

Lost Among the Skeletons:

Mapping the potential for live oak ghost forests in Southeast Louisiana & exploring cultural losses



In the southernmost tip of southeast Louisiana, trees stand barren in waves of green underbrush or dark waters. Stripped of their leaves and suspiciously pale, these trees are the still standing

skeletons in what was once a healthy forest. "Ghost forest" is the common name for this phenomenon, usually caused by habitat conversion due to saltwater intrusion. All throughout coastal Louisiana, the ghosts of live oak forests and cypress swamps dot the landscape.

-A description of ghost forests by R. Billiot-Bruleigh

The Mississippi River Delta has built a biodiverse estuary system in Louisiana, made up of extensive coastal wetlands and islands in a mosaic of environments crossing saltwater, brackish, and freshwater systems. Live oak forests exist within this mosaic situated on natural levees along the river or on islands in marshes and forested swamps, providing a variety of protective resources. All types of salinity levels exist around live oak forests (freshwater, intermediate, brackish, and saltwater) and gradients with coastal water bodies, beaches, marshes, and cypress and black gum swamps exist along forest edges (Frost and Johnson 2005; Ko et al. 2004; LNHP 2009). Live oak forests are a type of bottomland hardwood forest (forested wetlands which provide for water quality maintenance and flooding regulation) and are important natural communities for their role in storm protection, since they are able to withstand strong winds, periodic flooding, and salt-spray (LNHP 2009; Frost and Johnson 2005). The estuary is also “rich” in fossil fuel resources (such as oil and gas) and, on the natural levees, fertile soils suitable for agriculture (Colten 2017; LDWF 2005; Ko et al. 2004). These resources have put the environment at risk for exploitation. Live oak forests in southeast Louisiana are largely fragmented through developmental clear cutting (i.e. agriculture and residential infrastructure) and are considered imperiled in the region by the Louisiana Department of Wildlife & Fisheries. The surrounding environmental gradients (i.e. saltwater ecosystems) and other risk factors present due to ongoing human interference (e.g. canal dredging, pipeline building) affects habitat conversion of remnant live oak forests into ghost forests.

The coastal and wetland ecosystems of southeast Louisiana are in the midst of environmental crisis, experiencing devastating rates of land loss driven by erosion, subsidence, saltwater intrusion, and pollution and other anthropogenic activities. Saltwater intrusion into freshwater forests, from human activity such as canal dredging and natural processes such as storm flooding, contribute to ecosystem conversion and plant migration that changes the interactions and relationships between ecosystems. Canals have been implemented in Louisiana since the mid-1800s; dredging and construction peaked in the 1930s to 1970s for the purposes of oil exploration and ship transportation to the Gulf (Bethel et al. 2011; Ko et al. 2004; Davis 1973). Running through miles of wetlands with varying salinity levels, and even to the Gulf of Mexico itself, straight canals have acted as deep and direct passageways for saltwater transportation into freshwater systems (Bethel et al. 2011; Day et al. 2000; Ko et al. 2004; Salinas et al. 1986). Other contributors to saltwater intrusion include: leveeing of the Mississippi River, which halts seasonal flooding and starves the delta of freshwater and sediments that build up the land; withdrawal of oil and natural gas, which leads to downfaulting and increases subsidence rates along an eroding delta; and hurricane storm surge that becomes trapped in impounded wetlands (Bethel et al. 2011; Colten 2017; Day et al. 2000; Keim et al. 2019; Ko et al. 2004; Salinas et al. 1986). When looking at wetland losses from 1990 to 2000, the different natural factors and anthropogenic mismanagement of the environment have led to about 24 square miles lost per year over a 10-year period (Barras et al. 2003). As saltwater begins to intrude on freshwater habitats, such as swamps and hardwood bottomland forests, the associated vegetation dies off and is replaced with more salt-tolerant species. Continued erosion eventually leads to completely open waters; culturally and ecologically valuable habitats are lost to the sea.

Live oak forests provide wildlife habitat, plant biodiversity, and cultural protections. The unique plant diversity found in live oak forests act as protective habitats for different endangered animals, such as the Louisiana black bear, the bald eagle, the long-tailed weasel, and many different migratory bird species. Indigenous communities (local tribes including the United Houma Nation and various bands of Chitimacha and Atakapa-Ishak) have also traditionally relied on live oak forests for medicinal plants and food systems, as well as social functions from familial gatherings to honoring ancestral burial mounds. Trees such as the persimmon (*Diospyros virginiana*) and pawpaw (*Asimina triloba*) provide fruit from the limb, while others such as the swamp dogwood (*Cornus foemina*) and sugarberry (*Celtis laevigata*) hold medicinal remedies in their bark and roots (Speck 1941; Dunn et al. 1983; Moerman 1998). Live oak forests often host ancient burial mound sites, safe places to lay the dead to rest on natural levees unaffected by flooding (Giardino 2010; Hale 2017; Anderson 1997). Indigenous families continue to gather traditional foods and medicines in live oak forests, and travel to the burial mounds to honor the memory of ancient ancestors. My family is Houma and Chitimacha, two tribes with deep connections to the southern Louisiana live oak forests; when I was younger, my grandfather would take us out to the forests to pick black berries or visit the mounds to teach us about the ancestors that are buried there. However, these relationships with the land are at risk due to habitat conversion. The forests and plants we knew are dying.

My research examines how cultural ecological aspects of live oak forests in southeast Louisiana are affected by saltwater conversion to “ghost forests.” Understanding how the biodiversity of live oak forests is in danger from habitat conversion also informs the ways in which Indigenous cultural ties and environmental protective factors are at risk by environmental degradation. GIS imaging of four sample forests in Southeastern Louisiana- one ghost forest in

St. Bernard and three remnant forests written about in previous studies- were overlaid with land loss trend maps from previous research and compared with maps featuring canal, pipeline, and oil field placement in order to identify risks for future losses. Traditional ecological knowledge from ethnobotanical sources and mound location mapping projects were used to provide information on cultural relationships with live oak forests. Ghost forests are solemn reminders of habitat change leading to cultural and environmental losses. By understanding cultural relationships with live oak forests and the potential for future losses, better environmental management and adaptation measures can be considered.

Literature Review

Live Oak Forests & Previous Loss

Coastal communities are often at risk for environmental changes caused by anthropogenic factors (i.e. oil drilling, pipeline construction, agricultural development, etc.) and natural forces (i.e. hurricanes) that result in environmental degradation (i.e. erosion, saltwater intrusion, habitat fragmentation, etc). In previous studies done on live oak forests in southeast Louisiana, researchers tend to focus on infrastructure development and habitat fragmentation as the primary threats in forest vitality. Live oak natural levee forests and hardwood bottomlands were largely cleared for agricultural and residential development since Western colonization began (Colten 2017; White and Skojac 2002). Of the estimated 500,000 to 1,000,000 acres present before colonization, only about one to five percent of their traditional range still remains, and the remnants are extremely fragmented where found (LDWF 2005). Live oak forests face continued threats from saltwater intrusion, invasive species such as the Chinese tallow tree (*Triadica sebifera*), and infrastructure development in the form of pipelines, roads, and housing (White and Skojac 2002; Colten 2017; LDWF 2005). The study done by David White and

Stephanie Skojac observed that the oak forest recorded by Penfound and Howard in 1940 had been cut down to make way for homes and shopping centers, and that two of the forests they were studying had also been developed in a similar manner by the time the study was completed in 2002. While the effects of infrastructure development are the focus in these studies, I will be focusing in on the effects of saltwater intrusion in remaining live oak forests and the risk factors presented for ghost forests.

Saltwater Intrusion & Effects on the Environment

Saltwater intrusion has become a concern for coastal communities worldwide as climate change affects sea level rise and land loss. In southeast Louisiana, researchers note that saltwater intrusion is compounded by several different factors that take root in environmental mismanagement issues. Anthropogenic leveeing of the Mississippi River has isolated the estuary from seasonal floods that bring a reliable source of freshwater, sediments, and additional nutrients, essentially starving the land and allowing for saltwater encroachment in a naturally subsiding delta system (Bethel et al. 2011; Day Jr. et al. 2007; Colten 2017; Shaffer et al. 2009). Where wetlands remain impounded behind levees and separated from drainage paths, storm surge from hurricanes become trapped in the soil, killing freshwater plants since the saltwater is unable to flush out of the freshwater system (Keim 2019). The withdrawal of oil and natural gas has led to issues with downfaulting, aggravating subsidence rates and increasing land loss (Day et al. 2000; Colten 2017; Giardino 2010). Thousands of miles of deep straight canals dredged for oil exploration and ship navigation have acted as direct intrusion points for saltwater to move into live oak ecosystems (Salinas et al. 1986; Bethel et al. 2011; Colten 2017). Saltwater intrusion and subsidence play directly into ghost forest conversion in southeast Louisiana, as

conveyors of habitat change. The causes of saltwater intrusion identified in previous research can be mapped to identify conversion risk-factors for the remnant live oak forests I'm studying.

Live Oak Forests, Archaeology, & Culture

Live oak forests are areas of archaeological and historical curiosity, due to their association with prehistoric mounds and artifacts. Researchers seek to study live oak forests as indicators of archaeological hotspots. Archaeologists use live oak clumps standing above the water to spot submerged mounds, and a NASA researcher used GIS multispectral data to identify live oak forests and new mound sites within them (Anderson 1997; Giardino 2010).

Anthropologists study the forests as areas of importance for protection against heat and storms, or for the ethnobotanical uses of plant communities in the live oak forest around mound sites to understand the significance of the area to past civilizations (Dunn 1983; Anderson 1997). Live oak forests act as protectors of the ecosystem and Indigenous culture, areas of cultural importance that have traditionally been physical barriers against storm impacts, guardians of the dead, and providers of food, shelter, and medicinal remedies. In addition to the archaeological research done around the cultural importance of live oak forests, a traditional ecological knowledge approach will be brought in to further explore these relationships between live oak forests and local Indigenous communities.

Data Methods

To address the presence of live oak ghost forests in southeast Louisiana and the potential for remnant forests to be at risk for conversion, I utilized previous studies on remnant live oak forests, GIS data, map comparison and overlay analysis, and informal interviews with tribal community members. The Jackson and Lafitte forests studied by White and Skojac (2002) and the Bayou La Loutre - Bayou St. Malo Alluvial Ridge Complex addressed by Coastal

Environments, Inc (2012) were pinpointed as locations of remnant live oak forests. By using these datasets, identified forests were compared to current ghost forests in Yscloskey, St. Bernard for the purposes of my own research. GIS provided imaging and visual analysis of the forests; comparing maps of canals, pipelines, oil & gas fields, land loss, and forest data highlighted land conversion risk factors in the area. Datasets and mapping materials came from prior NOAA data, ArcGIS, National Pipeline Mapping System (NPMS) Public Viewer, and Google Earth. Sources of Traditional Ecological Knowledge (TEK), such as articles on ethnobotanical plants and informal interviews with local members of the United Houma Nation, were used to connect live oak forests to cultural resources and identify ecological/cultural losses with live oak habitat conversion. I used journal articles describing live oak forests to discern locations of intact forests for the study. By using the forest locations provided in written about in previous research, I can examine current trends in forest health and risk factors for ghost forest conversion in remnant live oak forest environments. TEK methods put cultural relationships with regard to the region in perspective and help express cultural aspects at risk from saltwater habitat conversion.

Data Analysis

Biocultural Resources, Traditional Importance, & Loss

Plants play an important role in cultural, medicinal, and food systems, and yet saltwater intrusion and habitat conversion are endangering valuable species in oak forest communities. Live oak forests are cultural providers and caretakers, because the biodiversity present within the forest community foster plants used for construction, crafts, dyes, medicines, teas, and cooking. Table 1 lists a sample of the medicinal, food, and craft plants that grow within live oak natural levee forests. Some, like the pecan tree (*Carya illinoensis*) and the beautyberry (*Callicarpa*

americana), are classed as facultative upland plants; they need the naturally rich alluvial soils from the natural levee for best growth conditions (LDWF n.d.). Others, like the resurrection fern (*Pleopeltis polypodioides*), have a special relationship with live oak trees themselves. In Houma medicinal traditions, resurrection ferns can only be gathered from the live oak trees in order to use them in remedies (Speck 1941). Dr. Tammy Greer, a member of the United Houma Nation, describes live oaks as elders who teach us lessons about generosity, since they provide dyes and medicines from their bark and roots, and because they support Spanish moss and resurrection ferns (important craft and medicinal plants) despite there not being any apparent benefit to the tree itself (Personal Communications 2019). The ethnobotanical resources they provide for our tribes are invaluable parts of ancestral knowledge and connection, especially as we work to reclaim traditional ways of caring for ourselves and living with the land. As the forests are put at risk with saltwater intrusion, so are the individual plant species that reside within them, and we lose access to traditional remedies, foods, collection practices, and our relationship with these relatives.

Table 1: Sample of Vegetation Present in Live Oak Forests & Traditional Uses

Common Name	Scientific Name	Traditional Use
American Elm	<i>Ulmus americana</i>	Medicinal
Beautyberry	<i>Callicarpa americana</i>	Medicinal & Food (Berries)
Cherrybark Oak	<i>Quercus pagoda</i>	Medicinal
Dewberry	<i>Rubus trivialis</i>	Food (Berries)
Dwarf Palmetto	<i>Sabal minor</i>	Medicinal & Food (Root)
Elderberry	<i>Sambucus canadensis</i>	Medicinal
Sugarberry	<i>Celtis laevigata</i>	Medicinal and Food (Berries)
Live Oak	<i>Quercus virginiana</i>	Medicinal & Craft Dye
Resurrection Fern	<i>Pleopeltis polypodioides</i>	Medicinal
Spanish Moss	<i>Tillandsia usneoides</i>	Medicinal & Crafts
Pawpaw Tree	<i>Asimina triloba</i>	Food (Fruit)
Pecan	<i>Carya illinoensis</i>	Food (Nut)
Persimmon	<i>Diospyros virginiana</i>	Food (Fruit)
Red Bay	<i>Persea borbonia</i>	Food (Leaves)
Swamp Dogwood	<i>Cornus foemina</i>	Medicinal
Sweetbay	<i>Magnolia virginiana</i>	Medicinal
Sweetgum	<i>Liquidambar styraciflua</i>	Medicinal
Water Oak	<i>Quercus nigra</i>	Food (Acorns)
Southern Bayberry	<i>Morella cerifera</i>	Medicinal & Economic (Candles)
Willow	<i>Salix spp.</i>	Medicinal
Yaupon Holly	<i>Ilex vomitoria</i>	Medicinal, Ceremonial
Snakeroot	<i>Sanicula canadensis</i>	Medicinal

(Penfound and Howard 1940; Speck 1941; Moerman 1998; White and Skojac 2002; LDWF 2005; Coastal Environments, Inc. 2012)

Live oak forests are also protectors, and legacies, of ancient ancestors and sacred sites.

They guard ancestral burial mounds, mark graves, and signify areas of cultural importance.

Archaeologists use live oaks as “diagnostic” vegetation marking prehistoric archaeological sites in the wetlands of Louisiana (Giardino 2010). My grandfather, Jerry Billiot Sr., and uncle, Bryant Billiot, have said that these archaeological sites are ancient burial grounds. Natural levee forests were areas where the dead could safely be laid to rest, protected from flood water and storm conditions by the steady strength of live oak stands (Anderson 1997; Personal Communications 2019).¹ Shell middens in Southeast Louisiana were also built by Indigenous ancestors as far back as 0-400 A.D. (and even earlier), and were usually used as burial sites, though some had other uses (Coastal Environments, Inc. 2012; Hale 2017). When the middens were first built, they would have been barren; live oak seeds rooted themselves to the sites and built up forest communities that have thrived for hundreds of years, a living legacy to the mound builders and protectors to those buried beneath (Anderson 1997; Personal Communications 2019). As wetland loss continues to occur with erosion, saltwater intrusion, pipeline construction, and extractive resource production, these sites are continually eroded and put in danger of washing away. Our Indigenous ancestors and their legacies are at risk of being lost to the sea.

Conversion of healthy forests to dead skeleton trees and ghost forests also affects the physical health of living (human) communities due to a lack of protection from air pollutants. The conversion of freshwater forests to saltwater marshes has allowed for greater risks when it comes to storm winds and pollution, since the trees are becoming skeletons incapable of blocking the wind or purifying the air. Trees help control air pollution by absorbing gaseous

¹ Tammy Greer states that live oaks also teach us lessons about the strength of community. Live oaks intertwine their roots, allowing them to support one another in storms and strong winds, demonstrating that community is crucial to protection and survival.

pollutants through leaf stomata and physically catching particulate pollutants on the surface of their leaves, improving air quality and reducing incidences of acute respiratory diseases in human populations (Nowak et al. 2014). However, tree species suffer high mortality rates with higher salinity levels in the soil; forests are gone in places like Grand Bayou Village (an Atakapa-Ishak community in Plaquemines Parish), leaving the community exposed to chemicals and carcinogens from encroaching industries that bring down the air quality and increase the number of adverse health effects, which are different from diseases traditional knowledge and medicinal plants historically treat (*Shaffer et al. 2009*; NRCS Workshop 2012). Communities are contracting cardiovascular and respiratory illnesses from poor air quality forests once helped guard against, such as asthma, bronchitis, lower respiratory infections, lung and heart damage, and cancer (NRCS Workshop 2012; Bousquet et al. 2007). As live oak forests subside and erode into saltwater marshes, trees die-off from saltwater poisoning and the habitat shifts in favor of saltwater plants. With saltwater intrusion and subsequent ghost forest habitat conversion of healthy live oak communities comes the loss of biocultural resources, such as the concurrent loss of food and medicinal plants, degradation of ancient mound sites, or protective health factors in forests becoming health risk factors with encroaching chemical industries.

Land Loss and Environmental Mismanagement

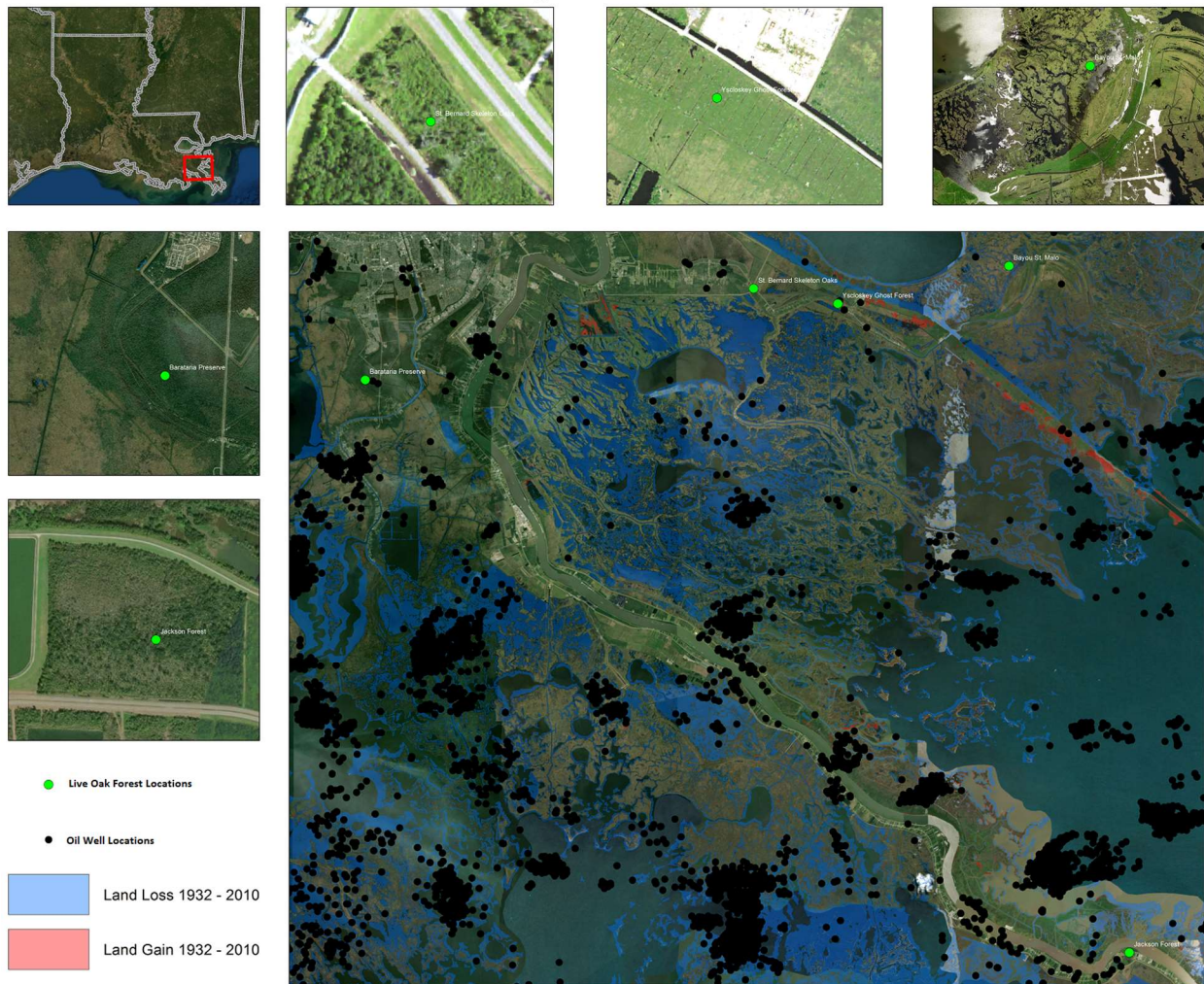


Figure 1: Land loss and land gain map featuring the locations of the live oak forest areas examined in this study and oil well locations across the region. Map overlay and figure courtesy of Josh Meisel.

Apart from the extensive clearcutting that significantly decreased the range of live oak forests in Louisiana, the forests are threatened by habitat conversion due to environmental mismanagement. Ghost forests are taking the place of once healthy live oak communities due to erosion exacerbated by anthropogenic development. Figure 1 illustrates the land loss patterns occurring in Louisiana for the years of 1932 through 2010; all of the forests surveyed are located in areas of encroaching land loss and a high density of oil wells, canals, and pipelines. Canals were built in Louisiana since the early 1700s for transportation and drainage, and construction rapidly increased in the 1930s with the discovery of oil and gas fields; by the mid-1980s, over

15,000 km of canals stretched throughout Southeast Louisiana for pipeline routing and drilling access (Colten 2017; Ko et al. 2004; Day et al. 2000). The canals are deep and straight in contrast to the shallow, sinuous flow of natural tidal channels, and the long canals that stretch from freshwater habitats out to saltwater inlets and the Gulf allow for saltwater intrusion leading to freshwater wetland and forest death (Salinas et al. 1986; Ko et al. 2004; NPS 2009; Shaffer et al. 2009). Rates of land subsidence are also found to be as much as 23 mm per year greater than the regional average for the Mississippi River Delta in fields producing oil and gas (Ko et al. 2004). Such environmental management practices increase the risk for, and lead to the occurrence of, ghost forests in Southeast Louisiana. Mismanagement and resource extraction within the wetlands are increasing freshwater forests and plant diversity die-off.

Figure 2: Yscloskey Ghost Forest, Land Loss (1932-2010), & Oil Wells

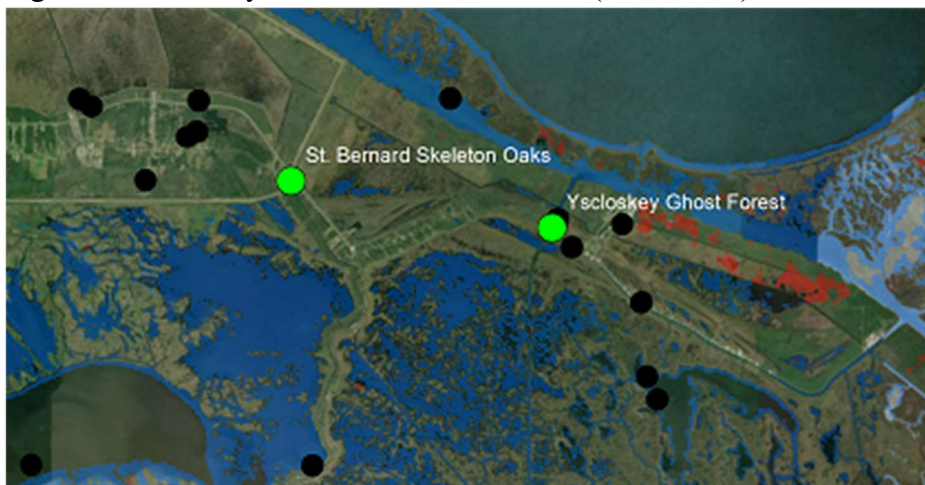


Figure 3: Pipelines & Commercial Navigation Waterways around Ysloskey Ghost Forest



The ghost forest in St. Bernard is surrounded by anthropogenic risk factors for saltwater intrusion, particularly oil wells, pipelines, and canals. Associated land loss and sea level rise since 1932 through 2010 are also significant, following canal and pipeline paths (see Figures 2 and 3). According to the 2012 St. Bernard Parish Coastal Zone Management Program, 144 acres were lost along this forest between 1932 and 2008 as a result of saltwater intrusion and subsidence, contributing to the death of live oak strands on subsiding natural levees and marsh vegetation migration among the remaining skeleton trees (Coastal Environments, Inc. 2012). The management program attributes the subsidence and erosion rates to natural processes for an abandoned delta environment (Coastal Environments, Inc. 2012). However, while natural subsidence does occur unchecked by river input in abandoned deltas, the addition of an estimated seven pipeline (Figure 3) and fourteen oil wells in the immediate vicinity (Figure 2), as well as two major canal structures (including the Mississippi River-Gulf Outlet (MRGO)) exacerbates loss rates and forest death. Pipelines, oil and gas production, and canals have known associations

with and direct impacts on saltwater intrusion and subsidence rates by acting as corridors for saltwater to be transported by or increasing erosion through direct resource extraction. The presence of pipelines, major canal structures, and multiple oil wells around the Yscloskey live oak ghost forest contributed to the environmental degradation seen along the natural levees, and can be associated as risk factors for future conversion of remnant forests in other areas.

Risk Factors in Remnant Forests

The Bayou La Loutre - Bayou St. Malo alluvial ridge complex has similar associated risk factors as the Yscloskey ghost forest for conversion that will also affect the Magnolia Mound Native American site and the protective role of the ridge. Canals, pipelines, and oil well density in the area, as well as maritime erosion, affect subsidence and habitat migration on the ridge and around the mound. The ridge is home to the Magnolia Mound site, an “extensive complex of clam middens and conical mounds of the Marksville period (0-400 A.D.) that surrounds a plaza with pyramidal mounds of the Mississippi period dating from A.D. 1000 to 1700” (Coastal Environments, Inc. 2012); it is an old sacred site. The alluvial ridge is also an important natural barrier that protects surrounding environments from saltwater intrusion and storm surge, since the forest canopies diminish wind penetration and reduce wind stress on surface waves, while the underlying vegetation lessen wave impact and subsequent erosion (Day Jr. et al. 2007; Coastal Environments, Inc. 2012). However, the presence of the MRGO (a major canal extending from the Mississippi to the Gulf) and a pipeline both intersecting the ridge (Figure 5), various oil wells in the immediate vicinity of the ridge (Figure 4), and persistent wave edge erosion enlarging surrounding water bodies (particularly during hurricanes and tropical storm events) are making the ridge vulnerable (Coastal Environments, Inc. 2012; Ko et al. 2004; Gittman et al. 2014).

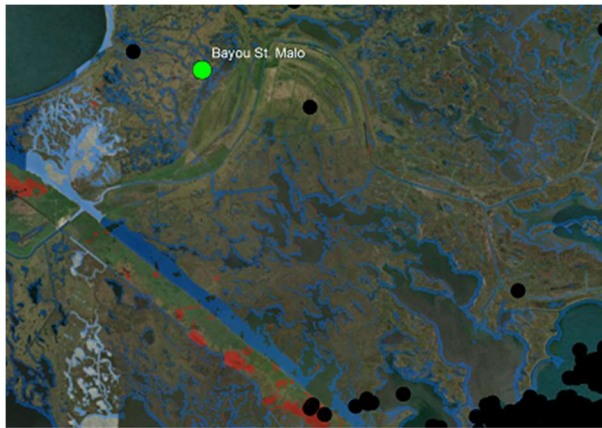


Figure 4: Bayou La Loutre- Bayou St. Malo Forests, Land Loss (1932-2010), & Oil Wells

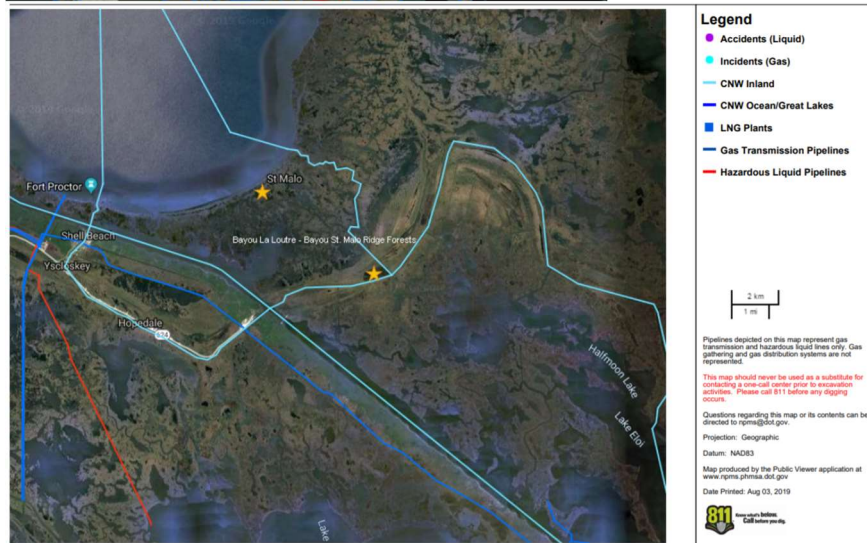


Figure 5: Pipelines near Bayou La Loutre- Bayou St. Malo Forests

The area lost about 7,102 acres of wetland habitat from 1932 to 2008 (illustrated in Figure 4), deteriorating surrounding marsh and tree remnants on adjacent ridges (Coastal Environments, Inc. 2012). The live oak forests on the Bayou La Loutre - Bayou St. Malo alluvial ridge complex are at risk for habitat conversion to ghost forests, weakening its ability to defend against storm surge and opening up the Magnolia Mound site to erosion. As the ridge complex continues to lose land, the biocultural resources of the area, from the more diverse freshwater vegetation in the live oak community to the mound and its history, are degraded and face being lost to the water entirely.

Figure 6: Jackson Forest, Land Loss (1932-2010), & Oil Wells

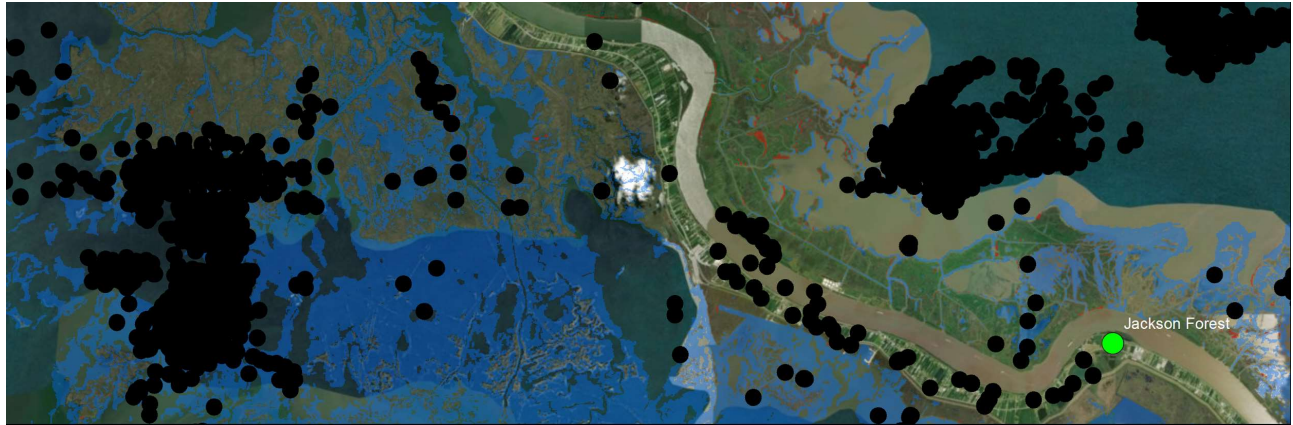
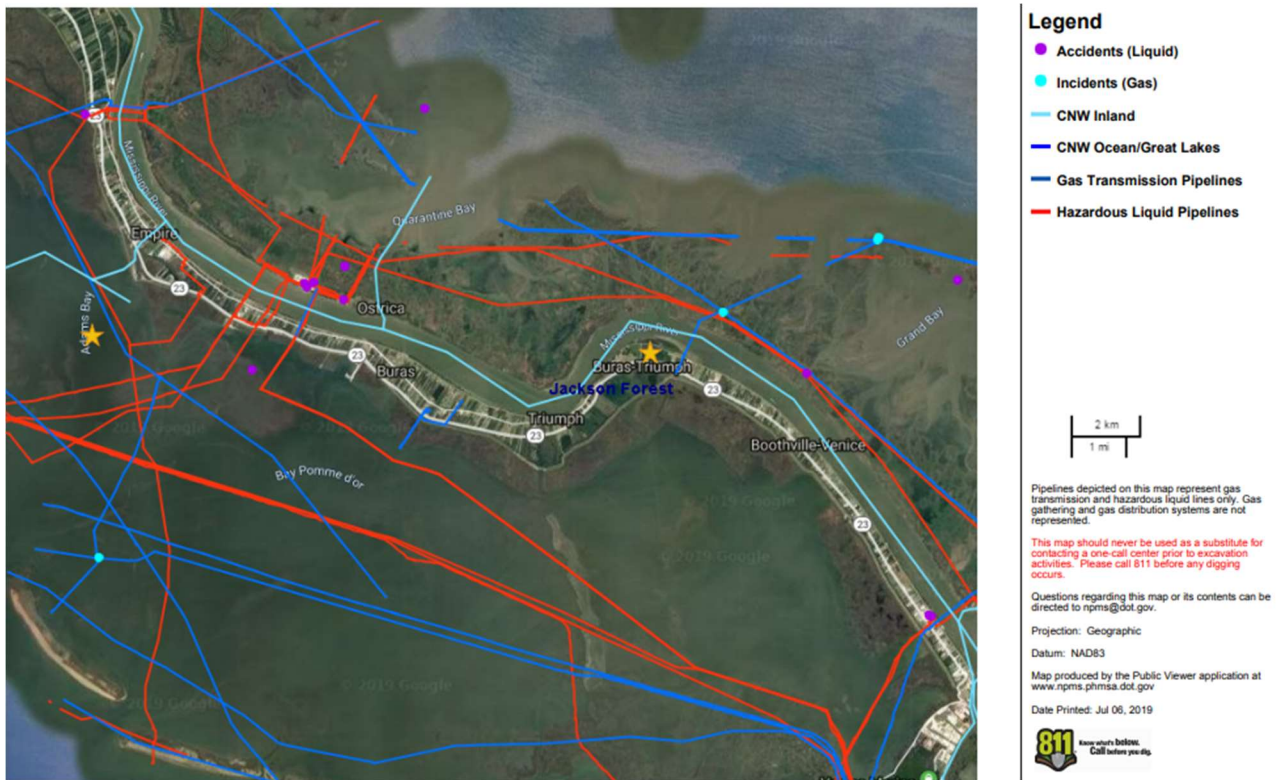


Figure 7: Pipelines around Jackson Forest



Despite growing right next to the current route of the Mississippi River, the old growth remnant live oak forest near Fort Jackson (in Buras-Triumph, Plaquemines Parish) is surrounded by rapid land loss rates and risk factors for habitat conversion. Extractive industry development of the area, through canal dredging, pipeline laying, and oil well drilling, has taken a toll on the landscape and the cultural sites within. Plaquemines Parish is Louisiana’s biggest oil and gas

producer (LGS 2000), which is partially illustrated by the vast number of oil wells and pipelines present just within the Buras-Triumph areas (Figures 6 and 7); the placement of the oil wells and pipelines correlate with the areas marked for land loss between 1932 and 2010 (Figure 6).

Jackson Forest as a particularly small remnant forest (about 300 m by 800 m) outside of Fort Jackson, distinguished for its “very old trees and its cathedral-like canopy structure” (White and Skojac 2002); to the northwest in Adams Bay are burial mounds marked with other remnant live oaks (Hale 2017). Live oak forests throughout Plaquemines Parish are deteriorating with subsidence and saltwater intrusion that are causing tree die-off (Evans-Graves Engineers, Inc. 2013; Shaffer et al. 2009), and the Adams Bay mounds are almost completely subsided - on one mound, only two live oaks remain standing just above the water (Hale 2017). Based on Jackson Forest’s location towards the end of the Mississippi River and the number of anthropogenic risk factors all throughout the surrounding area, it may be within a sacrifice zone - an area considered too degraded to include in protection strategies, or an area allowed to deteriorate for the benefit of industrialization and economic gain from extractive industry work (Colten 2012). Like the Adams Bay mound site and live oaks throughout the rest of the Parish, Jackson forest appears at risk for potential ghost forest conversion. The extractive industry activity has resulted in high rates of subsidence, land loss, and erosion along the Mississippi River, at the expense of cultural sites and resources.

Figure 8: Lafitte Oak Forests, Land Loss (1932-2010), & Oil Wells

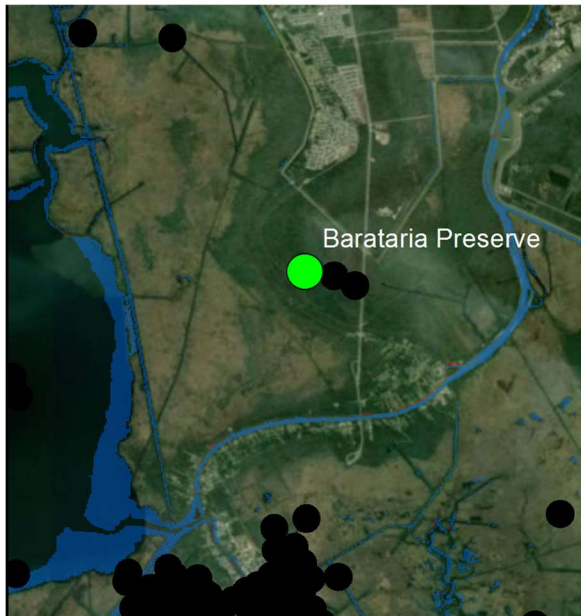
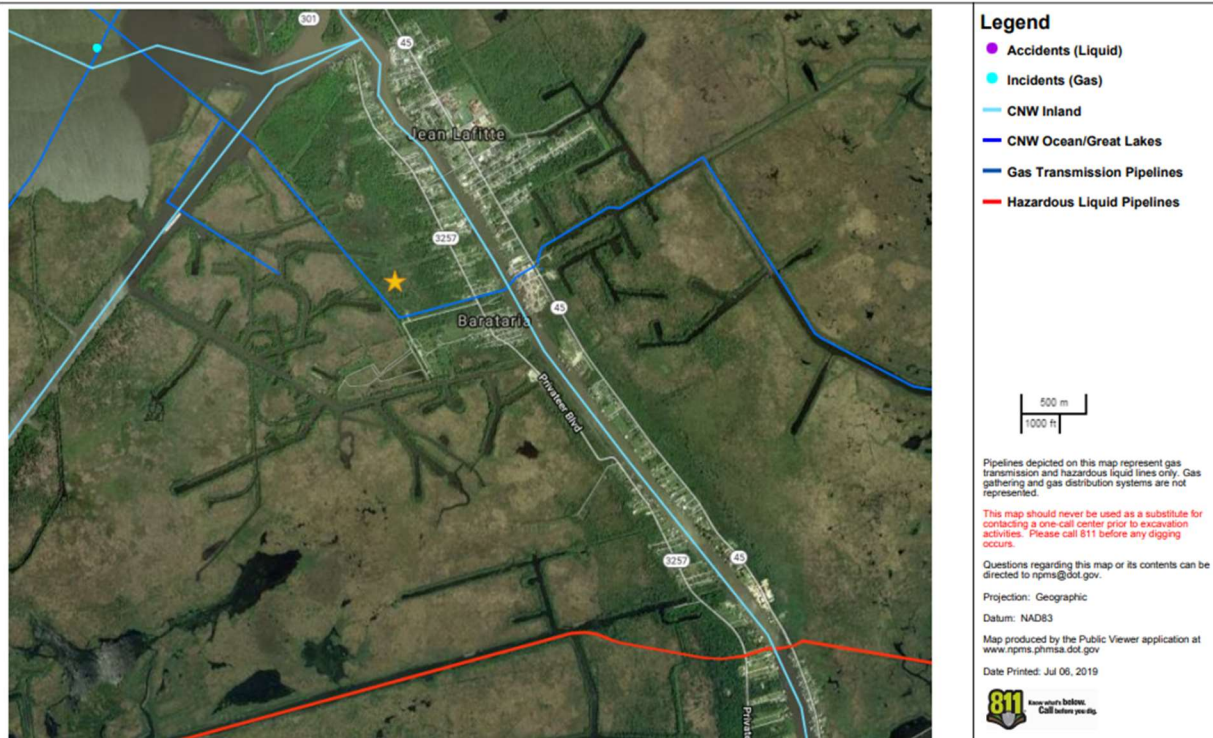


Figure 9: Pipelines around Lafitte Oak Forests



The Barataria Preserve in Jean Lafitte National Park has several stands of live oak forest communities and an ethnobotanically rich shell mound at the confluence of Bayou Coquille and Bayou des Families, as well as many left over canals and a few oil wells and pipelines from

before its designation as a protected area. Resource extraction activities present in the area from before its establishment as a federally protected park, as well as alterations to the Mississippi River, have led to subsidence, edge erosion, and saltwater intrusion that negatively impacts biocultural resources within the forests and surrounding wetlands. Barataria Preserve is cut off from sediment input by the Mississippi River by levee walls, which affects natural hydrology and has led to issues such as shore bank erosion and higher local rates of subsidence (NPS 2018; Colten 2017; Day et al. 2000; Keim et al. 2019). Abandoned canals, dredged from the 1950s to the 1980s for pipeline placement and exploratory drilling oil and gas wells, have also contributed to subsidence rates, as well as edge erosion and saltwater intrusion that is affecting the Bayou Coquille shell mound and hardwood bottomland forests in the park - forests are showing poor recruitment of new live oak (*Quercus virginiana*), sugarberry (*Celtis laevigata*), black willow (*Salix nigra*), and boxelder maple (*Acer negundo*) growth (Denslow and Battaglia 2002; NPS 2009; Giardino 2010; Ko et al. 2004). Restoration and reclamation efforts seem promising, though: in 2002, two exploration canals were reconnected with the surrounding marsh through backfilling (in which canal spoil banks are used to fill in the canal and encourage vegetation regrowth) to lessen habitat fragmentation, and by 2006 signs of successful reclamation helped provide for better wetland conditions (NPS 2009; Ko et al. 2004). River diversions are also providing a source of freshwater sediment input to help offset subsidence (NPS 2018; Brown et al. 2011). Canals are putting the environment at risk for habitat conversion through saltwater intrusion, leading to wetland and forest degradation that has the potential to get worse. However, protection and environmental management measures such as canal reclamation project and river diversions present hopeful solutions.

Discussion

Policy Suggestions

Natural restoration efforts emphasizing living coastlines should be implemented in these areas to protect the remaining forests. As Gittman et al. found in their 2014 study, living coastlines provide better protection over anthropogenic infrastructure (e.g. bulkheads). In southeast Louisiana, oyster shell reefs, river diversions, marsh restoration, and reforestation efforts are promising “living” protections for live oak forests. Oyster shell reefs are natural breakwaters that protect shorelines against wave erosion and storm surge, preventing further habitat migration and land loss (Bendick et al. 2018; Brown et al. 2011). My grandfather, Jerry Billiot Sr., taught his children the importance of returning oyster shells around the burial mound in Adams Bay, so reefs could replenish themselves and continue to protect the land (Personal Communications 2019). River diversions allow for freshwater and sediments from the Mississippi River to reach the wetlands and build the land back up, which also helps restore surrounding marshes, prevent land erosion and habitat migration, and may support reforestation in areas that were being affected by saltwater intrusion by flushing it out with freshwater diversions (Coastal Environments, Inc. 2012; Brown et al. 2011). These kinds of restoration activities work with the natural environment by imitating the way the estuary mosaic maintained itself for centuries. By building restoration projects that work with the natural environment and encourages the relationship different environmental communities had with one another (e.g. oyster reefs protecting marshes, marshes protecting forests), a more resilient and self-sustaining environment should be attained.

Furthermore, the health of these ecosystems need to be put before resource exploitation interests. New pipelines and canals should not be built in or around these areas; at most, existing

pathways and outdated infrastructure should be re-used. Pipelines and canals are risk factors for saltwater intrusion (Colten 2017; Bethel et al. 2011; Ko et al. 2004), as well as cause habitat fragmentation where they run (LDWF 2005). As forests continue to be put at risk by extractive industries or to be clear cut for residential development (LDWF 2005), the loss of these forests are felt by communities through the loss of storm protection and the addition of poorer air quality conditions leading to adverse health effects such as cancers and respiratory diseases (NRCS Workshop 2012). Even in areas with active environmental management protocols and viewed as in need of protection, activities such as oil and gas exploration and commercial development are seen as permissible uses (Coastal Environments, Inc. 2012), despite the known risks these activities bring in terms of erosion, subsidence, and saltwater intrusion (LDWF 2005, Ko et al. 2004). Healthy environments are able to provide for healthier people. When value is placed on resource extraction rather than overall environmental health, the community suffers. Halting further exploitative development in wetland environments and coastal forests would aid restoration efforts and help avoid adding to current loss trends.

Conclusion

Live oak forests provide many important biocultural resource protections for Indigenous communities in southeast Louisiana that are affected by habitat conversion and environmental mismanagement. Habitat change occurs as freshwater systems, like live oak forests, convert to saltwater marshes that can handle the new brackish conditions. Continued erosion eventually leads to completely open waters. All of the remnant live oak forests examined in this paper have associated risk factors for habitat conversion into ghost forests, and some of the old growth live oaks are over hundreds of years old. With the rates of land loss and habitat conversion Southeast Louisiana is facing, as well as the creation of sacrifice zones (areas left out of protection efforts

due to the cost of implementation), we face losing these live oak forests to skeletal remains. The old oaks are elders who teach lessons about community, support, change, and generosity. Live oak forests act as cultural protections for the way they provide food and medicinal plants, guard burial grounds, and shelter against intense heat or strong storms. In return, we must also protect these relatives and the natural communities they form.

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