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FLORIDA'S VANISHING HERITAGE: CLIMATE RISK AND ADAPTAION AT FLORIDA HERITAGE SITES

By

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B.A. UNIVERSITY OF CENTRAL FLORIIDA, 2017

A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Arts
in the department of History
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ABSTRACT

This thesis examines history and preservation at coastal cultural heritage sites threatened by climate change and explores climate adaptation strategies at two sites on Florida's Atlantic coast. Current climate change models indicate the planet may see as much as 1.1 meters, or four feet, of global average sea level rise by the year 2100, requiring site managers to intervene by using adaptation techniques to improve resilience and guard against the loss of cultural heritage monuments. Understanding the history and importance of these sites to the surrounding communities and their numerous stakeholders is the first step to ensuring these sites remain resilient in the face of a changing climate.

This project uses GIS mapping software, publicly available elevation and tide data, and publicly available sea level rise projection tools to evaluate areas vulnerable to sea level rise and the associated effects at Fort Clinch on Amelia Island in northeast Florida and Jupiter Inlet Lighthouse on south Florida's Atlantic coast. These two cultural heritage sites include both protected natural areas as well as examples of built environment that hold cultural significance for a number of stakeholder groups. While these two sites share similarities, climate change adaptation will look different at each. At Jupiter Inlet Lighthouse nature-based adaptation solutions like the current living shoreline project can provide a low-impact way to control erosion and improve resiliency at the site. Because of the coastal dynamics of Amelia Island, however, this type of adaptation project would not be effective at Fort Clinch. In the case of Fort Clinch several natural and anthropogenic factors contribute to an ever-present erosion problem which will worsen as sea levels rise. The changes that occur at these sites and adaptation efforts to respond to those changes will present future historians with opportunities to interpret the changes in the landscape for the public.

To Danielle
For propping me up every step of the way. Thank you.

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First, I would like to thank Dr. Connie Lester for her tireless patience, encouragement, and advice. Through numerous challenges and setbacks during my thesis project your guidance and counsel has served to keep me on track and plodding forward. Thank you for helping to shape me into a budding professional.

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Additionally, I would like to thank Dr. Peter Larson for the opportunity to gain real world insight into how public historians can work with local communities.

Furthermore, I would like to thank Josh Liller at the Loxahatchee River Historical Society, Peter DeWitt at the Bureau of Land Management, and Dan Pearson at the Florida Department of Environmental Protection, Division and Recreation and Parks. Your contributions were essential to understanding the conditions at each of the study sites and how adaptation at the sites might be approached. Thank you for sharing your knowledge with me.

Finally, I would like to thank my family. Without your support and encouragement, I would surely have given up long ago. Thank all of you for everything you have done. I have no doubt that I would not have been able to do this without you guys. Love you all!

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LIST OF ABBREVIATIONS

ACOE – Army Corp of Engineers

BLM – Bureau of Land Management

CFCs - Chlorofluorocarbons

CO2 – Carbon Dioxide

COP – Conference of Parties

FEMA – Federal Emergency Management Agency

FPAN – Florida Public Archaeology Network

GIS – Geographic Information Systems

HFCs - Hydrofluorocarbons

IPCC – Intergovernmental Panel on Climate Change

LPP – Locally Preferred Plan

LRHS – Loxahatchee River Historical Society

MHHW – Mean Higher High Water

MLLW – Mean Lower Low Water

NASA – National Aeronautics and Space Administration

NAVD88 – North American Vertical Datum 1988

NDC – Nationally Declared Contribution

NGO – Non-Governmental Organization

NOAA – National Oceanic and Atmospheric Administration

NPS – National Park Service

ONA – Outstanding Natural Area

RCP – Representative Concentration Pathways

SLR – Sea Level Rise

UN – United Nations

UNFCCC – United Nations Framework Convention on Climate Change

USGS – United States Geological Survey

CHAPTER ONE: INTRODUCTION

Since the beginning of the Industrial Revolution, when humans began burning coal and fossil fuels on a global scale, the level of carbon dioxide (CO2) in the atmosphere has risen significantly and the global average temperature has increased by nearly two degrees Fahrenheit.[1] According to the National Oceanic and Atmospheric Administration (NOAA), the level of CO2 in the atmosphere now is higher than at any point in the last 800,000 years.[2] CO2, along with other greenhouse gases, is magnifying the earth's natural greenhouse effect, causing the planet to warm. Much of this extra atmospheric heat is absorbed by the oceans, causing the oceans to undergo thermal expansion, glaciers and ice caps to melt and seas to rise.[3] The worlds ocean levels are directly tied to the amount of CO2 in the atmosphere. The last time the planet had a stable CO2 level equivalent that to that of today, oceans were roughly 50-80 feet higher than they are currently.[4] The level of CO2 currently in our atmosphere, however, is not stable but continuously increasing. Because the process of oceanic heat uptake and subsequent thermal expansion of the oceans is a very slow progression, and because greenhouse gas emissions are not being significantly reduced on a global scale, humans will be experiencing global sea level rise for perhaps hundreds of years.[5]

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[1] Rebecca Lindsey and Luann Dahlman, "Climate Change: Global Temperature," *Climate.gov – Understanding Climate,* Jan. 18, 2023. https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature

[2] Rebecca Lindsey, "Climate Change: Atmospheric Carbon Dioxide," *Climate.gov – Understanding Climate, Sept. 19, 2019.* https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide

[3] M.J. Widlansky, X. Long, & F. Schloesser, "Increase in sea level variability with ocean warming associated with the nonlinear thermal expansion of seawater." *Commun Earth Environ* **1**, no. 9 (2020). https://doi.org/10.1038/s43247-020-0008-8

[4] Lindsey, 2019

[5] Matthias Mengel, Alexander Nauel, Joeri Rogelj and Carl-Friedrich Schleussner, "Committed Sea-level Rise Under the Paris Agreement and the Legacy of Delayed Mitigation Action," *Nature Communications,* 9, no. 601 (2018) https://doi.org/10.1038/s41467-018-02985-8

Sea level rise in the range of 50-80 feet would be disastrous for countries around the world but, while that reality may come to pass if technology is not developed to help mitigate the effects of atmospheric carbon dioxide, that future is far off. The best estimates currently provided by scientists indicate we could see as much as a meter of global mean sea level rise by the year 2100.[6] Sea level rise will not happen evenly across the planet, with some areas experiencing more or less than the average amount of rise. In addition, communities around the state are planning for different levels of rise. The most current regional sea level rise models from NOAA indicate the southeast United States could see up to 2.1 meters of rise, or about 6.8 feet, though NOAA considers this scenario highly unlikely. According to NOAA, the level of rise by 2100 will likely fall in the intermediate-low to intermediate range, roughly .5 to .7 meters (1.6-2.3ft). The East Central Florida Regional Planning Council, however, is making plans based on the NOAA 2017 High forecast, which indicated a possible rise of roughly 2.6 meters, or 8.5 feet to ensure safety of critical infrastructure that is constructed in the future.[7] Similarly, the Southeast Florida Climate Compact suggests various sea level rise projections be considered for infrastructure and other large-scale projects based on the level of safety required for the projects. Examples included suggestions for using the IPCC Median Curve for short lifespan projects such as culverts, but they suggest the considerably higher NOAA High Curve when planning for

[6] M. Oppenheimer, B.C. Glavovic , J. Hinkel, R. van de Wal, A.K. Magnan, A. Abd-Elgawad, R. Cai, M. Cifuentes-Jara, R.M. DeConto, T. Ghosh, J. Hay, F. Isla, B. Marzeion, B. Meyssignac, and Z. Sebesvari, "Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities." In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, 2019, pp. 321-445. https://doi.org/10.1017/9781009157964.006.

[7] "Sea Level Rise," East Central Florida Regional Planning Council. https://www.ecfrpc.org/r2c-sea-level-rise. Accessed 11/17/2021.

critical infrastructure projects such as nuclear power plants and wastewater treatment facilities.[8] Even at the modest range of the NOAA Intermediate Curve, around 2.3 feet, sea level rise will present a challenge to managers of coastal cultural heritage sites, but through the use of adaptation techniques, particularly those laid out in the Cultural Resources Climate Change Strategy published by the U.S. National Park Service (NPS), it is possible that many of Florida's coastal cultural heritage sites can stay relevant and resilient for the remainder of the twenty-first century.

This paper explores the historiography of environmental history and the larger role historians have taken in the national, and global, discussion about adjustment to climate change, as well as the links between memory, identity, and physical representations of cultural heritage. Additionally, the topics of climate science, projected impacts on cultural heritage sites, and the types of adaptation strategies being employed will be discussed. This paper will also include case studies of two coastal cultural heritage sites in Florida: Jupiter Inlet Lighthouse and Fort Clinch on Florida's east coast.

This project does not address climate mitigation efforts in a meaningful way. Essentially climate mitigation is any effort to reduce or prevent climate change by shrinking or eliminating sources of greenhouse emissions.[9] Adaptation, on the other hand, is focused on living with the coming changes in the climate. Mitigation efforts are important in terms of easing the pressure of greenhouse emissions and cultural heritage sites should certainly investigate ways to reduce their

[8] "Unified Sea Level Rise Projection – Southeast Florida, 2019 Update, Southeast Florida Climate Compact Sea Level Rise Ad Hoc Work Group, Feb. 2020, Pg. 9, https://southeastfloridaclimatecompact.org/wp-content/uploads/2020/04/Sea-Level-Rise-Projection-Guidance-Report_FINAL_02212020.pdf

[9] NASA's Global Climate Change Website, "Climate Change Adaptation and Mitigation," Climate Change: Vital Signs of the Planet, Updated: 6/9/2023. Accessed 6/16/2023., https://climate.nasa.gov/solutions/adaptation-mitigation/.

carbon footprint. However, many coastal heritage sites, such as the two studied in this project, have a relatively low carbon footprint but are actively under threat from the effects of climate change. In these cases, site managers must focus on adaptation techniques that can improve the resiliency and longevity of the sites under their charge.

Research Questions

This thesis seeks to answer the following questions:

1. What risk does climate change pose to cultural heritage sites on Florida's east coast?
2. How vulnerable to climate risks are the chosen sites?
3. How are site managers dealing with the effects of climate change?
4. What adaptation strategies are being deployed at these sites?
5. How is climate change affecting the cultural heritage of the chosen sites?

To answer these questions, this project examines the science of climate change and the projected impacts of a changing climate, particularly on cultural heritage sites. Included will be an assessment of the vulnerability of each of the chosen sites to climate change factors using GIS sea level rise modeling techniques based on a modified version of the sea level rise mapping framework set forth by NOAA as well as the web-based NOAA Sea Level Rise Viewer. This kind of modeling, often referred to as a "modified bathtub" model, has its drawbacks, but it allows planners and site managers to develop an idea of the types of challenges they may have to deal with in the future.

This thesis visualizes the effects of climate change induced sea level rise on two of Florida's cultural heritage sites and examines elements of the NPS's Cultural Resources Climate Strategy to understand what types of adaptation strategies may be useful at these sites in the

future. While mitigation strategies will be necessary and useful in the future for sites that are not under directed threat from climate change, for many coastal cultural heritage sites, staying relevant and resilient means understanding and implementing adaptation strategies in the present.

While the adaptation field is a growing focus for multiple disciplines, the speed at which the field is developing can be overwhelming for those looking for guidance on adapting their sites in the future. Because the field is developing so quickly, many heritage site managers at the local and regional level might be unaware of new developments in the field and types of adaptation strategies at their disposal. One of the ways in which heritage organizations are connecting with sites and sharing knowledge is through citizen science programs such as the Heritage Monitoring Scouts program run by the Florida Public Archaeology Network (FPAN). This program involves volunteers who are assigned to monitor one or more heritage sites that are at risk from the effects of climate change and report back to FPAN periodically using a comprehensive evaluation form to monitor the condition of the site. These types of programs have the effect not only of putting preservation focused organizations like FPAN in contact with heritage sites around the state to share knowledge about climate adaptation techniques and developments in the field, but they also engage the public and encourage people to take an active role in the management and adaptation of heritage sites in their own communities.[10]

As an example of how site managers can perform basic vulnerability assessments for their sites with a relatively low barrier of entry, this thesis evaluates the current status of two cultural heritage sites, model sea level rise for each site using publicly available data, comparing it to the NOAA Sea Level Rise Viewer, and discusses current and future adaptation strategies for

[10] "HMS - Heritage Monitoring Scouts," Florida Public Archaeology Network, n.d., Accessed 6/16/2023. https://hms.fpan.us/about.

each site based on the Cultural Resources Climate Change Strategy published by the National Park Service. A companion website with additional images can be found at www.floridaslr.com.

The resources for this project are broad and the literature covers a wide variety of themes. Much has been written about climate change, both scientifically and culturally, in the last decade. Studying climate change from a humanities perspective is an inherently interdisciplinary task that blends techniques and information from numerous disciplines in the hard sciences and humanities from both the public and private sectors. In the last four decades there has been much written about the science behind climate change. It is not within the scope of this paper to give a comprehensive review of climate science literature, but this paper will explore the historiography surrounding human interaction with the climate and the interdisciplinary nature of studying climate in the humanities. A more detailed historiography of environmental history, and the relationship between memory, identity, and cultural heritage resources will follow in chapter 2.

Globally, the scientific authority on climate change is the Intergovernmental Panel on Climate Change (IPCC). In 2018 the IPCC published the IPCC Special Report on the Impact of Global Warming of 1.5°C, a report of nearly 700 pages which relies on more than 6,000 peer-reviewed publications concerning global warming. This report discusses the possible effects on the globe if global average temperatures rise to 1.5°C above pre-industrial temperatures. While the IPCC is the standard for reporting on climate change, many climate scientists believe the IPCC is conservative in their projections of 21st century climate change effects.[11]

[11] V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.), "Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty," Cambridge University Press, Cambridge, UK and New York, NY, USA, 2018, doi:10.1017/9781009157940.003.

In terms of climate change, sea level rise and the associated effects are the most pressing concern for cultural heritage sites located in coastal areas. For site managers and stakeholders attempting to create resilient, long-term management plans, understanding how future sea level rise will affect sites under their care is essential. One of the resources that is available to many cultural heritage site managers, particularly in Florida, is highly accurate contour mapping conducted by Lidar. Lidar is a way of mapping the ground from an aircraft by bouncing a laser from the craft to the ground, and back. The result is a highly accurate map of the ground that can be used by coastal heritage managers in a variety of ways, including mapping and modeling sea level rise at their sites. This mapping technique is used the world over, and often the data is made available to the public. The resulting elevation maps of the land are an important piece of the equation in constructing hydrological models of the area. For a discussion on the role Lidar plays in identifying climate change vulnerabilities, see Gresch and Crapoulet et al.[12]

In the last decade heritage site managers, planners, and stakeholders have begun to focus on the effects that climate change is having on cultural heritage sites and how the impacts to heritage sites can be dealt with. Dealing with the challenge of climate change at cultural heritage sites is sometimes more clearly defined in terms of adaptation, but efforts at mitigation cannot be ignored. The way that humans use natural resources, particularly in the production and consumption of energy, has a direct effect on the sustainability of some cultural heritage sites in the future. For cultural heritage sites to effectively contribute to the global effort at climate change mitigation, governments, managers, and stakeholders must be able to work together to

[12] Gesch, Dean B. "Analysis of Lidar Elevation Data for Improved Identification and Delineation of Lands Vulnerable to Sea-Level Rise." *Journal of Coastal Research* 25, no. 6 (2009): 49-58. http://www.jstor.org/stable/25737451.; Adrien Crapoulet, Arnaud Héquette, Franck Levoy, and Patrice Bretel. "Using LiDAR Topographic Data for Identifying Coastal Areas of Northern France Vulnerable to Sea-Level Rise." *Journal of Coastal Research*, 2016, 1067-071. http://www.jstor.org/stable/43752427.

prioritize and manage both adaptation and mitigation efforts. For discussions on the role of energy consumption in climate change's effects at cultural heritage sites and how governments and heritage professionals can approach climate change, see Smith and Bartel-Bouchier. [13]

One of the difficulties in adapting cultural heritage sites, or any site for that matter, is the inherently technical nature of climate science and climate change forecasting. Adapting to climate change at coastal cultural heritage sites requires an understanding of the individual characteristics of the site, the climate change related threats to the site and where the areas of vulnerability might be, an understanding of the coastal dynamics of the area, and knowledge of how adaptation solutions might be implemented at the particular site. This highlights the interdisciplinary nature of cultural heritage adaptation and the need to not only explore knowledge outside of one's own field, but also to seek out experts in other fields to gain a full understanding of how to approach adaptation.

One of the goals of this thesis is to map sea level rise vulnerabilities at the project sites and to explore how adaptation strategies are currently being employed, and which strategies may be useful in the future. To facilitate mapping of the project sites, this thesis makes use of the University of Florida's Florida Geographic Data Library.[14] This database houses numerous geographic datasets for counties around Florida. Included in this database are 2-foot contour elevation maps for more than thirty of Florida's coastal counties. These contour maps can be used to create digital elevation maps using GIS software, allowing for sea level rise inundation modeling. This modeling will be conducted using a modified version the framework for sea level

[13] Diane Bartel-Bouchier, *Cultural Heritage and the Challenge of Sustainability,* (Routledge, Milton Park, 2013); Peter F. Smith, *Climate Change and Cultural Heritage: A Race Against Time,* (Routledge, Milton Park, 2014)
[14] Florida Geographic Data Library, University of Florida GeoPlan Center, https://www.fgdl.org/metadataexplorer/explorer.jsp

rise mapping published by NOAA.[15] In order to correct for Mean Higher High Water (MHHW) during mapping, this project made use of publicly available tide gauge data from tide gauges nearest to the site. Using this data, an elevation correction factor was determined which allowed for the conversion from North American Vertical Datum 1988 (NAVD88) to Mean Higher High Water. More on the elevation correction used for vertical datum in this project and a more detailed discussion of the mapping process can be found in Appendix A: Project Method for Mapping Sea Level Rise Inundation.

This thesis suggests adaptation solutions that might be practical at each site. To facilitate these suggestions, this paper will rely on the Cultural Resource Climate Change Strategy which, in part, lays out the seven most common forms of adaptation employed at cultural heritage sites. A more in-depth discussion of the NPS adaptation strategy follows in Appendix 2.

This thesis also makes use of podcasts, particularly a podcast called *America Adapts,* which features interviews with climate adaptation professionals including scientists, preservationists, and policy makers.[16] While perhaps not the typical primary source relied on by historians, podcasts are increasingly becoming a medium employed by professionals in various fields to disseminate new information. In the case of climate change adaptation, the field is changing and progressing faster than new information can be released through scholarly journals and monographs. *American Adapts* gives professionals who are working at the cutting edge of climate adaptation in government and NGO's a platform to bring new advancements to the public. Utilizing these interviews will allow for a better understanding of the state of the field of

[15] NOAA, *Detailed Method for Mapping Sea Level Rise Inundation,* NOAA Office for Coastal Management, Jan. 2017. https://coast.noaa.gov/data/digitalcoast/pdf/slr-inundation-methods.pdf
[16] Doug Parsons, *America Adapts,* Podcast Audio

climate change adaptation and how climate adaptation professionals are applying themselves to questions of cultural heritage preservation.

The two sites chosen for this project are Fort Clinch on Amelia Island, the barrier island off the coast of Jacksonville, and Jupiter Inlet Lighthouse in Jupiter, Florida. Chapters three and four will include case studies of cultural heritage sites from around Florida: the Jupiter Inlet Lighthouse in Jupiter in chapter three, and Fort Clinch on the northwestern corner of Amelia Island, in chapter four. Each of these sites are culturally significant to the surrounding communities, and the state of Florida. Each case study will include a history of the site and the impacts of climate change that are currently being seen at these sites, an evaluation of the vulnerability to sea level rise and other climate change factors, and a recommendation for future adaptation in keeping with the National Parks Service's Cultural Resources Climate Change Strategy.

Fort Clinch was constructed on the north end of Amelia Island beginning in 1847 as a part of an effort at coastal fortification by the U.S. government, in response to the War of 1812. The fort was not completed by the time it was occupied by Confederate troops at the opening of the Civil War. Soon after it was taken by Federal troops and served as a base of operations for the Union war effort on the Florida and Georgia coasts. Except for a short period of activity during the Spanish-American war, Fort Clinch was essentially abandoned until restoration began on the facility as part of the effort to rejuvenate the economy after the Great Depression. After restoration of the fort, the land was included in a purchase of more than 250 acres by the state of Florida, which was eventually organized into Fort Clinch State Park. The park and the fort have been open to the public since 1938, except for a period during World War II, when the fort served as a communications post for the U.S. military. Today Fort Clinch is interpreted as a Civil

War era fort and connects visitors and locals to the history of Florida's role during the Civil War.[17]

The Jupiter Inlet Lighthouse was constructed on a high natural dune at the confluence of the Loxahatchee and Indian Rivers in 1860. The light was intended to serve as a navigation aid located between the Cape Canaveral light and the Hillsboro Inlet light, but shortly after its construction, the light was disabled by confederate sympathizers in the area and remained dark until 1866. After the light was relit, the reserved area surrounding the lighthouse was expanded and the facility served was a weather station and a signals station, in addition to its navigational beacon duties. With the onset of World War II, the site served as a station for both the U.S. Coast Guard and the U.S. Navy. While the Coast Guard maintained and operated the lighthouse, the Navy established a covert base responsible for intercepting messages from German U-boats operating in the Atlantic, code-named Station-J. The facility was operated by the U.S. military until the mid-1980s. In 1994 the Loxahatchee River Historical Society entered into a contract with the U.S. Coast Guard to maintain and operate the lighthouse, as well as give public tours of the grounds. Today the lighthouse and more than a hundred acres of the surrounding land have been designated an Outstanding Natural Area by the Bureau of Land Management, and the ONA area, the lighthouse and the Jupiter Inlet Lighthouse Museum continue to be managed and interpreted by the Loxahatchee River Historical Society.[18]

These sites were chosen for this project because of their similarities and their differences. Each of these sites have a long history on Florida's Atlantic coast and played roles, small and

[17] Florida – Fort Clinch, U.S. National Park Service, Accessed from: https://www.nps.gov/nr/travel/geo-flor/18.htm

[18] Loxahatchee Historical Society, *Jupiter Inlet Lighthouse History*, JupiterLighthouse.org. https://www.jupiterlighthouse.org/explore/history/lighthouse-history/

large, in United States military conflicts. Specifically, both sites have a connection to the Civil War and the World Wars. Particularly in the case of the Civil War, Florida can sometimes seem disconnected from the rest of the war, but each of these sites serve to connect the visitor to Florida's role in the war. In terms of climate change, each site is similar in its location and in its potential exposure to climate change factors. Both of these sites have culturally significant examples of built environment that are vulnerable to erosion, storm surge damage, and inundation related to sea level rise. Importantly, these sites also differ in significant ways. Particularly in terms of topography, they are different. Fort Clinch is located on Amelia Island on Florida's east coast and represents a large island site. Evidence of rising seas and past adaptation efforts are evident at the site, particularly on the northern side of Fort Clinch. The Jupiter Inlet Lighthouse is located adjacent to Jupiter Inlet, where the Indian River and the Loxahatchee River come together to meet the sea. The Jupiter light is a mainland coastal site, located on the western shore of Florida's intercoastal waterway. Because of the differences in topography, these sites differ in terms of exposure and climate adaptability. Fort Clinch is currently located extremely close to the water, and because of several factors, both natural and anthropogenic, the northern part of Amelia Island has a perpetual erosion problem. Currently the area is being maintained through beach replenishment and shoreline armoring in the form of rock groins. In the event of only moderate sea level rise these solutions may continue to work, but in the event of sea level rise in the intermediate-high or high range, these types of adaptation solutions may no longer be sustainable. In that event alternative options to physical adaptation may have to be explored to keep the site resilient in the future.

The Jupiter Inlet Lighthouse has a luxury uncommon amongst historic coastal sites in Florida; the ability to trade elevation for time. The lighthouse itself is constructed on a natural

high dune and sits roughly 45 feet above sea level. Because of this, it is unlikely the lighthouse itself will be threatened by sea level rise in the twenty-first century, but support facilities at the site, including the museum, are at lower elevations and may be threatened. It is likely that through proper management of the lighthouse and a policy of erosion control and coastal retreat for supporting facilities on the grounds, the Jupiter Inlet Lighthouse will be spared many of the problems forecast for coastal sites experiencing the effects of climate change, but site managers may find themselves responsible for interpreting the change in the surrounding landscape for future generations of visitors. It is important for this project to represent a large-island site and a mainland coastal site, because these sites face different challenges in terms of exposure and climate adaptation, but as a pair, they are representative of many of Florida's coastal cultural resource sites and the issues they will deal with as the climate continues to change in the coming decades.

This thesis project includes six chapters; following this introduction chapter, chapter two discusses the historiography of climate history and its growth out of the environmental history movement in the 1960s. The way historians have approached the climate has changed over the years, from its origins as a subset of environmental history to the historic climatology movement in the 1980s, to the modern multidisciplinary approach many historians take today. The role of memory and cultural heritage in forming personal identity will also be discussed.

Chapter three discusses the effects of climate change on coastal cultural heritage sites, particularly the effects of sea level rise and semi-permanent or permanent coastal inundation. This discussion will include the importance of cultural heritage sites to their communities, both in terms of heritage and in terms of economics, how climate change is impacting cultural heritage sites in different climactic zones around the globe, and how stakeholders and heritage

managers are approaching adaptation in a changing climate. In addition, this chapter examines climate change policy at the local, state, and federal levels, the main drivers of climate change, the impacts of climate change globally and in Florida, and the climate change factors that are driving sea level rise, as well as the potential impacts of sea level rise on coastal areas, and the factors that cause seas to rise at uneven rates in different parts of the world.

The fourth chapter of this paper focuses on Jupiter Inlet Lighthouse. This chapter explores the geography and history of the lighthouse and the surrounding area, as well as the cultural and economic contributions of the site to the local community and the state of Florida. Jupiter Inlet and the surrounding Outstanding Natural Area are inexorably tied to local culture and to United States history. The area where Jupiter Inlet Lighthouse is located today has been used by a number of Indigenous groups. The Spanish made contact with groups based around modern-day Jupiter numerous times, and for a short time English settlers in Florida made a home near the inlet. The lighthouse served as a base of operations for Confederate blockade runners during the Civil War and later served in support roles during World War I and World War II.

Based on sea level rise modeling of the area, there are several areas of the lighthouse grounds and the surrounding ONA that are experiencing the effects of sea level rise and associated erosion. Some of these areas are currently being treated with climate adaptation solutions to prevent further erosion of the shoreline and there are plans in the works to apply adaptation efforts to other areas of the site. Managers and stakeholders for the lighthouse are employing nature-based adaptation solutions that are intended to increase the resiliency of the site through low impact, environmentally friendly projects. Recently a living shoreline project was completed directly adjacent to the lighthouse museum, and there are plans in the works for

future living shoreline projects at the site along the western banks of the Indian River. Addressing these two areas will help to shore up two of the most vulnerable areas of the site.

Located on the northern tip of Amelia Island, Fort Clinch, the focus of chapter five, is likewise tied to local Florida history and has been a strategically important location for centuries. The area has a long history of settlement. For more than five hundred years various Indigenous groups, including the Timucua, settled and traded on Amelia Island. In the late sixteenth century, the Spanish and French struggled for control of the island until the Spanish, along with Franciscan monks, gained control over the area. While the Spanish officially controlled the area, Amelia Island continued to play an important role for Indigenous groups, runaway slaves, and traders well into the eighteenth century. When the East Florida Patriots crossed the St. Mary's River at the behest of the U.S. government in 1812, an incident that would play a key role in the Spanish decision to abandon Florida, they landed on Amelia Island. In response to the fighting that occurred in 1812, which included the British using inland waterways to penetrate deep into American territory, the United States began building a series of coastal forts to increase the country's coastal defenses. After Florida became a state in 1845, plans were drawn up for a fort on the northern end of Amelia Island, overlooking the St. Mary's and Georgia beyond. Although the Civil War intervened in construction of the fort, Fort Clinch was occupied by both Confederate and Union troops during the war. After the war the fort was abandoned for a time but was again garrisoned in 1898 as the Spanish-American War broke out. The fort also performed support operations during World War II.

While climate change certainly exacerbates coastal problems such as erosion, the island has some unique anthropogenic factors that make adaptation at the site difficult. The combination of the submarine channel from King's Bay Naval Station and the length of the

northern jetty at the St. Mary's Inlet, more than three and a half miles, causes sand to be continuously stripped from the north easter portion of the island which cannot be replenished through natural littoral drift. A policy of continuous sand replenishment has been in place for the last three decades. This is an expensive and disruptive process, but the tidal dynamics of the area make replenishment the only viable option at the current time. The lack of suitable adaptation solutions around Fort Clinch means the fort is highly vulnerable to future climate change and managers may find it a challenge to ensure the fort can remain resilient for the remainder of the century.

The concluding chapter of the paper discusses some of the challenges of adapting to climate change at both study sites. While these sites are similar in their locations and their exposure to the coastal effects of climate change, they differ greatly in their capacity for adaptation. Differences in coastal dynamics at each site mean that managers have to approach adaptation in unique ways that suit each site individually. While sea level rise inundation modeling can certainly be useful, mapping does not tell the whole story. Areas of vulnerability can be identified through inundation modeling, but the types of adaptation solutions that might be employed can differ widely. Understanding the coastal dynamics of the site is just as important as identifying the vulnerable areas, but organized, publicly available data on coastal dynamics are lacking.

CHAPTER TWO: CLIMATE HISTORIOGRAPHY AND MEMORY

The field of environmental history developed slowly after World War II, and really began to take shape during the counterculture movement of the 1960s. One of the precursors to this development, Fernand Braudel's 1949 publication of *The Mediterranean and the Mediterranean World in the age of Philip II,* applied the principles of the Annales School of thought to understand how different climatic and environmental factors affected development in the Mediterranean world. Braudel's work is not an environmental history in the conventional sense, but it incorporates climate and technology into his analysis of the development of the Mediterranean world over an extended period, the longue durée. For historians like Braudel, focusing on the long durée meant analyzing the long-term effects that features of the landscape such as mountains, seas, and rivers exerted over the development of agriculture, social organizations, villages, and technological advances to create a mentalité that defined the area. Braudel's work was published prior to the development of environmental history and the environmentalism movement, but the author's focus on the influences of the landscape foreshadows that of authors later identified as founders of the field of environmental history.[19]

The global movement towards environmentalism was initiated with Rachel Carson's sobering look at the use of pesticides in *Silent Spring* (1962), which had a deep impact on society and became a rallying point for environmentalism.[20] Carson, who made a living as a biologist for U.S Fish and Wildlife and wrote several popular science books for the general public, focused

[19] Fernand Braudel, *La Mediteranee et le Monde Mediteranee a L'epoque de Philippe II,* Paris, Armand Colin, 1949
[20] Rachel Carson, *Silent Spring,* Boston, Houghton Mifflin, 1962

her study on the use of pesticides in the United States.[21] Of particular interest to Carson was DDT, a pesticide that was widely in use in the United States in both residential and commercial settings. She argued that DDT and other pesticides like it had no ability to target only pests and were destructive to the entire ecosystem into which they were introduced. Carson was not the first scientist to sound the alarm about the harm humans were doing to the environment, but her experience writing science for the general public gave her the ability to connect to nonscientific people, explaining complex scientific ideas in a way that was approachable for someone who did not have an advance degree in science.[22] Her book cemented the idea in the public mind that seemingly small actions by humans, like the use of a new pesticide, could have drastic, widespread effects on the environment.

In the United States the outrage caused by *Silent Spring* found a home in the turbulent counterculture of the era and, in large part due to media attention, environmentalism landed in the cultural mainstream. It was in this atmosphere that environmental history emerged. Recognized as one of the seminal texts of environmental history, *Wilderness and the American Mind* (1967) took an intellectual history approach to looking at the concept of wilderness in American society.[23] Roderick Nash argued that as European settlers in the North American east began to move west, their interaction and struggles with the wilderness created a unique American, separate from that of the European homelands from which they originally came. This view of an unspoiled nature that settlers moved into is, of course, completely devoid of an autonomous Indigenous population. When Indigenous people are mentioned, they are viewed as background players who did not understand the potential of the land they inhabited. Indeed, the

[21] Marsha L. Richmond, "Women as Public Scientists in the Atomic Age," *Historical Studies in the Natural Sciences,* 47, no. 3, Special Issue: The Bonds of History (June 2017): 349-388
[22] Richmond, 2017
[23] Roderick Frazier Nash, *Wilderness in the American Mind,* New Haven, Yale University Press, 1967

opposite is true; Indigenous populations in North America were deeply involved in the management and exploitation of the land for their own needs. Despite the work's shortcomings in the area of Indigenous history and interaction with westward moving settlers, this was perhaps the first time the term Environmental History was used, and other historians followed suit to cement environmental history as a new sub-field of history. Included among these Alfred Crosby, Donald Worster, and William Cronon.

Alfred Crosby's *The Columbian Exchange* (1972) studies the arrival of Columbus in the Bahamas, and how the interactions between Europeans and Indigenous people affected the ecology of the Americas. When Europeans made contact with the Americas there began an exchange of both goods and diseases between the Indigenous population of the Americas and Europe. Diseases were exchanged both ways, but the thousands of years of isolation from the rest of the human population left Indigenous people in the Americas with no immunity. These diseases wreaked havoc amongst the population in the Americas at the same time that European livestock and other imports combined to put enormous pressure on the ecology of the Americas. An example of this can be seen in the introduction of European pigs to the Americas, which continue to destroy crops and devastate farmland in large sections of the United States and Mexico. Along with Nash's work, *The Columbian Exchange* has become one of the foundational works of the field of environmental history.[24]

Worster's work on the dust bowl took a legendary event in U.S. history and examined it from a new, ecological-minded point of view. Worster chronicles the decimation of the Southern

[24] Alfred Crosby, *The Columbian Exchange: Biological and Cultural Consequences of 1492,* New York, Greenwood Publishing Group, 1972

Plains as overproduction of farmland in response to growing agricultural demand sapped the resources from the land and created one of the three worst ecological disasters in history.[25]

William Cronon's work in *Changes in the Land* (1983) explored the alterations of landscapes in New England between 1600 and 1800. European ideas of ownership and exploitation, which were far removed from the concepts of stewardship and production practiced amongst the Indigenous population, transformed the New England landscape as European style farming and production techniques replaced those of Indigenous groups in the area.

Two common threads between these events stand out in the face of global climate change. First, humans have incredible power to alter the landscape and the environment. The landscape of New England was radically altered over two centuries as management of the land was wrested from Indigenous populations by European settlers. A new concept of land management by exploitation took hold in North America, and by the middle of the nineteenth century, that style of management set the stage for disaster; the creation of a dust bowl, from fertile lands, that blew sand and particulate high into the stratosphere and as far away as Europe.[26]

The second common thread is how fast changes humans make can affect the environment. In the case of both the transformation of the New England landscape and the creation of the dust bowl, anthropogenic factors coalesced to facilitate environmental changes in a short period of time, a blink of an eye in geological terms. Similarly in terms of climate change, in a relatively short period since the Industrial Revolution, anthropogenic factors have

[25] Donald Worster, *Dust Bowl: The Southern Plains in the 1930s,* Oxford, Oxford University Press, 1976
[26] William Cronon, *Changes in the Land: Indians, Colonists, and the Ecology of New England,* New York, Hill & Wang, 1983

led to unforeseen changes that are affecting the environment. The difference is the scale of current climate change compared to those previous events. Past events in which humans had significant effect on the environment happened on a regional scale, but the global consumption of fossil fuels and the emission of greenhouse gasses which, until the last couple of decades, went unchecked by virtually every nation on earth has led to unprecedented environmental and ecological changes around the globe, the consequences of which we are only beginning to understand.[27]

Because it is impossible to separate the events of human history from the environment in which they happen, the field of environmental history has expanded into smaller subfields as historians look at existing questions in history through the new lens of environmental history. Since the 1990s the field of environmental history has grown at a tremendous rate, becoming possibly the fastest growing subfield of history.[28] Because so much scientific data is required to understand climate patterns and the drivers that affect them, environmental history has always been an inherently interdisciplinary field. Environmental histories surrounding questions of science and technology are becoming more common and the topics they are addressing are of particular importance today.[29]

One of the subfields that emerged from environmental history is the field of historical climatology. Historical climatology uses historical records to examine past climates and the effects climatic changes had on civilization.[30] In the 1970s, as climatology developed as a

[27] Mengel et al, 2018
[28] J.R. McNeill, "The State of the Field of Environmental History," *Annual Review of Environment and Resources,* 35 (2010): 345-374
[29] Mark D. Hersey and Jeremy Vetter, "Shared Ground: Between Environmental History and the History of Science, *History of Science,* 57, no. 4, (Dec. 2019). https://doi.org/10.1038/s41467-018-02985-8
[30] Mark Carey, "Climate and History: A Critical Review of Historical Climatology and Climate Change Historiography," *WIREs Climate Change,* 3 (May/June 2012): 233-249

science, historians began using documentary evidence to understand past climates.[31] The development of historical climatology reinforces one of the hallmarks of environmental history. Namely, climate work in the humanities is inherently interdisciplinary. Because it is not possible to be an expert in every field, scholars and researchers in the humanities must work with professionals from other disciplines to ensure their work is on solid scientific footing.

The focus on climate in the humanities is climate change and how we are preparing to deal with the changes we are slated to encounter in the future. For public historians, preservationists, and heritage managers, climate change represents a looming existential threat to the sites they study and protect. These professionals are actively looking for mitigation and adaptation strategies that can help to ensure the resilience of their sites in the future. In fact, adaptation has become a sub-field all its own and has connected professionals from multiple disciplines as they brainstorm ways to adapt to the changes scientists predict will come.[32]

Climate change is a complicated, nuanced issue that is perfectly suited for the type of scholarship historians do. Scholars in the humanities are beginning to recognize that the humanities have "a crucial role to play in understanding and solving environmental problems," and the unique perspective provided by the humanities can help to improve modeling and planning for a resilient future.[33] This is particularly true in terms of cataloging and disseminating

[31] A.E.J. Ogilvie, "Historical Climatology, *Climatic Change,* and the Implications for Climate Science in the Twenty-first Century," *Climatic Change,* 100 (2010): 33-47

[32] For works on climate adaptation see: Lisa Dale, *Climate Change and Adaptation: An Earth Institute Sustainability Primer,* New York, Columbia University Press, 2022; Jem Bendell & Rupert Read, Eds., *Deep Adaptation: Navigating the Realities of Climate Chaos,* Cambridge/Medford, Polity Press, 2021; Peter Tangney, *Climate Adaptation Policy and Evidence: Understanding the Tensions Between Politics and Expertise in Public Policy,* New York, Routledge, 2017; Mark Pelling, *Adaptation to Climate Change: From Resilience to Transformation,* New York, Routledge, 2010; Alice C. Hill, *The Fight for Climate After Covid-19: A Council on Foreign Relations Book,* New York, Oxford University Press, 2021

[33] Robert S. Emmett and David E. Nye, *The Environmental Humanities: A Critical Introduction,* Cambridge, MIT Press, 2017; David Higgins, Tess Somervell, & Nigel Clark, "Introduction: Environmental Approaches to Climate Change," *Humanities,* 9, no. 94 (2020): 2-9

Indigenous knowledge and protecting the culture of disadvantaged groups. For thousands of years Indigenous groups have inhabited lands that are now threatened by climate change, and they should have a role in solving the climate crisis by offering insights from traditional knowledge.[34]

It must also be recognized that climate change disproportionately affects disadvantaged groups in the developed world, such as the United States, as well as the developing world. Professionals working in the environmental humanities should, therefore, keep in mind the stories of these groups and look for ways to not only educate the public about the disproportionate effects of climate change, but also provide opportunities for these groups to have a voice in adaptation and mitigation planning on the local, regional and global scale.[35]

The environmental humanities also have a role to play in placing climate change into the historical record of human development. Though the legitimacy of climate science is debated in the public arena, among scientists who study the topic there is no debate that climate change is real, and it is in large part driven by human actions.[36] By taking the historical approach, the humanities can show "historical attitudes, practices, and institutions that have brought about climate change as a material-discursive phenomenon, one which incorporates physical and social processes, cultural mediations, and proposed solutions."[37]

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[34] D. Green and G. Raygorodetsky, "Indigenous Knowledge of a Changing Climate, *Climatic Change*, Feb. 17, 2010. DOI 10.1007/s10584-010-9804-y; USGS Communications and Publishing, "Indigenous Knowledge: Providing Insight into Climate Change," Nov. 28, 2022. https://www.usgs.gov/news/featured-story/indigenous-knowledge-providing-insight-climate-change

[35] "Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts," U.S. Environmental Protection Agency, EPA 430-R-21-003, 2021. www.epa.gov/cira/social-vulnerability-report; Mark Carey, "Science, Models, and Historians: Toward a Critical Climate History," *Environmental History*, 19, no. 2 (April 2014): 354-364

[36] Raquel Bertoldo, Claire Mays, Wouter Poortinga, Marc Poumadere, Endre Tvinnereim, Annika Arnold, Katharine Steentjes, and Nick Pidgeon, "Scientific Truth or Debate: On The Link Between Perceived Scientific Consensus and Belief in Anthropogenic Climate Change," *Public Understanding of Science*, 28, no. 7 (2019): 778-796

[37] Higgins 2020, p94

Global climate anxiety is helping to drive an expansion of the field as historians look at what kinds of contributions, they can make to improving the climate situation of the planet. Many historians argue that it is the duty of the field to contribute to the conversation about climate change. Indeed, Mark Carey calls for a more critical climate history. He argues that historians hold a unique position in the current global climate conversation but that they are not involved enough in that conversation.[38]

The challenges of accounting for human activity in climate change models are numerous. Just as the history of human development cannot be separated from the surrounding environment, the environment cannot be separated from the activities of man. Humans react and adapt and innovate in the environment around them in real time. It can be difficult to gauge how a particular community will react to local effects of climate change in the future.

Because of these difficulties, when climate change modeling is conducted there is often no attempt to account for the future actions of man. Climate models, then, are weakened by the fact that human activities are not accounted for and result in environmental models that skew more towards an environmentally predetermined outcome. Environmental historians have the opportunity to help scientists and modelers understand how people in the past have adapted to changes in their environment and perhaps to understand and predict how people may react to similar changes today. When using models to try to understand future effects of climate change, input from historians would benefit the community as a whole, but their point of view is particularly beneficial to cultural heritage sites.[39]

[38] Carey, 2012
[39] Carey, 2014

Shared cultural heritage is one of the things that bond members of groups to one another and to a group identity. The customs, values, and traditions that are passed down to us are the things that help us construct our own identity. Examples of tangible cultural resources like buildings and monuments in the built environment and cultural landscapes in the natural environment are the basis for how we relate to our surroundings and tie our cultural identity to the land.[40]

Around the world climate change is already negatively affecting cultural heritage sites in many ways, and future climate change projections make it all but certain that these affects will worsen. In cold climates cultural heritage sites are contending with new or worsening freeze-thaw cracking and thawing permafrost that can upset foundations of buildings; in more arid climates drought and extreme heat affect wood structures and threaten cultural landscapes with specter of wildfire; and in coastal areas sea level rise, coastal erosion, and increased storm surge threaten to claim landscape and structure for the sea.[41]

For historic preservationists and cultural resource managers, climate change presents a challenge of adaptation, not only in the physical sense at heritage sites, but also adaptation in thinking about what preservation means. While the future of some heritage sites may seem uncertain, there is a growing recognition in the field of what it will take to ensure resiliency of these sites in the future. Preservationists, cultural resource managers, and planners at the local, state, and federal level are realizing that an understanding of the science of climate change, and options for mitigation and adaptation strategies, along with an understanding of how to

[40] Dolores Hayden, *The Power of Place: Urban Landscapes as Public History,* Cambridge, MIT Press, 1995
[41] Marcy Rockman, "An NPS Framework for Addressing Climate Change with Cultural Resources," *The George Wright Forum,* 32, no. 1 (2015): 37-50; Diane Barthel-Bouchier, *Cultural Heritage and the Challenge of Sustainability,* Walnut Creek, Left Coast Press, 2013

communicate this information to the public and other stakeholders is essential to ensuring the future of our threatened cultural resources.[42]

Historic preservation has a long history in the United States. From the first organized attempts to save Independence Hall and Mount Vernon, to the federal government's efforts at natural preservation, there have been numerous groups who have led the preservation movement in the United States. From the beginning of the movement in the early nineteenth century, there were two distinct avenues of preservation in the United States. One of these avenues consisted of private groups and citizens working together to preserve structures associated with important historical figures, such as George Washington's Mount Vernon and Thomas Jefferson's Monticello estate.[43]

The other avenue is usually distinguished by the involvement of the federal government in preserving landscapes through the establishment of national parks.[44] Throughout the nineteenth and twentieth centuries historic preservation gained popularity in government circles and with the public. The nation's first national park, Yellowstone National Park, was created in 1872 and was the beginning of a public land program unlike anything in the world.[45] The National Park Service (NPS), established in 1916, was placed in charge of national parks across

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[42] Norman Tyler, Ilene R. Tyler, Ted J. Ligibel, *Historic Preservation: An Introduction to its History, Principles, and Practice – Third Edition,* New York, W. W. Norton & Company, 2018

[43] "Historic Preservation," George Washington's Mount Vernon, MountVernon.Org, https://www.mountvernon.org/preservation/; "Monticello and the University of Virginia in Charlottesville," UNESCO World Heritage Convention, https://whc.unesco.org/en/list/442/;

[44] Tyler et al., 2018

[45] Richard West Sellars, *Preserving Nature in the National Parks: A History,* Hartford, Yale University Press, 1997. For other works addressing the history of the National Park system and the development of U.S. historic preservation, see: Fiske Kimball, "The Preservation Movement in America," Journal of the American Society of Architectural Historians, 1, no. 3/4, Preservation of Historic Monuments (Jul. - Oct., 1941): 15-17; Harlan D. Unrau and G. Frank Williss, "To Preserve the Nation's Past: The Growth of Historic Preservation in the National Park Service during the 1930s," The Public Historian, 9, no. 2, The National Park Service and Historic Preservation (Spring, 1987): 19-49; Philip V. Scarpino, "Planning for Preservation: A Look at the Federal-State Historic Preservation Program, 1966-1986," The Public Historian, 14, no. 2 (Spring, 1992): 49-66

the U.S. Congress formalized the federal commitment to historic preservation with the creation of the National Trust for Historic Preservation in 1949 and the passing of the National Historic Preservation Act in 1966. Since its creation the duties of the National Park Service have expanded to include overseeing not only national parks, but also management of tens of thousands of sites listed on the National Register of Historic Places and the list of National Historic Landmarks.[46] Increasingly, NPS finds itself the go-to organization cultural heritage managers who are concerned about the future of their sites and want to know what adaptation options might be available to them.[47]

In the face of a changing global climate, preserving heritage sites such as the cultural landscapes of the U.S. National Park system requires heritage managers to consider how energy and fuel consumption might impact their sites now and, in the future, and what they can do to be more energy efficient in order to mitigate the effects of climate change. In *Climate Change and Cultural Heritage* (2014), Peter F. Smith addresses the role of energy consumption in driving climate change.[48] The way we use energy is a key element in the anthropogenic contributions to climate change. As the production of energy emits more carbon dioxide into the atmosphere, a feedback loop is created that in turn releases additional, more potent greenhouse gases. For example, there are tremendous stores of methane trapped in glacial ice and permafrost. As the planet warms methane is released from trapped ice, increasing the greenhouse effect, causing additional warming and the release of additional methane. While the levels of ice-bound are not nearly as abundant as the carbon dioxide in our atmosphere, methane is roughly seven times as potent as carbon dioxide and even in small levels can perpetuate the warming trends being

[46] Tyler et al., 2018; "National Historic Preservation Act," *Advisory Council on Historic Preservation,* *https://www.achp.gov/digital-library-section-106-landing/national-historic-preservation-act*
[47] Rockman, 2016
[48] Peter F. Smith, *Climate Change and Cultural Heritage: A Race Against Time,* New York, Routledge, 2014

observed now.[49] Smith discusses the critical importance of mitigation techniques to help curb global emissions outputs, but he makes clear the fact that many cultural heritage sites are running out of time in terms of climate resiliency. This highlights the vital need for adaptation solutions that can help protect heritage sites immediately.[50]

The impact of climate change at heritage sites extends past the sites themselves into the surrounding community. Climate change, particularly for coastal heritage sites, is a threat to their continued existence. The loss of heritage sites can have a detrimental effect on the surrounding communities, especially if those communities are closely tied to the site in terms of identity and economics. Heritage sites are often tied to the local economy; in Florida tourism contributed more than 100 billion dollars in state revenue.[51] While heritage sites can be important to a community in terms of employment and income, perhaps more importantly they can help to drive tourism revenue into the community. Although the tourism attracted by heritage sites can be a benefit to the local economy, preservation and resilience of cultural heritage sites are overlooked when planning for disaster response in the community. In the United States, tourism related expenditures contribute more than a trillion dollars to the economy annually. Of this, a significant amount is contributed in the form of cultural heritage tourism.[52] Of course, tourism is an economic driver all over the world, contributing 9% GDP globally. In many developing countries tourism, and often heritage tourism, offers one of the of most sustainable sources of income available to the country's government. For this to be the case, however, there must be

[49] Wilson Flood, "The Methane Misconceptions," *Energy & Environment* 22, no. 3 (2011): 233-239
[50] Smith, 2014
[51] "About Visit Florida," Visit Florida, https://www.visitflorida.com/about-us/. Accessed 5/25/2023
[52] Sarah Osborne, "U.S. Travel and Tourism Satellite Account for 1999-2020," *Survey of Current Business* 102, no. 2 (Feb. 2022): 1-12

sustainable management practices in place for sites to be of any benefit to its stakeholders.[53] It is becoming increasingly clear that climate change is a pressing issue for heritage sites now and will become more so over the remainder of the century. Site managers will have to include the anticipated effects of climate change on their sites in future management plans if tourism at the sites is to remain sustainable. Climate related factors such as changing weather patterns, extreme weather events, water shortages, and exposure to disease can change tourism patterns at sites. Having a cohesive management plan that takes the impact of these effects into consideration is a must if threatened sites are to continue to be viable tourism sites.

In *Cultural Heritage and the Challenge of Sustainability* (2016), Diane Barthel-Bouchier explores the role of culture in society and what the symbols of culture mean to those who are a part of that culture. She also explores the intellectual shift on the part of heritage managers and preservationists regarding the value of tourism at their sites. In years past preservationists and managers treated tourism as something to be avoided because of the potential hazards to the site caused by large numbers of visitors. That attitude shifted as managers recognized tourism as a source of funding. While the value of cultural heritage tourism is now recognized, the drawbacks are often left unexplored. In the context of climate change, the emissions output required to visit a site is, paradoxically, one of the factors contributing to the slow decrease in sustainability that managers are trying to mitigate with tourism dollars.[54] For heritage sites to continue to be viable sites for tourism, governments, the tourism industry, and site managers must work together to disseminate knowledge about climate change and the effects on heritage sites, secure funding for

[53] A. Markham, Osipova, E., Lafrenz, Samuels, K. & Caldas, A., "World Heritage and Tourism in a Changing Climate," United Nations Environment Programme, Nairobi, Kenya and United Nations Educational, Scientific and Cultural Organization, Paris, France. 2016
[54] Barthel-Bouchier, 2013

mitigation and adaptation projects, and decide where that funding would be best utilized through the use of vulnerability assessments.

The history that a community tells about itself is an important part of the identity of a community and the identity that individuals build for themselves around that community. Physical reminders of the past, like heritage sites and monuments, are important parts of telling that story and interpreting the past for future generations.

In *La Memoire Collective* (1950) Maurice Halbwachs discussed the idea that individuals had their own personal memories, but also formed a group memory associated with groups they are a part of. These memories, which he referred to as collective memories, played a key role in bonding individuals to new groups they assimilate into. This worked laid much of the foundation for the later development of scholarship around collective memory but was published posthumously and never expanded on by Halbwachs.[55]

In the 1980s historians began to focus on the relationship between cultural heritage and memory and the role it plays in developing personal and group identity. In a seminal study on history and memory, Eric Hobsbawn and Terence Ranger analyzed the use of commemoration by political figures to influence public memory in *The Invention of Tradition* (1983).[56] Hobsbawm and Ranger built on Halbwachs' earlier idea of collective memory and monuments, pointing out the power that physical representations of collective memory, such as monuments, have to establish and reinforce a particular collective memory amongst a population.

[55] Maurice Halbwachs, *La Memoire Collective,* Paris, Presses Universitaires de France, 1950; Maurice Halbwachs, *The Collective Memory,* New York, Harper & Row, 1980 (English Translation)
[56] Eric Hobsbawm and Terrance Ranger, *The Invention of Tradition,* Cambridge, Cambridge University Press, 1983.

As historians and other scholars in the humanities expanded on Halbwachs' work, the study of collective memory developed into one of the three main branches of memory studies.[57] Historians continue to debate the legitimacy of the concept of collective memory, but individuals experience memory in a variety of ways. Personal, autobiographical memory is created individually, but as they assimilate themselves into larger groups, individuals gain new memories, both as personal memory and as collective memory of the larger group they assimilate into, referring to themselves as 'we' as it becomes part of their own identity.[58] This social memory is an important part of community building.[59].

Historians and preservationists have come to recognize the importance of places, not only monuments and landscapes but also ordinary buildings and urban landscapes, in evoking that sense of social memory that bonds individuals to their communities. In *The Power of Place* (1995) Dolores Hayden explored the relationship between urban places and cultural identity, saying, ". . . [historic] places trigger memories for insiders, who have shared a common past, and at the same time places often can represent shared pasts to outsiders who might be interested in knowing about them in the present."[60] She examined at how even ordinary buildings in the urban landscape can help trigger that sense of place memory that ties people to their community. Other historians engaged with what memory means in a cultural context as the study of memory in the humanities expanded exponentially throughout the 1990s.

[57] Patrick Hutton, "Recent Scholarship on Memory and History," *The History Teacher* 33, no. 4 (Aug. 2000): 533-548
[58] Aleida Assmann, "Transformations between History and Memory," *Social Research* 75, no. 1, Collective Memory and Collective Identity (Spring, 2008): 49-72
[59] Ibid
[60] Hayden, 1995, 46

As the field of collective memory was rapidly expanding, the field of historic preservation began to pivot its mission to saving as much of the historic built environment and cultural landscapes as possible, rather than focusing on built environment associated with 'great men' or significant historical events. Scholars from other fields have also dedicated time to the question of place memory associated with buildings. Sociologist Melinda J. Milligan explored how collective memory attached to buildings functions in society and how the field of historic preservation has come to focus its attention on preserving a wider array of cultural heritage resources than it previously did.[61] She concluded that the current historic preservation field focuses on a respect for history and people, but also a respect for the right of examples of historic cultural heritage to exist in an undisturbed state. Like Hayden, Milligan identifies a shift in the field from focusing on the history of the "great man" and preserving examples of built heritage associated with those figures to focus on preserving everyday examples of cultural heritage. The shift in focus resulted in global studies of cultural heritage resources and what they mean in terms of commemoration and collective memory for the people who identify with those communities.[62]

As professionals in the fields of history and preservation come to terms with climate change, an initiative emerged for historians to engage in conversation about environmental issues and open dialogs with climate scientists. First, they should engage with scientists to bring human agency to climate change models and help modelers understand how humans have reacted to a changing climate in the past, in anticipation of developing new insights about the potential

[61] Melinda J. Milligan, "Buildings as History: The Place of Collective Memory in the Study of Historic Preservation," *Symbolic Intercation* 30, no. 1 (Winter 2007): 105-123
[62] Cary Karacas, "Place, Public Memory, and the Tokyo Air Raids," *Geographical Review* 100, no. 4 (Oct. 2010): 521-537; Natasha Lyons and Yvonne Marshall, "Memory, Practice, and Telling Community," *Canadian Journal of Archaeology* 38 (2014): 495-517

human responses to climate change in the future. Second, they should also engage with the public more to discuss past climate instability to provide context for the changes we see now.[63] This makes the work of public historians, building dialogs and relationships with their communities, particularly important. As cultural heritage sites are lost and landscapes altered, public historians and preservationists will assume an essential role in preserving what is left of the past, interpreting the changes in the environment, and mitigating the sense of loss and displacement that can accompany the destruction of community cultural heritage. It is inevitable that some cultural heritage sites will be partially or completely lost in the coming decades, and such loss is particularly true for coastal sites that are experiencing sea level rise, increased storm surge, and increases in coastal erosion. By identifying and implementing adaptation strategies now, that sense of community loss can be mitigated, particularly if the community can be brought together in support of cultural resource adaptation projects.[64]

[63] David Glassberg, "Place, Memory, and Climate Change," *The Public Historian* 6, no. 3 (August 2014): 17-30
[64] Romy Chevallier, "Integrated Community- and Ecosystem-Based Approaches to Climate Change Adaptation," *South African Institute of International Affairs,* Policy Insights 49, (2017)

CHAPTER THREE: CLIMATE CHANGE AND ADAPTATION

The science of climate change is rooted in a long history of scientific inquiry that dates back to the early part of the 19th century. In 1815, while observing boulders strewn across the floor of a mountain valley in the Swiss Alps, Jean-Pierre Perraudin realized there was only one force powerful enough to move boulders of that size and leave the striations he saw on the exposed rock. He had studied similar patterns higher up in the mountains around glaciers. When looking at that valley he concluded that the glaciers must have at one time extended much further and, in places, must have been far larger than they were at the present time.[65] The idea that glaciers of that size could have existed in that part of Europe was met with trepidation. Perraudin relayed his conclusions to geologist Jean de Charpentier who, after initially rejecting the idea outright, became convinced it was a plausible explanation for the scattered boulders and deep grooves cut into the rock. During an 1836 trip to observe glaciers in Switzerland with Charpentier and other scientists, Swiss scientist Louis Agassiz conferred with botanist Karl Schimper about a theory he had developed about a time when large portions of Europe and North American were covered in ice. Agassiz presented this theory at a conference in 1837. The following year he termed these periods ice ages.[66]

As the glacial theory presented by Agassiz gained acceptance, scientists began looking for an explanation as to how the climate could have shifted so racially in the past. Scientists would eventually hypothesize that the presence of carbon dioxide, together with other gases, in

[65] Albert V. Carozzi, "Agassiz's Amazing Geological Speculation: The Ice-Age," *Studies in Romanticism* 5, no. 2 (Winter, 1966): 57-83
[66] Carozzi, 1966

the atmosphere created a greenhouse effect on the planet and varying levels of atmospheric carbon could have drastic effects on the planet's average temperature.

In 1827 Joseph Fourier was the first to make reference to the greenhouse effect when he compared the Earth's atmosphere to prior scientific experiments in which the temperature of air trapped between two panes of glass was monitored. This air would begin to retain heat when exposed to sunlight, causing the temperature between the glass panes to rise. Fourier reasoned that human-induced changes in the landscape which led to changes in the makeup of the atmosphere could result in temperature changes in the region over centuries, making him perhaps the first scientist to suggest humans could influence the climate.[67]

In her 1856 paper, "Circumstances affecting the Heat of the Sun's Rays," Eunice Foote described an experiment she conducted to determine how different gasses in a tube would react when exposed to the warming effects of the sun. She found that when exposed to sunlight, the glass tube filled with carbon dioxide retained the most heat. Based on the results of her experiment she posited that the atmospheric concentration of carbon dioxide might affect the global temperature. Her work was presented by at a meeting of the American Association for the Advancement of Science in the summer of 1856 and was subsequently published in the *American Journal of Science and Arts*.[68] Though her work had to be presented by a male colleague because as a woman, Foote was not invited to speak at the conference, her experiments were some of the very first to draw a direct correlation between carbon dioxide in the atmosphere and temperature.

[67] M.D.H. Jones and A. Henderson-Sellers, "History of the Greenhouse Effect," *Progress in Physical Geography: Earth and Enivronment* 14, no. 1 (1990): 1-17
[68] Eunice Foote, "Circumstances Affecting the Heat of the Sun's Rays," *The American Journal of Science and Arts* 22, no. 66 (Nov. 1856): 383-384

In John Tyndall's 1861 paper "On the Absorption and Radiation of heat by Gasses and Vapours, and on the Physical Connexion of Radiation, Absorption, and Conduction," he built on the work of Fourier and Foote and attempted to quantify the rate of absorption of various gasses in the atmosphere. This study was perhaps the first to calculate the infrared variation of the atmosphere[69] His study produced results that once again pointed towards a relationship between atmospheric carbon dioxide and the surface temperature of the planet.

In his 1896 paper "The Influence of Carbonic Acid in the air upon the Temperature of the Earth," Swedish scientist Svante Arrhenius worked to estimate the effect of carbon dioxide in the atmosphere. His work built on that of previous scientists who, in attempting to measure the surface temperature of the moon, realized that their temperature readings varied depending on how high on the horizon the moon was. They realized that when the moon was low on the horizon their measurements were weaker due to the increased amount of water vapor and other gases the heat from the moon had to pass through. Arrhenius calculated the surface temperature of the earth under several different atmospheric CO2 scenarios.[70] Based on these calculations he hypothesized that the level of atmospheric carbon dioxide could be a significant contributing factor in the previous occurrences of ice ages. He also predicted that a doubling of the level of CO2 in the atmosphere at his time would cause the planet to warm roughly six degrees.[71] Arrhenius's calculations were based on the known levels of carbon dioxide at the time. He understood that the oceans had the ability to sink carbon from the atmosphere and believed that

[69] John Tyndall, "On the Absorption and Radiation of heat by Gasses and Vapours, and on the Physical Connexion of Radiation, Absorption, and Conduction," *Philosophical Transactions of the Royal Society of London* 151 (1861): 1-36
[70] Svante Arrhenius, "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground," *Philosophical Magazine and Journal of Science* 41, no. 5 (April 1896): 237-276
[71] Ibid

the introduction of carbon dioxide into the atmosphere would take thousands of years to significantly alter the planet's climate.

The idea of carbon dioxide directly influencing the climate was developed by Thomas Chamberlin in a series of papers discussing the geological changes that might arise from variations in atmospheric carbon dioxide. This work was published in the *Journal of Geology* in 1899, entitled "An Attempt to Frame a Working Hypothesis of the Cause of Glacial Periods on an Atmospheric Basis." Chamberlin concluded that the variations in the climate that were likely to be caused by fluctuations in carbon dioxide that, while potentially drastic, would unfold over thousands of years and that human influences would not have much effect.[72] These early studies laid the foundation for the understanding of how changes in the climate occur and what roles various greenhouse gases play in those changes.

In the early twentieth century, scientists studying changes in the climate focused their energy on understanding the possible causes of past ice ages, but in the 1930s scientists began to once again look at the role of carbon in the atmosphere. In 1938, using newly available spectroscopic measuring technology to show the effectiveness of carbon in absorbing infrared radiation in the atmosphere, Guy Callendar revisited the theory of CO2 induced changes in the climate in his paper "The Artificial Production of Carbon Dioxide and its Influence on Temperature." He used this technology to show that both of temperatures and CO2 had been on the rise over the previous 50 years.[73] As spectroscopy technology improved, however, scientists were able to form a better idea of the makeup of the atmosphere. Scientists discovered that CO2

[72] T. C. Chamberlin, "An Attempt to Frame a Working Hypothesis of the Cause of Glacial Periods on an Atmospheric Basis," *The Journal of Geology* 7, no. 6 (Sept.-Oct. 1899): 545-584
[73] G. S. Callendar, "The Artificial Production of Carbon Dioxide and its Influence on Temperature," *Quarterly Journal of the Royal Meteorlogical Society* 64, no. 275 (April 1938): 223-240

is much more effective at absorbing infrared radiation than water vapor and is much more prevalent in the upper atmosphere than previously thought. Studies also showed that the oceans were not very effective in absorbing atmospheric CO2, which was previously thought to nearly completely counteract the buildup of carbon in the atmosphere. The scientific community began to realize that the level of carbon dioxide being emitted into the atmosphere could have serious global implications in terms of the climate.[74]

In 1960 Charles Keeling published his CO2 monitoring results from locations in Antarctica and Hawaii, which indicated that CO2 levels were indeed rising and at an increasing rate. His results, known as the "Keeling Curve," laid out the seasonal variation of global CO2 and made predictions for CO2 rise in the future. Based on his measurements, NOAA began monitoring global CO2 levels in the 1970s.[75]

During this time scientists studying ice core samples realized that rather than four long ice ages in the past, there had been multiple ice ages spaced at roughly regular intervals. This coincided with predictions made by astronomer Milutin Milankovitch in the 1920s. The Milankovitch Cycle, also known as axial procession, is a process in which the earth receives a varying amount of solar radiation throughout the cycle due to the axial tilt of the planet and eccentric orbit around the sun. The combination of varying amounts of CO2 in the atmosphere and solar radiation result in significant global cooling, from which the planet warms as cycle

[74] H. Le Treut, H., R. Somerville, U. Cubasch, Y. Ding, C. Mauritzen, A. Mokssit, T. Peterson and M. Prather, "Historical Overview of Climate Change." In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2007

[75] Charles D. Keeling, "Is Carbon Dioxide from Fossil Fuels Changing Man's Environment?" *Proceedings of the American Philosophical Society* 114, no. 1 (Feb 16, 1970): 10-17; Joshua P. Howe, "This is Nature; This is Un-Nature: Reading the Keeling Curve," *Environmental History* 20, no. 2 (April 2015): 286-293

continues.[76] While there is a cyclical nature to global warming and cooling periods, as shown by the Keeling Curve, the planet has undergone a significant increase in both temperature and global atmospheric CO2 levels since the beginning of the 19th century. In 2013 global CO2 surpassed 400ppm and, according to NASA are at the highest levels of any time in the last 800,000 years.[77]

There have been numerous international efforts to protect the atmosphere and combat the effects of climate change. In 1987 the Montreal Protocol agreement established a framework for how countries can work together to address environmental issues. The agreement, ratified by every country in the world, originally focused on the emission of chlorofluorocarbons (CFCs) which were causing damage to the planet's ozone layer. Through international efforts, these harmful emissions were virtually eliminated. In 2016 the agreement was amended to also include hydrofluorocarbons (HFCs) which contribute to climate change.[78]

The 1992 U.N. Framework Convention on Climate Change (UNFCCC) was the first global agreement that overtly focused on climate change. This agreement was ratified by 197 countries and established an annual meeting known as the Conference of the Parties (COP) to discuss the global effort to control climate change. This meeting has been held annually since

[76] Stephen R. Meyers and Alberto Malinverno, "Proterozoci Milankovitch Cycles and the History of the Solar System," *Proceedings of the National Academy of Sciences of the United States of America* 115, no. 25 (June 19, 2018): 6363-6368

[77] Rebecca Lindsey, "Climate Change: Atmosperic Carbon Dioxide," *Climate.gov,* June 23, 2022. https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide; Dieter Luthi, Martine Le Floch, Bernhard Bereiter, Thomas Blunier, Jean-Marc Barnola, Urs Siegenthaler, Dominique Raynaud, Jean Jouzel, Hubertus Fischer, Kenji Kawamura, and Thomas F. Stocker, "High-Resolution Carbon Dioxide Record 650,000-800,000 Years Before Present," *Nature* 453 (2008): 379-382

[78] Lindsay Maizland, "Global Climate Agreements: Successes and Failures," *Council on Foreign Relations,* Updated Nov. 4, 2022, https://www.cfr.org/backgrounder/paris-global-climate-change-agreements

1995, with the first meeting being held in Berlin, Germany. COP27 was held in Sharm el-Sheikh, Egypt in November, 2022[79]

COP3, held in Kyoto, Japan in 1997, resulted in an agreement known as the Kyoto Protocol. Going into effect in 2005, the Kyoto Protocol was the first legally binding international climate agreement. This agreement established greenhouse gas emissions goals for the participating countries, but focused only on developed countries and did not require developing countries to adhere to emissions reduction goals. Although the United States signed in Kyoto Protocol agreement in 1998, it was never ratified, and the U.S. eventually withdrew entirely from the agreement.[80]

Despite prior efforts, the planet is currently warming at an increasing rate. One of the goals of the Paris Climate Agreement (2015) was to limit global warming to 1.5 degrees Celsius. Although the increase of greenhouse gas emissions has slackened globally, the most recent nationally determined contributions (NDCs) set by participating countries are not ambitious enough to limit warming to 1.5 degrees. To limit warming to 1.5 degrees, greenhouse gas emissions across the globe would have to peak in 2025 and then drop by more than 40% by 2030. The current NDCs are at the high end of the measures it would take to limit global warming to 2 degrees Celsius.[81] This level of warming will contribute to rising seas throughout the 21st century, and likely much longer. As the fact of climate change became accepted by scientists and professionals in other fields, focus turned to understanding mitigation and adaptation strategies that could be implemented across a range of fields. The focus of heritage

[79] "Conference of the Parties (COP)," *United Nations Climate Change*, *https://unfccc.int/process/bodies/supreme-bodies/conference-of-the-parties-cop*
[80] "What is the Kyoto Protocol?" *United Nations Climate Change*, *https://unfccc.int/kyoto_protocol*
[81] "Climate Change 2022: Mitigation of Climate Change," *Intergovernmental Panel on Climate Change*, 2022. https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_FullReport.pdf

preservationists and cultural resource managers has centered on finding ways to prevent communities from experiencing the loss of the physical reminders that bind people to the community.

A significant number of cultural heritage sites around the world are in very close proximity to the coast. The coming decades will challenge the resiliency and interpretation of these coastal sites as preservationists and heritage managers work to ensure that these sites stay relevant and continue to hold a place of meaning in the community. Losing physical representations of cultural heritage can trigger a sense of loss in a community and lead people to feel disconnected from their community's history. Having strong adaptation plans in place can help to increase resilience at these sites and prevent a community from experiencing that loss. While adaptation is crucially important for the longevity of coastal heritage sites in particular, there are numerous barriers to adaptation that can affect the adaptability of sites. Four broad types of adaptation barriers have been identified by scholars and experts in the field: institutional, technical, socio-cultural, and financial.[82] All of these categories of barriers have factors that influence them independently but overall, they are all interconnected. This often makes implementation of comprehensive climate adaptation plans a challenge for communities because there are so many competing factors.

The most significant barrier that hinders climate adaptation is often a lack of institutional support from policymakers. Based on a pilot study conducted in the United States, a 2020 survey conducted in the Netherlands indicated that cultural heritage managers identified a "lack of climate change adaptation policy" as the biggest barrier to adapting cultural heritage sites to

[82] Sandra Fatoric and Robbert Biesbroek, "Adapting Cultural Heritage to Climate Change Impacts in the Netherlands: Barriers, Interdependencies, and Strategies for Overcoming Them," *Climatic Change* 162 (2020): 301-320. https://doi.org/10.1007/s10584-020-02831-1

climate change. In the United States cultural heritage managers are often disconnected from community disaster response planning done at the state level. A 2016 study that investigated the connection between state disaster response planning and cultural heritage preservation identified only fifteen states that had a strong or very strong connection between hazard mitigation and historic preservation in state plans; the remaining thirty-five states had little to no connection.[83]

Often polices and guidelines for how heritage sites should respond to the challenges presented by climate change are not in place and communication between stakeholders is poor.[84] Not including cultural heritage resources into hazard mitigation plans and the climate change response plans associated with them weakens a community's ability to respond to climate make related changes.[85] For a community to remain resilient in the face of climate change, the changes must be addressed by the entire community.

The next two types of barriers are closely tied. Socio-cultural barriers and financial barriers often go hand-in-hand because a lack of support from the public can result in a failure to prioritize cultural heritage resources when deciding how to allocate financial resources in the community. Often times cultural heritage resources are left out of the conversation surrounding budget because of a perceived lack of funds.[86] Adaptation plans for an entire city are enormously expensive. The new plan from the Army Corp of Engineers for climate adaptation in Miami is a 4.6-billion-dollar project that combines coastal armoring, natural solutions such as wetland construction and planting mangroves, and infrastructure changes to make Miami resilient to the

[83] Douglas Appler and Andrew Rumbach, "Building Community Resilience Through Historic Preservation," *Journal of the American Planning Association* 82, no. 2 (Spring 2016): 92-103
[84] Fatoric and Biesbroek, 2020, Pg. 304
[85] Appler and Rumbach, 2016, Pp. 96-97
[86] Fatoric and Biesbroek, 2020, Pg, 305

effects of climate change for the remainder of the century.[87] The plan is designed to incorporate much of Miami and the surrounding communities, but local cultural heritage sites are left out of the conversation. The only mention of cultural heritage resources was a provision for developing an impact plan for cultural resources if they were found to be endangered by the project, and only if they were listed on the National Registry of Historic Places. According to the ACOE, the plan will not affect any cultural heritage resources.[88]

The next often-cited barrier to adaptation is a technical one. Experts in the field have identified a lack of availability of tools and models that can aid in assessing the future level of a site's risk and exposure to climate change. Improved access to these types of tools can aid heritage managers in planning for future adaptation strategies at their sites. While professional climate change vulnerability assessments can be cost prohibitive, particularly for smaller heritage sites, there are tools available that can help managers perform preliminary vulnerability assessments on their sites. This can be useful in helping to secure future funding that can be used for more comprehensive vulnerability assessments and implementation of adaptation strategies. This is of particular importance for coastal cultural heritage sites that are at risk from exposure to sea level rise, storm surge, and coastal erosion.

It is important to note that climate change is a pervasive issue. The effects are not only being felt in coastal areas or areas where warming temperatures are affecting glaciers and permafrost. As the planet continues to warm the effects of drought are exacerbated, the transition

[87] U.S. Army Corps of Engineers, "Miami-Dade Back Bay Coastal Storm Risk Management Draft Integrated Feasibility Report and Programmatic Environmental Impact Statement," May 29, 2020. https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll7/id/14453

[88] U.S. Army Corps of Engineers, "Miami-Dade Back Bay Coastal Storm Risk Management Feasibility Study, Appendix E – Cultural Resources," May 29, 2020. https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll7/id/14463

between wet and dry seasons can be amplified resulting in particularly parched dry seasons and rainy seasons that dump deluges of rain in a single afternoon. Seasonal flooding gets worse, and the urban heat island effect makes cities feel hotter.[89] Nothing that humans do happens in a vacuum; everything we do is happening in the environment around us. Changes in the environment can lead to instability in the economy and heightened national security concerns.[90]

Although climate change affects everyone on earth, it is clear that the burden of climate change is unequally distributed. Climate change disproportionately affects poor communities, communities of color, and Indigenous groups. This is particularly true when comparing developing countries to their developed counterparts.[91] The countries that emit the most greenhouse gasses are also the countries with a large enough GDP to be able to afford adaptation efforts that can protect them from the coming effects of climate change. Take, for example, the Maldives as presented in Rob Nixon's *Slow Violence and the Environmentalism of the Poor*. Nixon argues that larger, developed countries, which are responsible for the vast majority of fossil fuel production and consumption throughout the world, reap the benefits of the consumption of natural resources while countries in the developing world are left to foot the bill. The long-term detrimental effects of climate change, deforestation, and mineral exploitation, amongst other things, play out over an extended period of time, often generations, and devastate communities and entire countries in the developing world while the wealth is extracted to the developed world.[92]

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[89] Smith, 2014;
[90] Nathan Jones and John P. Sullivan, "Climate Change and Global Security," *Journal of Strategic Security* 13, no. 4 Climate Change and Global Security (2020): i-iv; "The National Security Implications of a Changing Climate," The White House, May 2015; Sabine von Schorlemer and Sylvia Maus, Eds., *Climate Change as a Threat to Peace: Impacts on Cultural Heritage and Cultural Diversity,* Bern, Peter Lang AG, 2014
[91] Mathias Frisch, "Climate Change Justice," *Philosophy & Public Affairs* 40, no. 3 (Summer 2012): 225-253
[92] Rob Nixon, *Slow Violence and the Environmentalism of the Poor,* Harvard University Press, Cambridge, 2011

At the time Nixon's work was published the Maldives had a GDP of around 3.3 billion dollars. Since then, their GDP has risen to slightly over four billion dollars a year, but that is only a tiny fraction of the United States' 21 trillion dollars or China's 14.7 trillion (two of the world's top GHG emitters). The Maldives contributes only 0.003% of annual global emissions, but their country is slow sinking into the Indian Ocean as the planet warms and seas continue to rise.[93] The Maldives, of course, is not the only small nation paying a disproportionate price for climate change. Indeed, island nations around the world are calling out to the larger, mass-emission producing countries for help.

In 2009 the President of the Maldives held a cabinet meeting where he signed legislation committing the Maldives to carbon neutrality. To bring awareness to the cause, all the participants were clad in scuba gear and signed the pledge on a desk anchored to the ocean floor.[94] In a similar call for attention to the climate threat to his country, the foreign minister of Tuvalu recently addressed the attendees of the 26th U.N. Climate Change Conference (COP26) via video while standing knee deep in the ocean in Funafuti, Tuvalu. During his speech he referred to climate change as an existential threat to their home islands and referenced the importance of the island's cultural heritage to its people saying, ". . .our islands are sacred to us. . . They were the home of our ancestors, they are the home of our people today."[95] The cultural heritage of thousands of islands around the world, and hundreds of thousands of people is under direct threat from climate change today.

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[93] "Republic of the Maldives," *Climate and Clean Air Coalition, https://www.ccacoalition.org/en/partners/maldives-republic*

[94] Nixon, 2011

[95] "Tuvalu Minister Stands in Sea to Film COP26 Speech to Show Climate Change, *Reuters,* Nov. 9, 2021, https://www.reuters.com/business/cop/tuvalu-minister-stands-sea-film-cop26-speech-show-climate-change-2021-11-08/

These islands are not only threatened by climate change in the form of sea level rise, increased storm surge, wave-driven flooding, and other effects to the coast, their sustainability is also threatened from below as sea level rise pushes saltwater into their drinking water supplies. The conclusion of a 2018 study conducted by several groups including the U.S. Geological Survey, NOAA, and the University of Hawaii at Manoa was that many of the world's atoll islands would become uninhabitable by the middle of the century due to wave driven flooding and saltwater intrusion into drinking water sources.[96] Because of the porous nature of the aquifer where it draws most of its fresh water, Florida is also threatened by saltwater intrusion as seas rise.

Many of the small nations in attendance at COP26 have been pushing for larger nations to follow through on promises made to help smaller nations bear the financial burden of adapting climate change, but so far many larger nations have been hesitant to agree to any kind of "loss and damage funding."[97] These small island nations are literally the canaries in the coastal coal mine.[98] Tuvalu and the Maldives, areas in the Philippines, the Sundarbans in India, and even some places in the United States – Philadelphia, Charleston, and St. Augustine all come to mine – are experiencing periodic flooding and other effects of sea level rise at relatively low levels of rise when compared to the possibilities of future sea level levels. Coastal communities the world

[96] "Many Low-Lying Atoll Islands Will be Uninhabitable by Mid-21st Century," *United States Geological Survey Communications and Publishing,* April 25, 2018, https://www.usgs.gov/news/many-low-lying-atoll-islands-will-be-uninhabitable-mid-21st-century

[97] Sarah Kaplan and Brady Dennis, "Climate Change Brings Irreversible Harm to Poor Countries. At COP26, Rich Ones Face Pressure to Foot the Bill," *The Washington Post,* Nov. 8, 2021. https://www.washingtonpost.com/climate-environment/2021/11/08/climate-change-loss-adaptation-cop26/

[98] Nixon, 2011

over should be aware of the looming consequences of global energy policy. In the Unites States, Florida has the longest coastline of any state except for Alaska.[99]

Indigenous groups also experience the effects of climate change more than larger nations. In the U.S., treaties with Indigenous tribes often resulted in tribes being moved to reservations on land that was deemed less desirable in many cases by the U.S. government. Pushed onto a small reservation on Fidalgo Island in Washington State as a result of the 1855 treaty of Point Elliott, the Swinomish people worked to carry on old traditions that were important parts of their culture during the thousands of years they had inhabited the area around Skagit River and Puget Sound.[100] The Swinomish refer to themselves as the People of the Salmon; the fish has always played an important role in their traditions and customs. But today, because of climate change, the fish that has been such a cultural symbol to the Swinomish are harder to come by than ever before. According to the EPA, the Chinook Salmon population of the region has been reduced by around 60% since the mid-1980s.[101] Rather than letting their cultural heritage practices disappear with climate change, the Swinomish are one of more than fifty tribes in the U.S. that are actively fighting back against climate change. On Fidalgo Island the Swinomish are employing a number of nature-based adaptation solutions such as rebuilding oyster reefs and restoring wetlands to help protect coastal areas, in addition to wildlife population monitoring to understand how climate change affects local fauna.[102] Some of the practices they are employing reach far back in their people's history. In the case of tribes like the Swinomish, who were placed on reservations

[99] "Shoreline Mileage of the United States," *NOAA Office for Coastal Management,* *https://coast.noaa.gov/data/docs/states/shorelines.pdf*
[100] "The Swinomish Reservation," *Swinomish Indian Tribal Community.* https://swinomish-nsn.gov/government/the-swinomish-reservation.aspx
[101] "Chinook Salmon," *U.S. Environmental Protection Agency,* Updated June 2021, https://www.epa.gov/salish-sea/chinook-salmon
[102] Jim Morrison, "An Ancient People with a Modern Climate Plan," *The Washington Post,* Nov. 24, 2020 https://www.washingtonpost.com/climate-solutions/2020/11/24/native-americans-climate-change-swinomish/

on portions of their traditional homelands, their people have lived on those lands for thousands of years. The traditional knowledge they hold could be very valuable information to scientists and planners who are creating climate change models.

Indigenous history all over the United States, and particularly in Florida, has been co-opted and manipulated by euro-centric historians and self-serving interests. In Florida, Indigenous history is often completely ignored in favor of a history that focuses on Spanish colonization of the peninsula and boosterism and development around the turn of the twentieth century. Currently, however, there is an effort, led by scholars of Indigenous ancestry, to correct the record and give Indigenous people their correct place in the historical power dynamic that spurred development in Florida and the rest of the country. Of particular note, a recent special edition of the *Florida Historical Quarterly* entitled "Indigenous Florida," features articles exploring the Indigenous roots of Florida's history throughout the peninsula. Giving Indigenous groups their rightful place in Florida's history and including Indigenous voices in climate-based conversations is essential to understanding how the peninsula developed over the last several hundred years, how people have adapted to prior changes in climate, and what climate adaptation may look like in the future. This project has leaned heavily on the scholarship and insight provided by these historians, both in this special edition and their work elsewhere.[103]

As previously discussed, human activities constantly influence, and are influenced by, the environment. Taking into account the potential human reactions to climate change can help avoid the environmental determinism that is inherent in climate change models that only consider cause and effect from a scientific point of view. Historians and Indigenous leaders are essential

[103] "Indigenous Florida," *The Florida Historical Quarterly* 100, no. 1 (Summer 2021)

to bringing a human element to these projects. Not only does incorporating traditional knowledge into science-based models strengthen them, incorporating that knowledge into climate adaptation plans can strengthen those plans and add more tools to the climate adaptation toolbox.[104]

There are a variety of approaches to adaptation that cultural resource managers can take. In its Cultural Resource Climate Change Strategy, the National Park Service lays out seven options for adapting to climate change at cultural heritage sites. These options include strategies taking no action at sites that are not under direct threat from climate change to documenting and interpreting the change at the site as it is partially or completely degraded as climate change progresses.[105] These suggested adaptation strategies point the way for heritage managers to prepare their sites in a broad sense, but within these categories there is a wide variety of adaptation options that can implemented. Currently there is a big push in the adaptation field for the implementation of nature-based solutions that can both help keep sites resilient in the face of climate change and contribute to climate change mitigation efforts. Nature-based solutions are, "Ecosystem conservation, management and/or restoration interventions intentionally planned to deliver measurable positive climate adaptation and /or mitigation benefits that have human development and biodiversity co-benefits managing anticipated climate risks to nature that can undermine their long-term effectiveness."[106] Planting forests not only increases the amount of carbon that is scrubbed from the air, but the root systems can be critical in preventing mudslides and slowing flood water in areas that experience runoff-driven flooding. In coastal areas,

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[104] Carey, 2012

[105] Marcy Rockman, Marissa Morgan, Sonya Ziaja, George Hambrecht, and Alison Meadow. 2016. Cultural Resources Climate Change Strategy. Washington, DC: Cultural Resources, Partnerships, and Science and Climate Change Response Program, National Park Service. *Full text of suggested adaptation techniques included in Appendix 2.*

[106] "Nature-Based Solutions," *World Wildlife Fund* https://wwf.panda.org/discover/our_focus/climate_and_energy_practice/what_we_do/nature_based_solutions_for_climate/

restoring barrier reefs and planting mangroves can help to slow incoming storm surge and prevent damage to coastal infrastructure. As an added benefit, mangroves, along with peatland are two of the most efficient natural carbon sinks. Restoration and maintenance of mangroves and peatlands is another strong tool in the effort to reduce the abundance of atmospheric carbon dioxide.[107]

In many places it is becoming clear that the strategies that have the best chance of increasing resiliency in the area will be a combination of several approaches to climate adaptation and mitigation. In coastal areas, strategies such as physically armoring the coast against sea level rise will have to be combined with other infrastructure-based and nature-based solutions along with, in some cases, managed retreat from the sea to ensure that communities are protected and can stay resilient in the coming decades. The recent Army Corp of Engineers plan for climate change resiliency for the Back Bay area in Miami-Dade County suggested an enormous construction project that centered around a 20-25ft sea wall that encompassed a large portion of Biscayne Bay. This project would have combined the construction of this wall with some limited nature-based solutions and identified areas where they suggested managed retreat be employed.[108] This project was recently rejected by Miami-Dade County in favor of a Locally Preferred Plan (LPP) that employs a number of nature-based initiatives in addition to smaller construction projects. One of the criticisms of the Army Corp's plan was that it gave little attention to local cultural heritage, including the cultural landscapes which are such a big part of the cultural identity of Miami. Miami-Dade County Mayor Daniella Levine Cava referenced this

[107] Daniel Murdiyarso, Daniel Donato, J. Boone Kaufman, Sofyan Kurnianto, Melanie Stidham, Markku Kanninen, "Carbon Storage in Mangrove and Peatland Systems: A Preliminary Account from Plots in Indonesia," Center for International Forestry Research, 2009. https://www.nrs.fs.fed.us/pubs/jrnl/2009/nrs_2009_murdiyarso_001.pdf

[108] Doug Parsons, "Hello Miami!: Fundamentals of Local Climate Adaptation Reporting with Alex Harris of the Miami Herald," *American Adapts*, Podcast Audio, June 7, 2021, https://www.americaadapts.org/episodes/hello-miami-fundamentals-of-local-climate-adaptation-reporting-with-alex-harris-of-the-miami-herald

when informing the Army Corp of the county's intent to pursue an LPP, saying, "We look forward to continuing collaboration with USACE along with our residents, businesses, cities, and local stakeholders to develop a plan that incorporates community input and embraces the challenges and features of our unique, treasured natural environment."[109] For preservationists, heritage managers, and public historians working in places like Miami-Dade County that are actively trying to plan for climate change, it is important that make their voices heard in the community and advocate for local cultural heritage to make sure heritage is not shuffled to the side community plans are made. It is also vitally important that they understand the types of adaptation plans and techniques that are being implemented locally and also what types of vulnerabilities their sites have. Knowing this will allow them to be more fully informed when applying for funding for adaptation projects from state or federal sources.

The response to climate change in the United States has been uneven. Until recently there was little action on the part of the federal government to mitigate climate change and adapt to the effects we will face in the future. At the state and local level there have been varying degrees of climate action across the country. A 2016 survey of state historic preservation and climate mitigation plans found that across the United States there is little connection being made between climate action plans and protecting cultural heritage monuments in terms of policy.[110] This survey indicated that more attention was paid to mitigation efforts without consideration of the potential contributions that cultural heritage sites can present to their communities in terms of understanding past climate change. Little attention was being paid to adaptation solutions. Slowly things are beginning to change, but climate action is still uneven across the board. More

[109] Natalia Jaramillo (Media Contact), "Miami-Dade County asks for Locally Preferred Plan on Back Bay Study Focusing on Nature-Based Resilience and Continued Community Input, *Miami-Dade County News Release,* Aug. 30, 2021. https://www.miamidade.gov/releases/2021-08-30-mayor-back-bay.asp
[110] Appler & Rumbach, 2016

attention is being paid to adaptation techniques, and through the National Park Service, historic adaptation has been a big part of that conversation.

Still, in terms of policy, there is still an uneven emphasis on mitigation. The administration of U.S. President Joseph Biden has unveiled numerous departmental climate strategies aimed at reducing greenhouse gas admissions and helping to curb the influence of fossil fuels in the American economy. Resiliency in the face of climate change can only be achieved through a two-pronged approach of mitigation and adaptation. We are far past the point where mitigation alone can pull our collective bacon from the fire, so to speak. Around the globe, weather events are becoming more extreme, and in March 2022 a floating ice shelf roughly the size of Rome known as the Conger ice shelf broke off from eastern Antarctica and began floating out to see. This is of particular cause for concern because when floating ice shelves detach and move away from the shoreline, ice that is on land behind the ice shelf, and therefore not contributing to sea levels, known as "grounded ice," can begin to move towards the ocean at a quicker rate.[111] Strong adaptation plans are vitally necessary for populations around the world to stay resilient.

In January 2021 President Biden issued an executive order requiring all major federal agencies to develop agency-wide adaptation plans that will address climate change related to their agency. Currently more than twenty-five agencies within the federal government have submitted climate action plans. Later in the same year, the United States took a significant step forward in terms of national climate change policy. The Biden Administration reaffirmed the United States' commitment to the Paris Climate Agreement and went even further at the

[111] Hilmar Gudmundsson, Adrian Jenkins, and Bertie Miles, "Conger Ice Shelf as Collapsed: What you need to know, according to experts," *The Conversation,* March 28, 2022. https://theconversation.com/conger-ice-shelf-has-collapsed-what-you-need-to-know-according-to-experts-180077

Glasgow Climate Change Conference – also known as COP26 – by entering into agreements with other attendee countries to take much stronger steps to avoid an increase in global average temperature of 1.5 degrees Celsius.

This is a step further than previous administrations have gone, but the Biden administration has stopped short of creating a cohesive national adaptation plan that can be implemented across multiple government agencies. According to Alice Hill, Senior Fellow for Energy and the Environment at the Council on Foreign Relations and Biden nominee for Deputy Administrator for Resilience at FEMA, "One area where the United States is lagging is we do not have a national plan… Without a plan, it is very difficult to make sure that you are making those correct decisions in a whole-of-government and then a whole-of-community approach, so that the private sector, state and local governments, tribal governments, as well as the federal government are all rowing in the same direction as we make these important decisions."[112]

While the agreements made at COP26 are a step in the right direction, the U.N. warns that the agreements reached at COP26 will not be enough to curb the rising global temperature, which could rise well above the 1.5-degree threshold. While more than eighty countries recently released more ambitious climate action plans, heavy greenhouse gas producers like China and India have not. Even countries that have agreed to the terms of the Paris Climate Agreement and the new agreements at COP26 seem to be unsure about how they will proceed in terms of fossil fuel production. In the U.S., the position on climate change is inconsistent and subject to change based on the results of an election. Even as climate change forward as the Biden Administration is, they recently reversed a moratorium on sales of new offshore drilling permits in federal

[112] Anna McGinn, "A National Adaptation Strategy Could Guide the Way Towards a More Resilient Future," *Environmental and Energy Study Institute,* Feb. 14, 2022. https://www.eesi.org/articles/view/a-national-adaptation-strategy-could-guide-the-way-towards-a-more-resilient-future

waters, opening sections of the Gulf of Mexico and waters off the coast of Alaska to new drilling permits.[113] U.N. scientists warn that 2.7 degrees of warming could be reached by the end of the century. Global effects of such warming will likely be above and beyond what scientists have previously predicted, emphasizing the importance of adaptation planning as climate change progresses.[114]

In Florida, the state response has been rather slow and weak in many aspects. Historically, discussion of climate change was couched in terms of economic and natural resource resiliency but did not address the issue of climate change head-on. Under the administration of Governor Ron DeSantis, climate change is being addressed in a more direct manner, though there are some questions as to the efficacy of climate policy that has been introduced by the state. While there has been progress at the state level – under former governor Rick Scott's administration it was widely reported that state employees were banned from using the phrase 'climate change' in office reports - there still seems to be some hesitancy amongst state employees to discuss climate change and climate change policy.[115]

While Florida's state government has been slow to act on climate change, many governments at the county and community levels have been quite active in some parts of the state. This has led to the creation of numerous climate compacts around the state that are designed to manage climate change in their specific communities. Amongst these, the Southwest

[113] Ella Nilsen, "Biden Caught Between Climate Goals and High Gas Prices as Administration Releases New Drilling Plan, *CNN*, July 1, 2022, https://www.cnn.com/2022/07/01/politics/biden-offshore-drilling-plan-climate/index.html

[114] William Booth and Tyler Pager, "As Climate Pledges fall short, U.N. Predicts Globe Could Warm by Catastrophic 2.7 Degrees Celsius, *The Washington Post*, Sept. 17, 2021. https://www.washingtonpost.com/climate-environment/2021/09/17/un-climate-2030-biden/; U.N. Climate Press Release, "COP26 Reaches Consensus on Key Actions to Address Climate Change," United Nations Framework Convention on Climate Change, Nov. 13, 2021, https://unfccc.int/news/cop26-reaches-consensus-on-key-actions-to-address-climate-change

[115] Tristram Korten, "In Florida, Officials ban term 'climate change,'" *Miami Herald*, March 11, 2015

Florida Regional Resiliency Compact, Southeast Florida Regional Climate Change Compact, East Central Florida Regional Resiliency Compact, and Tampa Bay Regional Resiliency Coalition each work to create climate action plans and, of particular importance in Florida, local development policies based on climate science.

Adapting cultural heritage sites to climate change is an endeavor that occurs at the intersection of several, sometimes competing, areas of expertise. Climate science, cultural history, historic preservation, and the reality of the economics of climate change and heritage tourism must be addressed when planning for adaptation. The history and significance of a site influences the support for investment in adaptation projects; often sites associated with marginalized groups are left out of the conversation about funding for adaptation investment. Additionally, an understanding of the cultural memory and the meanings that each site holds for diverse stakeholders ranging from Indigenous people to transplanted communities to interested academics shapes the future scale and possibilities of adaptation at a given site. Two cultural heritage sites in Florida, the Jupiter Inlet Lighthouse and Outstanding Natural Area and Fort Clinch at Fort Clinch State Park, provide examples of the intersection of competing scientific, historical, cultural, and economic challenges and strategies at play when implementing adaption solutions to climate change.

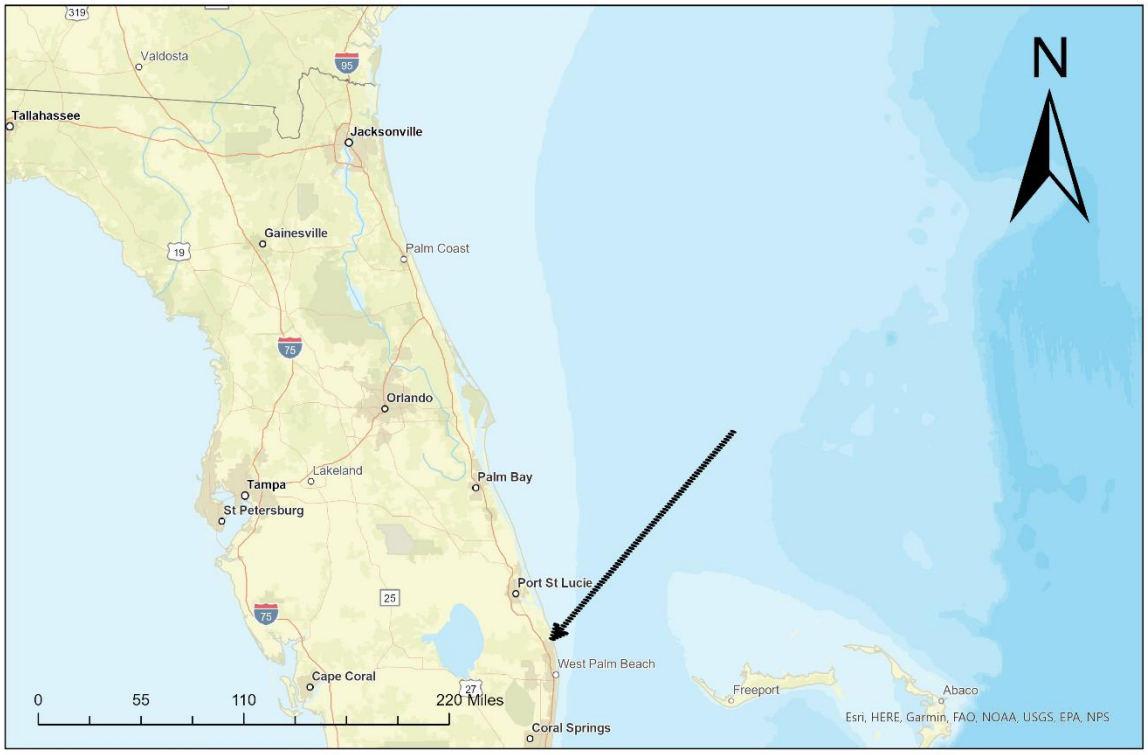
CHAPTER FOUR: JUPITER INLET LIGHTHOUSE

Figure 1: Jupiter Inlet Lighthouse. (Author's Photo)

Geography

Jupiter Inlet Lighthouse is located in Palm Beach County on Florida's Atlantic coast. The city of Jupiter is the northernmost community in the Miami Metropolitan Area. The light was constructed roughly 1500 yards north of the natural Jupiter Inlet, which silted over before construction of the light began. Currently, the lighthouse sits at the confluence of the Indian and

Loxahatchee Rivers, directly adjacent to the man-made inlet which was constructed in 1922.[116] This area is the eastern most point in Florida, where the coast juts out towards the Gulf Stream before retracting back to the west as it rounds Miami and reaches into Florida Bay. Because of its location, this point has a long history of European contact with native tribes as ships were wrecked in the treacherous waters between the Gulf Stream and what is today referred to as Florida's Treasure Coast. This area has also traditionally been highly susceptible to storm erosion and dune drift that, at times, closed the natural inlet in Jupiter.[117]



Jupiter Inlet Lighthouse ONA
Palm Beach County, Florida

Figure 2: Location of Jupiter Inlet Lighthouse. (Author's Map)

[116] "History," Jupiter Inlet District, https://www.jupiterinletdistrict.org/history
[117] Bessie Wilson DuBois, "Jupiter Inlet," *Tequesta*, no. 28 (1968): 19-35

History

The red brick lighthouse at Jupiter Inlet was constructed between 1859-1860 and was first lit in July 1860, but habitation at the site goes back thousands of years. The oldest evidence of human habitation in the area around Jupiter Inlet Lighthouse is perhaps five thousand years old, but it seems the majority of habitation has occurred in the last two thousand years.[118]

The people that lived in the area were primarily hunter-gatherers, relying on fishing and various shellfish native to the area. These inhabitants had a rich trade network that brought tools and pottery from outside the Florida peninsula.[119] Evidence shows that the local population was dynamic and mobile, likely establishing, and reestablishing villages in the area. At various times the site was used by the Calusa, Ais, and Jaega tribes, amongst others. By the time of European contact, the people in the area were known as the Jaega and controlled a well-established village known as Jobe.[120]

On the return trip following his landing on Florida's east coast, Juan Ponce de Leon entered Jupiter Inlet in search of firewood and fresh water but found a group of hostile and armed Jaega. A short skirmish ensued, and Ponce de Leon retreated to his ship, leaving the east coast of Florida for good. After Ponce left the east coast and met his fate at the hands of the

[118] "Early Native Americans," *Jupiterinletlighthouse.org – History*, https://www.jupiterlighthouse.org/explore/history/early-native-americans/
[119] Josh Liller (Historian, Loxahatchee River Historical Society), email communication with author, Jan. 2022
[120] Carey, 2012; Clarence Alexander, Nora Bynum, Elizabeth Johnson, Ursula King, Tero Mustonen, Peter Neofotis, Noel Oettle, Cynthia Rosenzweig, Chie Sakakibara, Vyacheslav Shadrin, Marta Vicarelli, Jon Waterhouse and Brian Weeks, "Linking Indigenous and Scientific Knowledge of Climate Change," *BioScience* 61, no. 6 (June 2011): 477-484

Calusa south of modern-day Tampa Bay, the number of Spanish ships passing along Florida's east coast was ever increasing.

By the time the English Quaker Jonathan Dickinson shipwrecked on Jupiter Island and began a journal of his experiences 1696, the Jaega were quite familiar with European explorers. When Dickinson and his companions washed ashore on Jupiter Island, the local tribes had been plundering Spanish shipwrecks off the coast for many years.[121] Dickinson's party was attacked by the Jaega and stripped of much of their clothes and belongings, but eventually allowed to make the journey on foot from Jobe to the area around St. Augustine, a harrowing journey of more than two hundred miles through hostile country.[122]

For the remainder of Florida's first Spanish period, which ended when the territory was transferred to British rule as part of the First Treaty of Paris following the Seven Years War, the area around Jupiter Inlet was sparsely populated. In many European-based sources from the time, and scholarly work more recently, Florida is described as being almost devoid of population when the Spanish abandoned the peninsula. Many of the native inhabitants who worked closely with the Spanish are described as having been evacuated to Havana; others were taken to Cuba as slaves. This is almost certainly not true, but rather a rehashing of the same "virgin land" narrative that was used as a justification by Europeans and Americans to expand further into Indigenous land.[123] For a variety of reasons, there was a certain level of population migration within the peninsula, as there had always been, but large portions of the Florida population stayed where they were as the political winds of the region changed. To be sure, a portion of the

[121] Jason Daniels, "Shipwrecked in the Atlantic World: Reevaluating Jonathan Dickinson's Interactions with Native Peoples along Florida's Southeastern Coast," *The Florida Historical Quarterly* 91, no. 4 (Spring 2013): 451-490
[122] Ibid
[123] Denise I. Bossy and Andrew K. Frank, "Charting a Path toward an Indigenous History of Florida," *Florida Historical Quarterly* 100, no. 1 (Summer 2021): 1-22

population of Florida did leave with the Spanish after the First Treaty of Paris took effect and the Spanish evacuated, but significant emigration of Indigenous populations from the interior South into Florida and other groups within the peninsula who either held the territory they controlled or moved as some territories freed up ensured that there was not an absence of people. During their short period of sparse occupation, the British never ruled over an empty landscape.[124]

After taking control of the Florida territory in 1763, the British began to investigate their new southern territory in continental North America. The territory was quickly split into two colonies; the area west of the Apalachicola River was West Florida, with East Florida to the east of the river. In 1770 the east coast of British East Florida was, for the first time, mapped in detail. At that time cartographers mapped a small plantation settlement on the Loxahatchee at Jupiter Inlet.[125] Based on this map and other sparse references, it was long suspected that Jupiter was the location of the oldest British settlement in South Florida. Archaeological digs in the early-2000s seem to support this hypothesis based on the age of some English artifacts found during renovation and excavation around the lighthouse.[126] The two Florida colonies continued to be administered by the British until it was transferred back to Spain as part of the 1783 Treaty of Versailles following the conclusion of the American Revolution. Thus, the Spanish again took political possession of the Floridas, though physical possession hardly changed.[127]

The Spanish had a tenuous hold at best in St. Augustine and Pensacola, but much of the coastline and the entire interior of the peninsula were controlled by various Indigenous groups.

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[124] Bossy/Frank, 2021
[125] "European Contact," Jupiter Inlet Lighthouse and Museum. https://www.jupiterlighthouse.org/explore/history/european-contact/
[126] "Dig May Have Found Lost Grenville Plantation," *Tampa Bay Times*, May 20, 2000, Updated Sept. 27, 2005 https://www.tampabay.com/archive/2000/05/20/dig-may-have-found-lost-grenville-plantation/
[127] Charlton W. Tebeau & William Marina, *A History of Florida, 3rd Edition*, Miami, University of Miami Press, 1999.

By the early 1800s the United States was very interested in adding Florida to the union. There were constant raids back and forth across the Florida-Georgia border as southern planters along the border fought to control a slave population that looked at the Florida border as a crossing to a better life than in Georgia and the Carolinas. A failed U.S backed militia raid into East Florida laid the groundwork for America's longest and costliest Indian war. The United States referred to these wars as the three Seminole Wars, but Seminole today reject the idea there were three separate wars and instead view the engagement as one long, drawn out war.[128] In 1812 a militia made up of Georgia planters supported by Indigenous people from the interior South and secretly backed by the U.S. government raided East Florida in an effort to seize control of the area from the Spanish at St. Augustine and turn control over to the U.S. government.[129] The East Florida Patriots, as they called themselves, were able to capture Fernandina on Amelia Island with the support of U.S. Navy gunboats, but were unable to capture Castillo de San Marcos in St. Augustine, and the effort fell apart. After the Seminole chose to back the Spanish during the invasion, tensions between the United States and the Seminole in Florida began to rise. By around 1816 these tensions boiled over into all-out war as Andrew Jackson again invaded Spanish territory in an effort to push the Seminole from North Florida.[130] Despite a number of treaties signed over the years, hostilities in the form of small raids and all-out battle would continue throughout the state for more than four decades. Throughout this time the Seminole were slowly pushed south as the U.S. military poured men and materiel into the peninsula. By the 1830s the Seminole had been pushed far enough south that some bands began to hunt and fish in the area of Jupiter Inlet and the Loxahatchee River. In early 1838 two battles between

[128] Bossy/Frank, 2021
[129] James G. Cusick, *The Other War of 1812: The Patriot War and the American Invasion of Spanish East Florida*, Athens, University of Georgia Press, 2003
[130] Ibid

Seminole and U.S. regulars were fought on the Loxahatchee just west of where the Jupiter lighthouse would eventually be built.[131] Following the battles at Loxahatchee, Gen. Thomas Jesup, who was commanding the troops in the area, established a stockade west of the inlet and garrisoned troops there as part of an attempt to build a strings of forts down the peninsula to be able to respond to the threat of Seminole raids. This hastily assembled wooden stockade was christened Fort Jupiter.[132]

When hostilities between the United States and the Seminole finally ceased in 1858 construction on the lighthouse was already underway. Because the inlet was silted over, all construction material had to be transferred from ships to shallow draft barges for the arduous journey down the Indian River. After 1854 the inlet was closed and didn't open again until around 1859, just before the lighthouse was completed in 1860 and was officially lit on July 10, 1860. The following year, Confederate sympathizers in the area disabled the light and it stayed dark until after the Civil War. With the inlet open however, Jupiter became a prime spot for Confederate blockade runners to enter the Indian River in an effort to avoid patrol boats.[133] For much of the Civil War confederate blockade runners used the lighthouse and the keeper's house as a base of operations from which they could operate until resupplied Navy gunboats could return from Key West to patrol the area. As the war progressed Navy patrols clamped down on confederate blockade runners and activity at the Jupiter light slowly dried up.[134]

[131] Kenneth J. Hughes, "Fort Jupiter: Crossroads to Southeast Florida," *Broward Legacy* 4, no. 1-2 (1981): 2-10
[132] Ernest F. Dibble, "Giveaway Forts: Territorial Forts and the Settlement of Florida," *The Florida Historical Quarterly* 78, no. 2 (Fall, 1999): 207-233
[133] DuBois, 1968
[134] James D. Snyder, "Jupiter Inlet Lighthouse: A Foothold on the Southeast Florida Frontier," *The Keepers Log* – U.S. Lighthouse Society, Fall 2006,

The lighthouse was relit in 1866 and is still operational today. Since its construction, the lighthouse has also served as a weather station, signal station, and radio station for various branches of the armed services. In 1939 operation of all lighthouses was transferred to the U.S. Coast Guard and a secret radio and code breaking installation known as Station J was established and operated against German U-Boats in the Atlantic.[135]

[135] Ibid

Figure 3: Jupiter Inlet Lighthouse's Fresnel Lens. (Author's photo.)

Jupiter Inlet Lighthouse features a First Order Fresnel lens, one of only thirteen still operational in the United States. In 1973 the lighthouse was placed on the National Register of Historic Places and in 1985 the adjacent archaeological site was added to the same list. In 1994 the Loxahatchee River Historical Society and U.S. Coast Guard entered into an agreement to

manage the lighthouse. In 2008 Congress designated the lighthouse and the surrounding 120 acres an Outstanding Natural Area (ONA), one of only 10 such designated areas in the United States and the only one east of the Mississippi River. Since that time the lighthouse grounds and the ONA have been managed jointly by the Loxahatchee River Historical Society and the Bureau of Land Management.

Cultural Context

The land that hosts Jupiter Inlet Lighthouse today has played host to many groups of people in the past. It is important to recognize that the cultural importance of the area extends past the lighthouse itself and the other features that are part of the built environment. Without a doubt, these features are of significant cultural importance to the area. The lighthouse is a prominent feature of the town logo and is one of the main attractions in Jupiter. The lighthouse is featured prominently in artwork and apparel by Florida based artist and conservationist Guy Harvey.[136] The lighthouse and adjacent buildings represent more than 160 years of United States history. The provided interpretation of these buildings gives great insight into pioneer life during the late nineteenth century and the military history of the area, particularly the lighthouse station's history as a Naval radio station during World War II.

As a cultural landscape though, the area has a much deeper history that holds significance for numerous stakeholders. Evidence from archaeological digs on the site indicate that the history of Indigenous people of the area goes back more than 5,000 years, with significant inhabitation in the last two thousand years. In fact, roughly 98% of Florida's history is Indigenous history, with Europeans only coming on the scene for the five hundred or so years

[136] Guy Harvey, "Jupiter Lighthouse," artwork. https://guyharvey.com/products/mens-jupiter-lighthouse-short-sleeve-crew-neck-pocket-t-shirt

while Indigenous populations have lived on the peninsula for roughly fourteen thousand years.[137] Indigenous tribes held power over the majority of Florida for the entire time that various European countries claimed possession of the peninsula. When Ponce de Leon sailed into Jupiter inlet, he was left with no doubt of who was in control of the area.[138] Nearly two hundred years later, Dickinson and other Europeans who documented their contact with the Jaega describe them as a tribe of hunter-gatherers living along the Loxahatchee.[139] But archaeological evidence and a deeper reading of their accounts reveal a tribe that may have relied on the abundance of the area for subsistence, but they were part of a vast trade network that stretched throughout the southeast.

Moreover, from their position along Florida's east coast, the Jaega played an active role in the international economy, salvaging European shipwrecks and then participating in inter-territorial and international trade. One European shipwreck survivor described the Jaega as becoming rich from the salvage trade along the coast.[140] They of course were also affected by the transformations that were taking place all over the continent and as the Jaega transitioned out of the Jupiter area, others moved in. The first British settlement in the area, the Grenville Plantation, was established amongst the Indigenous population of Jupiter. This was a repeating theme in the establishment of Europeans in Florida; they built their settlements amongst already established native populations, although that fact was later expunged from the colonial European history of the area.[141]

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[137] Bossy/Frank, 2021
[138] "European Contact," Jupiter Inlet Lighthouse and Museum. https://www.jupiterlighthouse.org/explore/history/european-contact/
[139] Daniels, 2013
[140] Ibid
[141] Kristalyn Marie Shefveland, "Remembering an Indigenous South: Regional Identity, Vero Beach, and Settler Tourism," *Florida Historical Quarterly* 100, no. 1 (Summer 2021): 106-127

Colonial political winds continued to change and before the United States officially gained control of the peninsula, they were waging war against the Seminole in Florida. The Seminole moved into the Jupiter area and, for a time, established themselves in what was formally Jaega territory.[142] It was not until after the Civil War that the United States had real control of the majority of the peninsula. Today the Seminole, in partnership with the Loxahatchee River Historical Society, take an active role in the interpretation of the area from an Indigenous perspective. The cultural context of many of Florida's cultural sites are often discussed in European or American terms but in reality, the Jupiter Inlet area, like all of Florida, is and has always been Indigenous land that Europeans and then Americans have operated in at various times.

[142] "Seminole Indians," Jupiter Inlet Lighthouse and Museum. https://www.jupiterlighthouse.org/explore/history/seminole-indians/

Figure 4: Seminole Chickee. (Loxahatchee River Historical Society)

Jupiter Inlet is an old place, and the land and the lighthouse hold cultural significance for a wide array of stakeholders. At various spots around the grounds, in representation and interpretation, many of these stakeholders are represented, though from a mostly European and American perspective. But there is a disconnect between the deep history of the site and the residents of the area. The lighthouse is recognized by the city government and residents as an icon of Jupiter Inlet, but the history of the lighthouse and the Indigenous cultural landscape where it stands is lost on many residents. This is a phenomenon that is not uncommon in Florida. Each year more than three hundred thousand people move to Florida. As they settle into their new communities, they of course build an attachment to the local community that begins to form part of their new personal identity as a member of that community, but those cultural attachments

will likely not be as deep as if they had lived in the area their whole lives, or their families for multiple generations.[143] It is through the important outreach work done by community historians like Josh Liller at the Loxahatchee River Historical Society and cultural organizations like the Cultural Council of Palm Beach County that this local history is kept relevant.

Economic Context

Cultural heritage sites are a driver of tourism and contribute to their communities both directly and indirectly. The financial contribution heritage sites bring to the area are significant and, particularly in developing countries, can be the financial lifeblood of the community. In addition to the financial contribution, heritage sites support other jobs in the community. In its 2017 cultural heritage economic impact report, the Cultural Council of Palm Beach County estimated that cultural heritage tourism contributed $584 million dollars to the county and supported the equivalent of more than 13,000 jobs in the county.[144]

Jupiter Inlet Lighthouse and the surrounding Outstanding Natural Area is a significant contributor to heritage tourism in the county. During the 2018-2019 fiscal year, the lighthouse and ONA received an estimated 112,000 visitors. While Jupiter Inlet Lighthouse is not a state park, it does offer many of the same amenities. Because of the similarities, a comparison between the ONA and state parks with similar visitation numbers can be illuminating. Around the state there are several parks in various districts that have similar visitation numbers. According to the most recent economic impact report on state parks, the state of Florida estimates that parks that have roughly 112,000 visitors per year generate roughly 17.5 million

[143] Josh Liller (Historian, Loxahatchee River Historical Society), email communication with author, Jan. 2022
[144] "Economic Impact of Cultural Heritage Tourism in Palm Beach County: Results from FY 17 Category B and C-II Organizations Attendee Surveys and Spending Data, *Cultural Council of Palm Beach County*, June 1, 2018

dollars in direct economic impact to the surrounding community. This means that Jupiter Inlet Lighthouse and the surrounding ONA contribute a significant portion of the cultural heritage tourism dollars that come into the county.[145] Like many of the other cultural heritage sites in Florida, Jupiter Inlet Lighthouse is quite close to the water and will be increasingly threatened by climate change as time progresses. It will be increasingly important for managers to take into account the projected effects of climate change on their site as the work to keep it resilient in the future.

Jupiter Inlet Lighthouse ONA Boundary

[145] Peter DeWitt (Jupiter Inlet Lighthouse Outstanding Natural Area – Bureau of Land Management), "Visits and Visitor Days by RMA, Fiscal Year 10/2018 – 9/2018, Bureau of Land Management Information System," email communication with author, 2/22/2022

Figure 5: Boundary of the Jupiter Inlet Lighthouse Outstanding Natural Area. (Author's Map)

Climate change & Predictions

Over the next several decades Jupiter Inlet and the surrounding areas can expect to experience about a foot of sea level rise.[146] This amount of sea level rise will not threaten the site with inundation, with the possible exception of some shoreline areas in the northern portion of the ONA. This will, however, increase the risk of climate-related problems the area already suffers from. With increased hightides, storm surge from offshore storms increases the risk that outer dunes may be overtopped, pushing water into the Intercoastal Waterway and possibly temporarily inundating interior areas such as the Jupiter ONA. While permanent damage to the site is unlikely in this situation, standing water on the site can disrupt operations and diminish the direct economic impact that the site can contribute to the community. Based on sea level rise modeling, the northeast corner of the Jupiter ONA is the most susceptible to inundation and by mid-century will almost certainly begin to experience inundation problems on a permanent or semi-permanent basis. Under a 6-foot rise scenario, the eastern shoreline of the ONA could retreat by as much as 500 feet along a portion of the shoreline that is roughly equivalent to three quarters of the length of the ONA and museum grounds. Under this same scenario, the area on the southern shore of the property is also threatened by inundation, particularly around the museum and administrative offices.

[146] W.V. Sweet, B.D. Hamlington, R.E. Kopp, C.P. Weaver, P.L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A.S. Genz, J.P. Krasting, E. Larour, D. Marcy, J.J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K.D. White, and C. Zuzak, "Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01." 2022, National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp. https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nos-techrpt01-global-regional-SLR-scenarios-US.pdf

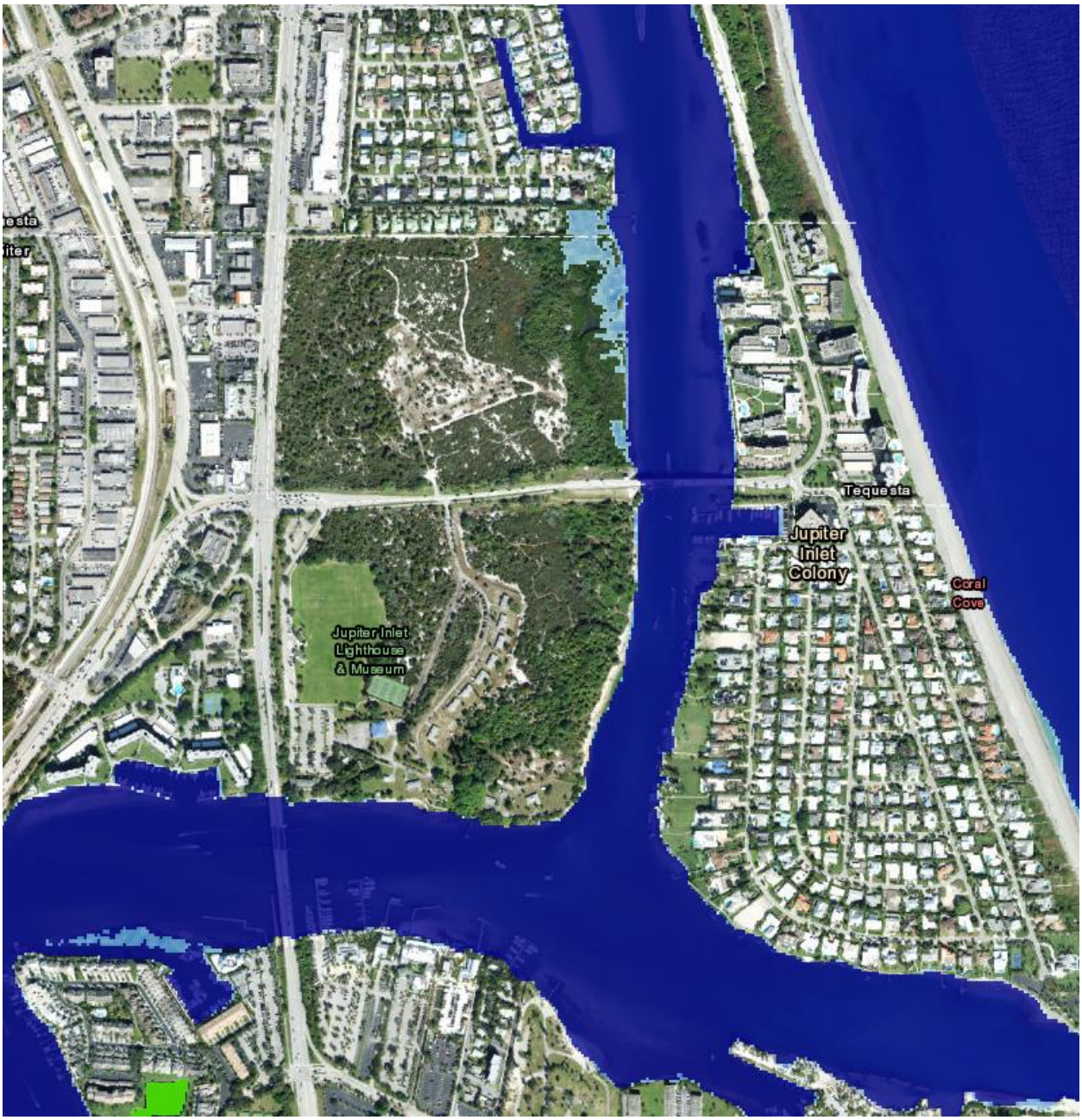


Figure 6: Projection depicting 1-foot of sea level rise at Jupiter Inlet Lighthouse. (NOAA Sea Level Rise Viewer)

Jupiter Inlet Lighthouse 3ft Rise Scenario

Figure 7: ARCGIS Projection of 3-feet of sea level rise at Jupiter Inlet Lighthouse. (Author's Map)

Figure 8: ARCGIS Projection of 6-feet of sea level rise at Jupiter Inlet Lighthouse. (Author's Map)

While future inundation is a concern, coastal erosion in the area is a more pressing problem, though not necessarily related to climate change. A combination of factors such as sea level rise, storm activity, loss of natural vegetation, and other anthropogenic causes such as the construction of jetties contribute to erosion and shoreline degradation in the area. Continued sea level rise and increased storm activity in the area will exacerbate the existing erosion problems that the Jupiter Inlet ONA is experiencing, making well informed adaptation decisions critically important in the future.

Sea level rise modeling for this area is useful because it lets site managers evaluate the areas that are most likely to be susceptible to sea level rise and storm surge based on elevation. Future projects can then be designed around the areas of the site most likely to be impacted. It is, however, important to keep in mind that these are static projections that do not take into account the dynamics of the coastline and the unique hydrology of each area. Storm events and erosion can change the shoreline, as can adaptation projects designed to bolster and regain areas that have suffered from erosion. As changes to the landscape occur, modeling for the area must be reevaluated.

Mitigation/Adaptation Projects

At Jupiter Inlet Lighthouse, projects are already underway that will change the shape of the coastline and introduce inaccuracies in the landscape that will have to be addressed in future models. As the field of adaptation progresses, nature-based adaptation solutions such as living shorelines have become an increasingly popular choice for fostering coastal resilience in the face of climate change. Creating a living shoreline involves using local vegetation, often in common with offshore components made from rock or wood designed to blunt the impact of wave action on the shore. As sand builds up behind the breaks, local marsh vegetation helps to anchor that sand in place and mitigate the effects of erosion.[147] Projects of this kind can help improve the resiliency of shorelines to the impact of storms and help absorb energy and slow storm surge as it is pushed onshore. Studies show that living shorelines can be more resilient than coastal armoring when it comes to the impact of hurricanes and, in addition, can help to mitigate carbon

[147] Niki L. Pace and Nathan Morgan, "Living Shorelines: Eroding Barriers to Coastal Resilience," *Natural Resources & Environment* 31, no. 3, Resilience (Winter 2017): 44-47

in the atmosphere through absorption, trapping the carbon.[148] Living shorelines are also cheaper to install and maintain than traditional coastal armoring.[149] This provides a coastal barrier to the increasing effects of climate change while also preserving the natural system of the environment.

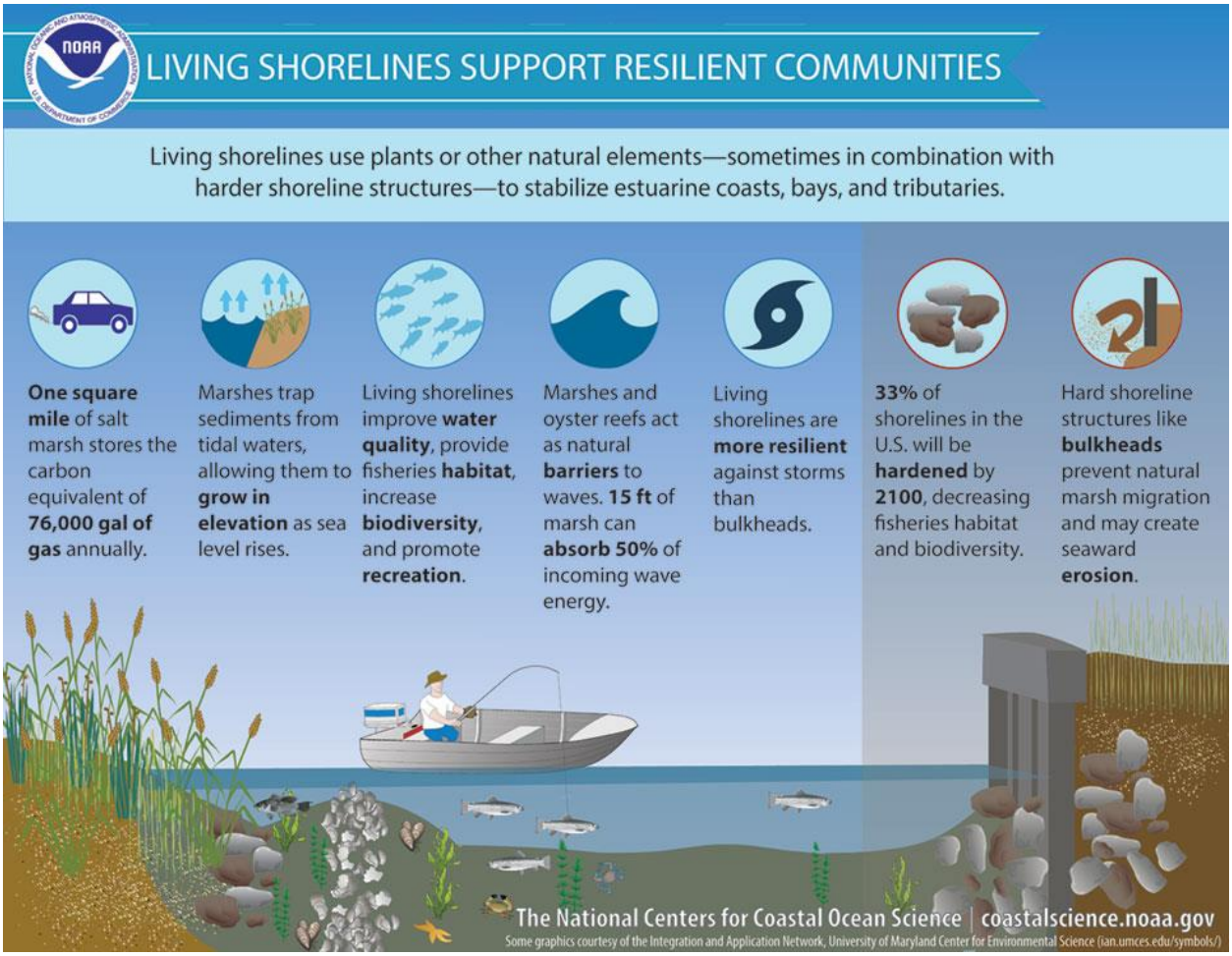


Figure 9: Living Shorelines Support Resilient Communities. (NOAA)

[148] Carter S. Smith, Brandon Puckett, Rachel K. Gittman, and Charles H. Peterson, "Living Shorelines Enhanced the Resilience of Saltmarshes to Hurricane Matthew (2016)," *Ecological Applications* 28, no. 4 (June 2018): 871-877

[149] "Natural and Structural Measures for Shoreline Stabilization," SAGE, U.S. Army Corp of Engineers, National Oceanic and Atmospheric Administration, Feb. 2016. https://coast.noaa.gov/data/digitalcoast/pdf/living-shoreline.pdf

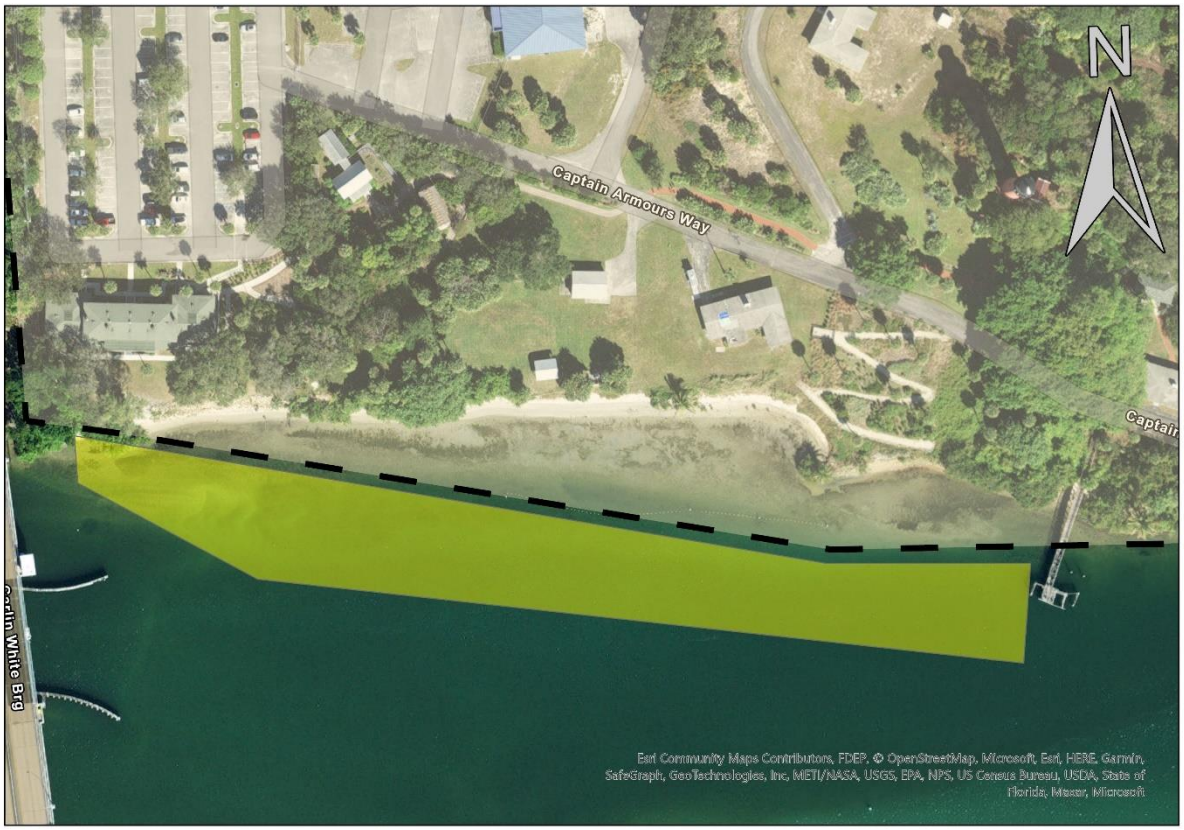
The installation of living shorelines can present some challenges, however, and may not be feasible in all coastal situations. Permitting and regulation challenges can contribute to extensive planning and approval processes. Factors such as ownership of the coastal area and the natural function of the sand and sediment system have to be considered as well. Additionally, in urbanized or highly developed coastal areas, traditional hard armoring of the shoreline may be the only suitable option due to adjacent development. Despite the challenges, however, where living shoreline projects are appropriate, they can often be less intrusive on the shoreline, more effective, and more economical than traditional coastal armoring.[150]

[150] Ibid

Figure 10: Living shoreline project area as seen from the lighthouse. (Author's Photo)

Recently the Jupiter Inlet District, in partnership with the Bureau of Land Management, completed a living shoreline project in the vicinity of the lighthouse in an effort to combat erosion. Completed in September 2021, the living shoreline project is already beginning to see results, with sand beginning to build up behind the rock breakwaters.[151] Ideally the vegetation that has been planted, mostly mangroves, will help to anchor the new sand in place and rebuild the sections of the shoreline that have been lost in the last two decades. According to site management, some areas of the shoreline along the Loxahatchee River have receded more than twenty feet.[152] As is often the case, the erosion problem along the shoreline around the Jupiter Inlet Lighthouse ONA has a number of causes that are not necessarily rooted in climate change but will be exacerbated in the future as the effects of climate change increase. Based on sea level rise modeling for the site, the two most vulnerable areas were the shoreline area south of the museum building and an area of the shoreline in the northern portion of the ONA, just south of the Cato bridge. The most recent living shoreline project, roughly 600-feet long, is designed to address the area near the museum building, making one of the most vulnerable areas of the site more resilient in the future.[153] This project is already starting to show promise as sand has begun to build up behind the breakwaters as intended.

[151] "Living Shoreline and Observation Pier Installation," Jupiter Inlet District. https://www.jupiterinletdistrict.org/living-shoreline-and-observation-pier-installation
[152] Ibid
[153] Sam Howard, "Shoreline, Sewer Projects Planned at Jupiter Inlet Lighthouse," *The Palm Beach Post*, May 29, 2019. https://www.palmbeachpost.com/story/news/local/2019/05/29/shoreline-sewer-projects-planned-at-jupiter-inlet-lighthouse/5028680007/



Area of Current Living Shoreline Project

Figure 11: Approximate area of recently completed living shoreline project at Jupiter Inlet Lighthouse. (Author's Map)

According to the Loxahatchee River Historical Society, the Bureau of Land Management is exploring a future living shoreline project that will stretch from the dock in front of the lighthouse north to the Cato bridge. Extending the living shoreline project to the Cato bridge would help to improve the resilience of the other most vulnerable area on the ONA site.[154] There will likely be further projects in the future as seas rise, but the living shoreline approach being taken by the Bureau of Land Management and the Loxahatchee River Historical Society at

[154] Josh Liller (Historian, Loxahatchee River Historical Society), email communication with author, Jan. 2022

Jupiter Inlet Lighthouse are the first steps to ensuring that the lighthouse and the Outstanding Natural Area surrounding it will stay resilient in the face of climate change for decades to come. A companion website with additional images can be found at www.floridaslr.com.

Figure 12: Approximate area of potential future living shoreline project at Jupiter Inlet Lighthouse. (Author's Map)

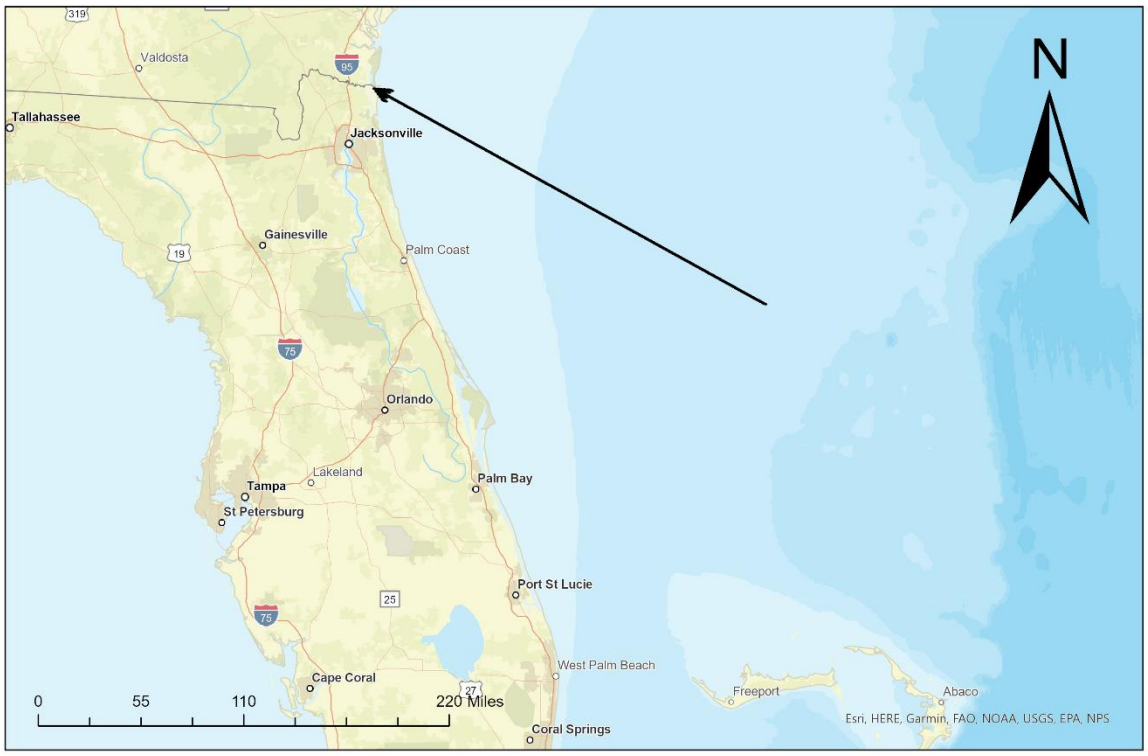
CHAPTER FIVE: FORT CLINCH

Figure 13: Aerial view of Fort Clinch at the state park, circa 1970. (State Archives of Florida)

Geography

Located on the northern coast of 13-mile-long Amelia Island, Fort Clinch looks out over the St. Mary's Inlet and the Atlantic Ocean. The St. Mary's Inlet is the point where the Amelia River, St. Mary's River, and Cumberland Sound meet and enter the Atlantic Ocean. Because of the energy involved with these waterways coming together, this section of the coastline is highly

dynamic and ever-changing. The natural littoral flow of sand has been interrupted by the installation of jetties on the north and south sides of the St. Mary's Inlet. In response to the interruption caused by the jetties and other anthropogenic factors, the inlet has been repeatedly dredged over the decades and the sand deposited on the shoreline around Fort Clinch as a type of shoreline resiliency effort. Despite this, the shoreline has historically changed rapidly and significantly. The continued erosion, which already presents a problem for the fort, will only be exacerbated in the coming decades as seas rise and erosion activity increases.



Fort Clinch
Nassau County, Florida

Figure 14: Location of Fort Clinch. (Author's Map)

History

Construction on Fort Clinch began on the northern end of Amelia Island in 1847, intended to protect the entrance to the Cumberland Sound as part of the Third System Fortifications that were constructed in response to the War of 1812. Following the War of 1812, during which British naval ships were able to penetrate far into U.S. territory using inland waterways, the United States began a program designed to bolster the nation's coastal defense. Earlier forts constructed in the United States, referred to as First and Second system forts, were made of lighter materials such as wood, a construction style that was vulnerable to naval bombardment. From 1816 until the program was abandoned in 1867, forty-two brick and stone fortifications were constructed along the Atlantic, Pacific and Gulf coasts.[155]

Long before the construction of the fort though, Amelia Island was recognized as a strategic location by all the various groups operating in the region. Archaeological evidence shows that the Timucua inhabited a large portion of north and central Florida, as well as portions of southern Georgia. Evidence of thriving habitation goes back thousands of years in the area of Amelia Island; one of the largest Timucuan cities was located in modern-day downtown Jacksonville. At the time of European contact there were perhaps as many as 200,000 Timucua living in the region. Timucuan society included a vast and complex religious and political society and a trade network that stretched to the Great Lakes region. As discussed in the previous chapter, Indigenous populations are often missing from European accounts of Florida except as background actors living in a sparsely populated area. Instead, like the Ais and the Jaega and

[155] "Third System of Coastal Forts," National Park Service. Updated 4/17/2020. https://www.nps.gov/articles/third-system-forts.htm

other tribes in Florida, the Timucua held sway over the landscapes in which Europeans operated. They actively participated in the developing geopolitics of the region, and actively recruited Europeans to take part in intra-tribal conflicts.[156] In 1565 the Spanish led an attack on the French settlement La Caroline after the French fleet was battered in a hurricane and could not reinforce the settlement against the Spanish. The Spaniards were the tip of the spear in this attack, but military aid from the Timucua in the form of logistical and intelligence support made the raid possible.[157] Throughout the eighteenth and into the nineteenth century the Timucua continued to play a role in the geopolitics of the region, but as regional conflict and prolonged contact with Europeans took their toll on the population of the Timucua, their influence began to wane.

As is often the case with histories of Indigenous groups in Florida, many accounts of the Timucua claim they were almost wiped out by European diseases, with the last remaining holdouts escaping to Cuba with the Spanish after the peninsula was transferred to the United States. This is probably not the case, however. More likely, as is the case with other tribes in the region, the Timucua moved and dispersed in response to various pressures in the region. Some migrated north, joining other tribes, while others moved to the less populated interior of the peninsula. Still others may have continued south through the region, joining with the Seminole as they struggled against the United States. Rather than dying out from disease or being evacuated to Cuba, Indigenous people in Florida adapted and shifted, separated and formed new communities and new social ties in the response to the complex political and social changes taking place in Florida.[158]

[156] Christophe J.M. Boucher, "The Greatest Dissemblers in the World: Timucuas, Spaniards, and the Fall of Fort Caroline," *Florida Historical Quarterly* 97, no. 2 (Fall 2018): 143-166
[157] ibid
[158] Bossy/Frank, 2021, Pg. 12-16

The War of 1812 brought changes to the Amelia Island region. During the American Revolution and the War of 1812, Britain was able to use the numerous waterways around the east coast to penetrate into the interior of the country. Beginning in 1816, while Florida was still under Spanish control, the United States began construction of a series of forts along the east coast of the United States to protect the coast. Eventually there would be forty-two such forts, collectively designated the Third System of Coastal Forts. These Third System forts were designed to prevent any military power probing the coastline the way the British had done. This was a time of particular upheaval in Florida, as the United States recognized the strategic value of Spanish Florida and the need for a system of permanent fortifications to protect waterways in the South. Florida was seen as a perfect place from which the United States could protect Georgia on the east coast and areas that were acquired during the Louisiana Purchase, if it could be acquired from Spain. When the United States, after mounting pressure on Spain, finally gained possession of Florida in 1821, a survey was conducted in part to determine the best locations for a series of forts in the territory.[159]

In 1842 the federal government purchased more than 1,100 acres of land on the northern end of Amelia Island and plans were drawn for a fort to protect Cumberland Island and the St. Mary's Inlet. Construction on the fort, however, was slow and when Florida joined the Confederacy at the outbreak of the Civil War the fort was only partially constructed.[160] Although Confederate troops did establish batteries around the fort, this was short lived as the fort was evacuated with the arrival of Union Troops in 1862. Today visitors can tour the fort as interpreted as a Civil War era Union fort, though this was never the case. Even when Union

[159] Frank A. Ofeldt III, *Fort Clinch, Fernandina, and the Civil War*, Charleston, The History Press, 2020
[160] Ofeldt, 2020

forces occupied the fort after 1862, construction was never complete. As a pre-war, and then Confederate, construction project, bricks for the fort were shipped from Savannah and when Union troops resumed construction of the fort bricks had to be shipped to Amelia Island from Philadelphia.[161] Construction continued on the fort until it was abandoned, unfinished, in 1869.

The fort sat abandoned until 1935, except for a brief period when it was reactivated during the Spanish-American War. In 1935 Fort Clinch became one of Florida's earliest state parks and restoration efforts by the Civilian Conservation Corps began in 1936. After serving as a communication and surveillance outpost during World War II, Fort Clinch reopened to the public and has been available for tours since. The fort was added to the National Register of Historic Places in 1972.

Cultural Context

Fort Clinch was built in response to the War of 1812, as part of a network of forts to defend the coast against attack from countries such as Great Britain, should war break out again.[162] But the United States knew the strategic value of Amelia Island and was very familiar with how vulnerable it was to capture. During the War of 1812, in part due to fears that Spain would ally themselves with Great Britain and give the British access to the southern United States via Florida, the United States government put a plan into action to pluck the Florida peninsula from Spanish control. Three decades before the United States purchased the land where Fort Clinch sits, the East Florida Patriots crossed the St. Mary's River to foment rebellion

[161] Ofeldt, 2020
[162] "History of Fort Clinch," *Florida State Parks* – Florida Department of Environmental Protection, *https://www.floridastateparks.org/learn/history-fort-clinch*

in Spanish East Florida. They came ashore on Amalia Island and attacked the Spanish garrison at Fernandina, a little over a mile south of where Fort Clinch would eventually be constructed.

Partially in response to the decision on the part of Indigenous Floridians not to help this clandestine U.S. raiding force in the fight against the Spanish for control of the peninsula, General Andrew Jackson ordered an attack on an abandoned British outpost that was being used by Seminole and runaway slaves from the U.S. This attack would mark the beginning of the decades long Seminole War that would eventually become America's longest and most expensive Indian war.[163]

The man at the head of that first attack was Lt. Colonel Duncan Lamont Clinch, namesake of Ft. Clinch. For Indigenous people in Florida then, Fort Clinch might be interpreted as a memorial to one of the men who led the charge to systematically persecute the remaining Indigenous population in the peninsula. This was the culmination of centuries of European and then American powers fighting over legal possession of lands that were owned by, and often totally controlled by, Indigenous tribes.[164]

Fort Clinch and the surrounding landscape hold cultural significance for a variety of stakeholders from a wide array of cultural backgrounds, but the official interpretation of the fort does not always coincide with the way different stakeholder groups view it. Today the fort is interpreted as a Civil War era Union fort, still partially under construction after being captured and liberated from Confederate forces. Like all static interpretations, this interpretation of the fort deals with only a snapshot of time in the site's history.

[163] James G. Cusick, 2003
[164] Ibid

In recent years there has been pushback, particularly in southern states, by African Americans who reject the traditional interpretations of Civil War monuments. In cities across the South statues and monuments to Civil War era soldiers and politicians have been removed by local and state governments or forcibly torn down by protesters.[165] These monuments are decried as symbols of oppression and hate by stakeholders in the community. In some ways, Fort Clinch falls into this same vain. The abandoned British fort which Duncan Lamont Clinch attacked in the opening salvos of the First Seminole War was being used as a refuge for runaway slaves from Georgia and the Carolinas. While the initiation of hostilities with the Seminole in Florida was in part retribution for lack of Indigenous support during the East Florida Patriot War of 1812, the first blows were in response to the Seminole giving safe harbor to African Americans who white Americans from Georgia and the Carolinas claimed as their property.[166]

When construction on the fort began, local contractors were hired to do much of the initial construction. As the docks were built and the fort began to take place, much of the labor being done at the site was performed by slave laborers. The federal government did not use slaves directly but made no distinctions about hiring contractors who used slaves. In this context then, the interpretation as a Union fort in some ways belies the circumstances under which the fort was constructed. It was a southern fort built with slave labor, named for a Georgia politician who hunted Indians and fugitive slaves in Florida as part of his military career, and occupied by the Confederate military before it became a captured Union fort, which is how the fort is interpreted and presented today.

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[165] Jasmine Aguilera, "Confederate Statues are Being Removed Amid Protests Over George Floyd's Death. Here's What to Know," *Time,* June 9, 2020. https://time.com/5849184/confederate-statues-removed/

[166] Kenneth Wiggins Porter, "Negroes and the Seminole War, 1817-1818," *The Journal of Negro History* 36, no. 3 (July 1951): 249-280; Nathaniel Millett, "Slavery and the War of 1812," *Tennessee Historical Quarterly* 71, no. 3 (Fall 2012): 184-205

Economic Context

Florida is a state that relies on numerous types of tourism to fund the state economy. In 2019 tourism contributed 96.5 billion dollars to the state economy and supported 1.6 million jobs. The category of industry that includes cultural heritage sites, marked as "Arts – Entertainment & Recreation" in the 2019 Florida Tourism Economic Impact report, contributed more than 8.2 billion dollars to the state economy, or roughly 8.5% of the yearly tourism contribution to the state.[167]

Fort Clinch State Park is one of 175 parks that make up the Florida state park system. Many of these parks prominently feature significant examples of built cultural heritage and cultural landscapes. As discussed previously, cultural heritage tourism contributes significantly to the local economy and the statewide park system shows how a network of such sites can make a largescale economic impact on whole states or the entire country at the national level. During the 2019-2020 fiscal year Florida state parks hosted nearly 25 million visitors and contributed more than 2.2 billion dollars in direct economic impacts statewide.[168] This means, on average, each visitor to a state park in Florida generates $91.48 in direct impact on the local community. Across the state this impact supports nearly 32,000 jobs. During that same time period Fort Clinch received more than 244,000 visitors, making it the sixth most visited park in the district. The expenditure from these visitors supported 308 jobs and contributed more than $22 million dollars to the community around Fort Clinch.[169]

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[167] Rockport Analytics, "Florida's Tourism Economy Experiences Another Record Year in 2019 But Shifts into a Lower Gear of Growth: 2019 Contribution of Travel & Tourism to the Florida Economy," *VisitFlorida.org*, https://www.visitflorida.org/media/30679/florida-visitor-economic-large-impact-study.pdf

[168] Florida Department of Environmental Protection, "Fiscal Year 2020-2021 Florida State Park System – Economic Impact Assessment," October 19, 2021

[169] Florida Department of Environmental Protection, "Fort Clinch Visitation by Fiscal Year."

Climate Change & Predictions

Like Jupiter Inlet Lighthouse and much of the rest of Florida's coast, Fort Clinch and the northern coast of Amelia Island are vulnerable to sea level rise, storm surge, and, in particular, coastal erosion. While the vulnerabilities of these two areas are similar, the area around Fort Clinch is faced with a unique set of challenges that make adaptation more difficult and call into question the sustainability of the site as climate change progresses over the remainder of the century.

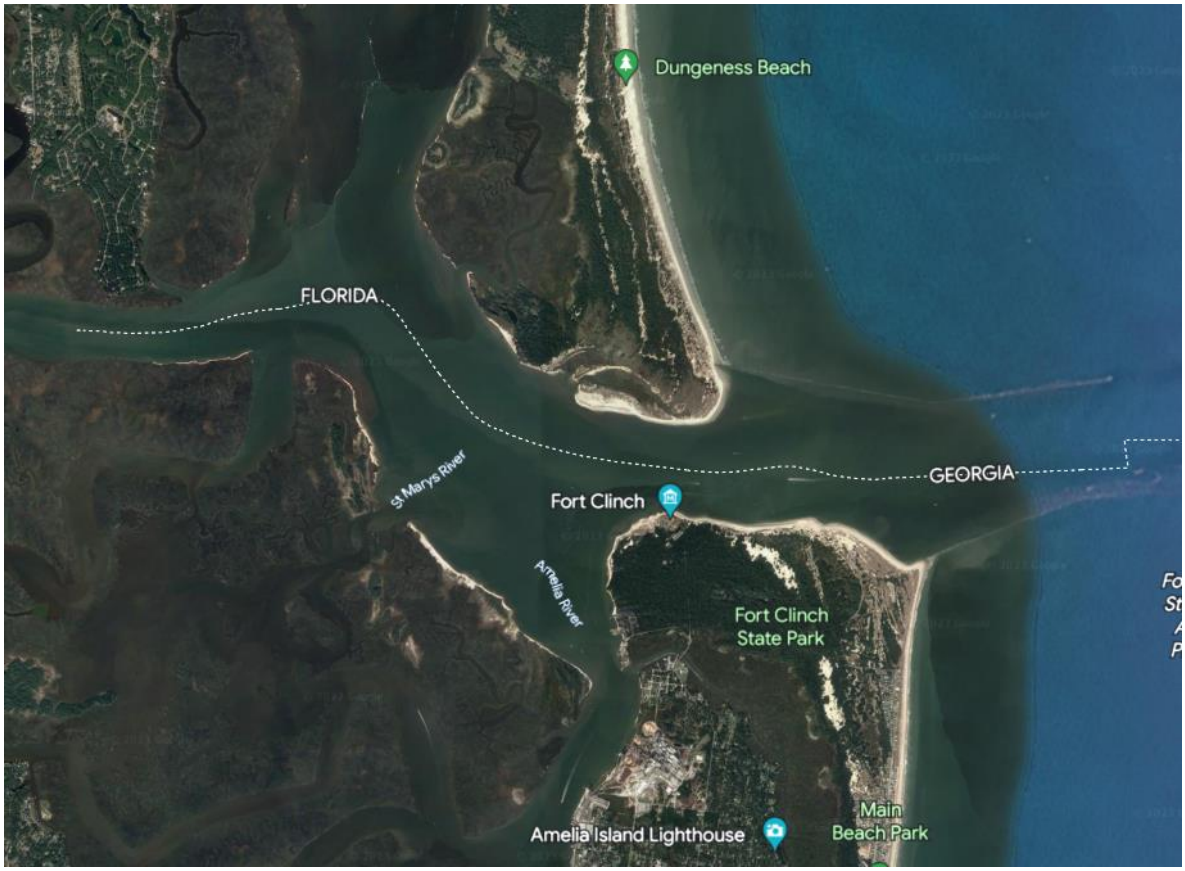

Figure 15: Fort Clinch and Cumberland Sound. (Google Earth)

Fort Clinch is located at the point where Cumberland Sound meets the St. Mary's River and exits into the Atlantic. This is a high-energy, dynamic coastline that has historically

undergone drastic changes.[170] From the middle of the nineteenth century to the middle of the twentieth century, the coastline of Amelia Island moved thousands of feet to the east and, to a lesser extent, the south. (Fig 16) The coastline directly adjacent to the fort underwent drastic changes in the twentieth century as erosion took effect and beach renourishment was implemented. Figure 5 compares a 2021 Google Earth image of Fort Clinch to an aerial photo of the fort, circa 1940, from a similar perspective. The effects of climate change will exacerbate the problems of these areas, but many of the problems that Amelia Island faces are largely the result of anthropogenic influences that have nothing to do with greenhouse gas emissions and climate change.

[170] Dan Pearson (Environmental Specialist III, Florida Department of Environmental Protection Division of Recreation and Parks), "Fort Clinch Historic Shorelines," email message to author, Feb. 16, 2022

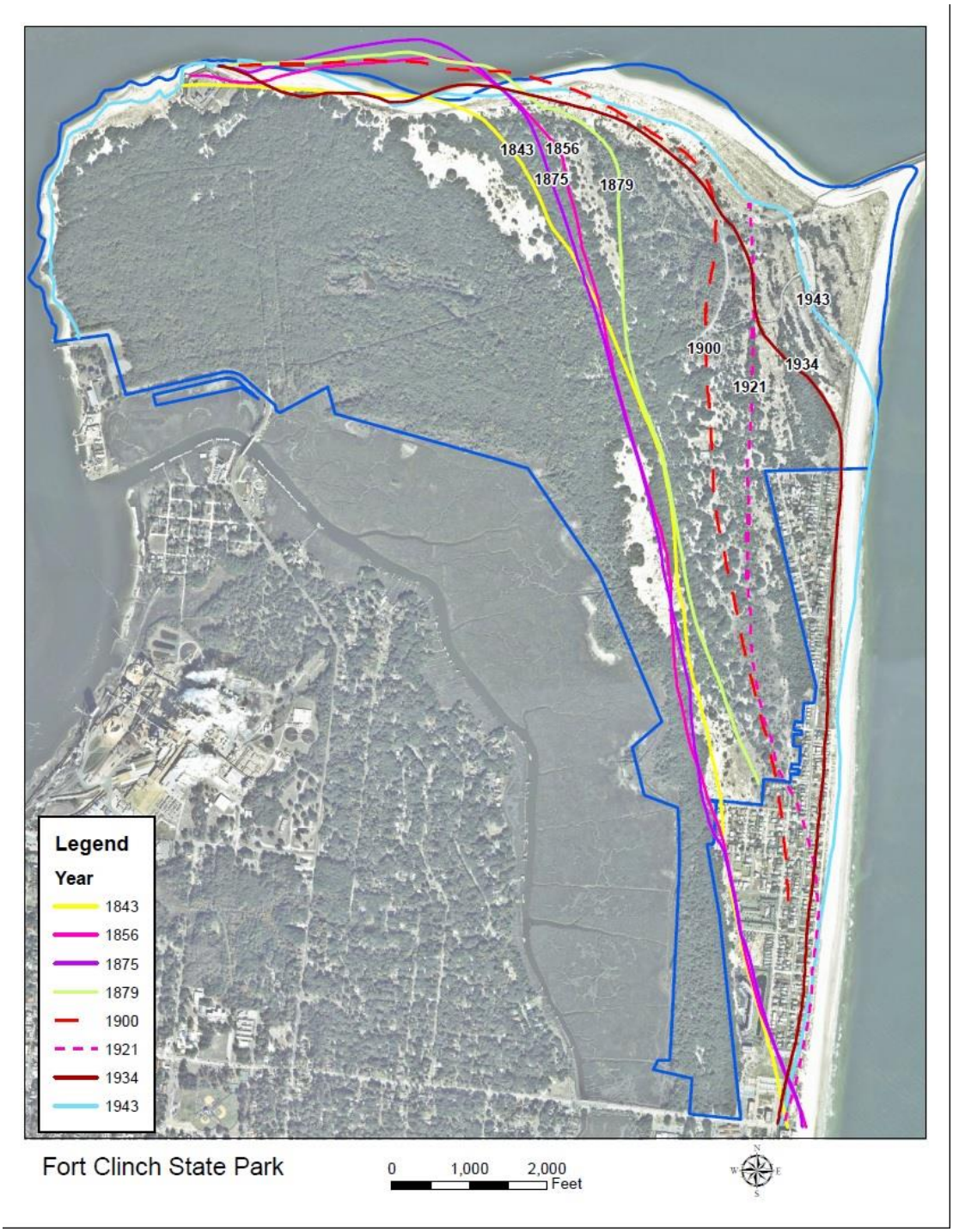

Figure 16: Historic shoreline of Fort Clinch. (Florida DEP, Division of Recreation and Parks)

Figure 17: Comparison of shoreline around Fort Clinch in 2021 (left) and 1940 (right). (Google Earth/State Archives of Florida)

Figure 18: Tidal damage to a wall at Fort Clinch, circa 1930. (State Archives of Florida)

The part of the island that is home to Fort Clinch faces two problems that cause erosion. One of these problems is a common coastal problem; the construction of jetties along the coastline interrupts the natural flow of beach sand, causing sand to build up on one side of the jetty while it is stripped away and goes unreplenished on the other side. Along Florida's east coast, the natural flow of beach sand, known as littoral drift, moves in a southernly direction. This is due to the greater energy of waves that approach from the northeast as compared to those that approach from the southeast.[171]

Figure 19: St. Mary's Entrance jetties. (Google Earth)

The northern jetty on the Cumberland Island side of the inlet is 19,500 feet long, nearly 3.7 miles.[172] This jetty traps an enormous amount of sand, interrupting the littoral flow across the inlet. Two consequences stem from the placement of the jetty. On the southern side of the inlet,

[171] Clay L. Montague, "Recovering the Sand Deficit from a Century of Dredging and Jetties along Florida's Atlantic Coast: A Reevaluation of Beach Nourishment as an Essential Tool for Ecological Conservation," *Journal of Coastal Research* 24, No. 4 (July 2008): 899-916

[172] Florida Department of Environmental Protection, Nassau Soil and Water Conservation District, "St. Mary's River Entrance Inlet Management Study and Implementation Plan," May 18, 1998.

the shoreline of Amelia Island is stripped of sand, causing drastic changes to the shoreline east of Fort Clinch. From the mid-1800s, throughout the twentieth century, the shoreline has moved back and forth by hundreds of feet.[173] The Florida Department of Environmental Protection St. Mary's River Entrance Inlet Management Study, first conducted in 1997 and updated throughout the 2000s, concluded that more than thirteen miles of coast south of the inlet is impacted by the interruption of littoral flow.[174] On the north side of the inlet, the placement of the jetty has caused sand to build up on the southern tip of Cumberland island adjacent to the north jetty. This has resulted in the formation of a significant shoal that is pushing the inlet channel further south, towards Fort Clinch. As the channel drifts south, it puts more erosion pression of the shoreline of the fort. The inlet management study for the St. Mary's Inlet determined that Amelia Island will require as much as 797,000 cubic yards of sand to be deposited on its shores each year to offset the impacts of the inlet.[175]

The other problem is unique to the area around Fort Clinch; just off the shore from Fort Clinch the U.S Navy maintains and operates a deep underwater trench meant to allow submarines to enter and exit King's Bay Naval Station completely submerged, if required.[176] This trench, much deeper than the surrounding areas, creates a faster current than would otherwise exist off the coast of Fort Clinch and, because of its proximity to the shore, strips sand from the shoreline as the current flows out. It also acts as a catch for sand that is moving across the sound, trapping it before it can be deposited on the shores of Amelia Island.[177] These factors

[173] Pearson, "Fort Clinch Historic Shorelines."
[174] Florida Department of Environmental Protection, 1998.
[175] Florida Department of Environmental Protection, 1998.
[176] "Naval Submarine Kings Bay In-depth Overview," *Military Installations – U.S. Department of Defense*, https://installations.militaryonesource.mil/in-depth-overview/naval-submarine-base-kings-bay
[177] Dan Pearson (Environmental Specialist III, Florida Department of Environmental Protection Division of Recreation and Parks), Interview by author, Feb. 16, 2022

combine to create a shoreline that is highly susceptible to erosion and particularly vulnerable to sea level rise which will exacerbate all the coastal dynamics problems that affect the area. The shoreline requires constant upkeep using beach replenishment to bolster the shoreline. To maintain the required fifty-foot depth and 200-foot width for the submarine channel, referred to as the U.S. Naval Station King's Bay Entrance Channel, the U.S. Army Corp of Engineers performs routine maintenance dredging of the channel.

A great deal of this sand is deposited on the shoreline of Fort Clinch in an effort at beach replenishment. Through dredging and replenishment hundreds of thousands of cubic yards of sand have been deposited and spread in the area surrounding Fort Clinch. Despite this ongoing effort, the shoreline around Fort Clinch is under constant assault from the sea and the beach is washed away on a regular basis. This is most evident in the area of the rock groins, installed in the 1940s to help stabilize the shoreline. The erosion between these points becomes glaringly obvious as wave action takes its toll in between replenishment projects.

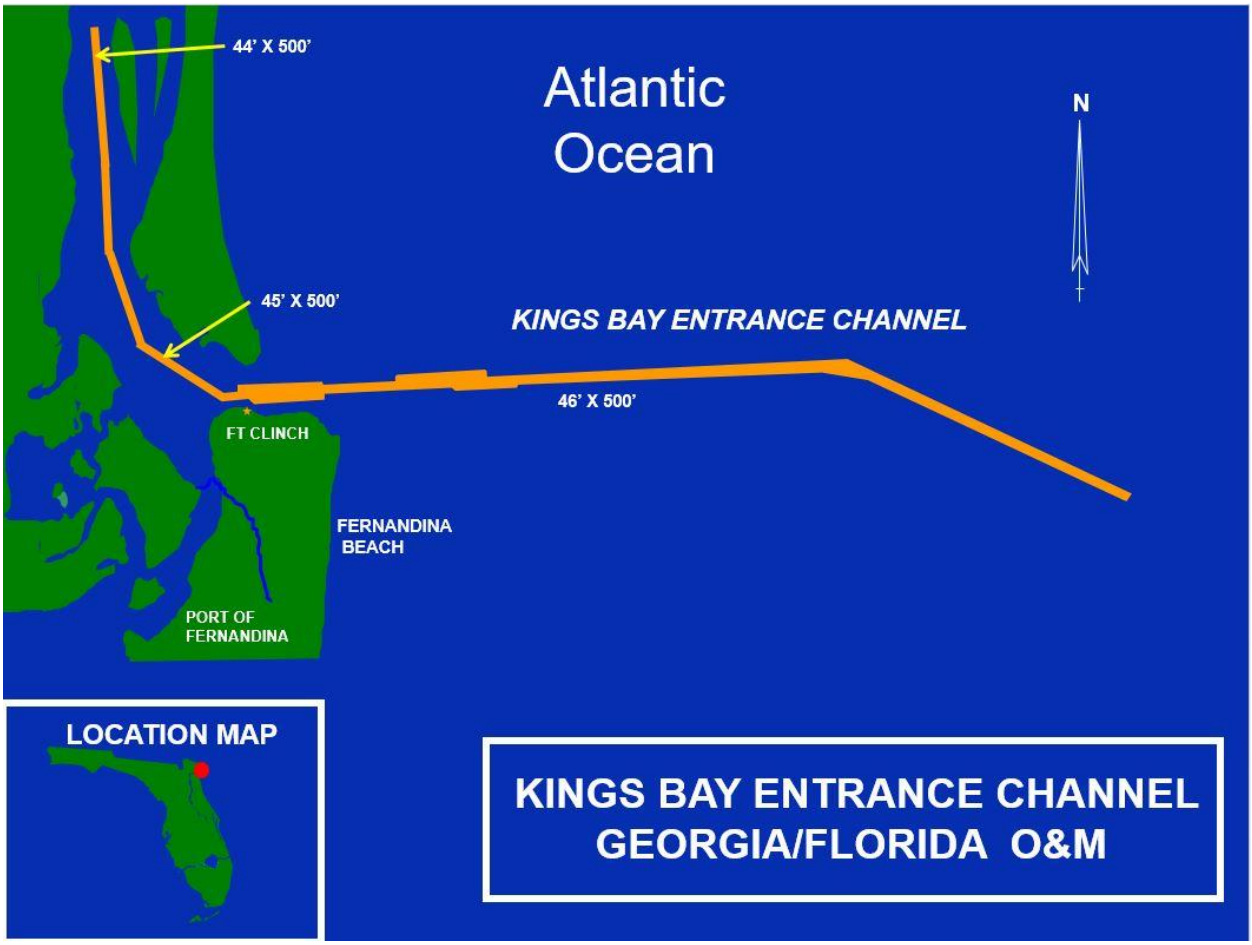

Figure 20: King's Bay Entrance Channel. (USACOE)

While this type of replenishment project is effective at preventing catastrophic erosion at Fort Clinch currently, this strategy will likely be untenable in the future. Current sea level rise projections predict that global average sea level with increase by one foot by 2050.[178] and by as much as 1.1 meters, or roughly four feet by the end of the twenty-first century.[179] For a number of reasons including wind patterns, groundwater extraction, and rebound from the weight of past glaciers, sea level rise is not uniform across the globe and may be higher or lower than the global

[178] Sweet, et al., 2022
[179] Martin Siegert, Richard B. Alley, E. Rignot, John Englander, "Twenty-first Century Sea-Level Rise Could Exceed IPCC Projections for Strong-Warming Futures," *One Earth* 3, no. 6 (2020): 691-703

average in various regions.[180] Based on the IPCC's Representative Concentration Pathways 8.5 (RCP 8.5), which assumes increased greenhouse gas emissions throughout the twenty-first century, planners and government officials in parts of Florida are planning for as much as 4.5 feet of rise by 2070 and as much as 11 feet of rise by 2120.[181] By mid-century, under a 1-foot-rise scenario, Fort Clinch will likely not be inundated, but the effects of erosion and storm surge will increase. Satellite images from 2019 and project photos taken in 2021 show the extent of erosion between the rock groins adjacent to Fort Clinch. (Figure 22) At times the high-water mark comes within 30-35 feet of the walls of the fort. This area is open and flat with virtually no barriers to slow storm surge. With one foot of rise, Fort Clinch may begin to suffer from periodic tidal flooding from particularly high tide events, such as king tides, unless efforts at shoreline protection are increased.

[180] Siegert et al, 2020

[181] Southeast Florida Regional Climate Compact Sea Level Rise Work Group, *Unified Sea Level Rise Projection – Southeast Florida, 2019 Update*, Feb. 2020 https://southeastfloridaclimatecompact.org/wp-content/uploads/2020/04/Sea-Level-Rise-Projection-Guidance-Report_FINAL_02212020.pdf

Figure 21: ARCGIS Projection of 1-foot of sea level rise at Amelia Island. (Author's Map)

Figure 22: Erosion between rock groins on the shoreline near Fort Clinch. (Author's photo)

Even in a world without seal level rise, this combination of anthropogenic factors affecting the St. Mary's Inlet would put the future of Fort Clinch in question. When factoring in the projected effects of sea level rise and increased storm activity, Fort Clinch will almost certainly succumb to inundation and erosion by the end of the century. In a scenario where the Atlantic coast sees four to six feet of sea level rise, the fort will be completely inundated, along with most of the rest of the northern end of Amelia Island.

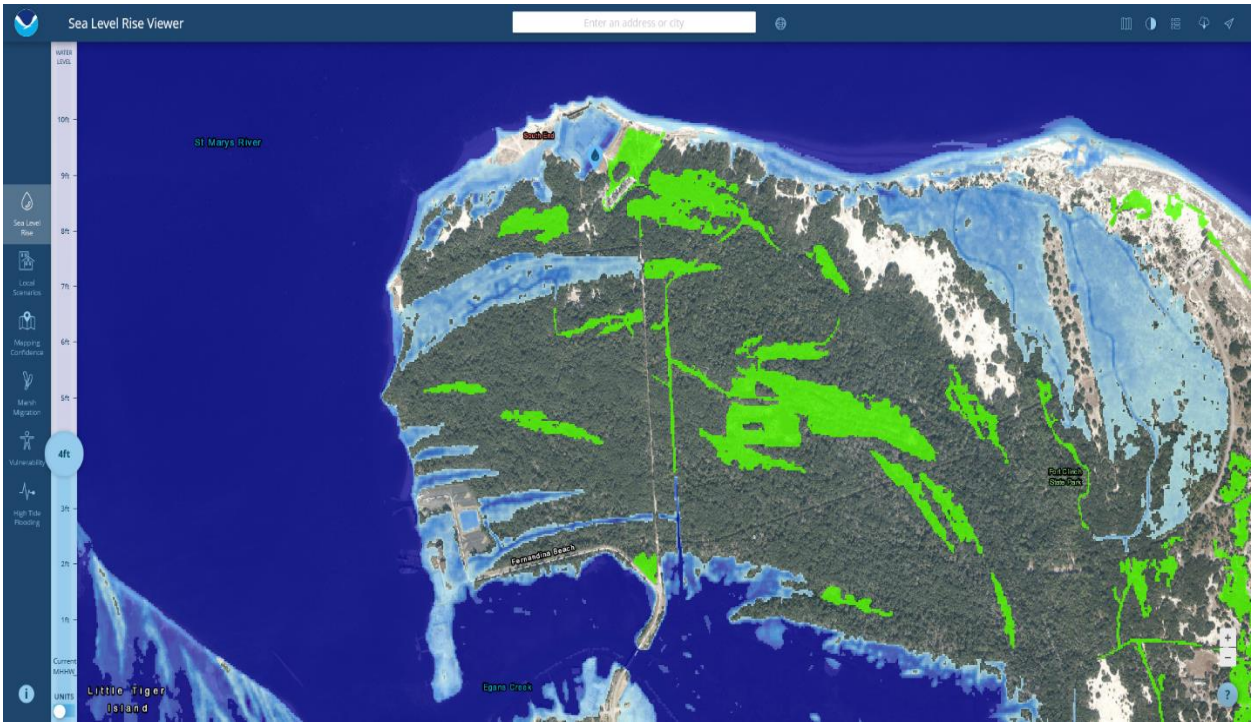

Figure 23: Projection of 4-feet of sea level rise at Amelia Island. (NOAA Sea Level Rise Viewer)

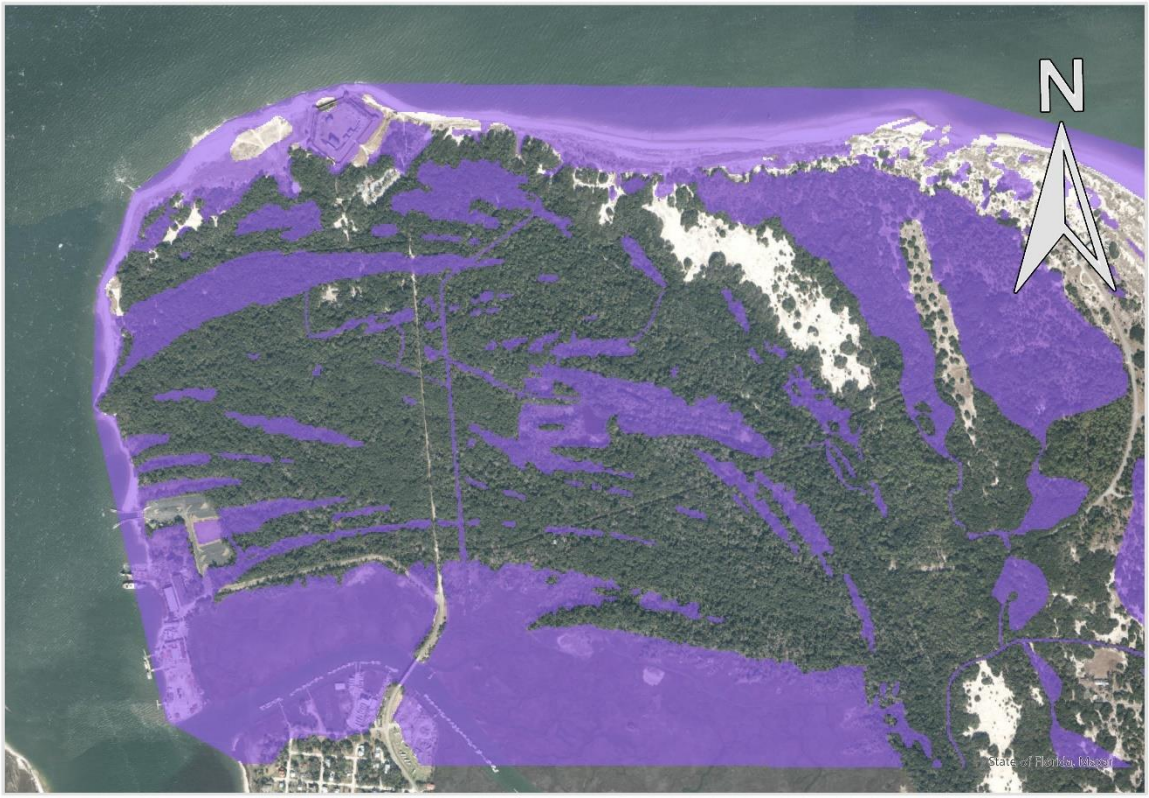

Figure 24: ARCGIS projection of 4-feet of sea level rise at Amelia Island. (Author's Map)

Figure 23 and figure 24 show the NOAA Sea Level Rise Viewer projection for four feet of rise on Amelia Island and the ARCGIS projection for four feet of rise, respectively. On the NOAA projection, the areas shaded in blue are areas of probable inundation, while the green shading represents areas that are below sea level but are not hydrologically connected to the coasts. These unconnected areas will likely experience some ponding during storm events but will not be permanently inundated. With six feet of rise, huge portions of the area between the St. Mary's River and Egan's Creek will be under water. This area includes not only the fort itself, but the majority of Fort Clinch State Park including access to the park from Fernandina Beach.

Figure 25 and figure 26 show the extent of inundation on the northern end of Amelia Island under a scenario of six feet of rise, and these series of images demonstrate a drawback of the mapping procedure used in this project. The projections created in ARCGIS for this project do not delineate between areas of inundation and areas that are below sea level, but not hydrologically connected to the coast. These areas may experience issues with retaining water under certain conditions, but likely would not be inundated. The projections created in ARCGIS show areas of coastal inundation with a similar accuracy as the NOAA Sea Level Rise Viewer but are not as precise when it comes to areas of possible inundation in interior areas.

Because of the fort's proximity to the water and the coastal dynamics of the area, managers and stakeholders will be faced with the unfortunate fact that Fort Clinch will likely not be accessible by the end of the century.

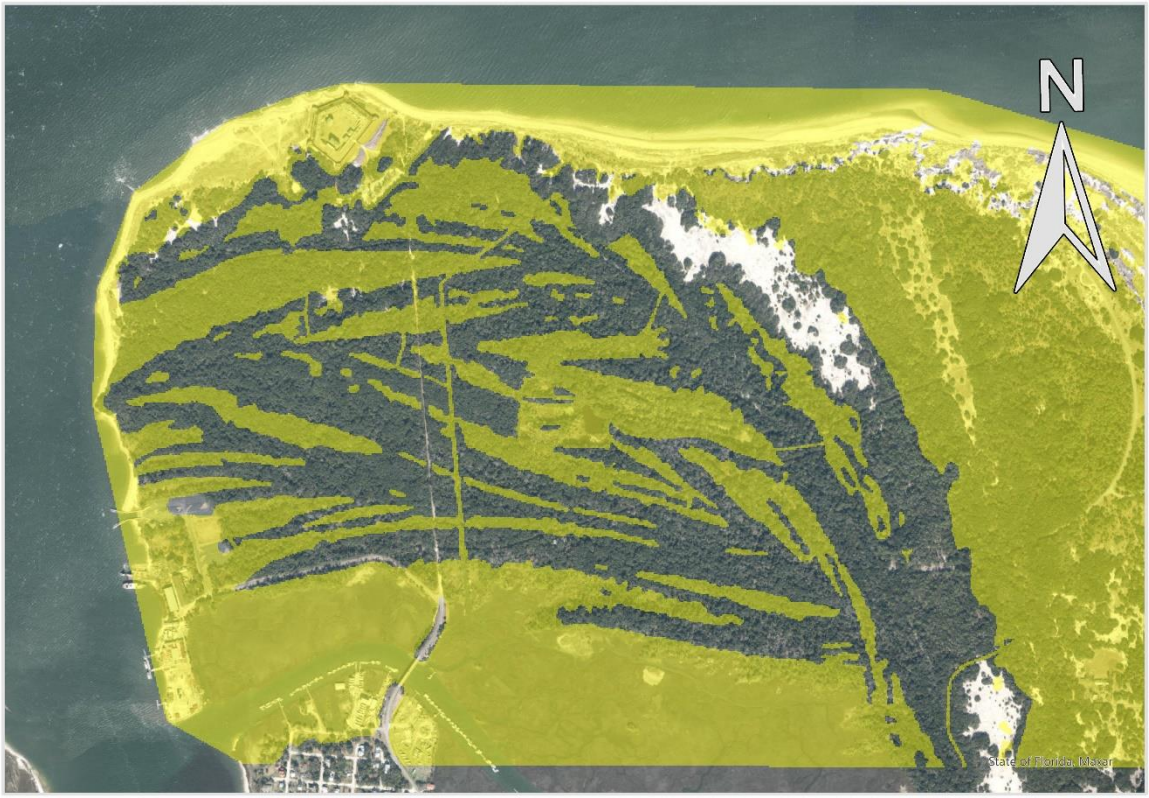

Figure 25: ARCGIS projection of 6-feet of sea level rise at Amelia Island. (Author's Map)

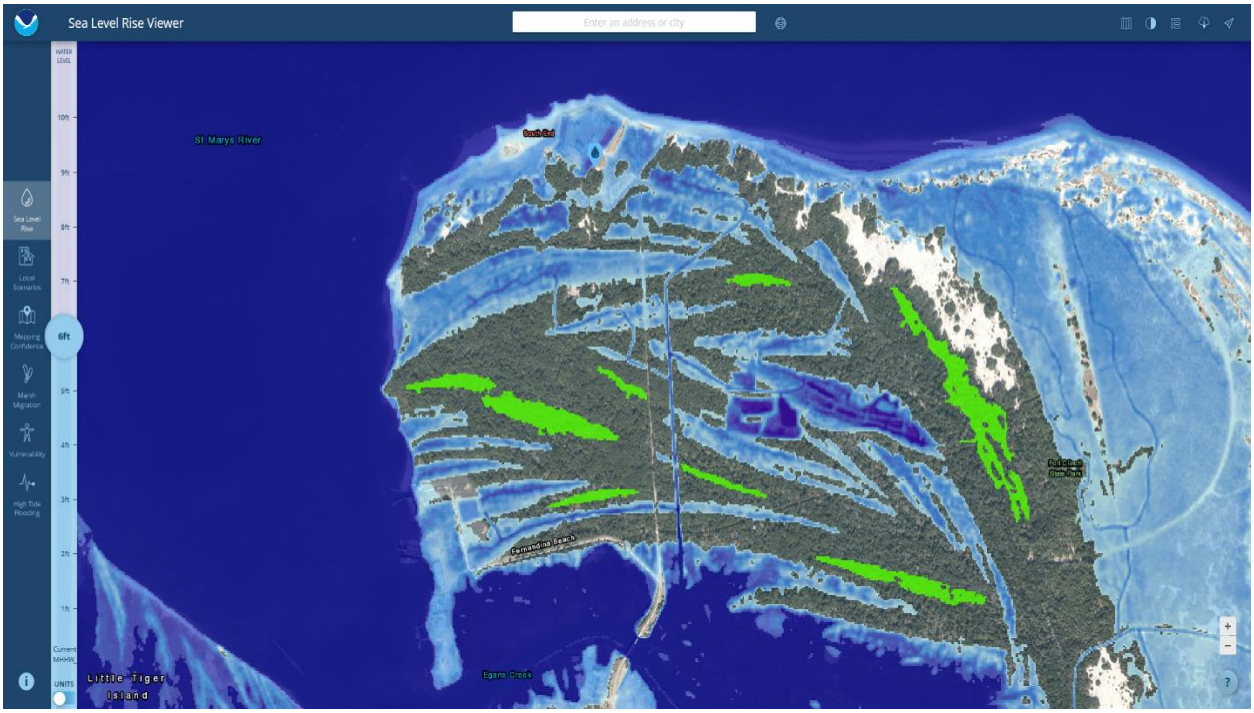

Figure 26: Projection of 6-feet of sea level rise at Amelia Island. (NOAA Sea Level Rise Viewer)

Mitigation/Adaptation projects

The highly dynamic, high-energy coastline around Fort Clinch limits the types of adaptation techniques that can be employed in the area. Some erosion prevention techniques have been employed in the Nassau Sound area between Amelia Island and Big Talbot Island but efforts to employ physical adaptation techniques on the northern end of the island have been few. In the original 1997 St. Mary's River Entrance Management Study, seven actions were identified which should be implemented to prevent critical erosion on Amelia Island. These seven actions were:

1. Continue to bypass suitable sediment to the downdrift beaches.
2. Restore the downdrift beaches, designated by the department as experiencing critical erosion, to mitigate the effects of the inlet.
3. Investigate the feasibility of constructing sand traps within the inlet interior and making modifications to the south jetty.

4. Restore the existing groin field and construct additional shore protection structures as necessary to protect Fort Clinch.
5. Investigate alternate means to recover suitable sandy maintenance material currently being placed offshore.
6. Develop an agreement between local, state, and federal governments to identify proponents for cost sharing to facilitate the bypassing and monitoring of maintenance material dredged from the entrance channel.
7. Implement a comprehensive beach and offshore monitoring program subject to the approval of the Department.[182]

While recommending restoration of the existing groin field adjacent to Ft. Clinch as well as additional coastal armoring as needed, the report also suggested working with the State of Georgia to remove the shoal that is building up behind the jetty on the north side of the inlet. This would help arrest the southern migration of the channel and take some of the coastal pressure off of Amelia Island.[183] To date, however, no such projects have taken place. As the shoal continues to build and push the entrance channel to the south, Ft. Clinch is being squeezed between a rock and a wet place, and eventually the narrow strip of beach that separates brick and sea will vanish. In all likelihood then, unless drastic action is taken to curb emissions and mitigate warming, Ft. Clinch will join other Florida forts like Ft. Dade and Ft. Jefferson as the last hold outs of a built environment, straddling that line between land and sea to serve as a reminder of the cultural landscapes that used to be there.

Recognizing the fate of sites like Ft. Clinch necessitates a reevaluation of what preservation means and how highly vulnerable sites can stay resilient. One of the National Parks Service suggested adaptation techniques is to document and interpret the change in the site for future generations.[184] This suggestion recognizes that strategies like armoring the shore and coastal

[182] Florida Department of Environmental Protection, Nassau Soil and Water Conservation District, "St. Mary's River Entrance Inlet Management Study and Implementation Plan," May 18, 1998.
[183] Ibid
[184] Rockman, et al. 2016

retreat are not going to be an option for every site that is critically threatened by climate change. Instead, managers and preservationists will have to explain to the public what the site was, what it meant, and what happened to it without having access to it. What does that look like at a place like Ft. Clinch? Technology will likely be the answer to keeping highly threatened sites resilient in the future. Laser scanning and 3d digital modeling can allow preservationists to create highly accurate 3d models of sites, allowing them to be preserved digitally. This kind of technology is already being employed at sites that are threatened by erosion and encroaching development.[185] Video game and virtual reality software can be employed to create immersive experiences that allow users to explore sites in a virtual environment. Software companies have released software allowing for the creation of 3D environments from various inputs and recently, a Louisiana organization called VR Preservation, which began as a student project at LSU-Ogden, has digitally preserved thirty-five cultural heritage sites, mapping roughly 400,000 square feet of area and creating virtual reality walk-throughs for the public to explore.[186] These types of technologies will play a prominent role in the future of historic preservation, particularly for sites like Fort Clinch. A companion website with additional images can be found at www.floridaslr.com.

[185] For examples, see work done at various sites in Florida by ChronoPoints (https://chronopoints.eecs.ucf.edu/portfolio/) and the Florida Public Archaeology Network (FPAN) (https://www.fpan.us/fpan-projects/). Sandra Averhart, "Laser Scanning may be Key to Preserving Threatened Archaeological Sites," WUWF.ord, Nov. 11, 2021. https://www.wuwf.org/local-news/2021-11-11/laser-scanning-may-be-key-to-preserving-threatened-archaeological-sites

[186] "Interactive Tours," Vrpreservation.org, https://vrpreservation.org/interactive-tours/; Matthew Marani, "New Virtual Reality Program Could Transform Historic Preservation," *The Architect's Newspaper, Nov. 19, 2018,* https://www.archpaper.com/2018/11/imverse-livemaker-virtual-reality/

CHAPTER SIX: CONCLUSION

Cultural heritage adaptation is an emerging field, and this can make it more difficult for managers at cultural heritage sites to plan for the future. Adaptation techniques are constantly being developed and refined, potentially making it complex for managers, already busy normal site operations, to keep up with emerging techniques that may be helpful at their site. Combined with the fact that future climate change models are constantly being updated to reflect new data and new climate predictions, managers are left to plan for resiliency in the face of climate change based on techniques, data and circumstances that are in flux. The IPCC and other scientific bodies continue to update future levels of sea level rise as new data is collected. Currently the planet is warming at a rate that is unprecedented in human history. The planet has not seen rates of warming like this in more than 10,000 years.[187] The increasing rates of warming and melting make it tough for managers to be confident in the planning decisions they make for the future.

An additional challenge to adaptation, particularly coastal adaptation, is the individuality of each site. Planning at coastal sites is more difficult because each site has its own unique hydrology that presents unique challenges and opportunities for planning and adaptation. The original intent of this project was to provide managers and planners at coastal cultural heritage sites a framework with which to evaluate their own sites, understand the challenges of adapting their site, and demonstrate their understanding of adaptation techniques in hopes of improving their chances of receiving funding to do more in-depth evaluations of their site and implement adaptation techniques. Because of the unique hydrology of the study sites, this is more difficult than originally envisioned. Jupiter Inlet Lighthouse and Fort Clinch may seem like as though

[187] "How Do We Know Climate Change is Real?," *Global Climate Change – Vital Signs of the Planet*, NASA, https://climate.nasa.gov/evidence/, Updated: Jan. 25, 2023

they occupy similar sites; both are located on an inlet on Florida's Atlantic coast, both are located adjacent to Florida's Intercoastal Waterway, and both experience a conventional tidal transition with two low tides and two high tides throughout the day. In terms of potential adaptation techniques that may be useful, each of these sites is far different. Amelia Island has more than six feet of tidal change from Mean Lower Low Water (MLLW) to Mean Higher High Water (MHHW), whereas Jupiter Inlet experiences less than two feet of change.[188] The higher rate of tidal change at Fort Clinch makes for much higher energy in the coastal system than at Jupiter Inlet. Faster flowing, higher volume water moving around Amelia Island make nature-based adaptation solutions such as living shorelines much less likely because of the significant infrastructure that would be required to protect and sustain the sand and vegetation planted during construction of a living shoreline. In addition, Fort Clinch has to contend with the King's Bay submarine trench just off the northern shore of Amelia Island. This trench creates a channel of deeper, faster moving water just offshore which has the effect of stripping sand from the Island's norther shore. Because of the exceedingly long jetty on the northern side of the St. Mary's River, this sand cannot be replenished, creating an erosion situation that will likely become untenable in the future. Currently the northern and eastern shores of Amelia Island are sustained through yearly dredging operations which serve to both keep the mouth of the St Mary's Inlet and the submarine trench clear of sediment, as well as replenish sand lost from the island. As seas rise in the future and move closer to the fort, there is the distinct possibility that there will not be enough beach between the fort and the water for beach replenishment to be successful.

[188] "Tides & Currents – 8722495 Jupiter Inlet, FL," NOAA, https://tidesandcurrents.noaa.gov/noaatidepredictions.html?id=8722495; "Tides & Currents – 8720030 Fernandina Beach, FL," NOAA, https://tidesandcurrents.noaa.gov/noaatidepredictions.html?id=8720030

These significant differences in coastal dynamics mean that planning for future adaptation is a process that is individual to each site. Adaptation planning, then, comes down to two factors. The first is understanding the vulnerabilities of the site. At these particular sites, sea level rise modeling is useful in identifying the lowest lying areas of a particular site. Typically, these areas are the areas that are most vulnerable to erosion, overtopping during storm surge events, and future inundation from sea level rise. Additionally, these areas may experience periodic nuisance flooding, such as during king tide events, depending on the tidal dynamics of the area.

After understanding the vulnerabilities of the site, the second factor is to understand the types of adaptation techniques that might be useful at the site. This is more difficult to determine without understanding the coastal dynamics of the area. As is the case with Fort Clinch versus Jupiter Inlet Lighthouse, even at similarly located sites, the adaptation techniques that are useful at one site may differ vastly from those at another site. To understand the coastal dynamics of a site for preliminary assessment, consulting with professionals who are familiar with the coastal dynamics of the area can give insight into how successful a particular adaptation technique may be at a given site. For this project, Dan Pearson was an invaluable source of information regarding the coastal dynamics of the Amelia Island area. His knowledge and insight were key to understanding why living shoreline techniques like those used at Jupiter Inlet would not be feasible. Mr. Pearson, however, is not in the hydrological or coastal engineering field, but is rather a wildlife biologist who studies shore nesting birds. His research into the nesting patterns of these birds in the Amelia Island and Big Talbot Island areas has given him vast knowledge about the coastal dynamics of the area, but his knowledge is only being put to use in his role as a biologist. This knowledge would be of great use in adaptation planning.

Rather than searching out individual experts that are familiar with the coastal dynamics of the site, it may be more beneficial for cultural heritage sites to partner with other organizations that can help plan and fund adaptation projects. In the case of the living shoreline project completed at Jupiter Inlet Lighthouse, the Loxahatchee River Historical Society partnered with the Bureau of Land Management and the local municipal district, the Jupiter Inlet District to complete the project. These kinds of collaborative partnerships can be invaluable across communities and can particularly benefit cultural heritage sites that are searching for funding. NOAA has initiated a program called Climate Adaptation Partnerships which is intended to build a network of collaborative partnerships between climate researchers and community decision makers. The Climate Adaptation Partnerships program hinges on the idea that, "climate adaptation and resilience is facilitated by and sustained across a wide range of experts, practitioners, and the public," reinforcing the interdisciplinary nature of climate adaptation.[189] Programs of this type offer a promising avenue for cultural heritage sites to participate in relationships with the community which can foster resilience at the site. The importance of community engagement is evident in the case of Jupiter Inlet Lighthouse. The lighthouse is a feature of the community that is a point of pride, and because of its location, is highly visible in the community. In contrast, Fort Clinch is located at the northern end of Fort Clinch State Park, far removed from the surrounding communities on Amelia Island. In part because of this, there is not the same kind of engagement between the local communities and management at the fort. At Jupiter Inlet that cooperation between site managers and the local community and municipal

[189] "Climate Adaptation Partnerships Program – Formerly Known as the Regional Integrated Sciences and Assessments (RISA) Program," NOAA Climate Program Office, https://cpo.noaa.gov/Divisions-Programs/Climate-and-Societal-Interactions/CAP-RISA

district has created a relationship climate adaptation can be planned for, funded, and implemented in a way that engages site stakeholders at multiple levels.

Ultimately, it would be beneficial to coastal cultural heritage sites, as well as their surrounding communities, if an organized source of information regarding coastal dynamics was publicly available. Through the Florida Department of Environmental Protection, the Florida Resilient Coastlines program is designed to help communities with adaptation projects. This program provides tools to communities to evaluate the vulnerabilities of the community and points communities towards funding options that may be available to them. This project recommends the creation of a database that categorizes coastal regions in Florida based on the energy level of the area and suggests adaptation strategies that might be appropriate for the area. To create a database of this nature, the entirety of the state's coastline will have to be evaluated to determine which areas would be classified as having high, medium, or low energy systems. More research will have to be conducted to determine what would constitute high, medium, and low-energy systems. Based on these classifications, appropriate adaptation solutions can be suggested for each type of energy system. This type of database would be a valuable tool for adaptation planning from the level of the individual site up to the regional level.

The lack of available coastal dynamics data is a symptom of the larger problem with climate change planning, both at the state and federal level. In general, in the United States there is little cohesion between governments and organizations across all levels in terms of information sharing about adaptation planning. Much of the climate change focus on the part of the federal government has been on planning for relatively short-term mitigation goals and, while departments within the government have been required to adopt adaptation plans, there is no national adaptation plan and no mechanism for adaptation related data to be shared across

departments or with other government entities at the state and local levels. This is true at the state level as well. In Florida, most of the initiative in terms of climate adaptation planning is happening at the local and regional levels. Still, there is no guidance from the state or federal government for how these regional planning committees should approach planning for climate change. For truly effective adaptation planning, action needs to be taken at the state and federal levels to make accurate climate data and other resources available for planners at all levels of government, down to site level management so that sensible, effective adaptation approaches can be implemented across all regions of the country.

Jupiter Inlet Lighthouse

In terms of adaptation and resilience, Jupiter Inlet Lighthouse is in a good position. The lighthouse itself is much higher in elevation than the surrounding land, and under current models, is in no danger of inundation in the 21st century. Presently the site is much more vulnerable to coastal erosion on its southern and eastern shores than it is to inundation from sea level rise. As the planet continues to warm however, sea level rise, increasing strength of storms, and storm surge will exacerbate the erosion issues being experienced at Jupiter Inlet Lighthouse and the surrounding ONA. As these factors worsen, additional physical adaptation projects may have to be undertaken, but it is likely that the Jupiter Inlet Lighthouse ONA will remain resilient and active through the remainder of the twenty first century and beyond. With the lighthouse being more than 40 feet above sea level, sitting well above the surrounding support facilities, the main attraction, so to speak, will likely stay safe from sea level rise and storm surge, while the lower lying facilities will have the opportunity to employ a number of physical adaptation techniques. These techniques could include nature-based solutions such as more extensive living shoreline projects, similar to what they are doing now, coastal armoring in the form of sea walls, and even

coastal retreat to the higher elevation of the site's interior for support facilities such as the museum and administrative offices.

Fort Clinch

Fort Clinch is more of a challenge in terms of physical climate change adaptation and may, in the future, become one of those sites that confront the very meanings of resilience and preservation. As previously mentioned, Fort Clinch's proximity to the coastline and the unique challenges, both natural and anthropogenic, the site faces make long term physical adaptation at the site unlikely. As seas rise throughout the remainder of the century, the erosion problem along the shoreline in front of Fort Clinch will continue to worsen, and the hightide mark will creep ever closer to the northern wall of the fort. In this event, direct exposure to sea water, storms, and continued erosion may eventually lead to partial collapse of the northern wall, similar to what has transpired at other sites, such as the batteries of Fort Dade on Egmont Key.[190]

Because of the high energy of the coastal system, traditional natural-based solutions like those being implemented at Jupiter Inlet Lighthouse are not feasible along Amelia Island's shoreline. Projects are currently underway to find nature-based adaptation solutions that would be effective in high energy coastal systems, but full-scale implementation of such techniques has not yet come to fruition. Some projects are showing particular promise, however. The Coastbusters project is a collaboration between numerous international companies involved in dredging, land reclamation, and coastal stabilization. The goal of the project is to ultimately develop nature-based adaptation solutions, particularly in high energy coastal systems, based on the use of mussels and oysters to create biogenic mussel reefs. The initial phase of the project

[190] Geoffrey Mohlman, "An Island Fortress: Egmont Key's Fort Dade," *Sunland Tribune* 23, no. 7 (1997). https://digitalcommons.usf.edu/cgi/viewcontent.cgi?article=1303&context=sunlandtribune

was able to generate substantial mussel reefs over two seasons as proof of concept. The second phase of the project, Coastbusters 2.0, designed to test the construction and effects of biogenic mussel beds is currently underway.[191] These private industry projects are pointing the way towards solutions for physical adaptation in difficult environments, but it remains to be seen if solutions of this type will be effective at sites like Fort Clinch.

While physical adaptation may be more challenging, there remains a number of adaptation solutions available to managers at Fort Clinch. High resolution photography, digital modeling, and virtual reality all offer alternatives to the traditional concepts of preservation and resilience. As we progress through the remainder of the twenty-first century and cultural heritage sites are affected in more and more dramatic ways, historic preservationists and site managers will have to recognize that preservation in the physical form such as what is likely at Jupiter Inlet Lighthouse will not be the solution for every site and digital preservation should be leaned on more heavily at sites which are under direct threat. This again reiterates the interdisciplinary nature of future cultural heritage adaptation. Because cultural heritage is so important to identity and community building, and because the physical representations of that cultural are important parts of how cultural heritage is passed to new generations and new members of the community, it will be essential that historians, preservationists, and managers work together to not only protect sites as well as possible, but also provide the public with an interpretation of the site that takes into account climate change and the events that led to the loss of those physical reminders. In this way, sites that are highly threatened by climate change, and those that have succumbed to

[191] "Coastbusters 2.0: Combatting Coastal Erosion by Cleverly Constructed Mussel Beds," Compendium, http://www.compendiumkustenzee.be/en/coastbusters-20-combatting-coastal-erosion-cleverly-constructed-mussel-beds; Thibaud Mascart, Tomas Sterckx, Sophie Delerue-Ricard, Jan Fordeyn, & Marc Huygens, "Coastbusters: A Nature-Based Solutions Coastal Management Alternative," Terra et Aqua 163, (Summer, 2021), https://www.iadc-dredging.com/article/coastbusters-nature-based-solutions-coastal/

the effects of these changes can stay relevant and experience a kind of digital resiliency that allows future generations to benefit from the site.

For heritage managers planning for the protection of their site in the future, the NPS Cultural Resources Climate Change Strategy lays out a framework for how to approach adaptation at cultural heritage sites in a variety of climates. The Climate Change Strategy is designed to give an overview of how climate change is affecting a variety of cultural heritage sites while the Adaptation Options section of the strategy is designed to provide a general plan of action for sites ranging in vulnerability from unthreatened to highly vulnerable.

The first two adaptation options discussed, No Active Intervention and Offset Stress are intended for use at low vulnerability sites that are not being actively threatened by climate change. Jupiter Inlet Lighthouse falls into this category. The lighthouse is in an area of low vulnerability and does not require extensive physical intervention to stay safe from climate change. Taking no active intervention is an approach that NPS describes as appropriate for sites that require no interventions because of low vulnerability and for sites where no other action can be taken due to challenges such as economic constraints or lack of physical adaptability. In reality, taking no intervention in this situation is likely not the appropriate response. As will be discussed later, even in situations where there is no chance of physically preserving a site, there will still be opportunities to document and interpret the changes in the site for future generations.

The goal of the Offset Stress adaptation option is to "enhance survival while minimizing physical or material changes to the resource."[192] The living shoreline being employed at Jupiter Inlet Lighthouse stabilizes the shoreline and helps to prevent erosion but is not as invasive as

[192] Rockman et al., 2016

coastal armoring. This adaptation option is for coastal sites that currently have vulnerabilities similar to JIL, low impact adaptation options can help to offset current effects of climate change and prepare the site for more intensive adaptation solutions in the future, should they be needed.

Adaptation options three and four, Improve Resilience/Resistance and Manage Change, are positioned as intermediate options for sites that are vulnerable to climate change and may require more substantial intervention to ensure future resiliency. Improving resiliency and managing change are broad terms and can mean many things. Adaptation strategies in these categories can range from elevating and making structural improvements to buildings to changes in landscape management to ensure the existence of cultural landscapes with new types of foliage even if the original species of flora are no longer viable in that climate. It is important to recognize as climate change progresses throughout the remainder of this century and beyond cultural heritage sites will have to employ numerous adaptation solutions as pressure from climate change increases on the site. These two categories will encompass the broadest range of cultural heritage sites around the world. The majority of sites around the world will require some kind of significant intervention that may in some part change the character of the site itself. The focus of these strategies is to ensure the longevity of the site even if the area is diminished in some way. For coastal heritage sites, sea walls and other types of coastal armoring may impact views of both the built environment and cultural landscapes, but emphasis is placed on making them as resilient as possible.

Adaptation solutions in these categories will be effective in many communities and at many heritage sites around the world, but implementation of these solutions can often be controversial in the communities for which they are proposed. As was the case with the Miami Back Bay project proposal presented to the city by ACOE, communities and individual sites will

have to balance the potential future benefits hard adaptation solutions such as sea walls with the impacts of implementing those solutions. Putting these plans into action can often require compromises that can reduce the efficacy of adaptation solutions, highlighting the importance of periodically reevaluating the risks and vulnerabilities to a site and considering updated adaptation solutions as circumstances at the site change.

One of the aspects of the Cultural Resources Climate Change Strategy that makes it effective is that it recognizes that not all cultural heritage sites that are threatened by climate change will be protected from loss. At some point in the future heritage sites in a variety of climates will become untenable and difficult decisions will have to be made about the future of these sites. Coastal heritage sites like Fort Clinch, threatened by sea level rise and coastal erosion and limited by a variety of factors in terms of adaptation solutions, will eventually face the choice of either retreating from the coast of accepting the loss heritage resource.

Retreating from the coast is plausible for heritage resources such as museum collections that are not tied to a particular building or landscape, but in terms of the built environment, retreat can be a difficult prospect. With retreat being such a large undertaking in terms of funding and logistics, many resources that could potentially be moved will likely be deemed financially infeasible. When states and communities are deciding if and how to protect cultural resources it is important, they have a full understanding of the contributions these resources bring to the table. This includes not only the monetary contributions in the form of tourism dollars and employment, but also current use of the site. Take for example the Cape Hatteras Light Station, which was moved inland to avoid inundation and erosion. While moving the entire light house intact was a monumental undertaking, retreating from the coast was considered a reasonable adaptation technique because of the lighthouse's contributions not only in terms of cultural

heritage, but also in terms of its usefulness as an active navigation beacon. Sites like Fort Clinch, which provide value to the community in terms of tourism dollars and as a symbol of built heritage, may find they are considered for adaptation funding only after adaptation solutions have been applied to more valuable sites.

The final two adaptation options laid out by NPS are Document and Prepare for Loss and Interpret the Change, and these two options should be approached as two halves of a single adaptation solution. Preservationists and heritage site managers, upon determining that it will not be feasible to physically save their site, should document the condition of the site and prepare for the resource to be physically lost to the effects of climate change. As this occurs, interpreting this change for future generations will be necessary to give context to the loss of the resource. This is particularly important for sites that are physically being lost to climate change, but interpretation of the effects of these changes should be considered for any site that has had to employ any adaptation solution. Documentation and interpretation of the changes occurring can take many forms and will be highly specific to each site.

As previously mentioned, in much of the United States there is generally poor connection between cultural heritage resources and emergency management planning at the state level. In Florida, emergency management planning and cultural heritage resources have a stronger connection than in many states, but as climate change continues and weather-related disasters increase in both frequency and intensity the pressure on emergency funding sources will increase. In this scenario cultural heritage resources may find increasing competition for funding and less consideration during planning at the state and local level.

This presents an opportunity for cultural heritage managers and public historians to both interpret the changes occurring and enter into discussion with communities about the meaning

and importance of cultural heritage resources. In planning for climate change communities must understand what a particular cultural heritage site means in terms of identity and heritage and how to come to terms with the sense of loss that might be felt if those resources were to vanish due to climate change. The loss of coastal heritage sites is something that communities around the world are going to have to deal with as sea level rise stretches into the twenty-second century. As those changes in the landscape happen and as heritage sites are damaged or destroyed by the effects of climate change, it will be more important than ever for historians to give context to the changes. Historians will have the duty of not only providing context for both to the changes that have occurred in the landscape and the circumstances that led to changes in the climate, but also looking into the past and interpreting the deeper history of the site and how humans have approached past changes in the climate. By taking this approach, historians can both contribute to the public having a better understanding of how climate change is affecting the world around them and the significance of the changes, but also improve future climate change modeling by providing context for how humans might react to particular climate situations.

In Florida, many sites around the state are already feeling the pressure of climate change. Numerous sites in and around St. Augustine have been damaged in recent years by unprecedented levels of storm surge and an increasing number of king tide flooding events. Sites in Miami and the Everglades face similar challenges. At the mouth of Tampa Bay, Egmont Key is shrinking and may disappear before the end of the century. And Fort Clinch with face increasing challenges as the effort to replenish the shoreline and prevent the high energy waters of the St. Mary's Inlet from consuming northern Amelia Island continue.

Recent weather events make it clear that the effects of climate change are being felt now. Recently, in what some climate experts are referring to as a thousand-year rain event, Fort

Lauderdale received more than two feet of rain in a single day, flooding large portions of the city and shutting down Fort Lauderdale International Airport for several days.[193] Weather events like this combined with storm drainage systems already swollen by rising seas threaten entire communities, including cultural heritage resources important to those communities. This will be a continuing reality for coastal communities in Florida. Recent studies indicate that sea level rise around the southeast United States is occurring at a higher rate than climate scientists previously thought.[194] As this trend continues, it will be critically important for site managers to stay abreast of updates in climate change models and work with professionals from a variety of professions in the adaptation sector to make sure their sites are adequately protected.

Still, hard decisions will have to be made in the coming years. Cultural heritage sites will have to compete with the rest of the community for adaptation funding, and in coastal communities there will likely be many stakeholders seeking a piece of that funding pie. Some sites may be too small to garner enough attention for focused adaptation and, without support, succumb to the pressures of climate change and the inability to adapt. Untold numbers of small-scale cultural heritage and archaeological worksites around the world will suffer this fate even under moderate sea level rise scenarios. If, however, the planet experiences a worst-case scenario in which warming causes a significant level of Antarctic melting there will be no chance of physically saving many low-lying sites. In a scenario of this type, in which we see 6-7 feet of sea level rise over the next ninety years, sites like Fort Clinch will be a total loss in the physical sense. That does not have to be the end of the story for cultural heritage resources though. By

[193] Alisha Ebrahimji, Joe Sutton, Travis Caldwell, & Jennifer Gray, "Fort Lauderdale Airport to Remain Closed Until Friday Morning After the Rainiest Day in the City's History Causes Severe Flooding, CNN, April 14, 2023, https://www.cnn.com/2023/04/12/weather/florida-flash-flood-fort-lauderdale/index.html

[194] Chris Mooney & Brady Dennis, "Seas Have Drastically Risen Along Southern U.S. Coast in Past Decade," The Washington Post, April 10, 2023 https://www.washingtonpost.com/climate-environment/2023/04/10/sea-level-rise-southern-us/

understanding the vulnerabilities and adaptation requirements of their site, well informed adaptation planning, and reinterpretation of the site to include climate change in its history, heritage managers and public historians can ensure the sense of meaning and importance that cultural heritage resources bring to a community can be preserved for future generations.

APPENDIX A:
PROJECT METHOD FOR MAPPING SEA LEVEL RISE INUNDATION

Appendix A: Project Method for Mapping Sea Level Rise Inundation

Introduction

The goal of the mapping process for this project is to provide an approachable path to creating sea level rise models for specific sites that coastal site managers can follow to model potential future sea level rise at their own sites. It is important for managers to not only be aware of their site's potential vulnerability to sea level rise, but also to take a hands-on approach to understanding why these vulnerabilities exist and what, in terms of adaptation, can be done to make the site more resilient. According to NPS's Cultural Resources Climate Change Strategy, the first step in determining the vulnerability of a site is pair current climate projections with a landscape scale vulnerability assessment to determine which areas of the site should be inventoried and further evaluated.[195] Full-scale, professional vulnerability assessments can be cost prohibitive for many cultural heritage sites. Managers who can take a hands-on approach to doing initial climate modelling on their own may find that, in addition to understanding the topography and vulnerabilities of their site, the modelling can help increase the chances of receiving grant funding for further vulnerability assessments.

The mapping process can be described as a simplified modified bathtub model based on a modified version of the mapping process laid out by the National Oceanographic and Atmospheric Administration (NOAA). This model attempts to account for local tidal variation but does not account for hydrological connectivity.

Numerous studies with a similar design have been conducted for various regions throughout the world. These various studies have utilized both high resolution lidar elevation

[195] Rockman et al., 2016, p.27

maps as well as courser maps that do not show as much detail. While lidar maps are the most useful for studying vulnerability of cities or neighborhoods, courser maps can be useful for studying the vulnerability of large areas where high levels of detail are not necessary. For example, the definitive study of U.S. coastal vulnerability performed by Titus and Richman in 2001, utilized U.S. Geological Surveys with a scale of 1:250,000. While the authors do recognize the downfalls of using such data, the study is often cited when discussing coastal vulnerability in the United States.[196]

For examples in other parts of the world one can look to studies conducted in the United States, Europe, and India to assess the SLR vulnerability of various coastal areas. For examples from Europe see studies conducted by Sterr in Germany and Crapoulet et al. in France. Examples from the United States include studies conducted by Gesch on a local scale in Mobile Bay, Alabama and Titus and Richman conducted on a large scale in the southeastern United States.[197]

Goals of Mapping

- Use the best publicly available and accessible elevation data
- Map levels of sea level rise that coincides with current literature
- Map sea level rise corrected for mean higher high water (MHHW)

[196] Titus, James G., and Charlie Richman. "Maps of Lands Vulnerable to Sea Level Rise: Modeled Elevations along the US Atlantic and Gulf Coasts." Climate Research 18, no. 3 (2001): 205-28. http://www.jstor.org/stable/24866758

[197] See Usha Natesan, and Anitha Parthasarathy. "The Potential Impacts of Sea Level Rise along the Coastal Zone of Kanyakumari District in Tamilnadu, India." *Journal of Coastal Conservation* 14, no. 3 (2010): 207-14. http://www.jstor.org/stable/40928192.; K. Nageswara Rao, P. Subraelu, T. Venkateswara Rao, B. Hema Malini, R. Ratheesh, S. Bhattacharya, A. S. Rajawat, and Ajai. "Sea-Level Rise and Coastal Vulnerability: An Assessment of Andhra Pradesh Coast, India through Remote Sensing and GIS." *Journal of Coastal Conservation* 12, no. 4 (2008): 195-207. http://www.jstor.org/stable/40301489.; Dean B. Gesch, "Consideration of Vertical Uncertainty in Elevation-Based Sea-Level Rise Assessments: Mobile Bay, Alabama Case Study." *Journal of Coastal Research*, 2013, 197-210. http://www.jstor.org/stable/23486513; Crapoulet et al., 2016; Horst Sterr, "Assessment of Vulnerability and Adaptation to Sea-Level Rise for the Coastal Zone of Germany." *Journal of Coastal Research* 24, no. 2 (2008): 380-93. http://www.jstor.org/stable/30137843.; Titus & Richman, 2001

Mapping Limitations

This project has several limitations associated with the mapping process. By their nature, modified bathtub models do not account for the unique hydrology of the mapped area. Ditches and culverts are not taken into account which results in areas which are not hydrologically connected being marked with inundation. Interior areas of the study area will have to be evaluated for hydrological connectivity.

Additionally, this map assumes that present conditions will continue and does not take into account future changes in geomorphology. Erosion and future coastal adaptation measures will affect the coastline throughout the century. Study areas will have to be periodically reevaluated in the future. The sea level rise modeling in this project will be useful for future planning, but is not intended for high-resolution site-level analysis. Further analysis including hydrological analysis and pipe network analysis would be required for a complete evaluation of the study area.

Tidal Datum

Mapping for this project is corrected to MHHW to represent the extent of possible inundation at the higher of the two daily high tides. The NOAA process describes creating a tidal surface in ArcMap on top of which sea level rise can be modeled. To simplify the mapping process and make it more approachable, a tidal surface was not used in this project. To account for local tidal variations an elevation correction factor was determined based on the difference in elevation between the elevation datum used in the original contour mapping and MHHW. The elevation datum used in the contour maps of Palm Beach and Nassau counties was North American Vertical Datum of 1988 (NAVD88). Using tide gauge data from NOAA, available at

http://tidesandcurrents.noaa.gov, vertical datum correction factors were determined. For the area around Fort Clinch tide data was gathered from the water level gauge at Fernandina Beach, FL. At this gauge MHHW is 2.74ft above NAVD88.[198] For Jupiter Inlet Lighthouse tide data was gathered from the gauge at Lake Worth Pier, the nearest water level gauge available. At this tide gauge MHHW is .55ft above NAVD88.[199] These correction factors of 2.74 and .55 were used to create layers in ArcMap which correspond to local MHHW for each of the study areas. A more detailed methodology for mapping as described by NOAA can be found at https://coast.noaa.gov/data/digitalcoast/pdf/slr-inundation-methods.pdf.

Detailed Mapping Process

This mapping process is based on ESRI's ArcGIS software.

Inputs

- Digital elevation model
- Sea level rise values

Process

1. Add Elevation Data

   Map tab > Add Data

   - Add data from database housing contour maps
2. Clip Contour Map to Study Area

[198] "Tides & Currents – 8720030 Fernandina Beach, FL," NOAA, https://tidesandcurrents.noaa.gov/noaatidepredictions.html?id=8720030
[199] "Tides & Currents – 8722495 Jupiter Inlet, FL," NOAA, https://tidesandcurrents.noaa.gov/noaatidepredictions.html?id=8722495

Catalog > Databases > File Name > Right Click > New > Create Feature Class

- Add Feature Class polygon. Edit

Edit Tab > Create > Select Feature Class > Select Polygon Tool

- Create polygon that encompasses the study area.
- Under Environments Tab – select output coordinate system as contour file.

Toolboxes > Analysis Tools > Extract > Clip

- Input Feature or Dataset = contour map file.
- Clip Features = study area polygon
- Output Features or Dataset = name of the new clipped contour file.
- Under Environments Tab – select output coordinate system as contour file.

3. Create TIN file

Toolboxes > 3D Analyst Tools > TIN Dataset > Create TIN

- Output TIN = save file name of new TIN
- Coordinate System = contour map file
- Input Features = study area clip file
- Height = Contour_El (elevation)
- Type = Hard_Line
- Tag Field = None
- Under Environments Tab – select output coordinate system as contour file.

4. Create Raster

Toolboxes > 3D Analyst Tools > TIN Dataset > Conversion > TIN to Raster

- Input TIN = TIN created in last step
- Output Raster = Name of new Raster File
- Output Data type = Floating Point
- Method = Linear
- Sampling Distance = Cell Size
- Sampling Value = 1
- Z-Factor = 1
- Under Environments Tab – select output coordinate system as contour file.

5. Sea Level Rise Layers

   Toolboxes > Spatial Analysis > Math > Logical > Less Than Equal

- Input Raster or Constant Value 1 = Raster from last step
- Input Raster or Constant Value 2 = height of rise using vertical datum conversion factor for MHHW.[200]
- Output Raster = name sea level rise layer
- Repeat Less Than Equal for each increment of desired[201]

[200] Vertical datum conversion factor used to determine MHHW. Add layers for incremental rise as desired. Ex. 2.74 = MHHW, 3.74 = MHHW + 1-foot, 4.74 = MHHW + 2-feet, etc.
[201] This project modeled sea level rise in 1-foot increments from MHHW to 6-feet of rise.

APPENDIX B: NATIONAL PARK SERIVCE ADAPTAION STRATEGIES

Appendix B: National Park Service Adaptation Strategies

In its 2016 Cultural Resources Climate Change Strategy, the National Park Service addresses climate change and the major actions that can be taken at cultural heritage sites to improve the chances of the site staying relevant and resilient in the face of future climate change. The four major goals of this strategy are to connect climate impacts and information, understand the scope of the issue, integrate practice, and to learn and share data. As part of this strategy, NPS developed seven broad approaches to climate change adaptation that can be employed at cultural heritage sites managed by NPS, as well as other sites around the country. Below is the full text, with examples, of the adaptation approaches as laid out in the Cultural Resources Climate Change Strategy.

"1. No Active Intervention

Taking no action is a decision. This may be an appropriate decision in situations of low vulnerability (no action warranted) or when, due to one or more of a range of constraints, including lack of technological or economic feasibility, no action can be taken. This decision may include assessment of the need for monitoring of resource condition, with a plan to revisit a no-action decision at a future point in time.

2. Offset Stress

Removing or deflecting stress is one or more actions taken at some distance from the resource to reduce or remove the environmental or other force(s) acting on the resource. The goal of this option is to enhance survival while minimizing physical or material changes to the resource. Constraints on this option are likely to include impacts of actions to surrounding resources, such as natural habitat or infrastructure.

Examples include: temporary measures such as sandbags or levee plugs; an offsite retaining wall, living shoreline, or engineered logjam to reduce shore erosion; upstream re-vegetation to reduce flood hazards, or changes in adjacent forest management to reduce wildfire risk.

3. Improve Resilience/Resistance

Improving resilience/resistance consists of one or more actions that change the nature and/or setting of a resource that are designed to make a resource better able to withstand or be recovered from environmental or other forces. The goal of this option is survival of the resource, despite possible impacts of actions on integrity of the resource, although this option does not necessarily mean the resource will be impaired.

Examples include: treatment of structural materials to better withstand increased moisture, wind, or an invasive species; elevation of a building to raise it above projected flood levels; addition of a cap over an archeological site; changes in landscape plantings or soil treatments; and alternate storage arrangement of museum materials.

4. Manage Change

Managing change is an action or set of actions that incorporate change into the form of the resource and/or into its management plan. The goal of this option is to maintain character-defining features of a resource, even if original specific materials or individual species are no longer part of the resource.

Examples include: change in tree species on cultural landscapes by removing an original species that has died and replacing it with a species that is healthy in that environment and will provide similar visual characteristics including shade and foliage conditions.

5. Relocate/ Facilitate Movement

Relocating/facilitating movement includes two types of action: (a) moving a resource, and (b) allowing movement to happen.

(a) Moving a resource is an action or set of actions to relocate all or a portion of a resource that cannot move on its own to a less vulnerable location.

Examples include: moving the Cape Hatteras Lighthouse inland from the coast. Another example is the temporary relocation of the NPS collections from Ellis Island following Hurricane Sandy to a facility in Maryland. Assisting with relocation of a human community to a safer location and assisted migration of a culturally important species to a refugium it would not have been able to reach on its own (for instance, salmon species to a new watershed) are also examples of this option. Movement is not feasible for some cultural resources such as cultural landscapes; in such instances movement may be an appropriate choice for components of a landscape once a decision has been made that the whole can no longer be saved.

(b) Allowing movement to happen involves action(s) either to enable movement or otherwise remove impediments to movement of living portions of resources to less vulnerable or more stable locations.

Examples include: allowing ecosystems such as a marsh or barrier island with cultural significance or which contains culturally significant species to migrate inland, or a given species

with cultural significance to shift ranges. Such shifts may move all or components of a resource outside of documented resource or park boundaries.

6. Document and Prepare for Loss

Any action modifying a resource includes appropriate documentation. "Document and Prepare for Loss" is a set of actions to record a resource and then subsequently allow the geographic location of the resource to undergo full effects of environmental or other forces that are likely to destroy or remove all or portions of the resource.

Documentation may be exhaustive, such as data recovery (full excavation) of an archeological site, or detailed recording of a building or structure or cultural landscape (such as HABS/HAER/HALS photographic, drawing, and laser scanning documentation, or a Cultural Landscape Inventory). Documentation also may be done at a less than exhaustive level. This may be appropriate when exhaustive approaches are infeasible (due to limitations in access, time, or financial constraints), not warranted (due to nature and scale of impacts), or there is merit in not recovering or preserving the whole of the resource (such as an archeological site may become inaccessible, but is not anticipated to be destroyed). This option differs from the data recovery in that it requires consideration and documentation of the sampling and preservation approach. Other examples of documentation techniques that may be used in either approach include collection of pollen and seeds or plant cuttings, and oral histories and video.

7. Interpret the Change

Climate change is the heritage of the future. Interpreting the Change is an action or set of actions that acknowledges and then serves to engage people in the future with the effects of climate change on a resource. This option may be used on its own or in combination with any of the other options.

Examples include: dramatic approaches such as preservation of a coastal resource such that its location and form remains either intact or otherwise visible from the coast once it is offshore or partially submerged. A hypothetical example would be Dry Tortugas National Park's Fort Jefferson encased in a large dome to protect it from rising seas and storm damage. Other examples include interpretive signage of freeze-thaw cracking in historic bricks, or photo series of changes in garden phenology or vegetation across a landscape. While interpretation may be developed across any of the adaptation options on this list, for this option, interpretation addresses not only preservation issues and history of the cultural resource, but also climate change itself, and seeks to tell the story of the place and climate change and how they are interacting."[202]

[202] Rockman, et al., 2016

APPENDIX C: SOURCES FOR LIST OF FIGURES

Appendix C: Sources for List of Figures

Figure 1 – Author's photo

Figure 2 – Map created by author using ARCGIS Pro

Figure 3 – Author's photo

Figure 4 – Image provided by Loxahatchee River Historical Society, courtesy of Josh Liller

Figure 5 – Map created by author using ARCGIS Pro

Figure 6 – Screenshot from NOAA Sea Level Rise Viewer

Figure 7 - Map created by author using ARCGIS Pro

Figure 8 - Map created by author using ARCGIS Pro

Figure 9 – NOAA

Figure 10 – Author's photo

Figure 11 - Map created by author using ARCGIS Pro

Figure 12 - Map created by author using ARCGIS Pro

Figure 13 - *Aerial view of Fort Clinch at the state park - Fernandina Beach, Florida.* 1970 (circa). State Archives of Florida, Florida Memory

Figure 14 - Map created by author using ARCGIS Pro

Figure 15 – Screenshot from Google Earth

Figure 16 – Image provided by Dan Pearson, Environmental Specialist with the Florida Department of Environmental Protection, Division of Recreation and Parks. Public domain.

Figure 17 – Screenshot from Google Earth/*Fort Clinch during restoration - Fernandina, Florida.* 1940 (circa). State Archives of Florida, Florida Memory. <https://www.floridamemory.com/items/show/149989>

Figure 18 - *Fort Clinch wall at half tide - Fernandina, Florida.* 1930. State Archives of Florida, Florida Memory. <https://www.floridamemory.com/items/show/140349>

Figure 19 – Screenshot from Google Earth

Figure 20 – U.S. Army Corp of Engineers, *Congressional Fact Sheet 2022 – King's Bay Entrance Channel (Navy O&M), Operations and Maintenance, Congressional District 4,* February 2022, https://www.saj.usace.army.mil/About/Congressional-Fact-Sheets-2022/Kings-Bay-Entrance-Channel-NAVY-O-M/

Figure 21 – Map created by author using ARCGIS Pro

Figure 22 – Author's photo

Figure 23 – Screenshot from NOAA Sea Level Rise Viewer

Figure 24 – Map created by author using ARCGIS Pro

Figure 25 – Map created by author using ARCGIS Pro

Figure 26 – Screenshot from NOAA Sea Level Rise Viewer

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