Preserving Puerto Rico's Historic Resources form Sea Level Rise

Research · May 2015
DOI: 10.13140/RG.2.1.1551.7602

CITATIONS
0

READS
428

1 author:

María Fernanda López
Goucher College
16 PUBLICATIONS 0 CITATIONS

Some of the authors of this publication are also working on these related projects:

- Climate Change and Heritage Conservation Literature Review View project
- Historic Resources and Sea Level Rise View project

All content following this page was uploaded by María Fernanda López on 22 May 2015.
The user has requested enhancement of the downloaded file.
Preserving Threatened Historic Resources in Puerto Rico form Sea Level Rise

Authors:
María Fernanda López
Pablo Méndez Lázaro
Caroline Cheong
Hugh Miller

This section of the Climate Change Adaptation Plan report consists in part of a Master of Arts in Historic Preservation thesis from Goucher College. The principal author is graduate candidate for 2015 and the committee members who commented and helped develop the thesis.

Coastal historic resources in Puerto Rico are threatened by the deteriorating effects of sea level rise. An increase of one to two meters is expected for the Caribbean by the end of the century amplifying the risk of coastal flooding, erosion and storm surge. National Register of Historic Places listed resources will be affected and efforts to preserve them require planning for future adaptations. Historically, Puerto Rico’s coastal development has been intense with a great number of resources located in the now susceptible shoreline. A resource prioritization system is needed to evaluate how to mitigate damage. There are one hundred and thirty-six (136) at risk National Register resources located in flood prone areas on the coast, approximately forty percent of the listed resources in Puerto Rico in thirty five (35) municipalities.¹ Fifty-four (54) Most threatened resources are located inside the intertidal zone and are most at risk. Resource lists are located at the end of this report. Three case examples from the most threatened resources at various locations have been analyzed for adaptation methods and recommendations.

The triage system medical emergency has been used as conceptual framework for sorting threatened historic properties and is applied to the decision making process. Given the number of resources at risk it is not feasible to save all of them. Parameters based on location relative to the shoreline are discussed since distance plays an important role in classification. Three resource examples are described for adaptation recommendations to sea level rise.

![At Risk Historic Resources by Tourism Region](chart.png)

Figure 1: Chart prepared by author depicting the amount of at risk historic resources by Puerto Rico Tourism Company five designated regions.
Cultural and Social Value of Historic Resources

Historic resources add wealth to society’s culture and way of life. Properties like archaeological sites, districts, buildings and structures, tell the story of a particular place, enhancing a community’s attachment to that place. Together, resources of a country tell the stories of how it came to be. This section is dedicated to the cultural and social value attributed to historic resources enhancing livelihoods because they have tangible and intangible value. The tangible is the monetary worth and intangible refers to cultural value associated with it. Measuring economic value of historic sites is an exercise attempting to understand quantifiable data for decision-making. Broadly speaking, this type of approach appeals to economists, businessmen, politicians and government agencies that speak the language of money. While it is important to consider, how much money a property is worth, this not necessarily influences people on how to appreciate them. More often than not, strictly valuing properties on direct economic impacts for maintaining a resource may prove insufficient. That is why historic preservation professionals have to argue for the support of resources continuity based on resulting economic analysis that proves their continuous value to society. For this reason “well-being seems to be better placed to become the primary measure of how engagement with heritage makes a difference to individuals’ own lives.”

It is difficult to separate the tangible from the intangible value arguments regarding historic buildings since these values are so
intrinsically linked. In this section the discussion of historic resource value will include both tangible and intangible aspects of historic resources.

**Intangible Value and Cultural Identity**

Communities tend to develop attachments to the places they live in. There is a collective understanding of the meaning of a particular place. At the same time, individuals create their own connections based on memories and experiences of a particular place. Attachment, connections and memory lend intangible values to historic resources. However these buildings, structures, districts or sites also contain tangible values they may envelop people in the place and contexts where events happened, thereby creating cohesion for a communities’ legacy.

Heritage offers a way that community identity can be recognized, articulated, and reinforced, and acknowledging a community’s heritage is a powerful way of recognizing that a community’s very existence, just as denying it expresses annihilation. Recognizing social value may encourage greater value to be placed on continuing traditions by that community and the wider community, and these traditional uses, or types of uses, may be essential for the future management of places of social value.

This description by Chris Johnston defines the power that meaning can hold for the places that people value. The conditions of historic resources contribute to how people relate with their environment. If resources are not well maintained, reflected within a community. Similarly, disappearing historic properties can have negative effects on attachments to place.

The official history of a place can serve to harmonize significance, however, “since values are identified and assigned, they are attributed rather than intrinsic”. As well, different groups and generations may have different understanding for resources that are part of their heritage. Values and opinions on the significance of a place change as time goes on and people reevaluate their meaning or create new ones. One clear example is how the fortifications and the old city of San Juan have changed meaning through the centuries. If the forts had only defensive purposes over the centuries, Puerto Ricans may have seen them in a different light and perhaps the structures may not have been preserved as they are today. Because defensive use would have been obsolete, the meaning would no longer be significant and preservation efforts may have been minimal or nonexistent. It is because the fortifications’ meaning changed and they were perceived as a monument of national importance that they were valued and maintained. The same could be said of the architecture in Arecibo and Ponce, resulting from rich sugarcane landowners but appropriated to signify towns with rich architectural heritage. Historic resources are part of a cultural heritage that creates identity for a community or country that attributes meaningful associations to the resource.

One important concern when discussing cultural values is that the term “cultural” is politically and socially constructed and manipulated for a variety of ends. Cultural values, similar to cultural identities, are not necessarily definable attributes that can be measured or codified, but they must be understood as negotiated, fluid and context dependent.
However, cultural identity’s ability to be transformed does not mean that historic resources are superfluous, as they are tangible resources representing continuity to society. Resources change meaning while contributing to the continuity of shared imagination. In the context of sea level rise, cultural and social continuity is threatened. “Cultural heritage exists among people and communities—and because it is linked to social interactions and to ideas of cultural identity and cohesion, it is not possible, in response to climate change, to separate the physical, cultural, and social dimensions of cultural heritage.” For this reason it is important to maintain continuity of resources in a tangible form to understand the interconnection between of communities’ cultural and social aspects. Faced with rising sea levels, communities will have to make hard choices. Since sea level rise is a problem that affects society, decisions have to be made taking into account the physical cultural and social aspects of historic resources.

Triage Method Applied to the Most Affected Resources
The valuation of threatened resources is essential to creating practical adaptation strategies for mitigating damage. Priority assessments for coastal management must consider the social, cultural and economic aspects of the most threatened coastal resources. “Integrated coastal management is a dynamic process in which a coordinated strategy is developed and implemented for the allocation of environmental, socio cultural and institutional resources to achieve the conservation and sustainable multiple use of the coastal zone.” National Register resources are chosen because they are already considered significant for Puerto Rican society to enjoy and derive benefits from. The continued benefits of historic resources for future generations contribute as long as they are standing. Historic resources give a place its unique character attracting investments in commercial investments and real estate close in and around were the old established urban areas are located. This is a form of continued benefits for future investments that benefit communities. Adaptation methods to preserve the resources are recommended as planning tool for operational management of the resources so they can continue to provide social benefit. Studies for adaptation methods should integrate the continued benefits as a way of measuring resilience and viability.

Risk as defined by the IPCC is “the potential for consequences where something of human value (including humans themselves) is at stake and where the outcome is uncertain.” Risk is also referred to as probability of occurrence because of hazardous events or trends. Vulnerability is defined as “the propensity or predisposition to be adversely affected.” It refers also to sensitivity or susceptibility to harm and lack of capacity to cope and adapt. Vulnerability to sea level rise can be measured by the amount of exposure or how sensitive it is to adverse conditions, thus determining the adaptive capacity to change. The degree of vulnerability therefore depends on each historic resource’s ability to adapt to the effects of sea level rise.

Depending on location, materials, ownership, condition and use, some resources will have different outcome for adaptation options. If a resource can be adapted easily, it means that it is less vulnerable and if on the contrary it is more difficult to adapt it can be more vulnerable. For the most threatened resources, I created a matrix to identify the resources vulnerability and use the triage evaluation system according to variables of low, medium or high vulnerability. The categories are general because each property will need further and more detailed study considering condition and context to be accurately assessed. However, I categorize proprieties for resource based on attention needed for assessment by owners and municipalities they are
located in.

![Most Threatened Resource Vulnerability](image)

**Figure 3**: Chart, created by the author, shows the ratio of vulnerability of the most threatened resources.

The matrix for the most affected resources is located in Appendix III. As evidenced in the matrix, there are different variables for each resource; I have made the judgment of a resource’s vulnerability based on existing physical condition, ownership, use, and type of property. The condition of the building will dictate a need to invest in maintenance and adaptations to the resource. Private resources present more risk than public ones because funding for adaptations vary, depending on availability. For private resources funds may be more limited than for public ones. From a total of fifty-four resources, there are twenty two of the resources are at medium risk, followed by twenty at high risk and then at low risk there are twelve resources. As demonstrated in the chart above, a 37% of the resources are at high risk. Prompt attention should be given to resources at high risk and start preparing adaptation plans for them.

The type of property and materials is another variant that indicates adaptation methods available including whether or not a building can be raised or moved. Building materials may be more or less resistant to flood or erosion damage which will influence vulnerability and adaptation capabilities. Resources that are sites may be more vulnerable because the location is exposed as in the case of Hacienda La Esperanza in Manatí with archaeological resources close to a river bank. A private house may be more vulnerable than a public recreational facility since the later has widespread associations for the community and therefore better chances of survival. Religious facilities and cemeteries may struggle to get funds for adaptation in part because the use is subordinate and are privately owned. On the other hand, a privately owned commercial or industrial building, whose use brings direct revenues to a company, will have more funds for adaptation than a different or less recurring use. An example is the Bacardi Rum Distillery building used to produce rum, in addition to a popular tourist destination. There are several classifications that can help determine the triage system of evaluation. This is why the categorization for the matrix is adjusted accordingly based on the variables presented for each resource.
Judging by the percentages from the chart, the majority of the resources are in good condition, followed by some in fair and few in poor conditions.

The resources with mixed conditions can be found in side historic districts because properties have their particular owners and therefore may be at different phases of conservation or neglect. Examples from the matrix are the only two designated historic districts that are at risk, San Juan Historic District and Central Aguirre Historic District. These districts have buildings in different conditions within and it is necessary, in these cases, to prepare further assessments of conditions for individual resources since some buildings are in good condition while others are in fair, poor or even ruined conditions.

Furthermore, understanding the amount of individual historic buildings within contained areas it is logical to believe that many already have potential to be designated as districts. Many of the old coastal towns in Puerto Rico may have the potential to become historic districts because they have a common history as Spanish colonial settlements and corresponding historic contexts. Individual historic resources are accompanied by their urban environment which is important to understand them. Context for historic building are essential to maintain and when a few historic buildings are recognized in the National Register list, they may be considered part of a group such as old towns. The scale and urban design usually corresponds even when the building era may vary. This is the case of Arecibo that has ten historic properties within the old town and other buildings harmonize with them creating a coherent district. Local lists already recognize it as a historic zone and including the town as a district in the National Register can make a stronger case for adaptation planning.

**Resource Matrix of Cultural, Social and Economic Values**

The triage method assessment is used as a model to understand how cultural, social and economic values influence the chances for adaptation. The use of cultural resource value techniques, non-use value and tourism value are some of the methods to determine resources economic and social benefit assessments. Determining specific cultural, social and economic values for each resource will depend on findings of future in-depth study for adaptation methods. “The economic value of cultural heritage can be defined as the amount of welfare that
heritage generates for society.” Historic resources offer advantages and challenges in the economic market because of their unique characteristics that have more to offer than just a tangible good. Historic buildings for example, provide a distinctive environment desired by many in established neighborhoods, which impacts real estate markets. Market value is different from economic value since the former is the dollar amount a property sells for and the former takes into account economic benefits of the property. “Prices are at best an imperfect guide to what people value. They do not take into account the social conditioning of desire, people’s budget constraints or a lack of choice due to a failure of competition between producers.” Therefore, market value is limited to what a person can afford or is willing to pay for a property. There may be extra costs when owning a historic property but the owner chooses it for the marginal benefits it can provide.

Tourism value is another way to assess how important historic properties are to business development. The amounts of money spend on travel costs and visitor spending can indicate the benefit derived from historic resources. Tourism represents 6% of the gross domestic product for Puerto Rico. The different methods to obtain tourism value are recommended to be evaluated as a way to assign a value to the resources when more in-depth adaptation planning studies are prepared. In subsequent sections, cultural value assessment will be discussed along with vulnerability to obtain the triaged historic resources.

**Revenues Collected by Direct Tourism Spending**

Much of Puerto Rico’s economy is tied to Old San Juan and the Fortifications’ ability to attract tourism and economic development. The Tourism industry for Puerto Rico represents only about 6% of the gross domestic product but is still a significant part of the island’s economic development strategy. Puerto Rico competes with many Caribbean Islands for tourism however it is distinguished by having important historic resources in addition to nice beaches. Further, 76% of tourism activities on the Island endorsed by the Puerto Rico Tourism Company take place in San Juan and most activities in San Juan are related to history and culture indicating these resources are a significant part of tourism and economic development for Puerto Rico. The latest statistics on cruise ship passenger movement show that a total of 1,209,196 people travel through San Juan including the homeport and in transit passengers for the period between July 2013 and June 2014. As for this year, available statistics demonstrate that between July 2014 and November 2014 about 450,252 more passengers to this amount, totaling 1,659,448 travelers. Hotel occupancy ranges from 60% to 85% depending on the season. Tourist spending can therefore be calculated to have an estimate of the dollar amounts the tourism economy offers to Puerto Rico.

In other cases individuals may reveal their demand for heritage goods through their decisions to travel to specific locations (travel cost method). Because this method relies on the assumptions that the heritage site can be visited and that travel is undertaken for the sole purpose of visiting the site this technique is useful for assessing the benefits of iconic publicly owned historic heritage places that frequently receive tourist visitors.

Historic resources serve as an appealing incentive to draw visitors, be they locals or nonlocals, to attract future business. Even if the resources are not in the best conditions today, they can serve as an investment strategy for municipalities looking to boost the local economy. A good
preservation strategy is for the resources to serve communities and be maintained in good condition to be more likely to endure the effects of sea level rise because people will desire to have them preserved. “There may be good reasons for investing in the public good even though it does not generate positive net benefits.” Additional reasons for preserving a public good according to authors Stale Navrud and Richard Ready may be that everyone can enjoy historic resources because they enhance their context and often serve as a backdrop to recreational places used by people enjoying the space and the view. Although the tourism economy is not the only reason to preserve historic resources it can be an instrument to assess how important they are to locals and visitors by how they contribute to business growth.

The fortifications are a means to project to other countries the uniqueness that Puerto Rico can offer. The characteristic sentry boxes are displayed on car license plates, are the official logo for Puerto Rico’s Tourism Company and are portrayed in every advertising campaign promoting the island. No one can afford to lose the very symbol that makes Puerto Rico one of a kind and distinct among the rest of the Caribbean islands. Imagining a time when the fortification walls crumble is an affront to local heritage. The Puerto Rico Tourism Company can benefit from having the appropriate information to make decisions and be better prepared for the challenges sea level rise will present. The island’s coastal attractions which help generate economic activity require special attention in the context of sea level rise for damage has a domino effect on the economy.

Tourism not only impacts the service business, real estate business and commerce development close to historic resources locations but it can also contribute to government budget. “State revenues generated from tourism are many and include: gasoline tax, sales tax, airport boarding fees, room tax, park admission fees, liquor and cigarette taxes, food and beverage taxes, amusement tax, and others. Depending on the state and the number of taxes levied, it is likely that somewhere between 10 and 20 percent of every dollar spent by visitors goes into the coffers of state and local governments.” Tourism means good business for many sectors as long as it is done in a sustainable manner so resources are not fatigued. Not only because of direct and indirect revenues collected but also because maintaining a worthy image requires the effort of everyone to give visitors a good impression. Therefore the importance of having well maintained historic resources is paramount for a healthy tourism economy.

Cultural Value and Risk Assessment of Historic Properties

Historic resources offer many immeasurable benefits to society like emotional wellbeing, aesthetic value and symbolic identity. Historic resources are an important symbol of place that gives the island its character. Moreover, emblematic historic resources have to be maintained since it speaks volumes of how the country takes care of its historical legacy and impacts that country’s overall image.

Choosing dissimilar levels for cultural value assessment is a difficult task. However since sorting for triage is a task with hard choices, I have assigned high, medium and low classifications to cultural value for the most threatened resources. As a triage strategy is essential to identify which buildings need early attention and in what order. This does not mean that these historic resources are unimportant, but it is realistic to say that not all hold the same value for people.
The classification for cultural value assessment on the matrix is given the high, medium and low value. High value is assigned to the resources that are very significant and have exceptional value. Resources that are important to their communities for their social contribution are given classification of medium value. And low value classification is for mostly residential use or abandoned resources since the involvement of the community is less for these historic resources. From a total of fifty-four most threatened resources, twenty one are at the high value category, fourteen have medium cultural value and nineteen have low cultural value. The resources with the high value category should have priority for prompt planning assessments and decision making. The table below shows the order from most important to less important categories when assessing the resources combining cultural value and risk. The triage system works according to these two categories to facilitate the adaptation planning process.

<table>
<thead>
<tr>
<th>Cultural Value</th>
<th>Risk</th>
<th>Triage</th>
</tr>
</thead>
<tbody>
<tr>
<td>high value</td>
<td>high risk</td>
<td>immediate</td>
</tr>
<tr>
<td>high value</td>
<td>medium risk</td>
<td>immediate</td>
</tr>
<tr>
<td>high value</td>
<td>low risk</td>
<td>minimal</td>
</tr>
<tr>
<td>medium value</td>
<td>high risk</td>
<td>immediate</td>
</tr>
<tr>
<td>medium value</td>
<td>medium risk</td>
<td>minimal</td>
</tr>
<tr>
<td>medium value</td>
<td>low risk</td>
<td>minimal</td>
</tr>
<tr>
<td>low value</td>
<td>low risk</td>
<td>minimal</td>
</tr>
<tr>
<td>low value</td>
<td>medium risk</td>
<td>expectant</td>
</tr>
<tr>
<td>low value</td>
<td>high risk</td>
<td>expectant</td>
</tr>
</tbody>
</table>

Combining the two classifications, top priority must be for high risk properties of high
value. Forts San Juan de la Cruz, Fort San Gerónimo, Escambrón Battery and Line of Advance Defense are all part of the external fortification system and are in precarious and important according to the analysis. Miami Building, Normandie Hotel, Hacienda la Esperanza in Manatí and US Custom House in Humacao are the resources that have high risk and high cultural value. These resources must be part of a timely plan to assess their potential for adaptation methods. Second in priority should be the combination of high cultural value and medium risk, followed by high cultural value and low risk. Then, the following the triage method would address the resources with medium cultural value at high risk followed by medium cultural value and medium risk and then medium value and low risk. Last to be assessed for adaptations are the resources with low cultural value with low risk, followed by low cultural value and medium risk, ending with the low cultural value and high risk.

**San Juan Fortifications’ International Status and Public Significance**

National symbols like the San Juan Fortifications are very important for citizens on many levels, and represent that what could be lost is more than a tangible resource. “A cultural heritage site might generate values even to those who do not visit the site”\(^{19}\) because the fact that a place of international importance exists is valuable to all of society, also called existence value. Non-use value denotes benefits that people enjoy when the site is being preserved. There are numerous studies on economic analysis for historic resources however these cannot be measured only for how much money it takes to repair them.

The benefits people derive from heritage protection are numerous and diverse. A critical distinction is between use value and non-use value. In addition to the direct benefits (e.g. aesthetic benefits, financial benefits) people receive through the use of a heritage resource, people may also derive passive or non-use value from historic heritage. In this situation people are willing to pay for something they do not ‘consume’.\(^{20}\)

Old San Juan and the fortifications must be continuously maintained since so much of Puerto Rico’s economy depends on them. As the most celebrated heritage resources in Puerto Rico, La Fortaleza and San Juan Historic Site is included in UNESCO’s World Heritage Site List since 1984. The fortification system represents the finest surviving example of military engineering during the Spanish Empire. They have been a constant figure in the San Juan Bay’s landscape to be admired and enjoyed as an intrinsic part of the topography. The system has transcended its military significance to give inherent meaning to the people of Puerto Rico. As it stands today, the fortification system is a representation of more than five hundred years of construction, additions, modifications and repairs. From 1521 to 1898 battles against the English, Dutch and French were fought adapting the bastions to better defend the old city in the interests of Spain. Its military purpose remained through World War I, World War II and the Cold War as strategic outposts for the United States until it was transferred in 1961 to the National Park Service and the Commonwealth of Puerto Rico.\(^{21}\) The forts of San Juan Historic Site have been a park since then; enjoyed by citizens and visitors as a significant experience of the old city.

For Puerto Ricans, the fortifications elicit the same strong national identity associations stirred by the Statue of Liberty\(^{22}\) for Americans. The possibility of losing significant national symbols stirs emotions within the people who strongly identify with them. For this reason the fortifications are closely tied with social cultural and economic value. On any given weekend, Old San Juan is full of locals and tourists walking around the city and along the paseos outside
the walls. Experiencing the relationship between coast and historic walls is an activity repeated over and over by the public. The fortifications are a real enjoyment and educational experience for the people who visit them. It reflects on the social wellbeing and traditions of Puerto Ricans that have been experiencing the old city for many generations.

Moreover, any change to the walls, whether by excessive cleaning or stucco repairs without warning, has detonated the public’s severe critique of the agencies responsible for the work. Witnessing the demise of vulnerable historic walls claimed by the rising seas would be a real misfortune to Puerto Rican society. More than just historic material will be lost, since it would represent the crumbling of society as well. When a resource is threatened, the cultural associations and sense of continuity are in danger of failing too. The loss of these resources will have a devastating effect on cultural identity. The general public is considerably attached to the fortifications of Old San Juan because they represent a source of pride and identity. The fortifications have an association with place, space and time and are intrinsic to the landscape. Attention needs to be given to this particular resource and all the components of the system that include the smaller fortifications and bastions.

The current replacement value for the Fortifications and all structures included in the San Juan National Historic Site have been calculated by the National Park Service in the Facility Management Software System. This value is obtained from standard industry costs of materials, supplies and labor required to replace a facility at existing size and functional capability. El Morro Fort is valued at more than $6 billion dollars, San Cristobal is valued at approximately $7 billion dollars and the Old San Juan Walls are valued at $4 billion dollars, for example. The amounts reflect staggering amounts of money that the resources are valued at if they were to be built again in current times. They also show what could be lost in terms of the material itself not counting damage to Puerto Rico’s overall economy. Since National Park Service resources compete for available Federal funds having an estimate for the tangible aspect of the resource in economic terms is useful to prioritize and prove eligibility. The number is used as an estimate to make decisions for resource treatment: maintain, repair, replace or removal. The formula can be applied to other properties outside of the National Park Service to obtain their current replacement value.

Analyzing the tangible and intangible benefits of historic resources to Puerto Rico’s cultural, social and economic wellbeing will help understand what is reasonable and advantageous to save. One way of achieving this is to determine the economic value of the historic resources by creating a cost benefit analysis for each of the threatened resources for planning purposes. Measurement can be done using existing methods to calculate value, based on what they contribute to the local and national economy. There are many methods that calculate how much resources may worth; one equation the National Park Service uses is current replacement value equations. The buildings or structures where to be replaced using the equation calculates how much money it would take. Economic contributions of historic resources is a way of understanding the value of resources, however cultural values may possibly transcend financial assessments.

**Involvement of Government Agencies and Municipalities**

The Department of Natural and Environmental Resources is the umbrella governmental agency in charge of coastal management. This and the Puerto Rico Coastal Zone Management
Program should have input on resources threatened by sea level rise. The Puerto Rico Council on Climate Change (PRCCC) is an organization that works with key partner groups, universities and government agencies serving as advising committee for the Governor providing the latest information available on climate change topics for the island. Since 2009, the PRCCC have met annually to present and discuss scientific findings with the purpose of advance the agenda for adaptation strategies “to help Puerto Rico cope with coastal hazards and future climate changes.”

The State Historic Preservation Office and Institute of Puerto Rican Culture need to be included in this conversation because threatened resources are like species in danger of extinction once lost, there is no recuperation.

The agencies are in charge of state and local historic properties registers and the information provided in this thesis analysis is a first step in assessments by creating the appropriate lists for future in depth studies needed for sea level rise resource adaptation. As a result of this study, collaboration and outreach with agency directors have already transpired in the hope that significant contributions for the effective management of coastal historic resources become a priority.

The Planning Board is the agency in charge of developing integral plans for the island and they ought to be compatible with public policies like in the Coastal Zone Management Program. The planning board is recently creating a new plan for the use of land to be more compatible with public planning that incorporates climate change concerns affecting the island. This broad plan has gone through a series of public hearings to consider the input of community’s residents. Natural environment is affected by overdevelopment of the coast and Puerto Rico depends on the efficient management of this area to have balance livelihoods. This new plan encourages a more sustainable and holistic coastal planning paving the way for historic resource adaptation planning.

The Tourism Company of Puerto Rico can benefit from the information to be prepared for the challenges that sea level rise and coastal erosion may have on the island’s attractions on the coasts. The Department of Economic Development and Commerce would be an interested agency since many of the key economic activities are derived from businesses located within or near coastal resources. It is essential that an intergovernmental cooperation exists to implement future plans for climate change adaptations that are in the best interest of the people of Puerto Rico. All this agencies are responsible for the resources alongside the State Historic Preservation Office and the Institute of Puerto Rican Culture since their decisions directly affect coastal historic resources.

The future goal should be for the government to coordinate the appropriate study groups, committees or associations to further assess the impacts on coastal erosion by sea level rise and formulate plans to manage coastal resources in a responsible sustainable manner for the future. The San Juan National Historic Site has commissioned a study on climate change to better understand how all the components affect the resources at the park system, sea level rise being one of them. The National Park Service has implemented a Green Parks Plan and the Climate Friendly Parks Program at San Juan National Historic Site and taking steps to become a more sustainable facility. This park is one of the first the National Park Service has chosen to implement assessment studies on climate change. Due to the importance of the resources in
Puerto Rico, action is anticipated since being prepared gives the park a better chance to get funding when needed in the future.

Creating liaisons with governmental agencies and the private sector is important for effective management of those threatened resources that are half public and half privately owned. The input of agencies is important for successfully applying adaptation methods on coastal resources. These include The National Park Service, Department of Natural and Environmental Resources, Puerto Rico Council on Climate Change Council, Puerto Rico Coastal Zone Management, Institute of Puerto Rican Culture, State Historic Preservation Office, Puerto Rico Tourism Company, Department of Economic Development and Commerce, Puerto Rico Industrial Development Company in management plans.

There is a wealth of knowledge and understanding in the arts and the humanities that is helping to broaden the debate on climate change by exploring cultural values, creative endeavors, ethics, aesthetics, critical reflection, and historical perspectives. We need to discover the creative meeting points between the arts and humanities and the physical and social sciences in conducting our research on the impact of climate change on cultural heritage.

The purpose of the triage matrix system in this thesis analysis is the practical use in preparing appropriate management plans to ensure continued enjoyment of historic resources for future generations. “The threat of loss to a beloved place is often a spur to action” Preparing for future disasters confronting our cherished resources is overwhelming. Moreover, in the wake of climate change resources in precarious locations like the coasts of Puerto Rico demand awareness, reexamination, and action. It is possible to make choices for threatened historic resources even when those choices are difficult to make. With the conscience that some resources will be lost, it is possible still to save some of the most important ones when using a systematic form. Like in an emergency triage, this system can bring order to a chaotic situation. This section of the treatise proves that with a matrix system that classifies threatened resources in order of conditions, use ownership, risk and cultural value Puerto Rico’s most important historic resources in need of attention can be effectively organized and managed so adaptation treatments can be implemented.

Historic resources in Puerto Rico contribute to social wellbeing, tourism economy and cultural value. For this, the enjoyment should be preserved for as long as possible so future generations are not deprived of them. “It is only with buildings that we can experience a place firsthand using all of our senses. We can see it in the brick, feel it in the banisters, smell it as we walk thought corridors, hear it in the echoes of the lobbies, and taste it in the air. We can literally be where the history of that place occurred.” The reason for why we preserve historic places is so people can experience the intangible feeling of a time and place through the tangible property. Historic resources give communities a sense of pride and identity to project to the outside world a dignified image. The image that Puerto Rico can portray is of a country that can manage and preserve their resources as well as possible in the face of an ocean that is inching its way forward without retaliation.

Conclusion

This section reviews the importance of cultural values in the role it plays for resource
assessment. Resources have intangible value and influence in cultural identity of communities. The most important and immediate resources to adapt to sea level rise have been discussed for their urgent need in planning. Understanding of the triage method is applied to the most affected resources in need of hastened attention. The relationship between cultural value and risk assessment is explained to recognize how the triage system can be used in this study and future assessments when needed. Other ways in which economic value for resources may be implemented in future in-depth studies for management and planning are discussed in this section for these can be useful for government agencies and municipalities. Resources’ planning for adaptation to sea level rise should be integrated in agencies and municipalities long term planning since these are essential for continued social and economic benefits.

Adaptation treatments for Resources

In the past there have been changes in the earth that have forced a number of adaptation methods. Humans have had to adapt in order to continue living in coastal areas. Over the years, methods have been used and implemented for this purpose. However sea level rise due to climate change will have an unprecedented effect, making adaptation a fundamental action. Sea level rise is a human crisis. By occupying the coast and developing it, people have created an inter-reliant way of life. The rupture of that livelihood will cause a social problem requiring various social and cultural and physical adaptation methods. Historic resources are non-renewable. For that reason, it is important to plan for their adaptation so they can keep providing a wealth of benefits to the accustomed way of living for as long as possible. Certainly “climate change-induced coastal impacts are fundamentally altering the field of coastal management planning by accelerating the need for innovative strategies to combat the associated storm surge erosion, salinization, and flooding.” 30 There will be many types of adaptation methods for the coastline in the next decades to protect life and property. Therefore a number of adaptations can be used simultaneously. The alternatives for social, physical and policy planning aspects of adaptation is discussed in this chapter. Proposed use of adaptation methods for the example resources in Puerto Rico will be analyzed for recommendations.

Adaptation Measures for the Most Threatened Resources

Coastal planning measures have been categorized in three conceptual groupings: armoring the shoreline, stabilizing erosion and shoreline change through accommodation and retreat. The first planning measure refers to what is known as hard stabilization methods using barrier protection and structural reinforcement. For this category physical barriers like: seawalls, jetties, and revetments are designed to prevent further erosion of the coast and protect resources. The second measure, soft stabilization methods, use beach stabilization systems such as beach nourishment and vegetation to control coastal erosion in a way similar to nature. Accommodation tools intent on controlling development with policies for low density coastal expansion and building elevation are also considered soft adaptations. These methods regulate future construction of the shoreline that contributes to erosion and property loss. The third adaptation measure is to retreat from the coast by encouraging rolling easements, setbacks and abandonment of eroding shorelines. 31
The term resiliency has recently become mainstream, more so than the concept of sustainability when referring to human capacity to adapt to the effects of sea level rise. The National Climate Change Adaptation Framework: Building Resilience to Climate Change defines the term resilience as: “a capability to anticipate, prepare for and respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy and the environment.” Resilience is an appropriate term to use when referring to coastal communities preparing for the effects of sea level rise because adopting plans to prepare for events is the best way to anticipate disaster. It should be the goal of communities of having resilient capabilities for protecting the historic resources they so depend on for economic, cultural and social wellbeing. In the article “The Rise of Resilience” the concept of engineering resilience is discussed in relation to physical adaptations. “Engineering resilience is concerned with both resistance to and recovery from disturbances, with a focus on recovery.” Physical adaptations involving engineering methods are meant to protect resources from the worst effects of sea level rise, thought damage can occur regardless of their implementation. However, resilience is the ability for communities to recover and be back to normal after disaster events. Since flood events now occur more frequently, stronger and higher storm surges are expected as sea level rises and adaptation methods for resilience become imperative.

Puerto Rico’s most threatened resources are in need of adaptation plans to protect them from the effects of sea level rise. Moreover knowledge of resource type and location is useful to properly recommend adaptation methods. Using the matrix analysis for the most threatened resources the building type distribution is assessed.

![Historic Resource Type](image)

Figure 7: Author’s chart showing the distribution of resource types for the Most Threatened Historic Resources list.

The chart above shows that of the fifty-four historic resources threatened by sea level rise, a majority, thirty eight of them, are buildings. It is followed by ten structures, four sites and two historic districts. Each resource building type has different adaptation methods that can be used to preserve them in addition to other coastal adaptation methods to protect the land between the resource and the sea. For example, historic buildings can be adapted in a different way than sites which may be more vulnerable. A number of preservation strategies are reviewed with
suggestions for treatments for each resource thematic example in Puerto Rico.

**Sea Level Rise Flood Mitigation Systems**

Flood planning is an important part of adaptation methods for historic resources threatened by sea level rise. English Heritage suggests three types of assessment for flood preparedness. First, understanding the type of flooding is the first important because coastal, river, or surface water flooding behave differently. Establishing flood risk and studying the applicable method to best mitigate damage is a second step. The Handbook *Flooding and Historic Buildings* from English Heritage, recommends being prepared for flooding because this reduces damage to historic properties. Taking into account the local history of flooding, the topography and having updated accurate maps of the location can be a logical first step to get ready for flooding. “By planning ahead and taking sensible, cost-effective precautions, it is possible to minimize and sometimes prevent the worst of flood damage and thereby reduce suffering and cut the financial cost to individuals, businesses and the public of cleaning up afterwards.”

Different methods exist for flood defenses at the historic buildings specifically to reduce interior and exterior damage to the structure. Flood-resistance proofing works by reducing the amount of water that enters a property. Permanent or removable barriers can be temporary flood barriers at street level, at existing property gates, or window and door watertight guards, reducing the amount of water that can reach the historic building. Barriers can also be sandbags that, although temporary, they are useful at preventing water from entering a building. Flood resilient adaptations, sealing all joints and building maintenance reduces the amount of damage when water enters a building.

![Puerto Rico Coastal Vulnerability Viewer](image)

Figure 8: Storm surge flood scenario map for San Juan with one meter sea level rise from category 1 to 5 from dark to light in a hurricane, from the Puerto Rico Climate Change Council, prccc.org
A flood protection survey and risk assessment can determine the appropriate protection to consider depending on the need of each resource. Flood water can enter a building through masonry and mortar joints, cracks, vents, window and door frames, gaps around pipes, basements, foundations and under the floor. Regular maintenance of older buildings helps the resources in being prepared for flooding events. Keeping mortar joints, masonry and –door and window gaps– sealed helps as well. Photographic records and documentation are valuable documents to have in case that repairs need to be made after a damaging flooding event. Also recording events and damage for future reference is useful. Understanding how flooding affects historic buildings and their materials is necessary in order to know how to protect them.

Masonry walls, recovering from flood water saturation can be damaged by soluble salts already inside the material and by salts absorbed from the rising water. “When masonry is saturated, the salts dissolve but when the water evaporates, the salt dissolve but when the water evaporates, the salts are carried nearer to the surface, where they crystalize and can appear as a powdery white residue called ‘efflorescence’.” 36

Water is not a harmful to masonry construction unless the salts are trapped under an impermeable surface, materials like water-repellent sealants, oil based paint or acrylic paint. However masonry can be a resilient material because of its inherent sponge like behavior.

Many historic buildings in Puerto Rico are built with reinforced concrete in part for its resistance to hurricanes. Deterioration of concrete is caused mainly by existing cracks especially in buildings are close to the sea. In themselves, cracks are not damaging unless structural, but salts carried by sea spray and moisture can penetrate and reach the metal reinforcement starting a reaction in the materials. Saltwater and rainwater can turn concrete more acidic and start a corrosion process on the steel reinforcements.37 The steel reinforcement inside the concrete can deteriorate even faster with more frequent flooding incidents, accelerating the damaging corrosion process. Concrete can take a long time to dry. A longer drying process allows corrosion to expand the metal unevenly making the cement cracks bigger and eventually dislodging the surface cement and cause the structure to fail.

Wood is an uncommon construction material among the threatened resources in Puerto Rico. When wood is saturated with water, it is more prone to rotting due to fungus and insects feeding on it. If wood is able to be ventilated after a flooding event, it can dry with no need to be replaced. However, if water is trapped inside wood members, and is unable to dry, it will rot or insects create problems. Ironwork in fences, doors and windows, which are exposed to floodwater, can cause problems if not dried and weathered properly after being submerged. Saltwater is damaging to metals yet if the material is dried fast, it will not create many problems. The important thing to consider is that recovery and cleaning after a flooding event helps reduce damage to historic buildings.

**Historic Resources in the Towns of San Juan and Arecibo and US Customs Houses**

An analysis of the data from information gathered, treatment recommendations for the sample historic resources for San Juan, Arecibo and the US Custom Houses is suggested for future planning and adaptation. Each individual resource from the examples can have an adaptation plan with multiple flood mitigation systems. In depth studies for local sea level rise,
and flooding scenarios should be included so that better planning for each resource can be implemented. Part of the process of adapting resources and making them resilient to sea level rise effects is to understand the threats and anticipating disaster situations. Hellen Philips describes adaptations as: “The development of indicators of vulnerability and adaptive capacity are important in order to assess vulnerability and identify ways this can be reduced, and to determine the robustness of response strategies over time.” The emphasis here is on reducing damage during an event and recovering afterwards.

Part of a general approach to adaptation is modification of development including building elevation, low-density development, utility and service line limits. For preservation, the elevation of buildings in place is a strategy that keeps buildings in their original location, but keeps them out of harm’s way. Creating policies to moderate coastal development is a practical adaptation method for the future when retreat will be necessary. Different adaptation approaches range from building adaptations so people can enjoy the resources available for a while longer until that time when humans have to adapt socially and abandon the coast and move inland. Building resilience by adapting needs to take into consideration all of the range of adaptation possibilities.

The action proposed is to first do a sea level rise study for the specific areas where the resources to be adapted are located. Historic flooding and erosion patterns need to be included as well as location measurements for altitude relative to current sea level. Conditions assessment of the structure of each resource is necessary to understand which adaptation measure is essential to
protect the building. As built drawings, interior and exterior photographs and notes on existing conditions should be included in the study. Recommendations for how to make buildings flood resistant, retrofitting structures and making necessary repairs are important for making the resources resilient to sea level rise flooding. Lastly, choosing adaptation measures must be implemented after a review of all previous studies is accomplished, for the best results can be achieved to preserve the resource.

**Documentation of Threatened Historic Resources as a Priority**

Documentation is recommended for all historic resources in addition to adaptation methods. In order to keep the memory of historic resources for future reference, it is important to document the actual conditions and create drawings, maps, videos and other media to retain them in a non-physical way. Historic American Building Survey (HABS) drawings have standard regulations that capture quality content, format and durability. The guidelines for the records include precise measure and scale drawings with actual dimensions recorded in the field produced by hand or with computer aided drafting programs. Black and white photographs, written history of context, and field records such as notes, sketches, digital photos and measurements are kept as part of the documentation process. Keeping digital and hard copies of the resources records is useful and using this format allows them to be kept at the Library of Congress so they can be consulted in their collections either in person or online guaranteeing archival preservation. For San Juan, there are eighty-five archival drawing entries at the Library of Congress with numerous drawings for the fortifications and the San Juan Historic District.

As part of a 2003 conditions assessment for the Department of Transportation, the agency with custody of the parts of fortification walls belonging to the Commonwealth of Puerto Rico, an inventory was created recording drawn for conditions, substrate, surface materials and repairs, water runoff, vegetation and fungi, and historical development were created. The drawings were based on aerial photographs taken at various angles of the walls but not sufficiently accurate since actual measurements were not taken for their production. The National Park Service has an archive at San Cristobal Fort with every project performed on the park system. Updated documentation project should be commissioned for the rest of fortification walls since the last Historic Structures Report for the fortifications by the National Park Service dates from 1991. Digital drawings and renderings are becoming more realistic as technology advances, making this an adequate tool for representing and explaining construction methods and functions. In the event that partial or complete loss occurs, a well-documented resource can be a tool for digital recreation and further study. This is the most common strategy used in preservation and one recommended in addition to any adaptation methods chosen for all the threatened resources in Puerto Rico. In case of flooding events having well documented resources can help rehabilitation projects needed afterwards. Properly documenting resources takes time and money so starting early is a priority because all threatened resources can benefit.

**Education about Adaptation Methods for the Resources due to Sea Level Rise**

Public education and awareness of the effects of sea level rise is important to keep the people aware of the changes that will take place in the future. Implementing the different strategies for the adaptation methods takes time and money for the owners of the resources. The people of Puerto Rico feel a strong attachment and identification with Old San Juan, the fortifications and other resources unique to the island that give places their distinctive character.
Therefore it is best if the public is well informed about adaptation measures needed in order to avoid misconceptions or misinformed critique. Understanding of the adaptation process should be clear to the public and constant communication is favorable during this type of undertaking to become a resilient society confronting changes. Subsequently, “adaptation is a social and political act”.  

While human adaptation to a changing environment is nothing new, “climate change brings a particular challenge. Uncertainty in the ways through which climate change will be felt set against its urgency and scale of impact, combined with the invisibility of casual linkages in everyday life, bring new challenges for the sustainability of socio-ecological systems.”  

One of the difficulties when dealing with a threat that will become more serious in the future is that unless there is a tragedy nobody wants to think about being prepared. Talk of sea level rise and the consequences to private owners of resources may not be well accepted. Some people may be in denial or think it will be someone else problems to deal with. It is also difficult to visualize how sea level rise will occur because not everyone understands maps. There are detailed models that create local sea level rise scenarios to help make accurate assessments of specific areas. These models can aid in sea level rise planning as well as public education since they are a tool that can help visualize flooding events in perspective view, it is up to governmental agencies to start commissioning them now.

**Protecting Resources with Hard and Soft Adaptations**

Hard stabilization as adaptation methods such as a seawall, bulkhead, jetty, revetment and groin are not generally recommended. In addition to being expensive, hard adaptation methods for coastal stabilization have been known to alter the beach erosion or accretion process at other areas of the coastline. By attempting to protect a specific coastal area another location may be affected with the use of this strategy. “In 1985, North Carolina banned hardened structures on the oceanfront because they negatively affect sediment transport and coastal erosion on adjacent beach segments. Instead, the state allows beach nourishment and temporary sandbag installations in front of oceanfront properties.” Hard stabilization methods could be seen as a response for protecting large areas such as historic districts from sea level rise but are not good solutions for long-term preservation at the cost of environmental damage. The best recommendation, if this method is needed, would be to consult with geologists and experts on coastal management to make a comprehensive cost benefit assessment.

Because of the cost and problems associated with hard stabilization methods, the next alternative is known as soft adaptations for shoreline stabilization. The areas to cover are smaller and more precise and consist, for example, of beach nourishment, dune addition, rock barriers and vegetation. Since the method is more natural and less intrusive, “soft stabilization remains the most ubiquitous and easiest tool category to implement in urban coastal areas.” Beach nourishment and dune addition supplements sand where eroding, however it may have to be repeated with some frequency depending on wave action and the rate of erosion. The addition of native vegetation acts as a natural defense against erosion since roots of plants give structure to the soil preventing loss.

Seawalls, embankments and revetments are solid more impermeable barriers then riprap that hold against adverse storm surge and flooding to penetrate the shoreline. Revetments can be
as permanent or removable barriers. This strategy would work for only a certain time for as sea level rise continues, it will cease to be effective in protecting the resources. Rock and concrete barriers built in front of historic resources in Puerto Rico are a solution that can absorb the strong waves and protect buildings from direct impact which itself causes a lot of damage to the resources closest to the seashore. Much the same way as it has been built for the historic fortification walls, rock barriers and riprap along the shoreline in front the resources can protect them. This strategy would mean a costly solution that would mitigate the damage caused by wave action but not by flooding.

Additional rock barriers extending the north sections of the fortification walls are a costly solution but will halt damage by absorbing the force of the Atlantic Ocean waves before they reach the coastline. The rock riprap barriers in addition to embankments should protect the section from El Morro to San Cristobal Forts continuing the work done at the south walls. Plans are already projected for El Morro Promenade Phase II for a portion of this north section. To implement this solution, funds will need to be raised over a period of time along with studies and construction projects for viability taking into consideration rise in sea level. The long term benefits of this strategy include continued protection at the fortification walls by strengthening the shoreline.

Rising in Place or Moving Resources to other Locations

The cost for moving resources to safer locations may be prohibited; concrete and masonry construction is more difficult that wood construction to move to another site. The majority of the threatened historic buildings in Puerto Rico are made of masonry or concrete which is more costly and difficult to move. Substitute locations for the buildings may be scarce in addition to altering the placement of resources and affecting integrity. Elevating in place may be more feasible for the properties of exceptional value. Forts San Gerónimo and San Juan de la Cruz may be candidates to be elevated in place because they are manageable for tasks of this magnitude. Moving the fortifications to other locations would be cost prohibitive and the resources will lose location associations that are very important for their understanding. Elevating the forts in place would imply adding strength to the footings with new structure under the forts. The cost is extravagant and it will not be a long term solution with sea level continuing to rise. Therefore it is recommended that this strategy requires a comprehensive study to evaluate its feasibility.

Do Nothing Scenario and the Loss of Valuable Information and Resources

Climate change acceleration is one of the consequences of the new millennium. Even if carbon emissions are reduced in the next ten to twenty years, sea level rise is expected to continue. Not acting to protect historic resources will result in damage that will increase as the sea rises. Doing nothing to preserve the resources shows a lack of responsibility for Puerto Rico’s built heritage. Therefore, even if nothing is prepared physically to protect the resources, at least planning for this scenario is necessary so the public can adapt sensitively and culturally to the changes. Education has to be part of a planning process, if this is the option.

As for resources of exceptional value for Puerto Rico as the case of Old San Juan and the fortifications, doing nothing more than has been done to protect the resources will mean the probability of the sea reaching low parts and soak up water constantly. Erosion can occur at the
bottom of the walls with salt water penetrating the rubble masonry. This would be especially
damaging to Fort San Gerónimo, San Juan de la Cruz and the north and east bastions
surrounding the city. In addition, stronger storm surges will batter the already soaked historic
walls accelerating the disaggregation process. Made primarily of clay, limestone, sandstone and
seashells\textsuperscript{48} the historic material is porous and the action of the waves battering against them can
cause disaggregation. The result will be letting the fortification walls be claimed by the sea and
becoming ruins of another era.

**Threatened Historic Resources in San Juan**

Trade winds at the north coast of San Juan are notorious for constant wave action even in
seasons of calm sea. The difference between the clam waters inside San Juan Bay and the rough
Atlantic Ocean are very marked. Geographically the land portions protect the bay but the exterior
coast receives the beating of salty winds and strong waves. The following is a detail of a map for
San Juan shows the relationship of the coast to the resources. San Juan Historic District is a
National Landmark and includes parts of the intramural and extramural city. For the intramural
section the threatened portions are next to the San Juan Gate and La Fortaleza. The city gate
itself has historic wooden doors that can be damaged if flooded. The sentry box structure in front
can be reinforced to protect the area and the old city gate adapted with watertight flood gates
preventing water from entering streets and buildings inside. La Fortaleza building is threatened
although perched high above Santa Catalina bastion because this portion of the wall is
precarious.

**Maintenance and Treatment for Historic Materials**

Portland cement has been used in the past to repair partial wall loss have caused damage
to the walls. Because cement is a stronger material it forms a barrier for the normal moisture of
the walls has to come out and when it cannot, sandstone material disintegrates on the inside. For
this purpose, material would have to be manufactured so as not to damage the historic ones.
Covering the walls with new materials always creates risks because of incompatibility. In order
to effectively create a stabilizer for historic materials, representative samples should be taken
from the walls and analyzed for compatibility because there are many mixtures of historic
materials used for construction over a 200 year period. If this strategy is performed, the wall
surfaces will have a uniformity that was never part of their aesthetics through the years. This
approach would require putting a team together of conservation professionals to study
possibilities and shortcomings of strengthening the historic walls.

For the buildings in San Juan extramural that are at sea level, like La Princesa Building,
that houses Puerto Rico Tourism Company, authorities need to be prepared for coastal flooding
since its location is exposed. The walls around the back of the building could crumble if water
saturates the lower portions. Floodgates are watertight doors that are placed at the entrance of a
gate or door openings to prevent water from entering the building in times of heavy precipitation
or storms.
Figure 10: Detail of National Register of Historic Places Map with location of the historic resources in San Juan, SHPO Puerto Rico Office.

Although perched high above the Bastion Santa Catalina Because of the precarious condition of this portion of the city wall, La Fortaleza Governor’s Mansion is a threatened resource. The recent power washing mishap removed surface materials and left the walls at Santa Catalina even more delicate. There is danger of collapse for the walls with storm surge increased by sea level rise. This can accelerate the disaggregation process started by the incompatible materials. Excess water intrusion could destabilize the patio of La Fortaleza and the building itself. It is recommended the prompt attention to this area protecting the historic wall, fixing the broken drainage systems and stuccoing the wall to prevent loss.

Superintendent of Lighthouses Dwelling is located at La Puntilla, south of San Juan historic core and his resource belongs to the US Coast Guard. It is exposed to the bay with the first floor level is about two feet from the ground. A temporary revetment can protect the perimeter of just the building’s wraparound balcony preventing flood water from penetrating the interior. Another method would be a new seawall around the perimeter of La Puntilla that will protect flood water from reaching this building and others on site like The US Custom House and the old Spanish Arsenal building next to it. La Puntilla can benefit from a seawall around the site and substituting the open concrete fence for a solid one that would protect all three resources. In addition, flood gates at the building doors are recommended for interior flooding prevention. Other Federal buildings may need temporary revetments at Comercio Street on the south building in addition to floodgates at the doors south of the building can prevent interior damage.

The base of the city walls in some areas of the north and east flanking El Morro are about one meter above mean sea level. Conservation of the fortification walls surrounding the northern
section of the city have to take this condition into account since water action is expected to increase. Special provisions need to be addressed in the management of the low portions of San Felipe del Morro, San Cristobal and the northern bastions for their susceptibility to weathering. The Fortification walls in the east have stabilization adaptation methods since 1949. A breakwater was installed that year with artificial rocks as embankments in order to mitigate the energy of the strong waves of the Atlantic Ocean from reaching the historic walls.

The Fortification walls were meant to reach the water’s edge, acting as a defense mechanism intrinsic to the system when it was used to protect the old city. Changes in fortification significance and the damaging effect of the original design, allowed preservation efforts to filled up the shoreline and the low parts of the walls with the creation of concrete esplanades. Land was gained in front of the vulnerable walls creating a walkway that in addition protected the foundations. Constant wind, rain and ocean waves erode the northern tip area where San Felipe del Morro is perched creating the need for a project using rock barriers as protection along the shoreline that started in the 1970s and was finished in 1990. In some areas, the exposed natural rock formation under the bastions was sprayed with a concrete coating called shotcrete at the slope to harden and protect it from erosion.\footnote{49}

The tip of El Morro is especially vulnerable and recent projects in 2013 continued the paved walkway along the outer edge of the fortification walls, is built from rock filling gaining land in front of the floating battery level. The portion forming the San Juan Gate to Santa Elena Bastion at the coastal entrance of El Morro is currently being documented by the National Park Service as part of a climate change assessment for the entire park.\footnote{50} The adaptation methods that exist today are localized and protect the low portions of the fort. Still, as sea level continues to

Figure 11: Proximity of the south fortification walls to the water in San Juan Bay from and the entrance to San Juan Historic District, author’s photo, June 2014.
rise, the current protections will not be as effective. Hence adding rock to the existing barriers will be needed as sea level continues to rise. For Escambrón Battery, Fort San Gerónimo and Fort San Juan de la Cruz the situation is dire since these scattered forts are at current sea level. The sea is a presenting a threat in addition to extreme the weathering from constant winds at this location. The action of the waves causes structural damage, material erosion and disaggregation.

Masonry walls will soon be absorbing greater quantities of sea water accelerating the deterioration processes, thus compromising the structural stability of the fort. The deterioration of historic material at the lower; more vulnerable sections of the walls that can unfasten and destabilize the higher bastions with eventual danger of collapse. Because the walls are more exposed to sea water at the lower areas, extensive repairs have been numerous. Repairs to the historic walls in the last one hundred years exhibit a range of experimental techniques the most damaging being the use of Portland cement. This material used as repair is incompatible with limestone materials, but removing it now may compromise the structural integrity of walls even further since large areas where covered with it. While cement absorbs little water, original masonry, limestone and brick soak up water that is meant to evaporate at the surface. The difference in materials exacerbates the water intake variance and the harder cement can detach faster from the historic material. For this reason is even more imperative to protect the walls since the absorption of sea water and the disaggregated material at the bottom will have a weakening effect on the top parts and gravity will soon win.51

San Antonio Railroad Bridge is a low bridge used for recreational purposes and it may need further study for structural evaluation and adaptation recommendations. The Miami Building is located in a strip of land flanked by the lagoon on the south and the sea to the north. The building will need a riprap barrier on the lagoon side to protect the existing enclosing cement walls in back of the building and flood gates at the street entrance. A solid gate or revetments to substitute the existing open metal fence of recent construction can prevent water from entering the site. The Condado Vanderbilt Hotel has a structural wall to prevent water to enter the underground parking lot created during recent renovations. Nonetheless the building is at sea level and will benefit from additional riprap at the existing barrier to protect the building from the Atlantic Ocean surge.

El Falansterio in Puerta de Tierra, could use a temporary revetment and installation of flood gates at entrance doors to the residential complex for protection. The Normandie Hotel needs flood and erosion studies for the north section since maps form the Coastal Vulnerability Viewer by PRCCC indicate that the building is at risk. Dra. Concha Méndez Residence in Condado would need flood gates at the fence entrance to prevent water entering the property. The surrounding fence is solid concrete and may hold off flood water from entering the site. Regular maintenance for all resources is a useful procedure to prevent damage by water entering through cracks and utilities connections.

**Threatened Historic Resources in Arecibo**

The historic town of Arecibo is located between the Atlantic Ocean and the confluence of three branches of the Río Grande de Arecibo. The town has a local historic district designation recognized by the Puerto Rico Planning Board and endorsed by with the Institute of Puerto Rican
Culture. A number of individual resources are designated historic. Moreover, the town’s characteristic architecture displays a coherent historic core. The National Register of Historic Places only has ten listed resources within the old town area. Yet a number of residential and commercial buildings with the characteristic of old town architecture deserve recognition at the National Register level, as well as a historic district nomination. The town is at risk from sea level rise and flooding of the expansive river bank to the south as shown in the map below.

![National Register of Historic Places map of Arecibo showing the location of historic resources in town, SHPO Puerto Rico.](image)

Figure 12: National Register of Historic Places map of Arecibo showing the location of historic resources in town, SHPO Puerto Rico.

During the flood of September 22, 1998 a day after Hurricane Gorges hit the island\textsuperscript{53} intense overflowing provoked the collapse of the bridge spanning Río Grande de Arecibo River. The force of flooding waters at the river basin combined with storm surge caused a lot of flood damage for the southern part of Arecibo town. A new bridge was build and it connects with the boardwalk surrounding the north of Arecibo town. It was built as a throughway bypassing the town and separating it from the sea, as it appears in the map above. The Atlantic Ocean has intense and constant wave action that hits the boardwalk at Victor Rojas Avenue with current sea level and without storm conditions. In addition, the southern part of town is lower towards the river and is therefore prone to flooding.

Some sections of the boardwalk, receive strong waves that break repeatedly against it. The avenue and boardwalk act as a barrier for the town however; the design of the boardwalk’s enclosure is segmented and uses different materials. It was not designed to purposely withstand storm surges with sea level rise. The low perforated walls or wood benches will not hold against coastal flooding during a storm event. In order to protect the town, a new sea wall would have to be built considering flooding with sea level.
The closest resources to the sea from the National Register list are Paseo Victor Rojas with the old fort, Oliver Theater, and Arecibo Town Hall. The masonic hall, a recreational park at the river’s edge and an old Custom House are also under threat. The old custom house in Arecibo, dating from the Spanish Colonial era, is listed under the local Puerto Rico Planning Board list of historic resources but not as part of the National Register thematic nomination. This building is very close to the sea north of Paseo Victor Rojas. The boardwalk north of the avenue can be reinforced to become a seawall to protect the historic district from strong storm surges. The addition of temporary revetments between the avenue and the town is another alternative that can protect from storm surge. Adaptation recommendations for the buildings should include new flood gates at doors to prevent interior flooding.

**United States Custom Houses as Puerto Rico’s Threatened Buildings**

The thematic subject for US Custom Houses in Puerto Rico includes buildings in San Juan, Fajardo, Ponce, Mayagüez and Humacao. These resources will need to have riprap additions surrounding the base of the buildings and strengthening of the foundations. For San Juan’s US Custom House in La Puntilla, a seawall is recommended around the site substituting the perforated concrete fence for a solid one that would protect not only the Customs building but also other resources in La Puntilla. Since this is the main building for the US Customs in Puerto Rico, which also houses the US Coast Guard, this site is an important one to keep disaster-ready. Also, flood gates at doors are recommended for interior flooding prevention. The US Customs building in Ponce is one lot away from the coast and creating a wall just for the building will be costly and inefficient. Therefore the installation of flood gates at the doors and windows would be a more feasible option to protect the building. In Mayagüez, the building is located two blocks away from the west coast and three blocks from Yagüez River towards the north. Accordingly, a recommendation for flood gates at door openings is a sensible option.
In Fajardo, the US Customs building is in constant use for ferry transportation that connects the municipal islands of Vieques and Culebra. The building serves an important function in town so protecting the building from flooding is vital. It is separated from the waterline by a single street, making it very vulnerable to sea level rise flooding. A seawall perhaps with additional riprap will be needed to mitigate storm surge and flooding. Flood gates at doors and windows can be added to prevent interior flooding. Humacao’s Custom House is no longer in use as such and is in an abandoned state, thus the investment in protecting the building has to be weighed with the condition and the future use it may provide.

**Retreat as an Inevitable Long Term Option**

Eventually, people will have to move inland and as Puerto Rico is losing its coastline, retreat will be inevitable. Sea level rise is expected to reach about two meters by the end of this century and the damage to existing infrastructure will be significant. Roads, airports, harbor ports and housing will be under water with a two meter sea increase scenario. Retreat from the coast will be an inevitable option in the long run as the coast becomes uninhabitable. When the time approaches, every coastal community will have abandoned the coast and move to higher ground further inland. The activities and strategies for retreat are beyond the scope of this research.

Managed retreat is done using any one of these procedures or combinations: abandonment, relocation, fixed setback, rolling setback, hazard reconstruction limits, hazard
zoning and purchase. The implementation of these measures will ensure an orderly retreat to safer and habitable areas. Abandonment and relocation refers to moving communities from their location to safer ground. Setbacks are mandated by law to gradually move inland the zone permitted to build so new construction is moved away from the shoreline. Designating hazard areas limits new construction from areas that will be at risk protecting life and property investments. Historic resources are meant to be preserved for generations in the future. However in time, historic properties too will be abandoned as part of retreat. But until this becomes the only option, preservation and adaptation efforts can take place. Consequently, adaptation measures for historic properties are temporary solutions to the problems of frequent flooding and storm surge events until the coast becomes permanently inundated by the sea and enjoyment of the resources becomes limited.

Retreat from the coastline in Puerto Rico may already be in its early stages of planning. The Coastal Zone Law P. del S. 674 of 3 July 2013 is a proposal from Senator María de L. Santiago Negrón that responded to climate change and the need to create a Coastal Zone Management Office to establish responsibilities among other issues. The proposed law addresses disproportionate construction and development of the coast in the past, intending, among other things to halt new construction that obstructs public enjoyment of the coasts. The Law refers to the fact that the coast is in danger of being claimed by rising seas. The original Ley Española de Aguas of 1886, established that the use and enjoyment of the seashore is for public domain. This statute of law dictated how the coast has developed in addition to the implementation of the 1972 US Coastal Zone Management Act. Excessive construction on the coast has been a result of laxer construction permits to the point where it has become a problem. The new Coastal Zone Law also proposes to redefine boundary limits to include more land if it is necessary to protect an important natural resource that needs conservation. As water advances what were inland properties segments will become part of the public domain even if they are private property. Current government action to redefine coastal boundaries is a first step to manage a deliberate retreat of the shoreline.

President Barack Obama’s new executive order from January 30, 2015 will curb state agencies’ unrelenting coastal development. With this executive order, Law 11988 of May 24, 1977 for floodplain management is amended to avoid long and short term adverse impacts associated with floodplain occupancy and modification by restricting floodplain development where there is an alternative. The executive action corresponds to the national policy on resilience and risk reduction on the President’s Climate Change Action Plan. Coastal floodplains are susceptible to sea level rise and this plan is thus a first step to halt development in these areas and engage in an eventual retreat.

**Historic Preservation Policy and the Need to Plan for Action**

The need to plan for the preservation of historic resources from sea level rise is certain. In order to accomplish this, clear polices need to be established. Without adequate planning, Puerto Rico stands to lose valuable resources. Policies that are implemented and followed are an important piece for adaptation strategies. Preservation policies have to be balanced, taking into consideration public welfare, stakeholder’s interests and the changing coastline. Sea level rise due to climate change will force unprecedented decisions. “Uncertainty in the ways through which climate change will be felt set against its speed and scale of impact, combined with the
invisibility of casual linkages in everyday life, bring new challenges for the sustainability of socio-ecological systems.”58 Planning for the preservation of historic resources against effects of climate change should not be a last minute decision nor after a major disaster occurs. “From the more restricted world of disaster management we know that the difference between investing in prevention and the cost of a disaster impact can easily exceed a ratio of 7:1. The costs of adapting to climate change are more far-reaching”.59 Knowing that disaster recovery is more expensive than preventive measures, it is only sensible to get adaptation planning underway. Disaster event losses from historical patterns will not be a useful measurement to judge future damages. Planning for the future has to be more proactive because sea level rise will certainly amplify any previous assumptions.

In previous chapters, the importance of historic resources for financial and social wellbeing has been discussed. However, where historic resources are concerned, it is important to consider the economic derivative that resources represent for their communities and cultural attachment. Mark Pelling in this book stresses that:

Adaptation has been framed in terms of identifying what is to be preserved and what is expendable, rather than what can be reformed or gained. Dominant development discourses put the economy as first to be preserved, above cultural flourishing or ecological health. There is a danger that adaptation policy and practice will be reduced to seeking the preservation of an economic core, rather than allowing in to foster the flourishing of cultural and social as well as economic development, or of improved governance.60

Making policies that consider cultural and social values beyond the economic ones makes collective sense. Further, such values are at the core of why preventing damage to historic resources is a crucial challenge for decision makers. More disaster policies are needed to prevent resource loss.

However, the more time that is wasted by not taking action the more difficult it will be for historic resources to be protected. Apart from time, another enemy for climate change is the short term efforts of changing government politics. The prevailing political process focused on short term goals, obstructs the need for long term planning that is vital in preparation for sea level rise. Sea level rise will in the long run affect the environment, people, corporations, government and the economy. Hence, planning for short term policy will not yield results in the long run and everyone will lose. It is the responsibility of every future elected government to care for important resources.

Conclusion and Recommendations

Methods exist to adapt and prevent flood and storm surge damage to historic resources from sea level rise. Planning for disaster prevention is the first step to prepare for sea level rise. Policy is an important component in preserving historic resources and adapting to sea level rise. Other organizations, such as English Heritage, have implemented plans that have produced detailed literature on how to prevent damage from flooding and protect historic buildings. England, like other countries, has had to deal in the past with flooding and as a result they have established guidelines to protect their resources. Their expertise can be useful when
establishing guidelines for preservation of resources in Puerto Rico. The construction materials and circumstances are certainly different but the principles are similar. For each municipality in the island, detailed studies should be commissioned for the resources in need of protection. The information provided in this thesis research is an outline to help create guidelines and plans to preserve Puerto Rico’s built heritage from the effects of sea level rise. It provides a list of the resources most at risk and the ones to pay early attention to, suggesting possible adaptation methods that will ensure the resources enjoyment in the future. However, the more time that is wasted by not taking action the more difficult it will be for historic resources to be protected. Apart from time, another enemy for climate change is the short term efforts of changing government politics. The prevailing political process focused on short term goals, obstructs the need for long term planning that is vital in preparation for sea level rise. Sea level rise will in the long run affect the environment, people, corporations, government and the economy. Hence, planning for short term policy will not yield results in the long run and everyone will lose. It is the responsibility of every future elected government to care for important resources.

Recommendations for Future Research

Sea level rise is overwhelming because the disasters associated with it cannot be accurately measured or predicted. The wide-ranging catastrophe will happen slowly and over time. However the more time that is wasted by not taking action the more difficult it will be for historic resources to be protected. Adaptation to sea level rise involves a social process as well. Coastal communities need to physically adapt historic resources to keep them functioning for people through a determined period of time. This thesis analysis considers the adaptation of resources for a period of approximately fifty to one hundred years; however as sea level increases coastal retreat may be inevitable. When adaptation methods prove inadequate or the cost of adaptations exceeds the benefits resources can provide, abandonment of coastal resources will be required. At the time when coastal retreat is mandatory, plans to abandon the resources will be needed. These planning processes have to take in consideration the social aspects and adaptations communities need to implement. Retreat has to be planned beyond the fifty to one hundred year mark or when the sea permanently claims the coast and is unable to be habitable. At this time society needs to adapt to the changes forced by a different environment.

Specific projected sea level rise data and maps due to climate change are not available to this date making accurate estimates difficult. This is something that should be created in the near future to make better decisions based on accurate flood maps for precipitation events and hurricane projections for the best approximations to real situations. Determining accurate flood susceptible zones where historic properties are located will be essential for adaptation assessments.

The local resources list from the Puerto Rico Planning Board and the Institute of Puerto Rican Culture needs to be updated to make proper assessments for coastal resources not included in the National Register. Some resources are included in both lists. Modern movement buildings that are recently appreciated for their cultural importance should be assessed also. The Docomomo organization in Puerto Rico should do an assessment of the resources at risk from sea level rise using the matrix in this study and reference their location according to the National Register. Nominating the modern buildings that are at risk from sea level rise to the National
Register will be an advantage for assessments. Financial assistance is necessary for adaptation methods, hence having the appropriate inventories and plans are assets when writing proposals for funding. Custodians of the resources should be interested in maintaining the resources in good condition to be resilient in the wake of disaster events.

Large scale adaptations, in the case with sea walls, are very expensive and require feasibility studies with years of planning. Small scale adaptations require less planning however standardization with guidelines for historic property owners require time to be produced. Then guidelines need to be distributed to both private and public property with the necessary education and training to be effective. In general the public has to be informed of how the buildings will be adapted or abandoned as part of a planning process. Even a do nothing scenario deserves an explanation so people are aware of the necessary changes.

**Recommendations and Future Action**

Public policy can aid in the process of adaptation by creating laws that protect coastal historic resources. Therefore these should be generated now and implemented soon to prepare as many historic resources as possible for sea level rise effects. Historic resources should be included in the environmental efforts against climate change for they are non-renewable resources as well. Creating official guidelines for owners to follow is not a very expensive way of helping preserve historic resources yet can make a big difference to be prepared. The ground is fertile in Puerto Rico to create guidelines and planning for historic resources with the amendments to Coastal Zone Law, the Land Use Plan and the Executive order for vulnerability assessment and adaptation plans on the agencies.

Current FEMA maps were used since these are the official maps for the National Flood Insurance Program and Emergency Management Program. These maps do not take into account sea level rise but flooding under current conditions. A future action would involve the creation of maps are revised for current and sea level rise flooding that are more accurate. Better assessments will be possible with data information that is specifically designed to obtain altitude location with projected sea level rise scenarios.

For the US Custom Houses in the towns of San Juan, Mayagüez, Ponce, Humacao and Fajardo, adaptation measures are advised since they are some of the closest resources to the sea by a few meters. They are at imminent risk owing their location to their use as control access of people and imported goods to the Island at strategic points. Built during Spanish regime and rehabilitated by the United States, the “US Custom Houses in Puerto Rico” is a National Register thematic subject. These five buildings need to be researched further for how sea level increase is going to affect them very soon. Therefore plans need to start to assess the risks now because there would not be much time before they are affected.

Puerto Rico is 3,425 square miles and shrinking. Maintaining use of the coast and its resources for as long as possible is imperative and must be done responsibly. Being resilient to sea level rise for will prove of the outmost importance. The places that people identify with are significant in creating a sense of place. There is still time to preserve threatened historic resources if policies and planning are set in motion, however, action must not be delayed.
Conclusion and Recommendations

Historic resources cannot be replaced. Once they are lost, future generations will no longer relish them. Therefore, preserving coastal historic resources presents a duty and an opportunity for Puerto Ricans that must be prioritized. The islands' coasts were aggressively developed over centuries and are now susceptible to sea level rise. As a result, historic resources are at risk from more frequent flooding, coastal erosion, and higher storm surges. National Register of Historic Places listed resources located on the coast will be severely affected. Preserving them requires extensive planning for adequate future adaptations. Given the real threat of sea level rise, a great number of historic properties located close to the receding coastline, need to be assessed for mitigation strategies.

The triage system of resource prioritization created for this study is a comparative method to evaluate coastal historic resources and mitigate damage. This classification method is a system to understand priority for allocation of funds that will be needed so adaptation measures are possible for the most important and resilient historic resources. Creating a system that evaluates economic, social, and cultural values attributed to Puerto Rico’s historic properties can help public and private organizations distribute funds in the most effective manner to adapt historic properties for frequent flooding. In the wake of sea level rise, it is not realistic to protect every coastal resource. The implementation of a triage system to help analyze which properties should be preserved is required for this task. Historic resources are ranked so those with a better chance against the approaching sea can be preserved. The owners of historic resources have to prepare their properties for sea level rise effects and this tool is essential to plan for assessments. This system is also useful to plan for mitigation of other historic resources not included in the National Register of Historic Places with the confidence that it provides assessment recommendations to deflect the effects of sea level rise. It is the responsibility of this generation to protect all historic resources so they do not become a liability that is sacrificed because of their intrinsic connection to an ocean that is inching its way forward without retaliation.

List of Most Threatened Coastal Historic Resources

The historic properties listed in the National Register of Historic Places that are most threatened by sea level rise in Puerto Rico are included in the following list. It includes properties located within the intertidal zone limit of fifty feet that will be the first to experience the effects of sea level rise so the need for attention is urgent. These properties are prone to frequent flooding, storm surges, and coastal erosion. The list was possible using Geographic Information System (GIS) location from the National Register Online Map created by the State Historic Preservation Office in San Juan.

Matrix Historic Resources

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Resource</th>
<th>Region</th>
<th>Conditions</th>
<th>Risk</th>
<th>Cultural Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Juan</td>
<td>Fort San Felipe del Morro</td>
<td>Región</td>
<td>fair</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td></td>
<td>Fort San Cristobal</td>
<td>Metro</td>
<td>fair</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td></td>
<td>Fort San Juan de la Cruz</td>
<td></td>
<td>poor</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>Location</td>
<td>Landmark</td>
<td>Fortification Walls</td>
<td>Line of Advance Defense San Antonio</td>
<td>San Antonio Railroad Bridge</td>
<td>La Fortaleza</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>---------------------------------------------</td>
<td>---------------------</td>
<td>-------------------------------------</td>
<td>-----------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Cataño</td>
<td>Bacardi Destillery</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>Manatí</td>
<td>Hacienda La Esperanza</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>Arecibo</td>
<td>Teatro Oliver</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td></td>
<td>Oliver Building</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td></td>
<td>Arecibo Town Hall</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>fair</td>
</tr>
<tr>
<td></td>
<td>Córdova Residence</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>fair</td>
</tr>
<tr>
<td></td>
<td>Paseo de Damas (el Fuerte)</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
</tr>
<tr>
<td></td>
<td>Gonzálo Marín 61 Residence</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
</tr>
<tr>
<td></td>
<td>Gonzálo Marín 101 Residence</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td></td>
<td>Marqués de las Claras Palace (Casino)</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td></td>
<td>Diosia Mita House</td>
<td>poor</td>
<td>poor</td>
<td>poor</td>
<td>poor</td>
</tr>
<tr>
<td></td>
<td>Casa Ulanga</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>Hatillo</td>
<td>Nuestra Señora del Carmen de Hatillo</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>Camuy</td>
<td>Old Casino Camuyano</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>Quebradillas</td>
<td>Puente Blanco</td>
<td>poor</td>
<td>poor</td>
<td>poor</td>
<td>poor</td>
</tr>
<tr>
<td>Aguadilla</td>
<td>San Carlos Borromeo of Aguadilla</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
</tr>
<tr>
<td></td>
<td>Old Urban Cementery</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
</tr>
<tr>
<td></td>
<td>District Courthouse</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td></td>
<td>Cardona Residence</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td></td>
<td>López Residence</td>
<td>poor</td>
<td>poor</td>
<td>poor</td>
<td>poor</td>
</tr>
<tr>
<td></td>
<td>El Parterre Ojo de Agua</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
</tr>
<tr>
<td></td>
<td>Casa de Piedra</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td></td>
<td>Conception Fort</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
</tr>
<tr>
<td>Mayaguez</td>
<td>US Custom House</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td></td>
<td>Duran Esmoris Residence</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td></td>
<td>Ramírez de Arrellano Residence</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>Ponce</td>
<td>McCabe Methodist Church Memorial</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>Location</td>
<td>Site/Building</td>
<td>Caribe</td>
<td>Antillas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>----------------------------------------</td>
<td>--------</td>
<td>----------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salinas</td>
<td>U.S. Custom House</td>
<td>good</td>
<td>low</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Empresas Ferré Building</td>
<td>good</td>
<td>low</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Playa de Ponce Municipal Building</td>
<td>fair</td>
<td>high</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humacao</td>
<td>Salinas Central Aguirre Historic District</td>
<td>mixed</td>
<td>medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>US Custom House</td>
<td>poor</td>
<td>high</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naguabo</td>
<td>Castillo Villa del Mar Residence</td>
<td>ruin</td>
<td>high</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bridge 122</td>
<td>fair</td>
<td>medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fajardo</td>
<td>US Custom House</td>
<td>good</td>
<td>medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luquillo</td>
<td>Williams Products Corporation</td>
<td>good</td>
<td>low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loiza</td>
<td>Parroquia del Espíritu Santo y San Patricio</td>
<td>good</td>
<td>medium</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

35
List of At Risk Resources

The coastal historic properties that are threatened by sea level rise are included in the following list at this appendix section. National Register of Historic Places properties comprise the list. To obtain the list the Geographic Information System (GIS) location form the National Register map created by the State Historic Preservation Office in Puerto Rico and the Federal Emergency Management Agency (FEMA) flood maps were used as reference.

<table>
<thead>
<tr>
<th>Municipality</th>
<th>At Risk Properties</th>
<th>Region</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Juan</td>
<td>Fort San Felipe del Morro (San Juan Historic Site)</td>
<td>Metro</td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>Fort San Cristobal (San Juan Historic Site)</td>
<td></td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>Fort San Juan de la Cruz (San Juan Historic Site)</td>
<td></td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>Fortification Walls (San Juan Historic Site)</td>
<td></td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>Fort San Jerónimo de Boquerón</td>
<td></td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>Escambrón Battery</td>
<td></td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>Advance Defense Line at San Antonio Bridge</td>
<td></td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>La Fortaleza</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>Superintendent of Lighthouses Dwelling</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>Polvorín de Miraflores</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>Miami Building</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>U. S. Custom House</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>Martin Peña Bridge</td>
<td></td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>San Antonio Railroad Bridge</td>
<td></td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>Condado Vanderbilt Hotel</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>Normandie Hotel</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>El Falansterio</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>San Juan Historic District</td>
<td></td>
<td>District</td>
</tr>
<tr>
<td></td>
<td>Hotel Normandie</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>Hiram Bithorn Stadium</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>Puente Rio Piedras</td>
<td></td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>Edificio Figueroa</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>Dra. Concha Mendez Residence</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td>Cataño</td>
<td>Bacardi Destillery</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td>Bayamón</td>
<td>Puente Marqués de la Serna</td>
<td></td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>Puente La Plata</td>
<td></td>
<td>Structure</td>
</tr>
<tr>
<td>Toa Baja</td>
<td>Church of San Pedro Apóstol de Toa Baja</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td>Dorado</td>
<td>Jacinto López Martínez Grammar School</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>Casa del Rey</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>Don Andrés Hernández Residence</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td>Vega Baja</td>
<td>Paso del Indio</td>
<td></td>
<td>Site</td>
</tr>
<tr>
<td>Manatí</td>
<td>Hacienda Azucarera La Eperanza</td>
<td></td>
<td>Site</td>
</tr>
<tr>
<td>Barceloneta</td>
<td>Rafael Blaseiro School</td>
<td></td>
<td>Building</td>
</tr>
<tr>
<td>Location</td>
<td>Site/Building/Structure</td>
<td>Name/Location</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------------</td>
<td>-------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Arecibo</td>
<td>Building</td>
<td>Arecibo Lighthouse</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Casa Ulanga</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Teatro Oliver</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arecibo Town Hall</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Córdova Residence</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paseo de Damas and Fort</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>61 Gonzálo Marín Residence</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Marqués de las Claras Palace (Casino)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diosa Mita House</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Puente Cambalache</td>
<td></td>
</tr>
<tr>
<td>Hatillo</td>
<td>Building</td>
<td>Church Nuestra Señora del Carmen of Hatillo</td>
<td></td>
</tr>
<tr>
<td>Camuy</td>
<td>Building</td>
<td>Old Casino Camuyano</td>
<td></td>
</tr>
<tr>
<td>Quebradillas</td>
<td>Structure</td>
<td>White Bridge</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Liberty Theater</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Porta del Sol</td>
<td></td>
</tr>
<tr>
<td>Aguadilla</td>
<td>Building</td>
<td>Punta Borinquen Lighthouse</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Church San Carlos Borromeo of Aguadilla</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Old Urban Cemetery</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>District Courthouse</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cardona Residence</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>López Residence</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>El Parterre Ojo de Agua</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Casa de Piedra</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conception Fort</td>
<td></td>
</tr>
<tr>
<td>Aguada</td>
<td>Structure</td>
<td>Coloso Bridge</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Punta Higuero Lighthouse</td>
<td></td>
</tr>
<tr>
<td>Rincón</td>
<td>Building</td>
<td>Boiling Nuclear Superheater Bonus Reactor Facility</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mayagüez Town Hall</td>
<td></td>
</tr>
<tr>
<td>Añasco</td>
<td>Structure</td>
<td>Añasco Bridge no. 65</td>
<td></td>
</tr>
<tr>
<td>Mayagüez</td>
<td>Building</td>
<td>Asilo de Pobres</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mayagüez Town Hall</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yaguez Theater</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plaza Colón</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Logia Adelphia</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Casa Solariega de José de Diego</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>U.S. Post Office and Courthouse</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gomez Residence</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heygler Residence</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mayaguez Municipal Cementery</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duran Esmoris Residence</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nazario Rivera Residence</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>U.S. Custom House</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ramirez Fuentes Residence</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>Site/Structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hormigueros</td>
<td>Ramirez de Arellano Residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Puente Torrens</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Puente Silva</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabo Rojo</td>
<td>Punta Ostiones</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guánica</td>
<td>Hacienda Santa Rita</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yauco Battlefield</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ponce</td>
<td>Cayo Cardona Lighthouse</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Caja de Muerto Lighthouse</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Iglesia Methodista McCabe Memorial</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>U.S. Custom House</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Empresas Ferré Building</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Casa de la Masacre de Ponce</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fernando Luis Toro Residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parque de Bombas de Ponce</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Villalonga Residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Catedral Nuestra Señora de Guadalupe</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Casa Miguel Godreau</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Iglesia de la Santisima Trinidad</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rosaly Batiz Residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mercado de Carnes de Ponce</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Old Spanish Military Headquarters</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Banco de Crédito y Ahorro Ponceño</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Town Hall</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ponce High School</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Residencia Subirá Reina Street 107</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Armstrong Toro Residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Font Ubidez Residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Playa de Ponce Municipal Building</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oppenheimer Residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Salassar Candal Residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zaldo de Nebot Residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ponce Casino</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Casa Paoli</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Faro Caja de Muerto</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>YMCA Building</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Casa Vives</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Iglesia Metodista Unida de Ponce</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Santa Isabel</td>
<td>Dr. Martin G. Brumbaugh Graded School</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salinas</td>
<td>Central Aguirre Historic District</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guayama</td>
<td>Iglesia Parroquial de San Antonio de Padua</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ingenio Azucarero Vives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>Name</td>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>-------------------------------------------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>Casa Cutiño</td>
<td>Building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Puente de Cayey #181</td>
<td>Structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arroyo</td>
<td>Punta Figuras Lighthouse</td>
<td>Building</td>
<td></td>
</tr>
<tr>
<td>Humacao</td>
<td>Humacao Custom House</td>
<td>Building</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Casa Roig</td>
<td>Building</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Guzman Family Pantheon</td>
<td>Site</td>
<td></td>
</tr>
<tr>
<td>Humacao Custom House</td>
<td>Building</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Casa Roig</td>
<td>Building</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Humacao Custom House</td>
<td>Building</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Guzman Family Pantheon</td>
<td>Site</td>
<td></td>
</tr>
<tr>
<td>Naguabo</td>
<td>El CastilloVilla del Mar</td>
<td>Building</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bridge 122</td>
<td>Structure</td>
<td></td>
</tr>
<tr>
<td>Ceiba</td>
<td>Firehouse Station</td>
<td>Building</td>
<td></td>
</tr>
<tr>
<td>Fajardo</td>
<td>Cabezas de San Juan Lighthouse</td>
<td>Building</td>
<td></td>
</tr>
<tr>
<td></td>
<td>U.S. Custom House</td>
<td>Building</td>
<td></td>
</tr>
<tr>
<td>Loíza</td>
<td>Williams Products Corporation</td>
<td>Building</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Puente de Villarán</td>
<td>Structure</td>
<td></td>
</tr>
<tr>
<td>Canóvanas</td>
<td>Parroquia del Espíritu Santo y San Patricio</td>
<td>Building</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cueva de los Indios</td>
<td>Site</td>
<td></td>
</tr>
<tr>
<td>Vieques</td>
<td>Loma Jalova 3</td>
<td>Site</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Laguna Jalova Archaeological District</td>
<td>Site</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paramayon 2</td>
<td>Site</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Punta Jalova</td>
<td>Site</td>
<td></td>
</tr>
<tr>
<td>Puente de Villarán</td>
<td>Building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canóvanas</td>
<td>Williams Products Corporation</td>
<td>Building</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parroquia del Espíritu Santo y San Patricio</td>
<td>Building</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cueva de los Indios</td>
<td>Site</td>
<td></td>
</tr>
<tr>
<td>Vieques</td>
<td>Loma Jalova 3</td>
<td>Site</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Laguna Jalova Archaeological District</td>
<td>Site</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paramayon 2</td>
<td>Site</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Punta Jalova</td>
<td>Site</td>
<td></td>
</tr>
<tr>
<td>Culebra</td>
<td>Isla Culebrita Lighthouse</td>
<td>Building</td>
<td></td>
</tr>
<tr>
<td>Mona</td>
<td>Isla Mona Lighthouse</td>
<td>Building</td>
<td></td>
</tr>
</tbody>
</table>
Endnotes

1 This information is gathered by using GIS flood maps as reference and GIS points for historic properties in the NRHP and maps. The information is used as part of the Climate Change Adaptation Plan for the Puerto Rico Tourism Company by University of Puerto Rico, Graduate School of Public and Department of Environmental Health.


9 Ibid., p. 28.

10 Presentation by Robert Young, PhD PG from the Western Carolina University, Climate Friendly Park Workshop, San Juan National Historic Site, December 9 to 11, 2014.


12 May Cassar, “Impacts of Climate Change on Cultural Heritage”, p. 58.


Rod Bogaards, p. 7.


The Statue of Liberty was used as the symbol for the National Geographic cover image composition flooded hip height to represent sea level of the world without ice, The National Geographic, September 2013 issue, Vol. 224, No. 3.
This value is assigned by the National Park Service. Current Replacement Value Notes were provided by Félix López, Cultural Resource Manager at the San Juan National Historic Site.


Climate Friendly Park Workshop, San Juan National Historic Site held at the training facilities of Fort San Cristóbal, December 9 to 11, 2014.

May Cassar, “Impacts of Climate Change on Cultural Heritage”, p. 2.

Chris Johnston, p. 39.

Donovan D. Rypkema, p. 78.


Ibid, p. 213.


Surface water is a result effect of sea level rise, when the water infrastructure becomes flooded and backs up to the source.


Ibid, p. 13


Caitlin S. Dyckman et al., p. 212.


Interview with Javier Martínez, National Park Service, at San Juan Military Archive, Castillo San Cristobal on February 19, 2014.


55 Caitlin S. Dyckman, et al., p. 217.


59 Ibid., p. 21.

60 Ibid., p. 9.