Coastal Habitat Protection Plan

VIRTUAL WETLANDS TECHNICAL WORKSHOP SUMMARY

August 19th, 25th, and 26th, 2020

Photo Credit: NCWetlands.org

NORTH CAROLINA
Department of Environmental Quality

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Coastal Habitat Protection Plan Overview

The overarching goal of the Coastal Habitat Protection Plan (CHPP) is the long-term sustainability of productive coastal fisheries through habitat and water quality protection and enhancement efforts and is mandated in the Fishery Reform Act of 1997 (FRA). The FRA statute requires the CHPP be drafted by the NC Department of Environmental Quality (NCDEQ) and reviewed every five years. The CHPP is compiled by NCDEQ staff to assist NCDEQ, Marine Fisheries, Environmental Management, and Coastal Resources commissions in the development of goals and recommendations for the continued protection and enhancement of fishery habitats of North Carolina. The CHPP helps to ensure consistent actions among these commissions as well as their supporting NCDEQ divisions. These commissions shall adopt rules to implement the CHPP recommendations as they relate to each commission's authority.

The 2021 CHPP Amendment focuses on five priority habitat issues. These are:

1. Submerged Aquatic Vegetation (SAV) protection and restoration with an emphasis on water quality improvements
2. Environmental rule compliance to protect habitat and water quality
3. Reducing inflow and infiltration (I & I) associated with wastewater infrastructure to improve coastal water quality
4. Habitat monitoring to assess status and regulatory effectiveness
5. Wetland protection and enhancement with an emphasis on nature-based methods

The 2016 CHPP can be viewed and downloaded here.

This workshop summary addresses the priority of wetland protection and enhancement.

Introduction

Seventy participants from state and federal agencies, non-government organizations, and academia attended a series of three virtual technical workshops on coastal wetlands in August of 2020. Hosted by the CHPP Planning Team, the three workshops were convened to solicit input from coastal and palustrine wetland subject matter experts. The first workshop was titled Coastal Wetland Mapping and Monitoring (August 19th, 2020), the second was Coastal Wetland Threats and Conservation (August 25th, 2020), and the third was Coastal Wetland Restoration and Living Shorelines (August 26th, 2020). Information and input gathered from these workshops will be incorporated into the CHPP 2021 Amendment issue paper, *Wetland Protection and Enhancement, with Focus on Nature-Based Methods*.

As part of workshop preparation, attendees who registered were asked to complete pre-workshop surveys. Results from these surveys were used to help inform in-workshop polling and focus discussions.

The following sections summarize presentations and discussion for each of the three technical workshops of the series. The agendas and presentations can be found here: agenda and presentations.

Attendees

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Photo Credit: C. Currin

Coastal Wetland Mapping and Monitoring

GOAL AND OBJECTIVES

The goal of the Coastal Wetland Mapping and Monitoring Workshop was to identify impediments to mapping and monitoring of NC's coastal wetland resources and identify strategies to obtain this necessary information.

Objective 1: Discuss efforts to develop a comprehensive synthesis of wetland mapping and monitoring efforts in North Carolina

Objective 2: Identify shortcomings of current mapping and monitoring efforts and help rank their relative importance.

Objective 3: Discuss strategies to address high priority wetland mapping and monitoring needs.

PRESENTATIONS

Mapping and Evaluating Wetlands in Coastal North Carolina: Project Overview, Ken Richardson (NCDCM)

This presentation reviewed the methodology and outputs of the most recent coastwide wetland mapping project conducted by the state of NC. This mapping effort included three major components: wetlands mapping inventory, a functional assessment of wetlands (NC-CREWS), and identification and prioritization of potential wetland restoration areas. Mapping covered the 20 coastal counties under Coastal Area Management Act (CAMA) authority, as well as the 17 additional counties in the coastal plain, using 1988 and 1994 data. The inventory was completed using National Wetland Inventory (NWI) maps, Natural Resource Conservation Service (NRCS) soil maps, Landsat 30M TM imagery, and hydrography classifications. Wetland classification was based on Cowardin classifications and included bottomland hardwood, pocosin, pine flat, hardwood flat, headwater swamp, managed pine, freshwater marsh, salt/brackish marsh, estuarine scrub shrub, estuarine forest, maritime forest, and human impacted. Some wetlands were characterized as ditched/drained, cut-over, or cleared. Over 600 verification field visits were conducted to verify the accuracy of remotely sensed (e.g. aerial imagery) data. Accuracy results ranged from 97% in marsh and bottomland hardwoods, to 65-75% in headwater forest, hardwood flats, and management pines. As the minimum wetland size to be included in this assessment was set at one acre, smaller wetlands were not detected and acreage was therefore likely underestimated. Wetlands were characterized by overall functional significance based on water quality, habitat condition, hydrology, and potential risks. Potential wetland restoration sites were also identified. An interactive wetland mapping tool is available online: Wetland Interactive Mapping Tool. While dated, it is still highly used for development, transportation, and land use planning. Updating of these maps by the NCDCM has been a challenge because of a lack of resources to update the wetland maps.

Emerging Technologies in Wetland Mapping and Monitoring, Justin Ridge (Marine Robotics and Remote Sensing Lab, Duke University Marine Lab)

This presentation reviewed several emerging technologies used to map wetlands. Currently there are low/moderate resolution satellite data (Landsat) and aerial imagery (LIDAR) that can be used. Additionally, current practices can be augmented with newer sources of imagery. Unmanned Aircraft Systems (UAS) can produce very high resolution two and three dimensional wetland maps (1-3 cm/pixel RGB; 3-8 cm/pixel multispectral). This allows better edge definition and species differentiation. An upcoming project in NC will be to groundtruth these emerging approaches, verifying the accuracy of several types of 2D and 3D products, and to provide guidance on best practices, reducing the need for

extensive groundtruthing. There are costs associated with purchasing drones and software, but it is not labor intensive and fairly quick. While UAS can provide high resolution imagery, it is not considered practical for coastwide mapping. To overcome this, a technique known as data fusion can use the high resolution UAS imagery to train classifications of lower resolution satellite imagery, such as WorldView (1.24 m resolution) or RapidEye (5.0 m resolution), improving accuracy of habitat classification with the satellite imagery, and is a method to generate 3D data. Another technique known as deep learning neural network uses a time series of satellite imagery to evaluate land cover change in a way that reduces post-processing time and increases speed of map creation. The Duke Marine Lab evaluated change in land cover in the Albemarle-Pamlico region between 1989 and 2011 with Landsat imagery and this deep learning technique. They were able to depict where uplands had transitioned to wetlands. Once proven, this technique could complete automated habitat classifications and change analysis rapidly (1 day of cloud processing). Costs would include hiring or training a qualified data analyst and cloud computing fees. Ridge went over the cost and benefits of the different remote sensing options.

PRE-WORKSHOP SURVEY

A pre-workshop survey was sent to registered participants to 1) build a more comprehensive picture of the current state of mapping and monitoring efforts currently being undertaken in NC; 2) solicit beliefs regarding the greatest barriers to and shortcomings of wetland mapping and monitoring as they relate to the efficacy of coastal habitat management, conservation and restoration; and 3) inquire about suggested approaches to overcome these shortcomings and barriers.

The following results were received.

Pre-survey Question: Briefly list any efforts you or your organization are currently undertaking to map and/or monitor NC's coastal wetlands (estuarine and freshwater in the coastal plain).

- NC NERR Sampling
- PKS Aquarium & Teddy Roosevelt Natural Areas
- Trent River Watershed
- Natural Heritage Program Mapping
- Drones to Delineate Salt Marsh Upland Boundary (location unspecified)
- Marine Robotics and Remote Sensing Lab Using Drones, Satellite Imagery, and Deep Learning to Map Wetlands Along NC Coast

Pre-survey Question: <u>Barriers or shortcomings</u> to estuarine and freshwater wetland <u>mapping</u> include: insufficient frequency, accuracy, funding, imagery resolution to differentiate habitat type, delineating edge, and identifying species. Are there other barriers you are aware of?

- Delineating salinity zones with remote sensing
- Delineating hydrological regimes with remote sensing
- Determining soil thickness from remote sensing
- Determining wetland function from maps
- Accurate tide level information during image acquisition
- Insufficient field validation
- Lack of standard mapping protocol
- Insufficient NCDEQ staffing to conduct mapping and compile data
- Lack of centralized repository
- Insufficient collaboration between groups conducting mapping

Pre-survey Question: Please list any recommendations you have to address the shortcomings of current mapping efforts?

- Increased collaboration to address duplicative and nonintegrated efforts via steering committee or Wetland Mapping Coalition
- Standardized mapping protocol
- Frequent communication of mapping needs to facilitate adaptive management
- Increased funding for mapping and ground trothing
- Leveraging citizen scientists
- Legislative mandate to reconcile and integrate collection platforms, collection systems, & datasets (Centralized repository)
- Outreach highlighting community resilience implications of impacts to wetland resources → increased funding

Curt Weychert with NCDCM reviewed the pre-survey results. Responses regarding current mapping and monitoring efforts were somewhat general. Weychert reviewed additional coastwide mapping and monitoring efforts that were not captured in the pre-survey. Two national wetland mapping datasets include the National Oceanic and Atmospheric Administration's (NOAA) Coastal Change Analysis Program (C-CAP) and United States Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI). The NCDWR conducts wetland monitoring throughout the state for various sampling durations. Additionally, NC's coast is a NOAA Sentinel Site Cooperative, with a total of 125 Surface Elevation Tables (SETs) to assess sea level change. Through this effort, data are collected on water level, vegetation, water quality, and meteorology. After discussing the answers to the pre-workshop survey questions the following poll questions were asked and subsequent discussion followed.

MEETING POLL QUESTION AND DISCUSSIONS

Please select the three (3) greatest barriers or shortcomings of, estuarine and freshwater wetland mapping.

Choices	Results
Lack of funding (grant and legislative)	52%
Insufficient spatial resolution of remotely sensed data	27%
Limited collaboration	27%
Lack of standardized mapping protocol	25%
Insufficient temporal resolution of remotely sensed data	19%
Lack of centralized data repository	19%
Impediments to remotely sensing (salinity, hydrology, soil thickness, etc.)	19%
Limited field validation	17%
Impediments to inferring function	0%
No Answer	29%

Please select the three (3) actions that would provide the greatest benefit to wetland mapping and its use in effective management and conservation.

Choices	Results
Increased funding for mapping and groundtruthing (grant and legislative)	65%
Increased collaboration via steering committee or mapping coalition	49%
Creation of centralized data repository	29%
Outreach highlighting community resilience implications of impacts to wetlands (justifying funding)	29%
Standardized mapping protocol	25%
Greater communication of urgent mapping needs for management	24%
Leveraging citizen scientists	8%
No Answer	4%

Mapping Discussion

Funding, insufficient spatial resolution of remotely sensed data that are currently easily available to agencies, limited collaboration, and lack of standardized protocols were identified as the most impactful barriers to or shortcomings of coastal wetland mapping by workshop participants. The top actions needed to address these shortcomings and improve our wetland mapping included securing funding, increasing collaboration through an interagency mapping committee, creating a centralized repository of wetland mapping products and metadata, and conducting outreach to highlight the need for wetland mapping to link between addressing wetland impacts to increase community resiliency.

It was noted that to increase funding, lawmakers and decision makers need to understand the benefits of mapping and how that information can address important management issues such as flooding and water quality issues, as well as fish habitat protection and restoration. If the outreach message is from a CHPP perspective, it should focus on key fishery needs. Protecting, restoring and/or replicating watershed hydrology is a critical need from a fisheries viewpoint, as well as protecting critical wetland habitats that provide nursery or water quality benefits. This emphasis for the CHPP may be more relevant than focusing on resiliency of coastal development.

There was discussion regarding wetland vulnerability research and how wetlands contribute to coastal resiliency. Katy Warnell (Duke University) noted that there is vulnerability mapping, but it is somewhat coarse. Updated coastwide mapping (referred to as wall to wall) would be helpful for statewide assessments and planning related to sea level rise and marsh migration, and that could be incorporated with other habitat priorities to target protection measures. The United States Army Corps of Engineers (USACE) is also doing some vulnerability work in the southeast.

Several participants discussed collaborating with NC managers regarding wetland mapping. In particular, NOAA's C-CAP is a long running program, that can be used synergistically with other mapping data. It is an incredibly powerful and spatially comprehensive approach; however, its resolution (30m X 30m pixel size) limits fine scale change analysis and attribution. A NOAA C-CCAP representative mentioned pilot projects with 1m pixel resolution and discussion opportunities to have NC participate in this pilot program. Additionally, the value of collaboration between NC state agencies and NOAA C-CAP was universally embraced.

Using multiscale mapping would be an efficient and powerful approach. Comprehensive mapping combined with more site-specific high resolution mapping would reduce the frequency needed for wall to wall mapping. The National Estuarine Research Reserves (NERRs) are using drone imagery that could be used to train software for auto-delineating satellite imagery for that type of multiscale mapping.

There was agreement that combining sentinel site monitoring with levels of scaled mapping would be a good idea. The NCDWR has a one year grant to assess remote wetland mapping methods statewide.

Citizen science was suggested as a means to obtain field observations on wetlands and basic water quality data to assist with mapping via remote sensing data.

Participants noted that marsh monitoring has shown changes in marsh species composition and that not all marshes are keeping up with sea level rise. Mapping could capture those changes on a larger scale.

What are the three (3) greatest barriers to, or shortcomings of, estuarine and freshwater wetland monitoring?

Choices	Results
Insufficient NCDEQ staffing and funding for monitoring	44%
Duplicative and nonintegrated efforts (lack of collaboration/communication)	31%
Insufficient spatial resolution (too few sentinel sites)	29%
Lack of centralized database	21%
Insufficient temporal resolution	19%
Lack of training and monitoring equipment for standardized monitoring	17%
Piecemeal assessments of wetland function	15%
Insufficient grant funding	15%
Limited access to private lands	13%
Destructive sampling techniques and incidental sampling impacts (trampling)	2%
No Answer	27%

Please select the three (3) actions that would have the greatest benefit to wetland monitoring and its use in effective management and conservation

Choices	Results
Increased funding for monitoring (grant and legislative)	64%
Increased collaboration via steering committee or mapping coalition	57%
Centralized data repository creation	32%
Outreach highlighting social and ecological benefits of wetlands (justifying funding)	32%
Development of standardized monitoring requirements for state-funded restoration	25%
Expanded sentinel site network	18%
Increased use of citizen scientists	9%
Increased availability of training and monitoring equipment for standardized	7%
No Answer	18%

Monitoring Discussion

Participants identified insufficient funding and staff, duplicative or non-integrated efforts, and insufficient spatial resolution (not enough sentinel sites) as the most pressing shortcomings to effective wetland monitoring to inform management. The top actions needed to improve wetland monitoring included securing greater funding, increasing collaboration through a steering committee, creating a central repository for data or monitoring results, and outreach highlighting the social and ecological benefits of wetlands.

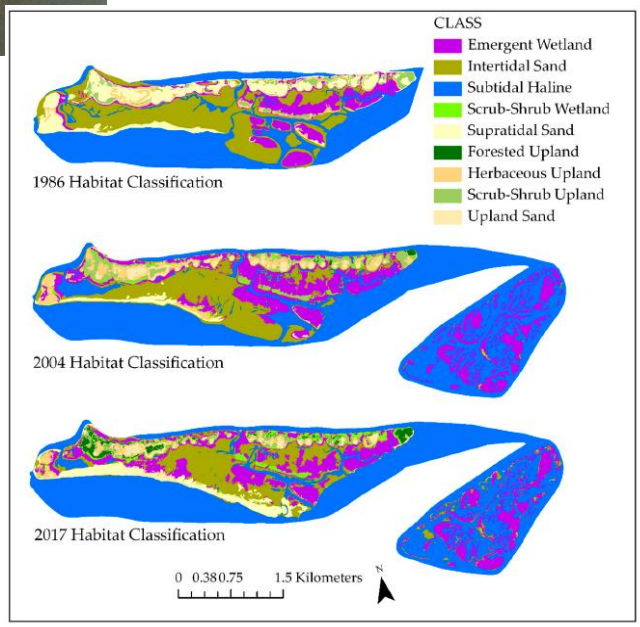
One common message was that standardizing metrics is challenging due to different project objectives. EPA has nationwide monitoring that is completed on five-year cycles using standardized methods and may be worth reviewing. Additionally, National Fish and Wildlife Foundation (NFWF) has established standardized monitoring protocols for NFWF funded restoration projects and are currently working on

establishing a repository. Participants discussed that it was more important to have a repository for project summaries, reports and data, rather than a standard database because of the challenges of standardizing data. A central repository is particularly important for restoration projects because you need to be able to demonstrate successful techniques and results to justify future funding. Before doing this, it is important to identify the user and purpose.

Another justification for comprehensive wetland monitoring is to provide status and trends that in turn aid in targeting implementation of watershed restoration and management plans. Actionable watershed restoration plans would benefit not only wetlands, but other CHPP habitats such as SAV and oyster reefs.

Communicating the benefits of monitoring, especially in a fisheries context, is essential since that provides information to identify and address wetland threats, conservation, restoration, and outreach on ecosystem services. Identification of end users prior to setting protocol for standardized mapping and monitoring was highlighted as imperative to the utility of mapping and monitoring data for effective management.

Photo credit: NOAA Beaufort Marine Lab



Source: Gray et al. 2018

Coastal Wetland Threats and Conservation

GOAL AND OBJECTIVES

The goal of the Coastal Wetland Threats and Conservation Workshop was to identify current and emerging threats to estuarine and palustrine wetland resources in the coastal plain, build consensus around which threats most urgently need to be addressed, and identify strategies to conserve North Carolina's wetlands (acreage and function).

Objective 1: Discuss and rank threats to estuarine and freshwater wetlands in the coastal plain.

Objective 2: Discuss management actions, policy actions, and outreach strategies to further estuarine and palustrine wetland conservation and protection.

PRESENTATIONS

North Carolina's Coastal Freshwater Wetlands: Caught in the Middle, Amanda Mueller (NCDWR)

This presentation summarized the threats to freshwater wetlands, reviewed regulatory authority for wetland impacts, and gave an overview of mitigation trends. The major threats to freshwater wetlands include: development, invasive species, litter and dumping, logging and farming, saltwater intrusion, sedimentation, stormwater runoff, and water level changes. As sea levels rise, coastal wetlands will naturally migrate inland given space to do so. Coastal development has removed many of these natural "migration corridors" and, as such, coastal wetlands are increasingly subject to "coastal squeeze" between rising oceans and developed land blocking their landward migration. As shown by a study in Smith and Town creeks, emergent wetlands are migrating through time. The NOAA C-CAP data show changes in NC coastal plain palustrine wetlands with declines from 1996 through 2011 and a slight increase from 2011 to 2016. These changes in wetlands depend on topography, drainage features, hardened structures, land use and property protection, plant rejuvenation and seeding rate. Estuarine wetland change, which small scale studies have documented as a result of saltwater intrusion and erosion, failed to be captured by NOAA C-CAP data, largely because of its 30x30m resolution pixel. Because of this, higher resolution mapping is needed to track smaller scale changes, particularly as they accelerate into the future if action is not taken.

The agencies that regulate NC wetlands were described. First, the USACE section 404 of the Clean Water Act (CWA), section 10 of the Rivers and Harbors Act, and the changes to the Waters of the United State (WOTUS) were reviewed. The Navigable Waters Protection Rule uses the same USACE definition of wetlands, but has redefined WOTUS based on direct hydrologic surface connectivity. Therefore, a wetland must abut or have a direct surface water connection with a territorial sea or traditional navigable waters; tributaries to those waters (perennial or intermittent); and lakes, ponds, and impoundments of jurisdictional waters. As a result, previously jurisdictional wetlands and streams that do not meet the requirements of surface water connectivity to other jurisdictional waters will no longer be considered jurisdictional. Floodplain pools, pine flats, pine savannas, non-riverine swamp forests, seeps, headwater forests, bottomland hardwood forests, basins, and bogs are some of the wetland types that may be affected by this jurisdictional change, regardless of subsurface flow connection. Ditches are only jurisdictional if they are navigable, or are relocated or constructed in an intermittent or perennial stream or an adjacent wetland. A study of 163 NC WAM Reference Wetlands (from specific projects, not randomly selected) showed that jurisdiction would be lost for 29.3% overall, and 17% in the coastal plain (Dorney 2020).

Next, the authority the state agencies have over wetlands were reviewed. The Coastal Area Management Act (CAMA), NC Dredge and Fill Law, and coastal development rules are under the

authority of NCDCM, and NCDWR has authority over section 401 of the CWA, as well as NC Administrative Code (15A NCAC 02B and 02H, which includes the buffer rules), and session laws including isolated and other non-404 jurisdictional wetlands and water permits.

The number of approved permits by impact (wetlands, streams, buffers) over time was discussed with approved permits with wetlands impacts spiking in 1995 and 2000 before steadily decreasing since 2007. A similar trend is seen in the total acres of approved wetlands impacts. However, the primary impact types have changed over the years. In the 1990s, most impacts were attributable to dredging followed by water dependent structures (marinas, docks, bulkheads), with a huge increase in mining impacts in the 2000s, largely attributed to PCS Phosphate Mine. Since 2010, most impacts have come from transportation. The amount and types of mitigation for wetlands impacts have also changed over time. On site mitigation has largely been replaced with the use of mitigation bank credits and the NC Division of Mitigation Services (NCDMS) in-lieu fee program. The presentation concluded with ways to conserve freshwater wetlands including avoidance and minimization (requires the identification of threatening activities), preservation, enhancement, and allowing room for change.

After the presentation, there was discussion about tracking impacts and restoration. Currently, NCDEQ does not keep track of acres of wetlands restored that are not linked to compensatory mitigation. Participants spoke about a workgroup (SNAPP) formed to create a database of all habitat restoration projects funded by Federal agencies (e.g. USFWS, EPA, NOAA, NFWS, USDA) in all coastal counties of the United States. Wetland specific projects are summarized in a recent paper by Gittman et al. A manuscript synthesizing all coastal habitat restoration and the corresponding database is expected to be published this year. It is organized at the county level and one is being developed for federally funded living shorelines as well. Participants inquired about tracking how mitigation bank use aligns spatially with where impacts are occurring and equivalency of impacted wetland type and the type of wetlands in the mitigation bank. Currently what mitigation bank is used is not being tracked by NCDWR because is a part of the permit, and the applicant has to include an acceptance letter from the mitigation bank or NCDMS. However, NCDMS does track location and impact type for permitted impacts when implementing mitigation projects. They have service areas that are typically at the 8-digit Hydrologic Unit Code (HUC) scale and also mitigate for riparian and non-riparian wetland impacts. If mitigation from a bank is purchased, the restoration needs to fall within the restrictions that would be used for implementation (service area and wetland type).

North Carolina's Salt Marshes: Threats and Conservation Opportunities, Carolyn Currin (NOAA NCCOS)

This presentation summarized the major threats to NC's salt marsh including drought, increasing relative sea level rise (SLR) attributed to climate change, and erosion. A study in New River at Camp Lejeune showed a significant decline in smooth cordgrass (*Spartina alterniflora*) biomass in 2011 to 2012 after a period of severe drought. The study concluded that high salt marshes are subject to long-term die off from drought events.

Next, the salt marsh response to relative SLR was discussed. For salt marshes to persist as SLRs, they must keep up by accreting sediment or move up through transgression. A study was conducted at several (30+) Surface Elevation Table (SET) locations to compare the rate of sediment accretion to SLR. It was found that all but two sites in the study are not showing sufficient increases in surface elevation change from sediment accretion to keep up with relative rates of SLR. Put more pointedly, most of NC's saltmarshes (*Spartina* sp.) below mean sea level are drowning in place. The marsh grass exhibits peak biomass at mean sea level which correlates with peak sediment accretion. Several studies have looked at salt marshes ability to transgress or migrate in response to SLR. It has been shown that predicted marsh migration varies by slope and rate of SLR. On the New River at two sites near Camp Lejeune

without any impediments to marsh transgression, topography was found to influence species change and the rate of marsh expansion. It is critical to have available migration corridors to maintain marsh habitat at sea level increases. A study in the Chesapeake Bay found that, without impediments to marsh migration, 94 km^2 of drowned/eroded marsh was replaces by 101 km^2 of new marsh in the uplands over the last century. Looking at a study in Carteret County, NC marsh landward expansion was documented at half of the sites without bulkheads, but only 16% of those sites maintained areal extent. Sites with bulkheads had no landward expansion and three times higher net loss of salt marsh area.

Erosion of the salt marsh was discussed next. Fringing salt marshes occupy 65% of the NC estuarine shoreline making up ~8,000 miles of marsh. Marsh shoreline erosion rates generally decrease from large bodies of water, as in Pamlico Sound, to narrower bodies, such as the New River Estuary, although features other than fetch contribute to variation in erosion rate. Studies have shown that erosion is the greatest during mid to low-tide periods, when the marsh edge is exposed. Marsh shorelines are generally resilient to hurricanes, as the water overtops the marsh and wave energy does not reach marsh sediment surface. A ramped marsh edge is better at minimizing erosion impacts than a scarped marsh edge. Sea level rise, wave energy, erosion rates, and storm activity are all projected to increase into the future, and conservation actions should plan for future conditions.

PRE-WORKSHOP SURVEY

A pre-workshop survey was sent to registered participants to help determine the most concerning threats to both freshwater and estuarine wetlands as well as to determine what conservation efforts may help address these threats. The following are the answers received, with some consolidation.

List the three (3) greatest current/future <u>threats</u> to <u>estuarine</u> wetlands.

- Sea Level Rise (SLR)
- Development and the direct impacts to wetlands
- Altered levels of precipitation and associated storm events caused from climate change
- Pollution/ degradation of water quality (storm water runoff, eutrophication, ditching, etc.)
- Human -induced erosional processes
- Lack of migratory corridors
- Regulatory failures
- Lack of conservation and restoration
- Invasive species
- Water table drawdown
- Human-induced changes in sediment supply

Identify up to three (3) management, policy, or outreach <u>strategies</u> that you feel are the most needed to address those threats to <u>estuarine</u> wetlands.

- Improve coastal planning specifically to allow for marsh migration
- Stronger regulatory protections for coastal wetland impacts
- Improve outreach efforts to inform the public of the importance of coastal wetlands
- Increase land acquisition for conservation
- Increased education for coastal landowners regarding low-impact development options
- Increased funding for monitoring
- Infrastructure upgrades for coastal resiliency
- Outreach and aid to land managers and owners to control *Phragmites* invasion
- Research to improve *Phragmites* control while limiting collateral damage

- Require mitigation for development impacts to coastal wetlands
- Identifying "at-risk" wetland areas and giving them special protection
- Regular wetland inventories
- Changing perspectives on natural vs developed shorelines

List the three (3) greatest current/future threats to freshwater wetlands.

- Sea level rise (SLR)/ salinity conversion
- Direct loss due to development
- Pollution/ degradation of water quality (storm water runoff, eutrophication, ditching, etc.)
- Land use changes
- Policy which allow for the destruction of wetlands
- Altered levels of precipitation and associated storm events caused from climate change
- Water table drawdown
- Invasive species
- Lack of conservation of lands to allow for migration
- Lack of controlled burning
- Animal pollution – Confined Animal Feeding Operation (CAFO)
- Silviculture

Identify up to three (3) management, policy, or outreach strategies that you feel are the most needed to address those threats to freshwater wetlands.

- Public information campaign and policy changes that acknowledge and value their ecosystem services
- Stronger regulations and enforcement
- More monitoring to detect change
- Better coordination amongst state and federal agencies for creating policies that will protect freshwater wetlands
- Increase public engagement
- Watershed planning
- Increase funding for monitoring
- Restoration of freshwater wetlands
- Fund research to better understand how to best manage invasive species
- Limit tree removal
- Active restoration in areas where these wetlands would otherwise transition to in the absence of human created barriers
- More closely manage ditch construction to account for up and down stream impacts
- Incentivize more controlled burning for pocosins and other headwater wetlands through which fire is ecologically essential but very difficult

MEETING POLL QUESTIONS AND DISCUSSIONS

After reviewing the answers to the pre-workshop survey questions the following poll questions were asked and subsequent discussion followed.

Select the three (3) greatest current/future threats to estuarine wetlands.

Choices	Results
Impacts from increase SLR	57%
Development and the direct impacts to wetlands	48%
Pollution/degradation of water quality (storm water runoff, eutrophication, ditching,	28%
Lack of migratory corridors	28%
Altered levels of precipitation and associated storm events caused from climate	24%
Human-induced changes in sediment supply	17%
Lack of conservation and restoration	11%
Human-induced erosional processes (e.g. boat wakes)	9%
Regulatory failures	7%
Invasive species	4%
Water table drawdown	0%
No Answer	22%

Participants discussed a wide range of concerns about threats and solutions to wetland protection. Extreme high tides and king tides are increasing in frequency and this is beginning to impact upland marsh as well as the marsh edge. Sea level rise may be seen as a double edged sword. It can be detrimental to community resilience but it may also result in an increase in wetlands through conversion of uplands or freshwater wetlands as groundwater levels and saltwater intrusion increase. Also, all the ditches/canals dug over the past 400 years will increase the range and rate of salt water intrusion and become corridors for migration. While existing marshes will drown, especially if SLR goes up dramatically, there may be a net increase in wetlands. Increase in marsh area due to SLR will only be feasible if migration corridors remain undeveloped. Prior converted wetlands are eligible for wetland restoration funding through the Federal Farm Bill and represent a large acreage potential near estuaries for wetland migration. Sea level rise acts synergistically with other stressors, and together, there is potential to push existing marshes over a tipping point into an alternative stable state. As such, it is important to acknowledge that the impacts of SLR are complex and thoughtful strategies are needed to address its impacts. Sea level rise threat encompasses the scale of the threat and multiplies the other challenges facing marshes individually to keep up with our "new normal".

Palustrine wetlands are caught in the middle and may be the most threatened by SLR, as these wetlands may convert to estuarine wetlands or become lost to development. They are afforded fewer protections than their estuarine counterparts and have historically been subjected to greater loss to development. It was noted that the definition change for WOTUS will have huge impacts on freshwater wetlands, as well as estuaries, since headwater wetlands protect the hydrology and water quality needed for estuaries. The state of NC joined a lawsuit opposing the new rule.

Remote sensing data looking at wetland change in the Albemarle-Pamlico peninsula showed that wetland areas almost doubled from 1989 to 2011; but scientists think they will start seeing some of those "tipping point" impacts in the more recent data. Group comments suggested a lot of the increase was due to conversion of palustrine wetlands, prior converted wetlands, and forest.

Identify up to three (3) management, policy, or outreach strategies that you feel are the most needed to address threats to estuarine wetlands.

Choices	Results
Improve coastal planning specifically to allow for marsh migration	60%
Increase land acquisition for conservation	34%
Stronger regulatory protections for coastal wetland impacts	32%
Identifying "at-risk" wetland areas and giving them special protection	28%
Require mitigation for development impacts to coastal wetlands	15%
Increased education for coastal landowners regarding low-impact development	13%
Improve outreach efforts to inform the public of importance of coastal wetlands	13%
Regular wetland inventories to support policy and management	13%
Changing perspectives on natural vs developed shorelines	11%
Infrastructure upgrades for coastal resiliency	9%
Research to understand merits for Phragmites control	4%
Outreach and aid to land managers and owners to control Phragmites	0%
No Answer	23%

The question of how to identify vulnerable wetlands was asked. Katie Warnell (Duke University) spoke to the coastal habitat vulnerability models they have worked on for marsh migration corridors, protected areas, land use outside the protected areas, and what areas will be altogether lost in the future. It is currently being updated to include the northern region of NC and there have been conversations with the Albemarle-Pamlico National Estuary Partnership (APNEP) about cross state planning with Virginia. The model does not include the NC/SC data, but it is available and can be modeled. The simultaneous localization and mapping (SLAM) models for migration corridors were also mentioned.

The discussion then turned to how to prioritize vulnerable areas as well as what metrics are required and what is the best approach to use in the prioritization of wetlands. Conservation criteria development is needed to focus on the marsh condition with elevated diversity in order to achieve the best bang for the buck with limited conservation and restoration resources. The approached used to identify and delineate Strategic Habitat Areas (SHAs) was suggested as a model for identifying priority wetlands.

It was mentioned that "prior converted cropland" is eligible for and has been the focus of wetland restoration funded through the Federal Farm Bill. These degraded wetlands (or currently non-wetlands) would not rank high on current wetland values, but by acreage represent the biggest potential near our estuaries for allowing wetlands to migrate in the future.

As SLRs, estuarine wetlands will migrate inland as will freshwater wetlands. Higher sea levels increase the groundwater levels upstream as natural and human-created drainage becomes less effective. Better documentation of the influence of rising sea level on ground water levels in the 12-digit watersheds adjacent to our estuaries is needed to fully understand this relationship. It is suspected we will see a surprising increase in freshwater wetland acreage from SLR.

Thin layer deposition was discussed as a possible solution to save drowning marshes but comes with several concerns. Some studies from other southern and gulf states suggest mixed outcomes, ranging from beneficial to accelerated degradation of marshes. As such, there appears to be a need for greater study of how thin layer deposition practices interact with marsh properties to influence outcomes and improve overall understanding on how to be successful with this technique. Another issue that was raised was the question of whether suitable sediment from dredge projects are even sufficient to

provide the volume of sediment that would be needed if thin layer deposition was embraced as a strategy.

Below are the responses to in-workshop polling questions in which participants were asked to identify the greatest current and future threats to freshwater wetlands and strategies to address these threats:

Select the three (3) greatest current/future threats to freshwater wetlands.

Choices	Results
Sea-level rise /salinity conversion	50%
Direct loss due to development	41%
Pollution / degradation of water quality (i.e. stormwater runoff, eutrophication,	35%
Lack of conservation of lands to allow for migration	24%
Land use changes	24%
Policies which allow for the destruction of wetlands	22%
Water table drawdown	9%
Altered level of precipitation and associated storm events cause from climate change	7%
Invasive species	4%
Silviculture	4%
Lack of controlled burning	2%
Animal pollution (CAFO)	0%
No Answer	26%

Below are the responses to in-workshop polling questions regarding strategies to address threats to freshwater coastal wetlands:

Identify up to three (3) management, policy, or outreach strategies that you feel are the most needed to address those threats to freshwater wetlands.

Choices	Results
Stronger regulations and enforcement	45%
Better coordination amongst state and federal agencies for creating policies to protect freshwater wetlands	38%
Public information campaign and policy changes that acknowledge their ecosystem	30%
More monitoring to detect change	26%
Watershed planning	26%
Active restoration in areas where wetlands would otherwise transition in the absence of human created barriers	17%
Restoration of freshwater wetlands	15%
Incentivize controlled burning for pocosins and other headwater wetlands where fire is ecologically essential	11%
More closely managed ditch construction to account for stream impacts	4%
Research to better understand how to best manage invasive species	2%
Limit tree removal	0%
No Answer	28%

The changes to WOTUS is a major threat to freshwater wetlands and our estuaries if we do not protect the hydrology in headwater wetlands. If that lawsuit is not successful, state level safeguards will be needed to address this threat. The Hardison Amendment, which specifies that environmental regulations be no more restrictive than Federal laws represents a legal impediment to state level protections against the deleterious effects of changes to WOTUS.

NOAA C-CAP data shows approximately 100,000 acres of palustrine wetland loss since the inception of C-CAP data. The conversions contributing to this loss have changed over time, with development accounting for the majority in the early years and conversion to estuarine or other wetlands types accounting for 90% in the most recent 5-year period. It is important to understand what is contributing to the losses in order to craft management and policy approaches to address them. Importantly, palustrine wetlands are a lot less homogenous than estuarine wetlands and there is a need to look at whether losses have been evenly experienced across all palustrine wetland types. Very preliminary analysis suggests that this is not the case and losses much larger than 100,000 acres of forested palustrine wetland have been offset by gains in other types of palustrine wetlands. This will have implications for services and function as each palustrine wetland type is not functionally equivalent. The management of these lands and the management of invasive species may be a crucial part of that functional outcome. There was further discussion about the need for higher resolution data in order to determine the types of actions (e.g. ditching, draining, filling) leading to the palustrine wetland conversions. Managing ditches to slow the transition to estuarine and conserve palustrine wetlands is a tool to address wetland restoration strategies.

Photo Credit: M. Burchell

Coastal Wetland Restoration and Living Shorelines

GOAL AND OBJECTIVES

The goal of the Coastal Wetland Restoration and Living Shorelines Workshop was to identify strategies to enhance restoration and protection of wetlands, wetlands hydrology, and increase resiliency of estuarine and palustrine wetlands through the use of living shorelines and other nature-based features.

Objective 1: Discuss strategies for prioritizing locations and methods for wetland restoration.

Objective 2: Learn about and discuss efforts needed to promote greater use of living shorelines.

PRESENTATIONS

Beneficial Use of Dredged Sediments for Coastal Marsh Restoration, Jenny Davis (NOAA NCCOS)

The presentation summarized efforts in coastal wetland restoration using beneficial use of dredged materials along the NC and Chesapeake regions. In eastern NC, thin layer disposal of dredge spoil was used to raise the surface elevation of various vegetated and unvegetated marsh habitats. Several methods and locations of beneficial use were investigated as potential solutions to address SLR, shoreline erosion, wetland protection and resiliency.

With supplemental marsh plantings, various sites exhibited a higher biomass per area in treatments of thin layer disposal compared to control sites. The presenter pointed out the need to investigate the ideal vertical height to achieve the highest biomass in vegetation. The presenter also discussed the challenges in developing effective methods of beneficial use of dredge spoil, pointing out the need for appropriate sediment size and texture, dewatering techniques, and the feasible distances in which this method can be used from a dredge area (<5 miles). The two main habitats investigated using beneficial use of dredged material were existing marshes potentially threatened by SLR and fragmented marsh habitat. In both cases beneficial use was successful to either increase or create marsh habitat. While concerns were raised as to the habitat value of marsh ponds and low-elevation inundated marshes, particularly for fisheries, the presenter acknowledged that these instances were a habitat tradeoff and decisions need to be made as to the siting of such projects.

The other example of beneficial use of dredged material was in the Chesapeake Bay, in which its beneficial use in shoreline protection and resiliency was investigated. An eroded marsh island adjacent to a coastal community utilized material from a dredged navigational channel to restore multiple habitats on the island within the islands historic footprint. The project achieved raised elevations along the island and reduced wave action from wind-driven waves.

Discussion after the presentation investigated the potential difficulties around permitting, scope, and scale of beneficial use projects. There was discussion about the value of restoring mosquito ditches or marsh ponds that fragment marshes. While that may be beneficial to offsetting marsh loss, it was noted that some less common estuarine fish such as marsh killifish and spotfin killifish prefer the salt marsh pools, and is excellent habitat, so there would be a habitat trade-off. The attendees all agreed that research drives policy and further investigation is needed on beneficial use projects - specifically, habitat tradeoffs, cost-benefit analysis, material compatibility, and long-term project success.

Increasing the Use of Living Shorelines to Protect and Restore Coastal Wetland Habitat in North Carolina, Lexia Weaver (North Carolina Coastal Federation)

A thorough history of living shorelines in NC was provided. The ecosystem services, efficacy, cost effectiveness, resiliency, water quality benefits, habitat, and aesthetics were clearly pointed out through work and research done by the NC Coastal Federation (NCCF) as well as peer reviewed literature specific to NC sites.

The presenter reviewed the various methods and materials used to effectively create living shorelines across the coastal regions of the state. Several site studies showed the efficacy and resilience of living shorelines when compared to hardened shorelines after severe storm conditions. Living shorelines at various sites showed less shoreline erosion when compared to other shoreline stabilization methods immediately adjacent to living shorelines.

The presenter discussed the importance and success of outreach to increase the use of living shorelines along public and private coastlines. Through work with local government, public agencies, as well as individual coastal property owners and home owner associations, the use of living shorelines has increased. Outreach workshops have been offered to marine contractors and developers in an effort to educate and inform industry of the benefits and successes of living shoreline construction. Efforts in expedited permitting and reduced permit costs have also reduced the time and costs necessary to create living shorelines. Through grant assistance, living shoreline projects can be a less costly method of shoreline stabilization compared to traditional methods and require little to no maintenance.

The presenter identified that much of the needed steps to further advance living shorelines has been identified by the Living Shoreline Steering Committee and the NC Coastal Federation 2015-2020 Oyster Blueprint. The upcoming 2021-2025 Oyster Blueprint will include a living shoreline strategy with recommended actions that benefits both oysters and shoreline protection. It addresses needs for increasing use of living shorelines in the future, including strong promotion of living shorelines by regulatory and resource agencies, financial incentive and grant programs, short-term construction insurance, more awareness and adoption of living shorelines by the public and marine contractors, and business programs for marine contractors.

Discussion after the presentation consisted of collective thinking regarding incentives versus disincentives and strategies to encourage use of living shorelines. The group agreed that more attention needs to be given to the scientific literature which illustrates the post-storm success of living shorelines in shoreline stabilization.

PRE-WORKSHOP SURVEY

A pre-workshop survey was sent to registered participants to help determine restoration techniques that are currently being used to restore wetlands and to get information as to what may be good strategies to consider to encourage greater use of living shorelines.

The following results were received.

What wetland restoration techniques have you or your organization undertaken within the last five years to restore NC's coastal wetlands (include wetland type, location)? (15 responses):

- Living shorelines
- Salt marsh planting
- Salt marsh planting with oyster reef substrate, oyster shell bags, oyster castles, riprap
- Beneficial use of dredged material to low elevation or ponded *Spartina* marsh – Camp Lejeune
- Hydrologic restoration – Hyde Co; North River Farms; USFWS Wildlife Refuges

- Atlantic white cedar planting
- Headwater and riparian wetlands restoration – Swansboro
- Freshwater wetlands in stormwater Best Management Practices (BMP)s
- Research to inform restoration techniques– e.g. wave attenuation, habitat function

What are the top three (3) strategies that you think could lead to greater use of living shorelines (specific incentives, outreach, policy improvements, etc.)? (16 survey responses):

- Lower costs of installing- e.g. cost-share programs, policies
- Highlight the benefit of increased coastal resiliency as an incentive
- Property tax credit
- Stronger incentives/disincentives for hardened shorelines to keep existing natural living shorelines in place (avoid need for restoration)
- Increased education/engagement for public and contractors
- Public info campaign on their benefits; target key events
- Demonstration sites with "open houses" to market living shorelines
- Free consulting on the benefits of living shorelines, better marketing
- Outreach to shift perspectives of natural shorelines vs developed
- Develop regulations, similar to MD, where hardened shorelines are legal only where deemed appropriate due to high energy/living shoreline can't work
- Higher fees and more review for bulkheads
- Agencies need to push for nature based solutions
- Legislative support
- Citizen volunteers for wetland restoration projects to build support (e.g. project at Cherry Point)
- Better science-based tools for siting and site-specific design of living shoreline projects
- Expand the NOAA/TNC Living Shoreline Coastal Resiliency Tool to all coastal counties

Staff from The Nature Conservancy (TNC) provided information about previous work using ditch plugs in the Albemarle Sound and Alligator River for hydrologic restoration. Areas of high erosion are a concern for future planning of projects. Tide gates have also been used by the USFWS.

The NCCF staff provided information about the hydrologic and wetland restoration work done in North River. Creating a more natural hydrologic pathway aids in retention of stormwater within a system before it drains into larger waterbodies, allowing for the sequestration of nutrients, restoration of natural wetland habitats, and associated ecosystem services. Post-restoration, water drains from the site in approximately two months, versus pre-restoration times of about two hours at the North River site. Converted farmlands were identified as a low hanging fruit for wetland restoration with the added benefit of Federal Farm Bill funding being available to fund their acquisition or secure easements. Siting these as close to the estuary was supported as being a way to maximize their water quality enhancement services. A question was addressed about the use of mitigation for 401 wetlands and its relative absence of implementation in coastal wetland habitats. Amanda Mueller (NCDWR) shared information about revised water quality standards which can require mitigation for any disturbances over a 1/10 acre. The South Atlantic Conservation Blueprint is currently being updated by the USFWS which can be used to prioritize restoration project siting. Priority sites for restoration could be overlaid with maps of agricultural lands to identify viable restoration areas. The NCCF and USFWS have restored wetlands on the Albemarle-Pamlico peninsula through planting of Atlantic white cedar.

MEETING POLL QUESTIONS AND DISCUSSIONS

What are the top three (3) strategies that you think could lead to greater use of living shorelines (specific incentives, outreach, policy improvements, etc.)?

Choices	Results
Disincentives for hardened shorelines	45%
Lower costs for installation (e.g. cost-share programs)	43%
Increased outreach for property owners and contractors	32%
Legislative support (e.g. financial, rule changes, etc.)	30%
Property tax credit	17%
Increased use of demonstration sites with "open houses" to market living shorelines	17%
Regulations that only allow hardened shorelines in high energy areas	17%
Science-based tools for siting and design of living shoreline projects	17%
Expand NOAA/TNC Living Shoreline Coastal Resiliency Tool to all coastal counties	11%
Free consulting to market and highlight benefits of living shorelines	6%
Increased citizen volunteer involvement in living shoreline projects on public property	4%
No Answer	19%

Strategies for outreach discussed the carrot or stick approach and outreach strategies and opportunities. Much discussion pointed out Maryland's approach of requiring living shorelines rather than hardened shorelines. A participant from Virginia pointed out that Maryland has political will and a cultural citizenry which values progressive environmental policy. However, Maryland still requires waivers for coastal property owners if hardened shorelines are to be used. The approval rate of the received waivers is around 50% and the waiver approval does not necessarily reflect unsuitable conditions for a living shoreline. There was also discussion on how coastal habitats help to mitigate coastal hazards such as flooding and erosion. Mapping and modelling has been done to identify areas with and without protective shoreline habitat, primarily wetlands. Areas without existing wetlands or other shoreline habitat could be prioritized for habitat restoration such as living shorelines. Duke University has produced a story map highlighting the value of coastal wetlands for coastal resiliency, which was done for the Natural Working Lands section of the NC Risk and Coastal Resiliency Plan.

Photo Credit: A. Deaton

Summary

The workshop series was attended by over 50 people at each technical workshop. The overall goal of the workshop series was to exchange information on the status of estuarine and palustrine wetlands on the coast, threats and stressors to them, and ongoing wetland mapping and restoration activities. Presentations provided valuable information on wetland status, threats, and ongoing restoration, supported by data and scientific references (see Literature Cited and website links below). Presentations are included in Appendix A.

Polls were used as a starting point for discussion and were not meant to limit recommendations in the Wetland Protection and Restoration Issue Paper in the 2021 CHPP. Discussion focused on potential strategies for assessing, protecting, and restoring wetlands in the future. Below are some key points from the workshop discussions.

MAPPING AND MONITORING

- *Comprehensive wetland mapping was initially done by NCDCM in the 1990s, but needs updating.*
- *Advancements in remote sensing could greatly reduce the cost and time needed to map wetlands.*
- *Using multiscale mapping in concert with strategic monitoring would be an efficient and effective approach.*
- *Attendees supported the idea of forming an interagency mapping committee to collaborate on developing a coastal wetland mapping plan.*
- *There is a need for a central repository for wetland mapping and monitoring projects.*
- *There is a need to reach out to decision makers on why resources are needed for wetland mapping and monitoring, and how this benefits management.*
- *More monitoring sites are needed throughout the coast for trend assessment.*
- *Not all marshes are keeping up with SLR and comprehensive mapping could assess that on a larger scale.*

THREATS AND CONSERVATION

- *Changes to the WOTUS definition are a significant threat to palustrine wetlands, and estuarine water quality.*
- *The cause of permitted wetland impacts in the coast has shifted from primarily dredging and marina related development in the 1990s to transportation and development in the past decade.*
- *Primary threats to estuarine wetlands are SLR, droughts, and erosion.*
- *Migration corridors are critical for fringing estuarine wetlands to survive with increasing SLR rates; marsh islands have no higher ground to migrate.*
- *Wetland erosion is higher on larger waterbodies and during mid to low tides when the marsh is exposed to wave energy*
- *Palustrine wetlands are probably the most impacted – SLR impacts them on the waterward side, and development on the landward side.*
- *Impacts of SLR to wetlands are complex and need careful consideration.*
- *Wetland vulnerability models can be used to identify potential migration corridors, areas to focus conservation or restoration (ie. living shoreline).*

RESTORATION AND LIVING SHORELINES

- *Thin layer sediment deposition is a possible solution for drowning marsh islands and has been successful, although more research would be beneficial for optimizing restoration success.*

- *To slow saltwater intrusion impacts to palustrine wetlands and restore hydrology of ditched wetlands, projects have installed tide gates or plugs in ditches, and planted salt tolerant wetland species*
- *Prior converted wetlands are an opportunity for wetland migration corridors or restoration.*
- *Protecting and restoring wetland hydrology is critical for fisheries.*
- *With thin layer sediment deposition and some other wetland restoration techniques, there will be habitat tradeoffs to consider since shallow subtidal bottom will be converted to wetlands.*
- *North Carolina has many successful living shorelines throughout the coast and research has demonstrated their value for fish habitat, ecosystem services, shoreline stabilization, and resilience to storm events. However, they continue to be under-utilized compared to vertical hardened structures.*
- *The highest needs for advancing living shoreline use include strong promotion of living shorelines by state agencies, financial incentives, increased awareness and adoption of living shorelines by the public, marine contractors, and business programs for marine contractors.*
- *The 2021 Oyster Blueprint will include recommended actions for living shorelines.*

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Ridge, J. T., A.B. Rodriguez, J. Fodrie, N.L. Lindquist, M.C. Brodeur, S. Coleman, J.H.Grabowski, and E.J. Theuerkauf. 2015. Maximizing oyster-reef growth supports green infrastructure with accelerating sea-level rise. Scientific Reports. 5. No. 14785

Theuerkauf, Seth J., D.B. Eggleston, B.J. Puckett, and K.W. Theuerkauf. 2017. Wave exposure structures oyster distribution on natural intertidal reefs, but not on hardened shorelines. Estuaries and Coast. 40: 376-386

Relevant Information and Links

Workshop webpage:

http://portal.ncdenr.org/web/mf/habitat/chpp/07-2020-chpp

2016 NC Coastal Habitat Protection Plan:

http://portal.ncdenr.org/c/document_library/get_file?p_l_id=1169848&folderId=28335811&name=DLFE-127603.pdf

Albemarle – Pamlico National Estuarine Partnership Living Shoreline Blog:

https://apnep.nc.gov/blog/2018/12/11/living-storm-protections-part-i
https://apnep.nc.gov/blog/2019/02/14/living-storm-protections-part-ii

NC Natural Working Lands Action Plan Appendix B:

https://files.nc.gov/ncdeq/climate-change/resilience-plan/Appendix-B-NWL-Action-Plan-FINAL.pdf
https://storymaps.arcgis.com/collections/2154ab2816674f7d8c7429fe87f48830?item=4

NC Sea Grant Surface Elevation Information:

https://ncseagrant.ncsu.edu/program-areas/sustainable-communities/north-carolina-sentinel-site-cooperative/nc-set-community-of-practice/

https://ncseagrant.ncsu.edu/ncSET/

The Nature Conservancy Resilient Coastal Sites for Conservation in the South Atlantic US (2019):

https://www.nature.ly/SEcoast

NC Oyster Blueprint:

https://ncoysters.org/

http://www.nccoast.org/wp-content/uploads/2015/03/Oyster-Restoration-Blueprint-2015-2020_FINAL.pdf

South Atlantic Landscape Conservation Cooperative:

http://www.southatlanticlcc.org/blueprint/

Division of Coastal Management Geographic Wetlands Data.

https://deq.nc.gov/about/divisions/coastal-management/coastal-management-data/setback-factor-maps-1998-shoreline/wetlands-gis-data

https://deq.nc.gov/about/divisions/coastal-management/coastal-management-data/setback-factor-maps-1998-shoreline/wetlands-interactive-mapping

NOAA Coastal Change Analysis Program Land Cover data:

https://coast.noaa.gov/digitalcoast/data/ccapregional.html

Appendix A. Presentations

Mapping & Evaluating Wetlands in Coastal NC: Project Overview

Ken Richardson – NC Division of Coastal Management

August 19, 2020

Outline: NC DCM Wetlands Mapping

1. Background
2. Methodology & Output
3. GIS Products
4. Where are we in 2020?

1 Background: Acknowledgments

- **James (Jim) Stanfill**
- Kelly Williams
- Chase Barnard
- Lori Sutter
- Mac Haupt
- Mike Wood
- Jim Wuenscher
- Brian Bledsoe
- Chris Bruce
- Lonnie Shull
- Sheila Balsdon
- Sean McGuire
- Greg Meyer
- Cherri Smith
- Steven Stichter
- …and many others

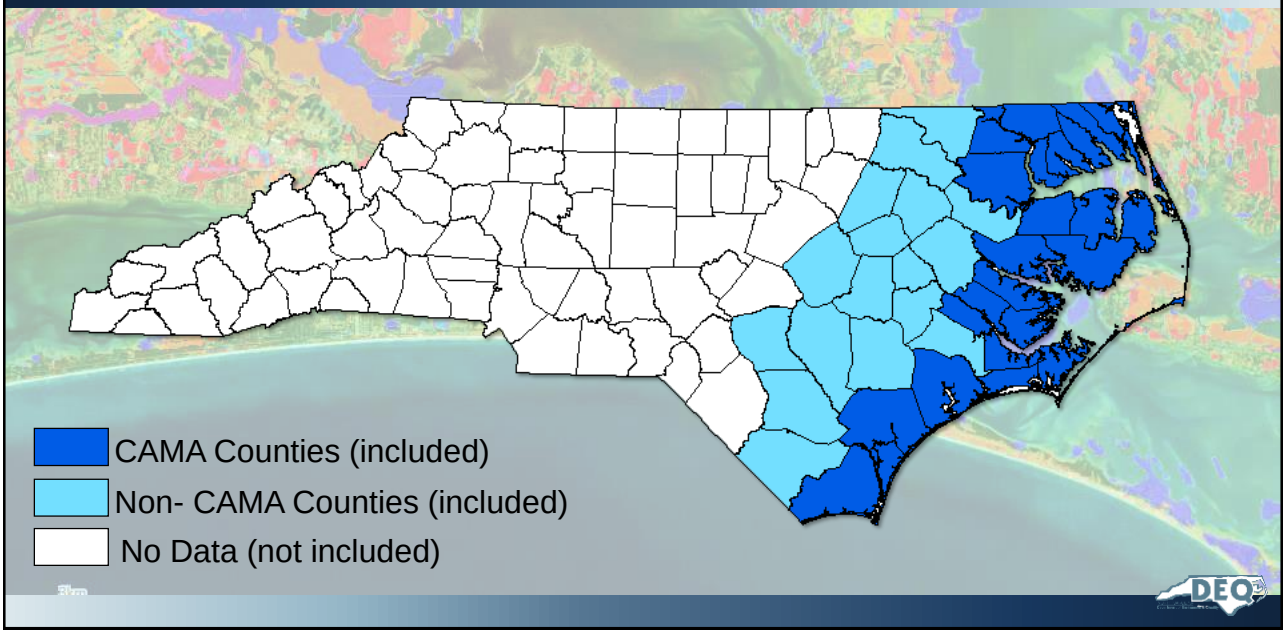
jim.stanfill@ncdenr.gov

1 Background: Conception and Components

1991 to 1999

1. **Wetlands Mapping & Inventory**
2. **Functional Assessment of Wetlands (NC-CREWS)**
3. **Wetland Restoration Identification & Prioritization**
4. Coordination with Wetland Regulatory Agencies
5. Potential Coastal Area Wetlands Policies
6. Local Land Use Planning

2 Methodology & Output: Geographic Extent



2 Methodology & Output: Initial Considerations

1. **Limited Resources**
2. **Limited Time Frame**
3. **Large Geographic Area** *(over 2.5 million acres of wetlands)*

- **Wide range of users**
- **Planning Tool**
- **Basis of Functional Assessment and Potential Restoration Efforts**

Accurate, Comprehensive, Understandable GIS Method

2 Methodology: Wetland Inventory

Goal #1: Identify location, type, amount of wetlands in coastal NC starting with GIS data

- **National Wetland Inventory Maps**
  - Most comprehensive inventory of wetlands
- **NRCS Digital Soils Maps**
  - Particularly useful in marginal areas
  - Identify omitted areas
- **Landsat 30M TM Imagery - 1988, 1994**
  - Most recent data source
  - Identify omitted areas
  - Identify cut-over and cleared wetlands
- **Hydrography**
  - Utilized in HGM Classification

2 Methodology & Output: Wetland Classification

Data Inputs:

- Cowardin Classifications
- Water Regime
- Soil Type
- Satellite Imagery
- Landscape Position
- Hydrography
- Over 400 Field Site Evaluations

DCM Wetland Types:

- Bottomland Hardwood
- Pocosin
- Pine Flat
- Hardwood Flat
- Managed Pine
- Freshwater Marsh
- Salt/Brackish Marsh
- Estuarine Scrub Shrub
- Estuarine Forest
- Maritime Forest
- Headwater Swamp
- Human Impacted

2 Methodology& Output: Wetland Classification

Each wetland polygon generated by the overlay analysis contains the following information:

- All attributes from the source data layers
- DCM wetland type
- Hydrogeomorphology (HGM) Class (used in later analysis)

Some wetlands are given a "modifier"

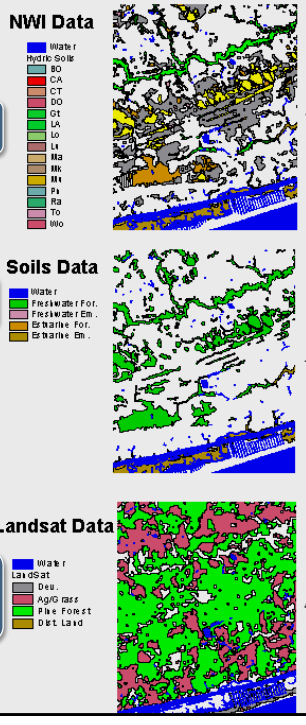
- Drained or Ditched
- Cut-over
- Cleared

2

NWI Data

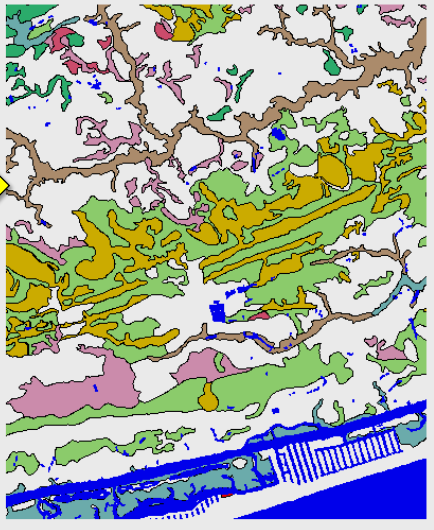
Soils Data

Landsat Data



GIS Data Layers for DCM Wetland Mapping

Wetland Type Map



2 Methodology & Output: Accuracy Assessment

- Over 600 field sites visited
- Accuracy
  - 89% for wetlands overall
  - 97% (marsh, bottomland hardwoods, swamps & pocosin
  - 65%-75% headwater forest, hardwood flats & managed pines.

2 Methodology & Output: Limitations of Wetlands Maps

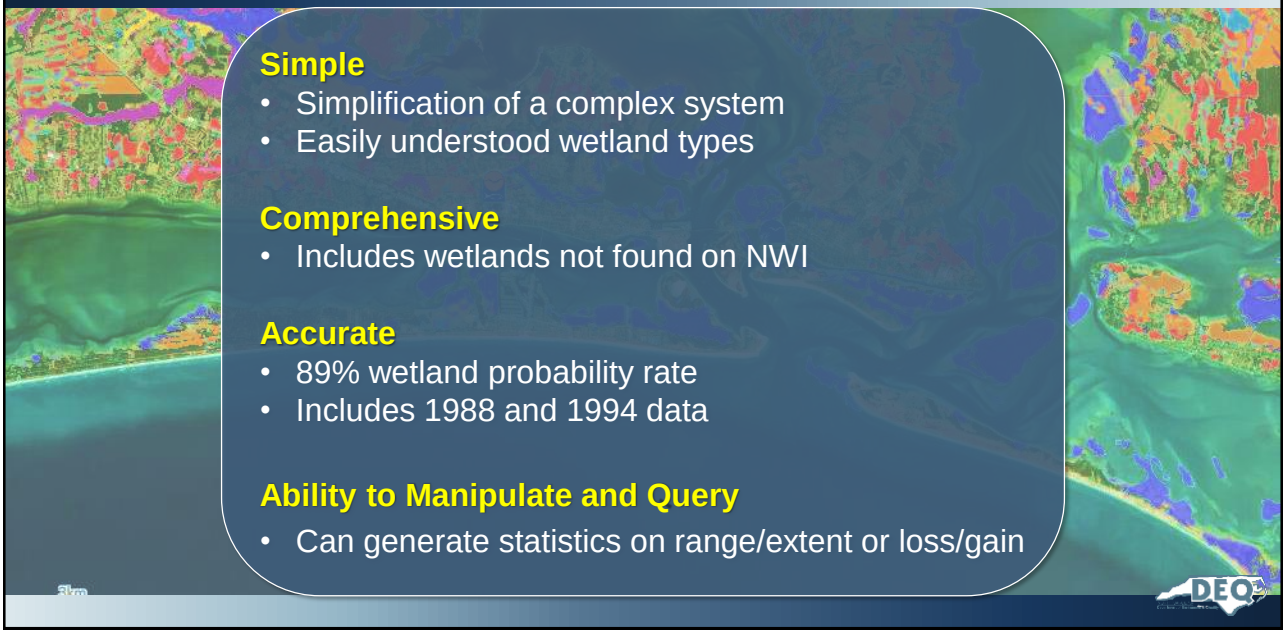
Limitations

- Minimum Mapping Size: 1 acre
- Source data is not perfect
- Maps show only the probability of finding a wetland in a particular area

Implications

- Small wetlands not included
- Data are an **Underestimation** of wetlands
- Maps **Cannot** be used for on-site wetland determinations

3 Methodology & Output: Strengths of Wetlands Maps



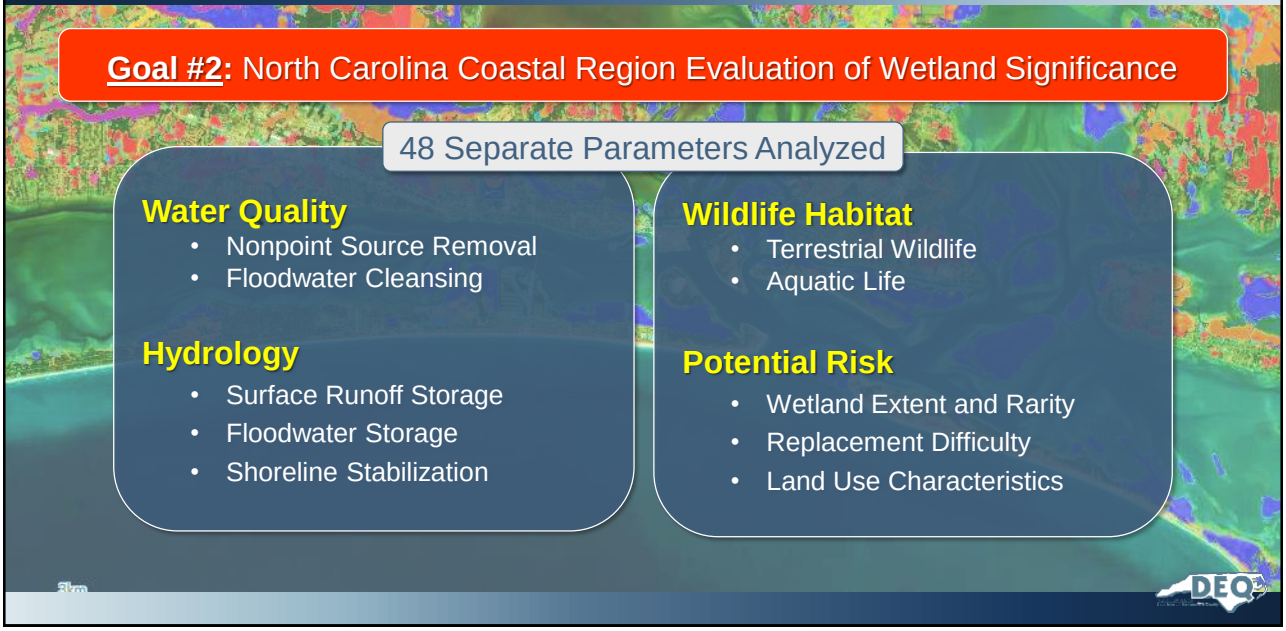
Simple
- Simplification of a complex system
- Easily understood wetland types

Comprehensive
- Includes wetlands not found on NWI

Accurate
- 89% wetland probability rate
- Includes 1988 and 1994 data

Ability to Manipulate and Query
- Can generate statistics on range/extent or loss/gain

2 Methodology & Output: NC-CREWS



Goal #2: North Carolina Coastal Region Evaluation of Wetland Significance

48 Separate Parameters Analyzed

Water Quality
- Nonpoint Source Removal
- Floodwater Cleansing

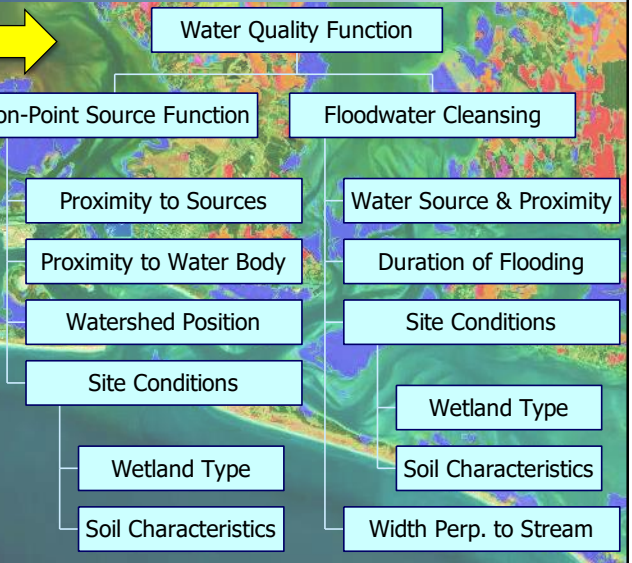
Hydrology
- Surface Runoff Storage
- Floodwater Storage
- Shoreline Stabilization

Wildlife Habitat
- Terrestrial Wildlife
- Aquatic Life

Potential Risk
- Wetland Extent and Rarity
- Replacement Difficulty
- Land Use Characteristics

2 Methodology & Output: NC-CREWS

Example: Water Quality Function



Considerations of both the capability and the opportunity to perform a specific function.

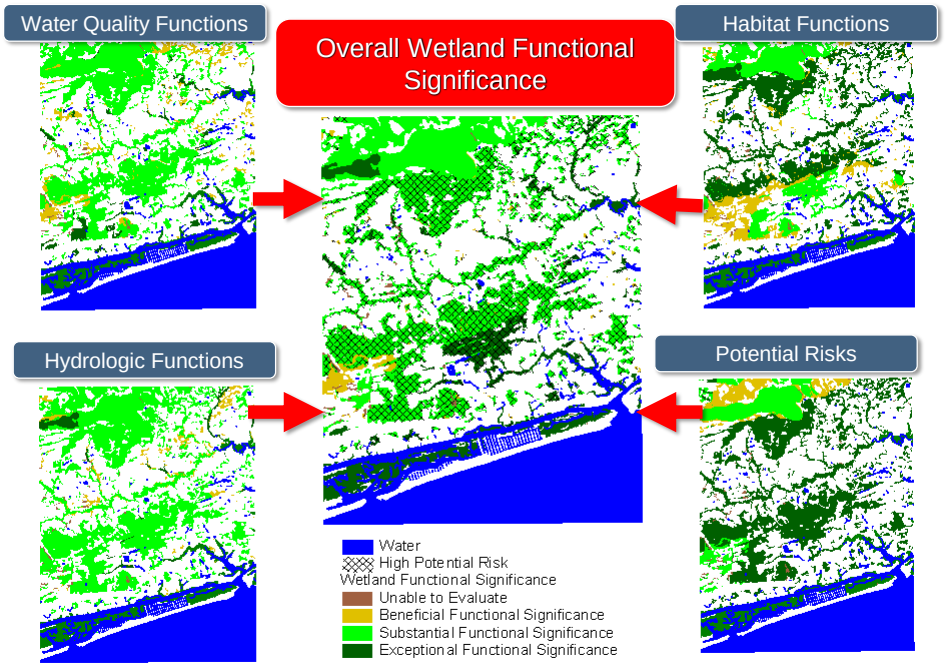
2 Methodology & Output: NC-CREWS

The model produces ratings for each wetland polygon:

- **Beneficial** Functional Significance
- **Substantial** Functional Significance
- **Exceptional** Functional Significance

Wetlands can be evaluated on the basis of an overall rating or in terms of individual functions.

2



2 **Methodology & Output: NC-CREWS Applications**

Development and Transportation Planning
- Wetland Identification of Most Significant Wetlands
- Wetland Avoidance of Most Significant Wetlands
- Identification of Functional Impacts

CAMA Land Use Planning
- Identification of Fragile Areas
- Development of Conservation Classification and Land Use Classification Maps

Acquisition of Ecologically Significant Wetlands

2 Methodology & Output: Enhancement, Restoration, & Creation

Goal #3: Wetland Enhancement, Restoration & Creation Potential

- **Wetland Creation** is the process of creating a wetland where none has existed before.
- **Restoration** refers to creating a wetland on a site which was at one time a wetland but currently is not.
- **Enhancement** is the process of enhancing an existing wetland to a higher level of functioning.

2 Step Process:

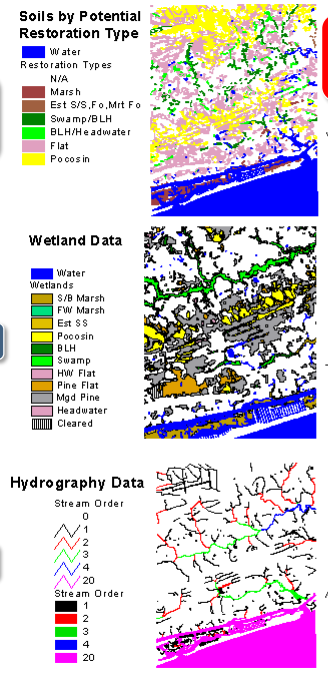
- **Step 1:** Classification of restoration type
- **Step 2:** Identification of Sites

2

Soils by Potential Restoration Type

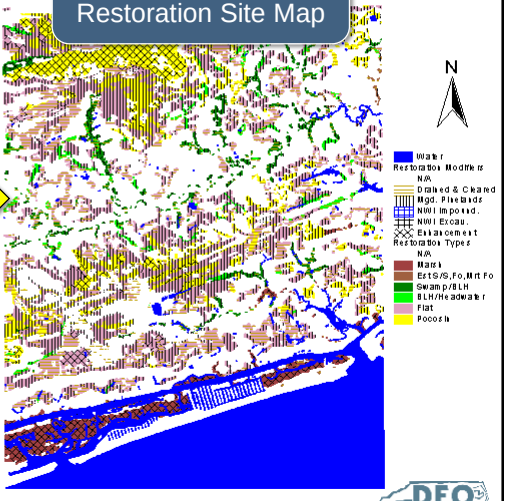
Wetland Data

Hydrography Data



GIS Data Layers for Potential Wetland Restoration Site Map

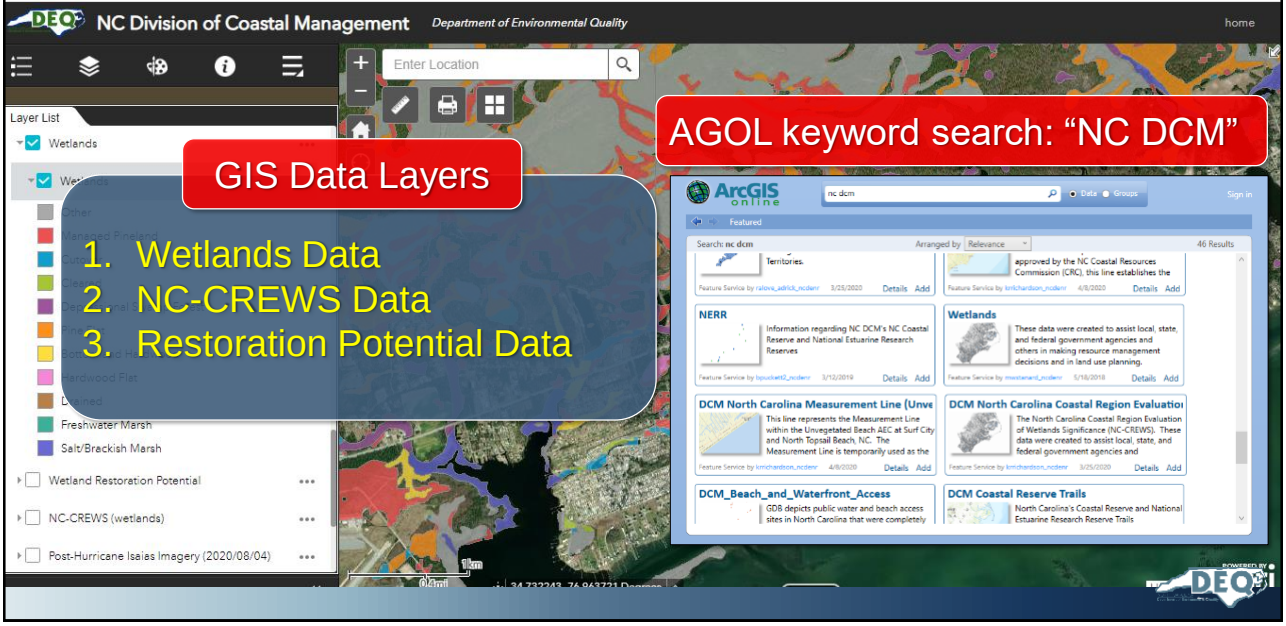
Potential Wetlands Restoration Site Map



2 Methodology & Output: Benefits of Restoration Potential Data

- Quick identification or scan of potential restoration sites.
- Better management of sites over a large geographic area.
- Landscape level/Ecological approach vs. “For Sale“ Sign.
- Further analysis can be used to prioritize sites based upon potential to perform specific functions.

3 GIS Products: ArcGIS Online (AGOL) & Downloads



4 Where are we in 2020?

- **1999** – project completed
- **2005** – No dedicated Wetlands DCM Staff
- **2020**
  - NC DOT & others continue to use data
  - NC DCM continues to make the data available
  - NC DCM has no planned updates

NC Division of Coastal Management

DCM Contact:
Ken.Richardson@ncdenr.gov

DCM Website:
https://deq.nc.gov/about/divisions/coastal-management
or
NCCoastalManagement.net

ArcGIS Online (keyword search):
"NC DCM"

EMERGING TECHNOLOGIES IN WETLAND MAPPING AND MONITORING

JUSTIN RIDGE

RESEARCH SCIENTIST

MARINE ROBOTICS AND REMOTE SENSING LAB

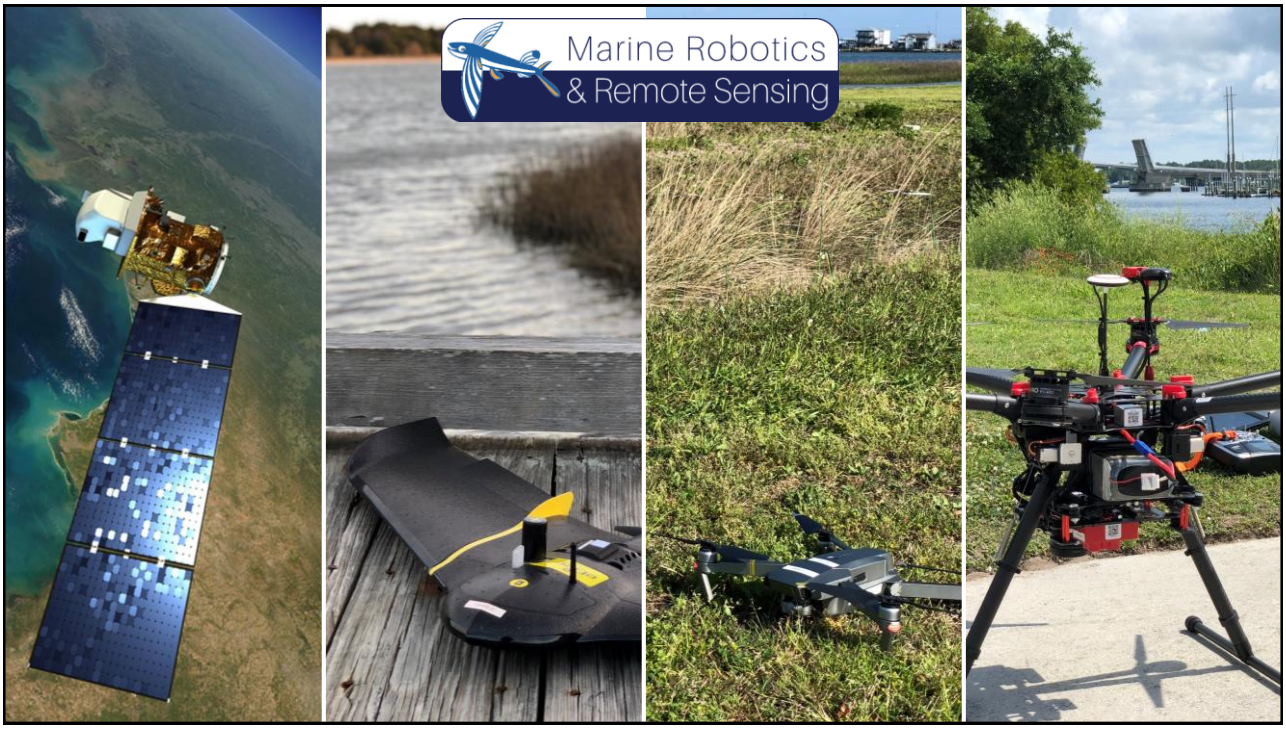
DUKE UNIVERSITY MARINE LAB

Marine Robotics & Remote Sensing

(Director: Dave Johnston)

Duke NICHOLAS SCHOOL OF THE ENVIRONMENT

DUKE UNIVERSITY MARINE LAB



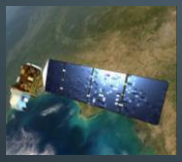
EXPLORING EMERGING TECHNOLOGIES

Examining collaborative efforts in:

- 2D Mapping/3D Modeling of Wetlands with UAS
- Data Fusion of Remote Sensing Products for Wetlands Mapping
- Advances in Imagery Processing (Deep Learning)
- Summary Considerations

REMOTE SENSING WETLANDS

- Currently: lower/moderate resolution satellite data (like Landsat) and aerial imagery/lidar



- Potential to augment current practices with new sources of imagery and ancillary data
- Platform decisions should be objective driven

2D MAPPING/3D MODELING WITH UAS

2D MAPPING

Very high resolution

- 1-3 cm/pixel RGB
- 3-8 cm/pixel Multispectral

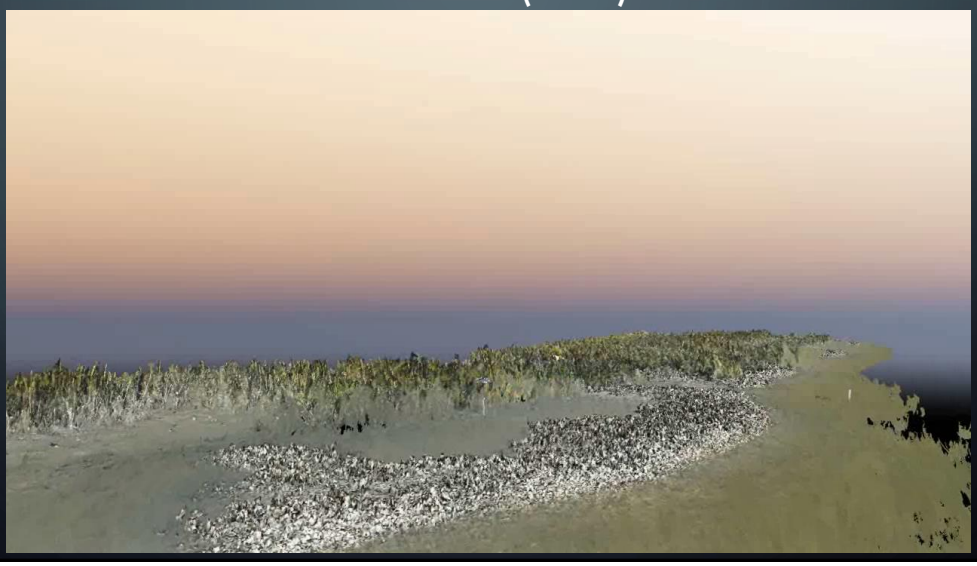
Increases:

- edge definition
- species differentiation
- temporal resolution

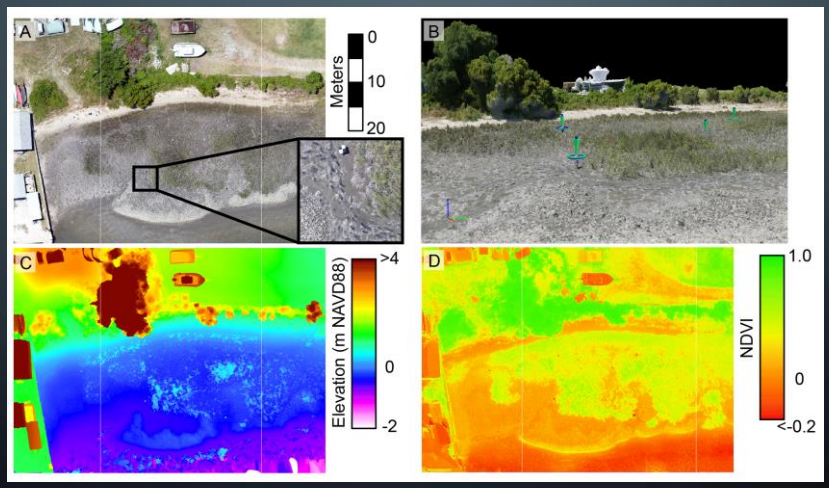
The use of Ground Control Points (GCPs) can achieve cm-scale accuracy if needed – also can be accomplished with RTK-equipped drones

NOAA LIVING SHORELINE (PIVERS ISLAND)

STRUCTURE FROM MOTION (SFM)



UAS PRODUCTS



Ridge and Johnston 2020

STEM HEIGHTS EXAMPLE

In addition to the SfM UAS products, data fusion provides multiple pathways to generate relevant 3D data.

The research community is working to understand what method yields the most reliable, accurate information.

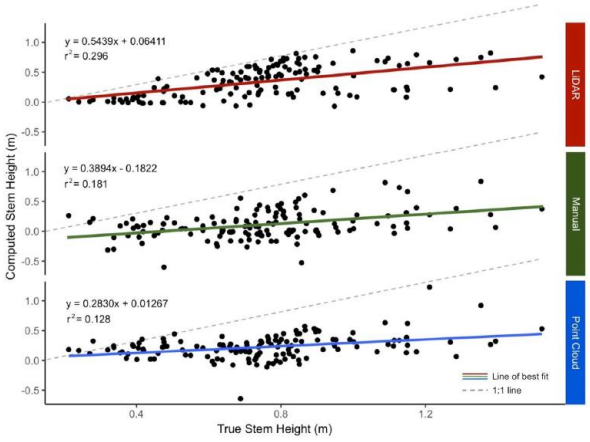


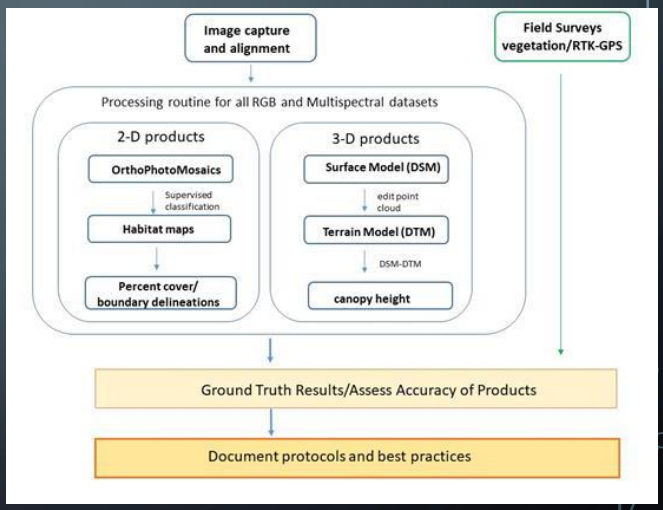
Figure 4. Computed vs. true regression mapped vegetation height derived from UAS imagery to field-measured true stem heights. The 1:1 line, where computed stem height is equal to true stem height, is displayed for reference. Computed vegetation heights are compared across the point cloud, manual, and Light Detection and Ranging (LiDAR)-derived digital terrain models.

DiGiacomo et al. 2020

UPCOMING WORK

Project Leads:

- Jenny Davis (NOAA)
- Brandon Puckett (NCNERR)



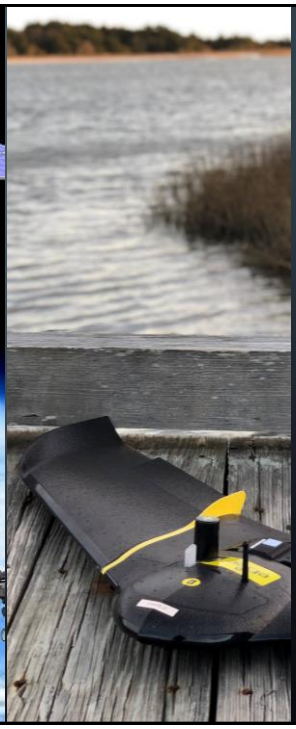
UAS SUMMARY & CONSIDERATIONS

- Benefits
  - Very high resolution look at wetland sites, providing **multiple layers of useful information** (2D & 3D)
  - Research conducted by the NOAA/NERRS/Duke team should provide **explicit guidance** and alleviate the necessity of heavy groundtruthing
- Costs
  - Not feasible for wide scale (all NC coast) application, but could be highly informative at select focus sites throughout the region
  - Not too manpower intensive, but 2-3 trained people would be preferred, especially if needing to capture all site imagery in a narrow window (e.g., peak biomass)
  - Costs to consider: drones, processing software, time

DATA FUSION

DATA FUSION

Use very high resolution UAS imagery to feed classifications of satellite imagery

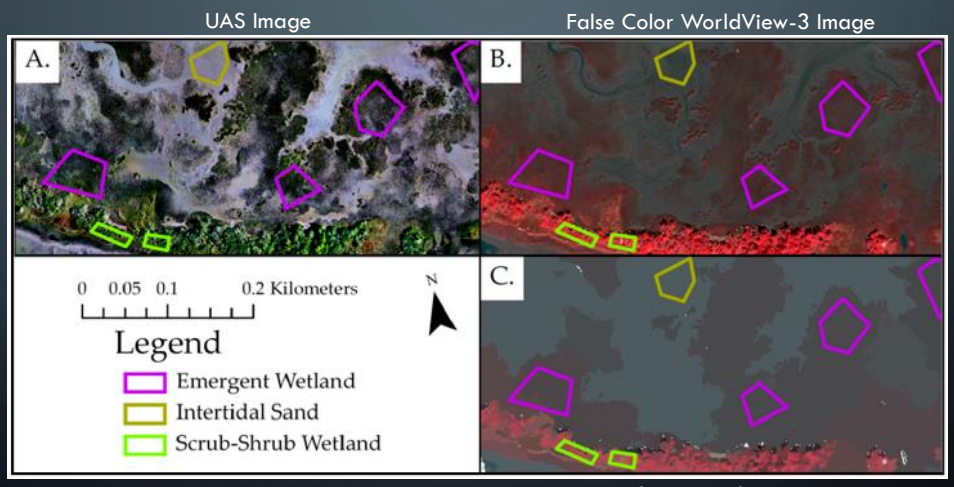


HIGH RES SATELLITE DATA

	WorldView-3	RapidEye
Imagery Details		
Spatial Resolution (m)	1.24	5.0
Radiometric Resolution	11 bit	12 bit
Revisit Rate	4.5 days	5.5 days
Revisit Rate (off-nadir)	Daily	Daily
Date of Acquisition	31 October 2017	20 July 2017
Time of Acquisition	16:14:35 UTC	16:04:21 UTC
Tidal State (m > MLLW)	0.22	-0.07
Bands (nm)		
Coastal Blue	400–450	-
Blue	450–510	440–510
Green	510–580	520–590
Yellow	585–625	-
Red	630–690	630–685
Red Edge	705–745	690–730
NIR 1	770–895	760–850
NIR 2	860–1040	-
Panchromatic	450–800	-

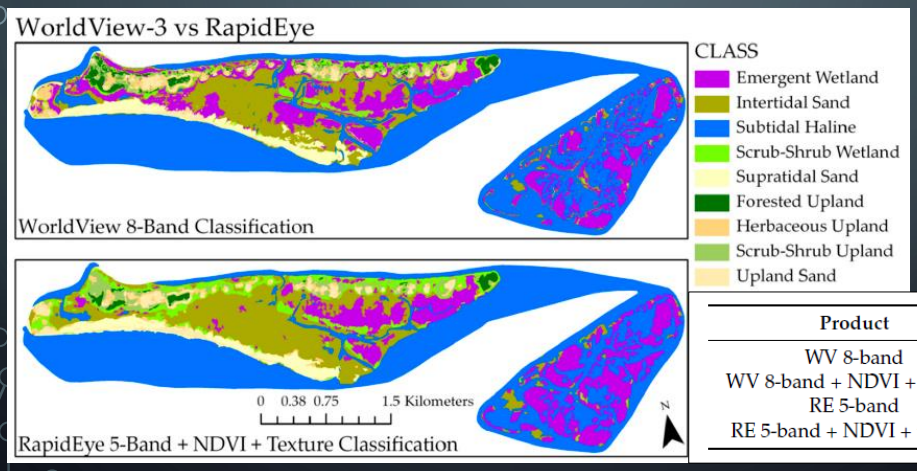
Gray et al. 2018

TRAINING WITH UAS



Gray et al. 2018

FINAL ACCURACY



Product	Field	UAS
WV 8-band	93%	93%
WV 8-band + NDVI + texture	79%	83%
RE 5-band	86%	90%
RE 5-band + NDVI + texture	87%	92%

Gray et al. 2018

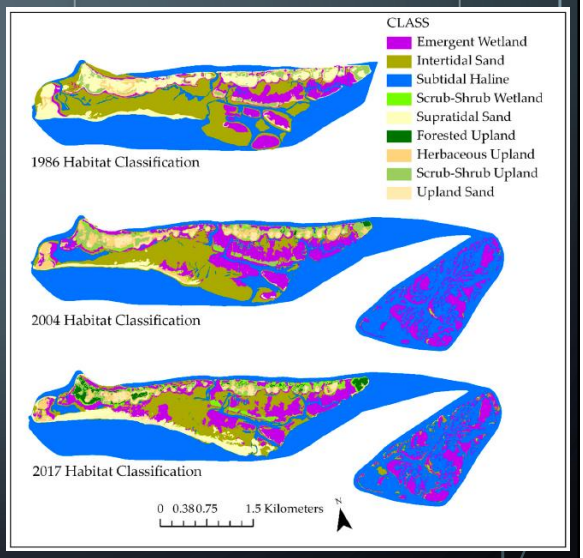
DATA FUSION SUMMARY AND CONSIDERATIONS

Benefits

- Provides the opportunity to scale up mapping and monitoring of potential UAS focus sites (previous section), providing increased accuracy of satellite imagery classification

Costs

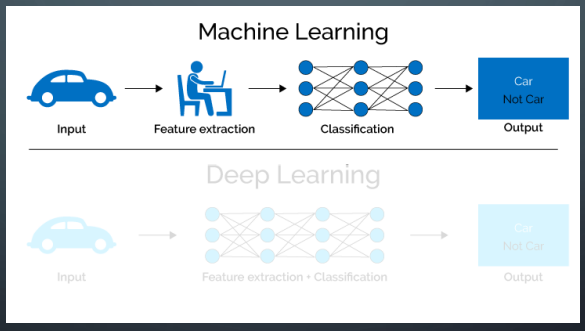
- Generally includes the costs from the UAS section
- Higher resolution satellite data if desired (e.g., WorldView-3), but could potentially still yield good results with other freely available datasets (e.g., Landsat, Sentinel)
- Some groundtruthing would likely be needed, but can be augmented with UAS



Gray et al. 2018

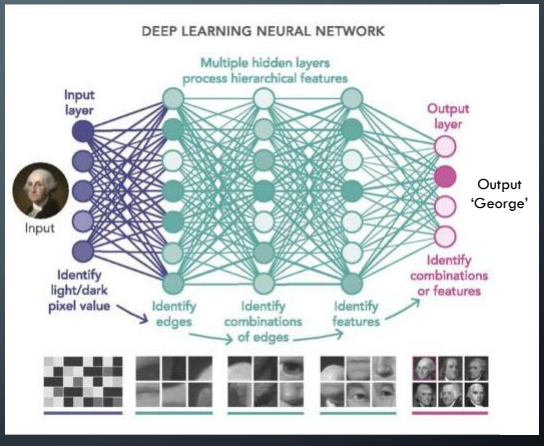
DEEP LEARNING

WHAT IS DEEP LEARNING?



Semiengineering.com

WHAT IS DEEP LEARNING?



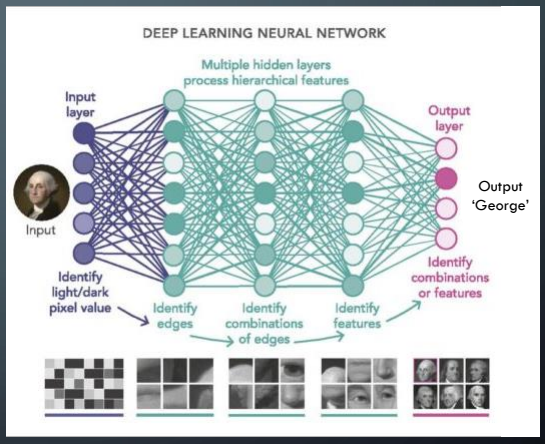
Nextbigfuture.com

BUILDING A NEW WORKFLOW

A **Recurrent Convolutional Neural Network (RCNN)** is being tested to see if we can decrease the amount of effort required to produce land cover maps.

This method should

- reduce post-processing burden
- increase generalizability
- increase speed of map creation



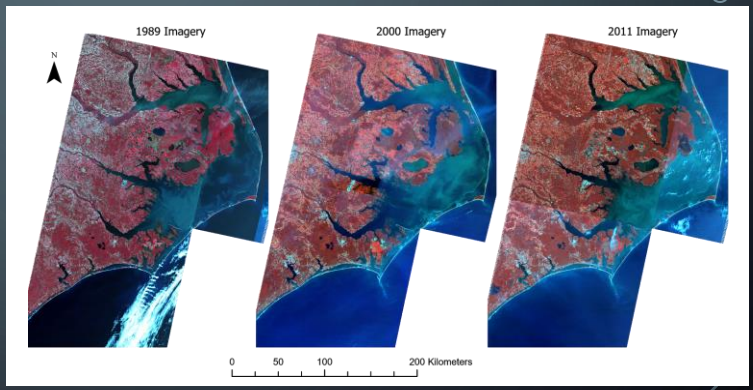
Nextbigfuture.com

ENC THROUGH TIME

Study area includes the Albemarle-Pamlico region of Eastern North Carolina

Recurrent (in RCNN) is referring to the time series

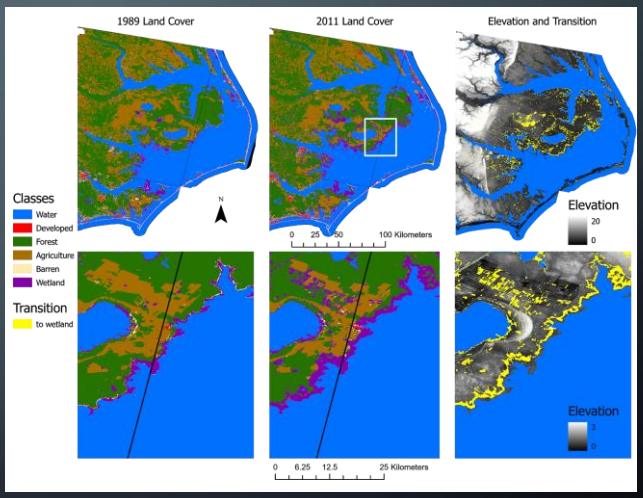
Landsat 5 imagery from **3 years** each with **5 time steps** (winter, spring, summer, early fall, late fall)



Gray et al. (in prep)

LAND COVER CHANGE

Identifying areas of major transition within the Albemarle-Pamlico region



Gray et al. (in prep)

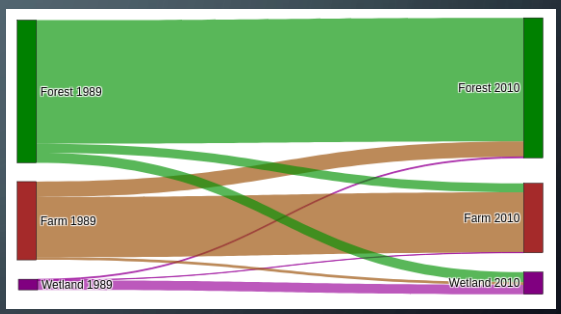
DEEP LEARNING SUMMARY AND CONSIDERATIONS

Benefits

- At full maturity, the RCNN should be able to ingest a new set of Landsat tiles (~4 for all of ENC) and output the classifications within **1 day of cloud processing**. This could provide automated area calculations/changes of wetland areas at almost any desired timescale (but also consider that Landsat resolution is 30m)

Costs

- A data analyst would need to be familiar with using jupyter notebooks, cloud computing (~$50-100/day) or be set up for local processing (processing time scales to hardware), and should conduct an accuracy check after a run (verifying randomly selected tiles)
- A series of groundtruth points throughout would be highly useful but could potentially be collected opportunistically, since high-precision GPS isn't needed
- The model could be retrained on higher resolution data, but that would require someone's time (likely on the order of 2-3 months)



Gray et al. (in prep)

NEWER SATELLITES

OTHER DATASETS (E.G., SAR, HYPERSPECTRAL)

DECIDING ON THE PLATFORM

Objective driven	Sat (Low Res)	Sat (High Res)	Drone
Large scale rough classification	X		
Large-moderate scale finer classification – 'macro view'	X	X	X (training)
Examining shorter term changes (< decade)		X	X
Examining fine scale changes (< m) – 'micro view'			X
3D modeling			X

COST/BENEFIT

Drone Platform	Costs	Pros	Cons
Quadcopter	1.5k – 7k	Less launch/recovery requirements Oblique imagery possible	Smaller flight areas
Fixed-wing	17k	Larger flight areas (>1km^2/flight)	Restricted recovery locations
Both	+3-4k for RTK +5k for multispectral	Increased accuracy and precision **Radiometric calibration**	

Satellite Platform	Costs	Pros	Cons
Landsat	Free	Large archive	Longer revisit time (~8-16 days)
Sentinel-2	Free	Good resolution (10-20 m) Shorter revisit (~ 3-4 days)	More data
WorldView-3	$15-20/km^2 (archive) $30/km^2 (tasking)*	High resolution (1.24 m) Revisit (~4.5 days)	Very data rich

Funding through:

NORTH CAROLINA MARINE FISHERIES

NC COASTAL RESERVE & NATIONAL ESTUARINE RESEARCH RESERVE

Sea Grant North Carolina

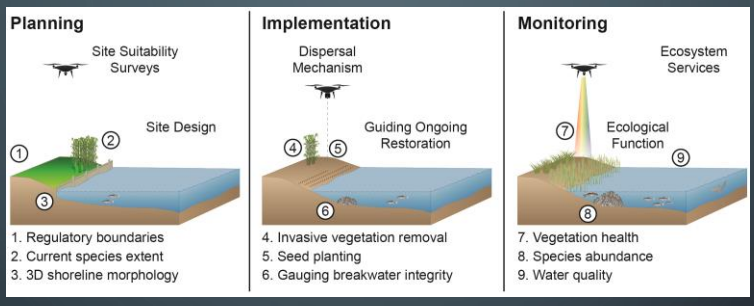
NORTH CAROLINA space grant

ESTCP

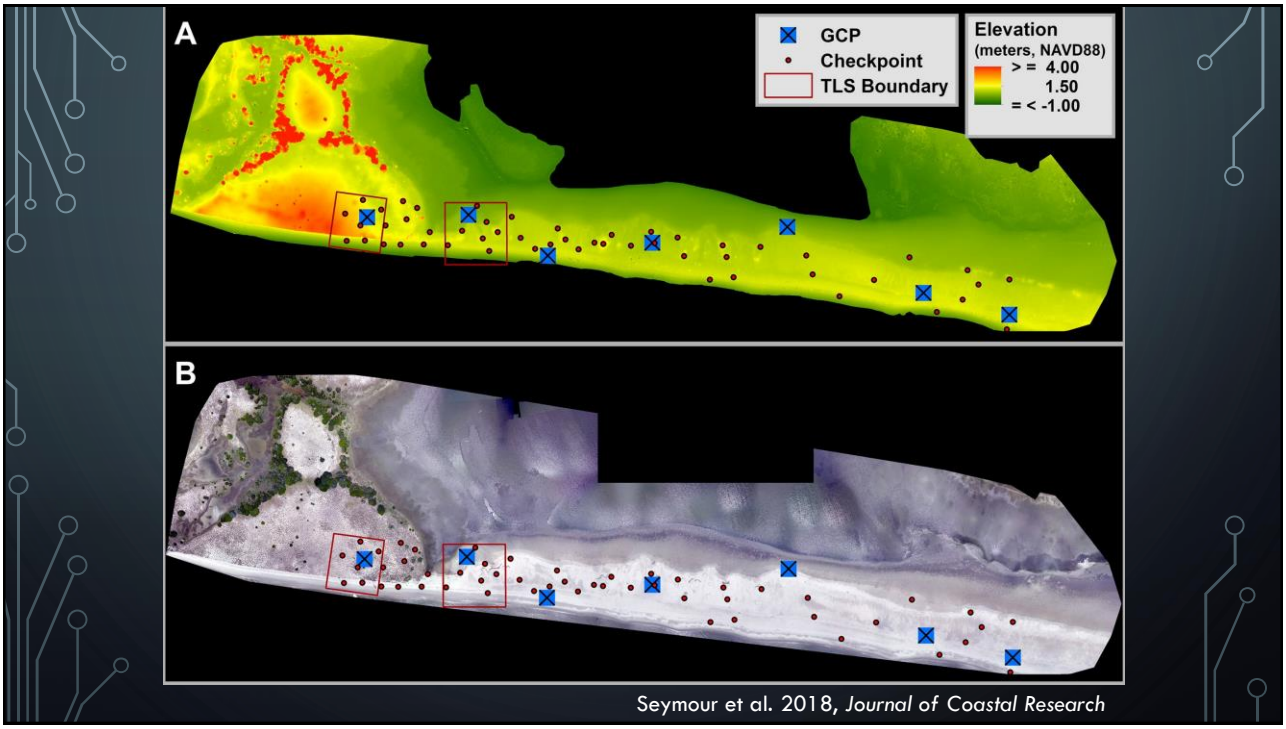
Duke UNIVERSITY | BASS CONNECTIONS

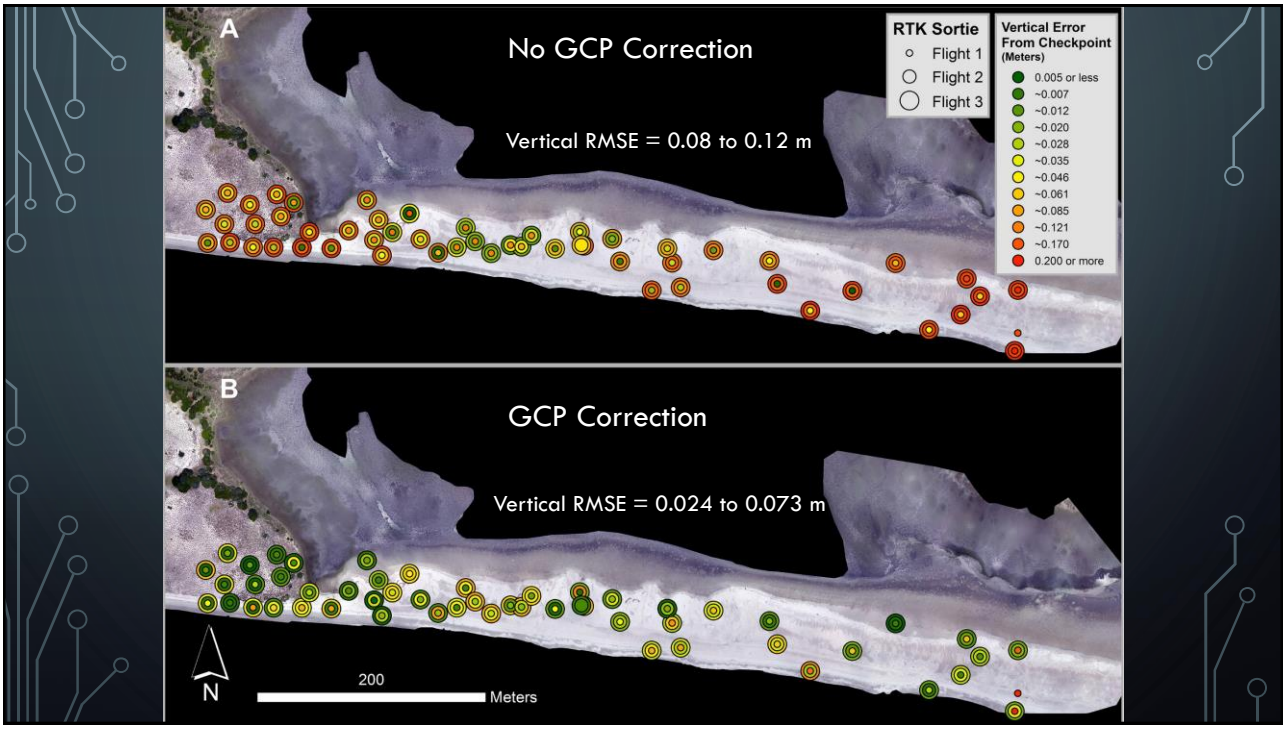
QUESTIONS?

SUPPLEMENTAL SLIDES



Ridge and Johnston 2020


A
GCP
Checkpoint
TLS Boundary
Elevation
(meters, NAVD88)
> = 4.00
1.50
= < -1.00
B
Seymour et al. 2018, Journal of Coastal Research


A
No GCP Correction
Vertical RMSE = 0.08 to 0.12 m
RTK Sortie
Flight 1
Flight 2
Flight 3
Vertical Error From Checkpoint (Meters)
0.005 or less
~0.007
~0.012
~0.020
~0.028
~0.035
~0.046
~0.061
~0.085
~0.121
~0.170
0.200 or more
B
GCP Correction
Vertical RMSE = 0.024 to 0.073 m
N
200
Meters

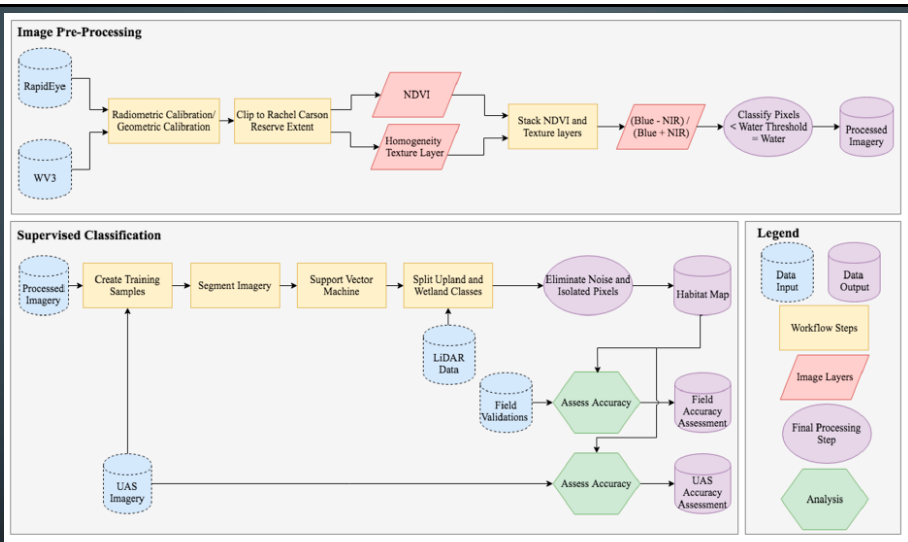
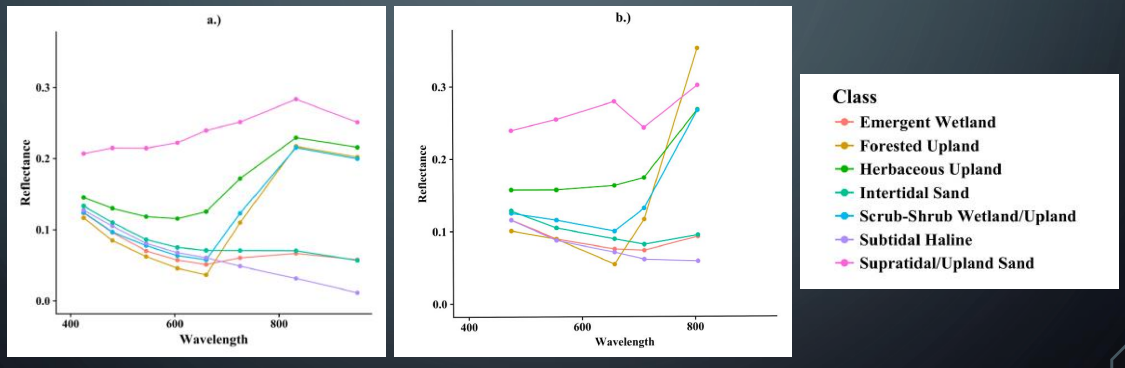


Figure 2. Image processing included calibration, creation of additional image layers to test impact on final accuracy, and thresholding to eliminate complex water pixels. The classification workflow included creation of training samples using unoccupied aircraft system (UAS) imagery, segmentation of RE and WV-3 imagery, classification using a support vector machine, and filtering the classification output by elevation using LiDAR data.

Gray et al. 2018

SPECTRAL CHARACTERISTICS



Gray et al. 2018

North Carolina's Coastal Freshwater Wetlands:
Caught in the Middle

Amanda Mueller

NC DEQ Environmental Specialist II

August 25, 2020

What Threatens Our Wetlands?

Logging & Farming

Development

Storm Runoff

Litter & Dumping

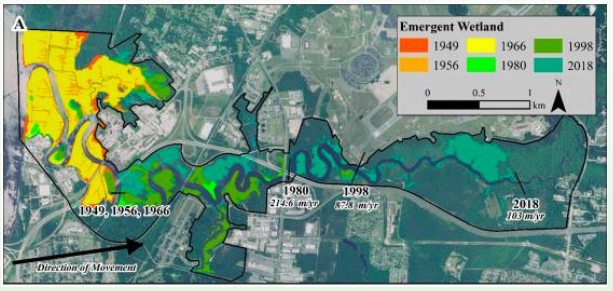
Saltwater Intrusion

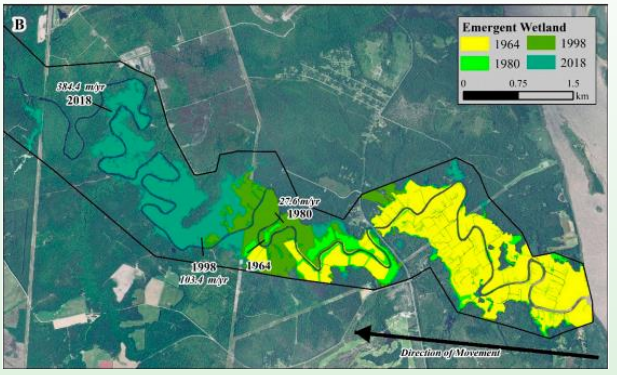
Sedimentation

Water Level Changes

Invasive Species

Emergent Wetlands Are Migrating

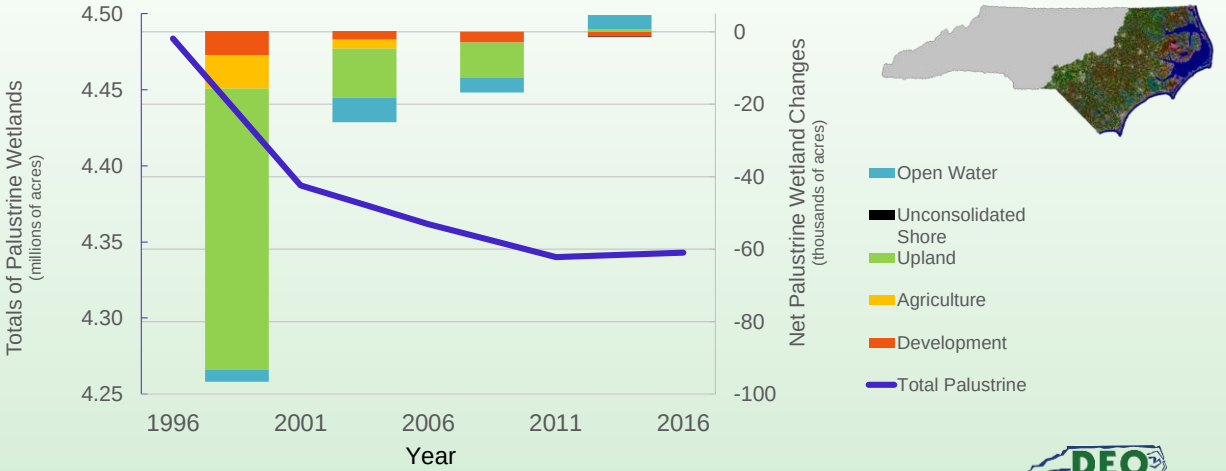




Emergent wetlands through time, where the upstream extent is shown by year and annotated with the rate of movement (m/yr) from the proceeding time period for (A) Smith Creek and (B) Town Creek.

Images from: Magolan, J.L.; Halls, J.N. A Multi-Decadal Investigation of Tidal Creek Wetland Changes, Water Level Rise, and Ghost Forests. Remote Sens. ***2020***, 12, 1141.

NOAA C-CAPS Data Shows Changes to NC Coastal Plain Palustrine Wetlands



NOAA C-CAPS map and data provided by Nate Herold (NOAA) with summaries by Christopher Baillie (ECU).

Wetland Changes Depend on:

- Topography
- Drainage Features
- Hardened Structures
- Land Use/ Property Protection
- Plant Rejuvenation/ Seeding Rates

Agencies Regulating NC Wetlands

Agencies Regulating NC Wetlands

US Army Corps of Engineers®

- Section 404 of the Clean Water Act (CWA)
- Section 10 of the Rivers and Harbors Act

Waters of the United States (WOTUS): What is different?

★ Using the same USACE definition of wetlands!

- Jurisdictional wetlands:
  - Abut certain jurisdictional waters
  - Inundated or flooded by certain jurisdictional waters
  - Separated by one natural feature
  - Direct hydrologic connection to certain jurisdictional waters
- Removes ephemeral streams (Wetlands cannot be jurisdictional through ephemeral features)

Image compliments of Robert Szucs
www.grasshoppergeography.com

Waters of the United States (WOTUS) What does this mean for N.C.?

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Study: Of 163 NC WAM Reference Wetlands, jurisdiction would be lost for:

- 29.3% overall
- 17% in the Coastal Plain
- 62.9% in the Piedmont
- 25.0% in the mountains

Data from *Dorney, J. (Moffatt & Nichol) The Effect of the Trump Administration's Proposed Waters of the United States (WOTUS) Definition in North Carolina. 2020 Presentation to NCAEP.*

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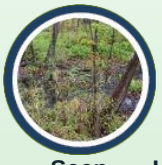
Wetland Types Most Likely Impacted by WOTUS

Floodplain Pools

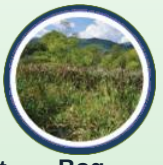
Pine Flat Pine Savanna

Non-Riverine Swamp Forest



Seep

Headwater Forest Bottomland Hardwood Forest



Bog

Data from *Dorney, J. (Moffatt & Nichol) The Effect of the Trump Administration's Proposed Waters of the United States (WOTUS) Definition in North Carolina. 2020 Presentation to NCAEP.*

Agencies Regulating NC Wetlands

US Army Corps of Engineers

- Section 404 of the Clean Water Act (CWA)
- Section 10 of the Rivers and Harbors Act

NC Division of Coastal Management

- Coastal Area Management Act (CAMA)
- NC Dredge and Fill Law
- Coastal Development Rules

DEQ

Agencies Regulating NC Wetlands

US Army Corps of Engineers

- Section 404 of the Clean Water Act (CWA)
- Section 10 of the Rivers and Harbors Act

DWR Division of Water Resources

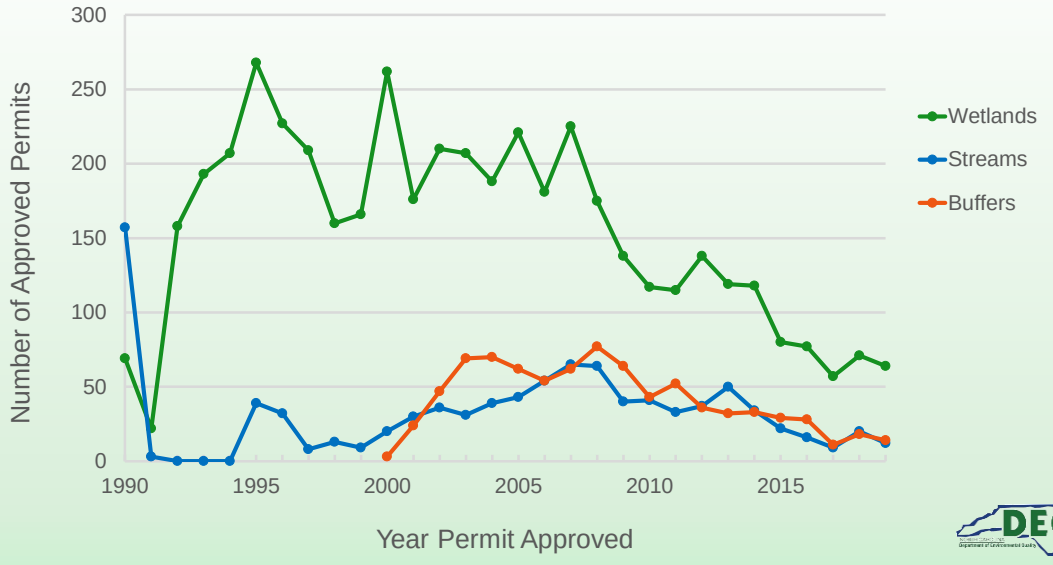
- Section 401 of the Clean Water Act (CWA)
- NC Administrative Code (15A NCAC 02B and 02H) and Session Laws
  - Isolated and Other non-404 Jurisdictional Wetlands and Water Permit
  - Buffer Rules (Catawba, Goose Creek, Jordan Lake, Neuse, Randleman Lake, Tar-Pamlico)

NC Division of Coastal Management

- Coastal Area Management Act (CAMA)
- NC Dredge and Fill Law
- Coastal Development Rules

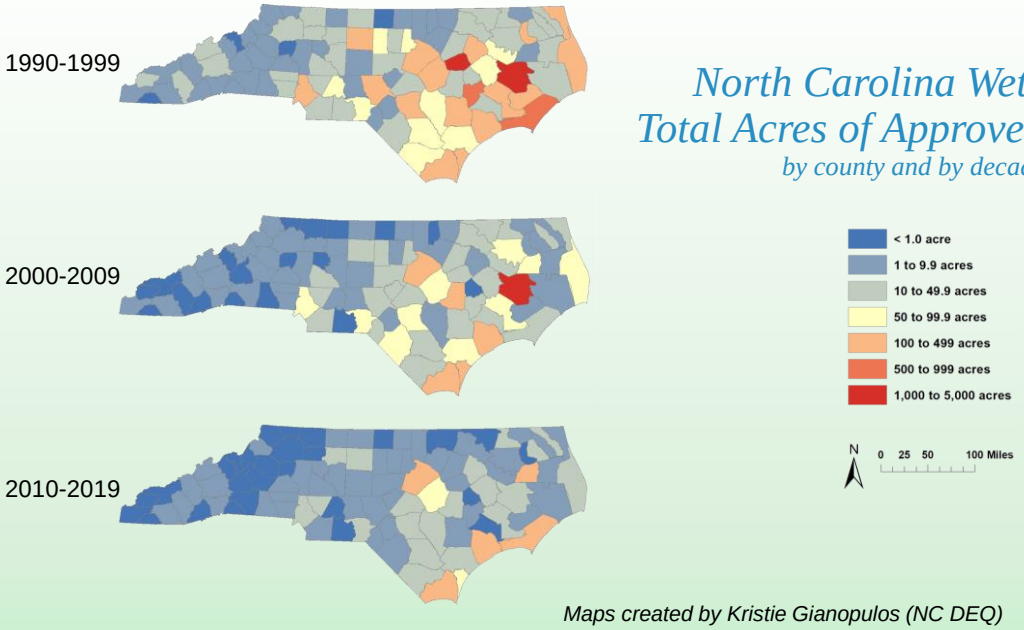
DEQ

Number of Approved Permits



North Carolina Wetlands: Total Acres of Approved Impacts

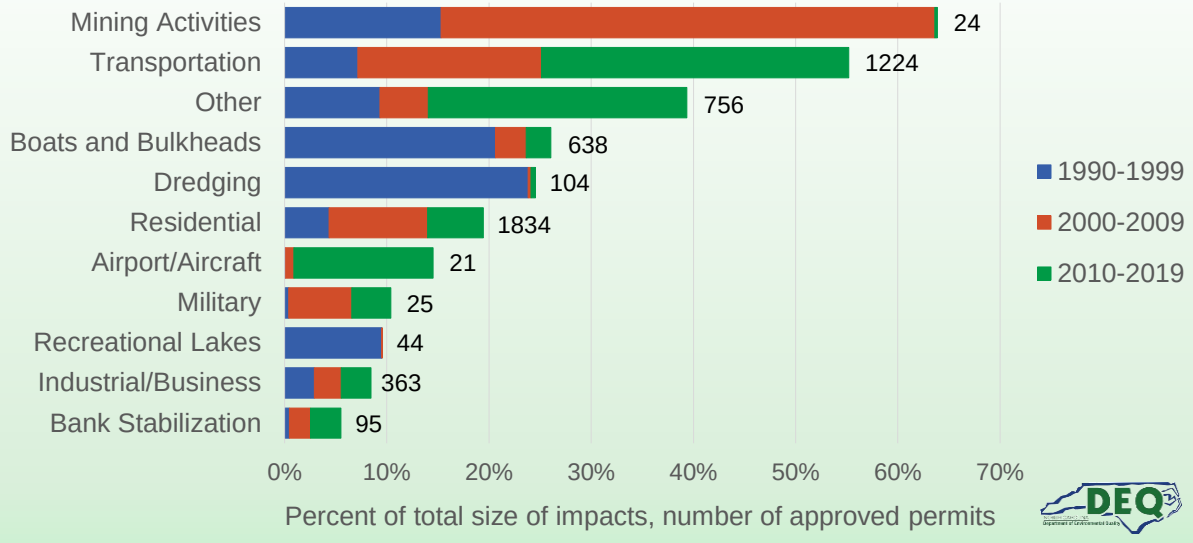
by county and by decade



Maps created by Kristie Gianopulos (NC DEQ)

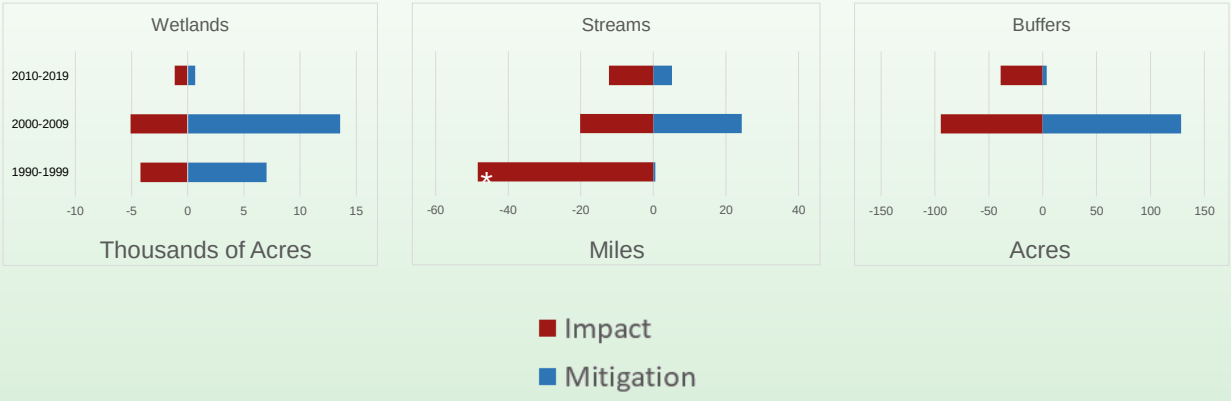
Primary Impact Types

by decade



Impacts vs Mitigation

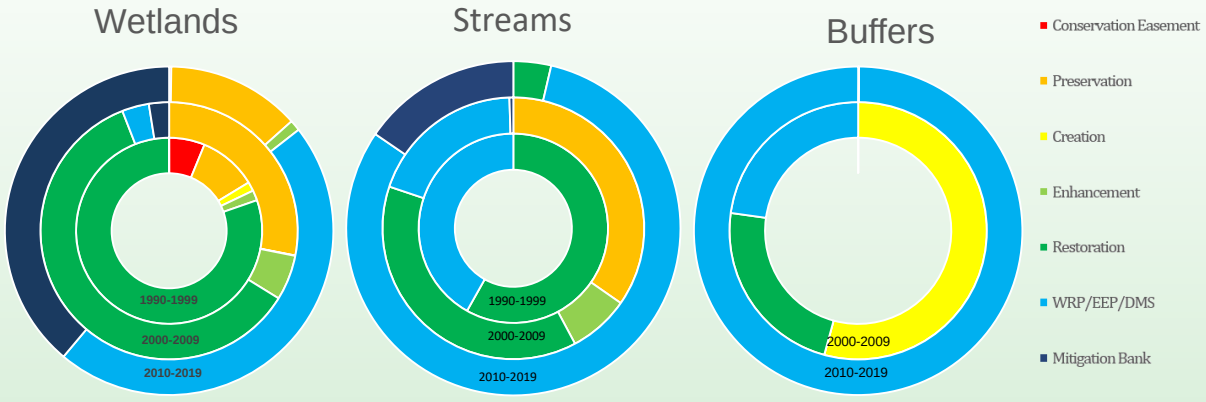
by decade



** Units for stream impacts in 1990-1999 included square feet and/or linear feet. All were converted to miles, so values on the map are higher than actual miles of impact.*

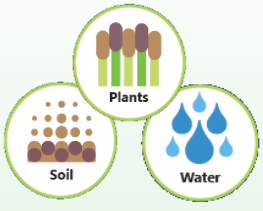
Types of Compensatory Mitigation

by decade



We Can Conserve NC Freshwater Wetlands

Avoidance & Minimization



Enhancement

Identify & Limit Threatening Activities

Preservation

Allow or make room for change

QUESTIONS

Amanda Mueller (NC DWR)
amanda.mueller@ncdenr.gov
919-743-8480

1990-1999*

*Units included square feet and/or linear feet. All were converted to miles, so values on the map are higher than actual miles of impact.

2000-2009

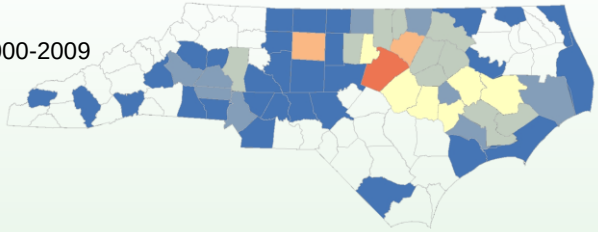
2010-2019

North Carolina Streams: Total Miles of Approved Impacts

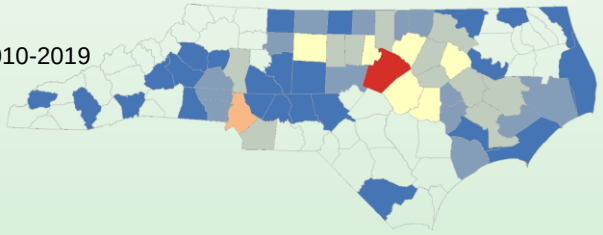
by county and by decade

Maps created by Kristie Gianopulos (NC DEQ)

2000-2009



2010-2019



North Carolina Buffers: Total Acres of Approved Impacts

by county and by decade

- <1 acre
- 1 to 4.9 acres
- 5 to 24.9 acres
- 25 to 99.9 acres
- 100 to 249.9 acres
- 250 to 499.9 acres
- 500 to 1000 acres

N

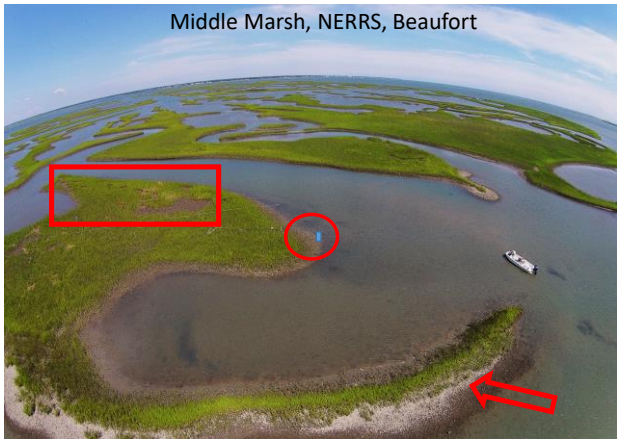
0 25 50 100 Miles

Maps created by Kristie Gianopulos (NC DEQ)

NC Salt Marshes: Threats and Conservation Opportunities

Carolyn Currin
NOAA NCCOS, Beaufort, NC

Middle Marsh, NERRS, Beaufort



NOAA Beaufort Lab Living Shoreline

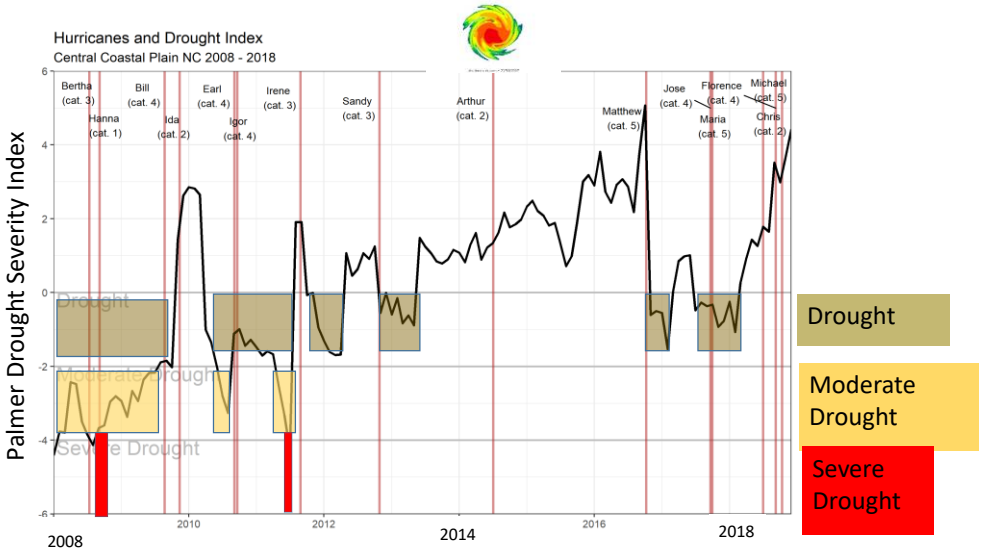
Drought **SLR** **Erosion**

Barriers to Landward Migration

NATIONAL CENTERS FOR **COASTAL OCEAN SCIENCE**
National Ocean Service

Eastern North Carolina Drought and Hurricanes

2008 – 2019

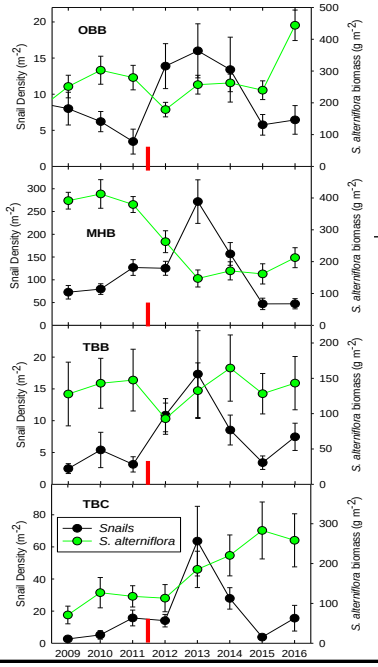


Drought

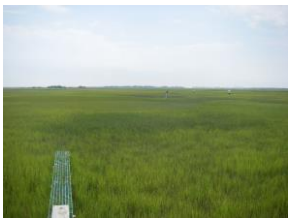
Moderate Drought

Severe Drought

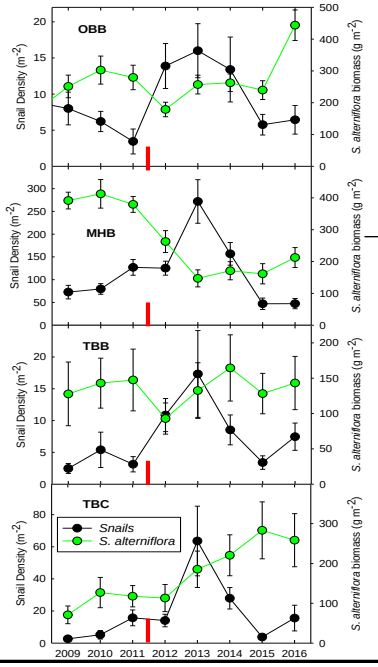
Drought impact on salt marsh biomass



- Significant decline in *Spartina* alterniflora biomass in 2011-12 in MCB Camp Lejeune marshes and Carteret County fringing marshes
- Marsh plant decline followed by *Littoraria* snail increase



Drought impact on salt marsh biomass



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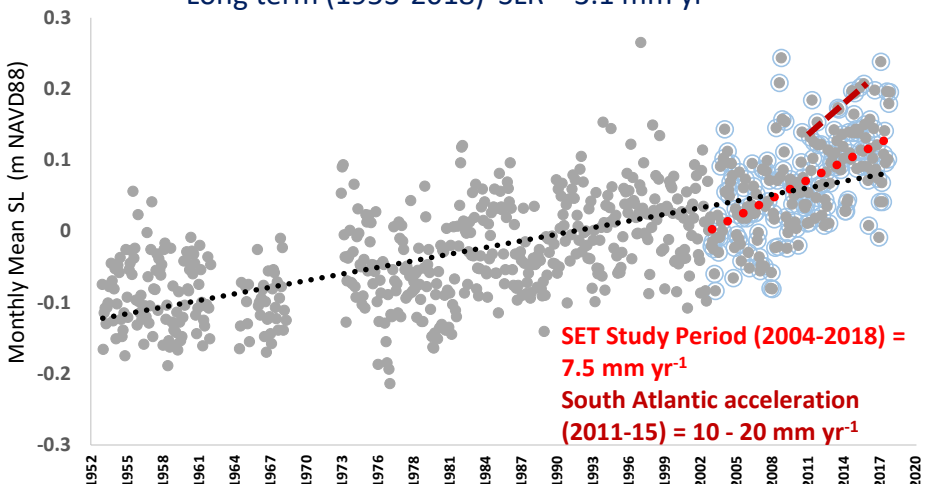
- Marsh plant decline followed by *Littoraria* snail increase

High marshes subject to longterm dieoff from drought events

Relative Sea Level Rise

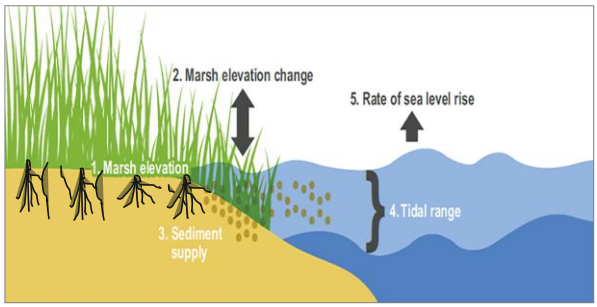
Beaufort NC tide gauge
Long term (1953-2018) SLR = 3.1 mm yr^{-1}



NOAA NWLON; Valle-Levinson et al. 2017 GRL

Marsh Response to Sea Level Rise

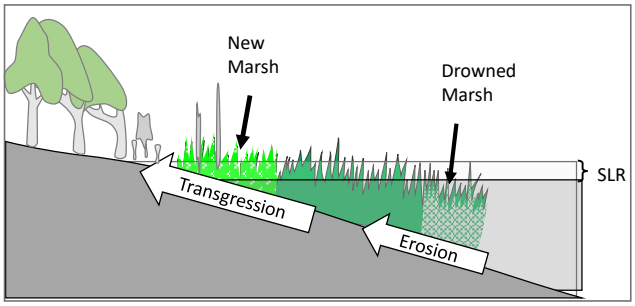
Keep Up (accretion)



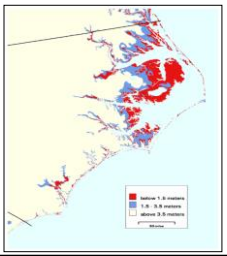
- Requires Adequate Sediment Supply and Plant Biomass

NC salt marshes
- microtidal
- <20 mg/l SSC
- Low end of *Spartina* primary production

Move Up (transgression)

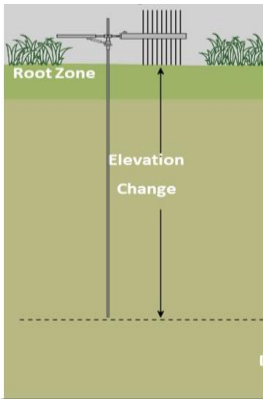


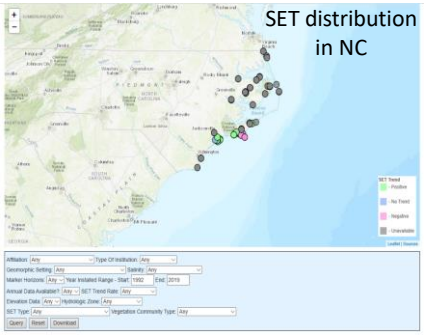
- Requires undeveloped space to move into and no topographical barriers

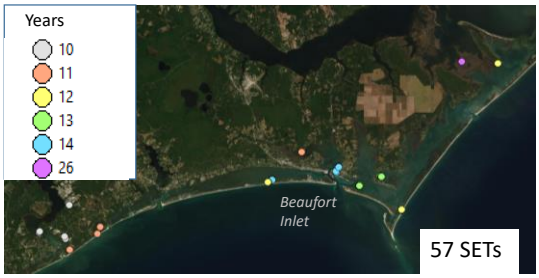


NC Salt Marsh Elevation Change

Surface **E**levation **T**able



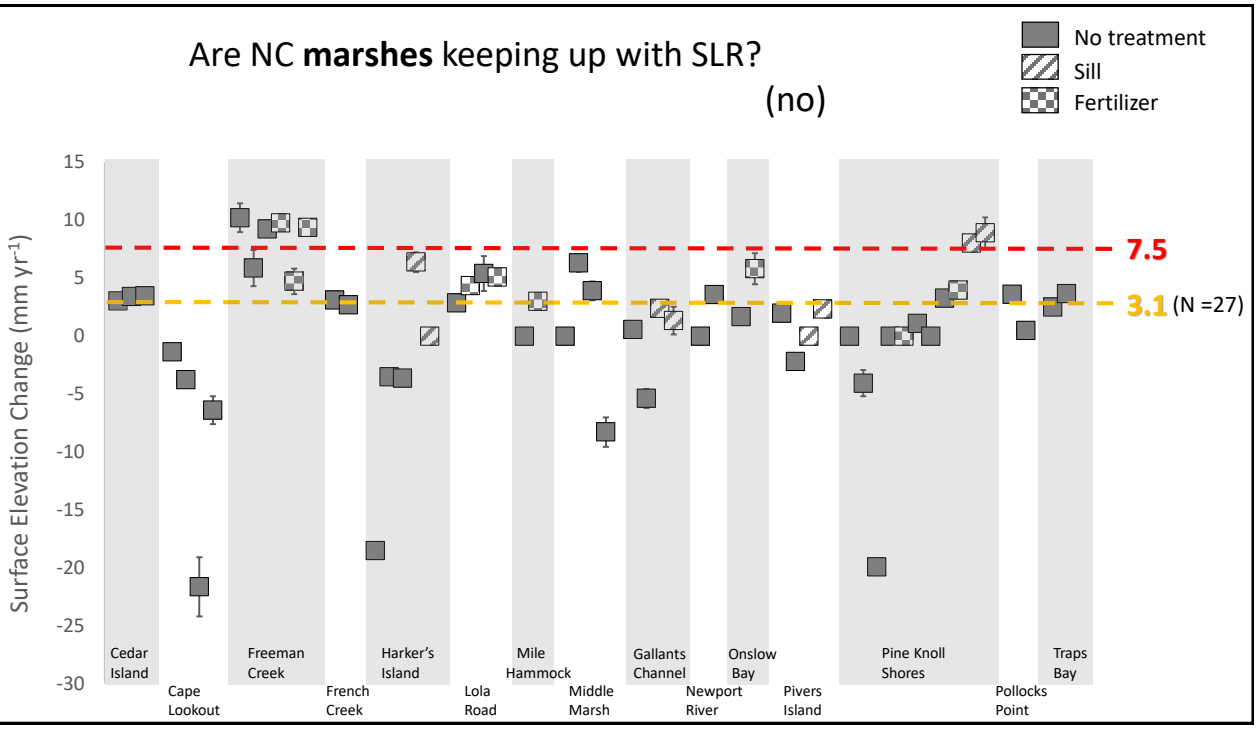




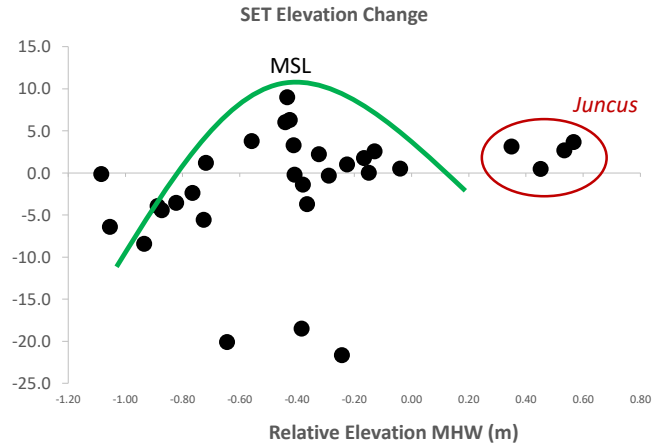
https://ncseagrant.ncsu.edu/program-areas/sustainable-communities/north-carolina-sentinel-site-cooperative/nc-set-community-of-practice/

Are NC **marshes** keeping up with SLR?

(no)

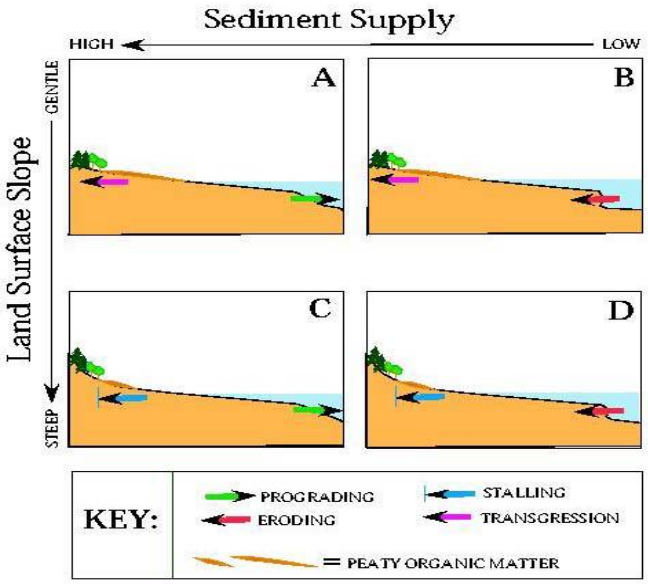


Importance of Elevation Capital for Marsh Sustainability



- *Spartina* marshes below MSL are drowning
- Peak plant biomass at MSL correlates with peak sediment accretion

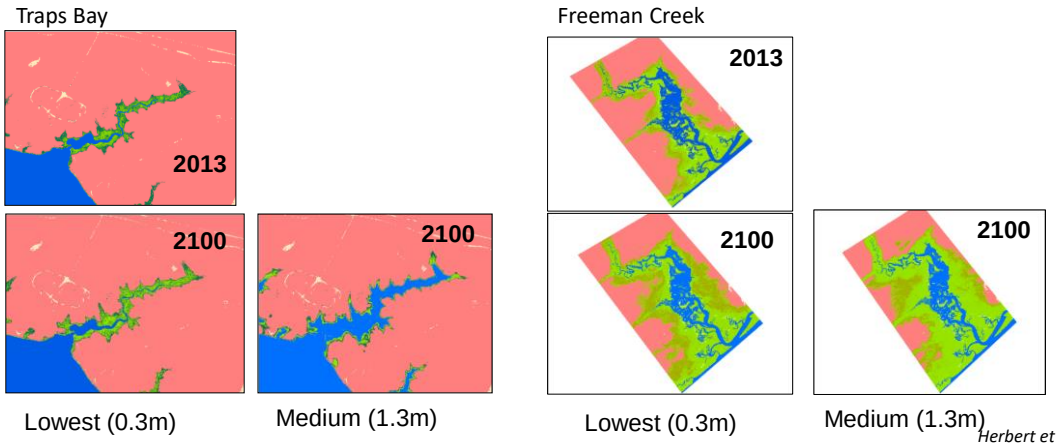
Predicted Marsh Migration varies by slope and SLR rate



Brinson, Christian & Blum. 1995 Multiple state in the sea-level induced transitons from terrestrial forest to estuary. Estuaries & Coasts 18, 648-659

Predicted Marsh Migration varies by slope and SLR rate

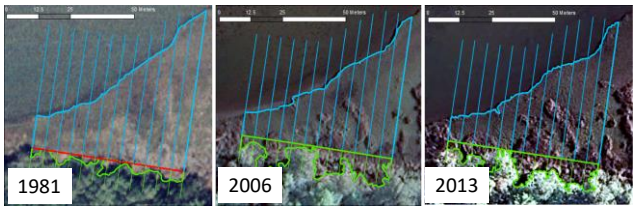
MCB Camp Lejeune marshes
-No built infrastructure barriers at these sites
-Species change and marsh expansion at coastal sites



Herbert et al. 2018
DCERP Annual Report

Migration Corridors critical to maintaining marsh habitat

- Chesapeake Bay – 94 km^2 of drowned eroded marsh replaced by 101 km^2 new marsh in uplands over last century (Schieder et al. 2018)
- Carteret County NC – Marsh landward expansion documented at half of non-bulkheaded sites, but only 16% maintained area
  -Bulkheaded sites, with no landward expansion, had 3x higher net loss of marsh area



Burdick et al, Submitted Est&Coasts

- Statewide modeling efforts to identify and protect corridors for marsh migration

TNC Resilient Coastal Sites for Conservation in the South Atlantic US (2019) https://www.nature.ly/SEcoast

NC NWL Action Plan Coastal Habitats Appendix B
Olander and Warnell https://storymaps.arcgis.com/collections/2154ab2816674f7d8c7429fe87f48830?item=4

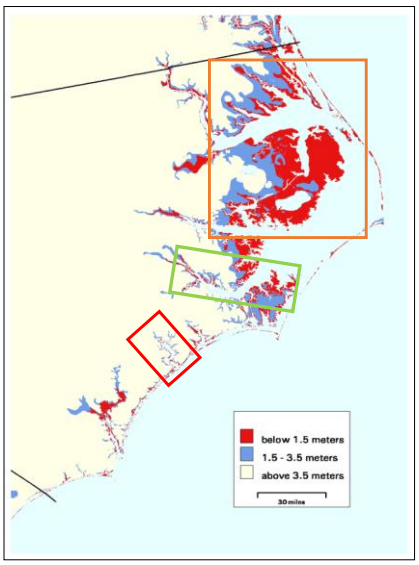
Marsh Erosion

Fringing Salt Marshes occupy 65% of the NC estuarine shoreline (8000 miles of marsh)






Erosion of marsh shorelines



NC Shoreline Change Rates

-0.8 m/yr Albemarle Pamlico Sound

(Riggs and Ames 2003, Eulie et al. 2017)

-0.6 m/yr Neuse River Estuary
-0.5 m/yr wetland shorelines

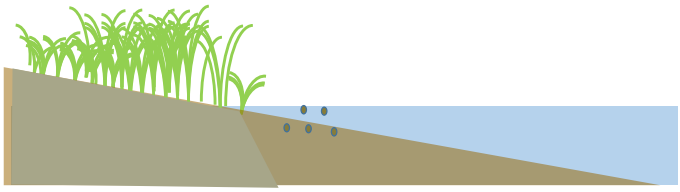
(Cowart et al. 2011)

-0.3 m/yr New River Estuary
-0.2 m/yr marsh shorelines

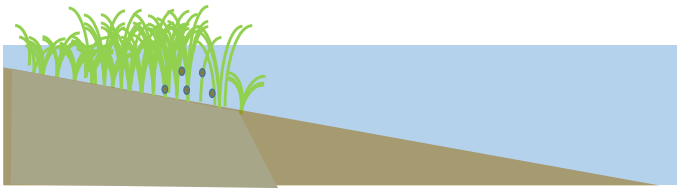
(Currin et al. 2015)

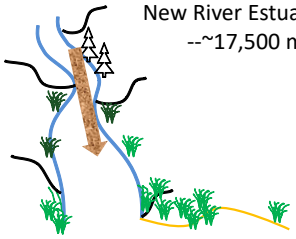
But, within a study area, little correlation between fetch/wave energy and erosion rate

Erosion of marsh shorelines



Erosion greatest when marsh edge is exposed
-can minimize hurricane impacts (Currin et al 2008, Gittman et al. 2014)
-scarped marsh edge > ramped edge (Theuerkauf et al 2015)



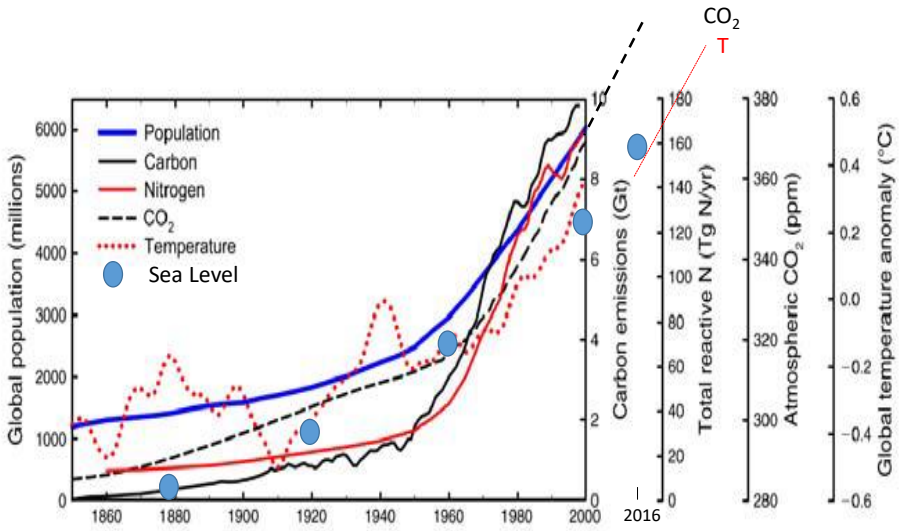


New River Estuary bank erosion
--~17,500 m^3 yr^{-1}

NRE marsh sediment accretion 3 mm/yr
+ ~15,000 m^3 yr^{-1}

Currin et al. 2015

Climate and Anthropogenic Drivers Impacting Coastal Wetlands



-SLR, wave energy, erosion, droughts, storms and built infrastructure will increase
-Conservation will need to plan for FUTURE conditions

Adapted from Smith et al. 2009, Church and White 2006

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Beneficial Use of Dredged Sediments for Coastal Marsh Restoration

Jenny Davis

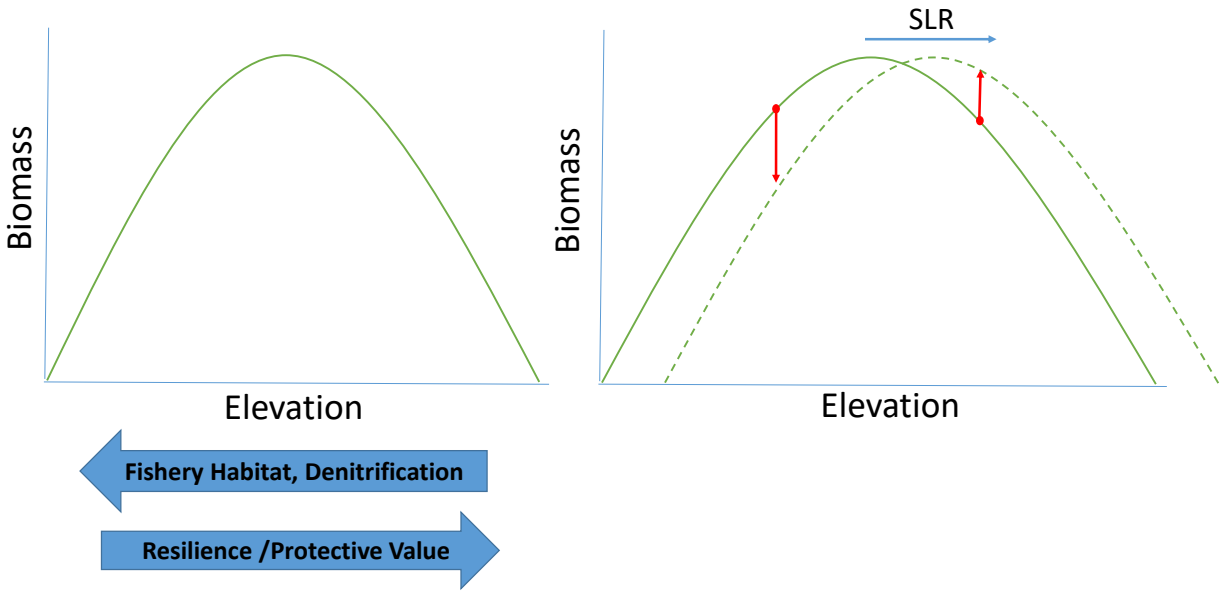
SCIENCE SERVING COASTAL COMMUNITIES

Beneficial Use of Sediments -"productive and positive uses of dredged material, which cover broad use categories ranging from fish and wildlife habitat development, to human recreation, to industrial/commercial uses"

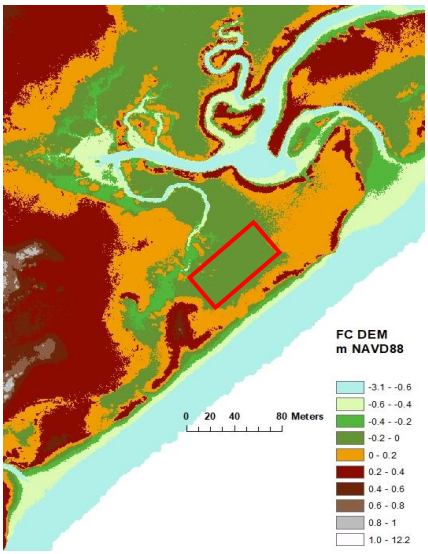
> 1 million metric tons dredged from ports, harbors and waterways each year

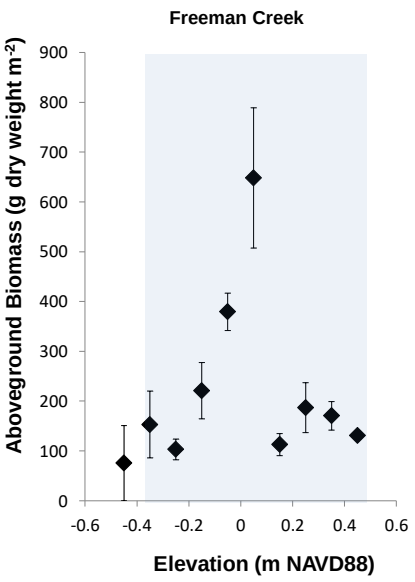
Traditional Sediment Disposal	**Beneficial Use**
Offshore	**Beach/Dune Renourishment**
Confined Disposal (CDF)	**Wetland Creation & Restoration**

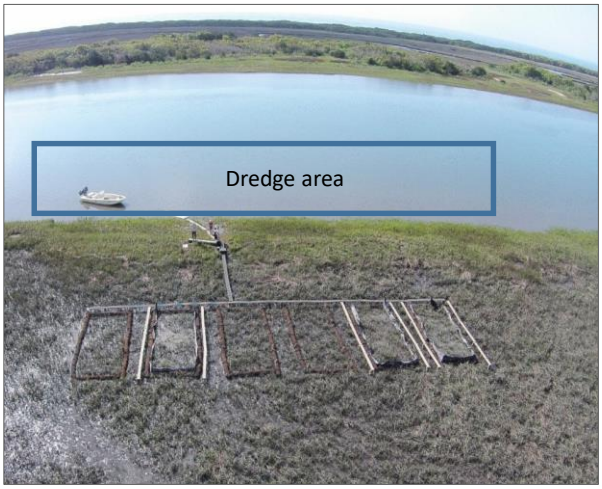
Beneficial Use to Enhance Coastal Marshes : Where and Why?

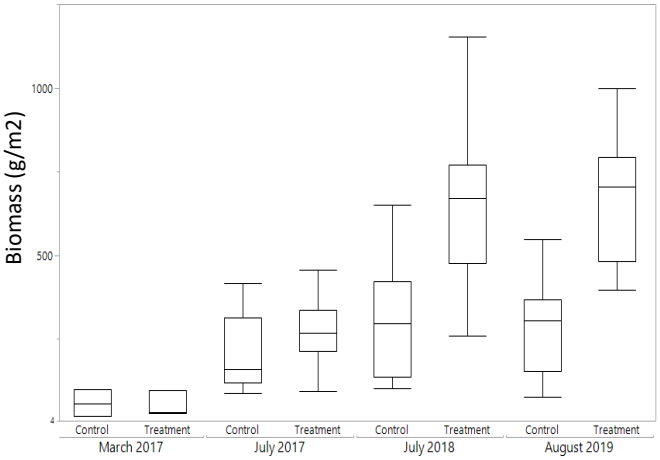


Example 1: Thin layer application of sediment provides a means of helping marshes keep up with sea level rise



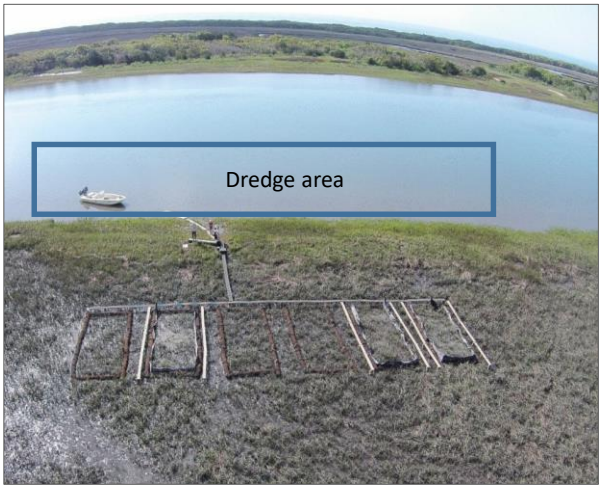


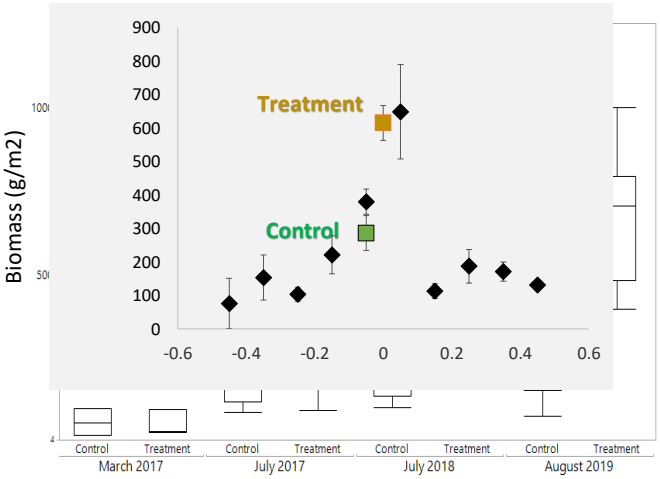




5 x 8 meter cell
Nationwide permit
~ 8cm elevation increase

Plants responded to increased elevation with increased biomass

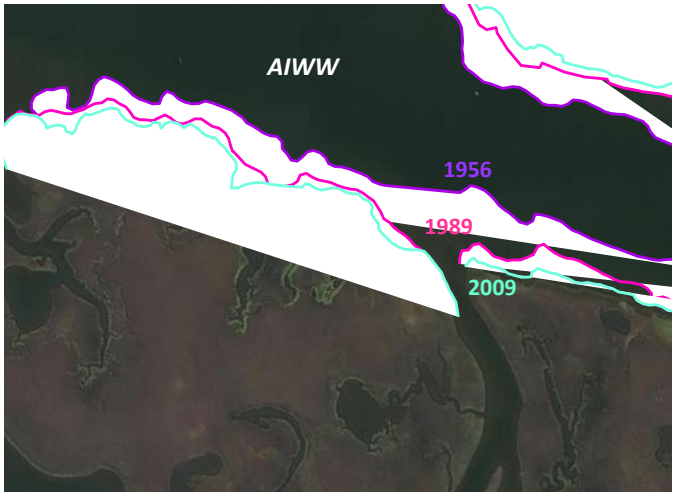


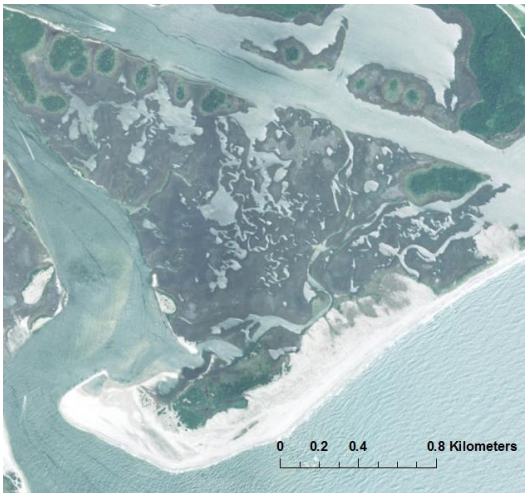


5 x 8 meter plots
Nationwide permit
~ 8cm elevation increase

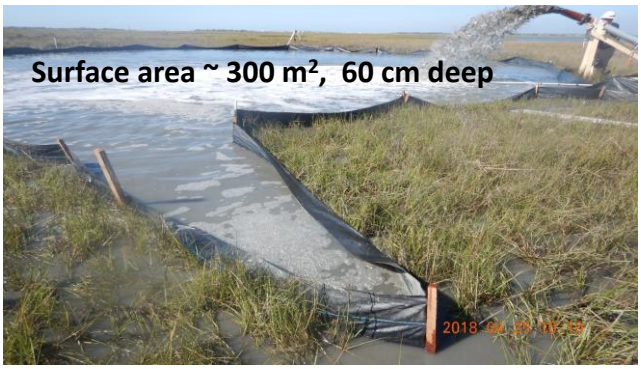
Plants responded to increased elevation with increased biomass

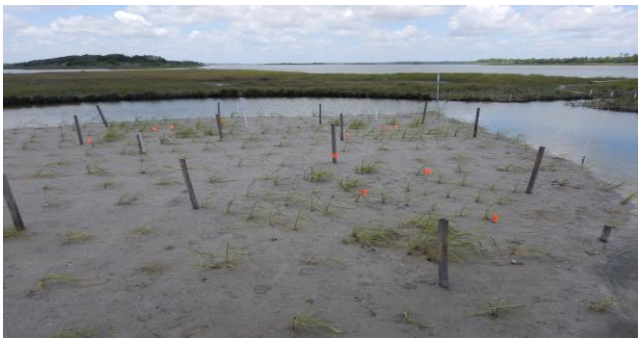
Example 2: Sediment Application to Restore Fragmented Marshes



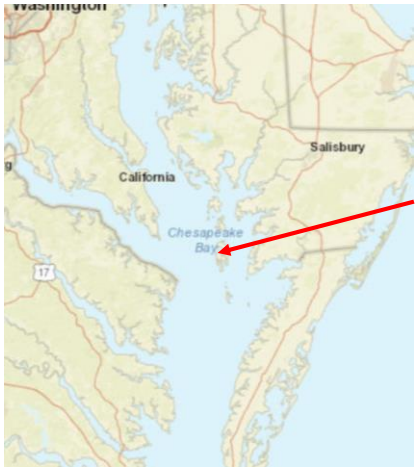


Marsh fragmentation likely contributes to the high erosion rates along this stretch of the water way





Example 3: Strategic Application of Beneficial Use to Increase Coastal Resilience



Swan Island
Maryland

GOAL: long term resilience through restoration of multiple habitats within the original island footprint

before sediment application

65,000 cubic yards of sediment
> 200,000 plants

Engineering With Nature

NATIONAL WILDLIFE REFUGE SYSTEM

MARYLAND DEPARTMENT OF NATURAL RESOURCES

NCCOS
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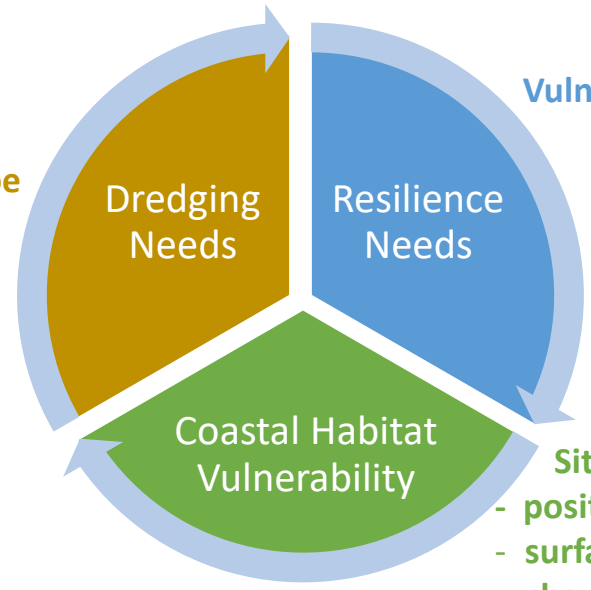
Optimal Implementation of Beneficial Use Requires Coordination

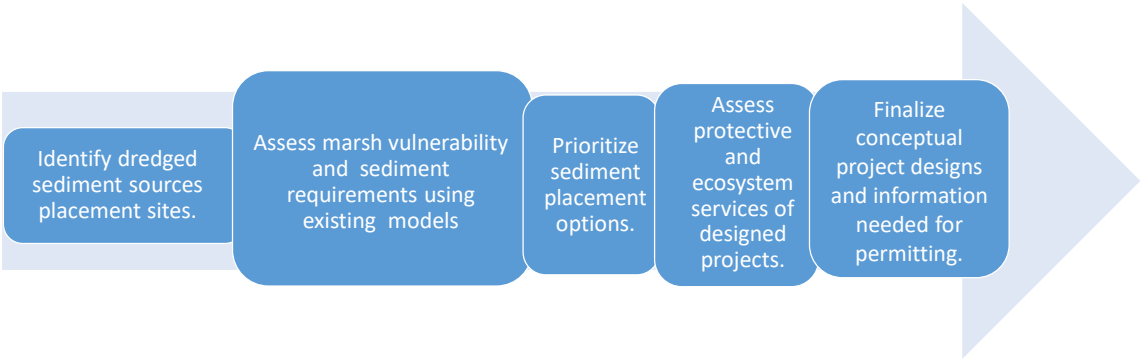
Location
Volume
Sediment Type



Vulnerable Infrastructure

Site specific indicators
- **position in tidal frame**
- **surface elevation change**
- **change in veg cover over time**

Keeping it in the System



ERDC

UNC INSTITUTE FOR THE ENVIRONMENT

EA Engineering, Science, and Technology, Inc., PBC

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Challenges to Project Implementation

- **Proof of Concept to Address Regulatory Hurdles (and efficacy)**
- **Cost/Benefit**
- **Alignment of Restoration and Dredging Projects**

Increasing the Use of Living Shorelines to Protect and Restore Coastal Wetland Habitat in North Carolina

Coastal Habitat Protection Plan Wetland Workshops: Coastal Wetland Restoration and Living Shorelines

August 26, 2020

Lexia M. Weaver, Ph.D., Coastal Scientist and Central Regional Manager

North Carolina Coastal Federation
Working Together for a Healthy Coast

North Carolina Coastal Federation
Working Together for a Healthy Coast

- Collaborate and engage people from all walks of life to protect and restore coastal water quality and habitat throughout the North Carolina coast
- Member supported organization founded in 1982
- 30 staff and 30 board members
- Cover North Carolina's 20 coastal counties
- Offices in Wanchese, Ocean and Wrightsville Beach, NC

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North Carolina Coastal Federation

What We Work For – Our Goals

- **Clean coastal waters** that support fishing and swimming
- **Living shorelines** that reduce soundside erosion and provide habitat
- **Thriving oysters** that support the coastal environment and economy
- **Effective coastal management** that protects our coast
- A coast that is **free of marine debris**

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Living Shorelines

Photo Credit: Vanessa Miller

Wetland Restoration through Living Shoreline Implementation





Wetland Restoration through Living Shoreline Implementation

Before Planting

After 1 Year

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Wetland Restoration through Living Shoreline Implementation

Before Planting

After 3 years

After 6 years

Wetland Restoration through Living Shoreline Implementation

Before Planting

After

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Wetland Restoration through Living Shoreline Implementation

Bogue Sound, Pine Knoll Shores, NC

Before (2007)

After 9 Years (2016)

Mud Bucket Dredging Inc.

Wetland Restoration through Living Shoreline Implementation

Bogue Sound, Pine Knoll Shores

Before (2007)

After 9 Years (2016)

Mud Bucket Dredging Inc.

Benefits of Living Shorelines

- Natural alternative to the traditionally used hard shoreline stabilization methods
- Attenuate waves and reduce shoreline erosion
- Restore and protect valuable fishery habitat (coastal wetland marsh and oyster reefs)
- Improve water quality
- Resilient and outperform bulkheads through storms
- Increase property value
- Less expensive than bulkheads

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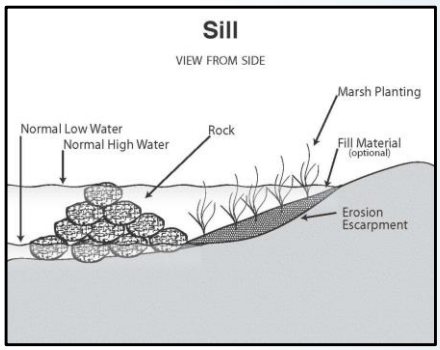
Living Shoreline Design Considerations

- Wave energy
- Fetch
- Predominant wind direction
- Water depths
- Proximity to navigation channels
- Shoreline orientation
- Extent of erosion
- Slope
- Natural abundance of oysters
- Cost
- Property owner preference



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Living Shoreline Materials

Oyster Shell Bags

Granite/Concrete/Marl

Oyster Domes/Reef Balls

Oyster Castles

Oyster Catcher™

Atlantic ReefMaker EcoSystems

The Nature Conservancy

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Living Shoreline Materials

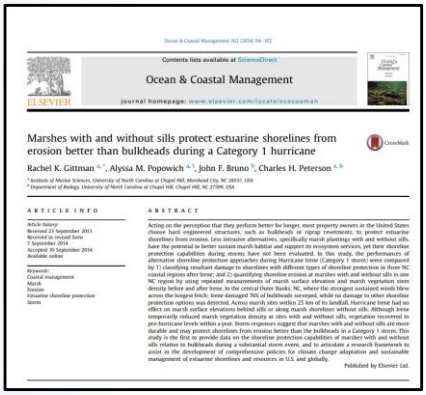
Testing Alternatives to Traditional Mesh Bags

filtrexx SUSTAINABLE TECHNOLOGIES

Tensar.

GREEN Recycling Solutions, LLC

Storm Resiliency of Living Shorelines



Contents lists available at ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

Marshes with and without sills protect estuarine shorelines from erosion better than bulkheads during a Category 1 hurricane

Rachel K. Gittman [a, *], Alyssa M. Popowich [a, 1], John F. Bruno [b], Charles H. Peterson [a, b]

ARTICLE INFO

ABSTRACT

Acting on the perception that they perform better for longer, most property owners in the United States choose hard engineered structures, such as bulkheads or riprap revetments, to protect estuarine shorelines from erosion. Less intrusive alternatives, specifically marsh plantings with and without sills, have the potential to better sustain marsh habitat and support its ecosystem services, yet their shoreline protection capabilities during storms have not been evaluated. In this study, the performances of alternative shoreline protection approaches during Hurricane Irene (Category 1 storm) were compared by 1) classifying resultant damage to shorelines with different types of shoreline protection in three NC coastal regions after Irene; and 2) quantifying shoreline erosion at marshes with and without sills in one NC region by using repeated measurements of marsh surface elevation and marsh vegetation stem density before and after Irene. In the central Outer Banks, NC, where the strongest sustained winds blew across the longest fetch, Irene damaged 76% of bulkheads surveyed, while no damage to other shoreline protection options was detected. Across marsh sites within 25 km of its landfall, Hurricane Irene had no effect on marsh surface elevations behind sills or along marsh shorelines without sills. Although Irene temporarily reduced marsh vegetation density at sites with and without sills, vegetation recovered to pre-hurricane levels within a year. Storm-responses suggest that marshes with and without sills are more durable and may protect shorelines from erosion better than the bulkheads in a Category 1 storm. This study is the first to provide data on the shoreline protection capabilities of marshes with and without sills relative to bulkheads during a substantial storm event, and to articulate a research framework to assist in the development of comprehensive policies for climate change adaptation and sustainable management of estuarine shorelines and resources in U.S. and globally.

Published by Elsevier Ltd.

One year before

One day after

Provided by Dr. Rachel Gittman

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Living Shoreline Maintenance

- Bulkheads often require costly repairs and replacement
- Living shorelines require minimal to no maintenance
  - Salt marsh is restored in 1-3 years
- Fared extremely well after Hurricane Florence
  - Salt marsh plants and rock sills were not affected by the storm
  - Oyster shell bags also remained in place

Post-Hurricane Florence

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Promoting and Increasing Living Shoreline Use through Implementation

Private Property

Community

State

Local Government

County

Promoting and Increasing Living Shoreline Use through Implementation

National and International Case Study:
US-Netherlands Infrastructure Resilience Collaboration

Promoting and Increasing Living Shoreline Use through Community Engagement

Hands on Education and Restoration

Living Shoreline Open Houses

Promoting and Increasing Living Shoreline Use through Engineers and Contractor Training

moffatt & nichol

RESTORATION SYSTEMS

ARENDELL ENGINEERS

TD EURE 252-728-4191

Bobby Cahoon Marine Construction 252.249.1617

Carolina Marine Structures 252.491.9223

Mud Bucket Dredging Inc.

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Promoting and Increasing Living Shoreline Use through Education and Outreach

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Promoting and Increasing Living Shoreline Use through Partnerships

- Students
- Community
- Waterfront Property Owners
- Businesses
- Marine Contractors
- Engineers
- Developers
- Universities and Colleges
- Local, State and Federal Agencies
- Other Non-profit Organizations

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Promoting and Increasing Living Shoreline Use through Funding

- N.C. Division of Soil and Water Conservation's Community Conservation Assistance Program
- N.C. Clean Water Management Trust Fund
- N.C. Division of Water Resources
- National Oceanic and Atmospheric Administration
- National Fish and Wildlife Foundation
- USDA Natural Resources Conservation Service
- Southeast Aquatic Resources Partnership
- Atlantic Coastal Fish Habitat Partnership
- Grady White Boats
- TogetherGreen

Living Shoreline Permitting

- Salt marsh planting alone: no permit required
- Marsh sill and marsh-toe revetment: Coastal Area Management Act (CAMA) General Permit
  - $200 fee
  - Project location map and designs
  - Adjacent property owner signatures
  - Valid for 120 days
- CAMA Major Development Permit
  - $400 fee
  - Additional application materials
  - Reviewed by 13 state and federal agencies
  - Valid for 3 years

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Needs for Increasing the Use of Living Shorelines in the Future

- Strong promotion of living shorelines by regulatory and resource agencies
- Projects should be expected to conduct an alternative's analysis to identify most effective shoreline stabilization method
- Financial incentive programs
- Grant opportunities for communities
- Short-term construction insurance
- Awareness and adoption of living shorelines by the public and marine contractors
- Business programs for marine contractors

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NORTH CAROLINA OYSTER BLUEPRINT
An Action Plan for Restoration and Protection

Living Shoreline Strategy

Draft Actions and Benchmarks for the 2021-2025 Oyster Blueprint Update

1 Year After Construction

2 Years After Construction

Living Shoreline Strategy Workgroup Members

- Jacob Boyd, *N.C. DMF*
- Bill Cary, *Brooke Pierce*
- Carolyn Currin, *NOAA*
- Jenny Davis, *NOAA*
- Anne Deaton, *N.C. DMF*
- Rebecca Ellin, *N.C. NERR*
- Devon Eulie, *UNCW*
- Erin Fleckenstein, *NC Coastal Federation*
- Rachel Gittman, *ECU*
- Niels Lindquist, *UNC-IMS, Sandbar Oyster Company*
- Todd Miller, *NC Coastal Federation*
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- Lexia Weaver, *NC Coastal Federation*
- Curt Weychert, *N.C. DMF*
- Ted Wilgis, *NC Coastal Federation*

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Living Shoreline Strategy Overarching Goal

- Expand the use of living shorelines to become the most commonly used stabilization method in estuaries to support wetland and oyster habitats.

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Action 1: Collaborate through the Living Shoreline Steering Committee

- Identify and bring together the multiple efforts focused on promoting the use of living shorelines.
- Provide the leadership necessary to reach the goal for living shorelines within this blueprint (and elsewhere).

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Action 2: Implement living shorelines to continue to demonstrate their benefits to wetlands, oysters and soundfront property owners.

- Build at least three miles of living shorelines on public and private lands where wetlands and oysters grow by 2025.
- Continue to site and design living shorelines based on research to date and lessons learned from decades of intertidal wetland and oyster restoration in North Carolina and elsewhere to promote wetland and oyster growth and development, as well as support other ecosystem functions and services.
- Devise and implement a communication and education strategy around each project to publicize benefits to gain more public and agency demand for these projects.
- Engage volunteers and contractors in building living shorelines to help increase public awareness of their benefits.
- Document the success of living shoreline projects each year (new and old) including their wetland enhancement and oyster recruitment potential, cost-benefits and resilience compared to other types of shoreline stabilization.

Action 3: Increase the use of living shorelines instead of bulkheads.

- Quantify the extent of living shorelines implemented to date that also serve as wetland and oyster habitat.
- Increase the percentage of living shorelines permitted for shoreline stabilization along shorelines that support wetland and oyster growth by 15 percent a year. The more living shorelines, the more wetlands and oysters in the water.
- Track the number and type of shoreline stabilization projects authorized each year.
- Educate marine contractors, engineers, consultants and regulators through technical trainings to encourage the use of living shorelines. Conduct three regional 2-day trainings for marine contractors, consultants, engineers, agency staff, beginning in Wilmington in February 2021.
- Conduct living shoreline consultations with five marine contractors per year.

RESTORATION SYSTEMS

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Action 4: Create and promote consumer demand for living shorelines by property owners with a special focus on shorelines that support wetland and oyster growth.

- Educate waterfront property owners, realtors, homeowners associations (Community Association Management Services), local governments and the general public on the value and benefits of living shorelines.
- Develop educational outreach materials (electronic and printed) to be distributed to these audiences.
- Conduct one on one living shoreline consultations with 50 waterfront property owners per year.
- Market the use of living shorelines by property managers and owners at three outreach events in three regions of the coast.

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Action 5: Protect regulated and permitted living shorelines that grow harvestable oysters.

- Explore the protection of oyster shell bag and Oyster Catcher™ living shorelines in the next update to the N.C. Coastal Habitat Protection Plan (CHPP).
- Experiment with the use of stronger bags or other sill materials that would not be damaged if oysters are harvested from them.

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Action 6: Test alternative living shoreline construction materials and methods that increase wetland habitat and oyster recruitment.

- Test non-plastic, alternative materials for living shoreline construction at five demonstration project sites.
- Monitor and report the performance of alternative materials.

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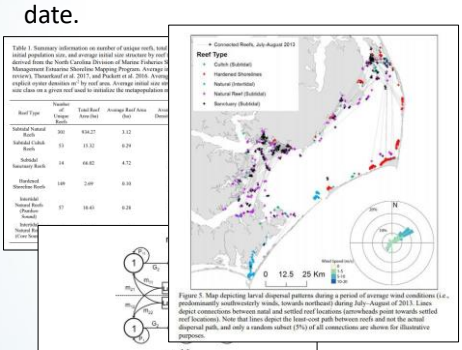
Action 7: Summarize living shoreline research accomplishments and major findings to date related to wetlands and oysters.

- Provide information on how to site and design living shorelines to promote wetlands and oysters based on research to date.



THEUERKAUF, SETH JOSEPH. A Geomorphological, Ecosystem Services, and Population Dynamics Approach to Oyster Restoration and Management. (Under the direction of Dr. David Eggleston).

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Action 8: Identify and answer living shoreline research questions and gaps as they pertain to wetlands and oysters.

- Continue quantifying the role of living shorelines in supporting wetlands and oyster populations.
- Document the degree to which living shorelines using wetlands and oysters can adjust to sea level rise.
- Research the nutrient (nitrogen, phosphorus) reduction benefits provided by living shorelines and use that information to provide incentives for living shoreline projects if warranted.
- Determine why is oyster recruitment on living shoreline materials more abundant on the seaward edge of the sill. How can they be designed differently to increase oyster recruitment?
- On average, how many oysters per ft. can be generated from a living shoreline? On average, how much water can be filtered by oysters on a living shoreline per ft. or other unit?

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Action 9: Qualify living shorelines for mitigation credits.

- Determine if living shoreline projects can be built to qualify for salt marsh ($560,000 an acre value) or nutrient mitigation credits.
- Issue formal policy recommendations.
- Inform mitigation bankers about this opportunity.

Statewide Stream & Wetland ILF Program Rates for Standard Service Areas

Service Area	Mitigation Type	DMS Rate Per Credit (Effective through 6/30/2020)
Statewide Standard	Stream	$525.65
Statewide Standard	Freshwater Wetlands (Riparian and Non Riparian)	$52,273.99
Statewide Standard	Coastal Wetlands	$560,000.00

(https://deq.nc.gov/about/divisions/mitigation-services/dms-customers/fee-schedules

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