PREPARING FOR FUTURE CHANGES:
LOUISIANA'S COAST

BACKGROUND

Coastal Louisiana is a hotspot for habitat change and rapid land loss (42.9 km^2 per year; 1985–2010 mean) resulting from multiple factors, including hurricane disturbance, significant land use change, and high subsidence rates contributing to high relative sea-level rise.[1,2,3,4]

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Preparing to adapt to this future means gaining a better understanding of what impact these changes will have on the coastal landscape on which so many people and businesses rely. In much of Louisiana's coast, the landscape depends on vegetation which can be sensitive to inundation and salinity changes resulting from the expected future alterations in hydrology.

Understanding the dynamics of marshes also provides an opportunity to address coastal, or blue carbon quantification that has emerged as a recognized tool to address numerous environmental challenges in a sustainable and long-term way. Coastal carbon describes the ability of aquatic and wetland plants to capture and store carbon from the air. The carbon captured in coastal wetlands presents an opportunity for restoration and infrastructure protection projects to generate greenhouse gas offset credits and incentivize private investment through the revenue that can be generated from carbon credit markets.

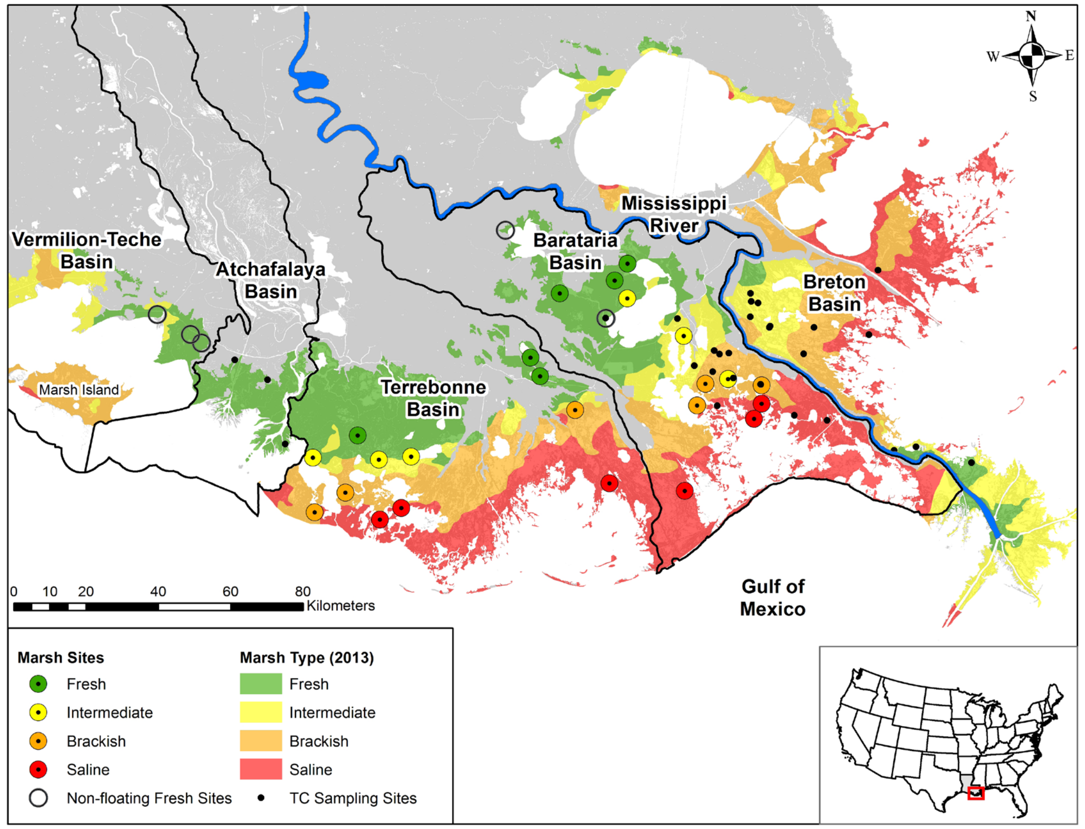
PROJECT GOAL

The goal of this work is to gain a better understanding of how climate change and restoration efforts can influence Louisiana's coastal wetlands. Gaining better knowledge of impacts on above and belowground productivity, decomposition rates, vertical accretion rates, and soil carbon accumulation rates in coastal Louisiana is vital for coastal planning. These landscape responses can inform what ecosystem services, such as fish habitat or freshwater availability, the wetlands can potentially provide in the future. Ultimately, a better understanding of these metrics provides decision-makers with information to impact coastal communities by supporting opportunities that prioritize restoration planning.

Researcher collecting data in habitats dominated by mangroves

STUDY SITES & MARSH TYPES

Louisiana's coastal marshes include four basic marsh types — fresh (0—0.5 ppt), intermediate (0.5—5.0 ppt), brackish (5.0—18 ppt), and saline (18+ ppt), moving from the inland river influenced areas south toward the marine Gulf of Mexico. The amount of salt in the water determines classification of marsh as shown in the figure below. While a marsh can be delineated into one of these four regimes, marshes are dynamic and can fluctuate between more and less saline over time. It takes a focused effort from a large team of collaborators to understand these complex processes.



MAP SHOWING THE 24 STUDY SITES IN THE FOLLOWING STUDIES

The Water Institute teamed with the U.S. Geological Survey (USGS), Coalition to Restore Coastal Louisiana, Gulf South Research Corporation, and Tulane University to sample 24 wetland sites in Barataria and Terrebonne basins across the four salinity regimes. Six sites in each of the four salinity-defined marsh types were included in this study. Each site was co-located with a Coastwide Reference Monitoring System (CRMS) site to take advantage of the long-term data collection at the CRMS sites and associated USGS study sites. Each of these sites was used in the following studies.

LOUISIANA'S FOUR MARSH TYPES

parts per thousand (ppt) of salt

0—0.5ppt	0.5—5ppt	5—18ppt	18+ppt
FRESH	INTERMEDIATE	BRACKISH	SALINE

References

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MEASURING MARSH POTENTIAL:
HABITAT SUITABILITY INDEX

"Tradeoffs in habitat value to maximize natural resource benefits from coastal restoration in a rapidly eroding wetland: is monitoring land area sufficient?"

Tim J. B. Carruthers, Erin P. Kiskaddon, Melissa M. Baustian, Kelly M. Darnell, Leland C. Moss, Carey L. Perry, Camille Stagg

Scan the QR code or visit tinyurl.com/habitatindex to read the full study.

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SUMMARY

Coastal Louisiana has some of the most rapid rates of emergent wetland loss globally and relies on a functioning ecosystem for a wide range of economic resources. Ecological restoration projects increasingly strive to maximize benefits to the greatest range of natural resources. The current approach of prioritizing restoration effort primarily based upon maintenance of emergent wetland area may not be delivering the greatest possible overall ecosystem value from that restoration.

To maximize benefits, there needs to be a measure of what type of habitat is most suitable. The Habitat Suitability Index (HSI) gives the ability to understand the potential range of natural resources (or range of species) that could potentially be supported by a coastal restoration effort.

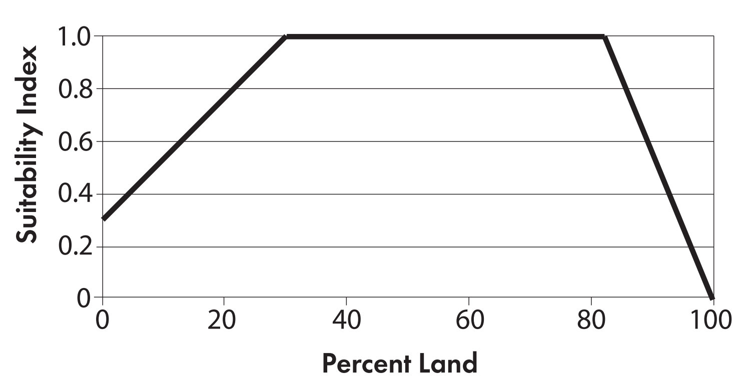
? What are relative habitat values of emergent wetland and shallow open water?

? Over a period of six decades of land loss, does inclusion of habitat value for land that eroded to shallow open water change the calculated rate of loss of habitat value?

HABITAT SUITABILITY INDICES (HSIs)

HSIs are tools that estimate the potential capacity of a habitat to support a species or specific ecosystem function. A value of 1.0 indicates an ideal habitat while a value of 0.0 indicates an unsuitable habitat.

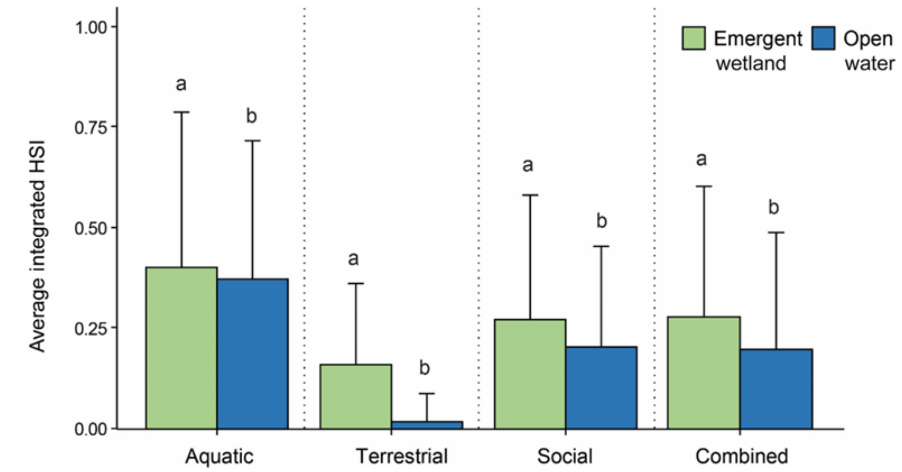
For example, this graph shows the ideal land to water ratio for juvenile blue crab (*Callinectes sapidus*). Blue crabs during juvenile stages need vegetative protection and so are commonly found in marsh edge areas. Continuous emergent marsh is poor habitat (little edge habitat) and so is open water — patchy marsh is the most suitable habitat for juvenile blue crab.



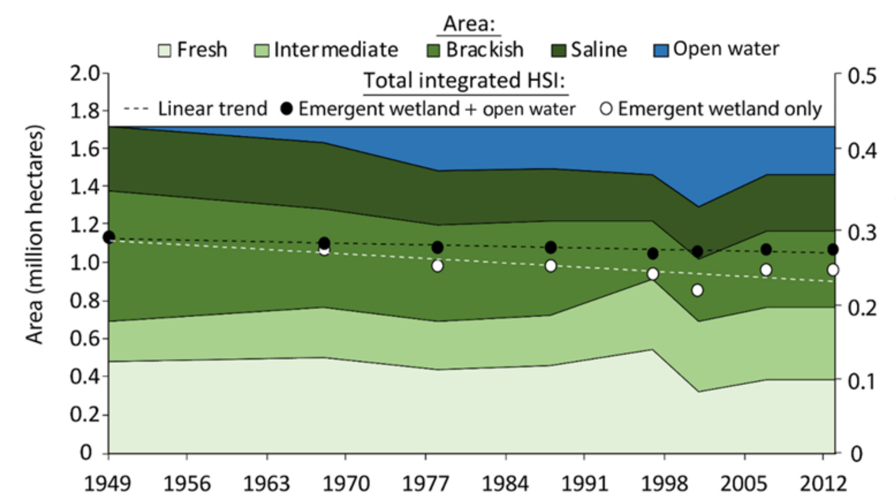
METHODS

Using publicly available output data from Louisiana's 2012 Master Plan, this study investigated aquatic fauna, terrestrial fauna, and societal indices. Societal indices of habitat types were defined by the potential to reduce storm surge, drive ecotourism, support agriculture, and provide freshwater for urban use.

The potential for each marsh type to provide a specific ecosystem function, whether for fauna, habitat, or community benefit, were totaled and the results analyzed to determine habitat potential of Louisiana's coast over time.



INTEGRATED HSI SCORES BY SPECIES GROUP IN EMERGENT WETLAND AND OPEN WATER AREAS CLASSIFIED BY THE 2013 EMERGENT WETLAND TYPE CLASSIFICATION FOR COASTAL LOUISIANA. BARS REPRESENT MEAN+SD AND LETTERS INDICATE SIGNIFICANT PAIR-WISE DIFFERENCES BETWEEN EMERGENT WETLAND AND OPEN WATER HABITAT TYPES.



AREA OF HABITAT TYPES (FRESH, INTERMEDIATE, BRACKISH, SALINE EMERGENT WETLAND, AND TOTAL OPEN WATER) IN COASTAL LOUISIANA FROM 1949 TO 2013. ESTIMATES OF INTEGRATED HSI SCORES (MEAN OF ALL GROUPS) OVER TIME FOR TOTAL EMERGENT WETLAND HABITAT AND EMERGENT WETLAND HABITAT INCLUDING OPEN WATER. THE RATE OF DECLINE IS SIGNIFICANTLY LESS WHEN THE CALCULATIONS INCLUDE BOTH EMERGENT MARSH AND NEWLY CREATED OPEN WATER AREAS

RESULTS

Despite decades of coastal land loss, the finding that potential HSI did not decrease rapidly over time indicates that habitat continued to retain some value as marsh edges were lost and replaced by shallow open water. Loss of coastal wetlands initially creates shallow open water that still has high potential habitat value for many natural resources.

A reassessment of restoration planning decision drivers may be beneficial to ensure maximum benefits from coastal restoration in Louisiana. For the purposes of high-level restoration planning at large spatial scales (100s km^2), integrating a range of habitat suitability values into decision drivers has the potential to improve ecosystem outcomes from large-scale restoration. Loss of ecosystem benefits due to land loss will be overestimated without accounting for the potential value of shallow open water habitat. Demonstrating multiple natural and social resource benefits from coastal restoration has potential to increase linkages to large Gulf of Mexico restoration programs.

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COALITION TO RESTORE COASTAL LOUISIANA

A CRITICAL LINK IN COASTAL CARBON:
ORGANIC MATTER DECOMPOSITION

"Direct and indirect controls on organic matter decomposition in four coastal wetland communities along a landscape salinity gradient"

Camille L. Stagg, Melissa M. Baustian, Carey L. Perry, Tim J. B. Carruthers, Courtney T. Hall

Scan the QR code or visit tinyurl.com/decompos to read the full study.

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SUMMARY

Decomposition of organic matter like stalks, stems, leaves, roots, and rhizomes play an important role in Louisiana's four marsh types. As organic matter decomposes, nutrients are released through mineralization which promotes the growth of living wetland plants subsequently affecting the amount of organic matter decomposition and wetland elevations. Measuring the rate of decomposition helps ecologists gain knowledge surrounding these ecosystem processes such as carbon accumulation in marshes.

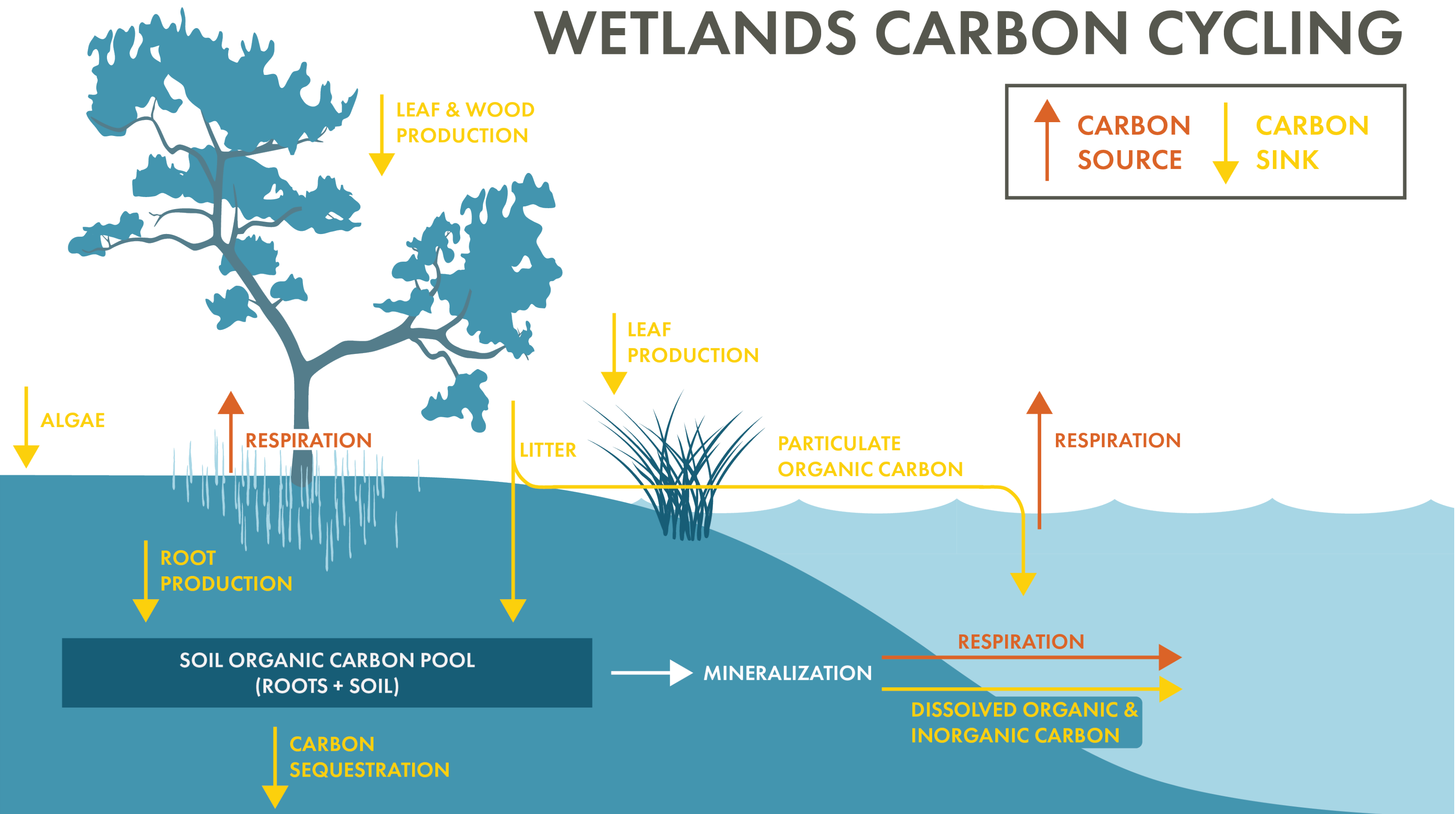
METHODS

Information on the rate of decomposition of above and belowground plant material was collected from 24 sites within fresh, intermediate, brackish, and saline marshes in coastal Louisiana. The plant material was air-dried, weighed, placed in mesh litter bags, and deposited at each site. Plant material was differentiated between typical aboveground and belowground biomass and was deposited in its corresponding location to observe potential variation in decomposition rates.

At each of the 24 sites, replicate plots were placed 10, 25, and 40 m from the shoreline with litter bags placed on the surface and inserted 10 cm belowground.

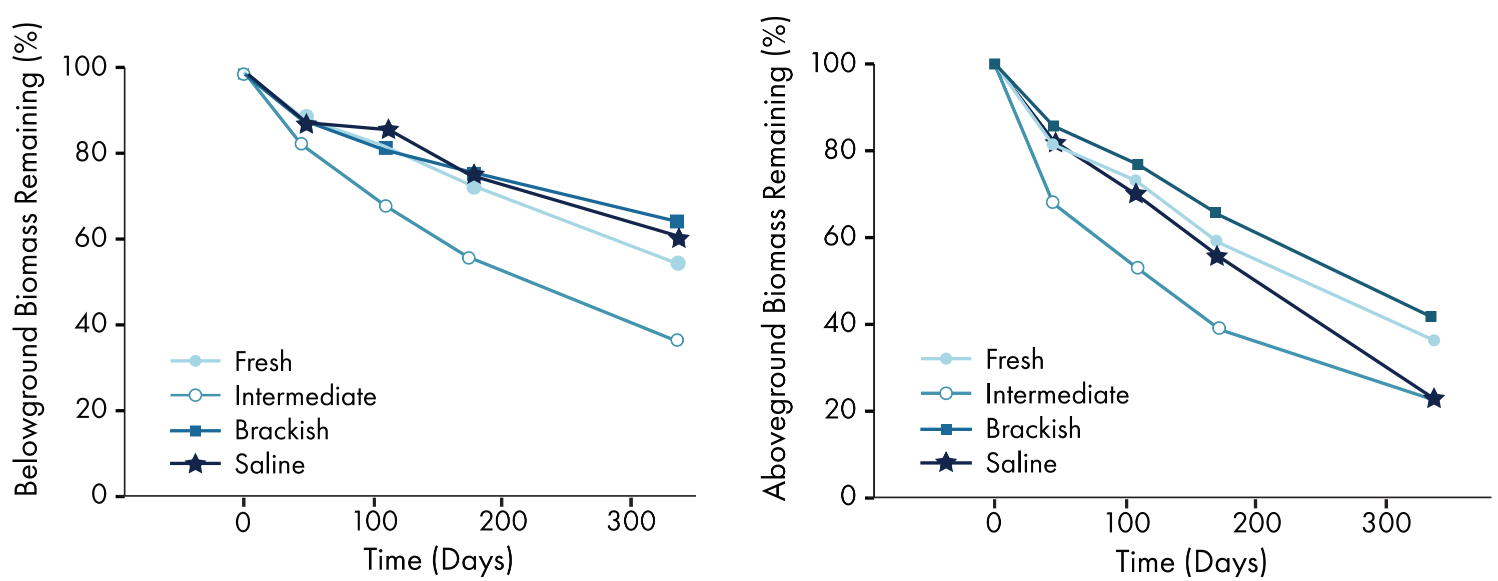
Over time, single litter bags were collected at various intervals to track any change in weight to determine decomposition rates across marsh types, with different types of plant material, and through various environmental conditions. Soil cores from the plots were also taken to measure variables such as soil pH, soil total C, N, P, nutrients, and elements of interest.

WETLANDS CARBON CYCLING



Litter bag that has been dug up from the field

Researchers collecting and freezing litter bags from the field.



ESTIMATES OF (LEFT) BELOWGROUND LITTER BIOMASS OVER TIME, (RIGHT) ABOVEGROUND LITTER BIOMASS REMAINING OVER TIME.

RESULTS

Working in the four marsh types of Louisiana, researchers found that, while salinity was related to decomposition rate of organic matter, the best predictors for both above– and belowground decomposition rates were how much nitrogen and lignin the organic matter contained. The results showing decomposition rates across marsh types improve our understanding of what controls decomposition and shines a light on potential effects of sea-level rise on decomposition. As sea level rises, salinity changes may initially begin carbon decay, but as saline wetland plant communities become dominant, the potential for long term carbon storage will increase.

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MEASURING SHORT-TERM & LONG-TERM
CARBON ACCUMULATION

"Relationships Between Salinity and Short-Term Soil Carbon Accumulation Rates from Marsh Types Across a Landscape in the Mississippi River Delta"

Melissa M. Baustian, Camille L. Stagg, Carey L. Perry, Leland C. Moss, Tim J. B. Carruthers, Mead Allison

Scan the QR code or visit tinyurl.com/shortcarbon to read the full study.

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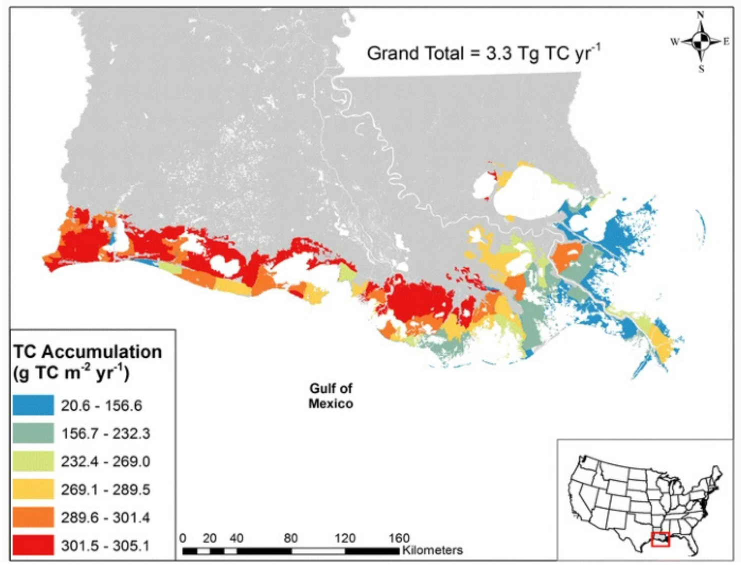
SUMMARY

Coastal wetlands carry significant value when accounting for soil carbon accumulation and burial on a global scale. This importance has only recently been identified with estimates suggesting upwards of one third of the total world's carbon being stored in wetlands (Roulet 2000; Mitra et al. 2005). However, carbon accumulation rates may vary by differences in vegetation and other environmental parameters such as salinity and flood duration and frequency. Data on carbon accumulation rates in various environments can support improved management of the global carbon budget.



MAP OF SHORT-TERM TOTAL CARBON ACCUMULATION RATE ESTIMATES IN THE MARSHES OF COASTAL LOUISIANA, USA, BASED ON PREVIOUSLY MODELED DATA.

METHODS FOR SHORT-TERM

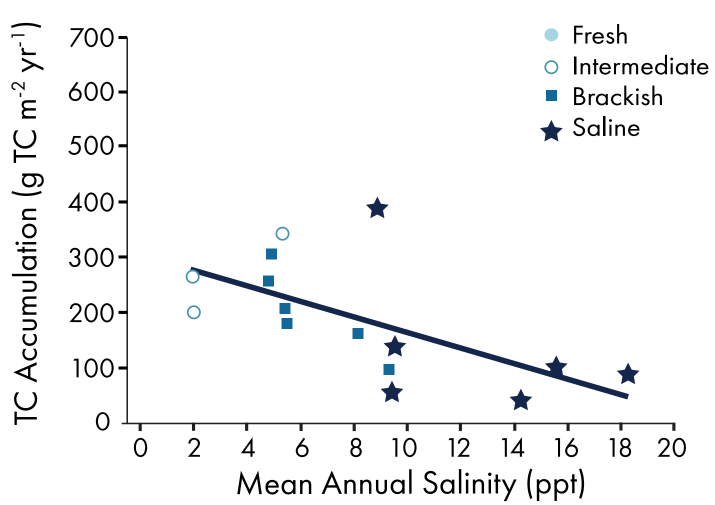
Soil cores 100 cm long were collected from 24 fresh, intermediate, brackish, and saline marshes in the Mississippi and Atchafalaya delta regions of Louisiana. Soil samples were used to determine soil properties such as bulk density and percent organic matter at each site. Percent organic matter was used to calculate percent total carbon (%TC).

At each of the sites, an accretion monitoring plot was established and sampled every six months for 2 years and less frequently thereafter. The carbon accumulation rate (g TC m^{-2} yr^{-1}) was then determined via a pre-established protocol of multiplying the carbon density by the accretion rate.

RESULTS FOR SHORT-TERM

While the soil properties for marsh types differed, the differences in total carbon accumulation rates were not significant between different salinity marshes. However, the surface salinity did have a significant negative relationship with total short-term carbon accumulation rates as seen in the righthand figure.

As salinity in wetlands rises, the amount of organic carbon in soil that can accumulate as a buffer against relative sea-level rise decreases. That also means additional rainfall or freshening of certain wetlands with coastal restoration projects such as sediment diversions being planned for the Mississippi River can help wetlands regain some of this organic storage ability and perhaps give these areas a buffer against succumbing as quickly to higher water levels. Louisiana's coastal marshes accumulate an estimated 5.9 billion pounds of short-term organic carbon every year which is a notable fraction of the world's yearly total carbon accumulation.



SHORT-TERM TOTAL CARBON (TC) ACCUMULATION RATES IN RELATION TO MEAN ANNUAL SALINITY WITHIN FOUR MARSH TYPES.

METHODS FOR LONG TERM

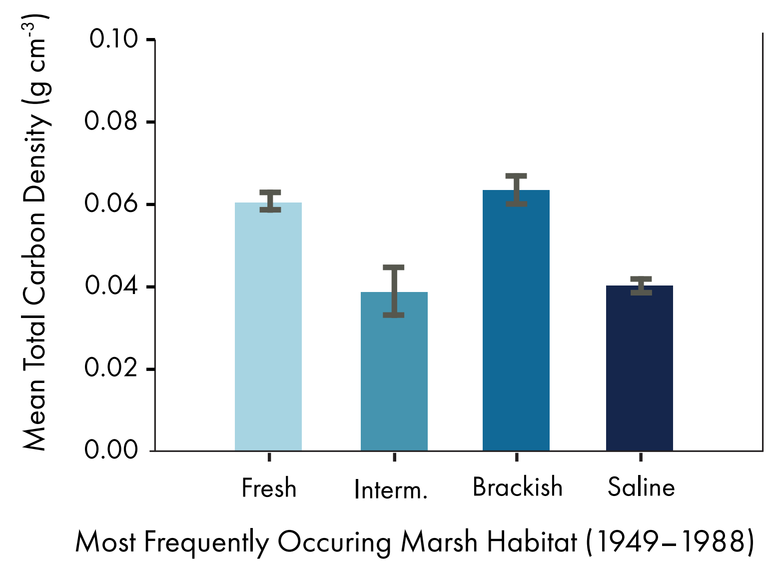
Soil cores 100 cm long were collected from 24 fresh, intermediate, brackish, and saline marshes in the Mississippi and Atchafalaya delta regions of Louisiana. Soil samples were used to determined soil properties such as bulk density and percent organic matter at each site. Percent organic matter was used to calculate percent total carbon.

The carbon accumulation rate (g TC m^{-2} yr^{-1}) was then calculated by radionucleotide (210Pb and 137Cs) dating each sample using known time markers. With these calculations, long-term carbon accumulation rates were determined and validated.

"Long-Term Carbon Sinks in Marsh Soils of Coastal Louisiana are at Risk to Wetland Loss"

Melissa M. Baustian, Camille L. Stagg, Carey L. Perry, Leland C. Moss, Tim J. B. Carruthers

Scan the QR code or visit tinyurl.com/longtermcarbon to read the full study.



MEAN LONG-TERM TOTAL CARBON DENSITY IN SOILS FROM THE FOUR MARSH TYPES.

Soil cores taken to measure carbon accumulation

RESULTS FOR LONG-TERM

Saline marshes trended toward lower mean total carbon density and lower mean long-term carbon accumulation rates relative to other marsh habitats. With the loss of coastal marshes between 1949 and 2013, the long-term TC burial rates were diminished significantly overall. This trend was evident in the Barataria and Terrebonne basins with carbon values declining from 2.3 ± 0.5 to 1.6 ± 0.5 Tg TC yr^{-1}. With no restoration activity and continued land loss, long-term carbon accumulation rates will continue to decline.

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LOOKING FORWARD:
COASTAL CARBON OPPORTUNITIES

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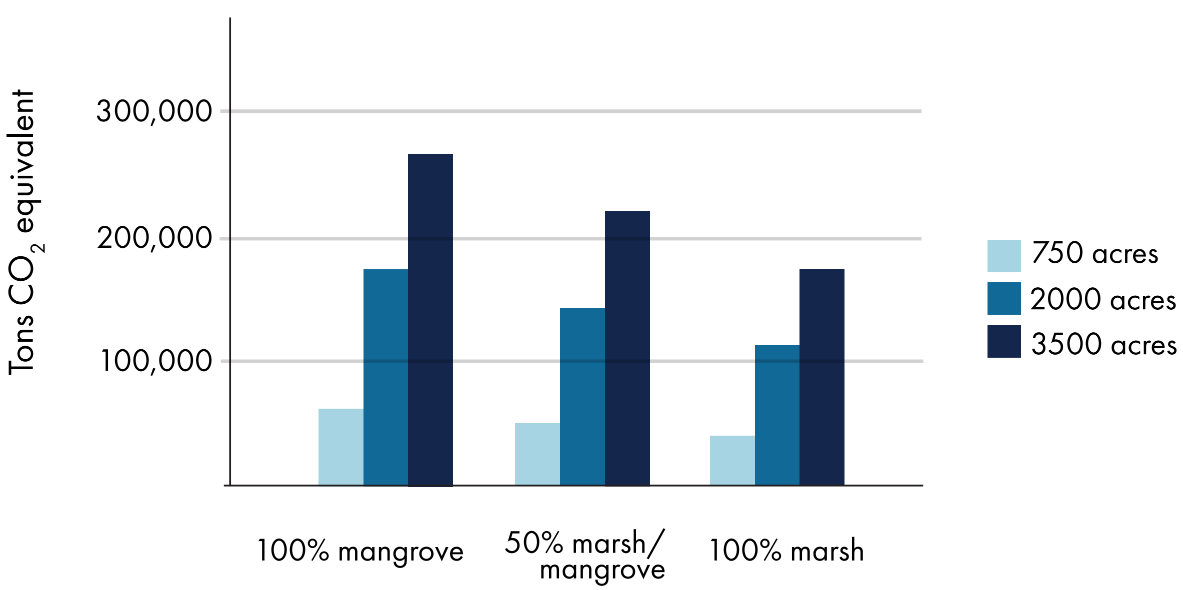
Climate change is currently considered by many to be the most important environmental issue of the 21st century. The climate is changing rapidly, and ecological responses to climate change are already evident. As a low-lying deltaic area with high subsidence rates, Louisiana's coast is among the most vulnerable regions in the world to the effects of climate change. For instance, changes such as sea-level rise, increased intensity of tropical storms, and increased atmospheric carbon dioxide may promote shifts in species dominance of coastal plant communities, which in turn may affect ecosystem processes in coastal habitats with statewide implications for housing, recreation, and economy.

With business-as-usual, subsidence may continue with subsequent loss of marshes resulting in the release of accumulated carbon through soil oxidation and the loss of an active sink for atmospheric carbon. With Louisiana marshes accounting for 5–21%[1] of the annual global carbon burial, the continued loss of Louisiana marshes may alter the global carbon budgets.[1]

However, with further understanding and accreditation, Louisiana marshes provide an economic opportunity in coastal carbon markets. Through further quantification and successful accreditation, Louisiana could become a global asset in the nearly $2 billion global voluntary carbon offset market. No carbon offsets in relation to Louisiana wetlands have been leveraged to date.

The development of a market could additionally present opportunities for large–scale marsh creation that maximizes natural resources. For this to occur, substantial industry-wide collaboration needs to occur to close scientific gaps, incentivize private sector investment, and create a sustainable funding mechanism that supports Louisiana's coast.

CARBON STORAGE OVER 30 YEARS FOR DIFFERENT AREAS OF CREATED LOUISIANA SALINE MARSH[2]



References

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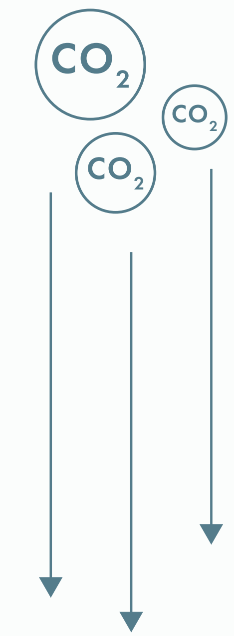
TIDAL MARSH BLUE CARBON IN LOUISIANA

10X FASTER CARBON REMOVAL FROM THE ATMOSPHERE VIA WETLANDS COMPARED TO TROPICAL FORESTS[3]



70X MORE SOIL CARBON CAN BE STORED IN WETLANDS THAN FORESTS[4]

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