GIVING PRECEDENCE TO MARSH MIGRATION IN SEA LEVEL RISE PLANNING ON THE GEORGIA COAST

by

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(Under the Direction of Stephen Ramos)

ABSTRACT

Alignment by Georgia coastal communities of sea level rise adaptation plans with the National Flood Insurance Program may mitigate the impact of sea level rise on tidal marshes. Coastal communities and environments are particularly vulnerable to climate change due to the potential for permanent coastal inundation and increasing coastal hazards associated with changing weather patterns and extreme weather events. This thesis deals with sea level rise only and the impact of this phenomenon on the tidal marshes of Georgia. In addition to this particular environmental impact, increased sea levels will have significant medium to long-term social and economic impacts on the Georgia coast, in part due to coastal communities' dependence on ecosystem services provided by tidal marshes. As an integral part of a planned response to climate change, this thesis proposes adapting to long-term rising sea levels in a manner that minimizes the resulting social and economic costs associated with tidal marsh impacts. To this end this thesis proposes relocation from the coast as a sea level rise planning action to mitigate the disruption of sea level rise on the entire coastal system.

INDEX WORDS: Sea Level Rise, Tidal Marsh, Marsh Migration, Sea Level Rise Adaptation

GIVING PRECEDENCE TO MARSH MIGRATION BY RELOCATING DEVELOPMENT FROM THE GEORGIA COAST

by

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DEDICATION

This thesis is dedicated to my mother and father who encouraged me to live a life outdoors and to the friends and family who have supported me. This thesis is also dedicated to a giant sequoia, Sequoiadendron giganteum, located in Kings Canyon National Park to which I made a promise to preserve nature.

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CHAPTER 1

INTRODUCTION

In fifty years, the climate of the Georgia coast could be dramatically different from the present. Consequently the lifestyle, prosperity, comfort, and health of the region will depend on how astutely the region prepares and responds to future geographical changes. This process will require planning backwards from future scenarios based on the best available science and the needs most likely to be experienced by future generations who will inhabit the coastal region. Amongst these future needs, this thesis includes a tidal marsh ecologically, socially, and economically viable as essential to the quality of coastal life.

Sea level rise will reshape and alter coastal tidal marshes. In response to sea level rise, some tidal marshes will be inundated and consequently altered to lagoons. Other tidal marshes will adapt by rising in elevation vertically and keeping pace with sea level rise while others will adapt by retreating vertically and horizontally to present day upland. This thesis addresses the second adaptation, the vertical and horizontal retreat of tidal marshes to present day upland, a transition termed marsh migration. Tidal marshes provide a number of societal benefits or ecosystem services such as fish, wildlife, and plant habitat, flood attenuation, and recreational opportunities. This thesis supports the importance of sea level rise adaptation methods in the preservation of tidal marshes' continuance of ecologic, social, and economic services to communities on the coast and beyond.

Although this thesis recognizes the importance of climate change mitigation actions, it does not address specific actions such as the reduction of greenhouse gas emissions or more general actions such as the evolution to a more sustainable lifestyle. Instead this thesis concentrates on climate change adaptation actions, and more specifically sea level rise adaptation actions, the logic being that if society were to severely limit greenhouse gas emission immediately, global temperatures would nevertheless be expected to rise and climate change exacerbated given the atmospheric lifetime of greenhouse gases. Consequently climate change adaptation is necessary regardless of the scale and quality of mitigation undertaken. To the extent possible, this thesis assumes that adaption actions must not further complicate or enhance the impact of climate change.

Although we cannot know exactly what the future will hold in terms of climate change impacts as related to sea level rise and tidal marshes, we must work with current climate science to develop a general picture. This picture includes the alteration by rising seas of tidal threshold locations for tidal marshes and the inundation of a large percentage of tidal marshes, to the degree that some tidal marshes of the U.S. coast will be so often inundated that they will no longer be able to thrive.[1] Because one third of the tidal marshes along the Atlantic coast of the U.S. are located on Georgia's coast, the fate of the Georgia tidal marshes has ramifications not just on a regional but also on state and national levels.

In response, this thesis argues for the inclusion of the preservation of future space for tidal marshes in any sea level rise adaptation plan in Georgia. Although

[1] NOAA Coastal Services Center, "Detailed Methodology for Mapping Sea Level Rise Marsh Migration."

Georgia statute protects the present location of tidal marshes, it does not consider the sea level rise induced upland movement of tidal marshes. This response coined marsh migration is the vertical plus horizontal upland movement of tidal marshes in elevation relative to the land. Under this scenario, present coastal upland area will move down in elevation relative to sea level, moving within the tidal spectrum and transitioning into a wetland environment. This thesis assumes that marsh migration to the extent possible should be included in sea level rise adaptation plans in order for the tidal marsh ecosystem to continue to provide valuable ecosystem services. Without a landing place, many tidal marshes will be drowned as they are squeezed between rising water and shore development. If marsh migration is not incorporated into sea level rise adaptation plans, protection of coastal development from sea level rise induced flooding and inundation in the form of levees, bulkheads, and seawalls will inhibit tidal marsh migration.

This thesis will present a suite of alternative adaptation actions for the Georgia coastal region to consider when adapting to sea level rise. These actions emanate from the planning objective of increasing the potential for tidal marshes to migrate upland where they can continue to provide valuable ecosystem services such as flood attenuation and wildlife habitat. Of the sea level rise adaptation measures, this thesis argues that relocation of development from the coast is the adaptation measure best suited to marsh migration. Under a relocation plan, coastal area is allowed to change under natural conditions. In a relocation scenario, protecting the coast from sea level rise induced flooding and inundation using seawalls and the like is prohibited. Instead coastal communities incorporate a planning scheme which gives precedence

to marsh migration over development. This thesis plans on the assumption that the economic resources injected to protect coastal real estate from sea level rise will often exceed the economic and social benefits derived from that same real estate. This thesis also assumes that a cost benefit analysis of protecting coastal property from sea level rise should also consider the ecosystem services provided by tidal marshes. Under these assumptions, a sea level rise adaptation plan would more completely address the entirety of adapting to sea level rise, including economic, social, and ecological issues.

Purpose and Outline

This purpose of this thesis is to increase scientific knowledge of climate change and sea level rise for the inhabitants of the Georgia coast, increase the understanding of the ecosystem services provided by tidal marshes and the threats these marshes face from sea level rise, and provide a suite of sea level rise adaptation actions that include tidal marsh migration as a goal. The logic behind the purpose assumes coastal managers and public alike will be better able to adapt to climate change and sea level rise if they more completely understand:

- the state of the climate and the seas
- the state of the tidal marsh in regards to threats from sea level rise
- the ecosystem services they stand to lose from the impact of sea level rise
- the adaptation actions which can be taken to minimize the loss of tidal marsh area due to sea level rise.

In short, this thesis aims to incorporate a greater understanding of the risks of sea level rise in order to reduce the vulnerability of coastal communities and tidal marsh ecosystem resources.

Chapter 2 of this thesis presents the present science of sea level rise, illustrates the role of tidal marshes in the ecology and the economy of the state, and details the impact of sea level rise and protection of coastal development on the long term health of tidal marshes. In the context of this thesis, tidal marsh will refer to a salt water or brackish water coastal marsh. The chapter concludes with an investigation into the impact of hard armor on the migration of tidal marshes. In the context of this thesis, hard armor will refer to any hard structural protection of the shore including seawalls, bulkheads, and revetments.

Chapter 3 inspects the drivers of relocation from the Georgia coast. The public trust doctrine is discussed as it relates to the tidal marshes of Georgia and what role it may play in planning for marsh migration. The chapter also looks into the changes in the National Flood Insurance Program brought about by the Biggert-Waters Amendment. The chapter concludes with a review of Georgia's Protection of Tidewaters Act and Coastal Marshlands Protection Act and their institutionalization of the Public Trust Doctrine as it relates to Georgia's salt marsh.

Chapter 4 considers sea level rise planning, marsh migration planning, and the relocation of development from the coast. The chapter begins with a description of sea level rise planning goals. Following is a study of planning tools that can be adapted to plan for marsh migration and relocation of coastal communities. In addition case studies of each tool are presented to better illustrate the concept.

Chapter 5 focuses on the City of Tybee Island, Georgia, as a case study for adapting to sea level rise within the context of marsh migration. The chapter conducts a site analysis of the City of Tybee Island, including the history,

demographics, infrastructure, environmental conditions, and present land use planning on Tybee Island. Chapter 6 concludes with a suite of recommendations for the City of Tybee Island to adapt to sea level rise. Using the research on adaptation measures of other coastal communities, the thesis suggests actions that will reduce the vulnerability of Tybee Island to flooding from sea level rise and protect the tidal marsh adjacent to the island from the hazards of sea level rise. Specifically this thesis will address the creation of a sea level rise overlay zone on Tybee Island.

Influences

The inspiration for this thesis grew from the influence of the sea level rise planning project on Tybee Island, Georgia. Conducted by the National Oceanic and Atmospheric Administration Sea Grant, the Carl Vinson Institute of Government, Georgia Sea Grant, and the City of Tybee Island, the Tybee Island Sea Level Rise Adaptation Plan is in the midst of formulating the first sea level rise plan in Georgia. The plan is scheduled to be completed in December of 2013. The Tybee Island City Council has worked through preliminaries of plan including a determination of the future height of sea level the plan will address and of the infrastructure vulnerable to sea level rise.

A detailed and accurate understanding by the public of sea level rise by the Tybee Island City Council has been crucial to the success of the sea level rise adaptation plan. The thesis reflects this step in the planning process, accurately presenting the science of climate change and sea level rise as a necessary step in the sea level rise planning process. Accordingly, this thesis presents findings of the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change

(IPCC). The AR4 is the fourth in a series of reports intended to assess scientific, technical and socio-economic information concerning climate change, its potential effects, and options for adaptation and mitigation. It is to date the largest and most detailed summary of the climate change situation undertaken. The AR4 directly states that the "warming of the climate system is unequivocal, and is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global sea level."[2] "The Summary for Policy Makers" of Working Group 1 included in this report describes the progress in the understanding of the human and natural drivers of climate change, observed climate change, climatic processes and attribution, and estimates of projected future climate change.[3] Over the next two decades, the IPCC has projected a warming of 0.2°C in global temperature per decade for a range of emission scenarios. Even if the concentration of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected.[4]

As a background into planning for marsh migration, this thesis was influenced by the ecological and economical value of tidal marshes to the coastal region of Georgia. In addition, the National Oceanic and Atmospheric Administration Coastal Service Center's Sea Level Rise and Coastal Flooding Impacts Viewer was an influence on the understanding of tidal marsh migration. The wetland transition modeling within the Viewer assumes that certain categories of wetlands occupy

[2] IPCC, "Summary for Policymakers. Climate Change 2007: Physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the the Intergovernmental Panel on Climate Change," ed. S. Solomon, et al. (Cambridge, United Kingdom
New York, NY, USA2007). 5.
[3] Ibid. 2.
[4] Ibid. 12.

designated ecological niches, based on their elevation in relation to existing and future tidal elevation ranges. Although elevation of tidal marshes depends on rates of accretion and erosion, the Sea Level Rise and Coastal Flooding Impacts Viewer models for accretion only. The mapping assumption behind the viewer's marsh migration modeling is: current sea level elevation + amount sea level rise – accretion = net marsh impact.[5] Accretion is the vertical rise of the marsh's surface due to buildup of organic and inorganic matter. Accretion rates can be highly variable within an individual habitat type, i.e. saltwater marsh, freshwater wetland, etc., and can also be variable within an individual geography no matter the size.

For the purpose of this thesis, 4 mm/yr was chosen as the accretion rate for the Sea Level Rise and Coastal Flooding Impacts Viewer. The accretion rate is based on the research of Chris Craft in "Freshwater input structures soil properties, vertical accretion, and nutrient accumulation of Georgia and U.S. tidal marshes."[6] Craft's research clearly delineates the accretion rates of freshwater and marine dominated marshes along the coast as well as the accretion rates of tidal fresh, brackish, and salt marshes along the Georgia coast.[7] This thesis planned on the 4 mm accretion rate of the Sea Level Rise and Coastal Flooding Impacts viewer which was closest to an accretion rate averaged from the mean accretion rates of tidal freshwater, brackish, and salt marshes of the southeast presented in Craft's research.[8]

[5] NOAA Coastal Services Center, "Frequent Questions: Digital Coast Sea Level Rise and Coastal Flooding Impacts Viewer," (2012).
[6] Christopher Craft, "Freshwater Input Structures Soil Properties, Vertical Accretion, and Nutrient Accumulation of Georgia and U.S. Tidal Marshes," *Limnology and Oceanography* 52, no. 3 (2007).
[7] Ibid. 1226-1227.
[8] Ibid. 1227.

Using the accretion rate of 4mm/yr, the NOAA viewer modeled for the impact of hard armor on sea level rise induced marsh migration near Tybee Island. The viewer treats high and medium density development classes as barriers to marsh migration, thus effectively modeling where the marshes along Georgia's coast will migrate if developed property were protected with hard armor. Figure 1.1 is the legend accompanying the marsh migration maps produced with the NOAA sea level rise viewer. Figure 1.1 illustrates the legend for the marsh migration model of the Sea Level Rise and Coastal Flooding Impacts Viewer. Figure 1.1 also illustrates the decrease in tidal marsh area adjacent to Tybee Island from the impact of hard armor and sea level rise. Models were conducted for time periods of 50, 75, and 100 years from the present. As time progresses, the tidal marsh adjacent to Tybee Island is largely replaced by unconsolidated shore and open water as upland marsh migration is hindered by the protection of development on the Tybee Island upland.

From research into sea level rise planning, the adaptation actions presented by this thesis were influenced by *Technologies for Climate Change Adaptation*, a document published by the United Nations Environment Program (UNEP). *Technologies* refers to adaptation actions as adaptation technologies and, in turn, defines these as the broad set of processes covering the know-how, experience and equipment used by humans to reduce the adverse consequences of coastal change and exploit any benefits. UNEP sub-divides these technologies into (1) capital goods

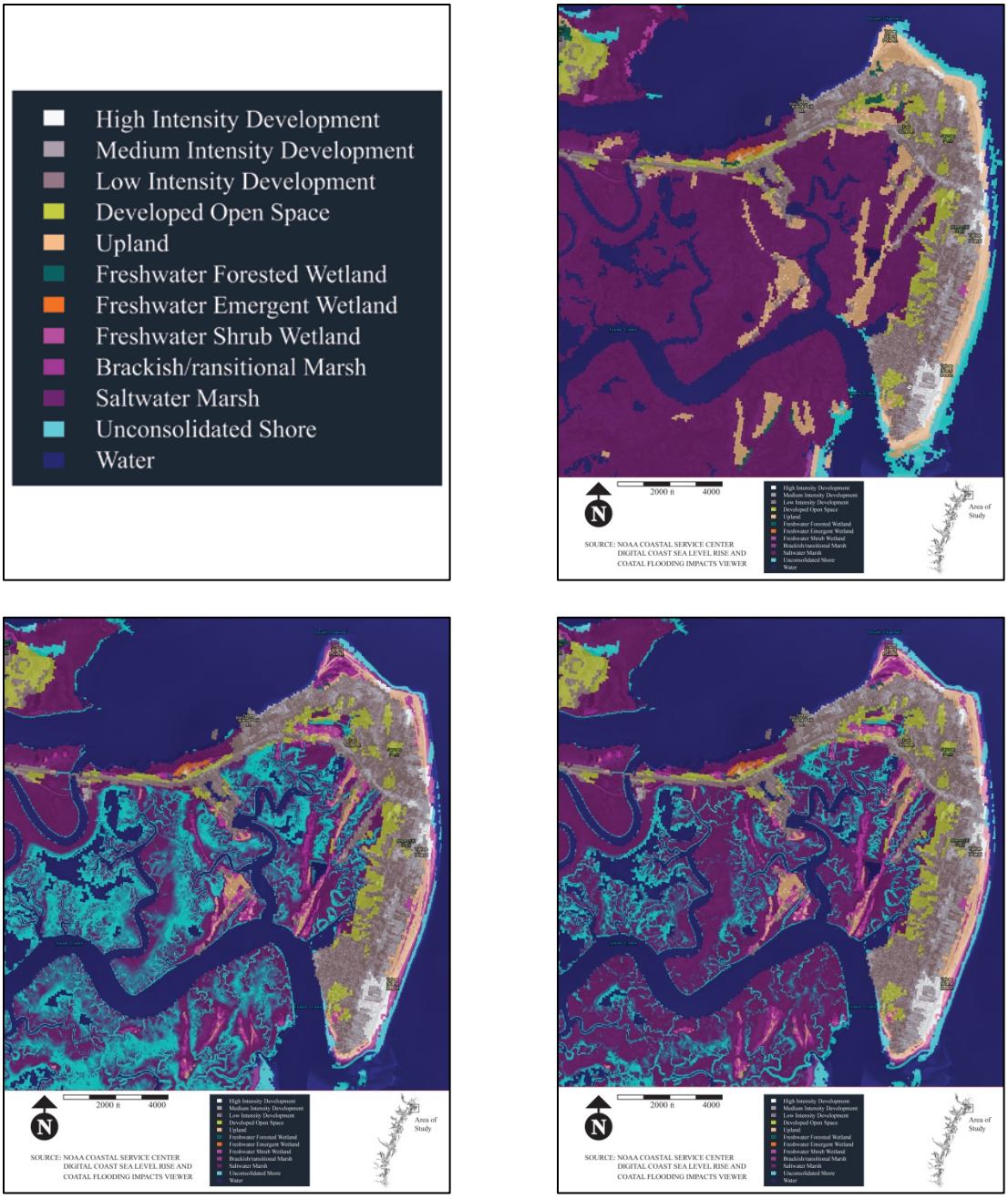

Figure 1.1. Sea level rise impact on the tidal marsh adjacent to Tybee Island assuming an accretion rate of 4mm. Starting clockwise from top left, the map legend, the present area and location of tidal marsh, and the effect of hard armor and sea level rise on the tidal marsh 50 and 100 years, respectively, from the present. Source: Map Legend and Maps by NOAA Coastal Services Center.[9]

[9] NOAA Coastal Services Center, "Sea Level Rise and Coastal Flooding Impacts Viewer," http://csc.noaa.gov/digitalcoast/tools/slrviewer.

such as dikes or seawalls and (2) technologies focusing on information, capacity building, institutional arrangements and policy and strategy development.[10] UNEP's document was the basis for the categorization of the available sea level rise adaptation actions.

An additional influence upon the classification of adaptation actions by this thesis was the classification system of the *Adaptation Tool Kit* published by the Georgetown Climate Center. The *Tool Kit* was important in arranging the sea level rise adaptation actions proposed in this thesis for planning for marsh migration. The *Tool Kit* grouped adaptation tools by the type of power exercised to implement the tool and the policy objective that the tool facilitates.[11] Based on the implementation power, tools are classified as planning, regulatory, spending, or tax and market-based tools. These same tools are then charted according to the sea level rise adaptation goals they fulfill which are protection, accommodation, or relocation.

[10] Matthew M. Linham and Robert J. Nicholls, "Technologies for Climate Change Adaptation: Coastal Erosion and Flooding" (2010). 1.
[11] Jessica Grannis, "Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use: How Governments Can Use Land-Use Practices to Adapt to Sea-Level Rise," (Washington, D.C.: Georgetown Climate Center, 2011). 1.

CHAPTER 2

CHANGES ON THE COAST

Introduction

Chapter 2 reviews current knowledge on the magnitude and causes of contemporary sea level rise, assuming that access to this knowledge will better prepare the Georgia coastal zone for the impacts from sea level rise. The chapter gauges the potential impact of sea level rise and hard armor on the tidal marshes of Georgia, and specifically the salt marsh. Salt marsh in the context of this thesis is taken to mean the low tidally influenced marshes of the Georgia coast characterized by the presence of the cord grass Spartina alterniflora. Hard armor in the context of this thesis is taken to mean seawalls, bulkheads, revetments, and other hard structural protection of the shore. In conclusion this chapter discusses relocation as a goal the Georgia coast should consider in preparing and adapting to sea level rise.

Sea Level Rise

Factors contributing to sea level rise are local and global in scale (Table 2.1). Increased flow rates of the Savannah River will increase local sea level in the Tybee Island area, but these same increased flow rates will not affect sea level along the Oregon coast.[12] Such as case results in the rise of local sea level. Conversely the melting of glaciers affects global sea level, which is the average height of all the Earth's oceans. Global sea level has been rising since glaciers associated with the

[12] Tonya D. Clayton, *Living with the Georgia Shore / Tonya D. Clayton ... [Et Al.]*, Living with the Shore (Durham : Duke University Press, 1992., 1992), Bibliographies
Non-fiction. 14.

most recent Pleistocene Ice Age began to melt 18,000 years ago.[13] More recently, through the 20th century, tide gages indicate that global sea level has risen between 4.8 and 8.8 inches at an average of about two-thirds of an inch a decade.[14]

Sea level rise is a combination of ocean volume and ocean mass changes. Ocean volume change is associated with thermosteric expansion of water. As water

Table 2.1. Factors affecting sea level. Source: Clayton et al.[15]

Factors	Global	Local
Volume of ocean basins (e.g. *decreasing volume raises sea level*)	•	
Volume of water in ocean basins (*melting land ice raises sea level*)	•	
Water temperature (*warmer water expands and raises sea level*)	•	•
Vertical movement of the land (*land subsidence is equivalent to locally raising sea level*)		•
Local atmospheric pressure (*decreasing atmospheric pressure locally and temporarily raises sea level*)		•
River runoff (*increasing flow rate locally and temporarily raises sea level*)		•
Winds (*onshore winds locally raise sea level*)		•
Tides		•
Ocean currents (*e.g. ocean gyres, upwelling, etc.*)		•

warms, it expands, increasing the volume of global ocean and causing global sea level to rise. Change in the mass of the ocean is mainly due to the melting of glaciers and ice sheets with some contribution from water stored in continental reservoirs or ground extraction.[16] Recently the major contributors to 20th century world sea level rise, in descending order of importance, were: (1) thermal expansion of ocean water,

[13] Ibid. 15.
[14] NOAA Coastal Services Center, "Shifting Shorelines, Shifting Conservation Strategies: Assessing Wetland Conservation Priorities in Maryland," (2011). 1.
[15] Clayton, *Living with the Georgia Shore / Tonya D. Clayton ... [Et Al.]*. 15.
[16] National Oceanography Centre, "Causes of Sea Level Change," http://noc.ac.uk/science-technology/climate-sea-level/sea-level/causes-sea-level-change.

(2) mountain glacier melting, and (3) the melting of the Greenland ice sheet (Table 2.2).[17]

Table 2.2. Observed rate of sea level rise and estimated contributions from different sources.[18] Source: Intergovernmental Panel on Climate Change.

Source of sea level rise	**Rate of sea level rise (mm per year)** 1961-2003	**Rate of sea level rise (mm per year)** 1993-2003
Thermal expansion	0.42 ± 0.12	1.6 ± 0.5
Glaciers and ice caps	0.50 ± 0.18	0.77 ± 0.22
Greenland Ice Sheet	0.05 ± 0.12	0.21 ± 0.07
Antarctic Ice Sheet	0.14 ± 0.41	0.21 ± 0.35
Sum of Individual Climate Contributions to Sea Level Rise	1.1 ± 0.5	2.8 ± 0.7
Observed Total Sea Level Rise	1.8 ± 0.5	3.1 ± 0.7

Ocean temperature data, collected over the past few decades, indicate that ocean thermal expansion significantly increased during the second half of the 20th century.[19] Observations since 1961 show that the average temperature of the global ocean has increased to depths of at least 3000 m and that the ocean has been absorbing more than 80% of the heat added to the climate system.[20] Since 1960 thermal expansion accounted for 25% of sea level rise. From 1993 to 2003, the percentage of sea level rise attributed to thermal expansion grew to 50%.[21] Recently, from 1993 to 2009, thermal expansion's contribution to rise in global mean sea level,

[17] IPCC, "Summary for Policymakers. Climate Change 2007: Physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the the Intergovernmental Panel on Climate Change." 7.
[18] Ibid. 7. Data prior to 1993 are from tide gauges and after 1993 are from satellite altimetry.
[19] Robert J. Nicholls and Anny Cazenave, "Sea-Level Rise and Its Impact on Coastal Zones," *Science*, no. 5985 (2010). 1517.
[20] IPCC, "Summary for Policymakers. Climate Change 2007: Physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the the Intergovernmental Panel on Climate Change." 5.
[21] Nicholls and Cazenave, "Sea-Level Rise and Its Impact on Coastal Zones." 1517.

the average height for the sea for all tidal stages, dropped to approximately 30%.[22] The drop in thermal expansion's contribution to sea level rise is not however a cause for relief. Sea level rise has continued at the same rate even with the drop in contribution from thermal expansion.

Increasing glacial and ice sheet mass loss may be compensating for the reduction in contribution to sea level rise by the thermal expansion of the world's oceans. Worldwide retreat of glaciers and small ice caps and the accelerating mass loss from the Greenland and West Antarctica ice sheet has been widely observed during recent decades with an appreciable acceleration during the 1990s.[23] Glacial contribution to sea level rise from 1993 to 2009 may be approximately 30%.[24] In addition, between 1993 and 2003 less than 15% of the global sea level rise was due to melting of the Greenland and Antarctic ice sheets. Since 2003 the contribution from the Greenland and Antarctic ice sheets has nearly doubled.[25] Estimates are that, on average, total land ice mass loss now explains approximately 60% of the rate of sea level rise from 1993 to 2009.[26]

No consensus exists on the magnitude of the response of ice sheet dynamics to climate change. Some current global model studies suggest that the Antarctic Ice Sheet will remain too cold for widespread surface melting and will gain in mass due to increased snowfall.[27] Other studies suggest that the 21st century will see the West

[22] Ibid. 1517.
[23] Ibid. 1517.
[24] Ibid. 1517.
[25] Ibid. 1517.
[26] Ibid. 1518.
[27] IPCC, "Summary for Policymakers. Climate Change 2007: Physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the the Intergovernmental Panel on Climate Change." 17.

Antarctic ice sheet become the major source of melt water, replacing thermal expansion as the leading cause of global sea level rise.[28] It is unknown whether ice sheet loss will continue into the future, resulting in partial collapse of the ice sheets after a few centuries or whether a new equilibrium will be reached so for the near term, the largest unknown factor in sea level rise will be the behavior of the ice sheets.[29] Recent observations of ice sheet dynamics suggest an increasing vulnerability to a warming climate. Also, rapid change observed in polar regions suggest the ice sheets are responding to current warming on much shorter time scales than previously anticipated. If these trends continue, the main drivers of future sea level rise could be, in descending order of importance: (1) melting of the West Antarctic ice sheet, (2) melting of the Greenland ice sheet, (3) thermal expansion of the oceans, and (4) mountain glacier melting.[30]

Another factor contributing to the uncertainty of the rate and magnitude of sea level rise is that most modeling is conducted based upon rates observed in the present. For example, the AR4 projects that global sea level will rise by up to approximately 23.62 in by 2100.[31] The IPCC's model-based range, however, excludes uncertainties

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[28] Orrin H. Pilkey and Rob Young, *The Rising Sea / Orrin H. Pilkey and Rob Young* (Washington, DC : Island Press/Shearwater Books, c2009., 2009), Bibliographies
Non-fiction. 178.

[29] Nicholls and Cazenave, "Sea-Level Rise and Its Impact on Coastal Zones." 1518.

[30] Pilkey and Young, *The Rising Sea / Orrin H. Pilkey and Rob Young*. 178.

[31] IPCC, "Summary for Policymakers. Climate Change 2007: Physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the the Intergovernmental Panel on Climate Change." 13. Advances in climate change modeling now enable best estimates and likely assessed uncertainty ranges to be given for projected warming for different emission scenarios. Approximate carbon dioxide equivalent concentrations corresponding to the computed radiative forcing due to anthropogenic greenhouse gases and aerosols in 2100 for the SRES (*IPCC Special Report on Emission Scenarios*) B1, A1T, B2, A1B, A2, and A1F1 illustrative marker scenarios are about 600, 700, 800, 850, 1,250, and 1,550 ppm respectively. The approximately 60 cm rise in sea level cited here is the high end of the A1F1 scenario (.26 - .59 cm). Radiative forcing is a measure of the influence that a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and

in climate-carbon cycle feedback and the full effects of future rapid change in ice sheet dynamics. The projections do include a contribution due to increased ice flow from Greenland and Antarctica at the rates observed for 1993 to 2003, but these flow rates could increase or decrease in the future.[32]

Tidal Marsh Drowning

Tidal marshes are ecosystems found in estuaries. An estuary is a transitional aquatic zone between freshwater river systems and the open ocean.[33] The particular marsh that characterizes the majority of Georgia's tidal marshes is the salt marsh. Salt marshes are principally defined by salt tolerant, grass-like vegetation and frequent inundation by tides. Salt marshes occur in many temperate and high-latitude estuaries and on sections of open coast which are protected from extreme wave action by wide intertidal flats and barrier islands.[34] These marshes and other ecosystems associated with estuaries such as intertidal flats and sea grass meadows have been heavily altered in the United States. More than 90 percent of the wetlands, including tidal marshes, along the San Francisco Bay have been destroyed. The sea grass ecosystem of Galveston Bay has been reduced by 70 percent. In the Chesapeake Bay, 90 percent of the sea grass meadows have been lost.[35] Relative to other states, Georgia's tidal marshes have been largely preserved. The state's salt marsh now comprises one third of the total salt marsh area along the East coast.

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is an index of the importance of the factor as a potential climate change mechanism. Positive forcing tends to warm the surface while negative forcing tends to cool it.

[32] Ibid. 14.

[33] American Planning Association, *Planning and Urban Design Standards: Student Edition* (Hoboken, New Jersey: Jon Wiley & Sons, Inc., 2007). 77.

[34] Linham and Nicholls, "Technologies for Climate Change Adaptation: Coastal Erosion and Flooding." 10.

[35] Association, *Planning and Urban Design Standards: Student Edition*. 77.

Along the Georgia coast, salt marshes dominate the two to five mile wide areas between the barrier islands and the mainland. Brackish and freshwater marshes fringe the area upland of the saltmarshes and extend inland for an additional ten miles or so.[36] In the widespread lower salt marshes, vegetation consists chiefly of Spartina alterniflora whose common name is smooth cordgrass. These salt marshes are shaped like large, wide, and shallow saucers with natural lips or levees along their creek edges.[37]

As sea level rises, the fate of tidal marshes depends on their ability to keep pace with rising sea level. If the elevation of the tidal marshes does not keep pace on a vertical plane with sea level rise, the salt marsh migrates on a diagonal plane to an upland position. The elevation of the salt marshes relative to sea level is normally maintained by the addition of new sediment and organic matter. New sediment arrives from rivers and storms and is trapped by the marsh. Organic matter is added from the decaying biotic components of the marsh.[38] The degree of permanent submergence of salt marshes depends on this sediment budget and the rate of sea level rise and the slope of the coastal area upland of the salt marsh. If local sediment supplies are reduced or sea level rises too quickly, the cord grass will die from stress, and the sediments trapped by the cord grass will disperse. Consequently the marsh will sink, becoming open water.[39]

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[36] The New Georgia Encyclopedia, "Geology of the Georgia Coast," Georgia Humanities Council, http://www.georgiaencyclopedia.org/nge/Article.jsp?id=h-2777.
[37] John H. Tibbetts, "The Dynamic Coast; Living with Shoreline Change," *Coastal Heritage* 24, no. 4 (2010). 10.
[38] Ibid. 10.
[39] Ibid. 10-11.

On balance, the salt marshes of the Georgia coast will decline with rising sea levels. Simulations modeling for a 52 cm (20.5 in) increase in sea level predicted a 20% decline in salt marsh area along the Georgia coast by 2100.[40] The decline of salt marsh was due to submergence and subsequent replacement by tidal flats and estuarine open water. Modeling for an 82 cm (32.28 in) increase in sea level by 2100, overall salt marsh decline was predicted at 45%.[41] Marine scientist James T. Morris, director of the University of South Carolina's Belle W. Baruch Institute for Marine and Coastal Services, believes that many of South Carolina's marshes, which closely resemble the marshes of coastal Georgia, will disintegrate from the inside out because of sea level rise, becoming open water lagoons. These lagoons could form in as little as 50 years.[42]

Tidal Marsh Services

The impact of sea level rise on the salt marshes of the Georgia coast will have a deleterious effect on society and the economy due to the importance of the salt marsh to each. The coastal food web is dependent on a productive salt marsh which is in turn tied to the productivity of spartina grass. Primarily because of spartina grass, Georgia's tidal marshes produce around ten tons of organic material per acre per year. One acre of Spartina alterniflora can produce as much as 17.8 tons of organic material annually. In comparison, one acre of corn in the United States

[40] Christopher Craft et al., "Forecasting the Effects of Accelerated Sea-Level Rise on Tidal Marsh Ecosystem Services," *Frontiers in Ecology and the Environment*, no. 2 (2009). 76.
[41] Ibid. 76.
[42] Tibbetts, "The Dynamic Coast; Living with Shoreline Change." 11.

produces 5.7 tons annually.[43] The productivity of the salt marsh on the Georgia coast is enhanced by the 378,000 acre area it encompasses, the high level of salt marsh tidal action, abundant nutrient supplies, conservation and rapid turnover of nutrients, and the additional primary production of benthic organisms and phytoplankton.[44]

The productivity of the salt marsh leads to economic benefits related directly to the fish and shellfish industry of coastal Georgia as well as the tourism sector and real estate sectors. The Georgia seafood industry was responsible for 7,390 jobs in 2010.[45] In 2010, Georgia fishermen harvested 7.4 million pounds of seafood with a total dockside value of $9.3 million.[46] The salt marsh serves as the primary nursery ground for many of the economically important fish and shellfish, including juvenile populations of crabs, shrimp, and fish. The commercial catches of popular offshore food fish show a direct relationship to the ratio of marsh versus open water inshore. In regions where the inshore areas contain abundant salt marshes, the offshore regions are more productive yielding more fish and other important food species.[47] Catches of many species of shrimp are greatly increased by the amount of salt marsh inshore of the commercial fishing area. Turner has shown that there is a statistically significant positive relationship between size of supporting marsh areas and yields of

[43] Janet Kealy et al., "Management of Georgia's Marshlands under the Coastal Marshlands Protection Act of 1970," (Carl Vinson Institute of Government, 1988).
[44] Ibid. 4.
[45] Inc. Gulf & South Atlantic Fisheries Foundation, "Who We Represent," http://www.gulfsouthfoundation.org/about/represent.
[46] Ibid.
[47] Georgia Department of Natural Resources Coastal Resources Division, "Georgia's Salt Marshes," www.coastalgadnr.org/ep/sm.

white shrimp.[48] White shrimp accounted for more than 3 million pounds of the 2010 seafood harvest in Georgia.[49]

A salt marsh diminished in size and productivity would result in an economic loss for the State of Georgia and its citizens and not only for the seafood sector. Salt marshes are also of great importance to the coastal tourism and real estate sectors. This thesis argues that were the area of salt marshes to be significantly reduced and thus subtracted from the view sheds of the coast, that the impact on the tourism and real estate sector would be substantial. In 2005 coastal Georgia tourism employed an estimated 27,150 in retail trade and services and supported a total volume of business approximating $1.6 billion, which was almost one-fifth of the state total.[50]

This thesis bases its argument for the importance of the salt marshes to the real estate and tourism sector on the state of development on Georgia's barrier islands. Only three of Georgia's eight major barrier islands are accessible by land via causeways. The remaining five islands are either publicly owned or managed by public agencies while remaining privately owned. It is highly unlikely that there will be any significant development of these remaining islands in the foreseeable future.[51] Due to the relative scarcity of development potential on Georgia's barrier islands, this thesis argues that the development potential of the Georgia coast instead will be found on mainland property fronting the marsh. At present the importance of the salt

[48] R. Eugene Turner, "Intertidal Vegetation and Commercial Yields of Penaeid Shrimp," *Transactions of the American Fisheries Society* 106, no. 5 (1977).
[49] Gulf & South Atlantic Fisheries Foundation, "Who We Represent".
[50] Georgia Department of Community Affairs Office of Planning and Quality Growth, "Regional Profile of Georgia's Coastal Counties," (2005). 5.
[51] Ibid. 31.

marsh to real estate can be seen in the value of barrier island property bordering the marsh which often sells for more per acre than interior lots on the same island.[52]

Resort and residential developments on the Georgia coast are capitalizing on the increasing numbers of affluent retirees seeking the benefits of the coast life style.[53] In comparison to surrounding regions, the state, and U.S. population projections, the population of the coastal region of Georgia is increasing at a greater rate and is predicted to continue to do so.[54] The difference in population growth can in part be explained by the coastal region's quality of life advantages including coastal resources and the availability of a wide range of employment opportunities.[55] It is the argument of this thesis that the benefits of the coastal life style and the coastal region's quality of life are, if not defined, at least largely influenced by the salt marsh.

Another service rendered by salt marshes to the coastal region of Georgia is its role in buffering the impact of storms for areas landward of the salt marsh. Salt marshes lessen the impact of floods by slowing the velocity of water, thereby reducing erosion damage and the severity of flood peaks.[56] Because of this fact, extensive programs were proposed after hurricane Katrina to restore thousands of acres of tidal marshes in the Mississippi delta to attenuate storm surge.[57] Storm surge simulations after Hurricane Katrina demonstrated that enhanced friction by coastal

[52] Kealy et al., "Management of Georgia's Marshlands under the Coastal Marshlands Protection Act of 1970." 5.
[53] Growth, "Regional Profile of Georgia's Coastal Counties." 33.
[54] Ibid. 2.
[55] Ibid. 2.
[56] Kealy et al., "Management of Georgia's Marshlands under the Coastal Marshlands Protection Act of 1970." 5.
[57] Stijn Temmerman, Mindert B. De Vries, and Tjeerd J. Bouma, "Coastal Marsh Die-Off and Reduced Attenuation of Coastal Floods: A Model Analysis," *Global and Planetary Change* 92–93, no. 0 (2012). 267.

marshes slowed storm surge with peak water levels increasing seaward of the marsh and decreasing landward of the marsh.[58] Data suggests that the extent of flood level reduction is highly variable between specific wetland locations and between specific flood events.[59] While coastal marshes may have a small attenuation effect on extremely high storm surges with peak water depth greater than or equal to 5 m, they effectively attenuate moderate storm surges with peak water depth 2 to 3 m above marshes.[60]

Wave attenuation is the reduction in wave energy or wave height. Wave attenuation by salt marshes is achieved through several means. When a wave passes through marsh vegetation, the aerial parts of the grass form a flexible mass which dissipate wave energy.[61] This drag is particularly important in the case of dense vegetation where velocities are greatly reduced.[62] In addition the marsh bed exerts drag on a wave through bottom sheer stress.[63] The continuity of a marsh also impacts the transfer of momentum in flow. Defined as the ratio of healthy marsh to open water area within the total wetland area, the continuity of a marsh considers discontinuous bottom friction and marsh elevation throughout a marsh system. The more open water within the total marsh area will decrease a marsh's impact on the

[58] Ibid. 268.
[59] Ibid. 267-268. The scarcity of knowledge is largely attributed to the scarcity and heterogeneity of field measurements of extreme flood water levels within and behind large tidal wetlands. The relatively few field data display a wide range of flood attenuation rates, ranging from 4 to 25 cm of flood level reduction per kilometer of tidal wetland.
[60] Ibid. 268.
[61] USACE (United States Army Corps of Engineers), "Environmental Engineering for Coastal Shore Protection," (1989). 6-4.
[62] N. M. Loder et al., "Sensitivity of Hurricane Surge to Morphological Parameters of Coastal Wetlands," *Estuarine, Coastal and Shelf Science* 84, no. 4 (2009). 625.
[63] Ibid. 625.

transfer of momentum in flow.[64] Lastly, spartina grass forms dense root-rhizome mats which add stability to shore sediment.[65] This protective mat is of particular importance during severe winter storms when the dearth of aerial stems provides limited resistance to the impact of waves.

Salt Marsh Degradation

Scientific modeling has demonstrated that the wave attenuation effect of tidal marshes decreases when degradation of coastal marsh vegetation is simulated.[66] As sea level rises, salt marshes and other coastal ecosystems are expected to migrate upland if they cannot keep pace on a vertical plane and assuming no hard armor blocks the route of migration. If hard armor protecting coastal development from flooding and inundation is present, the intertidal area seaward of the protection will remain submerged for longer and by greater depths, affecting the distribution of vegetation in the tidal marsh and increasing the tidal range upstream of the defense.[67] Figure 2.1 shows the impact of a seawall on salt marshes adjacent to Jekyll Island, Georgia, having degraded the marshes resulting in an ecological change of state to mudflats.

[64] Ibid. 627.
[65] Engineers), "Environmental Engineering for Coastal Shore Protection." 6-4.
[66] Temmerman, De Vries, and Bouma, "Coastal Marsh Die-Off and Reduced Attenuation of Coastal Floods: A Model Analysis." 268.
[67] Linham and Nicholls, "Technologies for Climate Change Adaptation: Coastal Erosion and Flooding." 41.

Figure 2.1. Coastal Squeeze, Jekyll Island, GA. Source: Photo by Jason Evans.

With sea level continuing to rise, these mudflats will be drowned between the rising sea and the unmoving hard armor. When coastal armor prevents coastal ecosystems such as salt marshes from migrating upland in response to sea level rise, the effect is termed coastal squeeze. Coastal squeeze can significantly narrow coastal habitat, reducing the extent of salt marshes and other coastal ecosystems found in the intertidal zone.[68] This phenomenon is illustrated in shown in Figure 2.2 where A2 illustrates marsh migration in the absence of coastal armor and B2 illustrates the flooding of habitat by coastal squeeze in the presence of coastal armor.

[68] Ibid. 41.

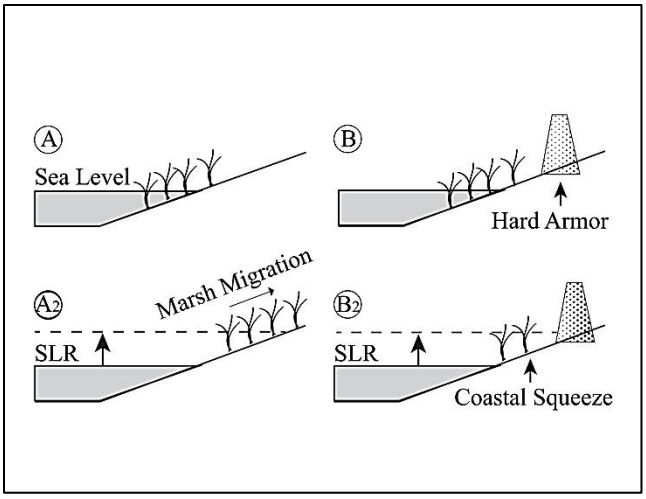

Figure 2.2. Coastal Squeeze (Adapted from "Technologies for Climate Change Adaptation: Coastal Erosion and Flooding," by Matthew M. Linham and Robert J. Nicholls, 2010).[69]

In addition to coastal squeeze, the negative ecological effects of hard armor include scouring of the salt marsh bed. Scouring occurs when hard armor is subjected to significant loadings as a result of wave impact and wave energy reflected by hard armor then creates turbulence capable of suspending sediments and causing erosion of the area seaward of the armor. Instead of preventing coastal erosion, armor transfers the erosion problem from the shoreline to the salt marsh bed immediately in front of the armor.[70] In a worst case scenario, reflected wave energy can interact with incoming waves to set up a standing wave which can cause intense scouring of the salt marsh bed.[71] The phenomenon of incoming water reflected upward and then falling downward and scouring a hole in front of the structure is shown in Figure 2.3[72]

[69] Ibid. 5.
[70] Ibid. 21.
[71] Ibid. 39.
[72] Ibid. 39.

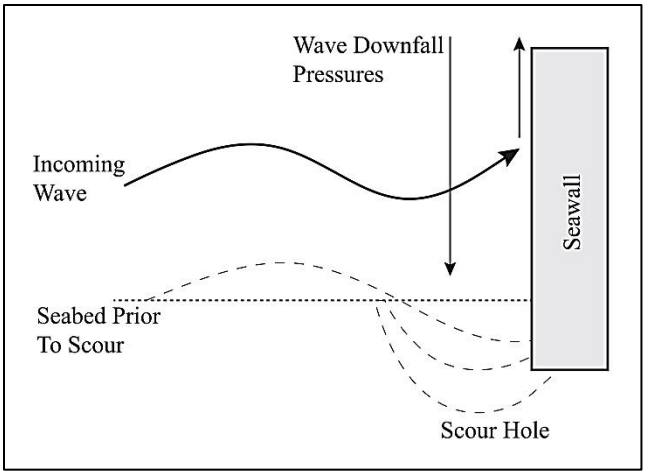

Figure 2.3. Scouring produced by wave energy on the seabed seaward of a hard structural technology. (Adapted from "Technologies for Climate Change Adaptation: Coastal Erosion and Flooding," by Matthew M. Linham and Robert J. Nicholls, 2010).[73]

The scouring effect can be reduced to some degree by incorporating slopes and irregular surfaces into the structure design.[74] Scouring can also be mitigated by placing rip-rap at a hard armor structure's toe in order to prevent erosion, but this protection measure is not entirely effective nor does it address the preservation of the salt marsh. Sediment underneath the rip-rap will also be subjected to erosion, eventually being undermined itself and losing its protective capabilities. Although the likelihood is probable that armor on the Georgia coast will be used to protect against sea level rise induced inundation and flooding, the incorporation of armor into a sea level rise adaptation plan without considering its effect on tidal marshes could be harmful for the coastal society, economy, and ecology. Therefore it is necessary to consider alternative sea level rise adaptation actions to armor.

[73] Ibid. 40.
[74] Ibid. 40.

Planning for Marsh Migration

Mitigating the impact of sea level rise induced impact on the salt marsh is a matter of extreme scope and complexity. While significantly curbing greenhouse gases within the state of Georgia would be a positive step towards climate change mitigation, such effort on the state's part would be outweighed while other states and countries continue to emit greenhouse gases. In addition, human induced warming and sea level rise will continue for centuries even if greenhouse gas concentrations were to be immediately halted.[75] Consequently, because the salt marshes are vital to the society, economy, and ecology of the Georgia coast, this thesis proposes that armoring the Georgia coast be considered only as a last resort. In its stead, development should be relocated and salt marshes allowed to adapt to sea level rise by migrating upland. It follows that preserving migration routes for salt marshes will be crucial in the preservation of this ecologically and economically rich ecosystem.

Such a prescription has been instituted by the United Nations Environment Program and in the United States. The United Nations Environment Program recommends the construction of proactive hard armor at some distance inland to reduce interfering with coastal processes while still creating buffer zones (i.e. tidal marshes) to protect against coastal flooding and erosion. The Environment Program also recommends that hard armor be used as a last line of defense.[76] In the town of East Hampton, NY, monitoring data has shown that the arbitrary construction of

[75] IPCC, "Summary for Policymakers. Climate Change 2007: Physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the the Intergovernmental Panel on Climate Change." 16.
[76] Linham and Nicholls, "Technologies for Climate Change Adaptation: Coastal Erosion and Flooding." 44.

bulkheads has created a major impediment to the natural progression of wetland migration. In light of the data, the town amended their comprehensive plan to prohibit the building of any bulkheads that would block wetland migration.[77]

The prohibition or limited use of armor to protect against sea level rise induced flooding and inundation will be difficult to implement. Presently, planners view shore protection as likely for at least 60 percent of the low land along the Atlantic coast if sea level rises three feet in the next century.[78] In addition, many landowners will decide to yield their lands to the sea as shore protection costs escalate but only after interim hard armor has blocked the inland migration of wetlands.[79] Consequently in order to prevent coastal armoring and promote marsh migration, it will be necessary to either incentivize or drive development upland of salt marshes to relocate from its present position.

Presently Governor Cuomo of New York is attempting a relocation scheme on Staten Island. Although his plan does not explicitly concern itself with marsh migration, it does concentrate on the preservation of the ecosystems services of tidal marshes, namely their storm surge buffering capacity. Oakwood Beach**,** on Staten Island's southeastern shore, was devastated by Hurricane Sandy's storm surge with the surge inundating the oceanfront blocks and wiping out or severely damaging most properties. Now the area has been targeted by New York and designated as a buffer

[77] Land Use Law Center, "Local Land Use Response to Sea Level Rise," (Pace University School of Law). 91-92.
[78] James G. Titus, "Rolling Easements," (2011). 4.
[79] Ibid. 4.

that will protect inland areas from future storms.[80] In order to create a buffer zone, Governor Cuomo has requested $200 million in federal housing funds to buy out coastal homeowners. Presently 141 homeowners are on record for taking the buyout of their property in Oakwood Beach. Oakwood Beach homeowners who sign up to have their properties bought will get 100% of their home's pre-storm value. Sellers will net another 10% of that value if their land is in a zone the state wants to return to nature as a storm buffer zone. Homeowners will be eligible to receive another 5% of their property's value if they relocate on Staten Island, and no homeowners will be pressured to sell.[81]

Conclusion

This thesis argues that planning tools that favor the salt marsh of the Georgia coast are necessary for the preservation of the economy and ecology of the coast. The nature and abundance of the salt marsh on the Georgia's coast has shaped public perception of the Georgia coast. This thesis asserts that the perception of the Georgia coast is inseparable from the presence of the salt marsh, an assertion also made by the Georgia Coastal Marshlands Protection Act.[82] The salt marsh is an agent that restricts development on the Georgia coast; the area of development of Chatham County is constrained by the presence and abundance of tidal wetlands.[83] At present and in the future, the restrictive nature of the marsh must be expanded to include pathways for marsh migration. Although the institutionalization of marsh migration will further

[80] Greg B. Smith, "Gov. Andrew Cuomo Announces First Purchase of Storm-Ravaged City Land to Give It 'Back to Mother Nature'," *New York Daily News*, February 25, 2012.
[81] Ibid.
[82] James Holland, "Are Our Coastal Marshlands Being Protected?," http://www.altamahariverkeeper.org/aboutus/stories/coastal_marshlands.asp.
[83] Growth, "Regional Profile of Georgia's Coastal Counties." 3.

restrict where development occurs on the Georgia coast, it is essential to maintaining the society, economy and ecology of the coast, and it must be institutionalized soon.

Pressure is increasing for development in environmentally-sensitive areas (i.e. salt marshes and land adjacent to salt marshes) on the Georgia coast, leading to polarizing conflicts between developers and conservationists.[84] These conflicts are expected to continue to intensify as general awareness and public support of environmental protection grow and contradict land development interests.[85] Additionally, as sea level rises, environmentally-sensitive areas are likely to shift as tidal marshes migrate upland, changing upland into new wetland.

[84] Ibid. 33.
[85] Ibid. 33.

CHAPTER 3

DRIVERS OF RELOCATION FROM THE GEORGIA COAST

Introduction

Chapter 3 investigates forces driving relocation from the Georgia coast in response to marsh migration. The relevance of the public trust doctrine to marsh migration is addressed. In addition two Georgia acts which frame coastal resources in terms of the trust relationship between the state and the public and current and future generations are discussed. The Biggert-Waters Amendment to the National Flood Insurance Program is also discussed but as a tangential driver of planning for marsh migration rather than one directly related to the welfare of the salt marsh.

Public Trust Doctrine

The Public Trust doctrine recognizes the coastline as a uniquely important location and grants the government special rights and responsibilities in coastal areas to act in the public interest. The Public Trust Doctrine dates back to Roman times and the Code of Justinian which proclaimed that the shores were not understood to be the property of any man.[86] In the context of the United States, the Public Trust Doctrine provides that navigable waters and the underlying lands were publicly owned at the time of statehood and remain so today unless the state has consciously transferred ownership to someone else.[87] The doctrine effectively establishes a 'public easement' held by a state over tidelands and submerged lands, including lands

[86] Tim Eichenberg, Sean Bothwell, and Darcy Vaughn, "Climate Change and the Public Trust Doctrine: Using an Ancient Doctrine to Adapt to Rising Sea Levels in San Francisco Bay," (2009). 247.
[87] Titus, "Rolling Easements." 15.

transferred to private ownership.[88] In all but five states, the public owns the land below the "ordinary high water mark." The most common definition of the "ordinary high water mark" is the mean high water line.[89] The definitions of tidelands, those lands considered under the Public Trust Doctrine, follow:

- Mudflats are found between mean low water and mean sea level.
- Low marsh is found between mean sea level and mean high water.
- High marsh extends from mean high water to spring high water.
- Collectively the lands between mean high water and mean low are commonly known as tidelands.
- In estuaries with no waves, the average high water mark is the mean high tide line.[90]

The majority of the salt marsh of Georgia is categorized as low marsh. The doctrine creates a duty for states to protect the common heritage of their coastal lands and waters for preservation and public use.[91] This duty may be invoked if sea level rise threatens coastal resources or public access to them.

In context of planning for sea level induced marsh migration, the Public Trust Doctrine could be interpreted to anticipate the preservation of the Georgia salt marsh into the future. This thesis argues that marsh migration should be included in sea level rise planning for the Georgia coast. If this consideration is excluded from the planning process, the migration routes of the salt marsh stand to be blocked by hard armor protecting coastal development from inundation and flooding. If the migration routes of the salt marsh are blocked, the salt marsh faces drowning due to sea level rise. Consequently, the area of salt marsh in Georgia, which is public land and the

[88] Eichenberg, Bothwell, and Vaughn, "Climate Change and the Public Trust Doctrine: Using an Ancient Doctrine to Adapt to Rising Sea Levels in San Francisco Bay." 247-8.
[89] Titus, "Rolling Easements." 18.
[90] Ibid. 18.
[91] Eichenberg, Bothwell, and Vaughn, "Climate Change and the Public Trust Doctrine: Using an Ancient Doctrine to Adapt to Rising Sea Levels in San Francisco Bay." 247.

common heritage of the people of the State of Georgia, will be reduced due to the protection of coastal development.

Two legislative acts in particular support the protection of the Georgia salt marsh as public trust property to be preserved for future generations. The Protection of Tidewaters Act places a current obligation on the state to preserve public access to tidewater areas, including the salt marsh, for enjoyment and recreational use. The Coastal Marshlands Protection Act obliges the state to regulate coastal marshlands, including the salt marsh, for the benefit of present and future generations. These two acts provide a legal mechanism whereby citizens of Georgia could potentially compel the state to take action for the protection of public trust property against the threat of sea level rise.[92] In the following paragraphs, this thesis discusses these two acts in more detail.

In 1976, the Georgia Supreme Court concluded in the case *State v. Ashmore* that the state owns all navigable tidewaters to the high-water mark.[93] The Georgia Legislature ratified this finding in 1992 with the passage of the Protection of Tidewaters Act which provides:

> The General Assembly finds and declares that the State of Georgia became the owner of the beds of all tidewaters within the jurisdiction of the State of Georgia as successor to the Crown of England and by the common law. The State of Georgia continues to hold title to the beds of all tidewaters within the state except where title in a private party can be traced to a valid Crown or state grant which explicitly conveyed the beds of such tidewaters.[94]

[92] Claire Ellis et al., "A Legal Analysis of Sea Level Rise," (2012). 10.
[93] "224 S.E.2d 334," (1976).
[94] *O.C.G.A. 52-1-2.*

Tidewaters are defined with the act as "the sea and all rivers and arms of the sea that are affected by the tide, where the tide rises and falls, which are capable of use for fishing, passage, navigation, commerce, or transportation, and which are located within the jurisdiction of the State of Georgia."[95]

The Protection of Tidewaters Act protects the right to the use of the salt marsh, explicitly identifying the State of Georgia as public trustee:

> The state of Georgia, as sovereign, is trustee of the rights of the people of Georgia to use and enjoy all tidewaters which are capable of use for fishing, passage, navigation, commerce, and transportation, pursuant to the common law public trust doctrine."[96]

In addition the Protection of Tidewaters Act states that the ecosystems within the act are of state-wide concern, and as thus, are a matter of regulation under the police powers of state.[97] As the salt marsh has been identified as being of state-wide concern within the act, this thesis proposes that the citizens of Georgia, in anticipation of sea level rise, plan for marsh migration routes so as to preserve the salt marsh. The Coastal Marshlands Protection Act also supports this argument.

Passed in 1970, the Georgia Coastal Marshlands Protection Act presently provides a review for activities that would alter the salt marshes along the Georgia coast.[98] The act defines coastal marshlands "…as any marshland intertidal area, mud flat, tidal water bottom, or salt marsh in the State of Georgia within the estuarine area of the state, whether or not the tidewaters reach the littoral areas through natural or

[95] Ibid.
[96] Ibid.
[97] Ibid.
[98] Kealy et al., "Management of Georgia's Marshlands under the Coastal Marshlands Protection Act of 1970."

artificial watercourses."[99] Under the act the Coastal Marshlands Protection Committee may issue a permit for construction, repair, or maintenance only after considering the proposed development in light of the public interest.[100] The Committee may condition the approval of any permit application on the following considerations:

> • Whether or not any unreasonable harmful obstruction to or alteration of the natural flow of navigational water within the affected area will arise as a result of the proposal.
> • Whether or not unreasonably harmful or increased erosion, shoaling of channels, or stagnant areas of water will be created to such extent as to be contrary to the public interest.
> • Whether or not the granting of a permit and the completion of the applicant's proposal will unreasonably interfere with the conservation of fish, shrimp, oysters, crabs, clams, or any other marine life, or any wildlife, or any other natural resources, including but not limited to water and oxygen supply, to such an extent as to be contrary to the public interest.[101]

The aforementioned language invokes a broad range of conditions requisite for marsh health. Based upon these conditions, this thesis asserts that the interpretation of the Coastal Marshland Protection Act is open to encompass the impact of sea level rise on the salt marsh of Georgia.

The preface to Coastal Marshland Protection Act refers to future obligations of the state to protect the salt marsh, especially with respect to the legacy of present development on the future health of the marsh and the future use of Georgia's citizens. The preface states that the:

> "General Assembly further finds and declares that activities and structures in the coastal marshlands must be regulated to ensure that the values and

[99] *O.C.G.A. 12-5-280*.
[100] Ibid. Any person who is aggrieved or adversely affected by the Committee's decision may petition for an administrative hearing. Only after the administrative law judge makes a final decision is there a right of judicial review.
[101] Ibid.

> functions of the coastal marshlands are not impaired and to fulfill the responsibilities of each generation as public trustees of the coastal marshlands for succeeding generations."[102]

Furthermore the preface states that the:

> "**General Assembly** further finds that this coastal marshlands resource system is costly, if not impossible, to reconstruct or rehabilitate once adversely affected by man related activities and is important to conserve for the present and future use and enjoyment of all citizens and visitors to this state."[103]

Paramount to the consideration of the future health of the salt marsh and the future access to the salt marsh is the consideration of the impact of sea level rise. The Protection of Tidewaters Act and the Coastal Marshlands Protection Act memorialize the Public Trust Doctrine and explicitly define the doctrine in terms of future generations, generations which will experience the impact of sea level rise.

There exist no Georgia cases in which a citizen has attempted to enforce the state's obligation as public trustee to protect coastal areas against the threat of sea level rise.[104] However, one recent example from the Georgia courts illustrates the present acceptability of expanding the reach of the Coastal Management Protection Act. In *Center for a Sustainable Coast v. Georgia Department of Natural Resources*, the court ruled that the issuance of a permit for a large parking lot adjacent to a development near the salt marsh was not within the scope of the Coastal Marshlands Protection Act to regulate. The Center for a Sustainable Coast had argued that because the parking lot as a source of pollutants harmed the health of the marsh that the parking lot

[102] Holland, "Are Our Coastal Marshlands Being Protected?".
[103] Ibid.
[104] Ellis et al., "A Legal Analysis of Sea Level Rise." 11.

should be included within the area protected by the act.[105] *Center for a Sustainable Coast* exemplifies the strict reading of the scope of the Coastal Marshlands Protection Act. This thesis argues that the threat that sea level rise poses to salt marshes should expand the scope of the act to include area not now inhabited by salt marsh but crucial to its future survival.

Examples from other states illustrate the potential future of enforcement of the public trust doctrine in the context of sea level. These examples show that the enforcement of the public trust may compel governmental action to protect marshlands and tidewater access in a manner that directly conflicts with private landowner interests. Thus the emergence of efforts to enforce the public trust could implicate takings law under both state and federal constitutions.

In *National Audubon Society v. Superior Court of Alpine County* the California Supreme Court found that the public trust doctrine placed an affirmative duty upon the state to consider the effects of the city of Los Angeles' water diversion from Mono Lake upon the protected uses of public trust property. Ultimately the court required the state to take action to preserve the public beneficiaries' interests.[106] *National Audubon Society* demonstrates a court's finding that the public trust doctrine may impose a duty upon the state to act in the face of threats to public trust property, i.e. the natural resources which are the people's common heritage. While other examples of such cases are sparse, commentators have remarked upon the likelihood that the doctrine, traditionally invoked to prevent certain uses on public trust lands,

[105] *Center for a Sustainable Coast, Inc. V. Ga. Department of Natural Resources*,(2012).
[106] *National Audubon Society V. Superior Court of Alpine County*,(1984).

has evolved into an affirmative obligation that states act to protect trust values in such lands.[107]

If hard armor is not prohibited in the coastal zone as a means of protecting public holdings, the Biggert-Waters Act of the National Flood Insurance Policy could act as a driver of relocation of development away from the coast. The Biggert-Waters Act is gradually compelling the private property owner on the coast to bear the full burden of living on the coast and the impact of sea level rise. The following section will review the National Flood Insurance Program and the changes to the program brought about by the Biggert-Waters Act.

The NFIP and the Biggert-Waters Act

Communities that regulate new development in their floodplains are able to join the National Flood Insurance Program (NFIP). In return, the NFIP provides federally backed flood insurance for properties in participating communities. In 1968 following several disastrous floods around the United States, Congress enacted the National Flood Insurance Act (NFIA). The act directed the Federal Emergency Management Agency (FEMA), under the NFIP, to identify and map flood prone areas, make flood insurance available to property owners, and promote state and local land use controls that would guide development away from flood hazard zones.

The program marked a significant shift in United States' flood policy away from levee protection and towards risk identification, risk financing, and floodplain management. Its original intent was to foster individual responsibility and build local

[107] Jack H. Archer and Terrance W. Stone, "Interaction of the Public Trust and the Takings Doctrines: Protecting Wetlands and Critical Coastal Areas, The," (1995). 91.

self-sufficiency in terms of land-use zoning ordinances and construction standards.[108] Specifically Congress passed the National Flood Insurance Act to:

- Transfer the costs of private property flood losses from the taxpayers to floodplain property owners through flood insurance premiums
- Provide floodplain residents and property owners with financial aid after floods, especially smaller floods that do not warrant federal disaster aid
- Guide development away from flood hazard areas
- Require that new and substantially improved buildings be constructed in ways that would minimize or prevent damage during a flood.[109]

Presently FEMA is prohibited from providing flood insurance to property owners in communities that do not participate in the NFIP.

Examples of requirements under the NFIP include locating all new structures landward of the mean high tide and elevating structures above the base flood elevation. Base flood elevation is the elevation shown on the Flood Insurance Rate Map for high-risk flood zones indicating the water surface elevation resulting from a flood that has a 1 percent chance of equaling or exceeding that level in any given year.[110] NFIP requirements also include anchoring structures against a 100 year flood (flood event that has a 1% probability of occurring in any given year) and prohibiting alterations of sand dunes and mangrove stands when these alterations will increase potential flood damage. The minimum requirement of flood proofing under the NFIP is to provide protection up to the 100 year flood level. FEMA estimates that $1.2

[108] Rawle O. King, "National Flood Insurance Program: Background, Challenges, and Financial Status: R40650," *Congressional Research Service: Report* (2009)., .3.
[109] "Unit 2: The National Flood Insurance Program - Federal Emergency Management Agency," www.fema.gov/pdf/floodplain/nfip_sg_unit_2.pdf.
[110] FEMA, "Fema Flood Brochure," FEMA, http://www.floodsmart.gov/floodsmart/pdfs/fema_flood_brochure.pdf.

billion in flood losses are avoided each year as a result of community floodplain management requirements.[111]

The NFIP also encourages a community to plan for flooding by operating the Community Rating System (CRS). The CRS is a voluntary program that incentivizes community floodplain management activities that exceed the NFIP requirements.[112] The CRS reduces flood insurance premiums to reflect what a community does above and beyond the NFIP's minimum standards for floodplain regulation. The objective of the CRS is to reward communities for what they are doing, as well as to provide an incentive for new flood protection activities. CRS participating communities are divided into classes. The CRS classes for communities are based on 18 creditable activities, organized under 4 categories, public information, mapping and regulations, flood damage reduction, and flood preparedness. Flood insurance premium rates for these classes are discounted in increments of 5%. The reduction in flood insurance premium rates is provided according to the community's CRS classification (Table 3.1).

Although the NFIP has succeeded in identifying hazard areas and providing low-cost flood insurance to property owners in areas deemed commercially uninsurable, the program has arguably failed to transfer the cost of living in a flood zone from the taxpayer to floodplain residents. This deviation from the program's

[111] King, "National Flood Insurance Program: Background, Challenges, and Financial Status: R40650."
[112] Jessica Grannis, "Floodplain Management Regulations and Building Codes and Standards," (Washington, D.C.: Georgetown Climate Center, 2011).

Table 3.1. CRS Class. Source: FEMA.[113]

CRS Class	Credit Points	Premium Reduction
1	4,500+	45%
2	4,000-4,499	40%
3	3,500-3,999	35%
4	3,000-3,499	30%
5	2,500-2,999	25%
6	2,000-2,499	20%
7	1,500-1,999	15%
8	1,000-1,499	10%
9	500-999	5%
10	0	0%

original intent can be seen in repetitive flood loss properties (RLP). An RLP is defined as an insured property that experiences two or more flood losses greater than the $1,000 within any 10 year period. FEMA approximates that 90% of all RLPs were built prior to December 31, 1974, or before the adoption of a FIRM, and hence have been grandfathered in before NFIP requirements for new homes and are thus subject to premium discounts. Because flood insurance rates to repetitive loss continue to be subsidized, the general public continues to bear the burden of individuals who wish to live in vulnerable coastal areas but who built homes before

[113] FEMA, "National Flood Insurance Program Community Rating System Coordinator's Manual," (2013).

NFIP requirements. The annual increase in new RLPs is now outpacing FEMA mitigation efforts by a factor of 10 to 1.[114] Additionally, the program has failed to guide development away from special flood hazard areas (SFHA). SFHAs are areas included within the 100-year floodplain as shown on the flood insurance rate map (FIRM). Presently the NFIP does not limit the uses that can be permitted in these vulnerable areas. Consequently local governments are not required to impose use restrictions in SFHAs.

The NFIP was self-supporting from 1986 until 2005, covering all expenses and claim payments out of annualized cash flow of policy premiums and fees. But over the past decade the federal government has not been able to utilize its capacity to spread losses over time with the NFIP's ability to borrow money from the U.S. Treasury to offset program deficits. Presently the program's outstanding debt to the Treasury stands at $19.3 billion. FEMA is not likely to be able to repay the debt because of the considerable amount of interest associated with that level of borrowing. Interest payments on the program's debt to the Treasury are almost $1 billion annually.[115]

This thesis argues that the role of government should be to help individuals adapt to sea level rise but in a manner that does not inhibit marsh migration. Up to the present, the NFIP has arguably encouraged risky behavior on the coast through

[114] Robert M. Friedman, "Summary of the Heinz Center Report on Coastal Erosion and the National Flood Insurance Program," *Journal of Coastal Research*, no. 3 (2002). Historically it is estimated that 1% of the properties insured under the NFIP have accounted for over a third of claims paid. About one in ten homes that suffer repetitive flood damages have cumulative flood insurance claims that have exceeded the value of the house.

[115] King, "National Flood Insurance Program: Background, Challenges, and Financial Status: R40650." 9.

the subsidization of flood insurance premiums for coastal property that, if protected, will inhibit marsh migration. Additionally, if the subsidization of coastal flood insurance continues, development of the coastal area will also continue, and the presence of armor in protection of development will be significant. It follows that marsh migration paths will be inhibited. Rather than continue the subsidization of flood insurance premiums on the coast with the public at large bearing the majority of the costs, this thesis proposes that society consider more deeply the impact of sea level rise and protection of development from sea level rise on coastal ecosystems.

In the past the Federal Government has removed federal subsidies for certain barrier islands. The Coastal Barrier Resources Act caused some of these islands to remain undeveloped and reduced the likelihood of shore protection for several that have been developed without subsidies.[116] Currently the Federal Government is reducing the subsidies it provides under the NFIP with the Biggert-Waters Act (fig. 22). On July 6, 2012, the Biggert-Waters Flood Insurance Reform Act of 2012 was signed into law. In addition to reauthorizing the NFIP through September 30, 2017, the law brings several substantive changes to the program including a change in the manner premium rates are calculated.

Congress has instructed FEMA to stop giving premium discounts to properties that are below the base flood elevation, even those properties that were up to code when built. Congress is also phasing out pre-FIRM (flood insurance rate maps) and grandfathered rates. In the past, many structures were allowed to keep their original

[116] Titus, "Rolling Easements." 4.

flood-risk rating, even when conditions and improved understanding had changed.[117] Both subsidies largely end with the implementation of the Biggert-Waters Act, which specifies subsidized rates are no longer available for:

- Property where NFIP coverage was deliberately allowed to lapse
- Properties receiving an *offer* of mitigation assistance following a major disaster, or in connection with a repetitive loss property
- Repetitive loss or severe repetitive loss properties
- Businesses
- Non-primary residences
- Substantially damaged properties
- Property at least 30% improved
- Newly purchased property

Subsidized insurance rates will be phased out for all properties except Pre-FIRM primary residences that have not lost their qualification for the rate.[118] Figure 3.1 illustrates the changes in insurance rates that properties below the updated base flood elevation might experience.

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[117] National Hazard Mitigation Association, "Nhma Biggert-Waters Act," http://nhma.info/nhma-biggert-article/. Pre-FIRM subsidies were given under tow conditions. (1) Buildings built before 1975 or before the community (governing jurisdiction) received its first Flood Insurance Rate Map (FIRM). These buildings have often been insured at Pre-FIRM rates, unless the owner opts out of this option. (2) The building was built Post-FIRM, in compliance with a FIRM, but a more recent FIRM shows the building to be at greater risk of flooding. These buildings have been grandfathered administratively, and were allowed to keep the rate-class (flood zone and building elevation relative to BFE) that applied at the time of construction.

[118] Ibid. A Pre-FIRM primary residence will lose its qualification for Pre-FIRM rates under the following conditions and situations: 1) When the policy-holder chooses to let the policy lapse; 2) When the property is sold. A new policy cannot be written at Pre-FIRM rates; 3) If, after July 6, 2012, the building is improved and the cost of improvement is more than 30% of the fair market value of the building before improvements were begun; 4) If, after July 6, 2012, the building is substantially damaged and the cost to restore it to its pre-damaged condition is 50% of the fair market value of the building before damage occurred. For substantial damage, the “cost” is the cost to restore the building to its pre-damage condition, even if you don’t plan to spend that much or to restore it fully. It also includes the cost of discretionary improvements you plan to make as part of the restoration project; 5) if the flood insurance claims history on the building meets one of the following criteria: (a) Total NFIP claims paid for flood-related building damage exceed the fair market value of the building. The property is a severe repetitive loss (SRL) property and; (b) A single family property with 1-4 residences is an SRL property if it has incurred flood-related damage resulting in four or more claims payments for building damage that exceed $5,000 each, OR, two claims payments for building damage that together exceed the value of the insured building and; (c) If the owner of a repetitive loss property refuses an offer of mitigation assistance (to raise or relocate the building), including an offer under the Hazard Mitigation Grant Program (HMGP)

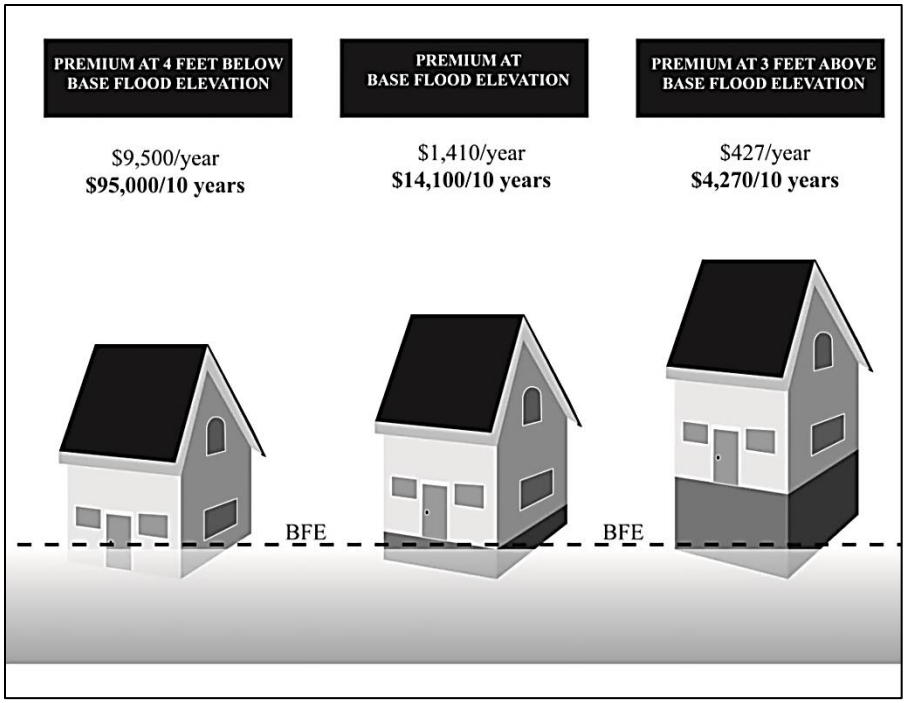

Figure 3.1. Changes in the NFIP. The above illustration is based on a standard NFIP deductible of $250,000 building coverage, not including contents, AE (high to moderate risk) zone, single family, one-story structure with a basement at 4 feet below base flood elevation (Adapted from FEMA flood insurance brochure).[119]

Currently insured properties that no longer qualify for Pre-FIRM rates will see their premiums increase 25% per year until actuarial rates are achieved. When updated maps show properties in higher-risk areas (flood zones), affected property owners will see premiums increases toward actuarial rates phased in over a 5-year period, beginning on the effective date of the map that identifies the increased risk. For example, if the actuarial rate is $1000 per year more than the subsidized rate, the premium would increase by $200 per year for five years.[120]

[119] FEMA, "Fema Flood Brochure".
[120] Association, "Nhma Biggert-Waters Act".

Conclusion

Based upon the value to society that Georgia's salt marsh provides, citizens may in the future enforce the protection of the public trust marshlands, including the salt marsh. Given the public trust values expressed in the Protection of Tidewaters Act and the Coastal Marshlands Protection Act, this thesis argues that a Georgia court is likely to find that the state has an obligation to prevent foreseeable harm to trust property attributable to sea level rise. The idea of protection of the public trust marshlands could be expanded to include protection of marsh migration paths to ensure the presence of the salt marsh on the Georgia coast. On this premise, the state could prohibit sea walls, bulkheads, and other hard structural protection of the estuarine shoreline to prevent the submergence of salt marshes. Such statute could also require a prohibition on any hard structural protection upland of the salt marsh's present position which coincides with future marsh migration pathways.

The role of government in the United Sates coastal zone is changing. The Biggert-Waters Act signifies a break from the historic pattern of promoting coastal development through subsidized flood insurance. Grandfathered rates will be largely phased out as the cost of living on the coast is actualized to represent the full risks of the dynamic shoreline. This thesis argues that among the effects of the Biggert-Waters Act on coastal development is a reconsideration of the benefits of relocating from the coastal zone. Relocation could in turn provide area for future marsh migration, remove development from area vulnerable to flooding, and decrease the cost of insuring life on the coast for the general public.

Relocation as a sea level rise adaptation goal is particularly relevant to the gentle slope of the Georgia coast. In general, the gentler the slope of the land, the farther the shoreline will migrate for a given increment of sea level rise. Considering the topography along the Georgia-South Carolina shoreline, a 1-foot vertical rise in sea level will result in the shoreline moving at least 200 feet landward on average, and considerably greater distances where the slope of the land is lower.[121] The Georgia coast will see flood events related to sea level rise increase over the near future. If individuals are not driven from the coast by the Public Trust Doctrine or the Biggert-Waters Act, this thesis proposes that property owners be incentivized to give precedence to marsh migration over protection of coastal development. Chapter 4 will propose planning tools which may aid this goal.

[121] Clayton, *Living with the Georgia Shore / Tonya D. Clayton ... [Et Al.]*. 16.

CHAPTER 4

SEA LEVEL RISE ADAPTATION TOOLS FOR RELOCATION

Introduction

Historically communities in the United States have adapted to dynamic coastlines using hard armor, strengthened building codes able to withstand high winds and flooding, and the NFIP, established to control the losses from hurricanes and storms.[122] In the 21st century, coastal populations are wrestling with adapting to sea level rise and its impact on coastal development, processes, and ecosystems, including salt marshes.

In terms of climate change, adaptation is the response by natural or human systems to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.[123] Relocation is among the three sea level rise adaptation actions, goals or policy objectives presently discussed in planning for sea level rise. The other goals are protection and accommodation (Figure 4.1). In a protection oriented scenario, a community defends coastal areas vulnerable to flooding and inundation from sea level rise, especially those of great societal concern such as population centers, economic centers, and natural resource areas.[124] In an accommodation scenario, a community continues to occupy vulnerable coastal areas but accepts the greater degree of flooding by changing land use, construction methods

[122] William J. Neal, David M. Bush, and Orrin H. Pilkey, "Managed Retreat," (2005). 603.
[123] United Nations Framework Convention on Climate Change, "Glossary of Climate Change Acronyms," http://unfccc.int/essential_background/glossary/items/3666.php.
[124] Linham and Nicholls, "Technologies for Climate Change Adaptation: Coastal Erosion and Flooding." 12.

and/or improving preparedness. In a relocation scenario, a community abandons structures in vulnerable coastal areas, resettles inhabitants and requires that new development be set back from the shore.

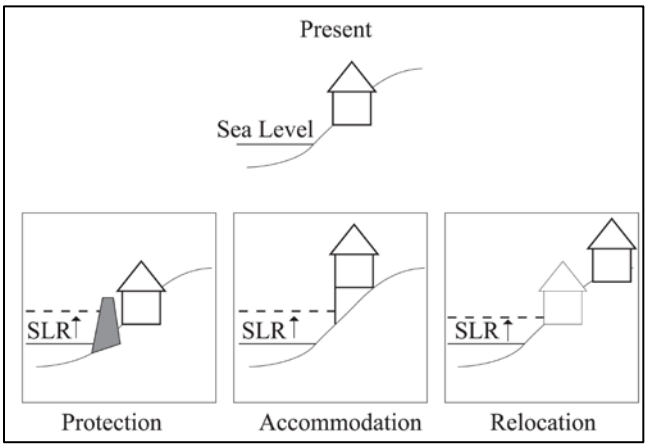

Figure 4.1. The three most common sea level rise adaptation goals, protection, accommodation, relocation. (Adapted from "Technologies for Climate Change Adaptation: Coastal Erosion and Flooding," by Matthew M. Linham and Robert J. Nicholls, 2010).[125]

Sea level rise adaptation goals can be further categorized as reactive, proactive or laissez-fare. Reactive responses are actions that a government takes after impacts have occurred. Reactive responses include rebuilding restrictions and armor. Traditionally property owners have managed floods and erosion with hard armor, e.g. engineered solutions like seawalls and bulkheads. However decision makers are increasingly recognizing the limitations and impact of armored solutions. Armoring is costly to build and maintain and can increase flooding and erosion of neighboring

[125] Ibid. 13.

properties.[126] Hard armoring can also increase risks from catastrophic failure of the structure because it facilitates development in vulnerable coastal areas. Armoring also has damaging environmental impacts to beaches and tidal marshes.[127]

A proactive response involves advance planning and implementation of measures that are designed to preemptively mitigate the negative consequences from natural hazards.[128] Proactive planning can help governments facilitate use of non-structural solutions to protect against risks. Non-structural solutions include using land-use measures to ensure that development is more resilient to flooding and erosion and reduce the cost and difficulty of a long-term retreat.[129] Generally speaking, communities that respond proactively hope to have more flexibility in their response to sea level rise.

Under a laissez-faire response, a community makes no effort to prevent either development or shore protection. Instead laissez-faire planning for sea level rise involves curtailing government subsidies for development and protection with the goal that the forces of nature and economics will lead owners to allow their lands to be submerged.[130] The laissez-faire response is based on the assumption that investors are more likely to appropriately manage known risks if they bear all of the ramifications of their decisions. This response can reduce eventual shore protection in areas where government subsidies would otherwise fund shore protection or coastal development. The ecological drawbacks of the laissez-fare response are

[126] Grannis, "Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use: How Governments Can Use Land-Use Practices to Adapt to Sea-Level Rise." 6.
[127] Ibid. 6.
[128] Ibid. 6.
[129] Ibid. 6.
[130] Titus, "Rolling Easements." 4.

considerable. Although many landowners will eventually yield their land to the sea as shore protection costs escalate, in the interim regulation will not be able to manage shore protection built upland and in the path of the inland migration, resulting in the blockage of marsh migration.[131]

This thesis argues for a proactive response to relocating communities from the coastal zone in order to create valuable upland space for marsh migration. As an auxiliary consequence, coastal communities will benefit socially and economically as development is relocated upland from areas vulnerable to flooding. In Chapter 2 the importance of the salt marsh to Georgia's coastal ecology as well as its coastal economy was outlined. In addition the chapter addressed the impact of sea level rise on the salt marsh and the additional deleterious effects of hard armor. In Chapter 3 the Public Trust Doctrine and the Biggert-Waters Act were identified as drivers of relocation from the Georgia coast. The Public Trust Doctrine was discussed in light of its role in the Protection of Tidewaters Act and the Coastal Marshlands Protection Act. Expansion of these acts was then discussed in the context of marsh migration. The Biggert-Waters Act was highlighted as an economic driver of relocation from the Georgia coast and tangential promoter of marsh migration.

Chapter 4 will more completely describe relocation within the context of sea level rise adaptation goals. Furthermore the chapter will propose particular land use tools that can be adapted to solve the problem of marsh migration. This thesis argues that coastal property owners who wish to allow marsh migration need to understand the mechanisms by which they can best relocate their investment. The majority of

[131] Ibid. 4.

this chapter will deal with the lands use tools which will assist, and, in some cases, incentivize relocation from the Georgia coast.

Setbacks and Buffers

Setbacks are building restrictions that establish a distance from a boundary line within which landowners are prohibited from building structures. Buffers require landowners to leave portions of their property undeveloped, thus ensuring that development adjacent to natural areas does not inhibit natural hydrological and ecosystem functions. Setbacks and buffers can be established through zoning ordinances, subdivision ordinances, and floodplain ordinances. Some state level coastal management statutes also establish special setbacks or buffer areas in coastal areas.[132]

Several different mechanisms exist for establishing setbacks and buffers. Fixed mandatory setbacks require that all structures, including seawalls, be set back a specific distance from a predetermined line. Erosion-based setbacks are determined by a projected shoreline position that assumes a specific increase in sea level and erosion rates over a specific time frame such as the life of the structure. Tiered setbacks require a lesser setback or buffer for smaller structures and a greater setback for larger structures that put more people at risk and are more difficult to move if they become damaged.[133]

Local governments or state agencies could require that new development along dynamic coastal shorelines evaluate potential impacts to the development from

[132] Grannis, "Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use: How Governments Can Use Land-Use Practices to Adapt to Sea-Level Rise." 26.
[133] Ibid. 26.

a specific rate of sea level rise. Governments could limit development where it cannot include sufficient setbacks to mitigate impacts from sea level rise over the life of the structure.[134] Buffer zones could be created along coastal zones to ensure that vulnerable beaches and wetlands have room to migrate inland as sea levels rise. Like setbacks, buffer zones could be determined based upon erosion and sea level rise rates for that area over a specified amount of time.[135]

Setbacks can be impractical where parcels are small or the slope of the land is gentle so that each lot cannot have a building site high enough to be safe for the next few decades. In most places with setbacks, development is only set back by at most a few hundred feet or enough to keep a home out of harm's way for a few decades.[136] Another drawback of setbacks is that they prevent development of coastal lands. Preventing development would impose a great cost either on landowners unable to put their land to its most profitable use, or on governments and private parties who purchase or otherwise pay landowners to refrain from development. Buying most of the nation's undeveloped coastal lands seems unlikely and economically infeasible.[137]

North Carolina's Coastal Resources Commission (CRC) adopted oceanfront setbacks based upon periodically updated erosion rates and banned hardening of the oceanfront shoreline in the 1980s. Although conflict has increased in recent years, these policies have protected both the public beach and private property. The CRC has adopted water quality buffers that help protect estuarine shorelines. The CRC has

[134] Ibid. 26.
[135] Ibid. 26.
[136] Titus, "Rolling Easements." 4.
[137] Ibid. 4.

debated but not adopted policies to ban hardening estuarine shorelines and to require setbacks based on erosion rates.[138]

Comprehensive Plans

Comprehensive plans are long range planning tools governments use to guide development. In a comprehensive plan, or master plan as it is sometimes called, governments or planning firms map present conditions by identifying the character and location of lands and facilities. Studies of population growth and development trends are conducted so that the plan can designate areas for future development, preservation, and proposed public improvement projects. Plans typically do not have a direct legal effect, but are implemented through a legally enforceable zoning ordinance and maps.[139]

Comprehensive plans can be powerful tools by which governments incorporate adaptation tools into the framework for making land-use decisions. Through comprehensive plans, governments can:

- Establish the degree of sea level rise and time period to be considered when making land-use decisions
- Study and identify potential sea level rise impacts
- Assess vulnerabilities
- Designate areas requiring special protection
- Site future public infrastructure outside of vulnerable areas
- Identify the specific land-use tools that will be used to respond to sea level rise in different areas
- Create a schedule for implementation[140]

[138] B. Holman and A. Pickle, "Climate Ready Estuaries: A Blueprint for Change," in *Climate ready estuaries: a blueprint for change* (Durham; USA: Duke University Press, 2011). 16.
[139] Grannis, "Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use: How Governments Can Use Land-Use Practices to Adapt to Sea-Level Rise." 16.
[140] Ibid. 16.

Comprehensive plans can serve as evidentiary justification when local governments amend their zoning ordinances to implement specific adaptive responses. They can also be used to build public support for adaptation measures by demonstrating the community's vulnerabilities.[141]

The primary disadvantage of addressing sea level rise through comprehensive plans is the nature of sea level rise itself. It is difficult to frame a comprehensive plan because (1) the full height of sea level rise is unknown, (2) the full effects of sea level rise are uncertain and (3) these impacts are not likely to be felt for several decades. Comprehensive plans which address sea level rise must therefore possess enough flexibility to adapt to a potentially immense change in conditions.

The Maryland Department of Natural Resources (MD-DNR) is working with three of the state's most vulnerable counties to help them incorporate sea level rise in their comprehensive plans and zoning ordinances. In its guidance to Dorchester County, MD-DNR recommends that the county plan for 3 feet of sea level rise over the next century and use a 25-year planning time frame. The guidance recommends that the county amend its comprehensive plan to limit subdivisions in vulnerable areas, promote infill in upland areas, restrict rebuilding of damaged structures to the existing footprint, and require increased freeboard.[142] Freeboard is any additional height above a flood elevation which a community can use to determine the elevation of a structure's lowest floor.[143]

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[141] Ibid. 16.
[142] Ibid. 18.
[143] Association, *Planning and Urban Design Standards: Student Edition*. 87-88.

Zoning and Overlay Zones

Zoning and overlay zones provide the framework that governs the use and development of land in a community. Zoning maps divide the community into different districts based upon the types of uses permitted. Within each zone the zoning ordinance specifies different regulations governing development within each zone, including setback, building density, and size of structures.[144] Overlay zones superimpose additional regulations on an existing zone based on special characteristics of that zone (e.g., floodplains and historic districts). Overlay zones allow greater flexibility because they do not require the locality to disrupt existing zoning classification. Overlay zones allow for targeted adaptation to complications from sea level rise specific to individual sectors within a community.

Before implementing most land-use tools, local governments will need to amend their zoning ordinances to designate areas vulnerable to impacts. [145] Special regulations on these areas could then prohibit or limit expansion or major renovation to existing structures and rebuilding of damaged structures. These zones could be based upon their adaptation goals, and depending on the goal, local governments could create sea level rise overlay zones.[146]

A sea level rise protection overlay zone could be applied to an area with either critical infrastructure or dense development where the locality will permit coastal armoring. Local governments could require that soft-armoring techniques be

[144] Grannis, "Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use: How Governments Can Use Land-Use Practices to Adapt to Sea-Level Rise." 19.
[145] Ibid. 2.
[146] Ibid. 2.

employed where feasible.[147] In an accommodation overlay, local governments could allow new development but limit the intensity and density of new development. In the accommodation zone, hard armoring could be limited and structures could be required to be designed or retrofitted to be more resilient to flood impacts.[148] In a retreat overlay zone, hard armoring could be prohibited. In addition, rebuilding of inundated or damaged structures could be prohibited, limited, or required to be removed or relocated. Local governments could combine these regulations with incentives and encourage landowners to relocate structures upland through tax benefits, acquisitions, or conservation easement programs.[149]

In order to create an overlay zone, a local government must (1) establish the purposes for creating the district, (2) map the district, and (3) establish the regulations to achieve the purposes for creating the district.[150] The disadvantages of overlay zones in the face of sea level rise are akin to those associated with comprehensively planning for sea level rise. In short, the uncertainty of the nature and impact of sea level rise limits a community's vision of definitive actions they can take to mitigate the effects of sea level rise. In the meantime, property values suffer as a result of being zoned in a vulnerable area where protection, improvement, or rebuilding of property is either limited or prohibited.

The Chesapeake Bay Critical Area law uses overlay zones to protect and restore water quality and habitat. The law creates overlay zones that regulate development adjacent to the bay based upon the status of development in three types

[147] Ibid. 19.
[148] Ibid. 19.
[149] Ibid. 20.
[150] Ibid. 19.

of areas. Intensely developed areas with little natural habitat are zoned as targets for new development. Limited developed areas are zoned so that new development protects natural habitat. Resource conservation areas, which are predominantly made up of wetlands, are zoned for very limited residential development.[151]

Chatham County, Massachusetts revised its zoning ordinance to prohibit residential development in the 100 year floodplain. The County justified the regulations on the grounds that development poses risks to adjacent parcels during storm events and poses dangers to rescue personnel during evacuations. Permissible uses under the ordinance include recreational, agricultural, and commercial fishing. The Massachusetts Supreme Court found that the regulation did not cause a taking of private property because it did not prevent all economic use of regulated properties.[152]

Acquisitions and Buyout Programs

In a relocation scenario, state and local governments, private land trusts or non-profit organizations could acquire property at risk from flooding or other hazards. Structures are typically demolished and the property is restored to a natural state. Undeveloped lands are then conserved as open space, public parks, or for natural resources.[153] Governments could extend floodplain buyout programs to properties threatened by sea level rise. They could also prioritize vulnerable properties with high natural resource value. Governments could also prioritize lands with potential to serve as a flood buffer for existing development or potential to serve as corridors for migrating beaches and wetlands.

[151] Ibid. 20.
[152] Ibid. 22.
[153] Ibid. 4.

Acquisitions have historically been linked to flood protection projects. Flood protection projects are developed at the local level and submitted to the state for approval under FEMA's Hazard Mitigation Grant Program (HMGP) and the U.S. Department of Housing and Urban Development's Community Development Block Grant program (CDBG). These acquisitions are commonly called "buyouts."[154] Additional expense includes demolition, appraisals, relocation assistance, and closing and legal costs.

Acquisitions can be expensive and local governments lose the tax revenue from acquired land. The value paid for acquired land will likely not be fully discounted for the future risk of flood impacts because of the uncertainties associated with climate change.[155] The government is typically required to pay the appraised fair market value of property upfront before the danger of flooding is realized. The government also has to hold and manage lands after acquisition. State and local governments, however, may be able to leverage federal monies to support acquisition programs.[156]

By acquiring properties that serve as natural flood buffers, governments can preemptively relocate vulnerable households. However, it is often difficult to get full participation in voluntary buyout programs. Lack of full participation can create a checkerboard effect; some parcels are acquired and converted but other parcels remain developed. The checkerboard effect can cause blight in the community, and

[154] Jessica Gannis, "Buyouts Dramatically Demonstrate Avoided Flood Damage," (Washington, D.C.: Georgetown Climate Center, 2011). 4.
[155] Grannis, "Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use: How Governments Can Use Land-Use Practices to Adapt to Sea-Level Rise." 49.
[156] Ibid. 49.

makes it more difficult to restore the ecological services provided by the acquired lands.[157]

Another drawback to buyouts is that it can be difficult for governments to determine how to set acquisition priorities. The viability of acquisition programs may also be politically tenuous because taxpayers may not want to spend scarce public funds.[158] Additionally when governments acquire land, they must expend additional public funds holding and managing acquired lands. Coastal managers may need to consider how acquired lands may be impacted by sea level rise, since some lands purchased with public funds may eventually become inundated.

The Georgia Environmental Management Agency (GEMA) defines hazard mitigation as any sustained action taken to reduce or eliminate the long-term risk to human life and property from hazard events.[159] It is a continuous process that occurs before, during and after disasters and serves to break the cycle of damage and repair in hazardous areas. The Hazard Mitigation Division (HMD) at GEMA is made up of a Planning Section and a Risk Reduction Section, with staff dedicated to providing technical assistance to all state agencies and local governments in Georgia. The Division also coordinates the update of the State Hazard Mitigation Plan every three years. The HMD also ensures the state and its agencies and all local governments remain eligible for future federal disaster assistance (as required by federal law) through the completion of FEMA approved mitigation plans.

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[157] Ibid. 49.
[158] Ibid. 49.
[159] GEMA, "Hazard Mitigation," http://www.gema.ga.gov/gemaohsv10.nsf/1c3c181c58c9b3f28525771b0058b098/c43f004a103bbf0a852577200052d3d2?OpenDocument.

In 1994, Tropical Storm Alberto caused major flood-related damage to central and southwestern Georgia. The Flint River cities of Newton and Albany were among the hardest hit by floods from the storm. Alberto, which meandered over the state for several days before dying out, dumped up to 28 inches of water in some areas. One-third of Georgia's counties were declared federal disaster areas.

Located in Baker County, Newton is a small rural town with a population of less than one thousand. The town lies about 20 miles southwest of Albany and is located next to the Flint River. The floods left the downtown area under 12 feet of water; elsewhere flood depths were as high as 20 feet. Approximately 150 homes and businesses flooded; and several historic structures were damaged. Newton suffered $4.5 million in damages.[160] In the Newton mitigation project, FEMA funded the acquisition and demolition of 20 residential and 19 commercial structures. The total cost of the project was $754,464. All but one business moved out of the floodplain.

In early March 1998, a storm system inundated Georgia with torrential rain. More than 40 percent of Georgia's counties had some level of flooding. However, the buyout of residential and business properties after the 1994 flood proved to be an effective investment in Newton and nearly $2 million in damages and losses were avoided. If these buildings had merely been repaired after the 1994 flood, many would have been completely destroyed in 1998.[161]

In Iowa relocation has been undertaken in a more proactive manner. The Federal Emergency Management Agency (FEMA) has increased its effort to assist

[160] FEMA, "Newton - Acquisition Project: Full Mitigation Best Practice Story," http://www.fema.gov/mitigationbp/bestPracticeDetail.do?mitssId=128.
[161] Ibid.

states in developing hazard mitigation projects to reduce future losses to flooding. In Iowa and eight other Midwest states, more than 20,000 buildings have been cleared form floodplains. Since the 1993 floods, Iowa has settled more than 46 acquisition or relocation projects. More than 1,000 properties have been removed from flood-hazard areas in the state. Over 20 critical facilities, such as hospitals, have been protected. At least 66 projects have been funded, with a total investment of $54 million in FEMA, state and local community funds. The long-term payoff is two dollars returned to every dollar invested, and in some communities the payoff is already greater.[162]

In the spring and summer of 1999, Iowa was inundated after heavy rains. In May of that year, 16 counties were again declared federal disaster areas due to tornados and floods. In July, 21counties were again declared disaster areas due to severe storms and floods. Eight of the counties declared disaster zones in 1999 had elected to participate in a hazard mitigation buyout program after the 1993 floods. In these eight counties, 271 families who were affected by the 1993 floods avoided the trauma and loss due to flooding because they no longer lived in the floodplain.[163]

The State of Iowa projects the 30-year benefit from this project to be over $6.6 billion in avoided damages. Since the beginning of the project in 1993, $872,202 in damages has already been avoided. Estimated avoided damages from the recent May and July floods of 1999 were $4,472,333. The total avoided damage for these events is $5,344,355, over $1 million more than the cost of the hazard

[162] Gannis, "Buyouts Dramatically Demonstrate Avoided Flood Damage." 2. Based upon a conversation by the authors with Dennis Harper, the State of Iowa hazard mitigation officer.
[163] Ibid. 3.

mitigation project.[164] All acquired properties are deed-restricted and must remain in public ownership permanently. Some of the properties will be saved as green space. All will be connected to existing parkland in the area. Barb Hugi, the city planner who handled the buyouts in 1993 said, "I've never run into any person who was not happy to be moved from that area."[165]

Conservation Easement Statutes

Enabling statutes typically authorize the creation of conservation easements that impose both negative obligations and affirmative obligations. This fact gives governments the broad authority to individually craft easement terms.[166] Conservation easements could be used to prevent development, in this case seawalls or bulkheads, in areas vulnerable to sea level rise. Similar to acquisition programs, agencies could prioritize vulnerable properties and purchase conservation easements across parcels that have particular ecological utility. These conservation easements could include specific covenants that prohibit shoreline armoring. The North Carolina Steering Committee recommends that the state reevaluate its existing conservation easement programs to ensure that properties in vulnerable areas are eligible to receive tax credits and to ensure that property owners have sufficient incentive to sell or dedicate easements.[167]

Conservation easements are less costly than acquiring full title to property, but they still require governments to use taxpayer funds to acquire easements in advance

[164] Ibid. 4.
[165] Ibid. 5.
[166] Grannis, "Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use: How Governments Can Use Land-Use Practices to Adapt to Sea-Level Rise." 52.
[167] Ibid. 50.

of flooding. In addition conservation easements are more politically popular than regulations because they essentially allow for transfer of development rights from private landowners to the government. Their utility is limited because enabling statutes often limit acquisitions to voluntary sales.[168] Legally they possess some flexibility. These statutes broadly allow for the creation of easements that impose both affirmative and negative obligations. The types of restrictions imposed can vary greatly between individual easements.[169]

In Georgia, the Conservation Tax Credit is a financial incentive for landowners to help protect the state's natural resources. Landowners who donate fee-title lands or permanent Conservation Easements to a government entity or qualified organization may apply for a credit against their state income taxes. Approved donors may earn credits equal to 25% of the fair market value of their donations, up to $250,000 for individual donors and $500,000 for corporate and partnership donors. (Donations made and recorded by partnerships before January 1, 2013, may earn a credit of up to $1 million in aggregate.) Any unused portion of the credit may be carried forward for ten succeeding years.[170]

There are about 1,000 conservation easements today in Georgia. There are about 50 organizations in Georgia that are qualified to hold conservation easements. The holder of the conservation easement has both the right and responsibility to monitor and enforce easement terms in perpetuity. State agencies that hold

[168] Ibid. 51.
[169] Ibid. 51. Negative obligations prevent an owner from engaging in certain activities on his or her land. Affirmative obligations grant the easement holder rights to use the property for certain purposes.
[170] Georgia Land Conservation Program, "Georgia Tax Credit," http://glcp.georgia.gov/georgia-tax-credit.

conservation easements include the Department of Natural Resources and the Georgia Forestry Commission.[171]

In 1988, the ACE (Ashepoo, Combahee, and Edisto Rivers) Basin Project of South Carolina was launched when Ducks Unlimited, The Nature Conservancy, the South Carolina Department of Natural Resources, the U.S. Fish and Wildlife Service and private landowners formed a coalition known as the ACE Basin Task Force. Westvaco Corporation, the Lowcountry Open Land Trust and Nemours Wildlife Foundation joined the Task Force in 1998. The mission of the ACE Basin Project is to maintain the natural character of the basin by promoting wise resource management on private lands and protecting strategic tracts by conservation agencies. A major goal of the protection efforts is to ensure that traditional uses such as farming, forestry, recreational and commercial fishing and hunting will continue in the area.[172] Through mixing voluntary conservation easements with private and public land donations, the ACE Basin Project, as of 2010, has protected 208,000 acres.

Rolling Easement Statutes

Rolling easements originated with policies in Texas. The Texas Legislature enacted the Texas Open Beaches Act to ensure free and unrestricted access to state-owned beaches, which include areas between the mean low tide line (seaward boundary) and the vegetation line (landward boundary) bordering the Gulf of Mexico. Because the statutes include provisions that allow public access to "roll" landward as the vegetation line migrates landward, the laws came to be recognized as rolling

[171] "Conservation Easements," http://glcp.georgia.gov/conservation-easements.
[172] The ACE Basin, "The Ace Basin Project History," http://www.acebasin.net/history.html.

easement statutes. The statutes prohibit construction or erection of barriers or restraints that would interfere with public access.

In the case of rolling easements in Texas, when pre-existing shoreline protection structures prevent the vegetation line from migrating landward, the public acquires an easement for access along the structure's entire landward edge. The state may order removal of structures that infringe upon public beach access or constitute an imminent hazard to public safety, health, or welfare. The state may contract for and publically fund removal. If a storm event causes the vegetation line to shift landward of a pre-existing house, the state may allow the house to remain for two years if it does not pose an imminent threat to public health and safety. This exception does not apply to houses located below the mean high tide line or that have been destroyed by more than 50% of their market value. For the sale of certain coastal properties, the law requires real estate disclosures notifying potential buyers that the properties may eventually be located on the public beach because of coastal erosion and storm events, and that the state may require removal at the owner's expense, among other provisions.[173]

Rolling easements would be unlike traditional conservation easements, which typically prohibit all development on burdened parcels.[174] Rolling easements make no effort to restrict land use. Private landowners receive up-front compensation for agreeing to limit development in the future. Meanwhile they can continue to develop

[173] University of Hawai'i Sea Grant College Program Center for Island Climate Adaptation and Policy, "Sea-Level Rise and Coastal Land Use in Hawai‘i: A Policy Tool Kit for State and Local Governments." 43-44.
[174] Grannis, "Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use: How Governments Can Use Land-Use Practices to Adapt to Sea-Level Rise." 52.

and use their property. From the present time until the land is threatened, valuable coastal land can be put to its highest market based use. Once the land is threatened it will convert to wetland as if it had never been developed.[175] Currently along estuarine shores, rolling easements are rare.[176] But this fact could change as more states and communities begin to recognize the value of tidal marshes and the threats coastal development poses to these wetlands.

Rolling easements enable ecosystems to migrate inland and allow society to avoid the costs and hazards from protecting low lands from a rising sea. Rolling easement statutes typically: (1) prohibit shoreline armoring; (2) establish a rolling design boundary, seaward of which the owner's property rights are reduced; (3) prohibit new structures seaward of the rolling design boundary; (4) encourage or require removal of existing structures when erosion leaves them seaward of the rolling design boundary (5) warn prospective buyers of the regulations and; (6) provide provisions for public access.[177]

Transfer Development Rights

Transfers of development rights (TDR) programs allow landowners to transfer the right to develop one parcel of land to a different parcel of land. Generally TDR programs are established by local zoning ordinances. In the context of sea level rise, TDR might be used to shift development from a vulnerable area to designated growth

[175] Titus, "Rolling Easements." 5. Unlike a true laissez-fare market approach, rolling easements are based on the assumption that to incorporate the risk of sea level rise, the market needs some clearly defined rules about which lands may be protected. Otherwise, uncertainty about future government activities can overwhelm an investor's ability to manage the risk of sea level rise.
[176] Ibid. 13.
[177] Ibid. 14.

zones in upland areas where development will be out of harm's way.[178] The parcel of land where the rights originate is called a "sending" parcel. When the rights are transferred from a sending parcel, the land is restricted with a permanent conservation easement. The parcel of land to which the rights are transferred is called a "receiving" parcel. Buying these rights generally allows the owner to build at a higher density than ordinarily permitted by the base zoning. TDR is known as transfer of development credits in California and some regions of New Jersey. Governments sometimes establish and calibrate a development credit market in a manner that gives affected landowners an incentive to transfer their development rights rather than build on threatened properties.[179]

TDR programs enable landowners to separate and sell the right to develop land from their other property rights.[180] TDR programs are based on the concept that property owners have a bundle of different rights, including the right to use land, lease, sell and bequeath it, borrow money using it as security, construct buildings on it and mine it, subject to reasonable local land use regulations. Some or all of these rights can be transferred or sold to another person. When a landowner sells property, generally the right to develop the land is transferred to the buyer.

Traditionally TDR has been most suitable in places where large blocks of land remain in farm use. Jurisdictions must be able to identify receiving areas that can accommodate the development to be transferred out of the sending area. The receiving area must have the physical capacity to absorb new units, and residents of

[178] Grannis, "Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use: How Governments Can Use Land-Use Practices to Adapt to Sea-Level Rise."
[179] Ibid. 57.
[180] American Farmland Trust, "Fact Sheet: Transfer Development Rights," (2001).

those areas must be willing to accept higher density development.[181] In the application of TDRs to sea level rise and marsh migration, existing and relocated residents of potential receiving areas would have to be persuaded that the benefits of protecting coastal ecosystems are equal to or greater than the costs of living in a more compact neighborhood whose view shed may not include the coast.

TDR programs are distinct from purchase of conservation easement programs because they involve the private market. Most TDR transactions are between private landowners and developers, and local governments generally do not have to raise taxes or borrow funds to implement TDR.[182] A few jurisdictions have experimented with public purchase and "banking" of development rights where a TDR bank buys development rights with public funds and sells the rights to private landowners.[183]

TDR programs also offer a potential solution to the political and legal problems that many coastal communities will face when they try to restrict development on valuable coastal property. Currently landowners often oppose agricultural protection zoning and other land use regulations because they can reduce property equity by prohibiting a property owner from realizing the full development potential of their land. Zoning to protect coastal ecosystems my benefit the region as a whole by preventing its submergence, but it may also reduce the fair market value of land. However, when re-zoning is combined with a TDR program, landowners can retain their equity by selling development rights.

[181] Ibid.
[182] Ibid.
[183] Ibid.

More than 60% of the land preserved through TDR easements in the United States is located in Montgomery County, Maryland. There, the program allows developers to increase residential density in designated receiving areas outside of the Agricultural Reserve through the purchase of Transferable Development Rights from farmers. For every unit of density transferred (one TDR per five acres) into a designated receiving area, one development right is extinguished on a corresponding farm parcel. Developers purchasing TDRs provide income to the farmer that is often used for purchasing additional farmland, farm equipment, or estate planning.[184]

The Florida Action Team recommends that state agencies consider planning tools to encourage the landward siting and relocation of structures and public facilities in areas adjacent to receding shorelines through transfer development rights.[185] Dade County, Florida, has used transfer development credits to preserve over 100,000 acres of everglades outside of the Everglades National Park. Properties adjacent to the park flood periodically and, therefore, cannot be developed. To provide some financial compensation, the county allocated owners Severable Use Rights that can be sold to increase the intensity or density on upland parcels.[186]

In Olympia, Washington, developers can purchase development rights either to increase or decrease the density in the residential area zoned for four to eight dwelling units per acre. To build four to 4.99 dwelling units per acre or anything

[184] Department of Economic Development Agriculture Services Division, "Tdr Program Overview," (2006).
[185] Grannis, "Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use: How Governments Can Use Land-Use Practices to Adapt to Sea-Level Rise." 57.
[186] Ibid. 58.

above seven dwelling units per acre, a development right must be acquired for each acre of development.[187]

The full potential of the TDR program has been realized only once in its 25 year history because of a general imbalance between sending capacity and receiving capacity. Although more than 9,600 TDRs have been sold and used in receiving areas, there are still more TDRs in the sending area than there is receiving capacity to absorb them. TDR receiving areas have consistently been planned at a 1:1 ratio in which every TDR sold from the sending area is used in a corresponding TDR receiving site. Realistically, a receiving capacity ration of 2:1, or two receiving sites for every one TDR in the sending area, is needed to counteract the problem of diminished receiving capacity. Diminished receiving capacity depresses the demand for and market value of TDRs and generally conflicts with the legislative intent of the TDR program. It must also be mentioned that receiving capacity at a given site can diminish through environmental regulation, landscape suitability, economic constraints or lack of use by the developer.[188]

Relocation Assistance

Michigan established the Emergency Home Moving Program (EHMP) in 1986 to provide orderly retreat from rising Great Lake levels.[189] The program was administered by the Michigan Department of Natural Resources (MDNR) and provided loan interest subsidies for the relocation of erosion-threatened houses. The

[187] American Farmland Trust, "Purchase of Development Rights and Transfer of Development Rights Case Studies," (2001). 14.
[188] Division, "Tdr Program Overview."
[189] Lisa A St. Amand, "Sea Level Rise and Coastal Wetlands: Opportunities for a Peaceful Migration," *Boston College Environmental Affairs Law Review* 19, no. 1 (1991). 27.

subsidies covered the costs of moving houses, septic systems, water lines, electric cables, and of demolishing and removing houses that would not survive a move inland.

The moving program offered homeowners two options for receiving a relocation subsidy. One option would be take out a loan from a public lending institution and then apply to the MDNR for a three-percent interest rate subsidy on the first $25,000 in costs.[190] The other option was to accept a one-time payment directly from the MDNR of up to $3500 to defray the costs of relocation.[191] To meet the conditions of the subsidy, the homeowner was required to move his building at least forty-five feet inland. Between August 1986 and February 1987, subsidies were paid out to 64 people for relocation.[192] Michigan did not renew the Emergency Home Moving Program after lake levels began to fall in 1987, and there are no plans to reactivate the program in the near future.[193]

The success of Michigan's Emergency Home Moving Program was in part attributed to its minimal paperwork. The MDNR processed applications over the telephone and developed one-page forms for both applicants and banks. The MDNR also found that direct subsidies to homeowners were preferable to interest subsidies, because the latter discriminated against the poorer homeowners who could not qualify for loans.[194] A weakness of Michigan's Emergency Home Moving Program was that it presupposed that property owners had either land on which to relocate or sufficient

[190] Ibid. 27.
[191] Ibid. 27.
[192] Ibid. 28.
[193] Ibid. 28.
[194] Ibid. 28.

capital to buy new land.[195] In addition, the program did not appeal to owners of buildings that could not be relocated because they were too large or structurally weak.[196]

In the context of sea level rise, a relocation program like Michigan's Emergency Home Moving Program could be established on either the federal or state level. Owners of property in upland areas threatened by sea level rise and deemed suitable for marsh migration could be given a payment large enough to make relocation the most attractive option.[197]

Conclusion

Under the NFIP, FEMA has not required state and local governments participating in the program to restrain development in flood-prone areas. Instead, FEMA requires participating communities to adopt and enforce minimum floodplain construction standards.[198] These requirements do not guide development away from flood-prone areas. Rather they seek to reduce damage to human constructed structures in the event of a major flood. The nature of the NFIP, however, is changing. The Biggert-Waters Act signals that individuals, not the federal government, will begin to bear the cost of flood protection. As the Biggert-Waters Act actualizes subsidized coastal insurance rates, houses and other structures that are not elevated will bear the heaviest burden in terms of increased flood insurance rates. These same houses also stand a very good chance of dropping in real estate value as the cost of insuring such property increases. This thesis proposes that these structures

[195] Ibid. 28.
[196] Ibid. 28.
[197] Ibid. 28.
[198] Ibid. 20.

vulnerable to flooding and inundation from sea level rise be relocated. The adaptation actions suited for relocation as well as those suited to accommodation and protection are illustrated in Figure 4.2 along with their benefits and drawbacks.

In the age of climate change and sea level rise, government can encourage individuals to think of property in a more flexible light by educating the public to the value of tidal marshlands and incentivizing relocation from the coast. Financial incentives for relocation can help individuals anticipate future sea level rise with actions other than building hard armor upland of the present coast which would eventually block marsh migration. Conservation easements provide flexible mechanisms by which public entities can preserve land in its natural state while allowing land to remain in private ownership.[199] Other tools such as transfer development rights encourage environmental planning on a regional scale. In order that these tools be adopted in the present before greater impacts of sea level rise are realized, precedence for marsh migration over hard armoring of coastal property must be incentivized. The federal government is in the midst of creating such a sea level rising planning atmosphere. This atmosphere includes a reduction in insurance rates by the Community Ratings System as a reward to coastal communities for purchasing property vulnerable to flooding and returning it to open space. Chapter 5 of this thesis will present a site analysis of the City of Tybee Island, Georgia, a coastal community that is presently planning for sea level rise. Chapter 6 will follow with recommendations that the City of Tybee Island can implement in order to promote marsh migration with a gradual relocation of development.

[199] Grannis, "Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use: How Governments Can Use Land-Use Practices to Adapt to Sea-Level Rise." 4.

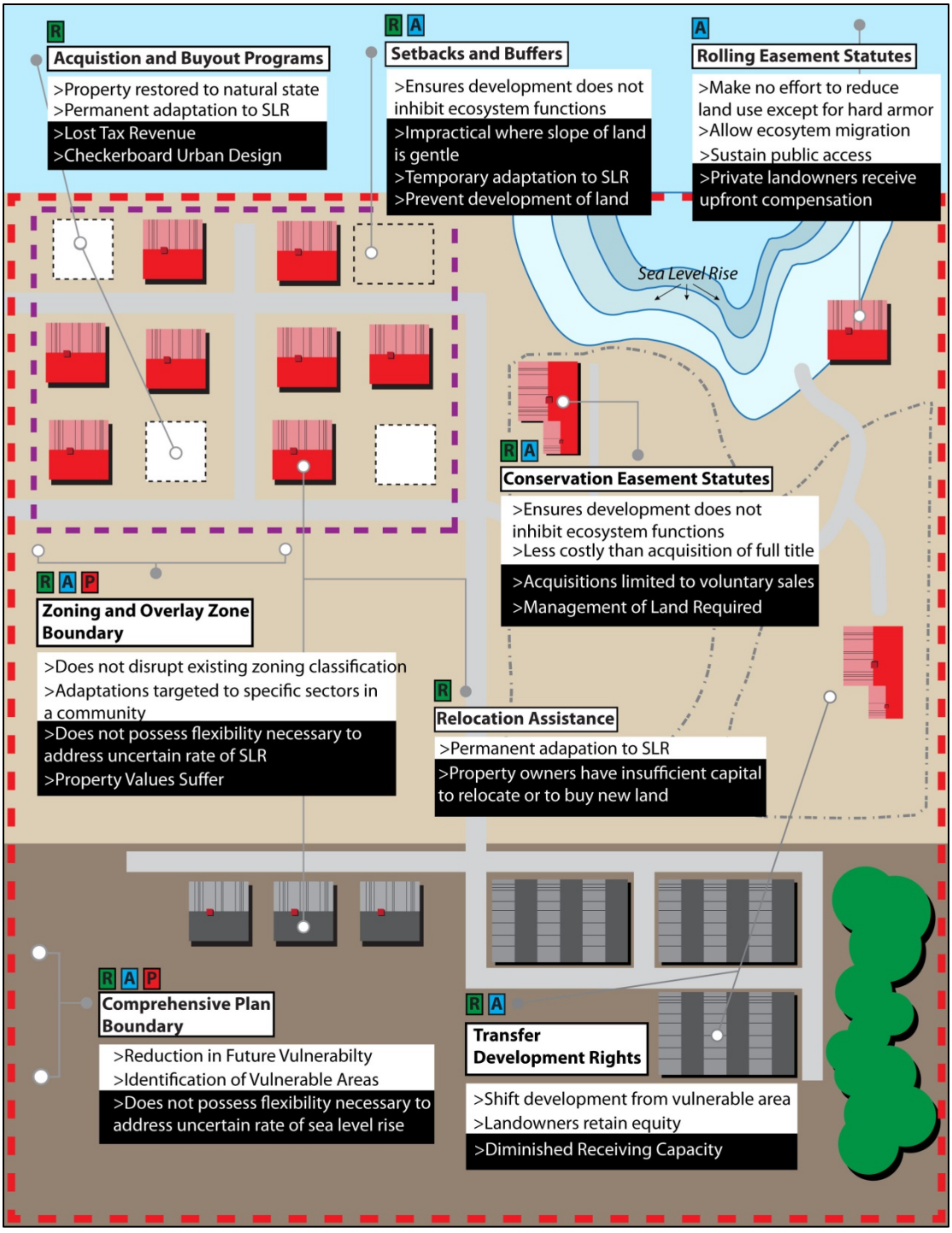

Figure 4.2. Matrix of adaptations to sea level rise assigned to their specific adaptation goal(s) with 'R' surrounded by green rectangle representing the goal of relocation, 'A' surrounded by blue rectangle accommodation, and 'P' surrounded by red rectangle protection. Benefits of action represented in black font and drawbacks in white. Source: Image courtesy of author.

CHAPTER 5

TYBEE ISLAND SITE ANALYSIS

Introduction

The City of Tybee Island has a population of around 3000 residents and is located on the small Atlantic coastal barrier island Tybee Island. Tybee Island is around 1.7 square miles in area and lies approximately 18 miles east of Savannah in Georgia's Chatham County. Similar to other low-lying barrier islands on the Southeast Atlantic coast, Tybee is highly vulnerable to climate change-related sea level rise and high intensity Atlantic coastal storms. A gage at nearby Fort Pulaski reveals a sea level rise trend of 2.98 mm/yr since 1935, which amounts to approximately 1 foot of sea level rise over 100 years even without expected rate increases from climate change.

Survival for most of the businesses on Tybee Island is dependent upon tourism spending by the guests who enjoy the Atlantic Ocean and surrounding environment; yet the location of the island makes the economy vulnerable to sea level rise related threats. Presently Tybee Island is reporting impacts from sea level rise, including increasing flooding during spring tides of US Highway 80, city roads, and the city beachfront. The flooding has raised public awareness of the community's vulnerability to sea level rise and prompted interest in long-term adaptation options for a city constructed during a time of lower sea level. Chapter 6 proposes sea level rise adaptation options for the City of Tybee Island which incorporate planning for sea level rise induced marsh migration. First Chapter 5 presents a site analysis of the

demographics, economy, and land use patterns of Tybee Island. In addition the chapter will present the city ordinances related to flooding as sea level rise will increase Tybee's vulnerability to flooding.

Tybee Island History

Longtime residents know Tybee Island as Savannah Beach, the name that reflects both the island's to Savannah and the Savannah River. The name Tybee originates from the name of salt used by the Euchee, American Indians who occupied the island at the time of European contact. In addition to the Euchee, Tybee Island has been occupied by Spain, France, England, and now of course by the United States. In 1520 it was claimed by Spanish explorer Lucas Vasquez de Ayllon. Later, in the 17th century, France became interested in the island because of the abundance of sassafras root thought to be a cure for various ailments. In 1736, General James Oglethorpe and the Trustees established the British colony of Georgia as a military buffer zone between the British colony of South Carolina and the Spanish territory of Florida. Presently, Tybee Island is both an island and a city in Chatham County, Georgia.

Recreational use of Tybee Island began during the early 1800's when steamboat transportation made the island accessible to affluent mainlanders. During the late 19th century, Tybee became the site of the first major modern island community on the Georgia coast as recreational and residential use of the island expanded. The Tybee Improvement Company was formed in 1873, resulting in daily boat trips and a hotel. Doctors began to urge patients to spend time on Tybee Island, believing the sea and sea air to be cures for asthma and other ailments, and in 1887 a

railroad to Tybee opened.[200] Construction of a highway to Tybee in 1933 spurred further growth. Later population and economic growth in Savannah together with postwar prosperity and the automobile attracted more people, both Georgians and non-Georgians, to Tybee Island.[201]

Demographics and Housing

As of the United States 2010 Census, the City of Tybee Island had a population of 2,990. The racial makeup of the city was 94.6% white, 3.3% African American, 1.2% American Indian, 1.4% Asian, and 0.7% of some other race. 1,360 total households were located on the island, and the population density of the island was 1,326.3 people per square mile.[202] The City of Tybee Island has experienced continuous population growth over the last 20 years. The City's population of 2,240 people in 1980 increased by roughly 27% to 2,842 in 1990. The population of the City continued to increase during the time span of 1990 to 2000 and from 2000 to 2005, with increases of 19.4% and 4.2% respectively.[203]

The City of Tybee Island operates under a unique set of demographic circumstances in that a significant percentage of the population is seasonal. Although the island has a year round resident population, the overall population increases greatly during the summer vacation season. The seasonality of Tybee is evident in the amount of housing units identified as seasonal, recreational, or occasional use. In

[200] Clayton, *Living with the Georgia Shore / Tonya D. Clayton ... [Et Al.]*. 8.
[201] Ibid. 8.
[202] U.S. Census Bureau, "American Factfinder," http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_DP_DPDP1.
[203] Georgia City of Tybee Island, "Technical Addendum Data Assessment: Tybee Island Master Plan," (2007). 5.

a report published in 2007, a seasonal population increase of approximately 2,702 tourists/visitors was possible (assuming all rental units were at full capacity with an average of two visitors per rental unit). Such increase would represent a total population increase of approximately 76% for a population of 6,238 during high volume summer months.[204]

The seasonal demographics of the City of Tybee Island are also evident in the housing statistics of Tybee. According to the 2010 U.S. Census, of the 3,366 total housing units (at an average density of 1,054.2 per square mile), only 1,360 were occupied while 2,006 were vacant. Of the vacant households, 338 were for rent, 11 were rented but not occupied, 123 were for sale only, and 15 were sold but not occupied. 1,473 of the vacant housing units were for seasonal, recreational, or occasional use, and 46 were unclassified. The overall homeowner vacancy rate of the island was 24.3% and the rental vacancy rate was 50.9%.[205]

According the *Technical Addendum Data Assessment: Tybee Island Master Plan of 2007*, the City of Tybee Island contained 3,091 residential properties, including single family homes, multi-family homes, condos, etc. It was determined that 872 of these properties were seasonal rentals, accounting for nearly 27% of the residential property on the island at the time.[206] Using the *Technical Addendum Data Assessment* as a guide, the 2010 U.S. census numbers concerning rent can be extrapolated to read that the total rental units on the island were probably far above the 349 units that were either for rent or were rented but unoccupied. It is highly

[204] Ibid. 3.
[205] Bureau, "American Factfinder".
[206] City of Tybee Island, "Technical Addendum Data Assessment: Tybee Island Master Plan." 3.

probable that many more units, especially many from the 1,473 listed as seasonal, recreational, or occasional use, are also being used as rental units at some point during the year on Tybee Island.

As of the 2010 U.S. Census, the values of housing units on Tybee Island were:

Table 5.1. Value of Housing Units on Tybee Island. Source: 2010 U.S. Census.[207]

Value	Estimate	Percent
Owner-occupied units	1,011	1,011
Less than $50,000	0	0.0%
$50,000 to $99,999	0	0.0%
$100,000 to $149,999	36	3.6%
$150,000 to $199,999	39	3.9%
$200,000 to $299,999	111	11.0%
$300,000 to $499,999	473	46.8%
$500,000 to $999,999	296	29.3%
$1,000,000 or more	56	5.5%
Median	$412,300	

Recently the value of real estate on Tybee Island has remained high. According to city-data.com, 1416 7th Avenue was sold for $505,000 on February 1, 2013. 10 TS Chu Terrace was sold for $290,000 on January 31, 2013. 19 Lighthouse Lane was sold for $270,000 on January 31, 2013. 10 11th Place was sold for $434,000 on January 31, 2013. The median house or condo value in 2011 for Tybee Island was $387,057 up from $174,000 in 2000. The same value for the state of Georgia in 2011 was $147,000.[208]

[207] Bureau, "American Factfinder".
[208] City-Data.com, "Tybee Island, Georgia," http://www.city-data.com/city/Tybee-Island-Georgia.html.

The 2010 Chatham County Pre-Disaster Hazard Mitigation Plan used Chatham County Tax Assessor Data to estimate the number of properties, their use, and their value for each community with Chatham County. Tybee's assets were listed as:

Table 5.2. Assets of Tybee Island, Georgia. Source CEMA.[209]

Use Type	Total Properties	Total Value
Agricultural	0	$0
Commercial	184	$194,186,960
Historic	7	$4,408,500
Industrial	0	$0
Residential	3,670	$2,182,503,084
Transitional	0	$0
Utilities	2	$167,553

Chatham County exerts significant influence on Tybee Island in the form of users of the island's resources. Many visitors of Tybee arrive from the mainland of Chatham County and have a direct impact on Tybee's ecology and economy. Subsequently, especially in relation to sea level rise, Tybee's demographics should take into account the predictions of the rate of growth of Chatham County as a whole. The population of The Georgia Office of Planning and Budget has predicted a 7.5 percent increase in Chatham County's population by the year 2015. According to Georgia Coast 2030, by 2015, the Chatham County population is expected to reach 275,057, an 18.5 percent increase over the 2000 population.[210]

[209] Chatham County Emergency Management Agency, "Chatham County Multi-Jurisdiction Pre-Disaster Hazard Mitigation Plan," (Savannah, Georgia2010). 19.
[210] Ibid. 25.

Existing Land Use and City of Tybee Island Zoning

Present zoning for the City of Tybee Island numbers 18 districts (Figure5.1). These are:

- R-1 Single Family Residential
- R-010-B Single Family Residential
- R-2 One and Two-Family Residential
- R-T Residential Tourism
- C-1 Beach Business
- C-2 Highway Business
- NM Neighborhood Marina
- TBR Transitional Business-Residential
- PC Parks-Conservation
- EC Environmental Conservation
- PUD Planned Unit Development
- MD Maritime District
- South End Business Overlay District
- North End Parks and Public Overlay District
- North End Cultural Overlay District
- Neighborhood Grocery Store District

The R-1 Residence District is established to minimize development densities in certain portions of the island to prevent overall development on the island from exceeding its environmental carrying capacity. The R-1 District provides quiet, livable, low-density single-family neighborhoods, including compatible low impact educational, religious, and public institutions, as well as limited provisions for bed and breakfast operations. The character of development in these areas is oriented for permanent residents. In the R-1-B Residence District land may be used and buildings or structures may be erected or used for the same purposes as the R-1 District but at with slightly more intensive density. R-1-B is intended to ensure adequate

infrastructure capacity and mitigate adverse impacts associated with more intensive land uses.

The R-2 One and Two Family Residential District provides affordable development of single-family and duplex style development. This district is intended for medium density residential neighborhoods which are quiet and livable. This district includes a mixture of one and two family homes with compatible educational, religious, and public institutions as well as limited home occupations. The R-T Residential Tourist District provides areas where tourists and residents are mixed. Development in this district is primarily residential. However, limited accommodations are made for the housing of the tourist population visiting overnight, weekends, weeks, or extended periods.

The C1 Beach Business District provides central locations for city business and services to meet the market needs of the city's residents and visitors. The focus of the C-1 Beach Business District is to provide for commercial and residential land uses that support and complement recreational use of the beach and general tourism of the island. The land uses permitted in this district provide for a substantial amount of the island's employment base. The amount of C-1 acreage is directly proportional to the city's economic activity. The C-2 Highway Business District provides central

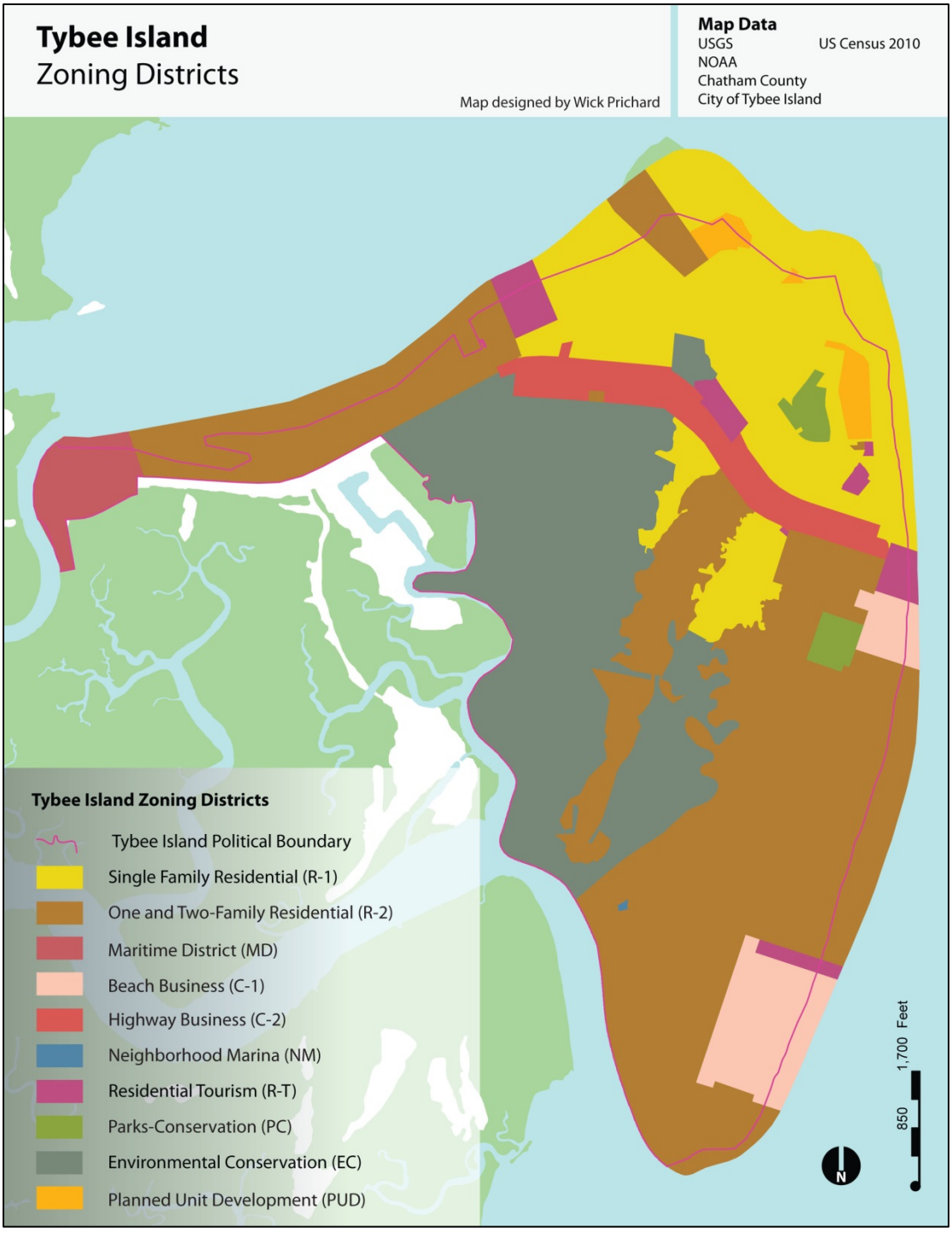

Figure 5.1. Zoning Districts of the City of Tybee Island. Source: Map by Author.

locations for city business and services to meet the market needs of the city's residents and visitors. The focus of the district is to provide for commercial land uses that support and compliment the motorized consumer. C-2 districts are intended for location along arterial streets where the negative impacts of traffic congestion, noise, and intrusions into residential neighborhoods will be minimized.

The purpose of the Neighborhood Marina District is to reserve those waterfront areas which have value for commercial land uses involving pleasure and commercial watercraft. The N-M district is intended to be used for neighborhood marina facilities with a modest scale of operation.

The purpose of the Transitional Business-Residential District (TBR) is to create an area, contiguous with the commercial-two (highway commercial district) where residential, professional, institutional and light business including convenience shopping, retail sales and services are permitted by right and can be intermixed and concurrently protect the neighborhood from blight and slum conditions. This district shall only be established in older sections of the community where intermixing currently exists and is found to be necessary and desirable, creating a buffer zone between two districts of varying uses.

The purpose of the Public Parks-Conservation District (PC) is to create an area or areas to be conserved for public use, to preserve areas established by tradition and custom for public use, and to prevent development of these areas for other than approved public and/or municipal use. Permitted uses include parks-public, playgrounds; ball fields and/or sports arenas, picnic facilities, public schools, public

libraries, public parking and municipal buildings/structures, other public uses as approved by the governing body of the city.

The purpose of the Environmental-Conservation District (EC) is to protect the ecologically sensitive areas of Tybee Island and to limit the active development to those uses which are compatible with natural limits of the land. No building permit can be issued for either a use permitted by right or a use permitted after special approval until the proper state and federal permits have been acquired by the applicant.

The Planned Unit Development District (PUD), at the time of the adoption of the ordinance from which this section is derived, shall remain. No further planned unit development district shall be created. The existing planned unit development districts are Northshore Subdivision, Seaside Colony, Oceanside Dunes, Oceanview Townhomes, and Gulick Row.

The purpose of the Maritime District is to protect the character of the commercial development along Lazaretto Creek within the city limits of Tybee Island.

In the South End business overlay district, all commercial and multi-family residential uses are permissible subject to site plan approval. In this district, the site plans established herein shall prevail over any setbacks in any other part of the Code, specifically including section 3-090 regardless of the use of the property. Mixed uses of the property are permissible. Site plan approval is required for new construction and redevelopment of existing sites. New construction and when a project includes the redevelopment of a parcel, a development agreement with the owner/developer

and the city specifying the site plan, location of utilities, improvements, setbacks, driveway locations and dimensions and lot coverage may be required.

The purpose of the North End Parks and Public Overlay District is to promote the development of properties in a manner that integrates public uses, open space, municipal uses, and recreational uses compatibly into a residential area. The north end parks and public overlay will provide for a livable environment for residents and visitors alike. The north end parks and public overlay may only be implemented within specific geographic areas as defined in exhibit A (water/sewer plant, DPW, campground, TIPD). The north end parks and public overlay shall be restricted to the redevelopment and enhancement of uses existing at the time of adoption of this subsection and to the development of uses to enhance or further support existing uses. Such uses include but are not limited to expansion of the water and sewer plant, expansion of the department of public works, expansion and/or enhancement of the River's End Campground, expansion and/or enhancement of the Tybee Island Police Department, the dedication of areas for parks, recreational facilities, or open space. Regulations applicable in the R-1 Zone shall not apply in the overlay district.

The purpose of the the North End Cultural Overlay District is to promote the development of properties in a manner that promotes arts, cultural, heritage, and educational opportunities in conjunction with recreational and light commercial uses while protecting surrounding residential uses from adverse impact. The north beach overlay will provide for a livable environment for residents and visitors alike.

The north beach overlay may only be implemented within specific geographic areas as defined in exhibit attached to the ordinance adopted January 8, 2009, codified in this subsection.

Geography

Tybee Island is the northernmost Georgia barrier island and is geologically very young, ranging from 750 to 1,500 years old. The Savannah River flows into the Atlantic Ocean just north of Tybee Island, and the Atlantic Ocean is located off Tybee's east coast. To the west, Lazaretto Creek splits the island from McQueens Island, and to the south Tybee Creek flows along Tybee Island and joins the Atlantic at the island's southeastern tip. Little Tybee Island is located across Tybee Creek to the southwest (Figure 5.2).

Tybee Island is approximately 3.5 miles long and 2.5 miles wide and has an average elevation of less than 15 feet.[211] The total area of the City of Tybee Island is approximately 3.2 square miles or 2,061 acres.[212] Like Georgia's other barrier islands, Tybee Island has sandy beaches on its eastern shore and tidal marshlands on its western. These marshes and beaches account for a significant percentage of the total area on the island. Together, the beaches and marshes represent 35% of the City area. Coastal marshlands total roughly 450 acres and beaches 260 acres (Figure 5.3). 30 miles of streams and waterways are located in the City limits.[213] The interior of the island is an upland of maritime forest and freshwater sloughs.

[211] Clayton, *Living with the Georgia Shore / Tonya D. Clayton ... [Et Al.]*. 70.
[212] Georgia City of Tybee Island, "Community Assessment: Tybee Island Master Plan," (2007). 48.
[213] Ibid. 48.

Roads and Development

The City of Tybee Island contains approximately 12 miles of streets and roadways. The island is accessed from the mainland by only one road, United States Highway 80 which enters on the northwest corner. Highway 80 turns first into 1st Street upon reaching the island and then into Butler Avenue as it runs north to south on the island. Chatham Avenue outlines the southwest tip of the island. From 1st Street to 19th Street the island is developed in a grid pattern with streets running east to west and avenues running north to south. North of 1st Street, new development on the island forewent a grid pattern.

The combination of people vacationing and daily visitors traveling to the island during the summer tourist season results in traffic congestion on the island. In an effort to alleviate some of the traffic to Tybee Island, the Chatham County Long Range Transportation Plan has proposed the widening of the US Highway 80 between Bull River and Lazaretto Creek from two lanes to four. This project has been identified with a "1B" priority which is a project programmed for preliminary engineering and right-of-way only. The project, if implemented, will be funded through a combination of Federal, State, and Local funds when money is available.[214]

[214] Ibid. 50.

Figure 5.2. Context Map of Tybee Island. Source: Map by Author.

Figure 5.3. Local Context Map of Tybee Island. Source: Map by Author.

The City maintains a few public nature preserves and parks including the Sally Pearce Nature Trail, Blue Heron Park, and the Rivers End Campground. This open space is counterweighted by development on the Island's eastern edge and the western or marsh edge. From the 1888 map *Plan of a Part of Tybee Island*, the development of the present can be seen as proposed development in area that was tidal marsh in the past (Figure 5.4). Made by Percy Sudge a civil engineer in Savannah to delineate proposed building lots on Tybee Island, the *Plan of a Part of Tybee Island* map indicates that a substantial amount of real estate on the western and southwestern sector of the island is situated on marsh fill.

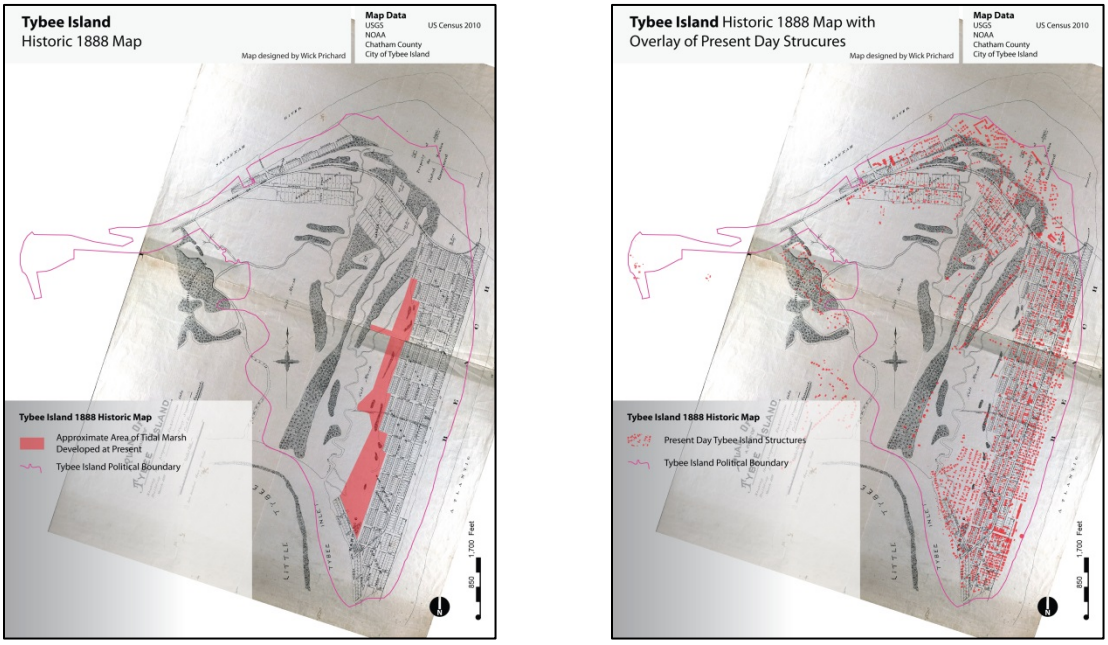

Figure 5.4. Present Development Overlaying 1888 Map Plan of a Part of Tybee Island. Source: Maps by Author.

During the mid-1900's many structures were set back from the beach along the island's middle and northern positions. This trend changed during the 1960's

when many structures built on Tybee were built much closer to the beach. Shoreline changes on Tybee's central portion have not been as severe, and only a few streets and structures have been lost to shoreline erosion. Actual shoreline changes have been greatest on the island's north end.[215]

Flood Problems

Tybee Island is subject to flooding caused by hurricanes and tropical storms. Major storms and hurricanes caused flooding in 1871, 1881, 1885, 1893, 1896, 1898, 1911, 1940, 1944, 1947, 1952, 1959, and 1979. The highest surges occurred during the hurricanes of 1881 and 1893 which caused flood heights of up to 15 and 18 feet respectively on Tybee Island.[216] Georgia has not been hit by a major hurricane in 108 years, but hurricanes do not have to be fully developed or even make landfall in Georgia to wreak havoc. More recently, according to the Georgia Emergency Management Agency, major storms and hurricanes caused flooding in 1989, 1994, 1996, 1999, and 2005.[217]

The primary factors contributing to flooding on Tybee Island are its openness to Atlantic Ocean surges and unfavorable bathymetry extending offshore. Many of the large streams near the coast have wide mouths and are bordered by extensive areas of low marsh. In addition, the terrain at the coast is generally too low to provide an effective barrier. Also, the offshore ocean depths are shallow for great distances, generating a high Atlantic Ocean surge.[218]

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[215] Clayton, *Living with the Georgia Shore / Tonya D. Clayton ... [Et Al.]*. 71.
[216] FEMA, "Flood Insurance Study: Chatham County, Georgia, and Incorporated Areas," (2008). 11.
[217] Ibid. 11.
[218] Ibid. 11.

Flood Planning Ordinances

Tybee Island has extensively planned for coastal flooding in their community, outlining flood prevention measures in the City of Tybee Island Land Development Code. The Code of Georgia Annotated delegates the responsibility to local governments to adopt regulations designed to promote the public health, safety, and general welfare of its citizenry.[219] To this end with respect to flooding, Articles 4, 5, 8 and 16 address flood prevention.

Article 8, the Flood Damage Prevention Ordinance, of the City of Tybee Island Land Development Code outlines measures to reduce harm from to property from flooding. The Flood Damage Prevention Ordinance, requires that all construction, additions, conversions and/or development comply with certain minimum standards intended to minimize damage from floods. For example, houses and certain other structures are required to be built one foot above the 100 year base flood elevation. In addition Article 8 declares that any substantially improved or substantially damaged home must be brought up to the NFIP and City's Flood Ordinance requirements. This is known as the 50% rule. The 50% Rule states that if the lowest finished floor of an existing house is below the base flood elevation (BFE) and the cost of repairs or renovations will increase the structures original Fair Market Value by more than 50%, then the lowest finished floor elevation must be raised or elevated to one foot above the BFE. In VE zones within the City the bottom of the lowest horizontal member must be brought up to one foot above the BFE.

[219] *The Code of Tybee Island Georgia*.

In addition to Article 8 which specifically addresses flooding, Articles 4, 5, and 16 tangentially address flooding through a permitting process that reviews development plans before the start of construction. Article 4, the Zoning Ordinance, requires that building permits be obtained from the Building and Zoning Department. Article 5, the Land Disturbing Activities Ordinance, requires permits for certain land disturbing activities and requires soil erosion control best management practices for construction, even if a land disturbing activity permit is not required. Article 16, the Storm Water Management Ordinance, of the Land Development Code has restrictions on the placement of fill in special flood hazard areas.

Present Flood and Sea Level Rise Planning

The City of Tybee Island Land Development Code addresses acute flooding from storms and spring high tides. As the City of Tybee Island has pre-existing regulations that mitigate the impact of flooding, these same regulations will be able to mitigate some of the future impact of flooding induced by sea level rise. The Land Development Code does not, however, specifically address sea level rise nor will it, in its present form, be able to adequately reduce the vulnerability the island to sea level rise. Flooding associated with sea level rise will be more frequent and occur at greater depths even to the point of permanent inundation of parts of the island. During king tide events flooding on the island not associated with hurricanes or storms is already present. King tides are high tides that occur when the gravitational pulls of the sun and the moon are in alignment. These tides produce water levels significantly higher than mean sea level. These high water levels may represent how

higher sea levels due to climate change might impact coastal communities in the future.[220]

During king tides on Tybee Island, flooding occurs both on the island and on United States Highway 80 in areas of low elevation located in the filled marsh areas. Assets of Tybee Island also vulnerable to flooding and subsequent sea level rise inundation include Tybee's beach area, the city well pumps, US Highway 80, and the parcels located in the southwest sector of the island as well as those on the western sector adjacent to the tidal marsh (Figure 5.5).[221] If these vulnerable assets are flooded, or even inundated, when sea level rises, their flooding will impact tourism based economy of the island. For example, the flooding of US Hwy 80 will result in decreased tourism access. Back island erosion and tidal flooding will increase flooding of marsh front yards and homes and create storm water drainage problems in the southwest sector during high tides, thus affecting the livability of the structures of that sector many of which are rented by tourists.[222]

Presently beach erosion is managed with a re-nourishment system operated on a 7-year cycle. Although the sand-sharing and erosion system along Tybee Island's beach is influenced by many variables, sea level rise may result in the need for more frequent and/or higher volumes of sand re-nourishment. With regards to the flooding

[220] California King Tides Initiative, "California King Tides Initiative," http://www.californiakingtides.org/resources/.
[221] Jason Evans, "Tybee Sea Level Rise Planning Project: Meeting 3," (March 4, 2013).
[222] Ibid.

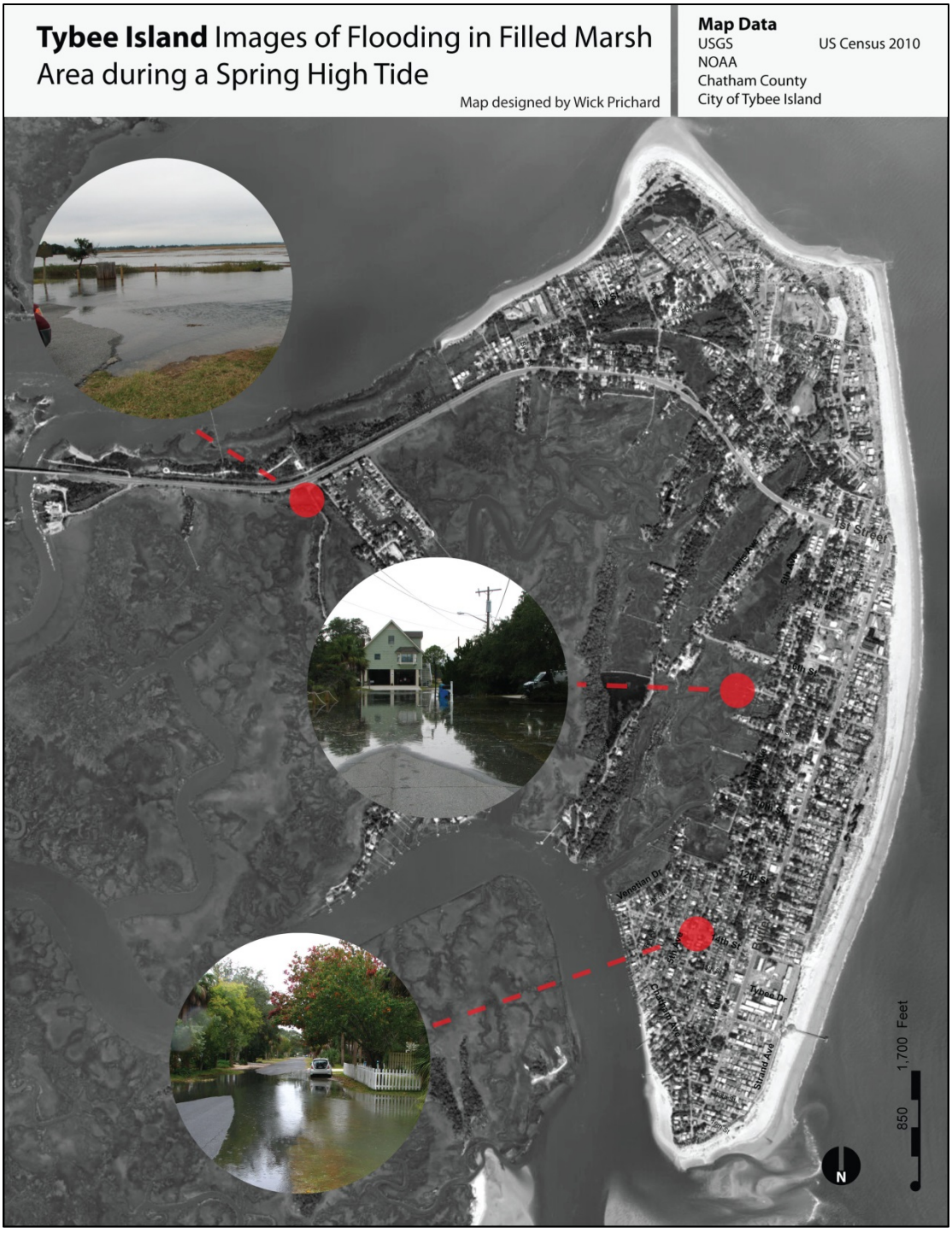

Figure 5.5. Assets of Tybee Island Vulnerable to Flooding and Subsequent Sea Level Rise Inundation. Source: Illustration by Author.

of the southwest sector of the island, the city is installing tide valves and large capacity pipes which mitigate the back-up of the storm water system with saltwater from an incoming tide. In preventing the backup of the storm water system,

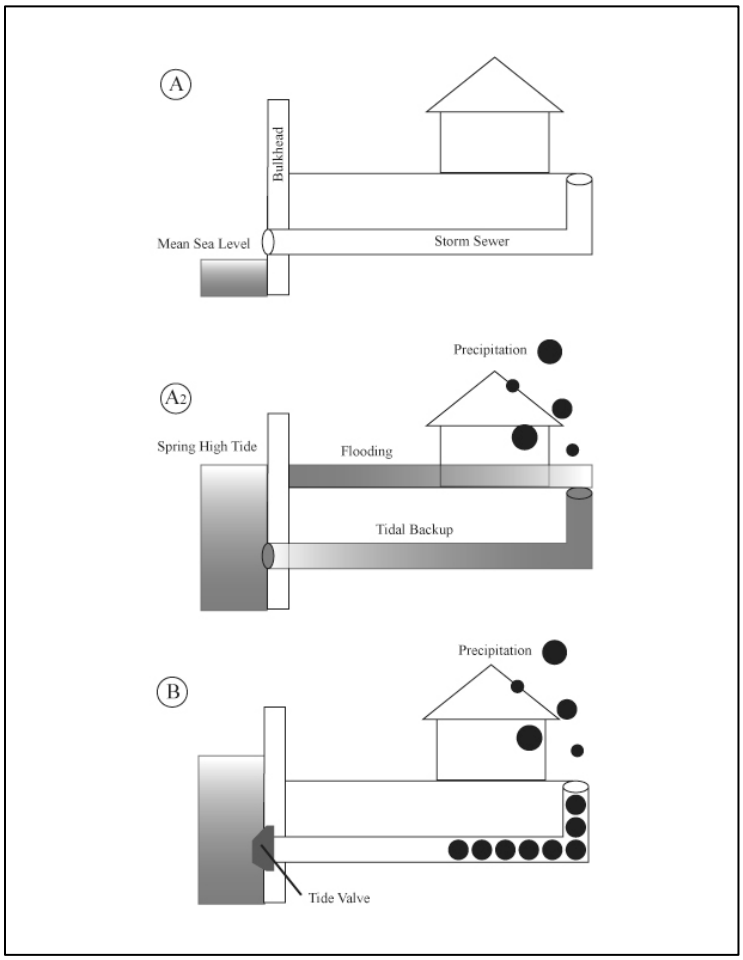

Figure 5.6. Prevention of Flooding by Tide Valves. Source: Illustration by Author.

tide valves and large capacity pipes create room for freshwater from a precipitation to enter the system. With respect to the well pumps, the city is moving forward with a plan to elevate and flood-proof these pumps.

Sections of US 80, Tybee Island's only road linkage to the mainland Savannah Metropolitan area, are low-lying and currently flood approximately 4-5 times each year during spring tide events. In the future, the frequency of road flood events is expected to increase significantly due to sea level rise if the road is maintained at its current elevation grade. The Georgia Department of Transportation is currently evaluating new plans for bridge replacements and other major improvements for US80. The City of Tybee Island is working with GDOT and other partners on potential options for elevating US80 several feet above its current grade, thereby mitigating current and future hazards associated with tidal flooding of the road corridor.

In addition to mitigating damages from flooding through adapting infrastructure and ordinances, Tybee Island also participates in the National Flood Insurance Program and the Community Ratings System. Tybee began participating in the NFIP on January 14, 1972.[223] The City of Tybee Island also participates in the Community Ratings System of the NFIP. At present the City of Tybee Island has a CRS rating of 7, a rating which discounts the cost of flood insurance 15 % for citizens of Tybee.

Conclusion

The City of Tybee Island has mitigated the impact of coastal flooding and the cost of flood insurance through ordinances, infrastructure adaptation, and participation in the National Flood Insurance Program. Although these measures mitigate risk they cannot totally prevent flood damage as the city webpage dedicated

[223] Agency, "Chatham County Multi-Jurisdiction Pre-Disaster Hazard Mitigation Plan." 44.

to emergency management states: Unfortunately the benefits of living on a Barrier Island have a price, an increased risk of Hurricanes and the Flooding that accompanies them.[224]

The City of Tybee Island attempts at preparing Tybee residents and visitors alike for life on a barrier island are straightforward and open. The city website explicitly states that all property located on Tybee Island is in the 100 year Flood Plain. Following this statement to the Tybee public, 10 facts that every Tybee Island Resident should know are listed:

- Tybee Island Local Flood Hazard
- What You Can Do to Protect Your Property and Be Safe
- Flood Insurance
- Property Protection
- Natural and Beneficial Functions of Flood Plains
- Flood Warning Systems
- Permit Requirements
- Substantial Improvement Requirements
- Drainage System Maintenance
- Tybee Island Flood Prone Areas

Although the flood mitigation measures and the flood education policy of Tybee Island have no doubt prepared island residents and visitors for the impact of flooding, the city's actions to mitigate flooding as of yet have been piecemeal. The piecemeal approach to adapting to coastal hazards is necessary because of the geography and development pattern of Tybee. The low relative height of the island taken together with the development of a large sector of the island that was once tidal marsh has created a predicament where protection of the island from sea level rise will necessitate either protecting at great expense with hard armor or relocating

[224] Georgia City of Tybee Island, "Do You Know Your Potential to Be Flooded?," http://www.cityoftybee.org/EmergencyMgmt.aspx?CNID=139.

residents off of the island. Much of the low lying sector of the island developed on filled tidal marsh is located on the western edge of the island with a particularly dense concentration in the southwest sector of the island. Continuing sea level rise will place these sectors of the island at great risk to flooding and inundation.

The City of Tybee Island Land Development Code defines flooding thusly: a general and temporary condition of partial or complete inundation of normally dry land areas from (a) the overflow of inland or tidal waters or (b) the unusual and rapid accumulation or runoff of surface waters from any source. This thesis argues that the language used by the Tybee Island Land Development Code to define and address flooding sets Tybee Island on a strong path to combatting the first effects of sea level rise. This thesis also proposes that the City of Tybee Island begin to look further into the future at the impact of sea level rise and prepare for a dramatic alteration in the shape of the island. To this end Chapter 6 proposes a sea level rise overlay zone that will remove residents of Tybee Island from areas vulnerable to sea level rise induced flooding and inundation. In removing residents form vulnerable areas, the sea level rise overlay zone will also create space for the tidal marsh of Tybee to migrate upland. In addition Chapter 6 proposes that Tybee Island align its ordinances more closely with the CRS so that the entire island will be better prepared for increased flooding from sea level rise and will see a reduction in the cost of federal flood insurance.

CHAPTER 6

SEA LEVEL RISE ADAPTATION OPTIONS FOR TYBEE ISLAND

Introduction

Chapter 6 provides a summary of adaptation actions the City of Tybee Island might pursue to mitigate the impact on tidal marshes from sea level rise. The first action proposed is a sea level rise overlay zone designating area adjacent to the present day tidal marsh that will not be protected against sea level rise, thereby encouraging marsh migration. Chapter 6 will also discuss two means by which structures in the sea level rise overlay zone could be funded. The second action proposed is the amendment of the code of the City of Tybee Island to reflect in greater scope the goals of the Community Ratings System (CRS) of the NFIP. By adhering more closely to the CRS, the City of Tybee Island can take measures that will both lower the federal flood insurance rates of its citizens. These two actions possess the capacity to work in tandem to prepare the City of Tybee Island for sea level rise. Many of the adaptation actions proposed by the CRS align with actions that could create space for marsh migration on Tybee Island.

Sea Level Rise Overlay Zone

This thesis recommends that the City of Tybee Island create a sea level rise overlay zone. This overlay zone would be designed for the gradual relocation of development in area highly vulnerable to flooding. In addition to removing residents from a hazard zone, these low lying areas would also be potential pathways for salt marsh migration. The overlay zone would aid the City of Tybee Island in limiting

development and rebuilding in areas of the island highly vulnerable to flooding and inundation from sea level rise. The overlay zone (Figure 6.1) would be split into two additional zones, the Core Protection Zone (CPZ) and the Marsh Migration Zone (MMZ).

Parcels within the CPZ would be protected from flooding and inundation associated with rising sea level. Any parcel outside of the CPZ would be designated as the MMZ. The defining characteristic of the MMZ would be the limitation of development in order to (1) reduce the overall structural area vulnerable to sea level rise and (2) to facilitate landward movement of the tidal marsh subject to dislocation by sea level rise. The MMZ would be planned for the gradual relocation of development away from areas highly vulnerable to flooding.

This thesis recommends that the CPZ include the area of the island the least vulnerable inundation and flooding from 3 feet of sea level rise. This thesis proposes that the area most vulnerable to inundation and flooding from 3 feet of sea level rise be included in the MMZ. This thesis has designated that area of the island south of U.S. 80 and 1st Street, north of 12th Street, and west of Miller Avenue and Venetian Drive as the MMZ. The area outside of this zone has been designated the CPZ. The area has been chosen using NOAA's Sea Level Rise Viewer and the 1888 map *Plan of a Part of Tybee Island*. The projection of the Sea Level Rise Viewer is shown side by side with the 1888 *Plan of Part of Tybee Island* Map. This comparison, showing NOAA's projections of 1, 2, and 3 feet of sea level rise for Tybee Island, illustrates the threat from sea level rise that the former tidal marsh area of Tybee Island faces (Figures 6.2, 6.3, and 6.4). The Historic 1888 Map of Tybee Island is

overlaid with red polygon. This polygon is an approximation of the tidal marsh of the island that is now developed. This thesis compared the street grid of the 1888 map with the street grid of today to generate an idea of currently developed area that was tidal marsh in 1888.

Furthermore, the area outlined in the 1888 map as tidal marsh that is developed in the present was compared with the sea level rise map of Tybee Island. The green color in the maps made using the Sea Level Rise Viewer indicates area that is likely to be partially flooded during high tide events and storms but not likely to be inundated. The range of blue indicates area already inundated or likely to be inundated in the future with light blue indicating area inundated by shallow water and dark blue indicating area inundated by deeper water. When comparing the two sets of maps, it is apparent that the area of Tybee Island most deeply at risk to sea level rise includes the western edge of the island closest in proximity to the tidal marsh.

The southwest sector of the island is at great risk of inundation from sea level rise, but this thesis suggests this sector not be included within the MMZ. It is a high density area of one and two family residential housing in close proximity to the central beach business district located off Butler Avenue, Tybee Drive, and Strand Avenue (Figure 6.5). Because of its location and housing density, the sector is a substantial economic generator in terms of tourism rentals and spending.

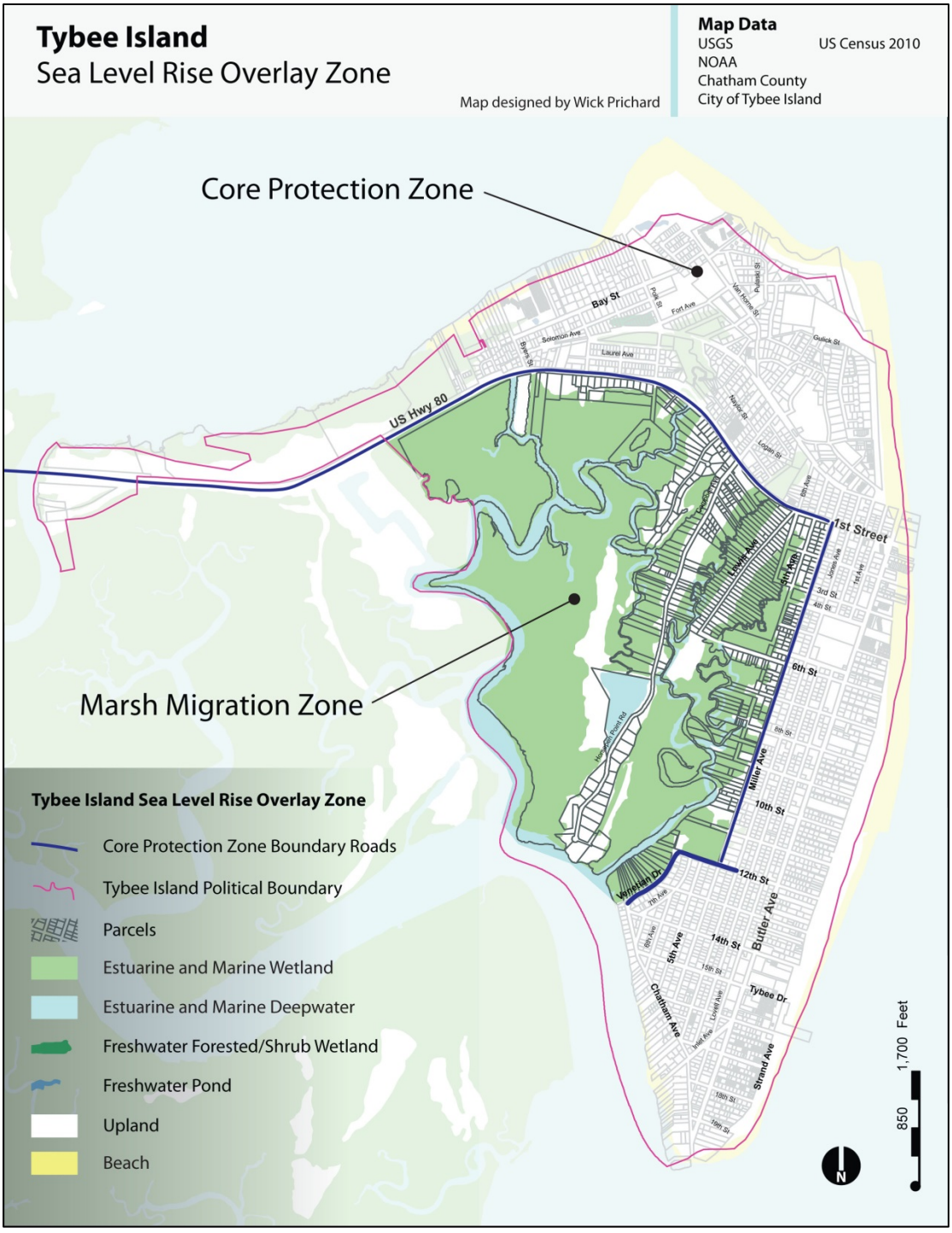

Figure 6.1. Tybee Island Sea Level Rise Overlay Zone with Core Protection Zone and Marsh Migration Zone. Source: Map by Author.

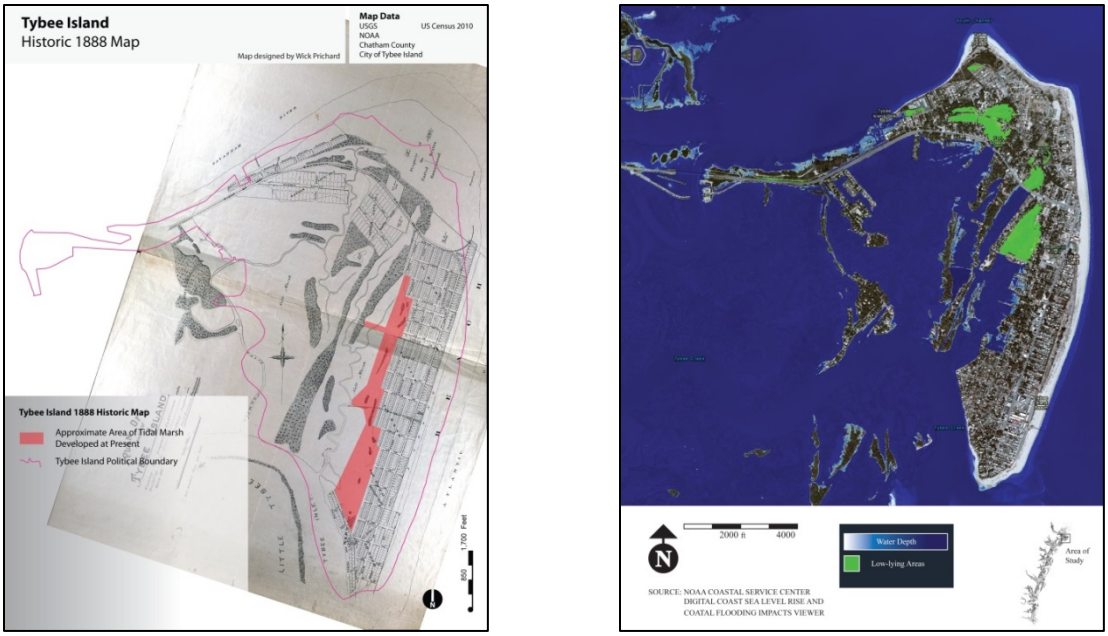

Figure 6.2. Comparison between of 1 foot of sea level rise and historic tidal marsh areas on Tybee Island presently developed. Source: Sea level rise map by NOAA.[225]

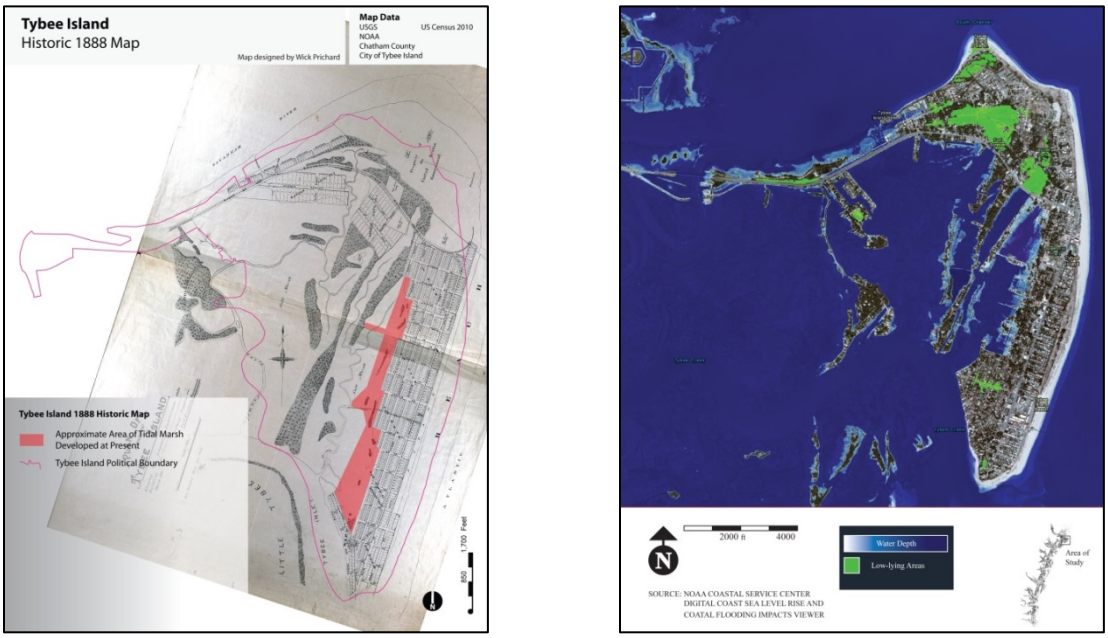

Figure 6.3. Comparison between of 2 feet of sea level rise and historic tidal marsh areas on Tybee Island presently developed. Source: Sea level rise map by NOAA.[226]

[225] Center, "Sea Level Rise and Coastal Flooding Impacts Viewer".
[226] Ibid.

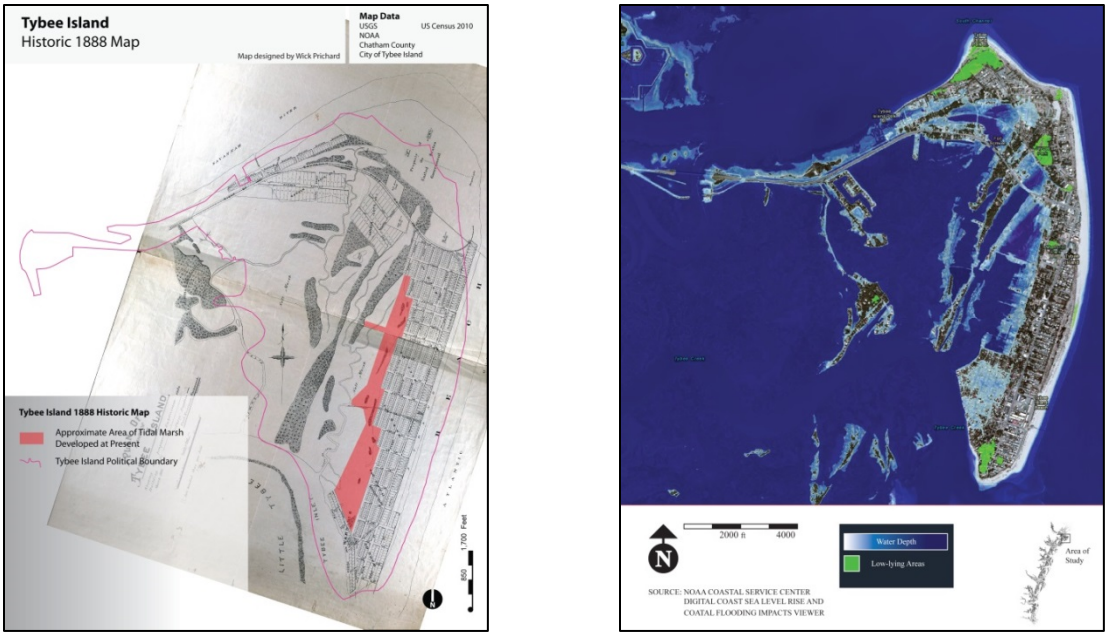

Figure 6.4. Comparison between of 3 feet of sea level rise and historic tidal marsh areas on Tybee Island presently developed. Source: Sea level rise map by NOAA.[227]

The southwest sector is also presently being adapted to sea level rise and flooding in the form of tidal valves located on storm sewer outlets. These tidal valves prevent flooding from storm water backup during high tide events.

The Sea Level Rise Viewer indicates that the area on the island that once was marsh will be the first area of the island to experience flooding and then inundation from sea level rise. The *Plan of a Part of Tybee Island* map shows the area on the island that once was marsh but now has been filled. Due to the low elevation of the fill area, this thesis argues that it is a prime area to consider not protecting from sea level rise. The logic behind this argument is that the City of Tybee Island should consider defending that area of the island which is higher in elevation assuming that

[227] Ibid.

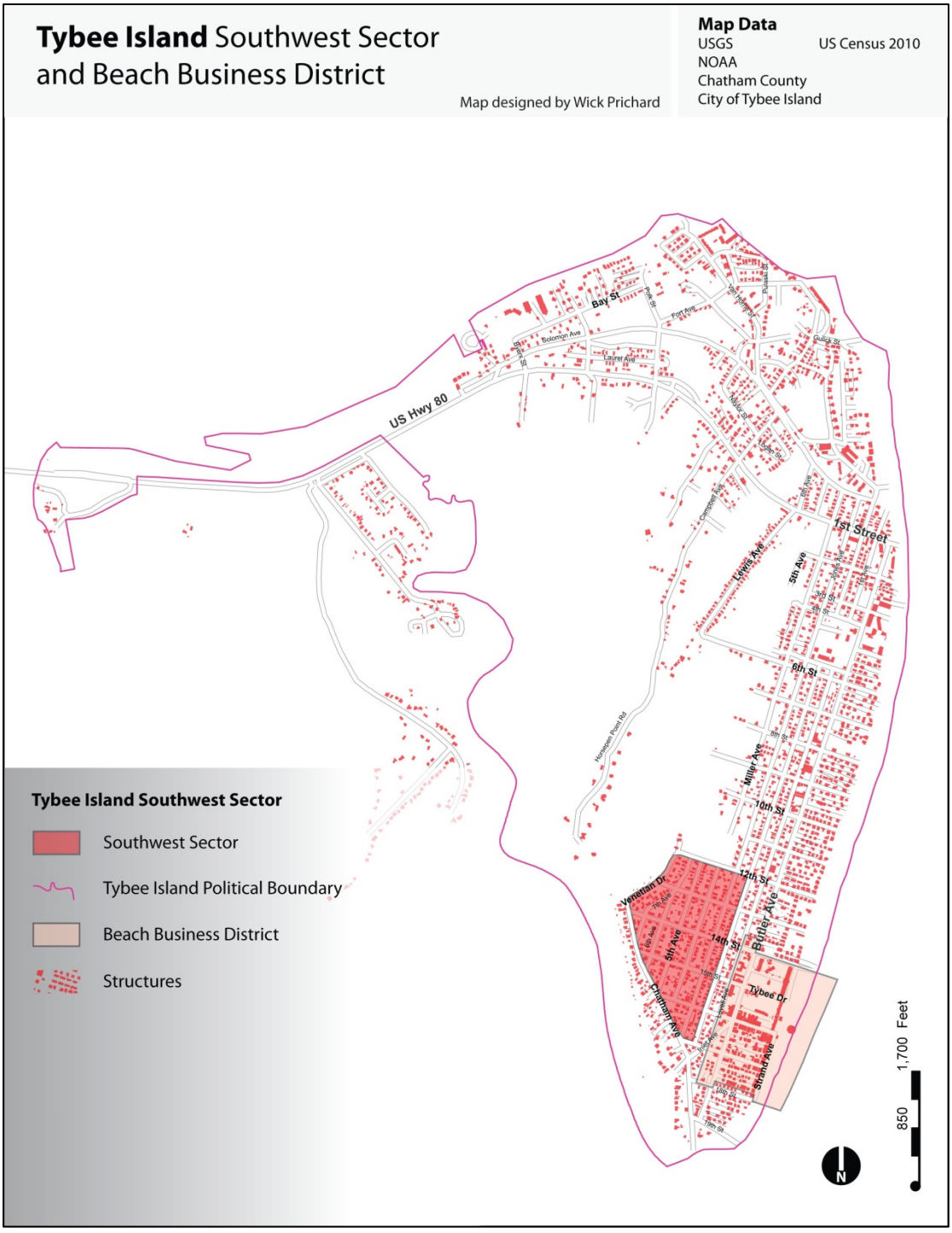

Figure 6.5. Southwest Sector of Tybee Island Vulnerable to Flooding from Sea Level Rise but Not Included Within Marsh Migration Zone. Source: Map by Author.

as sea level rises the cost of defending low areas will increase more rapidly than higher areas. Consequently, the City of Tybee Island would be, in the long term, better served to invest in the protection of higher areas of the island from sea level rise.

The MMZ will act as a buffer area, established to protect the present locations of the tidal marsh and the future upland location of the ecosystem. Inside the MMZ, in order to prevent new structures from being built or storm damaged structures from being rebuilt, the City of Tybee Island will have to consider the purchase of parcels within the MMZ. This thesis proposes that the City of Tybee Island purchase property inside the CMZ using two methods, reservation of occupancy and right to first refusal.

Reservations of Occupancy

In creating national parks, Congress occasionally gives the National Park Service the authority to grant "reservations of use and occupancy" to landowners who otherwise would be displaced because their property falls within the boundaries of the new park. The Park Service acquires the property through donation, purchase, or condemnation, but allows the previous owner to retain use of the property for either a set term of years or for life. The reservation is an interest in real property and is transferable. There are currently about 1600 such reservations on Park Service lands.[228]

The use of reservation of use and occupancy could be a cost effective means of acquiring upland private property adjacent to a salt marsh. This property might

[228] St. Amand, "Sea Level Rise and Coastal Wetlands: Opportunities for a Peaceful Migration." 19.

then allow space for tidal marsh migration. Reservations provide two advantages to outright government purchase of land. First, holders of the reservations may stay on their land. Second, reservations of use and occupancy ease the transition from private property to public ownership and do so at a reduced cost to the government. Purchase price in this scenario is calculated as the current value of the property less one percent for each year of the term of the reservation (or the life expectancy of the individual reserving a lifetime reservation). Because current predictions hold that the sea will rise gradually over the next century, the term of a reservation for use and occupancy of coastal areas could be measured in decades, enabling the government to take advantage of a substantial discount rate.[229]

Tybee Island would grant "reservations of use and occupancy" to landowners who otherwise would be displaced because their property falls within the boundaries of a new sea level rise overlay zone which plans for the reduction of dwellings below a given rise in sea level. Tybee Island would acquire the property through donation or purchase but allow the previous owner to retain use of the property for either a set term of years or for the life term of the property owner. As the reservation is an interest in real property, it is transferrable but, in the case of a transfer to a new occupant of the property, no new time table would be created for its transferal to Tybee Island no matter the age of the new occupant.

[229] Ibid. 19.

First Refusal

Right of first refusal (RFR) is a contractual right entitling the right-holder to purchase a subject asset on the same terms as those accepted by a third party[230]. Rights of first refusal together with rights of first offer are collectively referred to as 'first-purchase rights." First-purchase rights are employed in a variety of contractual settings including real estate sales and lease contracts. Typically an RFR is a contract right meaning that if the owner of the property sells the asset to a third party without first offering the holder the opportunity to purchase, the holder can then sue the owner for damages. In a sea level rise context, an RFR should instead be used as a property right. In the case of a property right, an RFR would be used to invalidate an improper sale.

Certain transactions would be exempt from the RFR. Namely these would include the sale or transfer of the property in question to a trust whose primary mission would be to return the parcel to a natural ecological state. The RFR would be persistent in that the right would run with the property and bind any new purchaser.

Community Ratings System

A problem of a sea level rise overlay zone is the likelihood of a negative financial impact on landowners from enforcing regulations that downzone property in the MMZ. Consequently, building public support for a sea level rise overlay zone may be difficult. This task could be made easier in the light of the changes to the NFIP being brought by the Biggert-Waters Act. These changes, which will result in higher flood insurance premiums, can be mitigated by the City of Tybee Island's

[230] Marcel Kahan, Shmuel Leshem, and Rangarajan K. Sundaram, "First-Purchase Rights: Rights of First Refusal and Rights of First Offer," *American Law and Economics Review* 14, no. 2 (2012). 331.

participation in the NFIP's Community Ratings System. If the City of Tybee Island adheres in more detail to the recommendations of the CRS, the City's flood insurance premiums will decrease. Many of the actions that the City of Tybee Island can take to lower its flood insurance premiums will also prepare the City for flooding associated with sea level rise.

In October 2014 the City of Tybee Island's 5-year CRS recertification will occur. It will be more extensive than the annual CRS review. With 1504 points, the City is 5 points away from being dropped to a CRS rating of 8. If the City dropped a class, the discount on the flood insurance premiums of the City's residents would also drop from 15% to 10% (Table 6.1)

Because the City of Tybee Island's last CRS certification occurred in 2009, there is discrepancy between the maximum point total of some actions and the point total of the City of Tybee Island in that action area. For example in CRS Action 320, the maximum point total is 90 for the 2013 CRS Manual and the City's point total is 140. Obviously the City will lose points in this action area. Also because the CRS point system has been revamped to include different goals since 2009, the City will not necessarily garner the maximum number of points in this action area.

At present the City of Tybee Island has a freeboard a 1-foot freeboard requirement in Land Development Code Article 8, Flood Damage Prevention, Section 8-190(1) and elsewhere in the City Code. However this freeboard was adopted in September 2008. Consequently, the 1-foot freeboard was not credited during Tybee's

Table 6.1. CRS Classes, Credit Points, and Flood Insurance Premium Reductions. Source: FEMA.[231]

CRS Class	Credit Points	Premium Reduction (inside the Special Flood Hazard Area)
1	4,500 +	45%
2	4,000-4,499	40%
3	3,500-3,399	35%
4	3,000-3,499	30%
5	2,500-2,999	25%
6	2,000-2,499	20%
7	1,500-1,999	15%
8	1,000-1,499	10%
9	500-999	5%
10	0	0

2009 5-year CRS recertification. The freeboard credits will, however, be applied for during the 2014 5-year CRS recertification, and this requirement will probably garner the City of Tybee Island additional CRS points. If the City of Tybee Island would take measures to incorporate additional CRS actions, the City could see its CRS rating of 7 rise and the discount on its flood insurance rates drop. Following is a list of CRS actions this thesis proposes the City of Tybee Island consider adopting. Many of these actions could compliment a sea level rise overlay zone.

[231] FEMA, "National Flood Insurance Program Community Rating System Coordinator's Manual," (2013).

Table 6.2. Comparison Between CRS Actions, Maximum Points for Each Action, and points presently awarded to the City of Tybee Island. Source: Table by Author.

Series 300	**Public Information**	**Max Points**	**City of Tybee Island**
310	Elevation Certificates	116	56
320	Map Information Service	90	140
330	Outreach Projects	350	207
340	Hazard Disclosure	80	10
350	Flood Protection Information	125	83
360	Flood Protection Assistance	110	54
370	Flood Insurance Promotion	110	0
Series 400	**Mapping and Regulations**	**Max Points**	**City of Tybee Island**
410	Floodplain Mapping	802	10
420	Open Space Preservation	2020	166
430	Higher Regulatory Standards	2042	209
440	Flood Data Maintenance	222	58
450	Storm water Management	755	16
Series 500	**Flood Damage Reduction**	**Max Points**	**City of Tybee Island**
510	Floodplain Management Planning	622	0
520	Acquisition and Relocation	2250	0
530	Flood Protection	1600	0
540	Drainage System Maintenance	570	268
Series 600	**Warning and Response**	**Max Points**	**City of Tybee Island**
610	Flood Warning and Response	395	165
620	Levees	235	0
630	Dams	160	62

Table 6.2 illustrates the maximum point total for each CRS action, the point total for each action for the City of Tybee Island, and the actions for which the City has no points or has room to garner additional points.

Under the CRS 300 Series, the City of Tybee Island could adopt regulations mandating the disclosure of sea level rise hazards, requiring deeds to show lot and building elevations relative to sea level rise elevation, and providing information about areas susceptible to flooding in the future. Under Activity 320 of the CRS 300 Series, CRS participating communities provide inquirers with information about the local flood hazard and about flood-prone areas that need special protection because of their natural functions. Under Activity 320, if the City of Tybee Island were to provide information about how deep food waters can be anticipated to be in a given area, the City could garner up to 20 points. Currently the City of Tybee Island receives 140 points for Activity 320. The 2013 CRS Manual revises the total points from Activity 320 to a maximum of 90. Under Activity 340 of the CRS 300 Series, participating communities disclose a property's potential flood hazard to prospective buyers before the lender notifies them of the need for flood insurance. Presently the City of Tybee Island receives 10 points for Activity 340. The 2013 CRS Manual gives out a total of 80 point for Activity 340.

Under the CRS 400 Series, the City of Tybee Island could garner points by implementing projects relating to improving the quality of the mapping that is used to identify and regulate floodplain development. Under Activity 410 of the CRS 400 Series, if the City of Tybee Island were to conduct a new study done to one or more standards, including sea level rise, higher than the FEMA mapping criteria, the City could garner up to 60 points. Presently the City receives 10 points. The 2013 CRS Manual allots a total of 802 points for Activity 410.

Under the CRS 500 Series, the City of Tybee Island could garner points by implementing projects relating to floodplain management planning, acquisition and relocation, and flood protection. Under Activity 510 in the CRS 500 Series, CRS participating communities take actions to produce an overall strategy of programs, projects, and measures that will reduce the impact of the hazard on the community and help meet other community needs. Under Activity 510, if the City of Tybee Island were to implement community-wide floodplain management plan, the City could garner up to 382 CRS points. If the City were to make a detailed mitigation plan for a repetitive loss area, the City could garner up to 140 CRS points. If the City were to adopt plans that protect one or more natural functions within the community's floodplain, the City could garner up to 100 points. Presently the City of Tybee Island receives no points for Activity 510.

Under Activity 520 of the CRS 500 Series, CRS participating communities receive points for acquiring, relocating, or clearing existing buildings out of the flood hazard area. If the City of Tybee Island were to acquire or relocate buildings located in the regulatory floodplain, buildings on the repetitive loss list, severe repetitive loss properties, critical facilities, or buildings located in the V or A Flood Zones, the City could garner up to 2,250 points. Each of these actions taken alone has the potential of garnering a community 2,250 points. Presently the City of Tybee Island receives no points for Activity 520.

Conclusion

With respect to structures, property owners' hands are already being forced by the Biggert-Waters Act. The Act is a signal that the federal government is beginning

to place an increasing amount of the cost of flood protection on individuals and communities. The Act's effects on the National Flood Insurance Program result in the actualization of the NFIP's subsidized rates for all communities at risk to flooding. On Tybee Island, many houses are one story ranch style structures, constructed of cinder block, and sit directly on the ground. If these houses are not elevated, they will bear the burden of these increased flood insurance policy rates. They incidentally will also begin to see a drop in real estate value as coastal property owners take on an increasing portion of the flood risk burden.

If the public users of Tybee Island grow more aware of the susceptibility to flooding from sea level rise that Tybee Island can expect, the City of Tybee Island might be more likely to regulate more intensely the construction on the island as it relates to sea level rise. The City of Tybee Island could garner points for implementing actions under the 300 CRS Series, actions that could be designed to create a Core Protection Zone and a Marsh Migration Zone. Through floodplain mapping as an action under the CRS 400 Series, the City of Tybee Island could make decisions about which areas of the island should be more highly regulated so as to prevent flood damage. In addition, the City of Tybee Island could purchase property most vulnerable to flooding and return it to open space, thereby garnering points under the CRS 500 series.

CHAPTER 7

SEA LEVEL RISE PLANNING

Sea Level Rise, Marsh Migration, and the CRS

The present incentive for adapting to sea level rise is the Community Ratings System of the NFIP. Since the establishment of the NFIP in 1968, the cost for coastal flood insurance has been subsidized by the public. The Biggert-Waters Act changes the subsidy based nature of the NFIP by actualizing the costs of flood insurance. As flood insurance rates are actualized, the price of coastal flood insurance will increase. The Community Ratings System will help coastal communities limit the impact of higher flood insurance rates, but only if coastal communities align their flood protection ordinances with the flood protection recommendations of the CRS.

As coastal communities align their ordinances with the recommendations of the CRS, they will benefit from increased adaptability to coastal flooding and reduced flood insurance rates. By doing so, coastal communities will be adapting to flood risks associated with future sea level rise. However resiliency of communities to sea level rise induced flooding will be temporary. Eventually the flooding will give way to lasting inundation of low lying coastal communities. Inundation will force communities to decide whether they will protect their land with seawalls and dikes or relocate. If protection is chosen as an adaptation goal, coastal communities upland of tidal marshes will prevent the tidal marshes from migrating upland, and the tidal marshes will drown.

This thesis argues that tidal marshes are vital to the health of the society, economy, and ecology of coastal communities. Specifically this thesis argues that the tidal marshes of Georgia, as the base of Georgia coastal life, should be allowed to migrate upland in response to sea level rise. Instead of protecting coastal property from inundation, coastal communities should adapt by relocating from the coast as the tidal marsh relocates.

The Community Ratings System does not specifically mention marsh migration. It does however award points for the protection of natural functions within a community's floodplain and the relocation of structures in exchange for open space in a community's flood hazard zone under Activities 510 and 520 respectively. This thesis recommends that Georgia coastal communities begin to plan for sea level rise and tidal marsh migration by aligning their ordinances with the CRS so they can benefit from increased protection from flooding and reduced flood insurance rates in the present.

Future of the Georgia Coast

The role of government, in the age of climate change, will be to help individuals adapt to environmental forces in such a fashion that considers the entirety of society versus the needs of any one community. Historically the cost for protection for United States coastal residents has been born by the nation at large. Typically the federal government pays the largest portion of the bill, with a smaller share paid by the state, and still smaller shares paid by the county, municipality, or

community receiving the coastal protection.[232] Coastal protection projects have benefited the coastal property owner, the public which visits the coast, and the commerce and business which flow from the country's ports and coastal areas. As sea level rises, the interest of these coastal players will be pitted against each other over the question of tidal marsh migration. As coastal areas draw upon state and national economic resources to adapt to sea level rise, publicly owned ecological resources including tidal marshes will be damaged as a result of hard armor sea level rise adaptation actions.

This thesis argues that flooding and inundation associated with sea level rise will encourage coastal development to consider the welfare of the general public over that of the coastal property owner. Due to mounting economic, societal, and ecological costs associated with sea level rise, society will be forced to accept structural engineering adaptations to sea level rise only as a last resort. Instead relocation and planned retreat from the coast will become viable sea level rise adaptation actions. Planned retreat is defined as allowing wetlands, beaches, and other coastal habitats to migrate naturally as the sea encroaches inland. During a planned retreat people are relocated out of harm's way, and new construction in vulnerable areas is prevented.[233]

The economic, societal, and ecological ramifications of planned retreat are immense, but it is necessary to institutionalize a presumed mobility of the coast and its ecosystems if coastal ecosystems are to be preserved. Until society adopts an ecological ethic or is financially forced to retreat from rising seas, planned retreat

[232] Clayton, *Living with the Georgia Shore / Tonya D. Clayton ... [Et Al.]*. 51.
[233] Titus, "Rolling Easements." 1.

must be promoted through the passage of legislation, the commitment on the part of regulatory agencies, and the broad-based willingness to give precedence to natural coastal processes over traditional property rights.[234] If we do not consider presumed mobility of coastal ecosystems in present sea level rise adaptation actions, we risk undertaking adaptations that will extinguish tidal ecosystems in the future.

In the case of the Georgia coast and, specifically Tybee Island, this thesis argues that sea level rise planning goals should consider relocation and planned retreat as the island plans for sea level rise. This thesis argues that future goals of planning for sea level rise on the Georgia coast will depend to a smaller and smaller degree on the needs of coastal residents. Instead future goals of sea level rise planning will depend to an increasing degree on the political climate of the state and the nation. Presently, society at large accepts the risk for development in coastal zones; the threat of sea level rise, however, is changing the qualifications of society's acceptance. The complexities of living with a dynamic shoreline are intensifying with sea level rise, and the viability of relocation as an adaptation action is swelling. By removing people and property from harm's way, relocation projects reduce the costs for disaster response, recovery, and repair. Relocation is especially effective at reducing flood losses because it is a permanent form of mitigation without the need for reenaction.[235] Relocation also makes room for the tidal marshes to migrate in response to sea level rise. The future area of tidal marsh occupation must be created

[234] St. Amand, "Sea Level Rise and Coastal Wetlands: Opportunities for a Peaceful Migration." 18.
[235] FEMA, "National Flood Insurance Program Community Rating System Coordinator's Manual." 520-2.

in the present while time exists before greater impact from sea level rise is experienced.

Afterword

The Carteret Islands, made up of 5 low lying islands with a total area of .37 square miles and a population of 1,700, are sinking into the Pacific Ocean. Tuvalu, an island nation made up of eight tiny coral atolls with a total area of 26 square miles and a population 11,200, is also sinking. The submergence of these islands is being hastened by sea level rise. The highest elevation on the Carteret Islands is 5 feet above sea level. On Tuvalu it is 14.7 feet above sea level. Tuvalu has already struck an agreement with New Zealand to accept its 11,600 citizens in the event that rising sea levels overtake the country.[236] Is it reasonable to look at these islands, extremely small in population and land area as well as very low in elevation, as precursors to the relocation that will be experienced by larger nations with millions of citizens and extensive land area high above sea level?

The Netherlands, a nation with an area of 42,000 square kilometers and a population of close to 17 million, is planning for relocation from the sea. The Room for the River project, a decades-long $3 billion program, is mitigating climate change along the rivers and waterways of the Netherlands. Dikes are being lowered, spillways created, and polders flooded in order to mitigate the impact of sea level rise. In addition people are being compensated for relocating from this area which has been designated indefensible to higher ground. Along the northern edge of the Overdiepse Polder, the dike is being lowered so that the Berge Mass canal will spill in, diminishing the water level in the canal by a foot, a height savings that will spare

[236] National Geographic, "Climate Refugee," http://education.nationalgeographic.com/education/encyclopedia/climate-refugee/?ar_a=1.

the 140,000 residents of upriver Den Bosch from a once-every-25-year flood.[237] In this action the government of the Netherlands displaced farmers within the polder so that a much larger portion of its citizenry located in Den Bosch would be protected.

Much of The Netherlands is a low lying country with a long history of flood protection from the sea, but unlike the Carteret Islands and Tuvalu, the Netherlands has the 18th largest economy in the world and, in Rotterdam, Europe's busiest port. The incorporation of relocation by the Netherlands into its sea level rise adaptation actions is a signal that nations are going to consider what warrants an area of land indefensible from flooding and inundation. This thesis argues that sea level rise planning on the Georgia coast should not only question the economic and social but also the ecological benefits and costs of defending against sea level rise.

The world's populated coasts, which became increasingly managed and engineered over the 20th century, will continue to see widespread protection from rising seas. The logic behind this assumption is that populated coastal areas have a high value and actual impacts from sea level rise will only be a small fraction of the potential impacts. This analysis is made even assuming high sea level rise (SLR) scenarios of greater than one meter of rise by the end of the 21st century.[238] On the other hand, the International Organization of Migration predicts the number of people displaced by environmental changes will grow to 200 million by 2050, though

[237] Michael Kimmelman, "Going with the Flow," The New York Times, http://www.nytimes.com/2013/02/17/arts/design/flood-control-in-the-netherlands-now-allows-sea-water-in.html?pagewanted=all&_r=0.
[238] Nicholls and Cazenave, "Sea-Level Rise and Its Impact on Coastal Zones." 1519.

estimates range from 50 million to 1 billion.[239] The International Red Cross estimates that refugees fleeing from environmental changes presently outnumber political refugees fleeing from wars and other conflicts.[240] The impact of great environmental change, including sea level rise, is upon us.

The landscape of the Georgia coast is unlike any other along the Eastern Shore of the United States. Approximately two-thirds of Georgia's islands are parks, nature refuges, or nature preserves. In this landscape the natural and manmade interact to create a theme of life and livelihood. If this theme is to be kept intact in the face of sea level rise, communities must approach sea level rise adaptation with a logic and perspective that can meet the requirements of marsh migration. Though the complexity of adapting to sea level rise by relocating from the coast is economically, socially, and ecologically daunting, relocation must be considered. The cost of defending the coast from sea level rise will reach a threshold above which it cannot be justified economically. If society does not make an ecological justification for relocation from the coast far ahead of the economic threshold, the tidal marshes will not be able to adapt to sea level rise, affecting the economic, social, and ecologic sustainability of the coastal region.

[239] UNESCO, "I Need a New Home, My Island Has Sunk," http://www.unesco.org/new/en/rio-20/single-view/news/i_need_a_new_home_my_island_has_sunk/.
[240] Geographic, "Climate Refugee".

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