Indices of Deltaic Sustainability Biophysical and Human Constraints and Opportunities

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Conceptual Framework

Indices of Deltaic Sustainability Should Reflect System Functioning From Both Biophysical and Human Standpoints

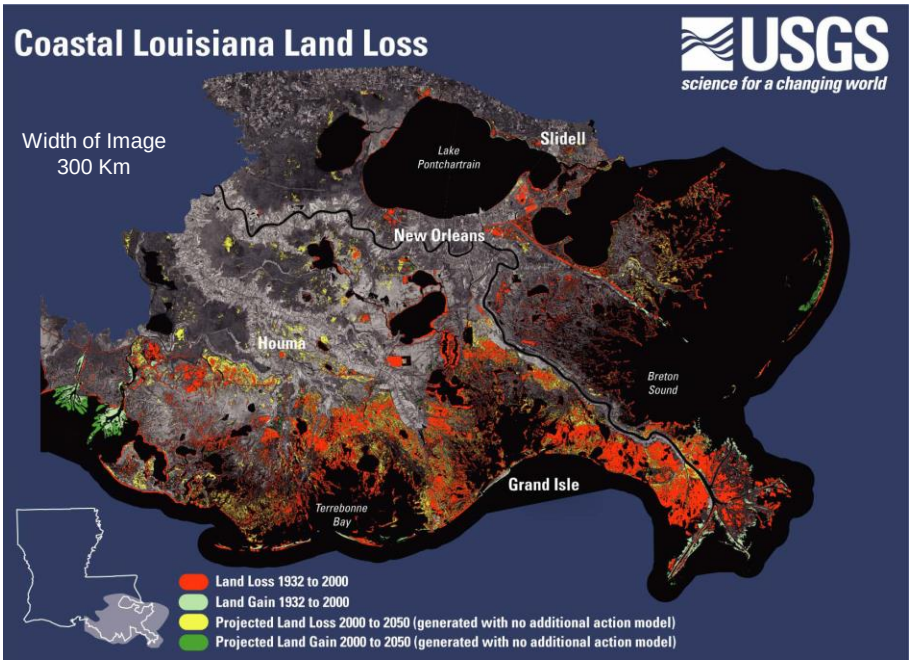
Indices of Deltaic Sustainability

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

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

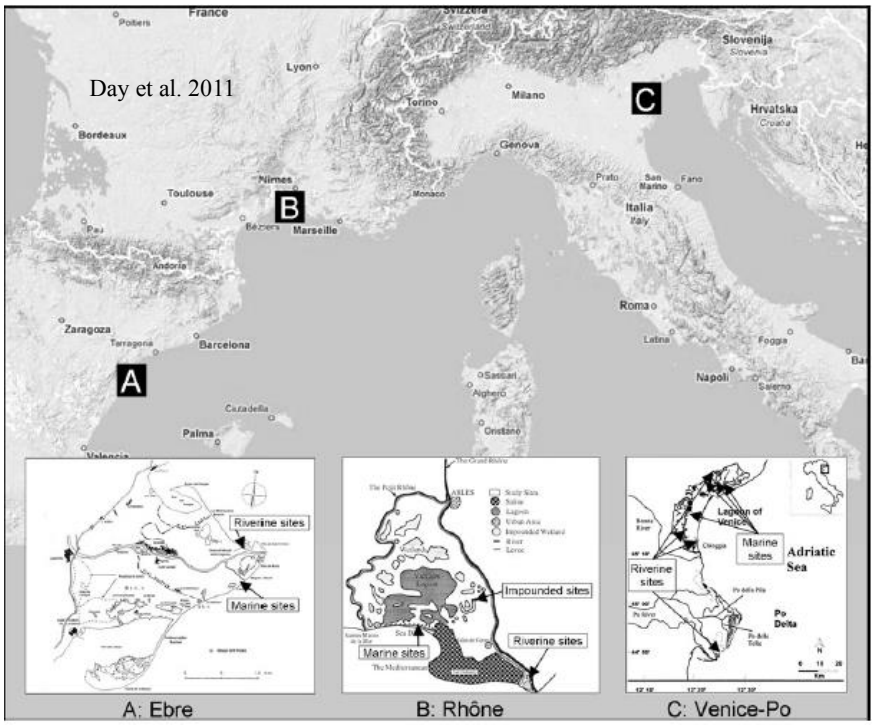


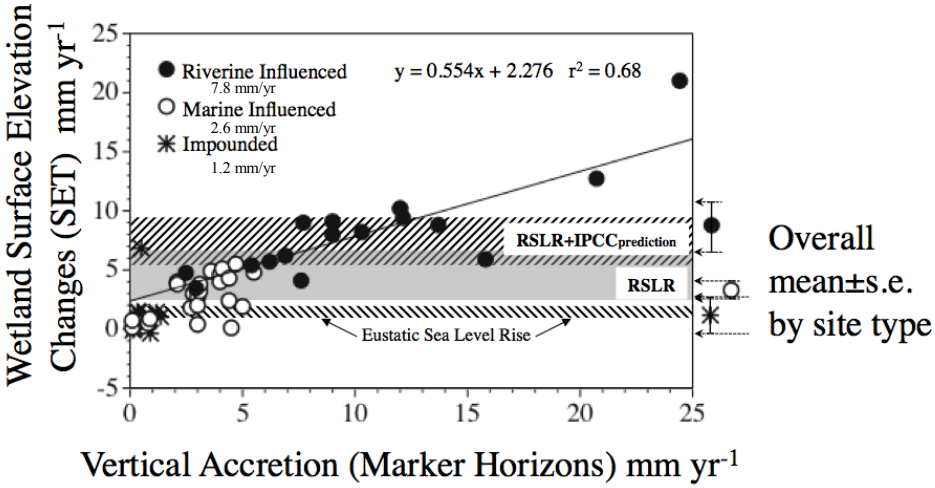
Year - 2009

Year - 2100

Map: Blum, M.D., and H.H. Roberts (2009), Drowning of the Mississippi delta due to 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

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

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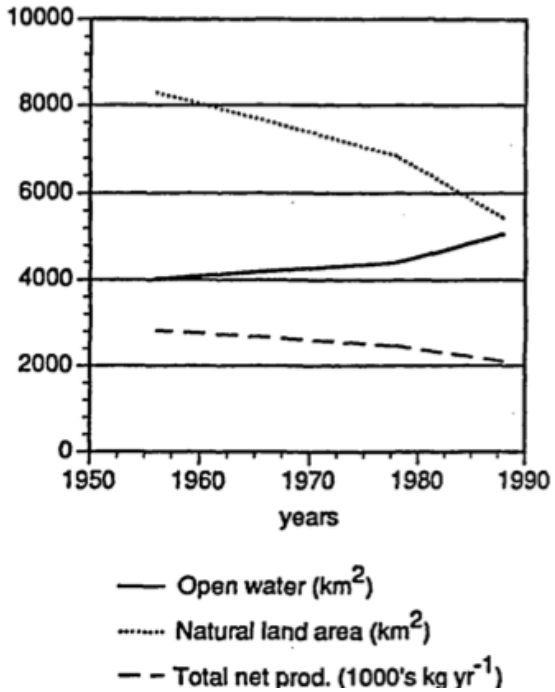

Change in Total
Net Primary Production
In the Mississippi Delta

Day et al. 1997

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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

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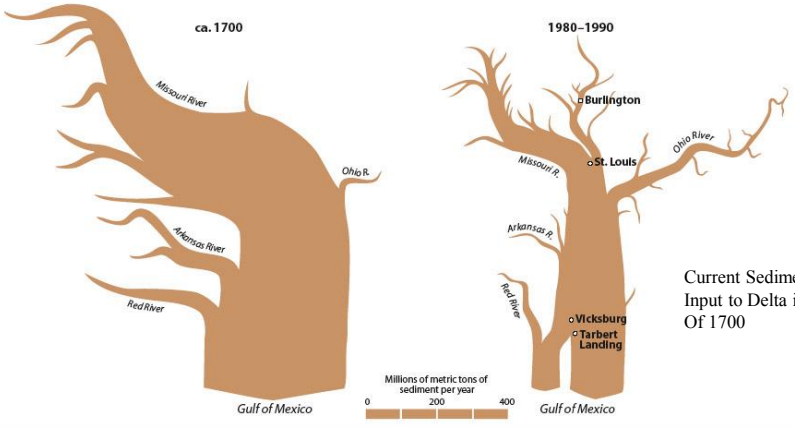
The sediment loads carried by the Mississippi River to the Gulf of Mexico have decreased by half since 1700, so less sediment is available to build up the Delta and counteract subsidence and sea level rise. The greatest decrease occurred after 1950, when large reservoirs constructed trapped most of the sediment entering them. Part of the water and sediment from the Mississippi River below Vicksburg is now diverted through the Corps of Engineers' Old River Outflow Channel and the Atchafalaya River. Without the controlling works, the Mississippi would have shifted most of its water and sediment from its present course to the Atchafalaya, as part of the natural delta switching process. The widths of the rivers in the diagram are proportional to the estimated (1700) or measured (1980–1990) suspended sediment loads (in millions of metric tons per year). (Meade, 1995 U.S. Geological Survey Millions of metric tons of Circular 1133, fig. 6A)



Current Sediment Input to Delta is 15% Of 1700

The Colorado River Basin in the U.S. and Mexico

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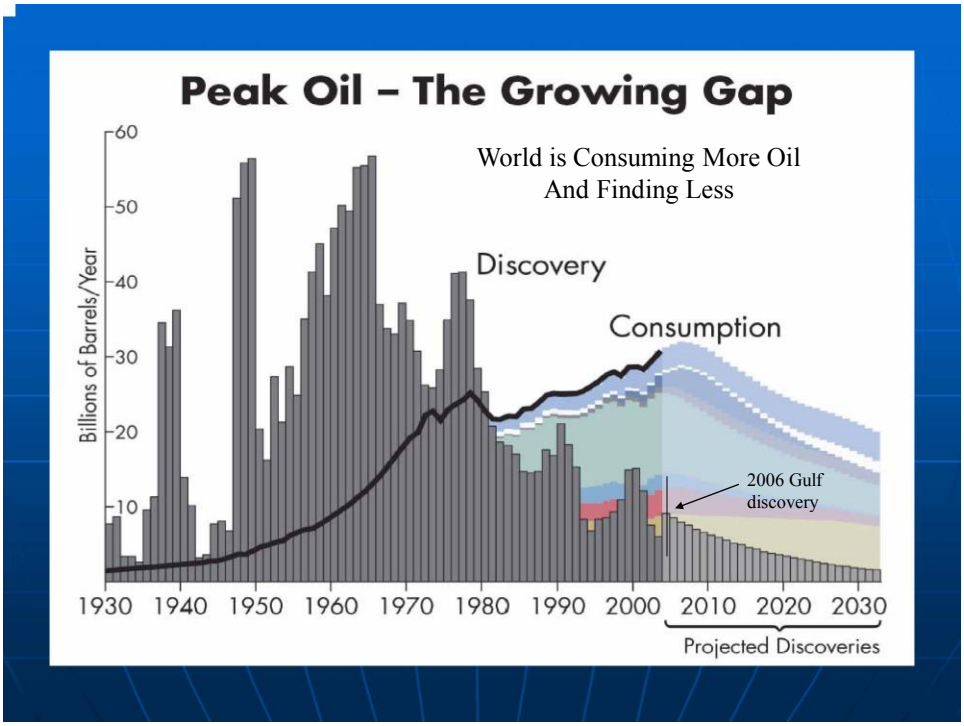
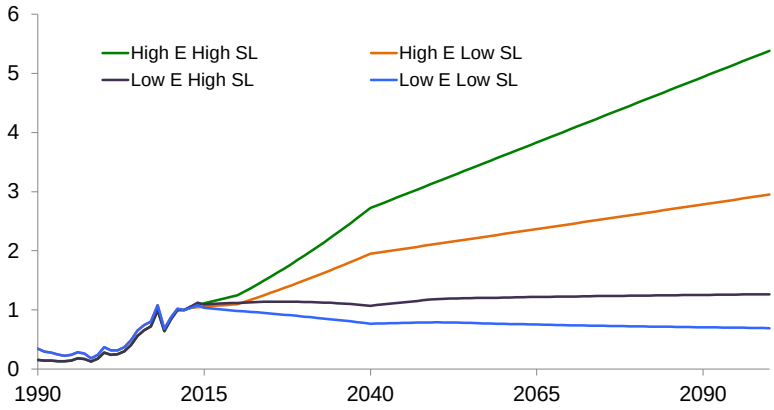
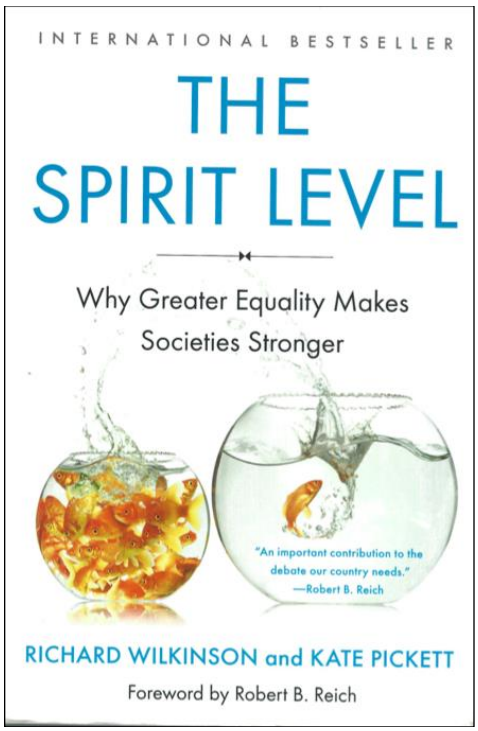
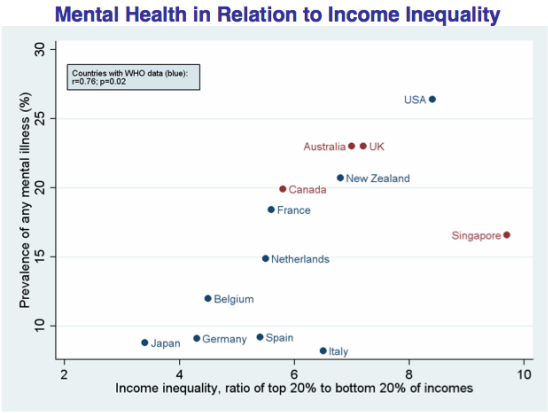


Restoration Cost Index (2012 = 1, Adjusted for Inflation)







Developed from: Pickett KE, James O, Wilkinson RG. Income inequality and the prevalence of mental illness: a preliminary international analysis. *Journal of Epidemiology and Community Health* 2006; 60: 646-7.

Summary

- Need to understand how future trends will impact delta sustainability.
- Need to understand what future trends society can adapt to and which not.
- 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