Envisioning Future Ecologies: Mangrove Afforestation as a Coastal Climate Change Mitigation Technique in the Terrebonne Region, Louisiana

Grace M. Boyd

ABSTRACT

The Terrebonne Region of Louisiana faces a catastrophic amount of wetland loss at a rate exacerbated by the impacts of human development. State and federal agencies largely impose grey infrastructure, such as levees, as a hasty way to suppress the impacts upon human-populated areas. Human populations most vulnerable to subsidence and storm damage are largely low-income fishers and Black and indigenous communities. However, rising air temperatures over the past 50 years in coastal Louisiana have allowed the range of Avicennia germinans, or black mangrove, to establish in the region. A. germinans provides many ecosystem services, including sediment stabilization and storm wave attenuation. To test to see if mangrove afforestation is a viable green infrastructure technique for the Terrebonne Region, I completed a literature review, a social vulnerability assessment, and a suitability analysis in ArcGIS. The results propose mangrove afforestation paired with grey infrastructure of oyster sills for a hybrid technique. The area of the Terrebonne Region most suitable for this proposal is the Port Fourchon area, due to its proximity to extant mangrove colonies and relative distance from oil and gas fields. To create a successful wetland loss mitigation plan, mangrove afforestation must be paired with community-specific resource equality. Keeping vulnerable communities engaged with land use planning is vital to fostering strong resource networks, and allows progress to be made with local needs in mind. The concept of future ecologies, a combination of human and environmental considerations within adaptive management, is focal to this study.

KEYWORDS

wetland loss, socioecology, hybrid infrastructure, land use planning, mangrove habitat

INTRODUCTION

Unchecked human development has caused serious damage to natural ecosystems and society. Implications are clear, but the public consensus has only recently begun to swing towards concern as our environment responds to climate change (Marlon et al. 2022). This is especially true in coastal ecosystems, which are at a confluence of natural habitats and human activities. The landscape is home to tidal marshes, beaches, kelp forests, barrier islands, mangrove forests, oyster reefs, and coral reefs, which provide economic opportunities and abundant biodiversity. However, these opportunities also expose an ample breeding ground for anthropogenic growth at the expense of the surrounding ecosystem (Powell et al. 2019). In this landscape, it is clear that socioecology – integrating anthropogenic factors into environmental frameworks – is the only way to address the mounting climate crisis (Wu and Wu 2013). However, socioecological procedures have been historically hasty and unintentional; leading to large-scale social demise at the benefit of advantaged and hegemonic systems that deepen inequities (Barbier and Hochard 2018). Disasters such as hurricanes and oil spills are contributing to an inordinate amount of physical, environmental, and social loss; especially impacting socioeconomic and ecological weaknesses (Lewis et al. 2017). Large-scale societal and environmental tragedies are becoming more common but so are erosion, sea level rise, and other distinct manifestations of climate change. These will only continue to increase in severity and frequency as development accelerates.

Louisiana in particular has faced an intense amount of coastal land loss, which is especially exacerbated by human-induced climate change (Khalil et al. 2011). For centuries, historic wetlands were developed on top of, and the impacts of which are compounded by the diversion of flood waters through artificial levees (Mumphrey et al. 1976). This has led to the loss of ecosystem services and natural wetland accretion of the area, both physically and within the institutional memory of urban planners (Van Heerden et al. 2007). There is no doubt that, in these conditions, a disaster such as Hurricane Katrina would lead to devastating consequences. The hurricane's overwhelming storm surge broke the levee system in 53 locations. This led to chemical contamination in water, infrastructure damage, home displacement, and an inordinate amount of death; among other physical and societal devastation (Petterson et al. 2006) (National Academy of Engineering 2006). Concurrently, exposure and vulnerability to the impacts of Hurricane Katrina are well-studied and determined to be influenced by factors of household income, racial demographics, and land abandonment; among others (Lewis et al. 2017) (Campanella 2007). From an ecological standpoint, historic wetland mismanagement is the primary cause of such destruction and the source of future mitigation and prevention efforts.

Habitat restoration can be used as an immensely important tool to combat the impacts of climate change on human livelihood in Louisiana. The state lies within the fundamental niche of black mangrove – *Avicennia germinans* (Alleman and Hester 2011). The expansion of mangrove reef habitat in this area is largely due to reduced incidences of extreme cold events (Perry and Mendelssohn 2009). Thus, warming seas have increased the suitability of mangrove restoration as a potential mitigation tool. When planted close to coastal urban areas, mangrove reefs can dampen the storm surge level and prevent it from reaching human infrastructure, much like a concrete or granite storm surge barrier would do (Hashim et al. 2010) (Powell et al. 2019). The development of mangrove habitats demands a highly diagnostic and integrated approach. In many cases, the soil community may not be suited to facilitate regeneration (Kandasamy and Bingham, 2001). However, there are global efforts to find restoration techniques that balance economic, ecological, and social factors; including inducing viviparous seedlings and in vitro (outside of the organism) micropropagation (Kandasamy and Bingham, 2001). Once the proper techniques are imposed, restoration creates a landscape upon which socioecological adaptation can be generated. This protection is vital for the safety and endurance of social and cultural networks. Restoration principles and theories utilized for this thesis may take many names and shapes – queer ecology, political ecology, human ecology, cultural ecology – but I propose "future ecologies" as a term to define this all-encompassing ideology. Future ecologies demand that natural resource management acknowledges the changes that humans have imposed upon our natural environment. It challenges the idea that the anthropogenic world is separate from the natural world and recognizes that the acknowledgment of the two in tandem can generate better outcomes for humanity and the earth in the face of future impacts from climate change. The theoretical framework of future ecologies will be explained in later sections, but understanding the core belief – human-nature interconnectedness – is paramount to comprehending this thesis.

In this study, I ask: how can we plan for future ecologies in the face of wetland loss in the Terrebonne region of Louisiana? The Terrebonne region, defined as the coastal bay between the Terrebonne and Lafourche Parishes, is used as a case study. To answer this, I ask further: What factors contribute to and exacerbate the impacts of coastal wetland loss in the Terrebonne region?

Who are the communities dependent upon the region's wetland network, and what are their vulnerabilities? How can we address the socioecological impacts of climate change utilizing species-based restoration? I hypothesize that the climatic feedback loops of human-environment disengagement – including but not limited to the building of levees, redlining of neighborhoods, and development on wetlands – can be mitigated through socioecological techniques, specifically hybrid infrastructure. In the Terrebonne region, I propose mangrove afforestation – the creation of mangrove habitat – as the blue-green infrastructure component of a hybrid technique to reduce wetland loss and initiate future ecologies. My null hypothesis is that the Terrebonne region is not an appropriate region for mangrove afforestation as a climate mitigation technique. This hypothesis will be studied by equating the findings of a literature review, a socioeconomic vulnerability analysis, and a suitability analysis; applying these to the proper infrastructure and economic considerations in the discussion. The triangulated approach, including both social and ecological data, is fundamental to a holistic study of coastal human-populated ecosystems and a clear understanding of what informs their pressures and susceptibilities.

RESEARCH FRAMEWORK

Planning for "future ecologies"?

Protecting future ecologies may sound like a simple principle – continue making the earth habitable for future life. However, taking one look at today's socioecological landscape it is clear that somehow along the way this priority has been abandoned. Structures such as capitalism and neoliberalism have informed environmental (mis)management; taking shape due to a history of imperialism, colonialism, and nationalism (Foster and Clark 2009). The damage done to disadvantaged communities in the interest of these systems is overwhelming and certainly one of the largest crises of current human history (Barbier and Hochard 2018). Examples in the United States are staggering and include the Flint water crisis and the fight against the Dakota Access Pipeline led by the Standing Rock Sioux Tribe.

Enter the concept of "staying with the trouble," as coined by ecological and feminist scholar Donna Haraway. Haraway calls to embrace the consequences of human actions, proposing that this is the only way to make actionable change. In her words:

> *...staying with the trouble requires learning to be truly present, not as a vanishing pivot between awful or edenic pasts and apocalyptic or salvific futures, but as mortal critters entwined in myriad unfinished configurations of places, times, matters, meanings.*

Planning for future ecologies, then, is an ongoing practice of adapting to the confluence of past choices, current circumstances, and future projections. In the field of urban planning and climate mitigation, it rejects solutions that only answer to temporary obligations. A prime example is grey infrastructure; an expeditious and precarious response to sea level rise that only leads to compounding complications over time (Rosenbloom 2018). If planning is inherently future-oriented, the field can certainly benefit from adopting practices that take into account how current landscapes will impact future systems. Thus, as this thesis attempts to address the socioecological landscape of coastal Louisiana, future ecologies must be placed as the precedence.

Coastal infrastructure: typology and modern discussions

Current intervention methods for impacts of climate change in human-populated coastal areas are primarily grey infrastructure – structures used to control natural processes including seawalls, levees, and storm surge barriers (Powell et al. 2019). Grey infrastructure blocks human relations to nature, imposes a sense of dominance over the natural environment, and is often built hastily; without thought of environmental, structural, social, or economic consequences (Hill 2018). The consequences, though not calculated in land use planning, are immense. Seawalls, levees, and storm surge barriers intensify erosion and alter the structure and natural function of shorelines. Thus, demand for "blue-green" or "natural" infrastructure – or mitigation techniques utilizing locally appropriate geomorphological systems and ecological habitats – is becoming increasingly necessary (Hill 2015). However, many ecosystems currently do not have the stability to be able to support blue-green infrastructure as a standalone intervention method. Thus, hybrid methods – integrating both grey and blue-green infrastructure – have great potential to address the reverberations of human-induced climate change (Powell et al. 2019).

Due to a historic landscape of grey infrastructure, a direct shift to blue-green infrastructure is impractical. This type of land use transition requires decades of research and development on top of gradual implementation of alternative techniques. Thus, with an objective of future ecologies in mind, hybrid infrastructure is the only foreseeable option upon the time scale of this thesis. Although hybrid infrastructure may be able to pave the way for a fully blue-green infrastructure-supported coastline, the Terrebonne Region requires a direct and immediate mitigation technique for wetland loss. This thesis posits hybrid infrastructure as a first step, with the associated benefits and objectives on the temporal and procedural scale of its implementation.

Ultimately, human-environment interactions provide a pathway for the Anthropocene to integrate into and thrive in the natural world. As coastal communities are continuously and increasingly threatened by sea level rise, increased incidences of catastrophic flooding, atmospheric rivers, and other anthropogenic manifestations of climate change, it is clear that grey infrastructure and separation of resiliency strategies is not a sustainable solution. Recognizing and integrating socioecological endeavors within our land use planning strategies is necessary for future ecologies.

Mangrove reef restoration as blue-green infrastructure

Mangrove plants vary in genus and family, with 5 species found in the United States (Spalding et al. 1997). Mangrove communities are found in highly saline environments and as a result, have evolved mechanisms to thrive despite risks of salinity, desiccation (extreme dryness), and anoxia (severe oxygen deficiency). These mechanisms include salt glands and diverse root structures – prop roots, cable roots, pneumatophores (specialized aerial roots for gas exchange), and viviparous propagules (structures dispersed with some stage of development while still being attached to parent plant) (Tomlinson 1986). This makes them uniquely suited to the geographical areas they inhabit.

Mangrove reefs are vital for their role in energy transfers in their ecosystems, especially for the cycling of nutrients from the decomposition of detritus (Kandasamy & Bingham 2001). It is remarkable to point out that mangroves appear to be specially localized in their contributions to the food web (Fleming et al. 1990). Though not necessarily contributive to larger faunal exchanges, they provide a great deal of structural and nutritive support to their ecosystem.

Mangrove habitats are sensitive to accelerated climate change, including but not limited to increasing atmospheric temperature, changes in hydrological regimes, sea level rise, and increases in tropical storm magnitude and frequency (Field 1995). Loss of habitat and desiccation are considerable concerns for fauna that rely on mangrove habitats for survival, positing mangroves as an important focus for coastal ecosystems as climate change worsens (Kjerfve et al. 1997). Due to this, they are of significant concern for future ecologies and are at the intersection of continued ecological functioning and human life.

For the purpose of this paper, the restoration objectives of focus are sediment stabilization and storm wave attenuation. The levee system and improper coastal management have led these manifestations of climate change to be the most detrimental to wetland loss in coastal Louisiana (Khalil et al. 2011). To encourage sediment stabilization and limit wave energy, efforts have been made to plant mangrove areas and complement them with grey infrastructure. A detached multiple structure, or breakwater, is employed; an artificial offshore structure (Hashim et al. 2010). The grey infrastructure was found to facilitate mangrove restoration efforts. Mangrove saplings were sheltered by the breakwater, with 30% of the original saplings surviving. 27% of the seedings died during transportation, attributed to differing conditions in the nursery vs restoration site. Results showed that sediment accretion occurred between planted mangroves and the breakwater, and was expected to ready a steady state after 2-3 years. Considering the fragility of mangrove seedling growth, this technique is relatively effective. Long-term efficiency needs to be studied, but preliminary results show that usage of both the structure and mangrove restoration – a form of hybrid infrastructure – are projected to improve sediment stabilization.

Terrebonne as a site – a racial, structural, and environmental history

An intersectional landscape of injustice

The state of Louisiana has perhaps one of the most complex socioecological landscapes in the world of coastal urban climate change mitigation. In New Orleans post-Hurricane Katrina, there was found to be a correlation between socioeconomic factors such as household income and racial demographics, and vegetation community composition and structure (Lewis et al. 2017). Though New Orleans specifically has faced an incredible amount of pressure from the impacts of its history of discriminatory urban planning and socioeconomic disparities, much of coastal Louisiana faces the same intensely segregated socioecological community outcomes (NIMHD n.d.). These factors are additive to the impacts of urbanization upon wetland habitats, which modifies hydrological and sedimentation regimes and increases flood frequency (Lee et al. 2023).

With largely non-white communities living on top of extremely vulnerable urbanized wetlands, the landscape of risk is disaggregated (Hemmerling et al. 2021). In Terrebonne specifically, the risk lies largely upon the indigenous Biloxi-Chitimacha-Choctaw and Houma communities (Randolph 2018) (D'Oney 2020). Thus, focusing on and recognizing these communities in future coastal urban development is paramount to creating a truly "resilient" socioecological system.

It has been identified that rural communities living in low-elevation coastal zones (LECZs) are among the most vulnerable to the impacts of climate change (Barbier and Hochard 2018). These communities are more likely to fall into "poverty-environment traps", wherein the primary industries rely on marine resources which accelerate environmental degradation and thus reduce the productivity and income opportunities of those reliant. Climate change further reinforces this positive feedback loop, which thrusts the LECZ communities into deeper poverty and exacerbates resource loss. The Terrebonne region may be identified as a low-elevation coastal zone, due to its primary economy being built upon coastal environmental resources such as fishing and oil and gas extraction. 20% of the state's seafood production is sourced from the small bay region, and Lafourche and Terrebonne parishes combined house 1,258 oil and gas facilities (CPRA 2023) (Louisiana Department of Natural Resources n.d.). Attention to how these sensitive poverty-environment traps currently and will continue to impact the Terrebonne region is of the highest importance to its future ecologies.

Louisiana is racing against time as coastal erosion generates massive amounts of wetland loss. Each parish exhibits unique geography and consequential environmental issues. The Terrebonne region is characterized by its extensive system of bayous and barrier islands, which are incredibly important for the cultural and ecological history of the area (CPRA 2023). The region sits on the alluvial plain of the Mississippi River, whose path into the Gulf of Mexico has been highly controlled by human-made spillways, levees, and floodgates; including but not limited to the regional Morganza-to-the-Gulf levee system and the seventy–six mile Mississippi River Gulf Outlet (MR-GO) shipping canal (Randolph 2018). These forms of grey infrastructure were created to allow humans to precisely control the hydrologic flow of the floodplain. This territory is uniquely jeopardized by the impacts of coastal climate change. Grey infrastructure restricts sediment deposition to the historical alluvial plain, establishing an unstable floodplain which makes hundreds of thousands of acres uninhabitable and prone to subsidence (Yuill et al. 2009). Thousands of residents live outside of areas protected by established levees and are threatened by the continued loss of wetlands and sea level rise (CPRA 2023). Terrebonne is threatened by thousands of acres of land loss accelerated by human ecosystem alteration and subsequent climatic impacts, making the unique and extensive marshland habitat of pressing concern.

CPRA Coastal Master Plan

Many state-funded and operated organizations are proposing and implementing coastal preservation and protection programs with varying levels of success and significance. One such organization is the Coastal Protection and Restoration Authority, or CPRA. According to the website, the mission of CPRA is to The Coastal Protection and Restoration Authority's mandate is to "develop, implement, and enforce a comprehensive coastal protection and restoration Master Plan" (CPRA 2023). This Master Plan – first published in 2007 and further updated in 2012, 2017, and 2023 – details financial and programmatic strategies for mitigating land loss and flood risk on Louisiana's coast.

Of interest to this thesis is the Master Plan's strategy for Terrebonne, where 11.3 billion dollars have been allocated to structural and restoration projects. The largest structural projects are 400,000 feet of levee construction around the Terrebonne region's human-populated centers – Houma, Dulac, and LaRose. This gray infrastructure will reduce flood depths by up to 9 feet and maintain much of the land humans depend on. However, the levees effectively create a barrier between the human-made coast and the receding wetlands, while further disrupting necessary hydrological and sedimentary regimes of the estuarine system (Randolph 2018). Communities dependent on levees – effectively every coastal town in Terrebonne Bay – experience higher impacts of flooding due to the dehydration of the groundwater table and subsequent sinking of the land (Sherwood 1973). Regardless of the implications of these projects, it is clear that the CPRA values grey infrastructure as the only viable coastal barrier for human populated areas.

Though physically and financially the area's plan for human-populated protection is focused on these levees, it also includes marsh creation and restoration, of specific note on the bay's barrier islands. The purpose of this restoration is to reduce wave erosion and is largely being done in the Bayou Lafourche with the Belle Pass-Golden Meadow Marsh Creation project ($1.2B). In addition to marsh creation and restoration with the goal of reducing erosion, two ridge projects within the Terrebonne region were proposed with the purpose of reducing wave and storm surge attenuation – the Bayou Decade Ridge and Mauvais Bois Ridge (1.3M each).

Sediment dredging for habitat restoration

Both ridge restoration and marsh creation involve sediment dredging in further open water areas and placing the sediment further upshore; planting native vegetation in this newly established area. This technique may not only reduce impacts of sea level rise but also prevent groundwater table rise; an extant risk whether or not levees are built as coastal protection (Hill 2023). Dredging is a commonly used technique by the U.S. Army Corps of Engineers for shipping channels, as well as by the oil and gas industry. The CPRA already includes sediment dredging within its 2023 Master Plan (CPRA 2023). Seeing as sediment dredging is actively being done within the CPRA's Master Plan, it may be considered as an option for the creation of mangrove restoration sites. Dredging infrastructure company Jan de Nul began a project in 2018 to utilize dredged sediment to restore mangrove habitat in Ecuador (Jan de Nul 2018). This project is considered an innovative and unprecedented strategy, and supports integration of mangrove restoration within CPRA's existing marsh creation plans. It is important to note, however, that the company is profiting off of the use of their dredging products and practices in this restoration project. Sediment dredging must be viewed with a critical lens, as there are many political motivations for wetland restoration via dredging practices.

A.Germinans *expansion in the Terrebonne Region*

The Terrebonne region has additionally seen the highest increase of mangrove habitat on the entire coast of Louisiana. A study completed in 2010 observed that the habitat of *Avicennia germinans*, or black mangrove, increased fivefold in coastal Louisiana from observation dates between 2002-2009. The majority of these observations occurred in the Terrebonne region (Michot et al. 2010). Between 1989 and 2009, extreme cold events in coastal Louisiana decreased due to climate change. As a result, the salt marsh habitat became more well-suited to the subtropical species, and today the distribution of *A. germinans* only continues to grow. In 2020, the National Oceanic and Atmospheric Administration (NOAA) financially supported two coastal restoration projects by the Coastal Wetlands Planning, Protection, and Restoration Act Program (CWPPRA) (NOAA 2020). The larger project, taking $24 million of the $30 million allotted, is located in Timbalier Bay; a small inlet between barrier islands in the Terrebonne region (CWPPRA 2021).

This project is specifically designed to restore mangrove habitat in the region, promoting sediment stabilization similar to and in conjunction with the CPRA's Belle Pass-Golden Meadow project. With mangrove habitat increasing in the Terrebonne region, an area that has existing marsh creation projects and requires coastal infrastructure that supports both urban and ecological life, *A. germinans* presents itself as a highly valuable blue-green infrastructure opportunity.

Financial ties to the oil and gas industry

Glaringly important in the CPRA's Coastal Master Plan are its intimate ties with the oil and gas industry, a partnership that imbues the plan with what Randolph termed "extractive thinking" (Randolph 2018). A neoliberalist view of nature as a commodity has ensured that industries that extract resources from Louisiana's coast create the valuation system and advance their infrastructure. This is especially true when the Coastal Master Plan is in its majority funded by oil royalties, including $170 million from the Gulf of Mexico Energy Security Act (U.S. Bureau of Ocean Energy Management 2006). This revenue allows oil and gas stakeholders to play a conflated role in the health and vitality of Louisiana's wetlands, enabling more money to go towards restoration projects by way of damages. This enables ecologically and culturally destructive industries to continue their practices so long as they have the money to pay for their impacts after the damage is done. This also places restoration advocates in a position to depend upon and advocate for extractionary practices, creating warped political rationality wherein destruction is reclassified as restoration on the state level (Houck 2015).

It is no secret that oil production contributes to a third of all wetland loss in coastal Louisiana, largely due to altered hydrological regimes (USGS 2000). Where this loss is sited and why has been widely researched and explored. The concept of "Sacrifice Zones" was coined by anthropologist Julie Maldonado in reference to the indigenous peoples of Louisiana's coast. This refers to geographical areas in which large parts of land are owned by oil companies, where the value of human life is weighed less than the economic value of natural resource extraction (Maldonado 2014). Sacrifice Zones may be viewed in tandem with LECZs, wherein disasters such as oil spills, hurricanes, and flooding are obscured as "natural disasters" when in reality are provoked by the function and disregard of the oil industry in conjunction with the state.

Site-specific summary

As demonstrated in the above paragraphs, interplaying factors of racial segregation, hegemonic control of land by the oil industry, and human-created erosion and flooding exacerbating climate change have created a complex landscape of socioecological injustice in the Terrebonne region of Louisiana. Current planning regimes are still controlled by discriminatory systems of neoliberalism which make even sustainability and wetland restoration highly politicized and influenced by the exploitation of nature and culture. However, a unique confluence of changing climatic conditions, state-led restoration efforts, and sociocultural unrest has created a niche for mangrove habitat creation as a way to promote wetland restoration, storm surge attenuation, and land rights for coastal communities; especially indigenous peoples. It is of the utmost importance to research and understand the potential of this technique while the window of opportunity still exists.

Theoretical frameworks are often criticized for their abstract mythologies, including but not limited to future ecologies as a principle for land use planning in coastal Louisiana. However, any system humans have engaged within the history of the Anthropocene is full of its own mythologies – it is simply that those that have gained traction are more widely accepted for the fact that human society has built itself around them (Arnold 1937). Indeed, structures such as capitalism and neoliberalism have taken shape due to a history of imperialism, colonialism, and nationalism (Foster and Clark 2009). This is especially true in the land management of coastal Louisiana. We must confront these corrupt and immoral systems while recognizing and honoring those who have been disadvantaged by them (Barbier and Hochard 2018). Therein lies the value of planning for future ecologies.

METHODS

Study site

The Terrebonne region is defined for the purposes of this study as the coastal area geographically bounded by two parishes: Terrebonne on the west side and LaFourche on the east. The region is also separated from the Gulf of Mexico by a network of barrier islands (Figure 1).

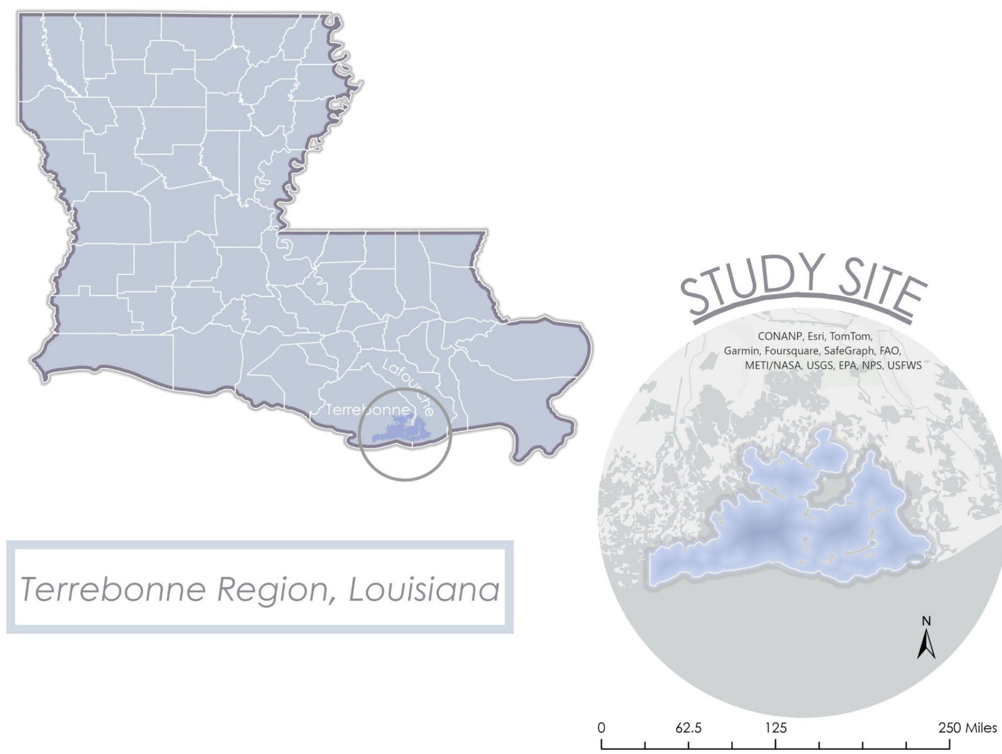


Figure 1. Study site. *Hereafter referred to as "Terrebonne Region" – a coastal region bounded by Terrebonne and Lafourche parishes and disjunct from the Gulf of Mexico due to a network of barrier islands. Figure by author, using Louisiana state and coastal boundary data taken from the US Census Bureau and USGS.*

Literature review

To understand the socioecological landscape of the Terrebonne region, I completed a literature review. Due to the fact that most research is exclusively scientific or social, most references are disjointed as such. To begin with, I chose literature which related to mangrove restoration as a climate change mitigation strategy and the socioeconomic disparities facing southern Louisiana. In reading these, I discovered other topics which I deemed as relevant to this thesis; facilitating the search for other literature. My thesis advisor supported the direction of the literature review, who introduced me to Terrebonne-specific literature and policy. Much of the extant policy also facilitated searches for related literature.

Social vulnerability assessment

Procedure

To understand how racial, class, and other social disparities create localized risk outcomes, I completed an assessment of present social vulnerabilities in the Terrebonne Region. Historic social vulnerability indexes (SVIs) are criticized for their one-dimensional and simplified analysis of complex and interdependent inequity factors (Hendricks and Van Zandt 2021). This criticism is complemented by limited statistical evidence that such indices are viable ways to draw large-scale conclusions about the vulnerability of a population. Rather, this study utilized existing written histories by way of personal narratives and/or ethnographic accounts (d'Oney 2020, Tidwell 2003, Misrach & Orff 2012, Randolph 2018). I associated each unique account with its geographic location on a map and attached a paragraph detailing the account. I organized the points into the following groups: *Plantations*, *Wetlands*, *Oil and Gas Facilities*, and *Communities*. These groups were chosen to illustrate the specific and extensive impact of slave plantations, ecological damage, the oil and gas industry, and BIPOC communities upon Louisiana, as the reverberations of these four systems play a large role in explaining the landscape of the state.

Data analysis

Although a full annotated map is available within the bibliography, I turned select narratives into annotated points on the final suitability map. These narratives were chosen for their robustness and ability to chronicle a larger history of coastal Louisiana and its communities. These narratives also spatially ground "highly vulnerable" communities that would otherwise be determined by statistical analysis. These communities were determined as having the most robust impacts from the four systems defined above. I chose this method carefully with the recognition that personal narratives and accounts are crucial to expressing, and subsequently advocating for, community needs in times of socioecological crisis. Existing narratives must be considered in future decision-making and land use planning, and this amended social vulnerability assessment incorporated this need.

In tandem with the annotated map, I created an actor power network map to visualize which actors hold power, which express the need for support in the face of wetland loss, and which actors impose influence over specific others. This actor power network supplements the discussion about the power dynamics impacting land use planning in the Terrebonne Region.

Suitability analysis

Procedure

To determine which sites in coastal Louisiana provide the most opportunities for mangrove afforestation, I completed a suitability analysis. A suitability analysis, as completed in ArcGIS, processes spatial information that has been manually determined to hold specific weights. Positive weights are considered opportunities, and negative weights are considered constraints. When opportunity and constraint layers are overlapped, a suitability analysis is created; geographically mapping the zones of highest suitability for afforestation of mangrove colonies.

I completed this suitability analysis in three phases, each phase designed to successively pare down the suitable area. Phase 1 included broad ecological factors: extant mangrove colonies and CPRA wetland restoration proposals. The analysis for Phase 2 was completed in the area subjectively chosen to be the most suitable based on the results of Phase 1. Phase 2 studied anthropological impacts, including oil and gas fields and human-populated areas. Finally, Phase 3 was the area determined to be the most suitable based on the combined results of Phases 1 and 2, including biological factors most critical to supporting mangrove afforestation: density of extant mangrove populations, water pH, water salinity, substrate type, and air temperature. The phases and ranks are detailed in Table 1.

I chose the area for e Phase 1 of the suitability analysis as the entire range in which mangroves were observed in the interest of rejecting a null hypothesis that the Terrebonne Region is not suitable for mangrove afforestation.

Table 1. Suitability Analysis Factors. *Suitability analysis factors and their values' corresponding ranks. Ranks may correspond to different values in the suitability analysis, which are in parentheses.*

	Suitable	**Adequate**	**Unsuitable**

Phase 1	*Extant Mangrove Colonies*	1000 < n < 1500 m ()	500 < n < 1000 m (1)	0 < n < 500 m (-1)
	Restoration Proposal	Yes (1)	No (0)	N/A
Phase 2	*Proximity to Oil and Gas Fields*	>1 mile (0)	½ < n < 1 mile (-2)	<½ mile (-3)
	Proximity to Human Populations	5 < n < 10km (2)	0 < n < 5km (0) n < 0 km (1)	N/A
Phase 3	*Density*	Class 5 (3) Class 4 (2)	Class 3 (1) Class 2 (0)	Class 1 (-1)
	pH	6.5 < n < 7.5 (2)	3.3 < n < 6.5 (1)	n < 3.3 (-1) n > 7.5 (-1)
	Salinity	0 < n < 25 ppt (2)	25 < n < 60 ppt (1)	n > 60 ppt (-1)
	Substrate Type	Silty Clay (2)	All others (1)	Gravel (-1)
	Air Temperature	28 < n < 32 °C (1)	32 < n < 40 °C (0)	< 40 °C (-1)

Extant mangrove colonies

The presence of extant mangrove colonies determines whether or not there is afforestation potential, by using existing areas as a backbone for further afforestation. If there are no existing mangrove colonies within a suitable range, the area was deemed inconsiderable as it was not already identified as a location whose conditions could support mangrove afforestation. However, restoring near naturally settling mangroves may disrupt their growth process (Wetlands International 2016). Thus, the suitable location is within a buffered geographic range around present colonies while not including direct sites in which mangroves were observed. Coastwide vegetation survey data for Louisiana was restricted to only points in which *A. germinans* was documented. This data was taken from a public database and was captured by the Louisiana Department of Wildlife and Fisheries.

Restoration proposal

Whether or not there were restoration proposals in a specific geographic area, as determined by the Coastal Protection and Restoration Authority (CPRA)'s Coastal Master Plans (CPRA 2023). Published versions exist for 2012, 2017, and 2023. Shapefiles sourced from the 2023 version were chosen due to their relevancy and recency.

Proximity to oil and gas fields

According to the Oil and Gas Threat Map, areas within a ½ mile radius of oil fields are at risk for degrading human and non-human wellbeing (Oil and Gas Threat Map 2023). Mangroves are a flora highly sensitive to oil pollution, which causes immediate structural damage, reduced stabilization and reduced recovery (Kandasamy and Bingham 2001). This area of Louisiana contains thousands of coastally located wells, compressor stations, and processors; making oil seeps of high concern for wetland health. Oil and gas wells are individual infrastructures that drill for petroleum, and they were chosen as the data points for this analysis due to their ability to represent the density of infrastructure in a geographic region. Oil and gas well data were sourced from the Louisiana Department of Energy and Natural Resources' Strategic Online Natural Resource Information System (SONRIS).

Proximity to human-populations

The purpose of this study was to utilize mangrove afforestation as a technique to promote sediment stabilization and storm wave attenuation in human-populated areas; thus, proximity to human populations was a fundamental factor in this suitability analysis. The distance intervals determined for this study were influenced by research which concluded that the highest amount of mangrove loss existed between 5-10 km of human-populated areas (Branoff 2017). Although there is no “unsuitable” area for mangrove afforestation on the basis of proximity to humans – as mangroves may even be planted within estuarine cities – areas with a higher risk of mangrove loss (5-10km) were prioritized over those without such risk. The data chosen to represent human-populated areas is the Louisiana Department of Transportation and Development’s “Metropolitan Planning Areas,” which includes currently urbanized areas and future municipally-agreed upon sites of development. This data was chosen over extant populated areas due to its consideration of future changes to the urbanized landscape, which may impact future wetland restoration planning.

Density

The percent vegetative cover of mangroves within an area may determine its ability to support future mangrove afforestation efforts. The coastwide vegetation survey data utilized for the *Extant Mangrove Colonies* factor includes Braun-Blanquet cover classes for each vegetation type observed. These cover classes correspond to the densities of each species recorded in 5 intervals of 25%, with Class 1 being 0% cover. These classes were preserved for the density ranks.

pH

Although various pH sampling projects have returned multiple ranges of acceptable pH values for *A. germinans* development, they converge at an acceptable range of 6.5-7.5 (Useful Tropical Plants Database 2024; University of Texas at Austin 2022; University of Arizona 2017). The unsuitable range was determined using the upper and lower limits as documented in prior research, and the adequate range included all other values that are not within the suitable range yet are still acceptable. pH data was sourced from a larger database by the Gulf of Mexico Coastal Ocean Observing System, compiled from data by different agencies.

Salinity

A. germinans is a facultatively halophytic species, meaning that it is able to grow in non-saline conditions. For this reason, the most suitable range of growth for *A. germinans* is between 0-25 parts per thousand (USDA 2005). *A. germinans* may tolerate conditions up to 60 ppt, although these are not considered adequate for growth. Salinity ranges over 60 ppt are deemed unsuitable. Annual mean salinity data was taken from the CPRA Master Plan Data Access Portal, whose model-predicted scenarios use factors of high/low environmental impacts, with/without CPRA master plan implemented, and years lapsed. The scenario used for this study was low environmental impact, without CPRA master plan, and 2 years elapsed – occurring in 2025. This was chosen because there are negligible differences between low/high and with/without master plan scenarios within the first five years when compared on the CPRA Data Access Portal. Two years was chosen for its relevance to a timeline in which mangrove planting projects may be completed. It should be noted that at the most extreme scenario (high environmental impact, without master plan, 52 years), expected salinity ranges cap at 35.0ppt. This is within the acceptable range for *A. germinans* development, and thus it was expected that salinity is not a determining factor in the Terrebonne region for mangrove afforestation.

Substrate type

Mangroves are tolerant to many substrate types, including sandy, loamy, clayey, saline, and brackish environments. (University of Texas at Austin 2022). However, they are found to be the most productive in silty clay and unsuitable in gravel (Ruzanna et al. 2019). Mangroves should not be grown upon open intertidal mudflats, sand flats, coral reefs or seagrass beds; as these are habitats which would be threatened by mangrove afforestation. Substrate data was taken from the US Soil Survey Geographic Database.

Air temperature

Mangroves thrive in temperatures between 28 and 32°C to produce maximal shoot growth and photosynthetic development (Field 1995). However, temperatures above 40°C have a negative impact on mangrove growth. The impacts of rising temperatures on mangrove growth are becoming an important consideration due to climate change. Although *A. germinans* is a relatively hardy plant, withstanding temperatures down to -6.5°C, temperature consistency is an important consideration when it comes to supporting afforestation efforts (Lonard et al. 2017). For this reason, more conservative temperature cutoffs were chosen. It is important to note that this data was unable to make it to the final suitability map due to the inability to find viable and publicly available geospatial air temperature data sources.

Data Analysis

I opened the shapefiles of relevant data into ArcGIS and created folders depending on their respective phases. For each phase, I added factor rank values to their attribute table either through the *Multiple Ring Buffer* or *Reclassify* tools. I changed the symbology of the factors to reflect the values, and all factors within the same phase were combined using the *Union* tool. Once the *Union* tool was implemented, I combined the factor rank values in the attribute table. I changed the symbology to graduated colors of these combined factors to visualize the full range of values. Once the phase was completed, I drew a rectangle around the site determined to be the most suitable based on the results of the suitability analysis using the *Create Features* tool. I clipped the shapefiles of the subsequent phase to this rectangle, and the process repeated for each factor. I combined the analyses from all previous phases to produce the next phase's analysis, using the *Union* tool. For example, the site determined to be the most suitable by Phase 2 was determined from the results of both Phases 1 and 2. Specifics on data cleaning and processing for each factor are detailed below.

Extant mangrove colonies

I downloaded coastwide vegetation survey data in point form from USGS. Each point contained data on the Braun-Blanquet cover classes for each vegetation type observed. I selected points by attribute if *A. germinans* was present in at least one cover class. Only the points in which *A. germinans* was present were used in the final analysis. I used the *Multiple Ring Buffer* tool to create the ranks for each circumference range, as indicated in Table 1. I created a new field titled "Value" to attribute values to each of the distance ranks and altered the symbology to reflect these values.

Restoration proposal

I downloaded CPRA Restoration Proposal data in polygon form from CPRA. I created a new field titled "Value" to attribute values of 1 to each polygon and altered the symbology to reflect this value.

Proximity to oil and gas fields

I downloaded oil and gas field data in point form from SONRIS. I clipped points to the suitability rectangle determined by Phase 1. I used the *Multiple Ring Buffer* tool to create the ranks for each circumference range, as indicated in Table 1. I created a new field titled "Value" to attribute values to each of the distance ranks and altered the symbology to reflect these values.

Proximity to urban areas

I downloaded metropolitan planning area data in polygon form from LaDOTD. I clipped polygons to the suitability rectangle determined by Phase 1. I used the *Multiple Ring Buffer* tool to create the ranks for each circumference range, as indicated in Table 1. I created a new field titled "Value" to attribute values to each of the distance ranks and altered the symbology to reflect these values.

Density

I utilized the previously edited *Extant Mangrove Colonies* data to represent density. I clipped points to the suitability rectangle determined by Phase 2. I created a new field called *Percentile* to combine the Braun-Blanquet cover classes for each *A. germinans* account. I used the *Heat Map* symbol type with the Weight Field being *Percentile* to create a raster to display density.

pH

I downloaded pH survey data in point form from GCOOS. I downloaded points if they were within the suitable area determined by Phase 2. I utilized the Generate Grids and Hexagons tool to create hexagons of 25 square miles in area. I utilized the Summarize Within tool to find the mean of the pH points within each hexagon and altered the symbology to reflect the average pH values of each hexagon, normalized by the number of points in each polygon.

Salinity

I downloaded projected salinity with low environmental impact, without CPRA master plan, and 2 years elapsed in point form from CPRA. I clipped points to the suitability rectangle determined by Phase 2. I created a new field titled "Value" to attribute values to each of the salinity ranges as determined by Table 1 and altered the symbology to reflect these values.

Substrate type

I downloaded soil survey data in polygon form from SSURGO. This data is classified into soil classifications, consisting of soil series and smaller soil types. I altered symbology to reflect these different soil classifications. I utilized soil classification metadata to create an analysis of soil series compositions and predominant soil types, which was displayed in tandem to the map in the final figure. Data available represents five soil classifications, with *Felicity loamy fine sand* being the only classification reported to support mangrove habitats (SSURGO n.d.). I then compared reported soil classifications to literature-supported substrate types suitable for mangrove afforestation.

Air Temperature

I was unable to download air temperature due to the lack of appropriate public data sources. Thus, I omitted it from the final suitability analysis. However, it is still important to recognize the need for air temperature in mangrove suitability.

RESULTS

Suitability analysis

Phase 1 shows the largest cluster of extant mangroves lies in the Port Fourchon area, on the southeast peninsula of the Terrebonne Region. The suitable area chosen for Phase 1 includes all areas in which mangroves are present in the region, narrowing the suitable area down to the greater Terrebonne Region (Figure 2). Phase 2 narrowed down the suitable area due to the impact of oil and gas wells in the area. With Phases 1 and 2 combined, an obvious suitable area is the aforementioned Port Fourchon, much of which is sheltered from the radius of oil and gas wells.

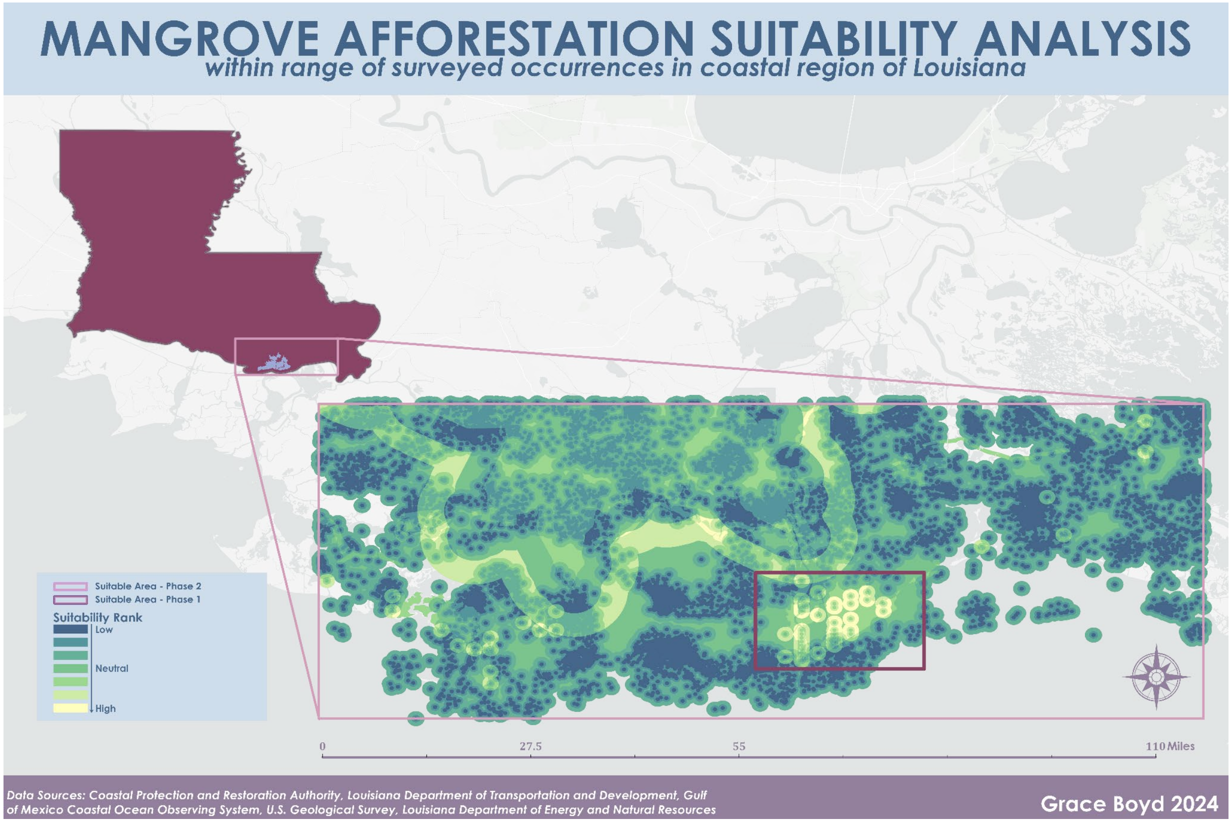


Figure 2. Suitability Map. Combined results of Phases 1 and 2 of the suitability analysis, color coded in order of suitability rank. Suitable areas determined from Phases 1 and 2 are bound by rectangles.

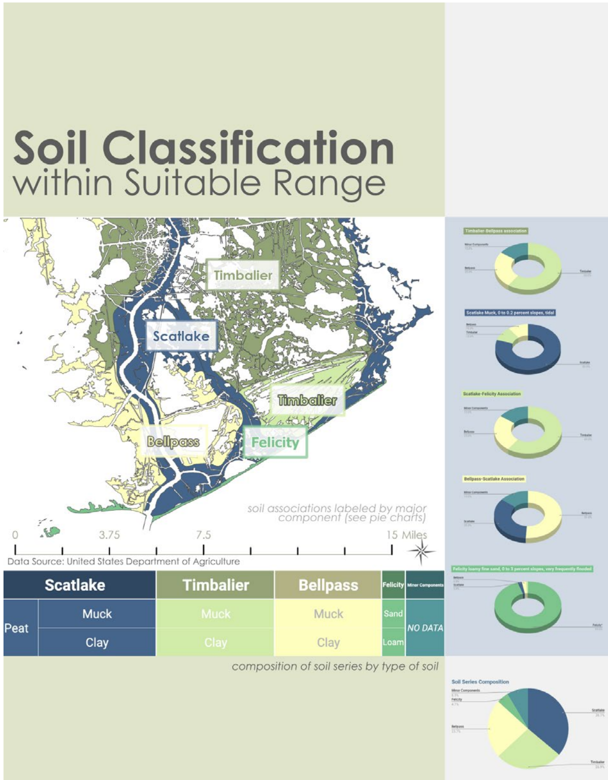
The data from Phase 3 displayed a large inconsistency of results, which made the analysis impossible to do with the same format as Phases 1 and 2. Thus, rather than formulating the factors together and assigning them rank values, I created individual figures that, when combined, tell a complete narrative of the availability and results from the biological factor data (Figure 3).

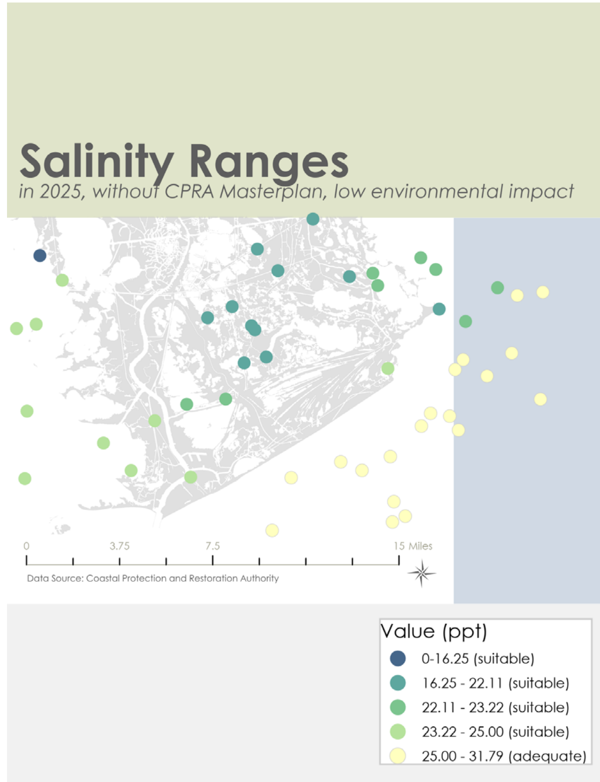
Although *Felicity loamy fine sand* was the only soil classification documented to support mangroves, overlaying the soil classification map with the density map shows that mangroves are only documented to be present in high densities within the Bellpass-Scatlake association (in yellow) and Timbalier-Bellpass association (in light green). These classifications are primarily composed of Bellpass and Timbalier soil series, respectively. Both of these soil series are composed of muck and clay, and for this reason it may be interpreted that such compositions are the most suitable for mangrove growth. Timbalier and Bellpass soil series comprise 50% of the entire soil composition of the suitable area, inferring there to be a large range of suitable afforestation areas within the region on the basis of soil type alone.

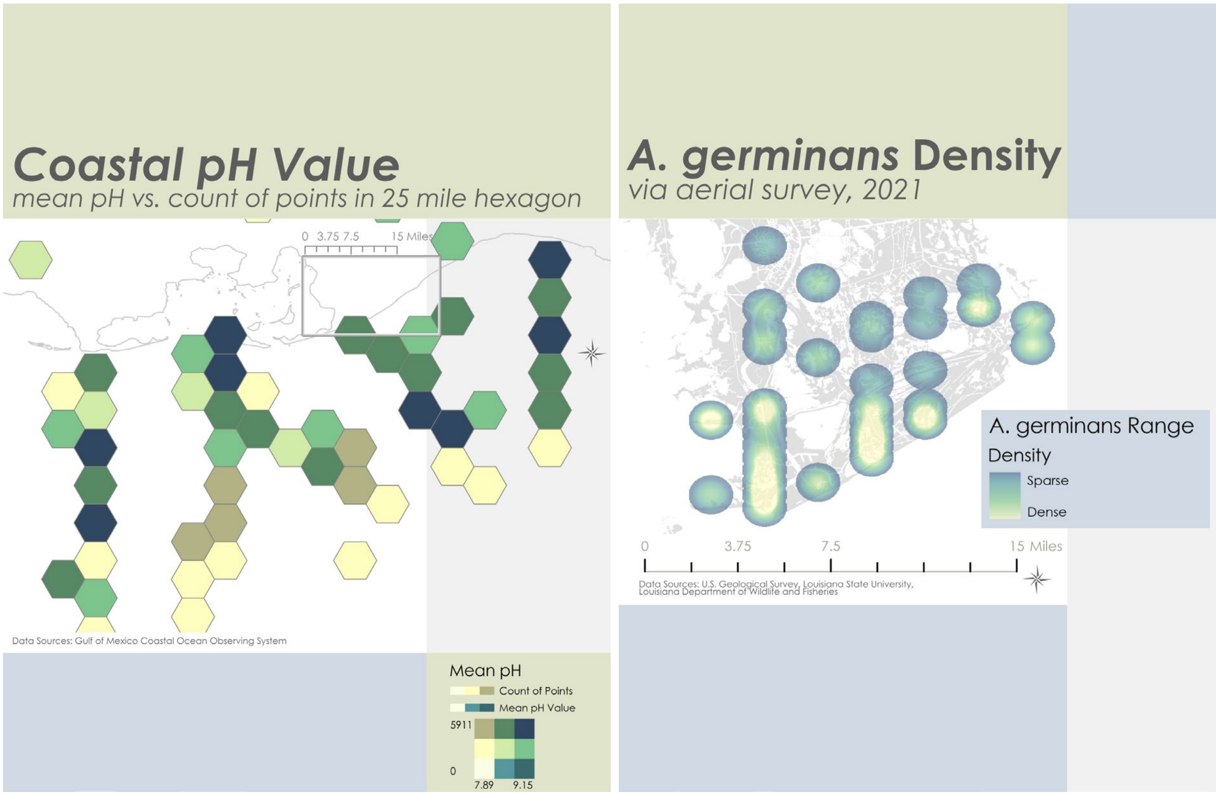
As is expected, salinity ranges are suitable in wetland regions (blue and turquoise dots) and adequate within marine regions (yellow dots). For this reason, salinity is not a limiting factor for the suitability of the region. Thus, it can be assumed that the suitable range is maintained to be within the Timbalier and Bellpass soil series, where mangrove densities are high and salinity is within an acceptable range.

The pH data publicly available was not conducive to analysis within the area of interest, as all collection points were offshore. However, it is still important to analyze the results in relativity. Hexagons with more counts of points have more accurate mean pH values. Taking this into account, most values lie with certainty around a value greater than 7.89. All of the mean offshore pH values are unsuitable within the standards of the suitability analysis, which is expected considering mangroves cannot grow in the open ocean. Thus, more point data must be collected within the suitable area in order to conclusively determine the suitability of the region based on pH.

All factors considered, the most suitable area for mangrove afforestation in the Terrebonne region is within regions where the soil series is primarily Bellpass or Timbalier. In these regions, it is important to conduct these same field surveys – pH, salinity, air temperature – in order to come to accurate and specific conclusions about biological suitability.


Soil Classification
within Suitable Range
Timbalier
Scatlake
Timbalier
Bellpass
Felicity
soil associations labeled by major component (see pie charts)
0
3.75
7.5
15 Miles
Data Source: United States Department of Agriculture
Scatlake
Timbalier
Bellpass
Felicity
Minor Components
Peat
Muck
Clay
Muck
Clay
Muck
Clay
Sand
Loam
NO DATA
composition of soil series by type of soil
Soil Series Composition


Salinity Ranges
in 2025, without CPRA Masterplan, low environmental impact
0
3.75
7.5
15 Miles
Data Source: Coastal Protection and Restoration Authority
Value (ppt)
0-16.25 (suitable)
16.25 - 22.11 (suitable)
22.11 - 23.22 (suitable)
23.22 - 25.00 (suitable)
25.00 - 31.79 (adequate)



Figures 3a, 3b, 3c, 3d. Biological Factors Maps. Maps examining suitability of mangroves on the basis of soil classification, salinity, pH, and *A. germinans* density.

Social vulnerability assessment

A narrative of displacement is clear within the history of Louisiana. Displacement persists via bases of slavery, indigenous genocide, extractive policies, and environmental degradation; substantiating the Terrebonne Region as a LECZ (Figure 5). In fact, many narratives are compounded upon by multiple displacement factors. For example, the city of Morrisonville, a location where the Army Corps displaced an African American community in order to build a levee, was evicted 60 years later due to concerns of chemical contamination and flood risks (Figure 4) (Misrach and Orff 2012). The buildings are now destroyed, and the community has been displaced twice. More narratives are outlined in the appendix. As addressed in the introduction and supported by this assessment, it is clear that indigenous, Black, and low-income residents relying upon the fishing and extraction industries are the most at-risk of community disruptions and displacement.

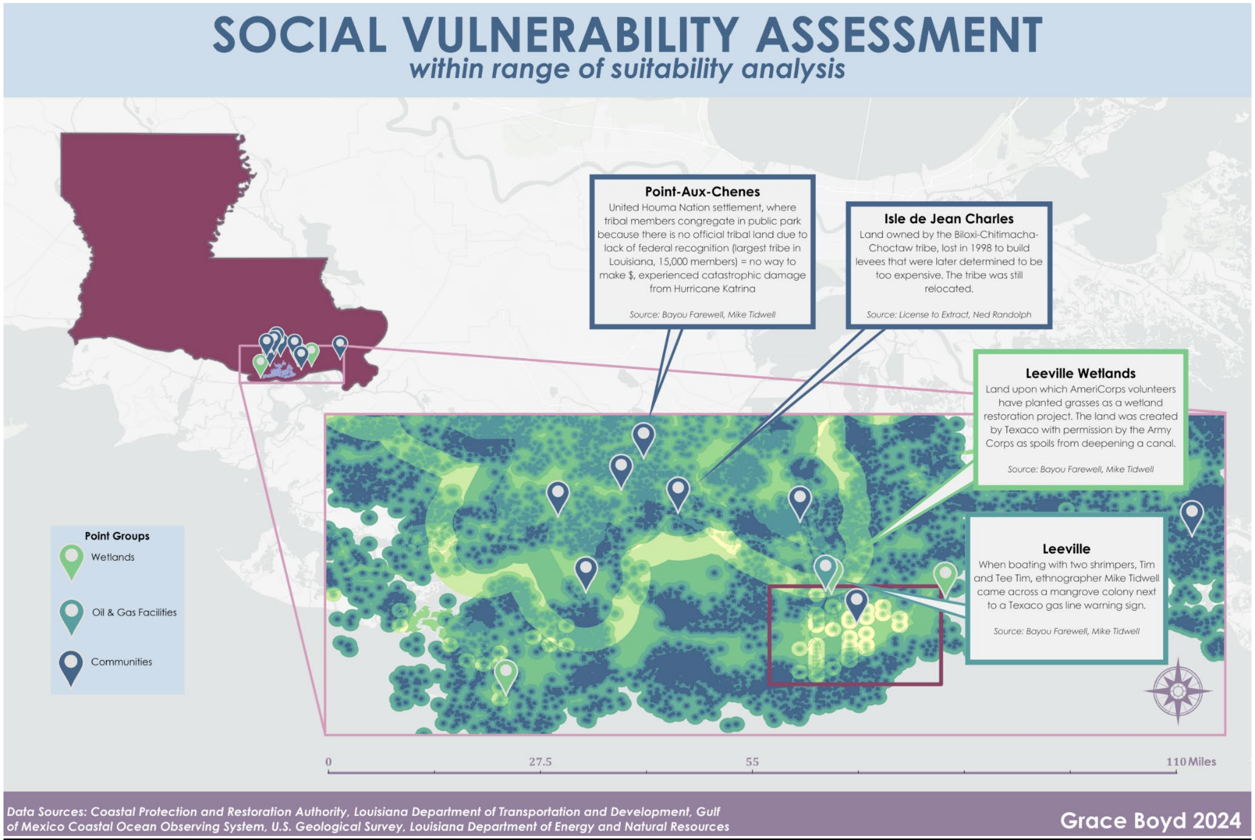


Figure 4. Final Social Vulnerability Assessment. Georeferenced findings from literature review, spatially grounding narratives of risk for communities in the Terrebonne Region.

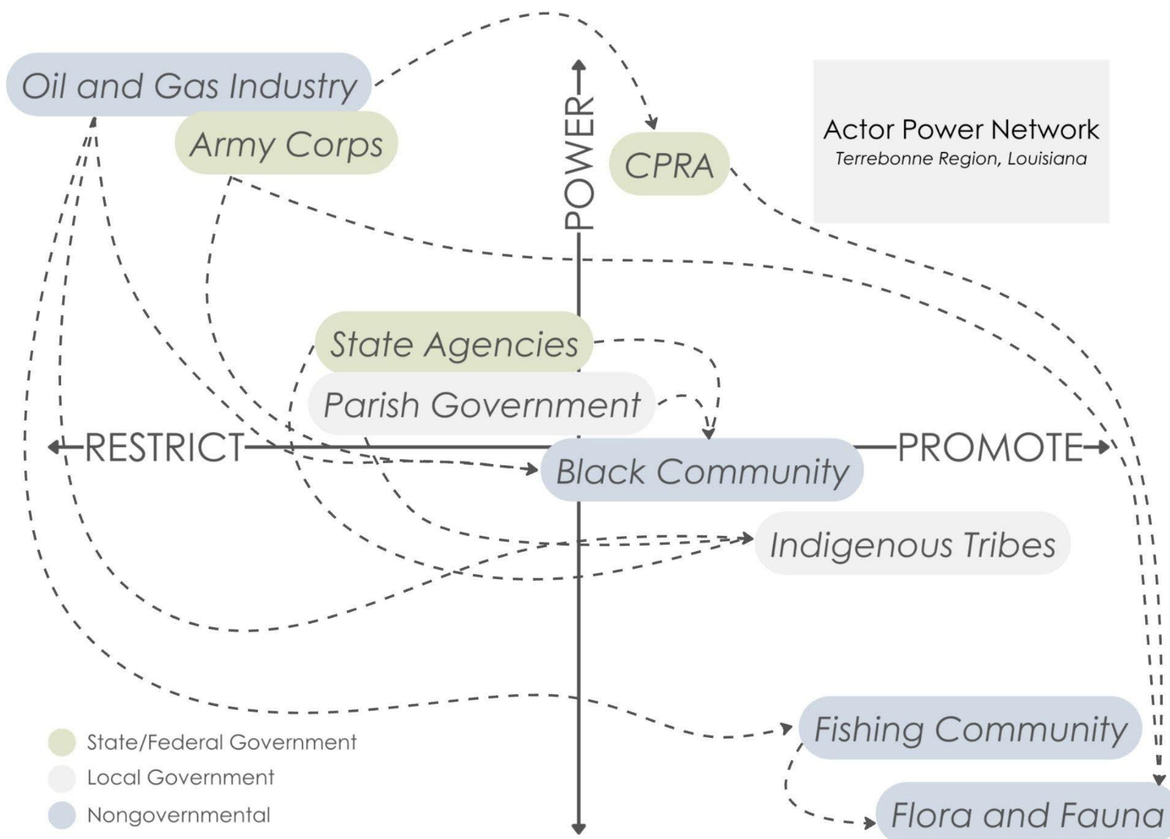


Figure 5. Actor Power Network. Physical representation of how power moves throughout the Terrebonne Region. On the y-axis is the relative amount of power each actor holds, and on the x-axis is whether that power should be restricted or promoted in future policymaking. Dashed arrows connect those who harness power upon those who have the power inflicted upon them.

Indigenous communities

The indigenous Houma nation has experienced a history of displacement by colonizers, who exploited rivers as a network between tribes to gain political power (d'Oney 2020). French settlers exercised violence, with pressure to move downstream and away from native land coming from threats of enslavement, debilitating effects of the introduction of alcohol, or epidemics caused by biowarfare. The French maintained a forced relationship to ensure a supply of food and soldiers at any moment, dehumanizing the Houma peoples and viewing them as expendable. Despite constant forced displacement spurred by these push factors, the Houma nation continuously settled upon major waterways to have transportation accessibility and maintain a community resource network. A large distance by land was shortened by water, and the habitat itself functioned as hunting grounds and a space to congregate. Over time, as displacement cornered the Houma nation into less and less livable regions, their relationship with waterways changed. Thus, the Houma nation's diminishing relationship to land as a result of colonial power has a direct impact on their systems of support today.

Nevertheless, as the Houma peoples fought for allyship and resource systems, they began to garner enough support to apply for federal recognition as the United Houma Nation in 1970. This process was extremely long, complicated, and fraught. The struggle for recognition by the United Houma Nation began centuries ago with colonist-led census data, or lack thereof. The French created censuses to garner an understanding of the utility of the Houma people, surveying the number of men and soldiers but not women or children. When the United Houma Nation began their fight for recognition in the 20th century, they were unable to produce sufficient census data due to these intentionally omitted demographics. Lack of "proper" documentation, coupled with a history of isolation and state-led fragmentation, led the claim to be denied. Even neglectful government cooperation allowed geographical miscalculations to be the basis for denial. The Branch of Acknowledgement and Research (BAR) mistook Louisiana's northern Bayou Boeuf as the Houma's land claim instead of its southeastern counterpart with the same name, and used the supposed geographical inconsistency as reason to deny tribal recognition. This, along with conflicts with breakaway tribes such as the Isle de Jean Charles Band of the Biloxi Chitimacha Confederation of Muskogees, positions these breakaway tribes and the United Houma Nation in an incredibly precarious position within the federal and state governments today.

With the discovery of natural gas in 1870, the "unwanted" land upon which the Houma had settled became valuable to the new industry, displacing the nation once again. This resource-based displacement distorted the perception of the once undesirable land upon which the Houma people built their community; redefining it as a resource and thus as a Sacrifice Zone (Maldonado 2014). The privatization of Houma land for oil and gas extraction in the 1920s shifted wetland properties to be almost entirely owned by the oil and gas industry. The industry also impacted the Houma people due to discriminatory hiring practices and boating insurance policies, creating another cause for community destabilization.

The Houma people and breakaway tribes are currently grappling with the generational trauma of displacement and the fight for federal recognition. At the same time, the very land in which they have been forced to settle is becoming unstable due to extractive practices and their climatic consequences. This dual instability of political and ecological factors must be recognized and acknowledged in the name of future ecologies.

Black communities

As discussed in the introduction, Black communities in Louisiana have faced an intense amount of discrimination. The Terrebonne Parish specifically has one of the highest percentages of race-based segregation in the state, at 58% (NIMHD n.d.). Place-based discrimination is heightened by the direct exploitation of the wetland network by the oil and gas industry (Misrach and Orff 2012). The origins arise in part from post-civil war land parcels given to Black communities and their subsequent devaluation with the mechanization of the agriculture industry and replacement by oil and gas plantations. Many oil and gas plantations are built directly upon these original land parcels, displacing predominantly Black communities that did not have legislative representation at the time.

One such risk of this proximity is contamination of water increasing cancer rates in the thirteen parishes that rely upon the Mississippi River for drinking water. Many Black communities have historically been dispossessed from their properties in the name of restoration. In one example, the land was considered environmentally dangerous due to its proximity to chemical plants and closed off to establish a "green buffer zone" (Misrach and Orff 2012). The Shell Oil Company also purchased the predominantly-black town of Sellers in 1934, renaming it Norco after its proximity to the New Orleans Refining Company refinery. Norco also faced racism-motivated arson when its local school was desegregated in 1968. Shell relocated its residents 70 years later due to heightened exposure to carcinogens.

When considering extraction-based wetland loss, the Black community faces obvious and pronounced impacts in the Terrebonne region. Not only are there well-documented historical accounts of redlining and post-Jim Crow era parceling leading Black communities onto "less favorable" land, but this land is actively being consumed into the Gulf of Mexico (Livia Brand 2024). For these reasons, it is important to view wetland loss as the eradication of community support structures for Black communities in the Terrebonne region.

Low-income fishers and oil field workers

Keeping the economy of the Terrebonne Region robust and stable are the economies of the fishing and oil and gas industries. The utilization of resource extraction as livelihood and culture generates an array of implications for both the residents of the Terrebonne Region and the land they live upon. Both fishing and oil extraction have environmental impacts for the region, but with vastly different consequences. The cyclical nature of shrimp rearing in the Gulf of Mexico allows shrimpers to produce millions of pounds of catch each year with enough shrimp escaping the maze of nets and traps to reproduce for the next season (Tidwell 2004). However, oil and gas extraction relies on a finite resource, one which is actively reaching its upper limit. Oil rig expansion is completed with an absolute disregard for the landscape, leaving abandoned canals upon the wetland system like a personal junkyard. This infrastructure disrupts ways of life for locals who depend upon fishing and shrimping seasons for their income, primarily Cajun, many of whom have everything to lose.

A history of governmental disillusionment and cultural discrimination has led the Cajun fishing community to be vulnerable to wetland loss and the oil and gas industry. Language differences led to lack of state representation and underfunding of public schools, roads, and health facilities. It wasn't until the 1970s that Louisiana saw a Cajun representative in state government, despite the fact that Cajuns make up >20% of the state's population. Discrimination of the Cajun community has decreased over time due to Americanization of culture with the discovery of natural gas, English-only schools enforced in 1916, and increased connectivity to the outside world with the imposition of radio, television, and roads. Lessened discrimination by way of assimilation came at the expense of Cajun ways of life and resource networks. Land loss exacerbates this with the destruction of culturally significant locations and community centers. These intense circumstances have led to denial and lack of government participation for shrimpers and the larger bayou community. Because the government is viewed as an all-powerful figure that brings about both destruction and restoration of the same systems, distrust is high. This, along with funding, is a reason why many conservation projects don't get implemented.

One reason why many locals have not historically been actively concerned with the region's wetland loss is climate-induced shrimp productivity. Wetland loss led more shrimp and other marine life to inhabit previously freshwater environments, and there was even an increase of productivity before eventual habitat collapse. Currently yields are down 50% from their rates 20 years ago, and the number is expected to decline (Turner 2021). However, locals have little to no choice. They will continue to create pieced-together storm surge barriers from old Christmas trees and watch their forested backyards become aquatic if yields are still producing a living wage. Many locals don't even have their homes or boats insured, compounding individual loss in a landscape of wetland loss. Even as oil spills force fishers to search for sites further from their homes and for longer times and as fatalities rise from boats hitting oil canals and exploding, despite an already dangerous industry becoming more deadly every year – the money is still there. For locals who are reluctant to put their life and livelihood on the line for a growingly unsustainable industry, working within the oil industry is the secure alternative. Children have left generations of shrimpers to work in the oil industry, exacerbating the environmental problems they have seen growing up on the bayou and being aware of the damage they are causing but prioritizing quality of life over ecosystem vitality. The short-term mindset that drives the Terrebonne Region's industry is adapted for survival but incapacitating its future.

Low-income fishers and oil field workers are highly implicated within the entanglement of their LECZ region. Lack of historic representation of and resource partitioning for the Cajun community furthers marginalization and isolates cultural support systems from governmental and agency ones. The economic and cultural significance of these communities upon the region's wetland network must be bolstered by future coastal restoration and social support programs.

DISCUSSION

Introduction

The results of this thesis open up many further topics within the landscape of socioecological risks to wetland loss in the Terrebonne Region. The results of the suitability analysis do encourage mangrove afforestation in the Terrebonne region, which prompts the creation of a conclusive proposal. As long as the need to implicate societal considerations in ecological restoration projects is recognized, which was clear in the literature review, afforestation is possible. In particular, the social vulnerability assessment provoked the recognition of geographic patterns, which cause differentiated patterns of risk. These patterns are dependent upon social factors such as race and economic background. It is prudent to address such a proposal in a responsible and comprehensive manner to limit further community vulnerability.

Ensuring the success of species-based afforestation

Afforestation proposals come with their fair share of criticism and concern due to the colonization of "invasive" or "introduced" species. For example, large-scale and long-standing afforestation practices in China's arid and semi-arid regions have been done without understanding of local climates, planting unsuitable species (Cao et al. 2011). The needs of the entire ecosystem are also not considered in China's planning policies, planting almost exclusively trees and shrubs. What's more, species-based restoration is equally as fraught and controversial. This thesis is, at its surface, a proposal for mangrove afforestation as a wetland loss mitigation technique – which is species-based afforestation. However, this is a conclusion derived from an intimate understanding and apprehension of the ecological and sociocultural landscape of the Terrebonne region, and in no way a large-scale solution for the phenomena at play. It is my firm belief that mangrove afforestation has the potential to successfully reintroduce valuable ecosystem services to the Terrebonne region, which in turn promotes the wellbeing and livelihood of populations dependent upon such services and resources. Afforestation is not a standalone method, yet it is still vital to beginning the shift towards planning for future ecologies. Mangrove afforestation as a species-based technique answers a larger question beyond achieving a "stable" ecosystem dynamic. Historical vegetation regimes often shape current planning practices, but one look at the exponential level of anthropogenic climate damage shows that this is not viable (Borgström et al. 2016). As has been seen, ecological niches are expanding and contracting due to climate change, which is true for the range of *A. germinans* in coastal Louisiana (Perry & Mendelsohn 2009). This, on top of oil and gas extraction impacting wetland loss, dissolves any case for complete restoration of past ecosystems. We are currently planning for conditions we are observing in the present, which are quickly evolving to more complex states of the future, utilizing principles from the past. In short, we are nowhere where we need to be.

Spatially grounding these shortcomings to wetland management in the Terrebonne Region – where planners and policy makers excel in technology, innovation and collaboration – the shortcoming lies in which ethos and values are used to make decisions. Planners are grey infrastructure reliant; building physical boundaries, exacerbating differences between the Anthropocene and nature, and ensuring future uninhabitability and degradation of wetlands. The debilitating price tags of restoration projects require oil and gas payouts to subsidize coastal protection, complicit to the very demise which they aim to address. Traditional planning regimes ensure that, on a longer timeline, the problems they aim to solve will be magnified. Changes or nuances are unprecedented, and fear of failure at the expense of human livelihood is a legitimate concern. Adaptive management in the face of uncertainty will require bold and unfamiliar responses. Current planning regimes must be transitioned slowly, with mangrove afforestation as a first step in the direction of reformation.

Proposal for mangrove restoration as afforestation technique

The Terrebonne Region depends on its wetlands. Humans, flora, and fauna all engage in an intimate and synergistic relationship with the ebbs and flows of sediment, water, and nutrients. As proven by the results of the suitability analysis, the Port Fourchon region in particular faces a pronounced need for salient and adaptive management strategies. Although a mangrove-filled Port Fourchon is not a replication of past vegetative states, its sediment stabilizations and storm wave attenuation benefits are a progression towards answering future climatic needs. I propose a hybrid infrastructure method as a means to promote and support wetland nourishment. Hybrid infrastructure would include mangrove afforestation as well as a living breakwater and/or non-biogenic (non-absorbable) moveable barrier, also called a "detached multiple structure". Such structures in past projects include but are not limited to oyster sills, coir logs, and rock berm (Powell et al. 2019). The structure type to be chosen is dependent upon the native biomaterial available in the area. Sediment would need to be sourced from a secondary location, and would follow the CPRA's extant plan for the Belle Pass/Golden Meadows area of sourcing sediment from the Mississippi River (CPRA 2023).

Considering the current use of artificial oyster reef creation in multiple projects done by various agencies along coastal Louisiana (CPRA 2023), I propose oyster sills as a living breakwater to support mangrove afforestation. Not only are oyster sills extremely effective as a barrier for sea level rise, they also create habitat for other marine organisms and sequester carbon (Comba et al. 2022). As mangrove growth from viviparous seedlings or in vitro micropropagation is extremely sensitive with low success rates expected, the use of oyster sills prevents storm surges from being a limiting factor to their success (Hashim et al. 2010). As oyster reefs provide many benefits to their local ecosystem, the sills do not need to be removed unless determined to be disrupting sediment accretion further offshore. If non-biodegradable products are used in the grey infrastructure, such as plastic mesh lining for the oyster sills or larger structures such as concrete seawalls, the components can be removed or phased out when determined that the mangrove colonies have been successfully established.

A preliminary order of magnitude cost analysis finds that mangrove restoration historically ranges from \$216,000 to \$225,000 ha^{-1}, with a study completed in Malaysia which utilized oyster sills as their grey infrastructure component costing \$142,000 ha^{-1} (Hashim et al. 2010). This price includes land cost, initial restoration, monitoring, and breakwater construction. The Belle Pass-Golden Meadows Marsh Creation project currently being completed in the Port Fourchon region costs \$1.1 to \$1.3B over an area of approximately 11,735 hectares (CPRA 2023). Comparatively, mangrove restoration over this same area would cost \$1.6B if approximating the cost from the aforementioned study.

Even with the results of the suitability analysis pointing towards mangrove planting being viable given biological and anthropogenic factors, there are still many considerations which must be studied before a single mangrove is planted in Terrebonne soil. This includes site-specific and full-scale microbiome, substrate, depth zone, and hydrology analyses. A cost-benefit analysis and socioeconomic assessment is also fundamental to the longevity and sustainability of mangrove afforestation projects.

A future ecology in the Terrebonne Region will ask for an incredible amount of acute transformations. These may be categorized into six key changes. Although not a definite resolution to these needs, mangrove afforestation provides a landscape upon which these changes may be implemented.

1. ***Wetland creation***

   The stabilization of sediment and storm wave attenuation provided by *A. germinans'* root system is a sustainable and viable method to "roll back the carpet" on wetland loss in the Terrebonne region.

2. ***Reduced reliance of of levee systems altering hydrological and sedimentation regimes***

In Louisiana currently, levees – Morganza to the Gulf and MR-GO in the Terrebonne Region – and artificial grey infrastructure are regarded as the only coastal protection option for LECZs due to their imposition and dominance as complete physical barriers (Powell 2018, Hill 2015). This affirms a clear agenda where human-populated areas are determined to be the only landscapes worth saving to coastal land loss; at the expense of biological habitat, economic ecosystem services, and wetland-centered cultural practices.

Clearly, there are more nuances to the landscape of levee structures that limit the ability to simply remove them altogether. This includes intense pressures from the oil and gas industry, which fund restoration projects while also producing a levee-reliant landscape through extraction (Randolph 2018). However, we have the power to envision a coastal Louisiana which minimizes its reliance on levees and instead transitions to natural buffers and infrastructures.

Historically, levees have been implemented as a lesser-harm infrastructure when compared to other coastline protection options for human populations. In Louisiana, the alternative is human retreat away from the coastline. Retreat is a viable option, however it is at the expense of populations uprooting their community, with repercussions to resource networks. The Terrebonne Region is a landscape in which continued anthropogenic development is viewed as the only priority in coastal protection, and over time this objective has magnified the reliance upon levees for the entire coastline. Taking this into consideration, levees provide the benefit of allowing a community to stay rooted in their spaces. Thus, a vision of future ecologies in the Terrebonne Region cannot support the full deconstruction of levee systems.

This proposal is intended to address the first steps towards a transformed Terrebonne Region. Although with more salient coastline protection efforts, levee systems may have the possibility to be fully replaced and dismantled, full and complete removal of levees is not possible within the scope of this proposal. If and when wetland ecosystem services become increasingly stronger and reliable as standalone climate mitigation techniques, levee systems may begin to be complemented with green infrastructure; no longer the only considerable coastal buffers for human populations. This would allow there to be two lines of defense against wetland loss for biological and human populations, reducing the reliability upon levees or retreat.

3. ***Reintroduction of sustainable fishing opportunities***

The fishing industry in Louisiana currently exists in an unstable state as resource availability is restricted by anthropogenic climate change (Tidwell 2004). Inaccessibility to reliable fishing opportunities exacerbates the negative ecological impacts of fishing as extreme measures are taken to secure catches and income. This positive feedback loop only worsens climatic impacts and habitat loss. The creation of wetland habitat via mangrove afforestation introduces flora and fauna into the ecosystem. The shrimping industry in Louisiana, which has brought in up to 43.2% of the total shrimp production in the United States (Griffith 2023), benefits indirectly from mangrove habitat. Increased organic detritus and nutrient outflows brought offshore from mangrove habitats increase opportunities for juvenile shrimp rearing in nearby seagrass beds and salt marshes, and waterways created by mangrove networks create a system for shrimp to migrate offshore and into shrimping areas (Kandasamy and Bingham 2001). This provides not only a more resilient ecosystem but also improves nutrient availability to facilitate increased fishing opportunities for an economy whose success is directly dependent upon stock of aquatic organisms and wetland health.

4. ***Phased-out reliance upon the oil and gas industry while establishing career opportunities for those currently employed in its system***

The oil and gas industry's influence upon Louisiana's landscape is clearly maintained by its dependence to the local economy. The major sources of income for locals of the Terrebonne region are fishing or oil and gas extraction, with extraction being a more predictable and reliable source of income. This is especially true as fishing opportunities are directly impacted by anthropogenic climatic impacts brought about by the oil and gas industry (Upton 2011). Thus, it is futile to promote the removal of the oil and gas industry without addressing its importance as a source of employment. Mangroves may facilitate a restructuring of the economic landscape of the Terrebonne region by producing new industry jobs as environmental technicians and field surveyors, lessening the dependence upon the oil and gas industry.

5. ***Cultural and institutional support of indigenous tribes***

    It is important to recognize the economic, social, and cultural use values of wetlands for indigenous tribes (d'Oney 2020). Wetland restoration to sustainable conditions via mangrove afforestation may facilitate tribal leader integration in land use planning, promoting the federal, state and local recognition of tribes. This in fact makes wetlands restoration more unified with community needs by the inclusion of indigenous input, while in turn strengthening the resource networks of indigenous tribes.

6. ***Confrontation of segregation and redlining pushing Black communities onto susceptible terrain***

    Black communities have historically been forced to build their neighborhoods upon unstable floodplains, making them vulnerable to the impacts of living upon a LECZ (Livia Brand 2022). The lack of blue-green infrastructure to support a coastline against storm surges in the face of wetland loss situates the impacts of climate change directly placed upon these communities (Rivera 2022). Mangrove afforestation creates a buffer between the coast and its communities, allowing Black communities to live in more secure and safe locations without being forced to relocate and disrupt their established resource networks.

These six key changes are actively being discussed, addressed, and comprehended in the Terrebonne Region. However, judicious focus upon the drivers of these concerns remains to be lacking in land use planning. Looking ahead at the next step in wetland loss mitigation in the Terrebonne Region, mangrove afforestation may be viewed as a catalyst. Despite being a seemingly isolated restoration method, mangrove afforestation has the potential to establish necessary grounds to address the most pressing socioecologcial concerns facing the Terrebonne region as a LECZ and broader coastal Louisiana. Mangrove afforestation is a method to integrate currently detached evidence and position socioecological theory into on-the-ground change. With the proper considerations and purposeful management scheme, we have the potential to envision a flourishing future ecology.

Community resource inequality

Historically, scientific research has been fastened in what may be described as "science for science's sake" or "study for study's sake" (Weber 1997). In other words, science which is completed only for the inherent value of new information. Though the purpose of this argument is not to discount this intrinsic value, the question must be asked: at what cost? The residents of coastal Louisiana specifically face an extreme amount of "participant fatigue" as their experiences become commodified in the context of ethnographic studies (Brand et al. 2024). Often the compensation for acting as a participant is negligible and may even exacerbate the impacts of the traumas resurfaced for a survey. A model example of this is Hurricane Katrina, with residents still reeling and disrupted by the community fractures and infrastructural impacts from 19 years ago. Participant fatigue is common in coastal Louisiana and embedded within generational trauma from decades of land loss and social fragmentation. The way ethnographic research is done in this region must be approached tactfully and cautiously.

In spite of a landscape of distrust and fatigue, socioecological experts have approached ethnographic work in valuable and judicious ways. The graduate students of J. Phillip Thompson, Professor of Political Science and Urban Planning from MIT, spent the first two months of their field work in New Orleans babysitting, cooking, and providing other support for the community to establish a sense of security and connection before engaging in community-based participatory research. Dr. Steven Canty's mangrove restoration efforts in the Gulf of Honduras establish an understanding of gender and social networks to determine where their resources and support goes. The throughline of effective ethnographic research is respect for and consciousness of community dynamics. In the case of the Terrebonne region, it is important to understand the fractionary landscape of risk and its impacts as outlined through the Actor Power Network (Figure 3).

There are key questions that must be asked while contriving a pathway to community kinship: Who uses the space? Who abuses the space? Who needs the space? And, most importantly, who hurts the most when it's gone? It is clear that every actor in the Terrebonne region uses its resources in one way or another, however the abuse of resource availability from the oil and gas industry greatly disrupts the livelihood and wellbeing in the face of wetland loss to fishers, indigenous peoples, and the Black community (d'Oney 2020, Tidwell 2004, Misrach and Orff 2012, Randolph 2018). Improper agency support and programs exacerbate these disruptions.

Socioecological ethnography demands an uncovering of disturbances that will exist in the future, whether or not they are visible or understood today. For example, although the livelihoods of fishers presently are insecure due to wetland loss, we must be prompted to plan within a future where fishing is not a conceivable income source. Clearly, planning for future ecologies is the only way to address socioecological crises.

It is important to mention the many citizen science and community-based conservation efforts that go under the radar of conventional scientific publications. Local indigenous tribes contribute considerably to on-the-ground wetland loss mitigation projects in the Terrebonne Region. For example, lack of federal recognition has led the United Houma Nation to be barred access to money for their efforts, and historic mistrust and disengagement exacerbates this detachment (d'Oney 2020). Thus, resources for preventative and restorative projects are limited, and the United Houma Nation is absent from larger agency discussions and decisions. Concurrently, although the Isle de Jean Charles Band of Biloxi-Chitimacha-Choctaw Indians has requested a levee for their rapidly disappearing terrain, objecting to the alternative of resettlement, their demands are rejected without explanation (Turner-Neal 2020). Regardless of whether or not levees are appropriate in Isle de Jean Charles, this abject technocratic hubris only furthers mistrust of agencies and officials, who deny the community the right to an informed decision about their livelihood in the face of climate change. Both the United Houma Nation and the Isle de Jean Charles Band of Biloxi-Chitimacha-Choctaw Indians maintain autonomy from the state and local governments due to these reasons, and despite the lack of proper resources. Recognizing both the right and need for autonomy by indigenous tribes, honoring and uplifting their community restoration efforts, is important in finding a pathway to collaboration within the Terrebonne Region.

Community work for future ecologies in the Terrebonne region may look like skill workshops for oil and gas employees, active participation of fishers in land management planning, landback initiatives and indigenous sovereignty, or strengthening the resource networks of Black communities. In the April 2019 Terrebonne Parish Adaptation Strategy published by the Louisiana's Strategic Adaptations for Future Environments (LA SAFE), a majority of survey participants identified "alternative energy" as their answer to the question "What is the most important issue for the future of Terrebonne Parish?", and the Adaptation Strategy acknowledges that transitions towards renewable energy should be a top priority for the Terrebonne Parish's economy and industry (LA SAFE 2019). It has been studied and proven that resources exist to make these changes, but they are not being distributed equitably or rationally. This is due to agenda-reinforcing policies in governmental agencies, which may be sustained by insufficient scientific research and ethnographic work. It is not necessarily proven that a more equitable and widespread resource system will lead to more advantageous outcomes for vulnerable communities, but agencies with power and influence within the Terrebonne Region have a responsibility to meet the needs of their most socioecologically disadvantaged citizens. Removing this obstruction takes one decision from governmental agencies: listen to and support the community. If the possibility to restore a sustainable socioecological landscape may lie within this one decision, then surely it is the sensible choice.

Limitations

Data acquisition was a limitation to the success and completion of the methods of this research paper. Although a robust amount of publicly available geospatial data exists, especially environmental data for Louisiana, much of the specific data needed to complete the suitability analysis was not accessible. How and why research is completed speaks to many of the limitations of this thesis. In the case of this study, which recognizes and highlights the socioecological damage being done on the backdrop of coastal wetland loss, many aspects of the research carried out are not supported by current agendas in the field. For one, the recognition of anthropogenic factors in environmentalism is still a relatively new phenomenon, one which researchers actively fight to promote and recognize. Even when it is accepted, other factors of this research still prohibit it from being traditionally accepted by the broader coastal conservation community. However, more endorsed research projects often fail to include socioecological considerations within the decision making process. This leads there to be wide gaps in subsequent conclusions; further pushing agendas of intensified discrimination. There are many reasons why these considerations are excluded from management decisions and research considerations, the most clear being the timeline demand of restoration-based projects. Conservation work is contrived in a manner which Kristina Hill described as “rolling back the carpet on climate change”; i.e. completing projects at controllable scales to prevent further destruction of what is actively happening to our ecological systems (Hill 2024). The urgency of such projects exacerbates their technocratic hubris, biased away from community members and towards the knowledge of perceived “experts”: engineers, environmental planners, hydrologists, and other professionals.

The rapidity and privatized nature of restoration projects also leads their completion to be disaggregated and multi-scaled in ways that are not conducive to understanding the larger socioecological mosaic of wetland loss (Holmes 2020). While one organization may be installing marsh terraces in a bay downstream, upstream levees may be imposed upon the alluvial plain that alter the hydrological regime and impact sedimentation flow. The neglect of crucial community input is indisputable in this work, and communities identified to be most vulnerable to wetland changes are at pronounced risk to failed or incomplete restoration projects (LA SAFE 2019). Although in scientific research a failure is perceived as an opportunity for growth rather than an objective shortcoming, how and why projects fail is important to recognize. Failure at the expense of communities due to hasty implementation or fragmentary methodology is clearly more damaging than an “unsuccessful” mangrove establishment project. As clear through the vulnerability impact analysis completed in this thesis, quantification of climatic impacts and mitigation efforts are all but absent in socioeconomic support systems of vulnerable communities. It is time that this changes.

Bringing it back to future ecologies, now, then and forever

Planning for future ecologies may be criticized as an idealistic objective which runs the risk of being grounded in theory over evidence. The way governmental, academic, and other systems are currently being run is not conducive for an immediate and large-scale transition into the schema outlined in this proposal. Indeed, there is a staggering amount of drawbacks and limitations to the completion of this proposal. These are often sourced in bureaucracy and structures of power which maintain agendas of injustice to natural and human-made communities. The ability to reshape these structures through a lens of future ecologies is limited to the availability of resources, sources, narratives, and frameworks. For example, providing infrastructure upon the unstable coastal terrain many indigenous communities live upon requires local, state, and national recognition of the United Houma Nation and Biloxi-Chitimacha-Choctaw peoples. Historically this has been denied and minimized, exacerbating environmental risk factors to these indigenous communities (d’Oney 2020). Now more than ever we must plan for the future which we have seen to be proven by scientific data: a future with intensified wetland loss, erratic storm surges, habitat loss weakening environmental resilience, and more. The limitations of fulfilling this proposal highlight the exact locations in our system where change must occur: within our socioecological reckonings.

The Terrebonne Region has a long road ahead, a road whose terrain is slowly being devoured by the Gulf of Mexico. Wetland loss is not isolated to physical grounds: a loss of land means a loss of history, culture, and ways of life. Just as stories, narratives, and traditions are fostered and passed down, so too must the land upon which they root. For many LECZ communities in the Terrebonne Region, these cultural ways of life are the core of resource networks against wetland loss. By creating a landscape in which future ecologies are integrated into land use planning and coastal management, we set in motion an opportunity to reduce the prevalence of threatening climatic events and the consequent impacts upon the most vulnerable communities. Mangroves act as a line of defense for both human and ecological systems, their roots extend across the vast wetland as enduring protection. Anthropogenic impacts are contributing to the rapid rate of wetland loss, and we must muster up the same force and power that caused this destruction in order to "stay with the trouble". With the same tools we use to acknowledge the grief and devastation inevitable to many residents of the Terrebonne Region, we must begin to plant seeds of renewal; of future ecologies. To integrate mangrove afforestation into restoration plans in the Terrebonne Region is to acknowledge and foster the undeniable, eternal legacy of Louisiana's coast.

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APPENDIX

Table 2. Social Vulnerability Assessment Accounts. *Includes accounts which do not fall within the Terrebonne Region, but still exhibit a larger narrative of socioecological disparity within Louisiana's wetland network.*

Location	Coordinates	Category	Narrative
Vacherie	30.01108, -90.71971	Plantations	Home of plantation that is a highly profitable source of income for an area ridden with impacts of the oil and gas industry. Economic and social impacts of plantation farms and the slave trade still seep into today. *Source: Petrochemical America, Misrach and Orff*

White Castle	30.16991, -91.14704	Plantations	Home of plantation that is a highly profitable source of income for an area ridden with impacts of the oil and gas industry. Economic and social impacts of plantation farms and the slave trade still seep into today. *Source: Petrochemical America, Misrach and Orff*
Edgard	30.04325, -90.56008	Plantations	Home of plantation that is a highly profitable source of income for an area ridden with impacts of the oil and gas industry. Economic and social impacts of plantation farms and the slave trade still seep into today. *Source: Petrochemical America, Misrach and Orff*
Destrehan	29.94298, -90.35174	Plantations	1811 revolt by enslaved man Charles Deslonde, executed and his head was displayed along the levee. *Source: Petrochemical America, Misrach and Orff*
Alligator Bayou	30.3059, -91.02281	Wetlands	Originally home to the Bayougoula and Houma tribes, and once a tourist location featuring old-growth cypress trees, birds, and alligators, this area was closed to the public due to overharvesting of the cypress forests and pollutant seepage. Clear cutting of forests and polluting are common degradation patterns seen. *Source: Petrochemical America, Misrach and Orff*
Isles Dernieres	29.05373, -90.81154	Wetlands	Barrier islands in a group of 4 in a 20-mile arc that used to be one island but have separated due to subsidence over the past 200 years. 78% of the land has been lost, and the whole landmass is estimated to be gone within 50 years without intervention. *Source: Mike Tidwell, Bayou Farewell*
Caernarvon	29.86361, -89.90638	Wetlands	Location on Mississippi just south of New Orleans where current diversion plans are being enacted/sourced

			from. *Source: Mike Tidwell, Bayou Farewell*
Grand Isle	29.23661, -89.98729	Wetlands	Only inhabited barrier island in Louisiana & largest, property owners' only insurance is relocation not damages, spot for commercial fishermen. *Source: Mike Tidwell, Bayou Farewell*
Leeville Wetlands	29.24442, -90.20097	Wetlands	Land upon which Americorps volunteers were planting grasses, created by Texaco with permission by the Army Corps as spoils from deepening a canal. *Source: Bayou Farewell, Mike Tidwell*
Norco	29.99909, -90.4123	Oil & Gas Facilities	The town of Norco was named by the Shell Oil Company as an acronym for New Orleans Refining Company. Home of Dow Chemical Corporation. Juxtaposition of public spaces, such as cemeteries and schools, directly next to refineries. These communities are predominantly black and have faced elevated levels of racism and race-based discrimination. *Source: Petrochemical America, Misrach and Orff*
Plaquemine	30.28908, -91.23427	Oil & Gas Facilities	Chemical waste burial site, 46,000 tons of toxic waste buried in unlined pits from 1958 to 1973 by the Dow Corporation. The company now attempts to pump the waste before it reaches the drinking water aquifer, but every time there is water table rise the burial site is flooded and toxic waste is carried along the Mississippi River. *Source: Petrochemical America, Misrach and Orff*
Morrisonville	30.32061, -91.22433	Oil & Gas Facilities	Established settlement by an African American community in 1870 was displaced to Morrisonville in

			1932 by the Army Corps to build the levee. In 1989 Dow bought out the residents due to health and evacuation concerns. Now the area is considered a "green" buffer zone and the buildings were destroyed. *Source: Petrochemical America, Misrach and Orff*
Leeville	29.24987, -90.21189	Oil & Gas Facilities	When boating with two shrimpers, Tim and Tee Tim, ethnographer Mike Tidwell came across a mangrove colony next to a Texaco gas line warning sign. *Source: Bayou Farewell, Mike Tidwell*
Lakeview	30.00856, -90.10741	Communities	The Lakeview neighborhood in New Orleans is a majority white community in a predominantly black city with higher salaries, rents, and rates of homeownership. The neighborhood was built upon alluvial soils and is susceptible to foundation collapse, which occurred during the 2005 hurricane. Post-Hurricane Katrina, this neighborhood saw faster residential returns and more recovery development. There was also a push by residents to effectively remove multi-family lots, pushing out lower-income and largely black renters from living in the area. *Source: Sedimentation of Whiteness as Landscape, Anna Livia Brand*
Isle de Jean Charles	29.39599, -90.48858	Communities	Land owned by the Biloxi-Chitimacha-Choctaw tribe, lost in 1998 to build levees that were later determined to be too expensive. The tribe was still relocated. *Source: License to Extract, Ned Randolph*
Lower Ninth	29.96827, -	Communities	98% black community was hit the hardest by Hurricane

Ward	90.01399		Katrina. New Orleans had become extremely segregated, and the lower class black community over time was funneled into an geologically unstable and impoverished area of the city. The MR-GO shipping canal broke open and flooded this neighborhood during Hurricane Katrina. *Source: Sedimentation of Whiteness as Landscape, Anna Livia Brand*
Cocordie	29.24689, -90.66147	Communities	Home of fishermen interviewed for Bayou Farewell, experienced catastrophic damage from Hurricane Katrina. *Source: Bayou Farewell, Mike Tidwell*
Golden Meadow	29.37911, -90.26007	Communities	Location where Hurricane Isidore hit, 4 days before Hurricane Lilly, huge amount of wetland retreat. *Source: Bayou Farewell, Mike Tidwell*
Houma Grand Village	30.14065, -90.93507	Communities	Original upriver relocation point of Houma tribe in 1718 due to forced relocation from French colonizers. Crossroads of the transportation network are indicative of Houma land. *Source: Kingdom of Water, J. Daniel d'Oney*
Bayou Black	29.6363, -90.9682	Communities	1800s forcible resettlement of Houma nation due to colonial pressures. Bayou Black was a specifically important waterway due to its east-west movement. *Source: Kingdom of Water, J. Daniel d'Oney*
Houma	29.59576, -90.71953	Communities	Population of 37,000, parish seat of Terrebonne Parish. Houma was considered the “Venice of America,” holding old money from sugarcane plantations and oil earnings. Houma is 35 miles north of the coast, and the

			rapidity of wetland loss means coast will reach Houma in 70 years, Some places are 2 feet above sea level and rate of sinking is 1 foot/century, the water source is contaminated by saltwater intrusion meaning drinking water is being drained from a swamp upstream. *Source: Bayou Farewell, Mike Tidwell*
Point-Aux-Chenes	29.49771, -90.55341	Communities	United Houma Nation settlement, where tribal members congregate in a public park because there is no official tribal land due to lack of federal recognition (largest tribe in Louisiana, 15,000 members) = no way to make $, experienced catastrophic damage from Hurricane Katrina. *Source: Mike Tidwell, Bayou Farewell*
Bayou Ferblanc	29.18689, -90.15368	Communities	Location where Vietnamese crabber Phan set up trap.s *Source: Bayou Farewell, Mike Tidwell*
New Iberia	30.00353, -91.81872	Communities	Location where Hurricane Lilly hit, 4 days after Hurricane Isidore, huge amount of wetland retreat. *Source: Bayou Farewell, Mike Tidwell*
Buras	29.35182, -89.52466	Communities	Eye of Hurricane Katrina. *Source: Bayou Farewell, Mike Tidwell*
Chauvin	29.43855, -90.59536	Communities	Home of fishermen interviewed for Bayou Farewell, experienced catastrophic damage from Hurricane Katrina. *Source: Bayou Farewell, Mike Tidwell*
Dulac	29.38883, -90.71397	Communities	Home of fishermen interviewed for Bayou Farewell, experienced catastrophic damage from Hurricane Katrina.

Source: Bayou Farewell, Mike Tidwell