

Protecting Cultural Resources in Coastal U.S. National Parks from Climate Change

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THE U.S. NATIONAL PARK SERVICE MANAGES OVER 84 MILLION ACRES OF LAND on which are located around 26,000 historic structures. One hundred fifty areas under Park Service management are designated as “cultural landscapes.” The impact of climate change on cultural resources will challenge many resource managers, in particular those responsible for protecting America’s heritage in national parks. Rising sea level and projected increases in average annual temperatures will undoubtedly impact many parks’ natural resources, which have led some to ask, “What is being done to protect cultural resources from climate change?”

This paper will discuss what steps have already been taken to uphold the Park Service’s mission to “preserve unimpaired the natural and cultural resources and values of the national park system...” (NPS 2007a). In particular, we discuss how cultural resources are being impacted by observed changes in climate and discuss how we expect cultural resources to be affected over the next century, based on projections by the Intergovernmental Panel on Climate Change (IPCC).

Fort Massachusetts in Gulf Islands National Seashore and Cape Hatteras Lighthouse in Cape Hatteras National Seashore will be used here as examples of large-scale measures that are being taken to preserve cultural resources that would otherwise be lost to a changing climate.

Literature review

When many of us think of climate change and cultural resources, we may think of the cultural resources that are currently endangered by rising sea level in

some of the oldest cities of the world, such as Venice or London. In early 2007, UNESCO listed twenty-six examples of World Heritage sites (out of 830 total) that are threatened by climate change (UNESCO 2007). These sites represent areas of global significance that are immediately at risk from changing climatic conditions. The list is categorized based on whether the sites are (1) glaciers, (2) areas of high marine biodiversity, (3) areas of high terrestrial biodiversity, (4) archeological sites, or (5) historic cities and settlements.

While these sites are important, they are merely examples of well-known sites that need protection. The question of how we protect those sites has been the subject of a number of reports and research conducted by various players, including those at multinational (e.g., UNESCO 2006, 2007), national (e.g., Cassar 2005) and academic (e.g., Dietz et al. 2003; Wallach 2005; Hassler 2006) scales. However, while the ecological impacts of climate change have been discussed extensively in the liter-

ature, Carter et al. (2001) have found any discussion of resource management and sustainability to be lacking. Overall, the discussion of what can be done to protect fixed sites that cannot naturally adapt to a changing climate, such as cultural heritage sites, has been largely overlooked by those in anthropology, archeology, geography, and other academic fields, leaving the discussion of what should be done about this issue almost exclusively to those in governmental institutions. This lack of research interest partly may be due to the lack of immediate “catastrophic” levels of impact by climate change. Patterson et al. (2006) point out that it can be difficult to plan for climate change due to temporal incongruities between cultural tourism (that can change over the scale of a few years) and ecological changes that are expected to occur over decades.

UNESCO (2006) outlined some suggested ways to predict and manage the effects of climate change. This report takes an even-handed approach to climate change that emphasizes preparation over a variety of temporal and spatial scales. In suggestions to resource managers, the report lists the following steps as part of a suggested strategy:

- Take preventative actions that include monitoring, reporting, and mitigation measures that should be “environmentally sound choices and decisions at a range of levels: individual, community, institutional and corporate.”
- Employ corrective actions to adapt to changing climatic conditions.
- Share knowledge.

This approach also follows the work of Patterson (2003), in which she states that climate and tourism is a “two-way street”

that needs both *mitigation* where (in this case) cultural tourism can impact climate, and *adaptation* to climate’s impact on cultural resources. Patterson et al. (2006) further echo the work by UNESCO by stating that mitigation and adaptation must involve stakeholders on a number of levels to be successful, which has been the case for the examples that will be discussed in this paper. Tourism is a vital part of protecting cultural resources because tourist dollars can contribute to protecting sites of cultural significance. However, it should not be forgotten that tourism itself can also harm these areas, not only by on-site impacts but also by less-obvious impacts such as using cars that release greenhouse gases to get to the sites. The National Park Service relies on fees paid by visitors to assist them in maintaining and protecting the parks. With escalating temperatures in some regions and increasing sea level among other threats from climate change, the question arises: “Can the financial cost of protecting these resources exceed their cultural value?”

Whitehead and Finney (2003) tested willingness to pay to protect cultural resources in North Carolina through a survey of 884 members of the public. The study asked respondents how much they would be willing to pay to protect submerged cultural resources (shipwrecks) found around Cape Hatteras, North Carolina, as a one-time tax increase. Respondents were also asked how much more they would be willing to pay based on the number of submerged shipwrecks saved. Overall, they found respondents willing to pay to protect cultural resources, although the number of shipwrecks being saved did not play a major role in their decision-making.

However, this work did not include any questions regarding the length of time that

these resources should be protected. Climate change, which works on a scale of decades to centuries, will test how long these resources can be protected. In this paper, moving Cape Hatteras Lighthouse is a case in point of a measure that can only mitigate for nature's impacts for a limited amount of time before more must be done. In the meantime, managers are reassessing what preventative measures can be used around Cape Hatteras itself, and are monitoring and reporting the progress of sea-level rise and erosion around the site.

In contrast, Fort Massachusetts requires more immediate attention—a situation that has managers asking what would be the best way to protect it. The planning for the fort is currently in the UNESCO “corrective actions” stage of protection, whereby the site has to adapt now to climate change.

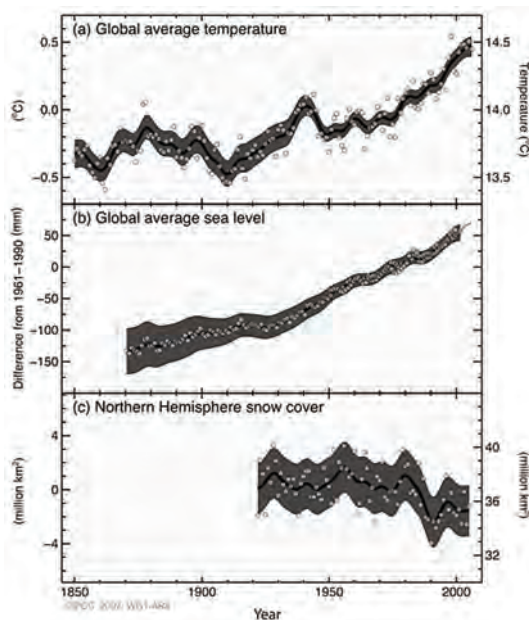
Climate change

In February 2007, the IPCC released its fourth assessment report on climate change. In addition to building on the work of their previous assessments by outlining its predictions for future impacts of climate change, the IPCC also discussed how changing climate is already impacting the Earth, and, crucially, what is causing these changes. For the first time the IPCC stated that changes in atmospheric gases (principally carbon dioxide, methane, nitrous oxide, and ozone) have significantly increased due to anthropogenic activities and that it is very likely (within a 90–99% probability) that these human influences are driving the observed changes in climate (IPCC 2007b).

IPCC predictions are built on six possible scenarios for future changes

in society that could impact the level of anthropogenic greenhouse gases. These scenarios take into account changing rates of population growth, technology, and rates of economic development. From these scenarios, changes in the rate of sea-level rise and regional temperatures have been calculated (Figure 1). Surface air temperatures in the United States are predicted to warm by 2–3°C by 2100 along the western, southern, and eastern continental edges, with greater warming of up to 5°C in the North (IPCC 2007a). This increase in average annual temperatures will be accompanied by a 20–30% increase in precipitation in most regions that will manifest itself as more intense, short-duration storms that could result in flash flooding, particularly in the summer months. Projections by global circulation models also show a northward shift

Figure 1. Observed global average temperature, sea level, and northern hemisphere snow cover. Averages are relative to the 1961–1990 period. Circles represent yearly values. Source: IPCC 2007a. Reproduced courtesy of the Intergovernmental Panel on Climate Change.



in hurricane tracks, with an increase in the number of higher-intensity hurricanes and a decrease in moderate-intensity hurricanes (IPCC 2007b).

However, from a coastal management perspective, one of the most important changes in climate will be rising sea level. The IPCC predicts a global average sea-level rise of up to 59 cm by 2100, with average rates of rise almost doubling from 1.7 mm/yr⁻¹ over the last century to 3 mm/yr⁻¹ since the early 1990s (Rahmstorf 2007; IPCC 2007a). This number is expected to increase to at least 4 mm/yr⁻¹ over the coming century (IPCC 2007a). In order to assess U.S. coastal national parks' ability to adapt to climate change, the National Park Service, in collaboration with U.S. Geological Survey, have published a number of reports using the rate of sea-level rise coupled with variations in mean significant wave height and tidal range and other geologic variables, such as the geomorphology, shoreline erosion/accretion rates, and regional coastal slope, to calculate a relative coastal vulnerability index (CVI) for 23 coastal parks to identify areas in the national park system that are susceptible to climate change.

While this research looks at physical parameters, this work can be used by cultural resource managers to help identify areas of cultural significance that could be submerged or lost to changes in landform (i.e., eroded or buried) in the future (USGS 2007a). Cultural resource managers can use the maps and reports to measure whether the area their resources are located in is of very low to very high vulnerability in comparison with the rest of their park. Results are also broken down further based on the six physical and geologic variables analyzed in each park report, which are posted on the

CVI website. However, the CVI index does not quantitatively take into account the cultural or social values of the coastlines that are physically changing.

Fort Massachusetts, Mississippi

Fort Massachusetts is an example of a nationally significant resource of great cultural value that is threatened by rising sea level. It is a brick structure that cannot be moved and will therefore have to be protected using engineered measures, or else risk being lost to the rising waters of the Mississippi Sound and surrounding Gulf of Mexico. The question of what would be the best approach to protect the fort has been the subject of some debate in recent decades, particularly in light of predicted rises in sea level and other factors resulting from climate change. A number of "hard" (engineered, long-lasting measures) and "soft" (more natural, shorter-term) approaches have been taken to protect Fort Massachusetts from its changing environment. Harder measures, such as installing groins and sea walls, are longer lasting, yet are expensive to install, affect down-drift sediment transport, and, some say, detract from the aesthetic enjoyment of the structure. Soft measures, such as beach replenishment, are less intrusive, but they are usually short-term and can be more expensive over the longer term (French 2001).

The fort is part of Gulf Islands National Seashore, located approximately 20 km south of Mississippi on West Ship Island in the Gulf of Mexico (Figure 2). The fort was built during the Civil War (between 1859 and 1866) and remained virtually untouched from 1870 until 1975. Gulf Islands National Seashore was created in 1971, with part of the legislation recognizing Fort Massachusetts as a structure of the first

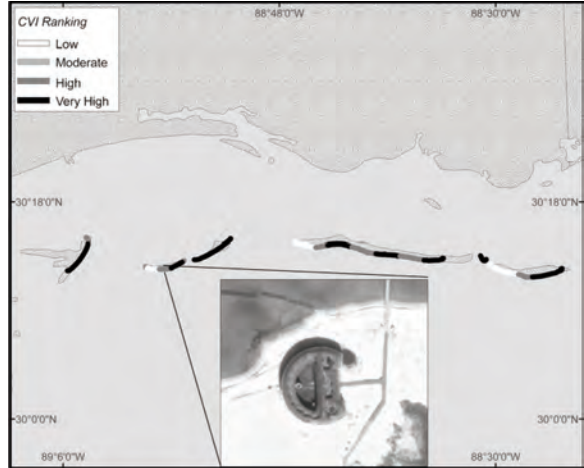
Figure 2. West Ship Island and Fort Massachusetts, with CVI assessment results (Pendleton et al. 2004a). Photo © 2007 DigitalGlobe, reproduced courtesy of Google.

order of significance because of its national significance as an “American Third System masonry fort” and for its unique “D” shape (Toscano 2004).

However, over a century of exposure to salt air, wave action from the Mississippi Sound, and a number of hurricanes, most notably hurricanes Camille (1969) and Katrina (2005), has begun to erode the brick building’s mortar. Hard structures consisting of a seawall and groin were built around the fort in 1917 to protect it from erosion. In the 1960s, funding was raised by citizens of the “Save the Fort” committee to construct a circular rock jetty around the fort as a provisional breakwater to deflect some of the energy of waves eroding the shore (Figure 3).

However, debris and remnants of a lighthouse east of the fort continue to exacerbate efforts because they act as an unintended “hard structure,” acting like a groin to capture sediment that could be used to protect the fort.

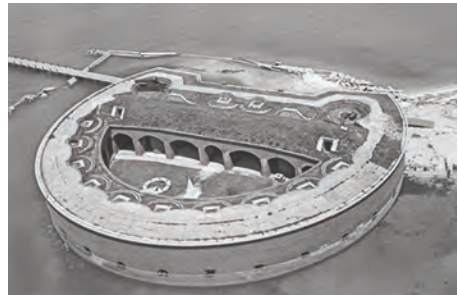
Soft approaches have also been taken, including dredging offshore and in channels to relocate sand back onto the national seashore’s beaches, particularly on West Ship Island to renourish what has been eroded, using sediment of a similar size and composition. But this is not a permanent solution and ongoing maintenance is required. However, sea level continues to rise which, coupled with the geology of the area, will threaten Fort Massachusetts by making the structure increasingly more vul-



nerable to shoreline encroachment and inundation.

Pendleton et al. (2004b) found West Ship Island to have a “high” to “very high” vulnerability ranking based primarily on its barrier beach geomorphology, very high rates of erosion (more than 2 m per year), near-flat coastal slope (<0.3%), and minimal tide range (less than 1 m). While Pendleton et al. (2004b) found relative sea-level change to only be moderate around the island (2.5–3 mm/yr), this is still significant when the above factors are also taken into account. Furthermore, this rate would still amount to a rise in sea level around Fort Massachusetts of 2.4–2.9 m by 2100. Given the fort’s current location a few meters

Figure 3. Fort Massachusetts during the 1950s, prior to funding for a rock jetty around the structure.



above sea level, it appears that intervention with either hard or soft measures to save the structure over the next century will be inevitable.

Cape Hatteras Lighthouse National Historic Landmark, North Carolina

Cape Hatteras Lighthouse National Historic Landmark provides an example of measures that have already been taken to react to changes in shoreline position resulting from a combination of natural and anthropogenic influences. The measures used to protect the lighthouse represent some of the more drastic (and costly) responses possible for resource managers. While a number of measures were employed over the years to protect the structure, ultimately the lighthouse had to be moved away from the receding shoreline. However, this type of action would not be available to many cultural resources, such as cemeteries, eroding battlegrounds, or historic forts such as Fort Massachusetts.

Cape Hatteras Lighthouse is one of three lighthouses found in Cape Hatteras National Seashore, the eighth-most-visited coastal park in 2006, with 2.25 million visitors (NPS Office of Statistics 2007). It was built during the period 1869–1870 for Atlantic ships passing along the Outer Banks of North Carolina in an area previously known as the “graveyard of the Atlantic” due to its treacherous conditions (NPS 2007b). Unfortunately these rough, stormy conditions have also proven hazardous to the lighthouse that was intended to protect ships from the storm-driven ocean waves and currents that wash over the Outer Banks and transport sediment into the sound. In 1869 and 1870 the lighthouse was constructed approximately 450 m from the shore. The lighthouse was a replace-

ment for the first Cape Hatteras Lighthouse, constructed in 1803. The 1869–1870 lighthouse is the tallest in the nation, measuring 58.8 m, although it is best known for its distinctive black and white diagonally striped exterior, painted in 1873. The lighthouse is a significant cultural resource as a record-breaking historic structure of engineering significance, but also because it adds to the aesthetic enjoyment of the coastline, having been described as “one of the most striking and beautiful structures on the Atlantic Coast” (NPS 2007c).

However, over the first 130 years of the lighthouse’s existence, erosion took its toll on the surrounding land. By 1935 already, waves had eroded most of the 450 m of beach in front of the lighthouse and the ocean reached to within 30 m of the base of the tower. A combination of natural changes and a number of protective measures postponed the threat for a number of years. Over the years, a number of erosion control projects have been initiated at the lighthouse site to protect the structure. They include: sheet pile groins (installed in the 1930s), beach renourishment (1966, 1971, and 1973), nylon sand-filled bags (1967), reinforced concrete groins (1967), a sandbag seawall (1971; Figure 4), piled rubble (1980), artificially created “seascapes” to capture sediment (1981), seawall revetment with artificial seaweed (1980s), and sand bag revetment (1990s) (Platt et al. 1988).

Despite these measures, increases in sea level and a number of high-intensity hurricanes continued to remove the sediment surrounding the lighthouse and threatened to engulf it. The National Academy of Sciences recommended in 1988 that the lighthouse be moved, but it was not moved until June 1999 due to



Figure 4. Sandbag seawall in front of Cape Hatteras Lighthouse, taken shortly after the seawall was constructed in 1971. The seawall was destroyed by wave action soon thereafter. Source: USGS 2007b. R. Dolan photo courtesy of U.S. Geological Survey.

lengthy planning and appeals against the plan. Eventually the lighthouse and keepers' quarters were moved southwest approximately 885 m to a new location that is again 450 m from the shore, at a cost of \$11.8 million (Figures 5–6). The lighthouse was opened again to the public on May 26, 2000.

In 2004, Cape Hatteras National Seashore's coastal vulnerability assessment was published. Overall, 26% of the park was classified as having a "very high" relative coastal vulnerability (Pendleton et al. 2004a). Cape Hatteras Lighthouse was also classified as a "very high" coastal vulnerability in five out of six assessment criteria: geomorphology, erosion, relative sea-level change, mean wave height, and mean tide range (Figure 7). The coastal slope of the location was assessed as "high" vulnerability because the grade was 0.60–0.30% (Pendleton et al. 2004a).

Based on tide gauge data, sea level in nearby Beaufort, North Carolina, has been rising over the past 27 years at a rate of 3.71 ± 0.64 mm/yr⁻¹ (Zervas 2001; Pendleton et al. 2004a), which is higher than current IPCC global averages (IPCC 2007a). The North Carolina Division of Coastal Management (2004) has also determined that the shoreline in front of the lighthouse

has been eroding at an average of 2 m/yr⁻¹ over the past 50 years (not accounting for additions to the shoreline using artificial forms of beach nourishment and reinforcement), with the shoreline to the south of the lighthouse location eroding at an average of 3.7 m/yr⁻¹. This is particularly troubling given the projected increases in sea level and associated shoreline erosion brought about by anthropogenic warming. Based on these rates, the sea level of Cape Hatteras is conservatively expected to increase by 3.67 m by 2100, not accounting for changes in volume from increased water temperature and salinity (Miller and Douglas 2004).

Furthermore, high-intensity hurricanes with storm surges also contributed to a large amount of erosion around the lighthouse when it was in its previous position. Some 28 recorded hurricanes have directly struck Cape Hatteras National Seashore since 1854 (NOAA 2006). In 2003, Hurricane Isabel particularly impacted the barrier islands of capes Lookout and Hatteras. In particular, the IPCC has noted increased intense tropical cyclone activity in the North Atlantic since the 1970s, which is linked to increased sea-surface temperatures (IPCC 2007a). Given the expected increases in sea-surface temperatures resulting from anthropogenic warming, the IPCC

Figure 5. Cape Hatteras Lighthouse in its original location. Inset: The lighthouse in its current location. Photos courtesy of the National Park Service.

(2007b) now finds it likely that intense tropical cyclone activity will increase, which could further jeopardize the Cape Hatteras coastline and its cultural resources.

Although Cape Hatteras Lighthouse is presently out of danger from sea-level change, this does not mean that it will be protected indefinitely. Without the added push by anthropogenically driven warming, it is expected (based on the current rate of erosion) that the location of the lighthouse would have to be reassessed again *at least* by 2199 (NPS 2007d). However, the factors discussed above brought about by climate change are expected to have a major impact on the rate of erosion around the historic landmark. This means that more may need to be done to protect the structure before the end of this century.

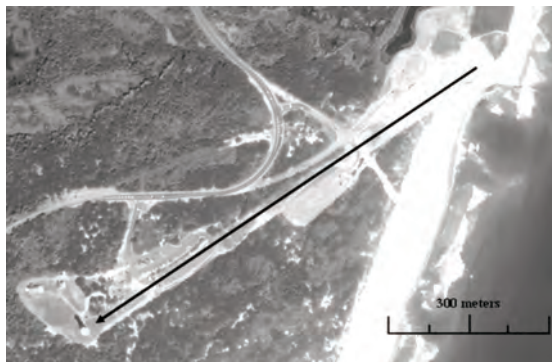
Discussion

Fort Massachusetts and Cape Hatteras Lighthouse are examples of corrective and preventive actions, respectively, that are part of Patterson's (2003) two-way street of adaptation and mitigation. However, UNESCO (2006) also stresses the importance of sharing knowledge to further protect cultural resources. The National Park Service has begun this process by encouraging national parks to take part in its Climate-Friendly Parks program, which is designed to



help and educate resource managers about the impacts of climate change on their parks. Research by Pendleton et al. (2004a, 2004b) has also been used by stakeholders and managers to assess their parks' vulnerability to rising sea level in an easy-to-interpret manner so that mitigation strategies can be put in place. Many of these mitigation measures take years to research and organize funding for—steps which should be taken now so that resource managers are not caught unawares when increased sea level is on their resource's doorstep. In the

Figure 6. The path of the Cape Hatteras Lighthouse move. The arrow indicates the direction of movement from the lighthouse's original location. Photo © 2007 DigitalGlobe, reproduced courtesy of Google.



case of Cape Hatteras Lighthouse, it took 11 years from when a move was first proposed (in 1988) to when it was accomplished (in 1999). During that time the shoreline in front of the lighthouse had eroded further by approximately 22 m. Fort Massachusetts may not have 11 years to wait before something can be done to further protect it from sea-level rise and an eroding shoreline.

The dissemination of information about climate change's impact on coastal cultural resources is an ongoing process that will involve participation from the individual/public to the global/transgovernmental level of stakeholders. It should also not be forgotten that most cultural resources cannot be moved as Cape Hatteras Lighthouse was. This may be for practical reasons or because it is simply not economically possible to do so. The National Park Service has approximately 25 parks that contain lighthouses. It is unlikely that every lighthouse in those parks could be moved if threatened by changing environmental conditions. The National Park Service also has a number of sites of cultural significance, such as Fort Massachusetts, that cannot be moved. At these sites, the National Park Service must consider a strategy of retreat with selective preservation efforts, or implement harder structures such as rock armoring or sea walls to protect vital cultural resources, as rising sea levels limit the feasibility of keeping a sand buffer along the shoreline. Hard structures will not protect Fort Massachusetts from the impact of increased temperatures and the possibility of more-intense storms that could damage its structure. In 2005, Hurricane Katrina generated a 9-m storm surge that washed

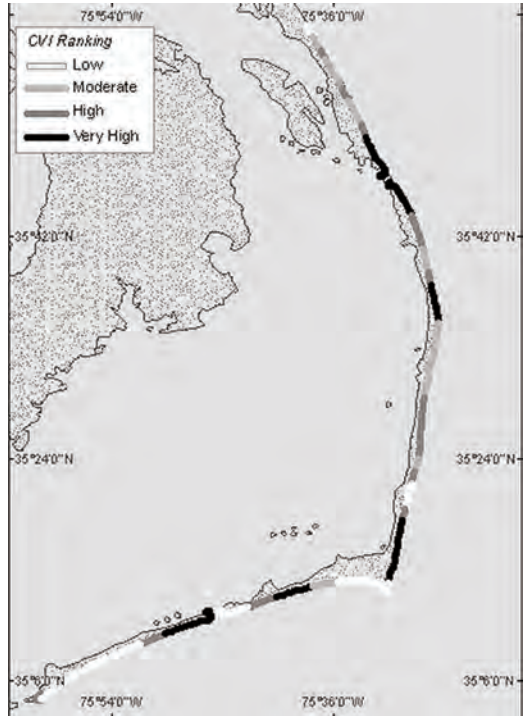


Figure 7. Cape Hatteras CVI results. Source: Pendleton 2007b.

over the fort, causing significant damage (Fritz et al. 2007).

It should also be considered that many national parks still contain valuable cultural artifacts on their grounds that have not yet been discovered. Recent erosion at Jamestown National Historic Site uncovered a location of significant archeological value that could have been eroded away had it not been for its discovery by park managers. There are still many sites on national park property that could be of significant cultural value to future generations but which cannot all be identified before the impacts of climate change take their toll (NPCA 2007).

Conclusions

The next decades hold a great deal of uncertainty for many cultural resources

throughout the world, particularly those in the coastal zone. Those in the U.S. national park system must be protected; however, this will be a difficult task in many cases, such as that of Fort Massachusetts. A number of financial and technological hurdles that require a high degree of resourcefulness must be overcome first. Cape Hatteras Lighthouse represents an extreme example of what engineering methods can be used to

protect these resources; it is also an example of managers taking a more proactive approach to planning for climate change. Overall, the three steps of conservation outlined by UNESCO (2006) are effective means of dealing with climate change, but the question still remains as to whether it will be feasible to prevent damage by increasing sea level or changing environmental variables to all cultural resources.

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