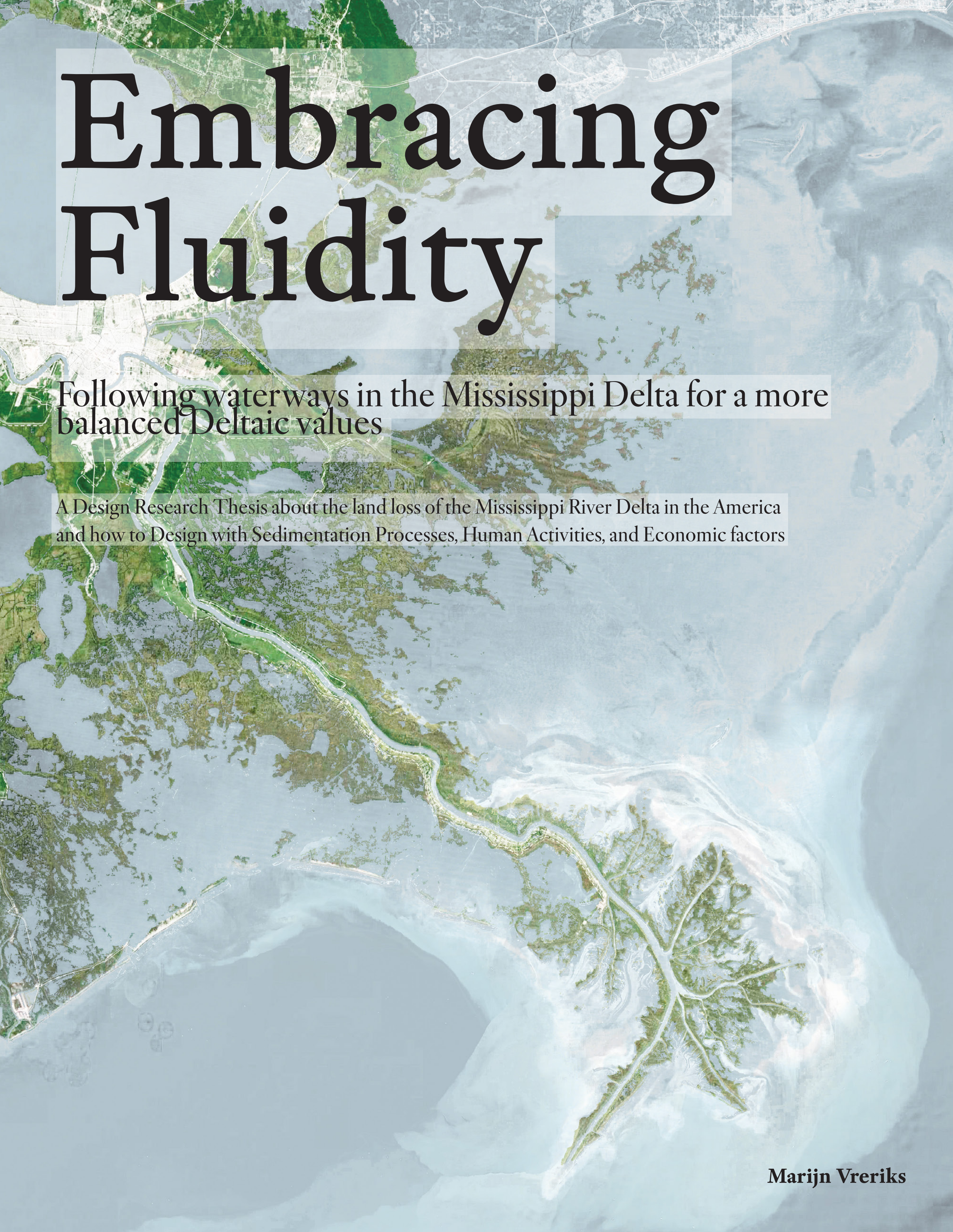

Embracing Fluidity

Following waterways in the Mississippi Delta for a more balanced Deltaic values

A Design Research Thesis about the land loss of the Mississippi River Delta in the America and how to Design with Sedimentation Processes, Human Activities, and Economic factors

Marijn Vreriks

Embracing Fluidity

Following waterways in the Mississippi Delta for a more balanced Deltaic values

COLOFON

Embracing Fluidity
Following Waterways for more Balance in the Mississippi Delta

Master Thesis Report
MSc Architecture, Urbanism and the Built Environment
Landscape Architecture Track

All images and illustrations are from the author, unless stated otherwise

Author:	Marijn Jonas Vreriks
Research Studio:	Landscape Architectural Princeples - LAP
First Mentor:	Ir. Denise Piccinini Lecturer Landscape Architecture Section of Landscape Architecture
Second Mentor:	Professor dr. ir. Anne Loes Nillesen Professor of Urban design Department of Urbanism
Examination Committee	Dr. ir. Negar Sanaan Bensi Lecturer| Architect | Researcher Chair of Borders & Territories

Department of Landscape Architecture
Faculty of Architecture and the Built Environment
Delft University of Technology
Delft, The Netherlands

P5 Report
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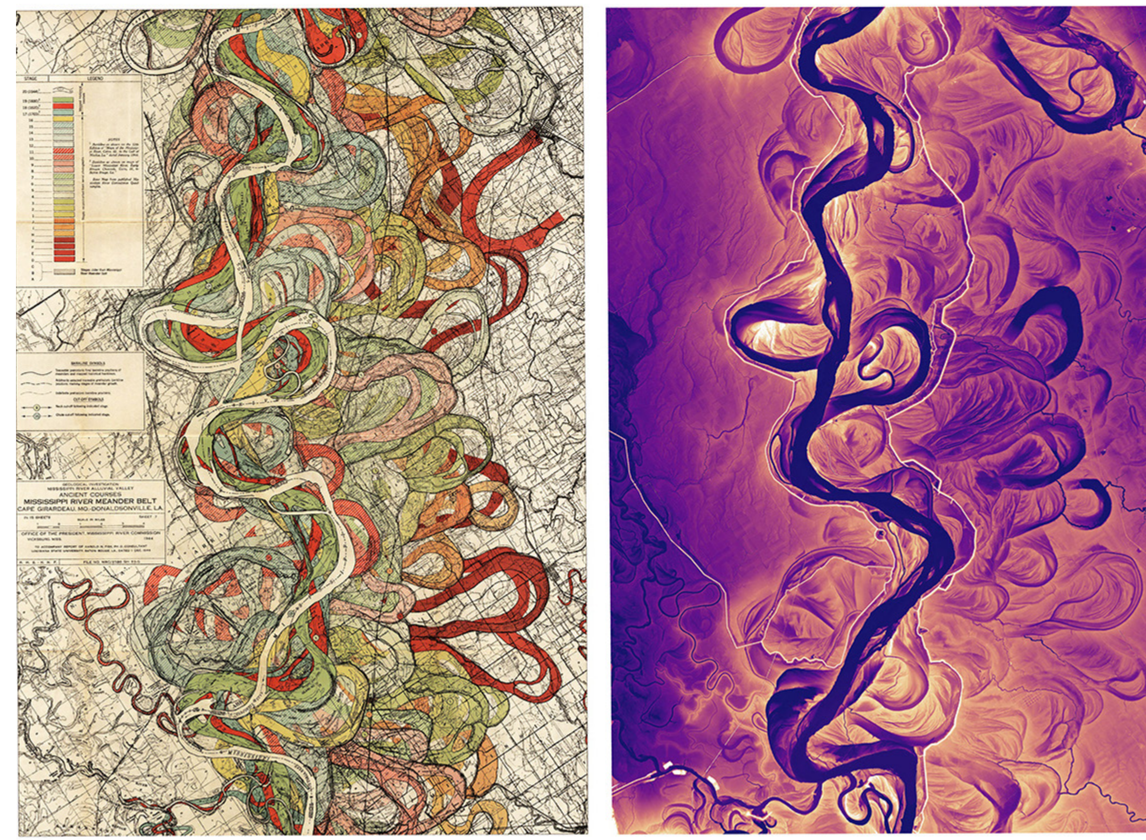
For further inquiries about the present Landscape Architecture
master thesis, please contact the author through the following email address:
marijn.vreriks98@gmail.com

Abstract

| **Mississippi Delta** | **Sediments** | **Landscape** | **Water** |
Anthropocene | **Resiliance** |

Delta landscapes are formed of dynamic natural, rich systems built up over thousands of years. Over time, the Deltas have been converted to the will of. Their strategic position for trade and the fertility of the lands are, among others, two clear conditions for human benefit. But what man did not consider was that with this exploitation the balance of natural systems in the Delta would be disturbed, leading to a decrease of the Deltaic value. With the pressing issue of urbanisation, sea level rise, and increase of temperatures Deltaic areas have to rely on balancing the natural system with Anthropogenic interest. This problem applies also to the Mississippi Delta in a relatively short period it has lost a great amount of sediments to the Gulf of Mexico causing a decline in size, which eventually resulted in a loss of local safety, economies, identity, and ecological value. This is a direct effect of the Anthropogenic system that has ignored the natural system. The rich history, the ecology, and the local economy need protection from future climate changes. A new attitude is needed to avoid more losses, not only of sediments but mostly of rich landscapes, ecologies and identity. An attitude where the natural system will be better understood and prioritized, where man-made interventions will be more in favour of increasing and maintaining this quite fragile and rich Deltaic system. Therefore a set of three main principles, supplying sediments, trapping sediments, and keeping sediments was established to direct an exploration of new ways of coping with the current problems and create new opportunities for the Deltaic system of the Mississippi.



Comparison of Plate 7 from Harold Fisk's 1944 report "The Alluvial Valley of the Lower Mississippi River" with a modern-day lidar derived image of the same area. (Carto, 2019)

Acknowledgement

I wish to thank my first mentor Denise Piccinini for her critical thinking and guiding methods during my project. You were able to make my project more nuanced and critical. I found joy and pleasure during my project.

Secondly, Anne Loes Nillesen thanks for the time and efforts you made in your busy schedule to give me tutoring on how to approach complex systems like the Delta. I appreciate the systemic approach you enabled in my project.

During my location visit to the Mississippi River Delta, I was able to talk to experts who deal with the Deltaic problems every day. First I want to thank Clinton S. Willson for showing me around the LSU River Center in Baton Rouge, I appreciate the time and effort you put into helping me understand the sedimentation and water processes of the Mississippi River. Second, Traci Birch helped me to activate the land usage of the Delta and the cultural value of the Mississippi River Delta. Thirdly, Richie Blink for showing me the Delta itself via a boat tour, I was able to take lots of pictures and see for myself how vegetation and animals are succeeding when sediments are introduced to the landscape.

In finalising my project I used the knowledge of the Faculty of Civil Engineering in determining how I should design with sedimentation processes. Stephan Toby thanks for your literature suggestions and enthusiastic impulse for my project. Tjerk Zitman for explaining how barrier islands are functioning and how to design them.

Further, I thank EFL-Stichting and NHBos for funding my field research in the Mississippi Delta. Without the funding, I would not be able to do such profound research and I would not meet the people who contributed significantly to my project.

Lastly, my co-students particularly Wessel Koolhaas and Filip Chládek for discussing and creating new perspectives in my project. Junjian Ju as well for lending me his camera for my field research.

Burning oil platform during the BP oil spill of 2010 in the Gulf of Mexico. (Fair, 2010)

DELTA DISCOVERY

EFL STICHTING

LSU

STICHTING N·H·BOS
ter bevordering van de landschapsarchitectuur

Content

People fleeing their homes during the aftermath of hurricane Katrina in 2005. (Doyle, 2019)

Anthropocene

The notion of the Anthropocene refers to humans becoming the main force that transforms the structure of the Earth. The word, first used by climate scientist Paul J. Crutzen (2016), defines a geological epoch that is thought to have begun a few centuries ago (specialists are still debating the issue) when human actions began to have lasting consequences on the geochemical balance of our planet. This period follows on from the Holocene – the interglacial period of the last twelve thousand years. Together with others that preceded it, they form the Quaternary period, which itself is part of the Cenozoic are that began more than 65 million years ago.

This notion is now widely used to refer to climate change and is intended to be written into long-term history. However, this is problematic for three reasons (Crutzen & Brauch, 2016), Firstly, it unifies the whole of humanity around the notion of Anthropos, but North Americans and Nigerians, for example, have quite different lifestyles and therefore different consequences on the geological structure of our planet. Secondly, it blames past modern generations and thus absolves contemporaries of their responsibilities. Finally, and most importantly, this "age of man" appears to be inescapable: because of its geological character, industrial and extractivist civilization appears to be part of a natural order. In Objectibe Earth: Designing Our Planet Kugler en Longfellow (2023) have therefore tried to reformulate the notion of the Anthropocene by pointing to its causes: Capitalocene (the age of money), Plantatiocene (colonialism), Entropocene (machine), Olysmocene (waste), Edentarocene (fossil extraction), Galiocene (intensive agriculture), etc. The Anthropocene underpins a new major narrative, wherein the power of man has led to essentially technological responses being made to social and environmental issues.

Delta

Deltaic areas are complex systems that represent a combination, and often confrontation, of dynamic natural environments with dynamic economic and urban developments. Discrete shoreline protuberances known as deltas are created when a river enters a body of water that is still and supplies sediments faster than basinal processes, like tides and waves, can redistribute them. This means that all deltas are dominated by rivers and that their basic nature is regressive (Bhattacharya, 2006). Often these places the largest and fastest-growing metropolitan regions of the world are taking advantage of their position in deltas, benefiting from the strategic position for navigation and the fertility of the landscape, at the same time while trying to deal with their vulnerability to flooding, salinization, and silting (Meyer & Nijhuis, 2014). This is in their nature; every day the delta grows with sediment and changes determined by flows of water, only for a big storm or high tide to take away big chunks of land. For humans, this can be disastrous but for delta nature, this is part of its system (Sijmons et al., 2017).

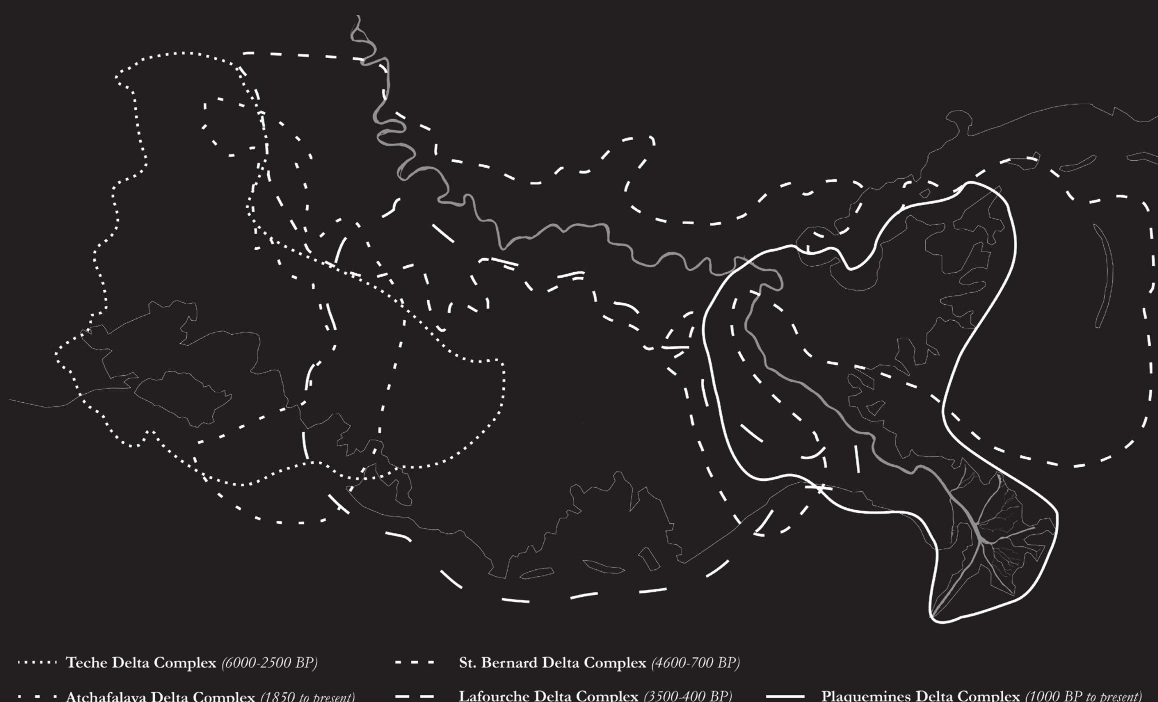
Based on ocean waves and river discharge regimes various Delta types can be formed. Delta morphology and internal stratigraphy are primarily the product of an interplay between fluvial sediment input and the reworking of sediment by marine or lacustrine processes (Galloway, 1975). It is important to know what kind of Delta you are dealing with to create a framework to operate a design in. Wright and Coleman (1973) established three delta types that are defined by oceans and rivers; (1) river-dominated, (2) tide-dominated, and (3) sea-dominated. The MRD is river-dominated. However, deltas become over time hybrid; partly natural and partly anthropogenic (Meyer & Nijhuis, 2014; Sijmons et al., 2017). The MRD is a river and anthropogenically influenced delta, therefore river aspects should be taken into account just as the anthropogenic aspects.

Deltaic Plain

This term is made of two different words, 'Delta' and 'Plain', and together they form an important word throughout the whole project. Beginning with the word 'Delta', there is a legend that the Greek historian Herodotus coined the name Delta, referring to the similarity of the form of the Nile Delta with the Greek letter A (Meyer & Nijhuis, 2014). Whether the legend is true or not, what matters is the meaning: the word delta refers to the final part of a river, with several distributaries, and alluvial land created by the sedimentation of rivers and seas. Not all rivers form deltas in this strict sense.

Whereas 'Plain' is less old than the word 'Delta', it still has a powerful meaning. Deriving from the Old French language, meaning an expanse of land with relatively low relief and few trees, especially a grassy expanse. This vastness and flatness is something humans can only comprehend when they experience it, it is a place where you can see the horizon endlessly evolving around you.

Together these words entail the whole flat area of the river mouth. In the Mississippi River Delta, there is almost no such thing anymore since humans have fragmented this place with objects. This term will be used to refer to the area that has been shaped or is shaped by the Mississippi River in any form.



Levee

The word 'Levee' can go by many names, as we use the meaning of the word, we often use the word 'Dike' in Dutch. But since the design location is in America the American word will be used. Most of us might know the meaning of this word, but it is still good to give a definition, and then mainly focus on the landscape aspects of the word.

To start with the more technical definition of a levee, dike (American English), dyke (Commonwealth English), embankment, floodplain, or stop bank is a structure used to keep the course of rivers from changing and to protect against flooding of the area adjoining the river or coast (contributors, 2024). It is usually earthen and often runs parallel to the course of a river in its floodplain or along low-lying coastlines.

The levee separates the river from its floodplain to protect human settlements, agriculture, and other human important areas. But by separating the river from its floodplain the river gets canalized, and the natural course of the river is restricted. This can lead to higher water levels, which, as can be seen under the definition of 'Crevasse', puts more pressure on the water management of the river.

Mississippi River Delta

The Mississippi River Delta is part of the Deltaic Plain, described previously, and refers to the current Delta landscape that has been shaped by only the Mississippi River. As the course of the Mississippi River changed over the last 6,000 years, sedimentary deposits resulted in a series of 16 distinct river deltas, also called deltaic lobes (Harris et al., 2016). The majority of these deltaic lobes are grouped into three of the five delta "complexes" seen here: the Teche, the St. Bernard, and the Lafourche. The modern Plaquemines Delta Complex forms the "bird-foot" Mississippi River delta that we are familiar with today, while the Atchafalaya Delta Complex is mostly the result of the man-made diversion of water by a U.S. Army Corps of Engineers project completed in 1963 (Day & Erdman, 2018).

If referred to the Mississippi River Delta the Plaquemines Delta Complex is meant, and therefore the most active part, in terms of natural processes, of the Deltaic plain.

Nature-based Solutions

Among the several definitions of NBS, the more comprehensive is "actions that conserve, manage or restore nature to support biodiversity to help address societal challenges, empower people and provide job and business opportunities can be powerful tools for combatting biodiversity loss and supporting climate change mitigation and/or adaptation and disaster risk reduction while delivering further benefits to human well-being (e.g. health) (Croci & Lucchitta, 2022)." Depending on their context, NBS is also framed as Ecosystem-based Adaptation (EbA), Green Infrastructure (GI), Ecosystem-based Disaster Risk Reduction (EcoDRR), or Natural Water Retention Measures (NWRM).

Three main types of NBS can be individuated (Eggermont et al., 2015):

- solutions that involve making better use of existing natural or protected ecosystems;
- solutions based on developing sustainable management protocols and procedures for managed or restored ecosystems;
- solutions that involve creating new ecosystems.

These kinds of solutions can address several urban challenges, thanks to the multifunctional characteristics of ecosystem services. Ecosystems in healthy condition provide a variety of functions and deliver multiple services contributing to benefit society. The main functions include: improving the environment, making cities more attractive, enhancing human well-being, restoring degraded ecosystems, developing climate change adaptation and mitigation, and improving disaster risk management and resilience (Bauduceau et al., 2015).

Resilience

The concept of resilience and its applicability to ecological, social, and management systems has been investigated extensively by an international group of researchers led by two noted ecologists, Lance Gunderson and C. S. Holling (2002). They have developed a general theory of adaptive cycles, arguing that all systems exhibit similar patterns of slow accumulation of resources, increasing connectedness, and decreasing resilience, punctuated by periods of crisis, transformation, and renewal (Holling, 2001). Based on an understanding of these patterns, humans may be able to intervene in appropriate ways that take advantage of the system dynamics rather than merely resisting change (Fiksel, 2003).

(i) System a is typical of engineered, highly controlled systems. It operates within a narrow band of possible states and is designed to resist perturbations from its equilibrium state. It recovers rapidly from small perturbations, but it may not survive a large perturbation. We call this a resistant system.

(ii) System b is typical of social and ecological systems. It can function across a broad spectrum of possible states and gradually tends to return to its equilibrium state. Through adaptation and evolution, it is capable of surviving large perturbations. We call this a resilient system.

(iii) System C is even more resilient than System B in that it can tolerate larger perturbations. Under certain conditions, it may shift to a different equilibrium state, representing a fundamental change in its structure and/or function. (Walker & Salt, 2006).

Resilience is the ability of a system, whether this is a natural system or a human system, to be able to deal with change. This does not necessarily mean that the system has to overcome this change, but that the system can establish a new equilibrium while maintaining its function.

(i) Resistant system *(ii) Resilient system* *(iii) System with multiple equilibrium points*

Scale-continuum

Landscape architecture, inherently interconnected with its context, considers various scales—physical, geological, hydrological, social, political, and ecological. The landscape is a space on the surface of the earth, with its distinct character, either topographical or cultural, and above all a space shared by a group of people (Jackson, 1985). Viewing landscapes from both distant and proximate perspectives is crucial, as it combines visual and tactile experiences (Lassus, 1998), this is a telescopic succession of spaces. As depicted in, the small movie, 'Powers of TenTM' (Office, 2010) this telescopic relation between 'things' can range between many scales possible. Design interventions impact not only the designated site but extend to larger systems and diverse stakeholders, emphasizing the need to understand the interrelations between intervention, influence, and effect (Burns & Kahn, 2020).

Sediment

Sediment refers to solid material that is transported and deposited by wind, water, or ice. It can consist of particles of varying sizes, including sand, silt, clay, gravel, and even larger rocks. Sediment can originate from various sources, such as weathering and erosion of rocks and soil, volcanic ash, or the remains of living organisms (Blum & Roberts, 2009). In the context of the Mississippi River Delta, sediment is particularly important because it contributes to the growth and maintenance of wetlands and landforms in the deltaic region. However, human activities like channelization and dam construction can disrupt the natural flow of sediment, leading to erosion, loss of land, and other environmental challenges.

(Dis)tributaries

(Dis)tributaries are smaller rivers or streams that flow into a larger, main river, contributing water, sediment, and nutrients. They originate from various sources like springs or lakes, joining the main river at confluence points. Tributaries increase the volume and flow of water, shaping the main river's drainage basin.

Distributaries, on the other hand, branch out from the main river, carrying water and sediment away to form complex networks in deltaic regions. They play a crucial role in depositing sediment and building landforms, particularly near the river's mouth. Distributaries distribute water across deltas and floodplains, contributing to the dynamic landscapes of these environments.

Wetland or Marsh

A wetland is an area of land where the soil is saturated with water either permanently or seasonally. These areas are characterized by the presence of water-tolerant vegetation, such as marshes, swamps, and bogs. Wetlands play vital roles in ecosystems, serving as habitats for diverse plant and animal species, filtering pollutants from water, and providing flood control by absorbing excess water during storms. They also contribute to nutrient cycling and carbon sequestration, making them essential components of healthy landscapes.

Glossary

Motivation

My intended topics for my thesis were related to human-defined landscapes, national borders, urban settlements, or industrial sites. Further research was required to find a good location and enough available materials to base my thesis on. I started reading news articles related to my ideas searching for a clue or trigger. On one of the websites I generally read news I found an article that caught my attention; 'As the Mississippi Swerves, Can We Let Nature Regain Control?' (Lewis, 2023). This one sentence stuck with me for a couple of days and questions arose; why doesn't the Mississippi River have control? What will it mean for the landscape if the river retakes control? And what will this mean for the people who live there? I knew little about the MRD to imagine how it looked and who lived there. Some things I did know, hurricane Katrina in 2005 and the BP oil spill of 2010 struck this area and caused a lot of damage to the environment. But what I didn't know was that the Mississippi Delta was the USA's No. 1 producer of crude oil, No. 2 in petroleum refining capacity, and No. 3 in natural gas production (Lam et al., 2018). And that the Delta was dealing with huge wet-land loss, which endangered the ecological values and inhabitants of the Mississippi Delta. (Clark & Norman, 2022; Depp, 2021; Edmonds et al., 2023; LSU Research Team, 2023; Willis, 2020).

The complexity of systems that are interwoven and dependent on each other is very present in the MRD, and therefore it is well suited for this graduation studio. Only for me, the social and environmental aspects played a big role in choosing this location. I have always been attracted to global issues and the human aspects of these global issues. These kinds of issues call for problem-solving and that is something I would like to do, contribute to living environments, deal with change, and make plans for a sustainable future. All of these aspects come together in the Mississippi Delta, which makes this place for me ideal to portray my ideas and develop myself as a complete landscape designer.

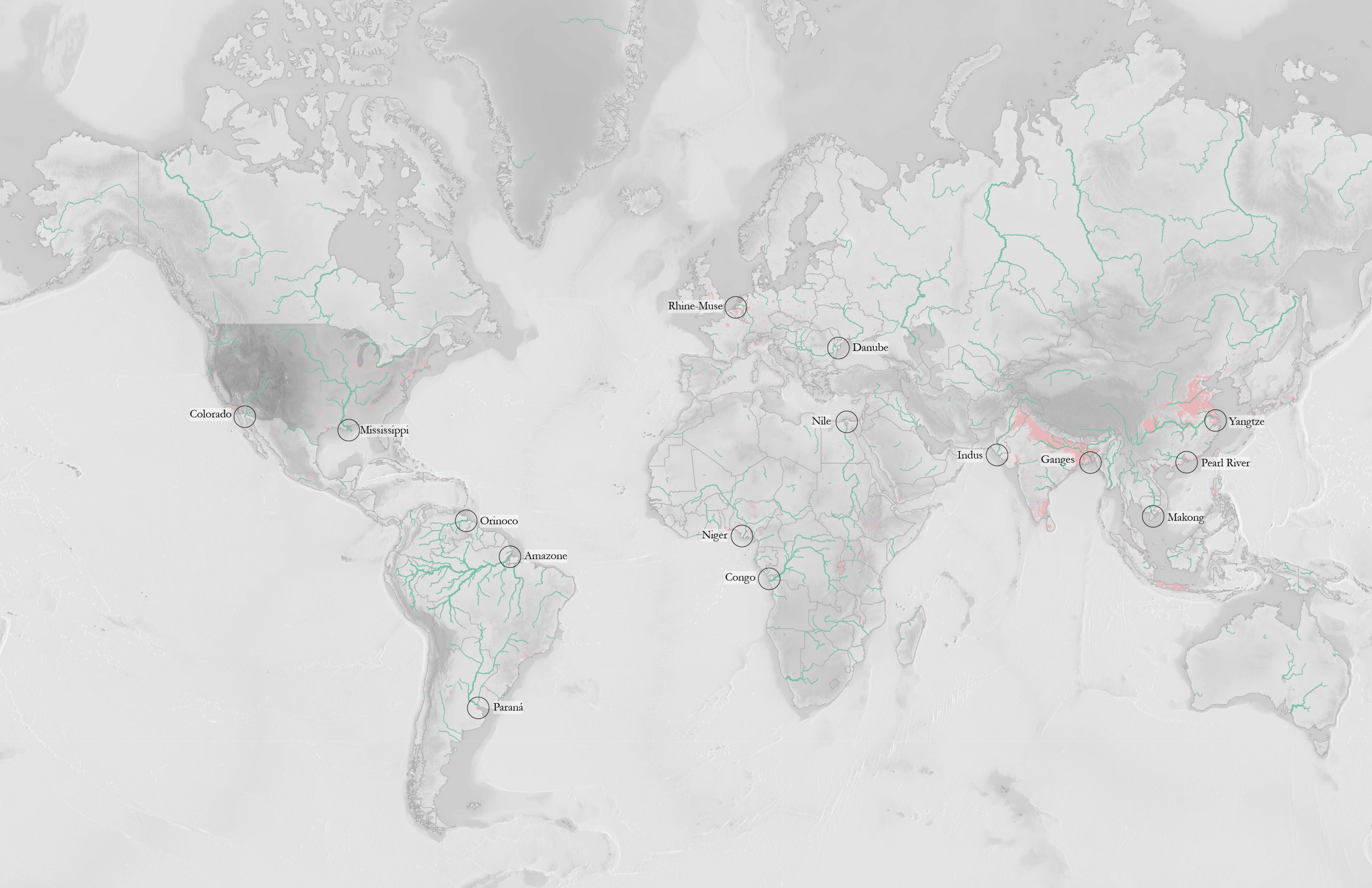
Anchored shrimp boats near the Mississippi River Delta, on the horizon oil and gas platforms. *Images by Delta Discovery Tours (2023)*

The delta is home to thousands of wintering waterfowl, wading birds, secretive marsh birds, raptors, shorebirds, and more. In the images seen Brown Pelicans and American White Pelican on a barrier island. *Images by Delta Discovery Tours (2023)*

Mississippi Delta
An Anthropocene Delta Landscape

Image from Besaw (2021) edited by Author

Part I The Anthropocene Landscape


Rhine-Muse
Danube
Colorado
Mississippi
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Yangtze
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Ganges
Pearl River
Makong
Orinoco
Niger
Amazone
Congo
Paraná


Washington
Oregon
California
Nevada
Idaho
Montana
Wyoming
Utah
Arizona
Colorado
New Mexico
North Dakota
South Dakota
Nebraska
Kansas
Oklahoma
Texas
Minnesota
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Kentucky
Tennessee
Mississippi
Alabama
Georgia
Florida
South Carolina
North Carolina
Virginia
West Virginia
Pennsylvania
New York
Maryland
Delaware
New Jersey
Vermont
New Hampshire
Massachusetts
Rhode Island
Maine

Introduction

Embedded downstream of most of Northern America lies the Mississippi River Delta (MRD), a region whose significance is only understood when zoomed out to the scale of North America. Despite its appearance of tranquillity, this terrain is a canvas of the relentless force of water over millennia. From above, it may appear like the waters have receded, leaving a seemingly tranquil landscape behind. However, beneath this first impression lies complex layers of history, geology, water management, and ecological dynamics.

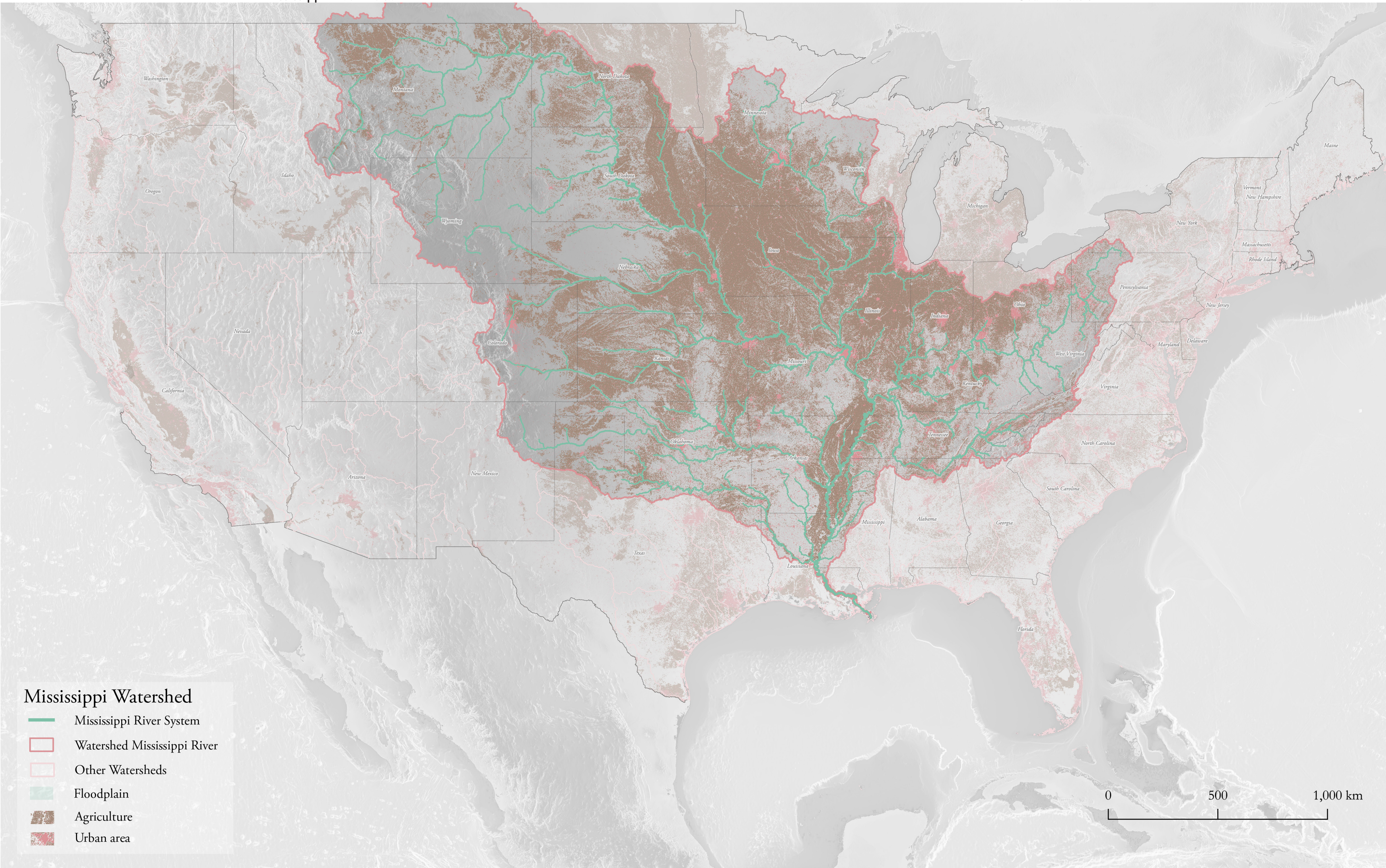
The Mississippi River (MR), once a mighty force shaping the land, now only occupies a fraction of the Delta it once dominated. Yet, the region bears witness to the immense power of sedimentation, a process spanning thousands of years. This sediment, accumulated over epochs, tells the story of a river in perpetual motion, shaping and reshaping the land with each passing era. The discharge of the MR is the fifteenth in the world, splurging 16.790 m^3/s of water into the Gulf of Mexico (Service, 2020).

In the present day, the Mississippi's course dictates the destiny of cities like Baton Rouge and New Orleans, along with countless smaller communities. Yet, this alignment is but a small interface in the river's journey. The landscape we perceive is a fraction of its true evolution, as water continues to leave its mark across the ages, depositing layers of sediment that shape the very fabric of the land. Additionally, the total amount of sediment carried by the Mississippi and Atchafalaya Rivers has been reduced from 500-400 million tons per year to about 150-200 million tons per year (Allison et al., 2012; Meade & Moody, 2010). This reduction in the amount of sediment carried by the river is the result of changes in land management practices that have reduced sediment runoff from the drainage basin and the trapping of sediment behind dams and locks constructed along the Mississippi and its tributaries, particularly the Missouri River (Meade & Moody, 2010).

Moreover, the coastal zone encompassing this region holds profound ecological significance. It is a mosaic of diverse ecosystems and resources, serving as a vital hub for various stakeholders. However, the spectre of climate change looms large, threatening to disrupt the delicate balance of these estuarine systems. The increasing frequency of extreme events poses a tangible risk, potentially upending the equilibrium of these ecosystems and impacting their biodiversity and productivity.

Amidst this rich context of natural and human influences, the Mississippi location stands as an indispensable artery of commerce. It serves as a vital shipping route for the United States, facilitating trade and commerce on a monumental scale. Moreover, the region boasts a burgeoning fossil fuel industry, further underscoring its economic significance on a global scale.

In essence, the Mississippi location embodies a convergence of natural forces, human endeavours, and ecological complexities. It is a landscape shaped by the relentless march of time and the indomitable power of water—a testament to the intricate interplay between nature and civilization.


Mississippi Watershed
Mississippi River System
Watershed Mississippi River
Other Watersheds
Floodplain
Agriculture
Urban area
0
500
1,000 km
Washington
Montana
North Dakota
Minnesota
Maine
Wisconsin
Idaho
Oregon
South Dakota
Vermont
New Hampshire
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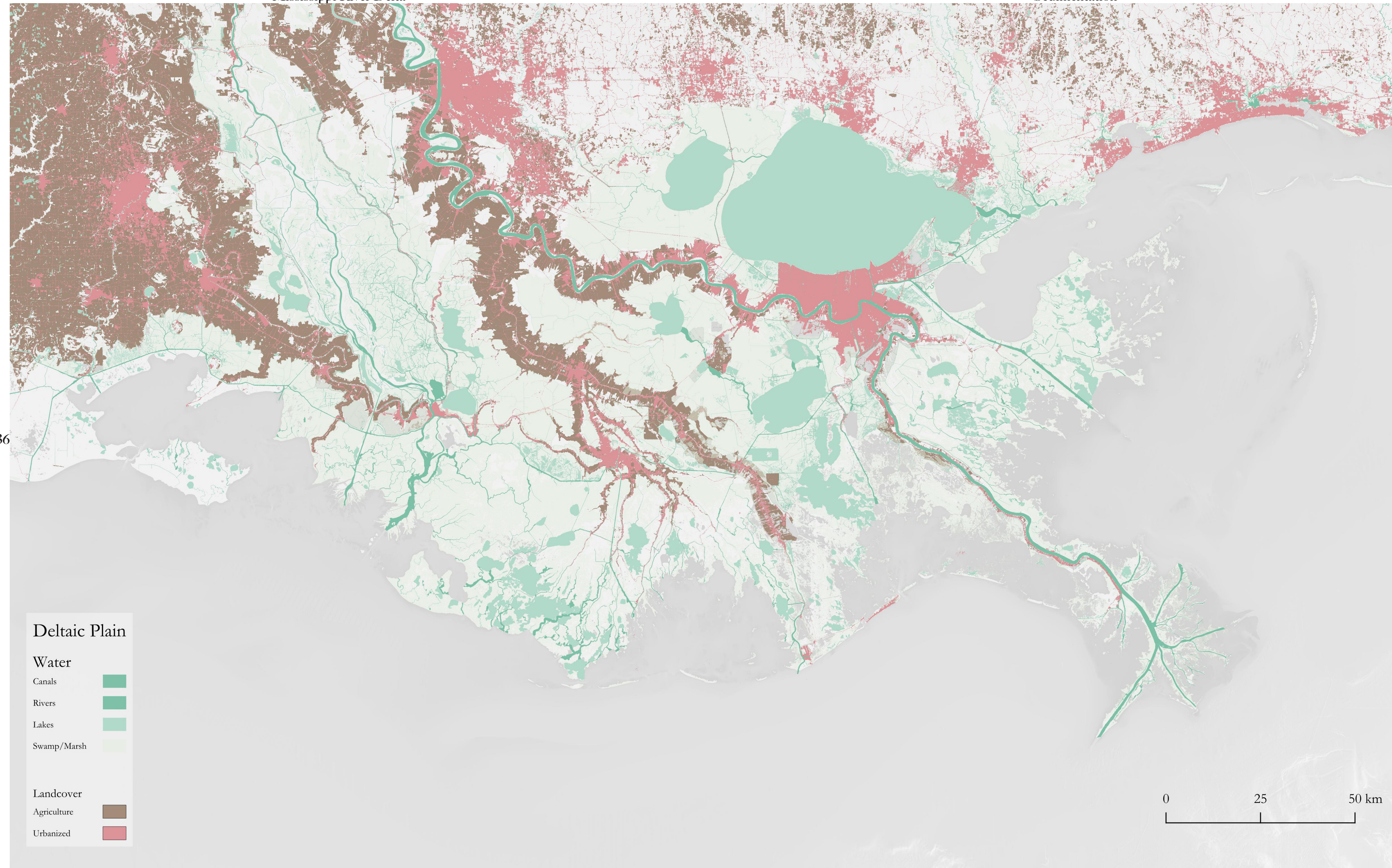
Louisiana
Florida

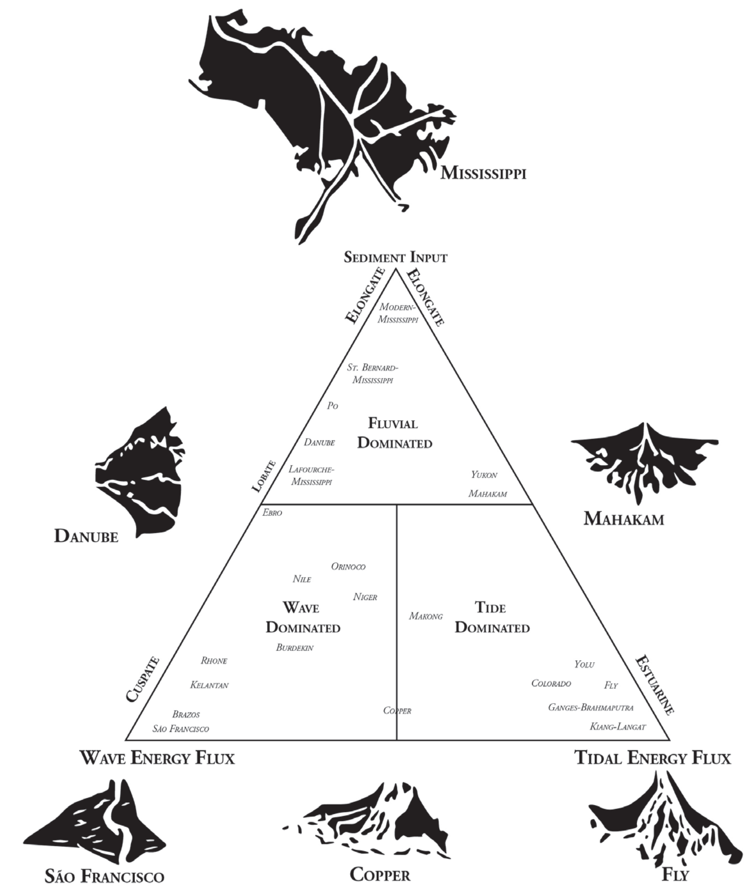

Deltaic Plain
Water
Canals
Rivers
Lakes
Swamp/Marsh
Landcover
Agriculture
Urbanized
0
25
50 km

Global Delta Issues

Rising sea levels are often pointed out to be the cause of vulnerability and floods of the delta landscapes (Nicholls & Cazenave, 2010). However, sea level rise has been something that has occurred since the last Ice Age, thousands of years ago. Delta areas are built by natural processes that took thousands of years, sediment rivers carry uncountable amounts of sand towards the mound of the river where it got disposed, and together with the sea currents a deltaic landscape appears. This long period is an ongoing process, where land is given by the rivers and sea, but also taken by them. Some processes are for a long durée others can happen quickly. From the natural perspective, a dynamic delta landscape is as normal as it has ever been, however, human interferences made the dynamic landscape static, and urbanization, flood defense systems, and water management are not made for dynamic occurrents (Blum & Roberts, 2012; Edmonds et al., 2023; Kesel, 2003; Törnqvist et al., 2008; H. J. Walker et al., 1987; Writer, 2023). Maintaining the current laid-out systems means intensifying the construction of ports, dredging shipping routes, and increasing water management for agriculture, which will lead to immense costs and a buildup of flood, subsidence, salinization, and land loss risks. This will lead to a serious decay of Delta's growth.

All deltaic plains face the same problems, as soon as human settlements started to urbanize quickly and exploit the lands of deltas, especially during the industrial area of the nineteenth and twentieth centuries, changes happened rapidly and fundamentally (Meyer & Nijhuis, 2014; Nillesen et al., 2016). In most urbanized deltas the urbanization that happened

Diagram of Delta Types

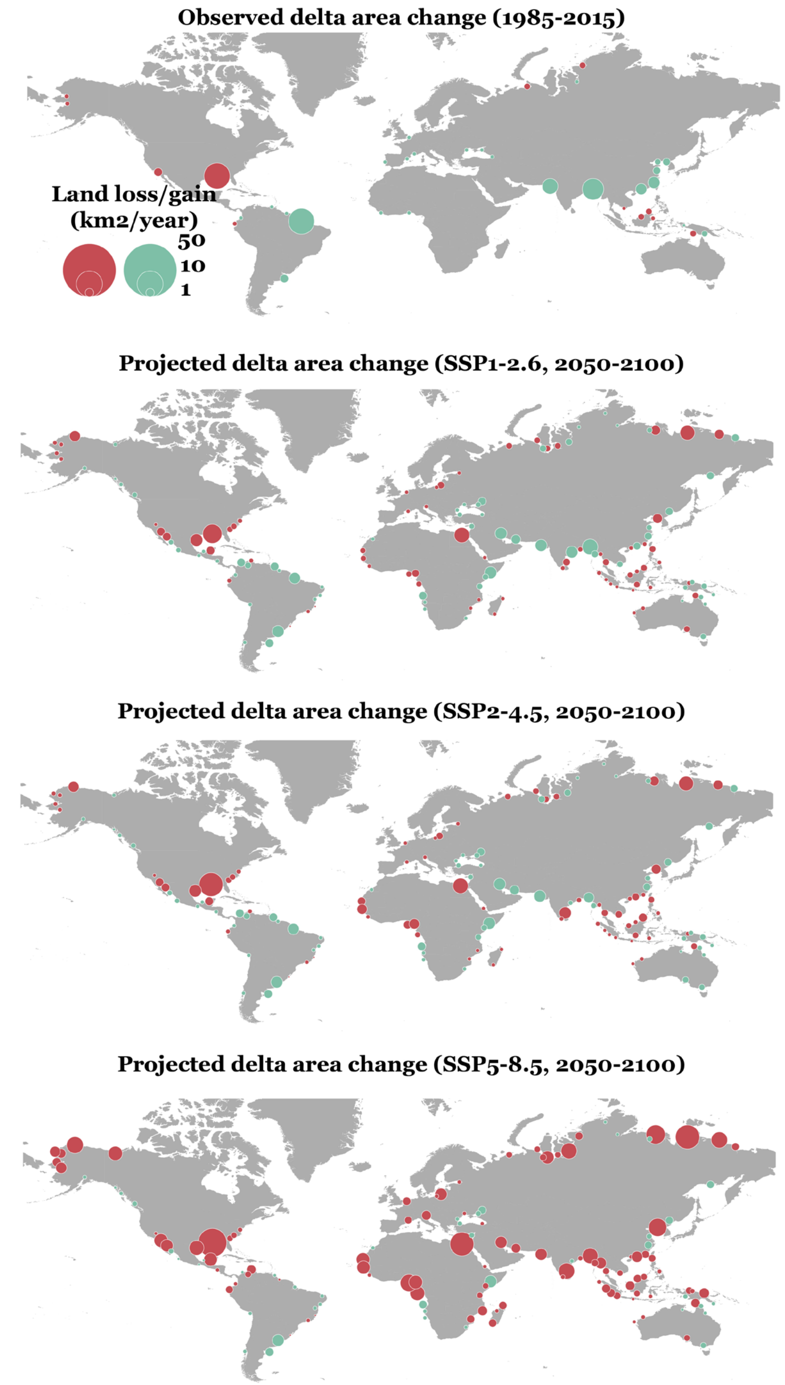


Classification of river deltas according to processes dominant in shaping of delta plains. Marine deltas can be characterized in terms of three end-member types: (1) fluvial-dominated deltas, (2) wave-dominated deltas, and (3) tidal-dominated deltas.
Diagram retrived from Galloway (1975)

together with drainage of the lands, navigation routes on water, and flood defense structures has transformed the natural systems of the deltaic plain. The slow natural process of land formation is changed into land subsidence and erosion, floodplains were canalized, fresh to salt water gradient disappeared and natural land surfaces changed into new functions (Meyer & Nijhuis, 2014). Resulting in the decline of Delta sizes over time, as illustrated in the picture to the right. The lack of room for water in these systems caused heavy flooding, as an answer, humans intensified their flood defense infrastructure. This creates potentially, more hazardous situations in deltaic areas, with pressing issues of climate change acting as a catalyst.

The Mississippi Deltaic plain is, just like most deltas, facing these issues of urbanization, human interventions, and land exploitation. Hurricane Katrina in 2005 perfectly exposed the vulnerabilities of the delta. During this category 5 hurricane water levels rose to a maximum of 9m+MSL, mean sea level, and the flood defense systems failed at 50 places along the MR, causing $81 billion in damage (Van Ledden et al., 2012). These excessive weather conditions call for action and a revision of the water system in the Lower Mississippi Delta. The current water system and flood defense system have proven to be insufficient. They cannot support stability for inhabitants of the Delta as for the valuable ecosystems in the MRD.

Varied futures for the world's deltas



Source: adapted from J.H. Nienhuis et. al.
AR Earth and Planetary Sciences 2023

Mississippi Delta
A Floodable Delta Landscape

Image from Doyle (2019) eddited by Author

Historic Events

The Delta we see now is shaped by humans, over a long period, based on the fundaments that nature has created. Once the MR dictated the landscape of the Delta, now nature was cornered into a rigid system with no possibility to move freely. How did the MRD become this rigid system and why did humans want to tame the mighty Mississippi? A small introduction is given on this topic by three past major events.

The first was the discovery of the Delta by European sailors, who later settled along the riverbanks of the MR. Before European arrival, the indigenous people of America lived in the Delta for hundreds of years. Settled on artificially made hills – called kitchen middens – they protected themselves from the seasonal floodings and storms of the Delta (Day & Erdman, 2018; Russo, 2008). The landscape they lived in was rich, from thick Bottomland Hardwood forests to widespread salt marshes, food was plentiful. Only European settlers did not know how to use the landscape as the indigenous people did. The settlers saw the same richness of the Delta, only to use it differently. By strategically placing their first settlement, now New Orleans, on a natural levee they wanted to control the area for trade and military reasons (Lam et al., 2018).

Secondly interfering with the natural water system, over time the seasonal spring floodings were complicating the rapid development of this area, and the people wanted to protect themselves from the floodings. The city of New Orleans was quickly expanding and to feed all the people more land should become arable. To protect the city and agricultural fields the first levees arose along the banks of the river (Day & Erdman, 2018; Lam et al., 2018). Over time the levee system was implemented along the whole river, resulting in the closing of the river branches, swamps, and wetlands from the seasonal floodings. What has not been considered was that the canalization of the MR would lead to immense pressure on the water system when extreme water conditions occur, eventually, this resulted in the big flooding of 1927 (Barry, 1997).

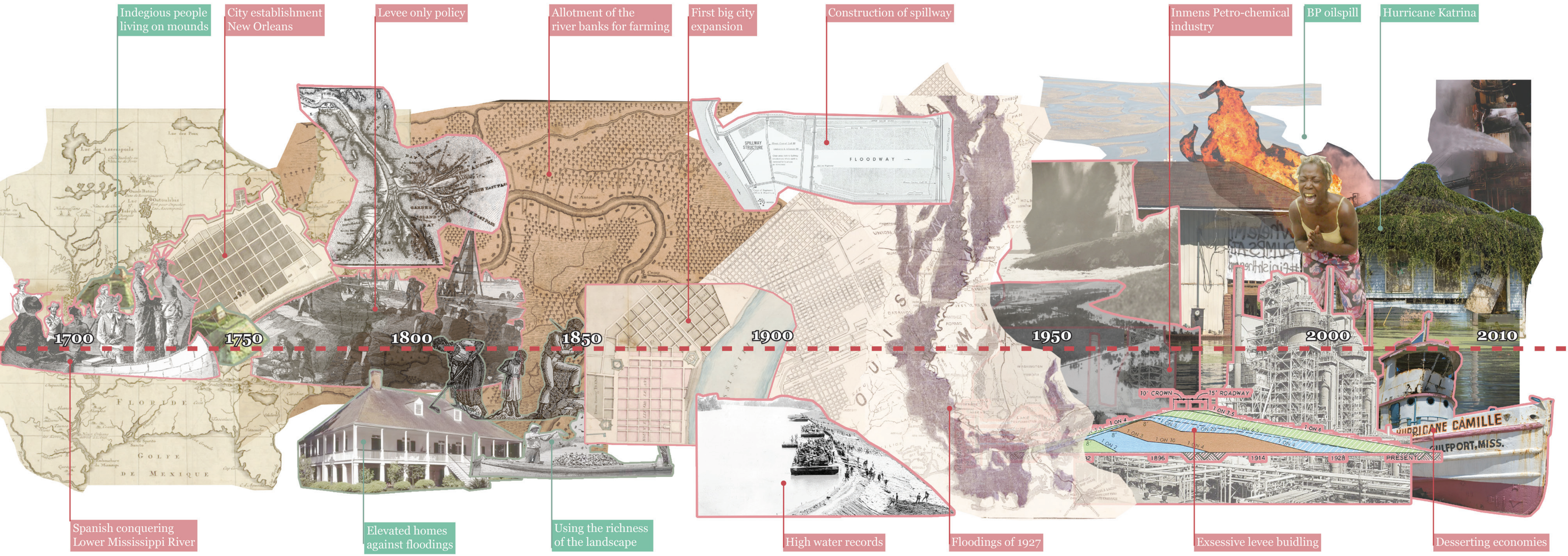
Lastly the start of extracting fossil fuels from under the marshes of the Delta. The first discovery of the existence of fossil fuel in the Delta was around 1930 (Day & Erdman, 2018). After the flood of 1927 the region could use an economic boost, and fossil fuel extraction began, peaking between 1960-1970. The extraction led to land subsidence in the whole Delta, but mainly in the marshes (Bernier et al., 2006; Blum & Roberts, 2012; H. J. Walker et al., 1987; Writer, 2023). To sell and distribute the oil and gas, Petrochemical plants were constructed along the MR, connecting the wells with pipelines to the plants resulting in pipeline canals throughout the whole delta landscape. The MR developed into a complex harbour system with sea-worthy ships that need a deep river bed, leading to a riverbed depth of around 50 meters from Baton Rouge to the Gulf of Mexico.

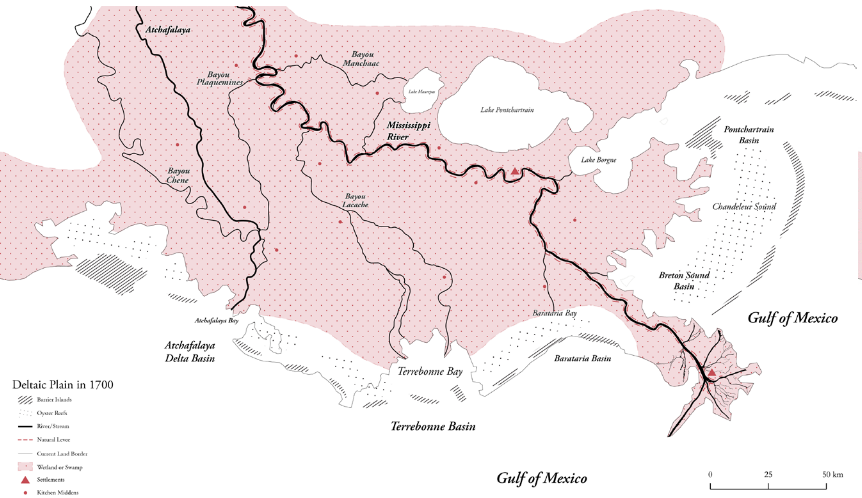
Concluding these three key factors that have led to the Delta we use and see now. In this decade a fourth key factor will be added to the shaping of the Delta. The eroding marshes, intensification of weather conditions (hence hurricanes), limitation of the water system, and the rise of sea levels are endangering the future of the Delta and its people. These changes are directly or indirectly related to the previous changes in the Delta, which just now become visible. The section shows in images the major events over time that have shaped the Delta, human settlement at the beginning of 1700, water management from 1800 and forward, and oil and gas extractions at the beginning of 1900. Concluding with the catastrophic events of the last two decades.

Catastrophic events of the last two decades in the Mississippi Delta.
Above the BP oilspill in 2010 (Fair, 2010), below the floodings during of Katerina in 2005 (Doyle, 2019).

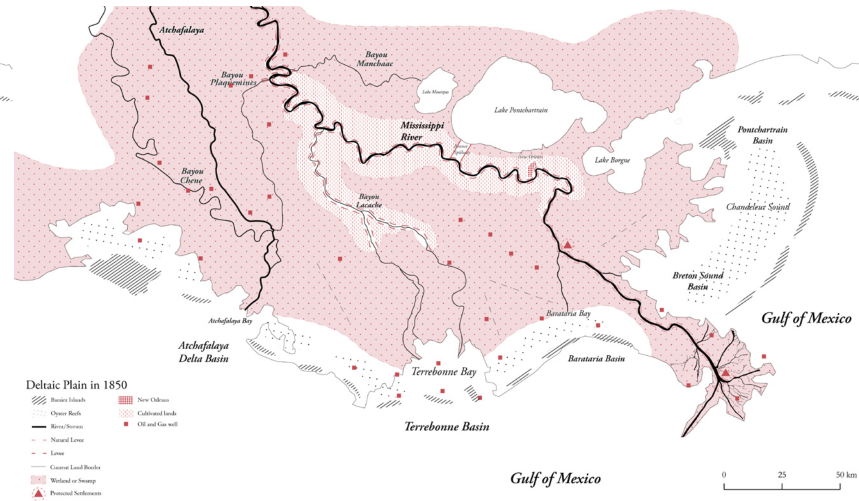
Mississippi River Delta

Sedimentation

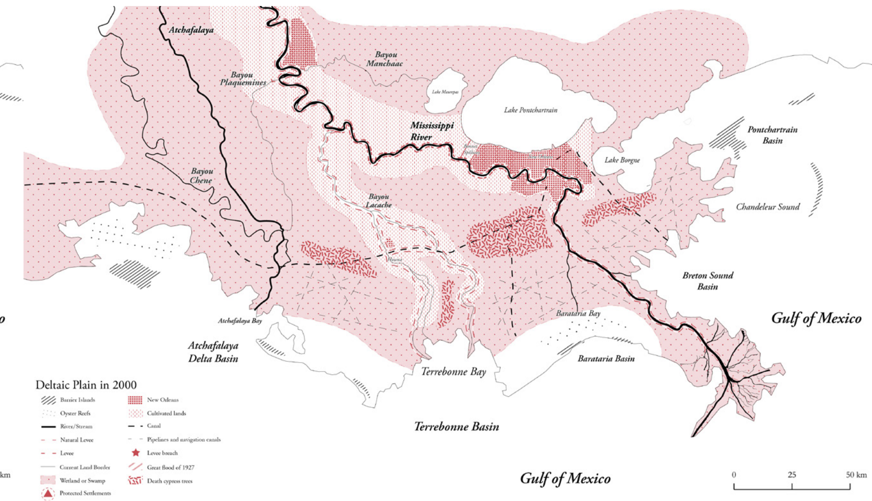




In the early 18th century, the Mississippi River Delta underwent significant changes driven by the challenges of sand banks and oyster reefs recognized by French sailors in 1718. To improve navigation, artificial levees were constructed near New Orleans in 1726, reaching a height of 4 to 6 feet and extending 30 miles upstream and 12 miles downstream. Concurrently, houses on poles adapted to the delta's dynamic environment, and agricultural experimentation, notably rice farming, began in 1745. This period marked a convergence of environmental management, infrastructure development, and agricultural innovation in response to the evolving needs of the delta's inhabitants.



In the early 19th century (1800-1850), the Mississippi Delta saw significant developments in landscape and infrastructure. Levees, initially extended to Baton Rouge and Bayou Lafourche in 1803, showcased early efforts to control the river's flow. By 1812, extensive levee expansion below New Orleans occurred, with 155 miles on the east bank and 180 miles on the west side. The construction aimed to mitigate flooding risks and enhance agricultural potential. In 1816, a proposal for a spillway east of New Orleans emerged, realizing in 1849 as Bonnét Carré, providing controlled water outlet. Successful flood control instances included a 1.5-foot levee in College Point and a 7.5-foot levee in Morganza, demonstrating their effectiveness in managing floodwaters.



Between 1950 and 2000, the Mississippi Delta underwent significant changes marked by intense urbanization and economic expansion. Post-World War II, urban sprawl led to the emergence of vast residential areas in the swamps, with buildings constructed in marshlands due to limitations in traditional pole construction. The demand for deeper shipping canals and the growth of the fossil fuel industry resulted in the construction of extensive draglines and pipeline canals spanning 16,000 kilometers. This had detrimental effects on cypress trees, oyster banks, and barrier islands crucial for coastal protection. The environmental impact highlighted the intricate balance between human development and the preservation of the Delta's unique ecological characteristics.

Anthropogenic Problems

Urbanizing Deltas comes with a wide variety of challenges and problems including, flooding, salinization, lack of space, and the complexity of water management (Meyer & Nijhuis, 2014). In the MRD, this is nothing new. The land was built by the sediments carried by the MR. This process took thousands of years resulting in multiple different deltas and eventually became the bird-foot delta now recognised as the MRD (or Plaquemines-Modern).

The natural system that shaped and defined the delta for a long period should now have to fit in the rigid system humans designed for their benefit. Various floods have pointed out the weak spots, only engineers to respond with a more rigid system that controlled the river even more. The water systems and the exploitation of the delta landscape have led to the natural system disappearing which is vital for a delta to sustain. The canalization of the rivers, building of dams, and closing of the river distributaries has led to sediments carried by the river not being able to deposit in the surrounding wetlands, but disappearing in the Gulf of Mexico, the natural land accumulation has disappeared over time. Not only did the water management principles lead to the disappearance of sedimentations, but oil and gas extraction from the sub-surface of the delta contributed (Chamberlain et al., 2018; Day & Erdman, 2018; LSU Research Team, 2023; Writer, 2023). The construction of pipelines in the wetlands has led sea water to intrude into the wetlands and take sediments with them to the sea. Further, the extraction of fossil fuels has caused the land

The Mississippi Delta has been built and still is being built by the sediments carried via the river. Before human interventions in the Mississippi water systems the river carried enough sediments to the delta to sustain itself, and it slowly grew into the Gulf of Mexico. In this schematic images the sediment supply is shown in metric tonnes a year, before major human interventions. Data is based on maps from Seibert and Doyle (2014).

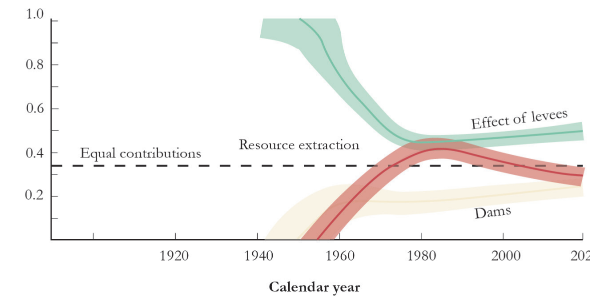
Between 1953 and 1962 dam construction increased mainly in the more mountain areas of the Mississippi watershed. The first decline in sediment carried by the river is visible.

After 1962 dam construction staggered but the impact it had on the sediment carried by rivers is still present. Although other studies point out that the land loss in the Mississippi Delta are merely related to the construction of dams in the Mississippi watershed, see (Edmonds et al., 2023; Upholt, 2023; Writer, 2023). According to Chamberlain et al. (2018) and Day and Erdman (2018) the Mississippi River still carries enough sediment to restore parts of the Mississippi Delta, if used correctly.

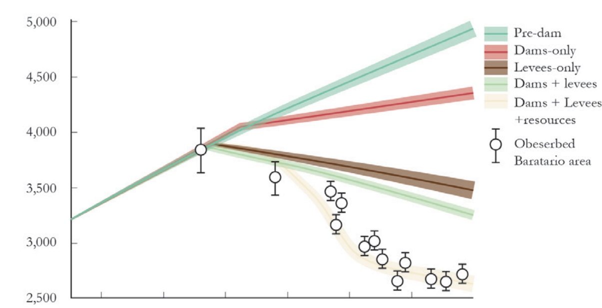
to subside, which caused the wetlands to sink, and therefore vegetation disappeared and sediments were easily taken away by the sea. The disappearance of sediments can be called (wet) land loss. Many of the human interventions designed to tame the delta create new, unforeseen hazards, which are countered with new interventions. This is the paradox of the human delta: by making the delta safer, we introduce new insecurities (Sijmons et al., 2017).

(Wet)Land loss is problematic for various reasons, endangerment of unique ecosystems, displacement of people, local industries (such as fisheries) are threatened, and increase of flood risks. Inhabitants of the MRD are often faced with the possibility of flooded homes or disappearing jobs, a direct link with land loss is difficult to say. Lam et al. (2018) studied the differences between communities in low-lying parts of the MRD and higher parts of the MRD. They concluded that low-lying parts of the Mississippi Delta communities are shrinking faster than other communities and stable incomes vary highly. A link between land loss and these problematic issues is not unthinkable. The MRD has a unique ecosystem that is vital for birds, fish, and other sea life (dolphins and sea turtles), and functions as a breeding zone and navigation zone for migrating animals. This ecosystem is unique for its huge area and location and is the only wetland of its size in northern America.

Needless to say, when the MRD landscape is lost a whole natural system is threatened together with the people living and using the landscape. The human interventions done within the MRD, water management (levee building), and the fossil fuel industry, create an effect on the landscape, and this effect creates different landscape problems; 1) an increase in flood risks, 2) a Decreased ecological value, 3) Decrease of the local economy, and 4) Loss of Identity.

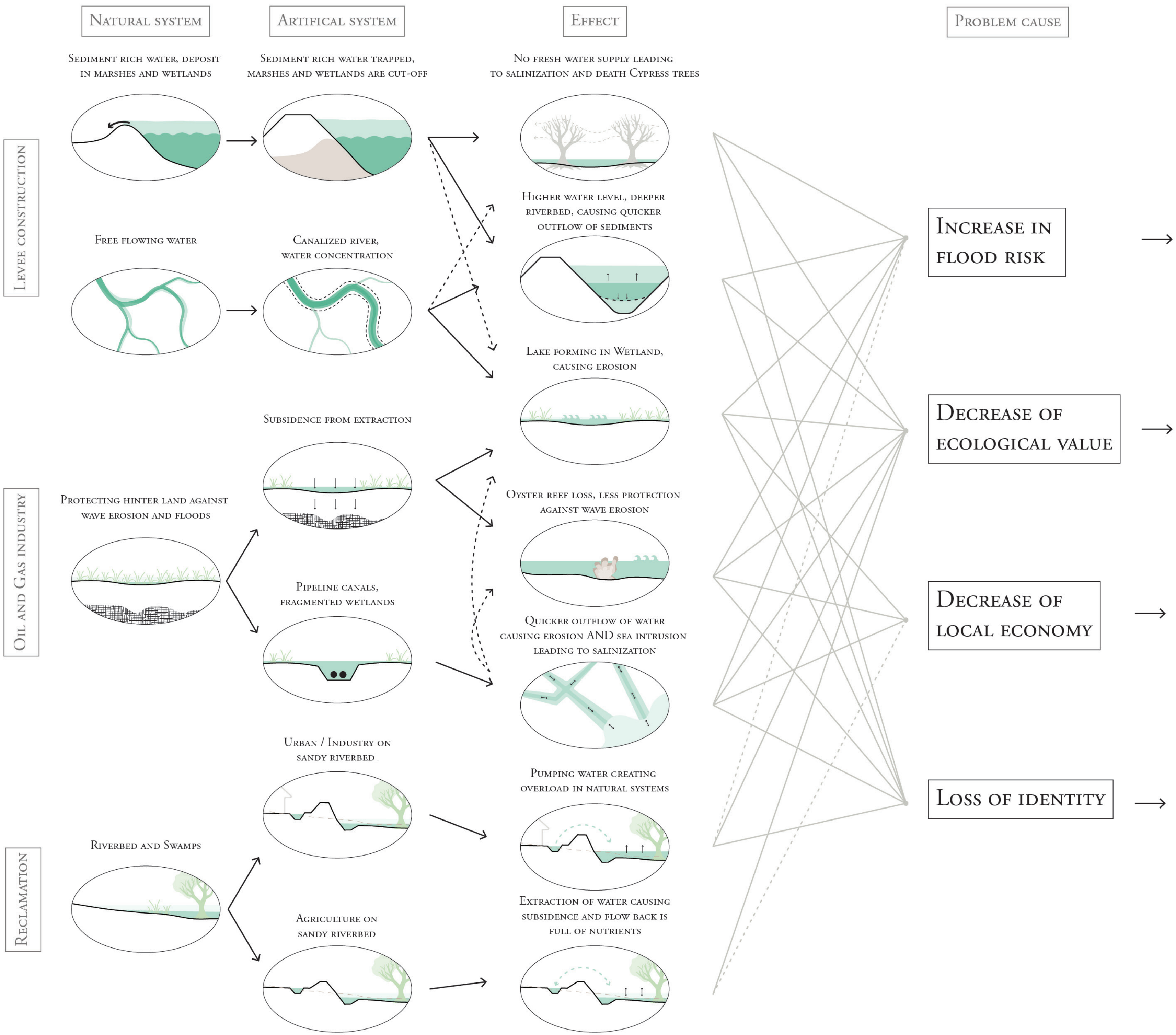


Land loss causes over time This graphic shows the estimated effects of levees, resource extraction and dams on land loss in the Barataria Basin over time. (Edmonds et al., 2023)



This visual representation illustrates the impact of different factors contributing to land loss, as identified in the study. The ascending blue line depicts the anticipated land growth prior to the construction of dams in the river. Contrastingly, the lower orange line illustrates the consequences of dams, levees, and oil and gas extraction. The data points on the graph correspond to the specific land areas measured during various time periods, as documented in a 2017 U.S. Geological Survey study conducted by Douglas Edmonds of Indiana University, published in Nature Sustainability. (Edmonds et al., 2023)

Mississippi River Delta



Sedimentation

Outcome


Doyle (2019a)


Doyle (2019b)

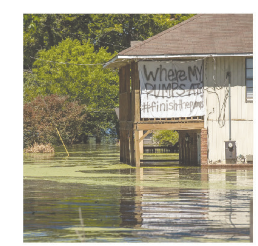

Delta Discovery Tours (2023)


Hammerschmidt (2022)

Highsmith (2020)


Doyle (2019d)


(Highsmith, 2020a)


Doyle (2019c)

Decline Ecology

Dead Trees, Toxic Waste Containment Site, Mississippi River, Dow Chemical Corporation, plaquemine, Louisiana, 1998

Flood risks

Hazardous Waste Containment Site, Dow Chemical Corporation, Mississippi River, Plaquemine, Louisiana, 1998

Decline Local Identity

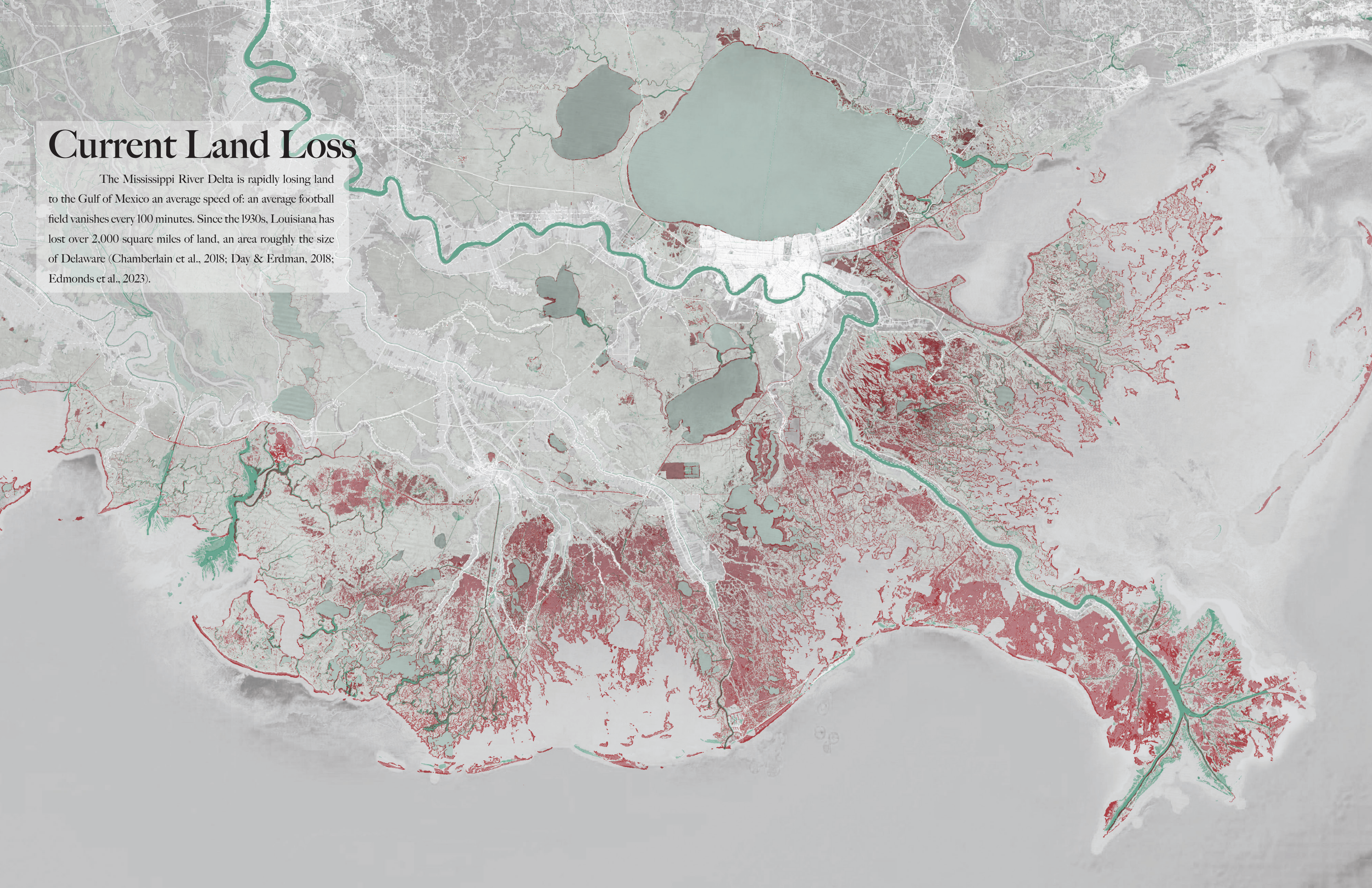
Abandoned Trailer, Mississippi River, Near Dow Chemical Plant, Plaquemine, Louisiana, 1998

Decline Local Economy

Holy Rosary Cemetery and Dow Chemical Corporation (Union Carbide Complex), Taft, Louisiana, 1998

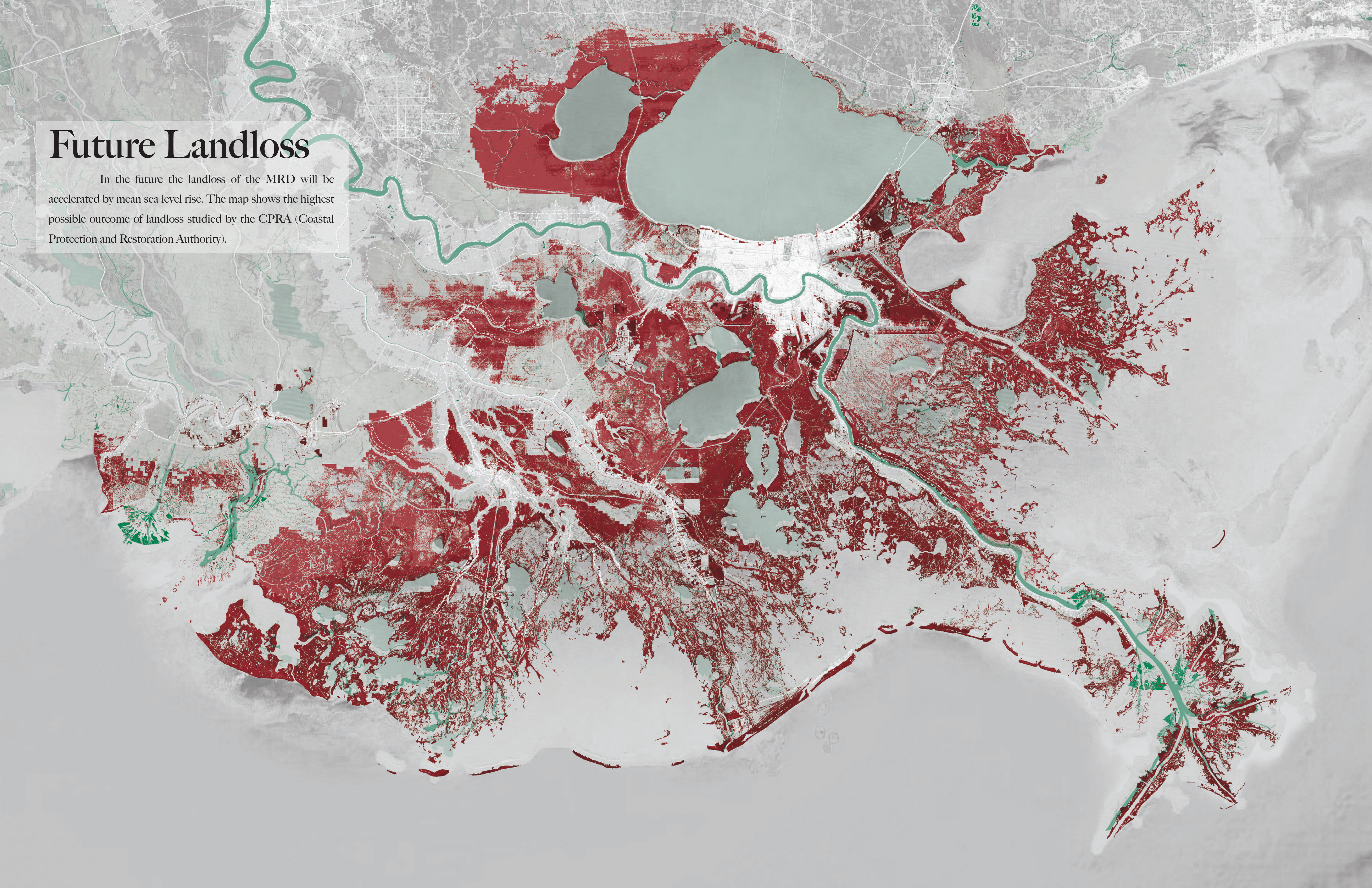
Current Land Loss

The Mississippi River Delta is rapidly losing land to the Gulf of Mexico an average speed of: an average football field vanishes every 100 minutes. Since the 1930s, Louisiana has lost over 2,000 square miles of land, an area roughly the size of Delaware (Chamberlain et al., 2018; Day & Erdman, 2018; Edmonds et al., 2023).



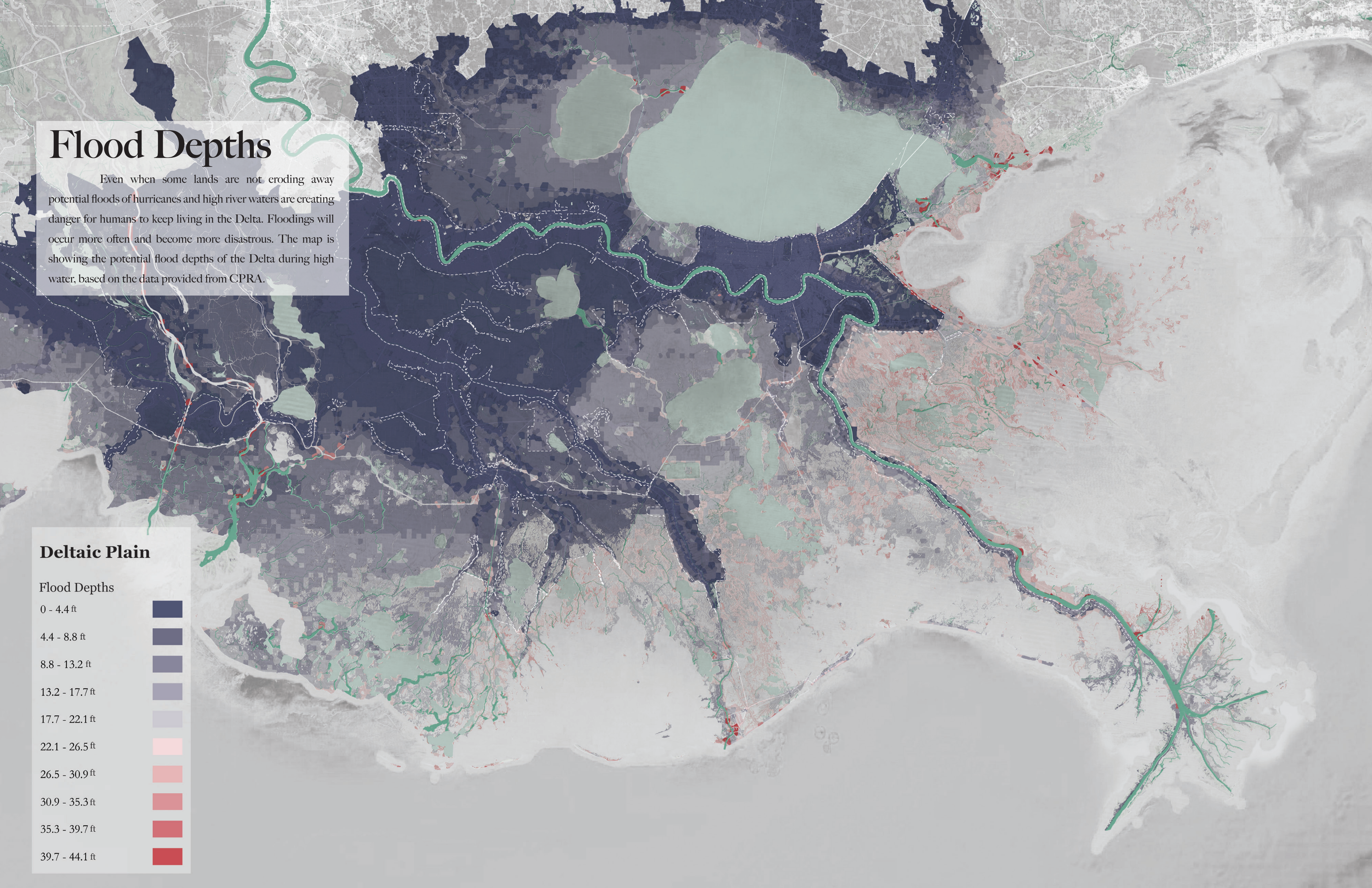
Future Landloss

In the future the landloss of the MRD will be accelerated by mean sea level rise. The map shows the highest possible outcome of landloss studied by the CPRA (Coastal Protection and Restoration Authority).



Flood Depths

Even when some lands are not eroding away potential floods of hurricanes and high river waters are creating danger for humans to keep living in the Delta. Floodings will occur more often and become more disastrous. The map is showing the potential flood depths of the Delta during high water, based on the data provided from CPRA.



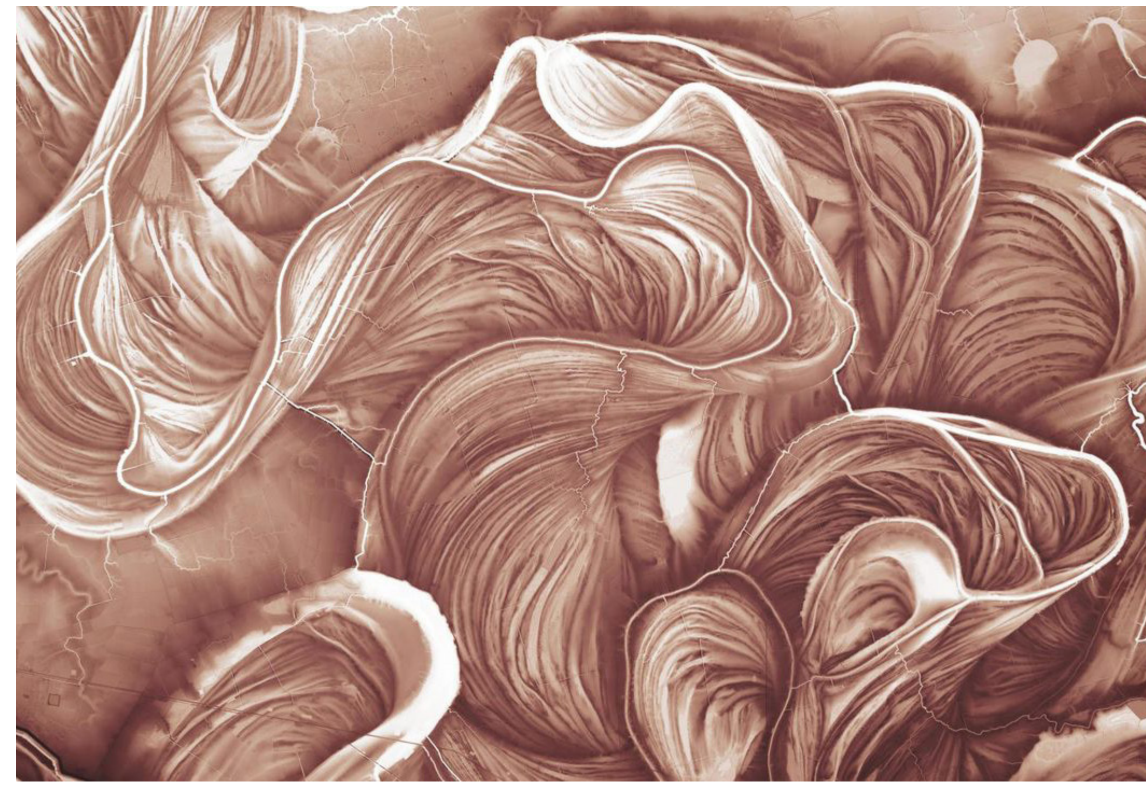
Scope & Relevance

Scope

The research topic explores the potential of an adaptive landscape strategy for a resilient and dynamic Delta that can adapt to the increasing effects of climate change on the landscape and strengthen local economies and local identities. This topic is of interest due to the evident impact of climate change on the landscape of Deltas, together with the high urbanization rate and the social effects Deltas have globally. Around 60% of the world's cities are located in or near coastal and Delta areas. Furthermore, around 40% of the world population is living within 100 km of the sea (Baztan et al., 2015). The Anthropogenic systems that have been imposed on the Delta systems and other regions are not sustainable in the face of future climate change-related challenges. This way of interacting with the landscape leads to an increasing strain on the landscape and its resources. The Petrochemical industry has been interwoven within the political system of most Delta's around the world. But to accomplish the goals set to become climate neutral, these industries are no longer viable. This project aims to cover a fresh perspective on coastal protection and an alternative for the strongly embedded Petrochemical industry. Translating conceptual ideas into visual plans can increase awareness of resilient solutions on a larger scale and improve understanding and acceptance of climate adaptive changes within existing societal systems. Additionally, it can encourage dialogue between the government and stakeholders on new management approaches for Delta areas around the globe.

Balancing the functional needs of human and natural Delta systems in the present and future is one of the biggest challenges facing Deltas globally. The Coastal Protection and Restoration Authority (CPRA) is making efforts to develop strategic visions for the Delta, during the aftermath of Hurricane Katrina. However, due to political borders and differing policies, it is challenging to create large-scale systemic solutions that can be implemented across different scales. Every five years, since 2007, the authorities publish an updated masterplan for the MRD. Only the plans focus on preserving the Delta in its current form, this does not fit the natural process of the Delta. In the broader context, this project explores the potential of landscape architectural design to enhance the resilience of the overall region. The research and analysis of the dynamics of the Deltaic region at different scales are translated into visually oriented plans, which aim to apply more abstract principles. Due to the project's freedom, various solutions and their implementation in the landscape can be explored without the need to consider political borders. Instead, the geomorphological borders of the MRD can be taken into account.

This project aims to make an academic contribution to the field of landscape architecture by translating academic theories into spatial principles and designs and also to reflect on the four landscape principles and their relationship within the design project. While a typical project is limited by political restrictions and must navigate specific frameworks due to budget and bureaucracy, this project aims to expand the possibilities of spatial thinking. As this project is not limited to governmental purposes and is allowed to think in extremes, it has the freedom to explore inspiring and intriguing topics. Design interventions, provocative imagery, and new ideas supported by academic theory and translated into the spatial context may contribute to the discourse of landscape architecture as a discipline.



Dan Coe, a cartographer for the Washington Geological Survey, turned data from the digital era using Lidar technology, a system of laser pulses emitted from an airplane to measure the topography below. Collected by the US Geological Survey (USGS), these data detect the shape of the river, dwelling and infrastructures, natural elements (vegetation, trees, etc.) with high precision. By reworking this database and eliminating or maintaining different layers – vegetation, infrastructures built by man (levees, diversions, buildings, etc.), Daniel Coe rediscovered the natural state of the river, with its meanders and transformations. Revisiting the traces left on the landscape by the Mississippi allowed him to better understand how it reacts to erosion, floods and landslides.

Reading itinerary

The graduation project comprises four parts and nine chapters in total. Part one introduces the research, while the remaining three parts attempt to answer one or two of the stated research questions. Part one focuses on introducing the research area and its related problems and formulating the overall project framework. The second part, which is focused on understanding, analyses the overall system across different temporal scales. The third part provides an inventory of design tools that are applied in the fourth part across multiple scales and time frames. The fourth part includes the discussion and conclusions of the research.

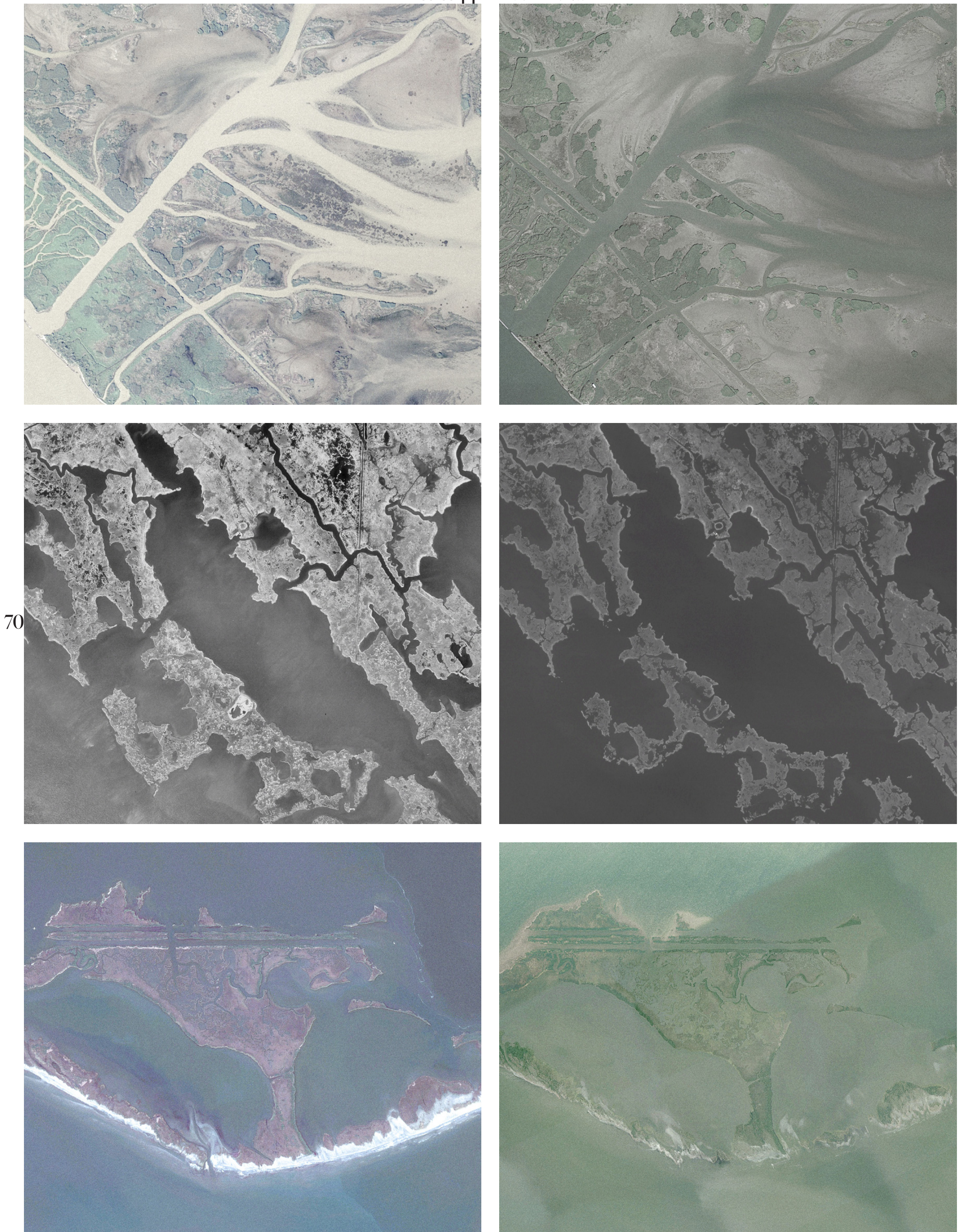
Part I // The Anthropocene Landscape: the first two chapters of the research are introductory chapters. Chapter 1 provides a brief introduction to the overall region, presents the problem statement, gives context, and discusses the relevance of the topic. Chapter 2 outlines the research questions, research structure, theoretical framework, conceptual framework, and necessary methods to answer the research questions. A precedent study showing different cases will be included to provide context-specific references for the approach and design of project sites.

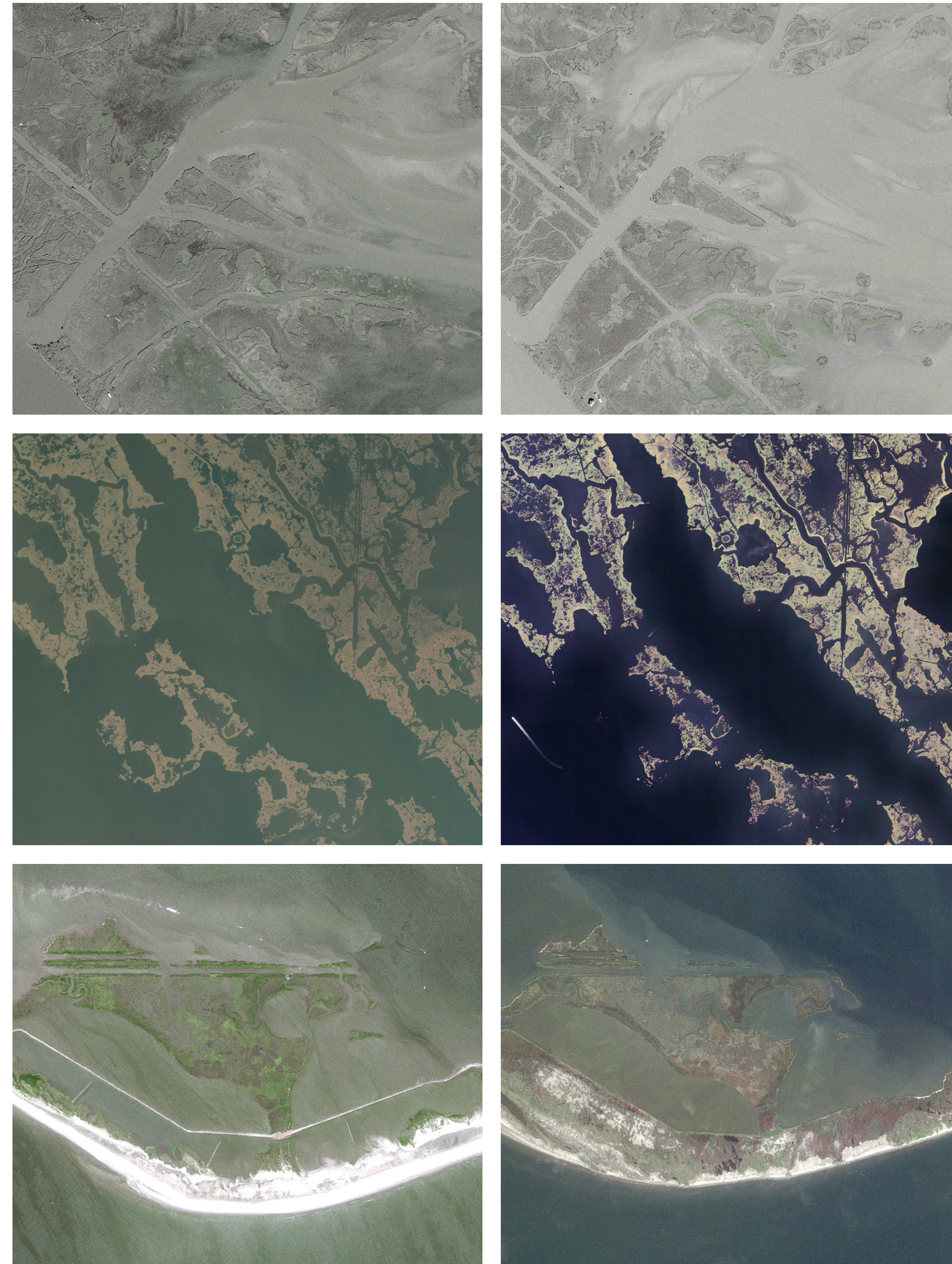
Part II // The (D)Evolving Landscape: this section will elaborate on the Mississippi River Delta system, its historical development, and current processes. The text will focus on researching past practices and the anthropogenic influence that has changed the landscape over time. It will also analyse existing challenges and place them in future scenarios. The will include structure maps of the overall region, its challenges, and potentials to provide a base for the design.

Part III // The operational Landscape: this section will explain the strategies and principles used in designing the project sites across different scales in the region.

Part IV // Towards an adaptive Landscape: the strategies and principles provided in Part III will
be applied across different scales in Part IV, towards an adaptive interface. This interface will
move along the gradient of the landscape, showcasing site-specific landscape design interventions on a smaller scale. Discoveries made on a smaller scale will be scaled up to an overall vision for the entire region.

Joshua's Marina in the Lower Mississippi River. Mainly used for fishing on crabs and salt water fish.





Part I The Anthropocene Landscape

Bottlenose Dolphine's are endangered by fossiel industry and reshaping of rivers in the Mississippi Delta. *Images by Delta Discovery Tours (2023)*

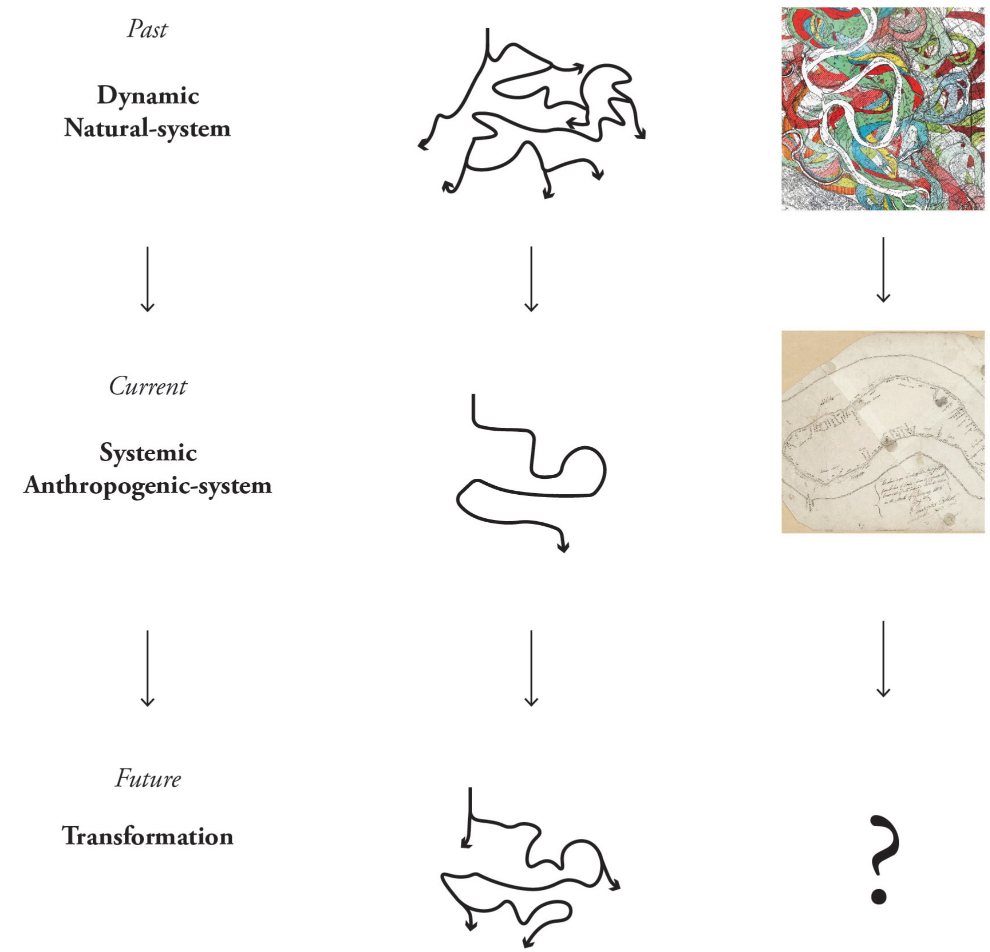
Dunlin bird, dependent on mudflats, between the wetland vegetation, for food and breeding. *Images by Delta Discovery Tours (2023)*

Mangrove root crab is not native to the Mississippi Delta, but due to warmer sea temperatures this species migrated north from the mangroves of Central America. *Images by Delta Discovery Tours (2023)*

Design Narrative

The Mississippi Delta has been converted to the will of humans, this is what we call an Anthropogenic system (Kennish, 2001), for exploiting the richness of the Delta. But what they didn't consider was that with this exploitation they disturbed the balance of natural systems in the Delta, leading to a decrease of the Deltaic value. With the pressing issue of urbanisation, sea level rise, and increase in temperatures Deltaic areas have to rely on balance in the natural system. In a relatively short period, the delta has lost sediments to the Gulf of Mexico causing a decline in size, which eventually resulted in the loss of local economies, identity, and ecological value (Kesel, 2003). This is a direct effect of the Anthropogenic system that has ignored the natural system.

The Anthropogenic system can no longer be sustained, enlarging and heightening levees, pumping water out of urbanized areas and agriculture fields, dredging, and extracting fossil fuels will not be able to last and overcome the current problems of the MRD. Therefore the MRD should become once more a thriving Delta relying on a natural system, and the Anthropogenic system should be fitted within the natural system. This means allowing the Delta to follow its course and define its path. This can cause conflicts with the Anthropogenic systems, therefore is a need for a framework wherein both systems can thrive. The natural system can sustain safety against flooding, restore ecological values, and boost local economies, and the cultural identity of the Delta. In essence, this means that the current layout of the MRD should be rethought or re-modelled, due to land loss, and climate change some parts of the Delta are not resilient and will not be able to become resilient in the future. Accepting this strategy means accepting that part of the MRD can disappear to let other parts of the MRD thrive or be rebuilt.



Research Question

Rethinking the water management systems and designing a shift in how to treat and perceive water is needed. However, the complexity of systems that come together in the delta is difficult to oversee and to solve only by opposing just one question that would need to overcome this complexity in this research by-design thesis. For sure it would be necessary to take one perspective on the problem. However, inside the scope of this thesis, sedimentation will be the central subject since sedimentation is at the core of the natural system and can give tools for future changes based on 'letting the natural system regain control' (Lewis, 2023).
From the introduction and the problem statement, the following research question is opposed;

RQ1: "How can better balanced man-made and solutions based on natural processes be designed in the Mississippi River Delta to let the deltaic system thrive, improve flood risk management, and strengthen local identities and economies?"

To support this research question the following sub-questions are made.

RQ2: "How did the current water system (management) come to be and what are the lessons to be learned?"

RQ3: "What landscape elements can reshape the Delta into a thriving natural system and strengthen local identities?"

RQ4: "How can the restoration of sediment flow help to make the Mississippi River Delta more resilient?"

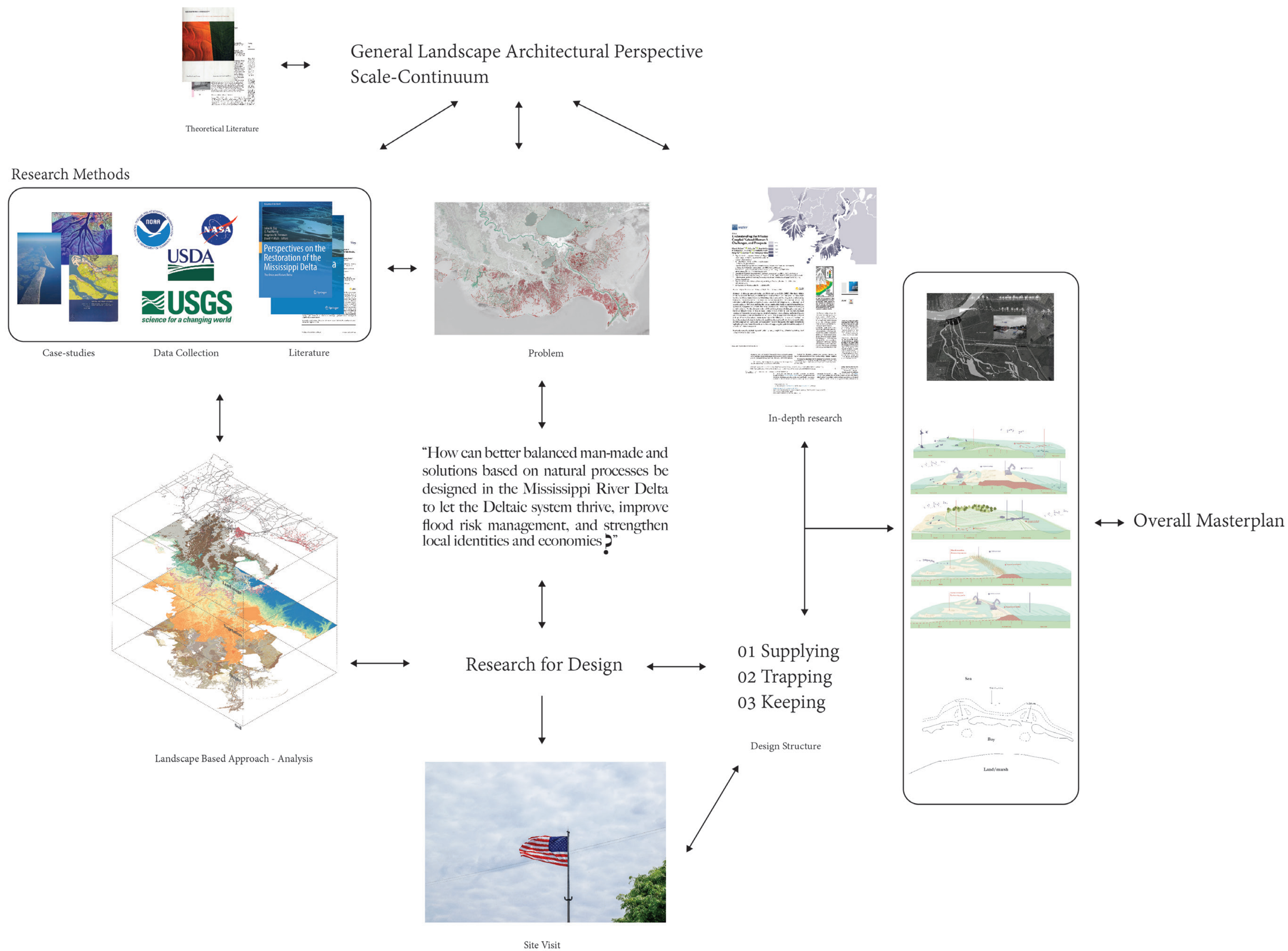
Bastian Island just after undergoing a restoration project. *Images by Delta Discovery Tours (2023)*

Methodology

The research question is answered through literature research, historical analysis, GIS (geographic information system), research by design, and research through design. This is a mix of quantitative and qualitative approaches.

These methods have been used to produce evidence-based scenarios. Based on the literature study the problem statement is created and defined by stakeholders and elements of influence. The relations between the subject and the delta are made and the complex system is understood by literature study, from mainly (Blum & Roberts, 2012; Chamberlain et al., 2018; Day & Erdman, 2018; Kesel et al., 1992; Walker et al., 1987), scientific and non-scientific. Subsequently, historical analysis was used to investigate landscape history, with natural and manmade changes that have been resulting in land loss of the delta, explained in (Barry, 1997). This has been done because the needed solutions require a change of the current system, but the cultural value of the landscape must be taken into account. Further is the coastal masterplan of the Coastal Protection and Restoration Authority (CPRA) used as a basis for the design principles. Other projects that are studied are from the Design teams that cooperated during a competition in 2015, Studio Misi-Ziibi, Moffat & Nichol, and The Baird Team. Based on literature research, the conditions and factors that influence the probability of success for sediment restoration and creation have been investigated. Based on this knowledge, the high-potential areas for wetland restoration or creation have been mapped out.

The data used in GIS is partly obtained by US governmental institutes and supplemented with data from open data sources. To prevent outdated data, this project made use of the latest available GEO data. Based on comparison with other sources, it was tested for the validity of the literature sources. Through GIS it was possible to analyse geographical information accurately. Overlapping these maps made it possible to classify different areas in the Mississippi River Delta with different potentials to be successful in the recovery or creation of sedimentation. This was based on related conditions. These conditions concern river flood risk, elevation height, type of sediment, potential economically important locations, and location of ecological areas. The variables used for the zoom-in interventions are type of land use, specific type of agriculture, landowners, and historical value. The variables used work well to do an initial exploration and determine where options are more likely to work better.



Fishing boat left behing along the banks of the Mississippi, apparaently not intervering with shipping routes.

Human traces and natural traces are intertwined, half sunken boats are resembling the present of natures power overtaking human activities.

Theoretical Framework

Interpretation

It is important to define my personal opinion about what a delta should be and what its qualities should be, to be able to determine my goal(s) for my design intervention. According to literature and personal experience, this opinion will be formed.

Huge amounts of soil have been discharged into the Gulf of Mexico forming the MRD, the slow and low currents of the sea made it able to keep the discharge in place. This process has developed various delta mouths in the last 7.000 years (Dubey, 2023). In the last 7.000 years, six delta mouths have been present; (1) Maringouin, (2) Teche, (3) St. Bernard, (4) Lafourche, (5) Plaquemines-Modern, and (6) Atchafalaya (Kapples, 2023). The river current determines where the mount of the river is, as seen from the development of the various deltas the Mississippi River is dynamic in its flows. This natural process happens (relatively) slowly and takes time to develop into a full-grown delta. As written before deltas offer a strategic place for settlements and urbanization, for multiple reasons. With this settlement, humans began to shape the delta to survive and exploit its richness, we call this anthropogenic interference. With this drift for survival and exploitation, the man-made interventions began and the natural development of deltas was neglected. These two systems operate in the same area, but the anthropogenic system goes quicker than the natural systems and is therefore not able to cope with each other. I see that as the Paradox of the delta. Many of the human interventions designed to tame the delta create new, unforeseen hazards, which are countered with new interventions. This is the paradox of the human delta: by making the delta safer, we introduce new insecurities (Sijmons et al., 2017). In the current MRD, the anthropogenic system is leading and causing major conflicts within the natural systems. A new balance should be created between these two systems, they are dependent on each other and therefore where it is possible to align with each other. Places of conflict are inevitable in these places sustainability and endurance should be leading. The anthropogenic systems should be adjusted to the natural system to be able to let the delta thrive.

Human intervention in one of the ditributaries of the Mississippi River, limiting the in and out flow of water.
Images by The Nature Conservancy (n.a.)

Conceptual framework

The conceptual framework provides an abstract overview of the fundamental structure of the study and helps in this way to define and understand the complexity of this study. Scale is important to comprehend the complex delta, deltaic areas have an important role in natural and anthropogenic systems and it operates in different scales. By determining the scales and their area of influence the complex system of the delta is better understood.

Within this thesis, multiple scales are used to express and explain topics. Some scales are easy to outline, from big to small, the national scale, the Mississippi watershed, and the Deltaic area. The Deltaic area (plain) is still rather big to be able how systems are related, but also when design implications are done to see their agency. Before we determine the smaller scales of the Deltaic Plain, we determine the bigger scales and their agencies.

National scale, this scale is the biggest scale and the most abstract scale. It will only be used to express the importance and impact something has, for example, the 'local' oil and gas industry in the Deltaic area is of importance and influence on the national scale, and as ecology, the Deltaic area is a bird hub for the whole of Northern America.

Mississippi Watershed, this scale illustrates the area of America that has a direct connection with the Deltaic area. Within this area, all the water is distributed via the Mississippi River towards the Delta. Dams are constructed upstream of the river and are causing stagnation of sedimentation flows, this has a direct influence on the Deltaic area, although this dam might be placed several hundred kilometres upstream. Nevertheless, there is a direct link between the watershed of the Mississippi and the Deltaic Plain this scale is also used to explain and express relations within the river systems, but this scale is too big for this project to operate within.

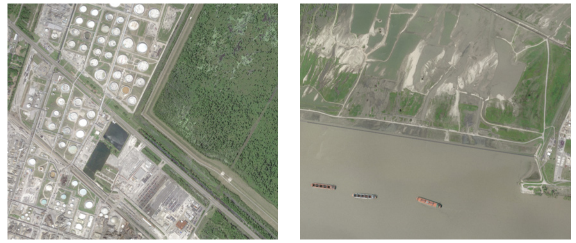
Deltaic area (plain), consists of active or abandoned deltas, which are either overlapping or contiguous to one another. A delta is a relatively flat area at the mouth of a river or a river system in which sediment load is deposited and distributed. This is one of the important scales and will function as the main scale where all other scales are related to, this scale is the biggest where design choices are made. Within the Deltaic area, there are two other scales, the distributaries watershed scale and the local scale.

Distributaries Watershed, the Deltaic area can be subdivided into different areas. From the mainstream of the Mississippi, there are multiple old and new distributaries leading toward the Gulf of Mexico forming their sub-deltas. For example, the Wax-Lake Delta, which is part of the Mississippi Delta area but has its distributary that feeds the delta with sediment. There is a direct link between all the Distributaries Watersheds in the Deltaic Area, and they can influence each other.

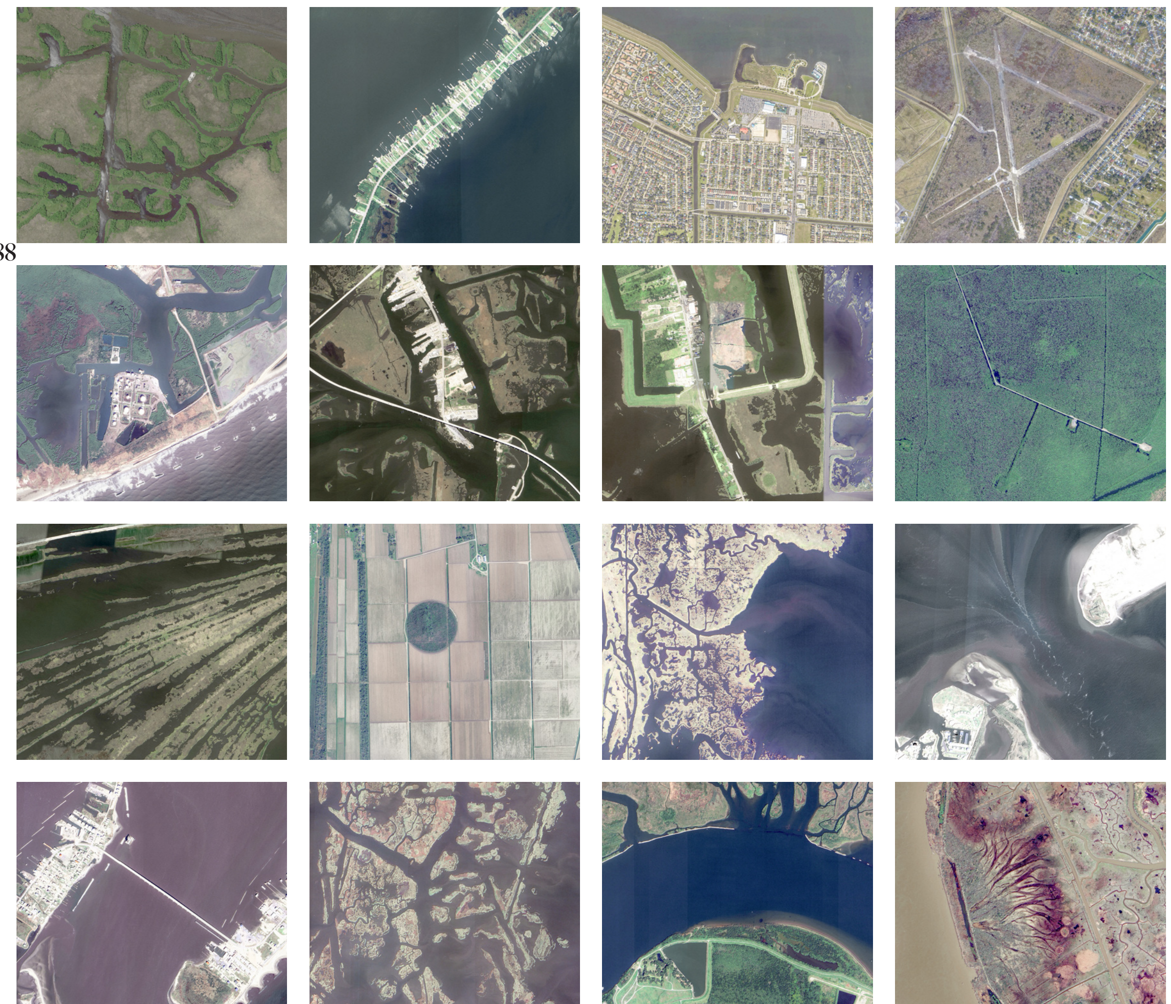
Local areas are specific areas with one or two tangible structures. Think about the water defence structures, harbours, houses, or sluices. These are direct objects where design can be made or the current tangible systems modified. This will be the design location, there can be multiple design locations over the Deltaic Area and they are related via the Deltaic Area scale and the Distributaries Watershed scales.

Joshua's Marina in the Lower Mississippi River. Mainly used for fishing on crabs and salt water fish.

Mississippi River Delta landscapes

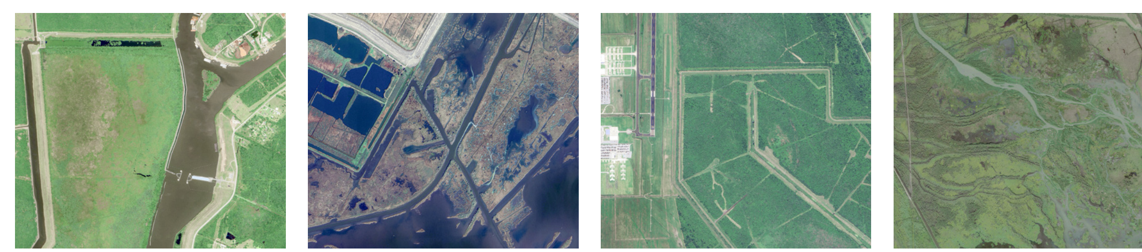


The landscape usages of the Mississippi Delta by people



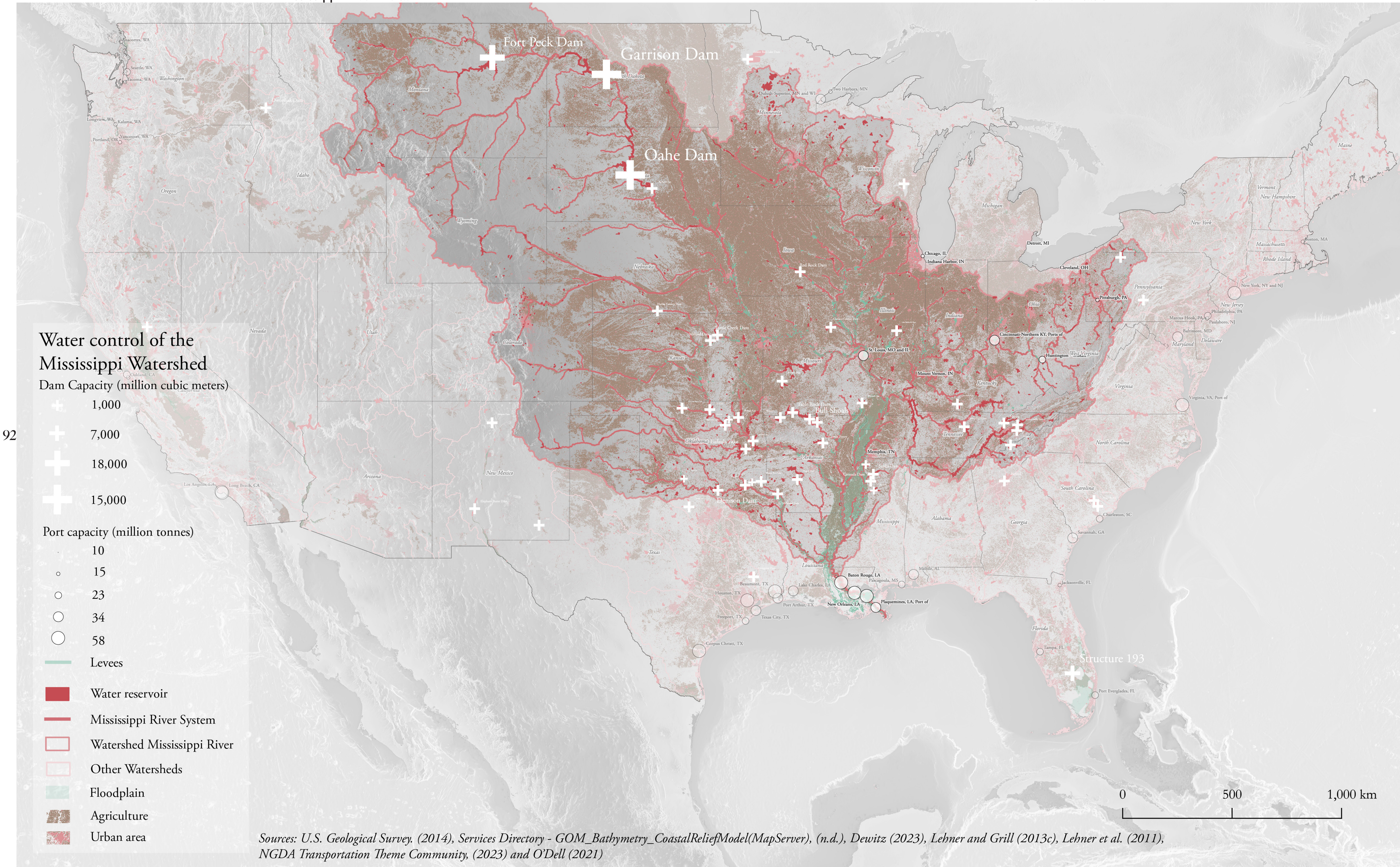
Where are the animals in the landsape?

Canals, wetlands, harbors, agriculture, levees and homes

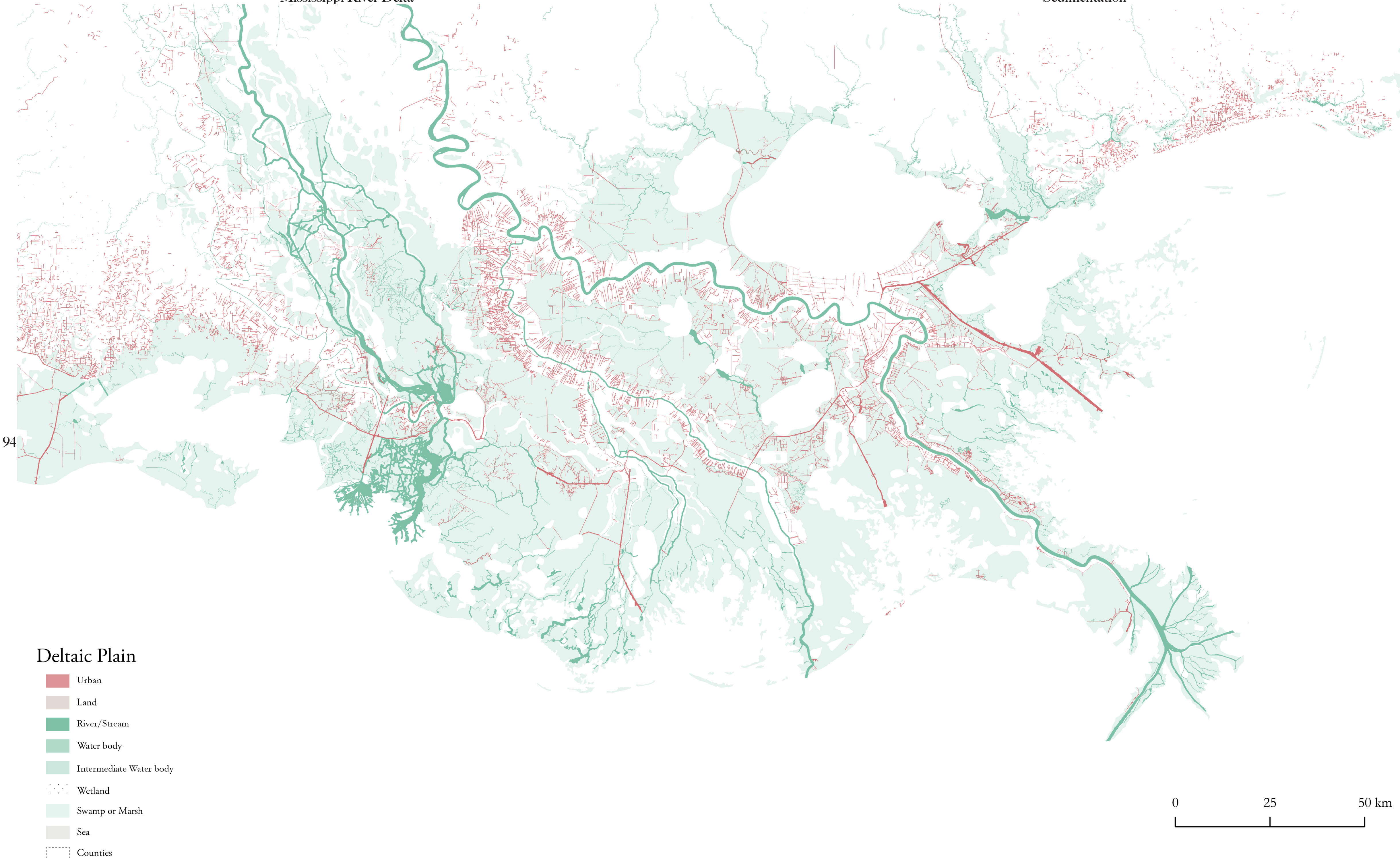


Images form Google Earth Pro 2016

Part II / The (D)Evolving Landscape



Sources: U.S. Geological Survey. (2014), Services Directory - GOM_Bathymetry_CoastalReliefModel(MapServer), (n.d.), Dewitz (2023), Lehner and Grill (2013c), Lehner et al. (2011), NGDA Transportation Theme Community, (2023) and O'Dell (2021)

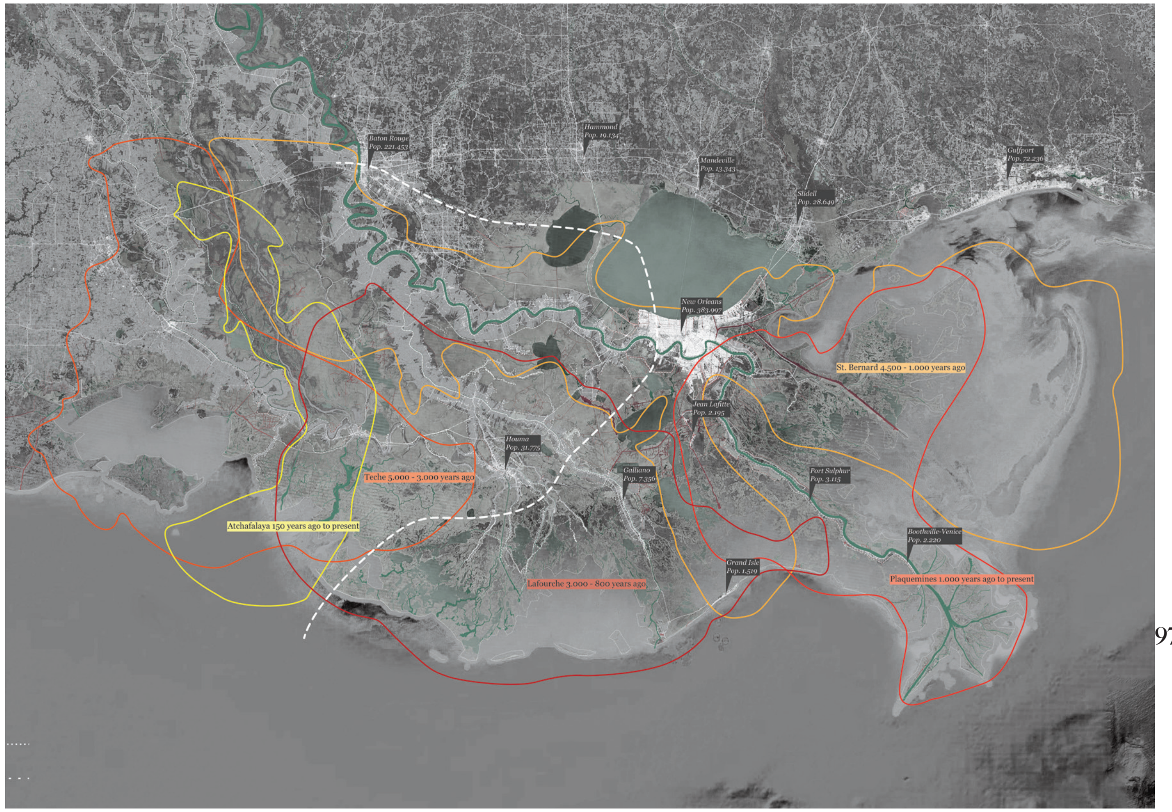

Deltaic Plain
Urban
Land
River/Stream
Water body
Intermediate Water body
Wetland
Swamp or Marsh
Sea
Counties
0
25
50 km

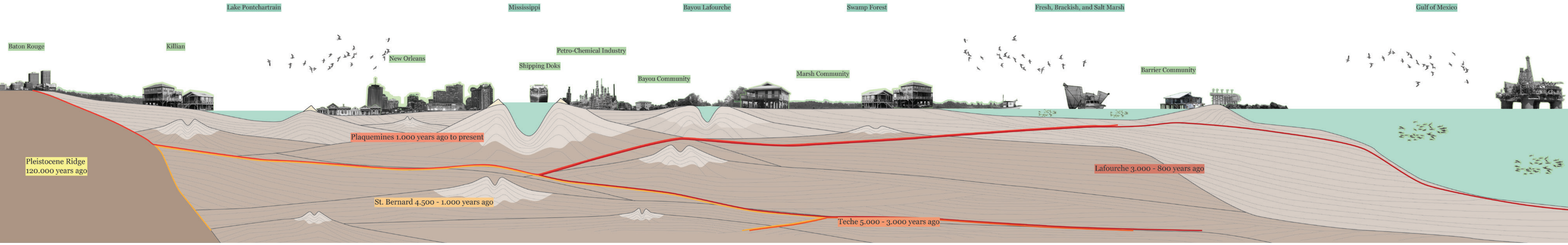
Geoformation

As each section of land—called a "delta lobe"—continued to build, the MR's path to the Gulf of Mexico became longer and more complex (Dubey, 2023; Kapples, 2023). In response, the river would eventually change course, abandoning the older lobe and cutting a shorter route to the Gulf, starting the process again. These abandoned lobes gradually sank and eroded, forming extremely productive estuaries and leaving behind barrier islands to mark their former boundaries. New lobes formed with the river's new route, building up new land for marsh plants and trees to take hold. This constant ebb and flow created a dynamic and ever-changing mosaic of habitats and natural resources.

The river also created the natural levees on which early communities were built, by depositing sediment during periods of high river flow or spring floods. At times, the river would break through its natural levees, depositing sediment and fresh water in the surrounding wetlands, keeping them healthy, productive, and intact. These lush and fertile wetlands protected our communities from storm surges and hurricanes.

By the time of European settlement, the MRD plain stretched across a remarkable 7,000 square miles, making it one of the largest river deltas in the world (Day & Erdman, 2018). At this time, the river passed through an area now often called the "Birdsfoot Delta." Because the end of this lobe lies near the continental shelf and thus deep water, it provided tremendous opportunities for waterborne commerce and transportation (Blum & Roberts, 2012), leading to the rise of New Orleans and other port cities and trade routes. A natural delta exists in a state of constant change.





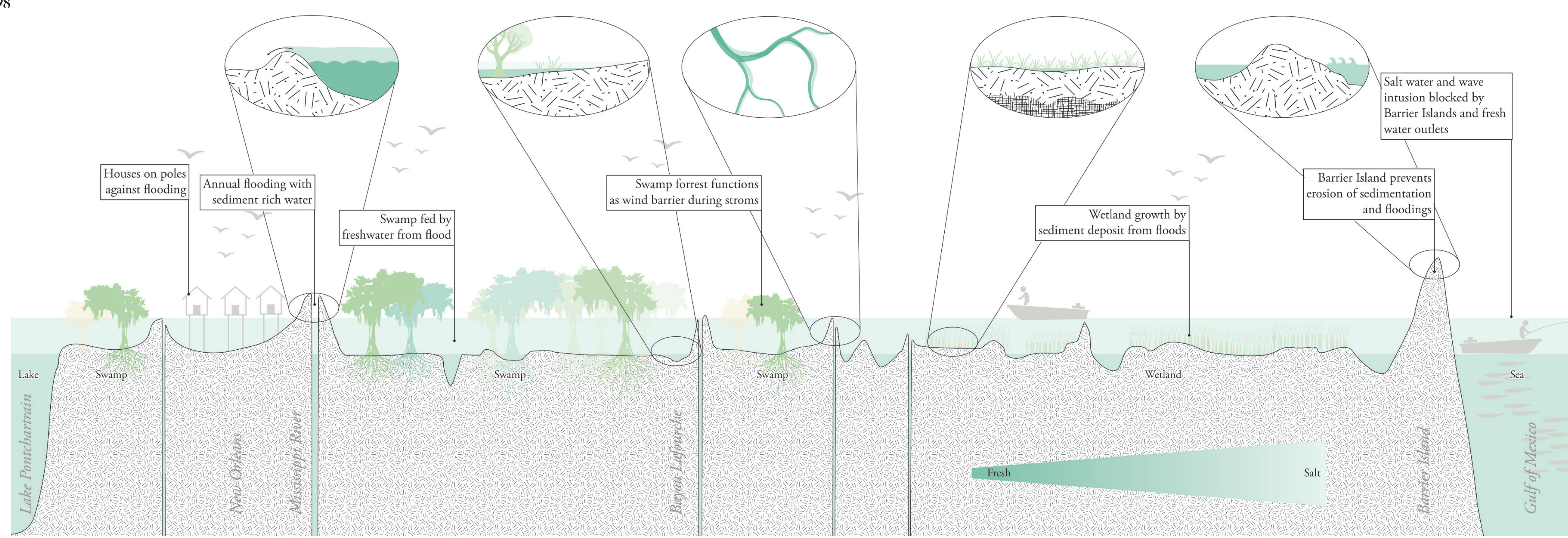
Dynamic Landscape of the Past

Few locations have as much historical and ecological significance as the MRD has in the history of the United States. The Delta is the birthplace of many narratives, this vast Deltaic region has been built from many layers of history, where the biography of the Delta takes root and flourishes. Nestled at the end of the Mississippi watershed, the MRD is not only a geographical hydrological entity but a living story of dynamic stories between land and water, and humans and nature. Trying to unravel all the layers of time and delve into the becoming of Delta's identity. From the river currents to the cultural layers woven by communities over centuries, each facet contributes to the rich narrative that unfolds the becoming of the MRD. To be able to start with the present layout of the Deltaic Plain, a biography is made of the Delta since the moment humans colonized the Delta and started shaping it to their will. From there the present layers are unravelled in, cultural, natural, geographical, economical, and hydrological layers, and connections are made between them.

A biography of the Delta from the start of colonization till now sheds more light on this topic of how the Delta came to be. This part is vital to answer the question of how and why. The whole biography is visible in the appendix of this document. The following paragraphs highlight the changes in the Delta over time, with a focus on the spatial landscape interventions.

Levee construction, land reclamation, barges channels, dredging, crevasses and other elements highlighting and illustrating.

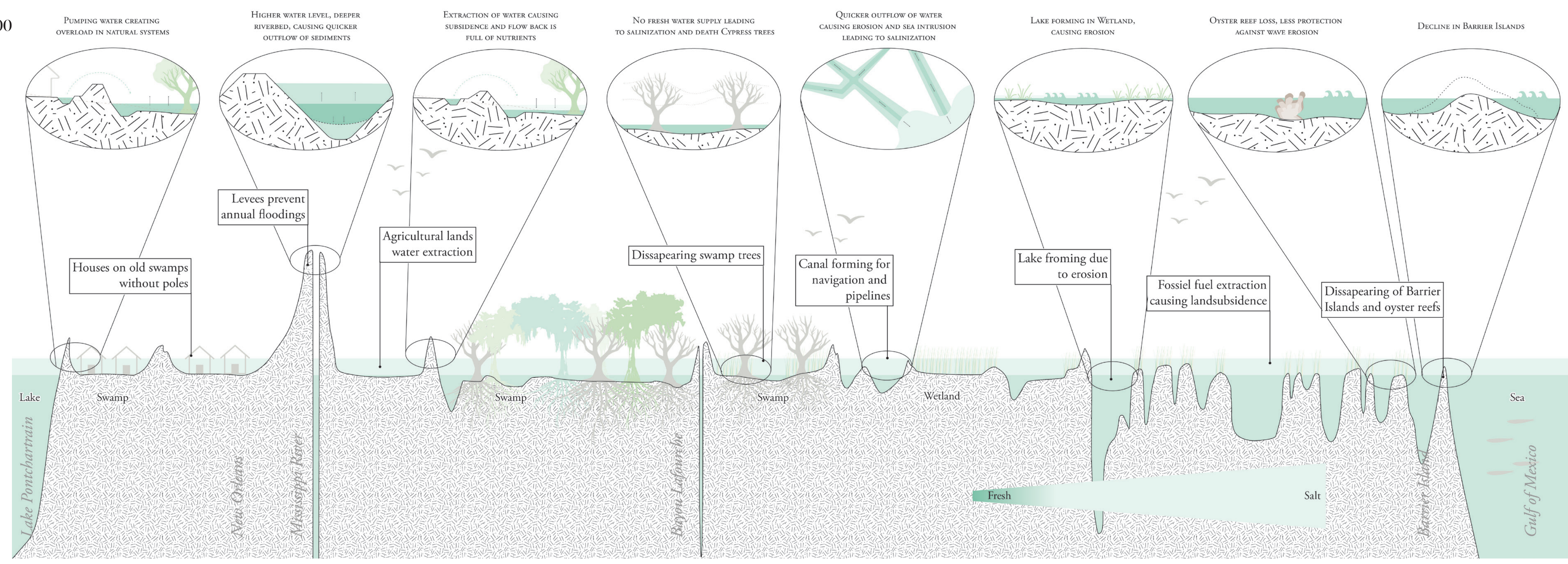
Pre 1800 section of the MRD



Conclusion

In conclusion, the history of the MRD is defined by humans reacting to the natural process of the MR system. Over the centuries, the Delta has witnessed significant changes driven by economic, social, and environmental factors. From the decline of mound-building societies due to European contact to the construction of levees and the expansion of agricultural practices, each period has left its mark on the Delta's landscape and ecosystem. However, alongside these developments, there have been unintended consequences, such as the degradation of wetlands, loss of biodiversity, and increased vulnerability to floods. As we move forward, it is crucial to consider the lessons learned from the Delta's history and strive for a more sustainable approach to managing its resources and preserving its ecological integrity for future generations.

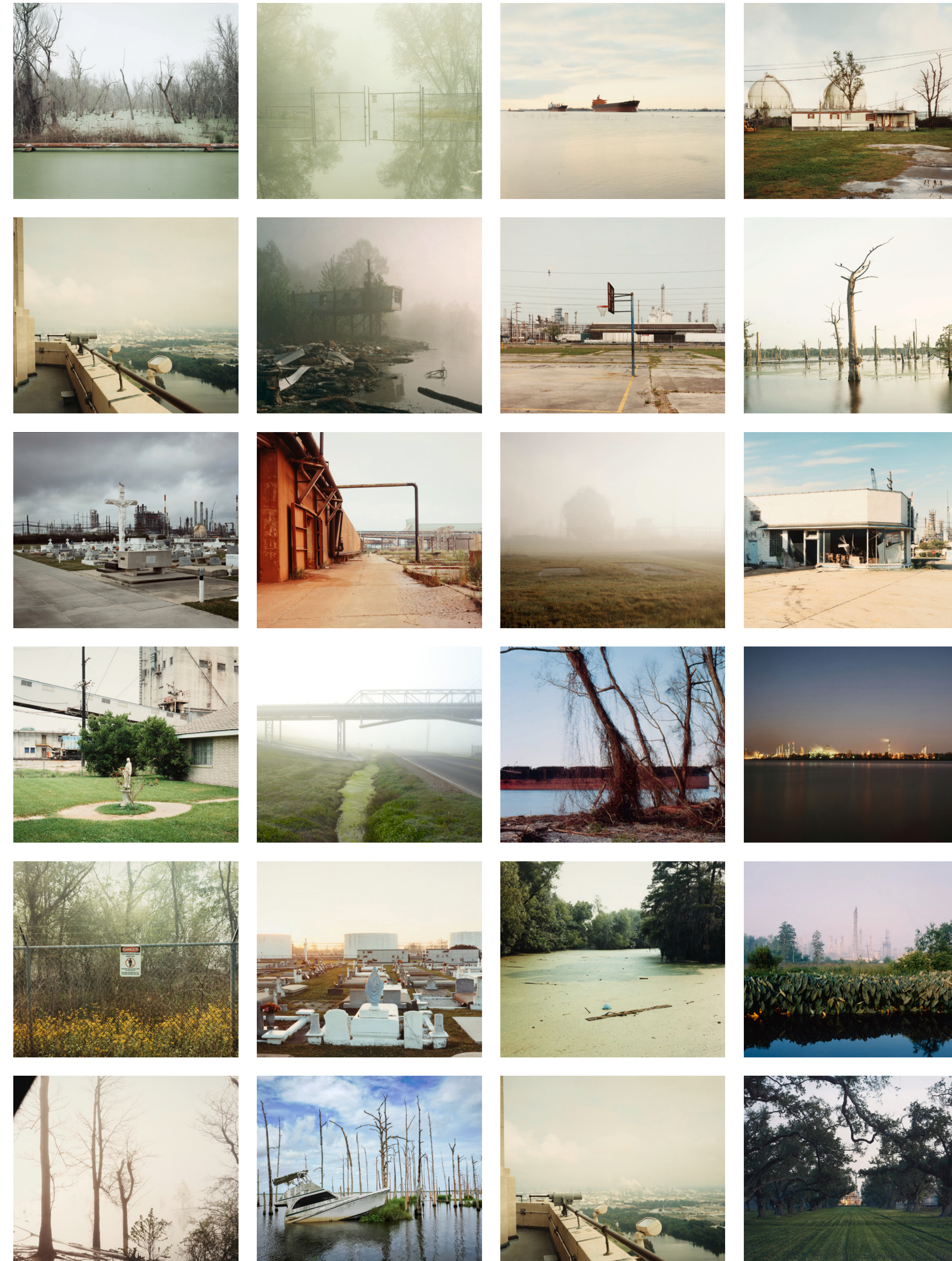
2000 section of the MRD



Petrochemical America

Richard Misrach, renowned for his contemporary landscapes of the American West, received a commission from the High Museum for its Picturing the South initiative in 1998. He chose to photograph the highly industrialized section of the Mississippi River between Baton Rouge and New Orleans known as Cancer Alley.

Misrach described Cancer Alley as a "remarkable corridor of historic, cultural, and natural resources, which in the past decades has been virtually decimated by the introduction of the petro-chemical industry. Alongside restored and potentially restorable classic antebellum plantations sit over 136 behemoth industrial sites—a bizarre juxtaposition of the charming and the horrific."



31°00'00.0"N 92°00'00.0"W

Location: *Louisiana, USA*

Funds: *H. B. and Doris Massey Charitable Trust - Lucinda W. Bunnen - High Museum of Art Enhancement Fund*

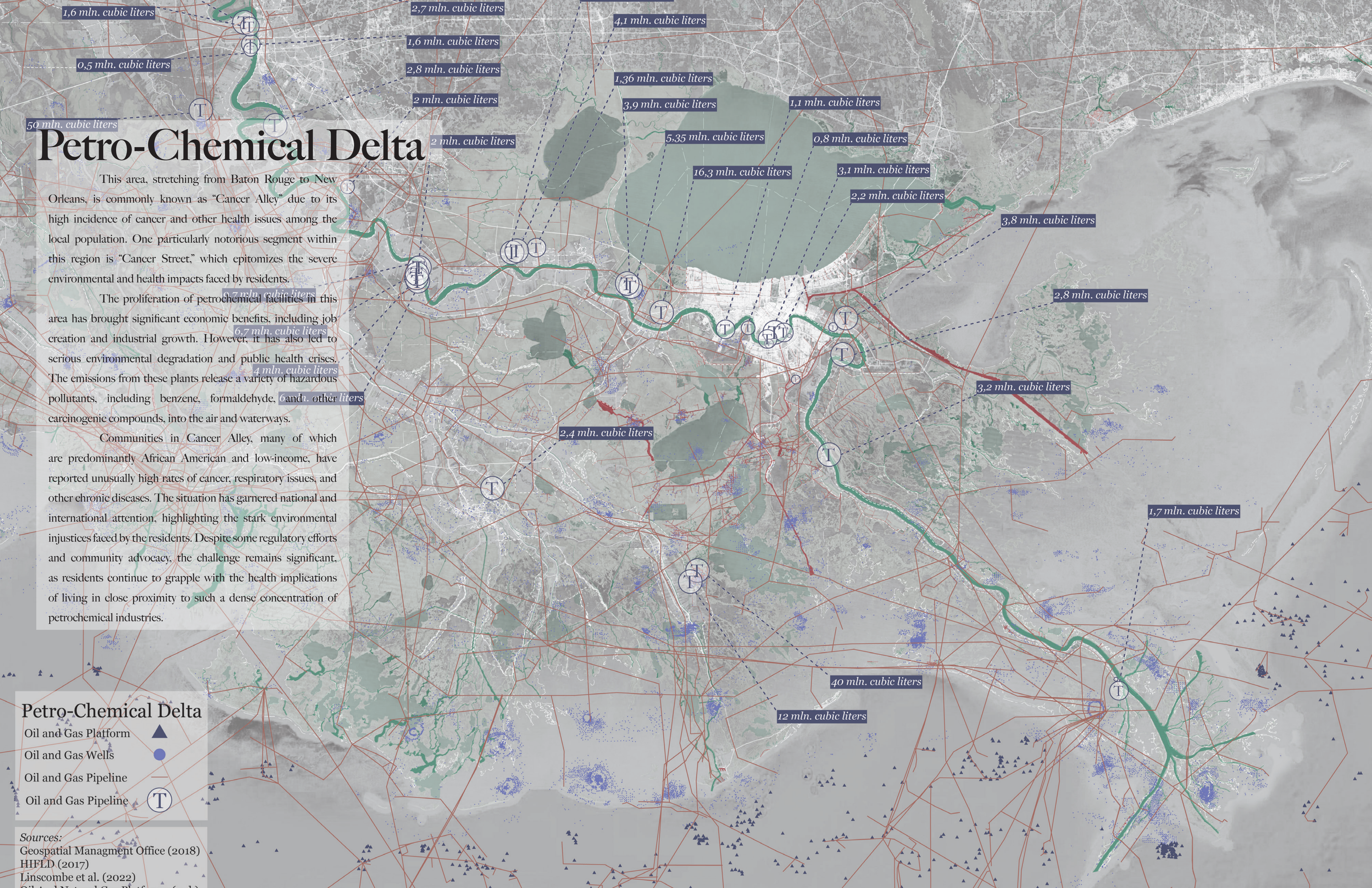
Courtesy: *Fraenkel Gallery - Pace-MacGill Gallery - Marc Selwyn Fine Arts*

Petro-Chemical Delta

This area, stretching from Baton Rouge to New Orleans, is commonly known as "Cancer Alley" due to its high incidence of cancer and other health issues among the local population. One particularly notorious segment within this region is "Cancer Street," which epitomizes the severe environmental and health impacts faced by residents.

The proliferation of petrochemical facilities in this area has brought significant economic benefits, including job creation and industrial growth. However, it has also led to serious environmental degradation and public health crises. The emissions from these plants release a variety of hazardous pollutants, including benzene, formaldehyde, and other carcinogenic compounds, into the air and waterways.

Communities in Cancer Alley, many of which are predominantly African American and low-income, have reported unusually high rates of cancer, respiratory issues, and other chronic diseases. The situation has garnered national and international attention, highlighting the stark environmental injustices faced by the residents. Despite some regulatory efforts and community advocacy, the challenge remains significant, as residents continue to grapple with the health implications of living in close proximity to such a dense concentration of petrochemical industries.



Sources:
Geospatial Managment Office (2018)
HIFLD (2017)
Linscombe et al. (2022)

Embedded Industry

As Richard Misrach projects in his photo sequence of the 'Cancer Ally' of America, the Petrochemical industry is visually present throughout the Lower Mississippi Delta. Various images in the booklet strengthen this idea. This industry is not only present in the landscape, it is an important factor of the economy of the state of Louisiana. The total state's revenue is $219.1 billion, making it the 49th largest economy of the United States of America (IBISWorld, 2024). Wherein Petroleum Refining $123.5b, Oil Drilling & Gas Extraction $44.7b, and Plastic & Resin Manufecturing $22.4b in revenue making it the three largest industries of the state (Deloitte & DataWheel, 2024; IBISWorld, 2024). When looking at the numbers of the economic activities of the Petrochemical industry it is assumed that it is the most vital industry of the State, this is partly true. Comparing the workforce of the Petrochemical industry to other industries, only a small percentage is part of the workforce of the industry (Deloitte & DataWheel, 2024). Only a small part of the state's workforce is directly earning from the Petrochemical industry, whereas the oil and gas companies headquarters are not based in the Lower Mississippi itself most of the revenue is therefore leaving the state. This design research thesis will not shed more light on this highly interesting topic, since it is mostly of a political and economic interest. However, it indicates that the people of the state of Louisiana need an alternative when the Petrochemical industry needs to disappear and be replaced in the Lower Mississippi.

Ottinger, G., Spears, E., & Orff, K. (2013).

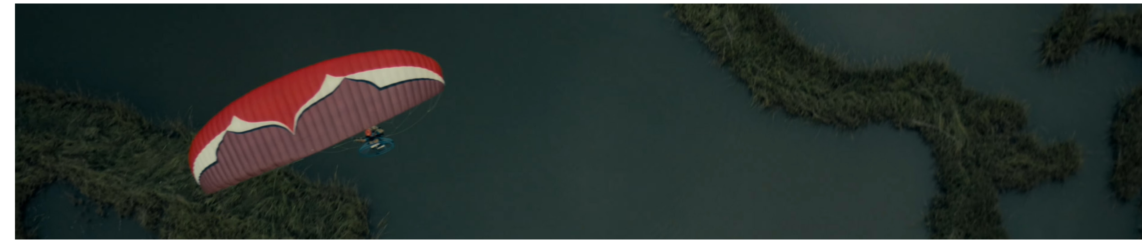
Tide Lines

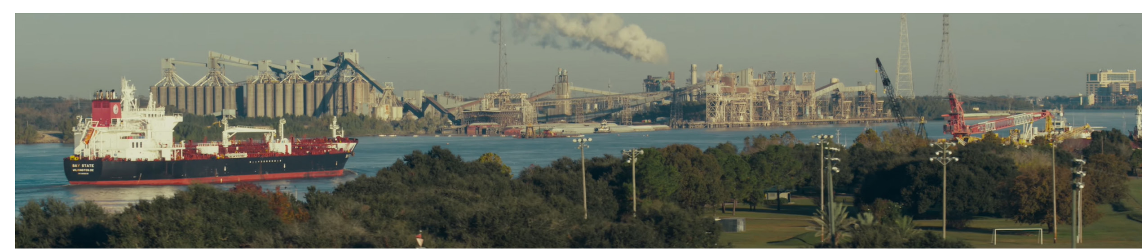
In Tide Lines: A Photographic Record of Louisiana's Disappearing Coast, Ben Depp's photographs capture the beauty, complexity, and rapid destruction of south Louisiana. Once formed by sediment deposited by the Mississippi River, the Louisiana coast is now quickly eroding. Two thousand square miles of wetlands have returned to open water over the past eighty years.

Depp's photographs communicate weather and seasonal changes — like the shifting high-water line, color temperature, and softness of light. A careful observer will notice coastal flora and distinguish living cypress trees from those that have been killed by saltwater intrusion, or see the patterns made by wave energy on barrier island beaches and sediment carried through freshwater diversions from the Mississippi River.

With a powered paraglider, Depp flies between ten and ten thousand feet above the ground. He spends hours in the air, camera in hand, waiting for the brief moments when the first rays of sunlight mix with cool predawn light and illuminate forms in the grass, or when evening light sculpts fragments of marsh and geometric patterns of human enterprise — canals, oil platforms, pipelines, and roads. Featuring an introduction by Monique Verdin and over fifty color images, Tide Lines is an intense bird's-eye survey that depicts south Louisiana from an unfamiliar perspective, prompting the viewer to reconsider the value of this vanishing, otherworldly landscape.

Images retrived from a documentery about Ben Depp on Youtube, The last Bayou 101 (Channel, 2020).

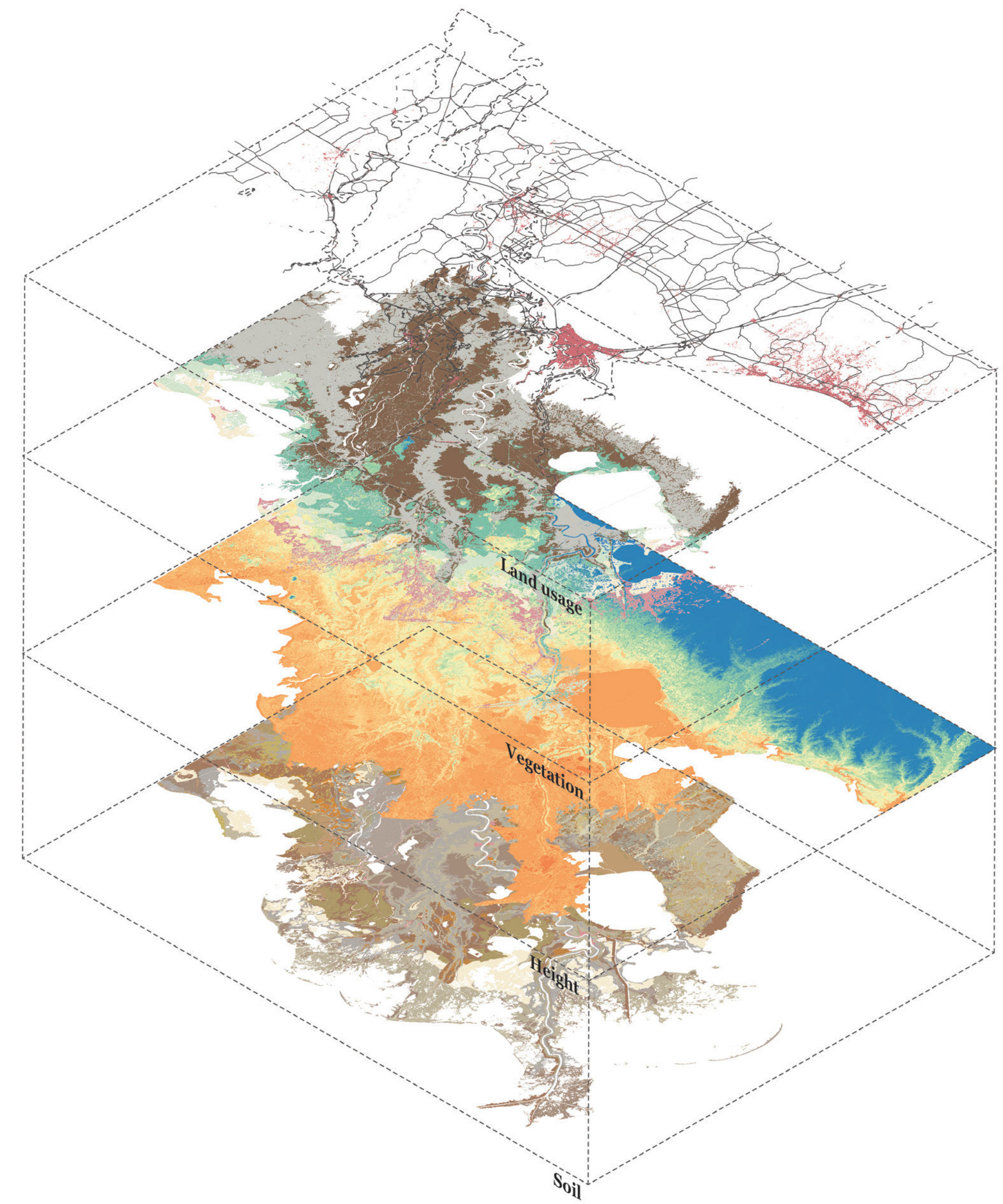




Part II / The (D)Evolving Landscape

Layers of the Anthropocene Delta

The biography taught how the MRD came to be, now we need to understand the current landscape and how it is functioning. To do so four layers are used to analyze the Delta; 01 soil types, 02 height map (DEM), 03 water system, and 04 land usages. The four layers are strongly connected and rely on each other. These four layers will lead to the design principles. Together with the biography of the MRD, these principles will form the initial concept and design for a resilient Delta system.



01 Soil

Soils are the basis for the vegetation, protection, and usage of the Delta. Soils from all over the middle of America have been deposited here and have been slowly building the Delta landscape as we see it now. The constant movement of the soils by water has determined where people could start living, produce crops, or where vegetation could thrive, but most importantly protect the Delta against erosion. Soils are important to have a balance in the Delta, when soils are taken away new soils should deposited to create new lands for the animals, plants, and humans to live.

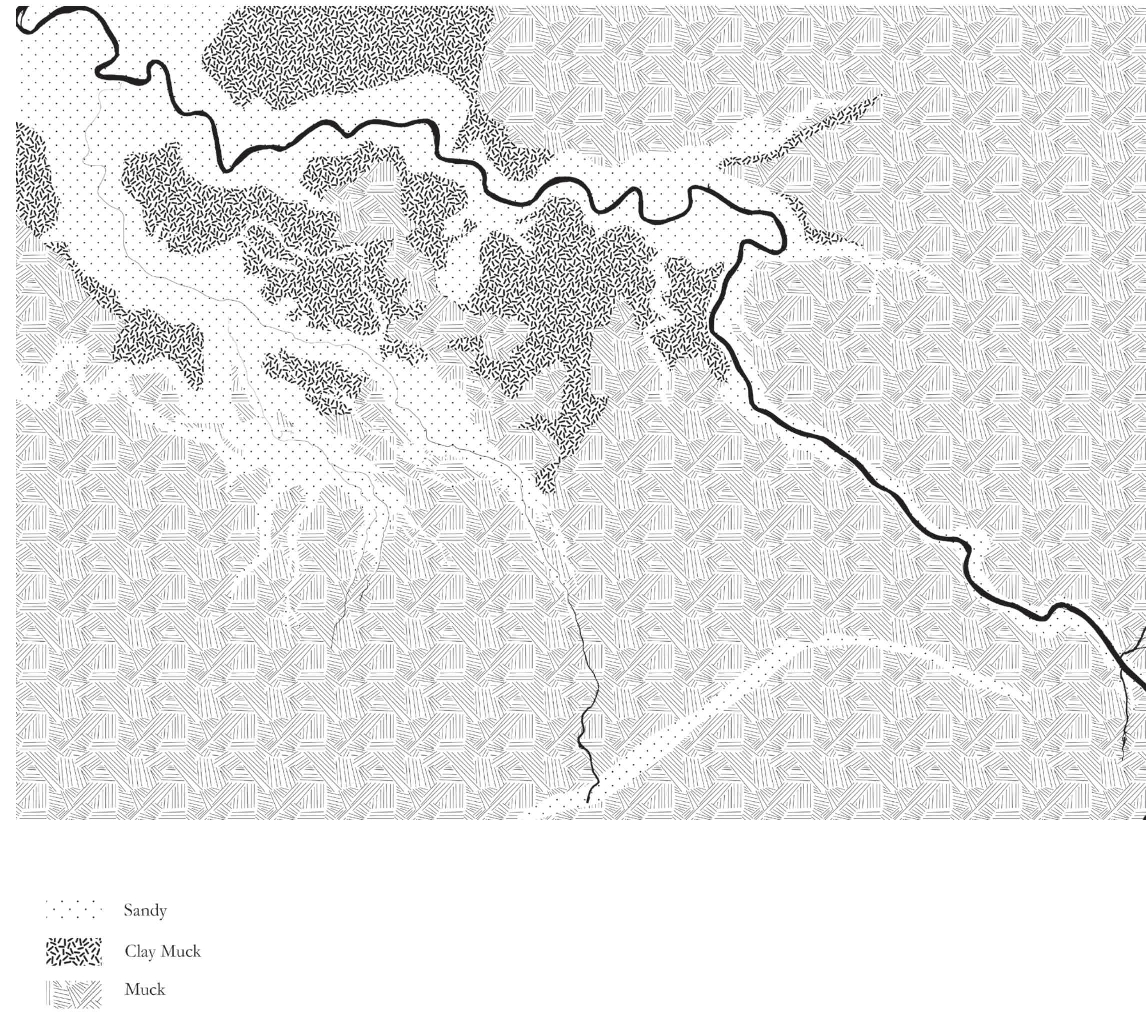
As described in the biography, the MR flooded annually inundation the swamps, and marshes with fresh sediment-rich water (Walker et al., 1987). By repeating this process over a long period heavier soil particles were deposited along the edge of the River, forming natural levees (Blum & Roberts, 2009; Chamberlain et al., 2018). These heavier soil particles not only constrained the MR, but they were also very fertile, creating a 'unique' zone along the river(s). In the overview map of all the soil types in the Mississippi, which looks more complex than it is, we can see a soil gradient from the river toward the Gulf of Mexico. The River is constrained by more sandy and clayey soils, after that there is a slow transition from clayey soil mixing with muck (peat) whereas muck will take slowly over the more we go to the Gulf of Mexico. The edge between marshlands and the Gulf of Mexico is boarded by sandy soils forming the barrier islands, and the old Delta mouths into the Gulf. These rough categorization in three soil types is illustrated in the following map, which can be used as a general basis for the soil structures.

Studying the soil map, old river streams were discovered, indicated by sandy soils. These sediment-rich places are vital for the restoration of the Mississippi Delta marshlands. The old distributaries and the soils they contain might be a key factor in supplying sediment in a constant stream towards the marshes.

The degradation of marshlands in the MRD due to erosion has become a pressing issue, prompting a call for action to replenish these vital landscapes with sediment-rich water. As sediment inputs have dwindled, marshes are losing their resilience, exacerbated by relative sea level rise and the impacts of pollutants carried by diverted river water.

The diverted river water, now laden with pollutants from agricultural runoff, poses a dilemma. While some argue for keeping these pollutants within the river to avoid further contamination of wetlands, studies suggest that wetland plants and low-oxygen soils possess unique capabilities for assimilating and treating nitrogen, a major pollutant. Morris et al. (2014) provide insights into managing river diversions to mitigate the risks associated with nutrient-rich water.

Failure to grasp the implications of these shifting biophysical baselines could have profound consequences for future political actions. Efforts to preserve what remains of the delta must be balanced with strategies to allow for its natural evolution. Much of the delta is in its final phase, with subsiding mineral soils overlain by low-strength organic peat soils. Marshes growing in these soils are increasingly susceptible to collapse, especially in the absence of new sedimentary inputs (Howes et al., 2010).



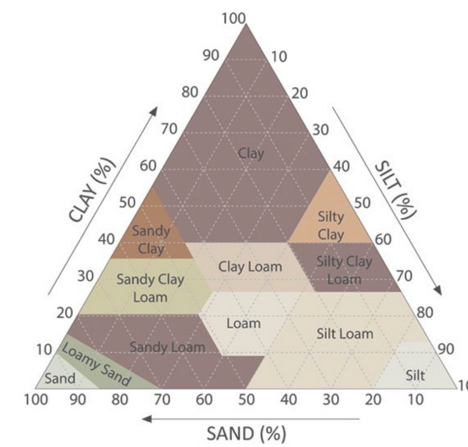
Abstract soil map of the Mississippi Delta, categorizing the Delta into three main soil types. To make a general understanding of the whole soil structure.

The closure of dams on the Missouri River and improvements in soil conservation have significantly reduced sediment flux reaching Louisiana, further exacerbating marsh loss. However, areas with direct river inputs, like Old Oyster Bayou, have shown greater stability and soil strength compared to those without direct input (Blum & Roberts, 2012; Kesel, 2003; Kesel et al., 1992; Meade & Moody, 2010; Thorne et al., 2007). Excessive nutrients, lack of sediments, and persistent low salinity conditions all contribute to marsh loss and weakening soil strength (Morton & Barras, 2011). Additionally, climate change could exacerbate erosion if drier conditions prevail over the Missouri basin.

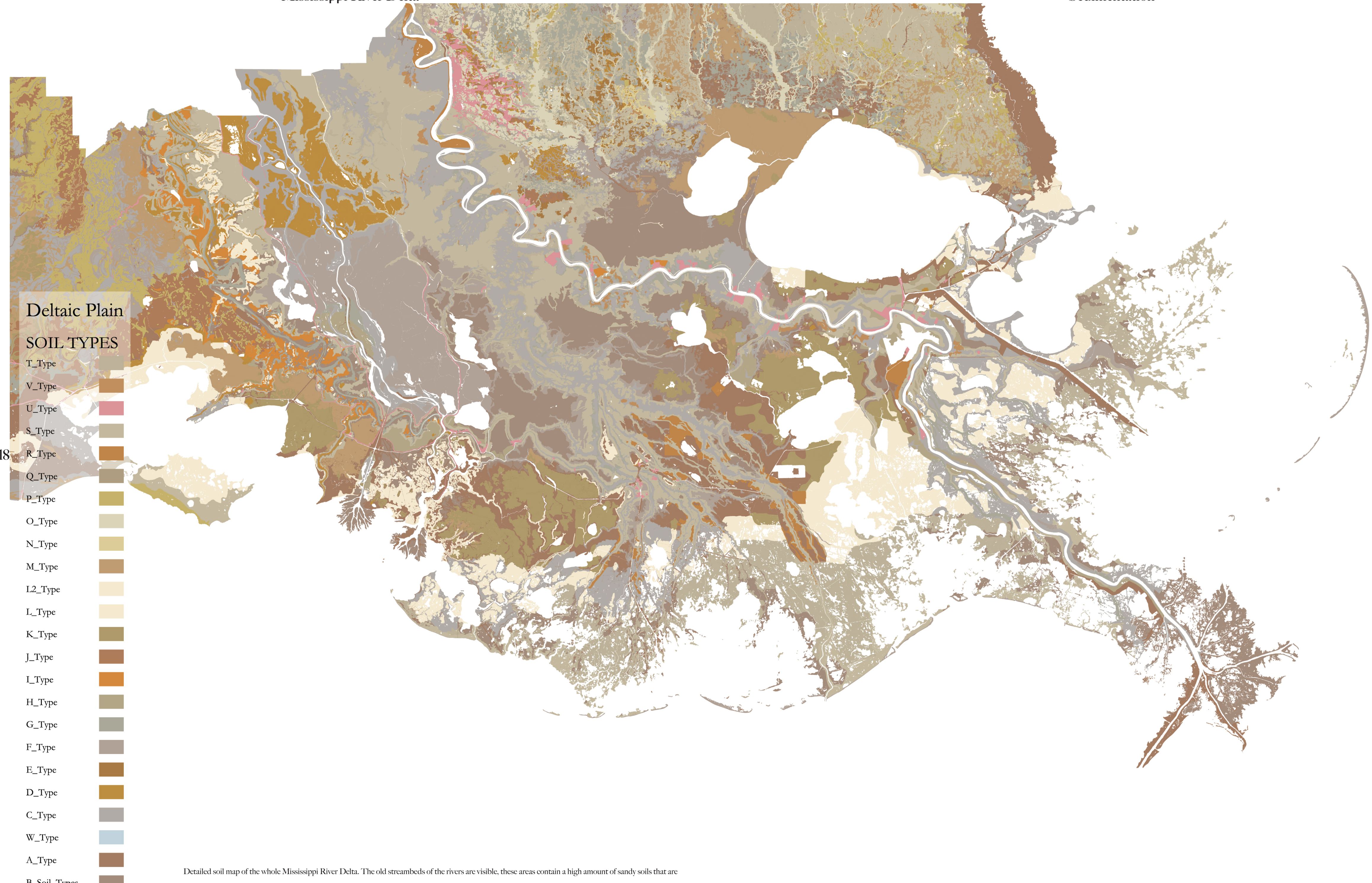
In conclusion, addressing the erosion of marshlands in the MRD requires a comprehensive approach that considers sediment management, nutrient control, and the preservation of natural processes. By understanding the complex interactions between human activities and the delta's ecosystem, we can develop strategies to sustain these critical landscapes for future generations.








source: TOPsoil PROS

Detailed soil map of the whole Mississippi River Delta. The old streambeds of the rivers are visible, these areas contain a high amount of sandy soils that are suitable for sediment deposit in the marsh lands of the Delta and can supply the barrier Islands with sufficient amounts of soil.

02 Height Map (DEM)

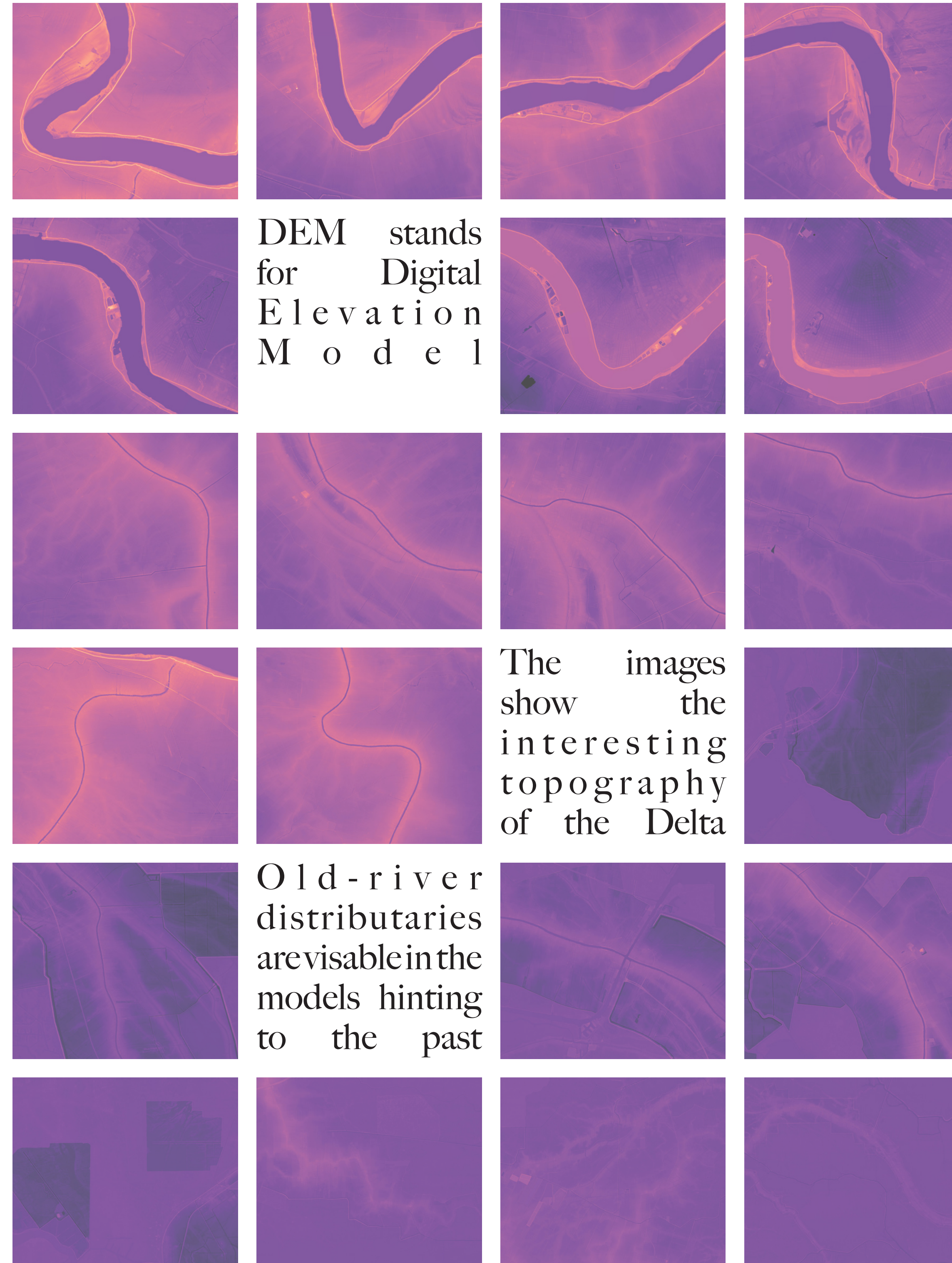
The elevation of the MRD plays a crucial role in its resilience and sustainability, but it is subject to dynamic changes influenced by various factors, including sediment supply, subsidence, sea level rise, and human interventions (Galloway, 1975). Historical data and recent observations shed light on the complexities of managing the delta's elevation to mitigate erosion and promote land-building (Ganti et al., 2016; Jensen et al., 2022). Together with the soil map the Digital Elevation Model (DEM), indicates weak and strong locations in the MRD for promoting land-building projects.

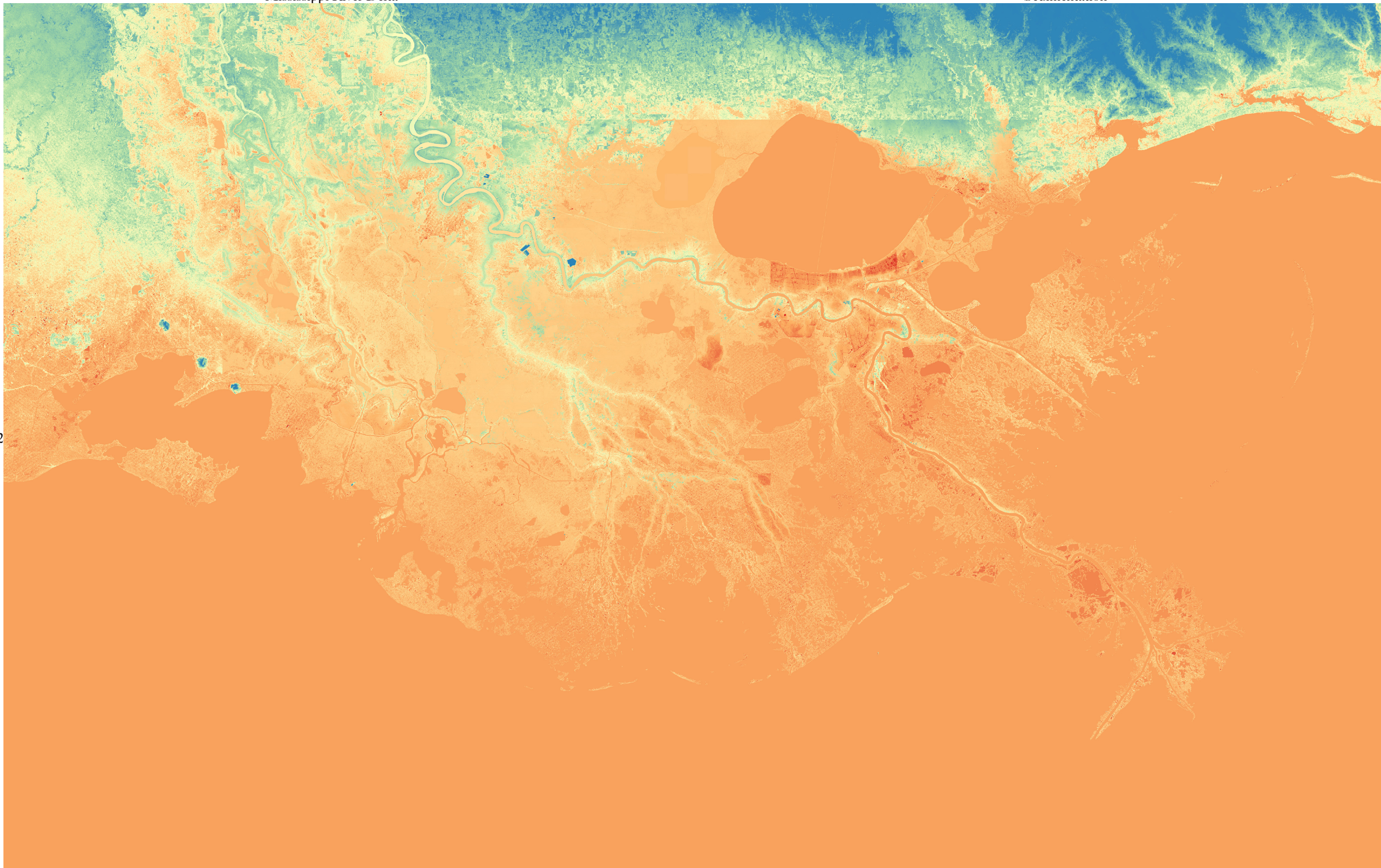
Historically, natural levees of the Mississippi River reached an average height of 1.8 meters when the river was still distant from the coast, surrounded by wetlands with elevated elevations and covered in mature saltwater-intolerant vegetation (Day & Erdman, 2018). However, events like Hurricane Katrina have demonstrated the vulnerability of coastal islands to extreme erosion and subsidence-induced sea level rise (Lavoie, 2009). For instance, the Chandeleur Islands experienced a drastic reduction in elevation and surface area during the hurricane, highlighting the challenges posed by natural forces and human-induced changes.

Recent studies have further illustrated the variability in thalweg, the line or curve of lowest elevation within a valley or watercourse (Wang, 2019), elevation along the Mississippi River, reflecting the complex dynamics of sediment transport and river morphology (Harmar, 2004). Various adverse bed slope zones have been identified, see map, suggesting areas prone to sedimentation and erosion. Large river diversions are proposed as a means to increase sediment retention and land building, but their effectiveness depends on factors such as sediment concentration, discharge volume, and distribution efficiency (Morris et al., 2014). The Old Oyster Bayou marshes have demonstrated high sediment retention rates and greater resilience to flooding compared to other marshes, underscoring the importance of sediment supply in maintaining wetland elevation and stability. However, the introduction of nutrients through diversions raises concerns about its impact on wetland ecosystems, particularly sediment organic matter production, and stability (Morris et al., 2014).

The complex interactions between sediment, nutrients, vegetation, and soil organic matter dynamics influence wetland accretion rates and plant community composition. While increased nutrient availability may enhance plant growth, it can also alter the balance between labile and refractory organic matter, affecting soil stability and erosion resistance.

In conclusion, understanding the intricate interplay of natural processes and human activities is essential for managing the elevation of the Mississippi Delta effectively. Balancing sediment supply, nutrient dynamics, and wetland vegetation dynamics is crucial for promoting land building, mitigating erosion, and sustaining coastal ecosystems in the face of ongoing environmental changes.





03 Water System

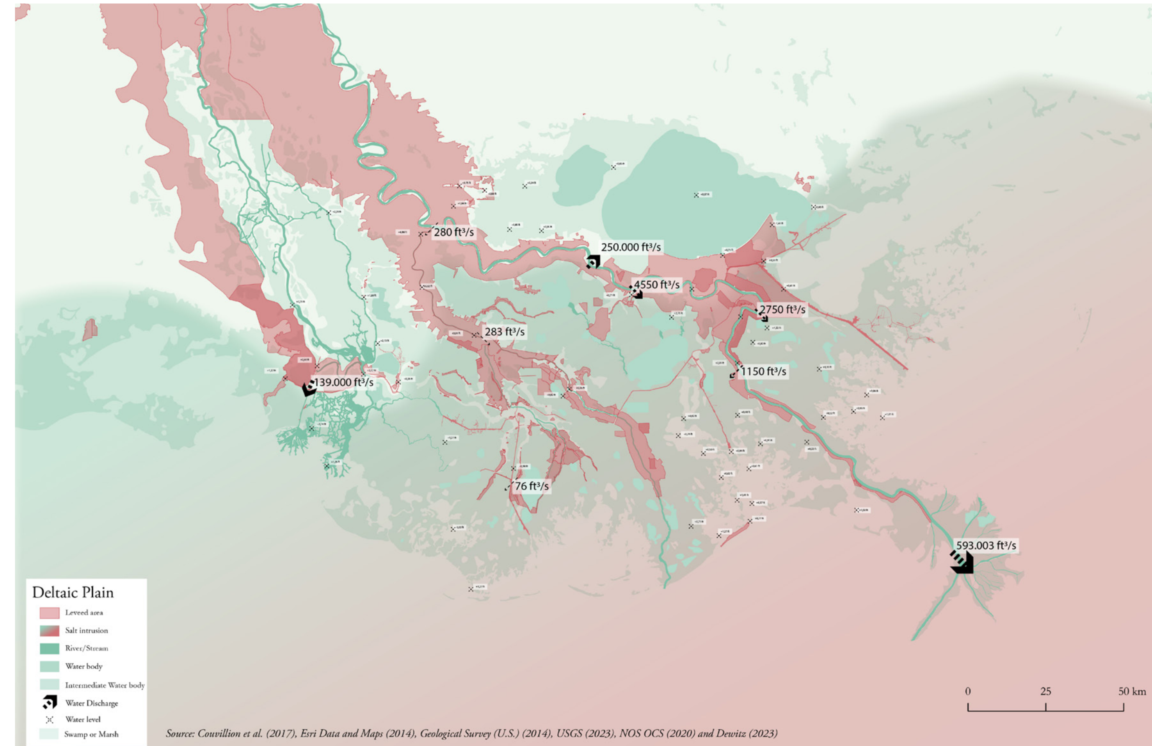
Today, the water system of the Delta is at a crossroads. Human activities have drastically reduced the volume of sediment reaching the deltaic estuaries, leading to the deterioration of coastal basins and the loss of wetlands. The consequences of this transformation are profound, affecting not only the natural environment but also the livelihoods of those who depend on it for fishing, trade, and industry. In response to these challenges, efforts are underway to restore the delta's water system to a more natural state. Managed diversions, designed to re-introduce water and sediment from the Mississippi and Atchafalaya Rivers into deteriorating coastal basins, are seen as a primary solution. By strategically redirecting water flow, these diversions aim to rebuild land and rejuvenate habitats along salinity gradients.

However, restoring the water system of the Delta is not without its complexities. Balancing the needs of navigation, flood control, and ecological restoration presents a formidable challenge. The current navigation system focused primarily on maintaining shipping routes and flood protection, is no longer sustainable. Increasing costs and diminishing results indicate the need for a new approach. Key to the success of delta restoration is understanding the historical dynamics of the region. Studies of the last naturally active delta complexes provide valuable insights into how the delta once functioned and offer guidance for future restoration efforts. By learning from the past, planners can design interventions that mimic natural processes and promote sustainable land building.

Therefore an elaborated map of the current water system is needed to change its parameters. Flood protection and navigation are the main drivers of the water system, these are shaped by levees and pumping stations. It can be considered as a polder system, like in the Netherlands. The leveed areas are most of the time low-lying areas, whereas rivers are higher than the polders. Pumping stations are placed at the edge of the leveed area and placed on the other side of the river, to pump rainwater and upcoming groundwater into the swamps and marshes, this is schematically displayed in images.. . The canalization of the MR has led to high water levels during the spring, during this period different outlets along the MR are opened. Lowering the MR water levels reduces the pressure on the levees along the MR, in the map these different outlets are illustrated. The maximal capacity of each outlet is retrieved from Interior and Survey (2024). Only the Bonnét Carre spillway is a significant outlet system that intervenes with the water levels on a bigger scale. Two main reasons for this are, that this needs significant construction which is difficult along the densely constructed riverbank of the MR further, the water level of the MR should be stable to allow navigation along the river. Therefore, smaller outlets are possible since they will have little interference with the water levels.

Central to the restoration strategy is the use of diversions to reintroduce sediment into coastal areas. Recent experiences with diversions like Wax Lake, Big Mar, and West Bay have shown promising results, with new land rapidly forming after periods of subaqueous development. However, the scale, design, and location of diversions are critical factors that must be carefully considered to maximize their effectiveness.

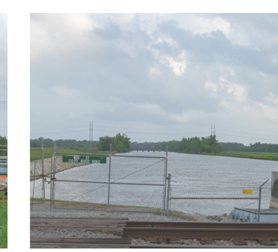
As the Delta faces the challenges of climate change and shifting water dynamics, the need for adaptive management becomes increasingly urgent. Redesigning river operations, harnessing gravity-driven water flows, and incorporating innovative diversion techniques will be essential for rebuilding and restoring the fragile coastal landscape of the Mississippi Delta. Through collaboration and forward-thinking stewardship, it is possible to create a water system that sustains both nature and communities for generations to come.



Levees are mostly constructed out of earth and sometimes reinforced with concrete slabes against erosion. This is mainly done along the Mississippi River, in aquatic envirionments the levee is just a concrete wall.

Sluices or watergates are structers that close during high waters and stroms. When open they allow water flow and shipping. Now-a-days 100 days a year on average these structures are closed, limitting navigation, waterflow, and animal migrations.

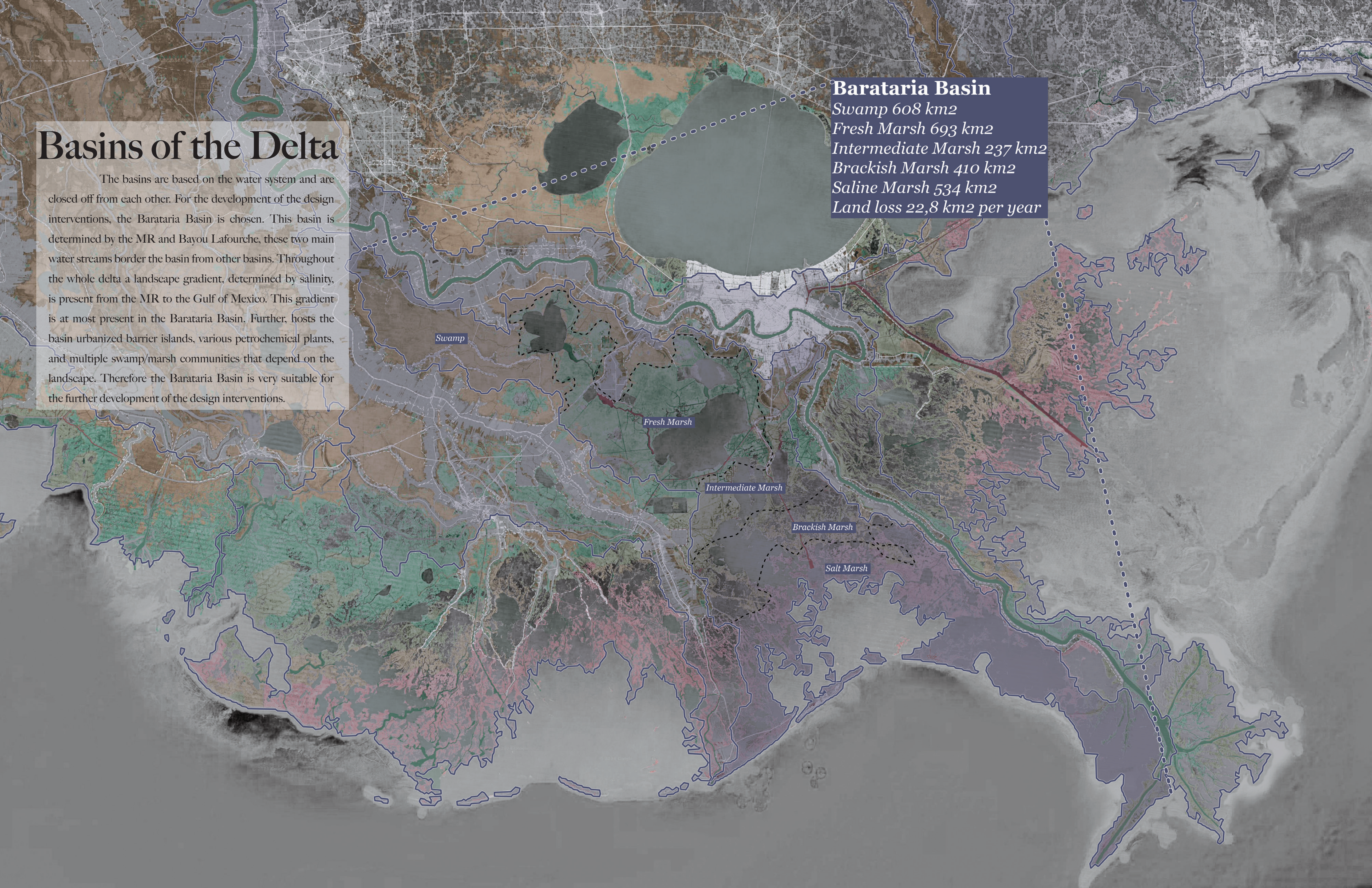
Pumping stations are mechanical structures that pump water from the polder towards a waterbody. In this images the water pump is pumping water from the Mississippi into Bayou Lafourche, this is rather strange since the Mississippi is laying higher than Bayou Lafourche.



Distribution channal is collecting the water from the pumping station and distributing it towards swamps, marshes or the Gulf of Mexico.

Basins of the Delta

The basins are based on the water system and are closed off from each other. For the development of the design interventions, the Barataria Basin is chosen. This basin is determined by the MR and Bayou Lafourche, these two main water streams border the basin from other basins. Throughout the whole delta a landscape gradient, determined by salinity, is present from the MR to the Gulf of Mexico. This gradient is at most present in the Barataria Basin. Further, hosts the basin urbanized barrier islands, various petrochemical plants, and multiple swamp/marsh communities that depend on the landscape. Therefore the Barataria Basin is very suitable for the further development of the design interventions.



Cities of the Delta

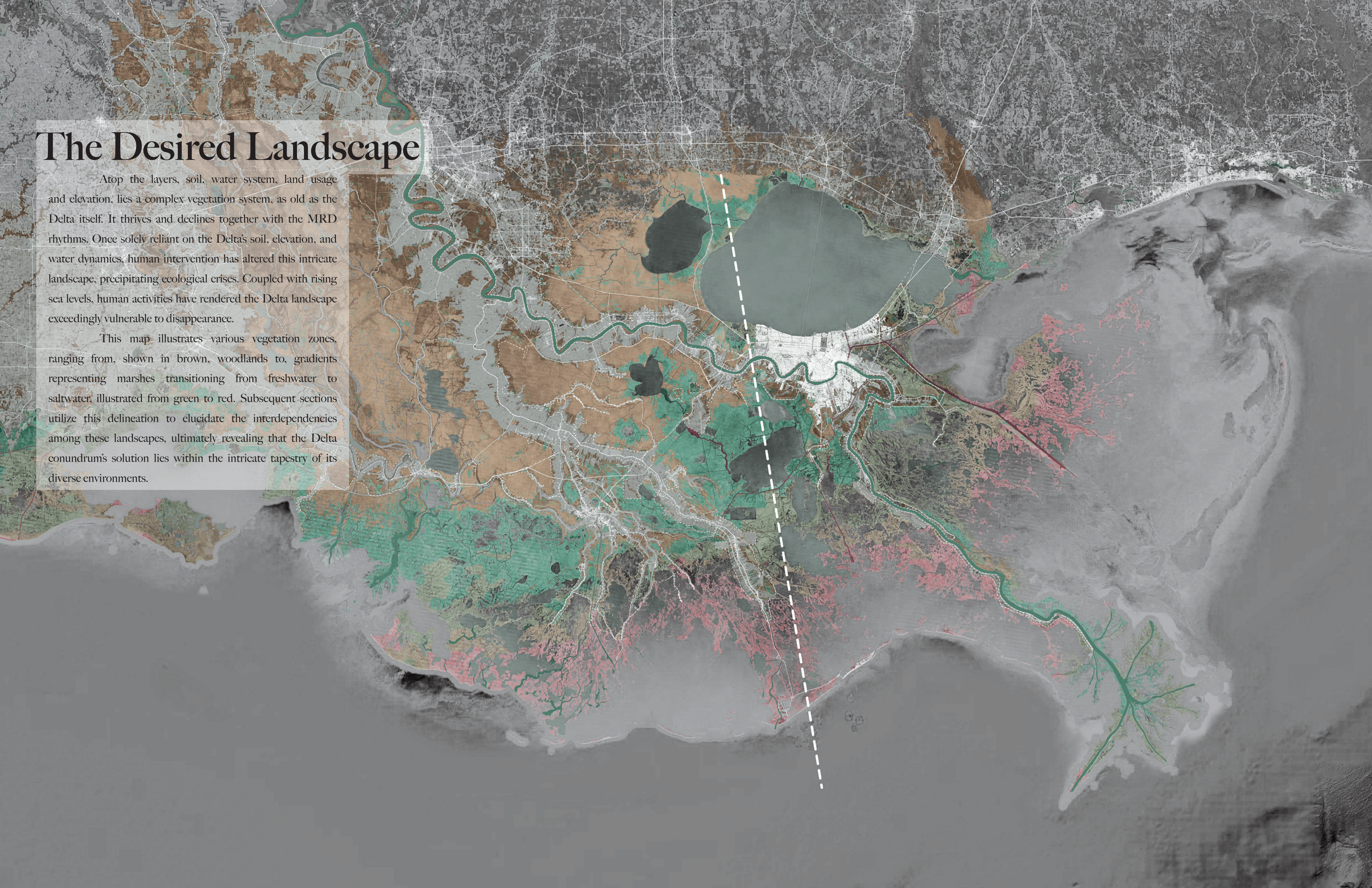
The land usage of the MRD is dominated by exploitation and natural beauty. Along the riverbanks of the river, huge complexes are constructed for trade a wide variety of companies is found in agriculture, sand storage, and petrochemical plants. The river is flanked by industry, urbanization, and agriculture. Three main reasons are, connectivity for trade via the MR, stable soils (mainly sandy), and higher grounds (relatively dry). Therefore, only the flanks of the MR or old river distributaries are used for human activity. In the heart of the different vegetation zones, humans are less present. This landscape ought to be natural, but incidental human traces are found. Pipeline channels, pumping stations, harbours, fishing docks, and isolated communities are found in the landscape. Intentionally or unintentionally shaping the landscape by their activity.

Site visit MRD

The Desired Landscape

Atop the layers, soil, water system, land usage and elevation, lies a complex vegetation system, as old as the Delta itself. It thrives and declines together with the MRD rhythms. Once solely reliant on the Delta's soil, elevation, and water dynamics, human intervention has altered this intricate landscape, precipitating ecological crises. Coupled with rising sea levels, human activities have rendered the Delta landscape exceedingly vulnerable to disappearance.

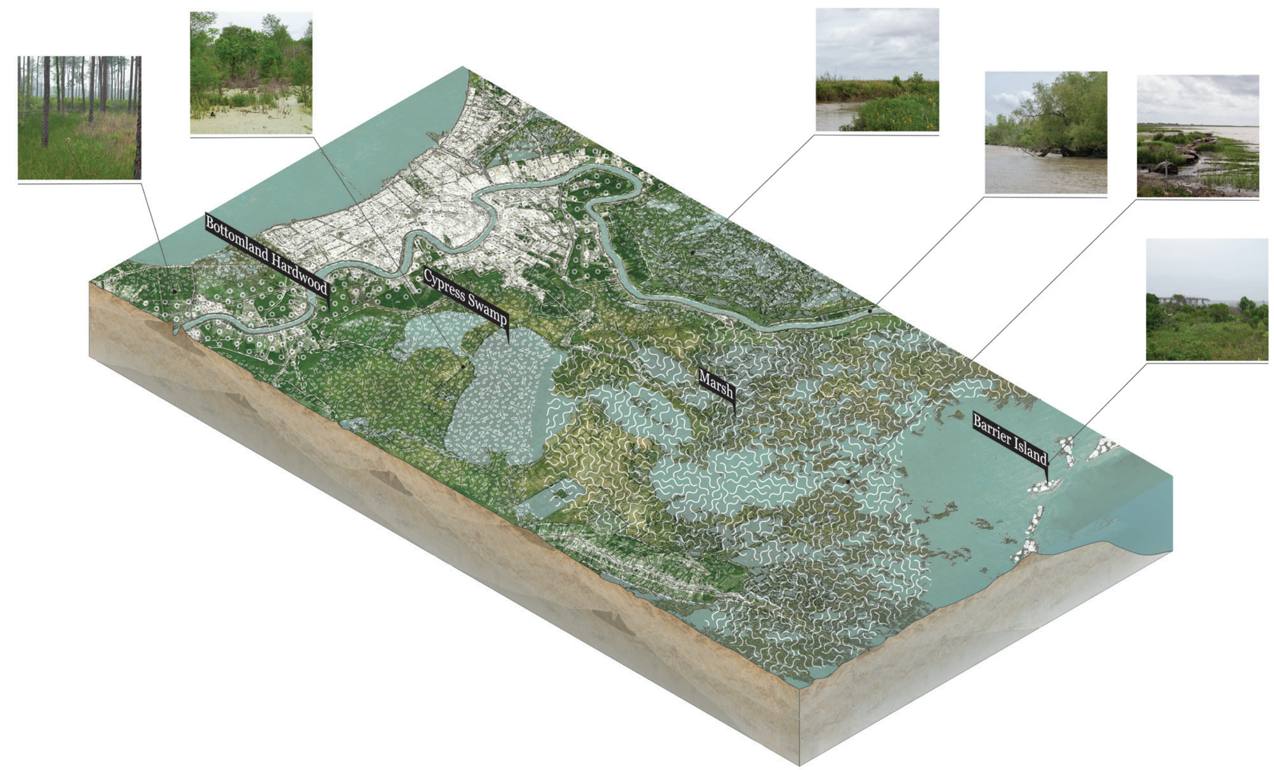
This map illustrates various vegetation zones, ranging from, shown in brown, woodlands to, gradients representing marshes transitioning from freshwater to saltwater, illustrated from green to red. Subsequent sections utilize this delineation to elucidate the interdependencies among these landscapes, ultimately revealing that the Delta conundrum's solution lies within the intricate tapestry of its diverse environments.



The landscape of the MRD depends on the water that is carried by the MR which contains silt, nutrients, and sand. Together with water, these three elements balance the complex landscape types of the MRD. The biography of the Delta helped to understand how humans have shaped the water system and how this harmed the landscape of the Delta. However, during the biography (see appendix), the effect on the specific landscapes has not been considered. In this chapter, the different landscapes are explained in how they function and are related to each other, but also how these landscapes contribute to a solution for the resilience of the MRD.

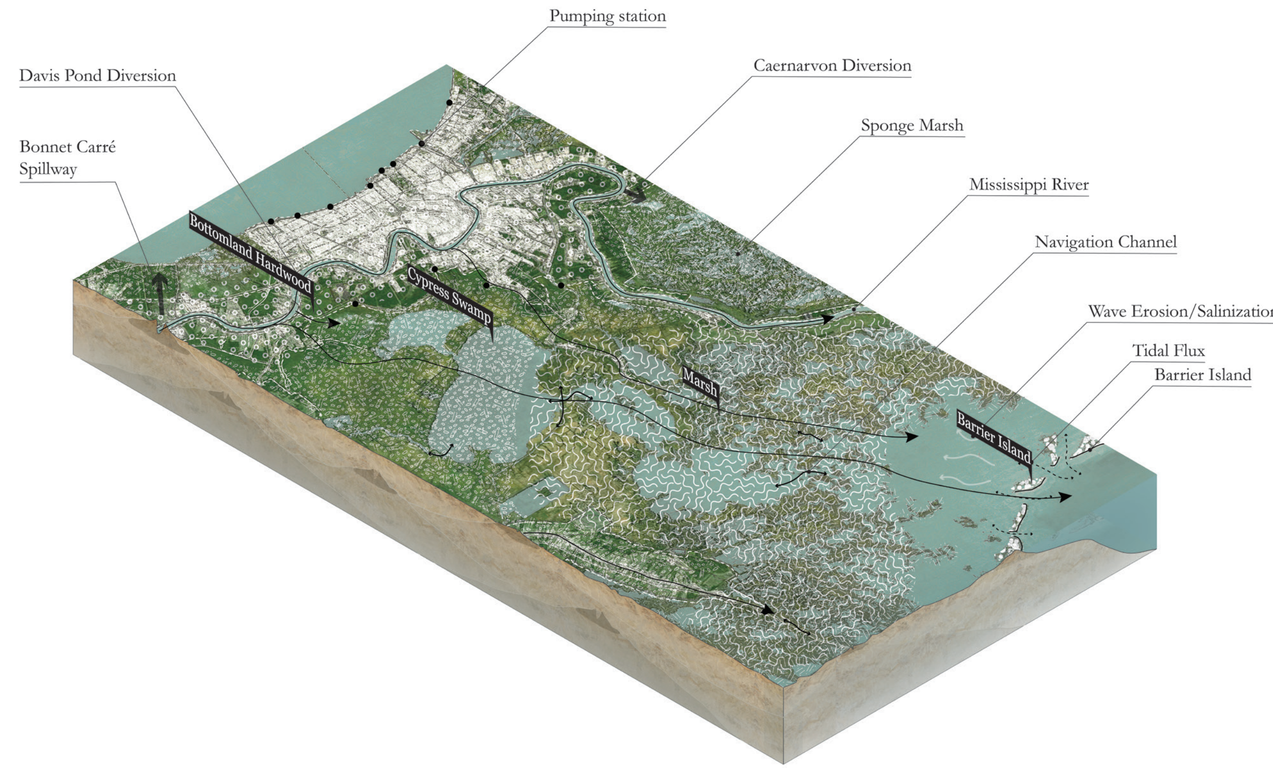
Following the water from the MR towards the Gulf of Mexico three main landscape features can be distinguished, wooded vegetation, marshes, and barrier islands. Whereas the wooded vegetation consists of Bottomland Hardwood, and Cypress Swamp Forrest, the Marsh landscape follows the gradient of salt, Fresh Marsh, Intermediate Marsh, Brackish Marsh, Salt Marsh, and finally the Barrier Islands. As the water is followed closer to the Gulf of Mexico the salinity increases and has a direct effect on the landscape. Not only does the salinity determine the landscape types elevations play an equally important role in the shaping of the landscape. In the section, the landscape is cut from the Mississippi River toward the Gulf of Mexico.

The vegetation of the Delta thrives and interacts once water is flowing. Yearly the MR and its distributaries overflow, supplying the landscape with fresh water, sediments, and nutrients. The section illustrates schematically how this flooding affects the landscapes. Once the water flows over the natural levees of the river it will flow through the Bottomland Hardwood forest, the bottomlands act as safety valves, detaining the flood water when

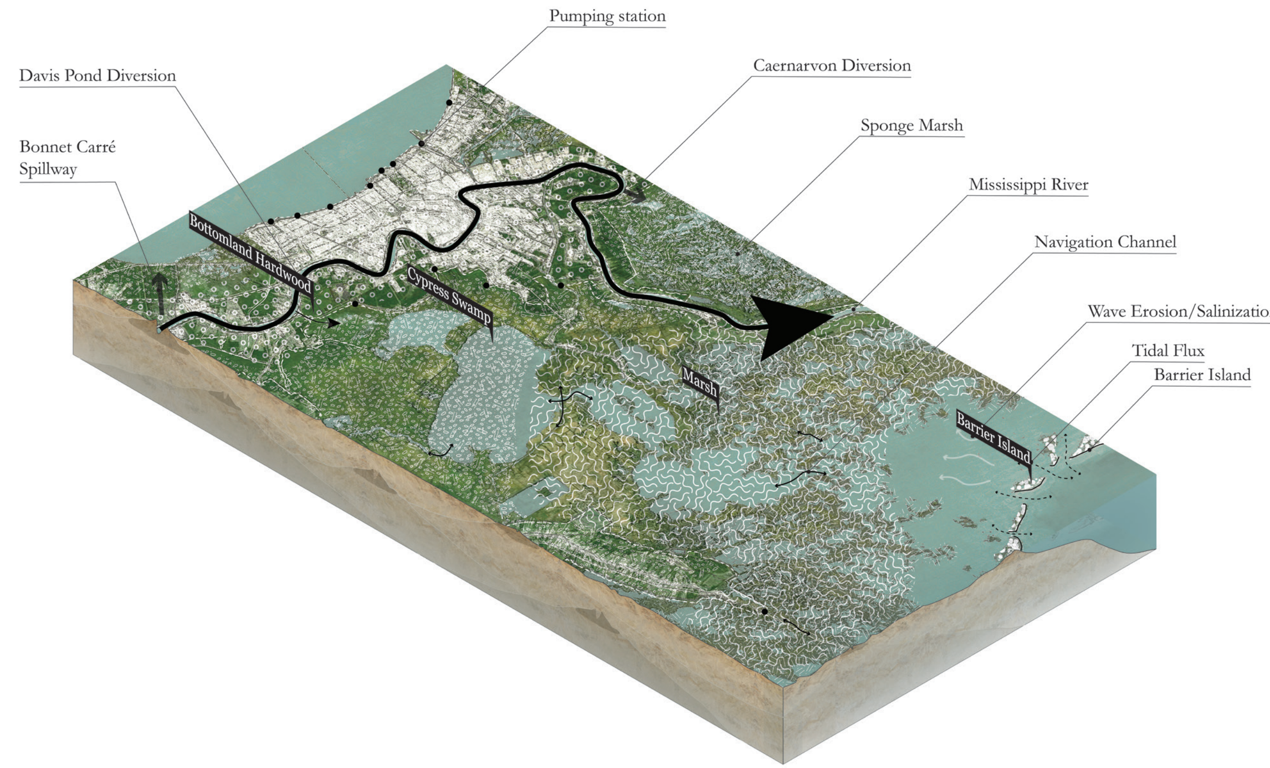


the river overflows the main channel (Strain, 1990). Another important function of the Hardwood Forest is hosting a refuge for wildlife since the forest is situated on higher grounds and has a high density of different vegetation species. The spring floods do not only increase fertility by depositing soil and nutrients, but they also speed up decay, releasing nutrients stored in leaves, branches, downed logs, and other dead material on the forest floor (Strain, 1990) taking it further with the water towards the Cypress Swamp. A Cypress forest is most of the time inundated with water and therefore has almost no ground-covered vegetation. The Cypress tree grows large and sturdy, with so-called 'knees' to support them during storms, since the soil is not stable. These knees are also filtering the water from nutrients, giving oxygen back to the water (Conner et al., 1986). The water has been filtered and stabilized by the wooded vegetation before it arrives in the Marshes. Wetland is characterized by grass-like plants that stand above the water or ground surface (Dahl et al., 1979). The fine-rooted vegetation is ideal for trapping sediments and filtering the excessive nutrients out of the water (Walker et al., 1987). The marshes are highly defined by salinity levels in the water, as the marshes are situated closer to the Gulf of Mexico the salinity increases. With the increase of salinity the vegetation and animal species change, but the function of the Marsh stays the same. Trapping sediments, reducing tidal flux, keeping water, and filtering nutrients out of the water (Day & Erdman, 2018). Before the water flows into the Gulf of Mexico it has to pass the Barrier Islands. These Islands are the result of abended delta lobes and consist mainly of sandy soils with wooded shrub vegetation (Blum & Roberts, 2012). The last parts of sediments in the water are deposited along the banks of the Barrier Islands before it is taken away by the tidal flux of storms. This last part is vital for the Barrier Islands because a balance occurs between deposition and erosion. The filtering of water is important for sea life, since algae growth blooms by high concentrations of nutrients in water. This will lead to lower oxygen levels in the water, which will affect the fish population.

The water that is coming from the Gulf of Mexico, is streaming into the landscape during high tides, storms, and periods of drought in the wetlands. During this period salt water intrudes far inland, and most species are (periodically) tolerant against saline waters. So they will be able to withstand the next spring flooding. During this period the drawback of seawater takes sediments from the Marshes and Barrier Islands. Long a balance between these two factors existed, the delta was river-dominated, and therefore more sediments were deposited in the landscape than taken away. This balance is vital for the survival of the landscape.



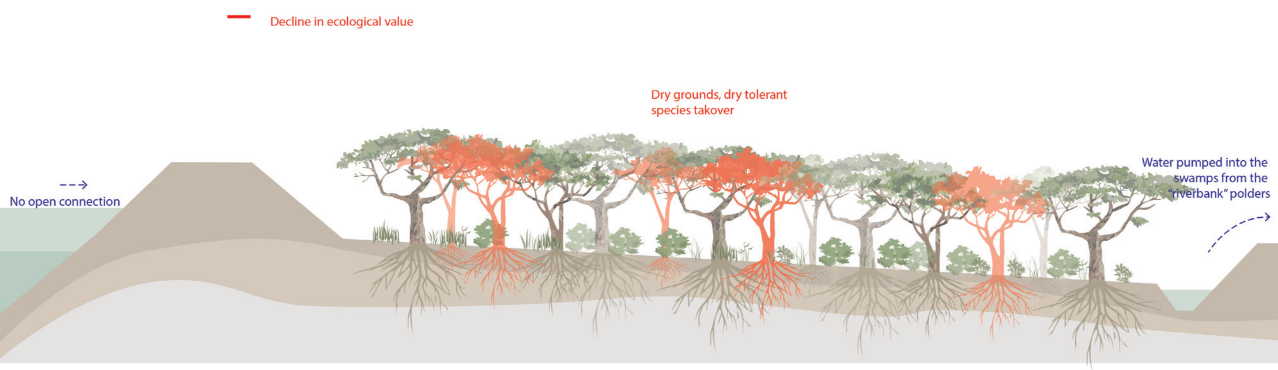
As described before humans have altered the natural water flow of the Delta. Landscapes are no longer supplied by the spring floodings leading to a decline in marshes and barrier islands. The canalization of the Mississippi River has caused the delta to be no longer river-dominated in most parts of the Delta, but a sea-dominated delta with no sediment supply. Taking away sediments and increasing levels of salinity of water, causing die-off from most plants in the Delta making the Delta vulnerable to storms and drought. Together with this land and vegetation loss, the landscapes are also losing their value for humans and animals. Humans and animals are no longer able to use the landscape as they have done centuries before the alternation of the water system.

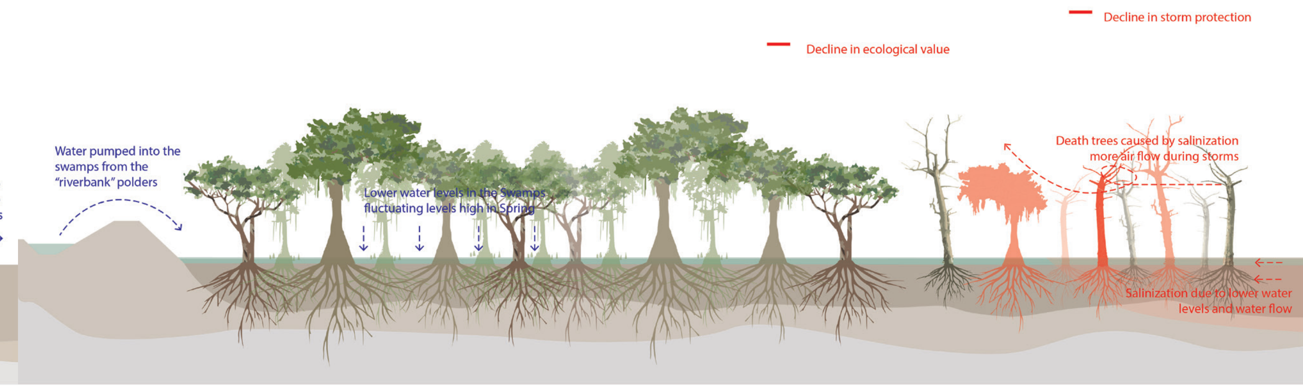


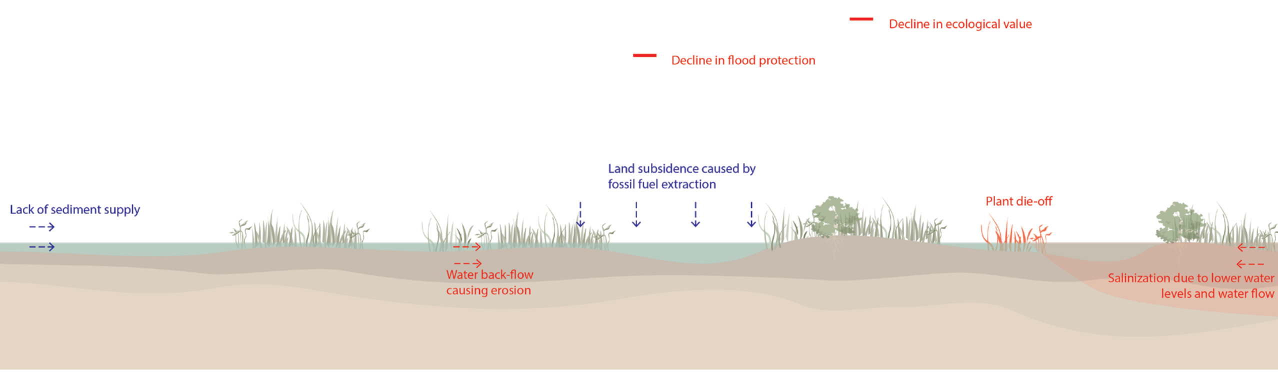
Mississippi River Delta

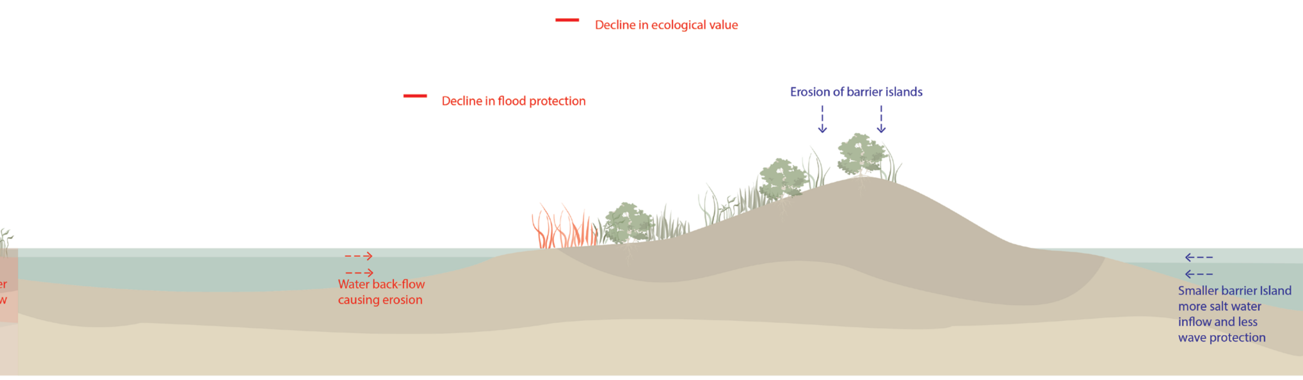
These schematic sections of the different landscape types show what has already been written previously. The sections make it insightfull what kind of effect the water managment has on the landscape. A wide range of effects are illustrated, from die-ing plants from draught or salinization, land subsidence and erosion caused by the lack of sediments.

Sedimentation





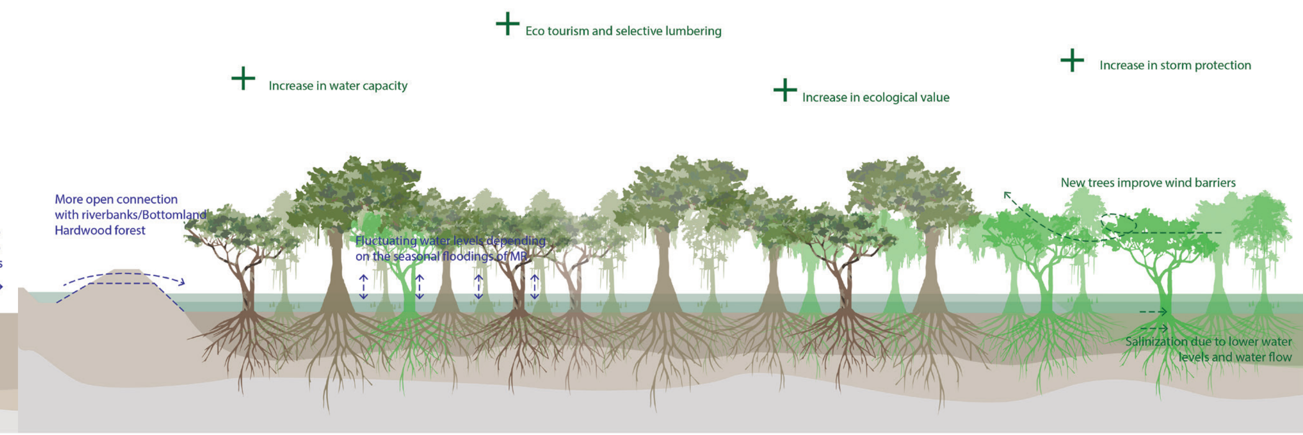


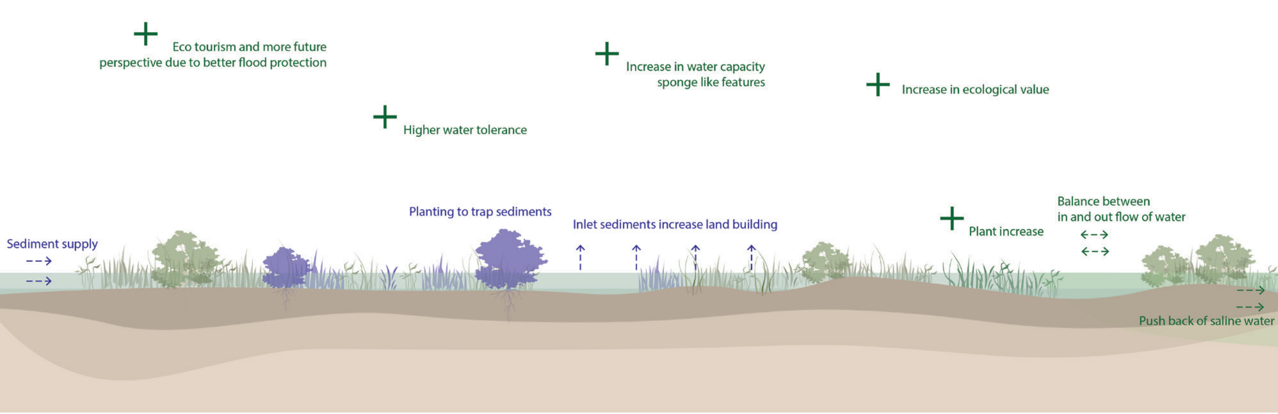


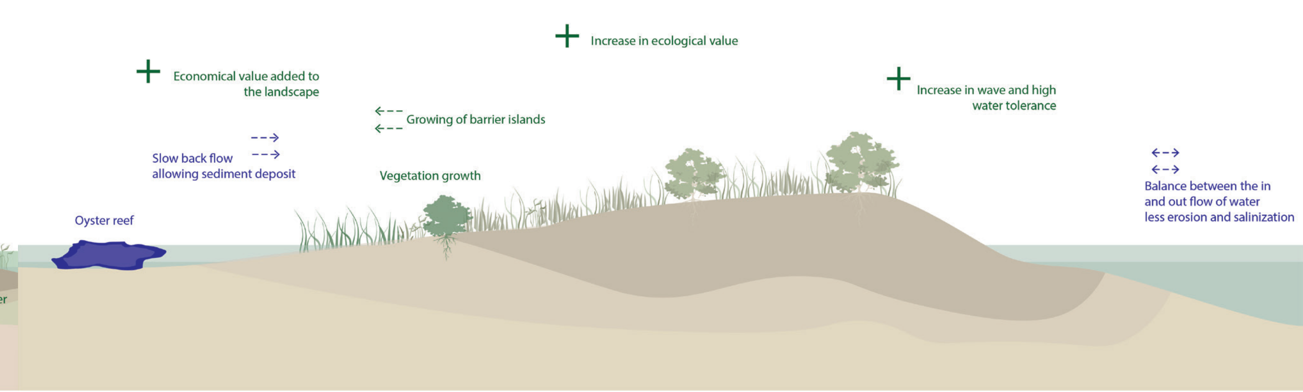
Mississippi River Delta

Sedimentation

These schematic section propose a possible scenario when the altered water management is restored to a more natural approach. By connecting the river water to the landscape, fresh water, nutrients, and sediments are re-introduced to the landscape. The sections show the possible effect it has on the landscape, from diverse vegetation species, to land growth by sediments.







Traditional landscape usage

Oyster fishing in the Mississippi River Delta has a long history, once supporting a lush ecosystem with abundant oyster reefs crucial for local communities. The industry thrived in the 19th century but faced challenges due to human activities like shell mining and hydrological changes, which disrupted the natural sediment flow and degraded oyster habitats (Snider, 2018). Restoration efforts now focus on rebuilding these habitats to enhance biodiversity and protect against erosion. These projects aim to create sustainable ecosystems that can withstand environmental changes and support future generations.

Library of Congress (2024)

LSU AgCenter (2024)

Rice cultivation in the Mississippi River Delta has a rich and evolving history, beginning in earnest in the late 1940s. By 1953, local farmers were already planting 70,000 acres and producing over 1.8 million hundred tons of rice. This region, particularly the Delta, had to adapt cultivation practices from other rice-growing states to fit its unique conditions. In recent years, rice production in the Mississippi Delta has continued to grow. In 2016, over 13 million hundredweight of rice was produced, with a production value of $139 million. Innovations such as Alternate Wetting and Drying (AWD) techniques have been introduced, reducing water usage while maintaining yields. These modern practices reflect a continuous effort to optimize rice farming in the Delta's specific environment.

The forests of the Mississippi River Delta were once dense with towering cypress trees, creating a thick canopy that blocked sunlight. These trees supported a rich ecosystem, including now-extinct birds like the Carolina parakeet and passenger pigeon. By the 1700s, cypress wood became highly sought after, leading to extensive logging. By 1900, only 2.3 million acres of the original cypress forests remained in Louisiana, and today, no old-growth forests exist. Logging for cypress mulch surged in the 2000s, but efforts by the Atchafalaya Basinkeeper halted operations by 2012. Despite continuous threats, the Basinkeeper's "Cypress Shield Campaign" remains vigilant in protecting these vital forests from further destruction.

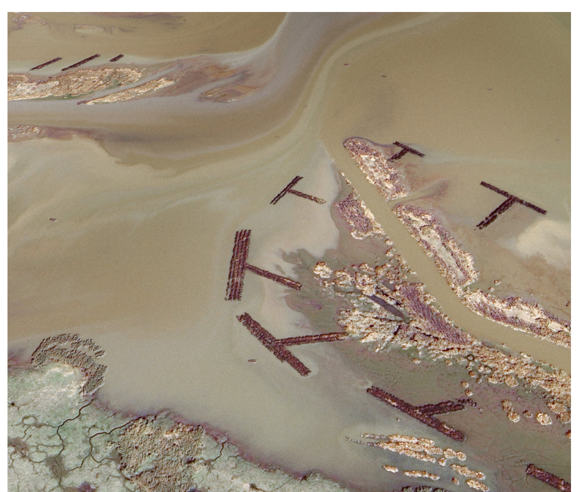
Albany Woodworks (2024)

Crawfish farming in the Mississippi River Delta has deep roots, starting with Native Americans like the Houma tribe, who revered crawfish as part of their heritage. It was initially harvested from the wild during annual floods and became commercially significant in the late 1800s. By the 1960s, rice farmers in Louisiana began cultivating crawfish in their fields, creating a more stable supply and providing an alternative income source when rice prices dropped. This shift coincided with growing demand during Lent, enhancing the popularity of crawfish dishes such as Crawfish Étouffée and boiled crawfish. The industry boomed, and Louisiana emerged as the leading crawfish producer in the U.S.. Today, over half of the state's harvest is exported, balancing wild and farmed crawfish to meet high demand.

LSU Library (2024)

Current land building

In various places in the MRD local people are already building land via nature-based approaches. Two main principles include planting vegetation in places where the water carries sediments. As illustrated in the images above, vegetation is planted to slow down water to deposit sediments. In this case hunter stuck willow branches into the soil to create cover. Therefore they caused a disturbance in the water flow enabling sediment deposits, and eventually vegetation growth. This informal or accidental way of creating land is a welcome by-product of the hunting industry. Secondly, on a bigger scale thick Spanish reeds are planted on existing vegetation strips. These reeds are sturdy and densely packed together, which creates an excellent deposit of sediments. They are planted into T-shaped forms to create areas that have a low inflow of water.



Concluding

Throughout history, the deposition of sediment-rich water from the Mississippi River has built and sustained the delta landscape, forming natural levees and supporting diverse vegetation zones. Various studies, including those by Walker et al. (1987), Blum & Roberts (2009; 2012), Chamberlain et al. (2018), and Morris et al. (2014) highlight the importance of sediment management, nutrient control, and natural processes in preserving the MRD. Efforts to restore the delta's water system through managed diversions and land-building projects, as described by Ganti et al. (2016) and Jensen et al. (2022), offer hope for re-establishing deteriorating coastal basins and habitats.

However, restoring the MRD's water system requires a comprehensive approach that considers the needs of navigation, flood control, and ecological restoration, as outlined in Interior and Survey (2024). By learning from past delta complexes and leveraging innovative techniques, such as gravity-driven water flows and strategic diversions, it is possible to sustainably manage the delta's elevation and promote land building.

Furthermore, understanding the complex interactions between sediment, nutrients, vegetation, and soil dynamics is crucial for mitigating erosion, maintaining wetland elevation, and preserving coastal ecosystems. The intricate tapestry of diverse environments within the MRD, as depicted in various vegetation zones and landscape features, underscores the need for holistic conservation strategies.

To conclude, addressing the erosion and degradation of the MRD requires collaborative efforts and adaptive management practices. By embracing the complexities of natural processes and human interventions, we can develop strategies to sustainably manage the delta's landscapes. This requires balancing between man-made structures that enable sediment supply but still ensure protection from water during storms, and the deltaic water system to take over to let nature evolve.

Planting vegetation is an effective methode to generate new land, duck hunters use Willow branches for shelter during the hunt. The vegetation supports accumelating sediments, the images show succesfull vegetation planting and less succesfull. The levee breach on the bottom picture is allowing the vegetation to accumelate new sediments.

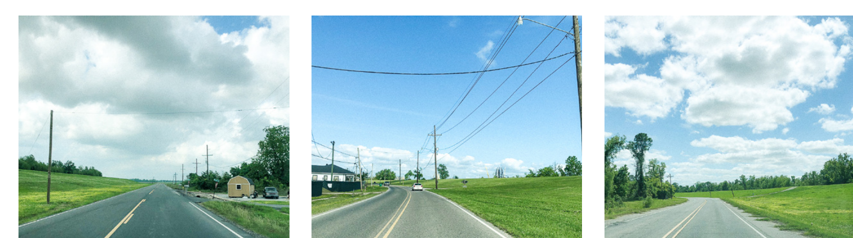
Along the Levee of the Mississippi River

Baton Rouge to New Orleans

Factories, grasses, agriculture and homes.

Shot during my site visit, return drive from the LSU River Center

Did you see the Mississippi River?



Part III / The Potential Landscape

Future Perspective

In envisioning the future of the Mississippi River Delta, the concept is to create a sustainable Delta that can thrive for centuries to come, sustained by the river's natural processes. To achieve this vision, the river sediments should be used very beneficially and placed in places that need it the most. This means opening and managing new river mouths over time to receive the river's sediment, and strategically building land and wetlands where they have the best chance of success. The result will be a more compact, robust deltaic landscape stretching from Vermilion Bay to Mississippi Sound, ensuring a sustainable Delta for generations to come.

The approach delivers immediate gains by reducing flood risk, enhancing navigation and marine commerce, and fostering economic growth and stability. By "following waterways" it can harness the natural power to nourish the human, economic, and ecological systems that depend on it. This transformational approach requires changes in all aspects of the Delta – its economy, ecology, and culture – but promises to ensure a more stable, productive, and sustainable delta for all. The case for action to preserve the delta is clear. For too long, the channelization of the river has forced its rich sediment to bypass the wetland landscapes it once replenished, causing the Delta to cease growing naturally. Valuable wetlands are disappearing at alarming rates, threatening the economy, ecology, and cultures of the Delta. Maintaining the status quo is not an option; bold action is needed to recapture the river's sediment load and create new land, protecting and expanding the Delta's rich heritage, ecologies, and economies.

The future layout of the Delta is rooted in restoring the land-building potential of the river, mimicking the natural processes that have shaped the Delta over millennia. By strategically locating new river mouths or outlets throughout the Delta, new sub-deltas with land and wetlands can be built, effectively "turning on faucets" to deliver water and sediment where needed. Building on existing infrastructure, we aim to maximize land building by capturing sediment, resulting in tremendous flood risk reduction and shipping advantages.

The new Delta is envisioned as a 100-year or longer evolution to a seventh Delta Lobe, well-suited for the Anthropocene Era. This new delta will be sustainable and smaller in area but have faster vertical accretion rates, relying on natural and human-based processes to redistribute sediment strategically. Through a combination of new river outlets, barrier islands, bay islands, reefs, and expanded wetlands, a resilient, transformative, and economically vibrant delta region can be created.

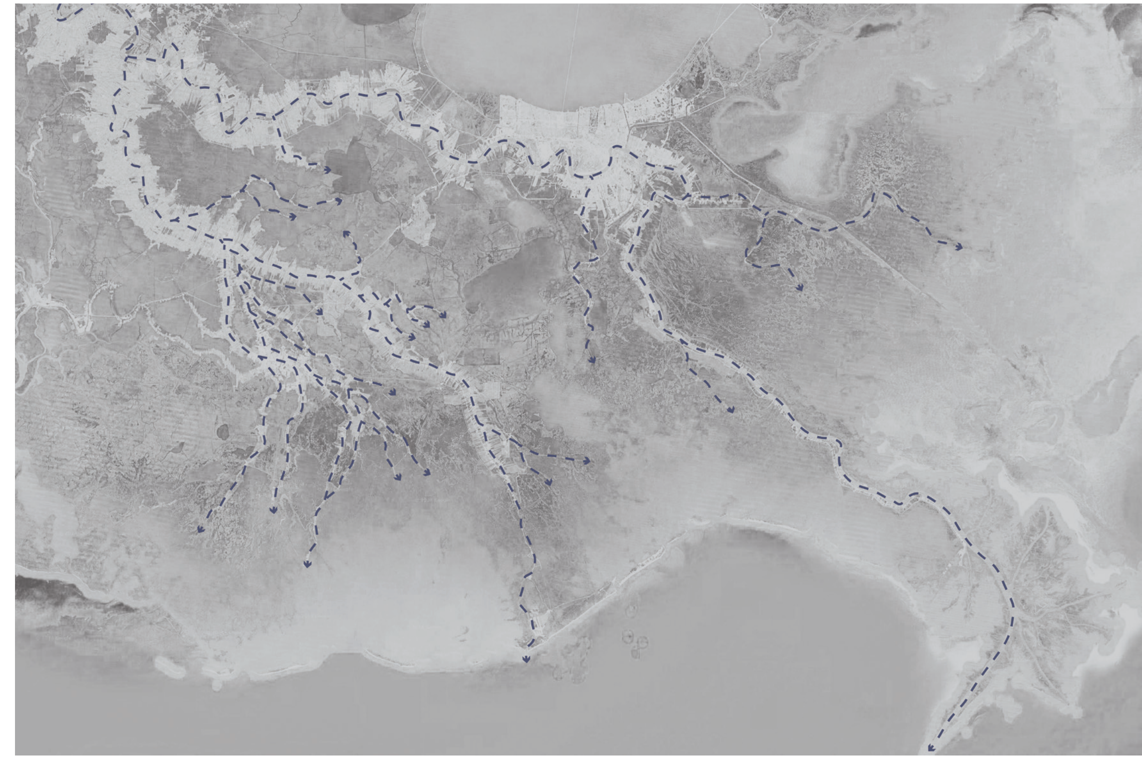
In planning for the future, it is essential to highlight the economic and community relevance of the Delta and engage stakeholders at all levels. Addressing varying timescales, bridging disciplines, and embracing change are crucial to success. By empowering the river and integrating investments to yield multiple benefits, we can ensure a safer, higher quality of life for all who call the Delta home.

A small hike on the north side of Lake Pontchartrain, this wide swamp landscape is mainly dominated by reeds and pine trees.

Design Scope

Nature is trying to overcome the disbalance, caused by man-made structures, but its capacity cannot cope with the speed of land subsidence and relative sea-level rise. Various papers and research have proven that these human alterations have caused nature to be completely desolated (Barras et al., 2003; Bernier et al., 2006; Blum & Roberts, 2009, 2012; Edmonds et al., 2023; Walker et al., 1987). To strive towards an equilibrium between human and natural processes design interventions are needed to help nature restore balance. The interventions are meant to give natural processes a boost, but allow them to take over. The key element to design with is sedimentation, determining how this natural process will act on the Barataria Basin a design-by-research approach is taken for this part of the design. Therefore, following water is leading concept of the design interventions.

Literature and case studies are taken to determine how to design interventions that should help the natural processes restore balance. First, the Barataria Basin is divided into three zones to become more location-specific when tackling this problem. Further, supplying sediments, trapping sediments and keeping sediments are researched in this chapter.



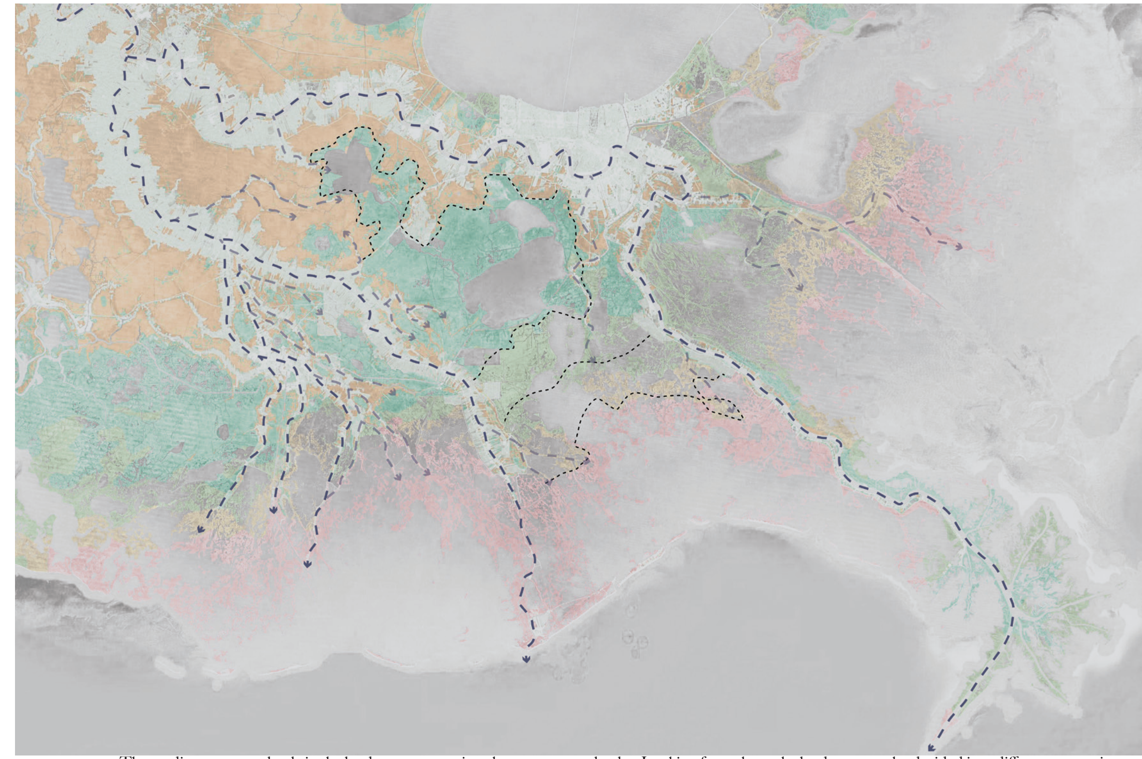
Following water from the Mississippi River towards the Gulf of Mexico, perpendicular with the landscape gradient. This course will give a clear structure and organization for determening the design interventions.

Deviding the Basin

To restore the MRD's fragile ecosystem, innovative design interventions are being deployed to create a new landscape that balances natural processes with human needs. Drawing insights from previous research and studies by Walker et al. (1987), Blum & Roberts (2009; 2012), Morris et al. (2014), Ganti et al. (2016), Jensen et al. (2022), and Interior and Survey (2024), these interventions aim to address the erosion, degradation, and loss of critical habitats within the delta.

Dealing with the complexity of the delta system and the possible solutions a clear order for this approach is needed. The following water gives a linear proposal of how the interventions are influencing each other. As shown in the cross sections previously the landscape interacts with each other in a linear process. Of course, the landscape is more complex than that, but water flows from high to low. From the Mississippi River towards the Gulf of Mexico.

Brown color



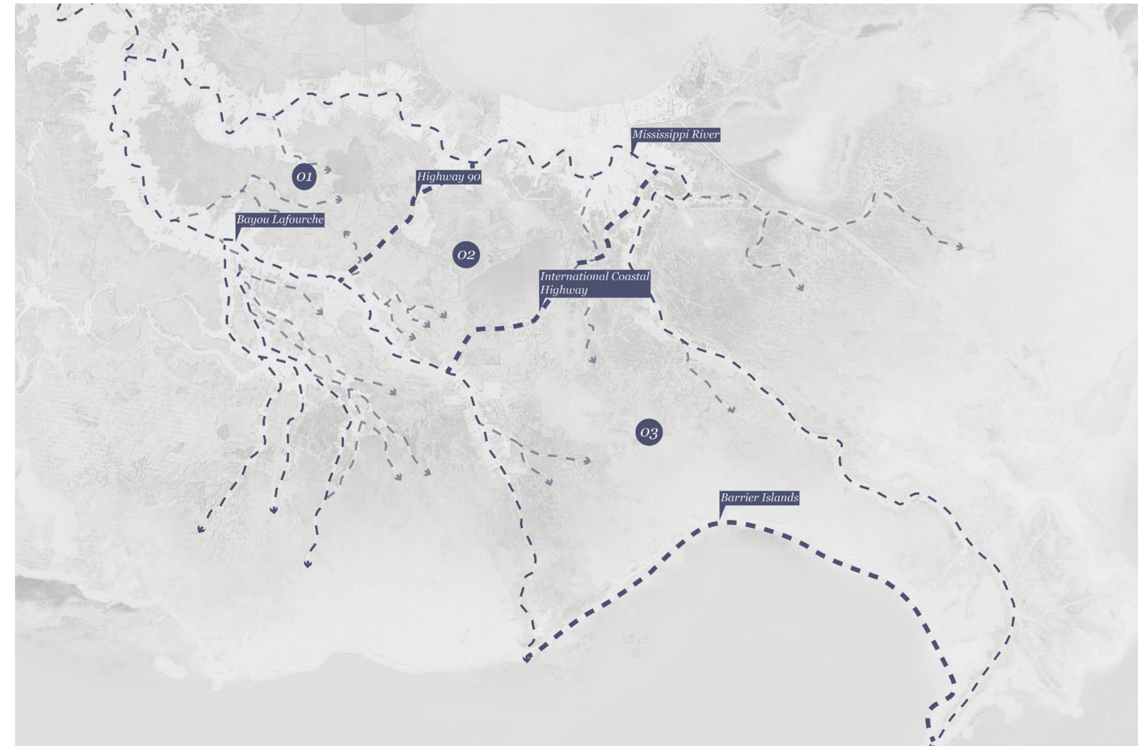
The gradient appears slowly in the landscape, vegetation changes appear slowley. Looking from above the landscape van be devided into different vegetation zones.

Green/Yellow color

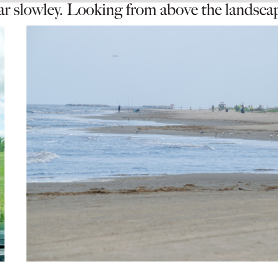
Red color

Following water from the MR towards the Gulf of Mexico, the vegetation gradient is followed. Each vegetation type has its landscape types, illustrated in the images along the map. Although the gradient has slow transitions which appear gradually, edges and borders can be determined in the landscape. Three main types are defined, wooded landscaped (brown colour), marsh landscape (green to yellow colour) and the islands (red colour).

Overlapping the different layers of the delta system, soil, height, water management, vegetation types, and infrastructure leads to a suggestion for basing the different concept zones. The zones are based on the needs for water management and for the landscape to thrive. The basin is bordered by the Mississippi River and Bayou Lafourche. Within this basin the elevated Highway 90 disconnects the wooded vegetation from the marshes, the intercoastal highway is a channel for ships to navigate through the delta landscape this hydrological infrastructure is interfering with water management, and lastly, the barrier islands which are a natural border between sea and land.



The gradient appears slowly in the landscape, vegetation changes appear slowley. Looking from above the landscape van be devided into different vegetation zones.



Mississippi River ▽ △Bayou Lafourche

Highway 90

Barrier Islands

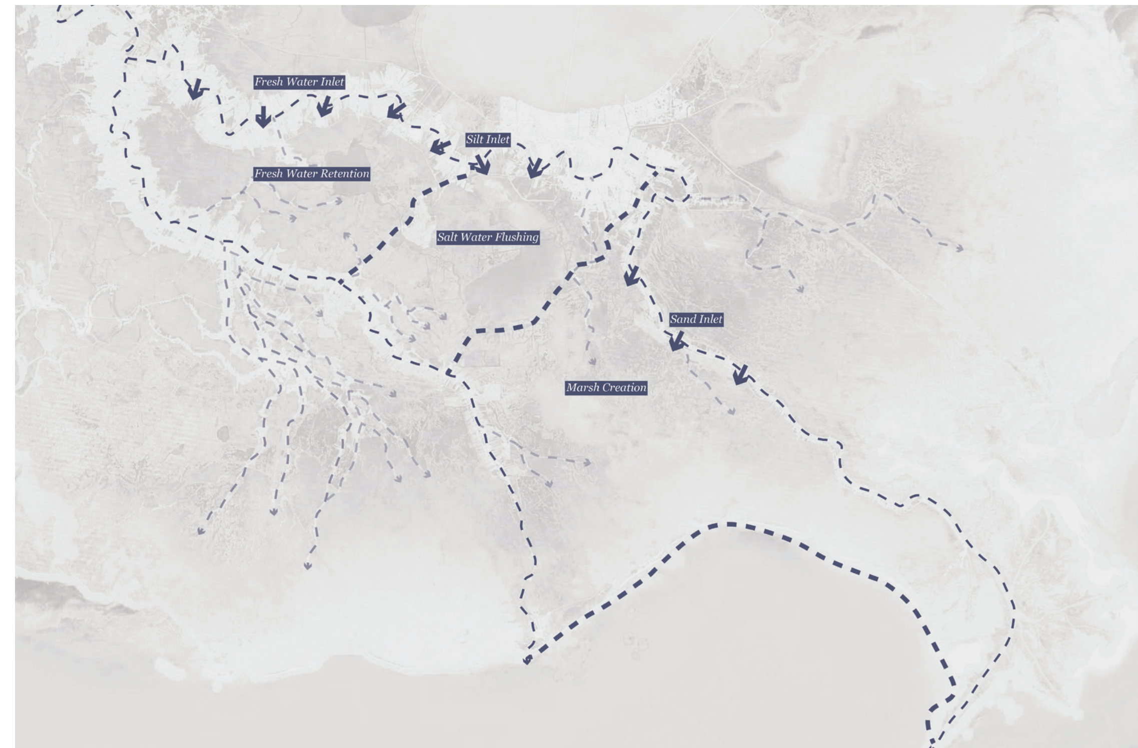
International Coastal Highway

The first zone serves as a freshwater buffer, during periods of drought and saline intrusion this buffer is used to sustain the landscapes from zones two and three. During the spring period, when water levels in the MR are high, this buffer zone is replenished by strategically placed inlets, providing vital resources for the surrounding ecosystems. This zone is designed to harness the natural flow of the MR while minimizing the impact of human interventions on water quality and sediment transport.

The second zone, located near New Orleans, consists of abundant swamp forests that require nutrients and fresh water to thrive. To meet these needs, a second river outlet for fresh water is established, containing nutrients and silt essential for the growth and sustenance of swamp forests. Human interventions in this zone focus on maintaining water quality and regulating flow patterns to support healthy vegetation growth. Silt, organic materials, nutrients, and sand are further flown towards the third zone.

The third and final zone of the new landscape is the marsh landscape, which is currently eroding away and in urgent need of sediment supply. In this zone, sand sediment from the MR is diverted into the landscape, providing a strong base for vegetation growth and marsh development. Human interventions prioritize rapid sediment delivery and erosion control measures to stabilize the marshes and prevent further loss of critical habitats.

The three zones together with their corresponding river inlets are forming a base for further design interventions that are needed in the marshlands. To establish these interventions the sediment processes need to be further understood.



Unlocking the qualities of the landscape will lead to a more resilliant delta for human and animals.

Introducing Sediments

Deltas, such as the Wax Lake Delta (WLD) within the MRD system, are dynamic landscapes shaped by complex processes of sediment deposition and erosion. Traditionally, the growth of deltas has been attributed to frequent floods, which lead to overbank aggradation and the gradual buildup of land (Edmonds et al., 2011; Falcini et al., 2012; Shen et al., 2015). However, recent research suggests that short-lived events, such as crevassing and avulsion, may play a more significant role in delta growth by rapidly depositing sediment in discrete locations (Chamberlain et al., 2018; Shaw & Mohrig, 2013). Therefore, creating an artificial bypass or outlet is very beneficial for sediment aggradation.

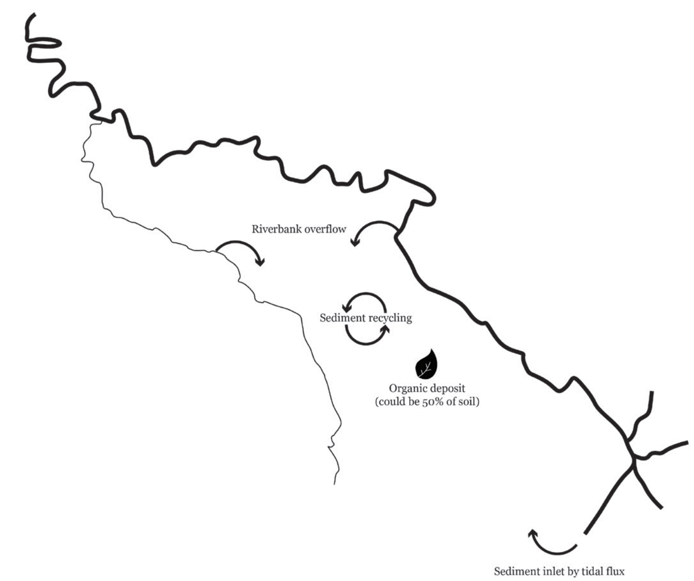
Sedimentation processes in the Barataria Basin are determined by five factors (Edmonds et al., 2023). The available sediments carried by the MR, sediment budget, has drastically dropped since the construction of dams in the MR around the 1970s (Törnqvist et al., 1996, 2008). During spring floodings parts of the sediments carried by the MR are flown into the marshes of the Barataria Basin, where vegetation traps the sediments. The same vegetation grows and dies, filling the spaces in between the sand. This is called organic sediment deposition (Edmonds et al., 2023), this kind of sediment deteriorates over time but it is a cyclic process and therefore, keeps balance. Further, displacements of sediments within the Barataria Basin itself. This is a natural process where nature is keeping balance within the system. Lastly, sediments are carried by tidal fluxes from the sea. These sediments are pushed into the sea by the MR and carried towards the marshes by tidal fluxes.

Mouth of the Mississippi River in the sub-delta Bird-foot, photo retrieved from Shutterstock (2022).

The Wax Lake Delta, like many river-dominated, see page 41, deltas, exhibits radial growth patterns driven by distributary channel activity (Chamberlain et al., 2018). Distributary channels serve as the primary conduits for sediment delivery to the coast, with avulsions redistributing sediment over broad spatial zones. However, the growth of deltas is not solely governed by deposition. Erosion processes, such as bed erosion during low flow periods (Nittrouer et al., 2011; Shaw & Mohrig, 2013) and cold-front-induced changes in water level (Allison et al., 2012; Feng & Li, 2010) and, submergence due to relative sea-level rise (Edmonds et al., 2023), also shape deltaic landforms.

Studies of the WLD challenge traditional assumptions about delta formation. While it is classified as a river-dominated delta, its channel kinematics are influenced not only by river flow but also by tidal and atmospheric dynamics (Shaw & Mohrig, 2013). For instance, tidal augmentation during ebb tide can reshape the delta front by providing the necessary shear stresses for sediment transport, countering the notion that bathymetric changes occur only during floods.

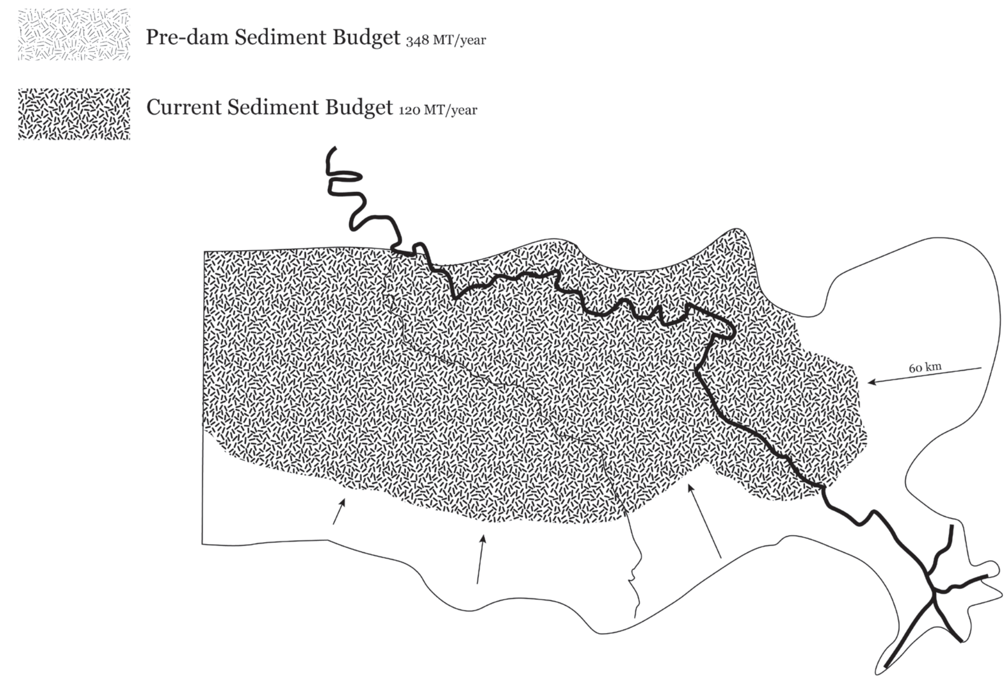
Furthermore, the traditional model of mouth bar deposition does not fully explain the sedimentary dynamics of the WLD (Chamberlain et al., 2018). Subaqueous sand shoals, once thought to be inactive mouth bars, persist beyond the channel tips, suggesting a more complex pattern of sedimentation (Shaw & Mohrig, 2013). High and low river discharge conditions have distinct effects on channel morphology, with erosion playing a crucial role in channel extension and network development during low-flow periods. In the image to the right all the different ways of sedimentation processes are illustrated.



Sediment deposition sources abstracted images form Edmonds, et al. (2023).

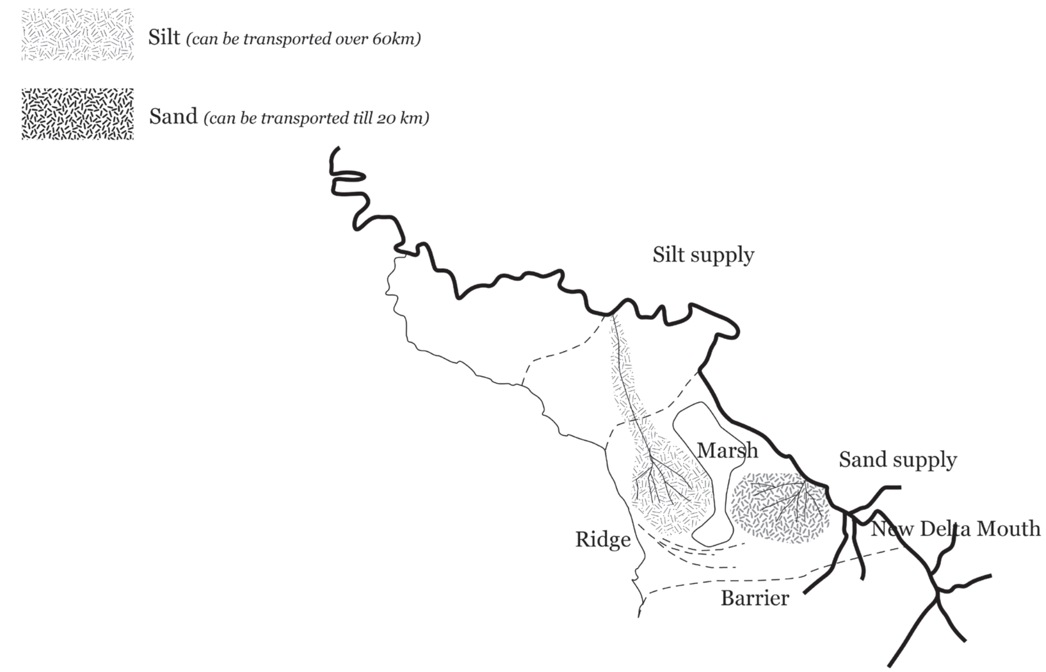
Edmonds, et al. (2023) studied how to estimate deltaic or wetland growth, this process depends on the sediment budget of the area. The amount of sediment source that is available depends on the amount of organic material in the sediment, this can fluctuate heavily from 0% to 60% of the sediment. Currently, the wetlands are exposed to erosion, to determine the growth of these areas the research needs to go back before humans interfered with the water system. Before dam construction, the MR carried 348 mega tonnages (MT) per year (Tweel & Turner, 2011). Before damming the MR occurred crevasse splays were important sources for sediment aggradation, contributing around 10 and 40 mm per year of sedimentation (Shen et al., 2015), in the Barataria Basin alone. Levee overtopping and splays occur during peak floods between 2.5 × 104 m3 per second 3.5 × 104 m3 per second (Edmonds et al., 2023). Post dam period of the delta leaves significantly less sediments in the river, suspended sediment concentration in the MR is 76% less compared with pre-dam (Blum & Roberts, 2009; Meade & Moody, 2010; Tweel & Turner, 2011; Xu et al., 2019), resulting in around 120 MT per year (Blum & Roberts, 2009; Giosan et al., 2014; Syvitski et al., 2009). This results when sediments are allowed to enter the Barataria basin in wetland growth of 5 ± 0.8 km2 per year (Edmonds et al., 2023).

The Wax Lake Outlet, created in 1942 by the Army Corps of Engineers, serves to divert water from the Atchafalaya River, impacting water levels in Morgan City. This outlet, along with the Old River Control Structure, regulates the distribution of water flow between the Atchafalaya and the mainstem Mississippi, influencing sediment transport and



Sediment budget of the Mississippi Delta has declined from 348 MT/y to 120 MT/y, therefore the amount of sediments do not match the required tonnage needed to restore the whole Delta landscape. Resulting in a nescessary decline of area in the Delta.

land-building processes (DeLaune et al., 2016). The sediment-laden waters of the Atchafalaya and Wax Lake channels have contributed to the formation and growth of deltas, including the WLD, which is renowned for its natural development compared to the Atchafalaya Delta (Harris et al., 2016). Over time, sediment deposition has filled in water bodies like Grand Lake and Wax Lake, while also building up land in areas like Atchafalaya Bay (Barras et al., 2003). Unlike the Atchafalaya Delta, which incorporates dredged materials, the WLD is entirely natural, providing scientists with a unique opportunity to study early deltaic processes and inform restoration efforts in other vulnerable coastal regions (Roberts et al., 2015). The ongoing growth of these deltas underscores the importance of understanding natural sedimentary dynamics for coastal management and restoration (Day et al., 2007). The Atchafalaya and WLD, situated within the Atchafalaya Wildlife Management Area and Game Preserve, support diverse ecosystems and recreational activities. These thriving deltas serve as valuable research sites for scientists studying delta formation, biodiversity, and ecosystem dynamics (Tweel & Turner, 2011). Recent initiatives, such as NASA's Delta-X project and proposals for the designation of the Atchafalaya Basin as a National Estuarine Research Reserve, highlight the significance of these areas for scientific research and conservation efforts (Blum & Roberts, 2012; Day et al., 2019; Nittrouer et al., 2011). Lessons learned from the WLD can inform future sediment diversions and coastal restoration projects, contributing to the



Different sediment materials, silt carries further into the landscape (60km) than sand (20-30km) .

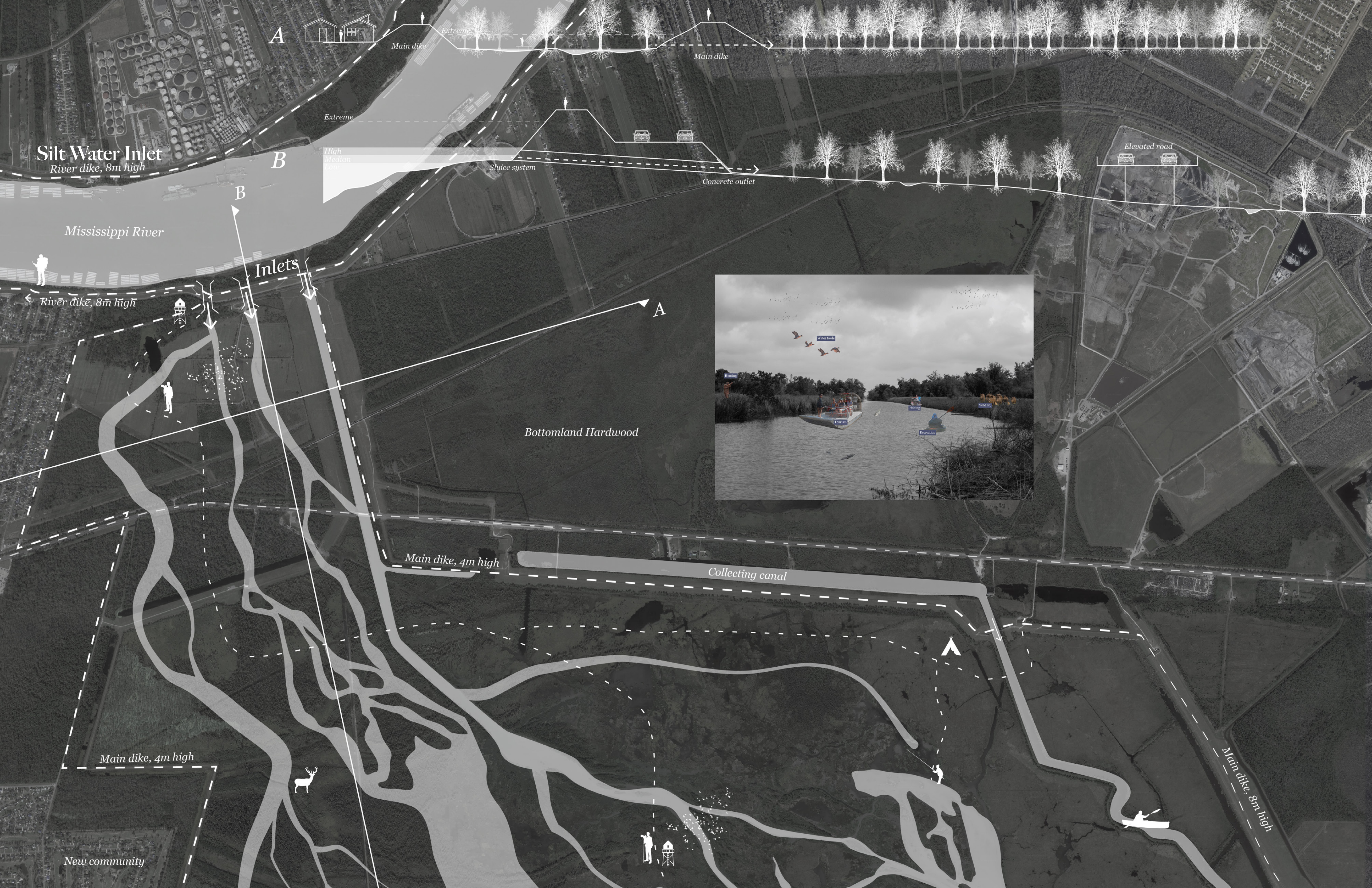
resilience of Louisiana's coast in the face of rising sea levels and environmental challenges (Day et al., 2007).

During a period of 21 years (1989-2010), the WLD grew by 59 km2 (DeLaune et al., 2016). The channel dug by the Army Corps of Engineers is 25 km long, has a width of 250 meters and an average depth of 2 meters, with a sediment budget between 25.6 and 38.4 MT per year (Shaw et al., 2013). This fully natural Delta system can be used as a great example for the newly proposed sediment outlets. It can be assumed that the sediment flux in the MR is the same as in the Atchafalaya Delta since they are part of the same river system. One major difference between the WLD and the newly proposed outlets is the barrier islands situated before the new sub-deltas. Barrier islands are slowing down the tidal flux and reducing the sediment outflow from marshes (Edmonds et al., 2023). Therefore it can be assumed that the growth of the new river outlets will be faster, although this cannot be precisely predicted.

These findings highlight the need for a nuanced understanding of deltaic processes to accurately predict future land change and manage sediment resources. By studying the intricate interplay between sediment deposition, erosion, and environmental forcings, researchers can gain insights into the resilience and vulnerability of deltaic landscapes in the face of natural and anthropogenic perturbations.

Radial growth of the Wax Lake Delta complex from the Atchafalaya River, growing on an average speed of 59 km2/year.

Fresh Water Inlet
Mississippi River
River dike, 8m high
Levee trail
A
Main dike
Extreme
Main dike
B
Extreme
High
Median
Low
Sluice system
Concrete outlet
Cattle
Bird watching
Wild life
Hiking
Main dike, 4m high
Bottomland Hardwood
Bottomland Hardwood
Main dike, 4m high
Main dike, 4m high
Flood protection trail
Bonnet Carre Spillway
River dike, 8m high
Mississippi River



Silt Water Inlet
River dike, 8m high
A
Main dike
Extreme
Main dike
Extreme
B
High
Median
Low
Sluice system
Concrete outlet
Elevated road
B
Mississippi River
Inlets
River dike, 8m high
A
Bottomland Hardwood
Water fowle
Hunting
Tourism
Fishing
Wild life
Recreation
Main dike, 4m high
Collecting canal
Main dike, 4m high
Main dike, 8m high
New community

Sand Water Inlet
A
B
Sea dike, 8m high
Main dike
Extreme
High
Median
Low
Wild life
Fishing
Recreating
Tourism
Sea dike, 8m high
River dike, 8m high
Mississippi River

Trapping Sediments

Trapping sediments is a critical aspect of ecosystem restoration and coastal management, aimed at stabilizing landforms, preventing erosion, and promoting habitat growth. So when sediments are introduced into the landscape they need to be trapped there to establish vegetation and land growth. There are several effective methods for sediment trapping, each leveraging natural processes or human interventions to capture and retain sediment. Here, we explore three prominent techniques supported by scientific literature:

1. **Creating Artificial Barriers/obstacles** (man-made): Artificial barriers, such as silt fences, geotextile tubes, and sediment traps, are engineered structures designed to intercept and capture sediment-laden water. These barriers can be installed along shorelines, riverbanks, or construction sites to mitigate erosion and sediment runoff. Studies by Bugg, et al. (2017) investigate the effectiveness of silt fences in trapping sediment runoff from disturbed landscapes, emphasizing their role in sediment control and water quality management.

2. **Slowing Down Water** (natural process): Slowing down water velocity is another effective method for sediment trapping, as it allows suspended particles to settle out of the water column. Techniques such as vegetated buffer strips, check dams, and erosion control mats help reduce flow velocities, facilitating sediment deposition. Research by Theisen (1992) evaluates the efficacy of erosion control mats in reducing runoff velocity and sediment transport, highlighting their potential for erosion prevention and sediment trapping in various landscapes.

3. **Planting Vegetation and Pollination** (man-made/ natural processes): Vegetation plays a crucial role in trapping sediments through root systems and canopy structures. Plants, especially those with deep roots like mangroves and marsh grasses, anchor soil particles and slow down water flow, allowing sediments to settle. Research by Barbier, et al. (2008) emphasizes the importance of salt marsh vegetation in sediment accretion and erosion control.

Keeping Sediments

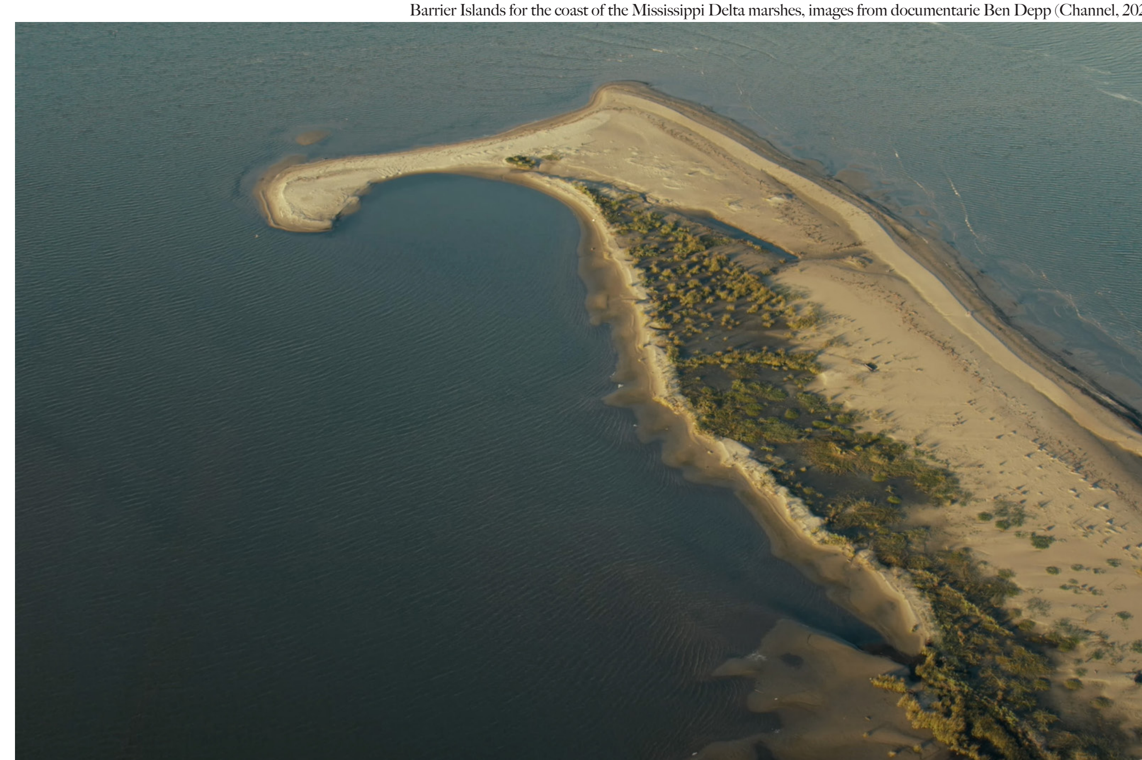
Barrier islands are dynamic landforms that play a crucial role in coastal protection and sediment transport processes. These islands are typically characterized by their elongated shape, parallel to the mainland coast, and are separated from the mainland by a lagoon or estuary. The formation and evolution of barrier islands are influenced by various factors, including tidal and wave dynamics, sediment transport mechanisms, and sea-level rise (van de Kreeke & Brouwer, 2017).

The main morphological features of a tidal inlet, which are integral to the barrier island system, include the inlet itself, the ebb delta on the ocean side, and the flood delta on the lagoon side (Escoffier & Walton Jr, 1979). The morphology of these features is shaped by the interaction of tides and waves. Tidal inlets are categorized as tide- or wave-dominant based on the relative importance of these forces (Davis Jr & Hayes, 1984; Hayes, 1994). Tides tend to keep inlets open by maintaining a larger tidal prism, which is the volume of water entering during the flood and leaving during the ebb. Conversely, waves can close inlets through longshore and cross-shore transport mechanisms.

The equilibrium morphology of tidal inlets is dynamic, with variations occurring over timescales ranging from weeks to decades (Escoffier & Walton Jr, 1979). Sediment transport, influenced by longshore currents and wave-driven processes, plays a crucial role in shaping the barrier island system. Sand is transported towards tidal inlets by longshore currents generated by waves approaching the coast obliquely. This sediment is then redistributed within the inlet system, contributing to the formation and maintenance of barrier islands (Escoffier & Walton Jr, 1979; van de Kreeke & Brouwer, 2017).

Barrier Islands photographed during the documentary of Ben Depp by Channel (2020).

Barrier Islands for the coast of the Mississippi Delta marshes, images from documentarie Ben Depp (Channel, 2020).



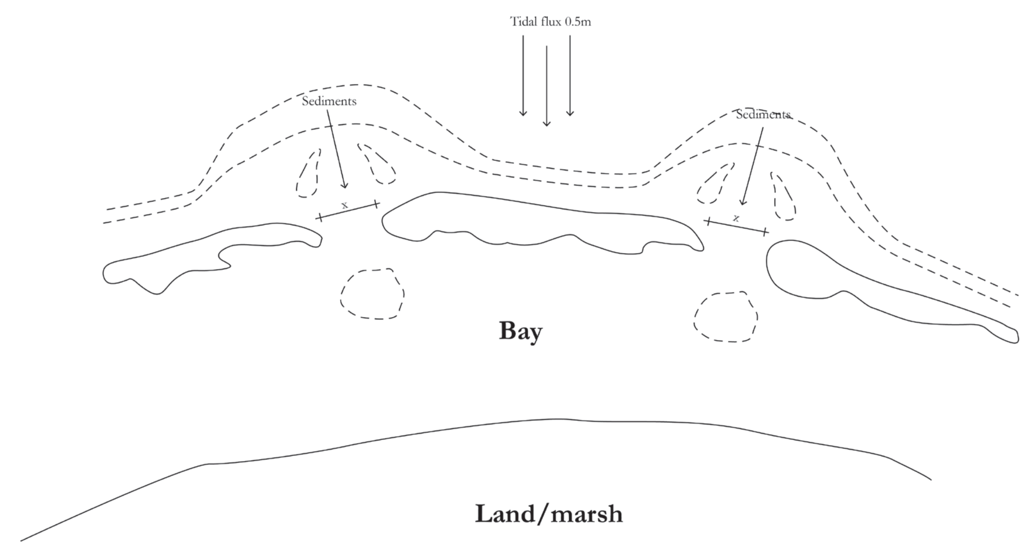
The design and management of tidal inlets are essential for maintaining navigable channels and preserving coastal ecosystems. Strategies for improving inlet flushing capacity and stability include dredging, bank protection, and the construction of jetties (Kamphuis, 2006). Dredging is used to maintain channel dimensions and remove sediment deposited by waves and currents. Jetties are constructed to stabilize the inlet channel and prevent migration, while also directing tidal currents and reducing wave action.

The dimensions and orientation of barrier islands are influenced by factors such as sediment supply, shoreline retreat processes, and sea-level rise (Escoffier & Walton Jr, 1979). Sediment supply from erosional shoreface retreat processes contributes to the formation and growth of barrier islands, while sea-level rise controls their vertical translation. Over time, barrier islands may undergo cycles of erosion and accretion, influenced by storm events and long-term environmental changes (Stommel & Farmer, 1952).

Understanding the processes driving barrier island formation and evolution is essential for effective coastal management and resilience planning. By studying the complex interactions between tides, waves, and sediment transport, researchers can develop strategies to mitigate coastal hazards and protect vulnerable ecosystems.

The water conditions that should be considered when designing barrier islands are as follows. The wave height mode seaward of the Mississippi River delta plain is 1 m, wave periods are 5-6 s and the average deep-water wave power is only 1.8 X 103 W per m (Boyd & Penland, 1981). Tides are diurnal with a mean range of 36 cm. The tidal regime in coastal Louisiana is complicated in fall and winter by extratropical cyclone passage which generates wind-driven tides over normal astronomical conditions (Penland & Ritchie, 1979). In Louisiana tropical storm winds, greater than 63 km/h, have a recurrence interval of 1.6 years, whereas the recurrence interval of hurricane, winds greater than 118 km/h, is 4.1 years (Doyle, 2009; Neumann, 1978). On the Louisiana coast, hurricanes are capable of generating overwash elevations of 2-7 m above mean sea level (Boyd & Penland, 1981). Maximum storm surge levels are capable of overwashing entire barrier shorelines and flooding the coast for many kilometres inland.

Roos, et al. (2013) studied the behaviour of barrier inlets and barrier island length. They used Escoffier's (1979) method for basin principles and Hayes (1994) principles for their calculations. They concluded that there is a maximum amount of inlets possible and that nature is striving for an equilibrium between the inlets and the basin/estuary behind the inlets. Further, the following Hayes (1994) smooth barrier coast, increasingly strong tides, the more inlets are present, compared to weak tides the study shows few inlets. The width of the inlets is determined by tidal fluxes and sediment discharge (Hayes, 1994; Roos et al., 2013), but generally higher tidal fluxes mean deeper inlet channels and more sediment discharge means shallow inlet channels. For the Mississippi Delta, with a low tidal flux and a high amount of sediment discharge (from the sea towards the estuary) we can assume that the length between the barrier islands should be sufficient (5-10km), to let enough sediments entre the estuary and the amount of inlets are limited compared to a high tidal flux delta. Further, the orientation of the barrier islands should be parallel along the marshes to limit the wave erosion effects.

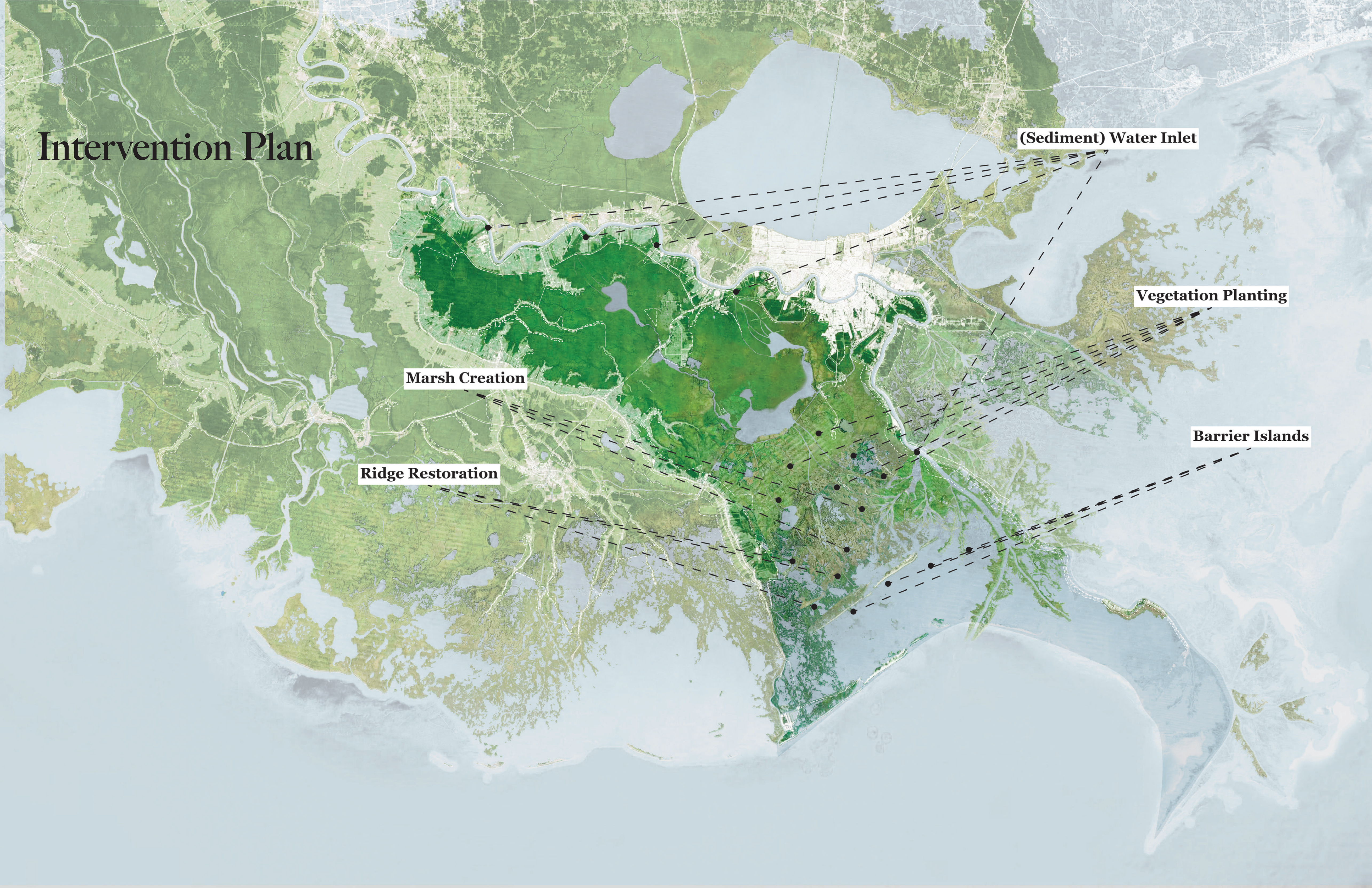


Schematic representation of barrier islands, parralel to the coast line, longitued island formation, and same inlet spacing.

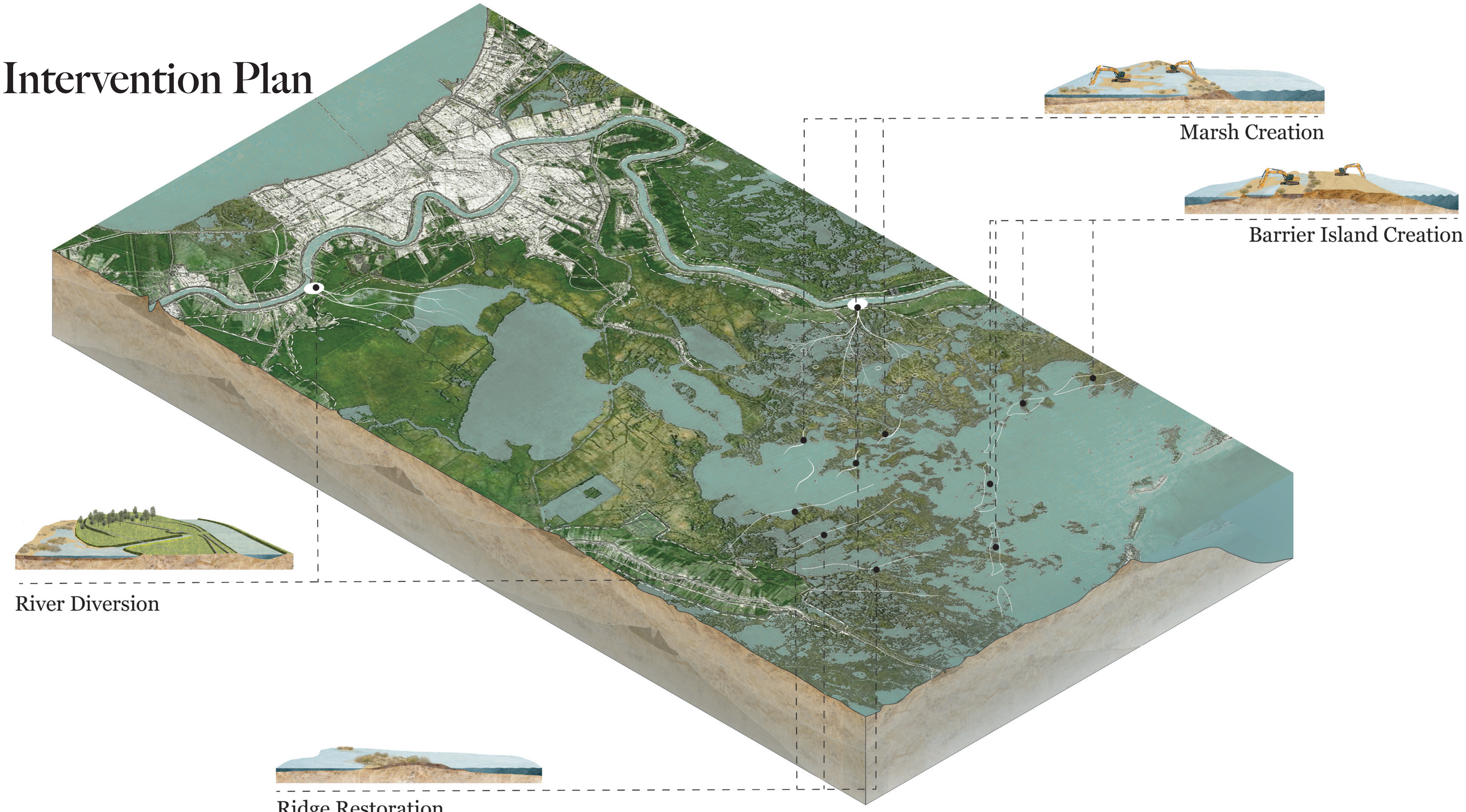
Concept

In conclusion, Introducing Sediments, Trapping Sediments, and Keeping Sediments form a sequential chain of events crucial for understanding and managing sediment dynamics in coastal environments. Restoring the balance between humans and nature in the MRD is possible using these steps in the design choices. The Barataria Basin is used to investigate and determine these principles. River diversions are necessary to let sediments replenish the marshes of the MRD, only the MR is carrying less sediments than when the current outline of the MRD was formed. Decreasing in size of the MRD is therefore necessary. Sedimentation is a complex process that is difficult to mimic and/or predict, lessons from the WLD should be implemented but will not guarantee success in the future. In combination with barrier islands a new natural equilibrium is established where humans can benefit from the safety and richness the landscape provides.

Intervention Plan



Intervention Plan



Hurricane Ida

Hurricane Ida struck the coast of Louisiana on Sunday afternoon as a Category 4 hurricane, bringing with it powerful winds, heavy rains, and storm surges. The hurricane forced so much water into the mouth of the Mississippi River that it reversed its flow near New Orleans. Following its impact on Louisiana, the remnants of Hurricane Ida moved to the northeastern United States, spawning tornadoes and causing catastrophic flooding in New York. Streets, metro stations, and basement apartments were submerged.

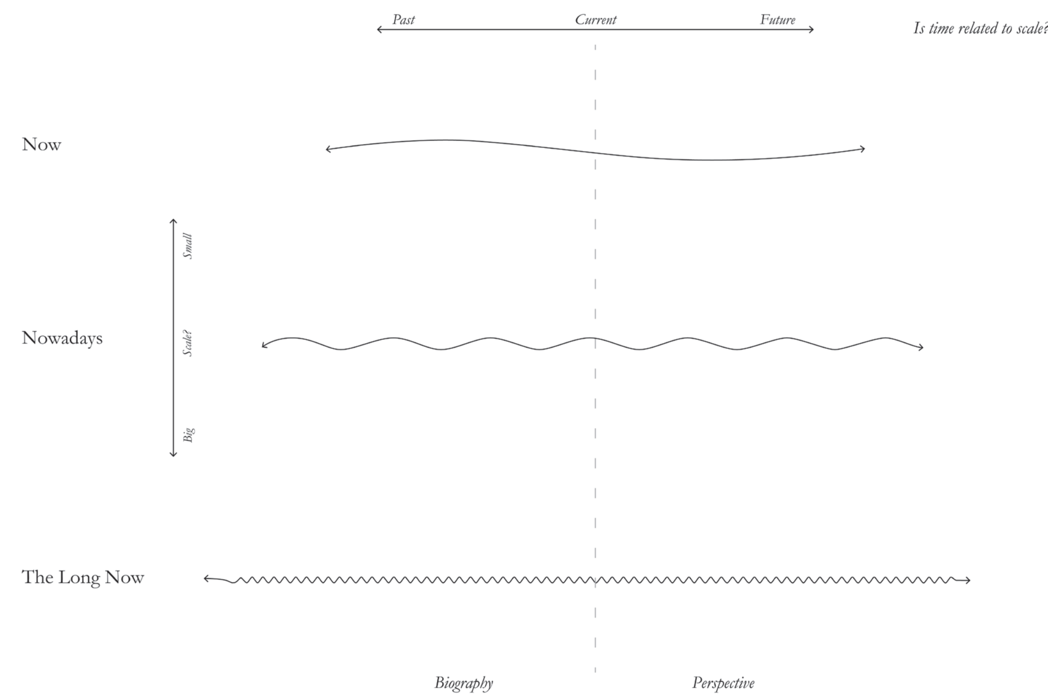
Ida's intensity decreased significantly 16 hours after reaching Louisiana, downgrading to a tropical storm by Monday morning. Despite this, it continued to bring heavy rainfall and strong winds, causing extensive tree damage and tearing roofs off houses. Residents in several Louisiana cities were urged to seek higher ground due to potential urban flooding. More than one million people in the state, one in four residents, were left without electricity, and New Orleans experienced a complete blackout. The hurricane also destroyed critical infrastructure over vast areas, including the Grand Isle levee. However, the new system of dams built after Hurricane Katrina helped prevent catastrophic flooding despite numerous floods.

Damage of Huricane Ida on the Grand Ilse.

Part IV / Towards an Adaptive Landscape

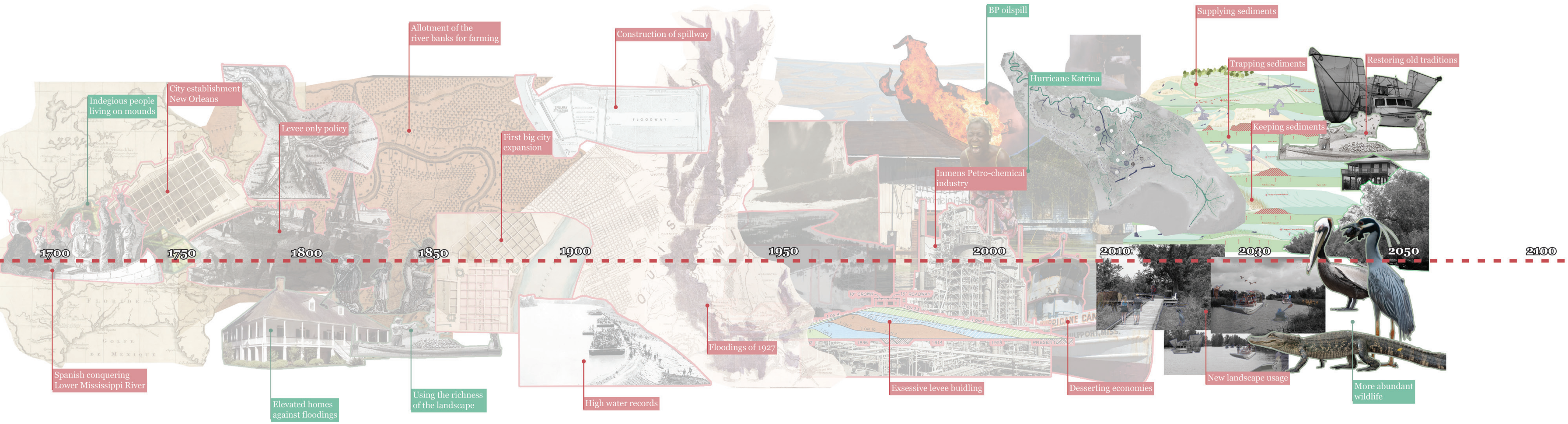
Design

Reintroducing sediments to the Mississippi River Delta means land changes, as deltaic landscapes are constantly in motion change is still important to be able to predict outcomes. Certainly when safety and economic factors are involved. As described before the MRD needs to convert to a providing landscape where communities can embrace their identity, where new local economic factors are implemented, and where people are protected by the landscape from flooding and hurricanes. Balacing between human interventions and natural processes the landscape will evolve overtime. How much is nature able to take control and how much does humans let nature regain control? Therefore the design interventions proposed in the previous chapter are spatially illustrated in changes over time, where the succession of vegetation, and human activities are highlighted.

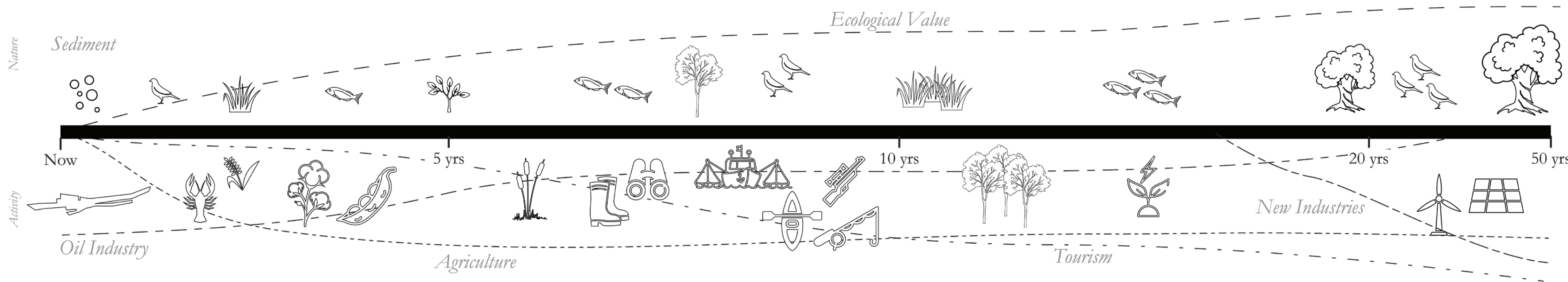


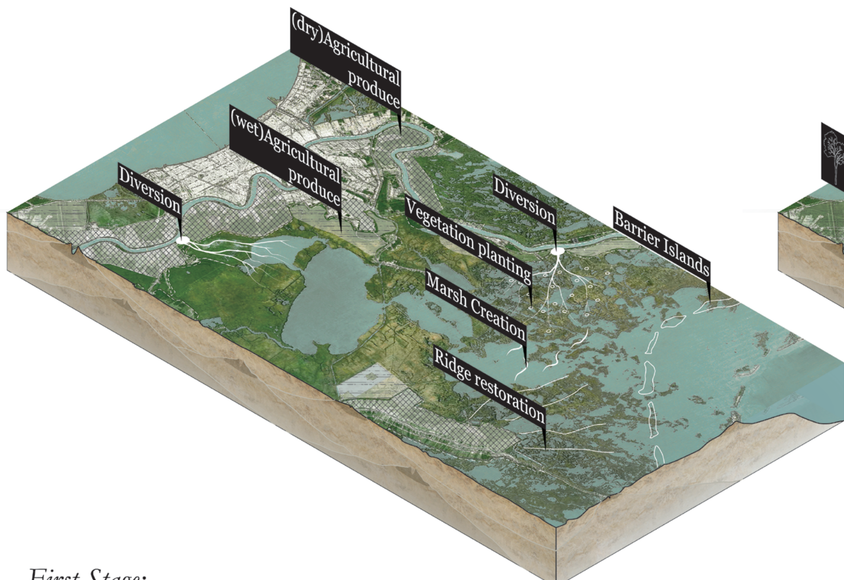
Conceptual drawing based on the Long Now from the Long Now Foundation (2023). Time and scales are related and influence eachother.

A New Perspective

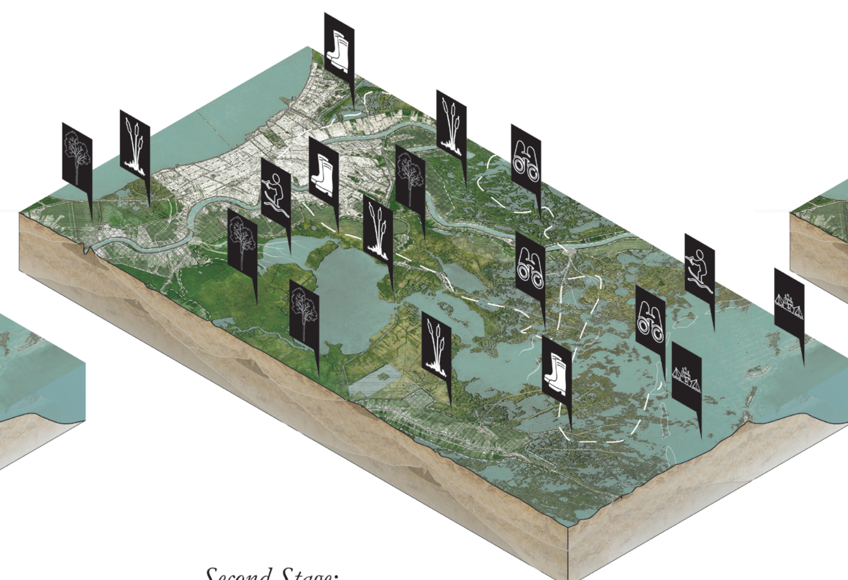


Relations

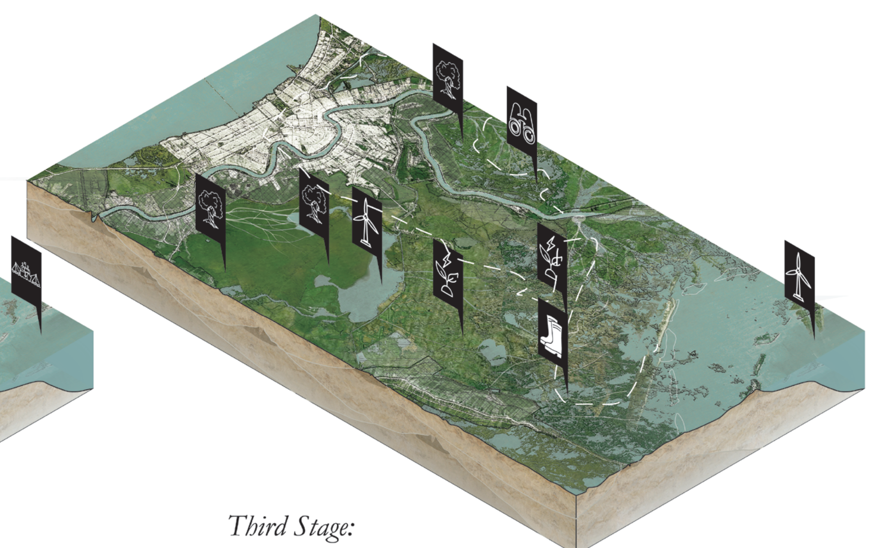




First Stage:
-sediment supply
-sediment trapping
-sediment keeping
-enable current lands for dry agriculture such as cotton, soy bean and corn



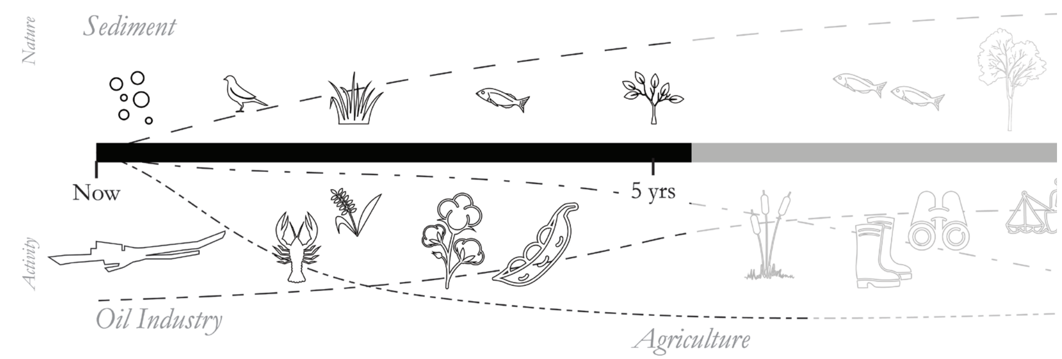
Second Stage:
-activities within the wet landscape

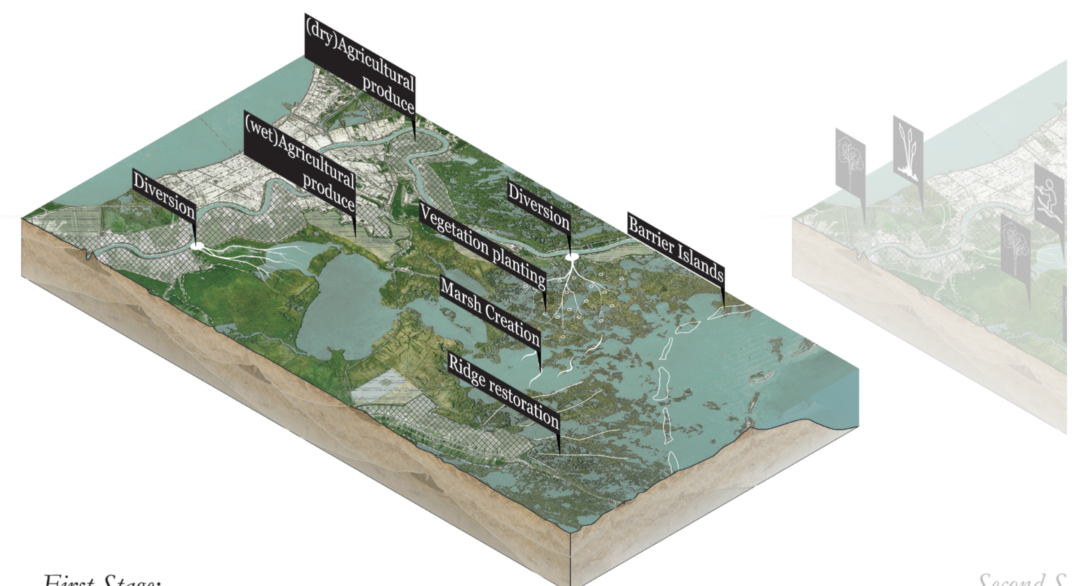


Third Stage:
-expansion of the landscape activities
-new forms of industries general or site specific

The three principles - supplying, trapping, and keeping - that will be implemented in the Barataria basin will develop over time and enable different land usage over time. The images on the previous page show the overall timeline for the design, from the moment the implementations are made to 50 years later. Human activities and natural processes are closely related and influence each other over time.

Starting from the action of implementation till 5 years later. Sediment supply in the form of river diversions, marsh creation, ridge restoration, planting of vegetation, and creation of barrier islands are all happening simultaneously throughout the whole basin. Together with the design principles new land usage could already be implemented on the existing landscapes, mainly within the leveed area. The implementation of new forms of crop, such as the annual crawfish and rice farming in the wetter parts of the leveed area. Traditional crops such as corn, soy, cotton and hemp can be placed on the higher and drier parts of the landscape. In the first 5 years, the main focus is supplying the landscape with nutrients, sediments, and freshwater, for vegetation and land to establish. The implementations need to function at the same time.

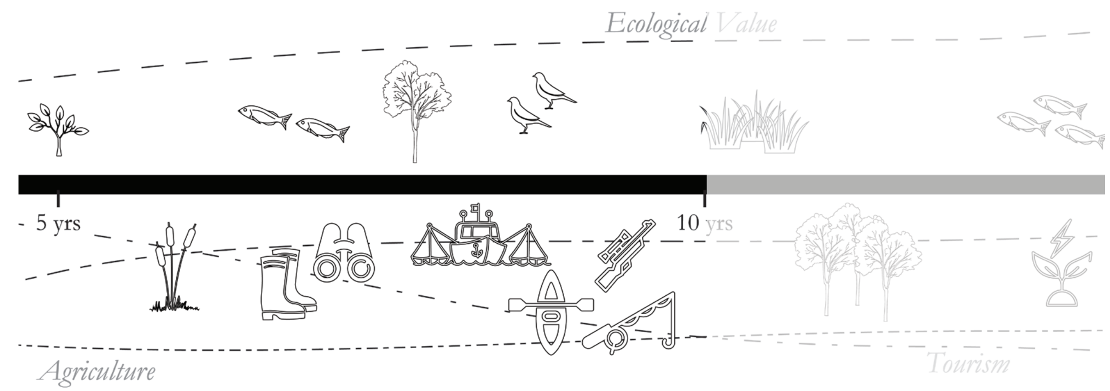


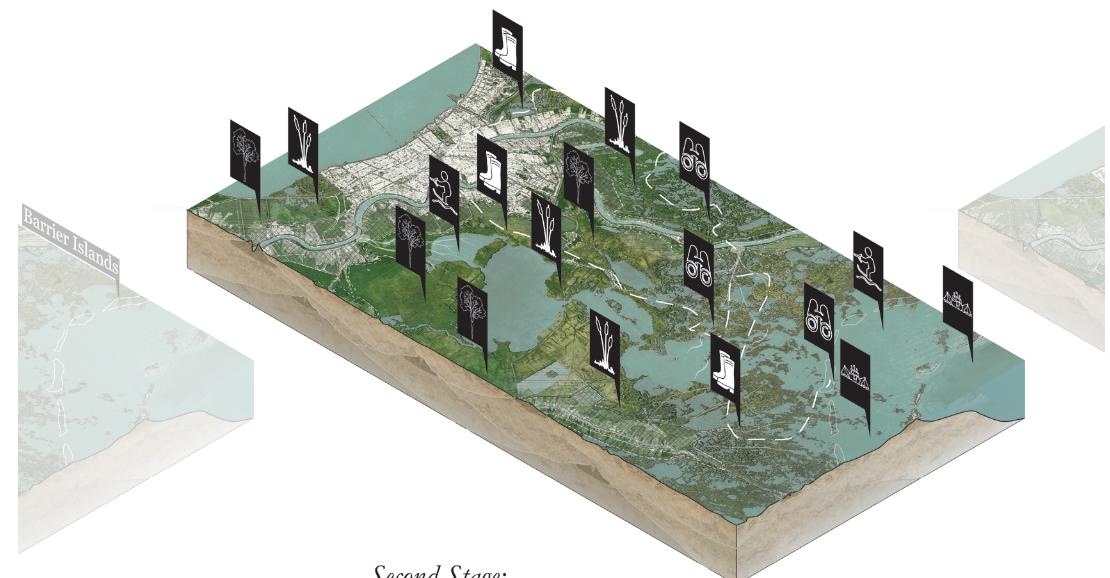


First Stage:
-sediment supply
-sediment trapping
-sediment keeping
-enable current lands for dry agriculture such as cotton, soy bean and corn

Second S
-activities
wet lands

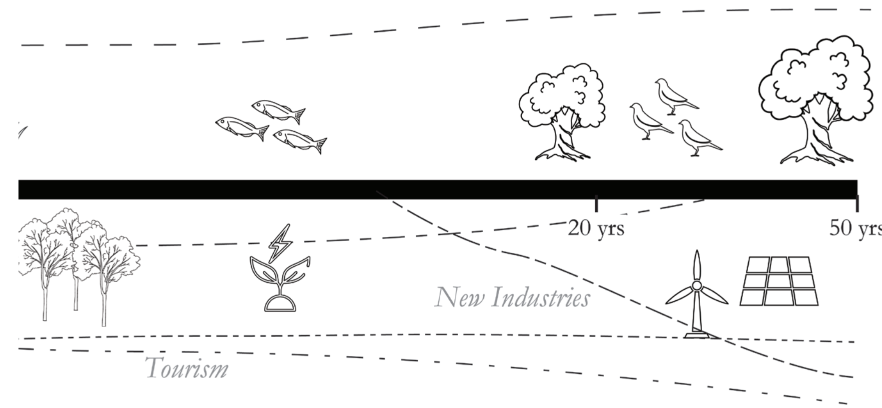
After the first year of finishing the design principles nature will be able to distribute the surplus of nutrients, sediments, and freshwater over the basin, guided by the design interventions. This creates a more balanced landscape where nature is rapidly developing. During this period, new smaller-scale land usage could be implemented by humans. Local communities can shape their surrounding within the boundaries of the overall principles, with the ingredients provided by the landscape in the form of sediments, and freshwater. Aquatic local agriculture is part of the new landscape usages, cattail production, fish farming, and establishment of cypress tree forests for wood production. Part of the current navigation channels of the basin could be used by local communities to establish new locations for land usage. A regulation should be made to regulate the amount of activities within an area. Places for nature should be preserved and kept untouched. Expansion and new touristic activities can be placed through the basin. locations should be chosen based on the success of the landscape. Hiking routes, fishing spots, bird watching, and boating areas.

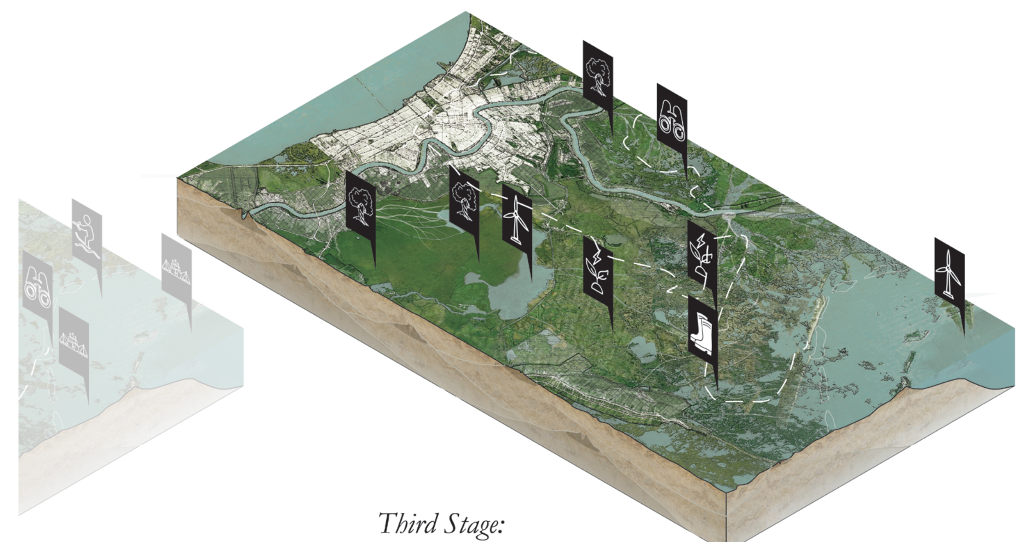




Second Stage:
-activities within the
wet landscape

After 10 years the landscape keeps developing, in size, vegetation, and animal diversity. This landscape is still in transition but more stable and balanced. Revisioning the design implementations is vital for the basin to become successful. When the landscape is strong and able to cope with changes from the surroundings, a new infrastructure, industries, and land usage could be established. New communities can be established in the basin, where people can live from the landscape. A possible new industry could focus on green energy, tourism, and distribution. This will all fit within the current infrastructure of the basin and no huge implementations have to be done.





Third Stage:
-expansion of the landscape activities
-new forms of industries general or site specific

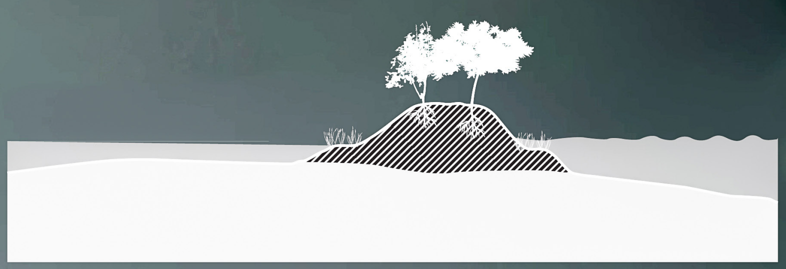
Evolving over Time

Human Action

Indicating the timespan each intervention will take is important for various reasons. Firstly, indicating to people how long it will take for the intervention to be productive or beneficial for human usage. Secondly, estimating the succession of the vegetation that will lead to the protection of the landscape. Lastly, what the different landscape qualities will be overtime.

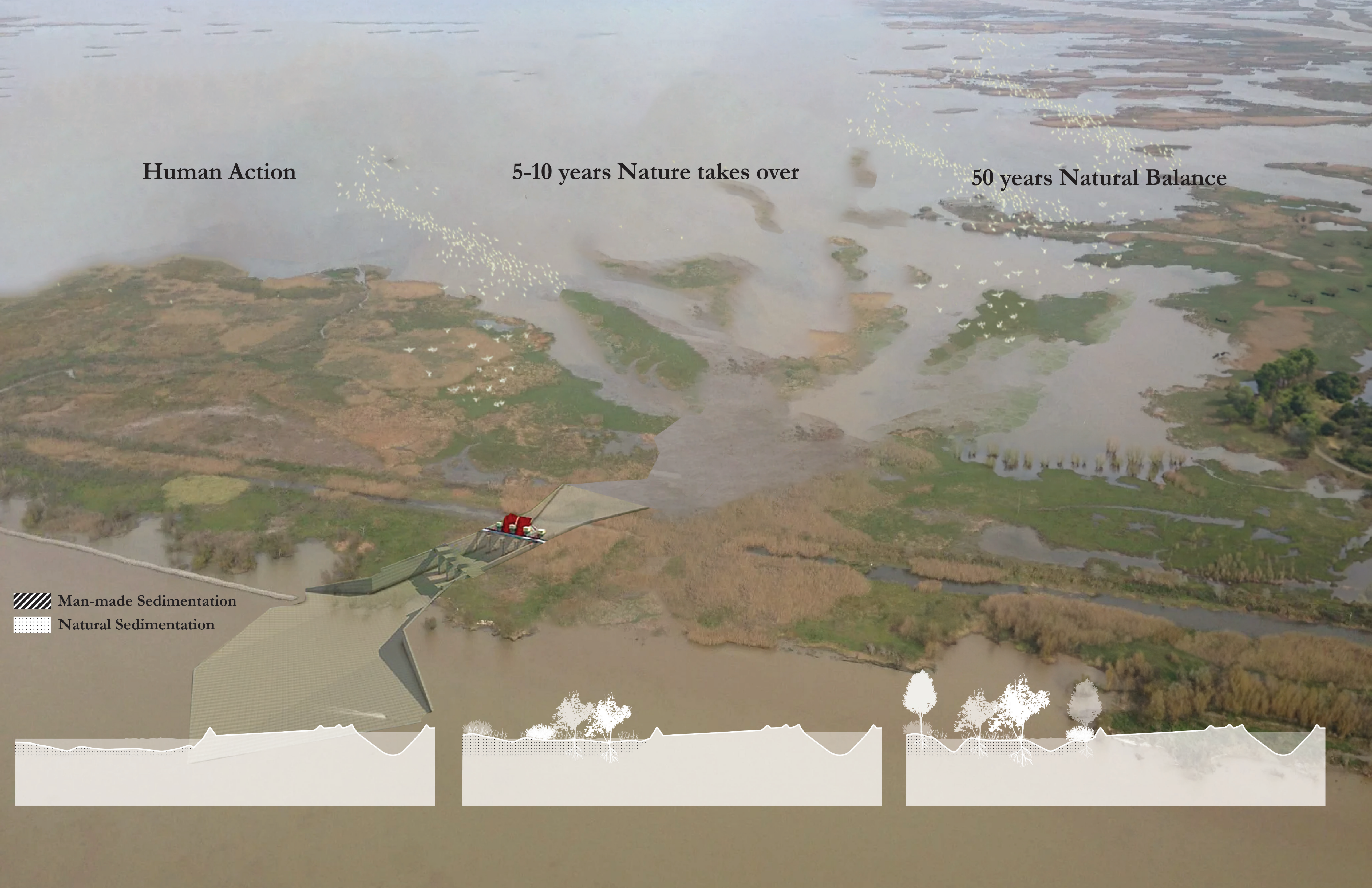
Man-made Sedimentation

Natural Sedimentation

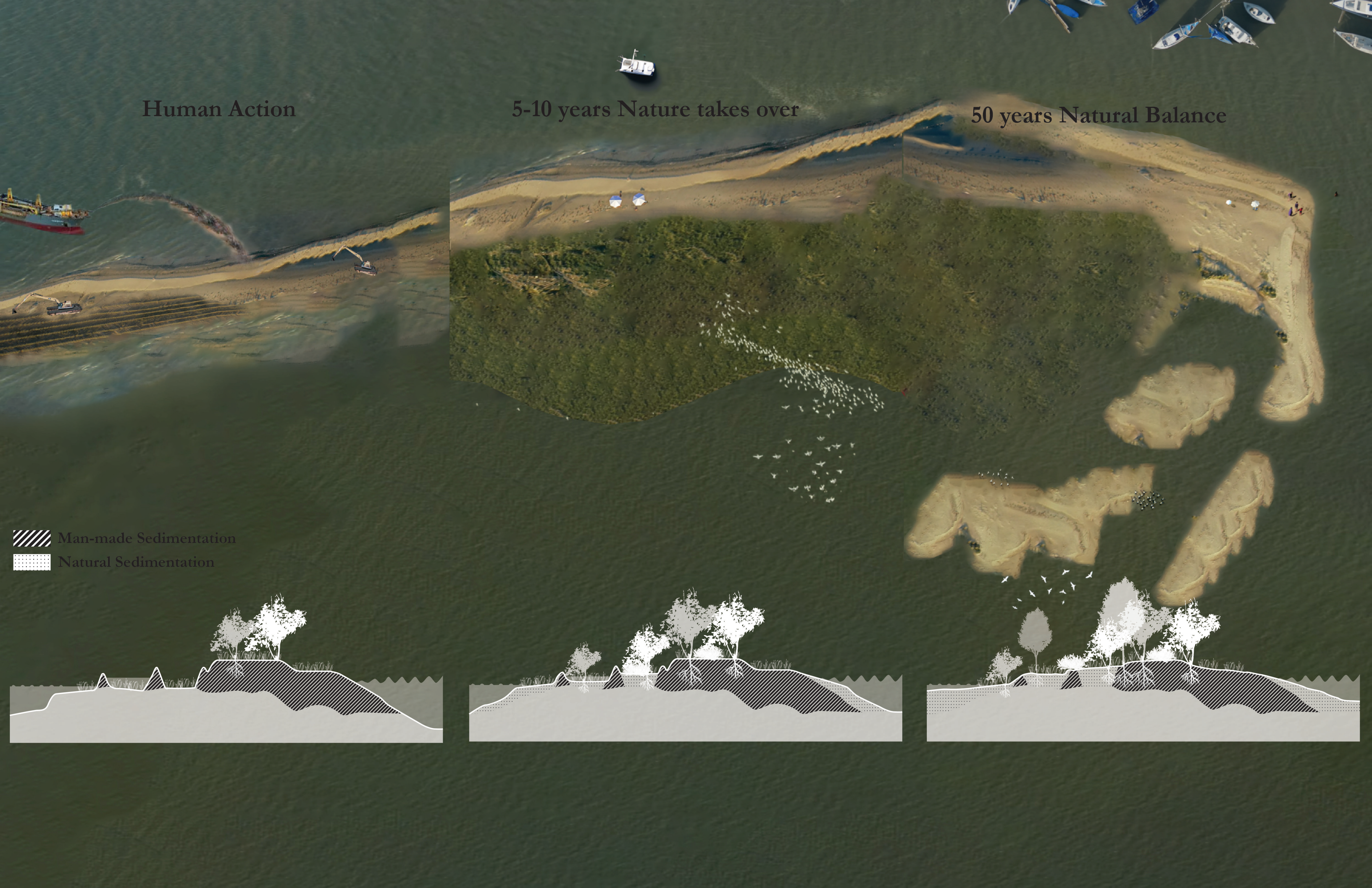


5-10 years Nature takes over

50 years Natural Balance


Human Action
5-10 years Nature takes over
50 years Natural Balance
Man-made Sedimentation
Natural Sedimentation


Human Action
5-10 years Nature takes over
50 years Natural Balance
Man-made Sedimentation
Natural Sedimentation


Human Action
5-10 years Nature takes over
50 years Natural Balance
Man-made Sedimentation
Natural Sedimentation

Masterplan

In conclusion, Introducing Sediments, Trapping Sediments, and Keeping Sediments form a sequential chain of events crucial for understanding and managing sediment dynamics in coastal environments. Restoring the balance between humans and nature in the MRD is possible using these steps in the design choices. The Barataria Basin is used to investigate and determine these principles. River diversions are necessary to let sediments replenish the marshes of the MRD, only the MR is carrying less sediments than when the current outline of the MRD was formed. Decreasing in size of the MRD is therefore necessary. Sedimentation is a complex process that is difficult to mimic and/or predict, lessons from the WLD should be implemented but will not guarantee success in the future. In combination with barrier islands a new natural equilibrium is established where humans can benefit from the safety and richness the landscape provides.

The relation with the Petrochemical industry is visual thourghout the whole delta. People either have a strong connection with the industry or do not. The abonded structures could be used as landmarks in the landscape, to highlight the natural succession of the Delta. These three images show how nature takes the landscape over and use the petrochemical infrastructure to establish.


WARNING
DO NOT ANCHOR
OR DREDGE
CRUDE OIL PIPELINE
CRESCENT MIDSTREAM
IN CASE OF EMERGENCY CALL
1-833-531-1942
U.S. FISH AND WILDLIFE SERVICE
Bald Cypress Trees
Sentinels of the Wetlands
NO HUNTING

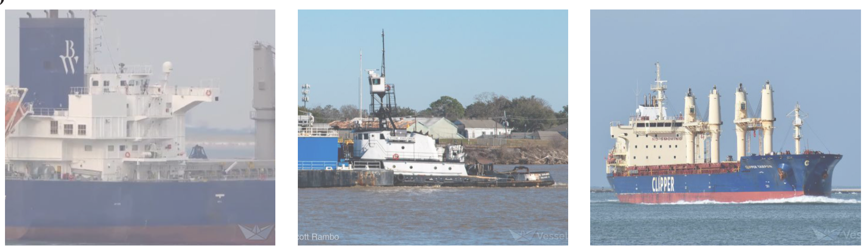

WARNING
DO NOT ANCHOR OR DREDGE
CRUDE OIL PIPELINE
CRESCENT MIDSTREAM
IN CASE OF EMERGENCY CALL
1-833-531-1942
U.S. FISH AND WILDLIFE SERVICE
Bald Cypress Trees
Sentinels of the Wetlands
NO HUNTING

Old River Diversion pumps are not necessary anymore when the natural connection between the landscape and the Mississippi River is restored. The pumps can be used as places to visit and a reminder of how the landscape used to be. In this sequence the current situation is seen, the situation with high water, and the situation with low water.


CYPRESS

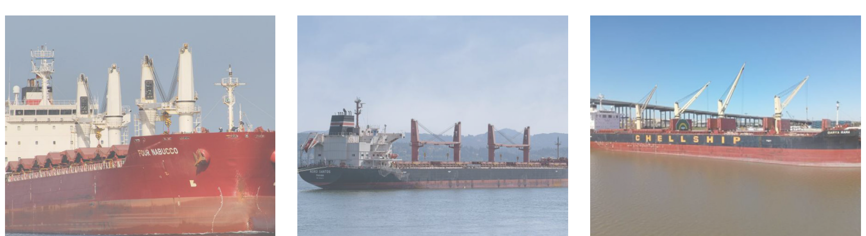

CYPRESS

Mississippi River the busiest marine highway of the U.S.A.



All the boats along the Mississippi on the 9th of April 2024 at 16:34

Data and images retrieved from Marine Vessel Trafic



Carrying cargo for the Petro-Chemical industry or the BIO-industry

To all the corners of the world, the Mississippi Delta is present

Part IV / Towards an Adaptive Landscape

Synthesis

This final chapter reflects on the design interventions at different scales and concludes the overall research. The research process, design process, findings and limitations are reflected upon and placed within the greater context of the field of landscape architecture. An overview of the sources used in the research is provided at the end of the report.

Petro Chemical plants along the Missisippi River from Baton Rouge.

Conclusion

RQ1: How can better balanced man-made and nature-based solutions be designed in the Mississippi River Delta to let the natural system thrive, improve the management of flood risk, and strengthen local identities and economies?

To design better-balanced man-made and nature-based solutions for the MRD, it is crucial to recognize the interconnected chain of events that drive sediment dynamics: introducing sediments, trapping sediments, and keeping sediments. This approach aims to let the natural system thrive, improve flood risk management, and strengthen local identities and economies.

The MRD, historically a thriving natural system, has been heavily modified by human activities, converting it into an anthropogenic system focused on exploiting its resources (Kennish, 2001). This transformation has disrupted the natural sediment balance, leading to significant land loss, ecological degradation, and economic decline (Kesel, 2003). To restore the delta, it is essential to reintroduce sediments effectively. This involves understanding the historical sediment dynamics, which include both long-term processes like overbank flooding and short-lived events like crevassing and avulsion that rapidly deposit sediment (Chamberlain et al., 2018; Shaw & Mohrig, 2013). Once reintroduced, sediments must be effectively trapped to stabilize and build land. Various methods can be employed:

01. . Creating Artificial Barriers/obstacles (man-made): Artificial barriers, such as silt fences, geotextile tubes, and sediment traps, are engineered structures designed to intercept and capture sediment-laden water. These barriers can be installed along shorelines, riverbanks, or construction sites to mitigate erosion and sediment runoff. Studies by Bugg, et al. (2017) investigate the effectiveness of silt fences in trapping sediment runoff from disturbed landscapes, emphasizing their role in sediment control and water quality management.

02. Slowing Down Water (natural process): Slowing down water velocity is another effective method for sediment trapping, as it allows suspended particles to settle out of the water column. Techniques such as vegetated buffer strips, check dams, and erosion control mats help reduce flow velocities, facilitating sediment deposition. Research by Theisen (1992) evaluates the efficacy of erosion control mats in reducing runoff velocity and sediment transport, highlighting their potential for erosion prevention and sediment trapping in various landscapes.

03. Planting Vegetation and Pollination (man-made and natural processes): Vegetation plays a crucial role in trapping sediments through root systems and canopy structures. Plants, especially those with deep roots like mangroves and marsh grasses, anchor soil particles and slow down water flow, allowing sediments to settle. Research by Barbier, et al. (2008) emphasizes the importance of salt marsh vegetation in sediment accretion and erosion control.

Long-term sustainability of trapped sediments involves maintaining barrier islands and other natural features that protect against erosion and sea-level rise. Barrier islands play a critical role in sediment dynamics by influencing tidal and wave interactions, and by stabilizing inlets that facilitate sediment transport (Escoffier & Walton Jr, 1979).

Balancing man-made and nature-based solutions in the MRD requires a paradigm shift that integrates the anthropogenic system within the natural system. This involves allowing the delta to follow its natural course, which may necessitate accepting the loss of some areas to support the resilience of others. Effective sediment management in the MRD must be grounded in comprehensive, adaptive strategies that incorporate both historical knowledge and innovative techniques. By fostering a balance between human activities and natural processes, it is possible to ensure the long-term health and resilience of the Mississippi River Delta, benefiting both the environment and local communities.

Delta Discoveries is a company providing tours through the Delta and replanting Cypress trees in wetland areas.

RQ2: "How did the current water system (management) come to be and what are the lessons to be learned?"

The current water management system of the MRD has evolved through centuries of human intervention aimed at harnessing the delta's resources while mitigating natural hazards. Initially, the delta's water system was characterized by natural processes such as sediment deposition and river meandering, which created a dynamic and fertile landscape. However, as human activities intensified, particularly following European colonization, the focus shifted towards controlling and exploiting the delta for economic gains.

1. Early Interventions: The earliest modifications to the MRD involved the construction of levees and drainage systems by European settlers. These measures aimed to protect agricultural lands from flooding and reclaim wetlands for cultivation. Over time, levees were expanded and heightened, culminating in an extensive network that confined the river's flow and disrupted natural sediment distribution (Kennish, 2001).

2. Industrialization and Urbanization: The 19th and 20th centuries saw a significant increase in industrial activities, including navigation improvements, dam construction, and fossil fuel extraction. These activities were driven by the need to facilitate trade, support urban growth, and exploit natural resources. Consequently, the delta's natural hydrology was further altered, leading to sediment loss and habitat degradation (Kesel, 2003).

3. Modern Water Management: In response to the Great Flood of 1927, the U.S. Army Corps of Engineers (USACE) implemented the Mississippi River and Tributaries Project (MR&T). This comprehensive flood control system included levees, floodways, and spillways designed to manage high water levels and prevent catastrophic flooding. While successful in flood mitigation, the MR&T project exacerbated sediment depletion and wetland loss by preventing natural sediment deposition.

The current water management system in the Mississippi River Delta is the product of extensive human intervention aimed at controlling natural processes for economic and safety benefits. This anthropogenic system, however, has led to significant ecological degradation and increased vulnerability to flooding. As the delta faces ongoing challenges such as sea level rise and climate change, a shift towards integrating natural processes with human systems is essential.

Effective management will require collaborative efforts among federal and state agencies, local governments, NGOs, researchers, and the private sector. By embracing strategies that reintroduce, trap, and sustain sediments, and by allowing the delta to follow its natural course, it is possible to restore ecological balance, enhance flood resilience, and support local economies. The lessons learned from the delta's history underscore the need for a holistic approach that values both human and natural systems, ensuring the long-term sustainability and prosperity of the Mississippi River Delta.

Joshua's Marina.

RQ3: "What kind of landscape elements can reshape the Delta into a thriving natural system and strengthen local identities?"

The MRD has been heavily modified by human activities, leading to significant ecological, economic, and cultural degradation. To restore the delta into a thriving natural system and strengthen local identities, it is essential to integrate both man-made and nature-based landscape elements. These elements must work synergistically to reintroduce, trap, and sustain sediments, thereby restoring ecological balance, enhancing flood protection, and revitalizing local economies and cultural heritage.

1. River Diversions:

- Purpose: Reintroduce sediments and nutrients into the delta's marshes and wetlands.
- Implementation: Construct controlled river diversions to direct sediment-laden water into specific areas, replenishing eroded land and supporting vegetation growth (Ganti et al., 2016; Jensen et al., 2022).

2. Restored Wetlands and Marshes:

- Purpose: Trap sediments, enhance biodiversity, and act as natural buffers against storm surges and sea-level rise.
- Implementation: Restore and expand wetlands and marshes using sediment deposition from river diversions and planting native vegetation to stabilize soils (Blum & Roberts, 2009, 2012).

3. Barrier Islands:

- Purpose: Protect inland areas from erosion and storm impacts while trapping sediments.
- Implementation: Rebuild and maintain barrier islands using dredged materials and natural sedimentation processes. These islands act as a first line of defence against coastal erosion (Escoffier & Walton Jr, 1979).

4. Vegetation Buffer Strips:

- Purpose: Slow water flow, trap sediments, and enhance water quality.
- Implementation: Establish buffer strips of native vegetation along waterways to intercept sediments and nutrients, reducing runoff and promoting land stability (Theisen, 1992).

5. Sediment Trapping Structures:

- Purpose: Enhance sediment deposition in targeted areas.
- Implementation: Install structures like silt fences, and geotextile tubes, and check dams to capture and retain sediments in critical areas, aiding land-building processes (Bugg et al., 2017).

To balance the anthropogenic system within the natural system, it is necessary to:

1. Reevaluate Urban and Agricultural Practices:

- Reduce Dependence on Levees and Pumps: Encourage the use of natural floodplains for agriculture and urban planning to reduce reliance on artificial flood controls.
- Implement Sustainable Practices: Promote sustainable farming and urban development that aligns with natural sediment and water flow patterns.

2. Promote Ecological and Cultural Resilience:

- Support Local Economies: Develop eco-tourism and fisheries that benefit from a restored natural landscape, reinforcing local identities and cultural heritage.
- Community Involvement: Engage local communities in restoration projects to foster a sense of ownership and stewardship over the delta's resources.

Restoring the Mississippi River Delta to a thriving natural system requires a comprehensive approach that integrates various landscape elements designed to reintroduce, trap, and sustain sediments. River diversions, restored wetlands, barrier islands, natural levees, vegetation buffer strips, and sediment-trapping structures all play critical roles in this process. By realigning human activities with natural processes, these elements can enhance ecological resilience, improve flood management, and strengthen local identities and economies.

The MRD's history teaches us the importance of working with natural systems rather than against them. By learning from past mistakes and embracing innovative, adaptive management strategies, we can ensure a sustainable future for both the Delta's ecosystems and its communities.

View over marsh lands, photographed by Channel (2020).

RQ4: "How can the restoration of sediment flow help to make the Mississippi River Delta more resilient?"

Restoring sediment flow to the MRD is essential for making it more resilient by addressing the degradation caused by historical human interventions and aligning it with natural processes. This involves a comprehensive approach that integrates sediment management, ecosystem restoration, and adaptive strategies.

Supplying Sediments: Historically, the MRD's formation and maintenance were driven by the natural deposition of sediment-rich water from the Mississippi River, building natural levees and supporting diverse vegetation zones (Blum & Roberts, 2009). Human activities like dam construction and channelization have disrupted these natural processes, leading to sediment loss and marshland erosion. To counter this, managed river diversions can be employed to reintroduce sediments into the delta's wetlands and coastal basins, mimicking natural flood events that deposit nutrient-rich silt (Ganti et al., 2016; Jensen et al., 2022).

Trapping Sediments: Once reintroduced, sediments must be effectively trapped to rebuild the land and stabilize the delta. Techniques such as planting vegetation (e.g., marsh grasses and mangroves) can help capture and hold sediments, reducing erosion and fostering habitat creation (Barbier et al., 2008). Additionally, constructing artificial features like berms, terraces, and islands can provide surfaces for sediment accumulation and protection against storm surges (Nittrouer & Young, 2013).

Keeping Sediments: Ensuring the long-term retention of sediments involves maintaining and enhancing natural barriers like barrier islands, which protect against wave action and erosion. These islands play a crucial role in sediment dynamics by stabilizing inlets and influencing tidal interactions. Strategic use of barrier islands, along with managed sediment flows, can help maintain wetland elevation and preserve critical habitats (Escoffier & Walton Jr, 1979).

Ecosystem Restoration: The MRD's ecological integrity depends on the balance between human activities and natural processes. Restoring natural water flow and sediment deposition patterns can help rebuild degraded wetlands, boost biodiversity, and enhance the delta's resilience to sea-level rise and climate change (Morris et al., 2014). This approach requires a reevaluation of current land use and infrastructure to accommodate natural dynamics, allowing some areas to transform naturally while protecting others.

Cultural and Economic Considerations: The MRD's restoration must also support local identities and economies. By revitalizing natural habitats, local fisheries, tourism, and cultural heritage sites can benefit, creating economic opportunities and enhancing community resilience. Integrating these aspects into restoration plans ensures that the benefits of a thriving natural system are equitably shared.

Restoring sediment flow in the MRD is critical for enhancing its resilience against environmental challenges. By reintroducing, trapping, and maintaining sediments, the delta can recover from past degradation and support both ecological and human communities. This approach requires a holistic understanding of sediment dynamics, ecosystem processes, and adaptive management practices. Embracing the complexities of natural and human systems can lead to sustainable management of the MRD, ensuring its health and vitality for future generations.

Wetland area near Joshua's Marina sustained by haybails against erosion.

Joshua's Marina in the Lower Mississippi River. Mainly used for fishing on crabs and salt water fish.

Discussion

Balancing Human and Natural Systems for the Greater Good

The restoration of sediment flow in the MRD requires addressing the historical imbalance caused by extensive human interventions. The Anthropogenic system, driven by the exploitation of the delta's resources, has disrupted the natural sediment deposition processes, leading to significant ecological and socio-economic degradation (Kennish, 2001; Kesel, 2003). In the face of urbanization, sea-level rise, and climate change, the MRD and other deltaic areas must pivot back to a more balanced system where natural processes are restored and human activities are integrated within this framework.

Ethical Dilemmas and Regional Landscape Planning

Restoring the MRD involves significant structural changes that can impact local communities. The necessity of allowing the delta to follow its natural course may conflict with existing human systems, leading to the potential loss of private spaces, goods, and livelihoods for some residents. This raises ethical questions about the extent of sacrifice required for the common good. Landscape architects must navigate these dilemmas, ensuring that ecological benefits are balanced with social and cultural considerations. The goal is to create spatial frameworks that adapt ecological processes to benefit both nature and human communities.

Investing in an Uncertain Future

Planning for the MRD's future resilience involves complex, long-term investments with uncertain outcomes. Implementing sediment management and restoration projects requires a vision that accounts for current and future environmental changes. Political, regulatory, and economic actors play crucial roles in this process, often weighing the immediate socio-economic benefits against the long-term risks of inaction. Landscape architecture can serve as a mediator, guiding stakeholders through adaptive management practices and helping shape policies that align with sustainable landscape management.

Navigating Uncertainty with Flexible Management

Adaptive management is essential for dealing with the uncertainties of restoring the MRD. Restoration designs must incorporate flexibility to allow for adjustments based on real-world outcomes and evolving environmental conditions. This approach ensures that interventions remain relevant and effective over time, avoiding mismatches between design intentions and actual developments.

Measurability and Societal Responsibility

Quantifying the effects of sediment restoration interventions requires extensive expertise, data, and modelling, often beyond the scope of initial projects. However, theoretical assumptions and case studies can provide valuable insights for guiding these efforts. The increasing urgency of the climate crisis underscores the need for landscape architects to reorient their profession towards community service, nature conservation, and sustainable development. This shift involves a deep sense of responsibility and the recognition that collaborative efforts are essential for meaningful change.

Creating Sustainable and Aesthetic Landscapes

Designing for the MRD's resilience involves more than technical solutions; it also requires creating landscapes that are aesthetically pleasing and meaningful to human communities. Combining human creativity with an understanding of natural processes can produce "deep forms" that harmonize with nature's evolving order. Landscape architects must gather knowledge, research natural and historical interventions, and experiment with designs that consider both functional and aesthetic qualities.

Conclusion

Restoring sediment flow in the Mississippi River Delta is crucial for enhancing its resilience against environmental challenges. This effort involves reintroducing, trapping, and maintaining sediments through strategic interventions that balance ecological processes with human needs. Ethical considerations, flexible management, and adaptive policies are key to navigating the complex landscape of restoration. Landscape architects play a vital role in mediating between stakeholders, fostering sustainable development, and inspiring communities to rethink their relationship with the environment. By embracing a holistic approach, we can ensure the MRD's health and vitality for future generations, creating a landscape that serves both humans and nature without degrading the environment.

Petroleum plant in the Delta documented by Channel (2020).

Reflection

Looking back at the work I have done so far midway through the design process will help me position myself once again in the master thesis. Therefore we start at the beginning of my initial thought choosing my location and design subject and go step by step through the process of my master thesis. A reflection on the LAB will be given in the following chapter.

While in search of a suitable design research topic I was reading articles, known problems, or just locations I felt connected to. In combination with the assignments given within my LAB, it took me a while before I could find a clear path or location for my research. I feel myself thorn between two perspectives at this point, in one way I feel like the first five to seven weeks were not so beneficial for my process of the master thesis, and maybe slowed me down or put me a few steps back in comparison with other students from different LAB's. But on the other hand, I feel like it was quite valuable to start this way, I could slowly position myself and find out what I wanted to do. If this process was in a way rushed I might have ended up with either another topic or location. One clear thing could be said, I might have underestimated the workload in the beginning, if I had put more energy into determining my goal or vision within the project I might had more substantial material to work with just after my P2 presentation.

If I look at the complexity of the Mississippi Delta I feel myself triggered and eager to further develop my knowledge and understanding of this complexity. Within the Deltaic system of the Mississippi, many aspects come together and influence each other, such as water management, ecology, landscape properties, and human usage (shipping, working, living). This complexity is for me in one way a blessing, as I described earlier, it triggers me to investigate, but not only that it also gives me the feeling of importance or value. Although my design will probably not lead to something significant, it feels like I am learning something significant that will help me in my future path.

My design objective, or design narrative, is making the Mississippi River Delta (MRD) a resilient delta that can rely on its natural systems, to protect humans, animals, and ecological value, but can also contribute to strengthening the position of local economies and identities. I believe my design objective is ambitious, which also reflects my personality, I would like to contribute in one way to societies around the world. But within this ambition, there is a weakness, in making my design objective rather full and broad. The boundaries of my design objective become stretched and vague. I was confronted with this when I tried to develop my project further into concrete design proposals. When is which aspect leading and how do I determine that? To give an example: Why do we want to restore the landscape values of the Mississippi Delta? Answer; to make the Delta resilient against changing conditions in the future, for example rising water levels, and temperature changes, and to create a water management system that is more robust. I think this answer covers all the aspects of my design objective, but it is not specific to one aspect. If I want to protect the Delta against climate change, I could as well build an excessive flood protection full of levees and sluices, exactly what they have been doing in the Delta. The vagueness lies in the fact that it is not clear which aspect is when profiting and which one is less relevant. In design nowadays we want to be as inclusive as possible, considering all the aspects, this is in my opinion necessary to make a resilient design. But I should make it more clear which aspects I am dealing with and that I can answer the Why? question to when which aspect is dominant. I believe by making a clear and structured landscape-based concept plan I can better position these why questions.

The wide landscape of the Mississippi Delta.

LAP LAB

Landscape designs can use guidance during the process, landscape designs are formed by designing with a wide variety of systems, as discussed previously. By relying on the inherent structure of the landscape, compositions in landscape architecture have the potential to serve as agents of transformation. They can facilitate changes in programs, cultures, societies, intentions, and interpretations. Enabling the participation of traditionally overlooked elements in the city's productive activities and opportunities provides enhanced access to avenues for social and economic advancement. A genuinely inclusive city goes beyond social justice; it is also environmentally conscious, fostering diverse social and natural processes. Achieving this requires deliberate spatial design. From a design point of view, this asks for two underlying attitudes: the ability to see any design assignment from different points of view (through different lenses or perspectives) and to create sustainable, flexible, and open designs, that allow for change (Bobbink & de Wit, 2022). Sebastian Marot established four so-called perspectives for designers to navigate designers through their design process. He distinguished four principles or ways of looking at the foundation of the unity of landscape architectural analysis and design: the choreography of specific materials and spaces in the landscape (bodily experience), recalling and building on history (palimpsest), staging and cultivating new condition (natural process) and creating relationships with boundaries, adjacent areas, the environment and context (scale continuum) (Marot & Corner, 1999). The Landscape Architecture section at TU Delft relies on these viewpoints as a foundational framework for examining and designing (urban) landscapes in both research and education. The guidance provided to students in their graduation projects has further developed and fine-tuned our comprehension of these perspectives over the years.

In this thesis one of the four principles plays a central role, scale-continuum, the other three principles are still closely related to each other. The goal of this thesis is not only to make a sufficient design proposal but also to review the relationship between the four principles and whether the four principles are sufficient or contribute to a better design. In this brief introduction, I will explain my understanding of these four principles and their relationship according to literature, I will go step-by-step through all four perspectives.

Scale-Continuum

Landscape architecture, inherently interconnected with its context, considers various scales—physical, geological, hydrological, social, political, and ecological. The landscape is a space on the surface of the earth, with its own distinct character, either topographical or cultural, and above all a space shared by a group of people (Jackson, 1985). Viewing landscapes from both distant and proximate perspectives is crucial, as it combines visual and tactile experiences (Lassus, 1998), this is a telescopic succession of spaces. As depicted in, the small movie, 'Powers of TenTM' (Office, 2010) this telescopic relation between 'things' can range between many scales possible. Design interventions impact not only the designated site but extend to larger systems and diverse stakeholders, emphasizing the need to understand the interrelations between intervention, influence, and effect (Burns & Kahn, 2020).

I see Scale-Continuum as a method to approach a landscape based design. When a landscape architect is working a in complex environment, such as the Mississippi River Delta, it needs to understand the coupled systems that are present in the Delta landscape. These processes are acting on different scale leve's, therefore zooming-in and -out is necessary to understand the landscape. For example, in this project the water system created by humans are acting on a smaller scale level, levee construction,

New lands of the Mississippi Delta are being claimed by hunting associations. The subsurface of the Dela is covered by traces from the fossiel fuel industry.

pumping stations, etc. Only they are acting on a lager system, such as the natural delta system of land growth and land loss. This interrelationship is only understood when a designer is able to connect these scales together by mapping, documenting, and data analysis.

Natural Process

Designing landscapes involves 'manipulating' time, as landscapes are dynamic expressions of ecological, social, and economic interactions (Jackson, 1985). The increasing dynamism of landscape systems due to population growth and technological advancements makes forecasting challenging. Landscape architects embrace uncertainties, creating open-ended designs that prepare for unforeseen futures rather than rigidly addressing current needs. This approach acknowledges the landscape's unfinished nature, emphasizing the planting of seeds, mobilizing residents, and structuring potentialities. Incorporating natural and social processes into design requires understanding implementation stages and project support measures. Landscape architecture must either integrate or oppose the changeability of materials, with the materiality closely linked to the creation process (Bobbink & de Wit, 2022).

This principle is I believe closes related to the Scale-Continuum. Natural process have been acting since the creation of live on this earth. They are the base for processes, such as a delta landscape. They are all related to each other on the biggest scale, but all have different outcomes on the smaller scale, when adjusted to the context of the location. When understood the natural process can be steered and manipulated in a good and bad way. Natural processes form the basis for the design principles in this thesis.

Palimpsest

Landscape architecture transforms existing landscapes by purposefully integrating new uses, practices, and meanings into the current topography. Viewed as palimpsests, landscapes are like reused parchments, where layers of past developments and meanings coexist (de Wit et al., 2005). As functions become obsolete, landscapes are 'reused,' and traces of the old persist, influencing the transformation process. These landscapes are readable biographies, revealing changes through layered entities. The physical development progresses through stages: the natural landscape, the cultural landscape shaped by human activity, and the bio-spherical landscape formed by hydrology, geology, and topography (Wascher, 2007). Landscape architectural design contributes successive chapters to this ongoing story, with an understanding of existing layers serving as a foundation for new transformations. The explicit expression of implicit forms in the design signifies a landscape architectural transformation, creating a three-dimensional coherence that establishes the landscape's independent identity. Landscape architects, while acknowledging the past, may undertake radical changes as a conscious response to the landscape's palimpsest nature, introducing new layers in dialogue with existing ones.

The palimpsest is the history of the location, it can derive from different context. Human traces, natural traces, animal traces, or a combination of all. They have all formed the landscape of the location. Together with the natural processes this principle shapes the landscape as we precieve it. The Mississippi is a dynamic landscape which leaves traces behind, such as the sand deposits of old river streams (ridges). This traces can give designers clues to understand the natural processes for example, or the cultural value of a landscape. In this thesis palimpsest is used to determine design location, by analysing the past of the landscape, predictions could be made and shaped.

Ship on the Mississippi River pushing water away.

Bodily Experience

In landscape and landscape architecture, space is not viewed as a mere abstraction or empty surface, but rather as a habitat where the sky and the underground engage in diverse relationships defined by their respective natures (Marot & Corner, 1999). Perceived space incorporates both tangible and intangible components (Berleant, 1997), including physical dimensions, proportions, materiality, plasticity of topography, and visual aspects such as color, texture, and light, which encompass dynamic elements like weather and seasonal changes. This perspective goes beyond visual components to consider the entire body's sensory experience, including feelings of rhythm, edges, elements' sizes, openings, closures, landmarks, and directions (Bloomer & Moore, 1978). Analysing and designing landscapes from the perspective of perceiving space emphasizes the landscape as experienced "from the inside" by an observer moving through it.

This last principles is a clear design tool for a landscape designer, by understanding how people perceive their environment a designer can steer peoples behaviour. This principle is not actively present in this thesis. The local identity and local economy are touching in my perception partly this principle, these aspects are part of how people live with the landscape. But is in a certain degree less emotional as the principle is intended.

Relation between the Principles

The four principles form together the basis of landscape architecture, according to TU Delft (Bobbink & de Wit, 2022), which means that they are interrelated and can be connected. But for every designer or design site, this can be different. Personal preference or design purpose is determining the hierarchy and connection between these principles. I think we need to distinguish the difference between two aspects of the design, long-term designing and short-term designing. In both aspects the design principles are present only in the hierarchy between them is different. I think that in long-term designing the scale continuum is the dominant principle, whereas natural processes and palimpsest are equally present and add great value to the design, but bodily experience is less relevant and not that present during the design. For the small scale designing it is the opposite.

A glims of New Orleans. Bourbon Street and St. Louis Cathedral

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Appendix

Few locations have as much historical and ecological significance as the Mississippi Delta has in the history of the United States. The Delta is a birthplace of many narratives, this vast Deltaic region has been built from many layers of history, where the biography of the delta takes root and flourishes. Nestled at the end of the Mississippi watershed, the Mississippi Delta is not only a geographical hydrological entity but a living story of dynamic stories between land and water, and humans and nature. Trying to peel back all the layers of time and delve into the becoming of Delta's identity. From the river currents to the cultural layers woven by communities over centuries, each facet contributes to the rich narrative that unfolds the becoming of the Mississippi Delta. To be able to start with the present layout of the Deltaic Plain, a biography is made of the Delta since the moment humans colonized the Delta and started shaping it to their will. From there the present layers are unravelled in, cultural, natural, geographical, economical, and hydrological layers, and connections are made between them.

"a vast seaward-advancing arc that occupied through four distributaries, extended across all of coastal Louisiana, characterized by plums of fresh water that extended for more than 10 km into the Gulf of Mexico During the spring floods"

Early French and Spanish mariners in Day and Erdman (2018)

1650-1700

Eight centuries in the past, the lower Mississippi Delta housed well-organized societies boasting roads, commerce, and cultural hubs anchored by remarkable earthen and shell mounded monuments. Unfortunately, by the 1500s, mound construction entered a period of decline. . They lived in harmony with the delta's natural features, utilizing kitchen middens – mounds of earth and shells – as signs of their presence (Russo, 2008) (Day & Erdman, 2018). These mounds stood as testaments to the rich bounty of the delta, providing sustenance from the surrounding marshlands, waterways, and oyster reefs. This coincided with the arrival of the first Europeans in the region, who brought epidemic diseases that ravaged native populations across the Southeast. Consequently, when sustained contact with European colonists commenced around 1700, the longstanding tradition of mound building was on the brink of extinction (Southeast Archeological Center, 2010).

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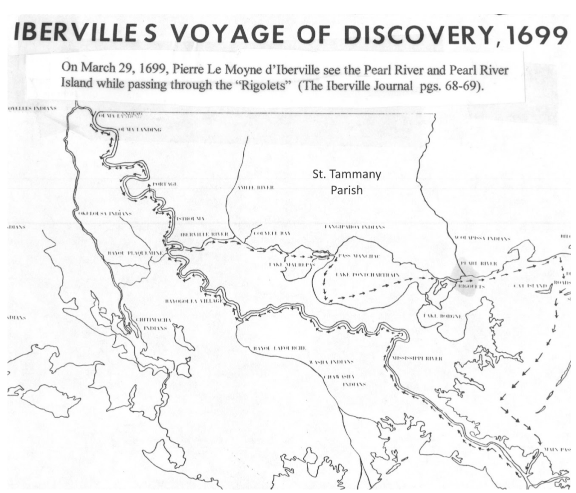
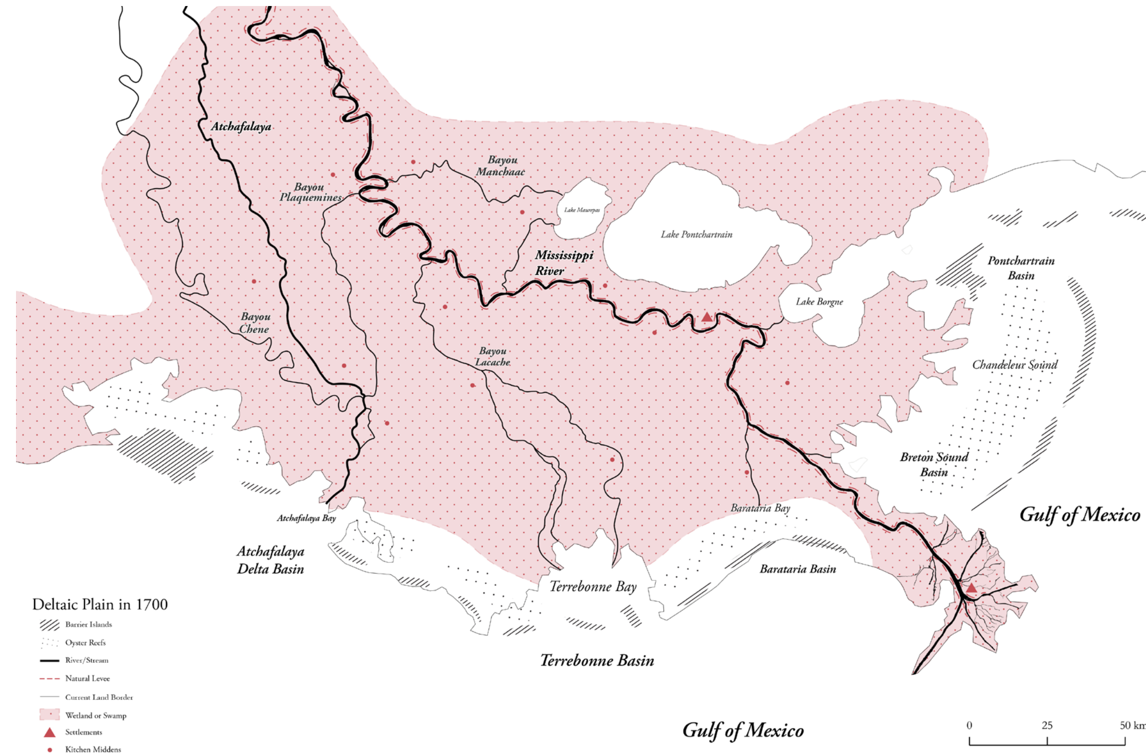


2.

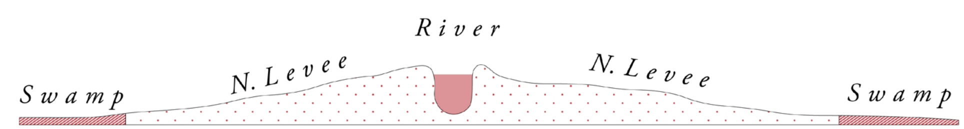
1. Representation of some of the hundreds of earthen and shell mounds built by American Indians in Southern America. (Southeast Archeological Center, 2010)

2. Map of Iberville's route in his exploration of southeastern Louisiana in 1699. It included passing through the Rigolets. (The Don Sharp Collection, 2010)

Map of the Mississippi River Delta around the year 1700, illustrating the features that determine the watersystems.



Section of the Mississippi River, featuring natural levees that constrained the River in the Delta.



"it is necessary to open the enty of the river, sand banks and oyster reefs are causing difficulies to navigate (1718)"

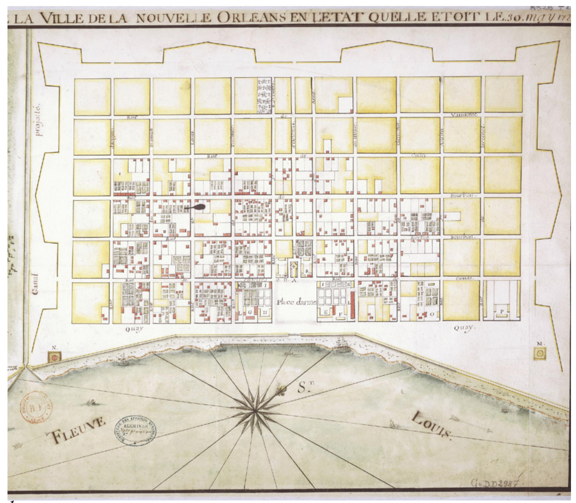
French sailors looking for a trading route to New Orleans.
(Barry, 1997, p.61)

1700-1750

In the early 18th century, the Mississippi River Delta faced a period of dynamic changes. In 1718, French sailors, recognizing the challenges posed by sand banks and oyster reefs, emphasized the necessity of improving the river's entry (Barry, 1997, p. 61). These natural obstacles created difficulties for navigation and trade along the vital waterway towards the newly conoliazed lands (Louisiana).

Responding to the annual flooding of the Mississippi River banks, in 1726, the construction of artificial levees commenced along the river near New Orleans. These levees, standing at a height of 4 to 6 feet, extended 30 miles upstream and 12 miles downstream (Day & Erdman, 2018, p. 30). Simultaneously, a distinctive architectural approach emerged as houses were constructed on poles, adapting to the delta's dynamic environment.

Amidst these efforts, the delta became a site for agricultural experimentation. In 1745, the exploration of rice farming began, reflecting a growing interest in diversifying the region's economic activities. This period witnessed a convergence of environmental management, infrastructure development, and agricultural innovation as the Mississippi River Delta continued to evolve in response to the changing needs and aspirations of its inhabitants.



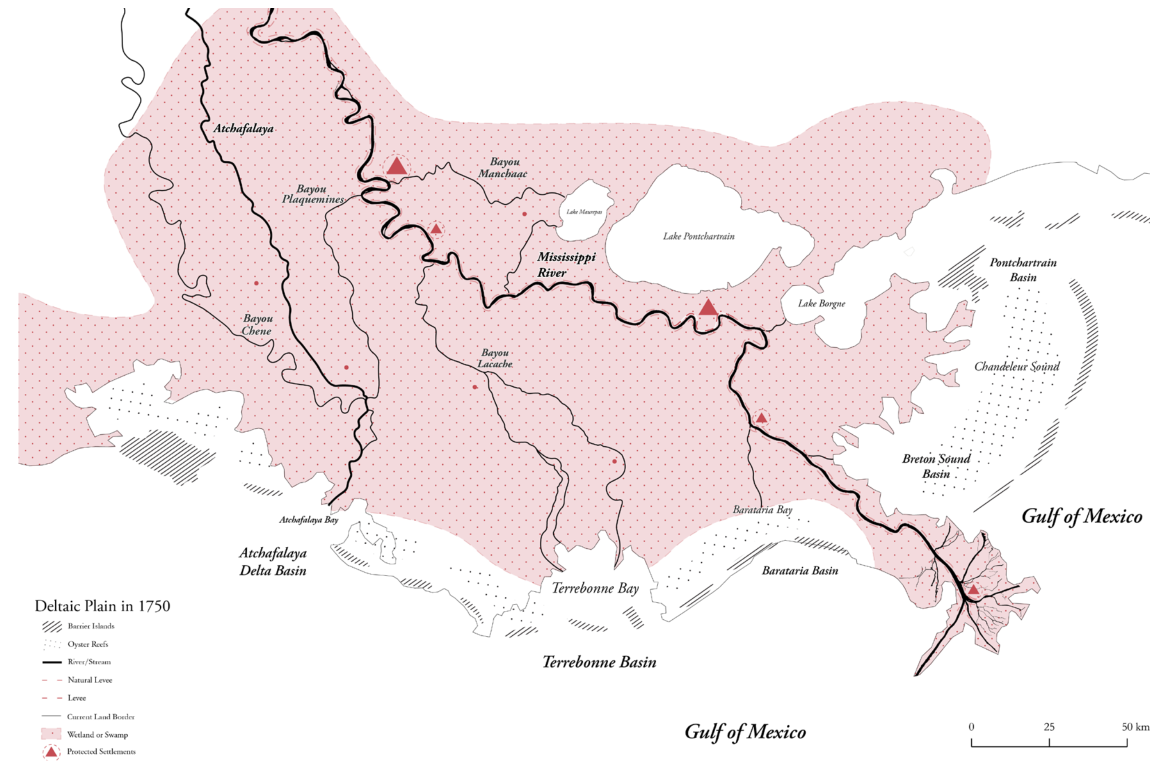
1.

2.

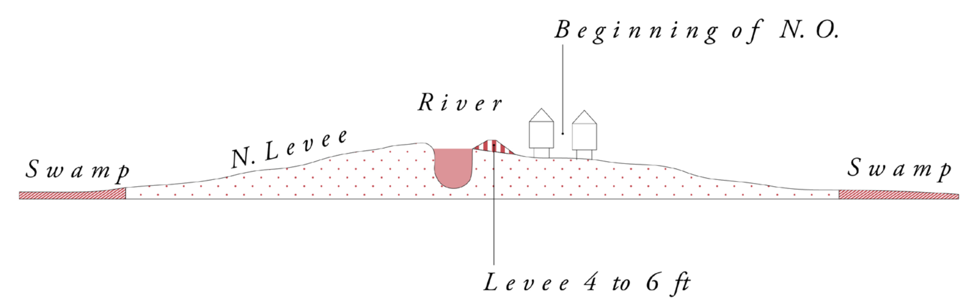
1. Early map of the city plan for New Orleans in 1725, river side was designated for levees and the city was drained with canals. (Library of Congress, n.d.)

2. Map of the Mississippi River, around 1750 the Louisiana state covered whole central of America. Corresponding to the watershed of the Mississippi River. (Bernard, 1737)

Map of the Mississippi River Delta around the year 1750, illustrating the features that determine the watersystems.



Section of the Mississippi River, featuring natural and artifical levees that constrained the River in the Delta.



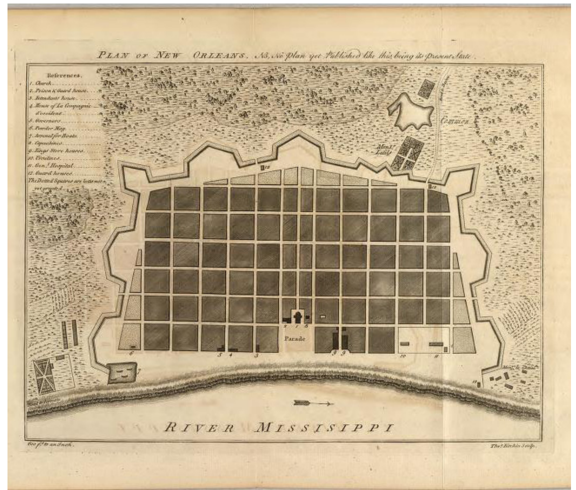
"a Woman chained to a Girl, and a Man in irons at work in the fields"

Quote in the anti-slavery almanac (1800)

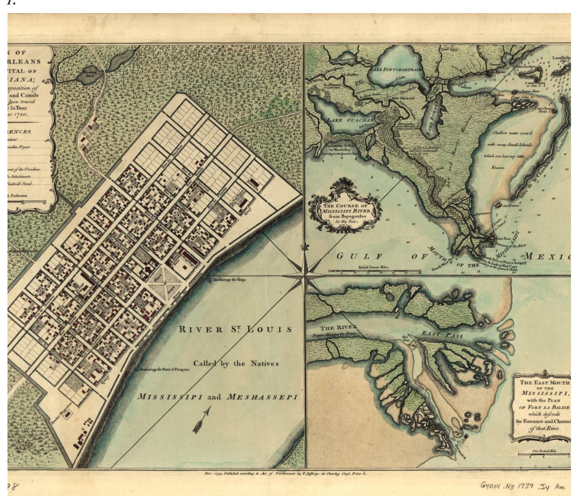
1750-1800

Between 1750 and 1800, the Mississippi Delta witnessed a steady development that shaped its cultural, economic, and environmental landscape. During this period, rice production emerged as a prominent economic activity, reflecting the region's adaptability to diverse agricultural practices. The fertile deltaic soils proved conducive to rice cultivation, marking a significant diversification of the local economy, during this period slavery started to become part of the economy.

The strategic importance of New Orleans prompted the construction of armed walls around the city, fortifying its defenses and establishing a distinct urban character. Amidst these transformations, natural systems persisted, and the delta's vulnerability to floods became evident. Crevasses, breaches in natural levees, led to recurrent floods in 1775, 1780, 1782, 1791, and 1796 (Day & Erdman, 2018, p. 30). These inundations, while challenging, also played a role in replenishing the deltaic soils and maintaining the dynamic balance of the ecosystem.



1.

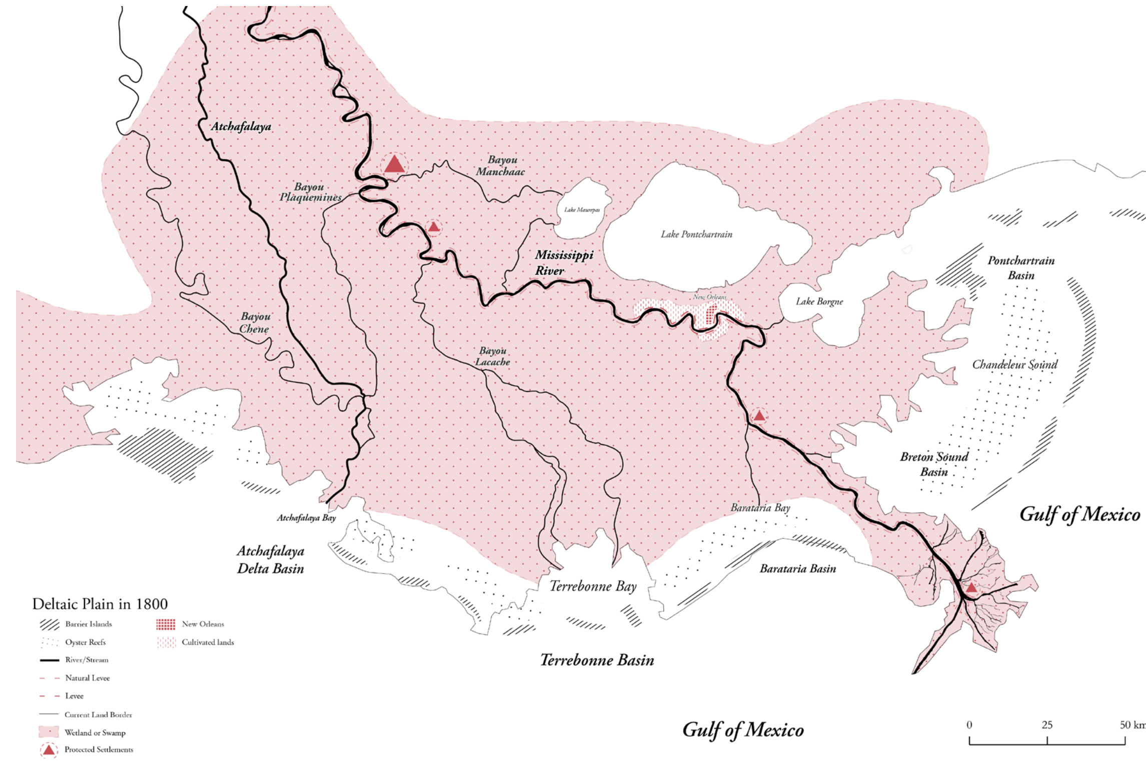


2.

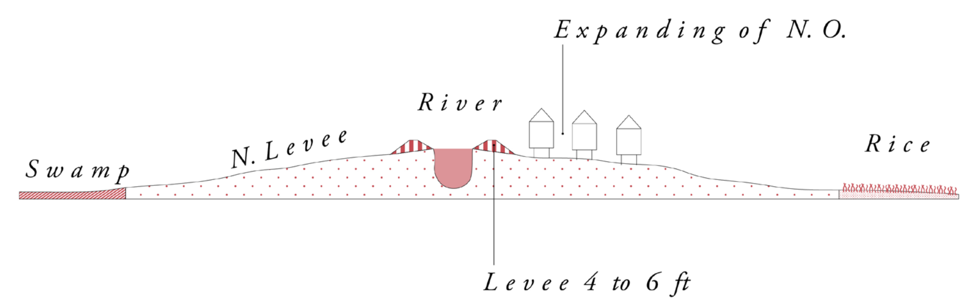
1. New plans for New Orleans with armed walls surrounding the city. (Pittman, 1770)

2. Detailed entry of the Mississippi Delta. (Jefferys & Brion De La Tour, 1759)

Map of the Mississippi River Delta around the year 1800, illustrating the features that determine the watersystems.



Section of the Mississippi River, featuring increase of levee system.



"1825 a last known inundation of New Orleans due to spring flooding"

U.S. Army Corps of Engineers (2019)

1800-1850

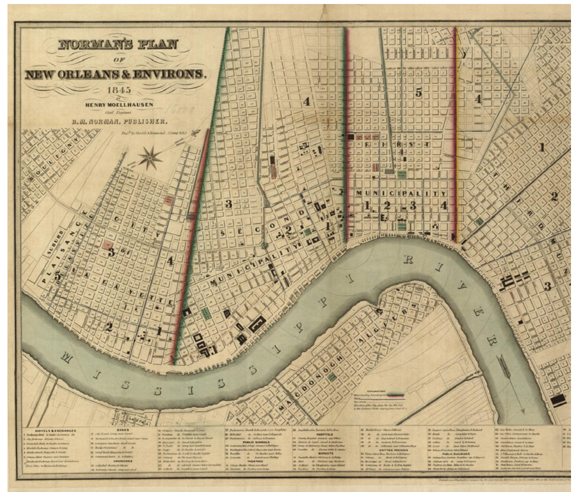
In the early 19th century, the Mississippi Delta underwent significant developments from 1800 to 1850, shaping its landscape and infrastructure. In 1803, levees were extended to Baton Rouge and along Bayou Lafourche, showcasing early efforts in levee construction to control the river's flow (Day & Erdman, 2018, p. 31).

By 1812, substantial progress was made in levee expansion just below New Orleans. On the east bank, an impressive 155 miles of levees were constructed, paralleled by 180 miles on the west side (Barry, 1997, p. 40). These levees aimed to mitigate the risks of flooding and enhance the region's agricultural potential.

Plans for expansion of New Orleans take serious forms, for military and urbanization reasons. The plans from 1813 and 1845 can be compaired and the attractiveness of the Mississippi Delta is understood.

In 1816, a proposal surfaced for the creation of a spillway, an artificial outlet, east of New Orleans, either leading to Lake Pontchartrain or below the city to Lake Borgne (Barry, 1997, p. 41). This marked a strategic effort to manage the river's water flow more effectively. The spillway opened in 1849, called Bonnét Carré, on the east of New Orleans. This marked the realization of the earlier proposal, providing a controlled outlet for excess water and reducing the risk of flooding in the region.

Notable instances of successful flood control were observed in the period. In College Point, a levee of 1.5 feet successfully held back a flood, showcasing the effectiveness of these protective measures. Similarly, at Morganza, a levee standing at 7.5 feet demonstrated its resilience in managing floodwaters (Barry, 1997, p. 91).



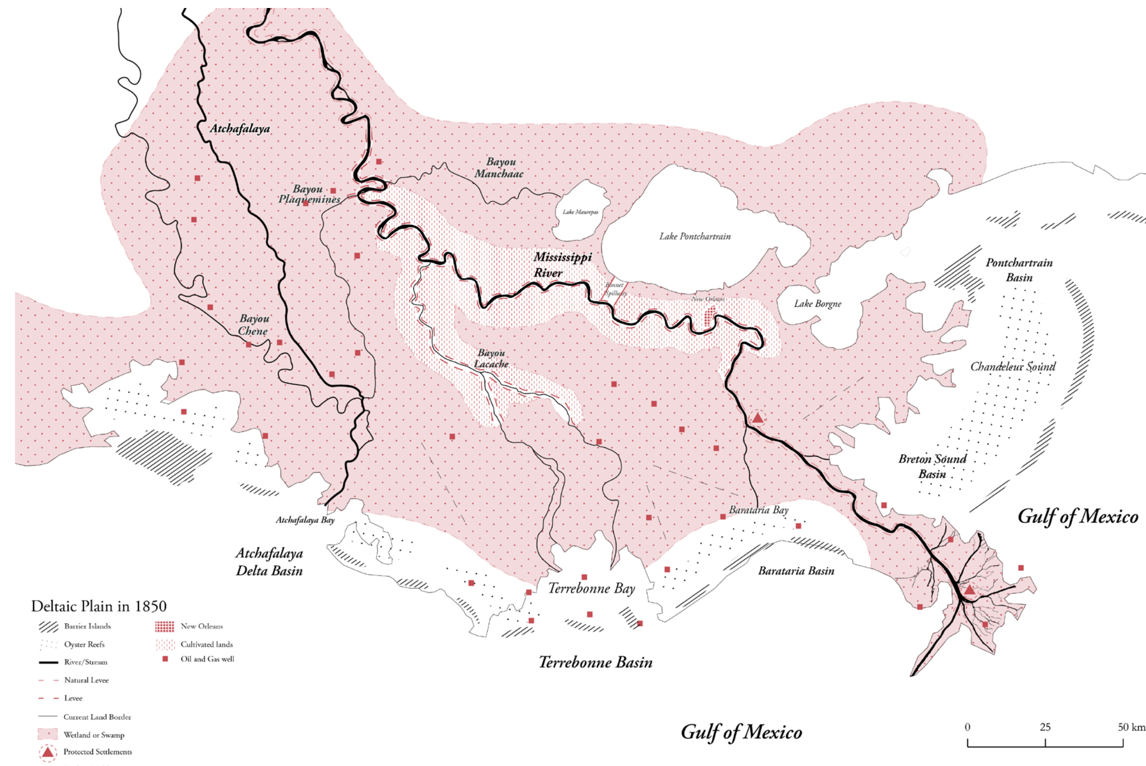
1.

2.

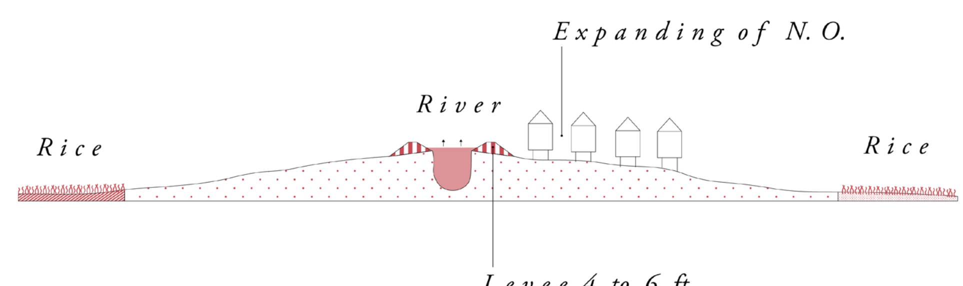
1. City expansion plan from the mid 19th century. (Möllhausen et al., 1845)

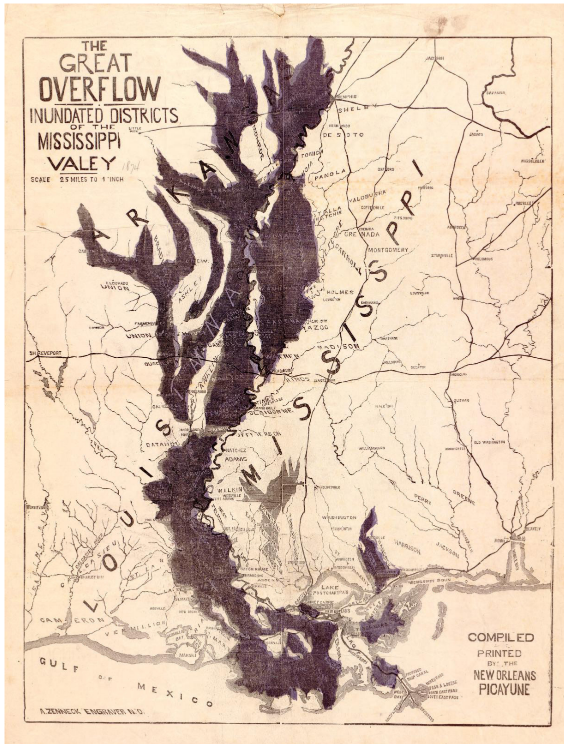
2. Spill way construction, the Bonnet Carré Spillway is just one element of a comprehensive U.S. Corps of Engineers flood control plan in the Lower Mississippi Valley. (St. Charles Parish Museum and Historical Association, 2022)

Map of the Mississippi River Delta around the year 1850, illustrating the features that determine the watersystems.



Section of the Mississippi River, featuring increase of levee system.





The Great overflow: Inundated districts of the Mississippi Valey. (Zenneck, 1874)

"The city itself was a poor position to defend against a hostile fleet. With high water outside the levees, Union ships were elevated above the city and able to fire down into the streets and buildings below."

Hearn (2006)

1850-1900

Between 1850 and 1900, the Mississippi Delta witnessed a dynamic period marked by significant changes in land use, infrastructure, and environmental impact. The Swamp Reclamation Act of 1850 facilitated the reclamation of swamplands, leading to a substantial increase in reclamation efforts. Over 1,000 miles of levees were constructed on both sides of the Mississippi River, with some reaching a remarkable height of 38 feet. These measures aimed to control the river's flow and protect the surrounding lands (Barry, 1997).

The American Civil War, spanning from 1861 to 1865, brought a challenging chapter for the delta. Many levees were intentionally destroyed for military reasons during the conflict. While numerous were hastily restored post-war, the quality of restoration often fell short, leaving vulnerabilities in the protective infrastructure.

Post-war changes in plantation practices, particularly the shift to sugarcane cultivation, led to extensive land drainage and disconnection from river systems. Distributaries were closed off from the Mississippi River, altering the natural flow patterns of the delta.

In 1882, a significant flood upstream on the river inundated an extensive area of 34,000 square meters with water reaching depths of 6.5 feet (Barry, 1997). Shortly thereafter, the Bonnét Carré spillway was closed off once again to manage the excess water (Day & Erdman, 2018).

This period also marked the initial decline in oyster reefs and barrier islands, representing a major disruption to the delta's water system. These ecological changes had far-reaching consequences for the delicate balance of the delta's environment, reflecting the intricate interplay between human interventions and the resilience of natural systems.

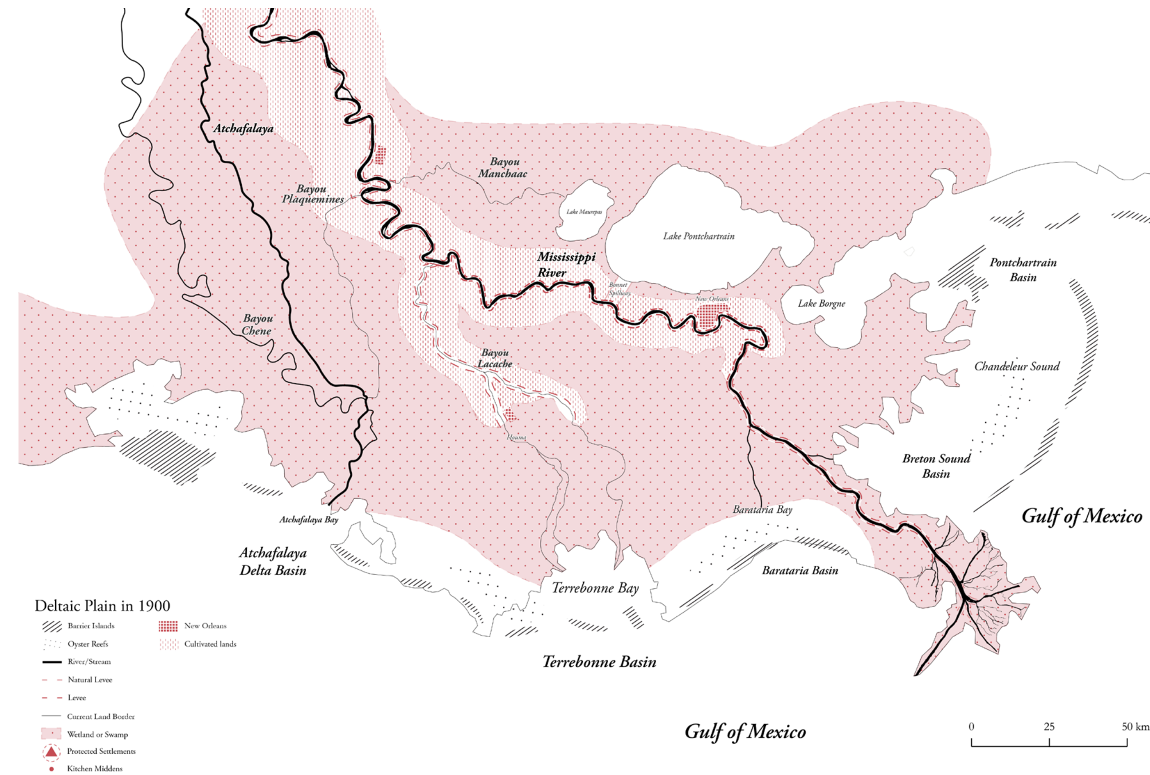
1.

2.

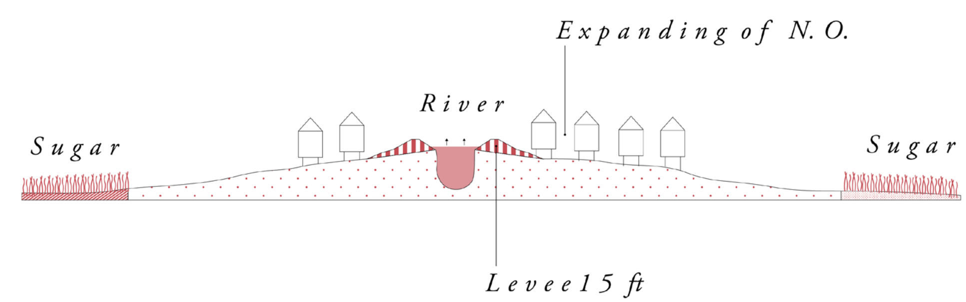
1. Map of a part of the State of Louisiana exhibiting the route of the New-Orleans, Opelousas & Great Western Rail Road. Bayley and Childs and Hammond (1853)

2. Repairing the levee at New Orleans at the expense of the U.S.government.

Map of the Mississippi River Delta around the year 1900, illustrating the features that determine the watersystems.



Section of the Mississippi River, featuring increase of levee system.



"Rising Tide: The Great Mississippi Flood of 1927 and How It Changed America"

Barry (1997)

1900-1950

Between 1900 and 1950, the Mississippi River Delta experienced a series of transformative events that shaped its landscape, infrastructure, and societal dynamics. Levee construction continued to evolve, with the levee at College Point reaching an impressive height of 20 feet and at Morganza towering at 38 feet, a significant increase from their earlier heights of 1.5 and 7.5 feet, respectively (Barry, 1997).

In 1912, the region faced a major flood event when the river at Cairo smashed height records, reaching 18 feet. The following year, devastating floods in Ohio resulted in over 2,000 deaths, with significant casualties in Hamilton, Zanesville, Dayton, and Columbus. In response to these floods, Cypress Creek, one of the last main distributaries of the Mississippi River, was sealed off (Barry, 1997).

New Orleans underwent significant growth during this period, transforming into a major city fueled by the discovery of oil and gas. By 1950, the city's population had swelled to 450,000 inhabitants.

The year 1927 witnessed the infamous Great Mississippi Flood, a catastrophic event chronicled in the book "Rising Tide: The Great Mississippi Flood of 1927 and How It Changed America." During the flood, a breach occurred at Dorena, prompting engineers to pump water to stabilize levees around New Orleans. In a dramatic turn, a Caernarvon businessman financed the artificial breach of a levee to prevent a potential disaster in the city.

Post the Great Flood of 1927, the exclusive reliance on levees was reconsidered, leading to the formulation of new plans for managing the river. The 1930s marked the boom of the fossil fuel industry, prompting the construction of pumping stations in the wetlands. This industrial expansion resulted in the creation of pipelines and canals, cutting through the natural habitat of the Delta and introducing further changes to the region's ecological dynamics (Day & Erdman, 2018).

3.

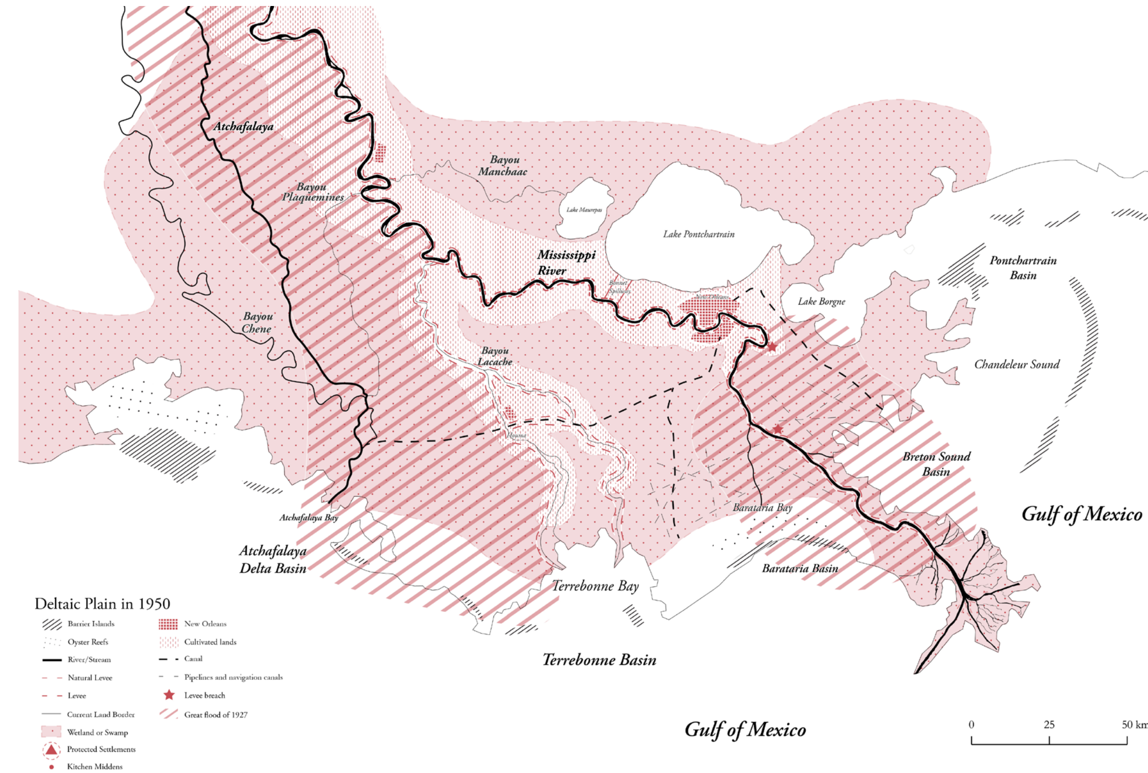
4.

1. Fighting to save the levee outside Lakeport, Arkansas. The wooden wall built along the levee crest protects from wave wash, sandbags raise the levee's height, and men are laying planks on the slope and covering them with sandbags to prevent sloughing. Arkansas Lakeport (1927)

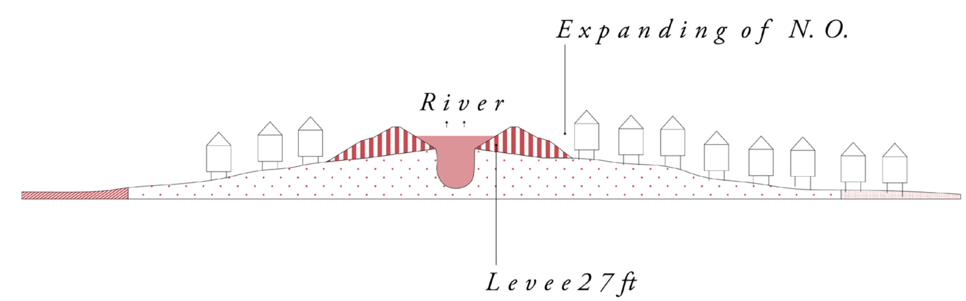
2. April 29, 1927, dynamiting of the Levee at Caernarvon, thirteen miles below New Orleans, flooded thousands of residents of two Louisiana parishes out of their homes.

(1927) Caernarvon, La.

Map of the Mississippi River Delta around the year 1950, illustrating the features that determine the watersystems.



Section of the Mississippi River, featuring increase of levee system



“When I’m flying, I often have this feeling of overwhelming beauty with this deep sadness for what’s been lost. Two feelings at the same time constantly.

Ben Depp in Last Call for the Bayou. (Channel, 2020)

1950-2000

Between 1950 and 2000, the Mississippi Delta underwent significant transformations, reflecting a period of intense urbanization and economic expansion. Following the Second World War, there was a massive surge in urbanization, commonly known as urban sprawl. Vast residential areas emerged, particularly in the swamps, creating a unique landscape with buildings constructed in marshlands on less-than-ideal foundations due to the inability to build on traditional poles.

The demand for deeper shipping canals to accommodate seafaring vessels surged during this period. The fossil fuel industry experienced substantial growth, leading to the construction of draglines and pipeline canals totaling a staggering 16,000 kilometers. While this expansion fueled economic prosperity, it had profound consequences for the natural system of the Delta.

The extensive canal network and increased industrial activity triggered land subsidence in the wetlands. Large sections of the wetlands began to disappear, contributing to the degradation of the delicate ecosystem. The once-thriving cypress trees faced decline, oyster banks vanished, and the barrier islands, vital for coastal protection, rapidly diminished.

The environmental impact of these human activities was significant, with repercussions felt across the entire Delta region. The disappearance of wetlands and natural habitats, coupled with the loss of key species, underscored the complex interplay between human development and the preservation of the Delta's unique ecological balance.

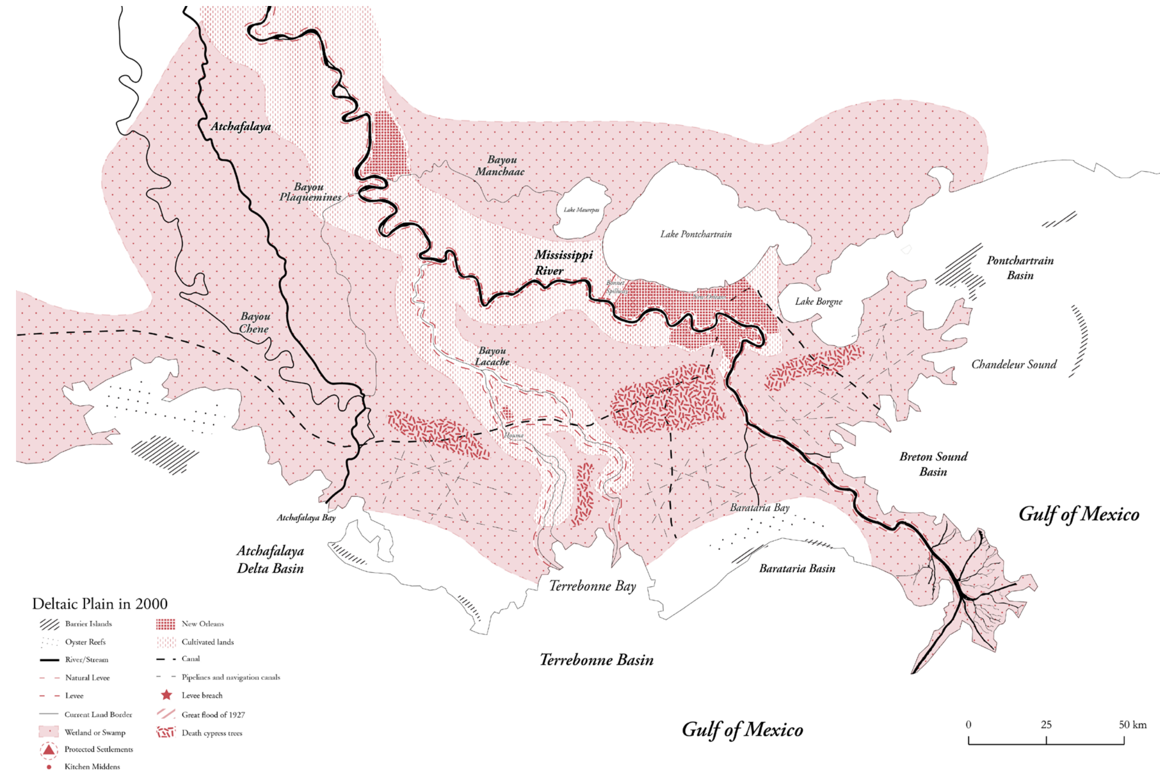
1.

2.

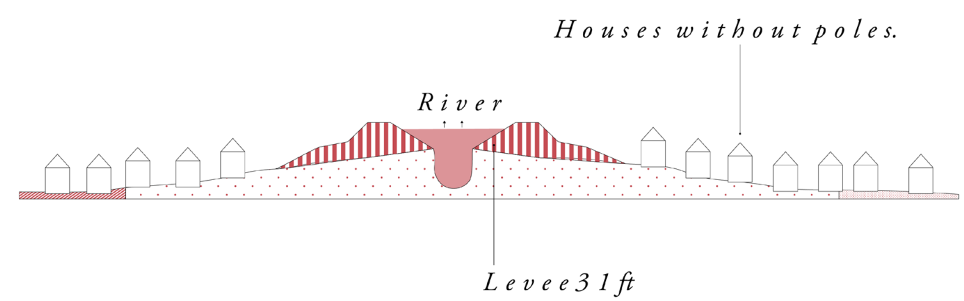
1. Video frame of the small documentarie Last Call for the Bayou following Ben Depp. (Channel, 2020)

2. Dead Cypress trees photographed along the highway towards the Grand Isle

Map of the Mississippi River Delta around the year 2000, illustrating the features that determine the watersystems.



Section of the Mississippi River, featuring increase of levee system



Department of Landscape Architecture
Faculty of Architecture and the Built Environment
Delft University of Technology
Delft, The Netherlands

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For further inquiries about the present Landscape Architecture
master thesis, please contact the author through the following email address:
marijn.vreriks98@gmail.com