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Heatwaves in the Arctic: Their Effects on Northern Alaska

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Abstract

Images of polar ice caps melting and news of global sea levels rising have dominated the media's coverage of climate change during the past three to four decades. Focusing on these broad-scale impacts without further context does not adequately explain the complexities of what is currently happening in the Arctic and SubArctic Regions. This paper examines why changes to natural cycles like sea ice melt and permafrost thaw are posing significant threats to both human and non-human life. Shifts from the natural pattern of warming and melting in the Arctic, caused by external, human-induced pressures, have thrown these cycles into patterns of positive feedback. The paper looks into how sea ice melt and permafrost thaw work as positive feedback loops that are adversely impacting northern Alaskan lands and people. Chapter One details the most up-to-date data on the state of global warming, and quantitative analyses of sea ice melt, permafrost thaw and their impacts on Alaskan communities, using past and projected trends. Chapter Two outlines the environmental history of the Alaskan Arctic and its inhabitants, including past and once-projected warming and cooling patterns. Chapter Three explains what the Arctic's fate may mean for the rest of the world in terms of economic and other human losses. Chapter Four presents the political implications of Arctic warming as well as perspectives from current and emerging activists that aim to address the effects of warming in the Alaskan Arctic. Chapter Five offers my own thoughts on policy recommendations to address Arctic heatwaves and discusses how halting or reversing the spin of positive feedback loops in the Arctic could possibly be achieved.

Keywords: climate change, permafrost, sea ice, Inupiat, Arctic, Alaska

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Most importantly, I have to thank my mom, my dad, and my entire family for their unwavering support throughout this process. I would not have produced nearly the same quality of work if not for their encouragement and numerous proof-reads. Dad, you went above and beyond. Thank you, I love you all big as heaven!

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Introduction: Alaska is Changing – Nuiqsut's Story

The issue of climate change has been the topic of exhaustive debates and discussions since the issue gained attention and rose to popularity in the 1970s. As the decades have progressed, scientists have reported climate data that has become more and more alarming, and in the 21st century we are beginning to experience the physical effects of climate change in communities all over the world.

The Arctic region is warming at a much faster rate than anywhere else in the world. This is especially troubling because the Arctic should be the second coldest location on Earth behind the AntArctic. As one of the planet's most valuable regions thaws, humans, flora and fauna, and physical environments alike will be greatly impacted. In Alaska, permafrost thaw and sea ice melt are already causing disturbances for local and indigenous communities, and the reverberations of these events are beginning to be felt around the world. Indigenous, local, and foreign activists have spoken out against climate destructive acts in favor of improving the Arctic's condition. They have made some progress, but not yet enough.

One American town is being hit especially hard by both the drivers and the effects of climate change. Nuiqsut is a small village of indigenous Alaskan people located on Alaska's North Slope. The town's location puts its people and environment at unique health disadvantages in that it is smack in the middle of one of the most profitable oil and gas drilling sites in Alaska. The region is also within the top three fastest warming places in the world. The people of Nuiqsut have experienced the graves of their elders filling with water as the result of heavy rains and sea level rise caused by Arctic sea ice melt. They have had to abandon numerous ice cellars, which are used to preserve meat, because the ground is no longer cold enough. They have experienced an increased caseload of respiratory illnesses directly linked to the timing of leaks

from nearby oil and gas drilling.[1] The town is located within ten miles of at least two oil wells. And it is of grave concern to Nuiqsut that the Willow Project, an oil drilling project approved by the Biden Administration on March 13th, 2023, is set to commence operations in the National Petroleum Reserve of Alaska; the edge of which is a mere mile from Nuiqsut.[2] Community leaders like Martha Itta, Nuiqsut's tribal administrator, are working hard to protect their community and help them adapt to the unique challenges they are facing as a result of climate change and the nearby oil and gas drilling sites.

Despite human effort, relatively little has been accomplished to slow global warming and resultant climate change but there are still actions we can take on both institutional and individual levels that would reduce the effects of climate-caused phenomena globally. At the moment, every individual, resident of the Arctic or not, should make themselves aware of what is happening to our planet as a result of human activity. Then, we can collectively try to minimize the damage.

Chapter 1 will lay out quantitative data on the issues of permafrost thaw and sea ice melt in the context of their direct impacts on Alaskan communities and their impacts on the world as general feeders of global climate change. In Chapters 2 through 4, I will explore the historical, economic, and political/social dimensions of climate change feedback loops as they interact with time, humans, human systems, and other aspects of nature. Finally, in Chapter 5, I will propose policy and adaptational recommendations that I believe would be beneficial for the sake of

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[1] Juliet Eilperin, "Facing Catastrophic Climate Change, They Still Can't Quit Big Oil," The Washington Post (WP Company, December 13, 2019), https://www.washingtonpost.com/graphics/2019/national/climate-environment/climate-change-alaska/.

[2] Sabrina Shankman, "Surrounded by Oil Fields, an Alaska Village Fears for Its Health," Inside Climate News, November 30, 2020, https://insideclimatenews.org/news/02082018/alaska-north-slope-oil-drilling-health-fears-pollution-risk-native-village-nuiqsut/.

promoting climate justice, adapting to the effects of warming, mitigating permafrost thaw and Arctic sea ice melt, and combating climate change as a whole.

Chapter 1: Crunching the Numbers

Global Climate Change and Its Causes. By now I'm sure that most people have heard the term "climate change" or "global warming" and have at least a vague idea of what those terms mean. Where there is less awareness is in how climate change will affect certain regions, their peoples, and the ecosystem services that those regions provide for both local and global communities. Ecosystem services are categorized into provisioning, regulating, cultural, and supporting services. Provisioning services are the products that humans can obtain from ecosystems, like energy and food. They are what we primarily think of when talking about the planet's natural resources. Regulating services include the benefits we get from the natural regulation of ecosystem processes, like climate regulation and carbon sequestration. We can think of these like maintenance services that keep the planet's natural processes running smoothly, and allow living things to continue to survive. Cultural services are the non-material benefits we get from ecosystems like recreation and education. Here, we recognize value in an ecosystem simply for its existence. Supporting services are those that are necessary for the function and production of all other ecosystem services, such as nutrient cycling and photosynthesis. Without them, life on Earth could not exist. According to the Millennium Ecosystem Assessment, human use of ecosystem services will increase substantially during the next fifty years.[3] "In some cases, this growth in demand will be met by unsustainable uses of the services, such as through continued depletion of marine fisheries… The quantity and quality of

[3] "Millennium Ecosystem Assessment: Ecosystems and Human Well-Being," World Resources Institute, January 3, 2005, https://www.wri.org/research/millennium-ecosystem-assessment-ecosystems-and-human-well-being.

ecosystem services will change dramatically in the next 50 years as productivity of some services is increased to meet demand, as humans use a greater fraction of some services, and as some services are diminished or degraded".[4] Ecosystems around the world will experience differing changes to the services that they can provide and receive due to climate change. "Some changes in [ecosystem services] result directly from changes in the physical environment (e.g., temperature moderation, stable ground supporting infrastructure, smooth surface for transportation), while others arise indirectly from effects on ecosystems of changes in the physical environment".[5]

How the climate is regulated affects the availability of physical goods such as food (provisioning environmental services) and also affects cultural environmental services for humans specifically. We can see the service of climate regulation being disrupted today by looking at global climate change.

For the Arctic region, climate change will have the most profound effect on provisioning, regulating, and cultural services. As the water becomes warmer, indigenous communities who rely on the hunting and fishing of marine animals will be affected. Warming waters lead species to alter their migration patterns and may even deter some species from coming back to the waters that they once frequented, causing food scarcity for others in these communities.

As sea ice melts, it becomes increasingly difficult for the planet to regulate its climate. Communities are being forced to move inland since they can no longer regulate how the environment interacts with them. The disproportionate temperature increase is putting stress on all Arctic ecosystems, changing the landscape and putting many species in danger of extinction.

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[4] "Millennium Ecosystem Assessment: Ecosystems and Human Well-Being," World Resources Institute, January 3, 2005, https://www.wri.org/research/millennium-ecosystem-assessment-ecosystems-and-human-well-being.
[5] Matthew Berman and Jennifer I. Schmidt, "Economic Effects of Climate Change in Alaska," *Weather, Climate, and Society* 11, no. 2 (2019): 245–58, https://doi.org/10.1175/wcas-d-18-0056.1.

The way in which people who live both locally and far away from the Arctic cherish these ecosystems will change because the ecosystems themselves will never look or function the same way that they do now.

These ecosystem services are changing faster than one might expect. According to the Intergovernmental Panel on Climate Change (IPCC)'s Sixth Assessment Report, global surface temperatures reached 1.1°C above 1850–1900 levels in 2011–2020. "In 2019, atmospheric CO2 concentrations (410 parts per million) were higher than at any time in at least 2 million years (high confidence), and concentrations of methane (1866 parts per billion) and nitrous oxide (332 parts per billion) were higher than at any time in at least 800,000 years (very high confidence)".[6] Methane and nitrous oxide remain in the atmosphere for a shorter amount of time than carbon dioxide, but are 28 and 265 times as potent, respectively.[7] "Global greenhouse gas (GHG) emissions have continued to increase, with unequal historical and ongoing contributions arising from unsustainable energy use, land use and land-use change, lifestyles and patterns of consumption and production across regions, between and within countries, and among individuals (high confidence)".[8] "In 2019, approximately 79% of global GHG emissions came from the sectors of energy, industry, transport and buildings together and 22% from agriculture, forestry and other land use (AFOLU)".[9]

There are five economic sectors recognized by the Environmental Protection Agency (EPA) that contribute the majority of anthropogenic GHG emissions in the United States: agriculture, transportation, electric power, commercial & residential, and industry. Agricultural

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[6] H. Lee and J. Romero, et al. "IPCC Synthesis Report: Summary for Policymakers," Contribution of working groups I, II, and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 4.
[7] "Overview of Greenhouse Gases," EPA (Environmental Protection Agency, April 13, 2023), https://www.epa.gov/ghgemissions/overview-greenhouse-gases#:~:text=.
[8] H. Lee and J. Romero, et al. "IPCC Synthesis Report: Summary for Policymakers," Contribution of working groups I, II, and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 4.
[9] [sic]

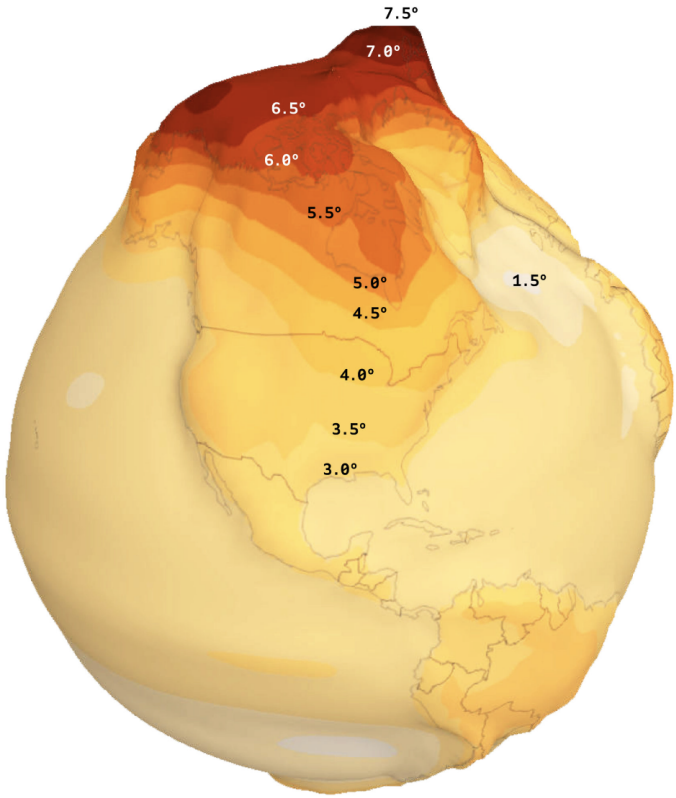
practices contribute about 10% of the total emissions, transportation 28%, electric power 25%, commercial & residential 13%, and industry 23%.[10] It is unclear whether or not these numbers account for the externalities associated directly with the extraction of fossil fuels, however, they do account for the emissions generated once these fuels are burned. Globally, we can expect intensified storm activity, rising sea levels, ocean acidification, extreme temperature changes, increased greater periods of droughts and flooding, species loss, food scarcity, higher risk of disease, poverty, and displacement to occur in increasing volume and/or frequency in the coming decades as the general results of climate change.

Disproportionate Arctic Warming and Positive Feedback Loops. The disproportionate warming that is occurring in the Arctic is causing permanent damage to the environment and the people who live in it. Figure 1 shows in Celsius degrees the extent to which the Arctic region is experiencing disproportionate warming. The map highlights anticipated change in global temperatures by region with the 1880–1920s average regional temperatures as a baseline. The specification in the Figure 1 description that states this data is anticipated in a "Business-As-Usual" Scenario means that this temperature increase is highly likely to come to pass if nothing is done to reduce GHG emissions and we continue on the current trajectory. The change we see at the tip of the Arctic is by 7.5ºC (13.5ºF). In the region of Alaska that this paper focuses on, the expected changes are between 6.5ºC and 6.0ºC (11.7ºF and 10.8ºF). The expected growth in average temperature within this same period for most of the world, including the mainland United States, is between 3–4ºC (5.4–7.2ºF). To be clear, the data presented in Figure 1 are not *rates* of warming, rather, expectations of how many degrees global temperatures will have changed by the time we reach the general period of 2040–2060. In other words, it is

[10] "Source of Greenhouse Gas Emissions," EPA (Environmental Protection Agency, April 28, 2023), https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions.

expected that regional temperatures will have reached these mapped measures of change by some point in the 2040–2060 time span. However, change rates are a critically important piece of the puzzle, as they are the mechanisms by which the Arctic will achieve greater temperature changes than the Earth's lower latitudes. What follows is a report of the current (2022) rates of global warming.

Figure 1. Disproportionate Warming By Latitude As Projected for the Years 2040–2060 In a "Business-As-Usual" Scenario.[11]



The current average rate of warming in the mainland United States is slightly over 1ºC (1.8ºF) per century, but specifically in northern Alaska, warming is currently occurring at an

[11] Greg Fiske, *Disproportionate warming as elevation,* (Woodwell Climate Research Center, 2022). https://www.woodwellclimate.org/research-area/Arctic/.

average rate of 2.5ºC (4.5ºF) per century.[12] This rate of climate change is not occurring anywhere else in the United States, but we can see that Alaska's numbers are similar to regions in the same or higher latitudes. It is clear that the rates at which global climates are changing vary, and the Arctic's are exponentially higher than anywhere else in the world. Some scientists refer to this phenomenon as the "Polar Heat Cap". With relatively low populations of people and attention upon these areas, the Polar Heat Cap is not a widely known concept. For a place that has been boreal forest and tundra since the dawn of the human race, a hot Arctic is alarming and prompts us to ask, what effects will these significant, disproportionate temperature changes have on Alaska, the Arctic region, and the world as a whole?

Two of these effects come in the form of permafrost thaw and sea ice melt. These are examples of positive feedback loops: the phenomena that are mainly responsible for the disproportionate increase in Arctic temperatures. Scientists specify that feedback loops are "positive" when they "enhance or amplify changes… [positive feedback loops] tend to move a system away from its equilibrium state and make it more unstable".[13] Acting in opposition to positive feedback loops are negative feedback loops. These "tend to dampen or buffer changes; [they] hold a system to some equilibrium state making it more stable".[14] When it comes to issues of climate change, we are dealing with positive feedback loops.

A common example used to help people understand how positive feedback loops work is to think about an oven with a temperature control. This example also makes itself relevant in that Earth's greenhouse effect is kind of like a big oven. When the temperature of the oven is set at some number X degrees, the oven will keep heating as it feeds the information back into its

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[12] "Climate Change Indicators: US and Global Temperature," EPA (Environmental Protection Agency, July 2022), https://www.epa.gov/climate-indicators/climate-change-indicators-us-and-global-temperature.
[13] "Feedback Loops," Starting Point (Carleton College, January 23, 2023), https://serc.carleton.edu/introgeo/models/loops.
[14] [sic]

system that it has not yet reached X degrees. The oven can also be used as an example of a negative feedback loop: the oven will stop heating when it feeds the information back into its system that it has reached X degrees. The system then holds itself stable at X degrees.

The two main positive feedback loops which are accelerating Arctic warming, as stated previously, are sea ice melt and permafrost thaw. While the main causes of global warming are in the first place anthropogenic, once the warming process gets going, nature's own processes take over and either accelerate it (positive feedback loops) or slow it down (negative feedback loops like carbon sequestration in forests). The role that Arctic sea ice plays in regulating the Earth's temperature is a lot like the oven example. When natural cycles are working as they should, the ice plays a part in a negative feedback loop that assists in keeping the planet's temperature cool. First, light from the sun hits the often snow-covered surface of the sea ice. The white color of the snow along with the ice's shiny surface reflects the sunlight's heat away from the Earth and prevents the Earth's atmosphere from heating up. This regulating service, however, is disappearing as a result of human impact and the subsequent loss of reflective snow cover. In addition, the increased number of GHGs in the atmosphere make it more difficult for the heat that is reflected away from the Earth to actually leave the atmosphere. As Arctic temperatures keep trending upwards, more ice melts. This is where it turns into a positive feedback loop. As the surface ice melts, the darker surfaces underneath absorb the sunlight's heat, melting it further. When all of the ice is gone, the even darker open water absorbs even more heat, warming the water and hindering the ocean's ability to freeze again. The Arctic Ocean's ice naturally goes through a cycle of freezing and melting that aligns with the seasons, but the ice hasn't melted completely, not even during the summertime, in the last 2.6 million years.[15] In the modern era,

[15] Eric Holthaus, "The Last Time the Arctic Was Ice-Free in the Summer, Modern Humans Didn't Exist," Slate Magazine (Slate, December 2, 2014), https://slate.com/technology/2014/12/the-last-time-the-Arctic-was-ice-free-in-summer-modern-humans-didn-t-exist.html

scientists have documented an exponential decrease in sea ice cover in the Arctic annually. This is exacerbated by this positive feedback loop into which the Earth's anthropogenic warming has thrown the Arctic's freezing cycle.

Figure 2. Arctic Sea Ice Yearly Minimum, 1979–2022.[16]

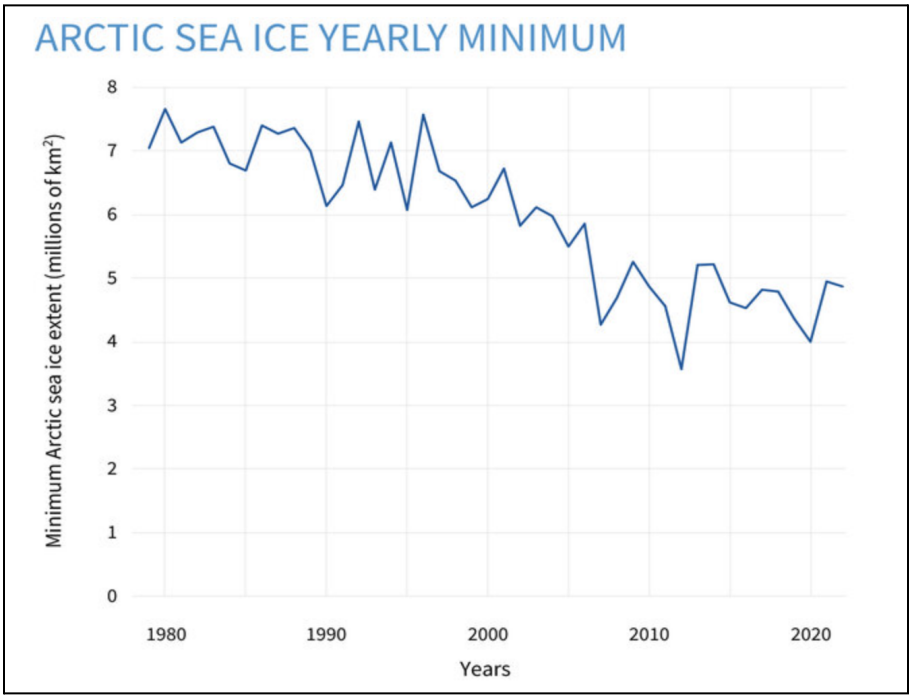

Figure 2 shows sea ice levels as determined by satellite imaging every September since 1979. September marks the end of the summer melt period, so these values are taken when ice cover is at its lowest. The downward trend of the graph tells us that the amount of sea ice that survives year round is steadily decreasing. NOAA recalls that, "old, thick ice made up a third of the Arctic Ocean ice pack at the winter maximum in March 1985. In March 2020, it accounted for less than 5%".[17] Arctic summers are called "ice free" when the amount of sea ice drops below

[16] Rebecca Lindsey and Michon Scott, "Climate Change: Arctic Sea Ice Summer Minimum," NOAA Climate.gov, October 18, 2022, https://www.climate.gov/news-features/understanding-climate/climate-change-Arctic-sea-ice-summer-minimum.
[17] [sic]

1 million square kilometers. Some researchers expect that, given the current melting rate, the Arctic will have ice free summers before the year 2050. “This prediction can be verified against data from the Last Interglacial Period (LIG), a period up to 130,000 years before present day. During the LIG, which is believed to be a reliable indicator of future climate change, summer land temperatures were 4–5°C (7.2–9ºF) higher than those in the pre-industrial era and the summers were ice-free. Models that include the LIG support the prediction that the Arctic will experience ice-free summers by 2035”.[18] Summers without Arctic sea ice mean a massive amount of “new” water is integrating itself with the other ocean waters instead of floating on top of it in chunks and sheets. The addition of this newly liquified water is pushing coastal boundaries further and further inland.

Figure 3. The Length of American Shorelines.[19]

	Ocean shoreline miles	Tidal shoreline miles
American shorelines	12,400	88,600
The Lower 48	4,993	53,677
East Coast	2,069	28,673
Gulf Coast	1,631	17,141
Pacific Coast w/o Alaska	1,293	7,863
Alaska—Arctic and Pacific	6,640	33,904
Hawaii	750	1,052
Florida, both sides	1,350	8,426
Puerto Rico	311	700
Virgin Islands	117	175

SOURCE: National Oceanic and Atmospheric Administration (NOAA).

[18] Alina Bykova, “Permafrost Thaw in A Warming World: The Arctic Institute's Permafrost Series Fall-Winter 2020,” The Arctic Institute - Center for Circumpolar Security Studies (The Arctic Institute, November 20, 2022), https://www.theArcticinstitute.org/permafrost-thaw-warming-world-Arctic-institute-permafrost-series-fall-winter-2020/.

[19] Pilkey and Pilkey, *Sea Level Rise: A Slow Tsunami on America’s Shores*, xiv.

Figure 3 outlines the number of miles that comprise the shorelines of various regions of the United States, and then the number of miles that are affected by regular tides as they ebb and flow. The tidal shoreline mile measurements demonstrate the complete number of miles that are going to be impacted by rising sea levels as tides creep higher.

Permafrost thaw is similar to sea ice melt in terms of their causes, but their feedback mechanisms are different. Instead of increased heat absorption by the ocean, it is the release of previously-sequestered GHGs in the thawing ground that is exacerbating the permafrost thaw feedback loop. Land that has been frozen completely for at least two years straight is considered to be permafrost. There still exists permafrost today that has been frozen for hundreds of thousands of years. An article out of the Arctic Institute outlines some basic data about permafrost in a concise, comprehensive way: "permafrost covers 24 percent of the surface of land masses in the northern hemisphere and accounts for nearly half of all organic carbon stored within the planet's soil... It is estimated that the world's permafrost contains up to 1,700 billion tonnes of carbon, which is almost double the amount of carbon in the Earth's atmosphere, and four times more than what has already been emitted by humans since the Industrial Revolution".[20] The disproportionate warming that the Arctic is experiencing is causing permafrost to melt, especially during the summer months. When permafrost thaws, it releases any stored gasses like methane and carbon dioxide into the air contributing to the greenhouse effect and ultimately leading to more permafrost thaw. It also frees up any organic matter once sequestered in the soil to be available for consumption by microbes, which also emit carbon dioxide as they break down the organic material. Another concern that arises from permafrost

[20] Alina Bykova, "Permafrost Thaw in A Warming World: The Arctic Institute's Permafrost Series Fall-Winter 2020," The Arctic Institute - Center for Circumpolar Security Studies (The Arctic Institute, November 20, 2022), https://www.theArcticinstitute.org/permafrost-thaw-warming-world-Arctic-institute-permafrost-series-fall-winter-2020/.

thaw is that any ancient bacterias and viruses being kept dormant in the soil have the potential to wreak havoc on today's world if they are released. It is possible that there are diseases frozen down there that we have never encountered, causing concern within the climate and health science communities that there are still more pandemics to come.

It does not take a scientist to conclude that releasing this stored carbon would be catastrophic for our climate. "Even if a small fraction of these greenhouse gasses are released, it will have major consequences on not only the Arctic, but Earth's entire climate system, as they intensify global climate change".[21] Bit by unfrozen bit, these gasses are being released into the atmosphere. The Arctic Institute also describes permafrost thaw as, "one of the gravest yet lesser discussed impacts of climate change".[22] The planet is already struggling to self-regulate its climate with the amount of GHGs that currently exist in the atmosphere. Today's natural ecosystems will not be able to recover from the addition of double the current GHG load to current the atmospheric stockpile.

The IPCC has created multiple Representative Concentration Pathways (RCPs), or possible emissions scenarios, in order to anticipate the outcomes of multiple emissions levels (see Figure 4). RCP 2.6 is a best-case scenario where very stringent emissions regulations result in the least possible overall climate change. RCP 4.5 projects a mediocre outcome where we start to reduce emissions after 2040. RCP 6.0 leaves us worse-off than RCP 4.5, but it is also relatively mediocre, representing the climate outcome if we get emissions under control after 2100. RCP 8.5 is the current worst-case-scenario that anticipates the temperature changes that will occur if we continue to increase emissions output at the current rate.

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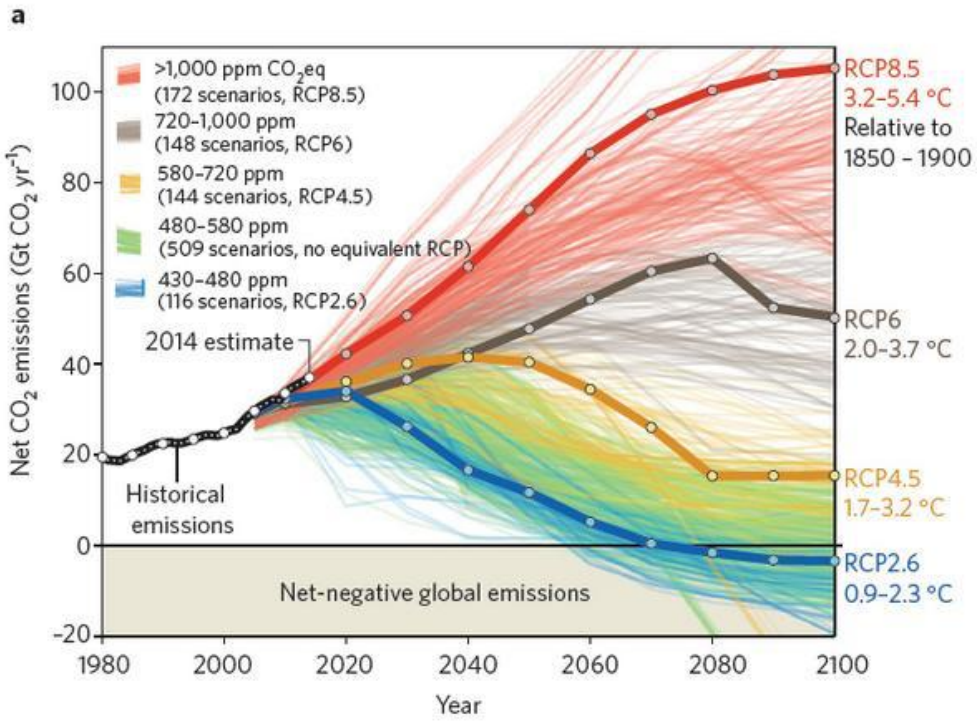
[21] Alina Bykova, "Permafrost Thaw in A Warming World: The Arctic Institute's Permafrost Series Fall-Winter 2020," The Arctic Institute - Center for Circumpolar Security Studies (The Arctic Institute, November 20, 2022), https://www.theArcticinstitute.org/permafrost-thaw-warming-world-Arctic-institute-permafrost-series-fall-winter-2020/.

[22] [sic]

Figure 4. IPCC Representative Concentration Pathways in Context With Carbon Emissions and Temperature Change.[23]



It is important that methane emissions be highlighted as a major threat due to its status as a very potent GHG. The Arctic experiences wildfires that feed on the methane coming out of thawing permafrost. The Arctic is naturally a very dry region; in the United States, the Alaskan Arctic is second in dryness only to the South West, so there is a persistent high risk that a fire can be started by either natural or human causes. The introduction of permafrost methane, however, makes boreal forest fires far larger and more devastating, demolishing the forests that once made the Arctic a carbon sink. The EPA notes that, "methane, which is a more powerful greenhouse gas than carbon, [is being powerfully emitted] directly into the atmosphere, and contributing to the spread of devastating Arctic wildfires. Though its lifespan in the atmosphere is much shorter than carbon dioxide, methane's impact on climate change has been found to be 25 times greater

[23] "RCPs as Scenarios," ...and Then There's Physics, December 17, 2015, https://andthentheresphysics.wordpress.com/2015/12/17/rcps-as-scenarios/.

over a 100-year period. While the Arctic was previously considered a carbon sink, new research shows that the region is emitting more carbon than it is absorbing, largely due to permafrost thaw".[24] This development will create ripple effects around the globe.

The point at which an uncontrollable spiral begins has been dubbed by scientists as a "tipping point". Tipping points vary depending on how different feedback loops affect the greater problem of climate change, and are usually expressed as a threshold number value for maximum manageable warming, melting, accumulation, etc. While human activity is a main factor which started these processes, if the melting of sea ice and permafrost hit or exceed tipping points in their individual spirals, then it will be impossible for humans to mitigate or reverse their effects. The situation would then be out of our hands, as if we are in the driver's seat of a runaway car with no brakes. Soon after these broad scale tipping points are exceeded we will no longer see, for example, ice in Greenland, and a carbon "bomb" of sorts will be released into the atmosphere via permafrost thaw. The Arctic without its signature freezing temperatures could instead come to look like it did millions of years ago when the poles were warm and dinosaurs resided there. It is critical that we understand and contextualize all current data about these Arctic feedback loops, their contributing factors, and their product events so that we can make informed decisions on both policy and individual levels.

Ecological and Human Effects in Northern Alaska. For many Americans, sea ice melt and permafrost thaw are not far away and arbitrary concepts, but issues that hit close to home and are already having deep impacts on their ways of life. The North Slope of Alaska is home to many indigenous towns, and unique wildlife. The Inupiat community of Nuiqsut is preparing for increased extreme weather events like increased lightning, intense storms, less extreme cold, and

[24] "Climate Change Indicators: US and Global Temperature," EPA (Environmental Protection Agency, July 2022), https://www.epa.gov/climate-indicators/climate-change-indicators-us-and-global-temperature.

more extreme heat. They are adapting to land changes like permafrost thawing, erosion, wildfires, and changes to their nearby lakes and vegetation. They are watching the Colville River that runs alongside the town have an earlier ice break up and a later freeze up, and are preparing for flooding from tidal surges. They are doing their best to anticipate and adapt to changes in what makes the optimal subsistence hunting season and changes in the prey's behavior and health. New species are emerging in the area, and those that are common staples of the Inupiat diet are getting sick. Small trees are beginning to grow on this land that has never been able to support such large flora. One resident, Rosemary Ahtuangaruak says of the trees, "there are willow stands that are now so deep and tall that it prevents the caribou from migrating".[25] The new species emerging in Nuiqsut are interfering with the processes of the species that are native. The landscape itself seems to be pushing some species away in that polar bears no longer have enough sea ice to live on and hunt from. "The Alaska Department of Fish and Game's list of ten "at risk" tundra species from climate change" includes important subsistence species for Nuiqsut - caribou, musk ox and eider".[26] In April 2014, Nuiqsut took inventory of its ice cellars. "Seven ice cellars are in use and those near the river are warming and in some cases filling with water. Residents observe that warmer air and soil temperatures have lengthened the time it takes to freeze the whale meat and blubber".[27] Ice cellars are of particular importance to many North Slope communities because they provide the means of drying and storing meat for long periods of time. The game they hunt includes whales, seals, and caribou, all too big to be eaten or used in one day. The ice cellars have provided the solution to their storage problem for hundreds of years. If the warming trends continue, the cellars will become unusable and the Inupiat will have

[25] Michael Brubaker et al., "ANTHC Center for Climate and Health," ANTHC Center for Climate and Health, July 2014, https://anthc.org/wp-content/uploads/2016/01/CCH_AR_072014_Climate-Change-in-Nuiqsut.pdf.
[26] [sic]
[27] [sic]

to completely divert from their long-honored practices. Nuiqsut's provisioning and cultural environmental services as we know them today will be decimated, and will have to be replaced with innovative adaptations.

Chapter 2: The Frozen History

Geological and Climatological History. The climate is supposed to fluctuate between warming and cooling trends like a seesaw rises and falls or a sine curve moves linearly. In line with how the pattern has unfolded over all of earth's geological history, we should be experiencing a cooling trend right now (2022). In fact, we are about 600 years past due for another ice age. The fact that the climate is changing in the direction of warming when it should be cooling is an occurrence unique to the anthropocene. Never before has the planet trended warmer when it should naturally be trending cooler. This unnatural occurrence suggests the introduction of a factor that did not play a role in determining the direction of any of earth's other climate changes: modern human activity.

Deniers of humanity's role in climate change often like to raise half-true arguments in order to try to justify their positions. Some of these people have referenced earth's geological history and have said that the climate has always fluctuated and that warming and cooling are natural processes. These statements are true, but do not tell the whole story. Deniers focus on the half of the truth that makes them right and block out the rest: the other side of the story that condemns humanity. The whole truth is that Earth has gone through multiple ice ages and has even experienced periods where there existed rainforests near the poles, however, the pattern within which these phenomena occur over time is being tampered with. By only focusing on the first half of my previous sentence, it is easy to understand why many people think that today's warming climate is a natural phenomenon. However, we need to focus on the second half, the

changes in the pattern of the planet's warming and cooling, in order to understand why today's climate change is not normal.

Around 720 to 630 million years ago (mya) scientists believe that the Earth was completely covered in ice and snow. This is called the "Snowball Earth Hypothesis", and it is believed to be a result of the Earth's thermal subsidence (cooling of the mantle causes a decrease in elevation). There are various guesses as to why the Earth experienced thermal subsidence at this time: "decline in the CO2 level, reduced concentration of greenhouse gasses, such as methane and/or carbon dioxide, perturbations of Earth's orbit, etc.", but it led to the formation of global snow and ice cover. "This is believed to have occurred between 2 and 5 times. The albedo effect (reflection of sun energy back to space) reinforced the global glaciation. The snow covering melted down soon after the level of the atmospheric carbon dioxide raised about 30 times the present level. The resulting extreme greenhouse conditions had a strong selective pressure on the evolution of life in the Proterozoic [era]".[28] Whatever the cause was for the planet to freeze over, the subsequent warming is on an extreme scale what we have seen happen with sea ice cover in the Arctic recently: the influx in greenhouse gas concentrations doesn't allow as much of the heat reflected by sea ice to escape the atmosphere, thus warming the atmosphere and melting more sea ice, resulting in decreased Arctic albedo. It is extremely unlikely that humans will ever see a day in which carbon levels increase 30-fold, but the processes occurring in these eras of changing climate are similar.

About 350–300 mya was the Carboniferous Period. It was also an "icehouse" period, meaning permanent ice caps existed at the poles. A mass extinction event occurred 305 mya when levels of carbon dioxide increased and the planet warmed, dried out, and experienced more

[28] Nelson R. Cabej, "Chapter 2 - Phanerozoic Evolution—Ediacaran Biota," in *Epigenetic Mechanisms of the Cambrian Explosion* (Academic Press, 2020).

intense seasonal fluctuations, making the climate intolerable for many rainforest plants.[29] This extinction ushered in the age of the dinosaurs, many of which lived in the Arctic. In Alaska, the first discovery of dinosaurs was made in 1961 by Shell Oil Company geologist, R. L. Liscomb. He found a variety of bones along the Colville River in Alaska's North Slope; closeby to the town of Nuiqsut. These bones date back to the late Cretaceous Period around 68–72 mya. The North Slope at that time was higher in latitude than it is today, and temperatures likely averaged 10–12ºC (50–54ºF) in the summer and 2–4ºC (35–39ºF) in the winter.[30] These creatures existed under much different conditions than are exhibited by the current Arctic environment.

The most well-known example of extreme climate change and extinction came 66 mya with the Cretaceous-Paleogene extinction event. An asteroid hit the Earth sending massive amounts of ashy debris into the atmosphere, blocking out the sun, and creating an "impact winter" and causing the extinction of non-bird dinosaurs. Over a period of 100,000 years afterward, the planet heated up, likely due to a volcanic eruption, ultimately reaching the Permian-Eocene Thermal Maximum around 55 mya. We can see this period of warmth in Figure 5 as the "hothouse". During the warmhouse and hothouse periods (also called greenhouse periods), oceans all around the world reached tropical temperatures and the Arctic was covered by rainforest.[31]

Figure 5. Climatological Timeline of Planet Earth From 70 Million Years Before Present.[32]

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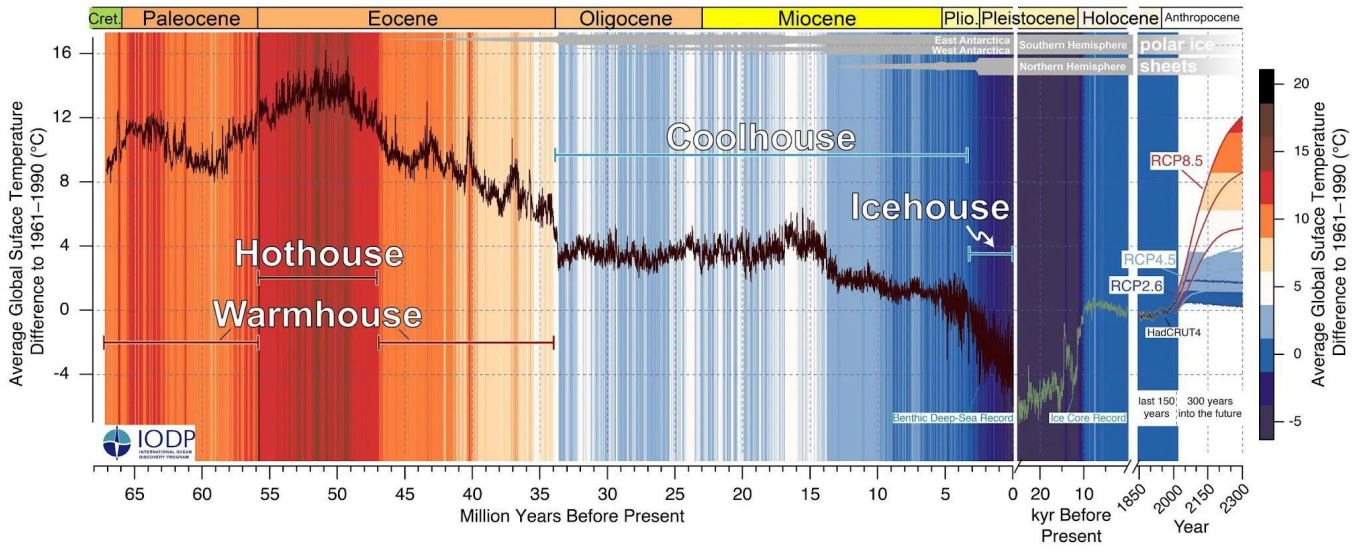
[29] "A History of Earth's Climate," National Parks Service (U.S. Department of the Interior, October 8, 2021), https://www.nps.gov/cajo/learn/nature/history-of-earths-climate.htm.
[30] Smith, *Interior & Northern Alaska: A Natural History,* 1.
[31] [sic]
[32] "66 Million Years of Earth's Climate History Uncovered – Puts Current Changes in Context," SciTechDaily (University of California Santa Cruz , September 10, 2020), https://scitechdaily.com/66-million-years-of-earths-climate-history-uncovered-puts-current-changes-in-context/.



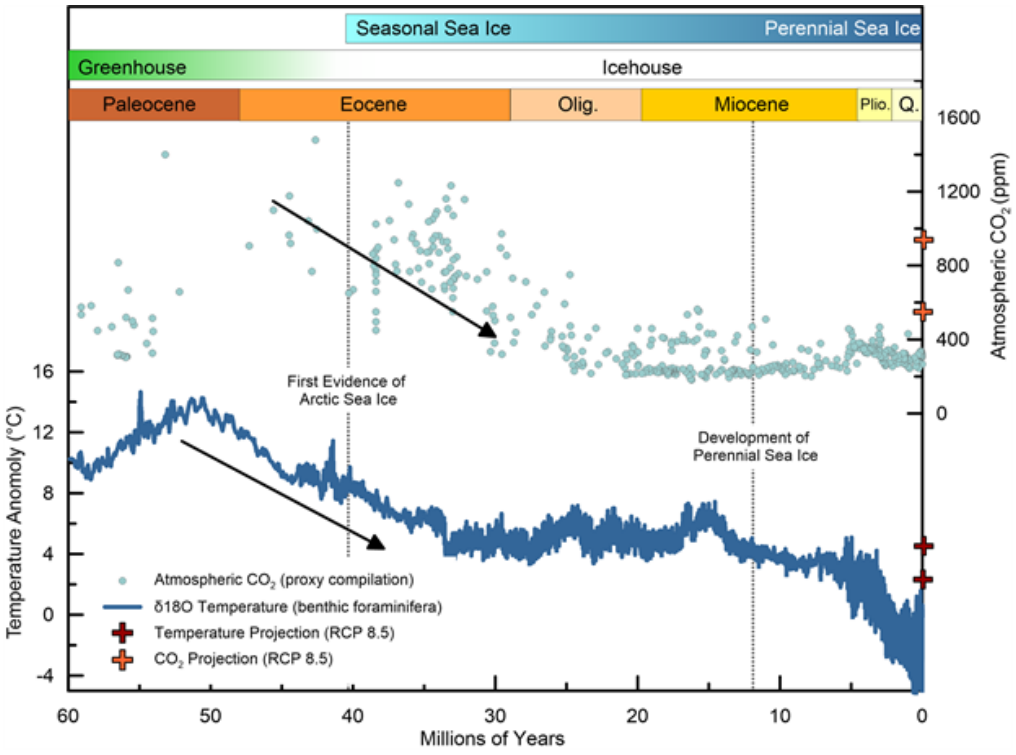
Toward the middle to end of the Eocene, "global atmospheric CO2 concentration and paleotemperature records indicate that the development of Arctic sea ice coincided with a period of global climate".[33] Atmospheric CO_2 concentrations and benthic water temperatures went down during this period, providing support for this evidence (see figure 6). The development of perennial sea ice began about 11 mya in the Miocene, and the cooling trend continued to plunge the planet into its last ice age about 33,000 years ago in the Pleistocene (fig. 5). The ice age ended at the beginning of the Holocene, which we are still in today; however some scholars and scientists believe the term "Anthropocene" is more appropriate to describe the current climatological era.

In addition to a deep climatological history of the planet, Figure 5 provides some future temperature projections based on different RCP scenarios to compare alongside those of the past

[33] E. Osborne, T. Cronin, and J. Farmer, "Paleoceanographic Perspectives on Arctic Ocean Change," NOAA Arctic Research (NOAA Arctic Research, December 5, 2017), https://Arctic.noaa.gov/Report-Card/Report-Card-2017/ArtMID/7798/ArticleID/690/Paleoceanographic-Perspectives-on-Arctic-Ocean-Change.

70 million years. If we continue to increase our emissions despite regulations as is specified under RCP 8.5, we will soon revert to the "hothouse" climate of the early to middle Eocene.

Figure 6. Atmospheric CO_2 Concentrations and Bottom Water Temperatures over 60 Million Years.[34]



Indigenous History. Native Americans have kept oral histories about their origins in the Americas that differ between tribes, and oftentimes from the contemporary scientific consensus. I mention this to acknowledge that the scientific theories I present stand respectfully alongside these indigenous accounts with which they may not be consistent. While there is still dispute in the scientific community about how and when exactly Homo sapiens came to populate the Americas, it is most likely given the current genetic evidence that Ancestral Native Americans arrived in Alaska from southern Siberia between 16,000 and 14,000 years ago via the Bering

[34] E. Osborne, T. Cronin, and J. Farmer, "Paleoceanographic Perspectives on Arctic Ocean Change," NOAA Arctic Research (NOAA Arctic Research, December 5, 2017), https://Arctic.noaa.gov/Report-Card/Report-Card-2017/ArtMID/7798/ArticleID/690/Paleoceanographic-Perspectives-on-Arctic-Ocean-Change.

Land Bridge.[35] The climate of the Arctic at this point in the early Holocene and up until recent years has been consistently frigid, averaging -40ºC (-40ºF) in January and 10ºC (50ºF) in the summer. Further inland, away from the temperature regulating effects of the ocean, temperatures can reach 21ºC (70ºF).

The Inupiat, especially those who still practice their traditional subsistence methods, rely heavily on the local plants and animals of the tundra. Main subsistence foods include caribou, bowhead whale, and seal. These animals have resided in the Arctic for many thousands of years. The practice of whaling is also thousands of years old and engages multiple whole communities in one killing effort. As these communities have migrated over the past many thousands of years, they have adapted to their surroundings, taking lessons with them, and have passed them down through generations. Through trial and error they have determined what it takes to survive the Arctic's harsh conditions. The knowledge that the indigenous people of the Americas have about their environments is often considered far more intimate and personal than the knowledge gained by scientists through research. Indigenous peoples are known for learning and growing with their environments rather than trying to compete against them or tap them for information. The Inupiat of Alaska's North Slope are no different. Inupiat children are taught early on how to identify minute differences in snow and ice because the centuries of elders before them have collectively concluded it necessary for survival. Traditional Inupiat education has been described as "nonverbal and ecological, facilitating weather prediction, recognition of blizzard warnings, and migratory patterns of game".[36] This information has traditionally been passed down orally, much

[35] Jennifer Raff, "Genomes Reveal Humanity's Journey into the Americas," Scientific American (Scientific American, May 1, 2021), https://www.scientificamerican.com/article/genomes-reveal-humanitys-journey-into-the-americas/.
[36] Emilio F. Moran, *Human Adaptability: An Introduction to Ecological Anthropology*, 122.

like their histories, making it difficult to determine concrete historical timelines of Inupiat societal progression.

The environmental history of Native Americans and indigenous peoples around the globe is much more difficult to access than that of their colonizers given the widespread erasure of their cultures and histories. However, their histories in and of the environment have roots that go much deeper in time. For example, scientists estimate that "the very first climate refugees in America must have been Native Americans who had to flee the rising sea that followed the end of the last glaciation. Relics from Native American settlements have been found under water on all our continental shelves".[37] The concept of moving due to changes that occur in the natural world is not new to history by any means, just new to the modern era and new based on the scale at which climate refugees are anticipated.

European Settlement to the Present. European interactions with the indigenous populations of Alaska did not begin until 1741 when the Russian explorer, Vitus Bering, met the Inupiat. "It is estimated that there were about 40,000 Inuit living in Alaska at the time, with half of them living in the north, both in the interior and in the far northwest. The Inuit, Aleut, and Native Americans living below the Arctic Circle were the most heavily affected by this early contact, occasioned by Russian fur traders. However, northern Inuit were not greatly affected until the second round of European incursions in the area, brought on by an expanded whale trade".[38] The expanding whale trade came to the Arctic in the 1870s. The competition that European whaling vessels brought to Inupiat territory put strain on the communities, as they were at a technological disadvantage. However, in the past 50 years whaling has made a comeback as a larger part of Inupiat life and hunting has lost some popularity. Since the 1870s

[37] Pilkey and Pilkey, *Sea Level Rise: A Slow Tsunami on America's Shores,* 6.
[38] J. Sydney Jones, "Inuit," Countries and Their Cultures, 2023, https://www.everyculture.com/multi/Ha-La/Inuit.html.

Inupiat culture has been changing, but the speed at which they are acculturating to Western societal practices has ramped up in the past 30 years. “The acquisition of rifles has meant that subsistence can be secured at a faster rate. As a result of their desire for Western goods and the necessity of having money to pay for them, the Inuit now work for wages”.[39] This quote comes from a book that was written in 1979 so the bias is a bit Western-centric, but the point remains that the norm that governs most of the world today is a Western capitalistic norm. Inupiat children now go to schools that are regulated by the state and less focus is put on the traditional ecological education that has been taught to young tribe members for centuries.

This cultural disturbance is the result of direct European influence on the Arctic, but there have been many indirect effects on the Arctic by European settlement in the Americas and modernization as well. Scholars and scientists agree that the Industrial Revolution was an important turning point for humanity and how we interact with the environment. Rates of change as they are measured today are often referred to in terms of “pre-industrial levels” and “post-industrial levels”. In the 1870s, we did not understand how human actions could affect the natural world. Factories would spew unfiltered smoke into the sky, letting soot rain down on cities. They would dump their chemical waste straight into rivers and lakes as if the water had the ability to make these pollutants disappear. Out of the Industrial Revolution came the birth of the coal-powered steam engine, which, considering coal is the dirtiest energy source in terms of pollutant production, created incredibly unhealthy living conditions for people, plants, and animals that lived close by to where the engines were utilized. The Industrial Revolution began the cycle of human GHG emittance that has proliferated and continues to this day.

[39] Emilio F. Moran, *Human Adaptability: An Introduction to Ecological Anthropology*, 132.

Figure 7. Arctic Sea Ice Extent Over the Last 1,500 Years.[40]

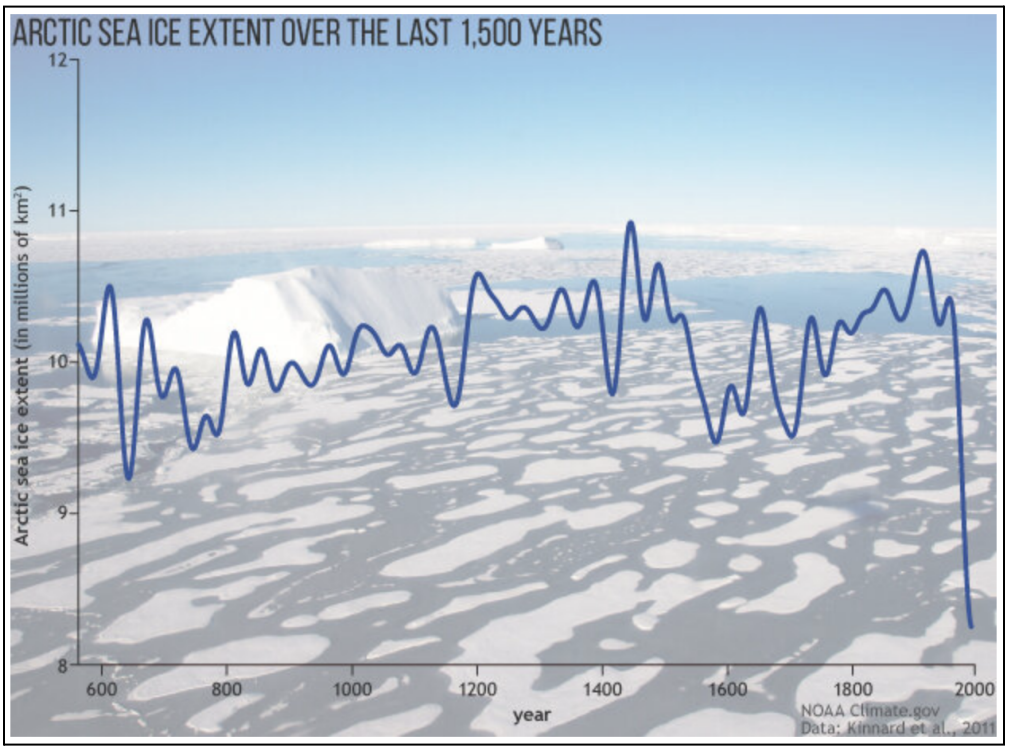


Figure 7 very clearly shows a fluctuation of warming and cooling trends as measured in levels of Arctic sea ice over the last 1,500 years. This is a very short amount of time in the context of Earth's geological history, but it is significant in demonstrating exactly how much of an impact the Industrial Revolution has had on the planet's temperature patterns. Even though we had been emitting high levels of pollutants for 100 years, it was only around the 1960s and the 1970s when people started to become aware of and concerned about human impacts on the environment and global warming. It is no coincidence that this increased awareness came shortly after the massive downward slope of melting that figure 7 shows occurring around 1960. Our actions finally caught up to us, but by that point, small, at-home lifestyle changes were not going to be enough to reverse the effects that all of our post-industrial actions had caused. Be reminded

[40] Rebecca Lindsey and Michon Scott, "Climate Change: Arctic Sea Ice Summer Minimum," NOAA Climate.gov, October 18, 2022, https://www.climate.gov/news-features/understanding-climate/climate-change-Arctic-sea-ice-summer-minimum.

that figure 7 is not measuring atmospheric carbon levels, it is measuring Arctic sea ice cover. If it were measuring emissions alone, dramatic change would have been observed shortly after 1870, not 1960. We are measuring Arctic sea ice cover; the post-1960 continual melting of which is an effect of increased emissions, which is an effect of the Industrial Revolution. Chain reactions take time to play out.

Another important plot point in the Arctic's environmental history was the 1896–1899 Alaskan gold rush. Miners would light fires on the permafrost in order to melt it so that they could dig deeper into the ground in search of gold. This was done on a much smaller scale than permafrost is melting at today, but it is still interesting to note considering this melt was intentional, not accidental. Undoubtedly, some amount of carbon and methane were emitted from the permafrost while miners were trying to get at the gold. Incidentally, heating up the permafrost helped to increase global emissions by 25.4% over the 4 years of the gold rush.[41] So far in the modern era there have been few climate refugees, but there have been instances of needing to move whole villages in Newfoundland, Canada. "Since the 1950s, Canada's Newfoundland government has moved a large number of small fishing village inhabitants into towns. This was done to improve lifestyles, reduce poverty, and improve government services through consolidation. Between 1954 and 1965, the state supported program moved 115 villages with a combined population of 7,500. Between 1965 and 1975, 148 more villages were relocated. The promised jobs and other opportunities never materialized, and the moves resulted in major disruption of economic, cultural, and social structures".[42] This is an example of well-intentioned action by a government, however, their efforts were corrupted by the fact that they did not

[41] Katie Lebling, Mengpin Ge, and Johannes Friedrich, "5 Charts Show How Global Emissions Have Changed since 1850," World Resources Institute, April 2, 2018, https://www.wri.org/insights/5-charts-show-how-global-emissions-have-changed-1850.
[42] Pilkey and Pilkey, *Sea Level Rise: A Slow Tsunami on America's Shores,* 23.

prepare the receiving communities to take in the fishing village residents in the first place. Villages of people cannot be placed into a vacuum where there are no jobs or familiarity for the area. Especially for fishing villages, taking them away from the water line removes their primary source of income from the local economy. In order to make relocation a viable option there need to be more preparations made for the quantity and types of people that will be moving. It's not as simple as just getting up and going somewhere. Lives need to be rebuilt. On the other hand, this example of full-town relocation is significant in that it proves it can be done. This action was an effort to improve lives, and that is exactly what will inevitably need to happen as sea level rise floods coastal towns. Examples like these are valuable today to look back on so that communities and governments can prepare for the day that relocation is required. The shortcomings that resulted from moving Newfoundland fishing villages will inform efforts to accommodate climate refugees in the near future.

It is clear that the changing climate and environment of the Arctic is now affecting both indigenous and non-indigenous communities without discrimination. For the indigenous, however, the Arctic environment has been a determining factor in their development and identity as a society. Non-indigenous communities who have come to the Americas came to conquer and triumph over the land and its "savage" people. While attitudes towards the indigenous communities of the Americas have largely changed, our practices when it comes to respecting and caring for the land for the most part remain unchanged. If emissions levels keep rising there is a chance that global warming will return us to conditions as they were early in the Arctic's history when the weather was near tropical. Humans have never known an Earth with warm poles. I anticipate it will be both heartbreaking and interesting to see how the United States, a

nation that has proven itself resistant to change, will respond to the environmental challenges we will inevitably have to face in increasing frequency.

Chapter 3: Why Should the World Care About Alaska?

What is happening to Alaska is a microcosm representative of the entire Arctic region. The severity at which Alaska is feeling the effects of climate change is the same severity that the whole world will experience in the coming decades if humanity doesn't change our destructive behaviors. Of course, people who live near the equator will not be experiencing the physical effects of melting permafrost or watching sea ice fade away. However, they will see rising sea levels in their own communities as the oceans attempt to balance themselves, and experience more intense storm activity due to abnormal temperature fluctuations and an increase in the amount of liquid and gaseous water in the water cycle. On top of it all, the carbon and methane emitted from the thaw and decay of permafrost will speed up the emergence and exacerbate the severity of these far away climate-related events.

Let's first focus on the regional effects of permafrost thaw. Permafrost is a term meant to refer to permanently frozen ground, however, the warming of the planet is calling the once permanent nature of permafrost into question. Recently, thawing permafrost has become a threat to life in the entire Arctic, impacting human and ecosystem ability to thrive in the region. Aside from emitting dangerous GHGs into our atmosphere, thawing permafrost contributes to increased erosion, the destabilization of infrastructure and landscapes, floods, hazard creation, forced migration, and the introduction of disease.[43] As I mentioned in Chapter 1, as permafrost

[43] Alina Bykova, "Permafrost Thaw in A Warming World: The Arctic Institute's Permafrost Series Fall-Winter 2020," The Arctic Institute - Center for Circumpolar Security Studies (The Arctic Institute, November 20, 2022), https://www.theArcticinstitute.org/permafrost-thaw-warming-world-Arctic-institute-permafrost-series-fall-winter-2020/.

unfreezes and refreezes seasonally it becomes unstable, leaving any buildings or infrastructure built on top of it in danger of collapse. Massive sinkholes have opened up as a result of permafrost thaw, swallowing homes and changing landscapes permanently. Liquid water that was once ice within the soil presents communities with the risk of flooding as wetlands emerge. If a person attempts to walk on melting permafrost, their boots would sink into the ground as they walked.

People are being forced to relocate to communities that are not built on top of permafrost, including indigenous tribes. Alaska is home to 229 federally recognized tribes who are all dealing with the effects of climate change in some capacity. However, at present, "more than 30 communities face an imminent risk of displacement and need for relocation away from erosion and floods – an endeavor that costs millions of dollars and further contributes to housing insecurity in the region".[44] Scientists hypothesize that select Arctic islands, specifically a few in the north of Russia, could soon disappear into the sea. Indigenous peoples who reside in the Arctic have seen their ancestral lands and burial grounds washed away.

Sticking with the theme of land turning to sea, washout and erosion along with ever-encroaching tide cycles in low-lying coastal areas are seriously threatening many indigenous Alaskan communities who rely on their oceanside locations to survive. "A few Native Alaskans have [already] moved from their tiny beachfront villages into towns because of the rising sea and the loss of protective sea ice along the Chukchi Sea and Arctic Ocean shores. It is likely that the rest will follow".[45] The loss of these ancestral lands poses major issues for many tribes considering much of their lifestyles are codependent upon the land on which they live.

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[44] Alina Bykova, "Permafrost Thaw in A Warming World: The Arctic Institute's Permafrost Series Fall-Winter 2020," The Arctic Institute - Center for Circumpolar Security Studies (The Arctic Institute, November 20, 2022), https://www.theArcticinstitute.org/permafrost-thaw-warming-world-Arctic-institute-permafrost-series-fall-winter-2020/.

[45] Pilkey and Pilkey, *Sea Level Rise: A Slow Tsunami on America's Shores,* 2.

Location is hugely important for indigenous tribes, and to be pushed out of their sacred lands by an encroaching sea is painstaking and harmful to their cultural identities.

Food Insecurity. Indigenous lifestyles, economies, food security, and customs are threatened as well, as changing ecosystems disrupt familiar natural patterns, and the melting ground destroys ice cellars, which are a key part in Indigenous subsistence lifestyles. "Instead of storing food in the frozen ground for months, a strategy that has been practiced for thousands of years, community food stocks are now at risk of rotting, creating further food insecurity in an already at-risk area".[46] Caribou, important animals to the Inupiat subsistence lifestyle, are in danger as a direct result of heightened local emissions and oil exploitation activity. Concentrated air pollution, say from a ground extraction facility, has the ability to wipe out lichen populations. In Alaska's North Slope there are plenty of oil and gas extraction sites that emit air pollution, and lichen is a staple of the caribou diet. This kind of interference has happened on a large scale in Siberia where one metal-smelting facility has "eliminated lichens from 300,000 hectares (almost 1,200 square miles) of the surrounding countryside and dramatically reduced lichens in an area twice as large".[47] Additionally, female caribou with calves "tend to avoid pipelines, roads, and other oil field structures".[48] This closes off a vast area of their natural habitat and could begin to make a recognizable impact on their herd populations. Their wariness of the increasing number of industrial structures also means that the indigenous communities who rely on caribou will have to travel farther in order to be able to hunt them. Melting permafrost zones also harm caribou by causing their feet to sink into the ground, either trapping or slowing them down, and

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[46] Alina Bykova, "Permafrost Thaw in A Warming World: The Arctic Institute's Permafrost Series Fall-Winter 2020," The Arctic Institute - Center for Circumpolar Security Studies (The Arctic Institute, November 20, 2022), https://www.theArcticinstitute.org/permafrost-thaw-warming-world-Arctic-institute-permafrost-series-fall-winter-2020/.
[47] Smith, *Interior & Northern Alaska: A Natural History,* 247.
[48] [sic]

by releasing pathogens that scientists believe have the potential to kill not only caribou, but muskoxen and nesting birds.[49]

Seals are another key component of the Inupiat subsistence diet that are being threatened by the warming climate. They use the sea ice to breed, molt, avoid predators, rear pups, and rest from swimming. Losing sea ice means changes in seal behavior patterns and a higher rate of predator capture. Additionally, "warming spring temperatures and earlier ice breakup could force pups into the water before they are independent from their mothers and able to feed on their own. If the seal is not strong enough to survive in open water, it could be killed and eaten by a marine predator—such as a killer whale or shark—or drown".[50] The lower the seal populations get the harder it will be for them to reproduce at a rate in which both the Inupiat and their animal predators can feed upon them. This is on top of the heightened difficulty of avoiding predators without abundant sea ice to flee to.

Even though Inupiat tribes are becoming acculturated to Western norms and are accepting non-subsistence foods into their lives, their remote locations on the North Slope make it a bit more difficult for food and other supplies to reach them. They still need to supplement their diets with hunted, foraged, fished, and whaled foods. The melting sea ice and warm waters are causing these flora and fauna to behave differently and in some cases become more scarce. The indigenous communities will have to adapt to the new reality of their environment and shift from their thousands of years old traditions in order to be able to continue to survive on their ancestral lands.

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[49] Ed Struzik, "How Thawing Permafrost Is Beginning to Transform the Arctic," Yale E360, January 21, 2020, https://e360.yale.edu/features/how-melting-permafrost-is-beginning-to-transform-the-Arctic.
[50] "Seals, Sea Lions, and Climate Change: Shifting Prey and Habitat Impacts," NOAA Fisheries, March 22, 2023, https://www.fisheries.noaa.gov/national/climate/seals-sea-lions-and-climate-change-shifting-prey-and-habitat-impacts.

It's All Connected. Permafrost thaw and sea ice melt work in tandem. According to the Arctic Institute, "Arctic sea ice supports the resilience of permafrost, which impacts multiple climate pathways. A study at the University of Oxford determined that past permafrost thaws correlated to time periods with ice-free summers. The research suggested that future Arctic ice-free summers could lead to the destabilization of existing permafrost".[51] This evidence demonstrates that no event in the Arctic happens on its own "desert island". When it comes to climate, phenomena manifest in a way similar to a series of interconnected loops, like a fabric: when one loop is pulled on, the whole piece stretches.

For most of today's world the heavy lifting of the sea level rise issue is not the displacement of native tribes, but "dealing with towns and cities, as there will be large numbers of people simultaneously affected, all asking for taxpayer support; first to hold off the sea level rise, next to help refugees start a new life, and finally to help the towns that will receive the refugees".[52] Climate refugees are not going to be small groups of people coming from far away lands, they are going to be millions of people all moving inland, with all of their belongings, all at once. This is not the stereotypical refugee situation, a person coming in with a small rucksack, that we see on television. These are our neighbors, friends, and fellow citizens who are going to be moving into cities and towns that do not have the capacity to accommodate them. "If the sea rises three feet, the number of moving Americans may exceed 4 million, and if the rise is six feet by 2100, the number of refugees may exceed 13 million, according to a study by Mathew Hauer, head of the Applied Demography Program at the University of Georgia, and his associates".[53] This is a conservative estimate that does not take into account all of the uncertainties of our

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[51] Alyssa Burns, "Dwindling Arctic Sea Ice and Impacts to Permafrost Health," The Arctic Institute - Center for Circumpolar Security Studies (The Arctic Institute, August 12, 2022), https://www.theArcticinstitute.org/dwindling-Arctic-sea-ice-impacts-permafrost-health/.
[52] Pilkey and Pilkey, *Sea Level Rise: A Slow Tsunami on America's Shores,* 4.
[53] Pilkey and Pilkey, *Sea Level Rise: A Slow Tsunami on America's Shores,* 5.

collective climatic future. Inland communities are not safe from the effects of sea level rise, they need to begin preparing their infrastructures to accommodate the thousands, in some cases millions of people that will arrive and that they do not currently have the capacity to hold.

Let's expand this even wider, beyond the scope of the United States. "A 2017 Cornell University research report in Science Daily stated this: 'In the year 2100, two billion people—about one-fifth of the world's population—could become climate-change refugees due to rising ocean levels. Those who once lived on coastlines will face displacement and resettlement bottlenecks as they seek habitable places inland'".[54] Two billion people is currently a quarter of the world's population and will be about a fifth of the population by 2100. To put this into perspective, that is more people than the 2022 populations of China and the United States combined. Humanity is going to need incredibly innovative ideas in order to solve the issue of where to put this impending massive migration.

Kivalina, AK. While Nuiqsut is located far enough inland that it is not yet in danger of being overrun completely by storm surges or flooding, there are plenty of Alaskan villages that are facing this problem. The small and isolated Inupiat town of Kivalina is located on a barrier island by the Chukchi Sea, 83 miles north of the Arctic Circle. Its population is only 400 and the town cannot be reached by road. The island has historically been protected for most of the year by thick sea ice sheets, but the sea ice is getting thinner and thinner. Without this ice, the residents of Kivalina can't continue the traditional subsistence practice of hunting bowhead whales and the coastlines are not protected from large waves and storm surges. Millie Hawley, president of the Native Village of Kivalina remembers, "as we grew up, we've never seen the water come over the village, but in the last 10 years, it came over the village at least three

[54] Pilkey and Pilkey, *Sea Level Rise: A Slow Tsunami on America's Shores,* 7.

times".[55] The island is so small that it is in extreme danger of being swept away by the sea. Residents and the government have known this for years and now the time has come to relocate. However, they aren't receiving as much help from the government as they would have hoped. Many residents believe that they should not be the ones that have to do the work of moving the community since it was the government that put them there in the first place. "As one historian notes, the establishment of government schools led to the 'consolidation' of previously mobile hunting and fishing communities in larger, stationary villages, like Kivalina".[56] We can see now that because they are no longer a traditional Inupiat mobile community, the institution of government-sanctioned education may not have helped Kivalina as much as officials had thought. Back when he was President, "President Obama proposed $50.4 million in federal spending to help Native American communities grapple with climate change. Yet that is less than half of what's estimated to be needed to relocate Kivalina alone".[57] This attempt at resolving the issue was clearly misinformed as to the gravity of the problem, but recently, as of March 4, 2022, the US Department of Agriculture announced that it will cover the costs of relocation for six Alaskan communities. These communities do not include Kivalina, but there is a live application for more communities to get funding for relocation. It is a step in the right direction.

Much of the erosion endangering coastal Alaskan communities is the result of the combination of rising sea levels, intensified storms, and permafrost thaw. Figure 8 depicts efforts to save a Kivalina home from the fate of the Shishmaref home in Figure 9. There, erosion moved so quickly that people were unable to prevent its fall into the sea. Shishmaref faces the same need to relocate as Kivalina and is located on the Alaskan coast just south of the Arctic Circle.

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[55] Chris Mooney, "The Remote Alaskan Village That Needs to Be Relocated Due to Climate Change," The Washington Post, October 27, 2021, https://www.washingtonpost.com/news/energy-environment/wp/2015/02/24/the-remote-alaskan-village-that-needs-to-be-relocated-due-to-climate-change/.

[56] [sic]

[57] [sic]

Figure 8. Kivalina Neighbors Band Together to Save a Home From Falling Into the Sea.[58]

Figure 9. A home destroyed by beach erosion tips over in the Alaskan village of Shishmaref.[59]

[58] Kavitha George, "Kivalina Neighbors Banded Together to Save a House from Falling into the Sea amid Last Week's Storm," Alaska Public Media, September 27, 2022, https://alaskapublic.org/2022/09/23/kivalina-neighbors-banded-together-to-save-a-house-from-falling-into-the-sea-amid-last-weeks-storm/.
[59] Andrea Thompson, "Alaska's Coast Is Vanishing, 1 Storm at a Time," Scientific American, November 30, 2017, https://www.scientificamerican.com/article/alaskas-coast-is-vanishing-1-storm-at-a-time/.

The *Deadly Secrets in Permafrost and Rising Seas.* Infrastructure collapse is one of the local effects of permafrost thaw. On a global scale this paper has already examined how permafrost thaw can dramatically increase atmospheric emissions, but it is impossible to know current or future mortality rates that come as the direct result of pollutants emitted by permafrost thaw since we cannot accurately attribute what atmospheric gasses came from where. What I have yet to discuss is permafrost's potential to release toxins. In 2016 "an anthrax outbreak from a rotting animal carcass found in the permafrost caused over 70 people to be hospitalized in northern Russia, and killed a child and more than 2,300 reindeer".[60] Unearthing microorganisms and organic carbon that have been frozen in the ground for thousands of years makes for some uncertainty about what is going to be introduced into our modern environment. This anthrax outbreak is one of many surprise effects of permafrost thaw that we will experience in the coming years.

Less surprising are the GHG emissions, which we will have to analyze the human cost of as an atmospheric whole. According to an article out of Forbes that reports on a study conducted by the peer-reviewed journal Nature Communications, "for every 4,434 metric tons of CO2 that we add beyond the 2020 rate of emissions, we will kill one person. Those 4,434 tons are equivalent to the current lifetime emissions of 3.5 Americans… On a global average, 4,434 tons equals the lifetime emissions of 12.8 people".[61] This data tells us two things: one, that Americans are emitting four times the amount of carbon as the rest of the world on average, and two, that

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[60] Alina Bykova, "Permafrost Thaw in A Warming World: The Arctic Institute's Permafrost Series Fall-Winter 2020," The Arctic Institute - Center for Circumpolar Security Studies (The Arctic Institute, November 20, 2022), https://www.theArcticinstitute.org/permafrost-thaw-warming-world-Arctic-institute-permafrost-series-fall-winter-2020/.

[61] Disha Shetty, "Climate Change Would Cause 83 Million Excess Deaths by 2100," Forbes (Forbes Magazine, November 9, 2022), https://www.forbes.com/sites/dishashetty/2021/07/30/climate-change-would-cause-83-million-excess-deaths-by-2100/?sh=3d4edc2445c4.

based on the increase in emissions levels from 2020 to 2022, we have already signed the death certificates of around 336,229 people.[62]

An article published in the journal "Weather, Climate and Society" estimates the number of deaths that will occur before 2100 as a result of extra coastal flooding to be between 84 and 139 deaths. As a separate indicator they then factored in the influence of Arctic glacial and sea ice melt into their estimate and concluded, "Higher-than-expected rates of [sea level rise] due to increased discharge from polar glaciers will raise this estimate to 277. Protection failure will also result in more fatalities. Conversely, adaptation, even when combined with coastal population increases, may lead to fewer fatalities".[63] These numbers are very low when the entire world is in consideration, but they are all avoidable deaths. As the text provides, if we prepare, adapt to the reality, and implement protection measures, there will be fewer fatalities.

Southern Effects. Dangerous sea level rise is not only affecting Alaskans, it is already beginning to necessitate relocation in the southern contiguous United States as well. Escambia County, Florida, for example, has been plagued recently by more intense storm activity and flooding. In April of 2014, Escambia County experienced record-breaking rainfall that resulted in heavy flooding. The damage was so severe that a federal declaration of disaster was issued for the area. Yong Jee Kim (PhD 2019) of the Korea Environment Institute and Purdue graduate advisors Juan Sesmero and Brigitte Waldorf (Department of Agricultural Economics) conducted a study to predict the timing and patterns of climate change-related migration in Escambia County. They looked at the 2014 flood along with other significant floods that have occurred in the area and analyzed homeowners' propensity to move. They found that "in the two years

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[62] Zeke Hausfather and Pierre Friedlingstein, "Analysis: Global CO2 Emissions from Fossil Fuels Hits Record High in 2022," World Economic Forum, November 11, 2022, https://www.weforum.org/agenda/2022/11/global-co2-emissions-fossil-fuels-hit-record-2022/#.

[63] Yosuke Adachi, "Human Lives at Risk because of Eustatic Sea Level Rise and Extreme Coastal Flooding in the Twenty-First Century", *Weather, Climate, and Society* 7, 2 (2015): 118-132.

following the 2014 flood, households with high perceived risk of flooding (as measured by home insurance relative to the home value) were more likely to move. However, households that made the decision to move tended to relocate to a new residence in close proximity to their previous home—and with a similar exposure to flooding. This preference for short distance moves was strongest for Black homeowners. In addition, the preference became stronger with a household's increasing financial security, perhaps reflecting greater ability to afford higher insurance premiums".[64] In many coastal American towns, the Federal Emergency Management Agency (FEMA) has been offering home buyouts after significant flooding or storms in order to ease the burden on American families of not being able to sell their ruined homes. The Escambia County study assesses the scenarios in which homeowners are preemptively relocating.

Economic Oversight. When firms conduct cost-benefit analyses before making big decisions, they don't often incorporate the environmental cost of their actions. Granted, it is very difficult to come up with a number that can reflect the dollar cost of air pollution on the health of birds, or what the financial damages of dumping waste into waterways would be. There are no property rights allocated to these collectively-borne costs. There are so many parties that bear the social costs of these externalities, and they bear these costs in so many different ways, that economists often have to guess their dollar damage values. Unfortunately for the environment, the economy doesn't deal in aesthetics or social costs. Pushpam Kumar, Chief Environmental Economist at the UNEP notes that the current way we calculate a nation's GDP is not a true representation of its peoples' well-being. "GDP captures some of the most tangible ways that nature contributes to the economy, such as supplying markets for timber and fish. But it largely omits nature's "non-market" benefits, including its spiritual, aesthetic, or recreational value. Also

[64] "Relocation, Retreat, and Rising Sea Level," Purdue Climate Change Research Center, February 8, 2021, https://ag.purdue.edu/climate/relocation-retreat-and-rising-sea-level/.

overlooked are fundamental functions such as the generation of fertile soil, the provision of clean air and water, and natural barriers to disease. Moreover, Kumar notes that market mechanisms typically fail to reflect the alarming erosion of the natural capital from which these vital benefits flow, such as the loss of forests and wetlands or the pollution of the atmosphere. 'This conceals how the foundations of human well-being are weakening even as financial incomes may have risen for most people,' he said".[65] In this way, GDP is actually disillusioning people as to the true success of a country's economy. By omitting critical factors from any assessment one skews the results dramatically. The natural mechanisms that provide the resources from which an economy thrives need to be included in calculations for that economy, otherwise those calculations cannot be considered reliable. If we think of all of the world's ecosystems as one interconnected economy and climate change as a threat to the health of the economy, then we can also consider the emissions that come from permafrost thaw to be one of the aforementioned overlooked yet critical factors of the equation, as these looming emissions are not accounted for in current climate projection models.

According to a study published by the American Meteorological Society in 2019, the "largest economic effects [of climate change in Alaska] were associated with costs to prevent damage, relocate, and replace infrastructure threatened by permafrost thaw, sea level rise, and coastal erosion. The costs to infrastructure were offset by a large projected reduction in space heating costs attributable to milder winters. Overall, we estimated that five relatively certain, large effects that could be readily quantified would impose an annual net cost of $340–$700 million, or 0.6%–1.3% of Alaska's GDP".[66] This data wraps my point into a neat little bow:

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[65] Pushpam Kumar, "Beyond GDP: Making Nature Count in the Shift to Sustainability," UNEP, 2022, https://www.unep.org/news-and-stories/story/beyond-gdp-making-nature-count-shift-sustainability.
[66] Matthew Berman and Jennifer I. Schmidt, "Economic Effects of Climate Change in Alaska," *Weather, Climate, and Society* 11, no. 2 (2019): 245–58, https://doi.org/10.1175/wcas-d-18-0056.1.

addressing Alaska's climate change to a greater extent would be economically beneficial to the nation and provide a lesser cost in the long-run to taxpayers. Another study out of the International Monetary Fund (IMF) shows climate change's economic effects on a larger scale: "large and interconnected economies vulnerable to climate change could trigger a drain of $1.8 trillion in international reserves (2 percent of 2019's global GDP). Domestic and multilateral macroeconomic policies can help reduce these global losses to about $0.8 trillion".[67] This study proves it true that even the people who care more about their bank accounts than climate change would benefit immensely from strong policy towards climate change mitigation and adaptation. A drain on national and international reserves means governments will need to come up with more money to pay their bills. This equals an increase in taxes, even if the taxpayer is from an area of the world where the effects of climate change are being minimally felt. Being a citizen of a country means contributing to a collective, so protecting that collective with preventative measures and adaptations is key to minimizing the frequency of costly disaster recoveries.

Chapter 4: Key Players and Actions

International Governance. As is the nature of politics, there are multiple international agreements and treaties that serve to govern the Arctic region. The Arctic Council is the primary collective to which treaties are expected to report. The Council is composed of eight permanent member states with territory in the Arctic region: Canada, Russia, The United States, Denmark, Sweden, Norway, Finland, and Iceland; and 13 observer states. The Council was formed via the Ottawa Declaration…"the eight Arctic States established the Council as a high-level forum to provide means for promoting cooperation, coordination and interaction among the Arctic States

[67] Yiqun Wu et al., "Stress Testing the Global Economy to Climate Change-Related Shocks in Large and Interconnected Economies," *IMF Working Papers* 2022, no. 189 (2022), https://doi.org/10.5089/9798400219641.001.

– including the full consultation and full involvement of Arctic Indigenous communities and other Arctic inhabitants".[68] The Arctic Council can be thought of as similar to the UN in terms of its use as a forum and as a governing body members must answer to. In terms of what the Council does in regard to the climate crisis, they work to "promote knowledge exchange and support small and remote Arctic communities in transitioning to sustainable energy," sponsor projects that "seek to reduce black carbon at its source and improve understanding of its impacts on Arctic inhabitants," and "provide specific expertise for a holistic approach on how to tackle future wildfire seasons," on top of serving as a "knowledge broker and global advocate for Arctic topics".[69]

The Arctic Offshore Oil and Gas Guidelines, more commonly known as the Arctic Guidelines or The Guidelines, is a set of rules and regulations adopted under the Arctic Council that detail how to conduct Environmental Impact Assessments (EIA's), when to conduct them, procedure to be followed when conducting extractive activities within the Arctic, and various other preventative, procedural, and recuperative specifics. They were developed by a group called PAME (Protection of the Arctic Marine Environment) "to ensure a recognized uniform understanding of the minimum actions needed to protect the Arctic marine environment from unwanted environmental effects caused by offshore oil and gas activities".[70] They are "intended to be of use to the Arctic nations for offshore oil and gas activities during planning, exploration, development, production and decommissioning," as these procedures have great potential to cause harm to the health of Arctic ecosystems and the marine animals that live near popular

[68] "International Cooperation in the Arctic," Arctic Council, accessed November 28, 2022, https://www.Arctic-council.org/explore/work/cooperation/.
[69] "The Arctic in a Changing Climate," Arctic Council, 2023, https://Arctic-council.org/explore/topics/climate/.
[70] "Arctic Offshore Oil and Gas Guidelines," PAME, 2009, https://www.pame.is/document-library/Arctic-offshore-oil-and-gas-documents.

extraction zones.[71] While the Arctic Guidelines are non-binding, they serve as a good point of reference for governments, groups, and individuals advocating for safer offshore extraction practices.

The United Nations Convention on the Law of the Sea, or UNCLOS, is an international agreement that has been signed by 167 countries and the European Union. Curiously, however, the United States is not one of those signatories. According to the International Maritime Organization (IMO)'s website, "[UNCLOS] lays down a comprehensive regime of law and order in the world's oceans and seas establishing rules governing all uses of the oceans and their resources".[72] UNCLOS is a comprehensive international maritime policy framework that does well in clearly outlining what signatories can and can not do and where at sea. Environmentally speaking, UNCLOS is often used as a reference point for international consensus on how to proceed with ocean environmental protection. However, the treaty does not do nearly enough to safeguard our oceans, leaving mandates open-ended, self-determining, and vague. The legislature does well in regulating oceans as a political arena, but not as a natural resource.

UNCLOS is relevant to the Arctic in that the majority of Arctic territory is comprised of the Arctic Ocean. As the result of dwindling sea ice cover in the Arctic Ocean, a power-grab arena is emerging: new opportunities will arise to create shipping lanes that can drastically reduce transit times between nations. This new commercial territory will need to be regulated and passage rights will need to be assigned. UNCLOS will be a key treaty of reference in navigating the politics of creating new shipping lanes across the Arctic Ocean.

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[71] "Arctic Offshore Oil and Gas Guidelines," PAME, 2009, https://www.pame.is/document-library/Arctic-offshore-oil-and-gas-documents.
[72] "United Nations Convention on the Law of the Sea," International Maritime Organization, accessed November 28, 2022, https://www.imo.org/en/OurWork/Legal/Pages/UnitedNationsConventionOnTheLawOfTheSea.aspx.

Without the barrier of ice, new trade routes are opening up at the top of the world, shortening the travel distance between countries that were once far from reach of one another by thousands of miles. The prospect is exciting for politicians and corporations, but scary for environmentalists. The United States government has always been wishy-washy on environmental protections and green undertakings, and this new development further calls into question the government's commitment to sustainable reform.

Will Congress and the President skimp on proposing and funding green solutions in favor of the new trade routes off Alaska opened up by the melted ice? If they decide to take after their eastern counterparts, climate may be pushed down the list of US priorities. "For many export-dependent Asian states in particular, the prospects of the Northern Sea Route through Russian-controlled Arctic waters are more salient than climate issues".[73] What's more, "it is anticipated that as early as 2025, the resources and infrastructure required to facilitate new trade along the Northern Sea Route and Northwest Passage will be in place (National Intelligence Council 2008). These routes would significantly decrease the length of transit for shipments from Europe and Asia by up to 5000 miles".[74] Less sea ice cover also opens up new opportunities for offshore oil and gas drilling. It's a lot more cost-efficient to not have to break through ice to get to the ocean floor. The promise of these new provisioning service opportunities will be difficult for governments to ignore.

The politics of the Arctic have been constantly changing throughout the past couple of decades, but most prominently in the last couple of years with the introduction of this new possible trade route. For a long time the Arctic was all about oil and wasn't a very contentious or

[73] Jensen and Hønneland, *Handbook of the Politics of the Arctic,* 133.
[74] Jensen and Hønneland, *Handbook of the Politics of the Arctic,* 29.

influential subject on the world stage. Now, that dynamic is being opened up and it will be interesting to see exactly how governmental attitudes towards climate change will evolve.

National Arctic and Climate Policy. One of the United States' biggest climate success stories is passing the 2022 Inflation Reduction Act. This piece of legislation, along with implementing multiple other social welfare-increasing initiatives, puts into place a plan to lower energy costs, increase cleaner production, and reduce the US's carbon emissions by 40% by 2030. Under this Act the government plans to invest "$369 billion in Energy Security and Climate Change programs over the next ten years".[75] No passed bill has ever been as progressive and proactive at fighting climate change in America's history.

The Inflation Reduction Act is the best legislation we have for climate on the national scale, but what about Alaska's municipal-level concerns? The most pressing climate matters that the towns of Nuiqsut and Kivalina are facing are different, but they are facing the same issue at the hands of the American government. One is plagued by pollution from drilling for fossil-fuels and one is being washed into the sea, but they both are getting insufficient help from the government in solving these problems. According to the U.S. Government Accountability Office, "federal agencies provided a total of about $391 million in obligations in fiscal years 2016 through 2020 to (1) repair damaged infrastructure in Alaska Native villages; and (2) build their resilience to environmental threats, including by implementing protection measures. However, more than one-third of highly threatened Native villages did not receive such federal assistance during these 5 years".[76] This is a great start, but there is still a lot more work to be

[75] "Summary: The Inflation Reduction Act of 2022 - Senate," US Senate, 2022, https://www.democrats.senate.gov/imo/media/doc/inflation_reduction_act_one_page_summary.pdf.
[76] "Alaska Native Issues: Federal Agencies Could Enhance Support for Native Village Efforts to Address Environmental Threats," U.S. Government Accountability Office, May 18, 2022, https://www.gao.gov/products/gao-22-104241.

done in order to address all of the issues that the Arctic and its inhabitants are facing from climate change.

Some American politicians have pointed out that the government's climate mitigation efforts are taking funding away from climate adaptation efforts. This is a difficult issue to reconcile given that both endeavors are necessary and worthy of government attention and funding. In an article about village relocation Senator James M. Inhofe (R-Okl.) noted, "[President Obama's] climate change agenda has only siphoned precious taxpayer dollars away from the real problems facing the American people".[77] By "real problems" he is in this article referencing issues like the fact that Alaskan villages are being overtaken by flooding and erosion.

While his statement is correct, there is more that needs to be considered here than just the immediate needs of the people. The question that the government has been grappling with is, where can we find the money to address the cause of these environmental problems while at the same time treating their symptoms? Americans are suffering and need repairs and adaptations today, but at the same time we could be spending the money fighting climate change and thus preventing more Americans from suffering tomorrow. With limited funds, this conflict poses a political and ethical dilemma to decision-makers.

Arctic Activists and Grassroots Efforts. By this point in time, Greta Thunberg, a 19-year-old Swedish environmental activist, is a household name. She has expertly organized and influenced thousands of youth protests and works every day to inform policymakers around the globe about climate change. Her many accomplishments have resulted in her being named

[77] Chris Mooney, "The Remote Alaskan Village That Needs to Be Relocated Due to Climate Change," The Washington Post, October 27, 2021, https://www.washingtonpost.com/news/energy-environment/wp/2015/02/24/the-remote-alaskan-village-that-needs-to-be-relocated-due-to-climate-change/.

Time's Person of the Year in 2019, and being nominated for a Nobel Peace Prize three times. She is truly a powerhouse in the world of climate activism.

Autumn Peltier is an 18-year-old, world-renowned, Anishinaabe, Canadian indigenous rights activist, and water protector. "In April 2019, Peltier was appointed Chief Water Commissioner by the Anishinabek Nation and has spoken about the issue of contaminated water on Indigenous reserves in Canada at the United Nations. For her activism, Peltier was nominated for the International Children's Peace Prize in 2017, 2018 and 2019".[78] She made headlines by publicly shaming Canadian Prime Minister Justin Trudeau for not adequately protecting indigenous Canadians' water supply and has since become a widely influential spokesperson for water issues. She sets an excellent example that people should not be afraid to speak their mind when it comes to issues as grand as the ones we are dealing with when it comes to climate change. Speaking one's mind regardless of age and not being afraid to question authority has the potential to yield hugely beneficial outcomes.

In Alaska, more native youth have been taking the lead in advocating for climate change mitigation policies. Nanieezh Peter is an 18-year-old Alaska native who has taken on a leadership role in Alaska's climate conversations. Her friend, Quannah Chasing Horse Potts is a 20-year-old Alaska native doing the same. Peter stated during the October 2019 convention of the Alaska Federation of Natives; "We're realizing that our leadership ... is not taking the mandatory steps to save our future and [we have] to step into that position …".[79] Potts and Peter were able to convince native Alaskan leadership to declare a climate emergency in Alaska. According to an article published by public radio program, The World, "their request for the

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[78] David Joseph Gallant, "Autumn Peltier," The Canadian Encyclopedia, October 25, 2021, https://www.thecanadianencyclopedia.ca/en/article/autumn-peltier.

[79] Emily Schwing, "Indigenous Youth Take Global Stage in Madrid to Voice Climate Change Worries," *The World from PRX*, December 5, 2019, https://theworld.org/stories/2019-12-05/indigenous-youth-take-global-stage-madrid-voice-climate-change-worries.

emergency declaration on the debate floor in a hockey arena in Fairbanks, Alaska, sparked a fervent and hours-long debate during the annual [Alaska Federation of Natives (AFN)] convention".[80] However, a climate emergency declaration was only a small part of what the girls hoped to accomplish at the convention. They had been long advocating for a "resolution urging the federation's voting members to take action on climate change as it affects Alaska Native people in a way that matches the scale and urgency of the problem".[81] At the AFN convention Potts and Peter gave their speech on behalf of the Elders and Youth Conference, an organization that ended up drafting their resolution.

At this same 2019 convention, Potts and Peter fought against the opinions and objections raised by indigenous Alaskan businessman, Crawford Patkotak, that declaring a climate emergency would mean that the native community is unnecessarily "[tying] our own hands up when it comes to developing our own resources".[82] By "developing our own resources," Patkotak is referring to the drilling of oil and gas along Alaska's North Slope. Potts' response to Patkotak was rather curious. She said, "I am not an environmentalist. I am Indigenous and we are not here to fight with our own people. We are here to stand together".[83] Potts' statement supports the contention that not all de facto environmental activists would care to be called as such. People advocate for the protection of the natural world for many reasons, some completely unrelated to any anxiety or anger over the threat posed by climate change; however, this is uncommon. Peter's and Potts' motivations are to protect their people and homeland above all else, and this

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[80] Emily Schwing, "Indigenous Youth Take Global Stage in Madrid to Voice Climate Change Worries," *The World from PRX*, December 5, 2019, https://theworld.org/stories/2019-12-05/indigenous-youth-take-global-stage-madrid-voice-climate-change-worries.
[81] Tripp J. Crouse, "Young Indigenous Activists Lead Climate Justice Action in Alaska," *High Country News – Know the West*, December 19, 2019, https://www.hcn.org/issues/52.1/indigenous-affairs-young-indigenous-activists-lead-climate-justice-action-in-alaska.
[82] Emily Schwing, "Indigenous Youth Take Global Stage in Madrid to Voice Climate Change Worries," *The World from PRX*, December 5, 2019, https://theworld.org/stories/2019-12-05/indigenous-youth-take-global-stage-madrid-voice-climate-change-worries.
[83] [sic]

endeavor happens to include fighting climate change. Peter added to her friend's response that their goal was to protect Indigenous rights and culture for generations to come, and that "economic growth and money is not a part of that conversation".[84]

However, Patkotak is not alone. In their anthology chapter titled "Arctic energy policy: global, international, transnational and regional levels," Aalto and Jaakkola note of the Arctic region's attitude towards energy policy as a whole that "the local people, indigenous peoples among them, do not only suffer from the resource extraction industry; increasingly they are also promoters and beneficiaries of such developments and therefore do not represent a homogenous group with shared interests".[85] Indigenous communities around the world are hugely diverse in every way that a group of people can be diverse. It would be presumptuous to think that just because these people are all indigenous that they would have the same commitment to and attitude toward nature as is stereotypical of the group. It is important that we make this distinction of ideas as we discuss the importance of the "indigenous perspective" on climate solutions, because this label is misleading and is not the outlook of all people who are indigenous.

One grassroots initiative called the Climate Justice Resilience Fund "makes grants that support women, youth, and Indigenous Peoples to create and share their own solutions for climate resilience. CJRF puts people, their rights, and their lived experience directly at the center of climate action… Since its launch in 2016, CJRF has pooled US$25 million in service to more than 40 major grant partnerships around the world".[86] The group is funded by philanthropists and private foundations. While the CJRF is not a specifically Arctic-focused organization, it is

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[84] Emily Schwing, "Indigenous Youth Take Global Stage in Madrid to Voice Climate Change Worries," *The World from PRX*, December 5, 2019, https://theworld.org/stories/2019-12-05/indigenous-youth-take-global-stage-madrid-voice-climate-change-worries.
[85] Jensen and Hønneland, *Handbook of the Politics of the Arctic,* 139.
[86] "About Us," Climate Justice Resilience Fund, 2021, https://www.cjrfund.org/about-us.

currently providing funding to Alaskan advocates who are in need of specific assistance. The group supports three main points specific to the Arctic climate issues. One is that they support "indigenous climate advocacy coalitions and structures to support exchange and peer learning among adapting communities". Another is that the fund "supports people and organizations that maintain, update, and augment Indigenous knowledge and adapt and sustain traditional livelihoods, resource stewardship, and wild food access". Finally, and arguably most importantly, they "pay particular attention to the challenge of climate-forced displacement in the Arctic, where ice loss and erosion of tundra have led some coastal villages to relocate. [They] support rights-based, community led approaches to relocation that safeguard life, livelihoods, community integrity, and self-determination".[87]

Funding for adaptation and relocation efforts does not necessarily need to come from governments, especially since there are few federal funds to go around when it comes to addressing climate issues. The CJRF does the critical work of connecting communities to pots of money and to nonprofits that are designed to assist them, but are difficult for the communities to reach.

Chapter 5: How We Can Pump the Brakes On Positive Cycles

Although I am focusing on the positive feedback loops associated with sea ice melt and permafrost thaw, it would be incorrect for me to claim that these forces interact independently of negative feedback loops, which can counteract or decrease Arctic warming. The albedo effect (reflection of the sunlight's heat) of the planet's polar ice caps, ocean circulation disruption (slowing ocean movement disrupting nutrient cycling), and ocean acidification (the changing pH of the ocean), among what I'm sure are a multitude of other phenomena, are more examples of

[87] "Places," Climate Justice Resilience Fund, 2021, https://www.cjrfund.org/places.

feedback loops that operate in the Arctic. The albedo effect is an example of a negative feedback loop, while ocean circulation disruption and ocean acidification are positive. Actions that would mitigate, halt, or reverse the effects of sea ice melt and permafrost thaw also have interconnected effects upon all Arctic feedback loops, both positive and negative. Real solutions, not just symptom treatments of individual positive feedback loops, will have global effects. Not only nature's own cycles and processes can act as negative feedback loops to mitigate global warming, but so can human actions and processes. After all, it was human actions which in the first place started the excessing warming and triggered the positive feedback loops in nature. I will be putting forth four policy recommendations with which humans will have the potential to act as/contribute to negative feedback loops, provide positive feedback loop mitigation, and/or make adaptive changes to account for their changing climates.

Energy. Informed by my research, the first action that I believe will further humanity's collective climate goals in general is one that people have been talking about for decades: switching to utilizing only 100% renewable energy sources. You're probably wondering how this suggestion connects to the specific issues in Alaska with sea ice melt and permafrost thaw. It is clear by now that GHG emissions from human activity are the primary driver of climate change as a whole. These heat-trapping gasses are responsible for the bulk of the abnormal warming that Alaska, and the entire world, are experiencing. Permafrost thaw and sea ice melt are products of the ever-warming climate, meaning their solutions don't reside in efforts to make ourselves more comfortable with the presence of these feedback loops, but in dramatic changes that aim to remove the cause of them altogether. Efforts to stabilize homes built on permafrost land and raising our sea walls higher to protect coastal infrastructure are necessary adaptive efforts, but moot points in the conversation of actually solving the issues of rising seas and thawing ground.

Divesting from fossil fuels is often viewed as the obvious, but nearly impossible solution to climate change. The use of oil and natural gas is so deeply embedded into our daily lives that the idea of having to rework the status quo that affects nearly every aspect of our modern lives, to many, sounds expensive and exhausting. However, it has been proven that switching to renewable energy sources will not only reduce our contribution to the greenhouse effect drastically, but improve the economies of states and create jobs.

It is true that concessions will need to be made. At the moment, fossil fuel energy is required in order to make the solar panels, wind turbines, and other equipment that we need in order to harness renewable energy. Many of the components required for the physical assembly of these clean energy capturers are oil based plastics and heavy metals. It is true that these plastics are not going anywhere anytime soon due to their convenience and affordability of manufacturing. All of this in mind, the benefits of renewable energy still outweigh the costs. Solar panels, for example, have energy paybacks of one to four years, but remain in working condition for up to 30 years. The carbon footprint of creating solar panels is paid back more than seven times over. In economic terms, renewable energy is already the cheapest energy option in most countries, and it's getting even cheaper. "The cost of electricity from solar power fell by 85 percent between 2010 and 2020. Costs of onshore and offshore wind energy fell by 56 percent and 48 percent respectively".[88] These dropping prices are reflective of the long term payoff of investing in renewable energy sources. If I buy a wind turbine today, I will have to shell out more money than I would ever want to pay for an electric bill, but in a few years time, I won't have to worry about my electric bill at all. For people who buy their energy from the grid, the companies

[88] "Renewable Energy – Powering a Safer Future," United Nations (United Nations), accessed November 27, 2022, https://www.un.org/en/climatechange/raising-ambition/renewable-energy#:~:text=Renewable%20energy%20makes%20economic%20sense&text=But%20investments%20in%20renewable%20energy,trillion%20per%20year%20by%202030.

that own the renewable energy on the grid will also over time feel this return on investment. As the profit margin becomes wider over time and the availability of renewable energy suppliers increases, prices will continue to go down. Furthermore, if the United States did not rely on fossil fuels, we would no longer need to subsidize it. 5.9 trillion dollars were spent subsidizing the fossil fuel industry in 2020 alone.[89] If we invest 4 trillion dollars in renewable energy every year until 2030, "the reduction of pollution and climate impacts alone could save the world up to $4.2 trillion per year" beyond.[90]

Some people are concerned that divesting from fossil fuels will result in the loss of the jobs of millions of people. This is true, but if fossil fuel companies restructure themselves in preparation for an energy shift, all of these jobs could be reworked to serve the green energy sector. "The IEA estimates that the transition towards net-zero emissions will lead to an overall increase in energy sector jobs: while about 5 million jobs in fossil fuel production could be lost by 2030, an estimated 14 million new jobs would be created in clean energy, resulting in a net gain of 9 million jobs".[91] If people decide to prepare for and embrace the green transition, no jobs have to be lost and millions more people can be given work. It is critical that renewable energies be embraced and adopted into everyday life as the default form of energy so that we can slow the progression of our warming climate.

Cool Roofs. The Arctic Ocean experiences seasonal ebbs and flows in its amount of sea ice. At times of heavy ice cover, the Arctic's albedo is higher due to the whiteness and reflectivity of the snow and ice. When more of the open ocean is visible, the Arctic's albedo is lower, and the ocean absorbs more heat. As the climate has warmed over the past century due to

[89] "Renewable Energy – Powering a Safer Future," United Nations (United Nations), accessed November 27, 2022, https://www.un.org/en/climatechange/raising-ambition/renewable-energy#:~:text=Renewable%20energy%20makes%20economic%20sense&text=But%20investments%20in%20renewable%20energy,trillion%20per%20year%20by%202030.
[90] [sic]
[91] [sic]

human emission activity, we have observed less and less Arctic sea ice coverage every winter. This also means that the Arctic's albedo is decreasing, triggering further heat absorption due to more exposed open ocean, which warms the Earth, causing even more Arctic sea ice to melt. Familiarly, the loop feeds into itself.

As my second suggestion I propose an action that every homeowner worldwide can take to do their part to help reestablish the planet's dwindling albedo. It may seem mundane and low-tech, but the idea has been proven by a study out of the Universitat Autonoma de Barcelona to reduce heat absorption by cities. We should all paint our roofs white. Dubbed "cool roofs" by the study, "cool rooftops can be obtained by painting the roofs white to increase [their] albedo, that is, the percentage of radiation that reflects from the surface, and that is not absorbed by the building… cool roofs [allow] the average temperature [absorbed by buildings] to be reduced by 0.67ºC, but [are] more effective during the day, reaching a maximum reduction of 3.83ºC at 3 pm, compared to the maximum decrease of 1.63ºC at night (7h)".[92] This study was conducted on a relatively small scale in a singular city, and yet it was able to observe a difference in heat absorption of a little over two degrees Celsius. NASA scientists conducted a study as well looking at the surface temperatures of white versus black rooftops in New York City during a heatwave in 2011. They found the white roof covering measured 23.3ºC (42ºF) cooler than the traditional black rooftop which reached the temperature of 94ºC (170ºF). "The white roof being tested was a low-cost covering promoted as part of Mayor Michael Bloomberg's effort to reduce the city's greenhouse gas emissions 30 percent by 2030… Widespread installation of white roofs, like New York City is attempting through the NYC CoolRoofs program, could reduce city

[92] Universitat Autònoma de Barcelona, "White roofs and more green areas would mitigate the effects of heat waves in cities," *ScienceDaily*, May 18, 2021, www.sciencedaily.com/releases/2021/05/210518114138.htm (accessed November 26, 2022).

temperatures while cutting down on energy usage and resulting greenhouse gas emissions".[93] Absorption of the sun's radiation is a key factor in determining the temperature of the Earth. The more infrared radiation that is absorbed, the warmer the planet becomes. Therefore, the more radiation that we can reflect back off of the Earth, the better. This is part of why having an ample amount of ice and snow covering the poles is so important.

One place where cool roofs have been in use for over 400 years is Bermuda. They have white stepped roofs that are used for both albedo increasing and rain-catch purposes. The steps are meant to funnel the rainwater into gutters to be collected in tanks under the building. Since the island has no sources of freshwater, the residents need to collect rainfall to survive. This roof style is so integral to survival in Bermuda that they are now required by Bermuda's building code laws. According to the BBC, "the design of the roof has multiple benefits. Made of limestone it is heavy and not easily shifted by hurricanes and in the past it was covered in a lime mortar, which had antibacterial properties. Now the mortar has been replaced by paint. It's still white, because this reflects ultraviolet light from the sun, which also helps to purify the water. And the system has a less visible benefit too - self-sufficiency encourages islanders to conserve water".[94] Bermuda's example shows that even though cool roofs were implemented for purposes other than to increase albedo, their institution brings a multitude of benefits. If we could implement these specific white stepped roofs all over the world we could solve issues with water scarcity along with helping to cool down the planet.

Creating albedo where there once was none by simply painting our roofs white is a method in which we can all take some responsibility for bettering the state of our planet and

[93] Patrick Lynch, "Bright Is the New Black: New York Roofs Go Cool," NASA, March 7, 2012, https://www.nasa.gov/topics/earth/features/ny-roofs.html.
[94] Harry Low, "Why Houses in Bermuda Have White Stepped Roofs," BBC News, December 23, 2016, https://www.bbc.com/news/magazine-38222271.

hopefully slow the rate at which the planet would otherwise warm. As an added environmental benefit, cooler homes will require less use of air conditioning units, thus lowering our electricity bills and reducing emissions by saving us from having to burn more fossil fuels.

Objective Authority. Third, I present a suggestion to be implemented on an institutional level rather than an individual one. It has been made clear by now that emissions from human activity are the primary driver of the unnatural climate change we are currently experiencing and that the increasingly accessible Arctic Ocean will leave countries clamoring for control over new shipping lanes and extraction locations. I have determined through my research that it would be beneficial for the Arctic if humanity were to establish a third-party intergovernmental association to oversee/monitor all activities that are being carried out in the Arctic environment by corporations and states. Member states would include all members of the Arctic Council. The observer states of the Arctic Council can be allowed membership into this new association by the discretion of the member states. Each nation would appoint a representative to serve on a panel which creates and enforces Arctic-protecting legislation using the resources of each country's military. When one nation, or a corporation based in that nation, acts in a way that goes against the agreed-upon terms of environmental protection, the other member nations will hold them accountable with fines that will cover the costs of repairing the damage done and generously pay the people fixing the damage.

The majority of the work of this association would include conducting Environmental Impact Assessments (EIAs) for potentially harmful activities. The responsibility for conducting EIAs has been tossed around from party to party and reallocated numerous times by various treaties and international agreements. For example, Article 206 of the United Nations Convention on the Law of the Sea (UNCLOS) dictates that, "when States have reasonable

grounds for believing that planned activities under their jurisdiction or control may cause substantial pollution of or significant and harmful changes to the marine environment, they shall, as far as practicable, assess the potential effects of such activities on the marine environment…".[95] Under UNCLOS, it is the responsibility of the state within which the action is occurring to monitor and assess the risk of that action. For the Arctic this means that for better or for worse, governments get to decide what takes place within their borders and are responsible for regulating their own actions at sea. Essentially, the Article provides that states can drill, fish, and move as they please in the ocean with few consequences. As a result, there is increased danger of environmental degradation.

For UNCLOS to provide a responsibility structure for monitoring the possibility of pollution is a good step, however a mere assessment of risk is not a clear action in opposition to pollution. Additionally, the phrase "as far as practicable" is essentially a cop-out clause that gives the state in question complete control over whether or not to investigate their own, or a company of their national origin's actions, which would inherently be within the realm of the state's primary interests. Under UNCLOS, states get to decide, without any frame of reference, whether or not drilling new oil wells is dangerous to the environment, and since there is no outlined rubric as to what qualifies as hazardous, they can get away with nearly any decision they should choose to make on the matter. In terms of environmental protection, UNCLOS sets up a framework that supports institutional corruption. It does not go far enough to safeguard the state of the oceans, and thereby, the Arctic.

The Arctic Council on the other hand has a similar, but slightly different idea on who should be monitoring environmental actions. "The Arctic Guidelines state that the operator (rather than the coastal State) 'should carry out environmental monitoring to ensure that the basis

[95] Jensen and Hønneland, *Handbook of the Politics of the Arctic,* 168.

for decision-making and the knowledge about the marine environment are sufficient to maintain acceptable environment conditions as a result of petroleum activities'".[96] While UNCLOS gives discretion to the State of operation, The Guidelines allocate responsibility for EIA conduction to the party responsible for the action in question. While it is pleasing to know that the Guidelines take time to outline exactly what this monitoring requires, the legal framework is still vague and leaves room for dismissal of self-interested actions. They do not dictate what "acceptable environment conditions" entail.

Neither of the two agreements that I have just described set up a system of unbiased environmental monitoring. This is why I conclude that having a third-party association that seeks out, monitors, and disciplines these extractive actions if need be, in addition to the provisions already described by UNCLOS and the Arctic Guidelines, would be beneficial for not only the directly affected Arctic landscape, but for humanity and the planet as a whole in terms of emissions reduction.

I've just made a long case for this third-party association, but I have to concede that the idea can only exist in a perfect world. The current political climate between many of the desired member states is pretty hot at the moment. Russia and the United States, for example, would not be okay with being policed by the other, even if the other was a part of this collective. They don't trust each other. One of the mechanisms that makes the EU's system of legal binding work is that the member states have a mutual understanding and at least a moderate level of trust. There is also a high enough number of them that one nation's influence cannot shine too brightly over all the others. I think that the idea in theory would work, but not in the current political climate.

National Adaptation Organization. As if having to relocate is not enough, many Alaskan towns that are at risk of flooding or falling into the sea are not getting adequate support from the

[96] Jensen and Hønneland, *Handbook of the Politics of the Arctic,* 169.

government. Moving whole towns requires a lot of equipment and manpower that these communities do not have, and the government has been largely unhelpful in helping towns obtain these materials. As my fourth policy proposal I suggest the creation of an agency within the government whose sole purpose it is to provide Alaskan towns with the equipment and support necessary to rebuild their towns in safer areas. This agency would scientifically scope out viable relocation sites, provide the heavy machinery and manpower needed to move, and work with the local authorities to create the new town, all while bearing the financial cost of the whole initiative. They would also work with communities who are not yet at the brink of ruin to try to delay the necessity of relocation for as long as possible so that Inupiat communities especially may remain in their ancestral lands. This would involve building seawalls (as was done in Kivalina by the Army Corps of Engineers), and reinforcing structures built on permafrost.

It is only suitable, in my opinion, that the government should pay for the cost of these relocations since residents have found themselves in peril by no fault of their own and the government has done little to prevent this environmental danger from reaching their doorsteps. However, I recognize that the American government is not a money-pit and it would be incredibly difficult to find enough funding to cover the costs of relocating every Alaskan town that faces environmental dangers. In the case of little government funding, the Adaptation Organization would be responsible for getting the necessary equipment to and from these remote communities so that they may move on their own. Funding for this could come from the same pools that fund disaster relief groups like FEMA (Federal Emergency Management Agency).

In an article from the Washington Post, Robin Bronen, a director of the human rights group the Alaska Immigration Justice Project and senior research scientist at the University of

Alaska Fairbanks comments about the same governmental issues that my idea for an Adaptation Organization seeks to address. “There’s no government agency that has the responsibility to relocate a community, nor the funding to do it… It means that for communities like Kivalina, they don’t know what steps they need to take to get which government agencies involved”.[97] Having one centralized organization to turn to to prevent and recover from climate-related dangers would lessen the complexity of seeking government aid and improve the lives of the residents of remote Alaskan communities.

In summary, humanity has a lot of work on our hands. International politics and the structure of the nation-state system make it a lot harder to actually accomplish pervasive change, but bit by bit, mitigation and even reversal is possible. By maintaining humanity’s current upward emissions trend, we will incur near worst-case scenario outcomes. Only finding ways to return to pre-industrial emissions levels will lead to the slowed or halted warming of the earth. With a cooler planet permafrost melt rates will slow and hopefully refreeze, truly permanently this time, trapping as much of the still unreleased carbon, methane, and toxins as it can along with it. The cooler planet will also allow sea ice to bounce back winter after winter, the warm seasons retaining more ice year round every year that goes by. It will be difficult for the water cycle to return to its pre-industrial state, but hopefully with more ocean ice freezing every winter it will regulate itself so that there are fewer intense storms and coastlines remain intact.

This outcome is a climate scientist’s dream, but it feels more like a pipe dream. If we were to somehow very suddenly begin removing more carbon dioxide from the atmosphere than we add, “some climate change trends, such as the increase in global surface temperature, would

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[97] Chris Mooney, “The Remote Alaskan Village That Needs to Be Relocated Due to Climate Change,” The Washington Post, October 27, 2021, https://www.washingtonpost.com/news/energy-environment/wp/2015/02/24/the-remote-alaskan-village-that-needs-to-be-relocated-due-to-climate-change/.

start to reverse within a few years. Other aspects of climate change would take decades (e.g., permafrost thawing) or centuries (e.g., acidification of the deep ocean) to reverse, and some, such as sea level rise, would take centuries to millennia to change direction".[98] Unfortunately, nearly every data point gathered trends further from what should be humanity's collective climate goals. The Arctic is on the verge of collapse, literally. What's encouraging is that action is already being taken by millions, maybe billions of people around the world, at home, every day. What needs to happen now is that significant action needs to be taken by heavy hitting actors, e.g. corporations and governments. This action needs to reflect the urgency with which the Arctic needs help adapting to and recovering from the perils that already plague the local people and landscape, and the urgency with which we need to address the perpetrator of these slow environmental disasters: human action.

[98] Sophie Berger and Sarah L. Connors, eds., "Frequently Asked Questions," IPCC AR6, 2023, https://www.ipcc.ch/report/ar6/wg1/resources/frequently-asked-questions/.

Appendix: An Interview with Dr. Susan Natali – Monday, May 1, 2023 2:30pm via Zoom

Dr. Susan Natali is an Arctic ecologist whose focus on permafrost thaw is motivated by an acute awareness of the risks it poses. She leads the Woodwell Climate Research Center's Arctic Program, which investigates the drivers and consequences of rapid Arctic changes. Her research examines the effects of climate change, including permafrost thaw and increasing wildfires, on northern ecosystems and the impact these changes have on Arctic residents and the global climate.

Dr. Natali's research team combines field research of permafrost and carbon cycling with remote sensing and modeling to assess the current and future impacts of climate change across the Arctic. She has worked extensively in remote regions of Alaska and Siberia, conducting research and, as the Director of the Polaris Project, training the next generation of Arctic scientists. Dr. Natali leads the Permafrost Pathways Initiative, which brings together leading experts in climate science, policy action, and environmental justice to inform and develop adaptation and mitigation strategies to address permafrost thaw.

Dr. Natali is committed to seeing the local and global impacts of a rapidly changing Arctic incorporated into policy. She has briefed federal lawmakers, testified before the U.S. Congress, and presented her work at events associated with international climate negotiations. Dr. Natali frequently speaks with the media, and has been quoted by the *New York Times*, *Washington Post*, *Newsweek*, *The New Yorker*, *CBS News*, and *BBC News,* and has presented her work on the TED stage. *(Taken from woodwellclimate.org)*

1. *What is your role at the Woodwell Climate Research Center?*

I'm a senior scientist and I'm the Arctic Program Director. I'm also the lead on the Permafrost Pathways Initiative.

2. *What is the project you have worked on that means the most to you?*

   It's definitely Permafrost Pathways.

3. *What makes the Permafrost Pathways project different from your other work within the Arctic program at Woodwell?*

   This is much larger in scale than any other project that I've ever worked on. Because of [its scale], because it is funded through philanthropists rather than shorter-term smaller government grants, and because of the flexibility and the size of the project, it's allowed the team and I to tackle the full, or what we understand to be many aspects of the permafrost problem; such as a lot of the local effects of permafrost thaw. It allows us to build the science in a partnership with the policy actions that we want to take. It also allows us a lot more freedom in the framework of giving us the time to develop more and better partnerships with some Alaskan tribes. To really spend the time in developing those relationships is really tough to do in other types of projects.

4. *One of the key missions of the Woodwell Climate Research Center is to bring the findings of climate science research toward informing policy makers whose role it is to enact policy regarding relevant contemporary issues. In the spirit of Woodwell's motto, "climate science for change", how has your research informed climate policy in the United States?*

A lot of it is work in action, so we're trying to do a couple of things. One is how do we do our science in a way that is useful to policymakers? Thinking about international policy, which also is relevant because the US is part of the Paris Climate Agreement, really means getting the science out to climate policy makers and also communicating it in a way that is useful. We think a lot about what will happen to permafrost when it thaws, under different emissions scenarios. We've also heard from policymakers and they really want to know what it means for 1.5ºC or 2ºC goals, so one of the things we're changing is doing our modeling in a slightly different way so we can come up with the information in the way that will be useful for policymakers. A lot of that work is working with our partners who live on the permafrost and meeting with different government agencies that make and implement regulations that are relevant when thinking about climate change in the Arctic. Working with government agencies to provide support to develop guidelines for communities that may be picking relocation sites, we ask, what are the environmental criteria? We currently don't really have that written down or a really clear framework for that in the United States. It's also thinking about questions about permafrost thaw and other slow-onset events that are increasingly becoming relevant as climate changes, like how does policy deal with that? Right now it doesn't. We have FEMA that primarily deals with hurricanes and larger disturbance events, but we don't have anything like that for permafrost damages. Those are the types of things that we're doing to make this work policy relevant.

5. *As a student of the environment, my peers have often asked me if there's hope for us. Do you think there's hope that we can preserve the Arctic as it is today? Is it possible to return to pre-industrial or 1950s emissions levels?*

    There will definitely be changes in the Arctic that are impacting people and lands and water because that's already happening. We've already made the changes, we can't just turn a switch and turn it down or go back, so there is going to be some additional impact. Where there is hope is that we can reduce that impact. Maybe that's not as exciting as it is to say that we can totally stop this, but we are already committed to some of those changes, people are already impacted, and people will continue to be impacted. I guess the hope is that we can provide support for the communities that are impacted, we can reduce that impact, and that's, to me, where the real work lies. Like how do we make this less bad and more fair and more equitable. And maybe in that, yeah we know people are going to be impacted, but we can think about how we function in this country in dealing with climate change and how we can do things better than we did the first time around. Can we make this a process where indigenous peoples and others being impacted are taking the lead and driving the decision making in terms of what happens and what our response is to climate change.

6. *As Woodwell's research has proven, releasing carbon stored in Arctic permafrost would raise GHG levels beyond the tipping point from which the effects of climate change may be irreversible. Most of the literature and reports I have read talk about reaching that tipping point in terms of "if" it happens. Do you think that emissions levels will reach*

this tipping point or perhaps already have? Is it still within our power to prevent the release of permafrost carbon? If so, do you think people will actually use this power?

There's a challenge with the term "tipping point" with permafrost because I feel like it's not one entity, it's this humongous place. There's the whole idea of a climate tipping point and then there's a localized tipping point, so there are some places where yes, the permafrost is going to thaw and places where it's already thawed, there's ground collapse, and we're not going back to how it was. You can refreeze it, but when the ground collapses and you get all that change in shape, we're not in our lifetime going to see it as it was. It's more that we're not going over a cliff, but we're maybe walking down a staircase. And it's harder to get back up. We've gotten to a point where now we've committed to additional permafrost that is going to thaw and when it thaws some of that carbon is going to go out into the atmosphere. Because the controller of permafrost thaw isn't necessarily direct, the solution may be protecting tropical forests, pulling CO_2 out of the atmosphere, or other ways of controlling it, so it's a tricky question to answer. So to give a short answer to that, no, I do not think we are at a tipping point. In some places, yes, we have already committed to thawing so there are localized places where we have passed that tipping point, but I think overall for the full Arctic the actions we take now can have an impact and it's not like we are on this runaway train and there's nothing we can do because the Arctic is going to thaw. Really, we need to vastly increase ambition on fossil fuel emissions now and the sooner the better. The longer we wait the more that's coming and the harder it's going to be because that's all the more emissions that we've committed to permafrost thaw.

7. *What roles have indigenous communities played in your research and/or how has your research affected their lives/lifestyles?*

In Permafrost Pathways we have ten Alaska native communities that are partners on the project; two, we've already started working with really closely. The way we work with each community kind of varies community by community on what their needs are, so a lot of the work that we're doing with them comes from their requests and needs for getting quantified rates of change. The communities know the changes that are happening, but say, to open up government agency support, they need to know that this variable X changed Y amount over the past year or the past ten years, and that information is very helpful. We also do some modeling for future projections of permafrost change. These are all communities that are really impacted by permafrost erosion and flooding and are making adaptation decisions. The work is providing the technical support for them to be making adaptational decisions. I think that in terms of what the indigenous communities have done for the research that I do… I don't know the landscape that well, like I'm not from there, and these communities and the people we work with, they live there, they hunt there, they fish there, their parents live there, their grandparents live there, so they have a really deep knowledge. I may be able to look at a map and see some changes in the land that are happening and say "I think this may have to do with permafrost thaw", but without their knowledge, without their wisdom, I don't know… You need somebody who has that in order to make the numbers make sense. The other thing is they have a really holistic view, like as PhDs we tend to get really narrow in scope. I talk a lot about permafrost, but it really is the whole system that's changing. I find that my indigenous colleagues haven't taken the world apart like PhDs tend to do,

for them the world is connected. They come at a problem seeing it from that connected space and that's actually really helpful for me in thinking about how I do my science, the impacts of the work, and just like how I think. I think it's a better way of thinking, we scientists tend to take it apart and then we work with lots of people and say we're doing interdisciplinary work and we try to put it back together again, but looking at the system as a whole I think is necessary and valuable. It's particularly valuable when thinking about climate change because its impacts are so complex and its solutions are so complex that you really need that more comprehensive way of seeing the world.

8. *From your perspective, how important has indigenous involvement been in the fight for climate justice and policy reform?*

I think it's critical. I think there needs to be more. I mean I think honestly the reality is that, at the table, indigenous knowledge holders and leaders aren't always there with decision makers at the federal level. But I think we're working on that, and we've had a couple of really fruitful meetings with a lot of tribal leaders, community leaders, and federal agencies where everyone has been in the same room. Overall I think it's key and more would be better.

9. *Do you think that the United States government is doing enough to safeguard the well-being of the Arctic environment, American citizens, and the local indigenous communities in Alaska that are being disproportionately affected by the effects of climate change?*

No. Nowhere near enough. I think there's been great progress and some pools of money that have opened up recently, but so much more needs to be done. Right now it seems like here's a pot of money, there's a pot of money, there's another pot of money, but there's no big picture leadership thinking and action taking place. There are communities who need to move homes because they're sinking from permafrost thaw or are on the verge of eroding, and these communities, that have moved homes themselves without support, don't have a truck because they don't have large equipment because the equipment broke. So here we are where there are many communities who are capable of doing this on their own but can't because they don't even have the infrastructure and we don't even have the mechanism in this country to figure out how to get equipment to them. These are communities who need to respond to climate change who are dealing with this by no fault of their own, so we are so far from doing enough. There's a lot of inertia in the government and I think there are a lot of people who really want to make a change. It's just a major challenge with lots and lots of barriers. To me, all of the energy and all of the agencies and all of the scientists and indigenous leaders need to be in a room and this needs to be prioritized. There have been other things in the history of the US where we said "this is a priority we need to put this front and center and let's find a solution" and that needs to happen here because the situation is, for many communities, dire, and it's not getting any better. When we want to do things we can do things, so climate change needs to be raised up.

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