Delta Decadal Initiative:
A framework for actionable research towards delta sustainability

Efi Foufoula-Georgiou
University of Minnesota

On behalf of an international team of collaborators

Joint Assembly, IAHS, IAPSO, IASPEI
Deltas Symposium
Gothenburg, Sweden
July 24, 2013

The “DELTAS Team”

Deltas: Landforms, Ecosystems and Human Activities 1
Proceedings of HP1, IAHS-IAPSO-IASPEI Assembly, Gothenburg, Sweden, July 2013 (IAHS Publ. 358, 2013).

A vision for a coordinated international effort on delta sustainability

EFI FOUFOULA-GEORGIOU

Department of Civil Engineering and National Center for Earth-surface Dynamics, University of Minnesota, USA
efi@umn.edu

Contributing authors I. Overeem (Univ. of Colorado, USA); Y. Saito (Geological Survey of Japan, Japan); S. Dech and C. Kuenzer (University of Wuerzburg, Germany), S. Goodbred (Vanderbilt University, USA); I. Harrison (Intern. Union for the Conservation of Nature, USA); E. Anthony (Aix-Marseille University, France); E. Brondizio (Indiana University, USA); J. Hutton (United Nations Univ., UK); R. Nicholls, Z. Matthews, J. Dearing, A. Lazar, and A. Baschieri (Univ. of Southampton, UK); A. Newton (Norwegian Inst. for Air Research, Norway); R. Ramachandran (Anna Univ., India); F. Renaud and Z. Sebesvari (United Nations Univ., Germany); C. Vorosmarty and Z. Tessler (City College of New York, USA); S. Costa (University of Vale do Paraíba, Brazil), K. M. Ahmed (Univ. of Dhaka, Bangladesh); M.M. Rahman (Bangladesh Univ. of Engr. and Technology, Bangladesh); G. Lintern (Natural Resources Canada, Canada); P. Van Cappellen and H. Durr (University of Waterloo, Canada), S. Gao (Nanjing Univ. China), M. Marchand and T. Bucx (Deltares, Netherlands); V. L. Nguyen (Vietnam Academy of Science and Technology, Vietnam); M. Goichot (World Wide Fund for Nature – Greater Mekong, Vietnam), and C. Paola, D. Mohrig, and R. Twilley (National Center for Earth surface Dynamics, USA).

Why Deltas?

1. Deltas are home to over half a billion people (occupy only 1% of the world's land)
2. They are home to biodiverse and rich ecosystems, such as mangroves, reedlands and marshes
3. They are economic hotspots, food baskets for many nations, supporting much of the world's fisheries, forest products, and extensive agriculture
4. They are ports of entry supporting significant growing cities and harbors

YET … they are disappearing at an alarming rate

1. Human actions from upstream deplete them from water and sediment : on a global scale >40% of river discharge and 26% of sediment are being intercepted by large reservoirs
2. Local exploration contributes to subsidence, loss of wetlands, and accelerated erosion
3. Sea level rise increases salinity and accelerates land loss
4. Tropical storms and cyclones cause devastating flooding

Places

Times

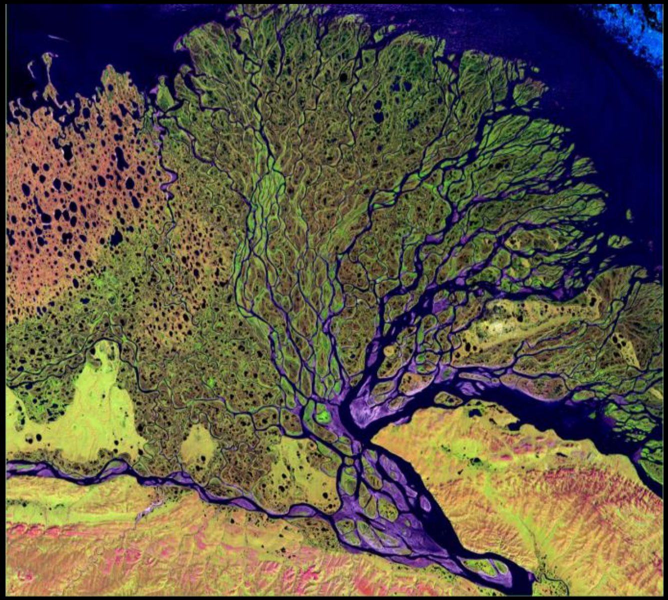
…

2100

Changing
Perspectives

New
challenges

KNOWLEDGE FOR THE FUTURE



Deltas

Foufoula, IAHS, 2013

"There is on the globe one single spot…"

Thomas Jefferson to Robert R. Livingston, Washington,

April 18, 1802

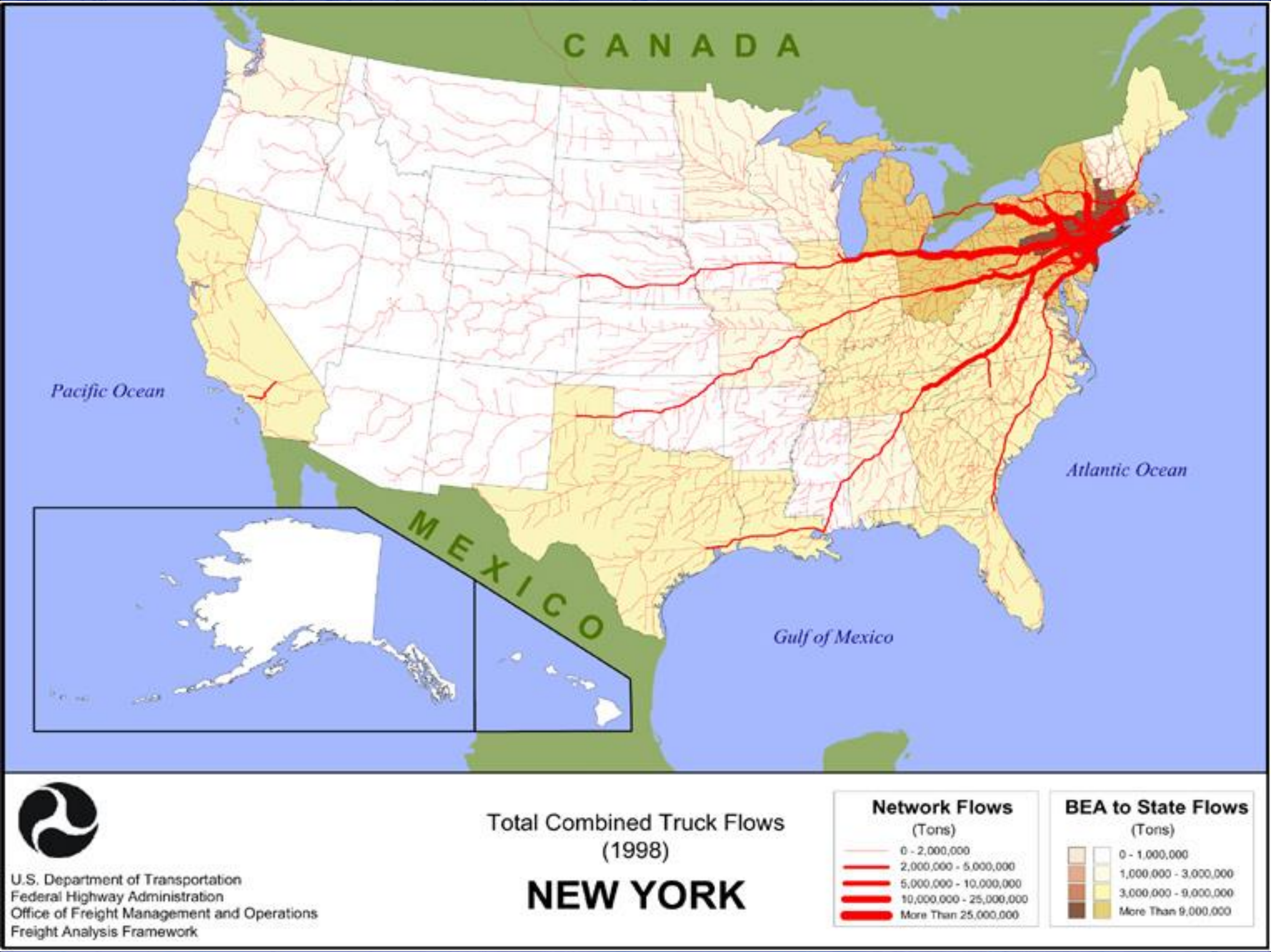
"There is on the globe one single spot , the possessor of which is our natural and habitual enemy."

Thomas Jefferson to Robert R. Livingston,
Washington,
April 18, 1802

The Louisiana Purchase

"It is New Orleans, through which the produce of three-eighths of our territory must pass to market..."

Thomas Jefferson to Robert R. Livingston,
Washington,
April 18, 1802


CANADA
Pacific Ocean
Atlantic Ocean
MEXICO
Gulf of Mexico
Total Combined Truck Flows
(1998)
NEW YORK
U.S. Department of Transportation
Federal Highway Administration
Office of Freight Management and Operations
Freight Analysis Framework
Network Flows
(Tons)
0 - 2,000,000
2,000,000 - 5,000,000
5,000,000 - 10,000,000
10,000,000 - 25,000,000
More Than 25,000,000
BEA to State Flows
(Tons)
0 - 1,000,000
1,000,000 - 3,000,000
3,000,000 - 9,000,000
More Than 9,000,000

U.S. Department of Transportation
Federal Highway Administration
Office of Freight Management and Operations
Freight Analysis Framework

Total Combined Truck Flows
(1998)

LOS ANGELES

Network Flows
(Tons)
- 0 - 2,000,000
- 2,000,000 - 5,000,000
- 5,000,000 - 10,000,000
- 10,000,000 - 25,000,000
- More Than 25,000,000

BEA to State Flows
(Tons)
- 0 - 1,000,000
- 1,000,000 - 3,000,000
- 3,000,000 - 9,000,000
- More Than 9,000,000


CANADA
MEXICO
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
U.S. Department of Transportation
Federal Highway Administration
Office of Freight Management and Operations
Freight Analysis Framework
Total Combined Truck Flows
(1998)
HOUSTON
Network Flows
(Tons)
0 - 2,000,000
2,000,000 - 5,000,000
5,000,000 - 10,000,000
10,000,000 - 25,000,000
More Than 25,000,000
BEA to State Flows
(Tons)
0 - 1,000,000
1,000,000 - 3,000,000
3,000,000 - 9,000,000
More Than 9,000,000

Total Combined Truck Flows
(1998)

NEW ORLEANS

U.S. Department of Transportation
Federal Highway Administration
Office of Freight Management and Operations
Freight Analysis Framework

U.S. Department of Transportation
Federal Highway Administration
Office of Freight Management and Operations
Freight Analysis Framework

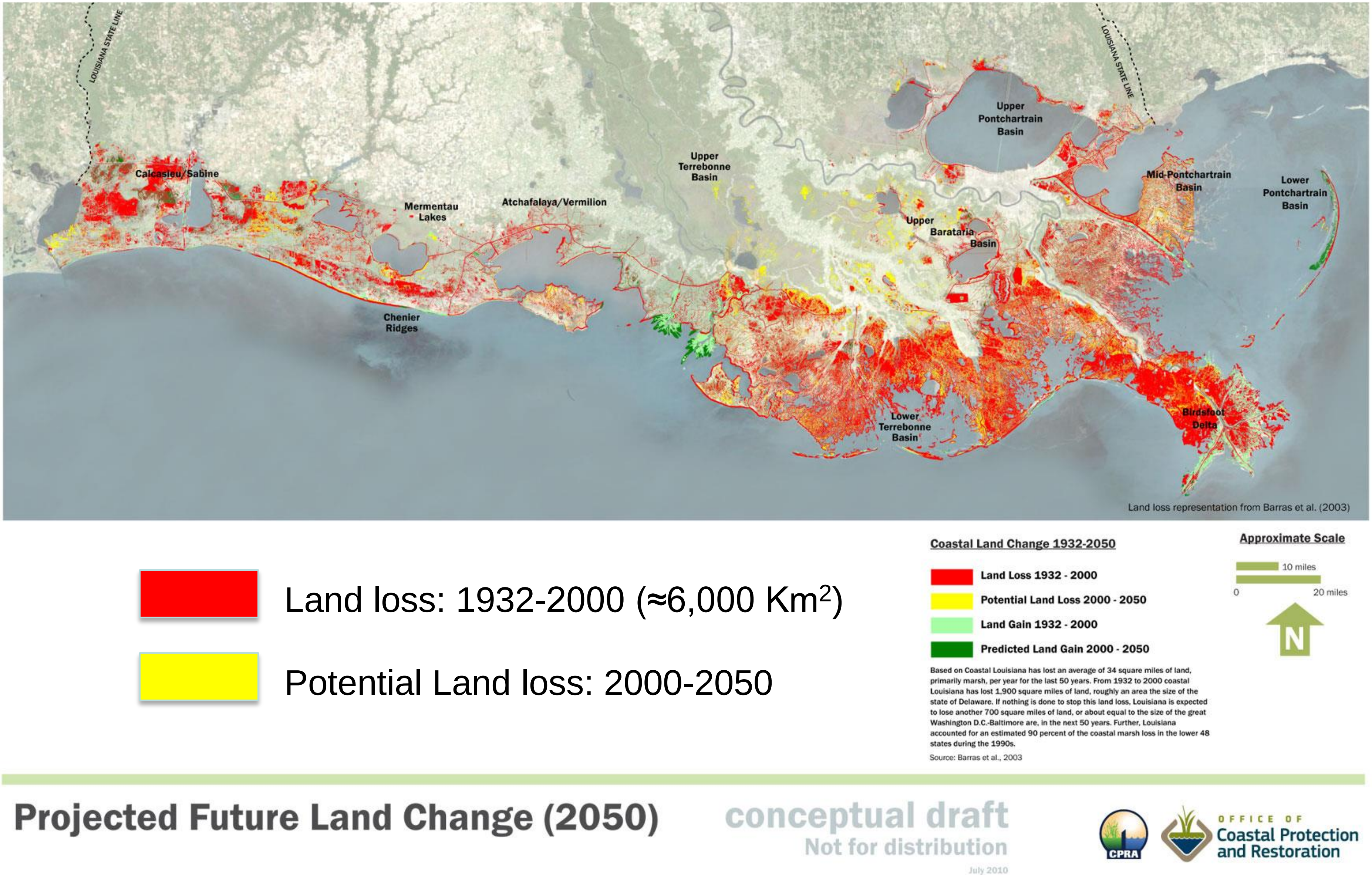
Total Combined Truck Flows
(1998)

LOUISIANA

Network Flows
(Tons)
0 - 500,000
500,000 - 1,000,000
1,000,000 - 10,000,000
10,000,000 - 50,000,000
More Than 50,000,000

State to State Flows
(Tons)
0 - 1,000,000
1,000,000 - 5,000,000
5,000,000 - 10,000,000
More Than 10,000,000

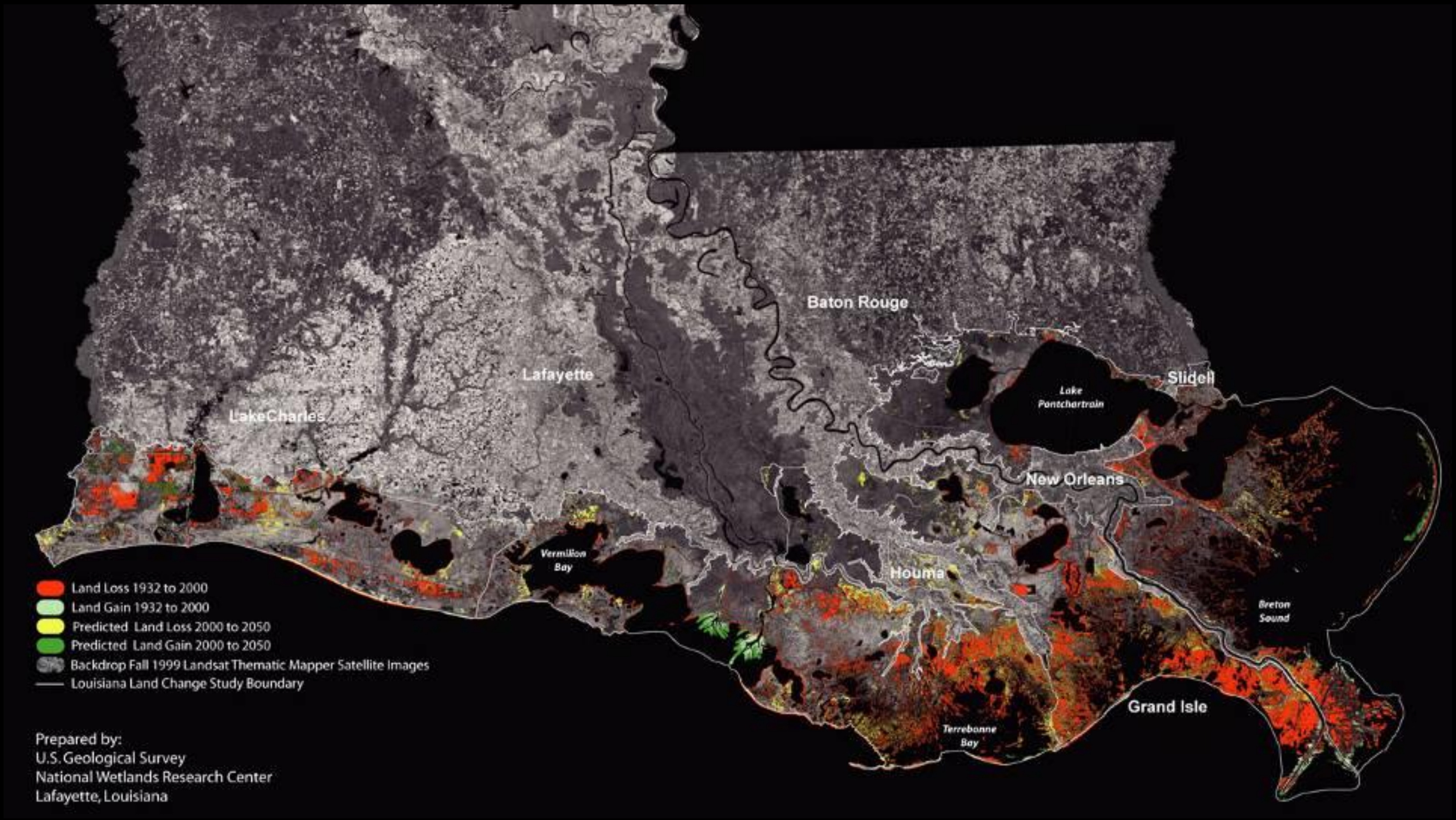
Coastal Louisiana is Facing a Crisis



Land loss: 1932-2000 (≈6,000 Km^2)

Potential Land loss: 2000-2050

The Mississippi River Delta is sinking



Delta Land loss: 1932 - 2000 (≈2,000 Km^2)

2005 Hurricane Katrina Effects

- **Over 1400 Louisianans died**
- **Over 200,000 homes and businesses destroyed, damaged or flooded**
- **1,000,000 displaced citizens**
- **Economic Impact Exceeded $100 billion**
- **State/parish budget/economy devastated**

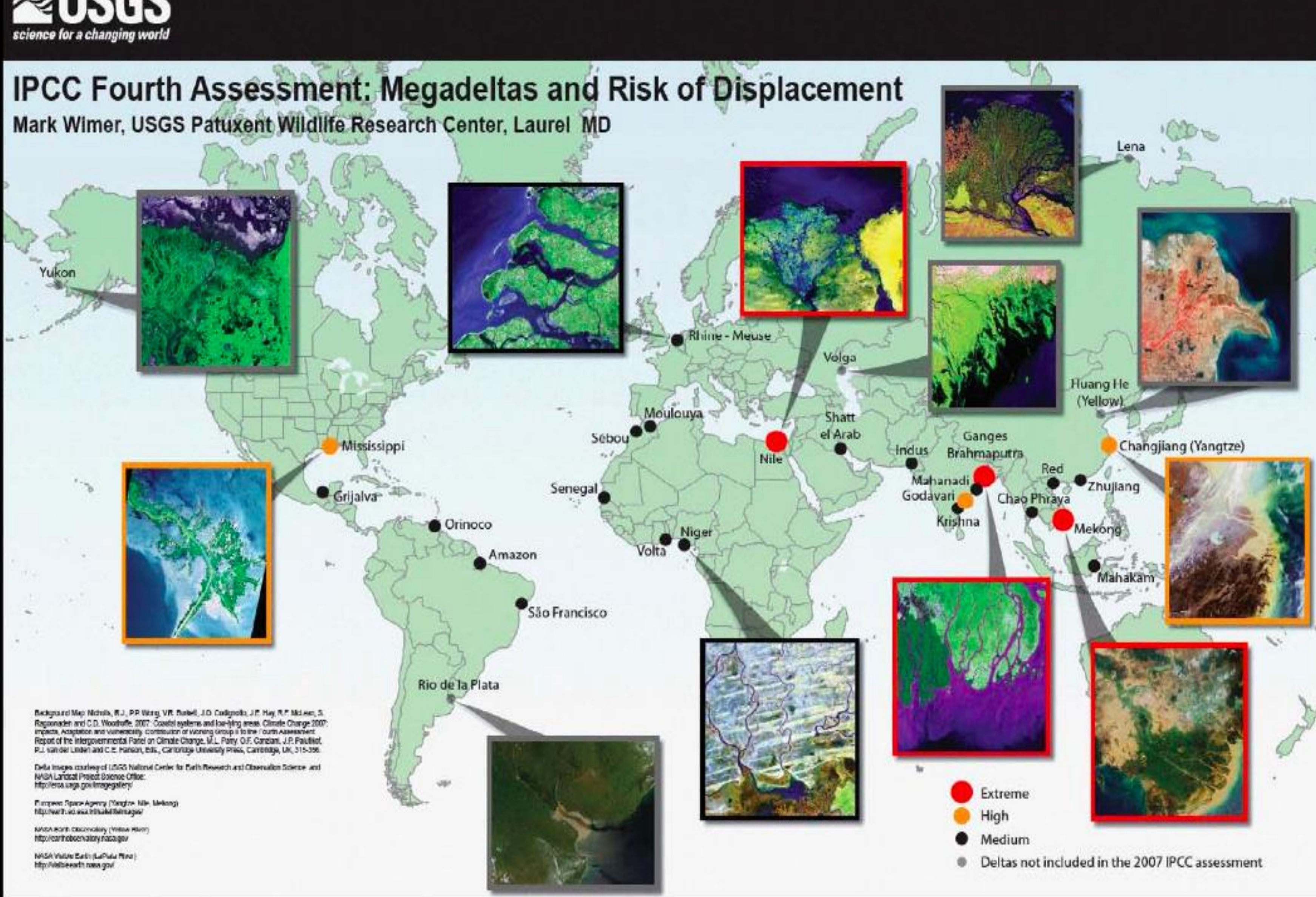
New Orleans is threatened …

2009

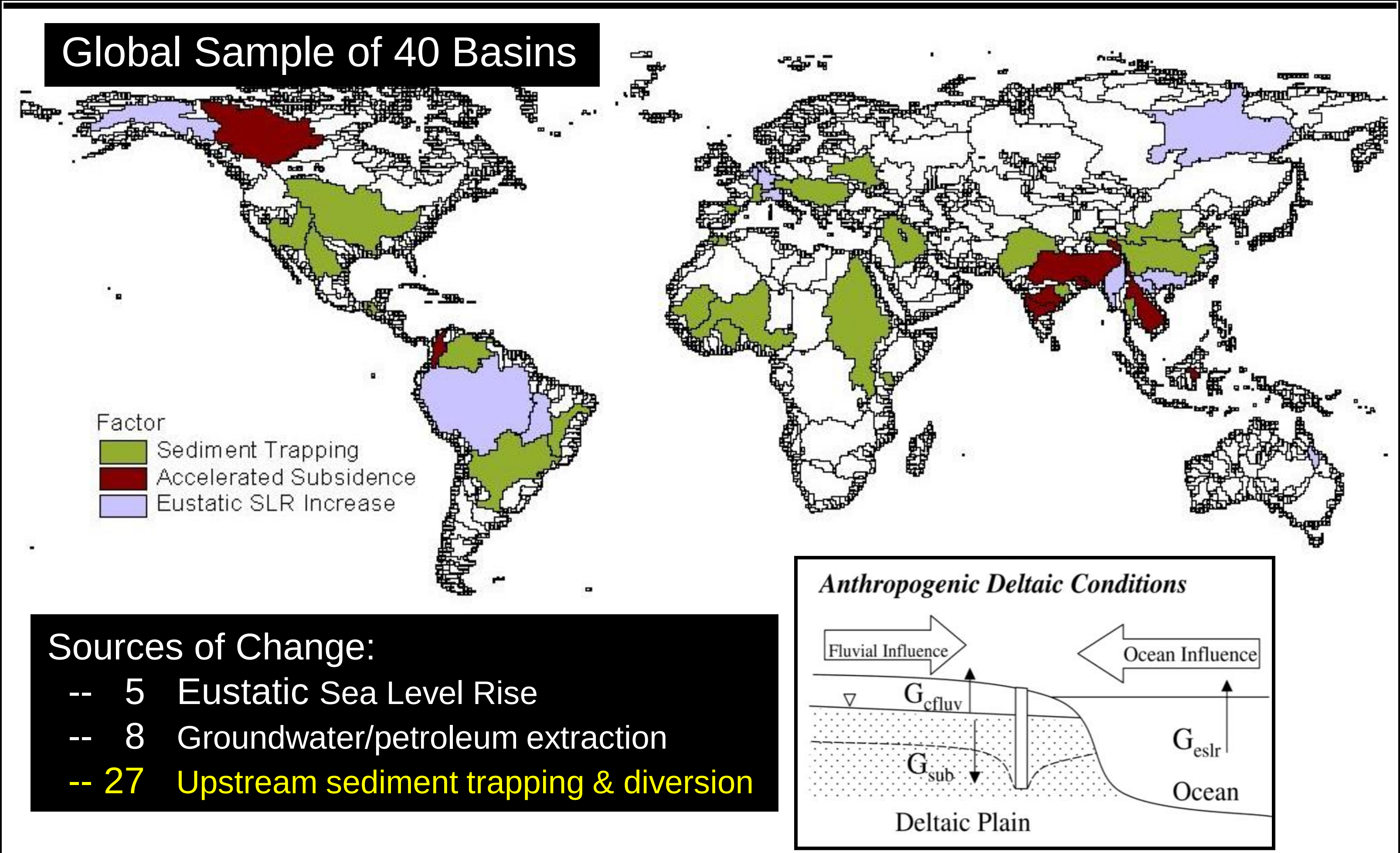
2100

Blum, M.D. and H.H. Roberts (2009), Drowning of the Mississippi Delta due to insufficient sediment supply and global sea-level rise, National Geosciences, 2, 488-491

World deltas Under Threat



Sediment Starved Deltas



Sources of Change:
- -- 5 Eustatic Sea Level Rise
- -- 8 Groundwater/petroleum extraction
- -- 27 Upstream sediment trapping & diversion

Ericson et al., 2006, *Global and Planetary Change*

Slide courtecy of C. Vorosmarty

The Great Flood 1927

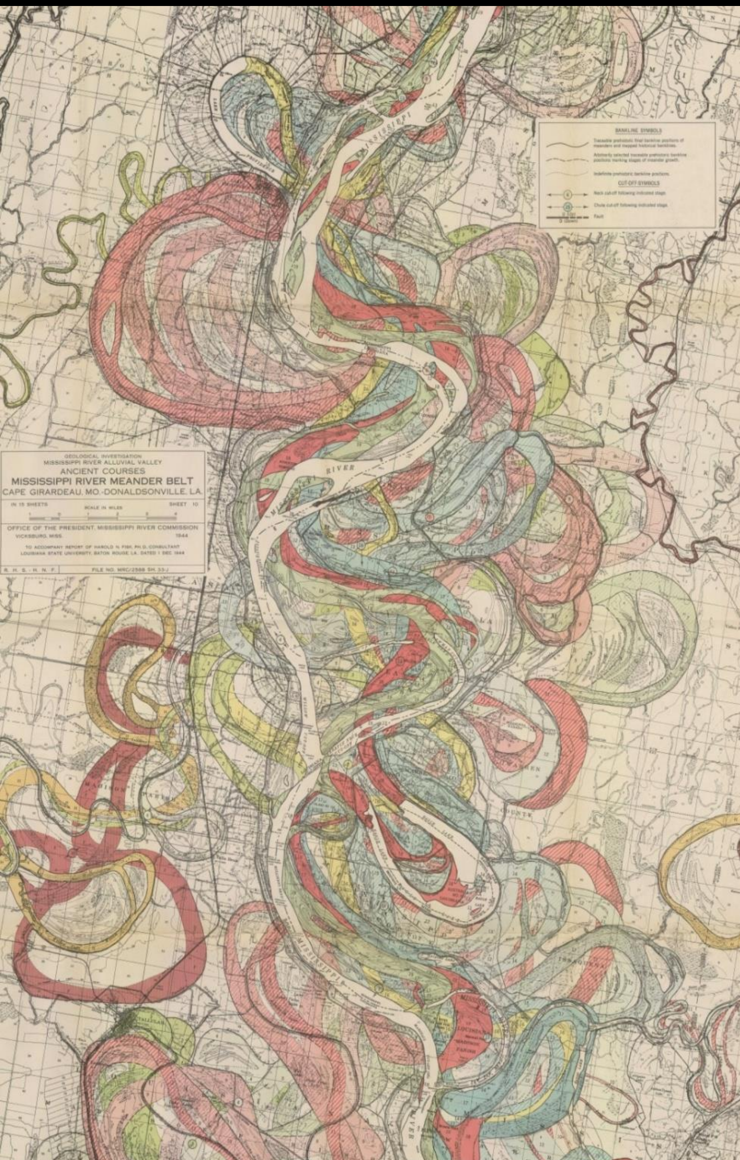
Displaced
700,000
Homes destroyed
130,000
Dead
246

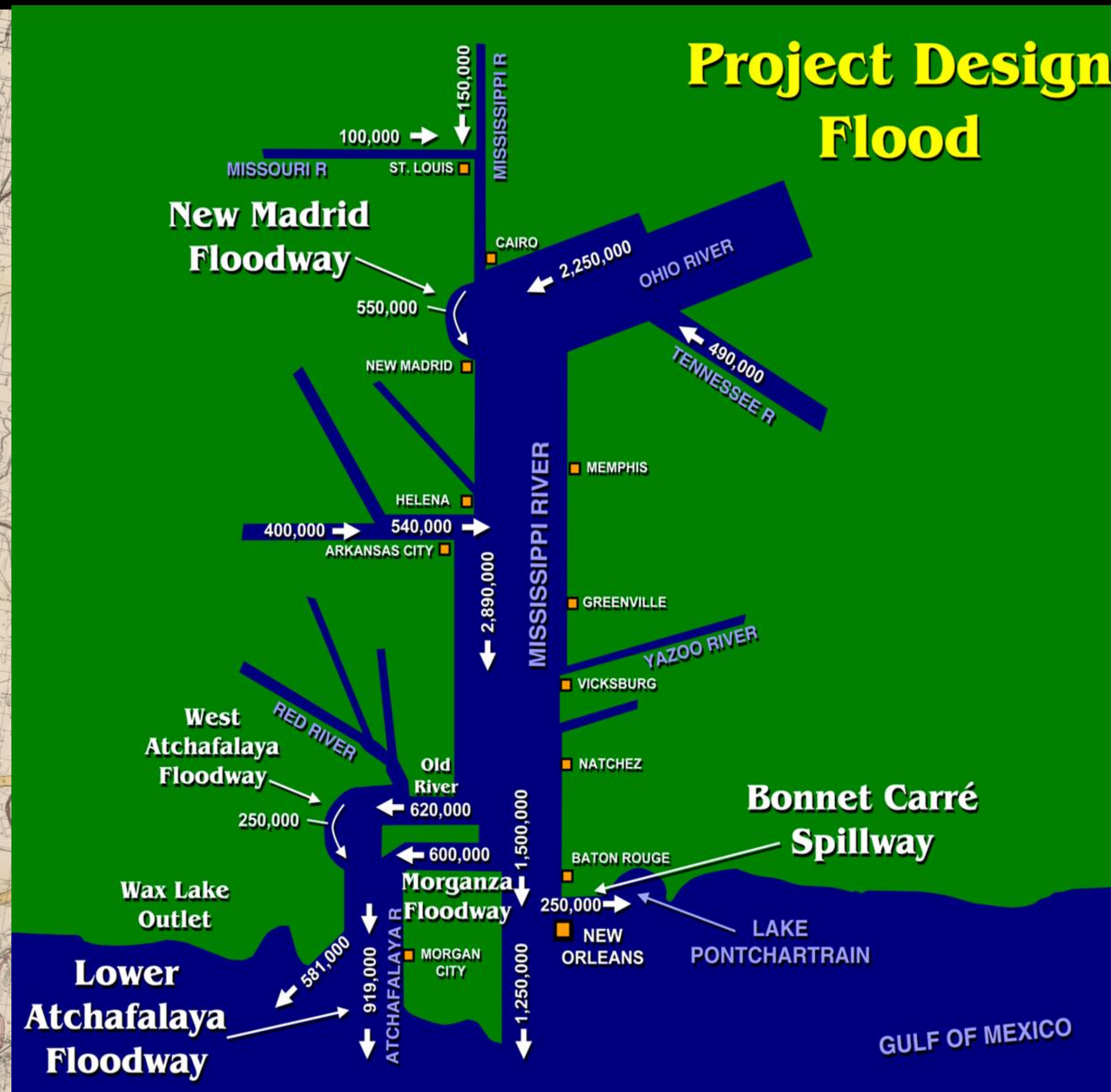
Library of Congress

John Stewart Curry
Hoover and the Flood
1940

Transformation of the Alluvial-Delta Landscape

1928 Flood Control Act





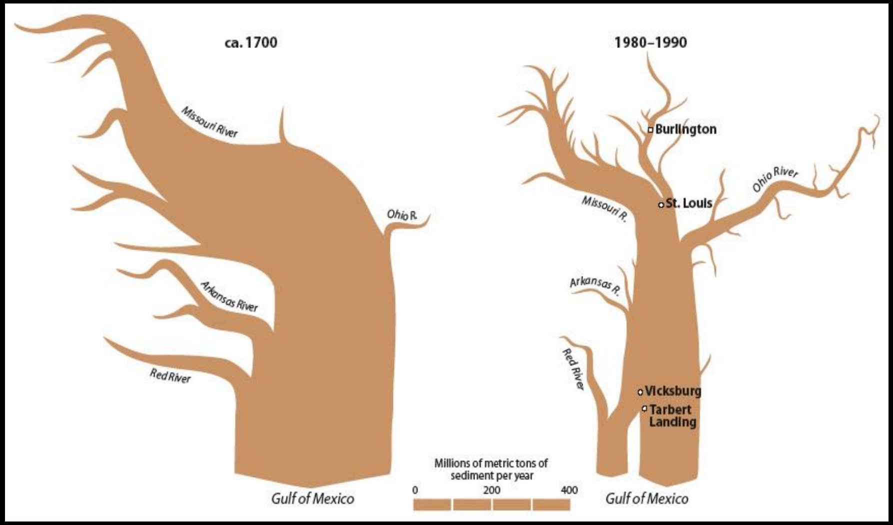
Slide courtesy of R. Twilley

Flood Protection Succeded…

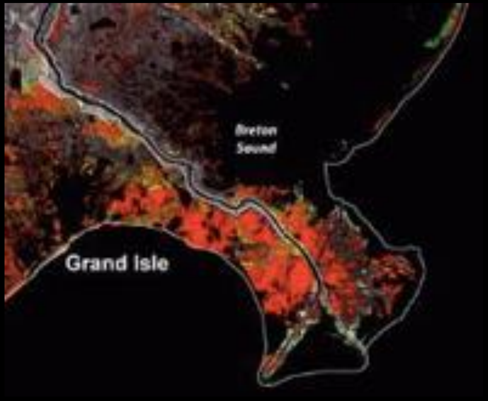
>> 3,486 miles of levees were put in place…

"Since inception of the project in 1928, no project levee built to MR&T standards has ever failed." (USACE April 2009)

>> But river was cut-off from its floodplain and sediment supply to delta was reduced with known consequences …



Sediment reduction



Delta land loss

'In making war with nature,
there was risk of loss in winning,''

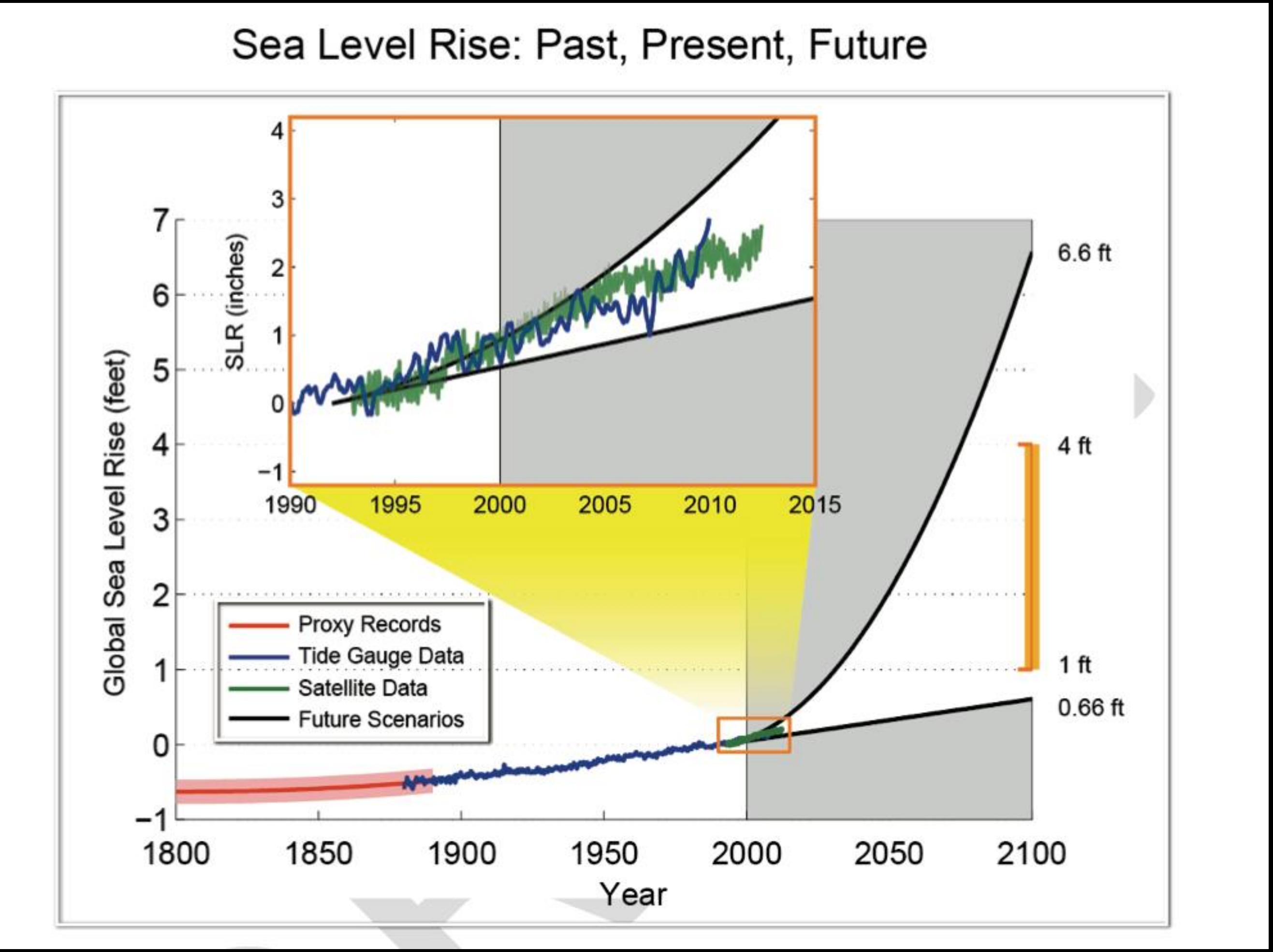
John McPhee, *The Control of Nature*

HISTORY REPEATS ITSELF …
w/ even larger stressors

Dam constructions
Local Resource exploration
Sea level Rise
Intensified tropical storms

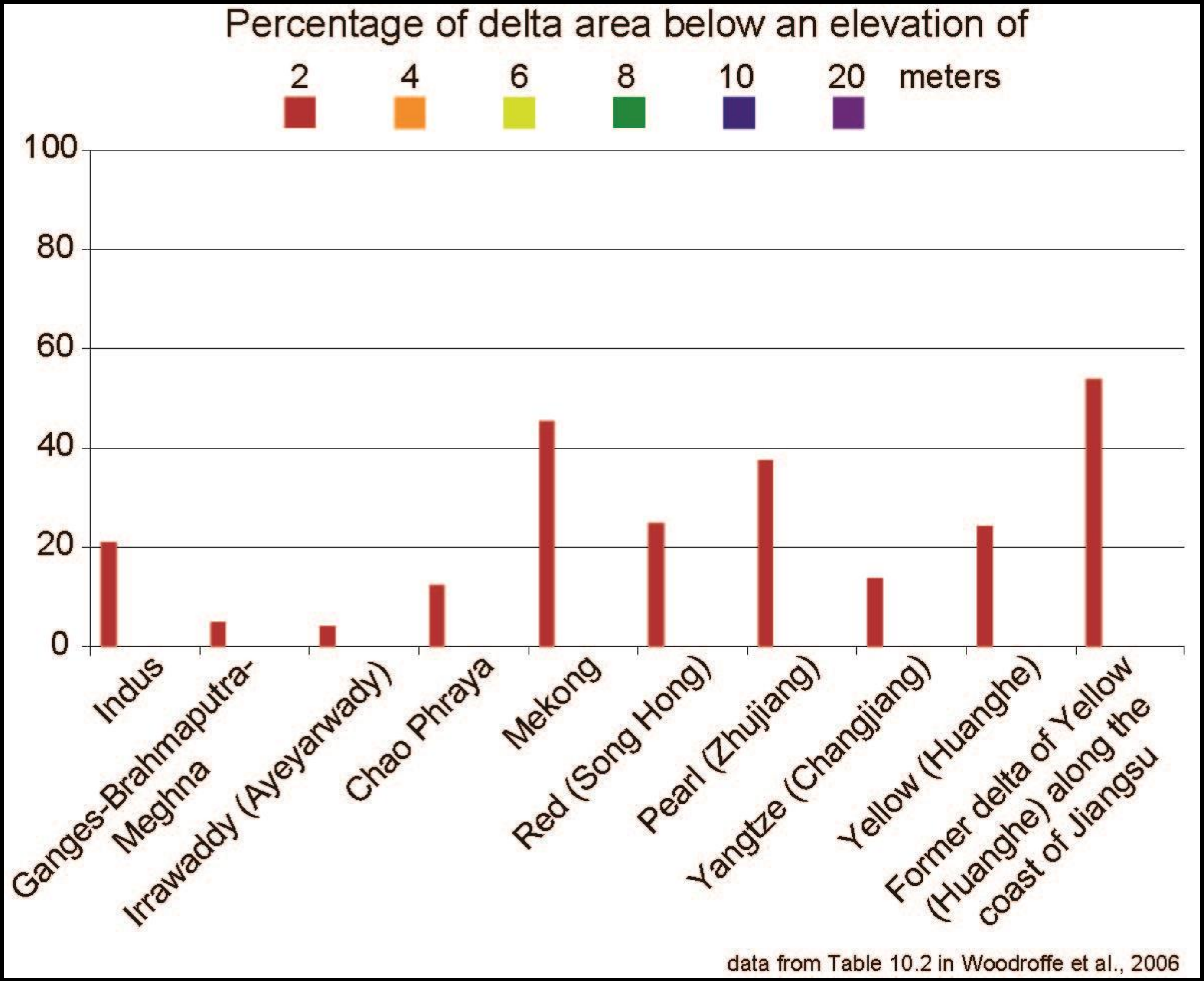
Food security
Political instability
Human health
Extreme poverty
Loss of biodiversity
Groundwater contamination

Projected Sea Level Rise: 2010 - 2100

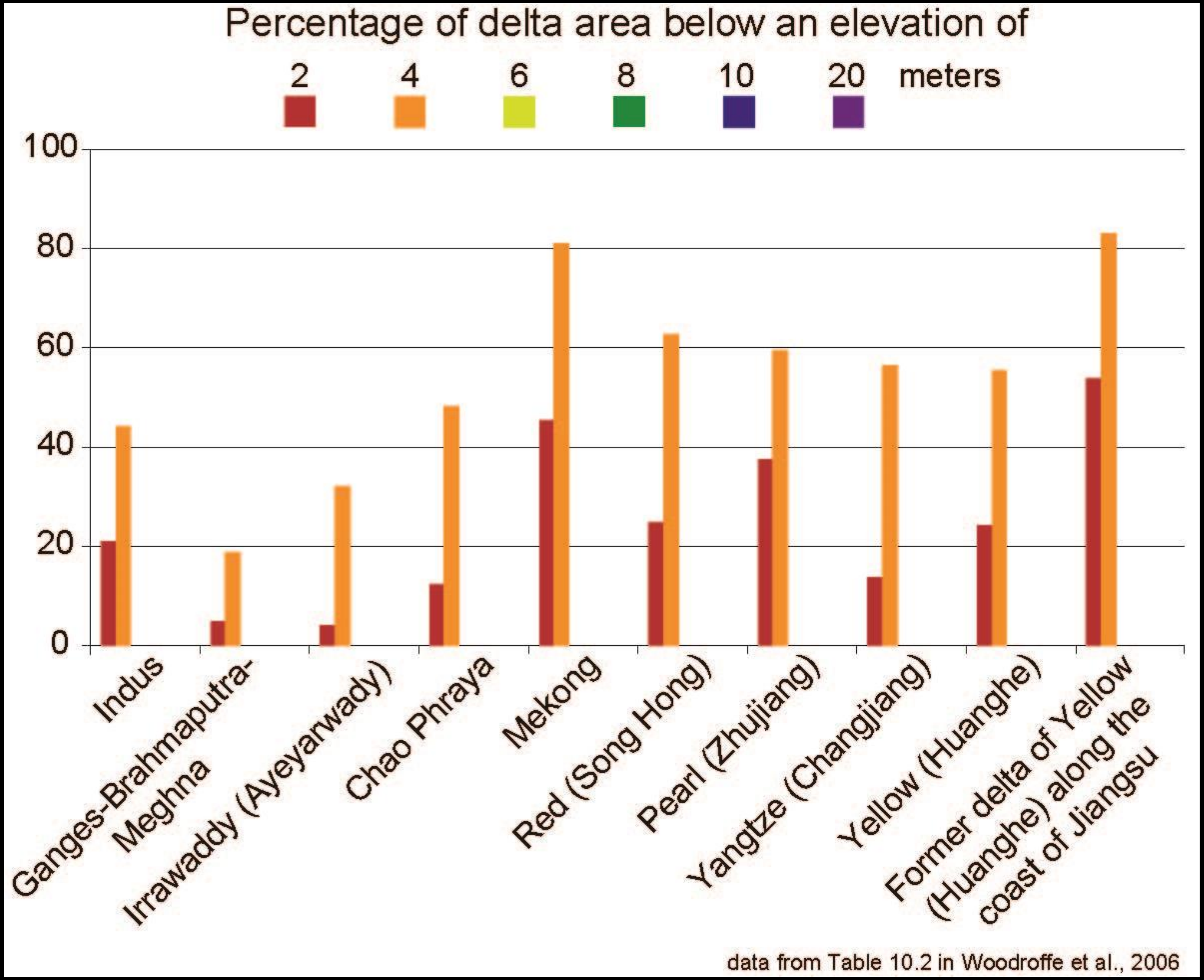


National Climate Assessment Report, 2013
Source: Josh Willis, NASA Jet Propulsion Laboratory

Vulnerability of Asian Megadeltas to Rising Sea Level

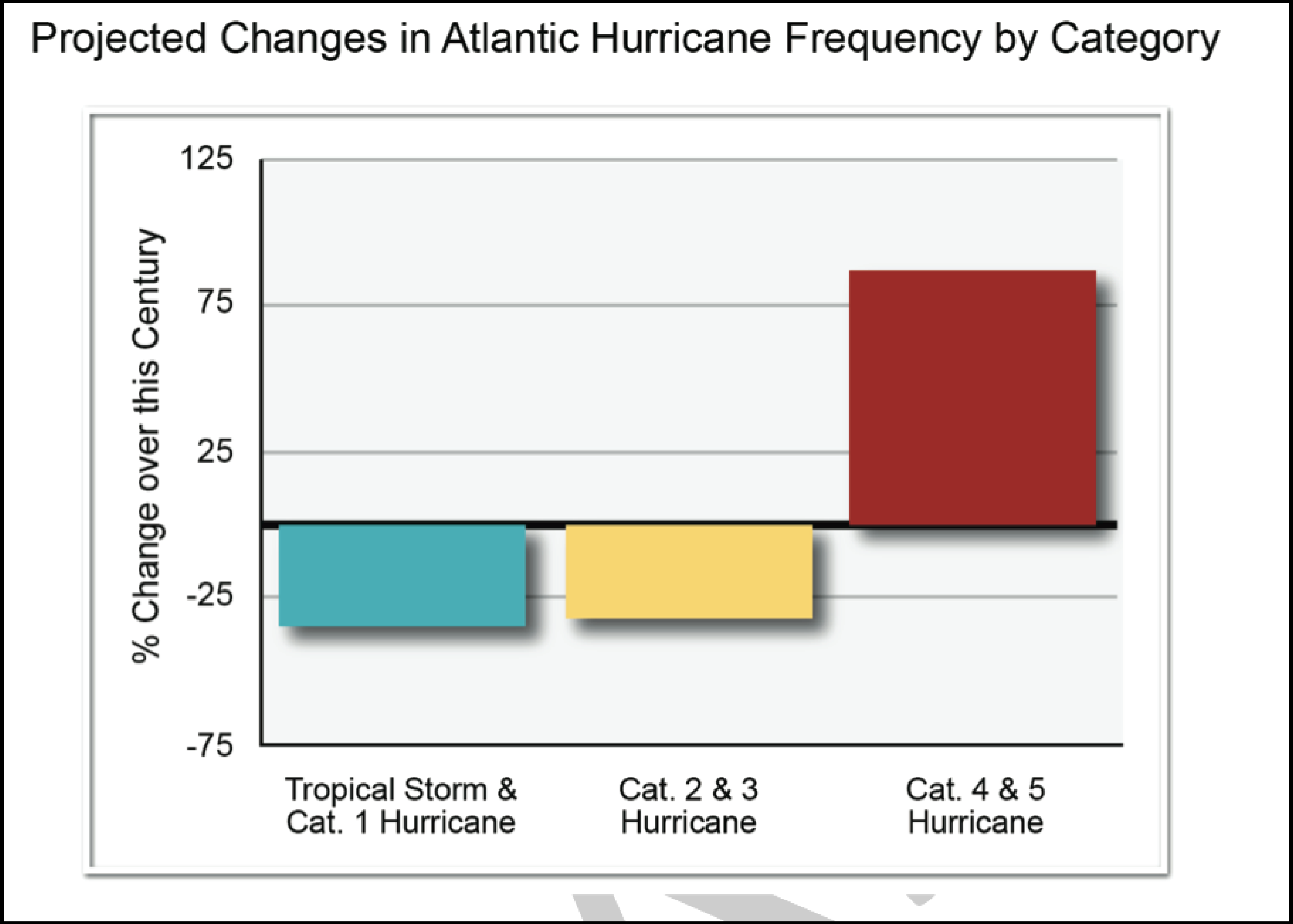


Vulnerability of Asian Megadeltas to Rising Sea Level



Projected Atlantic Hurricane Frequency

Period 2081-2100 compared with 2001-2020



National Climate Assessment Report, 2013
Source: NOAA GFDL

THE TIME IS NOW … for a
Global delta sustainability initiative

A coordinated campaign on deltas around the world for shared observations, research and strategies for adaptive management. An effort that is multidisciplinary in scope and international in participation.

Presentation can be found at: http://www.ce.umn.edu/~foufoula/presentations.php

INTERNATIONAL YEAR OF DELTAS 2013 : A PROPOSAL

We propose that 2013-2014 be designated the *International Year of Deltas* to: (1) increase awareness and attention to the value and vulnerability of deltas worldwide, (2) promote and enhance international and regional cooperation at the scientific, policy, and stakeholder level, and (3) focus and accelerate a comprehensive research agenda towards understanding and modeling these complex socio-ecological systems as the cornerstone of ensuring preparedness in protecting or restoring them in a rapidly changing environment.

FORUM

Foufoula-Georgiou et al., ***Oct., 2011***

International Year of Deltas 2013: A Proposal

PAGES 340–341

Marine and lacustrine deltas around the world are economic and environmental hot spots. They occupy approximately 1% of the Earth's land area but are home to more than 500 million people—a population density more than 10 times the world average [*Ericson et al.*, 2006]—all within 5 meters of

There is an urgent need to rally the international community for a focused effort toward a holistic physical-socioeconomic understanding of deltas as critically delicate and vulnerable systems undergoing change. Such understanding is a basic requirement for their management, protection, and restoration.

We propose that 2013–2014 be designated as the International Year of Deltas (IYD) to

geomorphology, ecology, sediment engineering, hydrology, coastal oceanography, stratigraphy, geography, history, anthropology, sociology, political sciences, and economics.

Basic research questions across these disciplines include the following:

1. What are the system dynamics of a delta, its main processes and reservoirs, feedback loops, system gains, and relevant parameters that govern dynamic equilibrium states? How strong is the two-way coupling between the ecological communities of the delta top and the geomorphic (physical) template?

2. How does the delta system (distributaries, wetlands, lakes, lagoons, and coastlines) self-organize into a dynamic structure capable of maintaining the subaerial delta over different time scales?

3. How do perturbations in the incoming

Vision for the IYD

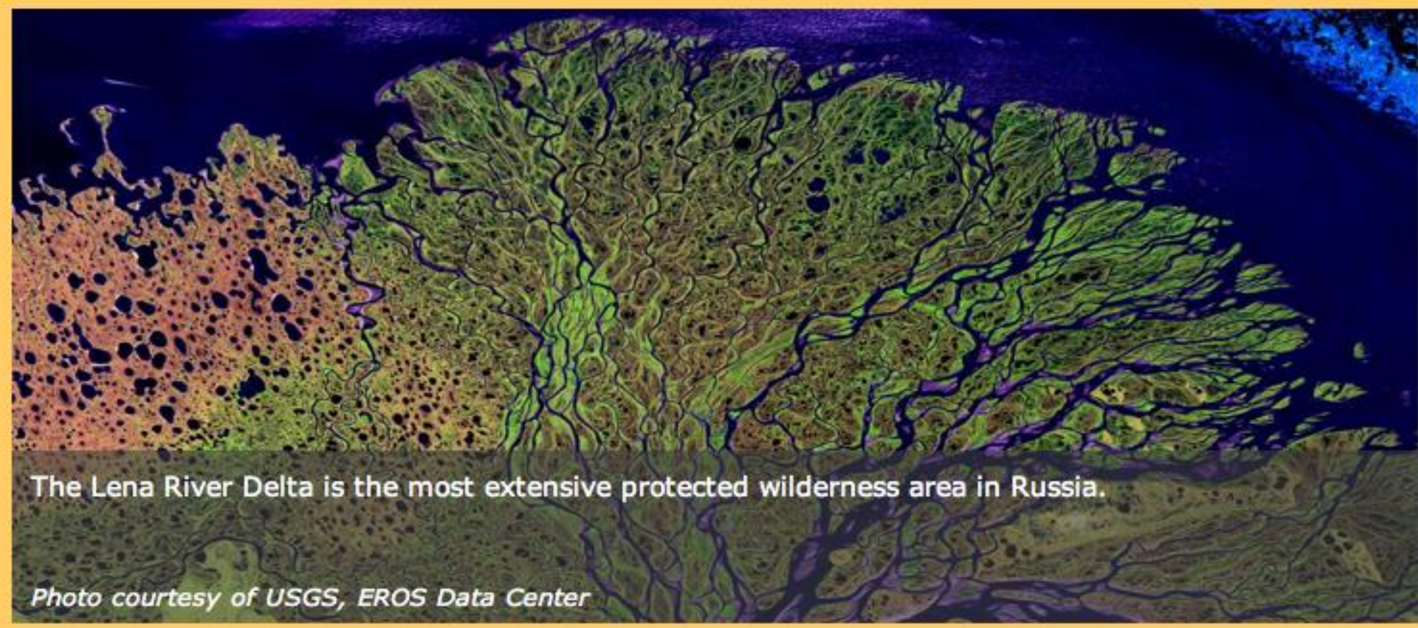
(1) Increase awareness and attention to the value and vulnerability of deltas worldwide

(2) Promote and enhance international and regional cooperation at the scientific, policy, and stakeholder level

(3) Launch a 10-year initiative committed to understanding these complex socio-ecological systems as the cornerstone of ensuring preparedness in protecting and restoring them in a rapidly changing environment

www.iyds-2013.org

- Why Deltas?
- IYD Goals
- Join us
- Delta Events
- Sponsors
- Documents
- Delta Resources
- Show me Deltas!



The Lena River Delta is the most extensive protected wilderness area in Russia.

Photo courtesy of USGS, EROS Data Center

Marine and lacustrine deltas around the world are economic and environmental hotspots. They occupy approximately 1% of the Earth's land area but are home to greater than 500 million people — all within 5 meters of present-day sea level. Deltas support high productivity, rich biodiversity, and

IYD Sponsors

International Union of Geodesy and Geophysics

International Association of Hydrological Sciences

IAHS AISH

NCED

Earth · Water · Life

Land-Ocean Interactions in the Coastal Zone

LOICZ

IUGS

Earth Science for the Global Community

WCRP

World Climate Research Programme

American Rivers

Rivers Connect Us

CSDMS

COMMUNITY SURFACE DYNAMICS MODELING SYSTEM

International Geographical Union

IGU UGI

isprs

information from imagery

GLOBAL IGBP CHANGE

International Geosphere-Biosphere Programme

IAPSO

International Association of the Physical Sciences of the Ocean

DELTAS Sustainability Initiative

A successful proposal to the Belmont Forum

G8MUREFU3FP-2201-037: Catalyzing action towards sustainability of deltaic systems with an integrated modelling framework for risk assessment

DELTAS Sustainability Initiative

USA: E. Foufoula-Georgiou (Univ. of MN); I. Overeem (Univ. of Colorado); S. Goodbred (Vanderbilt University); I. Harrison (Int. Union for Conservation of Nature); C. Vorosmarty and Z. Tessler (City College of New York); E. Brondizio (Indiana University)
Japan: Y. Saito (Geological Survey of Japan, Japan);
Germany: S. Dech and C. Kuenzer (University of Wuerzburg); F. Renaud (United Nations Univ.);
France: E. Anthony (Aix-Marseille University);
U.K: J. Hutton (United Nations Univ.); R. Nicholls, Z. Matthews, J. Dearing, A. Lazar, and A. Baschieri (Univ. of Southampton);
India: R. Ramachandran (Anna Univ.)

Netherlands: M. Marchand and T. Bucx (Deltares)
Bangladesh: K.M. Ahmed (Univ. of Dhaka); M.M. Rahman (Bangladesh Univ. of Engineering and Technology);
Vietnam: V. L. Ngugen (Vietnam Academy of Science and Technology); M. Goichot (World Wide Fund for Nature – Greater Mekong)
Norway: A. Newton (Norwegian Inst. for Air Research, Norway);
Brazil: S. Costa (University of Vale do Paraíba),
Canada: G. Lintern (Natural Resources Canada); P. Van Cappellen and H. Durr (University of Waterloo),
China: S. Gao (Nanjing Univ.),

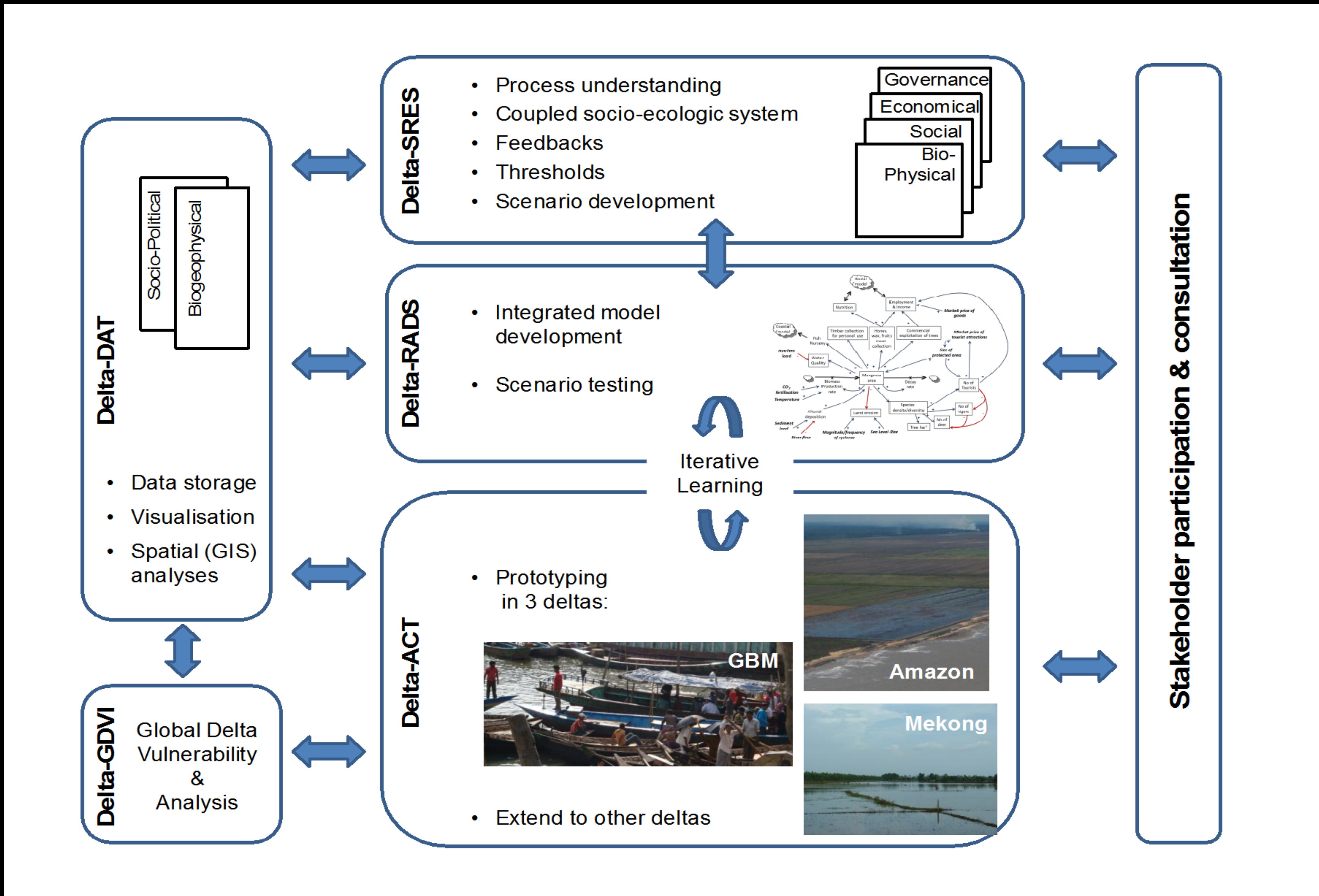
DELTAS Sustainability Initiative

BELMONT FORUM

1. Advance science on resilience and sustainability of deltas as critical coupled socio-ecological systems undergoing change (Delta-SRES)
2. Develop and deliver a science-based delta sustainability framework for risk assessment and decision support (Delta-RADS)
3. Build an international repository of data sets including physical, social, and economic data (Delta-DAT)
4. Implement and demonstrate the developed modeling and decision support framework in selected deltas in partnership with local stakeholders, and open to door for global use and adoption (Delta-ACT)

DELTAS Sustainability Initiative

BELMONT FORUM



Major science questions

(1) How do climate change, pressure on resources, and engineering/ infrastructure development make people, biodiversity, and delta ecosystems vulnerable?

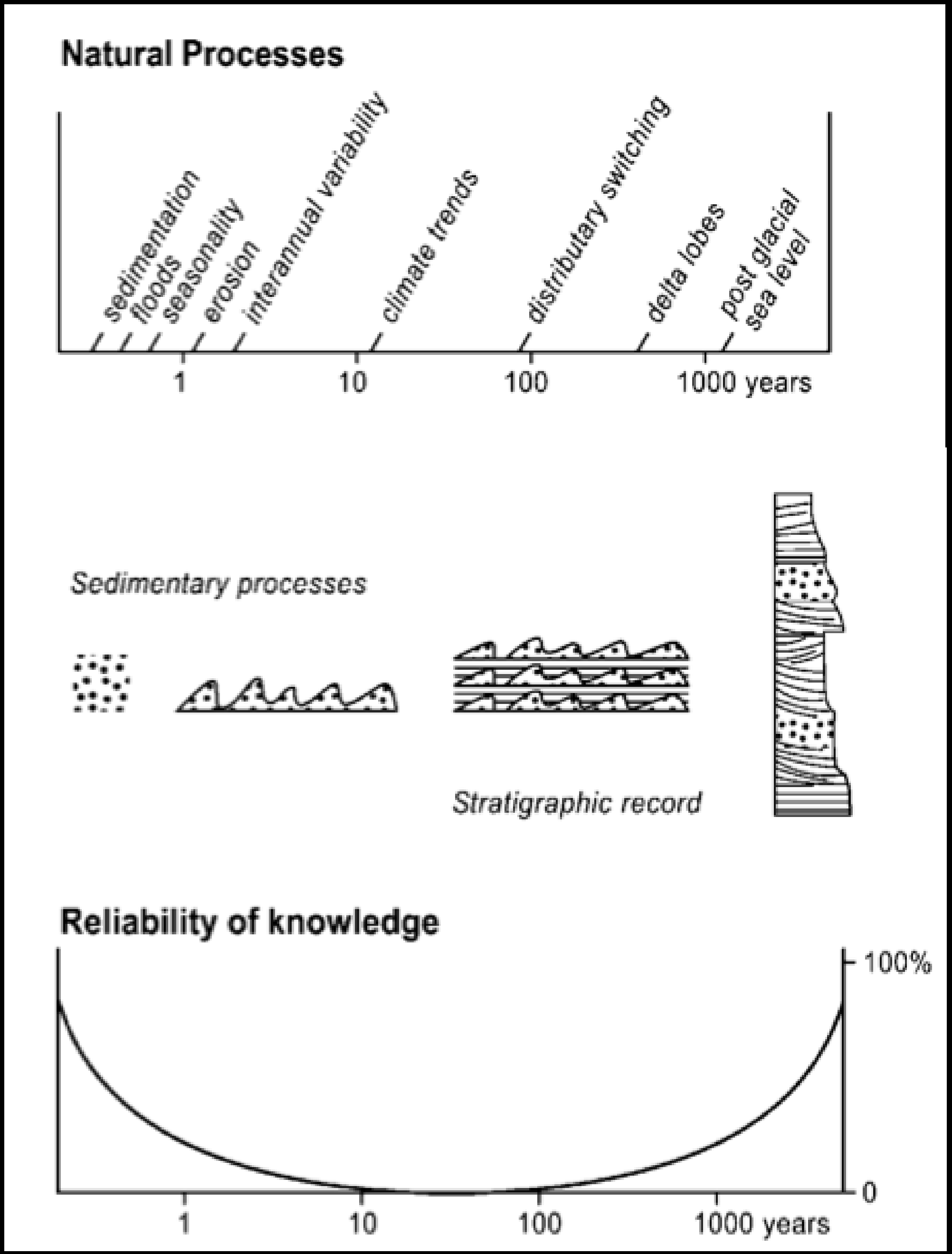
(2) How is this vulnerability to be measured?

(3) How do delta areas absorb extreme events? What are the hydrological and ecological thresholds underlying the integrity of a delta region?

(4) What are the relevant local and regional hydrological, biophysical and social stressors for a particular delta system, how do these interact, and how do they vary spatially and over time?

(5) How can regional delta sustainability be balanced with economic growth? and

(6) How can one reduce future risk while attaining sustainable development?

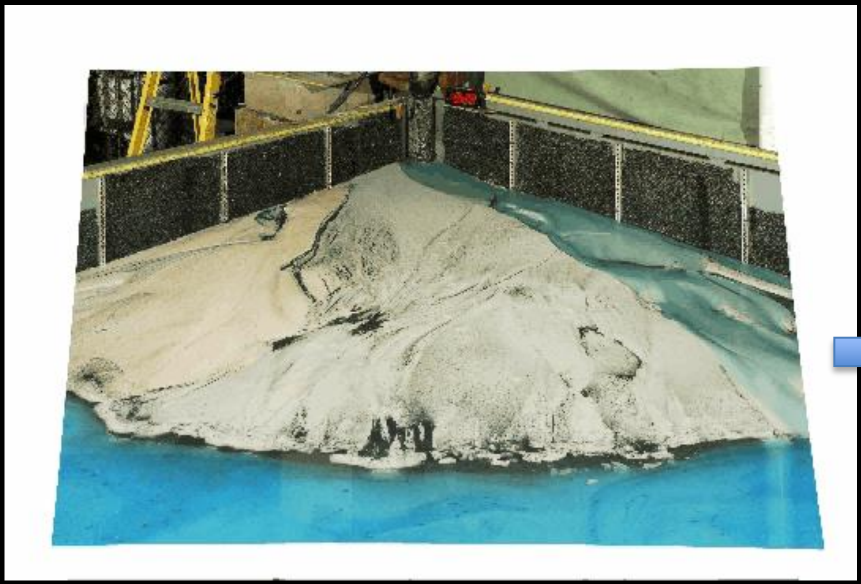


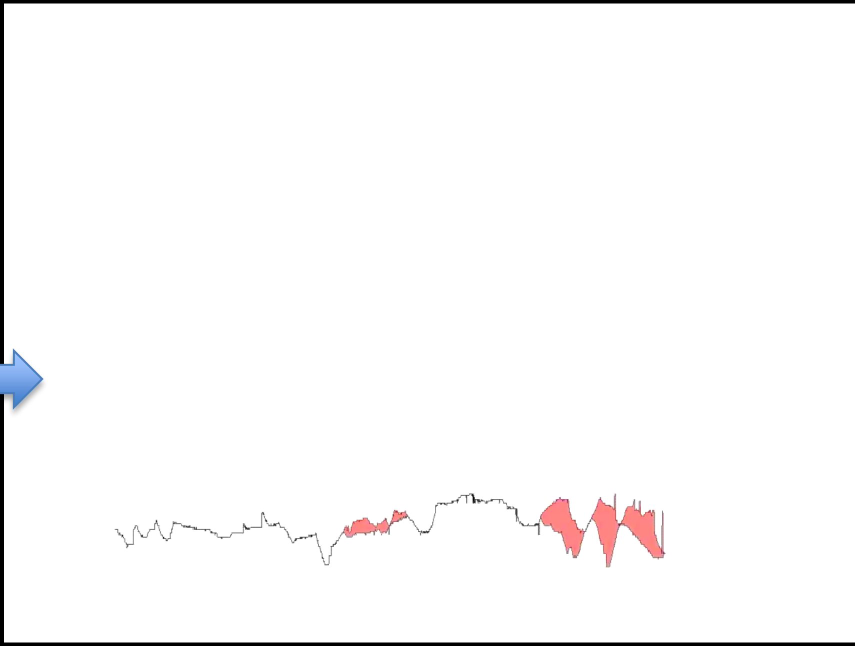
Gaps in Knowledge

Large range of scales
Large range of processes

Woodroffe, et al., Ch 10, Harvey et al. (eds), 2006

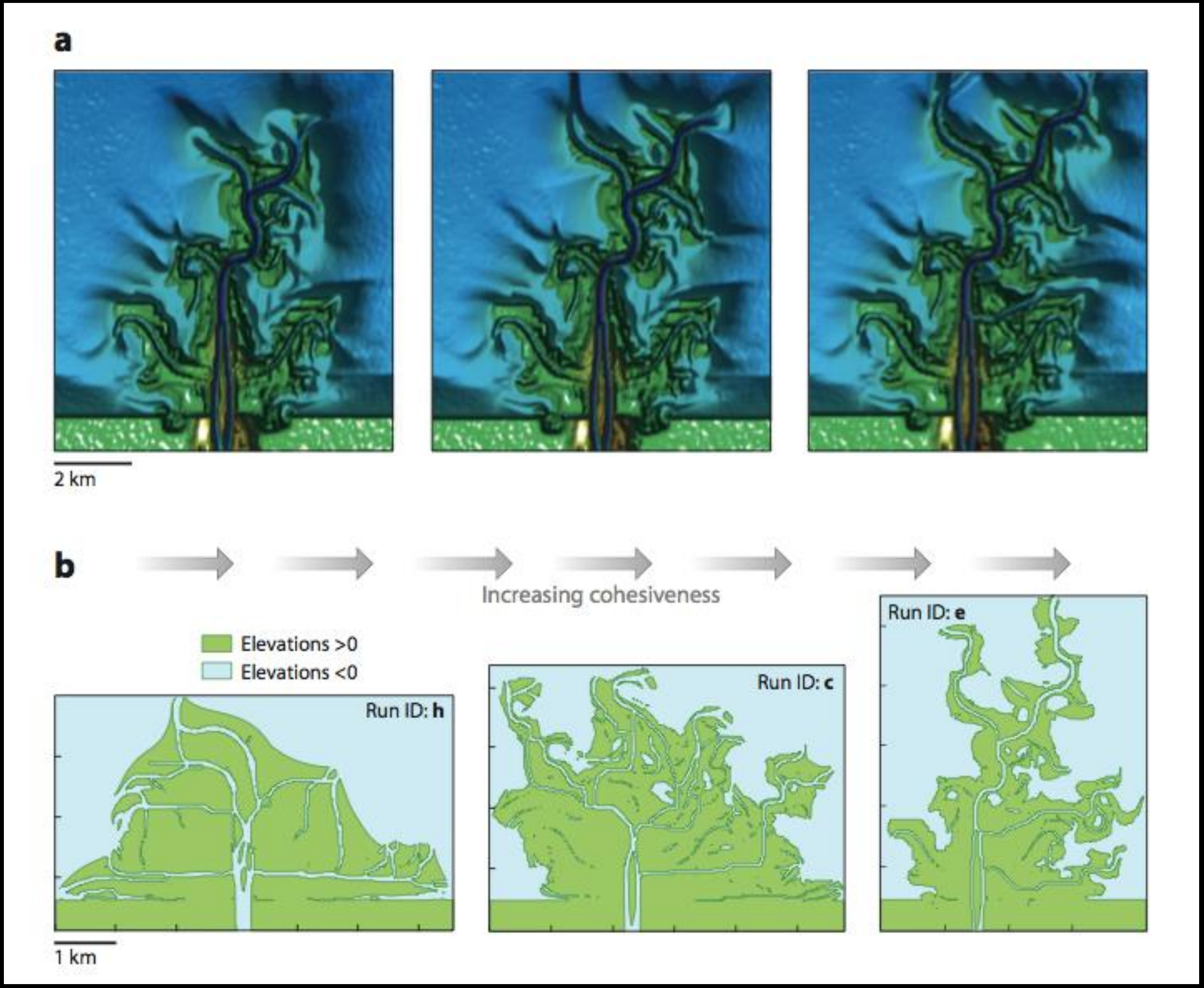
Controlled Laboratory experiments: Form Deltaic Surface Evolution to Stratigraphy





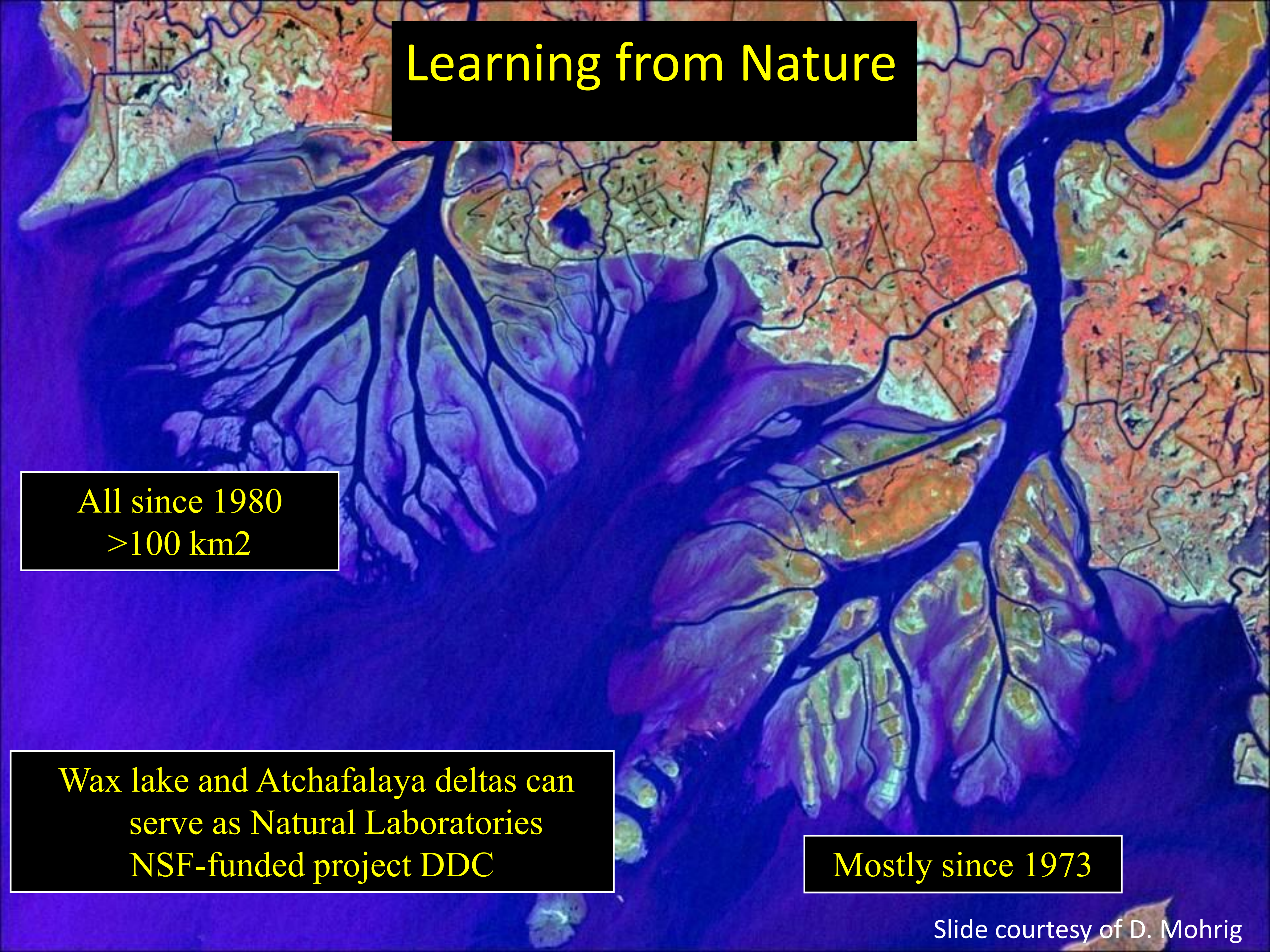
Experiment DB03, SAFL – see Sheets et al., 2007
Ganti et al., JGR-ES, 2011, 2013

Numerical Modeling: Effect of cohesiveness on delta form

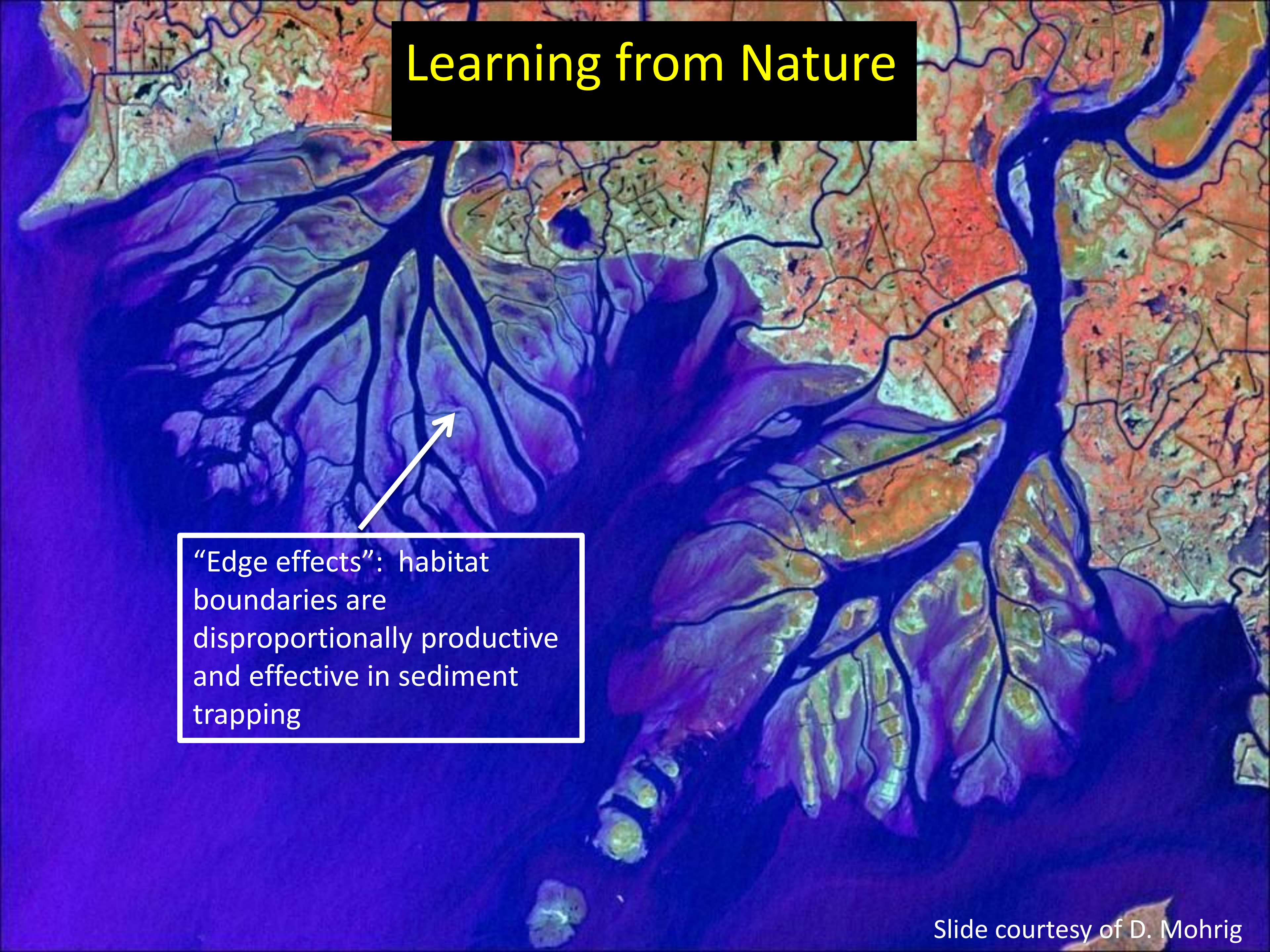


Edmonds & Slingerland (2010)

Learning from Nature

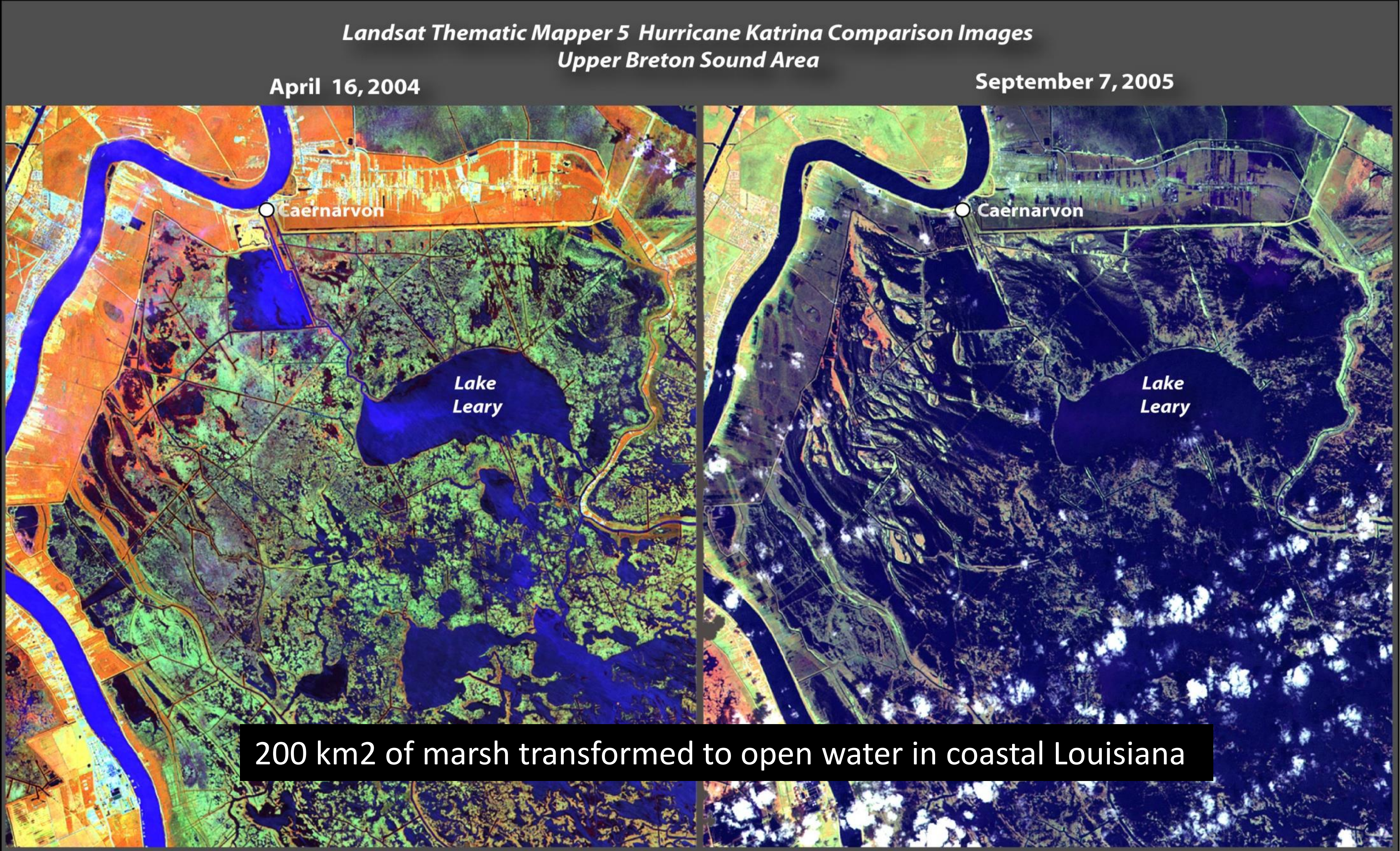


Slide courtesy of D. Mohrig


Learning from Nature
“Edge effects”: habitat boundaries are disproportionally productive and effective in sediment trapping
Slide courtesy of D. Mohrig

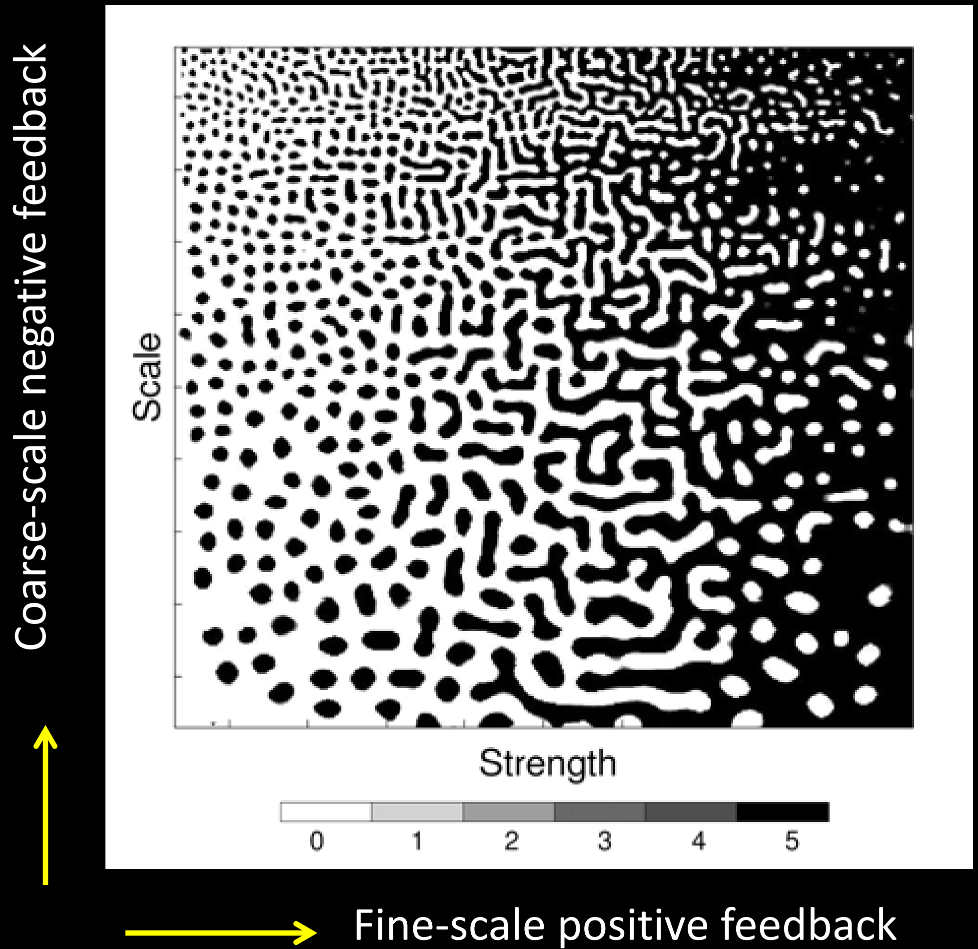
Response to Catastrophic events and thresholds to recovery

Hurricane Katrina, 2005



200 km2 of marsh transformed to open water in coastal Louisiana

Interplay of fine and coarse scale feedbacks for vegetation patterns ⟶ resilience



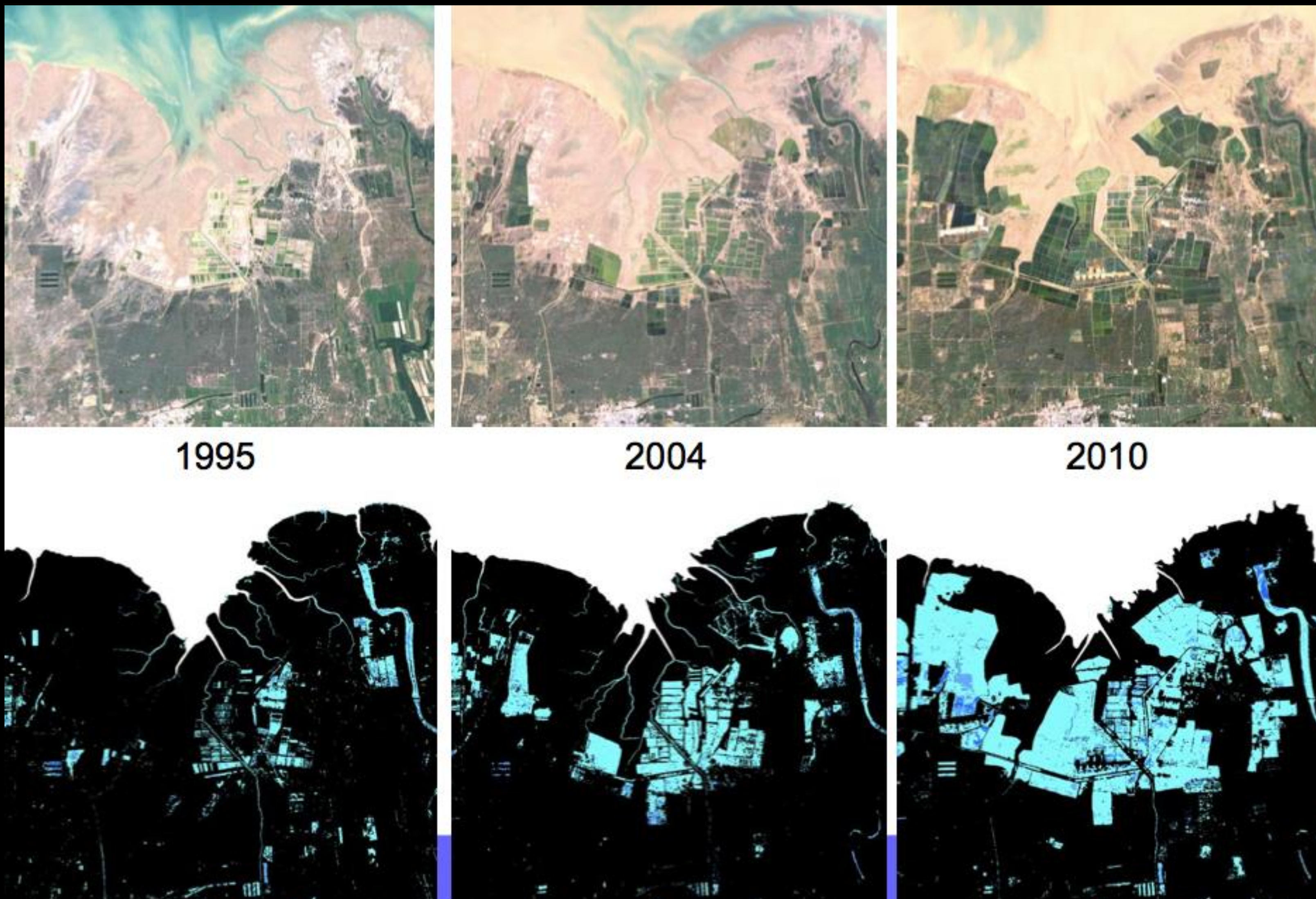
Vegetation patterns are the result of fine-scale positive feedback and coarse-scale negative feedback. .

Rietkerk et al, Sience, 2004

Lena Delta
Siberia
10 mi
Warnings to critical slow down?

Human modification of deltas

e.g., Yellow River Delta – Aquaculture Expansion 1995-2010



The Ganges-Brahmaputra-Meghna (GBM) Delta:

FACTS:

-- ~100,000 km^2 draining land from Bangladesh, Bhutan, China, India and Nepal.

-- 147 million people (in 2000) in extreme poverty. Population expected to increase by 28% by 2015.

-- 30% of Bangladesh is within 5 m of sea level, tidal water movement 100 km inland during the dry season

-- Proposed construction of mega dams and major diversions in India and China threaten sediment starvation and reduced water availability in the dry season

-- Reduced river flows and intensive shrimp farming cause severe saltwater intrusion in the coastal fringe degrading the ecosystem

The Mekong River Delta (MRD):

FACTS:

-- 94,000 km^2 and population of 17 million, one of Asia's main food baskets, and second only to the Amazon in terms of fish biodiversity.

-- Socio-economic transformation and urbanisation lead to degradation of forest and wetland areas and increased water pollution.

-- Large-scale sand mining, mangrove removal for shrimp farms, dikes and embankments to protect shrimp farms from flooding increase vulnerability

-- Hydropower needs expected to rise 7% a year over the next 20 years; exhausting the river's hydropower-generating capacity will lead to a 7 x increase in reservoir sediment trapping efficiency with adverse effects on fisheries and coastal erosion.

-- The Mekong river catchment is shared among six countries (China, Myanmar, Lao PDR, Thailand, Cambodia and Vietnam) – potential source of conflict in harnessing the resources of the basin, especially hydropower development.

The Amazon River Delta (ARD):

FACTS:

-- The world's largest, contributing 20% (175,000 m^3/s) of the total global river discharge to the oceans and discharging the highest total sediment load.

-- Influences the coastal economies of Brazil, French Guiana, Surinam, Guyana and Venezuela.

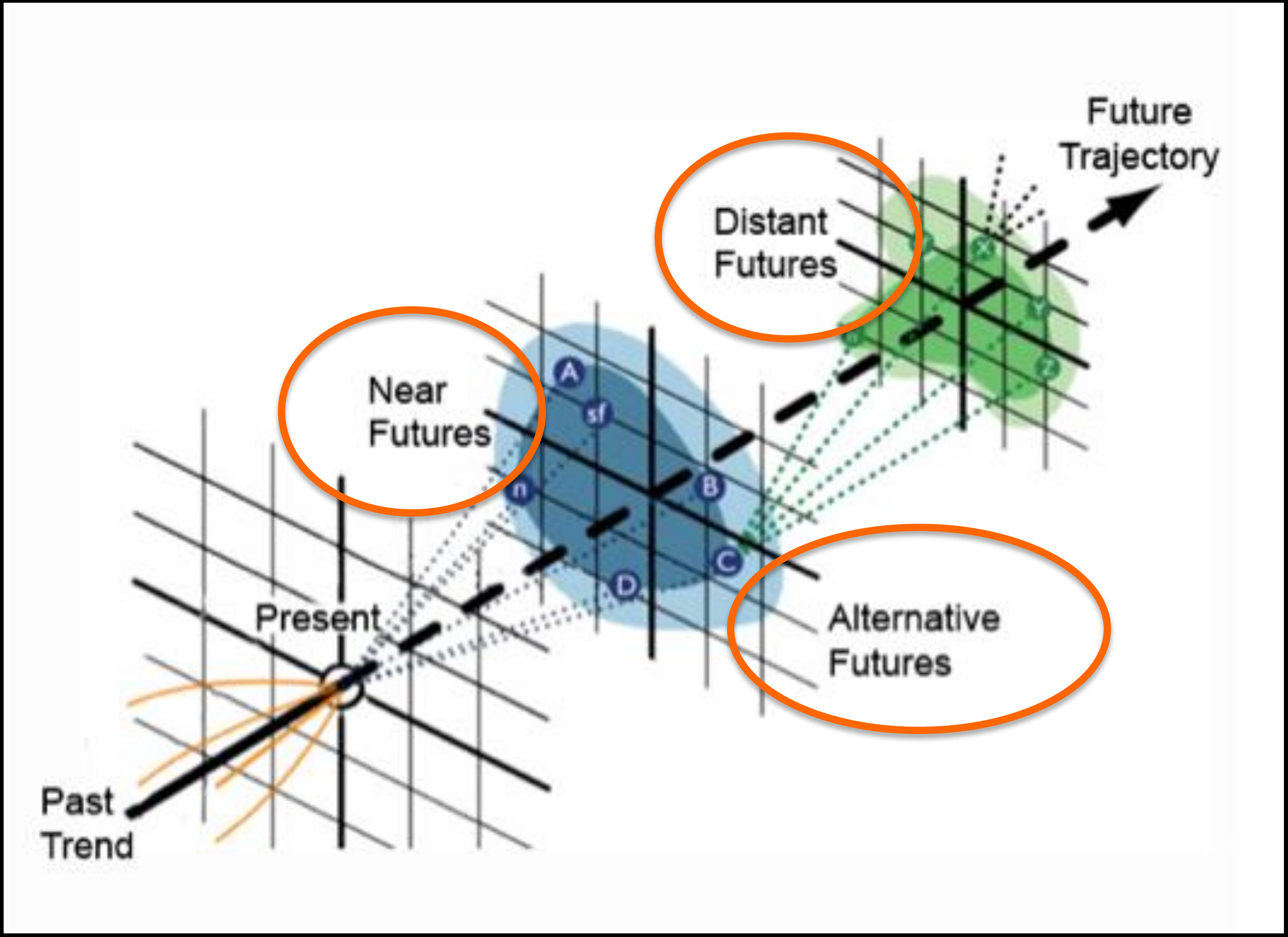
-- Often classified as 'low risk' because of its limited damming and water/oil extraction.

-- The conversion of mangrove forests to shrimp farms are an emerging environmental challenge.

-- Deforestation proceeds rapidly, and population, economy, and infrastructure are growing quickly.

-- The projected construction of dams, ports and aqueducts will impact water and sediment flow from large tributaries

We are at the junction of defining alternative futures

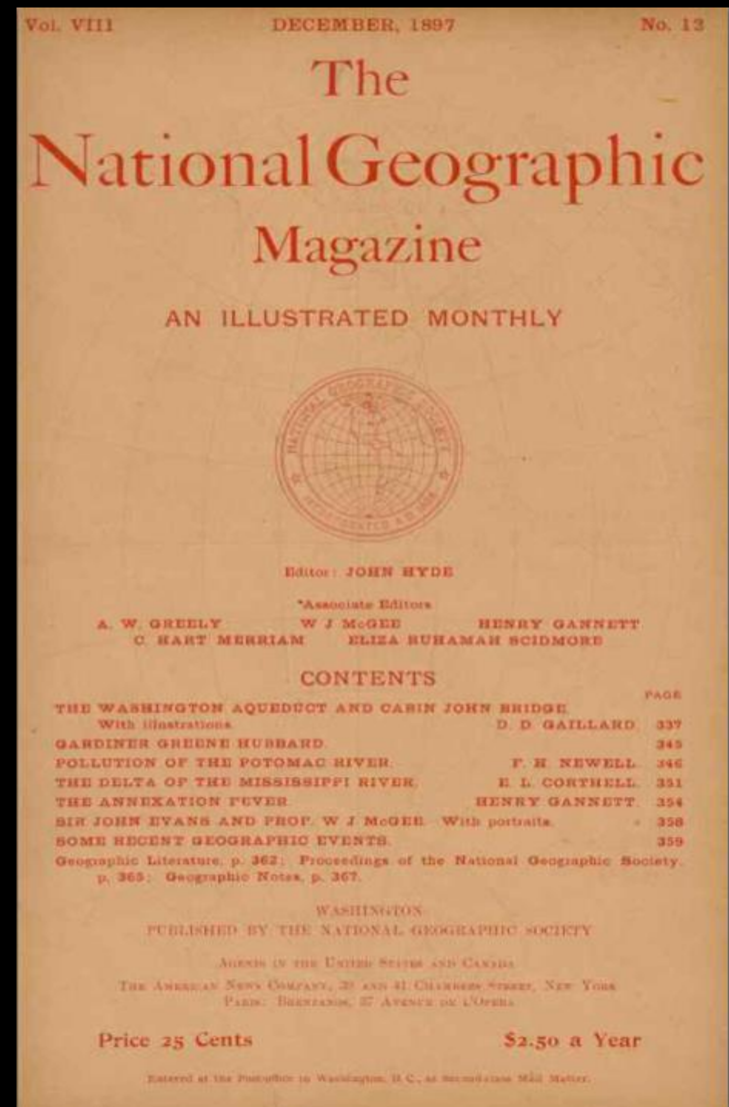


Morley et al, Past, Present, and Future Landscapes

Distant futures are not that distant …

"even given subsidence and reduction of sediment delivery…the great benefit to the present and two or three following generations…far outweighs the disadvantages to future generations…"

National Geographic, 1897


Vol. VIII DECEMBER, 1897 No. 12

The National Geographic Magazine

AN ILLUSTRATED MONTHLY

Editor: JOHN HYDE

Associate Editors

A. W. GREELY W J McGEE HENRY GANNETT
C. HART MERRIAM ELIZA RUHAMAH SCIDMORE

CONTENTS

WASHINGTON
PUBLISHED BY THE NATIONAL GEOGRAPHIC SOCIETY

Price 25 Cents $2.50 a Year

Slide modified from Robert Twilley

Laws of nature are “harder” than concrete …

“Every phenomenon and apparent eccentricity of the river …is controlled by law as immutable as the Creator, and the engineer need only to be insured that he does not ignore the existence of any of these laws, to feel positively certain of the results that he aims at. ”

“If the profession of an engineer were not based upon exact science, I might tremble for the result, in view of the immensity of the interest dependent on my success. ”

From James B. Eads, USACE, circa 1876
taken from ‘The Control of Nature’ by John McPhee, 1989

Slide modified from Robert Twilley

Closing Thoughts

1. We cannot ignore anymore the downstream effects of upstream river basin management and exploration (need a “multi-generational” perspective)
2. Nature is making some statements and will continue to make them so it is better to work with her than against her
3. It is not about hydrologic and hydraulic engineering anymore: it needs an understanding of “water-land-sediment-biota-ocean interactions” and an approach that acknowledges deltas as dynamic socio-ecological systems
4. Deltas are rich platforms for basic research but there is urgency to make this research actionable and start using our knowledge now having in mind an adoptive management approach
5. International coordinating efforts and local engagement are critical elements for progress and success

To leave in harmony in the Anthropocene demands that we must beat the "Tragedy of the commons"

… without clearly defined property rights, common resources will be overexploited because individuals ignore the effects of their actions on the overall pool ...

Thank you


biodiversity
hydrology
MODELING
COLLABORATION
INFRASTRUCTURE
PEOPLE
GAPS
change
economic
VULNERABILITY
vulnerability
RESILIENCE
SUBSIDENCE
SEDIMENTOLOGY
management
GANGES
international
extremes
MANAGEMENT
MISSISSIPPI
sustainable
fluvial
INFRASTRUCTURE
GEOMORPHOLOGY
INTEGRATIVE
DELTAS
RESILIENCE
GEOGRAPHY
NATURAL
rivers
DATA
MEKONG
LENA
coasts
INFORMATION
ECONOMIC
social
RIVERS
DELTAS
PLAN
UNITY
sustainable
CHANNELS
research
natural
POLICY
RESEARCH
SCIENCE
NILE
OCEANS
fluvial
human
geography
oceans
COLLABORATION
GOVERNANCE
MODELING
ESTUARIES
ADAPTATION
COOPERATION
QUESTIONS
INTEGRATIVE
ADAPTATION
COASTS
Lena
meetings
change
ACCESSIBILITY
COMMUNITIES
policy
HYDROLOGY
estuaries
communities
COOPERATION
climate
EFFECTS
GOVERNANCE
geomorphology
Copyright 2013
tagxedo.com