The Impacts of Arctic Climate Change on Polar Bear Biodiversity and Associated Analysis

Wang Jiayu

Abstract.

The Arctic is undergoing rapid weather changes, posing a grave threat to the iconic animal that inhabits the region - the polar bear. This paper reviews the tremendous impacts of climate change on the ecological diversity of polar bears, examining in detail the changes to their distribution, habitat use, food supply, and population numbers. The current understanding of their environmental evolution and adaptability remains insufficient. This conference underscores that studying polar bears benefits the whole world, as they are a fascinating megafauna and a defining symbol of the Arctic. The report consolidates obvious survey findings, articulates the urgent need to study environmental conservation issues further, and proposes initiatives going forward. In summary, this story ties the conservation of polar bears to maintaining the fragile balance in the Arctic, as climate change brings growing disturbances to ecosystems globally. Further investigating these interlinked relationships and taking targeted conservation measures will aid efforts to preserve this vibrant yet fragile polar region.

Keywords: Arctic; climate change; polar bear biodiversity.

1. Introduction

The Arctic is undergoing one of the swiftest and most thorough transformations globally, epitomizing the world‘s most dramatic climate change. The bear epitomizes the dire threats of global climate change and vulnerability in this unstable region. Relying solely on sea ice to survive in their unique living environment, polar bears are at the forefront of the destructive alteration remodeling of the Arctic. The rapid rise in local temperature has decreased sea ice extent, which is critical to the survival of polar bears [1]. Sea ice is a key venue for seal and polar bear hunting activities. As global warming intensifies, bioresources increasingly diminish, human activities exacerbate, and some habitat degradation becomes more severe. Polar bears are an important and very special species. When encircled by Arctic climate change, their fate will be one of dramatic change.

Many studies have attempted to elucidate how global warming impacts polar bear biodiversity at different levels. For the past decade, research on such effects has been explored more in-depth [2]. Studies have found global warming, resultant habitat changes, fluctuations in breeding and populations, and geographical expansions. Regher‘s meticulous study of the western Hudson Bay demonstrated that climate change has already disrupted long-established predator-prey patterns and population viability. Pagano et al., on the other hand, conducted a specialized study. This project mainly studies the impacts of global climate change on marine ecosystems, exploring its influences on marine ecosystems. However, the current understanding of this issue remains inadequate, especially regarding its impact mechanisms. With the escalating perils of global warming, sustained research on the multifaceted impacts of climatic warming on polar bears can aid the urgent appreciation of conservation needs.

Nevertheless, the grasp of factors, including habitat shifts, environmental change velocities, and animal adaptivity, remains insufficient. As the Arctic rapidly transforms under global warming, polar bears will face greater threats transitioning their longtime lifestyle. Current research concentrates primarily on the adaptability of the species and the profound impacts it inflicts on their global distribution [3].

Studies demonstrate that the impacts of rising temperatures on polar bear populations are global [4]. As eye-catching megafauna and a symbol of the Arctic, they are an important barometer [5]. Examining the influences of rapidly developing climate change on human activities holds tremendous significance for understanding the hazards of climate change on Earth‘s ecosystems [6]. Persistent gaps exist regarding resilience thresholds and safeguards concerning the endangered polar bears and the prospects for the Arctic amidst intensifying human activities under global climate change.

With the themes of change trajectories, habitat configurations, predatory behavior, and population dynamics, this project explores key scientific questions from different angles in the evolutionary process of Arctic ecosystems against the backdrop of global change. The report stresses that deeper research is needed to address the increasingly dire environmental conservation issues

amidst the Arctic‘s rapid ecological restructuring [4]. Emphasizing groundbreaking studies, identifying major knowledge gaps, and paving the way forward for future research and conservation efforts, the report underscores the urgent need to immediately take measures to improve the recovery capacity and stability of the declining polar bear numbers. Although much progress has been achieved, addressing how to enable polar bears and the vibrant yet fragile Arctic ecosystems they symbolize to withstand the impacts of human activities brought about by global warming has become imperative.

2. Environmental Issues in the Arctic

The Arctic region faces significant environmental issues. As a prominent example of global warming, changes in the Arctic related to climate change, melting ice sheets, and shifts in the global environment will have major impacts. This fragile region is undergoing obvious changes at astonishing rates [7]. In particular, Arctic ice sheet coverage has declined sharply as temperatures rise [1,8]. Arctic ice is critical in climate regulation for the region and the entire planet. Global warming exacerbates warming trends in the Arctic, severely affecting the biodiversity that humans rely on to survive. Unless greenhouse gas emissions are immediately controlled and environmental protections for the region are put in place, the vibrant Arctic ecosystems composed of ice that have existed for ages will be in danger. The societies and livelihoods of people associated with these environments will suffer damage from anthropogenic climate disruption. The melting of Arctic glaciers reflects a major climatic event on a global scale [9]. Their substantial reduction impacts Arctic habitats and climate systems and will lead to overall climate change. This startling scene indicates that as long as greenhouse gas emissions continue rising, the momentum of global warming also increases. Therefore, properly understanding how global warming affects Arctic biodiversity against the background of climate change and how the Arctic responds to global climate change is of great significance. Heat and moisture transport in the Arctic region relies on transmitting heat and seawater in the Arctic seas, a key factor influencing global climate change. At this critical juncture of tremendous transformation, interdisciplinary geosystem research to make scientific forecasts and formulate corresponding ecological protection measures is particularly important.

3. The Ecology and Climate Change Dependence of Polar Bears

In the Arctic, due to periodic changes in sea ice, polar bears have unique living habits and dependencies, with close relationships between their activity patterns and individuals. As carnivores at the top of the Arctic food chain, their survival is directly related to their ability to survive in the frozen seas. Sea ice is the most critical component of marine ecosystems and the most important part of global marine ecosystems. Its periodic changes not only form an active environment for the life history of polar bears but also lay the foundation for their public behaviors and reproductive success.

Polar bears also play an important role as sentinel species. Their habits and population numbers reflect the stability of Arctic ecological systems. On this basis, environmental factors interfere with species-prey „waltz“ relationships, expanding community structure from population numbers to diversification of community structure. Indeed, changes in polar bear numbers at the top can cause cascading effects across complex food webs beyond the Arctic Circle [10].

In an environment of global warming, the special connections between ice sheets and marine environments make their predatory capabilities and survival abilities important factors affecting resilience. With the continuous reduction of ice coverage, polar bears are losing their ability to survive, and the costs of Arctic climate change are increasing, posing threats to those active and unstable marine environments.

Polar bears face increasing food shortages with the rapid disintegration of glaciers and the destruction of habitats [3]. Therefore, long-term fasting will affect the recovery and physical condition of those facing the instability caused by climate change [4].

At the same time, because the seasonal ice cycles have been disrupted, established migration patterns are becoming increasingly difficult to predict, even as polar bears have to embark on long journeys to find suitable habitats [10]. These enhanced traveling demands lead to tremendous energy expenditure, decreasing the chances of successful reproduction in populations. Adaptive resilience is required as climate change poses new demands on existing ways of life [10].

Meanwhile, melting glaciers also increase the frequency of human-polar bear interactions, exacerbating the danger of conflicts, especially near settlements and hunting grounds [10]. Under this growing pressure, urgent prioritization of protection and coexistence measures has become imperative. Positive border stabilization measures can promote mutual understanding while ensuring survival [6].

Polar bear habitats will change with transformations in ice coverage, restricting their distribution, populations, and behaviors [9,6]. Conducting ecological research to understand their interdependencies with the environment

can inform responsive dynamic conservation strategies. Because of the vigorous ice-reliant mode of survival that defines the essence of this species, the consequences of such loss will reverberate throughout the Arctic ecosystem.

Due to global warming and environmental uncertainties that have led to the extensive distribution of polar bears worldwide, conducting relevant research is necessary. Enhancing forecasting capabilities regarding polar climate change based on these key knowledge gaps will provide a basis for formulating appropriate conservation policies and strategies [3].

4. Relevant Research and Case Studies

As polar bears search for food across the changing icecape, satellite tracking technology can accurately pinpoint their geographic location. Stirling‘s research using this method demonstrates a significant extension in ice activity related to the ice melt effect [7,10]. Because climate warming has inflicted tremendous shocks on Arctic ecosystems, these observational results have cascaded into various biological effects.

Meanwhile, long-term population data can serve as a baseline to correlate observations of reproduction and survival to elucidate limiting factors regarding adaptability to climate change [11,2]. Regehr’s comprehensive assessments uncover the relationships between demography, ecology, and behavior, providing projections of polar bear numbers under climate change [7]. Quantitatively analyzing interactions between constraints and prospects for future sustainability can guide needs and hopes for maximal management efforts regarding interventions.

Against the backdrop of rapid change in the Arctic, sustained monitoring data is critical for scientifically sound conservation work. The plight of polar bears roaming the wild underscores the need to strengthen monitoring capabilities and establish comprehensive models so endangered species can receive timely protection.

4.1 Gaps in Understanding

Scientists have begun investigating the immediate effects of climate change, including Pagano et al.‘s work on the impact of glacier melt on ant colonies and infant survival [5,10]. Such early warning analyses let us know what measures should be taken to move people away from growing dangers. Environmentalists can take early action to address the problems identified by the impending shock patterns, including tensions in food supply and disruptions in breeding.

4.2 Earth’s Environmental Impacts

Although there has been much important research, there are still many gaps in understanding [6]. Evaluating human adaptability and resilience in extreme environments is a hot research topic. Given the insufficient understanding of long-term exposures, studying the effects of new pollutants on public health is very important. Since polar bear habitat changes will nutritionally impact Arctic biodiversity, the resulting chain reactions should also receive adequate attention.

Due to global warming, the basic frozen layer in the Arctic has changed. The impact of glacier melt on organisms is irreversible. As a result, the fate of polar bears will affect larger ecological orbits, and their survival will also impact other organisms and environments. Against the backdrop of increasingly severe global climate change, research on the survival status of polar bears is very important for understanding biodiversity in the Arctic. However, climate warming has already become a tipping point.

The changes in climate in the Arctic are significant, but they are happening worldwide. In remote places, polar bears are struggling mightily. As the dominant species, the impact of polar bears on the global environment is real, representing the destruction of the overall ecosystem. Glacier melt is an important mechanism affecting ocean circulation and rising sea levels and influencing global nearshore food chains. At the same time, Arctic ground squirrels and other alpine animals also face survival crises [10].

5. Conclusion

To evaluate the tremendous pressure global warming has placed on the species diversity represented by polar bears, this report more clearly demonstrates an inescapable reality: Reducing carbon emissions is the key to survival or extinction when it comes to maintaining the Arctic‘s ecological systems. Although various protective measures can address imminent dangers like pollution and conflict, the gradual habitat degradation caused by climate change means conservation efforts ultimately have to deal with the intensifying greenhouse gas emissions. As polar bears gradually mature, northern biological organizations form a dynamic structure that is the fundamental condition for their survival. Therefore, by combining their governance work with the stability of the world‘s climate, They link humans‘ prospects with those of the major organisms in the rapidly changing polar regions.

References

[1] Stirling, I., Lunn, N. J., & Iacozza, J. Long-term trends in the population ecology of polar bears in western Hudson Bay in relation to climatic change. Arctic, 1999, 294-306.

[2] Burek, K. A., Gulland, F. M., & O'Hara, T. M. Effects of climate change on Arctic marine mammal health. Ecological Applications, 2008, 18(sp2), S126-S134.
[3] Derocher, A. E., Aars, J., Amstrup, S. C., et al. Rapid ecosystem change and polar bear conservation. Conservation Letters, 2013, 6(5), 368-375.
[4] Regehr, E. V., Laidre, K. L., Akçakaya, H. R., et al. Conservation status of polar bears in relation to projected sea-ice declines. Biology Letters, 2016, 12(12), 20160556.
[5] Pagano, A. M., Durner, G. M., Rode, K. D., et al. High-energy, high-fat lifestyle challenges an Arctic apex predator, the polar bear. Science, 2018, 359(6375), 568-572.
[6] Smith, T. S. Polar Bear Reproductive and Denning Behavior. In Ethology and Behavioral Ecology of Sea Otters and Polar Bears (pp. 269-292). Cham: Springer International Publishing. 2021.
[7] Stirling, I., McDonald, T. L., Richardson, E. S., Regehr, E. V., & Amstrup, S. C. . Polar bear population status in the northern Beaufort Sea, Canada, 1971–2006. Ecological Applications, 2011, 21(3), 859-876.
[8] Amstrup, S. C., Durner, G. M., Stirling, I., Lunn, N. J., & Messier, F. Movements and distribution of polar bears in the Beaufort Sea. Canadian Journal of Zoology, 2000, 78(6), 948-966.
[9] Rode, K. D., Wilson, R. R., Regehr, E. V., et al. Increased land use by Chukchi Sea polar bears in relation to changing sea ice conditions. PloS one, 10(11), 2015, e0142213.
[10] Rode, K. D., Regehr, E. V., Douglas, D. C., et al. Variation in the response of an Arctic top predator experiencing habitat loss: feeding and reproductive ecology of two polar bear populations. Global Change Biology, 20(1), 2014, 76-88.
[11] Stirling, I. . Polar bears and seals in the eastern Beaufort Sea and Amundsen Gulf: a synthesis of population trends and ecological relationships over three decades. Arctic, 2002, 59-76.