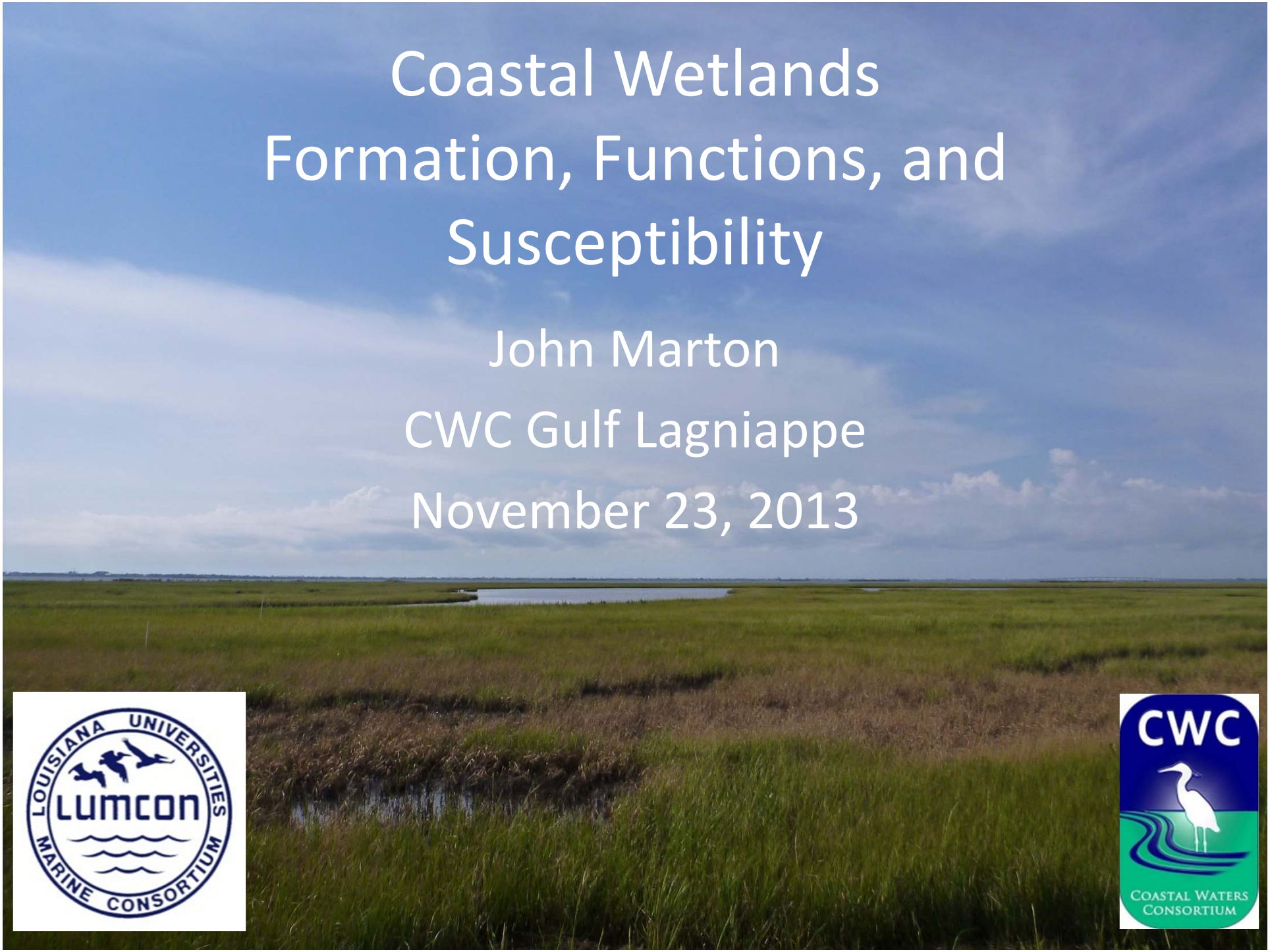
Coastal Wetlands Formation, Functions, and Susceptibility

John Marton

CWC Gulf Lagniappe

November 23, 2013



What is a wetland?

- Wetlands are distinguished by the presence of water, either at the surface or within the root zone
- Wetlands have unique soil conditions that differ from adjacent uplands
- Wetlands support vegetation adapted to the wet conditions- flood-intolerant plants are absent, as well


Satilla River, GA

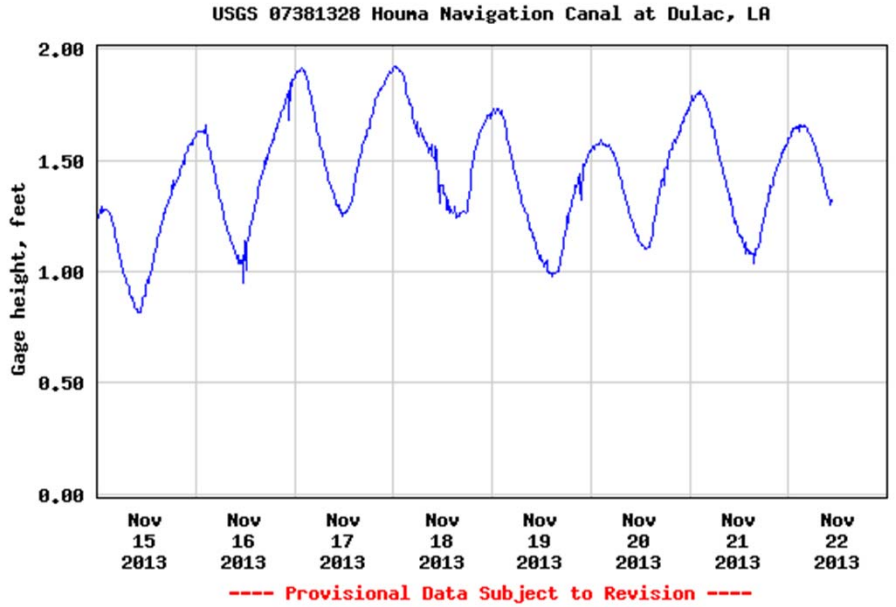

Ogeechee River, GA


Altamaha River, GA


Atlamaha River Watershed, Georgia

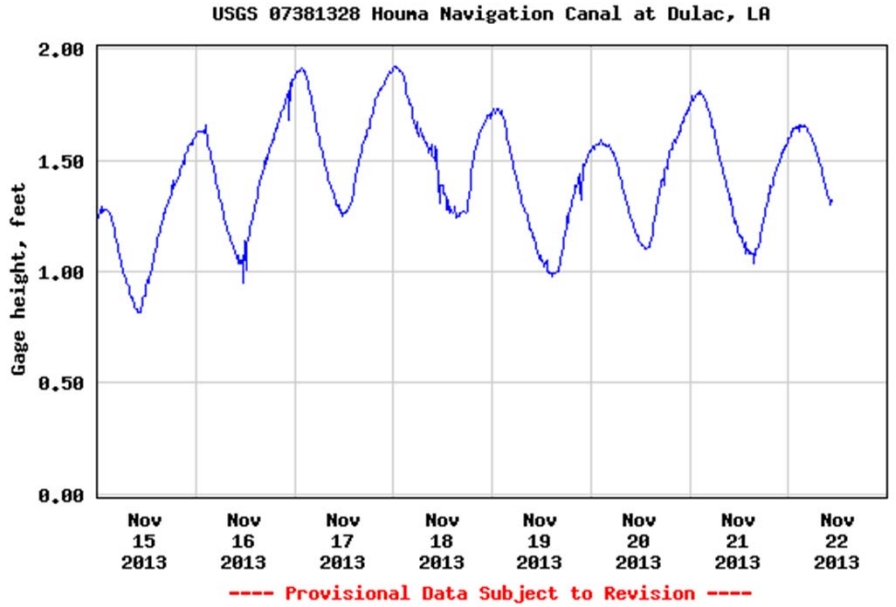
Wetland Components

- Hydrology
  - Frequency
  - Duration
  - Intensity
  - Flow
- Several sources
  - Rain
  - Surface flow (flooding from rivers streams)
  - Groundwater
  - Tides



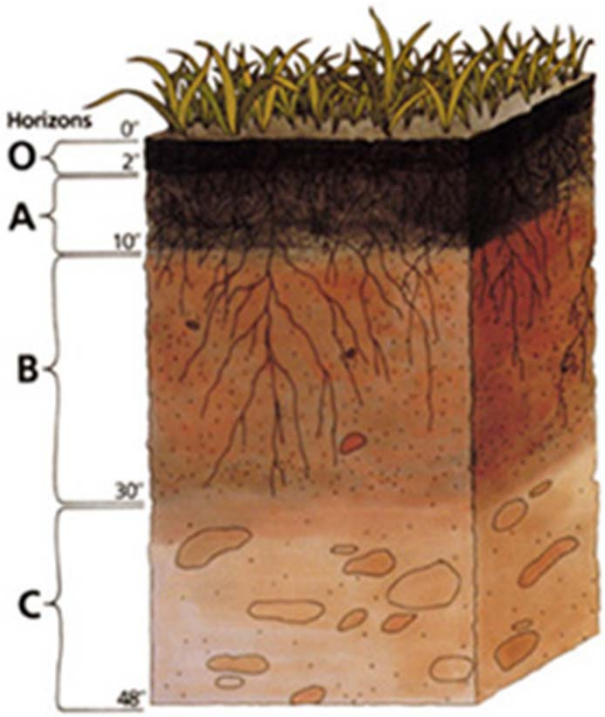
Wetland Components

- Multiple pathways out of the wetland
  - Evaporation/plant use
  - Seepage into groundwater
  - Flow/tides
- Directly influences soil and plants



Wetland Components

- First, what is soil?
  - Composed of mineral material (sand, silt, clay)
  - Upper limit is air or shallow water
  - Lower limit is bedrock or limit of biological activity
  - Consists of “horizons” formed through additions, losses, and transformations



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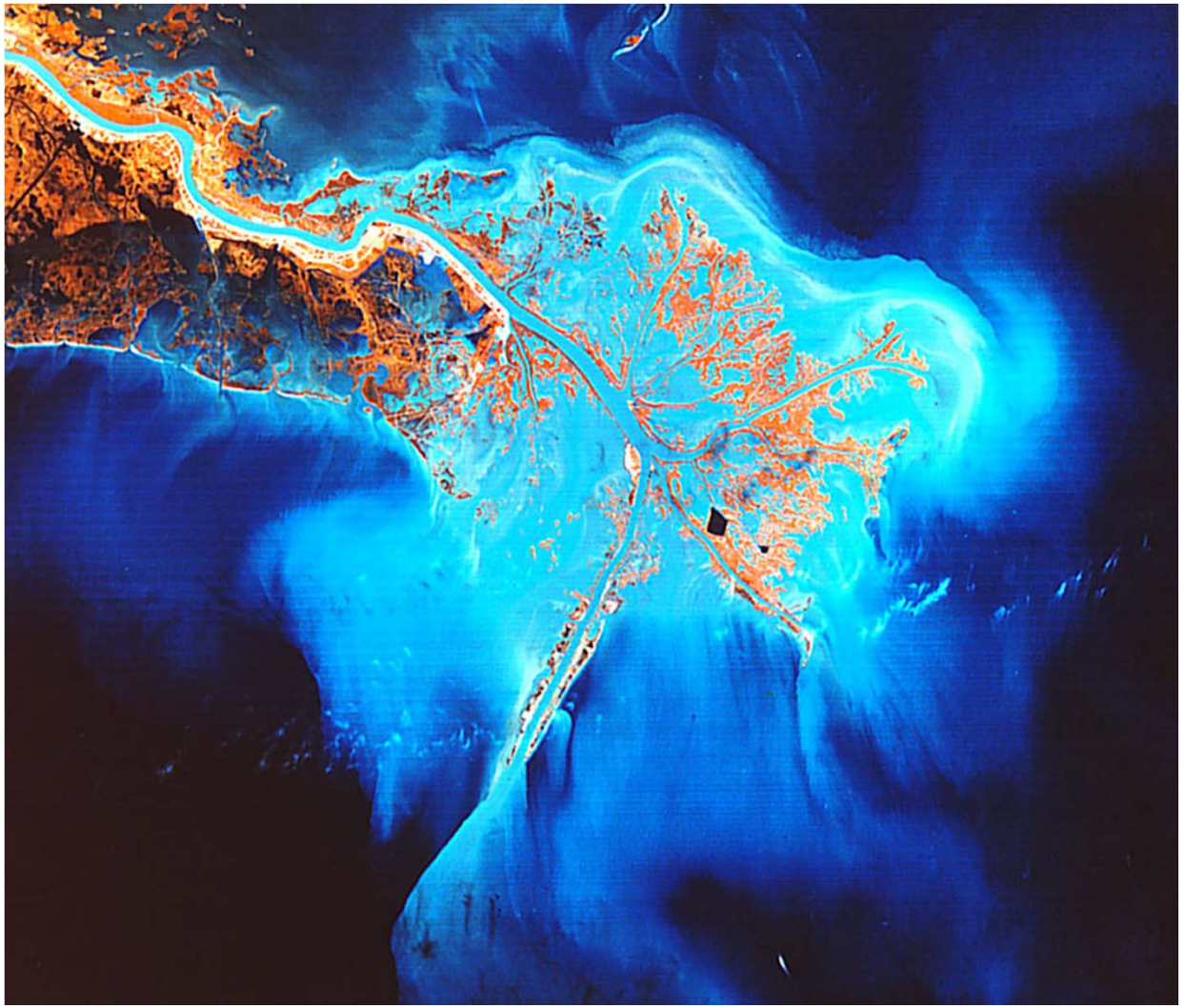
Wetland Components

- Soils influence
  - Water flow and storage
  - Nutrient (nitrogen and phosphorus) storage
  - Oxygen availability
  - Plant type and abundance

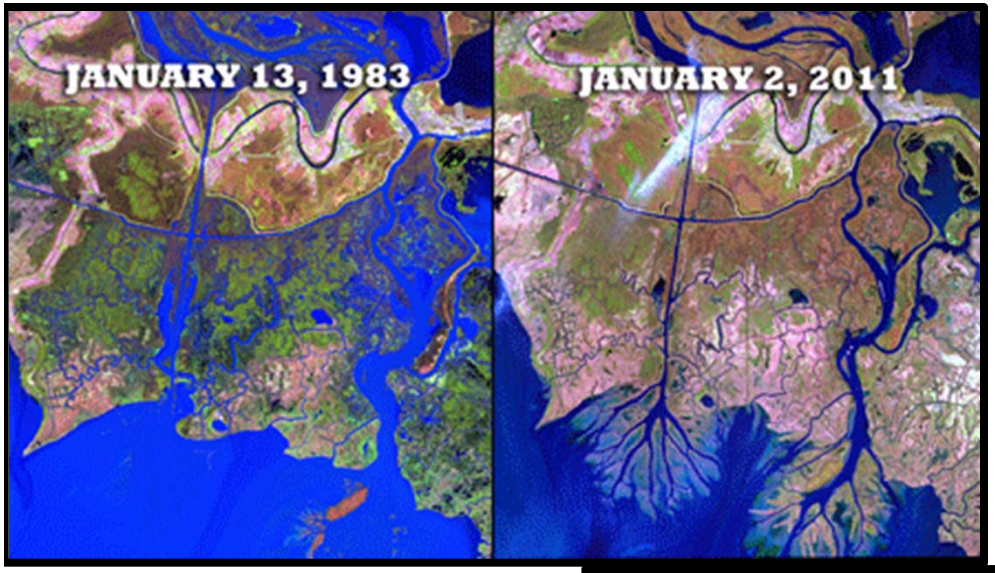
Wetland Components

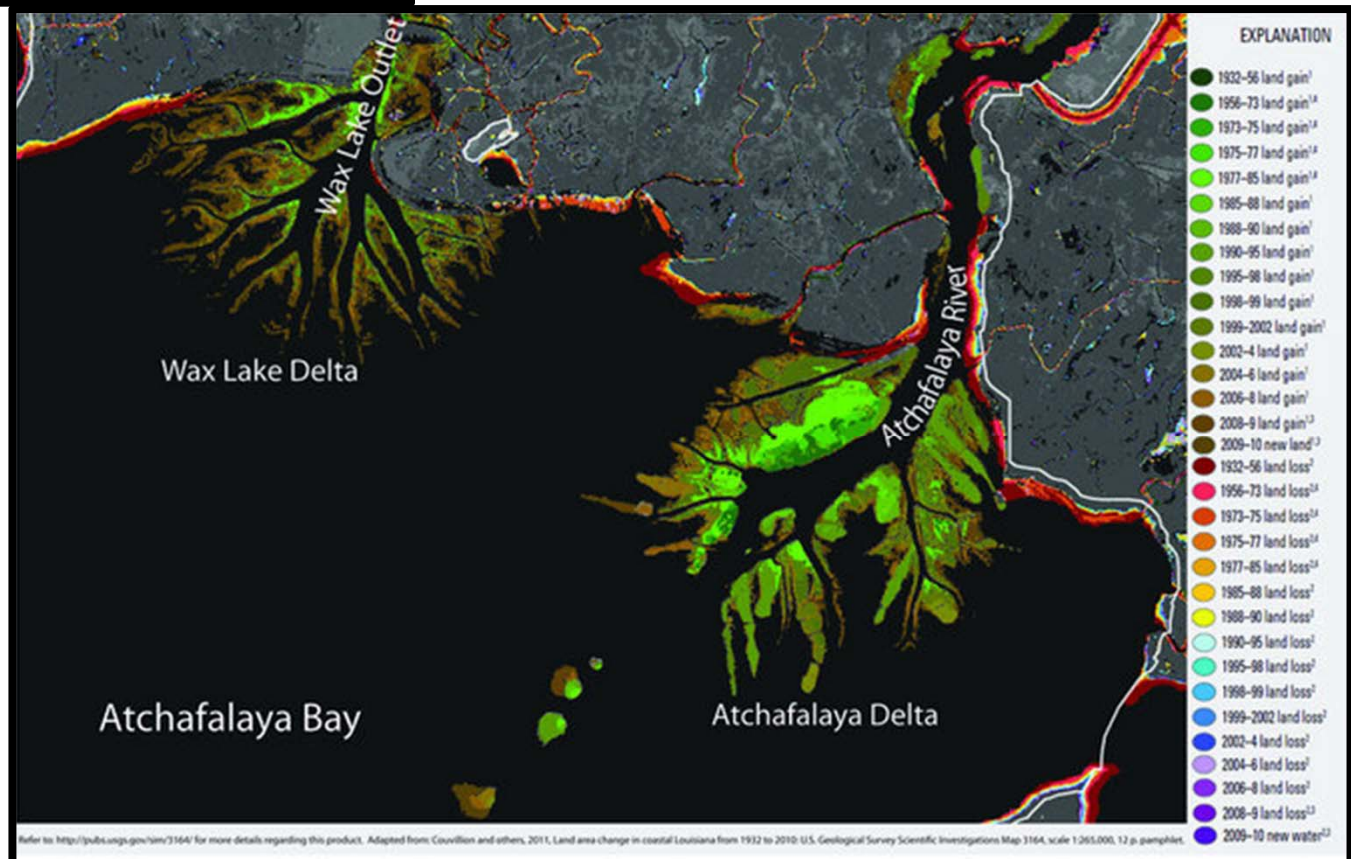
- Wetland Plants
  - Tolerate flooding
    - Low oxygen in soil
  - Structural adaptations to flooded conditions
  - Able to disperse
  - More competitive than “upland” plants

So how do coastal wetlands form?



1. Water delivers sediment
2. Sediment stores water, plants colonize
3. Plants trap sediment, accumulate sub-surface “stuff”
4. Feedback continues


JANUARY 13, 1983
JANUARY 2, 2011


Wax Lake Outlet
Wax Lake Delta
Atchafalaya River
Atchafalaya Bay
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EXPLANATION
1932–56 land gain
1956–73 land gain
1973–75 land gain
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1995–98 land gain
1998–99 land gain
1999–2002 land gain
2002–4 land gain
2004–6 land gain
2006–8 land gain
2008–9 land gain
2009–10 new land
1932–56 land loss
1956–73 land loss
1973–75 land loss
1975–77 land loss
1977–85 land loss
1985–88 land loss
1988–90 land loss
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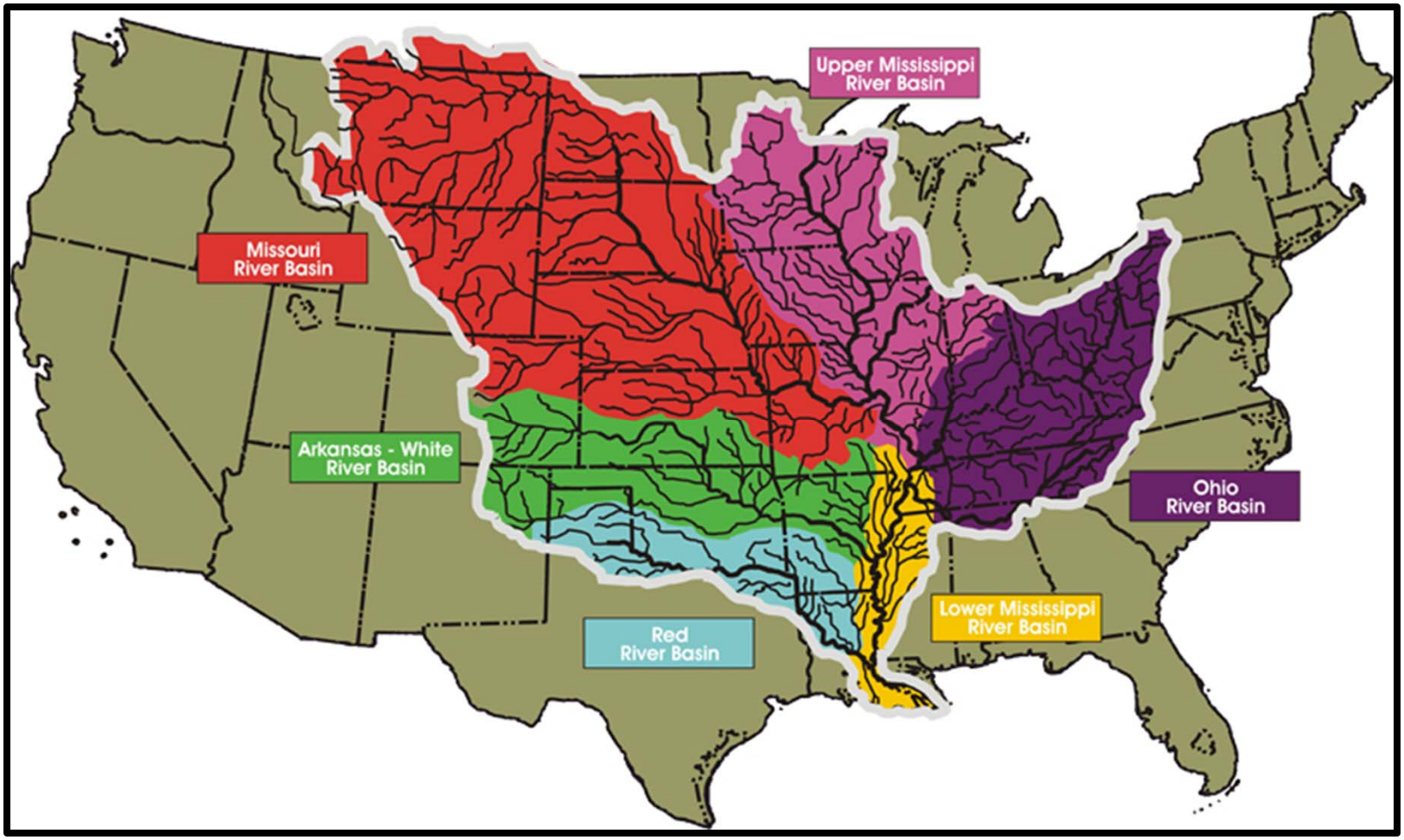
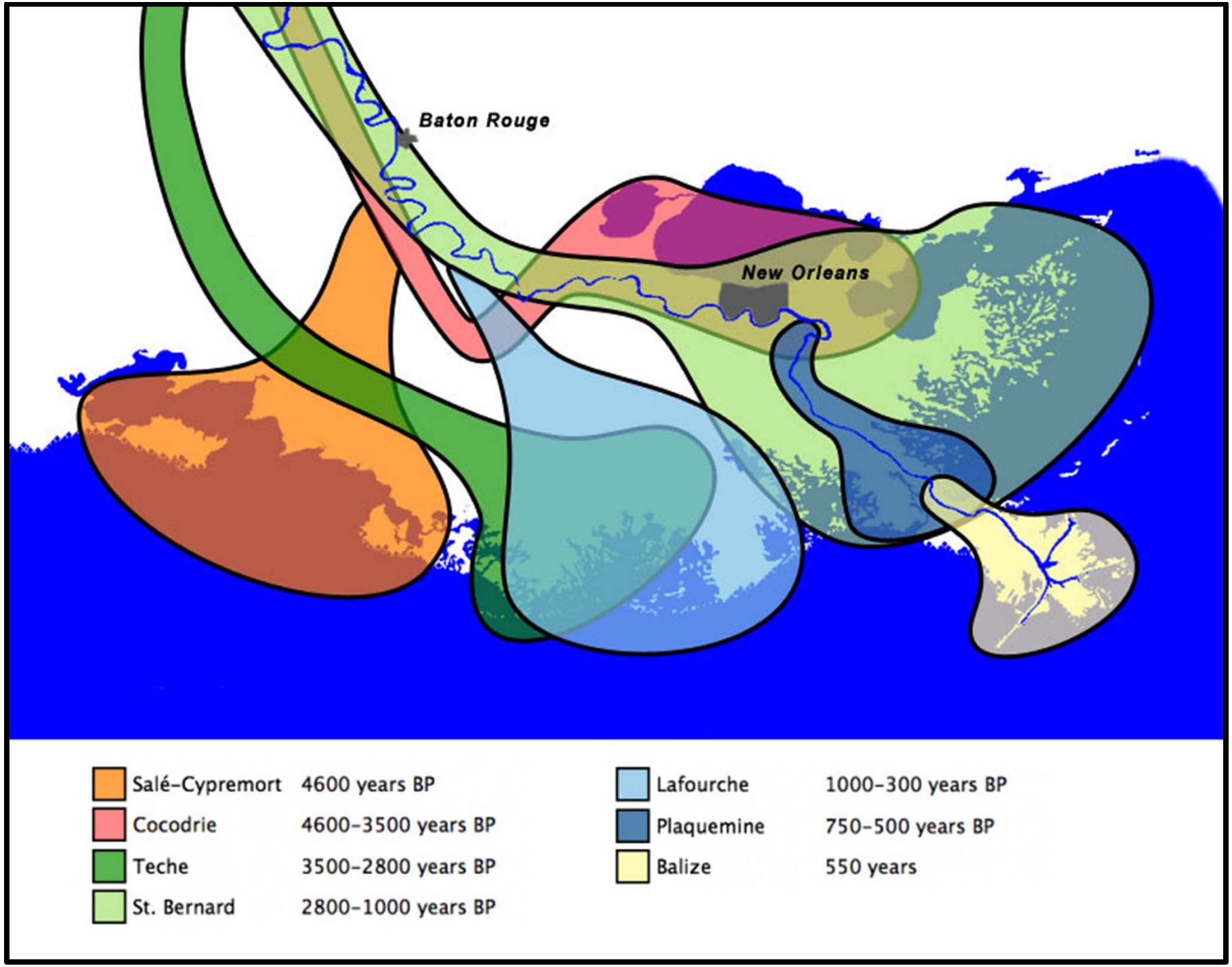
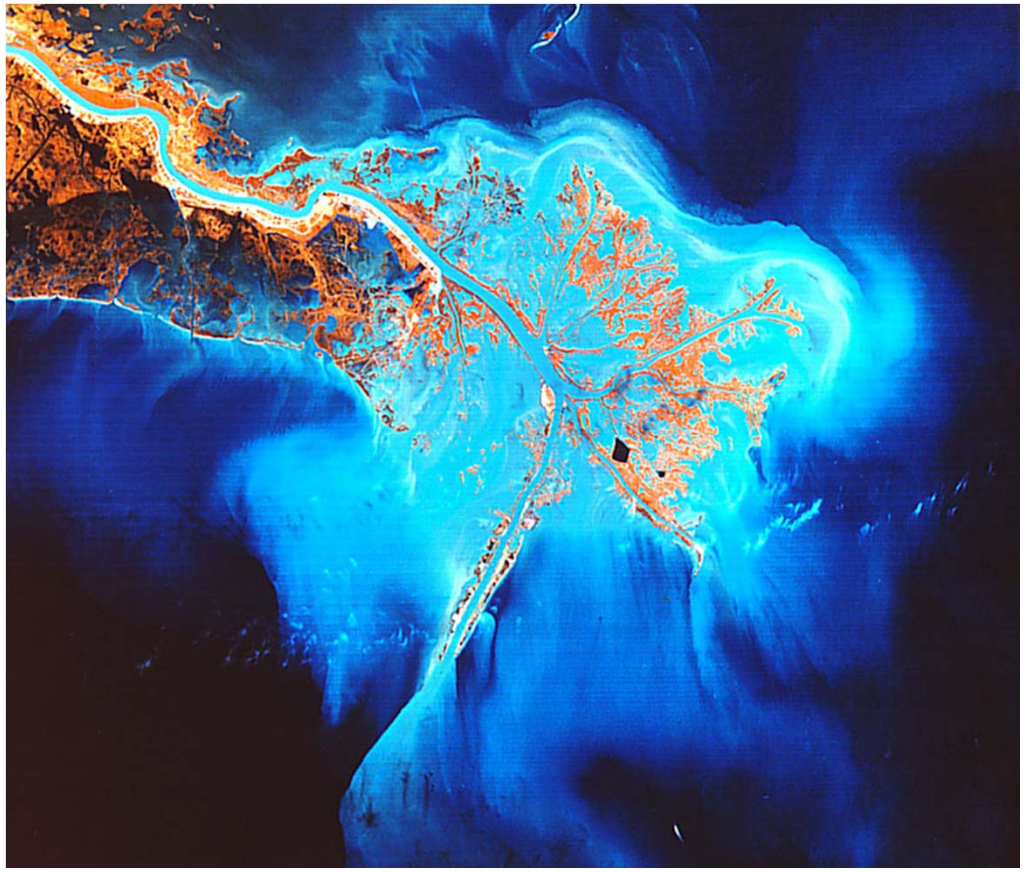

Upper Mississippi
River Basin
Missouri
River Basin
Arkansas - White
River Basin
Ohio
River Basin
Lower Mississippi
River Basin
Red
River Basin

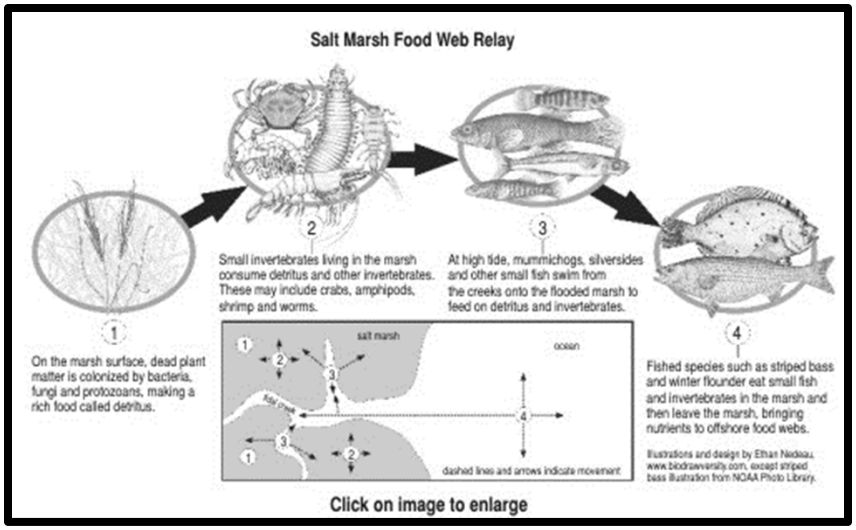

Baton Rouge
New Orleans
Salé-Cypremort 4600 years BP
Cocodrie 4600–3500 years BP
Teche 3500–2800 years BP
St. Bernard 2800–1000 years BP
Lafourche 1000–300 years BP
Plaquemine 750–500 years BP
Balize 550 years

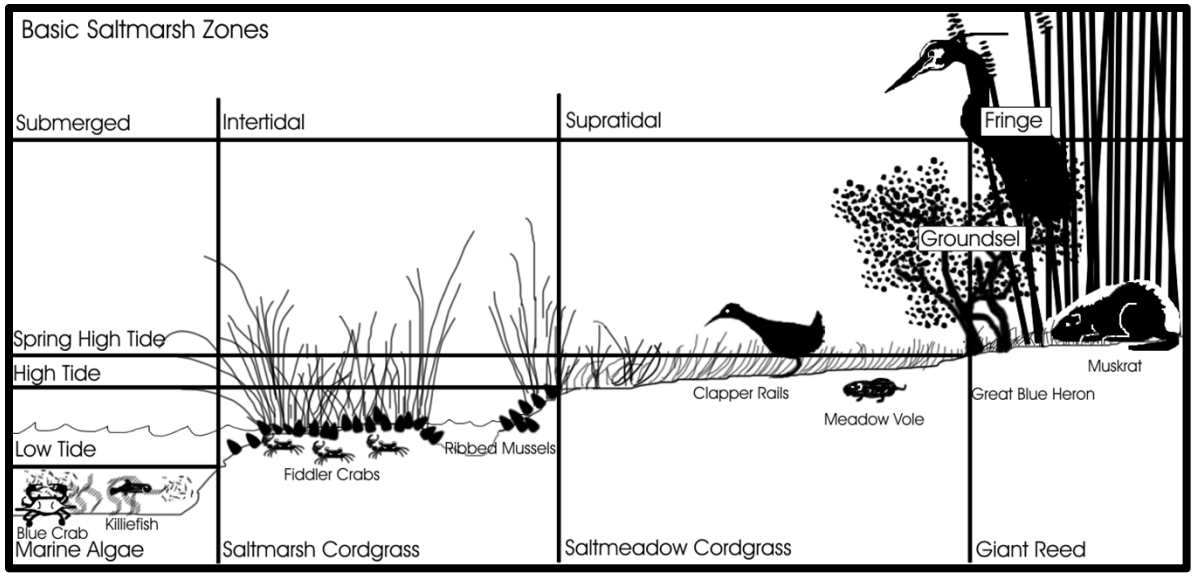
Louisiana's Coastal Wetlands

- Over 30,000 km^2 of wetlands
- Losses of >100 km^2 per year over the last 50 years
- Accounts for 80% of coastal wetland loss in US
- More on this later…



Louisiana's Coastal Wetlands



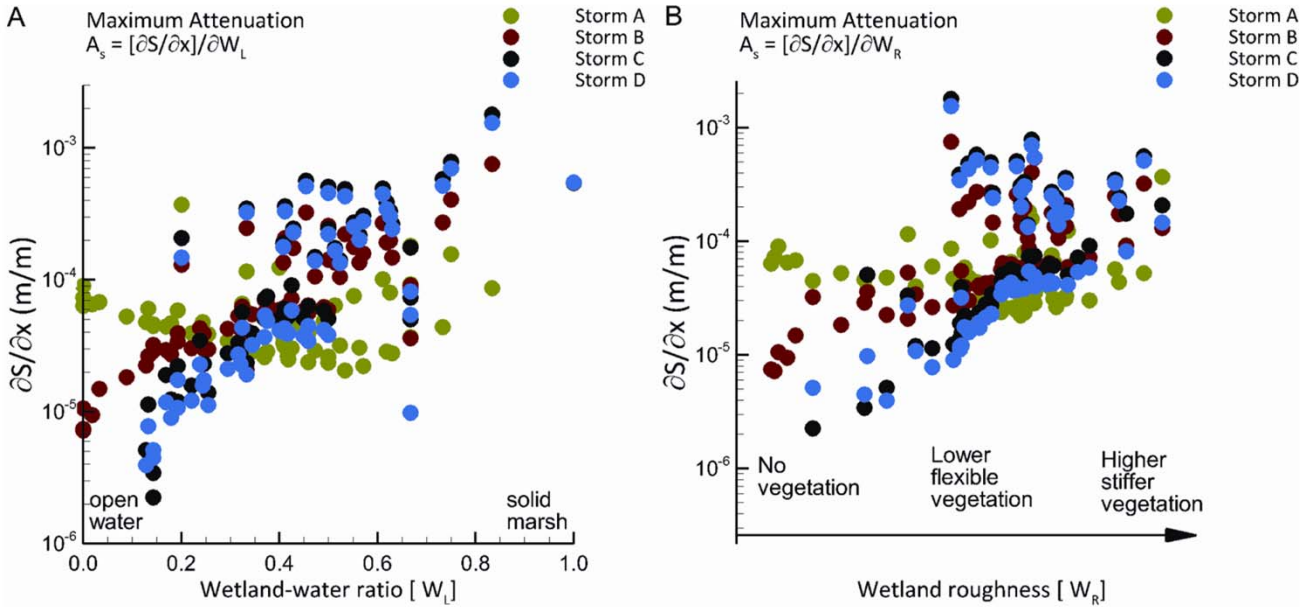


Louisiana's Coastal Wetlands

- Refuge for fin and shellfish
  - 1.1 billion lbs/year in landings (75% depends on wetlands)
  - Accounts for 16% of nations fisheries harvest

Louisiana's Coastal Wetlands

- Water storage
- Coastal protection from floods and hurricanes
  - Slow the movement of water
  - Dampen the strength of storm surge



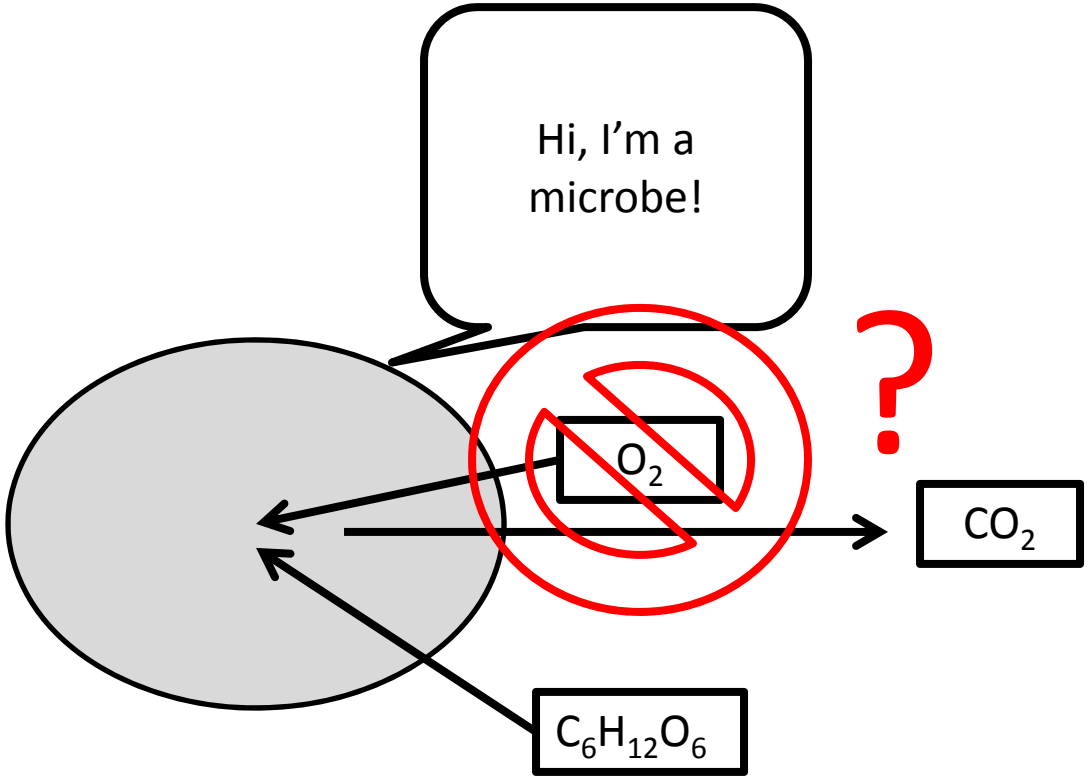
Source: Barbier et al. (2013) PLoS ONE

Dauphin Island, Alabama

Louisiana's Coastal Wetlands

- Important sinks for nutrients (nitrogen and phosphorus)
  - Water quality
- Stores carbon (carbon sequestration)
- A quick primer on microbes…

Think of microbes as little people…

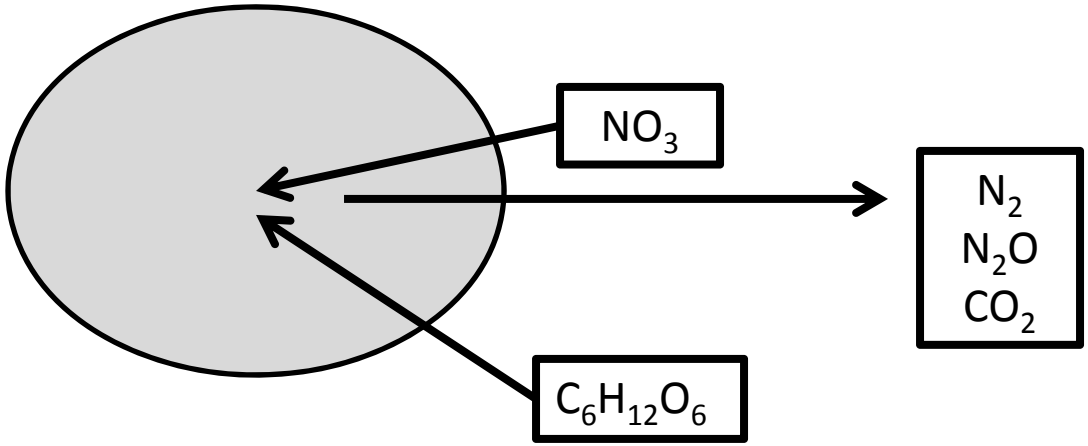


…who need to eat (carbon) and breathe (oxygen)

This is what we do, we need oxygen to get the energy from our carbon source (food)

Think of microbes as little people…

This is called denitrification, and
it removes nitrogen from the landscape

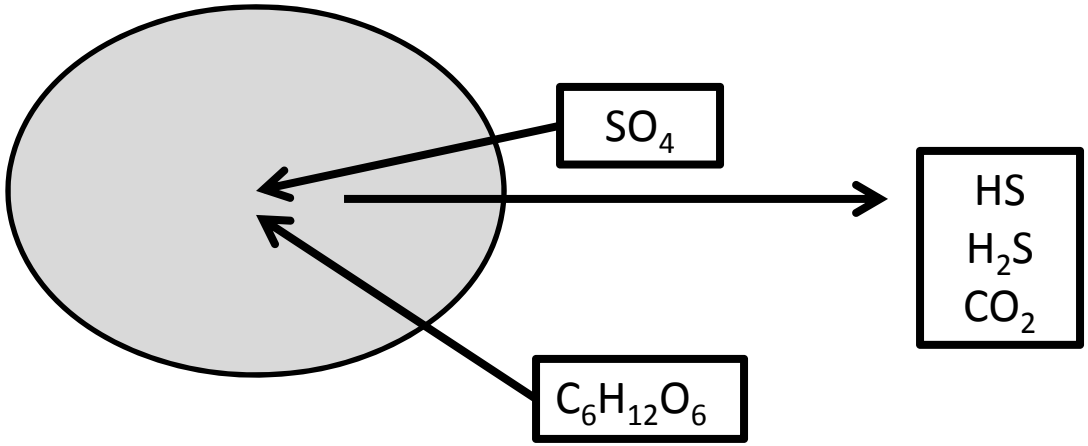


…who need to eat (carbon) and breathe (oxygen)

This is why microbes are cooler than we are…

Think of microbes as little people…

This is called sulfate reduction



…who need to eat (carbon) and breathe (oxygen)

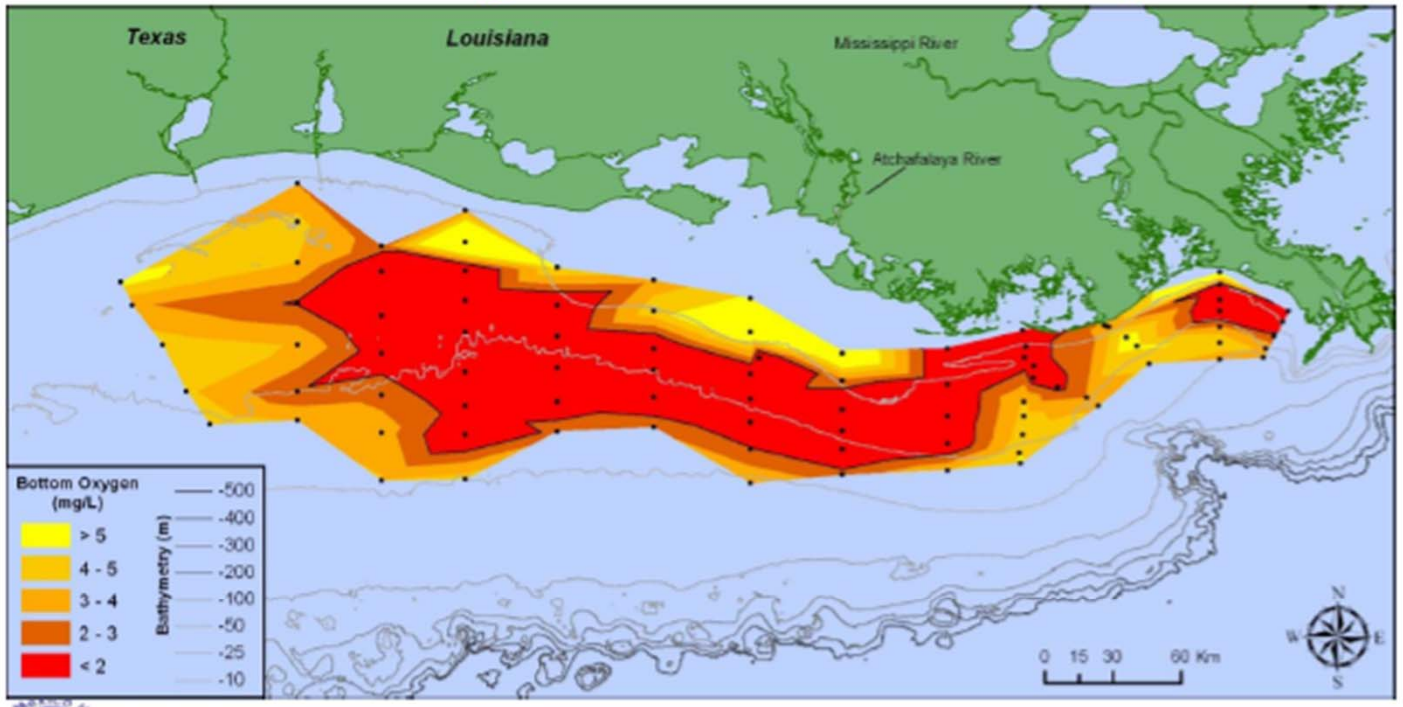
Out of nitrate? That's fine!

Louisiana's Coastal Wetlands

- These are known as anaerobic processes (no oxygen)
- Much slower and less efficient than aerobic respiration (involves oxygen)
- Therefore, the carbon source is stored in the soil
  - Less CO_2 emitted to the atmosphere

Why remove nitrogen at all?

Bottom-water dissolved oxygen across the Louisiana shelf from July 22-28, 2013

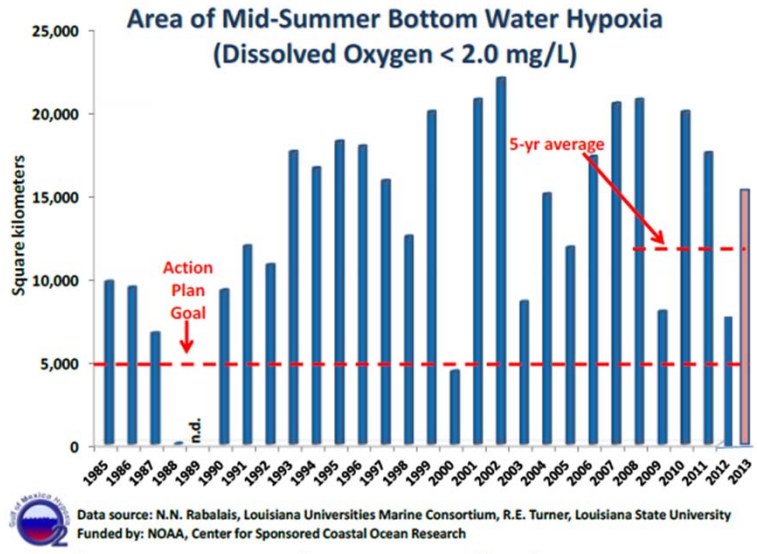


Data source: N.N. Rabalais, Louisiana Universities Marine Consortium, R.E. Turner, Louisiana State University
Funded by: NOAA, Center for Sponsored Coastal Ocean Research

Distribution of the concentration of bottom-water dissolved oxygen along the Louisiana-Texas shelf, July 22-28, 2013. The dark line delineates the area where the dissolved oxygen is less than 2 milligrams per liter, or hypoxia.

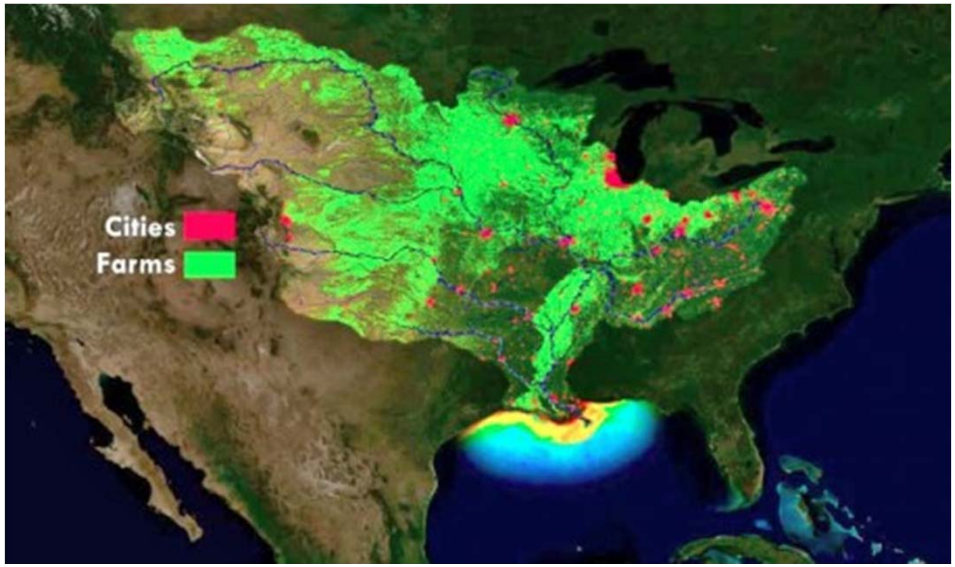
Why remove nitrogen at all?

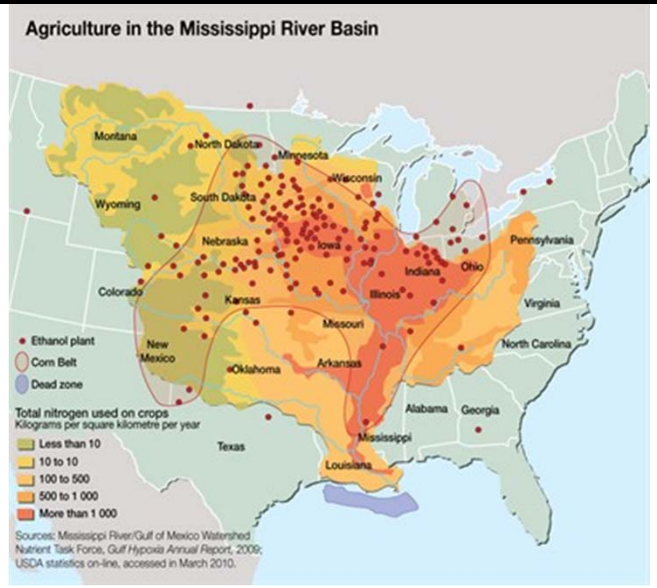
- Nitrate in the water causes a bloom of algae
- Microbes consume the algae, and the oxygen
- Wetlands can “filter” the water (think of them as the kidneys of the landscape)



Bottom-water hypoxia area estimates from 1985-2013. Although some mapping was conducted in 1989, the complete survey was not conducted, no data (n.d.). The five-year running average and goal for the Hypoxia Action Plan are represented by the horizontal lines.

Where does the nitrogen come from?





Louisiana's Coastal Wetlands

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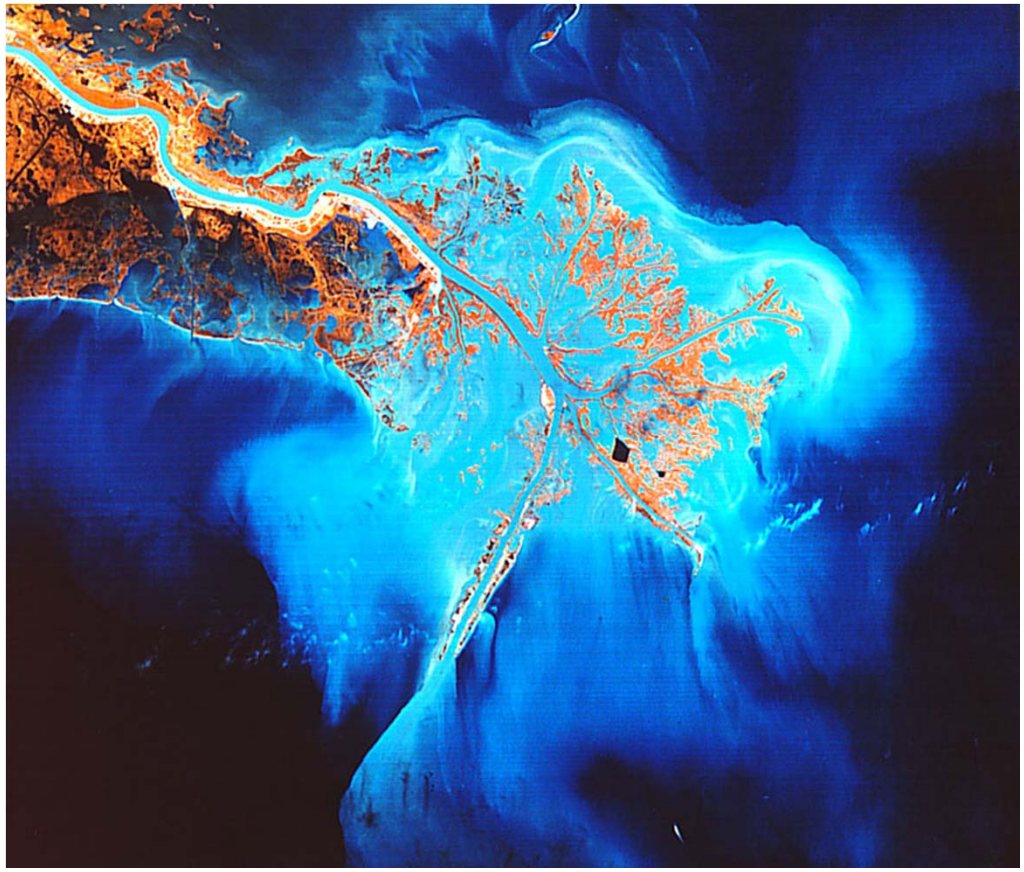
- Losses of >100 km^2 per year over the last 50 years
- Accounts for 80% of coastal wetland loss in US
- And now it's later…



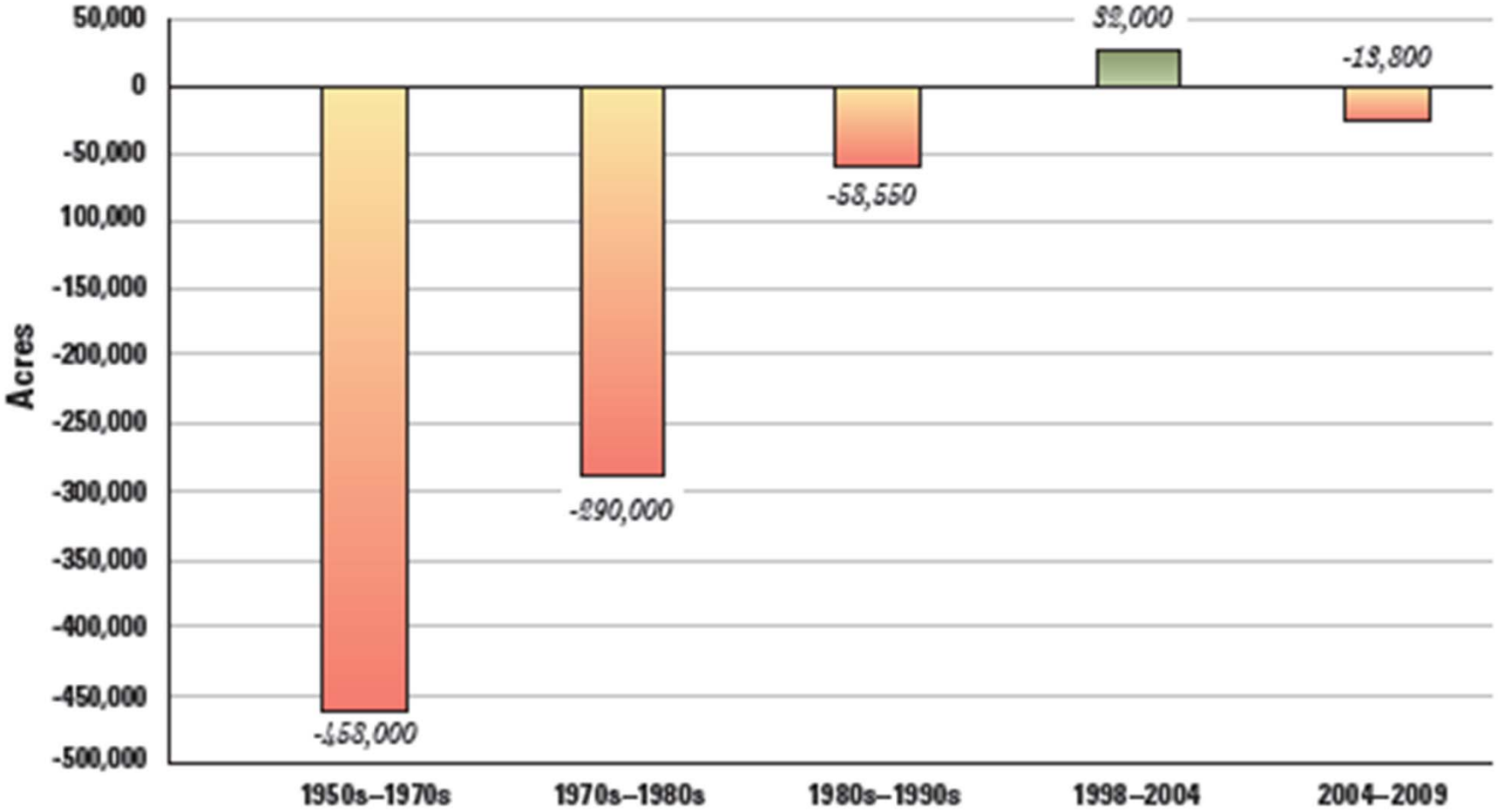
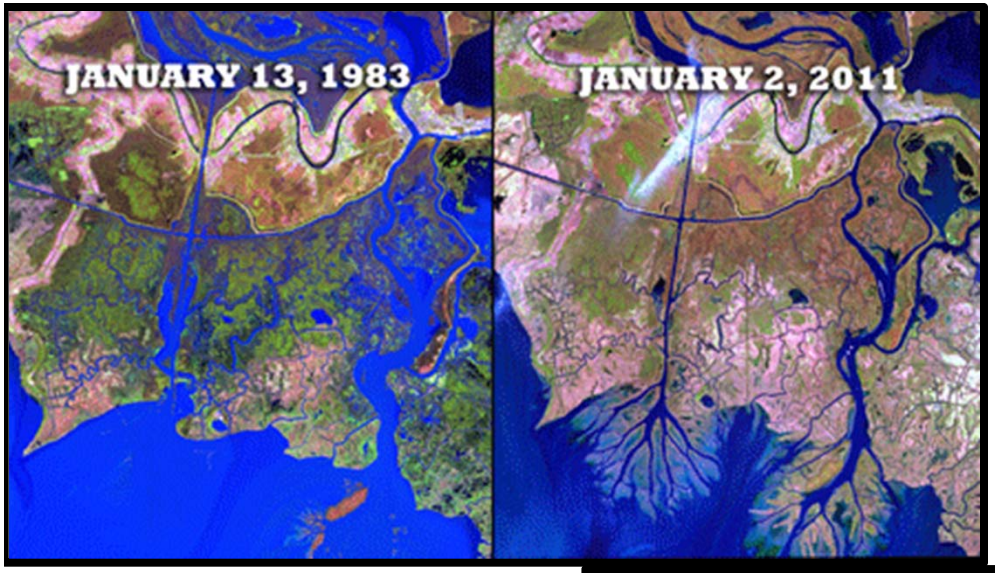


Figure 19. Average annual net loss and gain estimates for the conterminous United States, 1954 to 2009. Estimates of error are not graphically represented. Sources: Frayer et al. 1983; Dahl and Johnson 1991; Dahl 2000; 2006; and this study.

Susceptibility

- There are two primary drivers of coastal wetland loss in Louisiana
  - Lack of sediment delivery
  - Salt water intrusion
- These are big picture threats
  - Can be direct and indirect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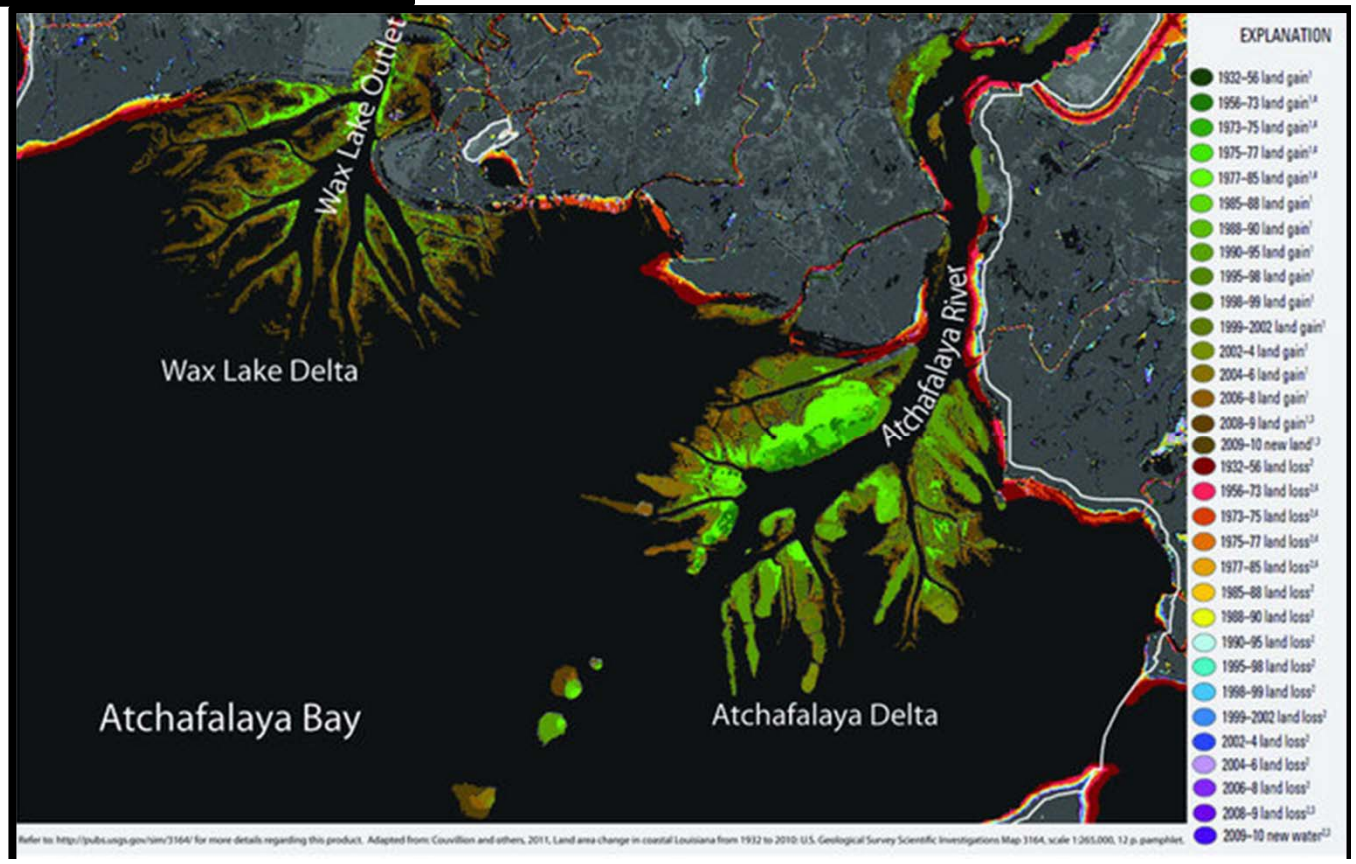
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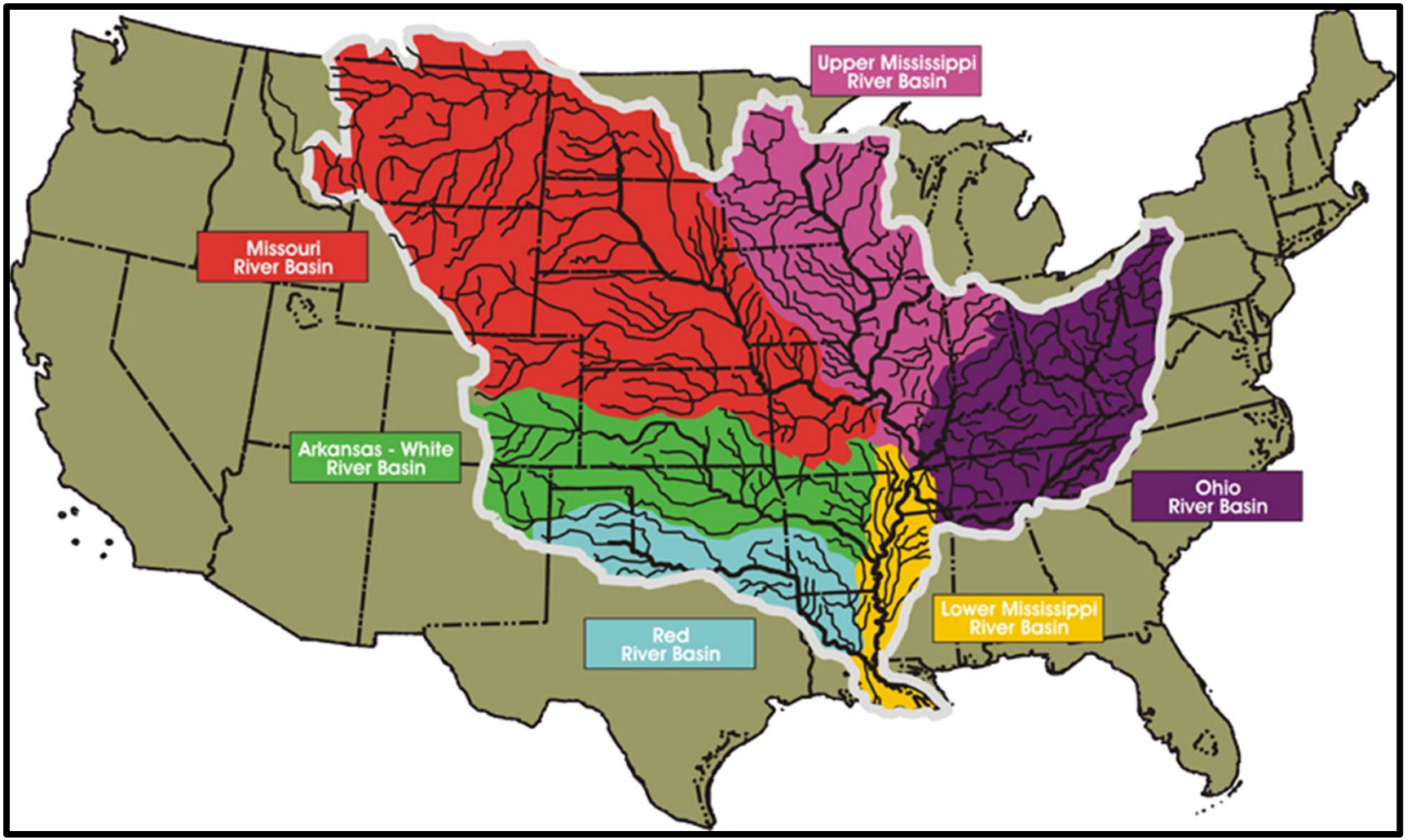

Upper Mississippi
River Basin
Missouri
River Basin
Arkansas - White
River Basin
Ohio
River Basin
Red
River Basin
Lower Mississippi
River Basin

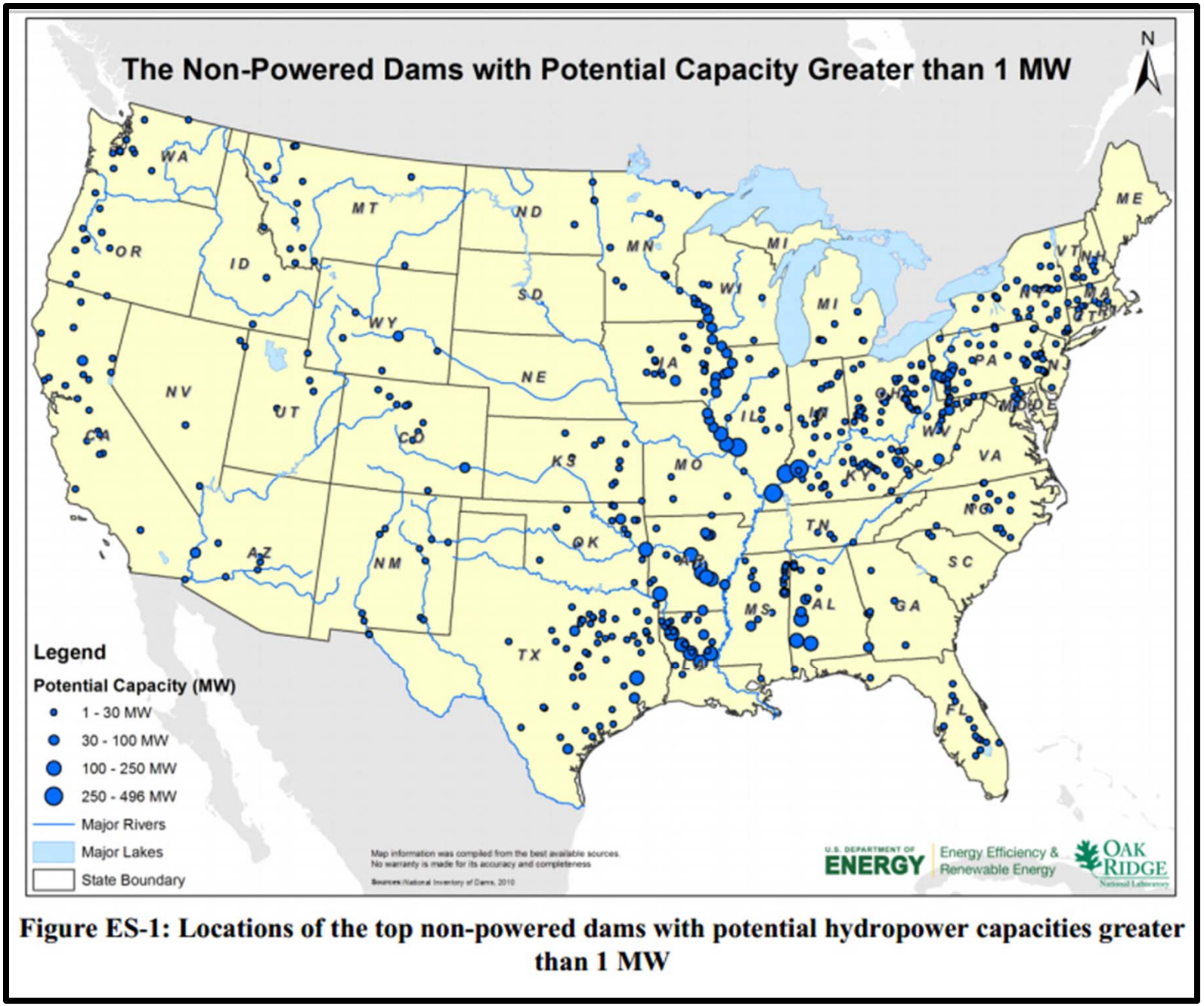
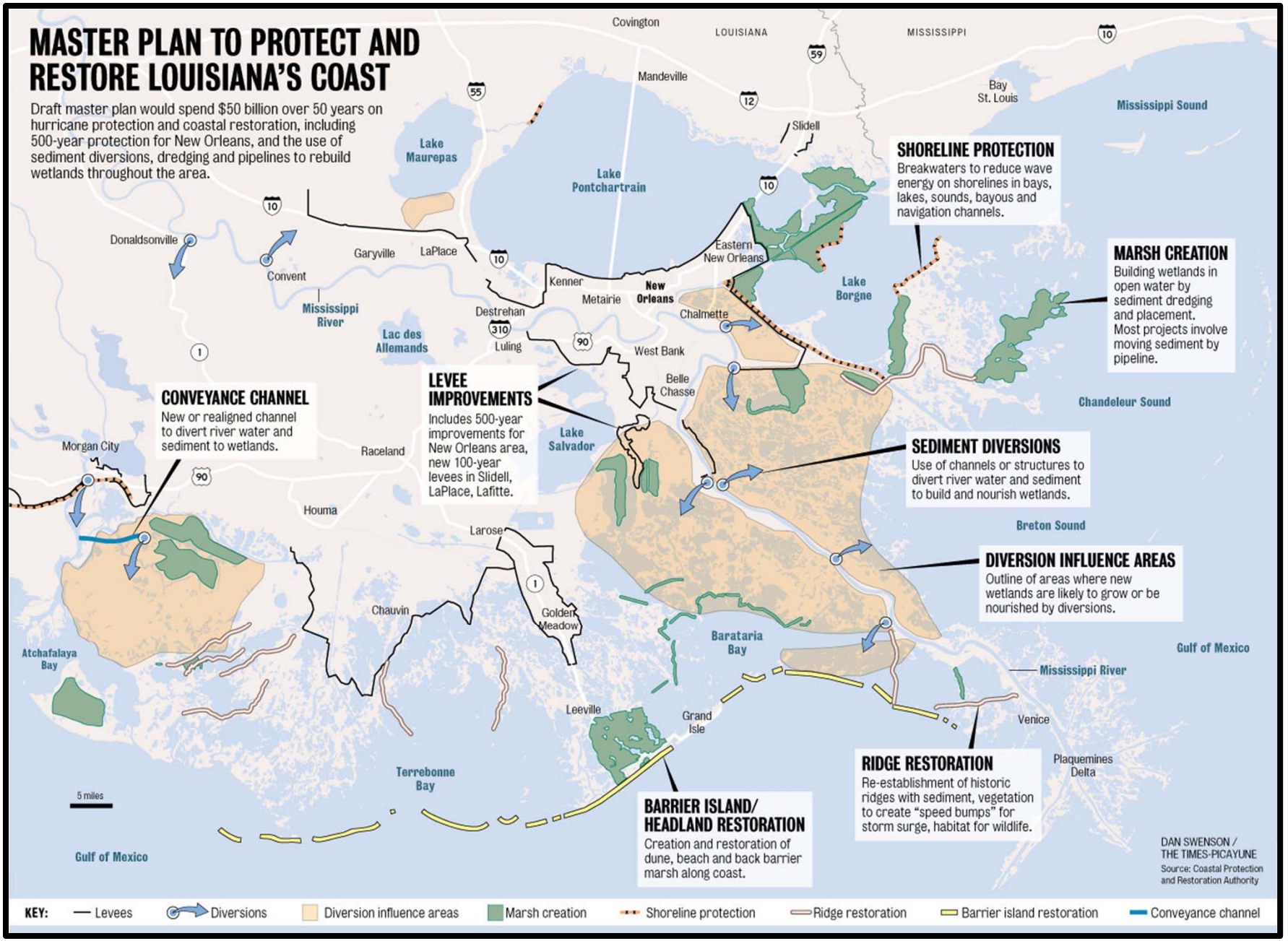
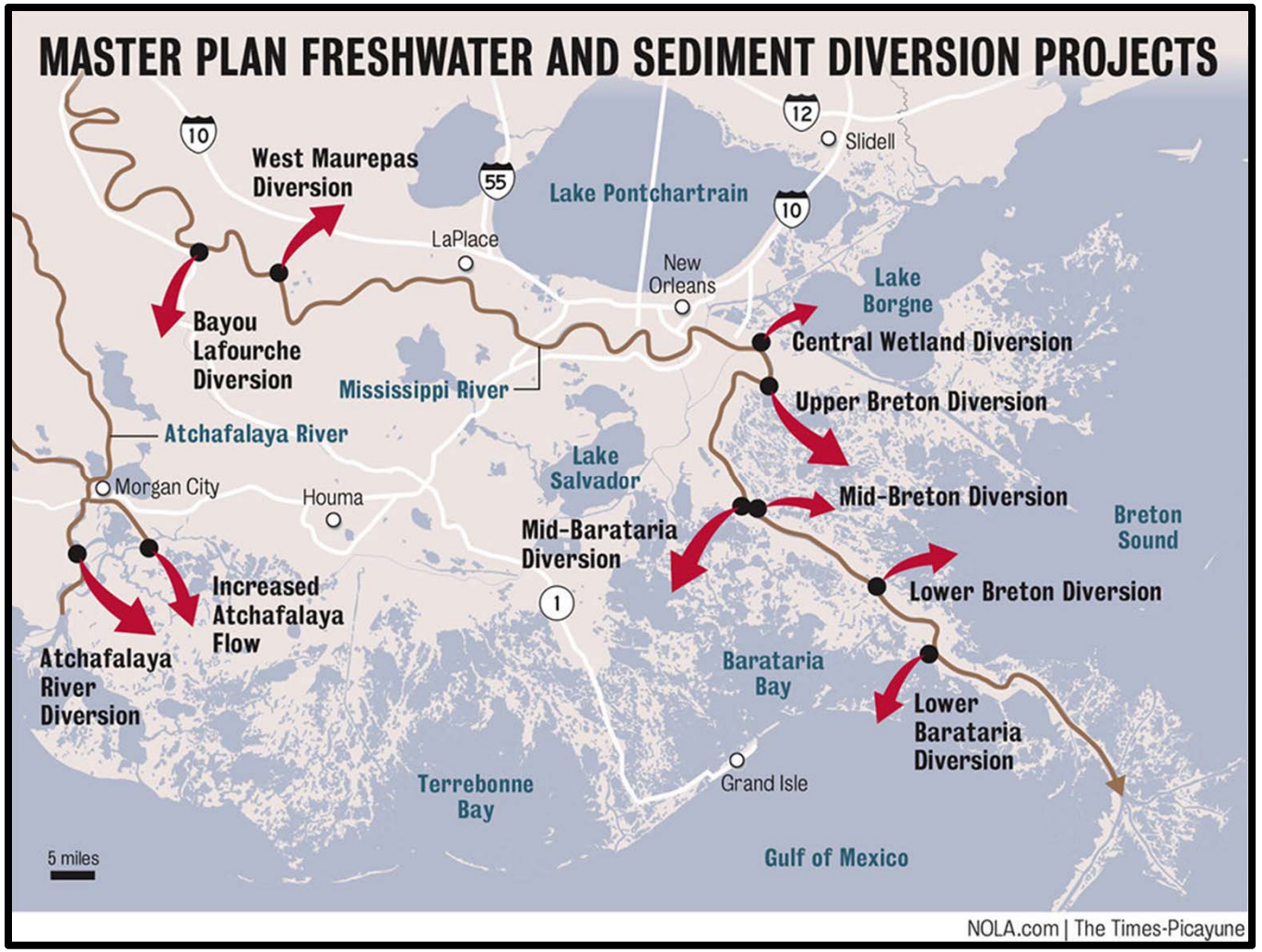
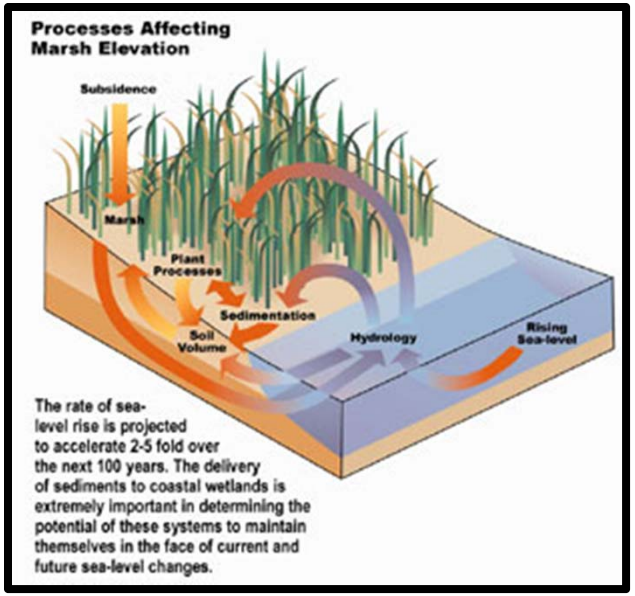


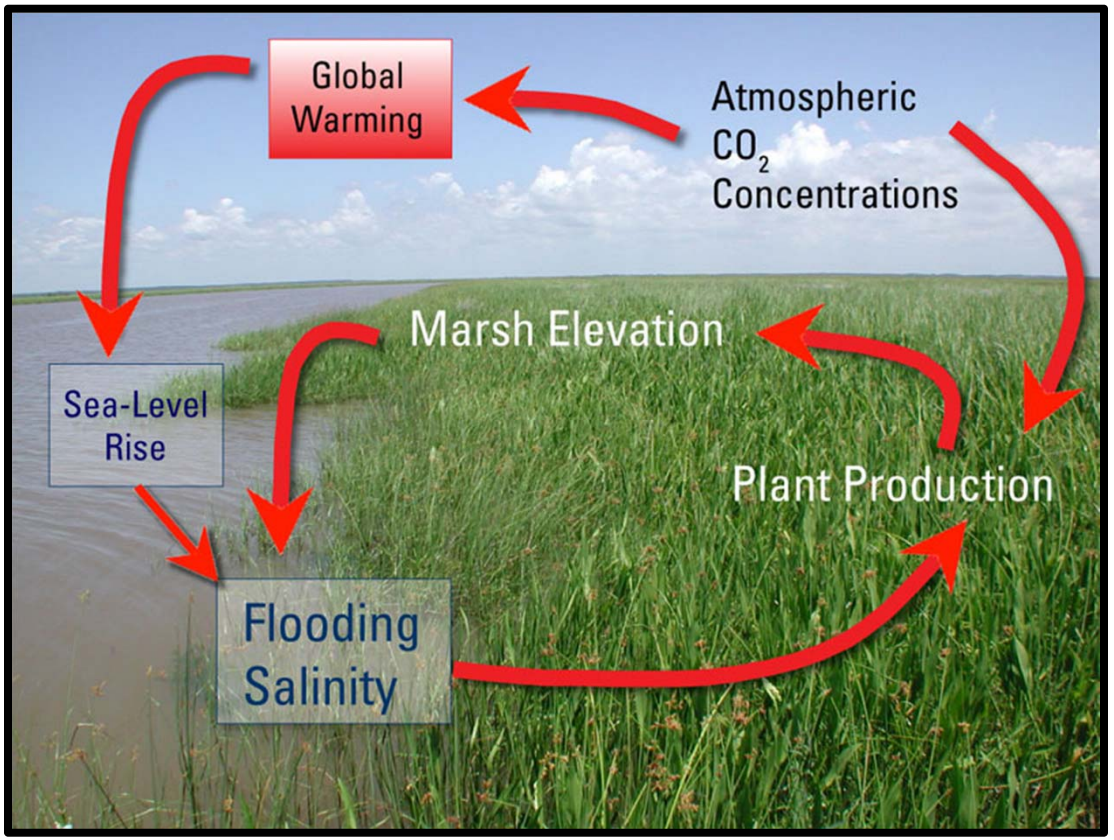
Figure ES-1: Locations of the top non-powered dams with potential hydropower capacities greater than 1 MW

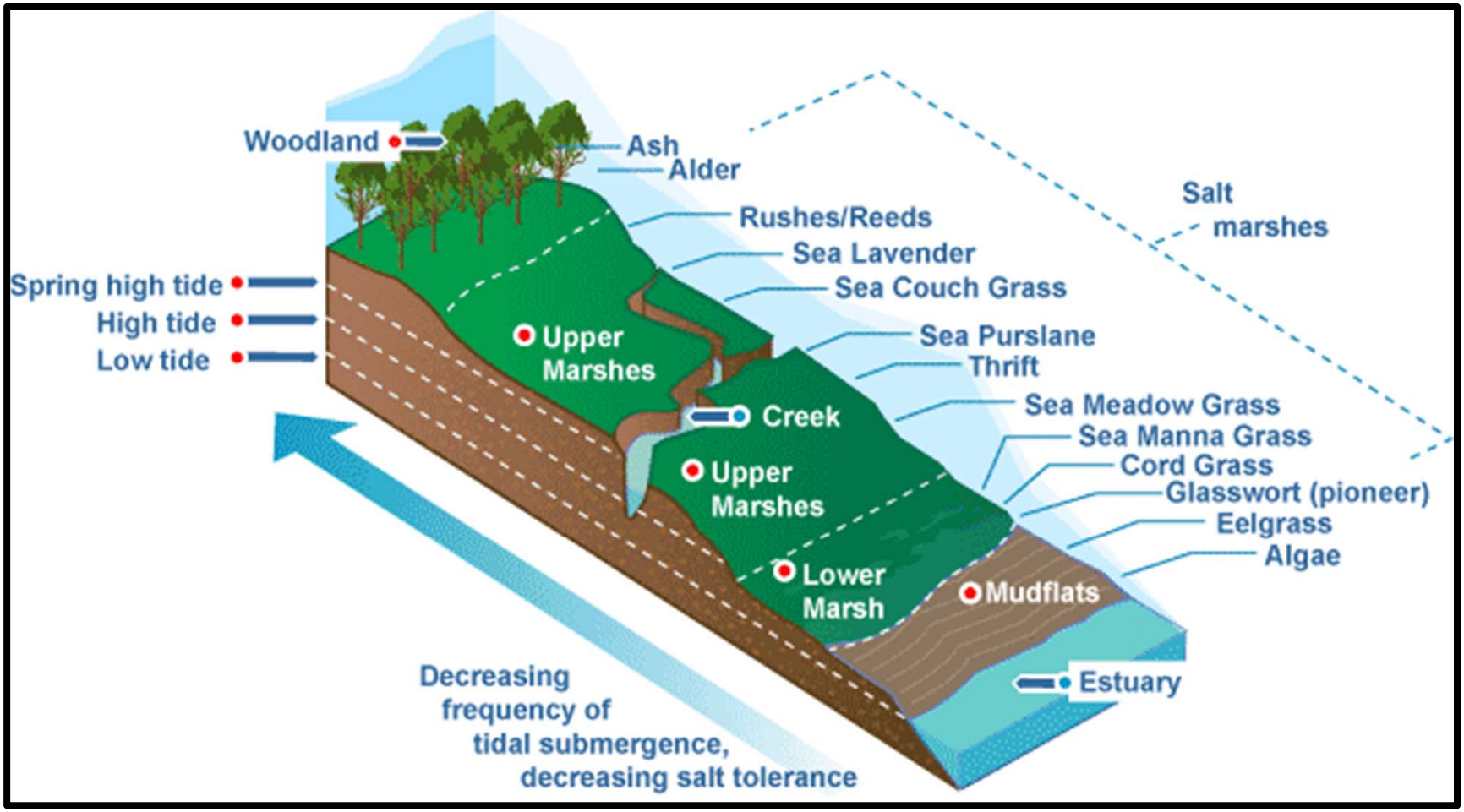

MASTER PLAN TO PROTECT AND RESTORE LOUISIANA'S COAST
Draft master plan would spend $50 billion over 50 years on hurricane protection and coastal restoration, including 500-year protection for New Orleans, and the use of sediment diversions, dredging and pipelines to rebuild wetlands throughout the area.
SHORELINE PROTECTION
Breakwaters to reduce wave energy on shorelines in bays, lakes, sounds, bayous and navigation channels.
MARSH CREATION
Building wetlands in open water by sediment dredging and placement. Most projects involve moving sediment by pipeline.
CONVEYANCE CHANNEL
New or realigned channel to divert river water and sediment to wetlands.
LEVEE IMPROVEMENTS
Includes 500-year improvements for New Orleans area, new 100-year levees in Slidell, LaPlace, Lafitte.
SEDIMENT DIVERSIONS
Use of channels or structures to divert river water and sediment to build and nourish wetlands.
DIVERSION INFLUENCE AREAS
Outline of areas where new wetlands are likely to grow or be nourished by diversions.
RIDGE RESTORATION
Re-establishment of historic ridges with sediment, vegetation to create "speed bumps" for storm surge, habitat for wildlife.
BARRIER ISLAND/ HEADLAND RESTORATION
Creation and restoration of dune, beach and back barrier marsh along coast.
Covington
LOUISIANA
MISSISSIPPI
Mandeville
Bay St. Louis
Mississippi Sound
Slidell
Lake Maurepas
Lake Pontchartrain
Donaldsonville
Convent
Garyville
LaPlace
Eastern New Orleans
Kenner
Metairie
New Orleans
Lake Borgne
Mississippi River
Destrehan
Chalmette
Lac des Allemands
Luling
West Bank
Belle Chasse
Chandeleur Sound
Lake Salvador
Morgan City
Raceland
Houma
Larose
Breton Sound
Chauvin
Golden Meadow
Barataria Bay
Gulf of Mexico
Atchafalaya Bay
Mississippi River
Leeville
Grand Isle
Venice
Terrebonne Bay
Plaquemines Delta
5 miles
Gulf of Mexico
DAN SWENSON / THE TIMES-PICAYUNE
Source: Coastal Protection and Restoration Authority
KEY:
Levees
Diversions
Diversion influence areas
Marsh creation
Shoreline protection
Ridge restoration
Barrier island restoration
Conveyance channel


MASTER PLAN FRESHWATER AND SEDIMENT DIVERSION PROJECTS
10
West Maurepas Diversion
55
Lake Pontchartrain
12
Slidell
10
LaPlace
New Orleans
Lake Borgne
Central Wetland Diversion
Bayou Lafourche Diversion
Mississippi River
Upper Breton Diversion
Atchafalaya River
Lake Salvador
Morgan City
Houma
Mid-Breton Diversion
Breton Sound
Mid-Barataria Diversion
Increased Atchafalaya Flow
1
Lower Breton Diversion
Atchafalaya River Diversion
Barataria Bay
Lower Barataria Diversion
Terrebonne Bay
Grand Isle
5 miles
Gulf of Mexico
NOLA.com | The Times-Picayune



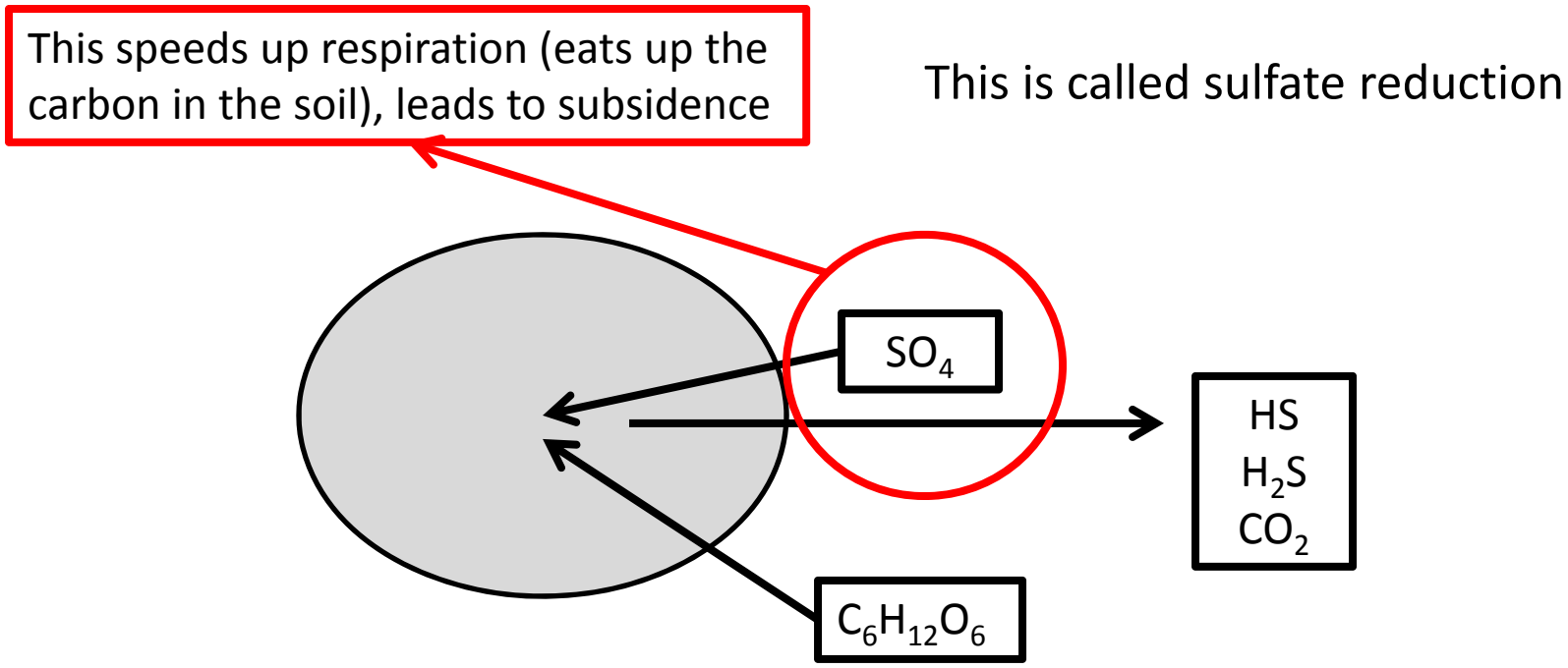
But sediment is only one problem…





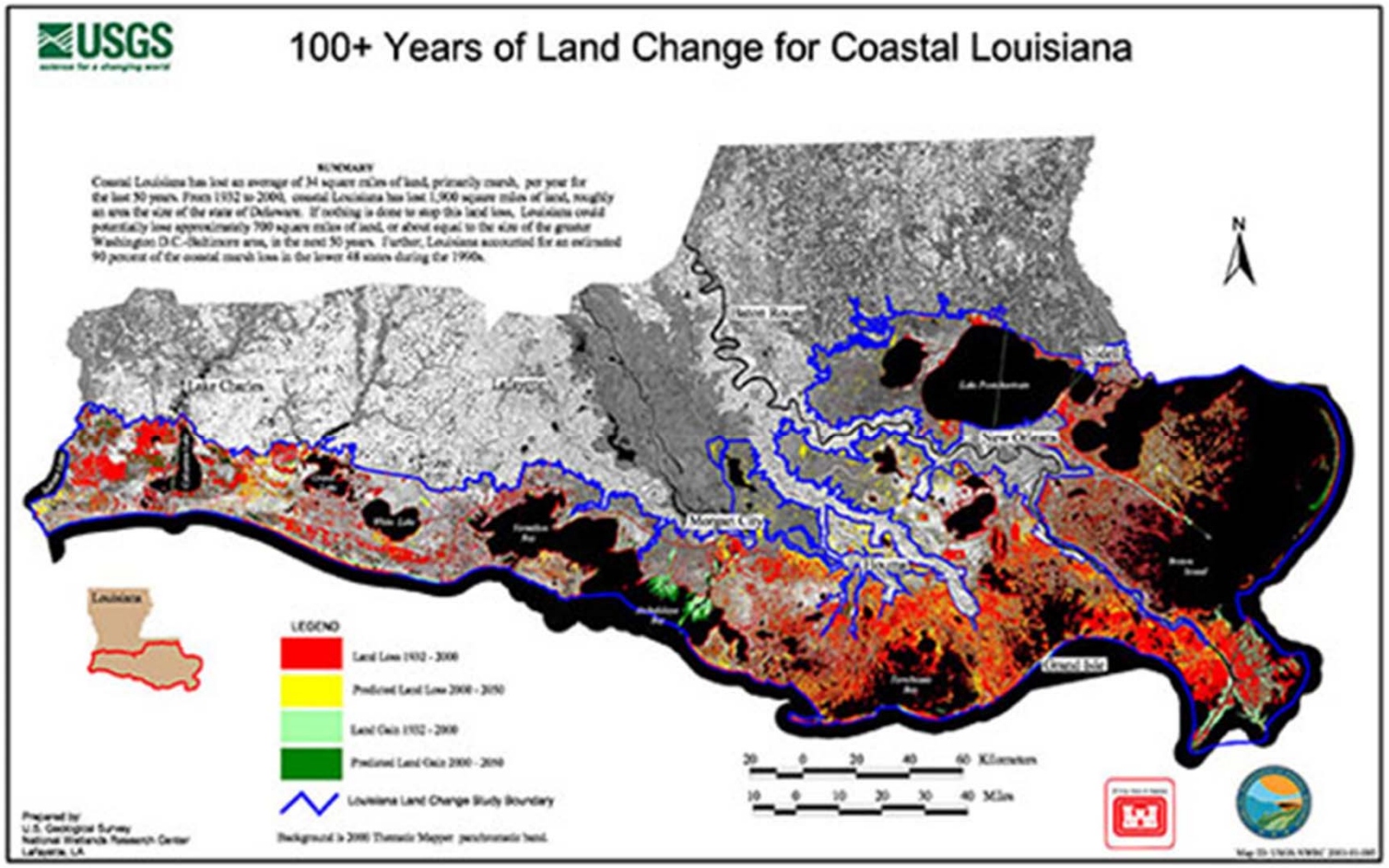
This is where microbes come in as major players…

Think of microbes as little people…

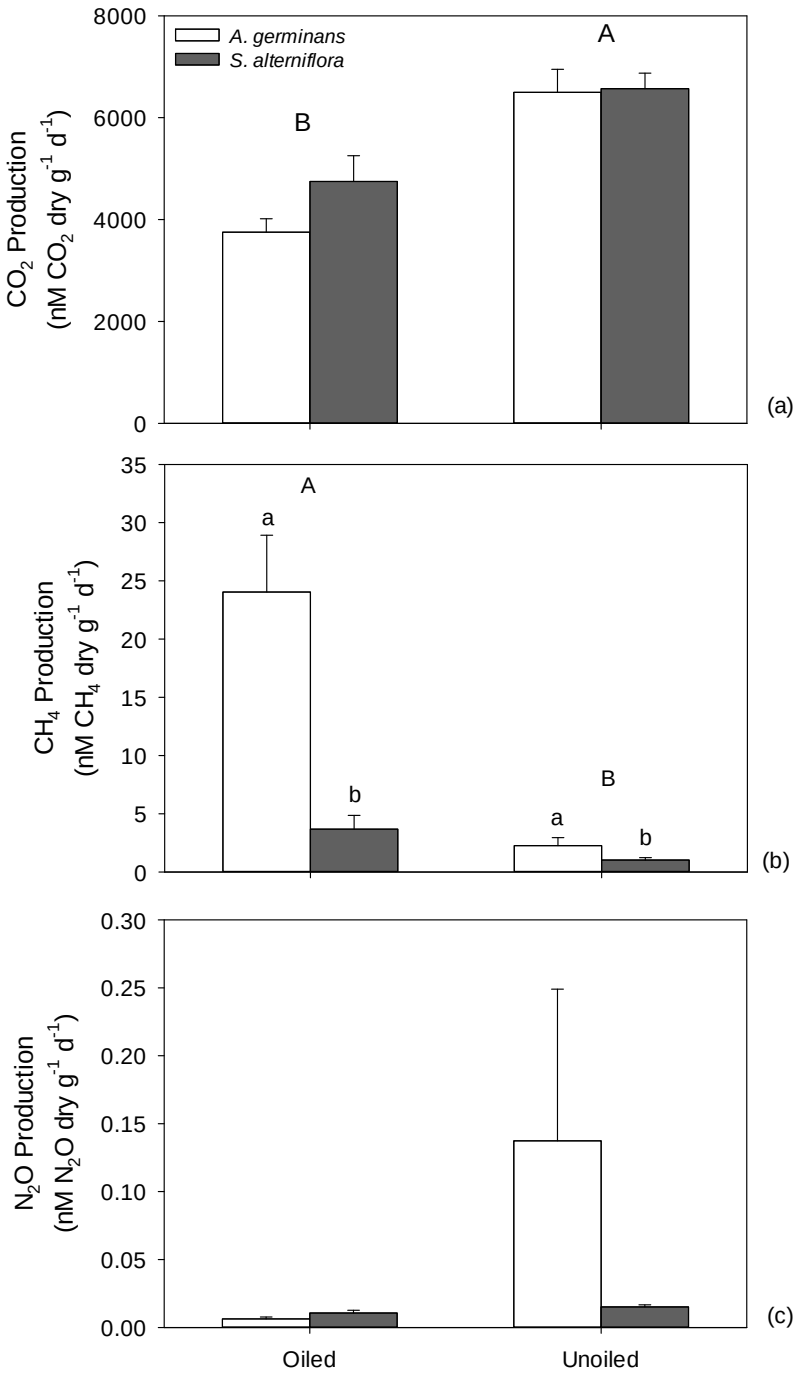


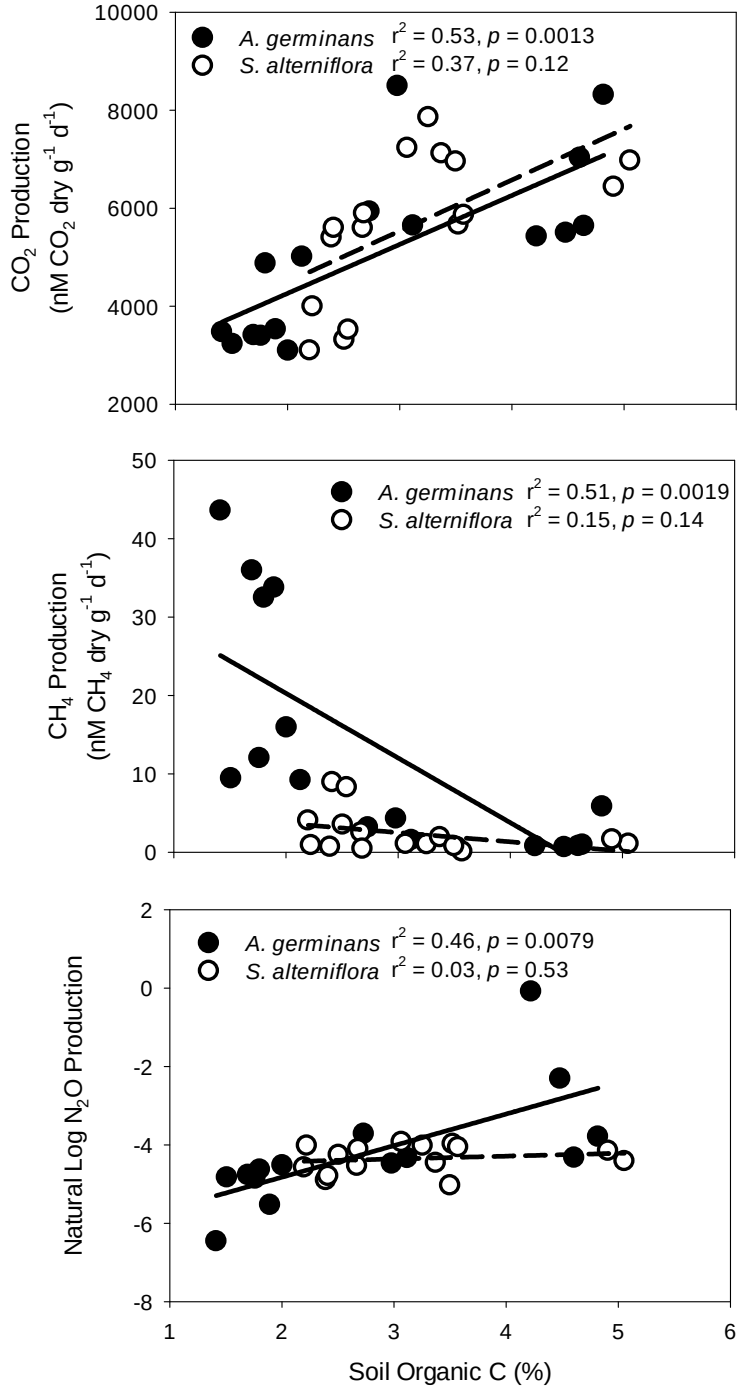
…who need to eat (carbon) and breath (oxygen)

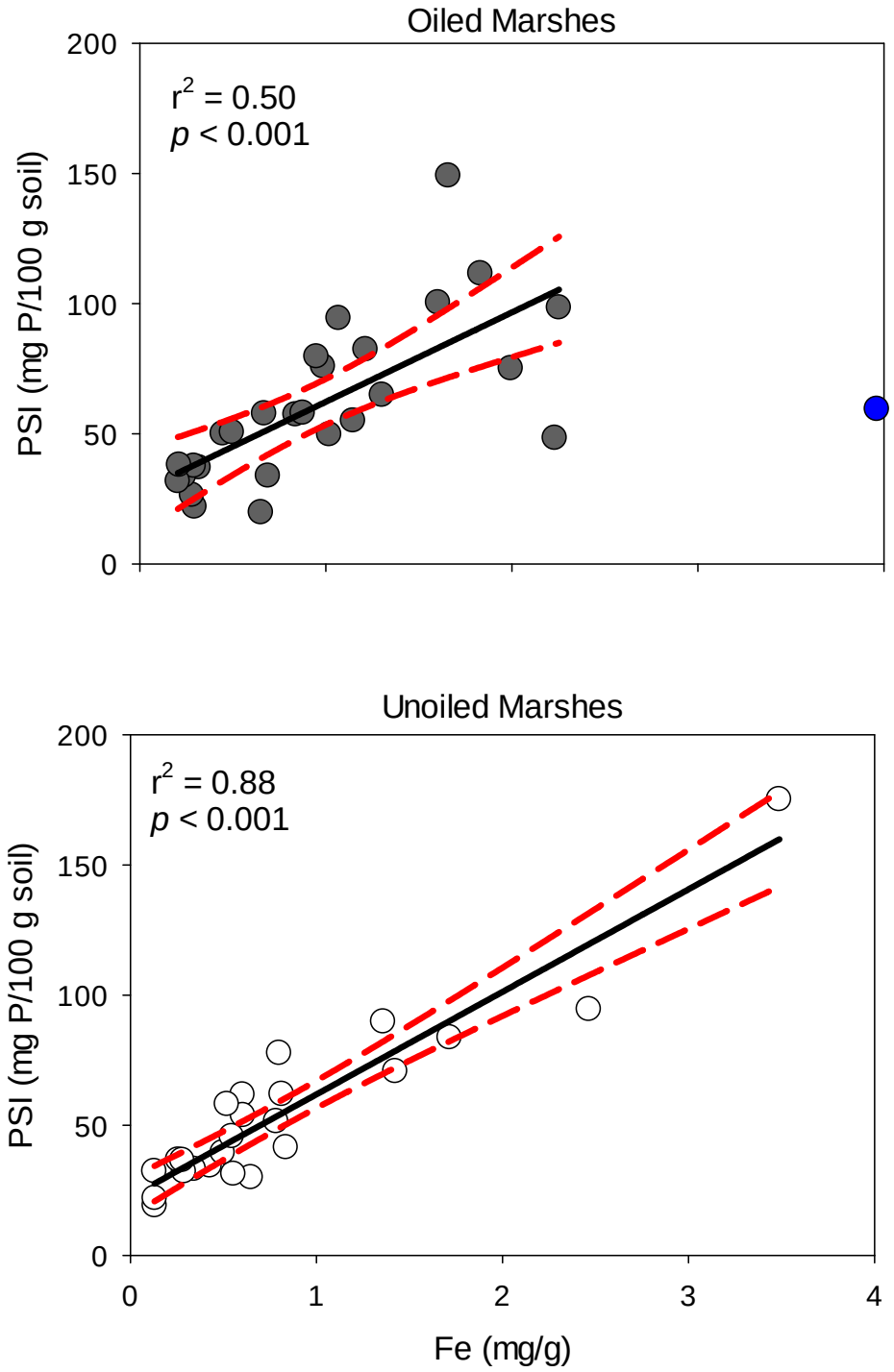
Remember this?


USGS
science for a changing world
100+ Years of Land Change for Coastal Louisiana
SUMMARY
Coastal Louisiana has lost an average of 34 square miles of land, primarily marsh, per year for the last 50 years. From 1932 to 2000, coastal Louisiana has lost 1,900 square miles of land, roughly an area the size of the state of Delaware. If nothing is done to stop this land loss, Louisiana could potentially lose approximately 700 square miles of land, or about equal to the size of the greater Washington D.C.-Baltimore area, in the next 50 years. Further, Louisiana accounted for an estimated 90 percent of the coastal marsh loss in the lower 48 states during the 1990s.
N
Lake Charles
Lafayette
Baton Rouge
Houma
New Orleans
Morgan City
Louisiana
LEGEND
Land Loss 1932 - 2000
Predicted Land Loss 2000 - 2050
Land Gain 1932 - 2000
Predicted Land Gain 2000 - 2050
Louisiana Land Change Study Boundary
20 0 20 40 60 Kilometers
10 0 10 20 30 40 Miles
Prepared by:
U.S. Geological Survey
National Wetlands Research Center
Lafayette, LA

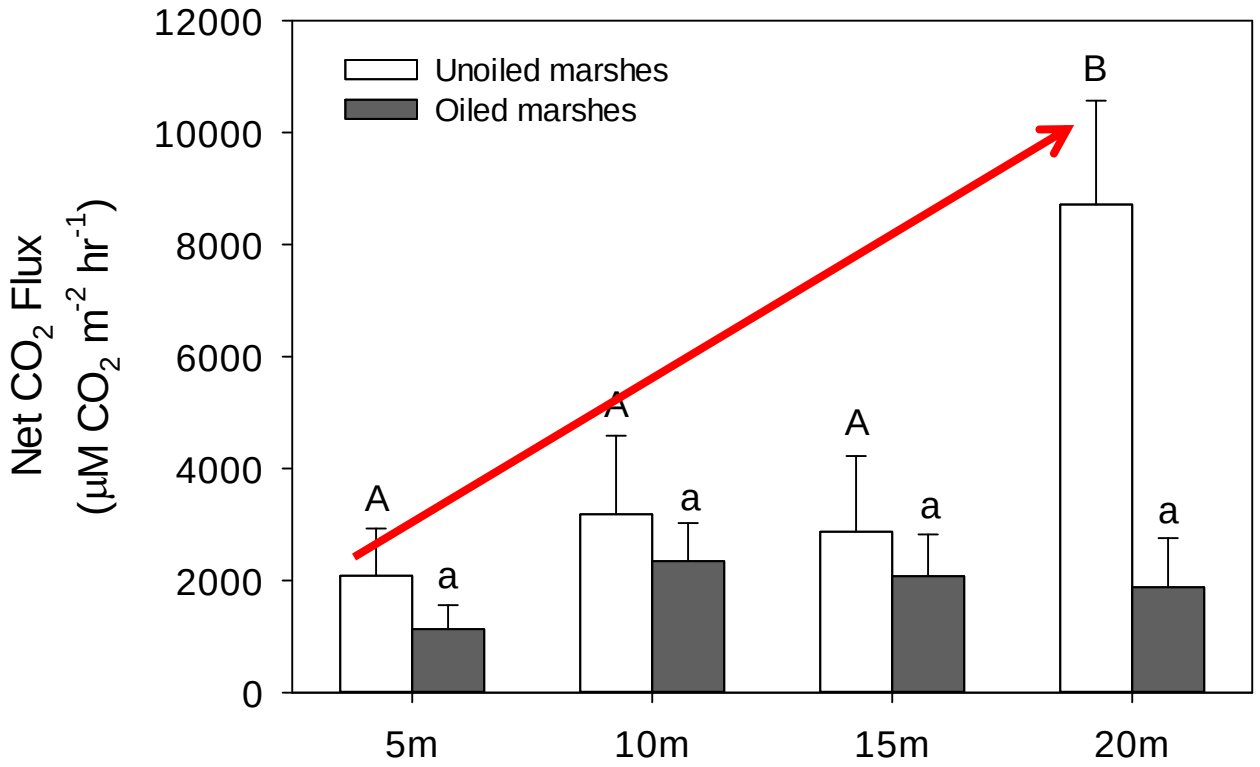
Wasn’t there an oil spill?


A. germinans
S. alterniflora
CO2 Production (nM CO2 dry g-1 d-1)
8000
6000
4000
2000
0
B
A
(a)
CH4 Production (nM CH4 dry g-1 d-1)
35
30
25
20
15
10
5
0
A
a
b
B
a
b
(b)
N2O Production (nM N2O dry g-1 d-1)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
(c)
Oiled
Unoiled


A. germinans r2 = 0.53, p = 0.0013
S. alterniflora r2 = 0.37, p = 0.12
CO2 Production (nM CO2 dry g-1 d-1)
10000
8000
6000
4000
2000
A. germinans r2 = 0.51, p = 0.0019
S. alterniflora r2 = 0.15, p = 0.14
CH4 Production (nM CH4 dry g-1 d-1)
50
40
30
20
10
0
A. germinans r2 = 0.46, p = 0.0079
S. alterniflora r2 = 0.03, p = 0.53
Natural Log N2O Production
2
0
-2
-4
-6
-8
1
2
3
4
5
6
Soil Organic C (%)

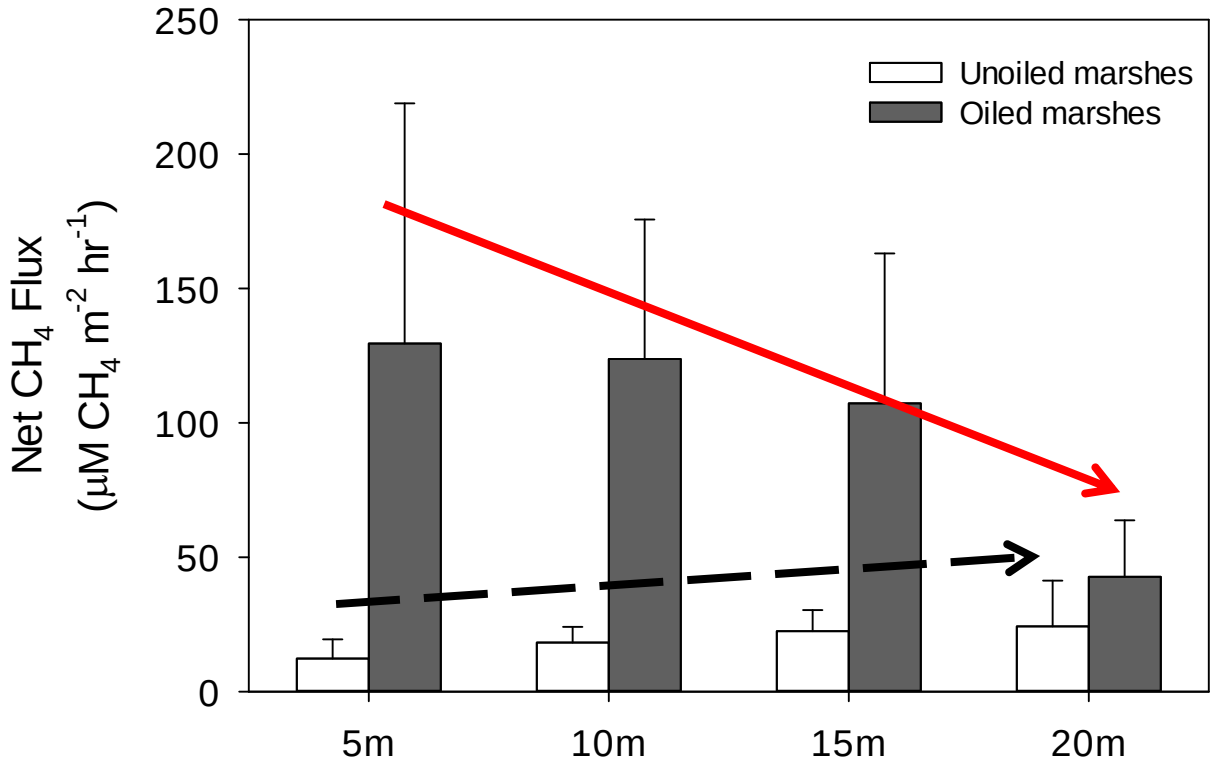

Oiled Marshes
r2 = 0.50
p < 0.001
PSI (mg P/100 g soil)
200
150
100
50
0
Unoiled Marshes
r2 = 0.88
p < 0.001
PSI (mg P/100 g soil)
200
150
100
50
0
0
1
2
3
4
Fe (mg/g)

Results?
Greenhouse Gas Fluxes



Spatial pattern only present in unoiled marshes

Results?
Greenhouse Gas Fluxes



Spatial patterns differ between oiled and unoiled marshes


Questions?