Cultural Heritage and Coastal Resiliency: An Assessment of Archaeological Sites in North Carolina

By

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ABSTRACT

Climate change is impacting archaeological sites on North Carolina's coast. Sea-level rise and landscape inundation are often emphasized as the primary threat to cultural heritage from climate change; erosion is identified as the more significant hazard for archaeological sites because of its deterioration of the landscape. A meta-analysis of coastal vulnerability assessments provides a framework for cultural resource managers to address heritage sites under their management. An interdisciplinary assessment applies decadal projections to rank North Carolina's 5000-plus coastal archaeological sites by vulnerability to erosion and cultural significance, establishing a foundation for near-term planning. Finally, a case study examines a major archaeological site in North Carolina experiencing rapid erosion. Innovative mitigation measures deployed at the site are considered within the context of archaeology and the implications for future research.

Cultural Heritage and Coastal Resiliency: An Assessment of Archaeological Sites in North Carolina

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Introduction

Vulnerability of coastal cultural heritage sites from climate change has been a global concern for the past two decades (Anderson, 2017; Caffrey, Beavers, & Hoffman, 2018; Daire, et al., 2013; Dupont & Eetvelde, 2013). Identifying which climate-change effects deserve attention and prioritizing action has become a concern for cultural resource managers, researchers, and stakeholders (Daly, 2014; Forino, Mackee, & von Meding, 2016; Westley, Bell, Renouf, & Tarasov, 2012). Archaeological sites are distinct from other heritage sites. Preservation and integrity are critical conditions for all cultural heritage; preservation and integrity of archaeological sites are dependent on the conservation of its terrestrial environment (Hardesty & Little, 2000).

Coastal North Carolina is home to over 5000 known archaeological sites vulnerable to climate change (Fig 0.1). Sea-level rise and accelerated erosion are the two effects of climate change directly impacting coastal archaeological sites. Although marine transgression and landscape inundation are destructive events, erosion is prioritized here for sites in coastal North Carolina. Inundation does not necessarily eliminate any chance of preservation; erosion removes the conditions on which sites depend for integrity and preservation. This motivates the primary research questions for this dissertation: *Which sites are most vulnerable to erosion*? and *Which sites are most vulnerable within an actionable timeframe*? Secondary research questions are *How should a cultural resource manager approach constructing a vulnerability assessment*? and *What can be learned from erosion and mitigation at a major archaeological site?*

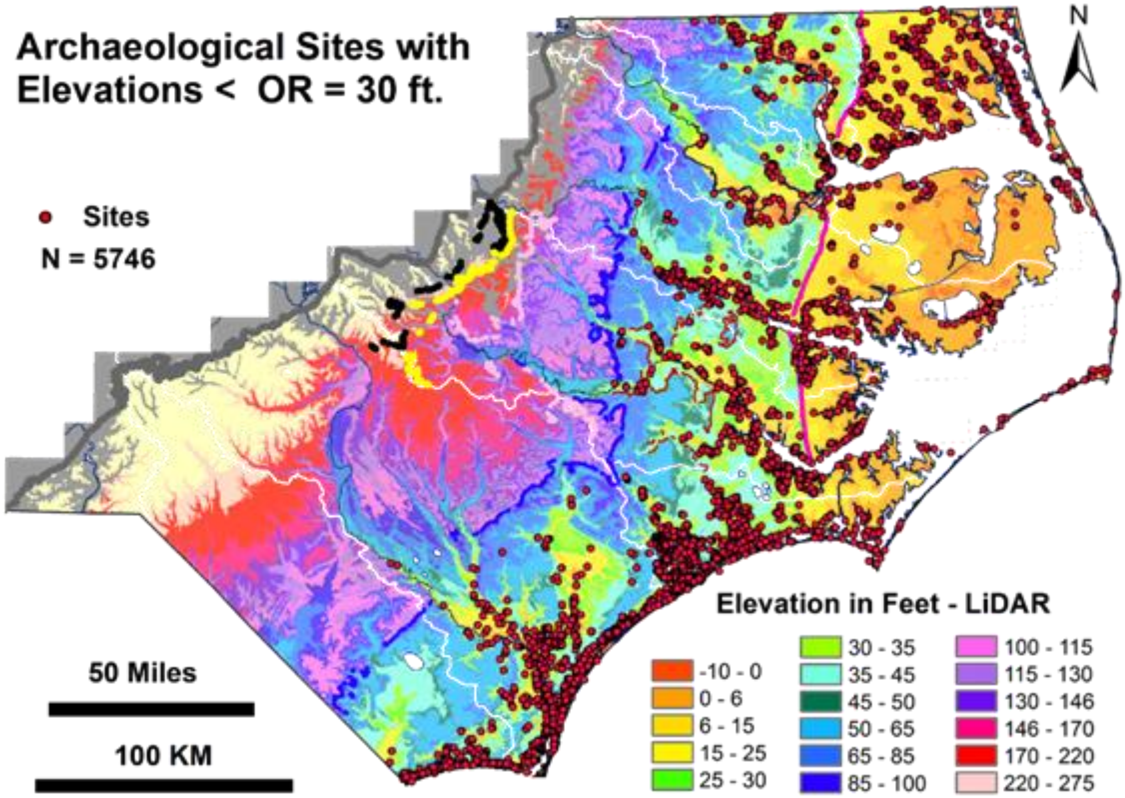

Figure 0.1 Archaeological Sites Coastal North Carolina; Image courtesy Lea Abbott

Global mean sea-level (GMSL) is largely a result of warming oceans and land ice mass loss. Relative sea-level rise (RSLR) varies between regions, driven by glacio-isostatic adjustment (GIA), ocean dynamics, and other processes (Kopp, Horton, Kemp, & Tobaldi, 2015). North Carolina's Science panel endorsed a projected 1-meter sea-level rise by 2100 for planning purposes (N.C. Coastal Resources Comission Science Panel on Coastal Hazards, 2010). More recent studies refine those studies temporally (decadal) and regionally (Outer Banks, Wilmington). Kopp projects a highly likely rise of 24-59 cm in Duck, NC by 2050, and 18-58 cm in Wilmington by 2050. Studies of erosion rates in North Carolina's estuarine system (The Neuse River and a Tar-Pamlico River sub-estuary) find an average of .5-meters per year for all shoreline types (Eulie, Corbett, & Walsh, 2017; Riggs and Ames, 2013). These rates are also relative to local conditions, for example the height of sediment banks or in the case of BrunswickTown/Fort Anderson on the Cape Fear River, river dredging, and wave action generated by passing vessels.

Coastal vulnerability assessments were developed in the United States Geological Service (USGS) to project potential physical responses from shorelines based on relative (local or regional) sea-level rise projections (Thieler & Hammar-Klose,1999). This effective method creates a numeric value system which can weigh incongruous variables of vulnerability and is expressed as a Coastal Vulnerability Index (CVI). Cultural resource managers have adapted and modified CVI's in the last decade, assessing heritage sites in diverse shorelines around the globe (Daire, et al., 2013; Reeder-Myers, 2015; Johnson, Marrack, & Dolan, 2015). This innovation has proven effective in identifying likely effects and sites potentially needing mitigation. Resource managers naturally assess sites within their purview, but without standardization of methodology results have been uneven. This dissertation examines vulnerability assessments by cultural resource managers, develops a modified CVI for North Carolina, and presents a case study of erosion, mitigation, and archaeology at BrunswickTown/Fort Anderson.

A "journal" or "chapter" approach is employed in this dissertation. Each chapter is meant to stand alone for publication, while informing the other chapters. Although each chapter addresses vulnerability differently, a degree of redundancy is unavoidable. The chapters are organized in a "3 Pass" hierarchy of increasingly narrowing scope. This organization is adopted from a proposed method of approaching vulnerability assessments of coastal sites (Westley, 2019). A 1st Pass assessment is usually a broad and geographically large analysis, for example the southeastern coast of the United States. 2nd Pass assessments address regional or local issues; 3rd Pass assessments address specific sites or tightly constrained groupings of sites.

Chapter 1, *Coastal Vulnerability Assessments for Cultural Resource Managers: Systematic Approaches and Key Considerations* provides cultural resource managers and planners with a framework for beginning vulnerability assessments. Published assessments were evaluated for effectiveness, synchronization of data and geographic size. Key characteristics of effective assessments are identified as appropriate scale, data selection and data resolution. The identification and incorporation of recent, local studies of sea-level rise projections, erosion rates, or other pertinent data is a best practice. The inclusion of cultural value rankings is endorsed as a tool for refining vulnerability assessments, especially for large datasets despite limitations and spatial variation. Two studies are considered as 1st Pass assessments of the coastal United States (Anderson, 2017; Reeder-Myers, 2015).

Chapter 2, *A regional vulnerability assessment: archaeological sites on North Carolina's coast* is a 2nd Pass, regional assessment which prioritizes identifying sites vulnerable to erosion over inundation by leveraging relative sea-level rise projections and local erosion rates. Elevation, distance to shoreline data and cultural significance are used in constructing a modified CVI. Using short-term projections, the modified CVI narrows over 5000 potential sites vulnerable to climate change to an actionable 958 sites vulnerable to erosion by 2050. 21 sites are found to be very highly vulnerable, 169 highly vulnerable, 461 moderately vulnerable, and 307 having low vulnerability. Underscored is the necessity of refining analyses further to the local or site level, where the condition of specific shorelines, especially hardened ones, will affect vulnerability.

Chapter 3, *A vulnerability assessment of BrunswickTown/Fort Anderson State Historic Site, Brunswick County, North Carolina, USA* is a 3rd Pass case study which considers the local processes and mitigation efforts which are endangering this important site. BrunswickTown/Fort Anderson (BTFA) is experiencing heavy erosion from sea-level rise, channel dredging, passing container ships, wave action, and increased storm activity. The commitment of enormous resources resulting in innovative erosion control measures such as wave attenuators which also provide oyster habitats are likely to mitigate site deterioration for a large portion of the site. Here the archaeology of BTFA is considered within the context of these protective measures. Low-lying areas remain vulnerable to erosion and inundation, however, including a colonial-period port and a potential antebellum slave quarter. Prioritizing these areas for research, more accurate mapping of their archaeological features, monitoring shoreline erosion and accretion along the waterfront, and stakeholder collaboration provide a sound basis for preserving BTFA's cultural heritage.

A 3 Pass organization facilitates the identification of erosion as the most significant threat for North Carolina's coastal sites from climate change. What was previously a vaguely defined problem of how to address thousands of sites being inundated within a hundred years can now be narrowed to less than one thousand sites at risk of eroding by 2050, with less than two hundred being highly vulnerable. This identification frames the issue with a much higher utility for managers, planners, and stakeholders. It also provides a framework for further refining assessments by examining best practices for CVI construction for cultural resource managers and examining the innovative measures undertaken at BTFA.

Chapter 1: Coastal Vulnerability Assessments for Cultural Resource Managers: Systematic Approaches and Key Considerations

Abstract

In the past decade, cultural resource managers have begun adopting vulnerability assessments as a tool for determining the resiliency of cultural heritage sites in coastal regions. Here published coastal vulnerability assessments are categorized using a “3 Pass” organization relating to broads-scale, regional, and site-specific assessments. Key characteristics of practical assessments include:

- Appropriate spatial scale
- Adopting local physical data
- Data resolution
- Selective socio-economic data
- Measures of significance

The inclusion of difficult cultural value rankings, thus far largely avoided, will expand assessments at regional and site-specific level by providing managers with a more refined toolkit for resource allocation and decisions on mitigation.

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Introduction

Almost five decades have passed since the UNESCO World Heritage Convention (1972) affirmed the interaction between natural processes, anthropogenic activities, and the necessity of preserving cultural resources. Since then, accelerated marine transgression and coastal erosion as products of human-induced climate change have concerned cultural resource managers and stakeholders (UNESCO, 1972; Dawson,2011; Erlandson, 2012; ICOMOS, 2020). The relatively recent adoption and accessibility of technologies such as GIS and remote sensing in the field of cultural resource management (CRM), along with increasing public awareness of the potential threats related to climate change and a willingness by cultural resource managers to use interdisciplinary methods of assessment have resulted in a proliferation of coastal vulnerability studies focused on tangible cultural resources.

Without a standard methodology, including an agreed upon system of determining vulnerability, and definition of terms, the effectiveness of published assessments is uneven. Wide variation exists in methods, data, and purpose, leading in some cases to mismatched scale, data, and processes. Despite the twenty years since Hammar-Klose and Theiler published their Coastal Vulnerability Index (CVI), applying the CVI to cultural resources is still generally in a "first-pass" embryonic stage (Westley, 2019). Westley advocates for a 3-tiered assessment of coastal resources which is adopted here: a large-scale 1st pass to identify major hazards; a 2nd pass which addresses regional vulnerability; followed by 3rd pass, site-specific assessments (Westley, 2019). What are other methods and key characteristics for cultural resource managers to consider before constructing vulnerability assessments? How do scales, data, and other variables correspond with one another? This study uses published vulnerability assessments to provide cultural resource managers with a basis for building CVI's.

Background

While no standardized methodology exists for vulnerability assessments of coastal cultural resources, the groundwork is in place based on the CVI developed by the United State Geological Survey (USGS) along with guiding documents from cultural heritage management institutions.

Coastal vulnerability assessments took shape largely within the USGS in 1990 with Gornitz' *vulnerability assessment of the East Coast of the United States to sea-level rise.* (Gornitz, 1990). Gornitz also published *A coastal hazards database for the U.S. West Coast* and *The development of a coastal vulnerability assessment database, vulnerability to sea-level rise in the U.S. southeast* (Gornitz, 1994). He followed this with a geographically refined study in 2001, *Impacts of sea level rise in New York City metropolitan area.*

Hammar-Klose and Thieler's 2001 publication *Coastal Vulnerability to sea-level rise; A preliminary database for the U.S. Atlantic, Pacific, and Gulf of Mexico coasts* introduced the Coastal Vulnerability Index (CVI), the basis for many vulnerability indices and methods used today. The CVI ranks geological and physical process variables that contribute to coastal vulnerability such as erosion and inundation: Tidal Range (influences inundation); Wave Height (associated with inundation); Coastal slope (linked to shoreline retreat and inundation); Shoreline Erosion Rates; Geomorphology (linked to erodibility of a shoreline); and Historical Rates of Relative Sea-Level Rise (linked to eustatic sea-level rise and isostatic processes) (Thieler & Hammar-Klose, 1999; Thieler & Hammar-Klose, 2000) (Table 1.1). Each physical variable was assigned a numeric value based on the vulnerability of a shoreline. For example, the rocky-cliff shorelines of the northeastern United States, with relatively slower rates of sea-level rise, were considered less vulnerable than the Gulf Coast sandy shorelines, which have higher rates of sea-level rise and higher rates of erosion. The CVI is expressed mathematically as the "the square root of the geometric mean of these values, or the square root of the product of the ranked variable divided by the total number of variables, or CVI= $\sqrt{((a*b*c*d*e*f)/6)}$, where a=geomorphology, b=coastal slope, c=relative sea-level rise rate, d=shoreline erosion/accretion rate, e= mean tide range, and f=mean wave height. The following is an example of geologic and physical process variable ranking:

Variable	Very Low 1	Low 2	Moderate 3	High 4	Very High 5
GEOMORPHOLOGY	Rocky cliffed coasts, fjords	Medium cliffs, Indented coasts	Low cliffs, Glacial drift, Alluvial plains	Cobble Beaches, Estuary, Lagoon	Barrier beaches, Sand beaches, Salt marsh, Mud flats, Deltas, Mangrove, Coral reefs
SHORELINE EORSION/ACCRETION (m/yr)	>2.0	1.0-2.0	-1.0-1.0	-2.0- -1.0	<-2.0
COASTAL SLOPE (%)	>2.0	1.20-0.90	0.90-0.60	0.60-0.30	<0.30
RELATIVE SEA-LEVEL CHANGE (mm/yr)	<1.8	1.8-2.5	2.5-3.0	3.0-3.4	>3.4
MEAN WAVE HEIGHT (m)	<0.55	0.55-0.85	0.85-1.05	1.05-1.25	>1.25
MEAN TIDE RANGE	>6.0	4.0-6.0	2.0-4.0	1.0-2.0	<1.0

(m)					

Table 1.1 Ranges for Vulnerability Ranking of Variables on the US Atlantic Coast; from Coastal Vulnerability Assessment of Cumberland Island National Seashore to Sea-Level Rise (2004)

This approach required several caveats. The authors note that predicting coastal evolution was not straightforward and lacked a standardized methodology. Furthermore, the authors observed that human modification of the shoreline, such as commercial and residential development, beach nourishment, jetties, and other engineered adaptations along with state and federal permitting processes might be the primary driver of coastal evolution in certain areas (Thieler & Hammar-Klose, 1999).

Two key developments spurred the use of vulnerability assessments by cultural resource managers. First, a series of "raise the alarm" articles were published, especially *As the world warms: rising seas, coastal archaeology, and the erosion of maritime history*, cited in every Western Hemisphere article studied for this analysis (Erlandson, 2012). Rather than a ranking of vulnerability or other quantitative process, it simply lays bare the likelihood of lost coastal heritage from climate change. Erlandson suggests that a global collaborative effort is needed, that archaeologists should consult more with indigenous populations, and radiocarbon dating should be incorporated more into coastal resource surveys. Second were influential directives and guidance documents produced by the United Nations and its educational wing (UNESCO), advisory bodies such as the International Convention on Monuments and Sites (ICOMOS) and guidance from the National Park Service (UNESCO, 1972; ICOMOS, 2020; National Park Service, 2018). These form a consensus that coastal cultural heritage vulnerability assessments should assist in determining future mitigation management. These documents in some ways defined the process for resource managers.

The definition of vulnerability (or vulnerability assessment) itself is not agreed upon in the literature but is determined by the characteristics being measured. Daly's (2014) definition is "Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (Daly, 2014, pp. 270-271). Daly notes that it is largely subjective, and usually a combination of biophysical and socio-economic factors. McLaughlin and Cooper (2011) express it as narrative-like equation: *Vulnerability = characteristics (resilience and susceptibility) + coastal forcing + socio-economic factors*. Forino et al. (2016) defines a vulnerability assessment as "assessing the degree of susceptibility to which elements at risk are exposed to a hazard". In some instances, vulnerability is used interchangeably with risk. This stems from lack of standardization and borrowing from associated fields; translation from other languages might also play a role. The CVI continues to heavily influence cultural resource managers because of its explicit ranking system and relative ease of translation for land managers who are concerned with projections of landscape change. Rendering physical data into a data ranking system provides a coherent approach to managers who are tasked with putting them into practice.

Methods

In order to develop guidelines and approaches for cultural resource managers assessing vulnerability, ten published vulnerability assessments from around the globe were selected based on geographic diversity and their focus on cultural heritage management. These stood out as the most utilitarian on the basis that they used geologic or physical process data, were not just theoretical or merely suggested approaches, and could be reasonably categorized into the 3 pass categories. The assessments are focused on cultural heritage, and do not include the studies discussed above.

Assessments were evaluated on their effectiveness in determining vulnerability for cultural resources and whether a synthesis of study objective, method, scale, and data resolution (the ability to differentiate between two closely spaced data points) exists (Table 1.2). An example would be if the scale of the study correlated with the stated objective and available data. One article from each "Pass" is discussed more fully below.

First Author	Country	Scale	Area (sq.km)	# of sites	Assessed
Daire	France	1st Pass	2974	2500+	SLR; Erosion
Reeder-Myers	CA., TX., VA. USA	1st Pass	4343	3623	Multiple
Ezcurra	Puerto Rico	1st Pass	9104	1185	SLR
Anderson	SE USA	1st Pass	na	14000+	SLR
Hadjimatsis	Cyprus	1st Pass	9251	8	Seismic
Wang	Taiwan	2nd Pass/Regional	2053	113	Flooding
Reeder-Myers	Houston USA	2nd Pass/Regional	2336	na	Hurricane
Westley	N. Ireland	2nd Pass/Regional	5	67	Erosion
Dupont	Belgium	Site Specific	2.5	1	Multiple
Forino	Australia	Site Specific	.5	1	Multiple
Thompson	Hawaii USA	Site Specific	.5	2	SLR

Table 1.2 Selected vulnerability assessments

Results

The studies in Table 1.2 examined a range of natural processes (sea-level rise, flooding, erosion) at different scales and assessed a wide variety of cultural heritage sites. Only Reeder-Myers used a form of the CVI as part in a study of separate geographic regions within the United States. Wang (2015) used a ranking system which incorporated a physical process variable (precipitation), and Daire et al. (2012) used a ranking system which incorporated vulnerability to erosion. Reflecting the early stages of utility for cultural resource managers, Anderson (2017) and Ezcurra (2017) used only elevation data as an indicator of vulnerability to sea-level rise. Creatively, Johnson (2015) incorporated data from a tsunami to project landscape change from sea-level rise.

The synthesis between scale, objectives, and data resolution is reflected in the utility of the assessments (Fig 1.1). Issues with scale often interact with the other components of vulnerability assessments. Data resolution might not be available or usable for the intended analysis. For example, Westley's assessment of sites in Newfoundland initially proposed local bathymetry as part of the study (Westley, Bell, Renouf, & Tarasov, 2011). The assessment was modified as the objective was a 2nd pass regional study, while the available bathymetric resolution was 1 km, more suitable for a 1st pass assessment. Anderson's 1st pass study of sea-level rise on coastal archaeological sites in the southeastern United States presents an applicable synthesis of data and scale: using elevation as proxy for vulnerability, the author reveals over 14000 vulnerable sites (see below) (2017). Similarly, Reeder-Myer's use of the CVI in examining archaeological sites in three different coastal regions in the United States, including areas of California (rocky cliffs), Texas (low-energy Gulf Coast), and southeastern Virginia (Atlantic) depicts an appropriate synthesis of scale and objectives (2015). The author uses a modified CVI to compare each region's vulnerability versus the United States as a whole. In each geographic region, archaeological sites are restricted to 5 km from shoreline and less than 1 meter above mean sea level, illustrating the differences in vulnerability for sites near each shoreline type.

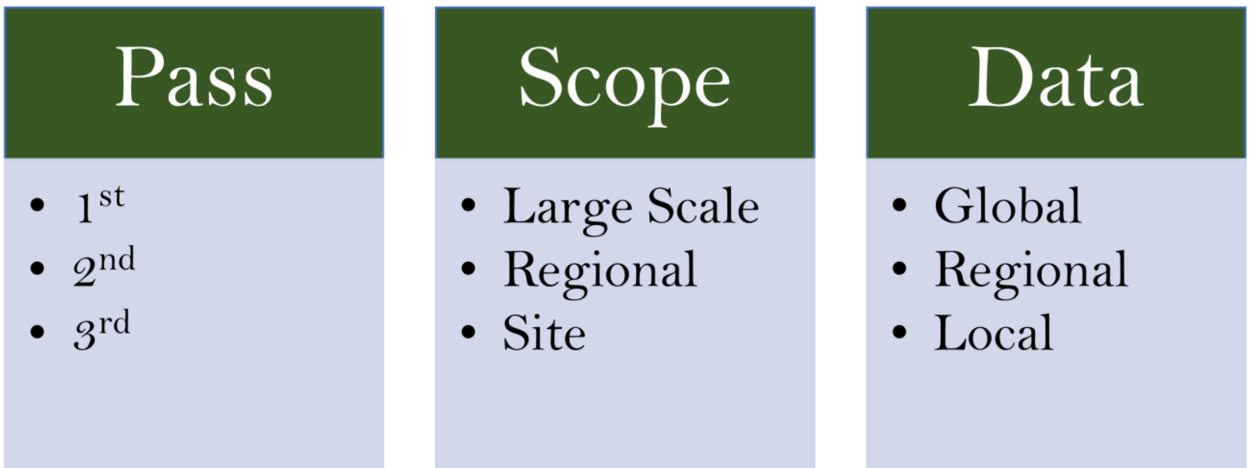

Figure 1.1 Pass, Scope, and Data relationship

Data accessibility is one of the biggest contributors to usability among the studies. Several studies, in particular theory-based ones, avoid the implementation of physical process data altogether. The authors of a vulnerability assessment of an abandoned wastewater treatment plant in Newcastle, Australia, present a Cultural Heritage Resiliency Index (CHRI) based on Hazard, Exposure, and Vulnerability Scores (Forino, et al, 2016). In this study, Hazard analysis metrics consists of Location, Probability of Occurrence (storms), Magnitude and Duration. The Exposure metric is scored on Current Use, Direct Economic Impacts, and Indirect Economic Impacts. Vulnerability is based on Structural Condition, Heritage Fabric, and Historical

Damage. The scores are tallied and scored on a 100-point system. However, no process data at all is presented. For example, recent strong storm activity meant that probability, magnitude, and duration received high scores (no other data was given). Although low-lying and near the coast, no sea-level rise data is included, but location and elevation scores are high. The structure of the assessment appeared well-thought out, but lack of any data makes it difficult to examine the CHRI's utility.

An example of a flawed synthesis of scales and resolution is a 1st Pass assessment of heritage sites in Cyprus. The authors focused on only eight cultural heritage sites, discussed only four, with little description of the sites (Hadjimitsis, Afapiou, Alexakis, & Sarris, 2013). They use two different statistical methods to prioritize the sites, which was unnecessary for such a small sample size and with little variation in the topography, climate, or erosion. Their use of seismic maps is interesting and might be applicable in the region, but the inclusion of a "distance to roads" variable as a measure of vulnerability does not match the other broad-scale features of a 1st pass assessment. These asynchronous approaches ultimately don't reconcile satisfactorily.

Socio-economic measures have been included in several assessments, especially theoretical ones (Wang, 2015) (Forino et al, 2016) (Dupont & Van Eetvelde, 2012). Parsing out the myriad variables and methodologies for determining socio-economic strength and weaknesses is beyond the scope of this paper. A case can be made that there is a correlation with the adaptive capacity of a population and the adaptive capacity of its heritage sites. Economists make this case in terms of the value of cultural heritage increasing through development, tourism, and higher population density (Throsby, 1999; Eppink & Wright, 2016). But at odds with this is the manner that most cultural resource management is conducted and its purpose. Cultural resource management is generally used to protect sites from being destroyed by development. Thus, areas of intense development, which are, in fact, being subjected to greater scrutiny and preservation-related activities (which in itself spurs economic development in terms of tourism, etc.) are going to have higher socio-economic values over the course of time. A stronger case must be made that socio-economic scores are indeed a measure of vulnerability in the case of cultural heritage preservation. A case could also be made for the inverse; poorer areas are less likely to have their cultural heritage impacted by development.

The dearth of cultural value (significance) data is perhaps the most glaring omission in the studies. It is generally understood among cultural resource professionals that many sites are lost or in the process of being lost and there is simply not the resources, time, or desire to save them all. Avoiding this thorny issue is certainly pragmatic, but it leaves the decision or consequence to local resource managers without guidance. This might be the most appropriate place for decisions related to preservation to be made, but in some cases cultural significance absolutely needs to be considered, especially 2nd and 3rd pass assessments. This may be seen as a data resolution issue as well, particularly the assessment of archaeological sites which might not have been fully surveyed. Some studies categorize sites chronologically or by other generic methods which at least allow identification of significant sites (Daire, et al., 2012) (Westley, 2019) (Forino, Mackee, & von Meding, 2016). It should also be noted that 2nd and 3rd pass studies might be used to determine significance in cases where new sites are discovered.

Discussion

The "3 Pass" hierarchy of coastal vulnerability assessments organizes studies based on geographical size and data refinement. Determining which pass is appropriate prior to developing a CVA would benefit cultural resource stakeholders by guiding choices in how refined acquired data needs to be, potentially saving significant time and resources. This organization is also useful because cultural heritage CVA's are created by two different stakeholders with two different approaches: cultural resource professionals interested in coastal physical processes, and natural scientists interested in cultural heritage. Using an organization which spans both approaches is a necessary consistency for future CVA development.

1st Pass: Anderson's *Sea-level rise and archaeological site destruction: An example from the southeastern United States using DINAA (Digital Index of North American Archaeology)* is concerned with long-term processes over a large geographic area. The author examines a 1-meter rise along the southern Atlantic and Gulf Coasts, and projects 14000+ sites to be affected, including 1000 sites eligible for the National Register of Historic Places (NRHP). The study uses location data from DINAA, a multi-institutional digital repository for archaeological sites, to visualize site distribution. A representative large-scale study, it does not delve into the differences in localized sea-level projections. The study advocates for linking large, state-scale databases so guidance on mitigation can be determined at a federal level. Privacy concerns are seemingly assuaged by not publishing location or property ownership data. Resolution at 20-km sq. grid cells is far too large to examine local features. Using only elevation as a measure of vulnerability makes sense given the object of the study: investigating a large area, large datasets, and creating a decision-making process which might cover the entire southeastern United States.

2nd Pass: Westley's *Refining Broad-Scale Vulnerability Assessment of Coastal Archaeological Resources, Lough Foyle, Northern Ireland* is a 2nd pass assessment which builds on a 1st pass assessment of the region around Lough Foyle, Northern Ireland by the author (2019). The 1st Pass study entailed historic aerial photos overlain by decades-old inaccurate locational data, eliminating analysis of local erosion rates or the resiliency of sites to erosion. The 2nd pass assessment was an integrated desk-based study and field assessment of a 10km stretch of beach. Using the Digital Shoreline Analysis System (DSAS), an extension found in GIS, historic orthophotos (a digital image of an aerial photograph where distortions have been removed) were processed to show shoreline change in 20 meter transects. The orthophotos themselves had a 0.25-meter resolution, sufficient for local features. A field survey mapped vegetation change and location data for extant sites, as well as mapping 51 new sites, from iron-age lithics eroding from bluffs to WWII concrete and metal infrastructure. A priority classification system was developed from site significance (based on U.K. criteria), site condition and risk level (state of erosion). The study concludes by suggesting that local cultural resource managers should become familiar with shoreline or coastal change within their purview, and decision-making should be based on the best data available.

3rd Pass/Site Specific: Thompson's *Threats to Coastal Archaeological Sites and the Effects of Future Climate Change: Impacts of the 2011 Tsunami and an Assessment of Future Sea Level Rise at Honaunau, Hawai'i* studied the effects of the 2011 9.0 magnitude Tohoku earthquake off the coast of Japan which caused a tsunami in Hawaii (2015). The study area was a 13-acre ceremonial complex with extant walls, structures, and intact sub-surface archaeological deposits, within Pu'uhonua o Honaunau National Park. The survey used hand-tapes and hand-held GPS units to map a debris line deposited 150 meters from the shoreline within the park. It mapped 59 previously undocumented sub-surface features exposed by the tsunami and 49 displaced artifacts, including lithics, ceramics, marine material, and metal. The undermining of several structures and walls was evident as well. The study determined which areas might be affected most by sea-level rise, as well as the severity of the effects to cultural features. Although sea-level rise and a sudden series of large waves will produce rather different consequences, the visualization of increased sea levels within a specific site is invaluable for mitigation planning.

Summary

There may never be a uniform method of producing vulnerability assessments for coastal cultural resources. Differences in definitions, political environments, management structure, and interpretations of cultural significance are substantial obstacles. Nevertheless, these studies show key considerations, and a systematic approach can guide cultural resource managers grappling with long-term decision making for cultural heritage under their care. The following considerations should be considered:

Appropriate scale

The scale of assessment will be determined by the objectives and available data. A modified CVI for 1st Pass assessments can be used if topography is highly variable (rocky cliffs, low-energy beaches). Selecting one or two hazards (SLR, erosion) is advisable when addressing high numbers of sites. Anthropogenic or socio-economic data are better suited to 2nd Pass assessments. Where possible, these should build on earlier studies.

Adopting local physical data (if possible)

2nd Pass (regional) and site-specific assessments should pre-determine accessible process data prior to constructing CVI's. Shoreline change rates, local or historic SLR, tide gauges, lidar, and erosion rates are examples of data which might be incorporated. Where possible, local assessments and data should be chosen for assessments.

Use of applicable data resolution

In the case of coastal vulnerability assessments, adequate data resolution usually requires the use of remote sensing techniques (e.g., airborne lidar, terrestrial laser scanning, bathymetric sonar). 50-meter intervals aren't accurate enough on site-specific assessments; the geographic size and objectives will determine necessary resolution. For site-specific assessments, advances in remote sensing that can be deployed on drones make high resolution data much more accessible.

Selective socio-economic data

The inclusion of socio-economic data should be used with caution. Thus far, the relationship between socio-economic variables and cultural heritage valuation is unclear. In the event of inclusion, socio-economic data is most applicable as a measure of adaptive capacity most appropriate for 2nd Pass assessments.

Measures of significance

These should be evaluated and selective carefully; measures and processes of defining significance varies widely across political and social boundaries. In the United States, significance is based on a site's eligibility for inclusion on the NRHP. Sites must be at least 50 years old and fall under at least one of four criteria: a) The property must be associated with events that have made a significant contribution to the broad patterns of our history; b) the property must be associated with the lives of persons significant in our past; c) the property must embody the distinctive characteristics of a type, period, or method of construction, represent the work of a master, possess high artistic values, or represent a significant and distinguishable entity whose components may lack individual distinction; or d) the property must show, or may be likely to yield, information important to history or prehistory. Criterion d is most often cited for archaeological sites (Little, 2007). The process for determining significance in any administrative or political environment must be explained.

Conclusion

3rd pass, site specific assessments are the most effective for cultural resource managers. This likely stems from the increasing use of GIS over the past decade by cultural resource managers, familiarity with the data, and familiarity with this type of assessment. A combination of remote-sensing, GIS, and a smaller circumscribed area and knowledge of the area through field work present the most straight-forward studies. Archaeologists and historians are often tasked with evaluating landscapes through a variety of methods.

Incorporating physical data is less of an obstacle in these cases. Less understood among social scientists are large scale impacts or physical process projections.

Awareness of climate change impacts to cultural resources has expanded in the past decade, and the CVI continues to influence assessors. As resource managers adopt and modify vulnerability assessments, issues with scale, data resolution, and the inclusion of anthropogenic variables should become less of an obstacle. The 3- pass organization provides a structure for cultural resource managers to consider before constructing vulnerability assessments. Interdisciplinary training is becoming more prevalent and should lead to better assessments from those in the profession of studying and preserving cultural heritage. While some professionals are already in the process of refining broad-scale assessments (see Westley and Reeder-Myers), more 1st pass studies are needed for resource managers to begin refining studies for resource allocation.

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Chapter 2: A regional vulnerability assessment of archaeological sites on North Carolina's coast

Abstract

Increased awareness of climate change by cultural resource managers has led to the adoption of vulnerability assessments identifying threatened coastal resources. Over five thousand archaeological sites in North Carolina's coastal region are vulnerable to erosion intensified by sea-level rise and greater storm activity. Here relative sea-level rise projections, local erosion rates and cultural significance are considered in constructing a regional vulnerability assessment. 21 sites are found to be very highly vulnerable, 169 highly vulnerable, 461 moderately vulnerable, and 307 having low vulnerability.

Introduction

Over five thousand archaeological sites have been documented along North Carolina's coast, threatened by natural and physical processes accelerated by climate change, including rising sea level, increased flooding, and more powerful storms (Fig 2.1). These processes in turn accelerate secondary effects like erosion, salt-water intrusion, and the change and migration of coastal habitats, posing a threat to the archaeological records of those who have lived there: Native Americans, Europeans, and African Americans.

North Carolina's coastal region consists of several drowned river-valley systems and interfluves buried under marine and estuarine sediments of varying thickness. Isostatic processes persisting from the last ice age c. 20,000 years BP and the nature of the underlying crystalline basement rocks define the region's geology and geography. From Cape Lookout to the Virginia border, land subsidence and a gently sloping continental shelf produce large estuaries, embayment's, and barrier islands jutting outward to the Gulf Stream. To the south, shallower crystalline basement and a slight uplift of the land and steeper coastal plain produce barrier islands hugging the shoreline and a slightly less-rapid rise in sea-level (Riggs & Ames, 2003; Van de Plassche, et al., 2014; Kopp, Horton, Kemp, & Tobaldi, 2015).

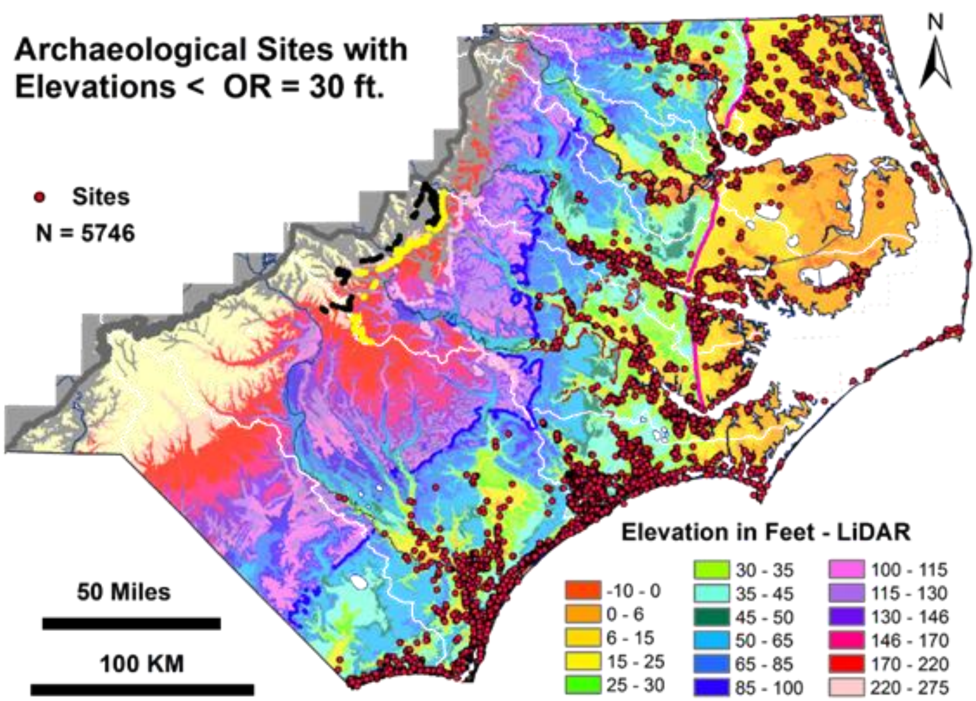

Figure 2.1 Archaeological Sites below 30 feet elevation; courtesy Lea Abbott

Sea-level Rise

Institutions which have analyzed Global Mean Sea-Level rise (GMSL) and local or Relative Sea-Level Rise (RSLR) include the Inter-Governmental Panel on Climate Change (IPCC), the North Carolina Science Panel, and the National Park Service. Kopp et al. (2015) studied RSLR for the North Carolina coast using a combination of process and statistical models, expert assessment, and elicitation. Analyzing historical tide gauge models, reconstruction of Common Era sea levels through rates of salt-marsh accretion and geological data, the authors constructed a Gaussian model which projects RSLR not substantially different from the North Carolina Science Panel (Table 2.1). Projections are usually given in a range according to how much reduction of green-house gases is achievable, or Representative Concentration Pathways (RCP). The figures below are from the 8.5 RCP, or "Business as Usual" model which projects no change in greenhouse gas emissions (IPCC, 2016).

Sea level rise projections are more accurate in the near-term in part because green-house gases (GHG's) affect global climate relatively slowly, thus variability is lessened in the short term. Limiting the extent of projections to 30 years provides a more accurate assessment of potential impacts, limits the scope of possible actions, and focuses on archaeological sites which need immediate mitigation.

Year	Kopp et al 2015	NC Science Panel 2010	NPS 2018 (OBX)
2030	4.72-12.99 in (8-27 cm)		5.90 in (15 cm)
2040		5.51-10.63 in (11-24 cm)	
2050	9.44-23.22 in (18-48 cm)		11.91 in (30 cm)
2100	21.26-60.63 in (42-132 cm)	39.37 in (100 cm)	32.28 in (82 cm)

Table 2.1 Sea Level Rise Projections, Outer Banks, NC

Erosion on North Carolina's Coastal Plain

Erosion is the primary threat to coastal archaeological sites. Riggs and Ames' 2003 analysis of shoreline erosion along the Neuse River estuary in central and northeast North Carolina from 1958-1998 showed that ninety-three percent of the estuary was experiencing erosion (Riggs & Ames, 2003). Low sediment banks (Figure 2.2), defined as less than five feet of elevation and eighty-five percent of the shore-zone, eroded fastest at an average of 3.3 feet (1 m) per year. High sediment banks (Figure 2.3), defined as banks between five and twenty feet of elevation, and bluffs, defined as greater than twenty feet of elevation, eroded less rapidly, an average of 2.6 feet (0.8 m) a year from greater amounts of parent material and potential presence of stabilizing vegetation. The authors note that increased storm activity as a result of climate change will likely increase erosion rates in the study area. A more recent (2017) analysis of shoreline erosion in the Tar-Pamlico sub estuary found average erosion rates to be 0.5 meters per year (1.64 feet) (Eulie, Corbett, & Walsh, 2017). All of these processes place archaeological sites in peril.

Figure 2.2 Low sediment bank with exposed shell midden. Currituck County. Photo by Lea Abbott

Figure 2.3 Eroding high sediment bank. Roanoke Island. Photo by Lea Abbott

Site Significance and Cultural Resource Management

Archaeological sites reflect shared human history and represent important sources of data for the reconstruction of the past. The preservation and significance of archaeological sites are uniquely dependent on the integrity of the landscape in which they are positioned. Moving an intact archaeological site is quite different than moving a historic building, as was the case of the Cape Hatteras Lighthouse. While moving a historic building may alter its *significance* due to its removal from its original context (see below), much of the architectural data it represents remains available to the researcher (Hardesty & Little, 2000). This is not true of a buried archaeological site, where its removal destroys the original context. Hence, laws were passed to affect *in situ* preservation or, if not possible, the recovery of data that was threatened to be lost.

In the United States, most archaeology is regulated by legislation and agencies that are referred to under the rubric of cultural resource management (CRM). The modern CRM system was essentially created by the National Historic Preservation Act (NHPA) of 1966 and subsequent enabling legislation including the National Environmental Policy Act (NEPA, 1969), Archaeological and Historic Preservation Act (1974), Archaeological Resources Protection Act (1979) and the Abandoned Shipwreck Act (1987) (Little, 2007). Another key cultural resource regulation which provides the system in which most archaeology is completed includes36 CFR (Code of Federal Regulations) Part 60, which established the National Register of Historic Places (NRHP) and lists the criteria for evaluating cultural heritage sites. Finally, there are a series of guidelines produced by the federal government further expanding on these regulations, for example the Federal Register. To undertake their management responsibilities, many federal agencies in the United States employ their own cultural resource specialists and archaeologists, including the Department of the Interior, FEMA, and each major armed forces branch.

One important responsibility of cultural resource managers is to protect sites from land or real estate development. The implementation of these regulations is assigned to the states and a State Historic Preservation Office (SHPO). Cultural resources are assessed according to their significance. Legal significance is assessed according to the resource's eligibility for inclusion on the National Register of Historic Sites. Significance is a complex definition derived from a site's age and relationship to national or broad cultural values and may be assessed under four criteria: A) association with significant event; B) association with significant people; C) exemplifies a specific high artistic value, design, or type; and D) the site yields, or is likely to yield important information on history or prehistory. Archeological sites are usually assessed under criterion D. Significance generally requires a high amount of integrity, thus the position in or within a landscape is not only critical to data collection for scientific inquiry, but also its cultural significance according to federal guidelines. Ironically, the excavation of a site, while recovering important data, destroys its integrity, thus removing its eligibility for the National Register of Historic Places (Little, 2007) (Hardesty & Little, 2000).

In North Carolina, archaeological sites are administered by the North Carolina Office of State Archaeology (OSA). The OSA manages an archaeological preservation program, an inventory of archaeological sites, and the enforcement of G.S. 70 Article 2, the North Carolina Archaeological Resource Protection Act. Additionally, the OSA is tasked with the management of the NHPA, human burials, and the assessment of potential National Register sites (Section 106 Archaeology Guidance, 2009). Depending upon the nature of the threat, a CRM archaeological survey may be required. Factors such as geology, landscape slope, loss of integrity, poorly drained soils, and presence of other know archaeological sites may either rule out the need for a survey or determine the intensity of a survey. As such, a pragmatic threat-assessment system is crucial to the cultural resource manager.

CRM archaeological surveys fall under three general categories, or phases, depending on the assessment needs of a site. Phase I surveys consist of pedestrian assessments, often of large tracts of land, to determine if there are potential cultural resources extant. Phase II surveys assess the significance of discovered resources by incorporating sub-surface testing, such as test pits placed at intervals or limited excavation units; and Phase III occurs when a site cannot be avoided. It is the data recovery phase accomplished through the excavation of a site (Section 106 Archaeology Guidance, 2009). From 2009-2019 three hundred and thirty-three CRM investigations (all phases) were conducted in the 25 coastal counties included in this study.

Some archaeological sites may be deemed significant to local communities or interest groups, but do not meet the criteria currently in place for inclusion on the National Register. These criteria change over time. For example, the study of marginalized, or enslaved populations is a relatively new field of research, and prior to 1960 most archaeologists were concerned with the reconstruction of prehistory and thus focused on sites related to indigenous populations. New methods following the development of historical archaeology propagated research into colonial and antebellum lifeways, and eventually into more specialized research topics such as the industrial period, military sites, and farmsteads among many others. Technology and new analytic techniques such as: remote sensing, geoarchaeology, and computer applications expanded rapidly in the 1980's and 1990's. Consequently, the concept of significance began to shift as well, encompassing a much broader range of sites and greater landscapes which now require management.

Site Survival: Topographic Analogues

The biggest threat to coast archaeological sites is erosion. Erosion by marine transgression is a destructive event primarily through the re-leveling of topographic features, followed by the overall inundation of the landscape. The survival of a terrestrial site post-transgression depends on its position in the landscape prior to a transgressive event (Garrison, 2011; Lenihan, et al., 1982). Studies of analogous events such as reservoir construction resulting in flooding of cultural sites and underwater (inundated) sites on the continental shelf in North America and Europe concur that while erosion is wholly destructive, rapid inundation without total re-leveling (on deeply buried sites) provides a measure of preservation (Lenihan, et al., 1982; Flemming, 2020). Rapid inundation can be beneficial to the preservation of sites and the material culture retained therein. Because of the anaerobic environment, inundated sites have provided a wealth of organic material rarely found on terrestrial sites, such as prehistoric paddles, canoes, leather items and funerary features (Flemming, 2020).

Reliable projections of which sites might survive, or which sites are most at risk have yet to be developed. Site survival is tied to protection against erosion. Extensive features of the pre-inundated landscape survive on the continental shelf of Europe which faced the open sea. These sites survived multiple cycles of sea-level rise and decline and highly dynamic environments (Flemming, 2020). Broad conclusions may be drawn for site survival. A pre-condition for survival is being deeply buried pre-inundation, with enough over burden to withstand erosive action, or rapidly buried through sedimentation post-inundation. These conditions do not predict survival; they are only a pre-condition of survival (Garrison, 2011). For example, prehistoric sites re-examined after the filling of reservoirs in the American Southwest found that sites which were rapidly inundated were better preserved than those at the shallower areas near the water's edge that were subject to prolonged wave action (Lenihan, et al., 1982). The most important factor for survival is a significant source of sediment. Contributing factors which may favor archaeological site survival include very low beach gradient and offshore gradient which attenuate wave action, minimum wind fetch, local geography featuring estuaries and beach bars, near-shore islands, or other local landscape characteristics which protect from wind and wave action during marine transgression.

Partially preserved landscape features which survive on the continental shelf of North America include paleo-river channels, related terraces, and freshwater sediments. The discovery of sites within these drowned landscapes is usually the result of industrial activities such as gas and oil exploration and fishing, further complicating the relationship between terrestrial and offshore sites (Flemming, 2020). It is difficult to determine whether the sites are found because of an intrinsic ability to survive a particular environment, or because exploration focuses on one area and ignores another.

Coastal vulnerability assessments (CVA) developed in the United States Geologic Survey (USGS), began in 1990 with *Vulnerability of the East Coast, U.S.A. to sea level rise,* followed by a coastal hazard database for the U.S. West coast, and a vulnerability assessment and coastal vulnerability database for the U.S. southeast (Gornitz V. , 1990). The Coastal Vulnerability Index (CVI) was introduced in 2001 by Hammar-Klose and Theiler. The CVI assigns a numeric value of shoreline vulnerability by ranking physical process and geological variables linked to inundation, erosion, and relative sea-level rise: tidal range, wave height, coastal slope, shoreline erosion rates, geomorphology, and historical rates of relative sea-level rise. The CVI illustrated the relative vulnerability of distinct coastlines and allowed non-specialists to consider more specific projections of coastal change, for example rates of relative sea-level rise versus global ones.

Following the CVI, publications by the National Park Service (NPS) and international organizations (UNESCO, ICOMOS) provided initial guidance in developing coastal vulnerability assessments for cultural resource management, advocating for the inclusion of physical variables and measures of cultural significance. In 2012, Erlandson's paper *As the world warms: rising seas, coastal archaeology, and the erosion of maritime history* influenced cultural resource managers to seriously consider the ramifications of climate change for the resources under their administration. The CVI's ranking system provided an approach and method for managers to incorporate the data into their assessments. The adoption of GIS and remote-sensing has allowed managers to construct desk-based assessments of large geographic areas and large numbers of cultural heritage sites.

Coastal vulnerability assessments for cultural resources are still in an early stage and have been applied to diverse environments such as Cyprus, Northern Ireland, and Puerto Rico (Hadjimitsis, Agapiou, Alexakis, &Sarris,2013; Westley, 2019; Ezcurra&Rivera-Collazo, 2017). While extremely diverse methods and approaches have been proposed, a standard methodology has yet to be agreed upon or implemented. Differences in political environments, approaches to valuing cultural heritage, and access to technology appear to be mitigating factors delaying the adoption of a universal methodology. The assessment strategy proposed here adopts a "3 Pass" hierarchy for organizing and systemically refining coastal vulnerability assessments as outline by Westley (2019).

A hierarchical approach can be phased in or targeted according to the resource or threat being managed. 1st Pass, broadscale assessments identify generalized vulnerabilities such as sea-level rise or site distribution for large areas; 2nd Pass, regional assessments refine analyses to a more constrained area where localized effects can be considered; 3rd Pass studies are site specific or might incorporate a limited number of sites in a tightly constrained location. The vulnerability assessment considered here, for archaeological sites in North Carolina's coastal region is a regional, 2nd Pass assessment.

Two 1st Pass studies, Anderson's *Sea-level rise, and archaeological site destruction: An example from the southeastern United States using DINAA (Digital Index of North American Archaeology)* and Reeder-Myers' *Cultural Heritage at Risk in the Twenty-First Century: A Vulnerability Assessment of Coastal Archaeological Sites in the United States* provide an overall context for the possibility of the effects of sea-level rise on coastal archaeological sites in the United States. Anderson links large databases of location and elevation data in the southeastern United States against a backdrop of global sea-level rise projections, advocating for federal-level decision making. 1st Pass studies' identification of generalized threats and consideration of broader themes such as site distribution provide a primary framework for refined analysis. Reeder-Myers (2015) demonstrates relative vulnerability of different coastal systems: Pacific coast, Gulf coast, and Atlantic coast corresponding to early CVI's by Hammar-Klose and Theiler (2000).

Methods

For this study, legacy data on elevation, distance to water, and significance were gathered from the North Carolina Office of State Archaeology. Several counties (Tyrell, Hertford, Camden) usually included in the coastal region were excluded from the study because data were incomplete across variables. Onslow county was excluded due to the presence of Camp Lejeune, a large United States Marine base which dominates the county and retains its own cultural resource management program, thus skewing the distribution of site data. Collection of initial site data was restricted to areas of less than thirty feet of elevation and within 100 feet (30.48 m.) of the shoreline. This is based on the most rapid erosion rate of 3.3 ft (1 m)/year in the Neuse River Estuary study projected to 2050 (3.3 ft.x30 years).

This study uses a modified cultural heritage vulnerability model (Vulnerability = Exposure + Sensitivity) adjusted to North Carolina's coastal environment (Appendix A). The following definitions are adapted from Daly's framework for archaeological site vulnerability (Daly, 2014):

Vulnerability: The extent of a climate-change related event on an archaeological site.

Exposure: The extent to which an archaeological site is exposed to climate-related impacts. Distance to water and elevation are used in this study.

Sensitivity: The extent to which external stimuli will affect an archaeological site. Cultural Significance as evidenced by eligibility for the NHRP is used as a measure of sensitivity.

The data are in two different forms: physical (Elevation and Distance to Water) and subjective (Cultural Significance) and were placed in categories from low to very high and ranked 1-4 (Table 2.2).

The index expressed as an equation is Vulnerability= (Elevation+Distance to Water+Cultural Significance)/# of variables (3).

Vulnerability

Variable	Low 1	Moderate 2	High 3	Very High 4
Elevation feet(m)	>20 ft (6.09m) Bluffs	10-20 ft (3.048-6.09m) High Sediment Banks	5-10 ft (1.52-3.048m) High Sediment Banks	0-5 ft (0-1.52m) Low Sediment Banks
Distance to shoreline feet (m)	75-100 ft (22.86- 30.48m)	50-75 ft 15.24-22.86m)	25-50 (7.62-15.24 m)	0-25 ft (0-7.62 m)
Cultural Significance (Eligibility for NHRP)	Not Recorded	Unassessed	Not Eligible	Eligible

Table 2.2 Vulnerability

Results

Due to legal privacy restrictions, no exact site locations or identity of ownership] will be published here.

The index produced scores from 1-4, with 4 considered the most vulnerable. 21 sites received scores of 4 across all variables and are considered extremely vulnerable (Table 2.3) (Fig 2.4) (Appendix A). These sites are eligible for the National Register, at 0 -5ft (0-1.52m) elevation and at the water's edge.

Vulnerability	Very High	High	Moderate	Low
Score	4	3.5-3.9	2.5-3.5	1-2.5
# of sites	21	169	461	307

Table 2.3 Vulnerability scores

Vulnerable Archaeological Sites Coastal North Carolina

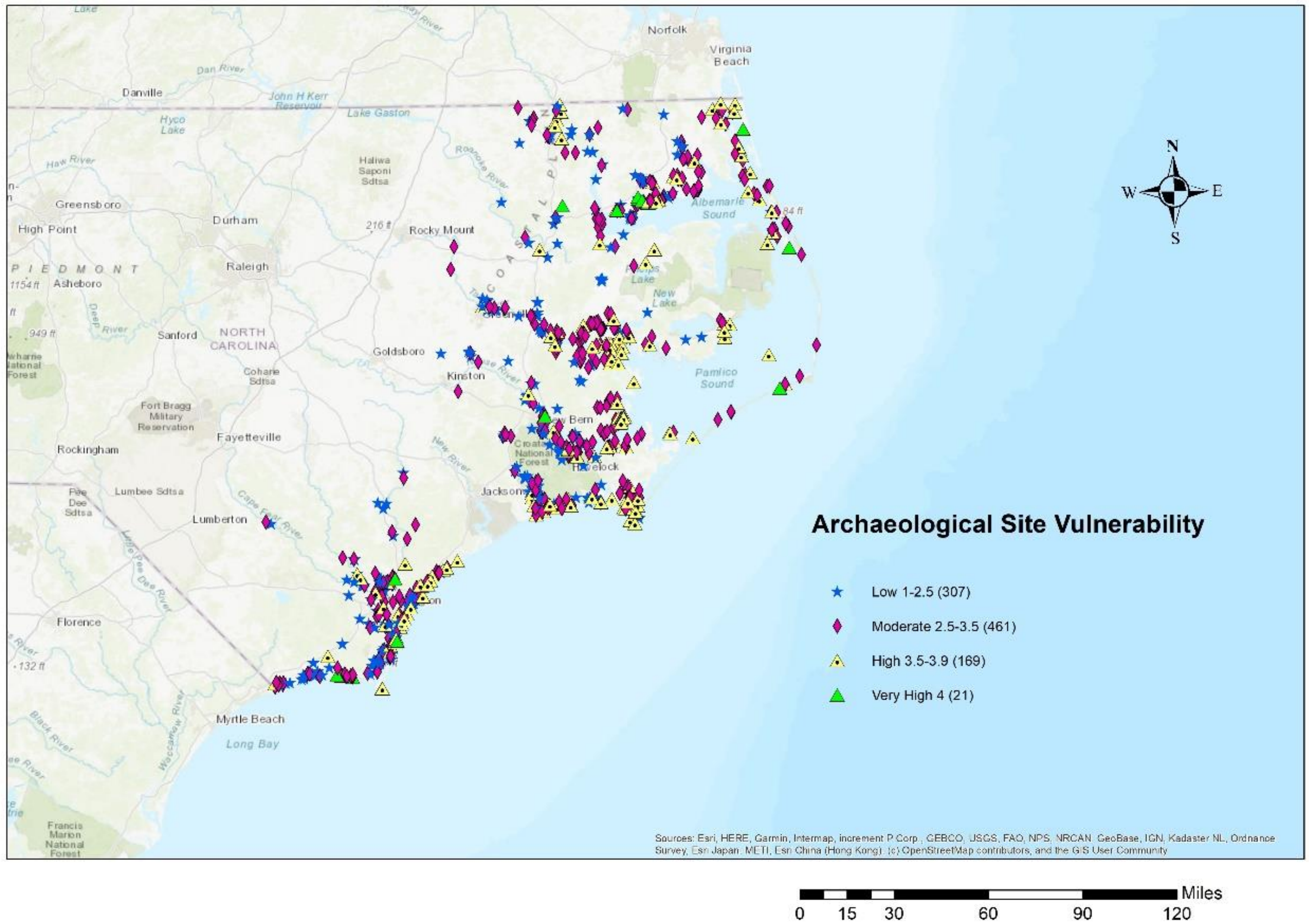

Figure 2.4 Vulnerable Sites Coastal North Carolina

Discussion

Three Woodland sites (a prehistoric indigenous culture spanning 100 BC-1600 AD) along the Yaupon River in northeastern North Carolina were selected to illustrate vulnerability scores (Fig 2.5). These sites (31PQ11, 31PQ154, 31CO170) in Perquimans and Chowan counties are less than 2 miles from one another and are found in similar geographical and environmental settings. The similarities in culture and setting show the vulnerability scores are sensitive to a site's position in the landscape and erosion vulnerability and eligibility for the NRHP.

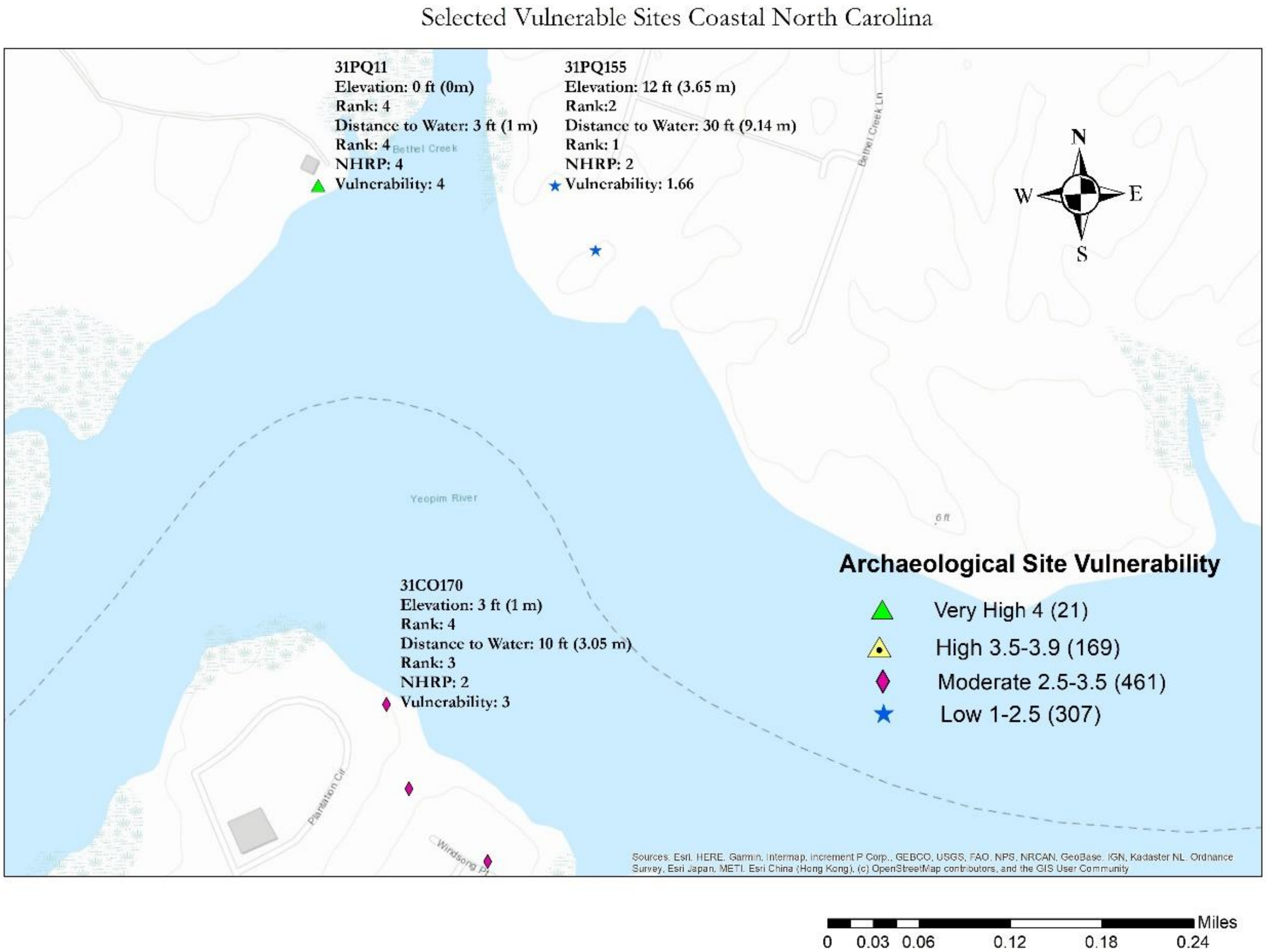

Figure 2.5 Selected Vulnerable Sites

31PQ11 is eligible for the NHRP and is scored as Very Highly Vulnerable. 31PQ11's is only 3 feet (0.91 m) and 0 feet (0 m) from the water's edge, making it highly vulnerable to erosion with a vulnerability score of 4. It is possible the site may have already experienced deterioration from erosion and a single storm could destroy much of the site. An unknown factor is the site size but given the 3.3 ft (1m) / year average erosion rates used in this study, it's clear the site is a great risk to being lost. It is highly unlikely this site will survive until 2050.

31PQ154, across Bethel Creek (a tributary of the Yaupon River), has a much greater chance of survival in the next 30 years than 31PQ11 given its position in the landscape. At 12 feet (3.65 m) in elevation and 30 feet (9.14 m) from the creek, it is unlikely to completely erode in the coming decades, however storms, boat wakes, or changes in shorelines might impact it significantly.

31CO170 is a moderately vulnerable site on the south side of the Yaupon River. Like 31PQ154, 31CO170 has an NHRP score of 2, and like 31PQ11 is 3 feet (1 m) in elevation. However, it is 10 feet (3.05 m) from the shoreline, therefore is likely to survive for a few years before becoming highly vulnerable.

Fig (2.5) makes it easy to visually compare site's vulnerability based on distance to water. But vulnerability scores are influenced by eligibility for the NRHP (only those with a score of 4 are rated Very Highly Vulnerable). The three sites compared above also illustrate how crucial it is for local studies and ground-truthing. While the sites vary widely in their vulnerability scores, any of the events mentioned above could drastically change the scores or in the case of shoreline hardening, remove them from this study.

Figure 2.4 displays site distribution of the vulnerability index. Two observations are evident: sites cluster along prominent rivers and are more heavily concentrated in the central and north-eastern regions versus the south-eastern. The construction of the index, which uses distance to water as a variable, is a factor in this result. But more importantly, this distribution underscores the interaction between North Carolina's coastal environment, history of human settlement, and the history of archaeology in the region. Underlying geology, as discussed above, results in different natural environments which heavily influence settlement patterns. Central and north-eastern coastal North Carolina are largely characterized by one of the largest estuary systems in the world, the historically resource-rich Albemarle-Pamlico estuary. Major rivers include the Roanoke, Tar-Pamlico, Neuse, Pungo, Chowan, Pasquotank, and Alligator, along with smaller tributaries and bays. Off-shore barrier islands (the Outer Banks) circumscribe a shallow, wide estuary. The south-eastern region has 1 major river, the Cape Fear, along with the smaller New River and the White Oak River. (The New and White Oak Rivers are found in Onslow County which has been excluded from this study as noted above). Barrier islands are adjacent to the coast, and no major estuaries are present. While the index is attenuated to sites vulnerable to erosion, and therefore sites will be along waterways, site distribution also reflects fundamental regional distinctions which influenced human settlement and North Carolina's maritime heritage.

Beyond regional distinctions in natural resources, this is also a result of more archaeology being conducted in the area during the 20th century, and the emphasis on prehistoric sites for much of the 20th century. In the mid-1950's archaeologist William Haag from LSU conducted a series of archaeological surveys in the region, focusing on the Albemarle region, and exclusively searching for prehistoric sites (Haag, 1958). In the 1960's archaeologists Joffrey Coe, Lewis Binford, and Stanley South conducted numerous surveys in the Albemarle region, especially along the Roanoke River. Many of the sites eligible for the NRHP were discovered from these surveys.

The development of CRM archaeology also likely influences distribution of sites along the coast, especially in the Wilmington/ New Hanover County area which has experienced tremendous growth leading to infrastructure and deployment of CRM archaeology. Site distribution from the vulnerability index scores must therefore be seen as the result of the interplay of regional distinctions in available natural resources, settlement patterns, and the processes of recovering the past.

The distribution maps also underscore the weaknesses of desk-based assessments. This study uses legacy data, and each of the sites are close enough to the shoreline to have been impacted by erosion, for example a storm event, and therefore would fall under a different score.

Future Research

This study focuses on archaeological site loss; a future companion study of site *protection* would provide a more accurate picture of vulnerability. Importantly, sites already afforded protection by shoreline hardening (riprap, bulkheads, artificial and natural oyster beds,) should be evaluated. If in good condition, these sites could be considered low risk, despite proximity to water. However, in North Carolina's dynamic environment, shoreline hardening is rarely a permanent exercise and care should be taken to evaluate these structures. Ground-truthing is a crucial next step in determining each site's integrity and assessing activities on the adjacent shorelines which may change rapidly.

Monitoring activities can certainly be accomplished by citizen science. Many regions, particularly in Europe, have implemented successful schemes. But simply importing a system into North Carolina likely will prove to be difficult. Differences in approaches to archaeology, legal and privacy concerns, and access to resources should all be considered.

An interesting focus for future research is the projection of site survivability after inundation. As noted, this is largely the purview of underwater archaeology and generally consists of research on submerged prehistoric sites or shipwrecks. Accurate projections of survivability in a localized setting seem remote, however.

Site erosion threatens the recovery of data on historic populations who left little or no documented records. Marginalized populations often lived in marginalized areas and were unlikely to have been able to choose where they lived and worked. These areas were likely much closer to water and lower elevations, meaning a greater risk of inundation, erosion, and flooding. Many of these areas are likely already inundated or eroded and since lost.

Conclusion

North Carolina's obstacles in terms of mitigating risks to eroding archaeological sites are a dynamic natural coastal system, a rapidly growing population, and increasingly popular coastal destinations. A regulatory environment characterized by overarching federal guidance and local or state implementation makes it difficult to simply import a model developed in other countries or even other regions with different sets of obstacles and differing approaches to archaeology. The 3 Pass approach is a method of organizing and systematically refining coastal vulnerability analyses. This desk-based approach is useful in resource planning, management, and characterizing vulnerability for large geographic areas.

Although regional CVA's provide a method for CRM professionals to analyze large quantities of sites, several weaknesses are evident, derived from the approach as well as specific to the environment of North Carolina's coastal plain. Including cultural significance variables is complex and easily misunderstood and must be understood within the context of how significance is determined.

Archaeological site size and topography present another difficulty. A small, well-constrained site on a bluff is quite different than a large site spanning different elevations and in the process of heavy erosion. Sites can vary widely in size, to include dozens of acres and different vulnerabilities within the same site.

This is also a snapshot of a rapidly changing environment. There are other mitigating factors to natural threats to archaeological sites. The desirability of living in North Carolina's coastal region may lessen the impact of erosion in terms of anthropogenic modification of the shoreline (such as shoreline hardening). In Eulie's 2017 study of shoreline change in the Tar-Pamlico sub-estuary, 27.4% of the shoreline had been modified, some 15.7 km, an increase from 19.6% in 1998 (Eulie, Corbett, & Walsh, 2017). These modifications were largely hardening of low sediment banks, using rock, piers, jetties, and other structures. This rapid change is reflected in Hammar-Klose and Thieler's assertion that coastal policy may be the most influential driver of shoreline change (Thieler & Hammar-Klose,1999).

Despite the attention given to sea-level rise and the drowning of cultural heritage sites, erosion is the more serious risk for archaeological sites in North Carolina's coastal region. This regional study has identified and categorized vulnerability for nearly 1000 sites containing the rich heritage of the region's maritime past. Future studies should focus on assessing the vulnerability of individual sites, using more refined methods and data, and monitoring shoreline change.

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Chapter 3: A vulnerability assessment of BrunswickTown/Fort Anderson State Historic Site, Brunswick County, North Carolina, USA

Abstract

BrunswickTown/Fort Anderson is a multi-component archaeological site in coastal North Carolina experiencing high rates of erosion from sea-level rise, channel dredging, passing container ships, wave action, and increased hurricane activity. Extensive and innovative erosion control measures partially mitigate site deterioration, but low-lying areas which have yet to be fully assessed remain at risk of inundation, including a colonial-period commercial port district and an antebellum slave quarter. Future mitigation should build on these actions by prioritizing low-lying areas for investigation, coordination between stakeholders, and preparation for salvage archaeology.

Introduction

North Carolina's archaeological resources are being lost. The coastal environment is eroding as correlated sea-level rise, wave action, and increased storm activity interact. Riggs and Ames' analysis of four decades of shoreline erosion of the Neuse River estuary in central and northeast North Carolina (1958-1998) showed that ninety-three percent of the estuary was experiencing erosion (Riggs & Ames, 2003). Low sediment banks, defined as less than five feet of elevation and compromising eighty-five percent of the shore-zone, eroded fastest at an average of 3.3 feet (1 m) per year. High sediment banks defined as banks between five and twenty feet of elevation, and bluffs, defined as greater than twenty feet of elevation, eroded less rapidly, an average 2.6 feet (0.79 m) a year from greater amounts of parent material and potential presence of stabilizing vegetation. The authors note that increased storm activity because of climate change will likely increase erosion rates in the study area. A more recent (2017) analysis of shoreline erosion in the Tar-Pamlico sub-estuary found average erosion rates to average approximately 0.5 meters per year (1.64 feet) (Eulie, Corbett, & Walsh, 2017).

BrunswickTown/Fort Anderson BTFA) is one of the most important archaeological sites in the southeastern United States (Figs 3.1, 3.2). Its complexity is one of its most intriguing features: a well-preserved earthen Civil War fort (Fort Anderson) superimposed on the foundations of a colonial port town (BrunswickTown). BTFA lies on the west bank of the Cape Fear River, midway between Wilmington, N.C., and the Atlantic Ocean. The 80-plus acre site is characterized by a central bluff approximately 30 feet (9.14 m) above sea-level, flanked by low-lying areas to the north and south.

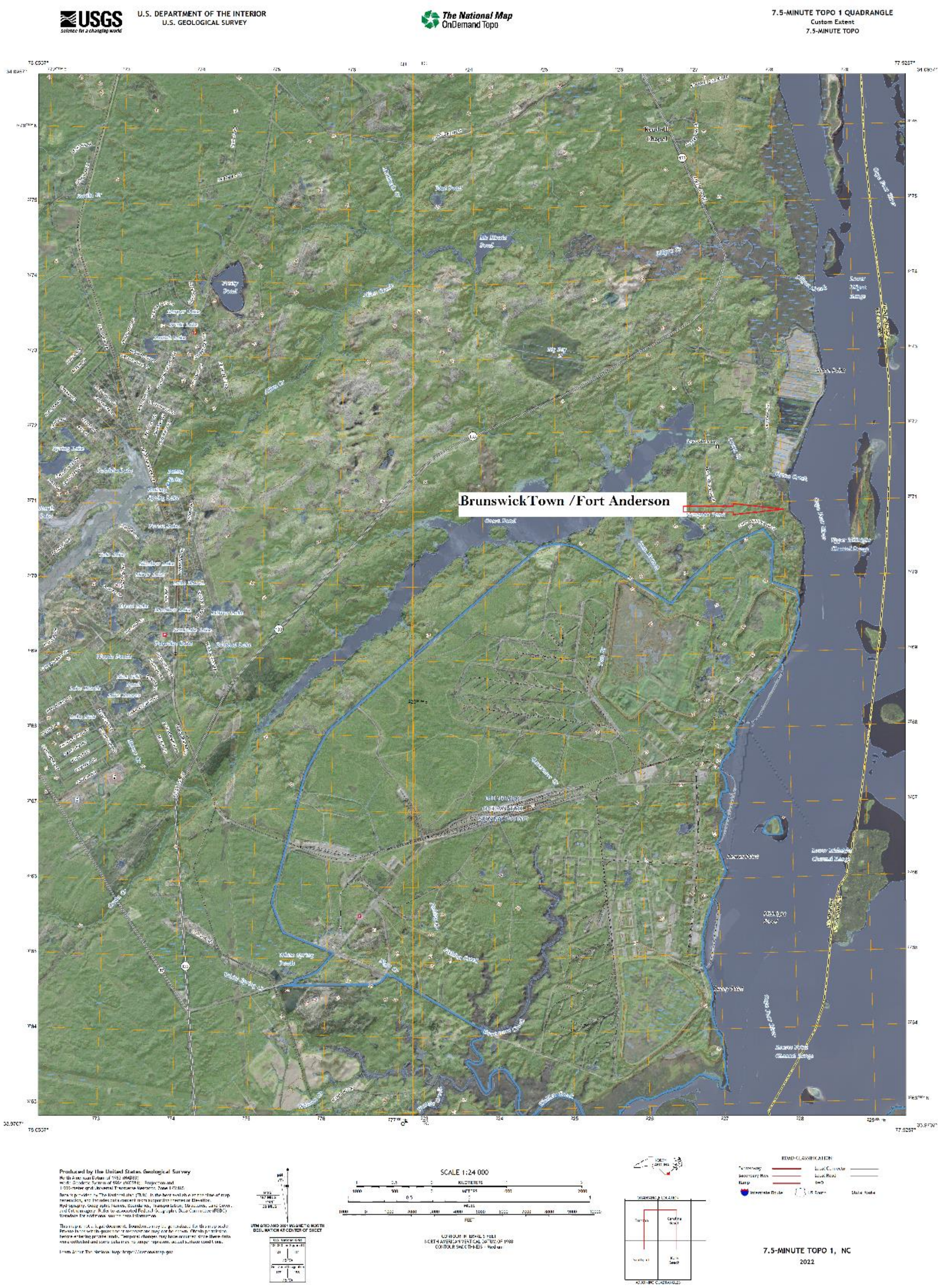

Figure 3.1 USGS NC 75min topographic map. BTFA (red arrow) at center-right.

Major figures in colonial North Carolina settled in BrunswickTown and the surrounding area beginning in 1725, including Roger Moore, Cornelius Harnett, Governor Burrington, Edward Mosely and William Dry. Events of the Stamp Act Crisis (1765), the first armed resistance to the landing of taxation "Stamps", unfolded here. It once had a jail, a courthouse, a church, and was the site of several governor's councils. BrunswickTown peaked in the mid 1700's, losing influence to a burgeoning port at Wilmington. After burning by the British and the capture of its enslaved population during the Revolutionary War, it was absorbed by neighboring Orton Plantation during the early antebellum (C. 1820) period (South, 2012).

Fort Anderson remains one of the best-preserved earthen forts in the southern United States. Constructed as one of a series of forts meant to cover blockade runners gunning up the Cape Fear River during the Civil War, it also provided protection for Orton's substantial rice fields and lumber mill. Although it wasn't the site of a major engagement, it was part of the overall operations which heralded the end of the war. Following the fall of nearby Fort Fisher, the nearly empty fort was shelled for three days. After the war, Fort Anderson, along with the walls of c.1760 St. Phillips church, remained an important site and touchstone for the local population.

After re-discovery of the colonial town by a history student in 1958, over eighty acres of Orton Plantation's southern boundary were eventually donated to the State of North Carolina by James Sprunt, inheritor of Orton. Encompassing Fort Anderson, St. Phillips, Russelborough (a colonial governor's mansion), BrunswickTown and the port/commercial area, BTFA is now administered as a State Historic Site and is on the National Register of Historic Places (South, 2012).

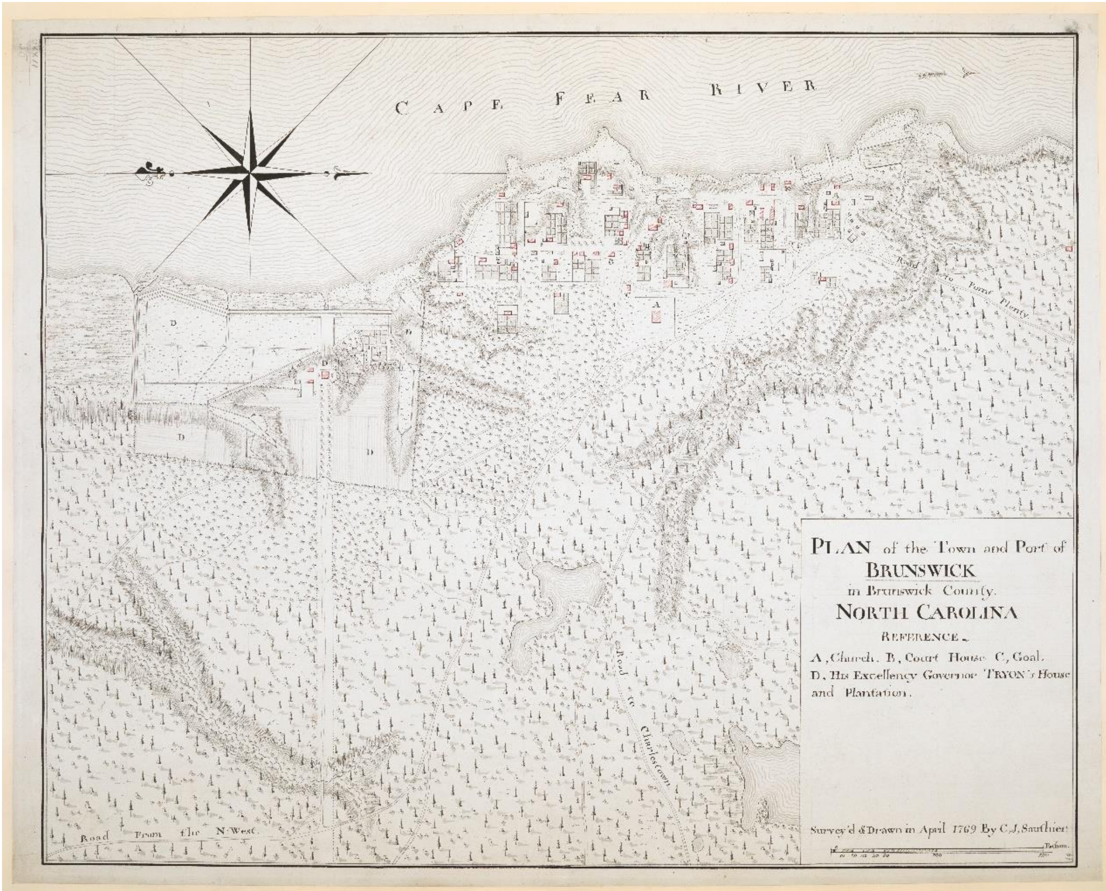

Figure 3.2 c.1765 Sauthier map of Brunswick Town, courtesy of ECU

Archaeology at BTFA

1958-1968 marked the first period of professional archaeology at BrunswickTown. Historian Lawrence Lee reconstructed the town's layout, followed by archaeologist Stanley South who led excavations of several structures in the central portion of town. South developed influential methods of analysis and interpretation in the nascent discipline of historical archaeology during his decade at the site. The dense undergrowth and lack of qualified personnel to assist with the digs constrained excavations to clearly observable brick and ballast stone foundations of the central bluff along with the ruins of the governor's mansion at Russelborough which is adjacent to BrunswickTown and part of the historic site. South surveyed much of the northern portion of the site. However, he took a new position in South Carolina before he could extend excavations into the lower areas such as the port area and the brick and ballast foundations.

South's archaeological work took place during the theoretical transition from primarily descriptive archaeology to scientifically oriented processualism. Influenced by his friend Lewis Binford and trained by renowned UNC-CH professor Joffre Coe, South developed his pattern-recognition techniques utilizing the data recovered at BrunswickTown (South, 1977). South published or disseminated his findings through academic journals and books, conference proceedings, lectures, and interested local groups. Among his notable publications are Method and Theory in Historical Archaeology (1977), Archaeological Pathways to Historic Site Development (2002), An Archaeological Evolution (2007), and Archaeology at Colonial Brunswick (2010). He developed the site for public interest, enlisting interpreters who used recovered clothing items such as buttons on their costumes for authenticity (South, 2012).

During the1990's research interest in the site revived, resulting in a symposium re-examining South's work (R.P. Stephen Davis, 1997). Archaeology did not resume until a joint William Peace University/Wake Tech field school in 2009 which investigated 10 brick and ballast stone foundations (see below) as well as a colonial-period foundation. Recovered artifacts include nails, spikes, faunal assemblages, projectile points, and antebellum-period ceramics (Beaman, Melomo, & McKee, 2018). Still, it would be another decade before fieldwork returned in earnest.

Erosion along the waterfront prompted ECU's initial field school in 2015 under Charles Ewen, Director of the Phelps Archaeological Laboratory (Fig 3.3) to begin salvage excavations. Exposed features of a colonial crib-cob wharf required data recovery between tidal cycles and recorded construction techniques and the terrestrial wharf terminus. Remote-sensing surveys recorded naval-store production sites (tar kilns) along the first terrace above the wharf. Tar kilns are characterized by a raised earthen ring 20-50 feet in diameter, surrounding a packed-clay floor. A banked floor was incised with a wooden trough leading to a catch-basin outside the earthen ring (Figs 3.4, 3.5). Longleaf pine stacked within the ring was fired up to a week, allowing the resin to reduce and flow through the trough as tar. As noted above, this was the raison d'etre for BrunswickTown.

Figure 3.3 Excavation of colonial wharf between tides; Triton oyster mattress in background

Figure 3.4 Cypress trough (yellow arrow) incised in clay floor

Figure 3.5 Catch basin for flowing tar (black arrow)

Following the 2015 field school a long-term research initiative was formalized between East Carolina University and the North Carolina Department of Natural Resources. In 2016 an ECU field school investigated what had been interpreted as features associated with what was then believed to be the Edward Moseley ruin, N5 and N6, on Lot 35. Excavations revealed a colonial period structure interpreted as the base of a beehive oven (Hollowell, Master's Thesis, 2018) (Fig 3.6). Simultaneously, a gun emplacement was investigated in Fort Anderson's Battery B in preparation for the placement of a restored Civil War period cannon (Hildebran, Master's Thesis, 2018). ECU's 2017 field school continued in the area of Lot 35 (Guttierez, Master's Thesis, 2018).

Figure 3.6 Foundation of beehive oven; previously Edward Moseley ruin Lot 35

Outbuildings associated with the Hepburn-Reanolds house were investigated in 2018 (Byrnes, Master's Thesis, 2019). The Hepburn-Reanolds house was originally excavated by Stanley South 50 years prior, and the outbuildings were suspected to be a detached kitchen (South, 2012). On the adjacent lot to the east, a structure interpreted as a Colonial-period tavern was discovered during GPR prospecting and partially excavated in 2018. Roughly half of the building was excavated in 2019; complete excavation has been paused until recovery from the pandemic (Mulkey, Master's Thesis, 2021).

Remote Sensing at BTFA

The innovative field techniques initiated by South in the 1960s continue in the present. Remote Sensing has been used extensively at BTFA. Lidar (Light Detection and Ranging) was used to accurately geo-reference Sauthier's map and identify the location of extant structures. This method interpolates elevation data to create a

Digital Elevation Model (DEM). Control points on the colonial period map and DEM (here shown as a Google Earth Image) are then rectified in ArcGIS (Geospatial Information System mapping) to produce an accurate representation. GIS was also used to explore the port area using the hydrology tool (Figs 3.7, 3.8). This tool employs a smoothed DEM to detect streambeds, which was overlaid by the georeferenced map. Most importantly for future archaeology, areas of historic and potential erosion within the heavy foliage can be delineated and show the evolution of the landform from the 1769 Sauthier's map to the present (Fig 3.9).

Figure 3.7 Control points for georeferenced map. St. Phillips Church (red rectangle in foreground)

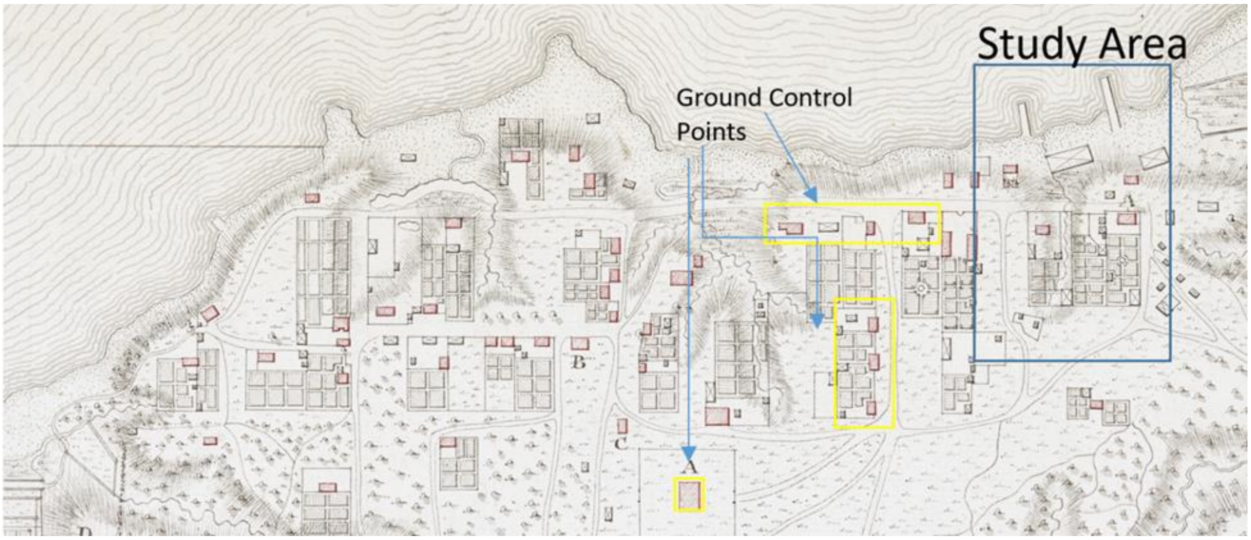

Figure 3.8 Control points for georeferenced map. St. Phillips church marked "A"

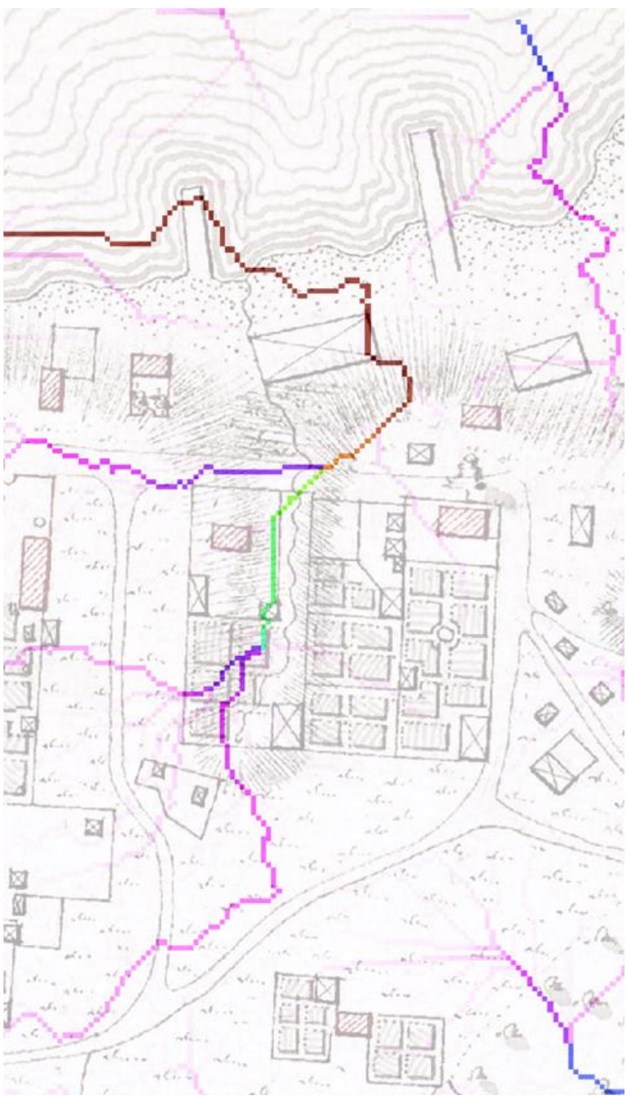

Figure 3.9 Streamflow in commercial port area depicting areas for potential erosion; colors denote stream segments

The erosion at BTFA is especially apparent in a comparison of Lidar imagery and the geo-referenced colonial map near Battery A of Fort Anderson (Figs 3.10, 3.11). Battery A appears in relief in both images; figure 3.10 shows the edge of Battery A ending adjacent to the Cape Fear River; the geo-refenced 1768 map indicates the loss of a significant amount of land and several buildings.

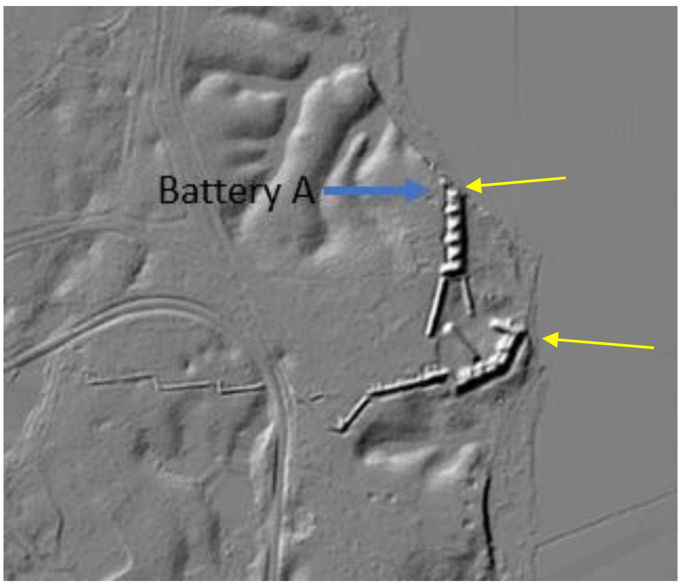

Figure 3.10 Lidar image of BTFA shoreline (yellow arrows)

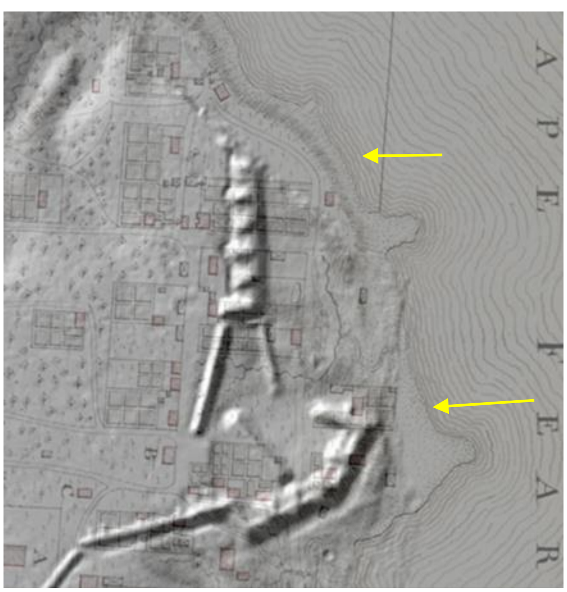

Figure 3.11 Sauthier map depicting historic shoreline

Ground-penetrating radar (GPR) surveys have been crucial for investigating other potential areas of research. The ability to rule out large areas without sub-surface testing is an overlooked utility of GPR. The colonial tavern was originally detected while prospecting an adjacent lot near the Hepburn-Reanolds outbuildings (Fig 3.12) (The Lost Tavern, 2019), and the tar kilns were excavated following detection by GPR and magnetometer surveys.

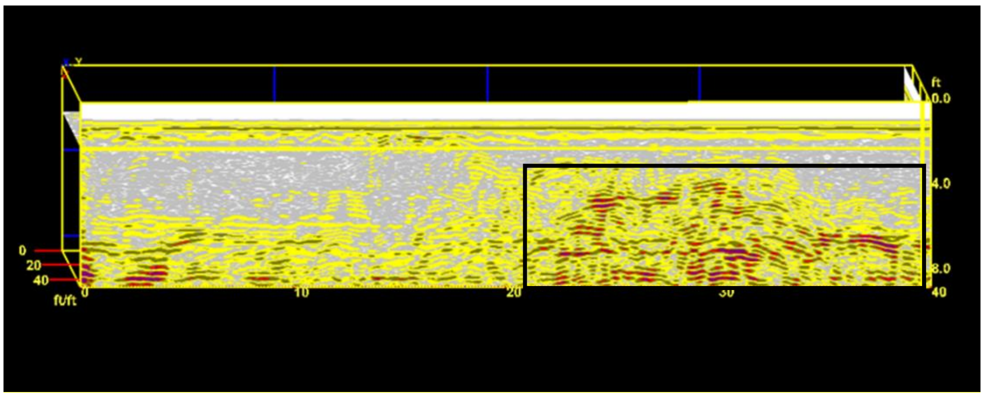

Figure 3.12 GPR image showing anomalies of tavern structure (black box). Data recorded with GSSI SIR 400 MHz; processed with Radan 7

ECU's Department of Maritime Studies has systematically surveyed BTFA's submerged waterfront using side-scan sonar (Fig 3.13). While results are preliminary, potential targets for further investigation have been identified (Borelli, 2021). This is likely to be an effective way of surveying BTFA's shoreline, which is fronted by a large platform marsh and features several incised coves.

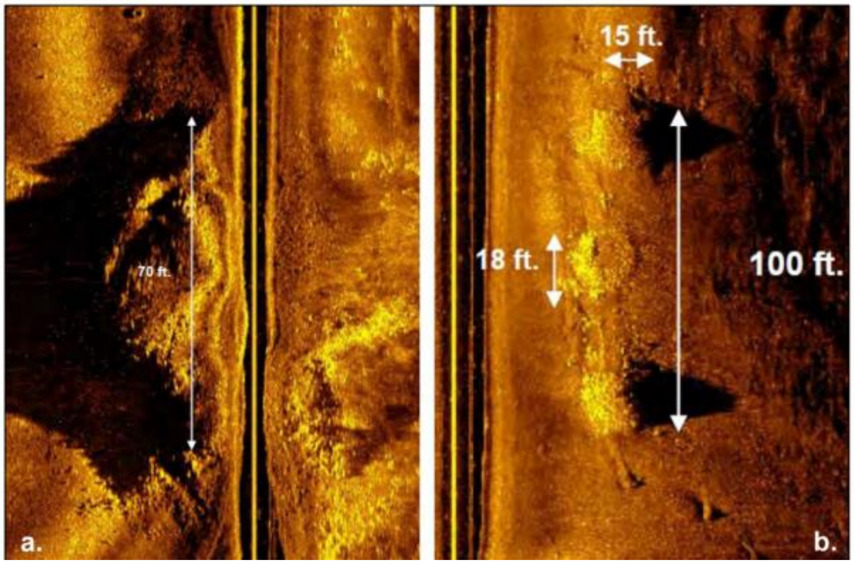

Figure 3.13 Image of potential ballast pile (a) and shipwreck (b), BTFA waterfront. Courtesy of ECU Maritime Studies

Erosion and Inundation at BTFA

BTFA was selected as a case study for vulnerability of coastal archaeological sites in North Carolina because of its historical importance, the environmental challenges it faces to loss of site integrity, and administrative efforts to slow or mitigate the increasing serious loss of cultural landscapes due to erosion and inundation. Recent studies project a possible 0.5m rise of sea level by 2050 in Wilmington, N.C., 13 miles upriver from BTFA (Kopp, Horton, Kemp, & Tobaldi, 2015; N.C. Coastal Resources Comission Science Panel on Coastal Hazards,2010) (Table 3.1).

Year	Kopp et al 2015	NC Science Panel 2010
2030	8-27 cm	
2040		11-24 cm
2050	18-48 cm	
2100	42-132 cm	100 cm

Table 3.1 Sea Level Rise Projections, Wilmington, NC

The erosion at BTFA became more extreme in 2008 after the United States Army Corps of Engineers dredged the channel in front of the wharf area in 2006, as part of a larger project which modernized and expanded the Port of Wilmington (Report, 2020). Deepening and widening the channel allowed more and larger ships to pass through. The intensified wave action along with repeated exposure to hurricanes exposed the crib-cob style wharf structure and inspired data recovery by East Carolina University's 2015 field school and efforts by the state of North Carolina to preserve the site (Byrd, Master's Thesis, 2018).

Under normal tidal forces and wave action, the tar-soaked timbers of the colonial wharf survived nearly three-hundred years. This was aided by a protective layer of marsh sediments. The erosive consequences of the passage of the huge container ships overwhelmed the natural stabilizing plant cover. The wharf examined here was exposed at the shoreline, but its full extent reached much farther into the Cape Fear to service ocean-going vessels forced to remain in the deeper channel. The threat to this historic feature and others, as yet undiscovered, led the state of North Carolina to undertake innovative mitigation efforts.

Mitigation at BTFA

In 2012, 279 linear feet of riprap was positioned in front of Battery A of Fort Anderson, and 500 linear feet of Triton Marine Mattress was constructed parallel to Battery B (fig 3.3). These initial efforts proved to be less effective at attenuating wave action than hoped. The increased waves produced by the expanded ship traffic combined with multiple hurricanes overwhelmed the mattresses and erosion continued beyond the barrier. More drastic action was called for.

Phase I of a large-scale effort to protect the shoreline commenced in 2016-2017 with the installation of 220 linear feet (of a planned 5000 ft) of the Atlantic Reefmaker System (ARM), which incorporates a design to attenuate wave action and simultaneously provide habitat for local faunal communities of oysters by allowing flushing throughout the system and sediment accretion by slowing material redistribution (Figs 3.14,3.15,3.16).

Figure 3.14 Passing container ship; ARM in foreground. (Image courtesy Atlantic Reefmaker)

Although the initial system proved effective, a redesign was implemented for Phase II (2018) and Phase III (2019) as a response to unexpected wave dynamics, which approached the shoreline at a direction more parallel than oblique (Todd & Eulie, 2017).

Figure 3.15 Wave attenuators and riprap near Battery A. (Image courtesy of Atlantic Reefmaker)

The redesign protected an additional 240 linear feet in phase II, and nearly 1000 feet in Phase III. The system includes a modular design for adjustments to sea-level rise as well as attenuating wave action. The design incorporates natural oyster shell and is saturated in oyster spat (oyster larvae attached to a surface) and accommodates recruitment of sessile (attached to a substrate) and non-sessile marine fauna (Todd & Eulie, 2017). Funding for the protective system came from a variety of sources: The National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management provided grants after Hurricanes Michael and Florence, of which $1,141,050 was appropriated by the North Carolina Department of Environmental Quality (DEQ) and matching funds of $830,000 were provided. The North Carolina Department of Natural and Cultural Resources (NCDCNR) allocated $2,002,500 along with $1,516,669 matching funds (Masselle, nd) (Report, 2020) (Todd & Eulie, 2017). Finally, substantial riprap has been placed on the northern side of the site which faces an exposed cove and the river (Fig 3.15).

Figure 3.16 Attenuating waves at BTFA (Image courtesy of Atlantic Reefmaker)

While an exact analysis of erosion mitigation at this stage has not been completed, early findings of the wave-attenuation efforts suggest the preventative measures against sediment distribution have led to the accretion of a one-meter sediment bank in at least one area shore-ward of the ARM (fig 3.17). Local marine species have begun to utilize the structure as well, with reports of a suitable habitat for several bass species, crab, and flounder (Todd & Eulie, 2017). A notable uptick in recreational fishing near the structure has been reported.

Figure 3-17 Sediment accretion at BTFA

Vulnerable Sites

While wave attenuators are expected to alleviate some of the erosive forces of wave action, especially to the higher bluffs, flanking these to the extreme northern and southern portions of BTFA are low-lying areas which have not been systematically surveyed. These are difficult environments to access archaeologically, characterized by intermittent creeks and swamps surrounded by dense vegetation, making it too wet for easy land excavation and too shallow for underwater archaeology. However, both areas are at risk (fig 3.18).

Southern Section: A colonial commercial port

The southern end of BrunswickTown is the location of a commercial district including a colonial-period port. The only surviving map of the area (Fig 3.2, 3.19) depicts large warehouses, the intersection of multiple roads, and various outbuildings. As a naval store export site, the warehouses are likely where tar and pitch, along with other commodities, were stored prior to shipping. Topographical features, such as an incised shoreline facing a creek, appear to be associated with the port area but their usage has yet to be determined. Pedestrian surveys into the area reveal ballast and brick foundations, and Lidar imagery confirms other structures are likely present in the dense undergrowth.

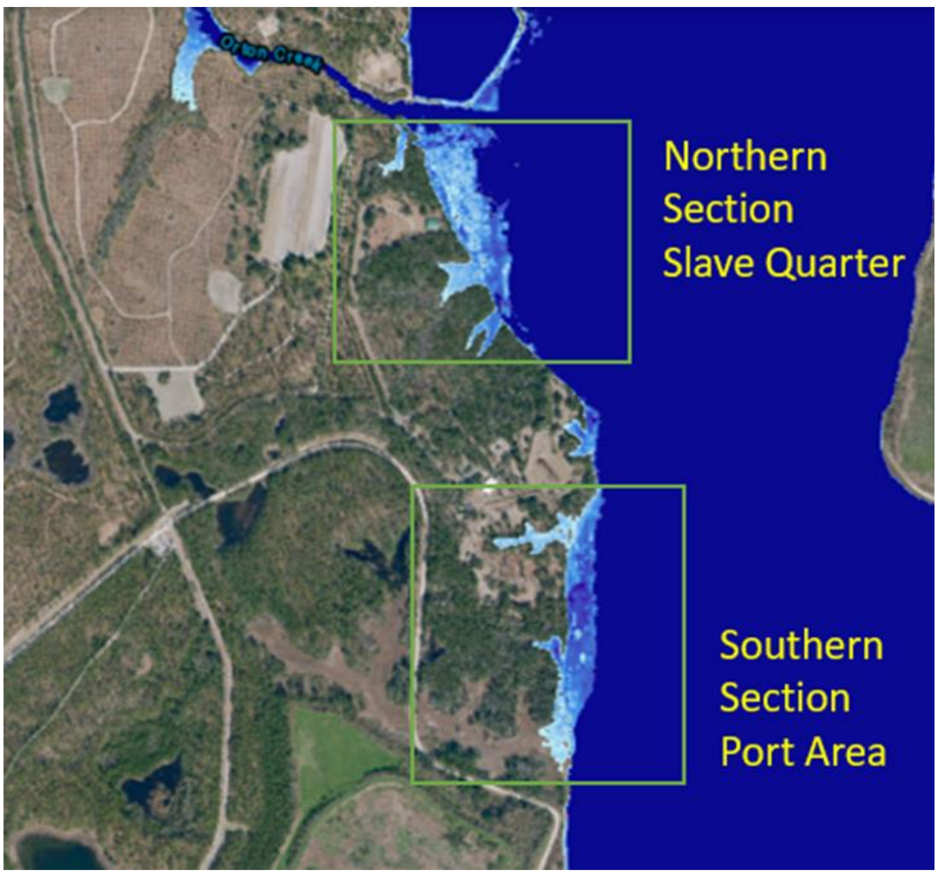

Figure 3.18 Light blue indicating inundation with 0.5m sea level rise. NOAA SLR Viewer

South excavated a multi-room structure perched on the edge of higher ground along the road to port area (South, 2012). He interpreted the structure as a tailor-shop or boarding house. Closer inspection of recovered artifacts such as clinkers (coal) and tools suggest a black-smith shop serving the needs of the port and town.

The commercial port area could potentially reveal local aspects of the trans-Atlantic trade and BrunswickTown's role in the extraction of resources from the Carolina's coastal plain and sandhill regions. The location of the ferry which connected Charleston with points north during the early colonial period should be a focus for further surveys. Features of a working colonial port should be expected: blacksmiths, kilns for reducing tar into pitch, ship repair, and storage for the naval stores and other exports.

Further research and excavations in the southern section would also illuminate the lifeways of those workers of the colonial period who held property and are present in the historical record: carpenters, block makers, brickmakers, victualers, merchants, and surgeons. Crucially, excavations would expose the lifeways of those only sparsely encountered through Brunswick Burnished ware, the pottery attributed to Brunswick Town's colonial enslaved population (South, 2012). This important research topic was not a priority during the 1960s and should be addressed while the data are still relatively intact.

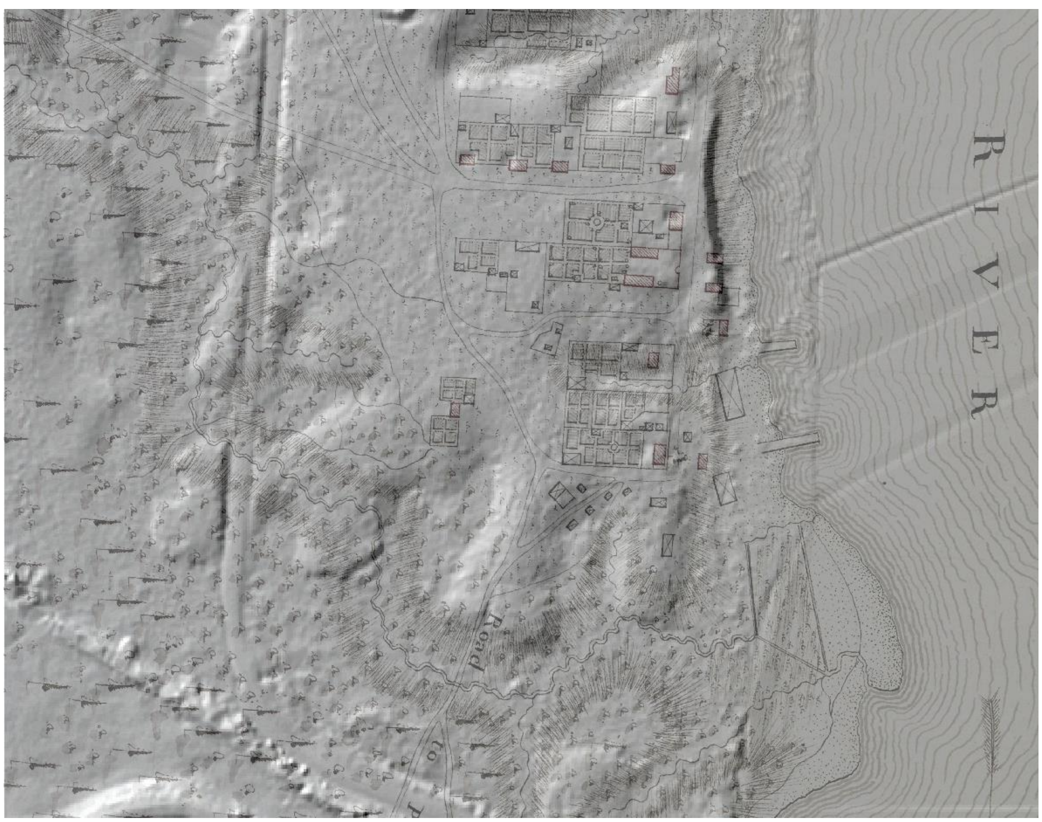

Figure 3.19 Georeferenced Sauthier's Map, southern port area (ESRI, 2015)

Northern Section: A potential slave quarter

On the north side of BTFA, approximately 40 brick and stone features are found (fig 3.18), mortared with daub, abandoned in the woods south of an antebellum rice plantation (Orton). The main group consists of 4 rows of 6 features oriented east-west, with the remaining brick and ballast piles scattered along the ridges of a swamp. These are likely the remains of the chimney bases of a short-lived slave quarter and its environs of lower-lying swampy creeks.

Earlier interpretations associated these foundation rows with Fort Anderson, as "overflow barracks" which housed soldiers emptying other forts (South, 2012; Beaman, Melomo, & McKee, 2018). This interpretation arose from several sources: the proximity of the earthworks, the absence of archaeology related to slavery during the initial investigations during the 1960's, and the map of Fort Anderson, shown above, which depicts barracks on the southeastern edge of the fort (thus not the original barracks). It's difficult to conceptualize soldiers fleeing abandoned forts and gunboats as the war ended in chaos, stopping to build neatly laid out houses, carrying with them decades-old ceramics. Another interpretation has been housing for post-war refugees (freed slaves). Re-use remains a possibility but not yet supported by historic accounts. The most parsimonious interpretation is that they are the remains of an ephemeral slave village, of a potential imported Gullah-Geechee culture, lasting only a few decades until the outbreak of war. The Gullah-Geechee culture, largely associated with enslaved populations on low country South Carolina rice plantations has been documented more recently in southeastern North Carolina. The National Park Service has included Brunswick County in its "Gullah-Geechee Cultural Heritage Corridor" (NPS, 2019). Descendants of enslaved populations at Eagle's Island, a rice plantation upriver from BrunswickTown, consider themselves Gullah-Geechee (Ring Shout wit de NC Gullah/Geechee Famlee!, 2022). While still circumstantial, the presence of antebellum artifacts on a rice plantation within the corridor suggests this conclusion. However, this area is also threatened, requiring further investigation to settle the disputed interpretations.

Orton Plantation, founded by Roger Moore, fell into disrepair after the Revolutionary War through mismanagement. By the 1820's, however, Orton was again a working plantation. From 1820-1840 it changed hands several times, and importantly began cultivating rice, using techniques from the South Carolina low country which relied on tidal forces. Its slave population grew as well, likely with laborers familiar with tidal rice agriculture. In the early 1840's Orton was put up for sale, advertised as having 200 slaves and 40 slave houses (Hood, 2013). The question is whether the 40-plus foundations represent these houses.

Archaeological site survival post-marine transgression and eventual inundation depends on several pre-conditions, which do not necessarily ensure survival (Garrison, 2011; Lenihan, et al., 1982; Flemming, 2020). A site's position in the landscape is crucial to surviving the re-leveling of topographic features. Sites which are deeply buried, have an abundance of parent material, or experience rapid sedimentation have some measures of resiliency. These may be subject to anoxic environments, inhibiting aerobic bacterial growth, which breaks down organic compounds. Factors which might influence site survival include beach and offshore gradients which attenuate wave action, local geography, and wind fetch. While erosion is not as sharply evident in the northern and southern section as the central high bluff and the batteries of Fort Anderson, the Northern and Southern sections discussed here represent the most at-risk portions of BTFA as well as the areas most likely to shed light on less-understood aspects of the colonial and antebellum experience of laborers in southeastern North Carolina.

Discussion

Erosion at BTFA illustrates the challenges for North Carolina's coastal archaeological sites. Fortunately, Brunswick Town/Fort Anderson has been the recipient of resources to slow the most rapidly eroding portions of the site. The installation of wave attenuators is innovative and addresses continuing sea-level rise. The design promotes sediment accretion, provides a habitat for local species, and hopefully introduces a successful oyster population. Mitigation of shoreline loss has been flexible. The initial oyster mattresses, while also innovative and provided a potential oyster habitat, were ineffective against the wave-action of the passing container ships. The ability to adjust where necessary as local conditions change is an important lesson. The effects of sea-level rise, erosion, and increased storm activity and intensity should be viewed as an ongoing event. Although few sites will warrant the resources dedicated to BTFA, there are lessons which might be applied to other coastal sites. Each site must be evaluated within a local context. BTFA's unique threat of channel dredging and increased wave action from container ships called for a specialized solution.

Coordination among stakeholders is crucial. ECU's Department of Anthropology and Phelps Archaeology Lab has been engaged in research and excavation at BTFA since 2013. ECU's Program in Maritime Studies continue to assess BTFA's submerged waterfront as placement of the ARMs continues. UNCW is monitoring the ARM installation for shoreline accretion and habitat changes and has conducted its own archaeological field school at BTFA. These entities, along with BTFA's management team and North Carolina's Office of State Archaeology, should facilitate a plan for salvage operations, especially for storm events. Large hurricanes and storms are projected to occur more often in the coming decades (IPCC, 2016). In addition, North Carolina recently announced further expansion to the Port of Wilmington, providing capabilities for more shipping (Perchick, 2022). Increases in storm activity and shipping will likely cause destructive events similar to the waterfront damage which spurred ECU's initial field school in 2015.

The low-lying southern port section, at greatest risk for inundation, should be prioritized for future research. Pedestrian surveys and remote sensing show that it is potentially rich in archaeological sites and data. A systematic mapping survey, possible subsurface testing, along with an assessment of erosion will provide a basis for excavation. Continuing to leverage technology is the most effective method of preliminarily investigating these areas. Employing GPR will be extremely challenging given the dense foliage, but significant areas might be cleared. A Lidar-capable drone would be an efficient place to start, providing a higher-resolution map than the aerial Lidar currently used. For features nearest the waterfront, synchronizing with side-scan sonar surveys would provide a larger picture of potential areas for investigation.

While important features have been discovered using GPR and Lidar, ruling out potential targets helps prioritize sites for further work. Lidar, as shown above, has been used to accurately geo-reference Sauthier's map, demonstrating the location and significance of shoreline loss. In both the northern and southern sections, closer correlation of features identified through Lidar imagery and Sauthier's map should be included in future surveys.

Resources are limited; the installation of wave attenuators allows prioritization of sites which now have become most at risk. Coastal sites as large as BTFA are rare, but the same strategy can be applied to smaller sites. Resources should be prioritized for the most vulnerable areas while moving investigations into areas which won't receive protection. Finally, low-lying areas with known archaeological sites should be considered as especially vulnerable not only from potential inundation and potential erosion, but from the likelihood that these areas contain valuable information on historically marginalized populations which were crucial to the construction, operation and maintenance of historic BrunswickTown.

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Conclusion

North Carolina's maritime heritage is being lost to erosion. Archaeological sites are often the only method of reconstructing past lifeways in the absence of written documents. Preservation of coastal heritage against climate change is an enormous challenge facing cultural resource managers and stakeholders. Focusing on long-term projections of sea-level rise and inundation does little to provide answers for planning over the next decades. This study re-frames the problem by centering the issue on erosion rather than sea-level rise, or landscape deterioration over landscape inundation. It identifies significant sites most likely to be lost from erosion, and examines research and mitigation at BTFA as an important and innovative example of site preservation. Refining studies to a more local or site perspective in order to capture local conditions is re-iterated through each chapter.

The primary research questions for this study were *Which sites are most vulnerable to erosion*? and *Which sites are most vulnerable within an actionable timeframe*? Secondary research questions were *How should a cultural resource manager approach constructing a vulnerability assessment*? and *What can be learned from erosion and mitigation at a major archaeological site?* Answering these questions was facilitated by the organization of chapters into a "3 Pass" hierarchy (see introduction), adopted from examples of other vulnerability assessments (Westley, 2019). Thus, it informed the focus of each chapter (from broadscale to local), but also the organization itself. It should be noted that a 1st Pass study of coastal United States were considered unnecessary for this study as effective, broadscale ones were already published (Anderson, et al., 2017; Reeder-Myers, 2015).

Chapter 1, *Coastal Vulnerability Assessments for Cultural Resource Managers: Systematic Approaches and Key Considerations* addressed the problems in constructing coastal vulnerability index. Published studies from around the globe varied widely in data, methods, and scope, but key elements were still identifiable. The synchronicity of objectives, geographic size, and data are important characteristics of utility. Cultural resources have esoteric qualities that are difficult to quantify but attempts to include measures of cultural significance assist managers in refining analyses.

Chapter 2, *A regional vulnerability assessment: archaeological sites on North Carolina's coast* prioritizes erosion over inundation as the most significant threat**.** identified sites vulnerable to erosion rather than inundation. Local, short-term projections were used to construct a modified Coastal Vulnerability Index (CVI), which ranked sites according to vulnerability. Of 5000 potential sites vulnerable to climate change, 958 sites are vulnerable to erosion by 2050. 21 sites are very highly vulnerable, 169 highly vulnerable, 461 moderately vulnerable, and 307 having low vulnerability; this provides a more actionable description of archaeological sites potentially needing mitigation. This study should be complemented by a companion study of shoreline hardening. This dissertation has focused on which sites are vulnerable; the follow-up should be identifying which sites are protected from erosion. This will greatly refine the study and provide a solid footing for mitigation planning. Initial studies might be desk-based and completed through GIS, but change is constant for North Carolina's shorelines, and shorelines are rapidly hardening in many areas (Eulie, Corbett, & Walsh, 2017). Therefore, ground-truthing will be necessary in refining this assessment.

Chapter 3, *A vulnerability assessment of BrunswickTown/Fort Anderson State Historic Site, Brunswick County, North Carolina, USA* is a 3rd Pass case study which considers local processes and mitigation efforts. BTFA is an exceptional site on the west bank of the Cape Fear River. Not only famous for archaeological methods developed there, but it has also hosted numerous field schools over the past decade which have helped re-interpret North Carolina's colonial maritime history. Heavy erosion has threatened colonial, antebellum, and Civil War-period archaeological features, and North Carolina has invested heavily mitigating loss through the installation of innovative wave attenuators which also provide oyster habitats. This study examines how mitigation can inform future research, and prioritizes lower-elevation sites vulnerable to inundation, including a largely unstudied colonial commercial port area and a potential antebellum slave village. Stakeholder collaboration, planning for future erosional events, and more accurate mapping are principles for guiding future work at BTFA.

Future Research

The next steps in preserving North Carolina's coastal archaeological heritage should be centered on involving and collaborating with more resource managers, stakeholders, and the public. Re-framing the issue around erosion will provide more clarity than simply reciting sea-level rise projections.

An analysis of erosion of archaeological sites on the lower Cape Fear River should be considered. The past decade of research and work at BTFA has been highly successful and transformed how the site (as part of Orton plantation) is interpreted. Once considered a colonial rice plantation, the production and export of naval stores is now the most significant theme. But the larger interpretation of BTFA and Orton is within the larger context of the regional settlement of the lower Cape Fear. As noted in chapter 3, the port at Wilmington is expanding, meaning even greater vessel traffic; sea-levels will continue to rise causing greater inundation and erosion. A desk-based study using GIS could quantify shoreline change for the 13 miles from Southport to Wilmington, providing an overview of the compounding effects of wave action from vessel traffic and climate change.

Cultural resource management firms physically visit potential sites and perform most archaeological surveys in North Carolina. Site loss undermines their business; therefore, they are already significant stakeholders and should have a sound understanding of the challenges ahead. Involving them in the process of shoreline assessment as a way to leverage preservation efforts is crucial. For CRM projects near vulnerable sites, a shoreline assessment or at minimum a description (hardened, eroding) of the shoreline might be included in reporting for the Area of Potential Affects (APE). Similarly, projects often begin with a scoping process where recorded sites are identified within a 1-mile radius of a potential undertaking. For projects near shorelines, the APE might be modified to consider large portions of the relevant shoreline.

Citizen science is a current buzzword in natural and environmental sciences. It implies the inclusion of the public, usually in monitoring the environment in some way. Citizen science has been used effectively Europe, in particular Scotland, to map coastal archaeological sites and monitor them for erosion. Volunteers are sometimes trained in filling out and submitting basic forms assessing erosion, especially after storm events. While this brings tremendous resources to bear, it also requires a system in place to organize and manage volunteers, incorporate erosion assessments into planning, and action when sites are at high risk for deterioration. Further complicating the importation of this system are the differences in the relation of citizenry to public and private land. Private landowners in North Carolina are not likely to allow regular monitoring of sites on their property. However, initial incorporation of citizen science might take place on state owned land where managers might lack the resources to cover all areas on a regular basis. Volunteers might be organized on the community level, providing feedback to local resource managers.

Assessing site protection from shoreline hardening, involving CRM firms, engaging in citizen science, and emphasizing the lower Cape Fear River underscore the lessons of BTFA. The refining of assessments to the local and site level and understanding local conditions will be key in preserving North Carolina’s coastal archaeological heritage. The process of assessment must be seen as ongoing and continuous process of monitoring shoreline erosion and hardening. North Carolina’s stakeholders should be commended for their efforts in addressing eroding cultural heritage. The innovative work at BTFA, from the design by Atlantic Reefmaker to the willingness to invest resources, complements the work of site personnel, students and archaeologists. Limited resource will require innovation, flexibility, and collaboration in the future to slow eroding heritage. Hammar-Klose and Theiler cautioned in their seminal 1999 CVI that despite all of these efforts, human manipulation and engineering of the coastline may ultimately determine how a coast evolves, overtaking natural processes. This will hold true for the integrity of coastal archaeological sites.

Appendix: Archaeological Site Vulnerability Data

Vulnerability Data

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31BW117	Brunswick	5	4	0	4	4	4
31BW130	Brunswick	5	4	0	4	4	4
31BW358	Brunswick	3	4	0	4	4	4
31BW39	Brunswick	5	4	0	4	4	4
31CK58	Currituck	1	4	0	4	4	4
31CK59	Currituck	1	4	0	4	4	4
31CK60	Currituck	1	4	0	4	4	4
31CO89	Chowan	3	4	5	4	4	4
31CV148	Craven	4	4	0	4	4	4
31CV89	Craven	4	4	0	4	4	4
31DR87	Dare	1	4	0	4	4	4
31DR90	Dare	1	4	0	4	4	4
31NH730	New Hanover	0	4	0	4	4	4
31NH731	New Hanover	5	4	0	4	4	4
31PQ10	Perquimans	3	4	0	4	4	4
31PQ11	Perquimans	3	4	0	4	4	4
31PQ14	Perquimans	3	4	0	4	4	4
31PQ16	Perquimans	3	4	0	4	4	4
31PQ18	Perquimans	3	4	0	4	4	4
31PQ20	Perquimans	3	4	0	4	4	4
31PQ21	Perquimans	3	4	0	4	4	4
31BF156	Beaufort	1	4	0	4	3	3.666667
31BF255	Beaufort	0	4	0	4	3	3.666667
31BF258	Beaufort	4	4	0	4	3	3.666667
31BF259	Beaufort	4	4	0	4	3	3.666667
31BF260	Beaufort	2	4	0	4	3	3.666667
31BF261	Beaufort	2	4	0	4	3	3.666667
31BF262	Beaufort	2	4	0	4	3	3.666667
31BF263	Beaufort	5	4	0	4	3	3.666667
31BF264	Beaufort	5	4	0	4	3	3.666667
31BF265	Beaufort	2	4	5	4	3	3.666667
31BF268	Beaufort	3	4	0	4	3	3.666667
31BF269	Beaufort	0	4	0	4	3	3.666667
31BF287	Beaufort	0	4	0	4	3	3.666667

31BF3	Beaufort	4	4	3	4	3	3.666667
31BF31	Beaufort	1	4	1	4	3	3.666667
31BF37	Beaufort	3	4	0	4	3	3.666667
31BF44	Beaufort	1	4	0	4	3	3.666667

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31BF47	Beaufort	0	4	5	4	3	3.666667
31BF64	Beaufort	0	4	0	4	3	3.666667
31BF74	Beaufort	2	4	0	4	3	3.666667
31BF89	Beaufort	3	4	0	4	3	3.666667
31BW267	Brunswick	5	4	0	4	3	3.666667
31BW72	Brunswick	5	4	0	4	3	3.666667
31BW73	Brunswick	5	4	0	4	3	3.666667
31BW74	Brunswick	0	4	0	4	3	3.666667
31BW84	Brunswick	5	4	0	4	3	3.666667
31CK10	Currituck	1	4	0	4	3	3.666667
31CK11	Currituck	1	4	0	4	3	3.666667
31CK118	Currituck	3	4	0	4	3	3.666667
31CK13	Currituck	3	4	0	4	3	3.666667
31CK19	Currituck	1	4	1	4	3	3.666667
31CK22	Currituck	2	4	0	4	3	3.666667
31CK25	Currituck	1	4	0	4	3	3.666667
31CK26	Currituck	0	4	0	4	3	3.666667
31CK31	Currituck	1	4	0	4	3	3.666667
31CK32	Currituck	3	4	0	4	3	3.666667
31CK61	Currituck	2	4	0	4	3	3.666667
31CO19	Chowan	3	4	0	4	3	3.666667
31CR104	Carteret	2	4	0	4	3	3.666667
31CR121	Carteret	3	4	0	4	3	3.666667
31CR122	Carteret	5	4	0	4	3	3.666667
31CR123	Carteret	5	4	0	4	3	3.666667
31CR124	Carteret	5	4	0	4	3	3.666667
31CR126	Carteret	0	4	0	4	3	3.666667
31CR136	Carteret	5	4	0	4	3	3.666667
31CR138	Carteret	5	4	0	4	3	3.666667
31CR149	Carteret	0	4	0	4	3	3.666667
31CR152	Carteret	2	4	5	4	3	3.666667
31CR165	Carteret	1	4	0	4	3	3.666667
31CR174	Carteret	1	4	0	4	3	3.666667
31CR177	Carteret	3	4	0	4	3	3.666667
31CR178	Carteret	0	4	0	4	3	3.666667
31CR181	Carteret	5	4	0	4	3	3.666667
31CR188	Carteret	5	4	0	4	3	3.666667
31CR190	Carteret	0	4	0	4	3	3.666667
31CR191	Carteret	1	4	1	4	3	3.666667
31CR192	Carteret	5	4	6	4	3	3.666667

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31CR2	Carteret	0	4	0	4	3	3.666667
31CR250	Carteret	5	4	0	4	3	3.666667
31CR273	Carteret	3	4	0	4	3	3.666667
31CR30	Carteret	0	4	0	4	3	3.666667
31CR305	Carteret	2	4	0	4	3	3.666667
31CR306	Carteret	2	4	5	4	3	3.666667
31CR31	Carteret	0	4	0	4	3	3.666667
31CR310	Carteret	2	4	1	4	3	3.666667
31CR311	Carteret	2	4	1	4	3	3.666667
31CR32	Carteret	2	4	0	4	3	3.666667
31CR325	Carteret	0	4	0	4	3	3.666667
31CR330	Carteret	5	4	0	4	3	3.666667
31CR38	Carteret	4	4	0	4	3	3.666667
31CR4	Carteret	0	4	0	4	3	3.666667
31CR59	Carteret	4	4	0	4	3	3.666667
31CR62	Carteret	0	4	0	4	3	3.666667
31CR65	Carteret	0	4	0	4	3	3.666667
31CR67	Carteret	2	4	0	4	3	3.666667
31CR69	Carteret	5	4	0	4	3	3.666667
31CR78	Carteret	0	4	0	4	3	3.666667
31CV118	Craven	1	4	3	4	3	3.666667
31CV13	Craven	4	4	0	4	3	3.666667
31CV14	Craven	3	4	0	4	3	3.666667
31CV17	Craven	5	4	0	4	3	3.666667
31CV253	Craven	3	4	5	4	3	3.666667
31CV329	Craven	5	4	0	4	3	3.666667
31CV330	Craven	5	4	0	4	3	3.666667
31CV85	Craven	5	4	1	4	3	3.666667
31DR28	Dare	5	4	0	4	3	3.666667
31DR44	Dare	1	4	1	4	3	3.666667
31DR77	Dare	0	4	0	4	3	3.666667
31DR8	Dare	1	4	0	4	3	3.666667
31GA2	Gates	0	4	5	4	3	3.666667
31GA3	Gates	5	4	0	4	3	3.666667
31GA4	Gates	5	4	0	4	3	3.666667
31GA6	Gates	5	4	0	4	3	3.666667
31GA7	Gates	3	4	5	4	3	3.666667
31HF17	Hertford	3	4	5	4	3	3.666667
31HY22	Hyde	1	4	0	4	3	3.666667
31HY25	Hyde	1	4	0	4	3	3.666667

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31HY28	Hyde	3	4	0	4	3	3.666667
31HY29	Hyde	2	4	0	4	3	3.666667
31HY48	Hyde	3	4	1	4	3	3.666667
31HY5	Hyde	3	4	0	4	3	3.666667
31MT6	Martin	4	4	5	4	3	3.666667
31NH107	New Hanover	5	4	3	4	3	3.666667
31NH118	New Hanover	5	4	1	4	3	3.666667
31NH145	New Hanover	3	4	1	4	3	3.666667
31NH151	New Hanover	5	4	5	4	3	3.666667
31NH177	New Hanover	2	4	0	4	3	3.666667
31NH217	New Hanover	5	4	1	4	3	3.666667
31NH255	New Hanover	3	4	0	4	3	3.666667
31NH260	New Hanover	2	4	0	4	3	3.666667
31NH374	New Hanover	0	4	5	4	3	3.666667
31NH416	New Hanover	5	4	0	4	3	3.666667
31NH417	New Hanover	5	4	0	4	3	3.666667
31NH449	New Hanover	5	4	1	4	3	3.666667
31NH45B	New Hanover	5	4	5	4	3	3.666667
31NH497	New Hanover	2	4	0	4	3	3.666667
31NH501	New Hanover	0	4	0	4	3	3.666667
31NH504	New Hanover	0	4	0	4	3	3.666667
31NH557	New Hanover	5	4	0	4	3	3.666667
31NH559	New Hanover	5	4	0	4	3	3.666667
31NH563-2	New Hanover	5	4	0	4	3	3.666667
31NH579	New Hanover	5	4	0	4	3	3.666667
31NH737	New Hanover	5	4	0	4	3	3.666667
31NH98	New Hanover	5	4	0	4	3	3.666667
31NH99	New Hanover	5	4	0	4	3	3.666667
31PD168	Pender	5	4	0	4	3	3.666667
31PD19	Pender	5	4	0	4	3	3.666667
31PD2	Pender	0	4	0	4	3	3.666667
31PD297	Pender	0	4	0	4	3	3.666667
31PD298	Pender	0	4	0	4	3	3.666667
31PD3	Pender	0	4	0	4	3	3.666667
31PD300	Pender	3	4	0	4	3	3.666667
31PD4	Pender	0	4	0	4	3	3.666667
31PD5	Pender	0	4	0	4	3	3.666667
31PD6	Pender	0	4	0	4	3	3.666667
31PD78	Pender	5	4	0	4	3	3.666667
31PK13	Pasquotank	0	4	0	4	3	3.666667

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31PK15	Pasquotank	0	4	0	4	3	3.666667
31PK85	Pasquotank	0	4	0	4	3	3.666667
31PK9	Pasquotank	0	4	0	4	3	3.666667
31PM101	Pamlico	4	4	0	4	3	3.666667
31PM102	Pamlico	4	4	0	4	3	3.666667
31PM11	Pamlico	4	4	0	4	3	3.666667
31PM20	Pamlico	1	4	0	4	3	3.666667
31PM36	Pamlico	3	4	5	4	3	3.666667
31PM6	Pamlico	1	4	5	4	3	3.666667
31PM90	Pamlico	4	4	0	4	3	3.666667
31PM92	Pamlico	1	4	0	4	3	3.666667
31PM93	Pamlico	4	4	0	4	3	3.666667
31PM94	Pamlico	4	4	0	4	3	3.666667
31PM95	Pamlico	4	4	0	4	3	3.666667
31PM96	Pamlico	4	4	0	4	3	3.666667
31PM97	Pamlico	4	4	0	4	3	3.666667
31PM98	Pamlico	4	4	0	4	3	3.666667
31PQ172	Perquimans	5	4	1	4	3	3.666667
31PQ201	Perquimans	4	4	5	4	3	3.666667
31PT35	Pitt	3	4	0	4	3	3.666667
31WH10	Washington	5	4	0	4	3	3.666667
31WH12	Washington	0	4	0	4	3	3.666667
31WH4	Washington	5	4	1	4	3	3.666667
31WH5	Washington	5	4	1	4	3	3.666667
31WH6	Washington	5	4	1	4	3	3.666667
31BF81	Beaufort	5	4	10	3	4	3.666667
31CK67	Currituck	5	4	10	3	4	3.666667
31CR290	Carteret	10	3	0	4	4	3.666667
31DR57	Dare	10	3	0	4	4	3.666667
31PQ19	Perquimans	7	3	0	4	4	3.666667
31PQ24	Perquimans	3	4	10	3	4	3.666667
31PQ32	Perquimans	7	3	0	4	4	3.666667
31BF232	Beaufort	5	4	0	4	2	3.333333
31BF250	Beaufort	5	4	5	4	2	3.333333
31BF256	Beaufort	5	4	0	4	2	3.333333
31BF389	Beaufort	0	4	1	4	2	3.333333
31BF416	Beaufort	5	4	0	4	2	3.333333
31BF419	Beaufort	0	4	0	4	2	3.333333
31CK129	Currituck	0	4	0	4	2	3.333333
31CK170	Currituck	3	4	7	4	2	3.333333

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31CK197	Currituck	3	4	0	4	2	3.333333
31CK214	Currituck	1	4	-1	4	2	3.333333
31CO141	Chowan	3	4	0	4	2	3.333333
31CO172	Chowan	3	4	0	4	2	3.333333
31CO173	Chowan	3	4	0	4	2	3.333333
31CO174	Chowan	3	4	0	4	2	3.333333
31CO175	Chowan	3	4	0	4	2	3.333333
31CO176	Chowan	3	4	0	4	2	3.333333
31CO177	Chowan	3	4	0	4	2	3.333333
31CR186	Carteret	0	4	0	4	2	3.333333
31CR196	Carteret	1	4	2	4	2	3.333333
31CR199	Carteret	5	4	2	4	2	3.333333
31CR201	Carteret	0	4	2	4	2	3.333333
31CR203	Carteret	3	4	0	4	2	3.333333
31CR249	Carteret	5	4	0	4	2	3.333333
31CV366	Craven	5	4	2	4	2	3.333333
31HF246	Hertford	5	4	1	4	2	3.333333
31HF247	Hertford	5	4	3	4	2	3.333333
31HY74	Hyde	1	4	0	4	2	3.333333
31NH780	New Hanover	0	4	0	4	2	3.333333
31NH90-4	New Hanover	5	4	0	4	2	3.333333
31NH92-1	New Hanover	5	4	0	4	2	3.333333
31PD308	Pender	5	4	1	4	2	3.333333
31PD329	Pender	5	4	5	4	2	3.333333
31PK104	Pasquotank	2	4	5	4	2	3.333333
31PK78	Pasquotank	2	4	5	4	2	3.333333
31PK79	Pasquotank	2	4	5	4	2	3.333333
31PK96	Pasquotank	0	4	0	4	2	3.333333
31PK97	Pasquotank	2	4	5	4	2	3.333333
31PK98	Pasquotank	2	4	5	4	2	3.333333
31PK99	Pasquotank	2	4	5	4	2	3.333333
31PM13	Pamlico	0	4	5	4	2	3.333333
31PM32	Pamlico	1	4	0	4	2	3.333333
31PM33	Pamlico	0	4	0	4	2	3.333333
31PM34	Pamlico	1	4	0	4	2	3.333333
31PM35	Pamlico	2	4	0	4	2	3.333333
31PM50	Pamlico	5	4	0	4	2	3.333333
31PM51	Pamlico	5	4	5	4	2	3.333333
31PM53	Pamlico	5	4	5	4	2	3.333333
31PM54	Pamlico	5	4	5	4	2	3.333333

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31PM62	Pamlico	2	4	0	4	2	3.333333
31PM66	Pamlico	1	4	0	4	2	3.333333
31PM87	Pamlico	1	4	0	4	2	3.333333
31PM91	Pamlico	4	4	0	4	2	3.333333
31PQ209	Perquimans	3	4	0	4	2	3.333333
31PQ215	Perquimans	1	4	2	4	2	3.333333
31PQ216	Perquimans	1	4	2	4	2	3.333333
31PQ68	Perquimans	3	4	0	4	2	3.333333
31BF117	Beaufort	7	3	7	4	3	3.333333
31BF17	Beaufort	1	4	15	3	3	3.333333
31BF206	Beaufort	5	4	15	3	3	3.333333
31BF211	Beaufort	5	4	10	3	3	3.333333
31BF212	Beaufort	0	4	10	3	3	3.333333
31BF56	Beaufort	1	4	15	3	3	3.333333
31BF58	Beaufort	10	3	0	4	3	3.333333
31BF87	Beaufort	1	4	10	3	3	3.333333
31BF95	Beaufort	5	4	10	3	3	3.333333
31BF96	Beaufort	1	4	13	3	3	3.333333
31BR27	Bertie	8	3	0	4	3	3.333333
31BR39	Bertie	3	4	10	3	3	3.333333
31BR45	Bertie	4	4	10	3	3	3.333333
31BW384	Brunswick	3	4	15	3	3	3.333333
31BW390	Brunswick	1	4	15	3	3	3.333333
31BW411	Brunswick	10	3	2	4	3	3.333333
31BW464	Brunswick	5	4	10	3	3	3.333333
31BW702	Brunswick	10	3	5	4	3	3.333333
31CM65	Camden	1	4	10	3	3	3.333333
31CR10	Carteret	6	3	0	4	3	3.333333
31CR129	Carteret	8	3	0	4	3	3.333333
31CR147	Carteret	0	4	10	3	3	3.333333
31CR166	Carteret	1	4	10	3	3	3.333333
31CR185	Carteret	1	4	14	3	3	3.333333
31CR29	Carteret	5	4	10	3	3	3.333333
31CR304	Carteret	10	3	0	4	3	3.333333
31CR323	Carteret	8	3	0	4	3	3.333333
31CR42	Carteret	5	4	15	3	3	3.333333
31CR63	Carteret	8	3	0	4	3	3.333333
31CR70	Carteret	5	4	10	3	3	3.333333
31CR76	Carteret	5	4	10	3	3	3.333333
31CR77	Carteret	5	4	15	3	3	3.333333

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31CR90	Carteret	7	3	0	4	3	3.333333
31CRMAM	Carteret	5	4	10	3	3	3.333333
31CV18	Craven	6	3	0	4	3	3.333333
31DP210	Duplin	10	3	0	4	3	3.333333
31DR11	Dare	7	3	0	4	3	3.333333
31DR19	Dare	5	4	10	3	3	3.333333
31DR21	Dare	5	4	10	3	3	3.333333
31DR34	Dare	5	4	10	3	3	3.333333
31DR35	Dare	5	4	10	3	3	3.333333
31DR49	Dare	8	3	1	4	3	3.333333
31DR50	Dare	6	3	1	4	3	3.333333
31DR65	Dare	1	4	10	3	3	3.333333
31DR82	Dare	9	3	0	4	3	3.333333
31GA1	Gates	3	4	15	3	3	3.333333
31GA11	Gates	0	4	10	3	3	3.333333
31GA25	Gates	3	4	10	3	3	3.333333
31HF282	Hertford	10	3	0	4	3	3.333333
31HF41	Hertford	3	4	10	3	3	3.333333
31HY2	Hyde	1	4	10	3	3	3.333333
31HY20	Hyde	5	4	10	3	3	3.333333
31HY4	Hyde	1	4	10	3	3	3.333333
31HY7	Hyde	4	4	15	3	3	3.333333
31JN37	Jones	6	3	0	4	3	3.333333
31NH109	New Hanover	5	4	10	3	3	3.333333
31NH174	New Hanover	5	4	10	3	3	3.333333
31NH175	New Hanover	10	3	5	4	3	3.333333
31NH230	New Hanover	10	3	7	4	3	3.333333
31NH258	New Hanover	3	4	10	3	3	3.333333
31NH401	New Hanover	10	3	5	4	3	3.333333
31NH403	New Hanover	10	3	0	4	3	3.333333
31NH412	New Hanover	10	3	5	4	3	3.333333
31NH437	New Hanover	10	3	5	4	3	3.333333
31NH451	New Hanover	6	3	0	4	3	3.333333
31NH490	New Hanover	5	4	10	3	3	3.333333
31NH574	New Hanover	10	3	5	4	3	3.333333
31NH79	New Hanover	10	3	5	4	3	3.333333
31PD296	Pender	10	3	0	4	3	3.333333
31PD299	Pender	5	4	10	3	3	3.333333
31PK16	Pasquotank	7	3	0	4	3	3.333333
31PK84	Perquimans	1	4	10	3	3	3.333333

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31PM16	Pamlico	1	4	15	3	3	3.333333
31PM18	Pamlico	3	4	10	3	3	3.333333
31PM2	Pamlico	4	4	15	3	3	3.333333
31PM22	Pamlico	5	4	10	3	3	3.333333
31PM26	Pamlico	4	4	15	3	3	3.333333
31PM27	Pamlico	1	4	10	3	3	3.333333
31PQ33	Perquimans	1	4	10	3	3	3.333333
31PT11	Pitt	4	4	8	3	3	3.333333
31BF245	Beaufort	10	3	10	3	4	3.333333
31BF246	Beaufort	10	3	10	3	4	3.333333
31BW106	Brunswick	7	3	15	3	4	3.333333
31BW139	Brunswick	10	3	10	3	4	3.333333
31BW140	Brunswick	10	3	10	3	4	3.333333
31BW20	Brunswick	5	4	20	2	4	3.333333
31BW361	Brunswick	11	2	0	4	4	3.333333
31BW423	Brunswick	10	3	10	3	4	3.333333
31CO59	Chowan	13	2	5	4	4	3.333333
31CR197	Carteret	20	2	0	4	4	3.333333
31NH91	New Hanover	20	2	5	4	4	3.333333
31PD256	Pender	5	4	20	2	4	3.333333
31PQ22	Perquimans	3	4	20	2	4	3.333333
31PQ23	Perquimans	3	4	20	2	4	3.333333
31PQ34	Perquimans	3	4	20	2	4	3.333333
31BR90	Bertie	3	4	0	4	1	3
31CK133	Currituck	1	4	0	4	1	3
31CK9	Currituck	1	4	0	4	1	3
31CR150	Carteret	2	4	6	4	1	3
31CR194	Carteret	5	4	0	4	1	3
31CR379	Carteret	5	4	5	4	1	3
31CR383	Carteret	5	4	5	4	1	3
31CR61	Carteret	5	4	0	4	1	3
31CV124	Craven	3	4	5	4	1	3
31CV404	Craven	5	4	0	4	1	3
31NH662-2	New Hanover	5	4	0	4	1	3
31NH752	New Hanover	4	4	0	4	1	3
31PD273-5	Pender	0	4	0	4	1	3
31PM19	Pamlico	4	4	0	4	1	3
31PM52	Pamlico	5	4	0	4	1	3
31BF122	Beaufort	10	3	0	4	2	3
31BF205	Beaufort	5	4	15	3	2	3

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31BF233	Beaufort	5	4	10	3	2	3
31BF248	Beaufort	10	3	0	4	2	3
31BF347	Beaufort	5	4	15	3	2	3
31BF391	Beaufort	7	3	2	4	2	3
31BF407	Beaufort	5	4	10	3	2	3
31BF408	Beaufort	3	4	10	3	2	3
31BF409	Beaufort	3	4	10	3	2	3
31BF415	Beaufort	10	3	0	4	2	3
31BR188	Bertie	2	4	10	3	2	3
31BW391	Brunswick	10	3	5	4	2	3
31BW744	Brunswick	5	4	10	3	2	3
31BW746	Brunswick	10	3	1	4	2	3
31BW747	Brunswick	10	3	1	4	2	3
31BW758	Brunswick	10	3	5	4	2	3
31CO170	Chowan	3	4	10	3	2	3
31CO171	Chowan	3	4	10	3	2	3
31CV147	Craven	5	4	10	3	2	3
31CV15	Craven	5	4	15	3	2	3
31CV361	Craven	5	4	10	3	2	3
31CV362	Craven	5	4	10	3	2	3
31JN102	Jones	7	3	5	4	2	3
31JN115	Jones	5	4	14	3	2	3
31JN120	Jones	10	3	5	4	2	3
31NH674	New Hanover	6	3	0	4	2	3
31NH90-13	New Hanover	6	3	0	4	2	3
31NH95-3	New Hanover	10	3	0	4	2	3
31PD303	Pender	10	3	5	4	2	3
31PK101	Pasquotank	2	4	15	3	2	3
31PM15	Pamlico	10	3	5	4	2	3
31PQ135	Perquimans	3	4	10	3	2	3
31PQ202	Perquimans	4	4	15	3	2	3
31PQ207	Perquimans	3	4	10	3	2	3
31PQ208	Perquimans	3	4	10	3	2	3
31PQ214	Perquimans	3	4	15	3	2	3
31PT609	Pitt	10	3	5	4	2	3
31WH18	Washington	10	3	0	4	2	3
31BF103	Beaufort	5	4	20	2	3	3
31BF105	Beaufort	5	4	20	2	3	3
31BF106	Beaufort	5	4	20	2	3	3
31BF114	Beaufort	5	4	20	2	3	3

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31BF278	Beaufort	5	4	20	2	3	3
31BF30	Beaufort	1	4	20	2	3	3
31BF35	Beaufort	4	4	20	2	3	3
31BF39	Beaufort	0	4	20	2	3	3
31BF40	Beaufort	5	4	20	2	3	3
31BF45	Beaufort	10	3	10	3	3	3
31BF71	Beaufort	7	3	12	3	3	3
31BR169	Bertie	12	2	0	4	3	3
31BW125	Brunswick	10	3	15	3	3	3
31BW127	Brunswick	20	2	5	4	3	3
31BW235	Brunswick	15	2	5	4	3	3
31BW42	Brunswick	16	2	0	4	3	3
31CK119	Currituck	3	4	20	2	3	3
31CK14	Currituck	20	2	0	4	3	3
31CK33	Currituck	7	3	10	3	3	3
31CK5	Currituck	3	4	20	2	3	3
31CR101	Carteret	15	2	0	4	3	3
31CR120	Carteret	4	4	20	2	3	3
31CR132	Carteret	15	2	0	4	3	3
31CR137	Carteret	4	4	20	2	3	3
31CR162	Carteret	10	3	15	3	3	3
31CR164	Carteret	1	4	20	2	3	3
31CR39	Carteret	11	2	0	4	3	3
31CR52	Carteret	15	2	0	4	3	3
31CR55	Carteret	5	4	20	2	3	3
31CR84	Carteret	1	4	20	2	3	3
31CR85	Carteret	4	4	20	2	3	3
31CR87	Carteret	1	4	20	2	3	3
31CV2	Craven	3	4	20	2	3	3
31CV26	Craven	5	4	20	2	3	3
31CV312	Craven	5	4	20	2	3	3
31CV352	Craven	10	3	15	3	3	3
31DR12	Dare	3	4	20	2	3	3
31DR18	Dare	13	2	0	4	3	3
31DR22	Dare	5	4	20	2	3	3
31DR40	Dare	4	4	20	2	3	3
31GA119	Gates	20	2	0	4	3	3
31HF16	Hertford	5	4	20	2	3	3
31HF80	Hertford	15	2	5	4	3	3
31HY34	Hyde	5	4	20	2	3	3

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31HY40	Hyde	5	4	20	2	3	3
31NH112	New Hanover	14	2	0	4	3	3
31NH281	New Hanover	15	2	4	4	3	3
31NH316	New Hanover	15	2	0	4	3	3
31NH321	New Hanover	14	2	0	4	3	3
31NH364	New Hanover	20	2	0	4	3	3
31NH366	New Hanover	15	2	5	4	3	3
31NH367	New Hanover	15	2	5	4	3	3
31NH372	New Hanover	15	2	5	4	3	3
31NH378	New Hanover	5	4	20	2	3	3
31NH392	New Hanover	15	2	5	4	3	3
31NH42B	New Hanover	20	2	5	4	3	3
31NH49	New Hanover	20	2	2	4	3	3
31NH496	New Hanover	0	4	20	2	3	3
31NH78	New Hanover	10	3	10	3	3	3
31NH89	New Hanover	20	2	5	4	3	3
31PD218	Pender	7	3	10	3	3	3
31PD37	Pender	20	2	0	4	3	3
31PK14	Pasquotank	7	3	10	3	3	3
31PK18	Pasquotank	7	3	10	3	3	3
31PK2	Pasquotank	3	4	20	2	3	3
31PK77	Pasquotank	3	4	20	2	3	3
31PM23	Pamlico	5	4	20	2	3	3
31PM24	Pamlico	5	4	20	2	3	3
31PM5	Pamlico	5	4	20	2	3	3
31PM7	Pamlico	5	4	20	2	3	3
31PQ171	Perquimans	9	3	10	3	3	3
31PQ199	Perquimans	4	4	20	2	3	3
31PQ56	Perquimans	7	3	10	3	3	3
31PT264	Pitt	13	2	0	4	3	3
31PT29	Pitt	20	2	0	4	3	3
31PT502	Pitt	16	2	0	4	3	3
31BF226	Beaufort	10	3	20	2	4	3
31BF244	Beaufort	10	3	20	2	4	3
31BR161	Bertie	25	1	5	4	4	3
31BR162	Bertie	26	1	5	4	4	3
31BW77	Brunswick	10	3	20	2	4	3
31CO87	Chowan	6	3	20	2	4	3
31DR75	Dare	1	4	30	1	4	3
31ED372	Edgecombe	12	2	15	3	4	3

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31PD242	Pender	7	3	20	2	4	3
31PD244	Pender	13	2	10	3	4	3
31PD257	Pender	7	3	20	2	4	3
31PQ27	Perquimans	7	3	20	2	4	3
31BF26	Beaufort	5	4	15	3	1	2.666667
31CK24	Currituck	10	3	0	4	1	2.666667
31CO144	Chowan	10	3	5	4	1	2.666667
31CR151	Carteret	2	4	10	3	1	2.666667
31CV27	Craven	5	4	10	3	1	2.666667
31JN109	Jones	10	3	5	4	1	2.666667
31NH747	New Hanover	4	4	10	3	1	2.666667
31NH750	New Hanover	6	3	0	4	1	2.666667
31NH755	New Hanover	4	4	10	3	1	2.666667
31WH13	Washington	10	3	0	4	1	2.666667
31BF102	Beaufort	5	4	20	2	2	2.666667
31BF120	Beaufort	0	4	20	2	2	2.666667
31BF123	Beaufort	20	2	5	4	2	2.666667
31BF186	Beaufort	10	3	13	3	2	2.666667
31BF188	Beaufort	10	3	10	3	2	2.666667
31BF228	Beaufort	10	3	10	3	2	2.666667
31BF229	Beaufort	10	3	10	3	2	2.666667
31BF230	Beaufort	10	3	10	3	2	2.666667
31BF231	Beaufort	10	3	10	3	2	2.666667
31BF412	Beaufort	3	4	20	2	2	2.666667
31BF413	Beaufort	6	3	10	3	2	2.666667
31BF421	Beaufort	5	4	20	2	2	2.666667
31BF422	Beaufort	1	4	20	2	2	2.666667
31BR234	Bertie	13	2	1	4	2	2.666667
31BW615	Brunswick	19	2	5	4	2	2.666667
31BW693	Brunswick	20	2	5	4	2	2.666667
31CK200	Currituck	12	2	5	4	2	2.666667
31CK209	Currituck	12	2	0	4	2	2.666667
31CK40	Currituck	3	4	20	2	2	2.666667
31CK72	Currituck	3	4	20	2	2	2.666667
31CO178	Chowan	4	4	20	2	2	2.666667
31CR184	Carteret	5	4	21	2	2	2.666667
31CR339	Carteret	15	2	5	4	2	2.666667
31CR382	Carteret	10	3	10	3	2	2.666667
31CV1	Craven	4	4	20	2	2	2.666667
31CV141	Craven	5	4	20	2	2	2.666667

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31CV201	Craven	20	2	6	4	2	2.666667
31CV226	Craven	5	4	20	2	2	2.666667
31CV251	Craven	20	2	5	4	2	2.666667
31CV290	Craven	18	2	5	4	2	2.666667
31CV332	Craven	20	2	0	4	2	2.666667
31CV334	Craven	20	2	0	4	2	2.666667
31HF249	Hertford	20	2	2	4	2	2.666667
31JN138	Jones	11	2	0	4	2	2.666667
31JN64	Jones	16	2	0	4	2	2.666667
31JN99	Jones	5	4	20	2	2	2.666667
31NH201	New Hanover	20	2	7	4	2	2.666667
31NH49-1	New Hanover	20	2	5	4	2	2.666667
31NH621	New Hanover	15	2	5	4	2	2.666667
31NH685	New Hanover	10	3	10	3	2	2.666667
31NH742	New Hanover	10	3	15	3	2	2.666667
31NH749	New Hanover	10	3	10	3	2	2.666667
31NH784	New Hanover	10	3	10	3	2	2.666667
31PD332	Pender	20	2	0	4	2	2.666667
31PK19	Pasquotank	7	3	15	3	2	2.666667
31PK80	Pasquotank	3	4	20	2	2	2.666667
31PM58	Pamlico	15	2	5	4	2	2.666667
31PM86	Pamlico	4	4	20	2	2	2.666667
31PM89	Pamlico	5	4	20	2	2	2.666667
31PQ118	Perquimans	3	4	20	2	2	2.666667
31PQ147	Perquimans	3	4	20	2	2	2.666667
31PQ148	Perquimans	3	4	20	2	2	2.666667
31PQ149	Perquimans	3	4	20	2	2	2.666667
31PQ66	Perquimans	3	4	20	2	2	2.666667
31BF195	Beaufort	10	3	20	2	3	2.666667
31BF2	Beaufort	5	4	30	1	3	2.666667
31BF25	Beaufort	15	2	10	3	3	2.666667
31BF27	Beaufort	8	3	20	2	3	2.666667
31BF270	Beaufort	0	4	25	1	3	2.666667
31BF29	Beaufort	10	3	20	2	3	2.666667
31BF34	Beaufort	2	4	30	1	3	2.666667
31BF38	Beaufort	10	3	20	2	3	2.666667
31BF46	Beaufort	10	3	20	2	3	2.666667
31BL56	Bladen	25	1	0	4	3	2.666667
31BR32	Bertie	5	4	25	1	3	2.666667
31BW128	Brunswick	15	2	10	3	3	2.666667

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31BW305	Brunswick	15	2	10	3	3	2.666667
31BW335	Brunswick	10	3	20	2	3	2.666667
31BW340	Brunswick	10	3	20	2	3	2.666667
31BW386	Brunswick	10	3	20	2	3	2.666667
31BW414	Brunswick	20	2	10	3	3	2.666667
31BW617	Brunswick	19	2	10	3	3	2.666667
31BW679	Brunswick	29	1	3	4	3	2.666667
31CK17	Currituck	20	2	10	3	3	2.666667
31CK39	Currituck	10	3	22	2	3	2.666667
31CM50	Camden	3	4	30	1	3	2.666667
31CO28	Chowan	6	3	20	2	3	2.666667
31CO9	Chowan	10	3	20	2	3	2.666667
31CR128	Carteret	0	4	25	1	3	2.666667
31CR14	Carteret	3	4	30	1	3	2.666667
31CR172	Carteret	10	3	20	2	3	2.666667
31CR236	Carteret	15	2	10	3	3	2.666667
31CR24	Carteret	5	4	30	1	3	2.666667
31CR331	Carteret	10	3	20	2	3	2.666667
31CR46	Carteret	20	2	10	3	3	2.666667
31CR68	Carteret	5	4	25	1	3	2.666667
31CR72	Carteret	5	4	25	1	3	2.666667
31CR73	Carteret	4	4	30	1	3	2.666667
31CR74	Carteret	5	4	30	1	3	2.666667
31CR86	Carteret	3	4	30	1	3	2.666667
31CR88	Carteret	5	4	30	1	3	2.666667
31CV12	Craven	5	4	30	1	3	2.666667
31CV307	Craven	25	1	0	4	3	2.666667
31CV53	Craven	8	3	20	2	3	2.666667
31CV56	Craven	5	4	30	1	3	2.666667
31CV64	Craven	25	1	0	4	3	2.666667
31CV79	Craven	15	2	15	3	3	2.666667
31CV88	Craven	3	4	30	1	3	2.666667
31DR16	Dare	3	4	30	1	3	2.666667
31DR24	Dare	5	4	30	1	3	2.666667
31DR36	Dare	1	4	25	1	3	2.666667
31DR39	Dare	4	4	30	1	3	2.666667
31ED337	Edgecombe	22	1	0	4	3	2.666667
31HF103	Hertford	30	1	5	4	3	2.666667
31HF134	Hertford	25	1	0	4	3	2.666667
31HF159	Hertford	10	3	20	2	3	2.666667

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31HF168	Hertford	10	3	20	2	3	2.666667
31HY1	Hyde	1	4	30	1	3	2.666667
31HY27	Hyde	2	4	30	1	3	2.666667
31HY6	Hyde	1	4	30	1	3	2.666667
31HY9	Hyde	3	4	30	1	3	2.666667
31NH103	New Hanover	6	3	20	2	3	2.666667
31NH105	New Hanover	18	2	15	3	3	2.666667
31NH117	New Hanover	5	4	25	1	3	2.666667
31NH208	New Hanover	10	3	20	2	3	2.666667
31NH239	New Hanover	15	2	10	3	3	2.666667
31NH256	New Hanover	5	4	30	1	3	2.666667
31NH265	New Hanover	25	1	1	4	3	2.666667
31NH297	New Hanover	25	1	0	4	3	2.666667
31NH319	New Hanover	25	1	5	4	3	2.666667
31NH385	New Hanover	15	2	12	3	3	2.666667
31NH440	New Hanover	5	4	25	1	3	2.666667
31NH444	New Hanover	15	2	15	3	3	2.666667
31NH455	New Hanover	15	2	10	3	3	2.666667
31NH461	New Hanover	15	2	10	3	3	2.666667
31NH475	New Hanover	6	3	20	2	3	2.666667
31NH479	New Hanover	6	3	20	2	3	2.666667
31NH512	New Hanover	4	4	25	1	3	2.666667
31NH589	New Hanover	25	1	5	4	3	2.666667
31NH620	New Hanover	20	2	10	3	3	2.666667
31NH622	New Hanover	20	2	10	3	3	2.666667
31NH92	New Hanover	25	1	5	4	3	2.666667
31PD12	Pender	23	1	0	4	3	2.666667
31PD31	Pender	10	3	20	2	3	2.666667
31PD84	Pender	20	2	10	3	3	2.666667
31PK11	Pasquotank	2	4	30	1	3	2.666667
31PK26	Pasquotank	7	3	20	2	3	2.666667
31PK7	Pasquotank	7	3	20	2	3	2.666667
31PK86	Pasquotank	7	3	20	2	3	2.666667
31PM1	Pamlico	5	4	30	1	3	2.666667
31PM12	Pamlico	30	1	5	4	3	2.666667
31PM28	Pamlico	1	4	27	1	3	2.666667
31PM29	Pamlico	1	4	27	1	3	2.666667
31PM31	Pamlico	5	4	30	1	3	2.666667
31PQ158	Perquimans	12	2	10	3	3	2.666667
31PQ160	Perquimans	12	2	10	3	3	2.666667

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31PQ161	Perquimans	12	2	10	3	3	2.666667
31PQ162	Perquimans	12	2	10	3	3	2.666667
31PQ170	Perquimans	12	2	10	3	3	2.666667
31PQ53	Perquimans	12	2	10	3	3	2.666667
31PT10	Pitt	5	4	25	1	3	2.666667
31PT525	Pitt	3	4	30	1	3	2.666667
31PT7	Pitt	4	4	30	1	3	2.666667
31BR163	Bertie	26	1	10	3	4	2.666667
31BW157	Brunswick	15	2	20	2	4	2.666667
31BW608	Brunswick	18	2	20	2	4	2.666667
31CR198	Carteret	25	1	10	3	4	2.666667
31PD140	Pender	8	3	30	1	4	2.666667
31PQ1	Perquimans	7	3	30	1	4	2.666667
31BR205	Bertie	20	2	5	4	1	2.333333
31BW556	Brunswick	5	4	20	2	1	2.333333
31BW556-1	Brunswick	5	4	20	2	1	2.333333
31BW556-2	Brunswick	5	4	20	2	1	2.333333
31BW556-3	Brunswick	5	4	20	2	1	2.333333
31CR189	Carteret	10	3	15	3	1	2.333333
31CR218	Carteret	13	2	0	4	1	2.333333
31CR267	Carteret	15	2	1	4	1	2.333333
31CR53	Carteret	15	2	0	4	1	2.333333
31CV264	Craven	14	2	0	4	1	2.333333
31HF72	Hertford	13	2	1	4	1	2.333333
31NH700	New Hanover	10	3	10	3	1	2.333333
31NH707	New Hanover	8	3	10	3	1	2.333333
31PD273	Pender	12	2	0	4	1	2.333333
31PM8	Pamlico	15	2	0	4	1	2.333333
31BF124	Beaufort	21	1	5	4	2	2.333333
31BF307	Beaufort	15	2	10	3	2	2.333333
31BF384	Beaufort	25	1	1	4	2	2.333333
31BW433	Brunswick	25	1	1	4	2	2.333333
31BW439	Brunswick	7	3	20	2	2	2.333333
31BW529	Brunswick	10	3	20	2	2	2.333333
31BW610	Brunswick	13	2	10	3	2	2.333333
31BW640	Brunswick	29	1	0	4	2	2.333333
31BW647	Brunswick	18	2	15	3	2	2.333333
31BW741	Brunswick	15	2	10	3	2	2.333333
31BW748	Brunswick	15	2	10	3	2	2.333333
31BW749	Brunswick	15	2	10	3	2	2.333333

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31CK205	Currituck	9	3	20	2	2	2.333333
31CO136	Chowan	4	4	30	1	2	2.333333
31CO138	Chowan	4	4	30	1	2	2.333333
31CO139	Chowan	4	4	30	1	2	2.333333
31CO149	Chowan	7	3	20	2	2	2.333333
31CO160	Chowan	7	3	20	2	2	2.333333
31CO161	Chowan	7	3	20	2	2	2.333333
31CO163	Chowan	7	3	20	2	2	2.333333
31CR328	Carteret	22	1	0	4	2	2.333333
31CR353	Carteret	15	2	10	3	2	2.333333
31CR354	Carteret	15	2	10	3	2	2.333333
31CR364	Carteret	5	4	30	1	2	2.333333
31CV177	Craven	20	2	10	3	2	2.333333
31CV180	Craven	10	3	20	2	2	2.333333
31CV199	Craven	18	2	10	3	2	2.333333
31CV371	Craven	5	4	25	1	2	2.333333
31HF284	Hertford	20	2	10	3	2	2.333333
31HY60	Hyde	4	4	30	1	2	2.333333
31HY62	Hyde	5	4	30	1	2	2.333333
31HY63	Hyde	5	4	30	1	2	2.333333
31JN114	Jones	10	3	17	2	2	2.333333
31JN42	Jones	13	2	10	3	2	2.333333
31JN98	Jones	5	4	30	1	2	2.333333
31NH722	New Hanover	16	2	15	3	2	2.333333
31NH748	New Hanover	8	3	20	2	2	2.333333
31NH90-10	New Hanover	5	4	30	1	2	2.333333
31NH90-12	New Hanover	7	3	20	2	2	2.333333
31PD302	Pender	15	2	10	3	2	2.333333
31PD304	Pender	15	2	10	3	2	2.333333
31PK102	Pasquotank	2	4	30	1	2	2.333333
31PK103	Pasquotank	2	4	30	1	2	2.333333
31PK92	Pasquotank	2	4	25	1	2	2.333333
31PK93	Pasquotank	3	4	25	1	2	2.333333
31PM64	Pamlico	30	1	5	4	2	2.333333
31PM80	Pamlico	5	4	30	1	2	2.333333
31PQ127	Perquimans	5	4	30	1	2	2.333333
31PQ131	Perquimans	6	3	20	2	2	2.333333
31PQ156	Perquimans	4	4	30	1	2	2.333333
31PQ212	Perquimans	3	4	25	1	2	2.333333
31PQ213	Perquimans	3	4	25	1	2	2.333333

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31PQ217	Perquimans	3	4	25	1	2	2.333333
31PT358	Pitt	6	3	20	2	2	2.333333
31WH28	Washington	10	3	20	2	2	2.333333
31WH33	Washington	15	2	10	3	2	2.333333
31WH34	Washington	15	2	10	3	2	2.333333
31WH35	Washington	15	2	10	3	2	2.333333
31WH36	Washington	15	2	10	3	2	2.333333
31WH37	Washington	15	2	10	3	2	2.333333
31WH38	Washington	15	2	10	3	2	2.333333
31BF52	Beaufort	6	3	24	1	3	2.333333
31BR9	Bertie	10	3	30	1	3	2.333333
31BW176	Brunswick	25	1	10	3	3	2.333333
31BW181	Brunswick	15	2	20	2	3	2.333333
31BW182	Brunswick	15	2	20	2	3	2.333333
31BW184	Brunswick	22	1	10	3	3	2.333333
31BW339	Brunswick	15	2	20	2	3	2.333333
31BW382	Brunswick	25	1	10	3	3	2.333333
31BW412	Brunswick	20	2	20	2	3	2.333333
31BW60	Brunswick	6	3	30	1	3	2.333333
31BW619	Brunswick	13	2	20	2	3	2.333333
31BW694	Brunswick	29	1	10	3	3	2.333333
31BW695	Brunswick	30	1	10	3	3	2.333333
31CM9	Camden	10	3	30	1	3	2.333333
31CO13	Chowan	6	3	30	1	3	2.333333
31CO2	Chowan	7	3	30	1	3	2.333333
31CO37	Chowan	7	3	25	1	3	2.333333
31CO46	Chowan	13	2	20	2	3	2.333333
31CR109	Carteret	15	2	20	2	3	2.333333
31CR111	Carteret	6	3	30	1	3	2.333333
31CR116	Carteret	10	3	30	1	3	2.333333
31CR209	Carteret	20	2	20	2	3	2.333333
31CR359	Carteret	25	1	10	3	3	2.333333
31CR360	Carteret	25	1	10	3	3	2.333333
31CR9	Carteret	10	3	25	1	3	2.333333
31CV186	Craven	20	2	20	2	3	2.333333
31CV19	Craven	6	3	30	1	3	2.333333
31CV54	Craven	10	3	30	1	3	2.333333
31CV8	Craven	15	2	20	2	3	2.333333
31CV93	Craven	15	2	20	2	3	2.333333
31DR15	Dare	13	2	20	2	3	2.333333

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31GA43	Gates	13	2	20	2	3	2.333333
31HF102	Hertford	30	1	10	3	3	2.333333
31HF37	Hertford	10	3	30	1	3	2.333333
31JN53	Jones	20	2	20	2	3	2.333333
31JN69	Jones	25	1	10	3	3	2.333333
31JN85	Jones	25	1	10	3	3	2.333333
31JN86	Jones	25	1	10	3	3	2.333333
31JN87	Jones	25	1	10	3	3	2.333333
31NH111	New Hanover	8	3	30	1	3	2.333333
31NH127	New Hanover	10	3	25	1	3	2.333333
31NH14	New Hanover	20	2	20	2	3	2.333333
31NH220	New Hanover	15	2	20	2	3	2.333333
31NH330	New Hanover	25	1	10	3	3	2.333333
31NH331	New Hanover	25	1	10	3	3	2.333333
31NH380	New Hanover	25	1	10	3	3	2.333333
31NH397	New Hanover	15	2	18	2	3	2.333333
31NH400	New Hanover	20	2	20	2	3	2.333333
31NH408	New Hanover	25	1	10	3	3	2.333333
31NH453	New Hanover	6	3	30	1	3	2.333333
31NH462	New Hanover	6	3	25	1	3	2.333333
31NH480	New Hanover	6	3	25	1	3	2.333333
31NH491	New Hanover	6	3	25	1	3	2.333333
31NH552	New Hanover	25	1	15	3	3	2.333333
31NH613	New Hanover	20	2	20	2	3	2.333333
31NH616	New Hanover	20	2	20	2	3	2.333333
31PD146	Pender	6	3	30	1	3	2.333333
31PK27	Pasquotank	7	3	30	1	3	2.333333
31PK29	Pasquotank	7	3	30	1	3	2.333333
31PQ134	Perquimans	15	2	20	2	3	2.333333
31PQ159	Perquimans	12	2	20	2	3	2.333333
31PQ35	Perquimans	8	3	27	1	3	2.333333
31PQ55	Perquimans	7	3	30	1	3	2.333333
31PQ96	Perquimans	7	3	30	1	3	2.333333
31PT19	Pitt	25	1	10	3	3	2.333333
31PT225	Pitt	13	2	20	2	3	2.333333
31PT257	Pitt	7	3	30	1	3	2.333333
31PT503	Pitt	26	1	10	3	3	2.333333
31BR158	Bertie	26	1	20	2	4	2.333333
31BW413	Brunswick	20	2	30	1	4	2.333333
31BW500	Brunswick	13	2	30	1	4	2.333333

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31BW606	Brunswick	18	2	30	1	4	2.333333
31GA84	Gates	30	1	20	2	4	2.333333
31PD252	Pender	19	2	30	1	4	2.333333
31WH32	Washington	15	2	30	1	4	2.333333
31BF130	Beaufort	25	1	3	4	1	2
31BF22	Beaufort	5	4	30	1	1	2
31BW755	Brunswick	20	2	10	3	1	2
31CR337	Carteret	20	2	10	3	1	2
31CV263	Craven	21	1	0	4	1	2
31CV354	Craven	16	2	15	3	1	2
31NH662-1	New Hanover	15	2	10	3	1	2
31NH90-5	New Hanover	25	1	0	4	1	2
31PD273-2	Pender	3	4	30	1	1	2
31BF208	Beaufort	16	2	20	2	2	2
31BF353	Beaufort	10	3	25	1	2	2
31BF381	Beaufort	25	1	10	3	2	2
31BL150	Bladen	28	1	15	3	2	2
31BW574	Brunswick	10	3	25	1	2	2
31BW602	Brunswick	20	2	20	2	2	2
31BW723	Brunswick	10	3	30	1	2	2
31BW725	Brunswick	10	3	30	1	2	2
31BW728	Brunswick	10	3	30	1	2	2
31BW729	Brunswick	10	3	30	1	2	2
31BW745	Brunswick	10	3	30	1	2	2
31CO130	Chowan	7	3	25	1	2	2
31CO152	Chowan	11	2	20	2	2	2
31CO157	Chowan	10	3	25	1	2	2
31CO158	Chowan	13	2	20	2	2	2
31CO159	Chowan	13	2	20	2	2	2
31CO162	Chowan	13	2	20	2	2	2
31CO165	Chowan	13	2	20	2	2	2
31CR336	Carteret	9	3	27	1	2	2
31CR351	Carteret	30	1	10	3	2	2
31CR357	Carteret	25	1	10	3	2	2
31CR358	Carteret	25	1	10	3	2	2
31CV156	Craven	10	3	30	1	2	2
31CV246	Craven	15	2	20	2	2	2
31CV250	Craven	20	2	20	2	2	2
31CV275	Craven	10	3	30	1	2	2
31CV283	Craven	10	3	30	1	2	2

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31CV306	Craven	20	2	20	2	2	2
31CV397	Craven	25	1	10	3	2	2
31DR66	Dare	6	3	28	1	2	2
31GA63	Gates	7	3	30	1	2	2
31JN70	Jones	22	1	10	3	2	2
31MT159	Martin	6	3	30	1	2	2
31NH652	New Hanover	10	3	30	1	2	2
31NH717	New Hanover	20	2	20	2	2	2
31NH754	New Hanover	15	2	20	2	2	2
31PD286	Pender	12	2	20	2	2	2
31PD295	Pender	9	3	30	1	2	2
31PM40	Pamlico	25	1	15	3	2	2
31PT521	Pitt	26	1	10	3	2	2
31PT70	Pitt	10	3	30	1	2	2
31PT71	Pitt	6	3	30	1	2	2
31BF171	Beaufort	20	2	25	1	3	2
31BF18	Beaufort	17	2	24	1	3	2
31BR218	Bertie	20	2	25	1	3	2
31BW108	Brunswick	25	1	20	2	3	2
31BW159	Brunswick	18	2	30	1	3	2
31BW299	Brunswick	15	2	30	1	3	2
31BW306	Brunswick	15	2	30	1	3	2
31BW486	Brunswick	20	2	30	1	3	2
31BW673	Brunswick	25	1	20	2	3	2
31CR103	Carteret	11	2	30	1	3	2
31CR208	Carteret	30	1	20	2	3	2
31CR242	Carteret	27	1	20	2	3	2
31CR57	Carteret	15	2	25	1	3	2
31DP121	Duplin	26	1	20	2	3	2
31GA113	Gates	15	2	30	1	3	2
31JN15	Jones	30	1	20	2	3	2
31JN18	Jones	25	1	20	2	3	2
31MT52	Martin	16	2	30	1	3	2
31NH114	New Hanover	15	2	25	1	3	2
31NH154	New Hanover	25	1	20	2	3	2
31NH155	New Hanover	25	1	20	2	3	2
31NH233	New Hanover	15	2	25	1	3	2
31NH280	New Hanover	15	2	25	1	3	2
31NH282	New Hanover	15	2	25	1	3	2
31NH326	New Hanover	20	2	25	1	3	2

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31NH351	New Hanover	25	1	20	2	3	2
31NH454	New Hanover	15	2	25	1	3	2
31NH488	New Hanover	15	2	25	1	3	2
31NH643	New Hanover	15	2	30	1	3	2
31NH718	New Hanover	25	1	20	2	3	2
31NH719	New Hanover	25	1	20	2	3	2
31PD215	Pender	30	1	20	2	3	2
31PD83	Pender	20	2	30	1	3	2
31PT440	Pitt	30	1	20	2	3	2
31PT45	Pitt	20	2	30	1	3	2
31PT511	Pitt	30	1	20	2	3	2
31CV328	Craven	30	1	30	1	4	2
31CR346	Carteret	27	1	10	3	1	1.666667
31CR350	Carteret	25	1	10	3	1	1.666667
31CR352	Carteret	25	1	10	3	1	1.666667
31NH656	New Hanover	10	3	30	1	1	1.666667
31NH701	New Hanover	22	1	10	3	1	1.666667
31PT259	Pitt	15	2	20	2	1	1.666667
31BF209	Beaufort	15	2	25	1	2	1.666667
31BF306	Beaufort	16	2	25	1	2	1.666667
31BF355	Beaufort	20	2	25	1	2	1.666667
31BF359	Beaufort	25	1	20	2	2	1.666667
31BR207	Bertie	15	2	30	1	2	1.666667
31BW616	Brunswick	16	2	30	1	2	1.666667
31BW618	Brunswick	23	1	20	2	2	1.666667
31BW623	Brunswick	23	1	20	2	2	1.666667
31BW642	Brunswick	17	2	30	1	2	1.666667
31BW645	Brunswick	28	1	20	2	2	1.666667
31BW696	Brunswick	19	2	30	1	2	1.666667
31BW737	Brunswick	15	2	30	1	2	1.666667
31CO155	Chowan	13	2	30	1	2	1.666667
31CR238	Carteret	15	2	30	1	2	1.666667
31CR244	Carteret	25	1	20	2	2	1.666667
31CR245	Carteret	20	2	30	1	2	1.666667
31CR344	Carteret	20	2	30	1	2	1.666667
31CV287	Craven	20	2	30	1	2	1.666667
31CV293	Craven	27	1	20	2	2	1.666667
31CV301	Craven	26	1	20	2	2	1.666667
31CV333	Craven	25	1	20	2	2	1.666667
31CV345	Craven	12	2	30	1	2	1.666667

SITE	COUNTY	ELEV_FT	Rank	DIST_WATER	Rank	NRHP	Vulnerability Score
31GR202	Greene	20	2	30	1	2	1.666667
31HF255	Hertford	20	2	25	1	2	1.666667
31NH546	New Hanover	15	2	25	1	2	1.666667
31PD287	Pender	15	2	30	1	2	1.666667
31PM72	Pamlico	11	2	25	1	2	1.666667
31PQ153	Perquimans	11	2	30	1	2	1.666667
31PQ154	Perquimans	14	2	30	1	2	1.666667
31PQ155	Perquimans	12	2	30	1	2	1.666667
31PT520	Pitt	26	1	20	2	2	1.666667
31BW245	Brunswick	30	1	25	1	3	1.666667
31BW253	Brunswick	22	1	30	1	3	1.666667
31BW626	Brunswick	26	1	30	1	3	1.666667
31BW670	Brunswick	26	1	30	1	3	1.666667
31BW680	Brunswick	29	1	30	1	3	1.666667
31DP10	Duplin	26	1	25	1	3	1.666667
31HF32	Hertford	29	1	30	1	3	1.666667
31HF42	Hertford	26	1	30	1	3	1.666667
31NH149	New Hanover	25	1	30	1	3	1.666667
31NH169	New Hanover	25	1	30	1	3	1.666667
31NH186	New Hanover	25	1	25	1	3	1.666667
31NH202	New Hanover	25	1	25	1	3	1.666667
31NH222	New Hanover	25	1	25	1	3	1.666667
31NH43	New Hanover	25	1	25	1	3	1.666667
31NH68	New Hanover	25	1	25	1	3	1.666667
31PT493	Pitt	30	1	30	1	3	1.666667
31BF142	Beaufort	25	1	30	1	2	1.333333
31BF147	Beaufort	25	1	30	1	2	1.333333
31BR248	Bertie	30	1	30	1	2	1.333333
31BW442	Brunswick	26	1	30	1	2	1.333333
31BW637	Brunswick	22	1	30	1	2	1.333333
31BW650	Brunswick	22	1	30	1	2	1.333333
31CV163	Craven	28	1	30	1	2	1.333333
31CV245	Craven	25	1	30	1	2	1.333333
31CV298	Craven	25	1	30	1	2	1.333333
31NH543	New Hanover	25	1	25	1	2	1.333333
31NH711	New Hanover	25	1	25	1	2	1.333333
31NH779	New Hanover	22	1	30	1	2	1.333333
31PT137	Pitt	24	1	30	1	2	1.333333
31PT46	Pitt	26	1	30	1	2	1.333333
31BF127	Beaufort	26	1	30	1	1	1