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Arctic Plant Life Under Siege:

The Dire Implications of Arctic Warming in the Age of Climate Change

Majestic ice formations in Greenland

https://science.howstuffworks.com/environmental/earth/geophysics/ar

When someone says the word Arctic, what comes to your mind? Perhaps it is a vision of an Eskimo, wading through the blowing snow of a winter blizzard in pursuit of dinner for his family. Or maybe it is those old Coca-Cola commercials that come to mind, and you imagine a polar bear lounging on an iceberg with its pups. To most, what comes to mind is a limitless expanse of snow and ice. In fact, type 'Arctic' into Google images and this is exactly what you will find.

Snow buttercup emerging after winter.

https://phys.org/news/2018-10-coverage-threaten-biodiversity-arctic-nature.html

It is very unlikely that green appears anywhere in those visions. Apart from those who have not traveled to or studied that Arctic, many of us do not understand the vital role that photosynthetic plants plays in the ecosystem of the Far North-- a region where resources and nutrients are already limited. As the effects of climate change are beginning to become apparent, many plant species are under siege from rising temperatures and climate variations that threaten their continued existence in the harsh landscape of the Arctic.

Frigid Flora: Surviving the Cold

Because the conditions of the Arctic are so harsh and vary greatly with seasonality, the plants that inhabit these ecosystems have generally adapted to grow together and close to the ground[1]. Many species of lichen, moss, and vascular plants call the Arctic their home, though the Low Arctic is much more diverse floristically than the harsher High Arctic[1]. Plants that grow in the Arctic have adapted to the harsh climate in a number of different ways[2]. These include reproductive adaptations such as perennial growth and seed dormancy that is triggered by

photoperiod, low temperatures, and drought. They also develop adaptations that affect food storage and photosynthetic processes that capitalize on production when the climate allows for it. But, perhaps the most important of adaptations are those that allow for survival even after the ground has hardened and winter freezing has set in[2]. Despite our preconceptions about Arctic plant life, some of the most iconic and important plants to the Arctic ecosystem are flowering. The purple saxifrage, prairie crocus, and Arctic poppy all brave the harshness of the Arctic climate and bloom-- providing food for grazers and beauty in an otherwise barren landscape[3]. Many Arctic plants are also used for medicinal purposes such as the bearberry bush that flowers each spring and provides berries for wildlife[4]. Also important to the Arctic ecosystem are lichens and moss. Lichens are both one of the primary producers in the Arctic and one of the most biodiverse groups of organism. Though they may not seem like much, this composite organism comprised of fungi and algae or cyanobacteria growing together are one of the main grazing plants for animals like caribou[5].

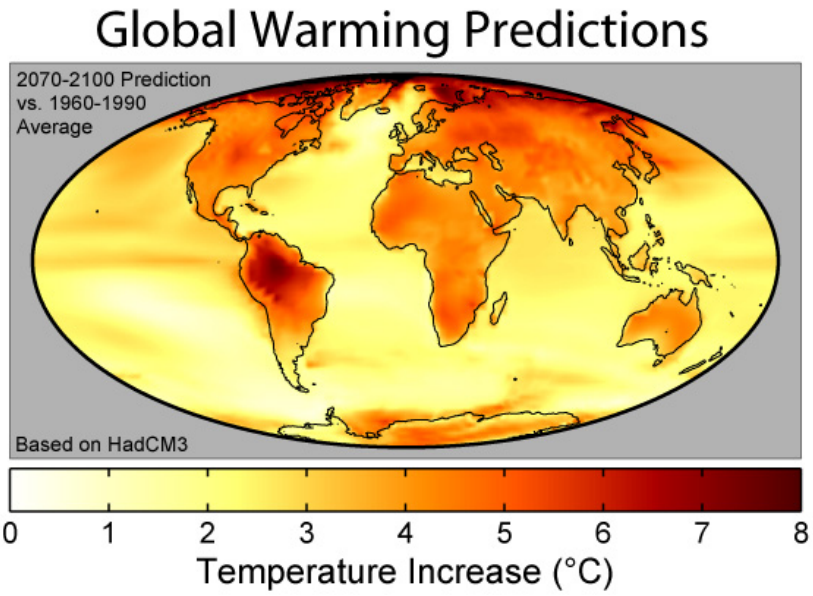
Mosses are also an essential part of the Arctic ecosystems. With waters that typically hover around 0°C, mosses are often the only multicellular plant that can grow in aquatic environments. Mosses grow slowly-- as little as 1 cm per shoot per year-- to conserve nutrients and increase the likelihood of being able to survive to the next reproductive cycle when more sunlight and nutrients become available[6]. No matter what species you look at, plants play an essential role in the Arctic community, which explains the immense concern for their continued survival.

The boreal pixie-cup lichen (Cladonia borealis) can be found on soil and rock in arctic and alpine regions.
NPS Photo / Nina Chambers

Why is temperature so important?

Though many of you are probably familiar with the influence of climate change on changes in temperature, you may be unsure of the direct and indirect affects that this can have on an environment. Here we will specifically address the impact on Arctic plants, although many similar affects are being experienced around the globe. If we begin by thinking solely about the implications that Arctic warming will have on plant life, the benefits are obvious. Less snow and warmer temperatures means longer growing seasons and therefore greater primary production, but composition and abundance changes to this basal trophic level will have cascading effects on all other trophic levels[7]. First, lets address the direct implications that an increase in temperature may have on Arctic flora. Generally studies show that plants' response to warming varies significantly between species[7,8]. This includes changes in number of inflorescences, inflorescence height, leaf length, and day of flower emergence-- measurements which can give insight into plant

growth and reproduction[7] . Despite differences in the magnitude of impact, most Arctic plants in simulated warming experiments saw a general increase in productivity. However, there was a marked decrease in productivity in the long-term (13-18 years) as compared to short-term (1-6 years)[7]. This long-term lag in productivity is likely due to adaptations developed to return the plant to an optimum equilibrium. Studies have shown that plants that have a faster generation turn over rate are able to adjust to changes in temperature more quickly[9]. This means that while certain Arctic plant species may be able to adapt to changes in temperature without significant detriment, those that reproduce slower (such as mosses) will face greater challenges. The greatest implications faced



Map of average global increase in temperature due to climate change.

http://ete.cet.edu/gcc/?/globaltemp_teacherpage/

Polar bear wading through blooming Arctic foliage.

https://www.treehugger.com/climate-change/arctic-becoming-lush.html

by Arctic plants however are the indirect repercussions caused as a result of the increase in temperature. A study conducted by Chapin et al. (1983) found that though their essential processes are impacted slightly by temperature, Arctic plants are actually less sensitive to changes than plants that grow in more temperate climates[10]. However, they were significantly more vulnerable to the indirect effects that an increase in temperature will trigger-- specifically the rate of resource acquisition[10]. Another concern is that as northern temperatures increase, species that typically grow in warmer climates will begin to encroach on Arctic territories. A case study done by Stubbs et al. (2018) used purple saxifrage to study the implications of climate warming on cold-adapted plants. The results showed that under current warming predictions, there would be an average geographic area loss of 72% of cold-adapted plants as they are forced to migrate further North-- both as they are pushed out by incoming temperate species and forced to seek an area that meets their temperature requirements[11]. The loss will be even greater for species that grow in high elevations as their ideal climate, unable to shift to a colder environment as it will not exist, will disappear[11].

The northward range migration of temperate plants will also put the delicate balance of the Arctic trophic system under stress as invasive species will begin to compete for the already limited amount of resources that the Arctic has. Plant species that consumers have depended on for nutrients for thousands of years could become scarce, and there is no guarantee that a suitable replacement will be colonized in their place. The unknowns of what might happen to Arctic flora as warming continues are vast, but the implications are even more severe. The direct and indirect repercussions of temperature changes are likely to have drastic effects on the composition of plant life-- an imbalance that could prove deadly for life at every trophic level.

Plants, Pollinators, and Phenology

With the capability to have the largest impact on not only plants but the Arctic ecosystem at large, the phenological mismatches that are likely to occur because of climate change are not to be overlooked. Phenology describes process in plant and animal life cycles that are tied to seasonality and typically is influenced by both temperature and photoperiod[12]. For Arctic plants this includes processes like growth, budding, and flowering that are typically correlated with snow melt. However, as climate change increases the average temperature and effectively shortens winter, these phenological processes are beginning to happen earlier in the season. This has implications in a variety of different ways. Research on vascular plants native to Greenland found that with earlier snowmelt there was an increased chance of plants dying due to exposure to freezing conditions-- as weather changes can be highly variable as seasons transition from one to the next. Additionally, it has been shown that the greatest predictor of net ecosystem productivity is the correlation between the timing of ecosystem CO_2 release with the growth of photosynthetic plants[14]. Just after snowmelt (early July), the ecosystem releases CO_2 into the atmosphere, and just a few days after this snowmelt the ecosystem became a CO_2 sink as plant life began to grow[14]. If the timing of these two events got mismatched and the seasonal release of CO_2 became discoupled, plants could lack the resources they need to be able to grow. This could drastically decrease the net primary productivity of an ecosystem, or even alter the hierarchy of dominant plant species[14]. Even more impacts are

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https://oceanservice.noaa.gov/facts/coralreef-climate.html

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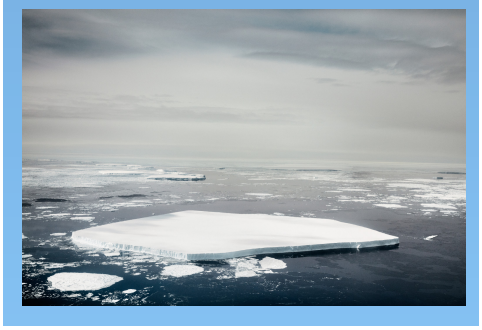
https://www.climatechangeinaustralia.gov.au/en/

Antarctica

https://discoveringantarctica.org.uk/challenges/sustainability/impacts-of-climate-change/



likely however, as these seasonal changes will alter the relationship between plants and their pollinators. Phenological research shows that changes in flowering and gamete production due to temperature changes can alter the relationship between pollinator and plant[15]. While this can have rebounding effects on all plants that rely on fertilization for reproduction, the effects would be stronger for those that rely fully on pollinators to propagate their lineages. Research on Arctic plant and pollinator interactions seem to suggest that this mismatch would more strongly affect plants that bloom early in the season than those that bloom later[15]. However, they recognize that the subtleties of these changes are hard to predict and many Arctic plant-pollinator interactions and unknown. One of the final impacts of phenological mismatches is on the relationship between plants and their consumers. Simulated mismatch scenarios show important interactions between the peak of plant production and migration

Flies are one of the main pollinators in the Arctic.

https://phys.org/news/2016-09-flies-key-pollinators-high-arctic.html

patterns of primary consumers[16]. A decoupling of these two events could result in a situation where a necessary plant was consumed before migrating consumers returned or where migrating animals returned with their primary food source still underground. The implications that shifts in phenology have on the Arctic ecosystem are vast and difficult to predict, and as warming continues to worsen, the effects are likely to only become more dire.

Save the Plants

Though the Arctic might seem like a snow-laden wasteland to the outside observer, this vast ecosystem is home to many diverse organisms that cannot be found anywhere else on the planet. Plants should not be discounted in this assertion. The plant life found here is beautiful and vast and essential to the continuation of life in the Arctic. Arctic plants evolve slowly and many of the species have been present for more centuries than humans could fathom[17]. So the next time your heart strings are pulled by the World Wildlife Foundation and you open your wallet to save a polar bear, remember the plants. Show them some love too.

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Final page image hyperlinks:

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http://www.indefenseofplants.com/blog/2018/10/1/arctic-vegetation-is-growing-taller-amp-why-that-matters

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