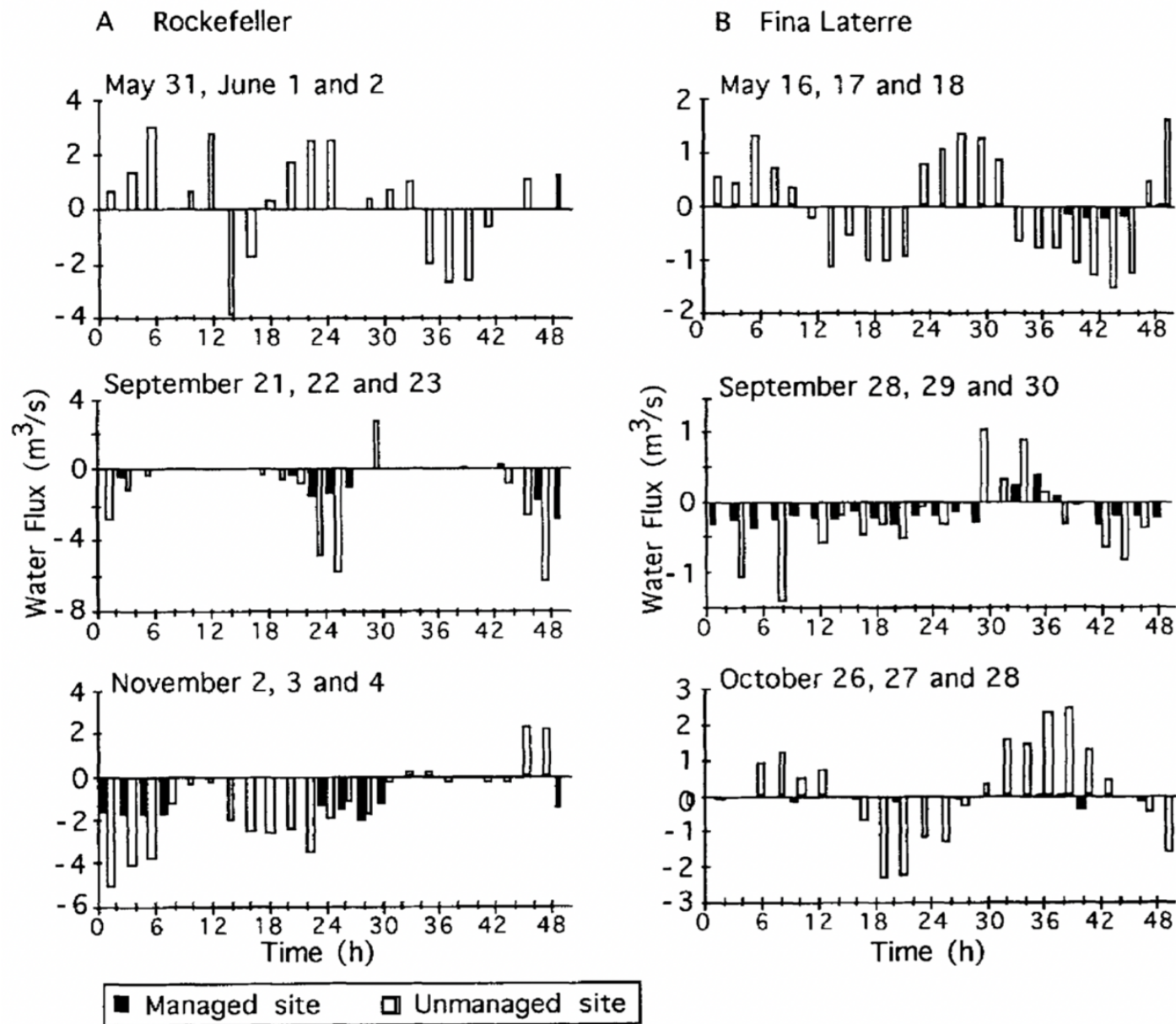
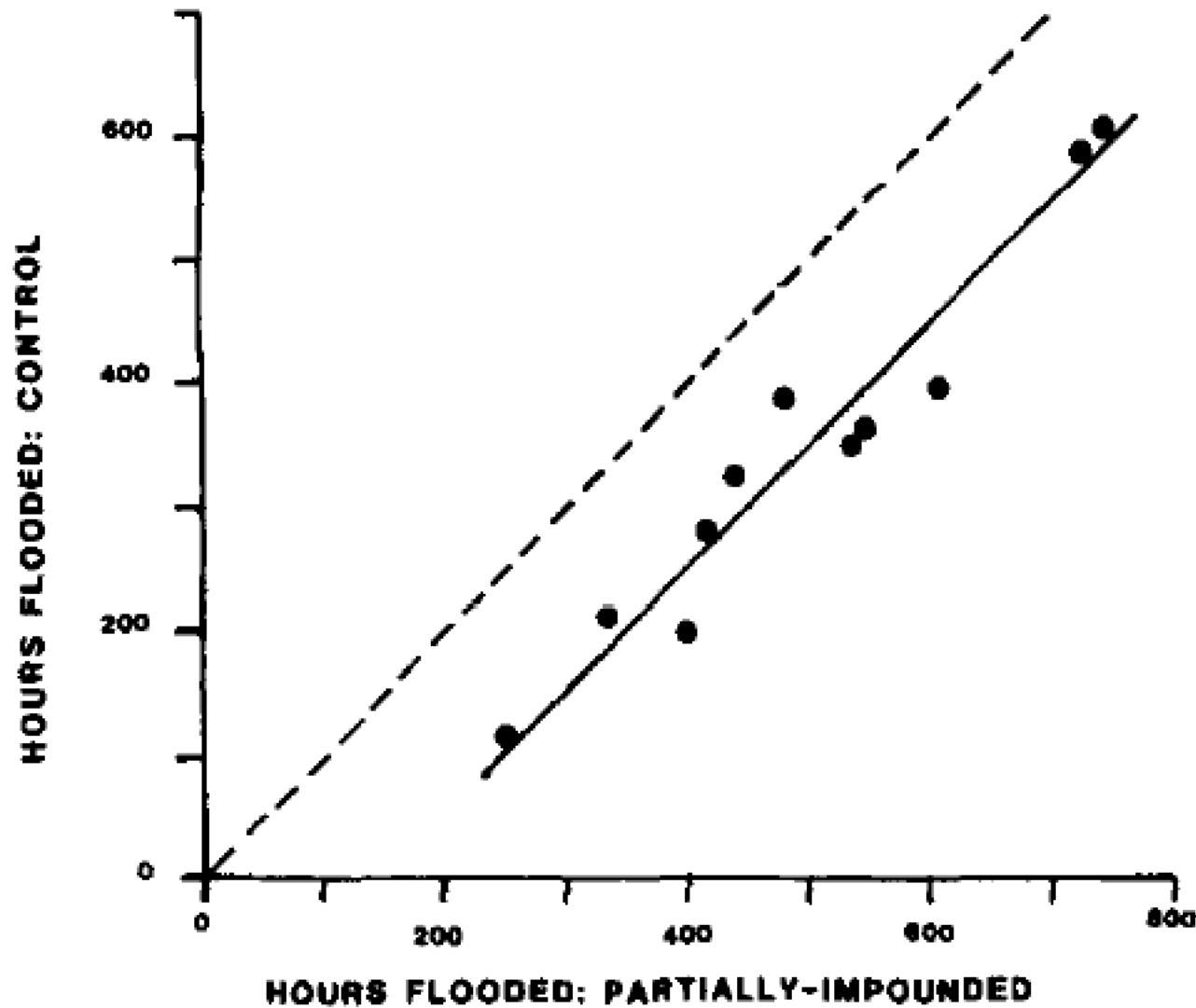


Figure 2. The relationship between canal density and the density of natural channels. The data are averages of replicate 1-km² grids (number shown by symbol) in the region of Leesville, La., a saline marsh area.



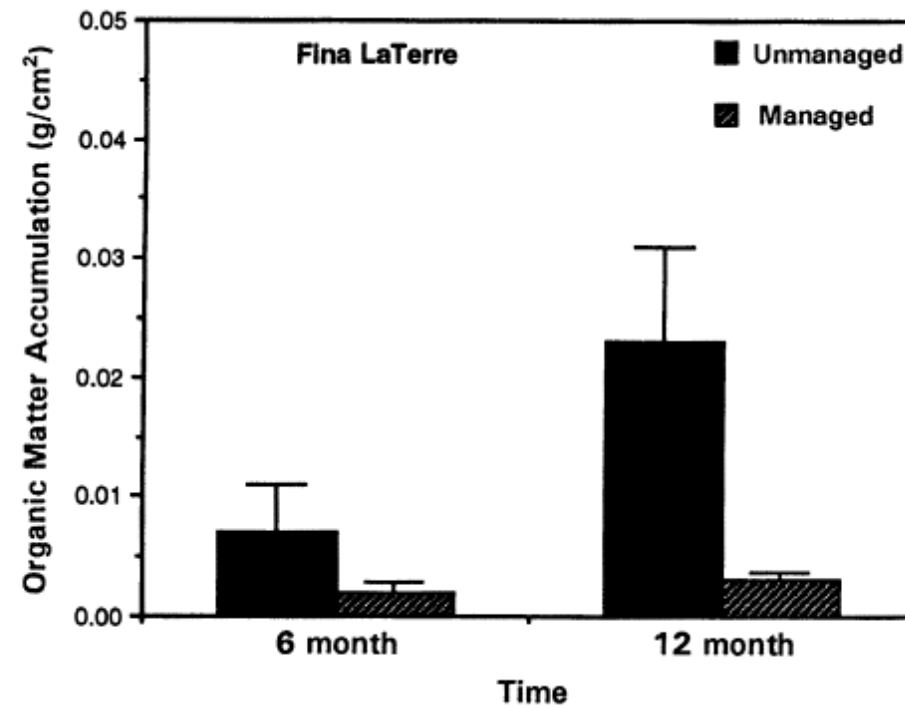
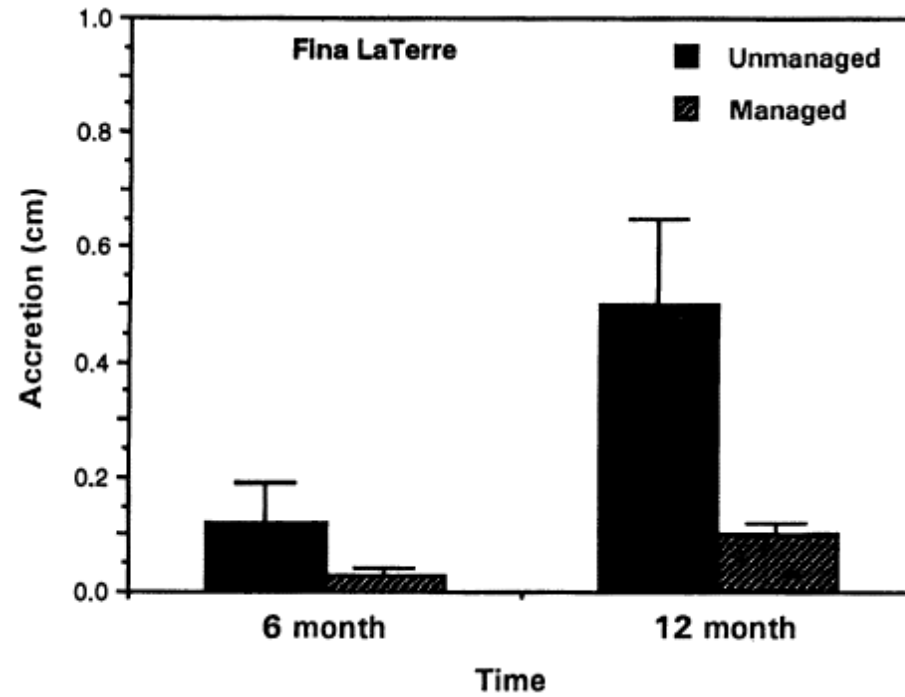
Water flux in Natural and Impounded Marshes

Figure 3. Instantaneous water fluxes per m^2 drainage area measured each two hours for three tides. Positive values indicate flux into the area, and negative values are flux out of the area. A. Rockefeller. Water flux for the managed area was measured at the control structure in the southwestern corner of Unit 4. Water flux for the unmanaged area is for water exchange in East Little Constance Bayou north of East Constance Lake. B. Fina. Water flux for the managed area was measured at the control structure north of Falgout Canal. The water flux for the unmanaged area is for water exchange at 5 points with Falgout Canal.



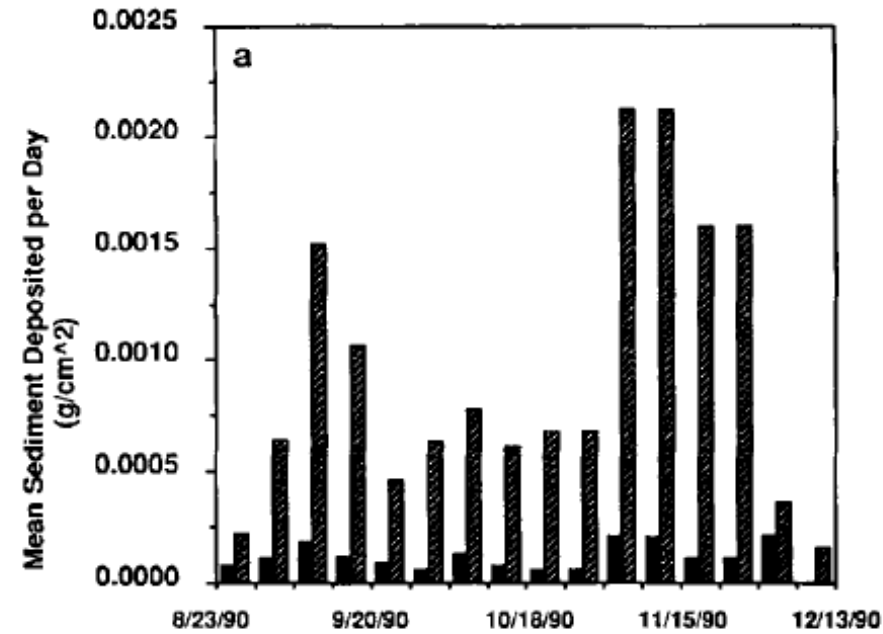
Partially Impounded Marshes Are Flooded For Longer Periods Of Time Than Natural Marshes.

Total hours flooded, for one month, at a reference marsh with a natural berm and a partially-impounded area where about 75% of the natural berm had been replaced by a dredged canal spoil bank, Golden Meadow oil and gas field south of New Orleans, LA (Turner and



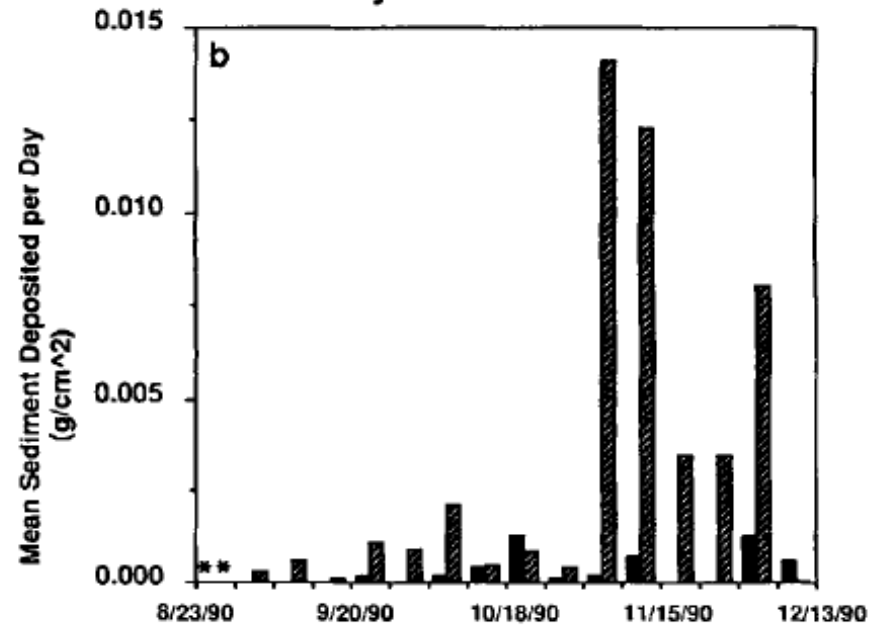
Rates of vertical accretion (left) and organic matter accumulation (right) in managed and Unmanaged marshes at Fina LaTerre, LA (means and 1 SE; Cahoon 1994).

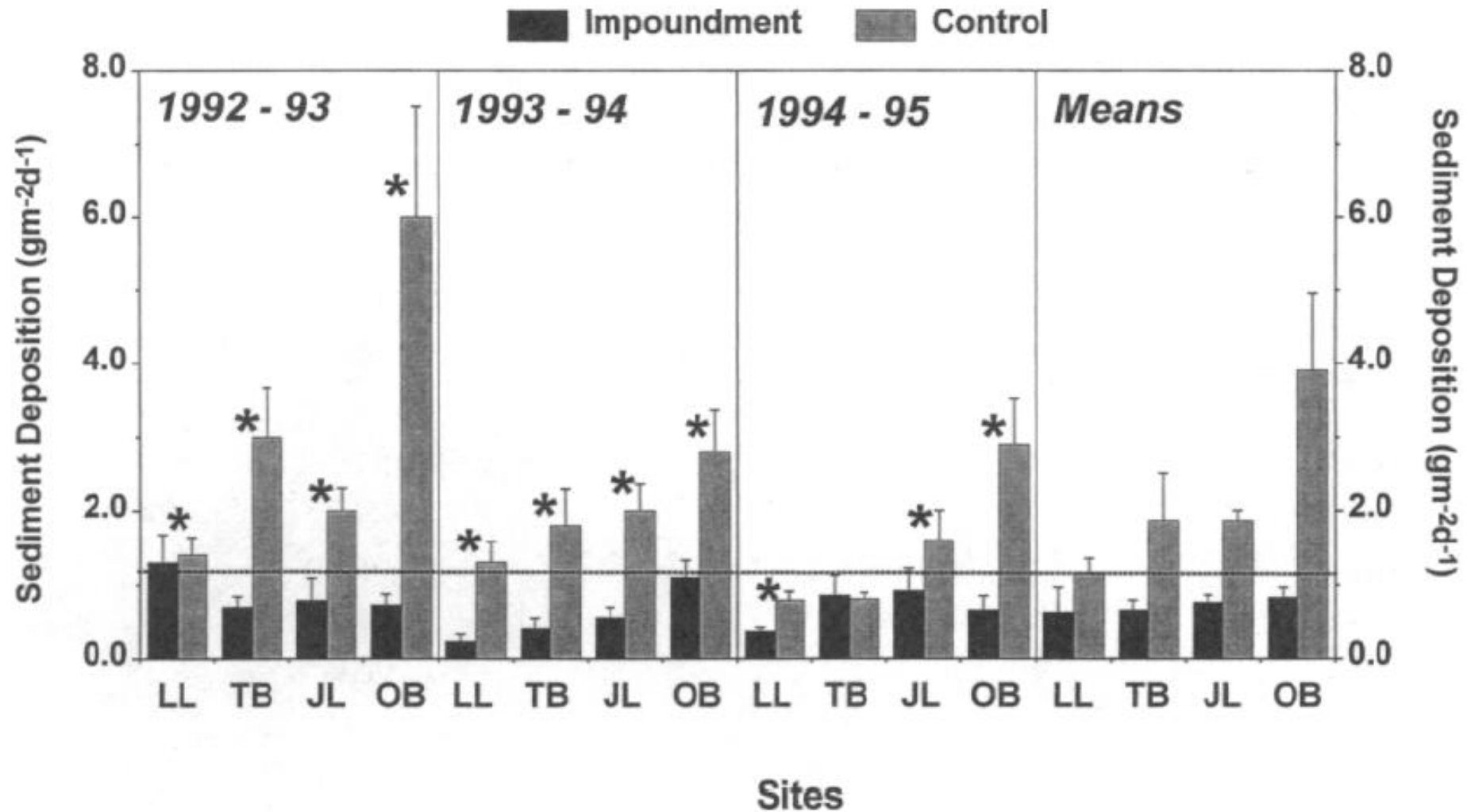
Bayou DeCade - BDC



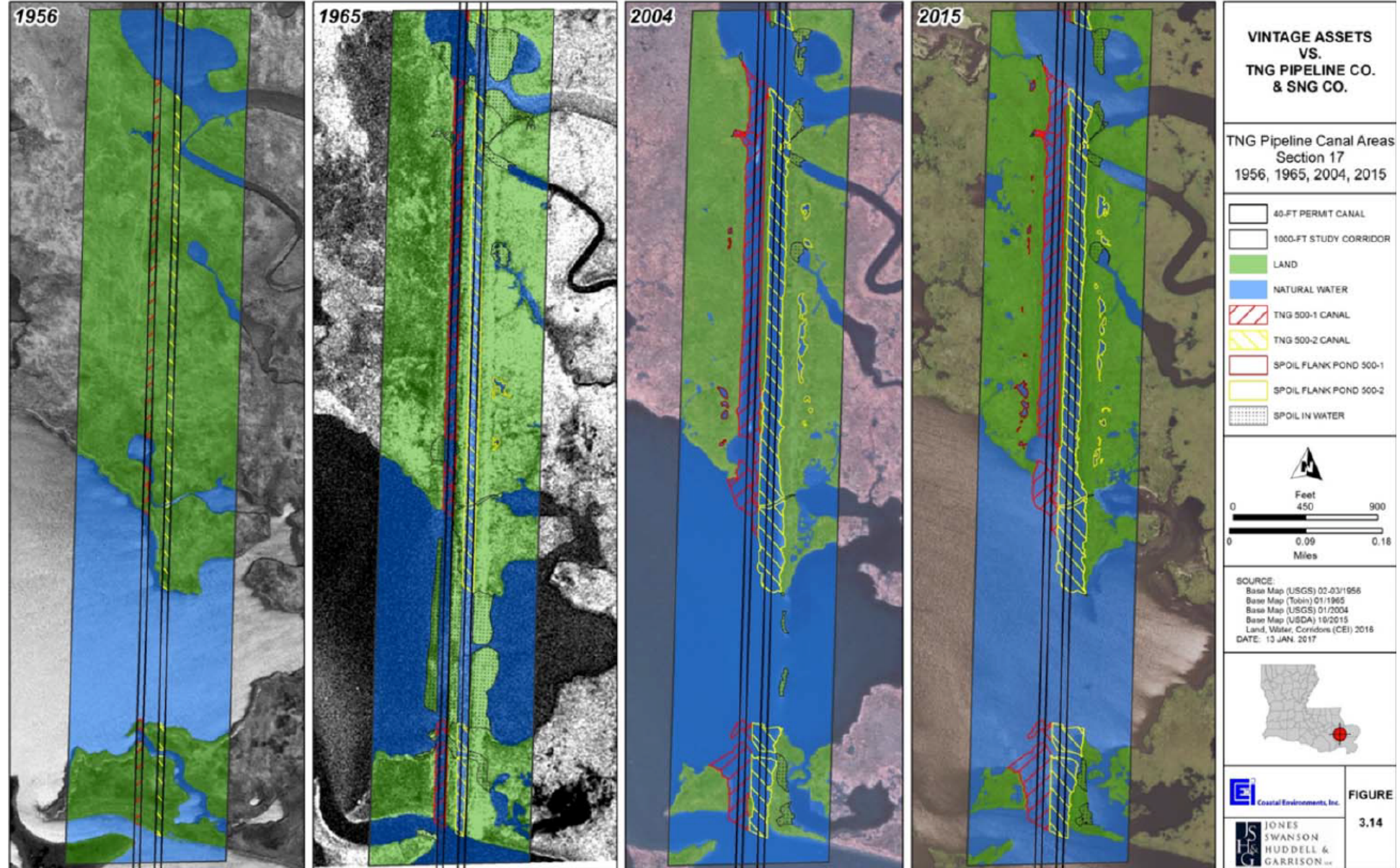
Deposition of Sediments
On the Marsh Surface Inside
And Outside of impoundments

Bayou Chauvin - BC



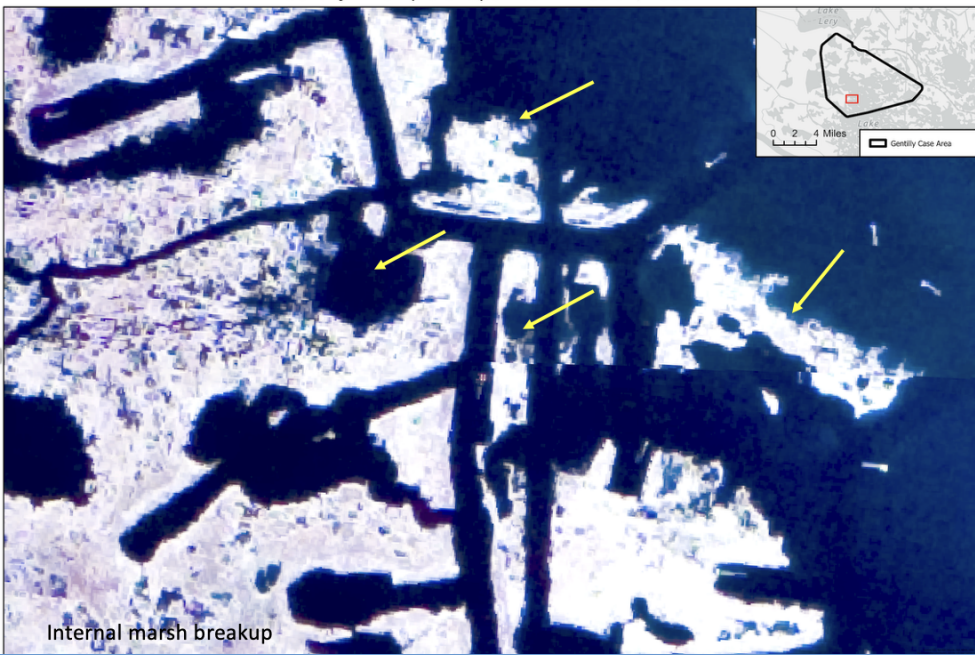


Comparison of marsh surface sediment deposition rates between impounded and reference sites by management year (means $\pm$ 1 SE) and means for all years. Stars indicate statistically significant differences at $p = 0.05$. The horizontal line indicates the 1.1 $\text{g/m}^2/\text{day}$ of inorganic accumulation required for fresh marsh soils (Reed et al. 1997).

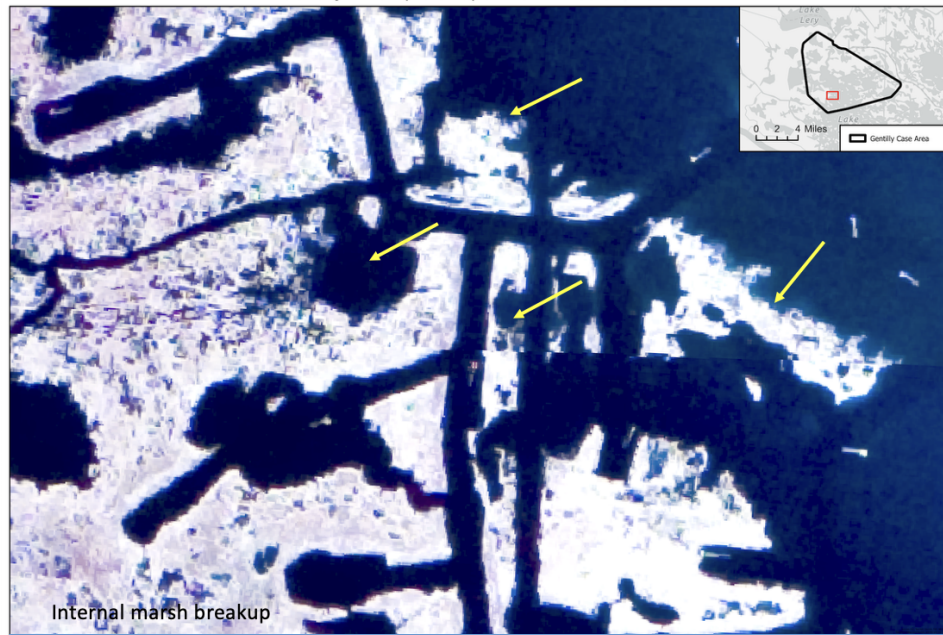


Widening of the Tennessee Natural Gas pipeline canals and formation of spoil flank ponds (CEI 2017).

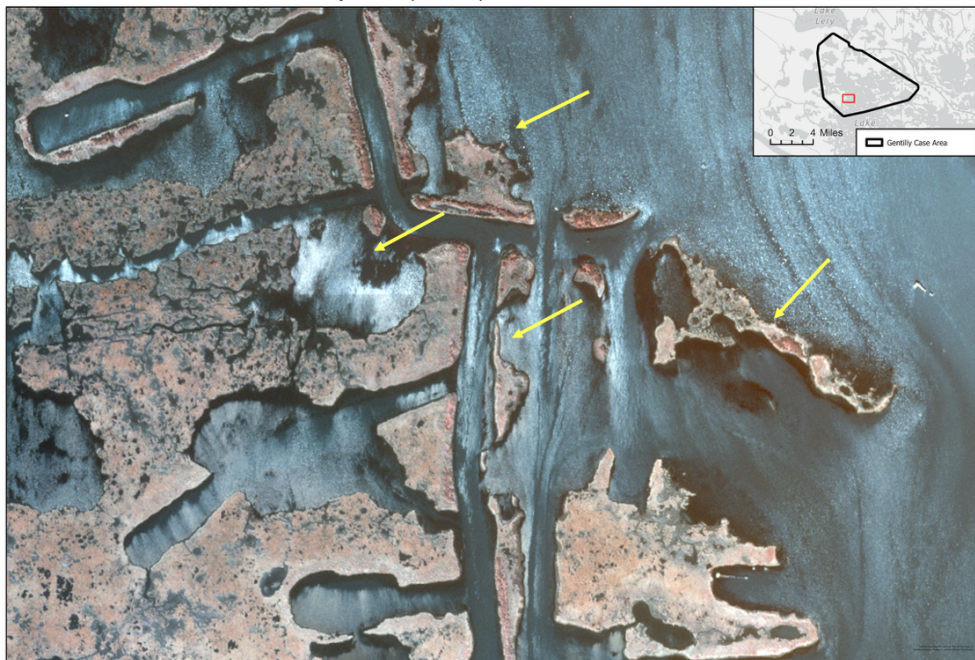
Gentilly: Example of Spoil Bank Erosion, 1989



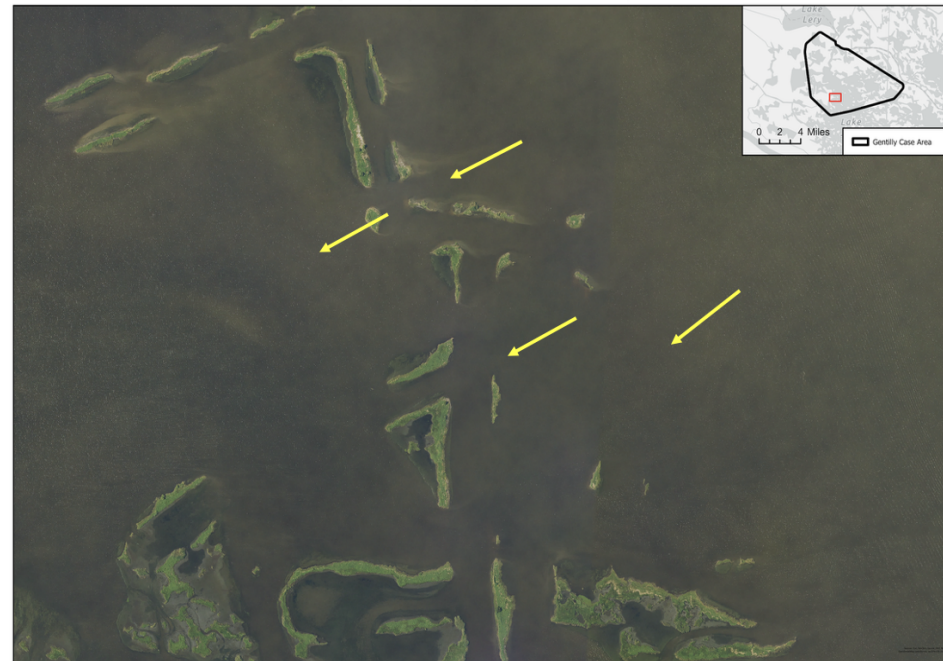
Gentilly: Example of Spoil Bank Erosion, 1989

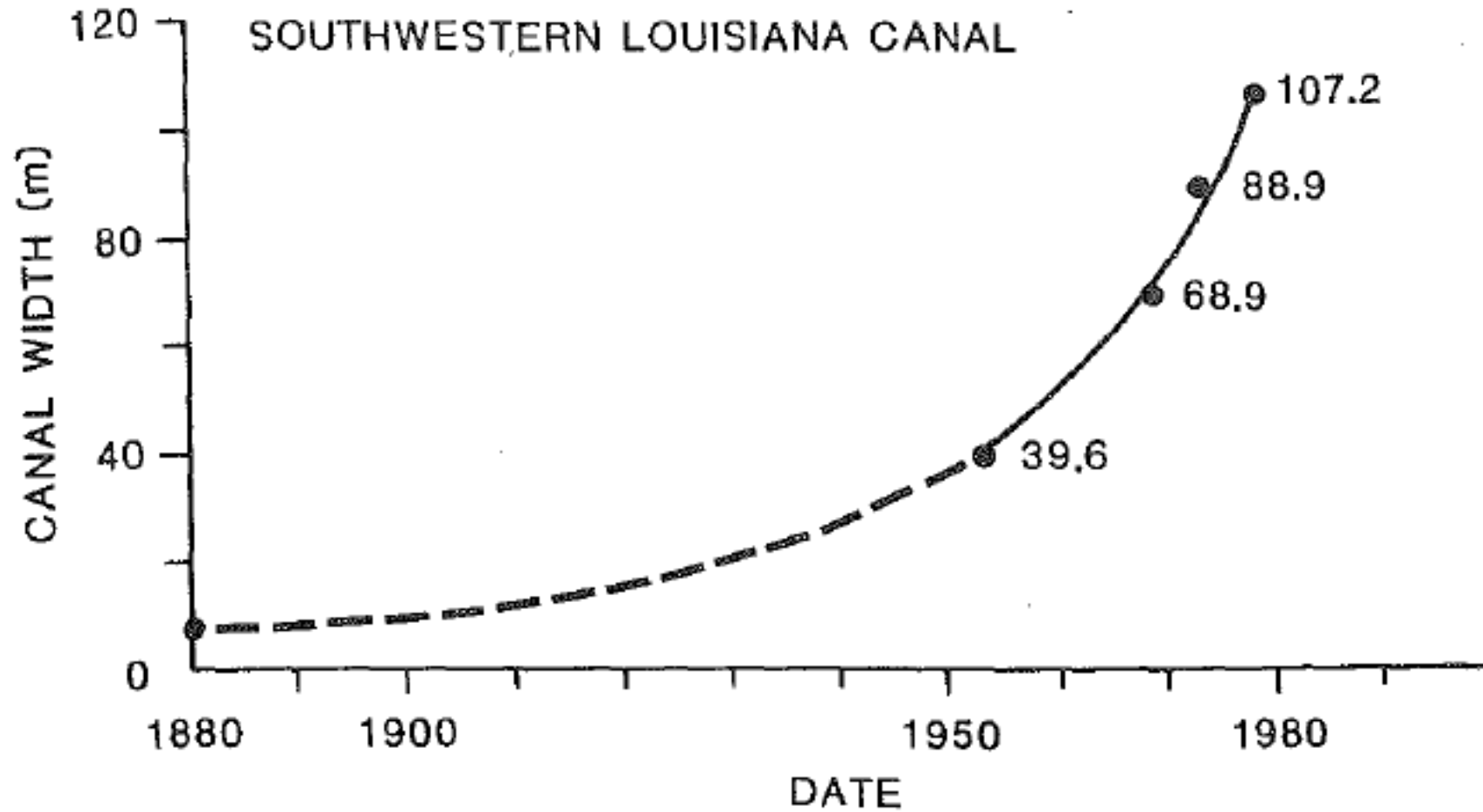


Gentilly: Example of Spoil Bank Erosion, 2004



Gentilly: Example of Spoil Bank Erosion, 2003

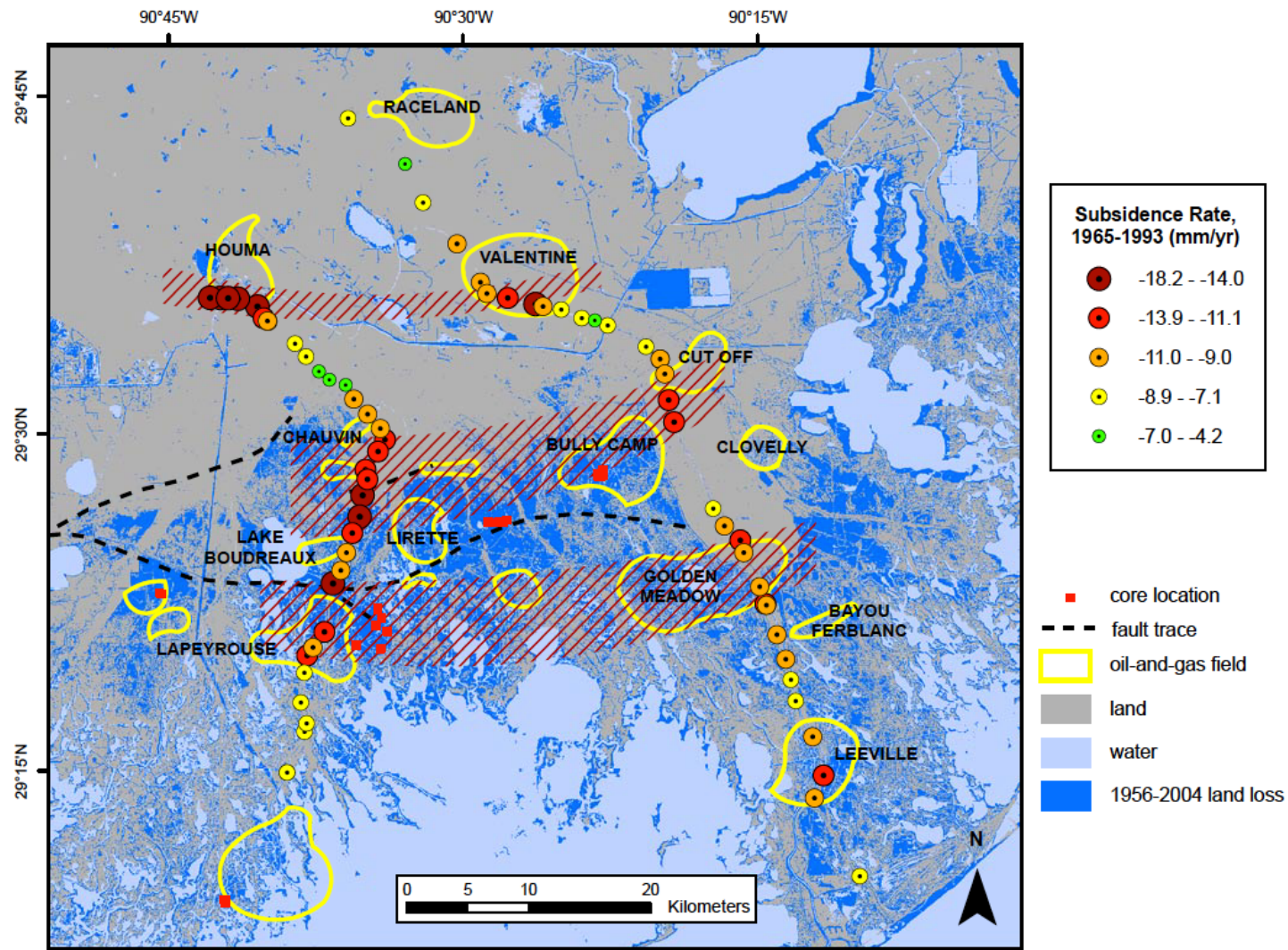




Relationship between canal width and age for the Southwest LA Canal, LaFourche Parish, LA (Johnson and Gosselink 1982).

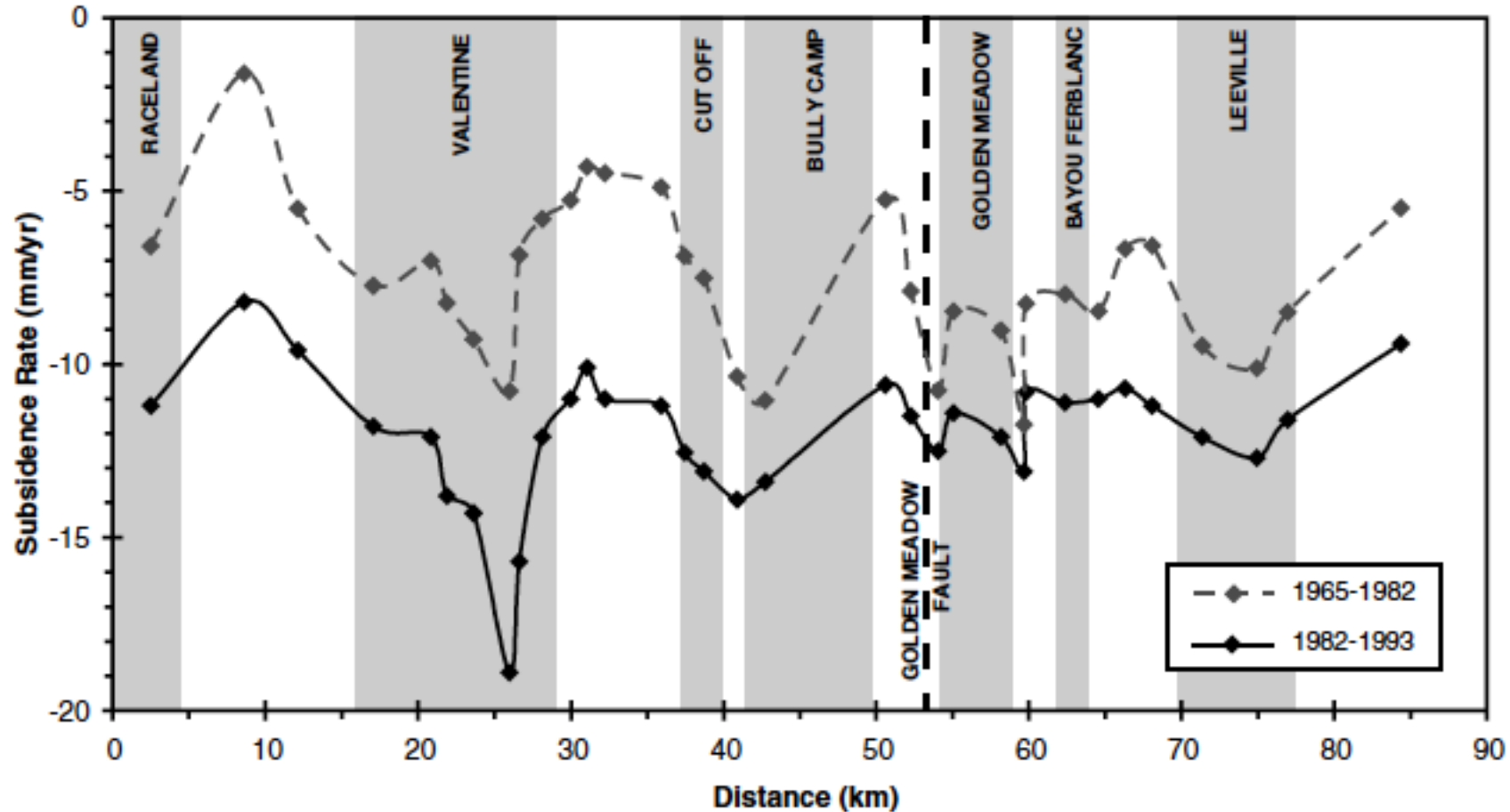
INDUCED SUBSIDENCE

- Reservoir Collapse due to oil and gas withdrawal
- Secondary Collapse due to Slow Drainage of Water from Bounding Shales
- Induced Subsidence due to Changes in Pressure Across Faults

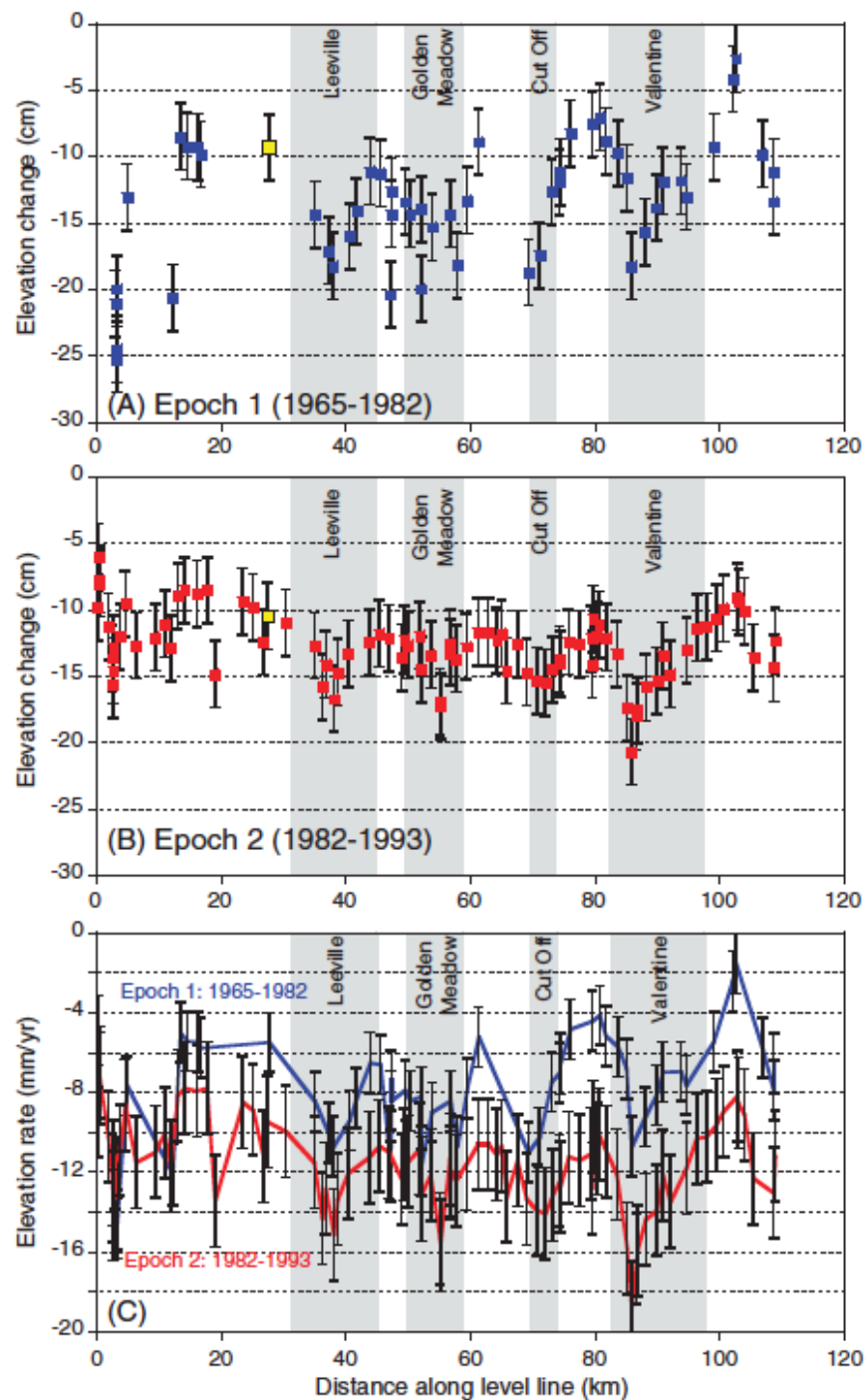


Map showing average subsidence rates between 1965 and 1993 in south Louisiana. Areas of highest subsidence rates (>12 mm/year; hatched pattern) correlate closely with locations of oil and gas fields. Lowest average subsidence rates are located between major producing fields.

NGS subsidence rates, Bayou Lafourche, 1965-1993



Plots of historical subsidence rates along LA Highway 1 between Raceland and Leeville, Louisiana showing a close spatial correlation between highest subsidence rates, hydrocarbon-producing fields (delineated in grey), and the projected intersection of the Golden Meadow fault zone (Morton et al. 2006).



Elevation changes during epoch 1 (1965-1982; A) and epoch 2 (1983-1993; B), and the rates of subsidence in the two epochs (C). Over the entire transect, subsidence rates were greater in epoch 2 than in epoch 1. The yellow squares in (A) and (B) indicate an arbitrarily selected reference station approximately 8 km south and outside of the projected Leeville field, to estimate the magnitudes of local production-related subsidence signals (Chang et al. 2014).

Slow drainage of pore fluids from shales
 Fault activation
 Reservoir compaction
 Time dependent creep compaction
 Acceleration after decrease of production

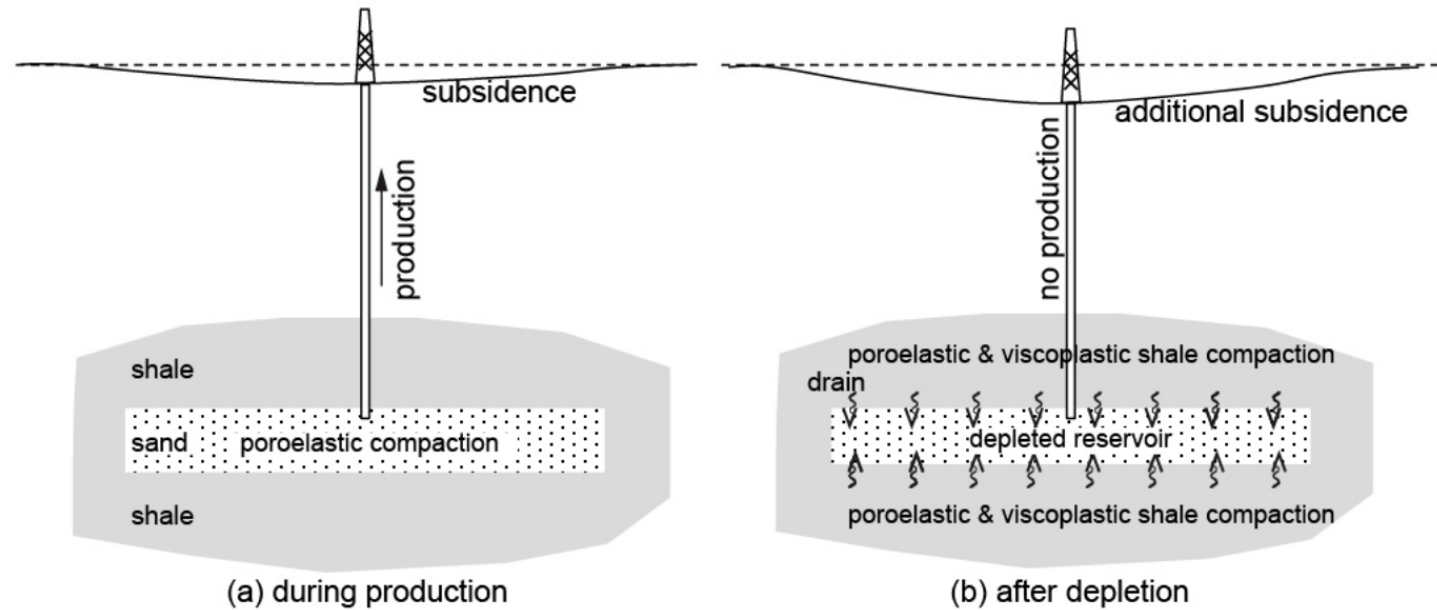
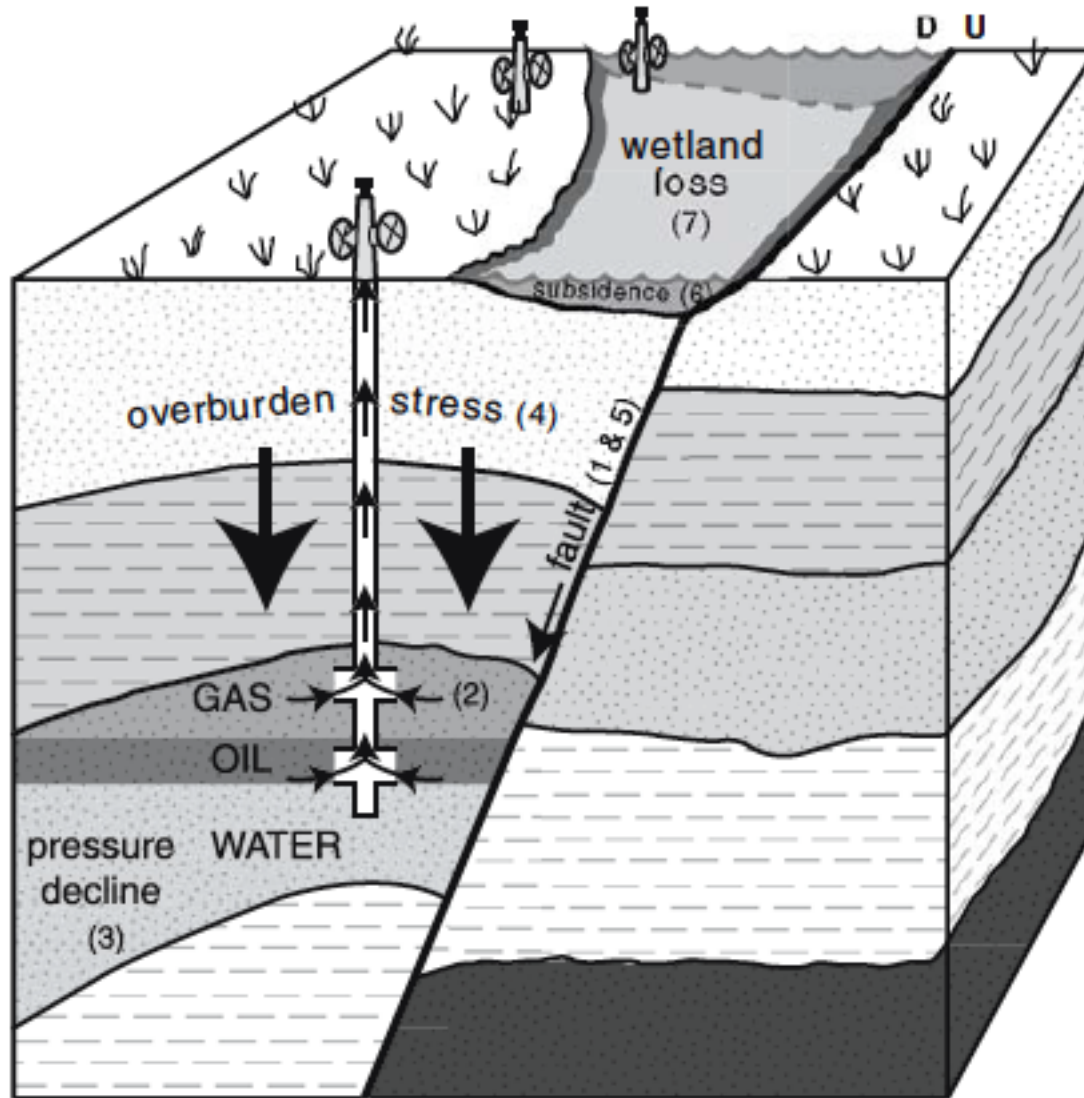
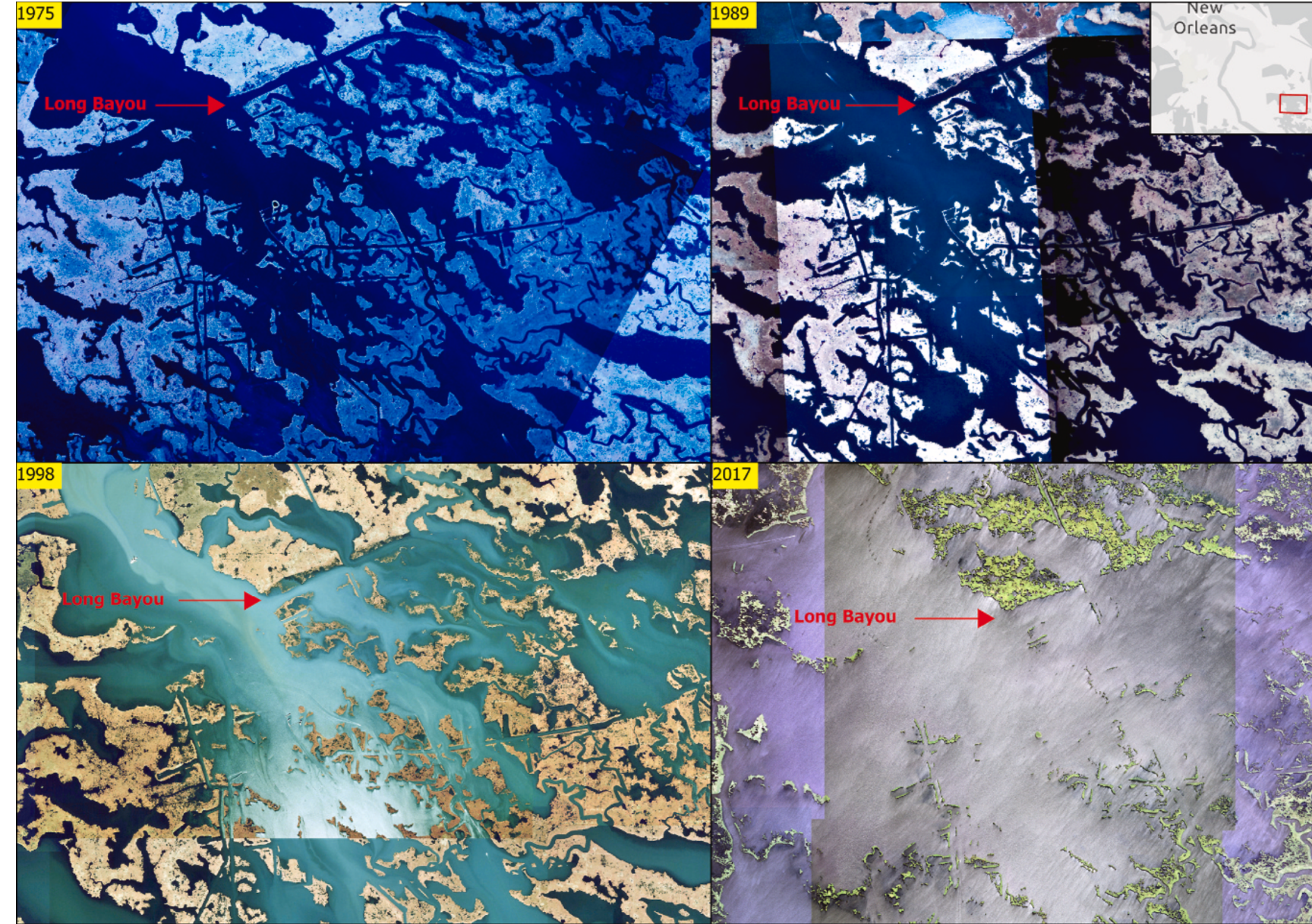


Figure 15. A simple compaction model of sand reservoir embedded with surrounding shale. It is assumed that during production stage, pore pressure depletion in a sand reservoir induces poroelastic compaction, and after depletion, a slow decrease in pore pressure in the bounding shale induces shale compaction in two independent rheological modes (poroelastic and viscoplastic) (modified from [29]).



Sequence of production-related subsurface events that may induce land subsidence and reactivate faults. Prolonged or rapid production of oil, gas, and formation water (2) causes formation pressures to decline (3). This increases the effective vertical stress of the overburden (4), which causes compaction of the reservoir rocks and may cause formerly active faults (1) to be reactivated (5). Either compaction of the reservoir and surrounding strata or slip along fault planes can cause land-surface subsidence (6). Where compaction or fault-related subsidence occurs in wetland areas, the wetlands typically are submerged and converted to open water (7). Figure is not to scale (Morton et al. 2006).



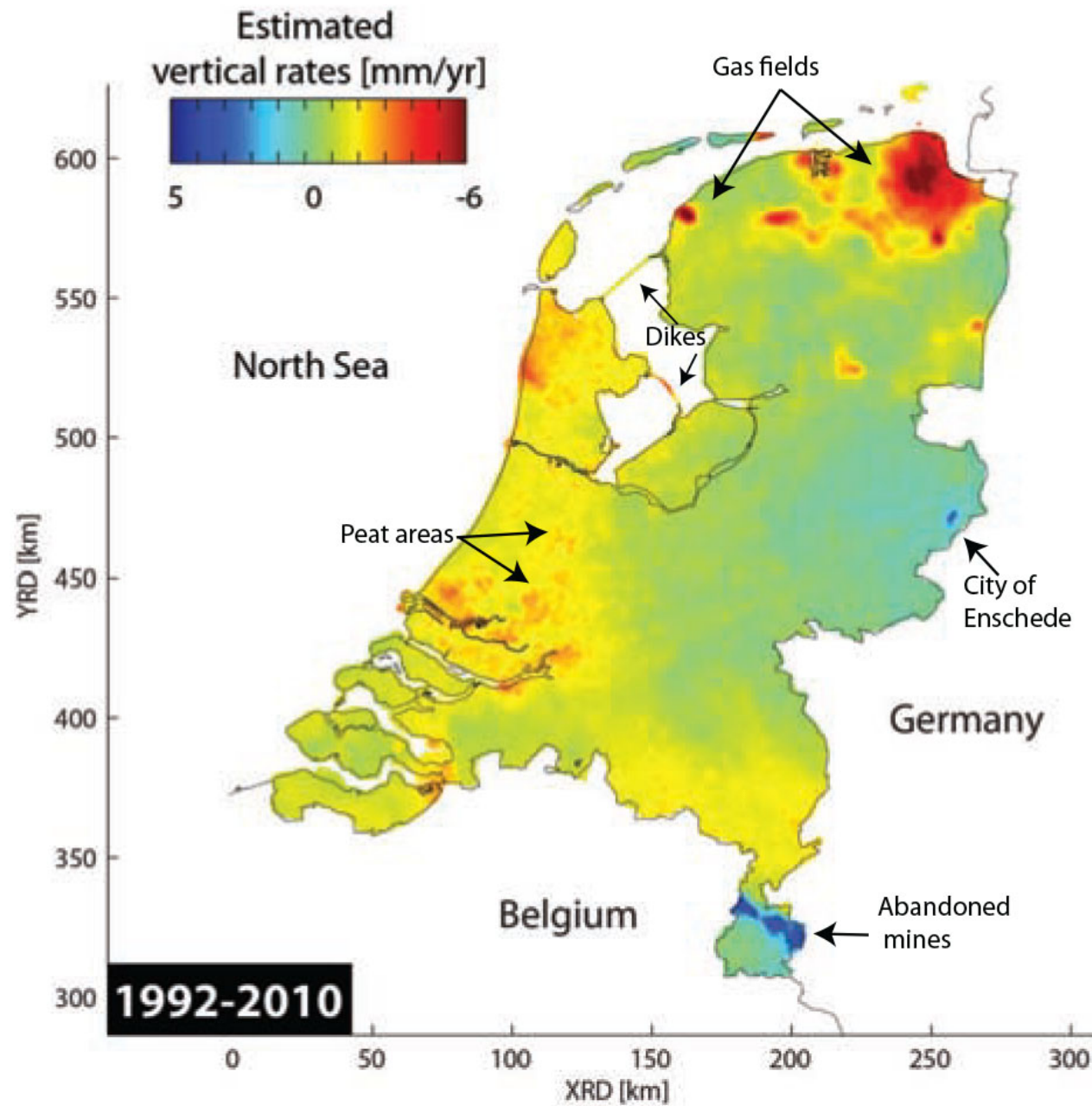
Breton Sound Basin (east of the Miss River). Wetland Loss mainly due to Petroleum impacts.

Canals and spoil banks altered surface hydrology, reduced sediment input to the marsh surface, and increased shallow subsidence.

Withdrawal of oil and gas increased deep subsidence due to fault activation (along Bayou Long), and reservoir collapse.

Wetlands north of Bayou Long have low loss rates because it is on the up thrown side of the fault with higher elevation. Wetlands on the down thrown side of the fault lost elevation

Wetland Loss South of Bayou Long Mainly Due to Oil and Gas Activities



TOXICITY IMPACTS

- **There are high levels of toxins from produced water in sediments. Strong mixing events such as frontal passages and hurricanes can mix these toxins into the water column and advect them over**

Table 2. Common components of produced water resulting from oil and gas production [103].

Category	Constituent
Metals	Aluminum, antimony, arsenic, barium, boron, cadmium, gold, iron, mercury, chromium, copper, lead, zinc, nickel, platinum, silver, strontium, tin, magnesium, molybdenum, titanium, thallium, vanadium
Naturally occurring radioactive materials	Radium-226, radium-228
Monocyclic aromatic hydrocarbons	Benzene, benzoic acid, chlorobenzene, di-n-butyl phthalate, toluene, ethylbenzene, isopropylbenzene, n-Propylbenzene, p-chloro-m-cresol, xylenes
Polycyclic aromatic hydrocarbons	Acenaphthene, anthracene, benzo(a)anthracene, cyrene, dibenzothiophenes, fluoranthene, fluorene, naphthalene, benzo(a)pyrene
Miscellaneous organic chemicals	Phenols, bis(2-ethylhexyl)phthalate, oil and grease
Miscellaneous other components	Calcium, potassium, radon, sodium chloride, total dissolved solids, ammonia, bromides, sulfates, sulfides

Produced Water is
More Toxic Than
Crude Oil

Not Used