2019

Looking Past, Looking Forward: America's National Parks, Archaeology and Climate Change

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Figure 1: Grand Prismatic Spring, Yellowstone National Park. Rachel Blumhardt

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There's a certain elation associated with finding a piece of the past. Unearthing a projectile point or an atlatl foreshaft, or any of a number of other things can be the first step in trying to paint a picture of what life was like for people who lived in an area thousands of years ago. America's national parks are set up to protect the natural and cultural attributes of certain areas of the country. By looking at archaeological evidence in these parks, we can try to gain a better understanding of the past, and how climatic conditions affected the ways of life of the people who lived there.

As time progresses and climatic conditions shift, however, these cultural sites are in danger. A changing climate is threatening the important cultural resources located within many of our nation's national parks. While the climate has shifted over the course of earth's four billion-year history, the past 15,000 or so years are of particular interest in America because modern humans have lived here for that length of time.

Figure 2: Grand Canyon of the Yellowstone. Rachel Blumhardt 2018

We know that climate has shifted dramatically throughout earth's long history due to natural processes. We can see evidence of those changes by looking at climate proxy data. There are numerous examples of these, each wielding different clues about past climates. Two important climate proxies are ice-core data and tree-ring data. Ice-core data is acquired from looking at bubbles trapped deep inside thick ice. These bubbles show the composition of gases that made up the atmosphere at certain times in a certain area throughout history. Ice core data allows us to see what the climate was like hundreds of thousands of years ago.[1] Tree-ring data is helpful for seeing how arid a place was at certain times. In the 1920s, A.E. Douglass discovered that there is a direct correlation between tree ring widths and precipitation. When there was less precipitation, trees grew less and therefore had thinner rings for that specific year. Using living trees, and trees that were used for constructing structures hundreds of years ago, scientists have pieced together a comprehensive chronology of precipitation levels for certain areas dating back hundreds or even thousands of years. This method is very helpful for archaeological research.[2] Using these and the rest of the many climate proxies, it has been determined that there is natural fluctuation in earth's climate and that temperatures have changed over time. Millions of years in the past, the climate was vastly different than it is today. However, up until recently, these changes have been fairly gradual.

Over the past 100 years or so, average temperatures on earth have increased much more rapidly than we have ever seen before. If this rapid temperature increase continues the way it has been, we will likely see temperatures average four degrees Celsius warmer than the 1961-1990 temperature averages.[3] Temperature changes that take place that quickly are very likely to effect almost every natural system, every living thing, and all of the archaeological evidence that allows modern humans to be connected to their past. This understanding helps to emphasize that human society has evolved in a relatively stable period of climatic conditions. We must never forget our past, or worse, let it slip through our fingers. It is our duty to protect it and continue to work to make sense of it, and to never stop appreciating from where it is we come.

[1] Henson, Robert. *The Thinking Person's Guide to Climate Change*. American Meteorological Society, 2014., 265

[2] Idib., 266

[3] "Earth Temperature Timeline." *Xkcd*, xkcd.com/1732/.

Yellowstone National Park

Geysers shoot columns of steaming hot water high into the sky. Bison, bears and elk roam the area. Geothermal hotspots dot the landscape. Yellowstone National Park was America's very first national park, created to protect this incredible place. It was founded by Congress and made law by President Ulysses S. Grant in 1872. The park is approximately two million acres of protected wild lands that gets, on average, over four million visitors from all over the world each year.[1] This area is home to numerous plant, animal and insect species, as well as containing some of the most incredible geologic wonders of North America. In addition to the natural features of Yellowstone, this area has an interesting cultural signature. In a place as majestic as this, with such a rich, storied past, archaeologists are always looking for new sites that will yield interesting artifacts that can help further our quest to better understand the past. As we uncover more artifacts and our knowledge of the history of places such as Yellowstone increases, we will continue to hypothesize about the context of artifacts such as these.

Figure 3: Yellowstone Lake. Rachel Blumhardt 2018

[1] Yellowstone National Park (U.S. National Park Service)." *National Parks Service*, U.S. Department of the Interior, www.nps.gov/yell/index.htm.

The Past

Many stone artifacts have been found in Yellowstone National Park and we can learn a lot from them. Projectile points made of various types of stone have been found in the park, some that date back thousands of years. The larger, older points were used with a hunting tool known as an atlatl. Smaller points are found in much later occupations, and would have been used with a bow. However, bow and arrow usage didn't begin in this part of America until around 1,500 years ago[2]. These projectile points were made from a variety of stone materials, but one of the most interesting materials is obsidian. Obsidian is a valuable cutting tool, as it can be made into points with extremely thin edges that are incredibly sharp. Obsidian flakes are also important archaeologically, as the distribution of obsidian flakes, points and debris can tell us a lot about where humans were living.[3]

Evidence of human occupation in the park goes all the way back to around 11,000 years ago, with the Clovis people. They made very large projectile points that exhibit a unique method of manufacture that involved chipping a flake out of the base, which is referred to as fluting. Clovis points are not as common as some of the other projectile points in the area, which likely means permanent settlements were not established until later, with the Cody Complex about 9,500 years ago. Points from the Cody time period have been found at over 50 sites throughout the park. Next was the early Archaic period (8,000-5,000 years ago). During this time, the altithermal, a climatic shift, brought hot and dry weather to the park. It was in the middle Archaic period (5,000-3,000 years ago) that the Native American populations in Yellowstone began to really increase. The Late Archaic period (3,000-1,500 years ago) had a climate very similar to that of today's climate. Finally, the late prehistoric period (1,500-300 years ago) saw the introduction of the bow and arrow into the Yellowstone region, which largely replaced the atlatl. This means that projectile point usage changed from larger spear points to smaller arrow tips. This period also saw the first pottery used by people living in the park.[4]

Figure 4: MacDonald, Douglas. *Comparison of Atlatl Dart Point (Left) and Bow and Arrow Point (Right) from Yellowstone Lake.*

[2] MacDonald, Douglas H. *Before Yellowstone: Native American Archaeology in the National Park*. University of Washington Press, 2018., 36

[3] Idib., 47

[4] Idib., 69

The Present

Today, we know much about the ways humans, wildlife, and plant life coexisted due to archaeological evidence, some of which is stored in ice patches. Ice patches are of immeasurable worth to archaeologists. These frozen snowscapes offer impeccably preserved organic materials, such as wood, antler and bone artifacts. These sites exist in high mountain regions, where snow doesn't melt, which means that any cultural activity that occurred there is preserved in the frozen landscape.[5] In areas such as these, archaeologists can uncover organic artifacts preserved in the ice patches that, in a different environment, would already be lost before an excavation could be done. These discoveries can lead scientists to make inferences and insights about the lives of ancient Native Americans that stone artifacts cannot provide. While the multitude of stone artifacts in Yellowstone are incredibly important and helpful in deciphering the stories of the ancient past, these organic materials tell a more intricate story. They help us see a more intimate side of life here; they illustrate cultural aspects that cannot be inferred from merely studying stone artifacts. With organic materials, we can attempt to reconstruct how ancient people lived their lives. Recently, ice-patch archaeologist Craig Lee uncovered a birch atlatl foreshaft in the park in 2009. This particular artifact is associated with the Late Paleoindian Cody culture and it is over 9,000 years old.[6] Even more remarkably, markings (two clusters of three parallel lines) were discovered on the foreshaft. After consulting ethnographic reports and speaking with modern hunter-gatherers, it was determined that these markings were likely engraved onto the foreshaft by the owner of the atlatl to signify ownership.[7] With such artifacts, researchers working with modern people can further expand on our current understanding of the ways of life of the people who occupied this land thousands of years ago.

Figure 5: Craig Lee. Ice Patch in Yellowstone National Park

[5] MacDonald, Douglas H. *Before Yellowstone: Native American Archaeology in the National Park*. University of Washington Press, 2018., 172
[6] Idib., 177
[7] Idib., 178

What Could We Lose?

Wildlife and plant life have coexisted and adapted to the natural ebb and flow of the ecosystem of Yellowstone for a very long time. For millions of years, the Yellowstone ecosystem provided sustenance, shelter and materials for millions of living things. After the first people arrived in the area, humans became a part of this ecological community as well.

Figure 6: https://www.huffpost.com/entry/whitebark-pine-functional_b_656201. Yellowstone National Park

While humans today do not craft projectile points from rocks in the park or count on the wildlife for subsistence, there is still potential for loss. Modern human impacts are putting many aspects of the park at risk, including ancient archaeological sites such as the aforementioned ice patches.

According to one of Yellowstone's previous park archaeologists, there are only a dozen or so ice patches left in the park, and many of them have been rapidly decreasing in size.[8] The artifacts frozen within these ice patches are preserved for the moment. However, if these organic artifacts are exposed to the cold, dry air they will quickly begin to decompose. Bone and antler artifacts will decay within ten years and wooden artifacts will decay even faster.[9] If ice patches melt before archaeologists have a chance to study them, the artifacts that lie within will be locked in the past forever, depriving modern researchers of the knowledge that can be gained from finding and studying them. Archaeologists are needing to work quickly to find these threatened areas and retrieve any artifacts that may be located there.

[8] Press, Associated. "Organic Artifacts in Yellowstone Being Lost to Ice Melt." *Great Falls Tribune*, 4 Feb. 2017, www.greatfallstribune.com/story/news/local/2017/02/04/organic-artifacts-yellowstone-lost-ice-melt/97501134/.

[9] MacDonald, Douglas H. *Before Yellowstone: Native American Archaeology in the National Park*. University of Washington Press, 2018., 178

National Park of American Samoa

Cerulean waves lap at the edges of pristine white sand beaches. Fish dart back and forth beneath the ocean's surface and coral reefs are alive with color as sunlight streams down into the depths below. This island paradise is a small US territory called American Samoa, located in the Pacific Ocean approximately 2,600 miles southwest of Hawai'i. The United States National Parks system has units on three of the islands of American Samoa: Ofu, Ta'u and Tutuila. The park was created in 1988 for the preservation of this unique landscape and rich cultural history. While it certainly isn't the largest national park, it is full of life, culture and beauty. The actual national park encompasses 21 square miles, separated out onto the three individual islands, with about 4,000 acres underwater.[1] In a few places within those 4,000 underwater acres, some of the planet's most interesting animals live: corals. While only hard corals build reefs, the ocean waters of American Samoa contain certain species of these hard corals and magnificent coral reefs can be seen off the coasts. These reefs are created when the individual animals, called polyps, build a structure around themselves for protection using calcium from the surrounding water. The corals survive through a symbiotic relationship with algae. The corals' structures provide shelter for the algae and then the coral polyps can feed on the algae. The algae are the reason corals are colorful. Without algae, the coral "bleach" and turn white. Coral bleaching occurs when temperatures get too warm and the polyps discard the algae, which can eventually cause them to die.[2]

Figure 7: Cornforth Images, Alamy. Ofu Island's Coral Reef, National Park of American Samoa

[1] "Plan Your Visit." *National Parks Service*, U.S. Department of the Interior, www.nps.gov/npsa/planyourvisit/index.htm.
[2] "What Are Corals?" *What Are Corals? | International Coral Reef Initiative*, www.icriforum.org/about-coral-reefs/what-are-corals.

The Past

There hasn't been as much archaeological research done in the confines of the National Park of American Samoa as has been done in other national parks. However, one of the most well-studied sites is on the volcanic island of Ofu, one of the Manu'a Islands, which is to the east of the main island. At this site, called the To'aga site, radiocarbon dated materials have shown that people likely occupied the area beginning around 3,000 years ago.[3] Evidence of an Ancestral Polynesian occupation is extremely evident at the To'aga site. The Ancestral Polynesian time period occurred from about 2,500-1,900 years before present. The To'aga site has yielded a lot of new information about the Ancestral Polynesian phase. Unfortunately, archaeologists in American Samoa have trouble finding organic materials here because of the acidity of the soil.[4] However, this site did provide an artifact assemblage that included a variety of ceramics, fish-hooks, and faunal materials from the Ancestral Polynesian cultural period. Some very interesting shell artifacts were found here that updated the way archaeologists were looking at the artifacts from this cultural period. The shell fish-hooks found here during the 1987 excavation on Ofu were the first of their kind to be found.[5] The ceramics found at the site have led to an interesting discovery as well. Excavations done on the western Samoan islands have yielded ceramics with very similar features to the ones from the same time period at the To'aga site. However, these islands are geographically separated. This means that it is very likely that the people from the two areas shared cultural ideas and materials.[6] Different kinds of shell artifacts, coral abraders and hammerstones were among the artifacts found here.[7]

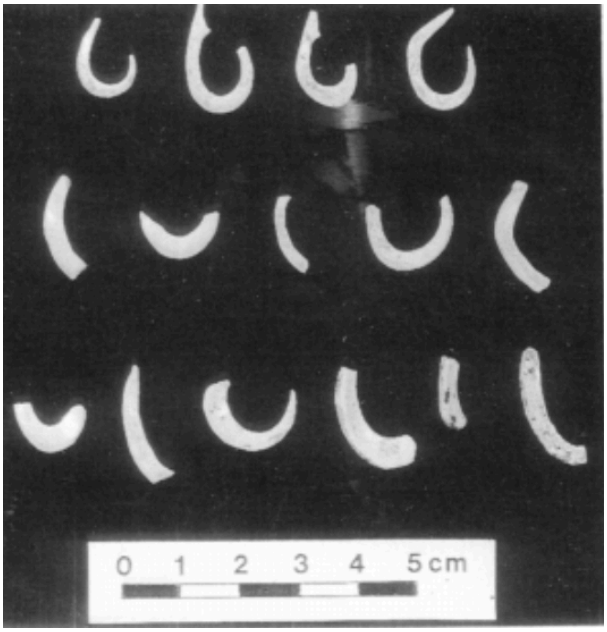

Figure 8: Reproduced from Kirch et. al 1990. Shell fishhooks from To'aga site

3 Kirch, Patrick V., et al. "An Ancestral Polynesian Occupation Site at Toaga, Ofu Island, American Samoa." *Archaeology in Oceania*, vol. 25, no. 1, 1990, pp. 1–15., doi:10.1002/j.1834-4453.1990.tb00225.x., 1

4 Idib.,11

5 Idib., 11-12

6 Idib., 11

7 Idib., 12

The Present

The National Park of American Samoa is unique because it has units on three different islands. However, climate-induced oceanic changes are affecting all of them. One of the main issues at present is rising ocean levels. There are a few mechanisms that cause this. The first is simply due to the basic properties of water. When water gets warmer, it expands. As a warming climate causes ocean temperatures to increase, it subsequently causes the warmer water to expand and take up more space. Additionally, as air temperatures continue to rise, land ice and inland glaciers in the Arctic and Antarctic regions are beginning to melt. As they melt, the meltwater flows into the ocean and further contributes to higher ocean levels.[8] Ocean levels have been rising at an average of 0.1 inches per year in American Samoa, and most of this rise has been due to thermal expansion. Accelerated sea level rise is expected throughout this century and will likely continue into future centuries, largely due to melting land ice.[9]

Figure 9: Eli Keene. Coast of American Samoa

Another climate change effect on American Samoa's marine ecosystems is ocean acidification, which is being caused by the increasing levels of carbon dioxide in the atmosphere. This is largely due to human activity. When people burn fossils fuels, carbon dioxide enters the atmosphere and some of it is absorbed by the oceans. It is estimated that approximately seven metric gigatons of carbon dioxide are absorbed by the oceans each year.[10] These high levels of carbon dioxide absorption lead to a shift in the pH balance of the ocean and this shift can damage much of the delicate ocean life.[11] For example, more acidic ocean waters can cause the calcium-based coral reefs and shellfish shells to break down.

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[8] *Climate Change in American Samoa* . Pacific Islands Climate Education Partnership, 2014, www.soest.hawaii.edu/coasts/publications/AmSamoa Climate 2016.pdf., 9

[9] Idib., 9

[10] Henson, Robert. *The Thinking Person's Guide to Climate Change*. American Meteorological Society, 2014., 166

[11] *Climate Change in American Samoa*. Pacific Islands Climate Education Partnership, 2014, www.soest.hawaii.edu/coasts/publications/AmSamoa Climate 2016.pdf., 10

What Could We Lose?

As previously discussed, Earth's warming climate is causing ocean levels to rise. One of the risks associated with the rising ocean levels is beach erosion, which would harm the national park's tourism and could threaten some of the coastal archaeological sites we have found.[12] Even worse, we could miss out on finding sites not yet discovered if they get eroded by the waves or if they get inundated with water as the ocean rises. If there is a significant ocean level rise in a short period of time, we could lose valuable cultural information associated with undiscovered sites.

Figure 10: NPS Photo. Coral Reef, Ofu Lagoon, American Samoa

Almost 25% of the acreage of the National Park of American Samoa lies underwater off the coasts of the three islands. In some of these underwater areas, vibrant corals can be seen under the waves. However, corals are very delicate sea creatures. They are especially vulnerable to ocean acidification and warmer water temperatures. Coral reefs are sensitive to even small water temperature changes. If the water temperature averages increase to even 1.8° Fahrenheit above typical temperatures and stay elevated for a few weeks or more, the coral becomes stressed and the process of algae expulsion and bleaching can be initiated.[13] Temperature measurements taken over the past 50 years have shown that the temperature of the Pacific Ocean has increased by about 0.7° Fahrenheit.[14] While this is certainly a concern in the park, recent studies on the shallow water coral reefs in the vicinity of American Samoa have shown that these specific corals are more tolerant to warmer waters, but only for short durations of time. The corals off the coast of Ofu live in shallow waters that undergo daily temperature fluctuations of up to 11.34° Fahrenheit each day.[15] This could be either good or bad for these Samoan corals. Researchers hypothesize that perhaps the corals are adapted to warmer water temperatures and therefore will be able to withstand warming oceans better than other species. However, the opposite could also be true. Since these specific corals are exposed daily to water that is almost too hot for survival, it could be inferred that, if ocean temperatures stay at these high levels for longer, these corals could die off more quickly than others.[16]

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12 *Climate Change in American Samoa* . Pacific Islands Climate Education Partnership, 2014, www.soest.hawaii.edu/coasts/publications/AmSamoa Climate 2016.pdf., 11

13 Henson, Robert. *The Thinking Person's Guide to Climate Change*. American Meteorological Society, 2014., 168

14 *Climate Change in American Samoa* . Pacific Islands Climate Education Partnership, 2014, www.soest.hawaii.edu/coasts/publications/AmSamoa Climate 2016.pdf., 12

15 Craig, P., et al. "High Temperatures Tolerated by a Diverse Assemblage of Shallow-Water Corals in American Samoa." *Coral Reefs*, vol. 20, no. 2, 2001, pp. 185–189., doi:10.1007/s003380100159., 186

16 Idib., 189

Glacier Bay National Park and Preserve

Alaska is one of the wildest places on earth. Here, nature is largely in charge. However, humans are increasingly impacting this untamed landscape as our actions continue to drive and exacerbate the negative effects of climate change. We go to places like Glacier Bay National Park and Preserve to experience wildness; to marvel at what nature has created. Glacier Bay National Park and Preserve was created by President Calvin Coolidge in 1925. It was meant to protect the unique landscape of tidewater glaciers for which the area is known.[1] Glaciers in general are the result of near constant snowfall in the high mountains of a region. When there is more snow accumulating than that which is melting, a glacier will eventually form.[2] Tidewater glaciers are a type of glacier found in Alaska's national parks. There are seven found in Glacier Bay National Park and Preserve. Tidewater glaciers are unique because, as evidenced in Figure 11, they begin in the mountains and flow down into the nearby ocean.[3] This creates the potential for large pieces of these glaciers to break off into the water.[4]

Figure 11: NPS Photo, nps.gov. Aerial View of Margerie Glacier

[1] Glacier Bay National Park & Preserve (U.S. National Park Service)." *National Parks Service*, U.S. Department of the Interior, www.nps.gov/glba/index.htm.

[2] Idib.

[3] Tidewater Glaciers." *National Parks Service*, U.S. Department of the Interior, www.nps.gov/subjects/oceans/tidewater-glaciers.htm

[4] Idib.

The Past

The Huna Tlinget people have lived in the Glacier Bay area of Alaska for thousands of years. Researchers have gathered multiple ethnographic accounts in order to try to understand the rich cultural history of this area. Unfortunately, ice advances in the park have destroyed much of the archaeological evidence that would have supplied scientists with even more information.[5] The Little Ice Age which occurred around AD 1700 caused one of the glaciers in the park to advance dramatically, which likely forced the Huna Tlinget people out of the area, while simultaneously destroying many of the older archaeological sites in that area. A select few sites were built above the current water line of the modern ocean and were missed by the glacial advance, but not very many.[6] This means that most of the cultural information uncovered from archaeological excavations is from the past two centuries or so. Therefore, archaeologists have been limited to uncovering a variety of relatively modern artifacts and only a few older artifacts. With the help of modern Huna Tlinget people, researchers have begun to piece together the lives of the Alaskan people of this region, with a focus on the last few centuries. The sites in Glacier Bay have been especially integral to an increased understanding of how these pre-modern people utilized the unique landscape in the area. It is important to look at how different factors, including the movement of European settlers into the area and the advance of glaciers, affected the Huna Tlinget settlement and subsistence patterns.[7] While several sites have been found in the park, excavations continue in the hope of finding out even more about the ways of life of the Huna Tlinget people.

Figure 12: Steve Schaller/National Park Service via AP. Huna Tlinget Tribal House recently dedicated in Glacier Bay NPP, Alaska

[5] Connor, Cathy, et al. "The Neoglacial Landscape and Human History of Glacier Bay, Glacier Bay National Park and Preserve, Southeast Alaska, USA." *The Holocene*, vol. 19, no. 3, 2009, pp. 381–393., doi:10.1177/0959683608101389. (page 382)

[6] Crowell, Aron. *The Hoonah Tlingit Cultural Landscape in Glacier Bay National Park and Preserve: an Archaeological and Geological Study*. U.S Department of the Interior, National Park Service, Glacier Bay National Park and Preserve, 2013.

[7] Idib., 85

The Present

Climate change effects different environments in different ways. Polar regions, including the Arctic region in which Glacier Bay is located, are being affected by climate change more quickly and severely than other regions because of what are referred to as positive feedback loops. Positive feedback loops can be triggered by one thing, and then either worsen and intensify or lead to other effects being triggered. One example of a positive feedback loop in the Arctic has to do with the fact that the atmosphere over the polar regions is thinner than it is over most of the planet. This means that the Arctic can receive the same amount of solar energy as the tropics receives, but there is more warming potential in the Arctic.[8] Another feedback loop is linked to a decreased overall albedo in the Arctic, as seen in Figure 13. Albedo is how much radiation a surface reflects. Objects and surfaces that are dark in color, like deep ocean water, absorb more radiation and therefore have a lower albedo. Anything that is lighter in color, like snow, reflects most of the sunlight that hits it; these surfaces have a higher albedo. Higher albedos are good for keeping something cool, since they don't absorb as much radiation. However, since the Arctic is warming, the snow and ice coverage is decreasing, and more of the surface is covered in deep, dark, low albedo ocean water. The feedback loop now comes into play because, as the Arctic warms and the snow and ice melt, the dark water is going to absorb a lot more radiation than the ice and snow were absorbing. This will ultimately lead to more warming.[9]

An example of a climate-induced impact that is particularly relevant to Glacier Bay National Park and Preserve involves melting glaciers. As the climate warms, the glaciers begin to experience rates of snow melt that are faster than rates of snow accumulation. This glacial melt causes ocean levels to rise slowly over time as the water runs into the ocean. Additionally, glacial meltwater generally has a higher pH than the ocean water into which it runs and can cause increased ocean acidification.[10]

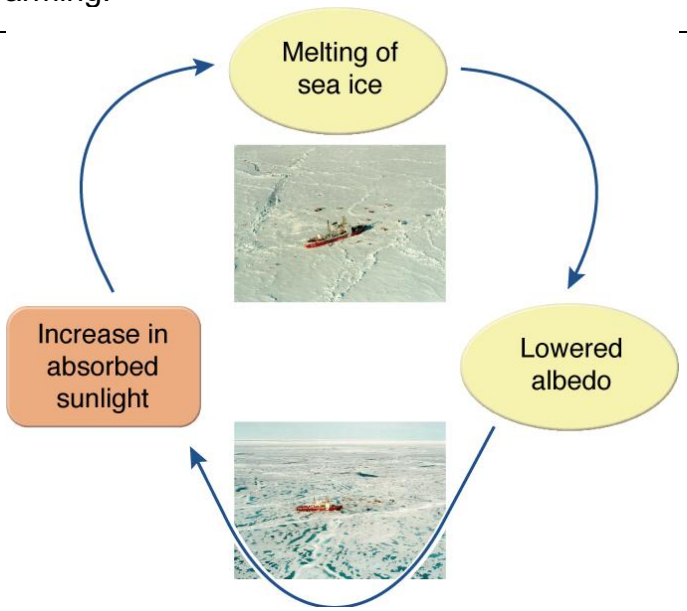

Figure 13: Albedo-ice feedback loop; courtesy of Hugo Ahlenius, UNEP/GRID-Arendal Maps and Graphics Library

[8] Henson, Robert. *The Thinking Person's Guide to Climate Change*. American Meteorological Society, 2014., 103

[9] Anisimov, O.A., D.G. Vaughan, T.V. Callaghan, C. Furgal, H. Marchant, T.D. Prowse, H. Vilhjálmsson and J.E. Walsh, 2007: Polar regions (Arctic and Antarctic). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth As- sessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, 653-685

[10] "Further Study of Ocean Acidification in Glacier Bay (U.S. National Park Service)." *National Parks Service*, U.S. Department of the Interior, www.nps.gov/articles/aps-15-1-9.htm.

What Could We Lose?

When looking at the ongoing climate change evidence, it becomes apparent that we stand to lose a lot in Glacier Bay National Park and Preserve due to climate change. The most obvious loss is the glaciers themselves. This park has over 50 glaciers that cover 48% of its land, seven of which are tidewater glaciers. The National Park Service has been monitoring the progression of the glaciers for many years. Overall glacial cover within the park has decreased by 11% from 1952-2010, and in that same time period, almost all of the individual glaciers have thinned and retreated.[11] One specific study on 16 of the glaciers within the park between 1995-2011 showed that all 16 of them experienced surface elevation decreases.[12] Another climate change effect that is threatening the ecology of Glacier Bay is ocean acidification. Ocean acidification in Glacier Bay is a bit different than in other regions, but is equally as harmful. With an increase in atmospheric carbon dioxide levels, ocean waters absorbing more carbon dioxide become increasingly acidic and have lower pH levels. Since we know that glaciers generally have higher pH levels than ocean water, the oceans within this park are likely going to be affected by ocean acidification rapidly because the water has a lower capacity to resist the pH changes and acidification.[13] Ocean acidification near Glacier Bay National Park and Preserve can have many detrimental effects on ocean life, including adversely affecting sea animals that live in shells by breaking down their calcium-based shells.[14]

Figure 14: NPS Photo. Margerie Glacier. nps.gov/glba/index.htm

[11] National Park Service. 2017. State of the Park Report for Glacier Bay National Park and Preserve. State of the Park Series No. 52. National Park Service, Washington, DC., 7

[12] Idib., 6

[13] Further Study of Ocean Acidification in Glacier Bay (U.S. National Park Service).” *National Parks Service*, U.S. Department of the Interior, www.nps.gov/articles/aps-15-1-9.htm

[14] Idib.

Mesa Verde National Park

Nestled beneath rock overhangs, incredible cliff dwellings mark the landscape of Mesa Verde National Park. Spectacular stone structures tower on the mesa tops, reaching high into the blue sky. This park is a stunning example of what humans are capable of accomplishing.

Figure 15: national-park.com/welcome-to-mesa-verde-national-park/. Cliff dwellings in Mesa Verde National Park, Colorado

With over 5,000 known archaeological sites, including 600 cliff dwellings,[1] Mesa Verde contains many impressive ancient architectural feats. Located on the Colorado Plateau in Southwestern Colorado, Mesa Verde is a unique and important cultural preservation site. Created in 1906, it was set aside in an attempt to protect the numerous archaeological sites and structures from looting and vandalism, and also to preserve the rich cultural history of this amazing place, while simultaneously teaching future generations how to protect and respect it.

[1] Mesa Verde National Park (U.S. National Park Service)." *National Parks Service*, U.S. Department of the Interior, www.nps.gov/meve/index.htm

The Past

Mesa Verde National Park was home to Native American groups for hundreds of years. The most significant occupation began in about AD 500, at a time period called the Basketmaker III period. This time period lasted for about 250 years before it evolved into the time period called Pueblo I. This period is marked with a transition from more isolated clusters of people to large village organization.[2] At this time, populations in the area exploded and the Ancestral Puebloan groups flourished. It is believed that populations may have numbered around several thousand people in the Classic period, from AD 1100- 1300.[3] A little before AD 1300, however, the population collapsed. While no one is certain as to why people migrated out of this area, one popular idea is that the mega drought that affected this area at the end of the thirteenth century adversely affected the way the inhabitants farmed the land. The farming practices of the Ancestral Puebloan people were heavily dependent on water resources. A long drought may have forced them to move to an area with more water and additional resources. However, many other factors were likely present and played a role in the mass migration out of Mesa Verde.[4]

Perhaps the most famous part of Mesa Verde National Park is the cliff dwellings located there. However, people only occupied these shelters beneath the rock overhangs for 100 years or so, beginning around the end of the eleventh century.[5] Although it is largely unclear as to why the people moved from the open mesa tops to structures beneath the cliffs, a few hypotheses have arisen. Perhaps these alcoves were utilized for defense against other groups of people, as they were more hidden and easier to defend. Or perhaps the people moved there because they sought protection from the weather, which can be unpredictable and harsh in this area.[6] We will probably never know the reason, but it is important to continue to study the artifacts found in the national park and to listen to stories from the native people who are descendants of the groups that lived here. The combination of these two things can help us piece together different ideas of what the past could have looked like.

Figure 16: Joshua Hardin. Cedar Tree Tower, a mesa top site in Mesa Verde National Park. http://www.viewfindermedia.com/guide/mesaverde.htm

[2] Crow Canyon Archaeological Center - Crow Canyon Archaeological Center." *Crow Canyon*, www.crowcanyon.org/
[3] *Ancestral Pueblo People and Their World*. National Park Service, www.nps.gov/meve/learn/historyculture/upload/ancestral_pueblo_people_2018_508_01-24-18-2.pdf.
[4] Jarus, Owen. "Mesa Verde: Cliff Dwellings of the Anasazi." *LiveScience*, Purch, 14 June 2017, www.livescience.com/27360-mesa-verde.html
[5] Holtz, Debra, et al. *National Landmarks at Risk: How Rising Seas, Floods, and Wildfires Are Threatening the United States Most Cherished Historic Sites*. Union of Concerned Scientists, 2014., 36
[6] Jarus, Owen. "Mesa Verde: Cliff Dwellings of the Anasazi." *LiveScience*, Purch, 14 June 2017, www.livescience.com/27360-mesa-verde.html

The Present

Today, climate change looms in the distance, threatening to catalyze a drought similar to the one that possibly had an impact on the Ancestral Puebloans' decision to migrate out of the Mesa Verde area hundreds of year ago. Some researchers hypothesize that a modern drought could affect this area by the end of this century, and it could be much worse than the one that occurred in the past.[7] Already, scientists are noticing downward shifts in precipitation trends in the area as temperatures rise. From 2000-2010, precipitation was found to be 4% lower and temperatures were shown to be 1.3° Fahrenheit higher than the twentieth century averages for both.[8] Increasing temperatures and decreased rainfall averages all contribute to longer, more intense fire seasons that can wreak havoc on the natural and cultural attributes of this park. Since Mesa Verde National Park was founded in 1906, it has lost almost half of its original tree cover. In addition to this, the park's pinyon pine tree populations are not regenerating very quickly, because the trees have to be fifty or sixty years old before they begin to reproduce. This means that swathes of blackened, fire-burned trees could become the new normal for the park.[9]

Figure 17: Bob Gibbons/Alamy Stock Photo. Mesa Verde National Park tree loss

[7] Jarus, Owen. "Mesa Verde: Cliff Dwellings of the Anasazi." *LiveScience*, Purch, 14 June 2017, www.livescience.com/27360-mesa-verde.html.

[8] *Mesa Verde Archeology and Fire*. National Park Service, 2007.

[9] "An Uncertain Future." *National Parks Conservation Association*, www.npca.org/articles/1622-an-uncertain-future.

What Could We Lose?

Mesa Verde's iconic cliff dwellings and fragile archaeological sites are at risk as the likelihood of fire and erosion damage increases with worsening climate change. The entirety of the American Southwest is getting hotter very quickly. In the adjacent mountain ranges, winter snowpack is melting almost a month earlier than previous decades show, and rising temperatures have made forests hotter and drier. This means that wildfire tendencies continue to increase.[10] Damage from wildfires is not limited to forests and modern structures. Unfortunately, wildfires can severely damage the Ancestral Pueblo structures and artwork as well. Petroglpyhs on the sandstone rock faces are very delicate and fire can accelerate a natural process called spalling, in which the water within the sandstone walls evaporates and deteriorates the images pecked onto the rock.[11] The 1996 Chapin 5 Fire caused the Battleship Rock Panel, seen in Figure 18, to be severely damaged.[12]

Fire can also exacerbate other potential issues. The intense heat of a wildfire dries out healthy soil that is ready to absorb water and turns it into burnt, hydrophobic soil that resists water absorption. This can lead to flooding and erosion, incredibly dangerous events that threaten to eradicate archaeological sites in the park completely. Unfortunately, the methods used to extinguish fires can also affect the physical appearance of the archaeological sites. Aerial drops of fire suppressant used to control fires in the past have stained the sandstone in certain places.[13] If archaeological sites are damaged or destroyed, crucial information about the past will be lost.

Figure 18: NPS Photos; Battleship Rock Panel before (upper) and after (lower) the Chapin 5 fire. *Mesa Verde Archeology and Fire*. National Park Service, 2007

[10] Holtz, Debra, et al. *National Landmarks at Risk: How Rising Seas, Floods, and Wildfires Are Threatening the United States Most Cherished Historic Sites*. Union of Concerned Scientists, 2014., 37
[11] Idib.
[12] *Mesa Verde Archeology and Fire*. National Park Service, 2007
[13] Idib.

About Me

As a person who has always possessed an affinity for the natural world and thrives in the outdoors, I am naturally drawn to the wonder of the wild landscapes America's national parks protect. After a couple of semesters attending college at the University of Montana and feeling unsure of what exactly I wanted to be studying, I took an Introduction to Anthropology class and I knew right then and there that Anthropology, and more specifically Archaeology, was the undergraduate degree I would pursue. I was also incredibly lucky that my college has an amazing innovative program in which a student can earn a minor in Climate Change Studies along with whatever degree they are pursuing. Over the next few years, I visited multiple national parks all over the country and continued to be amazed at all of the beauty that exists. However, as I learned more about climate change and the threats it is posing to these areas, I became motivated to not only visit these places and learn everything I could about them, but to someday work at one and teach other interested people about all the parks have to offer.

This project serves as my senior capstone, a culmination of what I have learned and an attempt at communicating that knowledge effectively. I wanted to try and fill in the gaps that exist in current park materials regarding the interrelationship between archaeology and the effects of climate change. Cultural resources are an integral part of understanding the ways of the world hundreds, and even thousands of years ago. I hope this project can serve as an engaging, educational resource for anyone who is interested in these topics, regardless of their educational background.

- Rachel Blumhardt

Overlooking the Grand Canyon, 2019