The Effects of Climate Change on Cultural Resources: A Preliminary Assessment

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The Effects of Climate Change on Cultural Resources: 
A Preliminary Assessment

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INTRODUCTION

The Applied Research Division of the South Carolina Institute of Archaeology and Anthropology (SCIAA-ARD) was tasked by the South Atlantic Landscape Conservation Cooperative (SALCC) to provide a preliminary overview of the effects of climate change on cultural resources within the region encompassed by the SALCC. This preliminary action plan will provide a working definition of the term ‘cultural resources,’ assess the literature concerning cultural resources and climate change, and provide information on other private and governmental organizations dealing with the same subject. In addition, this document will provide a glimpse of the effects climate change would have on the cultural resources within the SALCC. The final part of this project will be accomplished through the creation of a predictive model using the readily available data on cultural resources and historic properties contained in ArchSite database (geographic information system) for the state of South Carolina. The effects of sea-level increase, one of the main issues facing cultural resources as global temperatures increase, will be shown in relation to the cultural resources and historic properties of South Carolina.

Landscape Conservation Cooperatives (LCCs)

As part of a national network of Landscape Conservation Cooperatives (LCCs) within the Department of the Interior’s Fish and Wildlife Service, the South Atlantic Landscape Conservation Cooperative (SALCC) encompasses parts of six states in the southeastern United States. This area includes a small part of southern Virginia, a large part of central and eastern North Carolina, the majority of the states of South Carolina and Georgia, and a small part of northern Florida and the Florida panhandle (Figure 1.1). As such, the SALCC covers the main physiographical regions of the South Atlantic Slope: the Coastal Plain, Sand Hills, and Piedmont.

LCCs, in general, “are a network of partnerships working in unison...[to leverage] resources and strategically [target] science to inform conservation decisions and actions...[in order] to ensure the sustainability of America’s land, water, wildlife and cultural resources” (LCC Fact Sheet 2011:1, http://www.fws.gov/science/shc/pdf/LCC_Fact_Sheet.pdf, accessed 20 December 2011). The LCCs partner public-private sector groups (i.e. federal agencies, regional organizations, states, tribes, NGOs, and universities) on both a national and international level in order to take a more networked approach to the conversation of natural and cultural resources. This approach is described as ‘holistic, collaborative, adaptive and grounded in science” (http://www.fws.gov/science/SHC/lcc.html, accessed 20 December 2011). The LCC Fact Sheet outlines the four core functions of these cooperatives. They include the identification of “common science and conservation goals”, the development of “science-based tools and solutions” to meet these goals, the support of “biological planning, conservation design, and adaptive management,” and, lastly, the evaluation of the “effectiveness of scientific information and conservation actions” (LCC Fact Sheet 2011:2).
The SALCC, specifically, has further defined their mission in their charter as to “foster landscape scale conservation to sustain natural and cultural resources for future generations” (SALCC Charter 2011:1 (the SALCC Charter is available at http://www.southatlanticlcc.org/page/charter)). This mission will be accomplished through partnerships. By 2009, the SALCC had partnered with the U.S. Fish and Wildlife Service, the USGS Climate Change Response Centers, U.S. Environmental Protection Agency, U.S. Forest Service, the National Park Service, the Federal Highway Administration, the Natural Resources Conservation Service, the National Oceanic and Atmospheric Administration, the U.S. Department of Defense, The Nature Conservancy, The Conservation Fund, and Environmental Defense. These partnerships are constantly changing as new partners are added in order to meet the mission of the SALCC. By 2011, the SALCC was holding workshops, further defining their mission goals, and writing a charter while still working with the abovementioned partners. It was also in 2010 that the SALCC began to work towards understanding the effects of climate change on cultural resources (i.e. understanding the “effects of climate change and other critical challenges such as competition for water, wildlife disease, and exotic species invasion” within the South Atlantic Slope and across state boundaries) (SALCC Fact Sheet 2009:1-2, http://www.fws.gov/southeast/SHC/pdf/DoISouthAtlanticLCCNarrative.pdf, accessed December 2011).
Report Organization

This report will be organized into four chapters. The initial chapter serves as an introduction to the project itself and briefly introduces the Landscape Conservation Cooperative with a specific focus on the South Atlantic Landscape Conversation Cooperative. The second chapter will provide background literature on the two most important concepts of this action plan—cultural resources and climate change—and will use the available literature to operationalize these key concepts. The third chapter will present a simple predictive model looking at sea level rise and its effect on the cultural resources of the South Carolina coast and discuss some of the limitations of attempting to model climate change. The final chapter will serve as a conclusion to this action plan and will address future avenues of research in terms of understanding the effects of climate change on cultural resources and remediation of these effects.
This chapter reviews the literature dealing with cultural resources, climate change, and the effects of climate change on cultural resources. The goal of this chapter is to define the concepts and then operationalize the concepts of cultural resources and climate change to understand what specific climatic events are actually impacting cultural resources and how the resources will be affected. This information will be useful during the creation and discussion of the predictive model to be presented in the following chapter. Peer reviewed journals, scholarly articles, and government websites were perused for literature concerning the effects of climate change on cultural resources. Limited information was recovered, however, when available, this data provides examples of affected resources and specific remediation projects dealing with these effects.

Few sources were identified through a literature search concerning the effects of climate change on cultural resources. Searches were conducted using online journal databases (i.e. JSTOR, Ebscohost, etc.), the University of South Carolina Thomas Cooper Library catalog, dissertation and theses databases, and Google Scholar in order to locate literature concerning climate change and cultural resources. A large body of literature exists among the anthropological sources concerning indigenous attitudes towards sustainability and working with indigenous populations to create cultural heritage and nature preserves (e.g. Amelung et al 2007; Ford et al 2006; Page 1999). Searches for literature on climate change and archaeology results in endless citations of reconstructing past climates to interpret the results of archaeological research at a specific site or in a specific region. This is especially true when it comes to studies based in the Southeastern United States where the reconstruction of past climate is an important aspect of archaeological research (e.g. Anderson et al 2007:457-490; Colquhoun and Brooks 1986).

Similarly, there is a vast amount of literature concerning the effects of climate change on natural resources, such as understanding the effects of climate change on specific plant and animal species. Searches for literature concerning climate change and heritage sites yielded better results and provided literature from international organizations concerned with the impacts of climate change on the built historic environment. This literature has been utilized in the following discussion of the concepts of ‘cultural resources’ and ‘climate change’.

**Cultural Resources: A Working Definition**

The phrase ‘cultural resources’ is broadly applied to places of historic, archaeological, and social importance. Cultural resources are non-renewable resources that hold significant value to certain populations or the nation as a whole. The term itself developed out of the historic preservation movement of the 1970s. As archaeological surveys and excavations became mandated under environmental and preservation laws, and as a response to being combined with ‘natural resource management’ and ‘historic preservation’, a group of archaeologists in the American Southwest began referring to their work as ‘cultural resource management’ (King 1998:18). Thus, the term ‘cultural resources’ focused attention predominantly on archaeologi-
cal sites, ignoring other cultural resources (i.e. traditional cultural places and resources with socio-economic value) during the implementation of the various federal laws (King 1998:18). Over the following decades, with the input of Native American groups, local communities, State Historic Preservation Officers, and other concerned parties, the term ‘cultural resources’ has expanded to include historic properties, traditional cultural places, socio-cultural landscapes and features, and archaeological sites. Thus, a more inclusive and accurate definition of a cultural resource is “any resource…that is of a cultural character” (King 1998:265).

This broad and inclusive definition is difficult to operationalize in terms of predictive modeling. This difficulty arises from the fact that without detailed, community-level research, it is impossible to account for all of the cultural resources in an area. Data on certain cultural resources, such as state recorded archaeological sites and historic properties listed on the National Register of Historic Places, are relatively easy to obtain. However, data concerning socio-cultural landscapes and socioeconomic practices of both current and historic populations are difficult to collect and map. In order to operationalize the concept, this report follows the definition used by the National Historic Preservation Act (NHPA). The NHPA uses the term ‘historic property’ in lieu of ‘cultural resources’. It defines a ‘historic property’ as “any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion on the National Register” (NHPA 16 U.S.C. Section 470(w)(5), http://www.achp.gov/nhpa.html, accessed January 2012). Historic properties have a geographical footprint and boundary which facilitates their use in a predictive model. For the purpose of this report, all archaeological sites on file in the South Carolina Archaeological Site Files housed at the South Carolina Institute of Archaeology and Anthropology are included in the predictive model regardless of their eligibility recommendation. The predictive models in the following chapter will utilize a more limited definition of cultural resources. This definition will focus primarily on the built environment and less on the social manifestations of a cultural resource. This limited definition fits better with the data available (i.e. archaeological site file data and National Register of Historic Places data for the state of South Carolina) for use in the predictive models.

Climate Change: A Definition

Climate change has received a lot of scientific and political attention in the last few decades. Global surface temperatures in 1998 and 2005 were the highest recorded temperatures since 1850 and global surface temperatures have increased by 0.74°C +/- 0.18°C from 1906-2005 (IPCC 2007:18). This temperature change is most likely the largest temperature change in any century during the past millennium (UNESCO 2007:25). Global temperature increases are responsible for changes in precipitation patterns, increases in El Niño cycles, increased frequency and intensity of extreme weather events (i.e. hurricanes, wildfires, droughts, floods, etc.), a rise in sea level, and increased acidification of the oceans due to increased carbon dioxide in the atmosphere (UNESCO 2007:25-26).

The impacts of these global changes will be discussed in detail below, but first, it is necessary to define what is meant by climate change. The definition of climate change used within this report follows that of the Intergovernmental Panel on Climate Change (IPCC). The IPCC was formed in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP). As an intergovernmental entity, its purpose is to perform “comprehensive assessments of the science, impacts and responses of climate change” while
remaining politically neutral (Agrawala 1998:622). According to the IPCC website, climate change “refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use” (IPCC 2001:788). This definition differs from the United Nations Framework Convention on Climate Change (UNFCCC) which defines climate change as a “change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods” (http://unfccc.int/essential_background/convention/background/items/2536.php, accessed December 2011). The UNFCCC views “climate change” as a result of human activities while “climate variability” is the result of natural causes (IPCC 2001:789); the IPCC acknowledges that multiple factors are to blame for the variation present in climate.

**Operationalizing Climate Change**

Several international organizations have been examining the potential impacts of climate change on cultural heritage. UNESCO, the European Commission, the European Parliament, the Council of Europe, the Centre for Sustainable Heritage at University College London, the European University Centre for Cultural Heritage in Ravello, Italy, and the European Union’s Noah’s Ark Project are among these organizations (Sabbioni et al 2008:5-8). The majority of these organizations (i.e. UNESCO, the European Commission, the European Parliament, and the Council of Europe) are concerned with policy and trying to identify at-risk resources and appropriate management responses. The Centre for Sustainable Heritage at University College London collected information on notable changes due to climate through an extensive questionnaire circulated among preservationists in England. After identifying the important issues facing cultural resource managers in this region, a report was written illuminating the problems and providing recommendations for addressing these problems before more resources are lost or damaged. Their recommendations included monitoring, maintaining, and the implementation of adaptive strategies for water management (e.g. drainage, irrigation, and water storage) at historic and archaeological properties in addition to building a more collective partnership with other agencies for dealing with the impacts of climate change on England’s historic properties (Cassar 2005). The European Union Centre for Cultural Heritage in Ravello, Italy, is an educational facility which offers courses dealing with cultural resources and climate change (Sabbioni et al 2008:8). The Noah’s Ark Project encompasses a diverse array of research partners, including experts in material science and climatic and atmospheric sciences from laboratories across Europe, an international insurance company, and a private company focused on environmental disaster recovery (Sabbioni et al 2008:7). The Noah’s Ark Project was originally designed to study the effects of air pollution on cultural resources; however, as the air quality of Europe improves, research is shifting to address the effects of climate change on these resources (Sabbioni et al 2008:7-8). The geographical focus of the above organizations is predominantly Europe although UNESCO has World Heritage and Cultural Heritage sites across the globe. Regardless of this geographical bias, the results of their research are very applicable to the United States and the South Atlantic Landscape Conversation Cooperative.

In 2006, the World Heritage Committee (WHC) of UNESCO identified seven climatic characteristics, referred to as “climate indicators”, which will have the greatest impact on cul-
tural heritage. These “climate indicators” are observable and measurable climatic events, such as an increase in humidity. In addition to the seven climate indicators, the WHC highlighted some of the impacts these changes would cause to cultural resources (UNESCO 2007:34-36). Its findings, presented below in Table 2.1 using the same format as the original document, in-

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<th>Climate change risk</th>
<th>Physical, social and cultural impacts on cultural heritage</th>
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<tr>
<td>Atmospheric moisture change</td>
<td>Flooding (sea, river) Intense rainfall Changes in water table levels Changes in soil chemistry Ground water changes Changes in humidity cycles Increase in time of wetness Sea salt chlorides</td>
<td>pH changes to buried archaeological evidence Loss of stratigraphic integrity due to cracking and heaving from changes in sediment moisture Data loss preserved in waterlogged / anaerobic / anoxic conditions Eutrophication accelerating microbial decomposition of organics Physical changes to porous building materials and finishes due to rising damp Damage due to faulty or inadequate water disposal systems; historic rainwater goods not capable of handling heavy rain and often difficult to access, maintain, and adjust Crystallisation and dissolution of salts caused by wetting and drying affecting standing structures, archaeology, wall paintings, frescos and other decorated surfaces Erosion of inorganic and organic materials due to flood waters Biological attack of organic materials by insects, moulds, fungi, invasive species such as termites Subsoil instability, ground heave and subsidence Relative humidity cycles/shock causing splitting, cracking, flaking and dusting of materials and surfaces Corrosion of metals Other combined effects e.g. increase in moisture combined with fertilisers and pesticides</td>
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<td>Temperature change</td>
<td>Diurnal, seasonal, extreme events (heat waves, snow loading) Changes in freeze-thaw and ice storms, and increase in wet frost</td>
<td>Deterioration of facades due to thermal stress Freeze-thaw/frost damage Damage inside brick, stone, ceramics that has got wet and frozen within material before drying Biochemical deterioration Changes in ‘fitness for purpose’ of some structures. For example overheating of the interior of buildings can lead to inappropriate alterations to the historic fabric due to the introduction of engineered solutions Inappropriate adaptation to allow structures to remain in use</td>
</tr>
<tr>
<td>Sea level rises</td>
<td>Coastal flooding Sea water incursion</td>
<td>Coastal erosion/loss Intermittent introduction of large masses of ‘strange’ water to the site, which may disturb the metastable equilibrium between artefacts and soil Permanent submersion of low lying areas Population migration Disruption of communities Loss of rituals and breakdown of social interactions</td>
</tr>
<tr>
<td>Wind</td>
<td>Wind-driven rain Wind-transported salt Wind-driven sand Winds, gusts and changes in direction</td>
<td>Penetrative moisture into porous cultural heritage materials Static and dynamic loading of historic or archaeological structures Structural damage and collapse Deterioration of surfaces due to erosion</td>
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<td>Desertification</td>
<td>Drought Heat waves Fall in water table</td>
<td>Erosion Salt weathering Impact on health of population Abandonment and collapse Loss of cultural memory</td>
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<td>Climate and pollution acting together</td>
<td>pH precipitation Changes in deposition of pollutants</td>
<td>Stone recession by dissolution of carbonates Blackening of materials Corrosion of metals Influence of bio-colonialisation</td>
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</table>

Table 2.1. Table created by the World Heritage Committee which highlights the climatic event, how the event will change as climate changes, and the threat each event poses to cultural resources. Borrowed from Working Document 30 COM 7.1 2006:34-36, available at http://whc.unesco.org/archive/2006/30com-en.htm.
Climate indicator | Climate change risk | Physical, social and cultural impacts on cultural heritage
--- | --- | ---
Climate and biological effects | Proliferation of invasive species Spread of existing and new species of insects (e.g. termites) Increase in mould growth Changes to lichen colonies on buildings Decline of original plant materials | Collapse of structural timber and timber finishes Reduction in availability of native species for repair and maintenance of buildings Changes in the natural heritage values of cultural heritage sites Changes in appearance of landscapes Transformation of communities Changes the livelihood of traditional settlements Changes in family structures as sources of livelihoods become more dispersed and distant

Table 2.1. continued. Table created by the World Heritage Committee which highlights the climatic event, how the event will change as climate changes, and the threat each event poses to cultural resources. Borrowed from Working Document 30 COM 7.1 2006:34-36, available at http://whc.unesco.org/archive/2006/30com-en.htm.

Include a list of potential impacts to the historic built environment, archaeology, and areas of socio-cultural and socioeconomic concerns (UNESCO 2007:34-36).

Table 2.1 breaks down the complex concept of climate change into specific climatic events, such as changes in humidity cycles. Once identified, these unique, observable indicators can then be documented and measured through time. This measurement data can then be modeled to understand what types of cultural resources will be impacted and to identify areas threatened the most by climate change. The seven climate indicators identified as having the greatest adverse impact on cultural resources are the change in atmospheric moisture, temperature changes, increasing sea levels, wind, desertification, the combined effects of climate and pollution, and, lastly, changes in biota (UNESCO 2007:34-36). Each of the seven climate indicators identified by UNESCO-WHC and the additional indicator of storm damage and erosion (Saunders et al 2007) will be discussed below. When possible, research addressing, or highlighting, each indicator will also be presented.

**Atmospheric Moisture**

Increases in global temperatures in addition to increased carbon dioxide in the atmosphere will lead to changes in atmospheric moisture. These changes will result in some parts of the world becoming wetter and more humid while other areas become drier [see Desertification section below] (Berenfeld 2008:67). Atmospheric moisture refers to the moisture content of the air. The amount of moisture in the air is measured in several ways which includes relative humidity, specific humidity, dew point, vapor pressure, water vapor mixing ratio, and water vapor density. Precipitation (e.g. rainfall) is not considered a type of atmospheric moisture. Increased air moisture will result in increased humidity, higher water levels in rivers, lakes, and seas, and an increase in an area’s overall water table. These changes can ultimately lead to changes in an area’s soil chemistry as well.

Research concerning the impacts of increased moisture on historic structures is limited. The main document identified for the United States concerning this topic is the National Park Services’ Preservation Brief 39 from 1996 which deals with the general topic of moisture and historic structures, not moisture as a result of climate change. Another document is Sabbioni et
al (2006) *Global Climate Change Impact on Built Heritage and Cultural Landscapes*. This article is derived from work on the Noah’s Ark Project and provides a brief overview of the predictive models being created by researchers involved with this project. The authors note that the models do examine future changes in “water derived parameters: precipitation, humidity cycles, time of wetness…[and] dry summers” (emphasis in origin Sabbioni et al 2006:396), however they do not delineate the specific adverse impacts of moisture changes to cultural resources. Common sense dictates that increased humidity will adversely impact historic built structures and buried archaeological sites. Wooden structures, such as historic homes, would be prone to increased mold and mildew in addition to an increased likelihood of major structural damage as the wood rots and decays. Oxidation, or rusting, of metal structures, artifacts, and structural elements will destroy some cultural resources (e.g. historic stills, etc.) and greatly affect the structural integrity of others (http://www.nps.gov/hps/tps/briefs/brief39.htm, accessed December 2011). Stone and brick structures or structural elements will also be impacted by increased moisture levels. Wet stone and brick will be most likely to crack as temperatures drop below freezing. In addition, damp bricks are prone to more rapid decay.

Buried cultural resources will also be affected by increased moisture. Sensitive organic materials such as bone, shell, wood, and other botanical remains will decay more rapidly in damper soils. Similarly, soil pH levels will change due to increased ground moisture. These changes will also damage bone and shell artifacts and remains. Cryoturbation (or frost heaving) damages archaeological sites by shifting artifacts from their original locations and contexts. As soil moisture increases in areas with seasonal climate variation, there will be an increased rate of cryoturbation. Another adverse impact of higher humidity levels and ground water levels will be an increased chance of flooding. Blankholm, an archaeologist in the Arctic and Sub-Arctic regions, addresses this concern and notes that increased ground water coupled with increased precipitation will increase the “frequency, force, and extent of floods in river and lake systems” (2009:18). Increased flooding of rivers and lakes will erode and damage archaeological sites in or adjacent to the rivers and lakes. Blankholm also notes that increased flooding could change the chemical balance of bogs and swamps and threatened the preservation properties of these fragile ecosystems (2009:18-19).

**Temperature Changes**

The adverse impacts of temperature change is a difficult aspect of global climate change to discuss because it is intertwined with other changes covered in this section. Global temperature changes are responsible for accelerating the other climatic events highlighted here. Thus, this section will briefly cover some affects resulting from changes in global temperatures. Global temperatures are changing as a result of increased levels of carbon dioxide in the atmosphere. As temperatures increase, seasonal events—such as heat waves, droughts, and snow falls—will become more extreme.

Saunders et al note concern over the increasing seasonal snow falls (snowpack) in the National Parks of the western United States. The increased snowpack in winter will cause an increase in springtime melting and runoff which will lead to an increase in flooding and erosion. Flooding and erosion are currently the “largest threats to the cultural resources in the West” and as these factors accelerate, so will the damage to cultural resources (Saunders et al 2007:57).
Blankholm addresses changes in vegetation which will result from global temperature increases. Specifically, he has observed a decrease in the amount of permafrost. Permafrost is noted for conserving fragile organic artifacts and ecofacts (e.g. bone, antler, floral remains, etc.). Once the permafrost melts, the preservation of these artifacts will decrease resulting in a loss of important archaeological data (2009:19).

Another aspect of rising temperatures is an expansion of pests into areas that were previously too cold for them. A major insect of concern for cultural resource managers is the termite which will adversely affect historic wooden structures (Berenfeld 2008:67). This effect is further discussed below.

**Increased Sea Levels**

Rising sea levels are the most measureable effects of increasing global temperatures. Sea levels rise as a result of numerous processes, including the thermal expansion of sea water; increased amounts of water deposited into the oceans as a result of melting glaciers, ice caps, and ice sheets; and changes in the topography of the ocean floor (IPCC 2007:83-99). As temperatures rise, glaciers and the polar ice caps melt and deposit water previously trapped in these ice sheets into the oceans. This process, in turn, causes the levels of the oceans to rise, flooding some parts of the world and eroding others. The influx of freshwater into the saline ocean results in decreased salinity, which has damaging effects on natural resources. However, rising sea levels cause the most harm to cultural resources. Damaging effects on cultural resources are already documented around the world and will continue to occur in the future as sea levels continue to rise. The IPCC has noted an approximate 10cm rise in sea level from 1990 through 2000 and predicts an additional rise in sea levels of 10-90cm in the next 100 years (Blankholm 2009:17; IPCC 2001, 2007).

Working in the Arctic and Sub-Arctic region has allowed Hans Peter Blankholm to view first-hand how climate change is affecting cultural resources (2009). Blankholm identifies five effects of climate change and their impacts on cultural resources in the Polar Regions. Foremost among these effects is the rising sea levels which are eroding and inundating coast lines and coastal archaeological sites. Coastal archaeological sites in northeast Greenland and Alaska have already been adversely affected by the melting of glaciers and erosion of the newly exposed ground surfaces by wave action. Blankholm also notes that rising sea levels coupled with increased acidification of the sea water will destroy coastal shell middens and other alkaline features (2009:17-18). Increased acidification of ocean water results from increased levels of carbon dioxide (CO₂) in the atmosphere (The Royal Society 2005).

Lautzenheiser, Bamann, and Gosser (2011) have documented the disappearance of archaeological sites through coastal erosion in North Carolina. The authors attempted to revisit six prehistoric archaeological sites along the sound side of the Outer Banks, the mainland, and on Roanoke Island. Five of these six sites have been adversely impacted by coastal erosion and rising sea levels. Site 31DR19 was originally identified in the 1950s by William Haag as the possible location of the Algonquian village reported by the Roanoke Voyagers on Roanoke Island. When Lautzenheiser et al. revisited the site in 2007, excavations suggested the site was completely eroded as no traces of it remained. The two sites dating to the Civil War (Camp
Reno and Fort Huger) were identified on the north end of Roanoke Island in 1988. The 2007 revisit showed that Camp Reno was intact although heavily disturbed by looters. However, the earthworks at Fort Huger have eroded into Roanoke Sound (Lautzenheiser et al 2011:2). The Baum site (31CK9) is located on the Currituck Sound side of the mainland. The site was identified and partially excavated in 1972 when human burials began eroding from the bank. Archaeological excavations were conducted at the site intermittently from 1972 through 1987 by both Eastern Carolina University and the North Carolina Office of the State Archaeologist to salvage the burials as they eroded. The number of ossuaries at the site suggested it was an extremely important village; therefore, it was listed on the National Register of Historic Places in 1980. First revisited in 2005, archaeologists noted extensive erosion. No features or ossuaries were identified although a large area covered in shell midden remained. In 2007, an additional 5-10 feet of site had eroded and, like the 2005 revisit, excavations did not identify any features or ossuaries (Lautzenheiser et al 2011:2-3). The Davis Bay site (31HY6) was also identified in the early 1950s by Haag. This Woodland period village was located on Pungo River, a tidal estuary of the Pamlico River. An historic component was identified at the site during a revisit in the 1980s. By 2005, the time of another revisit to site 31HY6, nearly 250 feet of the shoreline had eroded destroying the majority of the site. Historic and prehistoric ceramics were found on the shore and eroding from the river bank (Lautzenheiser et al 2011:4-6). The sixth and final site is 31BF43, a prehistoric site with a thick midden identified by Haag as the possible location of the Native American town of Aquascogoc. In addition to being eroded and inundated by water, part of this site is now located within a residential subdivision. During a 1995 revisit to the site, archaeologists noted that the site area was greatly reduced due to erosion and sea level rise (Lautzenheiser et al 2001:6-7). The loss of archaeological resources along the North Carolina coast led the authors to the logical conclusion that “coastal sites are not going to sit around and wait for us to get around to them. They are truly fragile resources” (Lautzenheiser et al 2011:4).

Blankholm (2009) and Lautzenheiser et al. (2011) address the effects of rising sea levels on archaeological sites; however, increases in sea level also effect the historic built environment. Caffrey and Beavers (2008) provide two examples of historic structures threatened by rising sea levels. The historic structures discussed in the article are the Cape Hatteras Lighthouse National Historic Landmark located on Hatteras Island in the Outer Banks of North Carolina, and Fort Massachusetts, a Civil War era fort, located approximately 20 km off the Mississippi coast in the Gulf of Mexico. In the first case, the eroding shoreline was threatening the structural integrity of the lighthouse. After numerous erosion control measures, the National Park Service decided to undertake the expensive endeavor of moving the lighthouse inland 885 m (Caffrey and Beavers 2008:91-92). Caffrey and Beavers view moving the Cape Hatteras Lighthouse as a “measure that can only mitigate for nature’s impacts for a limited amount of time before more must be done” (2008:88).

Fort Massachusetts is an important historical resource threatened by the rising sea level and increased storm surges. However, unlike the Cape Hatteras Lighthouse, Fort Massachusetts cannot be moved because it is located on West Ship Island in the Gulf of Mexico. For this reason, a variety of engineering projects—including a the construction of a seawall, groins, and a rock jetty surrounding the fort in addition to a dredging project which reconstructed beaches on the island—were undertaken. While there is no easy or permanent way to halt the erosion or
inundation of West Ship Island due to rising sea level, continued engineering projects and maintenance of the existing projects will have to suffice to protect Fort Massachusetts from eroding into the sea (Caffrey and Beavers 2008:89-91).

**Wind**

Wind is an aspect of climate change which is difficult to discuss because of limited research on the topic. Intuitively, wind will accelerate erosion of landforms and cultural landscapes. In addition, wind-driven rain, salt, and sand will increase the decay of the historic built environment. In fact, wind-driven salt water and sand from recent major hurricanes in the Gulf of Mexico—most recently Hurricane Katrina in 2005—have been blamed for the erosion of mortar from Fort Massachusetts. Fort Massachusetts, discussed above, is a brick fort constructed during the Civil War off the coast of Mississippi (Caffrey and Beavers 2008:90). Another potential adverse impact of changes in the frequency and strength of wind is that wind will also increase the effects of drought and be the driving force behind the expansion of wildfires.

**Desertification**

Increasing global temperatures and changing weather patterns will inevitably lead to a lack of precipitation, or desertification, in certain parts of the world or during certain seasons (Sabbioni et al. 2006:396). In areas where conditions are already arid or semi-arid, more frequent and intense droughts and wildfires would be expected. Saunders et al. note that scientists predict the western United States will experience the effects of climate change (e.g. drought and wildfires) sooner than other parts of the country and more intensely than some parts of the United States (2007:42). Thus, a look at the conditions and their impacts on cultural resources in the National Parks in the western United States will provide a preview of what the southeastern United States might expect in the near future as a result of climate change.

Saunders et al provide an excellent discussion of how climate change is impacting natural and cultural resources within the National Parks of the western United States (2007). The biggest threat to cultural resources is flooding and erosion which will be discussed separately below. Wildfires present the second biggest threat. Saunders et al. note that wildfires are already becoming more frequent and intense as a result of climate change and this trend will most likely continue (2007:57-58). Wildfires adversely affect both the built historic properties within the National Parks in addition to buried archaeological sites and artifacts, and cultural landscapes. The authors also note that efforts to fight wildfires should be considered an adverse impact to cultural resources. Efforts to contain or stop wildfires employ the cutting of fire lines/breaks. In such emergencies, lines can be plowed through archaeological sites and destroying subsurface features. In addition, the construction of temporary bases and camps to house the fire fighters can also adversely, and unknowingly, impacted buried archaeological deposits (2007:58).

Using data from Bandelier National Monument in New Mexico, Saunders et al were able to highlight some specific adverse effects caused by wildfires. The most obvious adverse impact to cultural resources is the total destruction of structures and artifacts made of flammable materials. After a severe wildfire in 2000, nearly all of the wooden homesteads associated with archaeological sites on the Pajarito Plateau were destroyed. In addition, the fires damaged
stone foundations and bone, ceramic, and stone artifacts. Lastly, the loss of ground cover throughout the park has lead to an increase in erosion which can damage archaeological sites. In the western United States, erosion is a far greater threat to cultural resources than the wildfires themselves. Erosion at archaeological sites is responsible for washing away large portions of sites, removing artifacts from their original locations and contexts, and destroying architectural features such as buildings, hearths, storage pits, etc. (Saunders et al 2007:58). Damaged cultural resources have also been documented at other National Parks in the western United States. Saunders et al cite examples of both historic properties (e.g. the lodge at Old Faithful in Yellowstone National Park) and archaeological sites (e.g. irreparable damage to a 1,000 year old petroglyph at Mesa Verde National Park) damaged as a result of wildfires (2007:59).

The article by Saunders et al (2007) provides a good overview of the destruction that can be caused by wildfires in terms of cultural resources. In addition, it presents information on the efforts being undertaken on the national, state and local levels to reduce “climate disruption,” a phrase they use to describe climate change (2007:69). These efforts appear to be generally conservation focused in terms of reducing energy consumption and greenhouse gas emissions in order to halt or reduce climate change. In terms of the damage to specific resources, the conversation shifts to policy changes. The authors provide some suggestions for the first steps that the National Park Service should take to address the adverse impacts of climate change on cultural resources. They state that “[i]t is time for the National Park Service to exercise its authorities to address climate change, the greatest threat ever to national park resources and values” (Saunders et al 2007:70-71).

It is unclear how much of an impact the research of Saunders et al (2007) had on National Park Service policy, but by 2010 the Director of the National Park Service, Jonathan B. Jarvis, had issued a statement detailing the agency’s plans for implementing new programs and sustainability practices, conducting collaborative adaptation planning, and educating future generations concerning climate change as contained in the National Park Service’s Climate Change Response Strategy (National Park Service 2010). Goal 7 of this document states that the NPS will “[d]evelop, prioritize, and implement management strategies to preserve climate-sensitive cultural resources” (2010:17). Four objectives were highlighted as ways to accomplish this goal: (1) to prioritize cultural resource adaptation projects using the best available science, (2) “increase the capacity and utility of the NPS Museum Program to preserve and protect resources,” (3) increased partnership and consultation with traditionally associated peoples in order to protect “ethnographically significant resources,” and (4) to increase archaeological inventory and monitoring or sites “in anticipation of climate change impacts and support cura-

Warmer global temperatures and decreased precipitation will also lead to longer more intense droughts. Droughts will not only contribute to an increased number of wildfires, they will also contribute to a decrease in ground cover. And, as noted above, limited ground cover will increase surface erosion which will adversely impact buried archaeological deposits and structural remains (Saunders et al 2007:57). Drought and desertification will also cause a decrease in the water table and a change in the pH level of the soil. For buried archaeological deposits, this could accelerate the decomposition of sensitive organic materials.
Climate and Pollution

Climate change alone will create many problems for cultural resources; however, when air and water pollution are factored in, there are additional problems to consider. The UNESCO-WHC identified two main problems resulting from the changing climate and pollution. These are acid rain, or a precipitation with a new pH level, and the re-deposition of pollutants. Acid rain corrodes metal, erodes stone and brick, and blackens other materials (Sabbioni 2006:397). The re-deposition of pollutants will greatly impact the historic built environment by discoloring stone and brick and by accelerating the decay of some materials.

Changes in Biota

The rise in global temperatures will facilitate the expansion of plants, animals, and insects into previously inhospitable areas (Berenfeld 2008:67). Blankholm notes that as temperatures increase, trees and vegetation are expanding into higher elevations and adversely impacting archaeological sites which up until now have not been inundated by trees and tree roots. He also noted that a similar trend can be seen in the lower elevations where old pastures and farm sites are being covered over in dense vegetation (2009:19). Berenfeld points out that termites and other pests will be found at higher latitudes due to warmer winters (2008:67). Termites will adversely impact historic wooden structures and artifacts. Another concern for historic structures is the spread of mold and lichen. A final consideration for historic wooden structures and artifacts is the expansion of non-native species into a region. As invasive plant species spread, native species will be replaced; thus, native, or original, wood types in some structures might not be available if the wooden structure, or artifact, is in need of repair.

There are, without a doubt, other invasive species which will adversely impact buried archaeological sites and historic structures. However, there is currently limited research available concerning invasive species of plants and animals that could threaten historic properties. Two potential threats are nutrias and fire ants which could impact cultural resources. Nutrias (Myocastor coypus) are South American rodents introduced into the United States over the last century. Nutrias spend most of their time in water and eat the root mat of marsh plants. Thus, they are destroying the root mat and, in turn, uprooting the marsh plants. This activity destroys marshland which then becomes infiltrated with water (http://www.pwrc.usgs.gov/resshow/nu-tria.htm, accessed December 2011). In the process, it would be expected that the nutria would destroy any buried archaeological deposits or historic earthworks, such as the levees associated with the rice fields in the South Carolina Lowcountry, in addition to the marshland. Red imported fire ants (Solenopsis invicta Buren) are also native to South America; however they are extremely common throughout the southeastern United States. The red imported fire ant digs into the soil in order to create ant mounds. Again, although not documented, it is logical to assume that the creation of an ant mound would churn up cultural material and disturb buried archaeological deposits.

Storm Damage and Erosion

Another factor influenced by climate change which will adversely impact cultural resources is an increase in the frequency and intensity of seasonal storms such as thunderstorms, hurricanes, and tornadoes. This climatic event was not included on the UNESCO-WHC, however since a large portion of the South Atlantic region is coastal and prone to hurricanes, it is important to consider. Cultural resources in coastal regions (e.g. light houses [such as Cape
Hatteras Lighthouse, forts [including Fort Massachusetts], sea island plantations, and buried archaeological sites) will be directly impacted by severe hurricanes (Caffrey and Beavers 2008). Tornadoes will negatively impact inland resources; the most damage would be to the historic built environment, but archaeological sites would also be impacted by tree falls.

A secondary, yet still important, impact from severe weather would be erosion by wind and water of archaeological sites on dry beach terraces in the area. The increased frequency of severe storms will also increase and accelerate coastal erosion and the erosion of coastal archaeological sites (Blankholm 2009:19). The erosion caused by an increase in frequency and intensity of severe weather would also negatively impact the cultural resources in the national parks of the western United States. Saunders et al (2007)

Summary

The goal of this chapter was to define two complex concepts important to a discussion of the effects of climate change on cultural resources. These concepts were, of course, cultural resources and climate change. The definition of cultural resources utilized in the next chapter focuses on archaeological sites and historic properties as defined by the National Historic Preservation Act. This definition is the most common definition used by cultural resource managers throughout the United States. However, as noted above, this definition omits resources with socio-cultural or socio-economic value due to the lack of available data on these resources. Climate change has been broken down into eight visible easily digestible aspects that will affect cultural resources. These eight changes to the climate are as follows: changes in atmospheric moisture, temperature changes, rising sea levels, wind, desertification, the impact of pollution on climate, biological changes, and storm damage and erosion.
MODELING CLIMATE CHANGE

Initially, the goal of this chapter had been to present and discuss a predictive model for the state of South Carolina which highlighted both specific cultural resources and geographic areas of the site most threatened by some of the factors of climate change. The factors, presented in the last chapter, were to be selected based on the available data. It was the availability, or lack thereof, of data and the state of the available data (how easily it could be modeled within a geographic information system) that resulted in a simplification of the model presented in this chapter. The model herein looks solely at the cultural resources directly impacted by raising sea level in the lower coastal plain of South Carolina. After a brief overview and discussion of this model, the remainder of the chapter examines the data that would have been useful in understanding the effects of climate change on cultural resources and the current availability of this data.

A Predictive Model

Climate scientists utilize a number of complex models in order to predict future changes in climate. These models take into account a number of factors including, but not limited to, circulation and jet streams, historic climate data, and variability. From this data, projections are determined concerning topics such as global temperature changes, global precipitation changes, and moisture increases and decreases. With limited time and resources, our model is very simplistic. It aims to predict the number and type of cultural resources that are most threatened by sea level rise. For this model, sea level rise was projected to rise one foot by 2100. This projection was taken from the IPCC Third Assessment Report (IPCC 2001:671). This projection for average global sea level increases incorporated thermal expansion of the seawater, land ice changes, changes in permafrost, sedimentation, and long-term changes in the ice sheets into seven Atmosphere-Ocean General Circulation Models. The results of all seven models were plotted and the 1 ft increase appears to be is the projected average for the year 2100 (IPCC 2001:671). Using a projected increase in intervals of whole feet (i.e. one, two, and three foot intervals) also fit better with the elevation data used in this model. These projections are only as good as the data used at the time of calculation, thus, as more data and better processing capabilities become available, the predicted amount of sea level rise will be more accurate.

The predictive model included herein utilized two datasets. Cultural resource data were obtained from the online cultural resource information system known as ArchSite. The following databases were gathered from ArchSite: archaeological sites (polygons), Civil War earthworks (points), historic areas, historic structures (points), National Register points, National Register polygons, Restricted National Register points, and Restricted National Register polygons. Information about the ArchSite databases, including disclaimers about accuracy and completeness, can be found at the ArchSite website (http://archsite.cas.sc.edu/ArchSite/). Elevation data was taken from the USGS National Elevation Dataset (NED). 1-Arc Second was used for this project. Version 10 of ESRI’s ArcGIS suite was used to analyze the data.
The polygon data was converted into three meter cell raster grids (Figure 3.1). The rasters were then converted into point layers, so that a given site area was now made up of a grid of points, three meters apart (Figure 3.2). This allowed coverage of sites that were 5x5m or 100x200m. The Extract to Point function in Spatial Analyst was used to extract the elevations from the NED into the point layers. The Select by Attribute function was used in the point tables to select out those points with elevations that were less than or equal to one foot (0.3048m), two feet (0.6096m), or three feet (0.9144m). Each selection was exported as its own data layer (Figure 3.3). Finally, the Select by Location function was used to select the polygons from the original layers that contained the new, one, two, or three foot point layers (Figure 3.4). For instance, polygons from the archaeological sites layer were selected if they contained any points from the one foot point layer, giving us the number of archaeological sites affected by a one foot rise in sea level.

Analysis of those layers that were already points began with the Extract to Point step. The NED elevations were extracted immediately into those databases, and the Select by Location function was unnecessary. A bias should be noted with the point layers. Where the polygons cover the entire area reported, the point layers cover just that, one point. If the point is
representing a historic structure, the elevations across the entire footprint of the structure are unknown.

Presented on the following pages are the results of this analysis. Three maps of South Carolina were produced showing the amount of land area lost to sea level rise at each increment: 1ft (Figure 3.5), 2ft (Figure 3.6), and 3ft (Figure 3.7). Below each map is a table (Tables 3.1, 3.2, 3.3, respectively) which shows the number of sites from each type of cultural resource

Figure 3.5. Area lost as sea levels rise 1 ft.

<table>
<thead>
<tr>
<th>ASL*</th>
<th>Arch Sites</th>
<th>Historic Areas</th>
<th>CW* Earthworks</th>
<th>Historic Structures</th>
<th>NR* Points</th>
<th>NR* Polygons</th>
<th>RNR* Points</th>
<th>RNR* Polygons</th>
</tr>
</thead>
<tbody>
<tr>
<td># lost</td>
<td>994</td>
<td>51</td>
<td>22</td>
<td>40</td>
<td>11</td>
<td>52</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>% lost</td>
<td>3.58</td>
<td>7.33</td>
<td>10.33</td>
<td>0.17</td>
<td>1.23</td>
<td>11.95</td>
<td>2.41</td>
<td>14.29</td>
</tr>
</tbody>
</table>

* - ASL based on the USGS NED; Arch = Archaeological; CW = Civil War; NR = National Register; RNR = Restricted National Register.

Table 3.1. Projected number and percentage of cultural resources lost due to a sea level rise of 1 ft.
Affected by sea level rise and the percentage of resources lost for each type of resource. This percentage of cultural resources lost has been calculated based on the number of each resource in the affected area divided by the total number of that specific resource identified within the state of South Carolina. As noted before, this model was only conducted for the state of South Carolina because data was most readily available for this state.

<table>
<thead>
<tr>
<th>ASL*</th>
<th>Arch Sites</th>
<th>Historic Areas</th>
<th>CW* Earthworks</th>
<th>Historic Structures</th>
<th>NR* Points</th>
<th>NR* Polygons</th>
<th>RNR* Points</th>
<th>RNR* Polygons</th>
</tr>
</thead>
<tbody>
<tr>
<td># lost</td>
<td>1224</td>
<td>60</td>
<td>30</td>
<td>50</td>
<td>15</td>
<td>57</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>% lost</td>
<td>4.4</td>
<td>8.62</td>
<td>14.08</td>
<td>0.22</td>
<td>1.67</td>
<td>13.1</td>
<td>4.82</td>
<td>17.86</td>
</tr>
</tbody>
</table>

* - ASL based on the USGS NED; Arch = Archaeological; CW = Civil War; NR = National Register; RNR = Restricted National Register.

Table 3.2. Projected number and percentage of cultural resources lost due to a sea level rise of 2 ft.
Discussion

The above model is a very simple model aimed at understanding the resources most threatened by rising sea levels in the state of South Carolina. The accuracy and applicability of this model are questionable because of the accuracy of the data layers and the omissions of additional, dynamic forces which could not be included into this model. Models used to under-
stand and predict climate change are very complex (see IPCC 2001, 2007 for a discussion of the models used to understand climate change) because they incorporate both static and dynamic actions such as changing jet streams and other variables outside the scope this model. The above model highlights the number and type of cultural resources that will be lost as sea level rises one foot, two feet, and three feet above its current level. This model does not take into account the everyday effects of wave action, wind erosion, or water erosion. In addition, the elevation data would only allow for an analysis at one foot intervals. Based on more complex climate models, sea levels will rise one foot by the year 2100; thus, the above model does not speak to the types or numbers of cultural resources threatened in the interim. The model presented above is the best that could be made given the limited resources available for this project.

Even with the limitations of the above model, it provides important insight into understanding the effects of one aspect of climate change on cultural resources. As sea levels rise one foot above their current level, the most threatened cultural resource will be archaeological sites. This is true in terms of the total number of resources affected (n=994). When considering the percentage of archaeological sites, the loss of recorded sites within South Carolina looks insignificant at 3.58% of the total number of sites. However, the types of archaeological sites lost as sea levels rise is unknown. Coastal sites of both prehistoric and historic periods provide different data than archaeological sites of the same period in a non-coastal setting. Thus, even though the percent of lost archaeological sites looks small, the impact in terms of scientific data could be substantial. One example of a great loss of data is coastal shell rings. As sea level rise, the Middle and Late Archaic (Middle Archaic period dates to circa 8,000-5,000BP while the Late Archaic period is dated to circa 5,000-3,000BP) shell rings along the South Carolina and Georgia coasts (Russo 1994; Thompson 2007) will be among the prehistoric coastal resources lost. In terms of coastal archaeological sites, Lautzenheiser et al.’s statement that “coastal sites are not going to sit around and wait for us to get around to them” is very applicable (Lautzenheiser et al 2011:4). It is suggested that future models look more closely at the type of archaeological site affected. Archaeological sites are classified by cultural/temporal period (i.e. PaleoIndian, Archaic, Woodland, Mississippian, Historic, etc.). Future models could be created to see if archaeological sites from a specific cultural period are more threatened than ones from another cultural period.

Based on the percentage of a resource lost, sea level rise will have the greatest impact on Restricted National Register polygons. Because this layer consists of polygons, the actual impact of sea level on these resources is unknown. In fact, due to the restricted nature of the data, the actual type of resource is unknown because both historic structures and archaeological sites can be listed on the National Register of Historic Places. Thus, the Archaic period shell rings could be included within this category along with historic structures and outlying fields (such as a coastal rice plantation and rice fields or a Sea Island cotton plantation and fields). If the former, then the impact will be great, if the latter, then the impact (i.e. flooding of the fields within a plantation complex) might not be as immediately damaging to the scientific research potential of the resource.

The model also highlights the fact that collaboration among researchers dealing with climate change is necessary. It is difficult for one entity to accurately model any aspect of cli-
climate change due to the vast amount of data needed to be incorporated into any model. The sharing of data among climate scientists, universities, government agencies, and international organizations is needed in order to create the most accurate models possible. Cultural resources can then be incorporated into these preexisting models.

Cultural resources, as noted in the previous chapter, are defined within this report as archaeological sites and historic properties. Data concerning the location of known archaeological sites is available to researchers; however, the form of the data varies by state. Within the SALCC region, there are five states. Archaeological site data in South Carolina and Virginia is available online. In South Carolina, as noted above, the online portal is called ArchSite. In Virginia, archaeological site data is available through the Historic Resources Data Sharing System (DSS). Both ArchSite and the DSS are subscription based services. The subscription allows the subscriber to view archaeological sites and National Register properties (both restricted and non-restricted properties) in terms of their geographical locations (in a geographic information system [GIS]) and the data recorded on the archaeological site form or the National Register of Historic Places nomination form (http://archsite.cas.sc.edu/ArchSite/ and http://www.dhr.virginia.gov/archives/data_sharing_sys.htm, accessed July 2012). Information for archaeological sites in the remaining states of North Carolina, Georgia, and Florida are not available online. In these states, information concerning the archaeological sites is available by visiting the Archaeological Site Files for each state. In North Carolina, site files are housed in Raleigh, NC, and are under the control of the Office of the State Archaeologist (http://www.archaeology.ncdcr.gov/ncarch/reporting/archres.htm, accessed July 2012). Within Georgia, site files are housed in the Department of Anthropology at the University of Georgia, Athens. The Georgia Site Files include “over 51,000 site forms, a complete set of USGS 1:24,000 maps for Georgia with all sites mapped, over 5500 CRM reports, and over 1000 additional manuscripts” (http://shapiro.anthro.uga.edu/GASF/policy.html, accessed July 2012). Florida State Site Files is located in Tallahassee; it currently houses information on more than 180,000 cultural resources and over 17,000 cultural resource management reports and manuscripts (http://dhr.dos.state.fl.us/preservation/sitefile/, accessed July 2012). Data on historic properties listed on the National Register of Historic Places is available through the National Park Service (http://nhrp.focus.nps.gov/natreg/docs/Download.html, accessed July 2012). The variability of the cultural resource data—South Carolina and Virginia data can be readily incorporated into computer generated model, while cultural resource data from North Carolina, Georgia, and Florida is only available on paper (copies of site file forms and sites plotted on USGS topographic maps)—must also be addressed prior to incorporating this data into any climate model. Appendix A provides contact information for the archaeological site file repositories for each state included in the SALCC.

The limited definition of cultural resources used in this report omitted socio-cultural and socio-economic resources because data on these resource types is difficult to acquire and not easily available. Thus, in order to create a model that accurately presents the effects of climate change on all cultural resources, ethnographic research will need to be conducted throughout the region in order to understand the current, and historic, socio-cultural and socio-economic resources of a particular area or group. A good example of this type of resource is sweet grass utilized by the Gullah of the South Carolina and Georgia coasts to make sweet grass baskets. Sweet grass (*Muhlenbergia filipes*) grows in swampy or marshy areas along the coast. Native
stands of sweet grass are threatened by coastal development which has destroyed areas where sweet grass grows and by the creation of coastal gated communities which restricts access to the remaining stands of sweet grass (http://www.sciway.net/facts/sweetgrass-baskets.html, accessed August 2012). Sweet grass is merely one important resource within the South Atlantic Region that has both cultural and economic benefits for a specific community. The impact of climate change on this resource is unknown and additional research will be needed to understand this impact and to identify other resources of this type.

One example of the research aimed at understanding the effects of climate change on socio-cultural and socio-economic resources is a Master’s thesis from the Department of Planning, Public Policy and Management at the University of Oregon. In this thesis, “Climate Change Adaptation Planning for Cultural and Natural Resource Resilience: A Look at Planning for Climate Change in Two Native Nations in the Pacific Northwest U.S.”, Katharine MacKendrick examines how two tribes, the Hoopa Valley and the Coquille, are planning to deal with climate change on a local level (2009). This document is intended to be an initial assessment of the tribes’ current policy on climate change and an important document in planning for future climate change policy. In terms of cultural resources, MacKendrick is not so much concerned with historic structures and archaeological sites as she is with cultural or traditional knowledge and the effects of climate change on these traditions. Her work does point out some important considerations when exploring the effects of climate change. Input at the local, community level is important in order to understand current cultural or social aspects that are threatened (such as language and the continuation of traditional practices) and how communities are prepared to handle these threats. Additional research of this type is necessary in order to understand the full impact of climate change on culture.

Summary

This chapter has presented a simplistic predictive model aimed at understanding the percentage and types of cultural resources most threatened by sea level rise. The model focuses exclusively on South Carolina because the data for this state was most easily accessible. Looking at the number of resources, more archaeological sites than any other resource will be lost. However, looking at the percentage of resources lost, Restricted National Register polygons are the most impacted. Because of the limited number of total Restricted National Register polygons within the state, the percentage lost was greater than the other cultural resources included in the model. The final section of the chapter addressed the limitations of the model, data, and the definition of cultural resources used.
CONCLUSION

This report has provided a preliminary overview of how climate change will affect cultural resources. In order to understand these effects, the concept of ‘climate change’ had to be broken down into separate climatic changes/impacts. Eight impacts were identified and discussed within this report. The impacts discussed herein follow those outlined by the United Nations Educational, Scientific and Cultural Organization World Heritage Committee (UNESCO-WHC) in their 2006 assessment of the impacts of climate change on World Heritage Properties (UNESCO 2007). Similarly, the phrase ‘cultural resource’ needed to be defined in order to operationalize the concept in the predictive model presented in Chapter 3 of this report. Our definition of a cultural resource focused specifically on resources with a geographical footprint (i.e. archaeological sites and historic properties). This definition was used because information concerning these resources was readily available for the state of South Carolina. This definition omitted resources of socio-cultural and socio-economic value. This chapter will provide a few concluding remarks concerning future directions in the study of the impacts of climate change on cultural resources.

Future Directions

While researching the topic of this report, the amount of literature on the subject of climate change and cultural resources suggests that few cultural resource managers, anthropologists, and archaeologists are concerned within the United States about the projected changes in climate and how these changes will affect archaeological sites and the historic built environment. This assumption is speculative, but a stronger body of literature is needed to suggest otherwise. The main studies of how climate change will impact cultural resources come from European sources, most notably England, and international organizations (UNESCO). It is interesting to note that the assessment reports compiled by the IPCC do not include data on cultural resources, however those reports do present data on how climate change will impact humans and development. Of the cultural resource managers within the United States concerned with climate change, the majority are focused in the western United States (i.e. Saunders et al 2007). As noted in Chapter 2, Saunders et al argue that the National Park Service “has the first obligation” to protect the nation’s national parks—both natural and cultural resources—from adverse impacts (2007:70). As of 2007, the National Park Service had not “exercise[d] its authorities to address climate change” (Saunders et al 2007:70). A perusal of the National Park Service website for their “Climate Change Response Program” shows that their attention is focused on the effects of climate change on natural resources (http://www.nature.nps.gov/climatechange/index.cfm). The website does mention cultural resources, but only once on the page discussing the consequences to the national parks (http://www.nature.nps.gov/climatechange/effects.cfm). Thus, it is still unclear if the objectives outlined in the 2010 National Park Service Climate Change Response Strategy are being met as no updates have been provided on the NPS website.
Saunders et al. provided a series of actions for the National Park Service to undertake (2007:70-72). Their suggestions listed the first objective as identifying the most threatened resources followed by an assessment of the possible steps needed to take action for protecting cultural resources (i.e., revising management plans). The third step suggested by Saunders et al. would be the creation of partnerships and, finally, Saunders et al. suggest that National Park Service officials and employees should be contacted for their input and then information should be disseminated throughout the National Park Service (2007:70-71). Within the National Park Service, four goals were presented in the National Park Service Climate Change Response Strategy Plan created in 2010 (National Park Service 2010). The overall objective of this document is to “[d]evelop, prioritize, and implement management strategies to preserve climate-sensitive cultural resources” (National Park Service 2010:17). The NPS aims to preserve cultural resources by prioritizing cultural resource adaptation projects using the best available science, increasing the capacity and utility of their NPS Museum Program, increasing partnerships and consultations with traditionally associated peoples in order to protect “ethnographically significant resources,” and increasing archaeological inventory and monitoring or sites “in anticipation of climate change impacts and support curation” (NPS 2010:17).

After reviewing the literature on climate change and creating a predictive model, a primary suggestion is to build strong partnerships with other entities concerned with understanding the effects of climate change. Through collaborative projects, such as the South Atlantic Landscape Conservation Cooperative, identifying the most at-risk cultural resources will be greatly facilitated because of greater access to better data needed to create dynamic and more accurate predictive models.

The second suggestion in working towards a comprehensive study of the impacts of climate change on cultural resources would be to identify the most at-risk resources in a specific region. This second step should also focus on collecting data on the socio-cultural and socio-economic resources of an area. Although difficult and time consuming to collect, this data will be needed to fully understand how cultural resources are being impacted by climate change. Once collected, the socio-cultural and socio-economic data can be coupled with the data concerning archaeological sites and historic properties to fully understand climate change impacts on the cultural landscape of prehistoric, historic, and modern populations.

A final suggestion is to mitigate for these adverse effects. In Chapter 2, two examples of mitigation were provided: the moving of Cape Hatteras Lighthouse, North Carolina, and the construction of various structures to slow down the erosion of the sandbar surrounding Fort Massachusetts within the Gulf of Mexico (Caffrey and Beavers 2008). Both of these mitigation projects were expensive and neither was a permanent solution. As shore line erosion continues, Cape Hatteras Lighthouse will again be threatened by rising sea levels. Similarly, the projects undertaken at Fort Massachusetts are only temporary fixes; waves and wind are continuing to erode the island and the fort’s brick walls. Creative mitigation projects such as these will be needed to preserve additional cultural resources threatened by the effects of climate change.

Deciding the best, most cost-efficient way to mitigate the adverse impacts of climate change on cultural resources is not easy. Ideally, the best solution is to decrease greenhouse gas emissions in the hope of halting, or at least slowing, global temperature changes. Although this
a suggestion would not immediately fix the situation, it would decrease the effects of climate change and limit the number of cultural resources impacted by climate change. Because decreasing greenhouse gas emissions will not solve the issues faced today related to climate change impacts on cultural resources, other mitigation options are needed. It is impractical to think that all cultural resources can be saved from the effects of climate change. Some resources will be irreversibly damaged and others will be completely destroyed. Thus, one suggestion would be to extensively record information from the most threatened resources. This would mean more detailed excavation or data recovery projects at archaeological sites and detailed recordation and documentation of historic properties. Archaeological surveys aimed at the identification of archaeological sites in areas threatened by climate change (i.e. coastal sites) should be required to include more intensive excavation at sites potentially eligible or eligible for inclusion on the National Register of Historic Places. This additional work would be more expensive and require more project time; however, it would collect important information that might otherwise be lost prior to the time that a site is revisited (see Lautzenheiser et al 2011). Excavation is an adverse impact to an archaeological site; however, recordation and excavation might be the only option available for collecting valuable data that would otherwise be lost to erosion and rising sea levels. Quoting Lautzenheiser et al, “[Coastal archaeological sites] are truly fragile resources” (Lautzenheiser et al 2011:4). Similarly, at-risk historic properties should be extensively recorded and documented. Thus, if the resource is lost, as much data as possible will have been recorded prior to its destruction.
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United Nations Educational, Scientific and Cultural Organization (UNESCO)
APPENDIX A:

ARCHAEOLOGICAL SITE FILE DATA BY STATE

FLORIDA
Archaeological Site File

Address:
R. A. Gray Building
500 S. Bronough Street, Room 425
Tallahassee, FL 32399

Contact:
Phone: (850) 245-6440
Fax: (850) 245-6439
Email: SiteFile@dos.state.fl.us

GEORGIA
Archaeological Site File

Address:
Riverbend Research Laboratory
Department of Anthropology
University of Georgia
Athens, GA 30602

Contact:
Phone: (706) 542-8737
Fax: (706) 542-8920

Hours:
Monday-Friday, 8am until 5pm.

NORTH CAROLINA
Office of the State Archaeologist

Mailing Address:
4619 Mail Service Center
Raleigh, NC 27699-4619
Location:
109 E. Jones Street
Raleigh, NC

Contact:
Phone: (919) 807-6552
E-mail: archaeology@ncdcr.gov

SOUTH CAROLINA
Archaeological Site File

Address:
South Carolina Institute of Archaeology and Anthropology
University of South Carolina
1321 Pendleton Street
Columbia, SC 29208

Contact:
Mr. Keith Derting
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Online archaeological site file database:
http://archsite.cas.sc.edu/archsite

VIRGINIA
Virginia Department of Historic Resources

Address:
2801 Kensington Avenue
Richmond, VA 23221

Contact:
Phone: (804) 367-2323