Sustainable Management of Deltas in a Climate-Challenged, Energy-Scarce World

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Conceptual Framework

Sustainable Management
Should be Based on
System Functioning

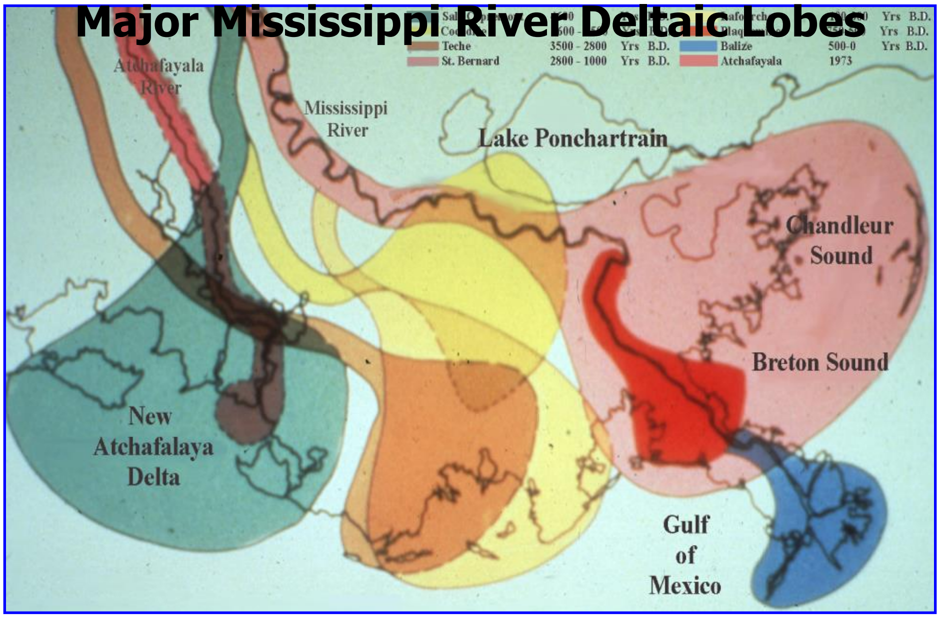
Must be Aware of Fundamental Biophysical Constraints:

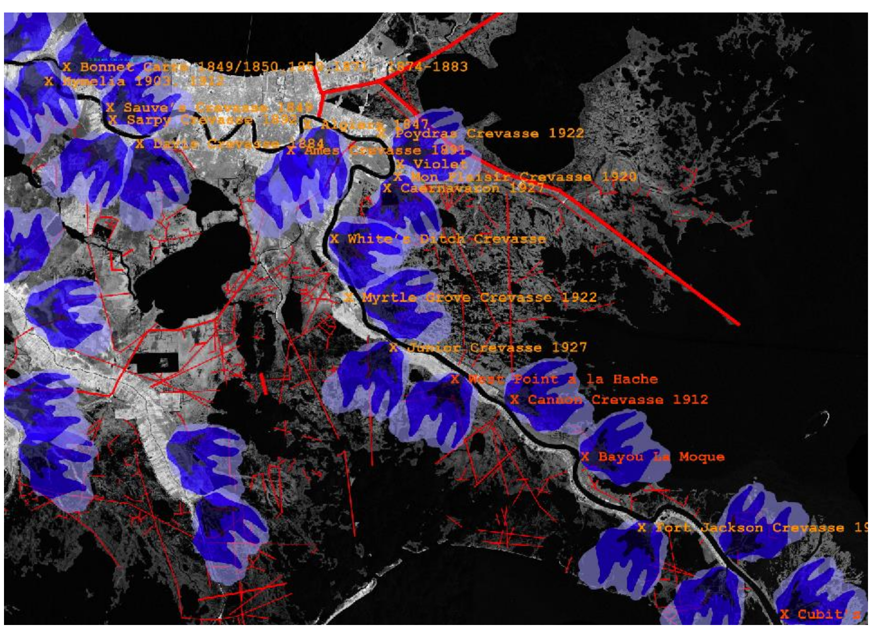
- Laws of Thermodynamics – govern flows of energy and materials into and out of human systems
- All systems at all scales are embedded within Earth systems – Boundaries are important
- Absolute constraints are imposed at global scale
- All sustainability ultimately depends on global sustainability

Temporal Scale of pulsing events in deltaic systems

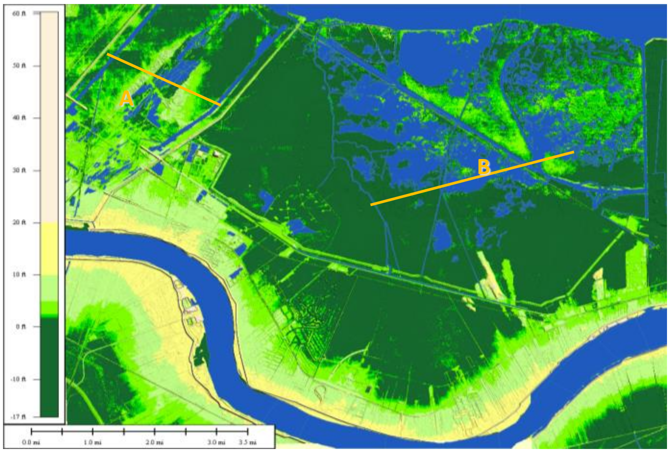
Event	Timescale	Impact
River switching	1,000 yrs	Deltaic lobe formation Net advance of deltaic landmass, Barrier Island Formation
Major river floods	50-100 yrs	Channel switching initiation Crevasse splay formation Major deposition
Major storms	5-20 yrs	Major deposition Enhanced production
Average river floods	Annual	Freshening (lower salinity) Nutrient input Enhanced 1º and 2º production
Normal storm events (Fronts)	Weekly	Enhanced production Organism transport Net material transport
Tides	Daily	Drainage/marsh production Low net transport

Day et al. 1995, 2007



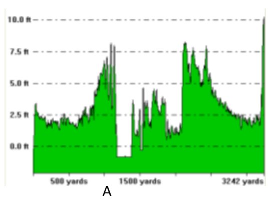


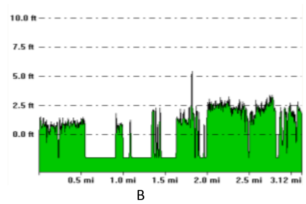
There were hundreds of crevasses along the lower Mississippi River since 1700. A number occurred in the first part of the 20th century.



Bonnet Carre Floodway
•Accretion 2.8 cm/yr
•Bulk density 1.0

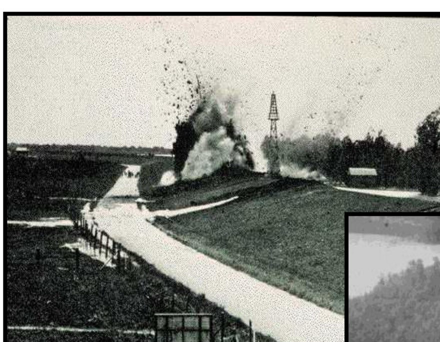
LaBranche Wetlands
•Accretion 0.38 cm/yr
•Bulk density 0.2-0.3





Hundreds of Natural Crevasses since 1700s

Bonnet Carre Spillway LaBranche Wetlands

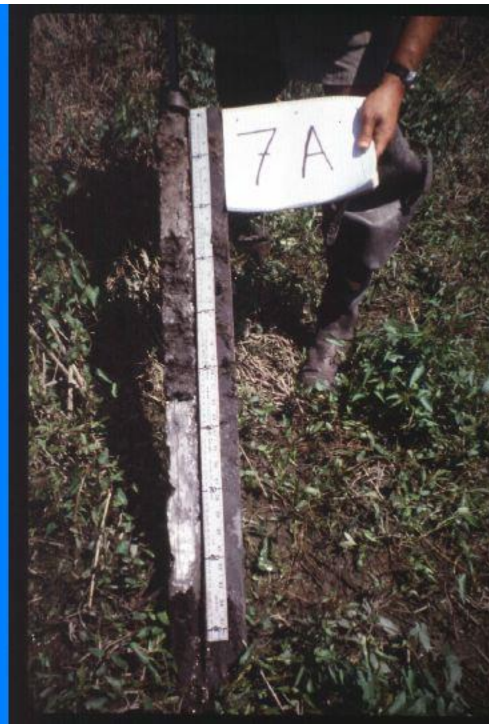


Caernarvon 1927

Sediment Deposition During

The 1927 Crevasse

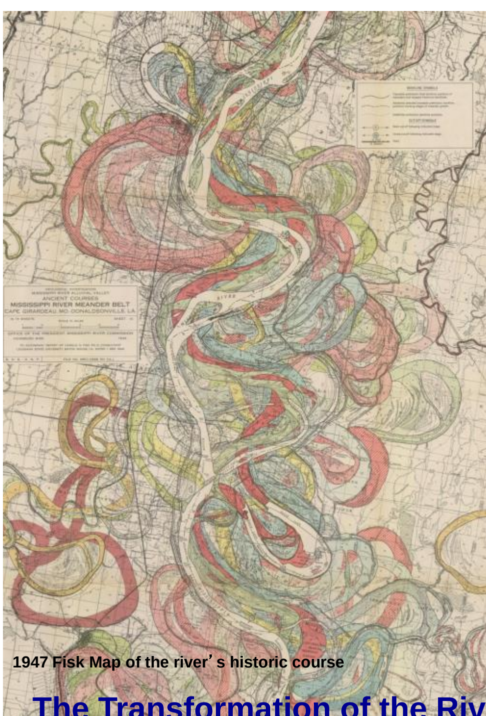
Flow Up To 10,000 m³/sec



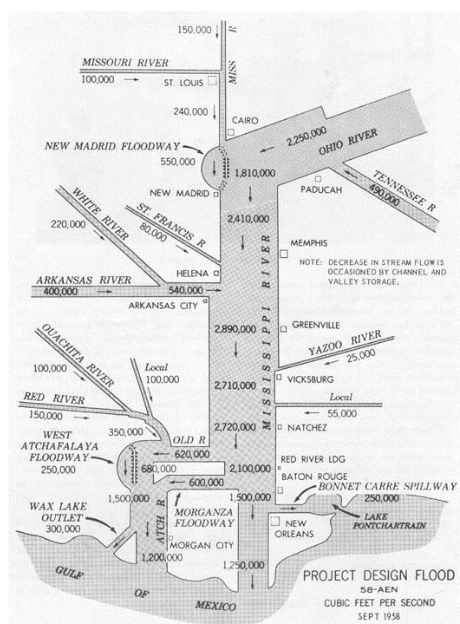
30 cm in 3 months in 1927

55 cm from 1927 to 2002

Also high sediment Input to Atchafalaya delta



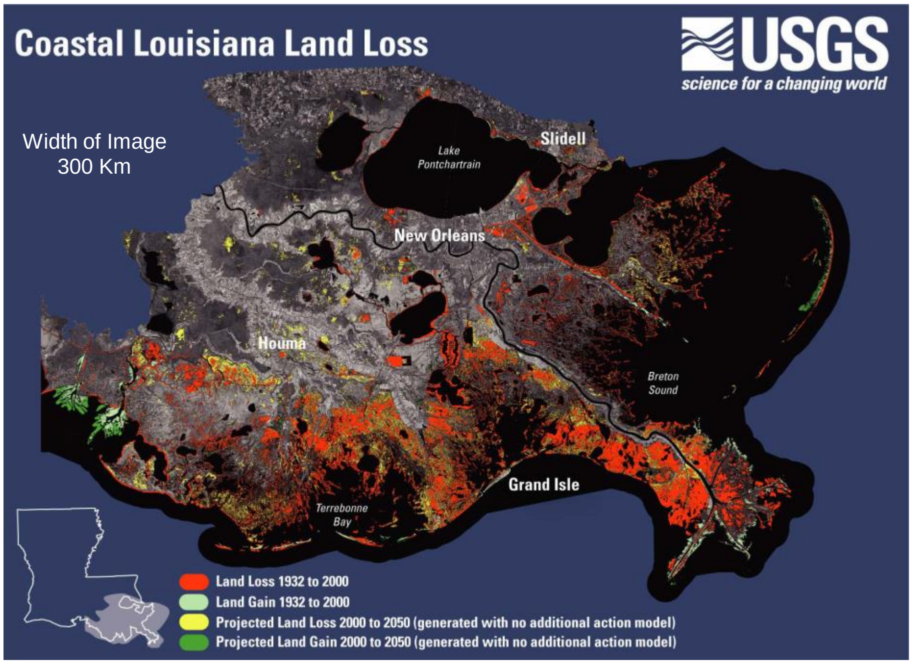
1947 Fisk Map of the river's historic course



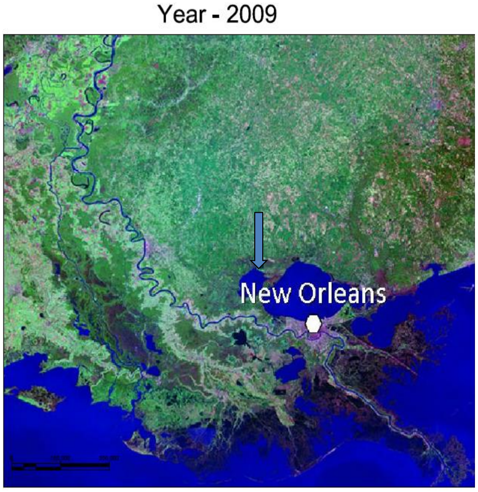
1958 River Flood Capacity Diagram

Highly Expensive and Energy Intensive

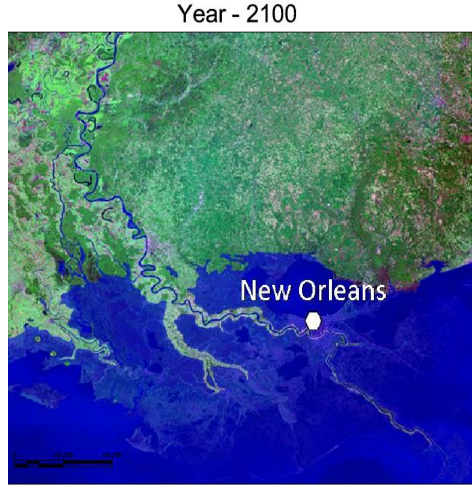
The Transformation of the River: From Flux to Control



Year - 2009

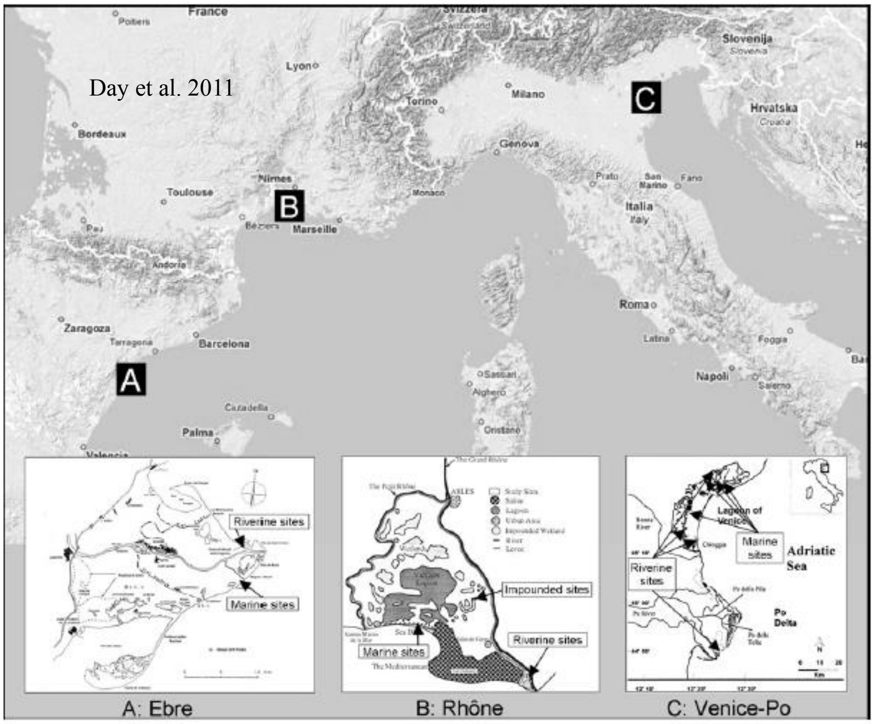


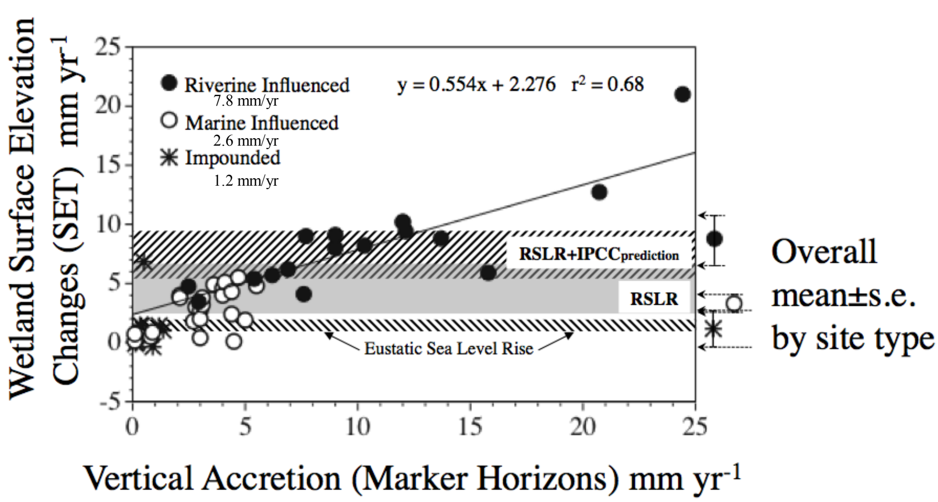
Year - 2100



Map: Blum, M.D., and H.H. Roberts (2009), Drowning of the Mississippi delta due tc insufficient sediment supply and global sea-level rise, *Nat. Geosci.*, 2, 488-491.

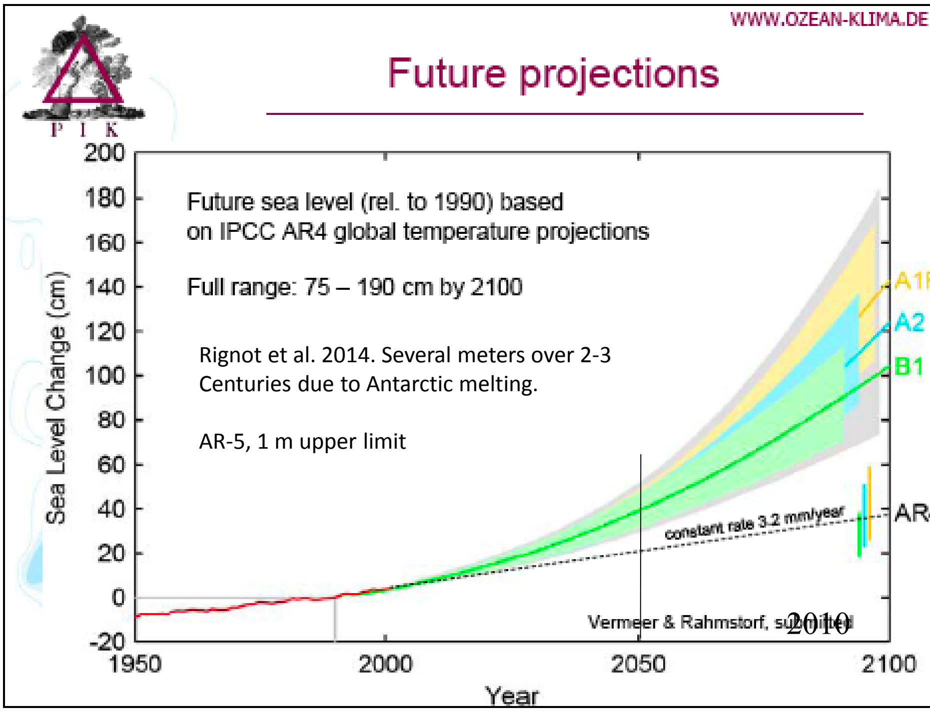
The Transformation of the River: The Future



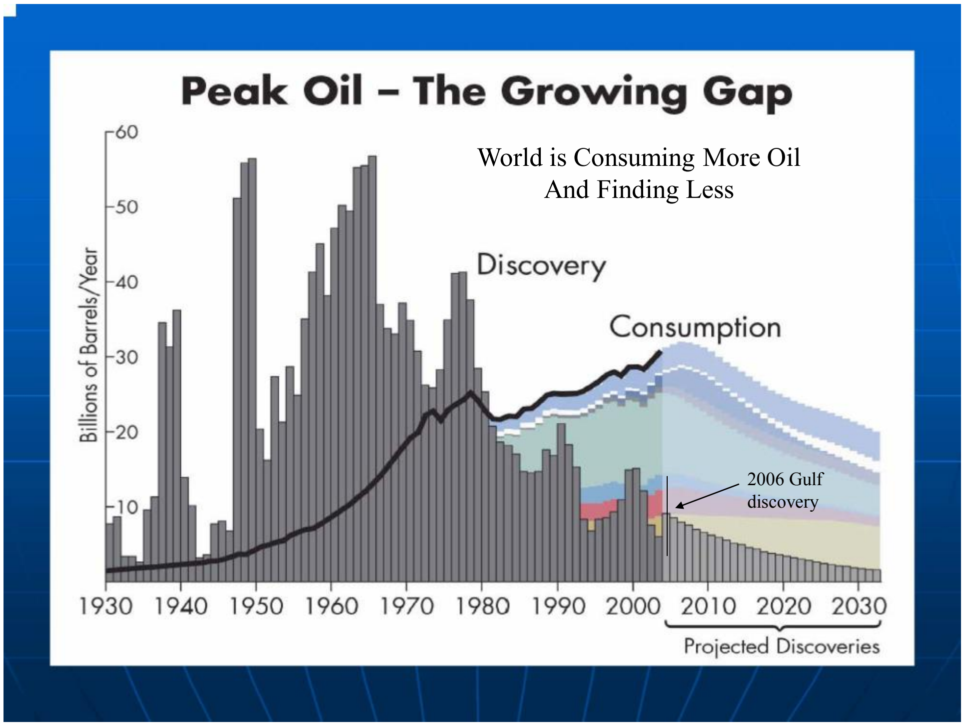


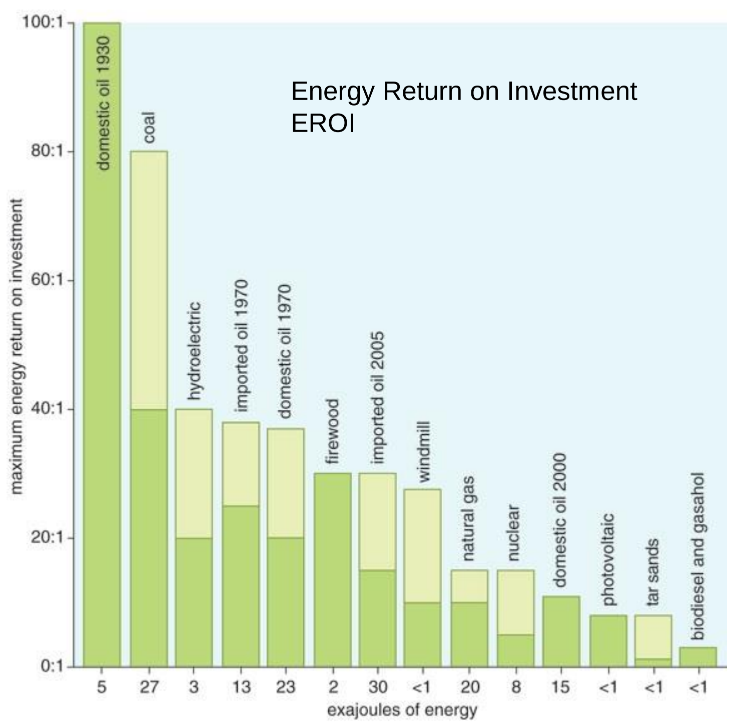
Only Areas with Riverine Input Will Survive Projected Sea-Level Rise

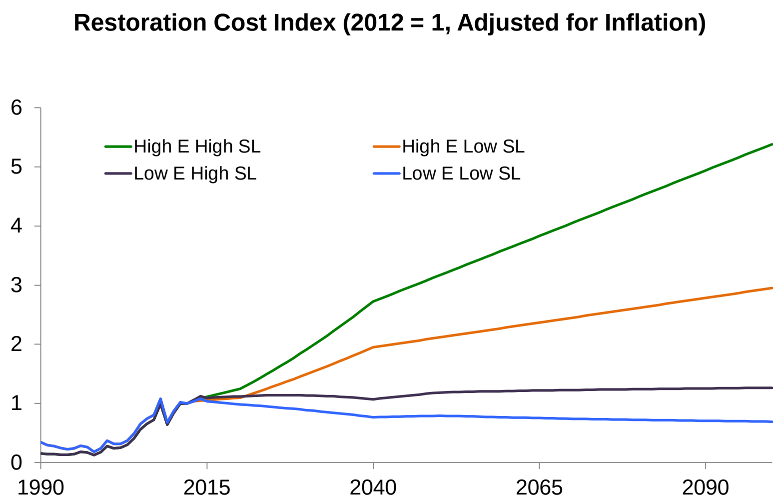
Day et al. 2011. Estuaries and Coasts



5 meters
Sea Level Rise


Peak Oil – The Growing Gap
World is Consuming More Oil
And Finding Less
Discovery
Consumption
2006 Gulf
discovery
Billions of Barrels/Year
60
50
40
30
20
10
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030
Projected Discoveries


Energy Return on Investment
EROI
maximum energy return on investment
100:1
80:1
60:1
40:1
20:1
0:1
domestic oil 1930
coal
hydroelectric
imported oil 1970
domestic oil 1970
firewood
imported oil 2005
windmill
natural gas
nuclear
domestic oil 2000
photovoltaic
tar sands
biodiesel and gasahol
5
27
3
13
23
2
30
<1
20
8
15
<1
<1
<1
exajoules of energy



Value of Ecosystem Services of the Mississippi Delta
Is Estimated at $12 to 47 Billion Dollars Annually

- $20 billion less with BAU
- $20 billion more with restoration

Value of the Natural Capital of the Delta is
$330 Billion to $1.4 Trillion

Batker et al. 2014

Problems with NeoClassical Economics (Question Current Conceptual Frameworks)

- Define economy independent of biophysical matrix
- Describe economic production independent of physical work
- Not consistent with laws of thermodynamics
- Not consistent with principles of ecology- continued growth (exponential vs logistic growth), lack of absolute scarcity (law of the minimum, limiting nutrients), infinite substitutability (Redfield ratio)
- Treat humans as rational

Hall and Klitgaard, 2011, Energy and the Wealth of Nations

Coastal Areas Below Sea Level

- Netherlands
- Mississippi Delta (New Orleans)
- Rhone Delta
- Po Delta (up to 5 m below MSL)
- Ebro Delta
- Sacramento Delta
- Fens
- Ganges Delta
- Vistula Delta
- Bangkok

Human Impact on Deltas

- Deltas developed with a relative stable sea level
- Deltas developed with a relatively predicable riverine inputs (water, sediments, nutrients)
- Deltas developed without engineered changes
- Human activity has changed all of this

Summary

- Climate Change Will Impact the Landscape Unevenly. Large Areas Will be Worse Off
- Energy Scarcity Will Limit Options for the Economy and Environmental Management
- Ecosystem Services Will Become Relatively More Important to the Human Economy
- Delta Restoration Will Have to Take Place on a Much Greater Scale. Climate Change Will Make Restoration More Difficult and Energy Scarcity Will Limit Options
- Work with Delta Dynamics as Much as Possible

Indices of Deltaic Sustainability

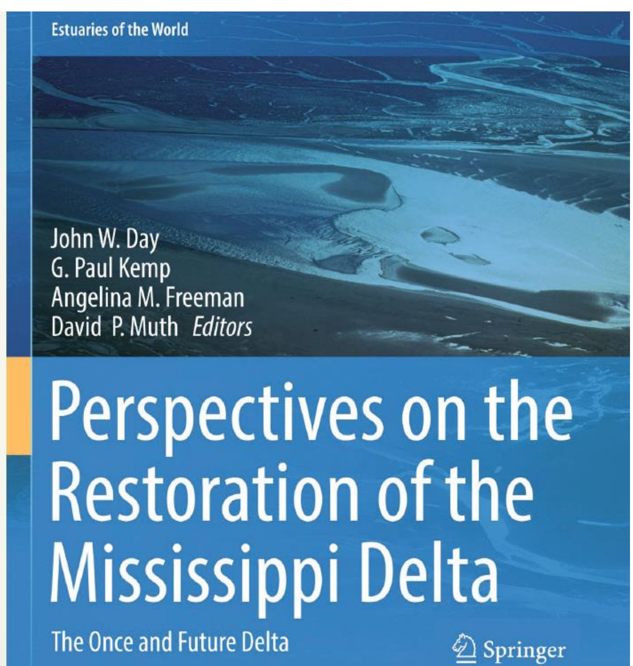
- Geomorphic Sustainability
  - Elevation Change $\geq$ RSLR
  - Total Area Change ≥ 0
- Ecological Sustainability
  - NPP ≥ 0
- Economic Sustainability
  - Economic Value Generated by Delta $\geq$ Economic Subsidies
  - Change in Value of Ecosystem Services ≥ 0
- Resource Sustainability
  - Resources needed (freshwater, sediments) available
  - Minimal long-term dependence on fossil fuels

Book

194 Pages

In depth, multi-disciplinary consideration of specific issues faced by one of the planet's great ecological systems with a legacy of mismanagement and an uncertain future

Audience: University Faculty, Students, High-Level Policy-Makers



RESTORE THE MISSISSIPPI RIVER DELTA

In Times of Extraordinary
Actuality, Consciousness Replaces Imagination

Wallace Stevens

The Weight of This Sad Time We Must Obey;
Speak What We Feel,
Not What We Ought to Say

Shakespeare, King Lear