



# Climate Change Impacts by Phenoma and Cultural Resource

	Impact on Cultural Resources				
	Archaeological Resources	Cultural Landscapes	Ethnographic Resources	Museum Collections	Buildings and Structures
<b>Temperature Changes</b>	<ul style="list-style-type: none"> <li>Faster deterioration of newly exposed artifacts and sites</li> <li>Microcracking of site contexts from thermal stress<sup>1</sup></li> <li>Deterioration of newly exposed materials from melting alpine snow patches<sup>2</sup></li> <li>Accelerated rusting in submerged and littoral resources from warmer ocean temperatures<sup>3</sup></li> <li>Accelerated decomposition of organics<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>Decline/disappearance of some vegetation species, other species favored<sup>4</sup></li> <li>Heat stress on culturally significant vegetation<sup>4</sup></li> <li>Increased stress (e.g. desiccation, warping, cracking, etc.) on constructed landscape features<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>Loss of necessary habitat for culturally significant species</li> <li>Potential loss of knowledgeable elders and culturally significant species due to increased disease threat<sup>4</sup></li> <li>Changes in prevalence of culturally relevant plant and animal species</li> <li>Changes to crop yields and food</li> </ul>	<ul style="list-style-type: none"> <li>Increased stresses on HVAC systems in storage facilities<sup>5</sup></li> <li>Increased space constraints due to more items requiring protection in storage facilities<sup>5</sup></li> <li>Increased need for environmental controls in facilities/house collections<sup>5</sup></li> </ul>	<ul style="list-style-type: none"> <li>Structures exposed to longer periods of wetness due to warmer (not frozen) winters</li> <li>Increased crystallization of efflorescent salts due to increased evaporation rates, leading to increased rates of structural cracking, deterioration</li> <li>Increased demand for complex air conditioning systems that can add stress to the building envelope and often requires significant alterations to a structure (including insulation, routing of extensive ducts and pipes, etc.)<sup>6</sup></li> </ul>
<b>Changes in Seasonality and Phenology</b>	<ul style="list-style-type: none"> <li>Site disruption from longer growing seasons and/or changing land use (irrigation use, harvest times)<sup>7</sup></li> <li>Changes in site or regional accessibility<sup>14</sup></li> <li>Reductions or alterations in length and timing of archaeological field seasons, affecting capacity for site identification or mitigation<sup>14</sup></li> <li>Possible reductions in site visibility<sup>14</sup></li> </ul>	<ul style="list-style-type: none"> <li>Loss of synchronicity between species</li> <li>Altered landscapes due to shifts in blooming times</li> <li>Loss of pollinators reduces plant fertility in historic agricultural landscapes<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>Loss of synchronicity between species</li> <li>Potential loss or reduction of plants used for medicine and ceremonies preformed at particular times of the year<sup>15</sup></li> <li>Loss of plants used for ceremonies, medicine, and food due to early frosts<sup>15</sup></li> </ul>	<ul style="list-style-type: none"> <li>Facilities, Collections</li> <li>Exacerbated impacts due to drastic temperature swings during seasonal transitions<sup>7</sup></li> </ul>	<ul style="list-style-type: none"> <li>Longer growing seasons lead to increased growth of invasive vegetation</li> </ul>
<b>Species Shift</b>	<ul style="list-style-type: none"> <li>Physical damage, loss of integrity, and spatial incoherence from new/increased plant growth<sup>16</sup></li> <li>Physical impacts from associated adaptive behavior of animals following plant species movements</li> <li>Disruption from new foraging or nesting animals, including insects<sup>2</sup></li> <li>Changes in soil chemistry due to root penetration of new vegetation<sup>17</sup></li> <li>Increased shrub growth on former tundra, may obscure features and artifacts<sup>3</sup></li> <li>Possible reductions in site visibility<sup>14</sup></li> </ul>	<ul style="list-style-type: none"> <li>Changes in historic/culturally significant vegetation patterns<sup>4</sup></li> <li>Emigration and/or local extinction of culturally significant species<sup>4</sup></li> <li>Changes in landscape appearance from altered growth patterns of lichen<sup>18</sup></li> </ul>	<ul style="list-style-type: none"> <li>Loss of major food sources</li> <li>Loss of culturally significant plant and animal species</li> <li>Altered appearance of important ceremonial sites</li> </ul>	<ul style="list-style-type: none"> <li>Increased need to expand voucher specimens (used for reference) in collection<sup>19</sup></li> <li>Increased need to identify existing voucher specimens, many uncatalogued in non-federal repositories, to serve as baselines<sup>19</sup></li> </ul>	<ul style="list-style-type: none"> <li>Increased growth of destructive organisms as temperatures warm (e.g. mold, algae)<sup>2</sup></li> <li>New threats to historic structures as incoming/colonizing species use them as habitat<sup>2</sup></li> <li>Spread of destructive vegetative species (like kudzu) farther north into new areas<sup>2</sup></li> <li>Loss of species that are necessary for historically appropriate repairs<sup>2</sup></li> <li>New/different micro-organisms cover surfaces of stone buildings - may reduce deterioration (possible benefit)<sup>2</sup></li> </ul>
<b>Invasive Species/Festivals</b>	<ul style="list-style-type: none"> <li>Disruption of site due to altered habitat structure</li> <li>Data loss, subsidence, feature collapse, structural damage from invasive consuming organics<sup>2</sup></li> <li>Damage from new and increased number of burrowing animals<sup>20</sup></li> <li>Possible reductions in site visibility<sup>14</sup></li> </ul>	<ul style="list-style-type: none"> <li>Potential loss of significant plants due to introduction of new pests</li> <li>Potential biological selection pressure for incompatible vegetation or other biotic species<sup>4</sup></li> <li>Changes in viewsheds, (e.g. battlefield parks)<sup>14</sup></li> </ul>	<ul style="list-style-type: none"> <li>Damage to distribution of subsistence crops, culturally significant plants<sup>3</sup></li> <li>Loss of culturally important animals due to changes in habitat from invasive plant species<sup>15</sup></li> </ul>	<ul style="list-style-type: none"> <li>Collections</li> <li>Increase in pest populations that damage organic materials (animal skins, wool)<sup>11</sup></li> <li>Need for updated integrated pest management plans to account for new pest risks<sup>11</sup></li> <li>Invasion of pests via new routes created by thermal stress on facility</li> </ul>	<ul style="list-style-type: none"> <li>New threats to wood structures and wooden architectural features as termites and other pests expand territory due to warmer, longer summers<sup>21</sup></li> <li>Spread of destructive vegetative species (like kudzu) farther north into new areas<sup>21</sup></li> </ul>
<b>Increases Freeze/Thaw Cycles</b>	<ul style="list-style-type: none"> <li>More rapid decay of organic materials</li> <li>Disruption of soil structure, especially in permafrost<sup>22</sup></li> <li>Destruction of archaeological deposits due to increased soilification (downhill flow of saturated soil) activity<sup>23</sup></li> <li>Increased rates of deterioration in metals from thermal stress<sup>27</sup></li> </ul>	<ul style="list-style-type: none"> <li>Decline/disappearance of some vegetation species due to recurrent freezing<sup>3</sup></li> <li>More rapid deterioration of constructed materials of landscape features (e.g. corrosion, decay, desiccation)<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>Starvation of foraging animals (horse, caribou) from impenetrable ice layers more likely to form on grazing fields<sup>5</sup></li> </ul>	<ul style="list-style-type: none"> <li>Facilities</li> <li>Surface cracking, flaking, and sugaring of facilities from humidity shocks<sup>3,1</sup></li> <li>Greater structural damage due to fluctuating environment, causing cracks in building that allow more access for pests to invade and damage collections<sup>10</sup></li> </ul>	<ul style="list-style-type: none"> <li>Surface cracking, flaking, and sugaring of building stone and spalling of brick due to increase in humidity shocks<sup>3</sup></li> <li>Damage to foundations due to increased frost heave action<sup>1</sup></li> <li>Physical decay of stones through disintegration and flaking, esp. soft porous rocks<sup>18</sup></li> </ul>
<b>Higher Relative Humidity</b>	<ul style="list-style-type: none"> <li>Increased deterioration of newly exposed items</li> <li>Increased corrosion of vulnerable/less stable metals<sup>2</sup></li> <li>Increased mold, especially in enclosed sites (e.g. vaults, tumuli, and caves)<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>Decline/disappearance of critical vegetation species, other species favored<sup>4</sup></li> <li>Increased desiccation, warping, cracking on constructed landscape features<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>Decline/disappearance of important vegetation species, other species favored<sup>4</sup></li> <li>Increase/Spread of some vegetation species<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>Facilities</li> <li>Increased wear on HVAC systems, and energy use to stabilize drastic changes in humidity<sup>24</sup></li> <li>Collections</li> <li>Increased rusting/corrosion of metals</li> <li>Damage to paintings<sup>8</sup></li> <li>Warping, cracking of wood<sup>16</sup></li> </ul>	<ul style="list-style-type: none"> <li>For brick and porous stone, increased moisture absorption, leading to increased risk of frost damage, mold growth, and stress from salt crystallization<sup>10</sup></li> <li>Decrease in crystallization and dissolution of salts withing stone and masonry<sup>16</sup></li> <li>Sulfur dioxide deposits on wet/damp surfaces, corroding stone, metal, and glass</li> <li>Swelling and cracking of wooden building materials and architectural features<sup>16</sup></li> <li>Increased growth of destructive organisms (e.g. mold, algae) for wood, stone, and masonry<sup>15,22</sup></li> <li>Increased potential for rot wood and other organic material<sup>16</sup></li> </ul>
<b>Wildfire</b>	<ul style="list-style-type: none"> <li><b>During Fire</b></li> <li>Damage or destruction of associated structures</li> <li>Heat alteration of artifacts<sup>25</sup></li> <li>Heat fracturing of stone pieces</li> <li>Paint oxidation, color change</li> <li>Physical damage from firefighting efforts (fire lines)</li> <li>Decreased accuracy of carbon-14 dating due to carbon contamination<sup>10</sup></li> <li><b>Post-Fire</b></li> <li>Damage from fire-killed trees<sup>10</sup></li> <li>Increased susceptibility to erosion and flooding<sup>11</sup></li> <li>Increased looting after fire exposure<sup>11</sup></li> </ul>	<ul style="list-style-type: none"> <li>Loss of associated structures<sup>23</sup></li> <li>Change in vegetation density and composition</li> <li>Bedrock and border spalls</li> <li>Increased susceptibility to erosion and flooding<sup>23</sup></li> <li>Loss of soil fertility due to high heat<sup>23</sup></li> </ul>	<ul style="list-style-type: none"> <li><b>During Fire</b></li> <li>Discoloration, exfoliation, spalling, and smudging of culturally significant rock images, geoglyphs<sup>26</sup></li> <li><b>Post-Fire</b></li> <li>Altered migratory patterns of traditionally hunted animals<sup>4</sup></li> <li>Significant alteration of landscape features critical for navigating during foraging, hunting, or ceremony<sup>26</sup></li> </ul>	<ul style="list-style-type: none"> <li>Facilities</li> <li>Damage to storage facilities and contents<sup>8</sup></li> <li>Increased strain on existing museum facility and staff due to increased advance preparation and salvage operations<sup>22</sup></li> <li>Smoke damage, strain on HVAC systems<sup>29</sup></li> <li>Collections</li> <li>Damage to items and disassociation of materials and records during emergency evacuations<sup>1</sup></li> </ul>	<ul style="list-style-type: none"> <li><b>During Fire</b></li> <li>Damage or loss of whole structures, or combustible components<sup>22</sup></li> <li>Cracking, physical damage of masonry components from extreme thermal stress<sup>30</sup></li> <li>Discoloration caused by smoke and/or heat<sup>30</sup></li> <li>Damage from fire-killed tree fall<sup>30</sup></li> <li>Damage to structure and/or associated cultural landscape from fire retardants<sup>22</sup></li> <li><b>Post-Fire</b></li> <li>Buildings may shift or settle due to associated erosion<sup>11,22</sup></li> <li>Pressure to change character defining features such as wood shake roofing to fire resistant alternatives<sup>4</sup></li> </ul>
<b>Increased Wind</b>	<ul style="list-style-type: none"> <li>Moisture penetration into porous materials<sup>20</sup></li> <li>Burial through redistribution of soil<sup>14</sup></li> <li>Abrasion of pictographs<sup>14</sup></li> <li>Erosion and deflation archaeological deposits<sup>2</sup></li> <li>Erosion of upper level of soil layer; redistribution of soils from surface layers disrupts lower levels and leaves artifacts and sites exposed<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>Damage or loss of culturally significant plants</li> <li>Change in historic/culturally significant vegetation patterns<sup>4</sup></li> <li>Increase need for protective structures that shelter landscapes<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>Reduced access to marine hunting grounds due to stronger/unusual wind patterns and shifting sea ice<sup>2</sup></li> <li>Reduced access to animals in open spaces due to wind chills that drop temperatures<sup>15</sup></li> </ul>	<ul style="list-style-type: none"> <li>Damage to wooden, paper, textile and organic objects from decreased relative humidity in facilities without climate control<sup>1</sup></li> </ul>	<ul style="list-style-type: none"> <li>Direct wind damage</li> <li>Scouring of exterior surfaces<sup>1</sup></li> <li>Increased cracking, spalling, splintering, weathering of buildings due to accelerated drying<sup>1</sup></li> <li>Damage from wind borne debris<sup>2</sup></li> </ul>
<b>Permafrost Melt</b>	<ul style="list-style-type: none"> <li>Loss of artifacts and contexts from increased erosion</li> <li>More rapid decay of organic materials<sup>26</sup></li> <li>Damage from disruption of soil structure, soilification<sup>25</sup></li> </ul>	<ul style="list-style-type: none"> <li>Decline/disappearance of some vegetation species<sup>4</sup></li> <li>More rapid decay, desiccation of constructed materials of landscape features<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>Destruction of land and buildings due to severe coastal erosion<sup>6</sup></li> <li>Forced relocation of communities<sup>5</sup></li> <li>Loss of access to wildlife corridors due to terrain that can no longer be traversed by foot or vehicle<sup>15</sup></li> </ul>	<ul style="list-style-type: none"> <li>Facilities</li> <li>Destabilization of buildings from cracks in foundations and other infrastructure<sup>10</sup></li> </ul>	<ul style="list-style-type: none"> <li>Destabilization of buildings; settlement into the ground<sup>16</sup></li> <li>More rapid decay of organic materials</li> <li>Change of use or abandonment due to changes in access as the surrounding ground becomes boggy<sup>2</sup></li> </ul>
<b>Precipitation Changes</b>	<ul style="list-style-type: none"> <li>Loss of stratigraphic integrity due to crack/heave damage from drier soils<sup>17</sup></li> <li>Destabilization of wetland or waterlogged sites<sup>13</sup></li> <li>Exposure of submerged sites due to lower water levels<sup>14</sup></li> <li>Sites more vulnerable to fire and wind<sup>14</sup></li> <li>Increased exposure from vegetation loss and erosion<sup>14</sup></li> <li>Subsidence due to drop in water table disrupts site integrity</li> </ul>	<ul style="list-style-type: none"> <li>Water stress may inhibit growth of some species</li> <li>Decline/disappearance of some vegetation species, other species favored<sup>4</sup></li> <li>Soil infertility due to decreased microbial activity<sup>4</sup></li> <li>Limited water supply inhibits established maintenance practices<sup>11</sup></li> <li>Increased soil erosion<sup>4</sup></li> <li>Challenges to current irrigation practices</li> </ul>	<ul style="list-style-type: none"> <li>Stress on culturally significant species impacts subsistence practices</li> <li>Indirect efforts to ceremonial cycles and religious practices involving weather control<sup>13</sup></li> <li>Decline/disappearance of important vegetation species, other species favored<sup>23</sup></li> <li>Reduced crop yields</li> <li>Loss of some harvestable animals<sup>15</sup></li> <li>Disruption of social networks dependent upon regular water supplies (transportation)<sup>15</sup></li> <li>Loss of regular sources of water for drinking, medicine, ceremony, paints, etc.<sup>15</sup></li> <li>Loss of culturally relevant plants and animals<sup>15</sup></li> <li>Limitation on travel due to loss of water sources<sup>15</sup></li> </ul>	<ul style="list-style-type: none"> <li>Collections</li> <li>Damage to wooden, paper, textile and organic objects from drying due to lower relative humidity<sup>13</sup></li> <li>Facilities</li> <li>Limited water supply for cooling, landscaping, other equipment</li> <li>Reduced humidity stress on building (possible benefit)<sup>23</sup></li> </ul>	<ul style="list-style-type: none"> <li>Increase in dry salt deposits near masonry and porous stone which hydrate and infiltrate during infrequent rain events causing spalls and fractures<sup>11</sup></li> <li>Reduced humidity stress on buildings (possible benefit)<sup>13</sup></li> <li>Cracking and splitting of wooden/organic features due to complete drying<sup>12</sup></li> </ul>
<b>More Rainfall and/or Heavier Downpours</b>	<ul style="list-style-type: none"> <li>Altered soil structure and in situ resources from river incision and lateral migration of rivers and associated erosion<sup>28</sup></li> <li>Burial due to increased erosion and alluviation<sup>15</sup></li> <li>Soil destabilization/shifting (ground heave, landslide, subsidence)<sup>3</sup></li> </ul>	<ul style="list-style-type: none"> <li>Tree fall due to waterlogging</li> <li>Limited ability to plant in waterlogged soil</li> <li>Loss of historical integrity with improved drainage systems<sup>4</sup></li> <li>Decline/disappearance of some vegetation species<sup>4</sup></li> <li>Decreased soil fertility from erosion, waterlogging, leaching<sup>4</sup></li> <li>Loss of landscape features<sup>4</sup></li> <li>Increased susceptibility to destructive fungi<sup>18</sup></li> <li>Erosion of earthworks<sup>4</sup></li> <li>Disruption or delay of traditional maintenance practices (e.g. burning)<sup>14</sup></li> </ul>	<ul style="list-style-type: none"> <li>Altered harvest times, especially having in herd cultures due to changes in precipitation patterns<sup>15</sup></li> <li>Delays in planting cycles, shifting whole agricultural calendar</li> <li>Increasing difficulty in predicting storms<sup>17</sup></li> <li>Indirect effects to ceremonial cycles and religious practices involving weather control<sup>15</sup></li> </ul>	<ul style="list-style-type: none"> <li>Facilities</li> <li>Added strain on existing museum facilities and staff due to salvage operations<sup>22</sup></li> <li>Potential leaks in collection storage areas and potential wetting of museum objects<sup>10</sup></li> <li>Increased cracking associated with ground heave and subsidence; destabilization of buildings and pipes<sup>10</sup></li> </ul>	<ul style="list-style-type: none"> <li>Swelling/distortion of wooden building materials and architecture features due to wetness and damp<sup>18</sup></li> <li>Increased risk of rot and fungal/insect attack<sup>18</sup></li> <li>Historic building drainage systems unable to cope with downpours<sup>17</sup></li> <li>Erosion of supporting ground around structure<sup>18</sup></li> <li>Seepage backup and overflow leading to saturation and related flooding, contamination and damage<sup>22</sup></li> <li>Increased rates of deterioration due to increase frost events in cold regions that were formerly dry<sup>11</sup></li> <li>Accelerated decay of masonry units and mortars due to increased extremes of wetting and drying<sup>18</sup></li> <li>Cracks in building infrastructure and associated destabilization of buildings and pipes due to ground heave and subsidence/shrink-swell soils<sup>15</sup></li> <li>Severe damage and loss of historic structures made of adobe<sup>12</sup></li> <li>Spalling, weathering of wood, brick, and stone materials due to salt infiltration during drying<sup>11</sup></li> <li>Corrosion of external masonry from agricultural runoff<sup>10</sup></li> <li>Increased pressure to relocate or elevate structures, and/or surrounding structures<sup>22</sup></li> </ul>
<b>Increase of Flooding events</b>	<ul style="list-style-type: none"> <li>Direct physical damage to site, from floating materials during floods<sup>14</sup></li> <li>Destruction/loss of artifacts after flooding</li> <li>Site erosion from overflow and new flood channels<sup>17</sup></li> <li>Increased risk of post-flood subsidence<sup>17</sup></li> <li>Impacts from post-flood mitigation (clean up, construction)<sup>14</sup></li> </ul>	<ul style="list-style-type: none"> <li>Wash out or damage to roads, trails, and landscape features throughout parks</li> <li>Decline/disappearance of important vegetation species, other species favored<sup>4</sup></li> <li>Loss of landscape features<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>Loss of cultural places due to inundation</li> <li>Loss/disruption of the use of foraging grounds</li> <li>Loss of both plant and animal species for subsistence, medicine, ceremony, etc<sup>15</sup></li> <li>Degradation of vital coral reef habitats from increased sediment discharge<sup>42</sup></li> </ul>	<ul style="list-style-type: none"> <li>Facilities</li> <li>Added strain on existing museum facilities and staff due to salvage operations<sup>22</sup></li> <li>Damage to items and disassociation of materials and records during emergency evacuations<sup>19</sup></li> <li>Structural collapse from moving force of floodwaters, particularly from flash floods<sup>41</sup></li> <li>Seepage backup and overflow leading to saturation and related flooding, contamination</li> </ul>	<ul style="list-style-type: none"> <li><b>During Flood</b></li> <li>Structural collapse from moving force of floodwaters particularly during flash floods<sup>41</sup></li> <li>Seepage backup and overflow leading to saturation and related flooding, contamination and damage<sup>22</sup></li> <li>Walls "implode" from hydrostatic force of standing water<sup>41</sup></li> <li>Fire damage from ruptured utility lines</li> <li>Fire damage to utilities, generators, and electrical systems</li> <li>Fire damage from ruptured utility lines</li> <li>Fire damage from ruptured utility lines</li> <li>Fire damage to utilities, generators and electrical systems</li> <li><b>Collections</b></li> <li>Increased rusting of metals<sup>10</sup></li> <li>Increased risk of mold<sup>10</sup></li> <li>Damage and destruction post-flood from humidity and moisture</li> <li><b>Post-Flood</b></li> <li>Damage to buildings lacking proper drainage systems</li> <li>Increased cracking due to associated ground heave and subsidence<sup>10</sup></li> <li>Submersion of coastal sites<sup>27</sup></li> <li>Introduction of additional salts into building materials from seawater at coastal sites<sup>22</sup></li> <li>Exacerbated damage from storm surge flooding</li> <li>Increased pressure to relocate or elevate structures, and/or surrounding structures<sup>23</sup></li> </ul>
<b>Sea Level Rise</b>	<ul style="list-style-type: none"> <li>Total submersion of coastal sites</li> <li>Downstream movement of items due to undercut shoreline sediments<sup>4</sup></li> <li>Changes in pH of buried artifacts and/or buried environments<sup>20</sup></li> <li>Reduced site integrity due to ground heave and subsidence<sup>14</sup></li> <li>Increased risk of looting from exposure<sup>14</sup></li> <li>Increased erosion of resource due to encroaching water levels, wave action exposure, and increased exposure to wet/dry cycles<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>Variable damage/loss of organic and inorganic materials and landscape features<sup>20</sup></li> <li>Decline/disappearance of some vegetation species, other species favored<sup>4</sup></li> <li>Soil erosion<sup>4</sup></li> <li>Soil infertility due to waterlogged, anaerobic conditions<sup>4</sup></li> <li>Damage to historical integrity due to ground heave and subsidence</li> </ul>	<ul style="list-style-type: none"> <li>Loss of or limited access to traditional places<sup>43</sup></li> <li>Loss of culturally important sites (e.g burial grounds, subsistence areas)</li> <li>Loss of both plant and animal species for subsistence, medicine, ceremony, etc<sup>15</sup></li> <li>Submersion of homelands in island and coastal communities</li> </ul>	<ul style="list-style-type: none"> <li>Facilities</li> <li>Potential leaks in collection storage areas and potential wetting of museum objects<sup>10</sup></li> <li>Added strain on existing museum facilities and staff due to salvage operations<sup>22</sup></li> <li>Increased cracking associated with ground heave and subsidence<sup>10</sup></li> </ul>	<ul style="list-style-type: none"> <li><b>During Flood</b></li> <li>Walls "implode" from hydrostatic force of standing water<sup>41</sup></li> <li>Increase in nuisance flooding leading to problems of access and higher likelihood of range of flood damage<sup>23</sup></li> <li>(Also see: Precipitation: More Rainfall/Heavier Downpour)</li> <li><b>Post-Flood</b></li> <li>Damage to buildings lacking proper drainage systems</li> <li>Increased cracking due to associated ground heave and subsidence<sup>10</sup></li> <li>Submersion of coastal sites<sup>27</sup></li> <li>Introduction of additional salts into building materials from seawater at coastal sites<sup>22</sup></li> <li>Exacerbated damage from storm surge flooding</li> <li>Increased pressure to relocate or elevate structures, and/or surrounding structures<sup>23</sup></li> </ul>
<b>Increase of Storm Surges</b>	<ul style="list-style-type: none"> <li>Destruction—total site loss</li> <li>Erosion damage from wave action</li> </ul>	<ul style="list-style-type: none"> <li>Destruction of hiking/access paths</li> <li>Immediate alteration/destruction of historic landscape<sup>44</sup></li> <li>Decline/disappearance of some vegetation species, other species favored<sup>4</sup></li> <li>Soil infertility from soil erosion, loss of topsoil<sup>181</sup></li> <li>Loss of landscape features</li> </ul>	<ul style="list-style-type: none"> <li>Coastal tribes at risk of inundation, esp. during unpredictable and extreme weather<sup>2</sup></li> <li>Coastal tribes at risk of loss of natural and cultural resources<sup>15</sup></li> <li>Coastal tribes at risk of loss of traditional knowledge associated with both natural and cultural resources<sup>15</sup></li> </ul>	<ul style="list-style-type: none"> <li>Facilities</li> <li>Added strain on existing museum facilities and staff due to salvage operations<sup>22</sup></li> <li>Potential leaks in collection storage areas and potential wetting of museum objects<sup>10</sup></li> <li>Limited storage capacity to protect growing numbers of at risk artifacts</li> <li>Seepage backup and overflow leading to saturation and related flooding, contamination, and damage<sup>22</sup></li> <li>Damage to items and disassociation of materials and records during emergency evacuations<sup>19</sup></li> </ul>	<ul style="list-style-type: none"> <li><b>During Surge</b></li> <li>Structural collapse from moving force of storm surge<sup>41</sup></li> <li>Damage to utilities, generators and electrical systems</li> <li>Walls "implode" from hydrostatic force of standing water<sup>41</sup></li> <li>Fire damage from ruptured utility lines</li> <li><b>PostSurge</b></li> <li>Damage to roofs, windows; internal damage to decoration, plasterwork<sup>45</sup></li> <li>Damage to buildings lacking proper drainage systems<sup>22</sup></li> <li>Cracks in building infrastructure and associated destabilization of buildings and pipes due to ground heave and subsidence/shrink-swell soils<sup>15</sup></li> <li>Swelling/distortion of wooden building materials and architecture features due to inundation<sup>18</sup></li> <li>Increased risk of rot, fungal/insect attack, mold and mildew<sup>18</sup></li> <li>Erosion of supporting ground around structure<sup>18</sup></li> <li>Corrosion of external masonry from agricultural runoff<sup>10</sup></li> <li>Changes to surrounding landform, which may affect future drainage</li> </ul>
<b>Increased Coastal Erosion</b>	<ul style="list-style-type: none"> <li>Full loss of coastal sites and artifacts</li> <li>Partial loss of sites and artifacts</li> <li>Exposure of new and known archaeological sites</li> <li>Altered erosion patterns from reduction/changes in Arctic sea ice</li> </ul>	<ul style="list-style-type: none"> <li>Decline/disappearance of important vegetation species, other species favored<sup>10</sup></li> <li>Soil infertility from loss of topsoil<sup>181</sup></li> <li>Loss or compromise of associated structures<sup>182</sup></li> </ul>	<ul style="list-style-type: none"> <li>Loss of cultural memory and connections to homeland due to increased migration and splitting of traditional communities<sup>183</sup></li> <li>Loss of culturally significant symbols, plants, and animals<sup>184</sup></li> <li>Coastal tribes at risk of loss of traditional knowledge associated with both natural and cultural resources</li> </ul>	<ul style="list-style-type: none"> <li>Facilities</li> <li>Limited storage capacity to protect growing numbers of at-risk artifacts</li> <li>Added strain on existing museum facilities and staff due to salvage operations<sup>185</sup></li> </ul>	<ul style="list-style-type: none"> <li>Loss or compromise of structure<sup>186</sup></li> </ul>
<b>Higher water table</b>	<ul style="list-style-type: none"> <li>Increased, more rapid deterioration due to increased shifts in wet/dry soils</li> <li>Damage to artifacts, stratigraphy, soil features from saturation of site from below<sup>14</sup></li> </ul>	<ul style="list-style-type: none"> <li>Decline disappearance of important vegetation species, other species favored<sup>4</sup></li> <li>Soil infertility due to waterlogged, anaerobic conditions<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>Submersion of homelands in island and coastal communities</li> <li>Loss of rituals<sup>10</sup></li> <li>Loss of culturally important sites (eg burial grounds)<sup>18</sup></li> <li>Decrease in productivity of arable land<sup>13</sup></li> </ul>	<ul style="list-style-type: none"> <li>Facilities</li> <li>Potential for higher relative humidity levels in collections storage areas<sup>10</sup></li> <li>Rising damp/rot from higher water tables<sup>17</sup></li> </ul>	<ul style="list-style-type: none"> <li>Rising damp often marked by efflorescence/salt deposits<sup>12</sup></li> <li>Rot of subsurface components from higher water table<sup>17</sup></li> <li>Flooding damage in basements and other below grade features<sup>22</sup></li> <li>Structural damage due to buoyant forces<sup>17</sup></li> </ul>
<b>Saltwater Infiltration</b>	<ul style="list-style-type: none"> <li>Deterioration of some artifacts due to change in surrounding soil and water chemistry<sup>4,20</sup></li> <li>Compromise of the site due to changes in soil and water chemistry<sup>4,2</sup></li> </ul>	<ul style="list-style-type: none"> <li>Decline/disappearance of important vegetation species<sup>4</sup></li> <li>Soil infertility<sup>4</sup></li> </ul>	<ul style="list-style-type: none"> <li>Reduction in or loss of habitat for culturally significant plants and animals<sup>4</sup></li> <li>Loss of drinking water supplies<sup>6</sup></li> <li>Loss of arable land for growing crops<sup>15</sup></li> <li>Loss of some harvestable animals<sup>15</sup></li> </ul>	<ul style="list-style-type: none"> <li>Collections</li> <li>Increased corrosion/rusting<sup>10</sup></li> </ul>	<ul style="list-style-type: none"> <li>Increased potential of corroding metals</li> <li>Introduction of additional salts into the ground and into building materials<sup>22</sup></li> </ul>

# Climate Change Impacts by Phenoma and Cultural Resource



Caption

## Purpose and Scope

The purpose of this impacts table is to succinctly describe how different manifestations of climate change will affect the different cultural resources. With an understanding of what resources are threatened and how resources are threatened, individual parks can implement policies that adapt and mitigate projected impacts to their cultural resources. The target audience is on-the-ground park managers who may be witnessing damage to resources without connecting what they see to larger regional trends. Although this table is directed primarily towards parks, many of the resources and associated impacts discussed reach beyond the boundaries of any park, and much of the information compiled in the table is applicable to most cultural heritage. Hopefully, other organizations find this table relevant to their work and can use it to help inform conservation and preservation decisions going forward.

## Data Sources

Climate change trends and observable phenomena were derived from the U.S. National Climate Assessment (2014) and NPS unit-specific reports developed by the NPS Climate Change Response Program (see Gonzalez, Fisichelli, etc.).

The impacts in the table were identified through a combination of literature review and consultation with cultural resource management specialists. An initial table was compiled from literature review (Sabbioni et al, 2012; WHO 2007).

Once a preliminary draft of the table was completed, experts in the National Park Service Reviewed and expanded sections of the impacts table directly related to their field of expertise— Archaeology, Museum Objects, Cultural Landscapes, Ethnographic Resources, and Structures and buildings.

Each resource section was edited by at least three people in their respected fields. A final group of editors then reviewed a final draft of the impacts table as a whole, and their edits were also incorporated.



Casa Grande Ruins National Monument, AZ

## Further Reading

“Energy Conserving Features Inherent in Older Homes” John A. Burns, AIA

Policy Memo 12-02 “Applying National Park Service Management Policies in the Context of Climate Change”

Policy Memo 14-02 “Climate Change and Stewardship of Cultural Resources”

Level 3 Guidance “Addressing Climate Change and Natural Hazards Handbook” (handbook)

Climate Change Response Strategy (2010)

Climate Change Action Plan (2012-2014)

A Call to Action: Preparing for a Second Century of Stewardship and Engagement

Green Parks Plan (2012)

“Revisiting Leopold”

Climate Change in National Parks (PDF)

Climate Change and Western National Parks (PDF)

“Alaska Region Climate Change Response Strategy”

Northeast Region “Climate Change Strategy and Action Plan 2011-2014 (PDF)

I&M’s Northeast Coastal and Barrier Network’s Artistic Visuals



Caption

## Acknowledgements

Thank you to everyone who helped bring this together. George Hambrecht, Ennis Barberr, Elizabeth VanDolah, Kevin Gibbons, Alison Meadow, Marcy Rockman. Museum Collections: Ron Wilson, Linda Blaser, Stephanie Stephens, Samantha Richert, Christopher Houlette, Brynn Bender. Archaeology: Teresa Moyer, David Gadsby, Jay Sturdevant, Jeff Rasic, Kirstie Haertel. Cultural Landscapes: Susan Dolan, Kristen Allen, Bob Page. Ethnographic Resources: Joe Watkins, Mike Evans, Rachel Mason. Structures: Lauren Meyer, Rick Kendall.

## Understanding Climate Change Impacts

Climate change impacts are being observed throughout the country, both in coastal zones and in the interior. Cultural resources are vulnerable to dramatic and well-publicized effects of climate change, such as sea level rise or storm surge. Service-wide evidence is beginning to indicate they are also vulnerable to other, more quiet processes, such as impacts of more freeze/thaw cycles on stone materials or more rapid wetting and drying cycles on adobe buildings, which can be just as dangerous to the integrity of a resource as other dramatic impacts. These quiet processes are exceptionally important because they may go unnoticed until it is too late. We must improve our understanding of these additional impacts, address them in our stewardship practices, and be able to communicate them to the public.



Buildings in Gateway National Recreation Area’s Fort Hancock Historic Landmark District were devastated by Hurricane Sandy in 2012.

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## Preserving our Cultural Heritage

Climate change is a global phenomenon that will affect, directly or indirectly, most aspects of modern society, including cultural heritage. Cultural heritage as managed by the National Park Service includes archaeological sites, cultural landscapes, historic buildings and structures, ethnographic resources, and museum collections. These types of cultural heritage, or resources, have long been subject to environmental forces. The risks climate change presents lie in the alteration and recombination of these forces, which together are increasing the types and intensity of impacts on cultural resources. These impact pose an especially acute problem for managing cultural resources because cultural resource are unique, have strong ties to place, and risk the loss of integrity if moved or altered. Cultural resources are also in large part non-living or non-reproducing; once lost, they are lost forever.

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