Climate Change and Its Impact on Global Biodiversity

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Additional material is published online only. To view please visit the journal online.

Cite this as: Shahzad A. Climate Change and Its Impact on Global Biodiversity. Premier Journal of Environmental Science 2025;3:100013

DOI: https://doi.org/10.70389/PJES.100013

Received: 9 November 2024
Revised: 19 January 2025
Accepted: 19 January 2025
Published: 20 May 2025

Ethical approval: N/a
Consent: N/a
Funding: No industry funding
Conflicts of interest: N/a
Author contribution: Ahmad Shahzad – Conceptualization, Writing – original draft, review and editing
Guarantor: Ahmad Shahzad
Provenance and peer-review: Commissioned and externally peer-reviewed
Data availability statement: N/a

ABSTRACT

Climate change is significantly altering ecosystems and poses a serious threat to biodiversity in all types of habitats. Recent analyses by NASA's Goddard Institute for Space Studies scientists indicate that since 1880, the global average temperature of Earth has increased at least 1.1 °C (1.9 °F) and is expected to increase 4.1–4.8 °C by 2100 if effective climate policies are not implemented. Consequently, these rising temperatures drive the melting of polar ice, lead to severe weather events, and alter seasonal cycles. Marine ecosystems, especially coral reefs, face significant threats from ocean acidification and warming waters; the Great Barrier Reef has already suffered from widespread coral bleaching. Terrestrial species are shifting their ranges in response to altered habitats, creating new ecological tensions and disrupting established ecosystems. This review compiles existing research into climate impacts on biodiversity, focusing on species-specific vulnerabilities affecting, for instance, amphibians, migratory birds, and coral-dependent organisms. It explores adaptive conservation strategies from habitat restoration to climate-resilient protected areas, emphasizing global coordination, and points out the role that international frameworks like the Paris Agreement and the Convention on Biological Diversity might play in biodiversity preservation. These findings indicate a need for integrated and science-driven efforts toward ecosystem resilience in the interests of natural system stability central to human and ecological health.

Keywords: Climate change, Biodiversity loss, Coral bleaching, Invasive species, Conservation strategies

Introduction

Climate change imposes extraordinary stress on global systems, driven by many natural and anthropogenic factors, including burning wood and fossil fuels, deforestation, and general industrial activities. Atmospheric CO_2 has increased considerably, exceeding more than 40% since the emergence of the Industrial Revolution. This rise has led to an increase in global temperatures, from 1 °C to 1.1 °C, with projections suggesting a potential rise of around 2 °C by the end of the century if mitigation mechanisms are inadequate levels. This warming trend now reshapes habitats, rearranges species distributions, and could potentially put biodiversity in a different kind of jeopardy than before.

According to the Intergovernmental Panel on Climate Change, roughly half of all species are already moving their habitats or changing behaviors in response to climate pressures that range from the Arctic species affected by the loss of polar ice to the transformation of drought-ridden fertile grasslands into desert landscapes. The frequency and strength of extreme weather events such as droughts, heavy storms, wildfires, and heatwaves have started to pose direct threats to the very survival of many species. In this context, it is relevant to emphasize that bushfires that occurred in Australia during 2019–2020 were significantly intensified by the nation facing record-breaking temperatures alongside prolonged drought, leading to massive habitat destruction and the displacement or death of billions of animals.

While coral reefs house almost a quarter of all marine life, rising sea temperatures have caused widespread bleaching of coral reefs. Projections indicate that if current trends persist without intervention, nearly 90% of all coral reefs may disappear by 2050. These changes push ecosystems beyond their adaptive capacities, highlighting an urgent need for immediate effective intervention (Figure 1).

Biodiversity's Role in Ecosystem Stability

Biodiversity is one of the cornerstones of ecological resilience and provides key services to natural systems and human societies. It ranges from genetic diversity to various species to complex ecosystems that foster resilience against environmental stress. Diverse ecosystems like rainforests and coral reefs exhibit greater resilience to climate extremes due to the presence of several species that can play ecological roles, even if some are lost or compromised.

Forests serve as an important carbon reservoir, absorbing enormous amounts of CO_2. The World Resources Institute indicated that tropical forests alone can store as much as 1.8 billion metric tons of carbon per year-equivalent to nearly half of all emissions from transportation worldwide. However, these ecosystems face significant threats due to climate-driven disruptions, creating a feedback loop where the loss of biodiversity accelerates climate change and vice versa (Figure 2).

Degradation will be detrimental to these essential ecosystem services. Key services, such as pollination, water filtration, soil nutrition, and disease regulation, will have an overall impact on human health and food safety. Agricultural systems rely significantly on certain pollinators, particularly bees and butterflies. The decrease in the population of pollinators is influencing crop yields in various parts of the world. Freshwater ecosystems provide essential resources such as drinking water and irrigation for humans while supporting uncounted numbers of species. They continue to face increasing threats from rising temperatures and pollution. According to the WWF, 2023,[1] the loss of biodiversity goes beyond ecological perspectives and

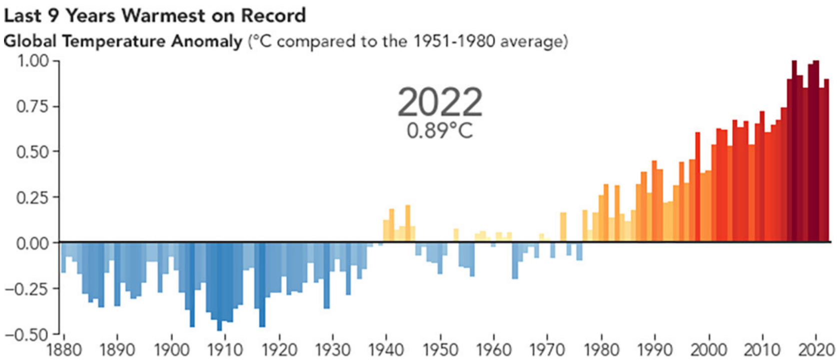

Fig 1 | Historical increment in global temperature (1881–2022)

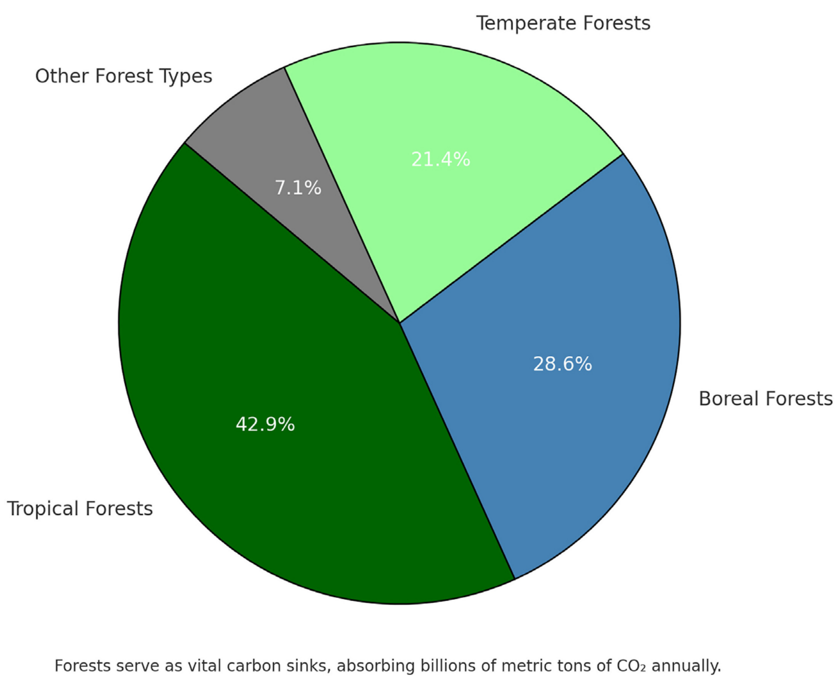

Fig 2 | Distribution of CO_2 sequestration among global forest types

presents key risks to food security, human health, and economic stability.

Mechanisms by Which Climate Change Affects Biodiversity

Temperature Increases

The average temperatures have increased by about 1.1 °C since the pre-industrial era due to global warming, leading to significant implications for biodiversity. Species with narrow temperature tolerances are especially vulnerable. For example, reptiles and amphibians have tender skins that require specific moisture levels, making them more prone to mortality under conditions of warmth. Changes in plant phenology, such as the earlier onset of flowering and fruiting seasons due to temperature changes, disrupt the timing with pollinators. According to the Japan Agricultural Journal, 2023, the consequences of such a mismatch include a loss in productivity within Japanese apple orchards that rely on simultaneous blooming and pollinator activities.[2] Polar bears face nutritional challenges as the dwindling Arctic ice restricts their platform for hunting, thus limiting their intake of calories and further affecting their reproductive success. The American pika, a small alpine mammal, cannot move to cooler habitats and faces the threat of local extinction in certain mountain regions.[3]

Extreme Weather Events

Climate change results in more frequent and intense extreme events like droughts, wildfires, hurricanes, and floods. Droughts have ruined the habitats of freshwater animals. For example, the Murray-Darling Basin in Australia has seen an alarming decline in the populations of native fish species that require stable water levels and well-oxygenated environments to survive. Driven by record levels of intense and persistent dryness, wildfires reduce whole ecosystems to ashes, with the Amazon Rainforest and California serving as prime examples. These destroy habitats on a large scale and release substantial CO_2, contributing to global warming. In Australia alone, over a billion animals were killed in bushfires during 2019–2020; many of them were koalas and native reptiles. Heavy rainfall floods cause soil erosion and nutrient loss and change water chemistry, thus impacting species adapted to stable water conditions, as evidenced by mass kills in freshwater systems (Figure 3).

Ocean Changes

The oceans absorb roughly 30% of the anthropogenic CO_2, acidifying ocean waters and further affecting marine life. The calcifying organisms such as coral, mollusks, and plankton cannot form shells and skeletons in acidic water. Coral reefs are now considered highly threatened because they are considered “rainforests of the sea,” with a high degree of biodiversity. For instance, a study shows that warming and acidification during the last three decades have caused a 50% loss in coral cover.

Furthermore, with the rise in sea level, the movement of coastal species inland is impeded, leading to additional loss of tidal habitats such as mangroves and salt marshes, which are important nurseries of many fish species and natural storm barriers (Figure 4).

Phenological Shifts

Phenological displacement, which refers to the alteration in the timing of seasonal activities, disrupts the mutual relationships within ecosystems. As springs become warmer, plants in the Northern Hemisphere are now flowering two to three weeks earlier than 50 years ago. This shift in timing has occurred independently of their pollinators, like bees and butterflies, resulting in mismatches that negatively impact plant reproduction and food availability. Migratory birds, such as the European pied flycatcher, rely on this timing to coincide with the peak abundance of caterpillars. With every new year, as caterpillars come out sooner and sooner, they consistently miss their opportunity to feed on them. This misalignment adversely

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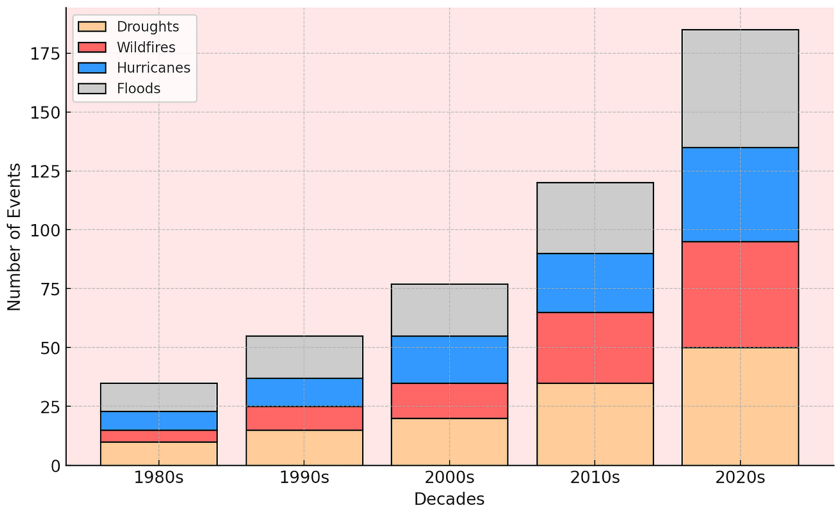

Fig 3 | Increasing frequency of extreme weather events linked to climate change

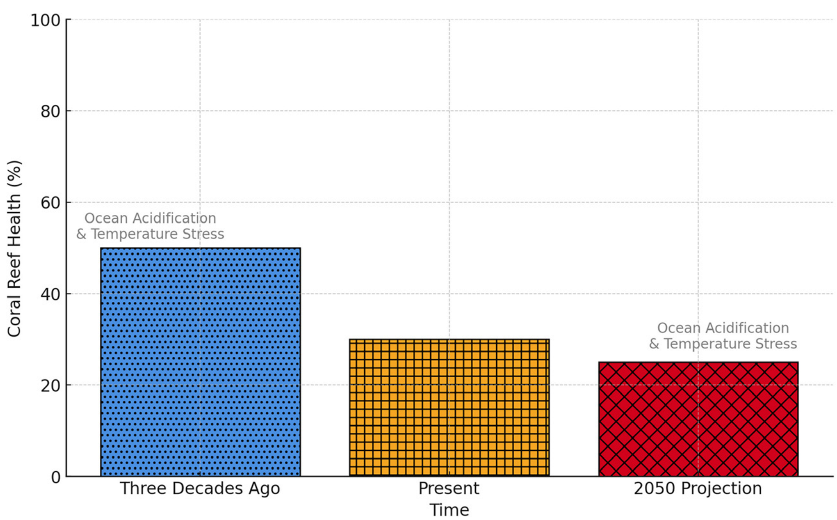

Fig 4 | Decline in global coral reef health due to ocean acidification and warming

affects their survival rate and negatively influences their populations.

Species Redistribution

This continued change in temperature and habitat drives the out-migration of species to more favorable environments, often with complex ecological dynamics. For example, while terrestrial species move at around 6 km per decade, marine species move poleward at 72 km per decade. Such migrations impact fisheries; the northward migration of the Atlantic cod has affected fishing communities that rely on such stock. In terrestrial ecosystems, invasive species like the Asian tiger mosquito, previously confined to tropical regions, now reach Europe and North America due to milder winters, posing a public health threat by spreading diseases such as dengue and Zika.

Impacts of Climate Change on Key Ecosystems

Marine Ecosystems

Marine ecosystems have been among the worst affected by climate change through ocean warming, acidification, and habitat loss. Oceans absorb around 93% of the additional heat from greenhouse gas emissions, leading to a tremendous rise in marine water temperatures.[4] A hike in temperature alters ocean biodiversity through changes in metabolic rates, reproductive cycles, and the migration patterns of species. Coral reefs are highly sensitive to even minor fluctuations in temperature, which frequently leads to coral bleaching. As many as 75% of the world's coral reefs may be at risk from warming and acidification by 2050.

Ocean acidification occurs due to the absorption of CO_2, which leads to a decrease in the pH level of seawater. The risk of dissolution increases for calcium carbonate-dependent marine organisms, such as corals, mollusks, and certain plankton. Coral reefs protect about 25% of all marine species and offer substantial ecosystem services concerning coastal protection, fisheries, and tourism.

Moreover, acidification caused a decline in calcification rates of 15–20%, impairing reef growth and stability. Fish migrate toward cooler waters at higher latitudes; for example, the Atlantic mackerel are migrating into native and new ecosystems and altering local species interactions, impacting the fishing industries of Norway and Iceland.

Polar and High-Altitude Ecosystems

Polar regions, especially the Arctic, are warming almost twice as fast as the global average. The consequences are widespread ice loss and habitat reduction for ice-dependent species. Arctic sea ice has decreased by more than 13% per decade since 1979, significantly affecting the hunting grounds and habitats of polar bears, seals, and walruses.[5] High-altitude species, such as the snow leopard and mountain pika, face similar challenges because their home ranges are shrinking due to rising temperatures. For example, studies have documented that the habitat range for mountain pikas in Asia has shrunk by more than 40% (Figure 5).[6]

The release of greenhouse gas emissions from melting permafrost, including potent methane, creates a snowballing feedback loop within the climate system. Modeling projections suggest that permafrost thaw through 2100 could release as much as 240 billion metric tonnes of carbon to fuel climate change further and, thus, impact these sensitive ecological systems.[7]

Forests and Grasslands

Climate change is seriously hitting biodiversity-rich ecosystems, such as forests and grasslands. Like the Amazon, tropical forests store about 450 billion tons of carbon, thus vital for climate regulation. These systems become more prone to droughts and fires under higher temperatures and changing rainfall conditions. For example, the Amazon fires in 2021 showed a 30% increase over 2020, affecting biodiversity and the capability of the forest for carbon storage. Habitat fragmentation due to climate change disrupts migration routes, isolates animal populations, and limits access to resources. Grasslands, including African savannas, depend on specific rainfall cycles for migratory

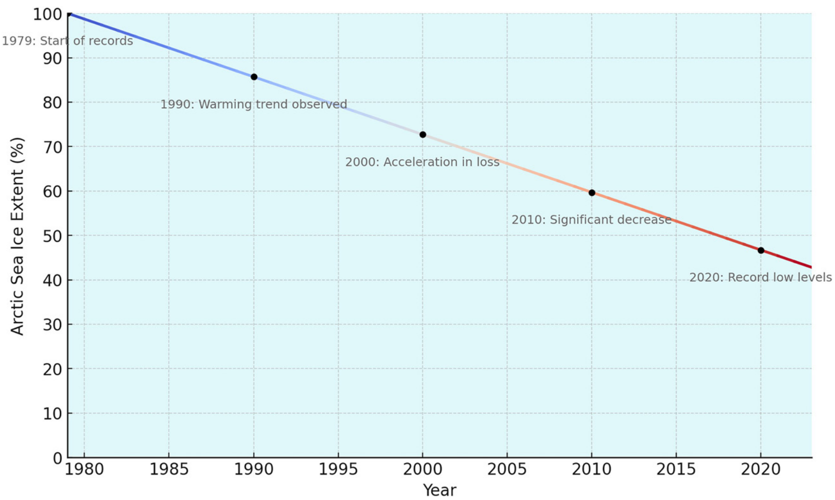

Fig 5 | Decline of Arctic sea ice extent (1979 - present)

herbivores such as wildebeests. Changes to these cycles have disrupted food supply and predator-prey dynamics within the entire ecosystem. Invasive grasses have fueled wildfires in the western U.S., changing natural fire patterns and reducing native biodiversity.

Freshwater Ecosystems

Freshwater ecosystems, including rivers, lakes, and wetlands, support a very high degree of biodiversity and provide a variety of human needs, such as drinking water and irrigation. Many species depend on such specific ecosystems. Changes in climate raise water temperatures in all freshwater ecosystems, which lowers oxygen levels and increases thermal stress. For instance, aquatic species such as salmon and trout survive and reproduce within specific temperature tolerances; once the water temperature exceeds that limit, the species begin to decline or disappear. Moreover, warming rivers in the Pacific Northwest have decimated salmon populations important to indigenous communities for cultural and nutritional reasons.[8] Changes in precipitation and long-lasting drought also cut down river and lake flows, further endangering species dependent on steady water levels. Even wetlands, which are among ecosystems with the highest level of biodiversity and serve as very important natural filters, are in danger because of warming up and pollution. WWF reports an estimated 87% loss of wetlands worldwide since the 1700s and states that the vulnerability in ecosystems has increased because of this.

Species-Specific Vulnerabilities and Genetic Diversity

Species at High Risk

Certain species, related to their necessary living environments and conditions, become highly vulnerable due to changes in the climate. For example, amphibians become highly sensitive to small increases in temperature or humidity. The physiology of the amphibia involves respiring through moist environments, which are also essential for laying their eggs and completing their life cycles; more than 40% of their species are now in jeopardy of extinction due to these habitat changes and other diseases like chytridiomycosis. The Golden Toad in Central America is a notable example of the challenges amphibians face, which are at a critical risk of extinction (Figure 6).

They also include entities like bees, butterflies, and bats, which are important in food security through the pollination of almost 75% of all crops worldwide. Climate change-induced shifts in flowering times create mismatches between pollinators and plants, ultimately reducing pollination rates and agricultural productivity.

Loss of habitat and pesticide exposure to climate stress have emerged as major contributing factors to the sharp declines of honeybee populations in North America and Europe, among other regions studied.

These biodiversity losses have, in turn, hurt agricultural economies, forcing up food prices and affecting the availability of food.

Loss of Genetic Diversity

Climate stressors add to a worrying loss of genetic diversity in many species. Genetic diversity is the raw material with which populations can adapt to environmental change. Population decline, as has happened in modern cheetahs, reduces genetic diversity, making species more vulnerable to diseases and less able to adapt. This situation was exacerbated by the genetic bottlenecks that cheetahs experienced in the past. Other risks include habitat loss and reduced prey, which portend a long-term survival catastrophe for cheetahs in the wild.[9] Indeed, marine systems, too, endure genetic erosion amidst coral populations often exposed to sequential bleaching episodes. Studies into the Great Barrier Reef have demonstrated that sequenced bleaching events further reduce the reproductive successes in affected coral populations, continuing to erode genetic diversities among corals.[10] This reduction limits their ability to adapt to ocean warming and acidification, putting coral reefs, which sustain about 25% of marine biodiversity, in danger.

Genetic loss has wider ecological implications for ecosystem stability and resilience. Salmon populations genetically diverse in the Pacific Northwest show the most resistance against environmental changes, further amplifying the importance of diverse gene pools in adaptive potential. In cases when some so-called 'keystone' species suffer a genetic loss, such systems may cause cascading effects, which will disrupt whole food webs and thereby increase biodiversity loss.

Disrupted Ecosystem Dynamics and Invasive Species

Spread of Invasive Species

Climate change promotes the spread of invasive species by altering environmental conditions and making new regions accessible to species that otherwise would not thrive in that region. Warmer temperatures, changing rainfall, and shifts in frost dates favor invasive species, allowing them to establish and outcompete native organisms. The Asian tiger mosquito,

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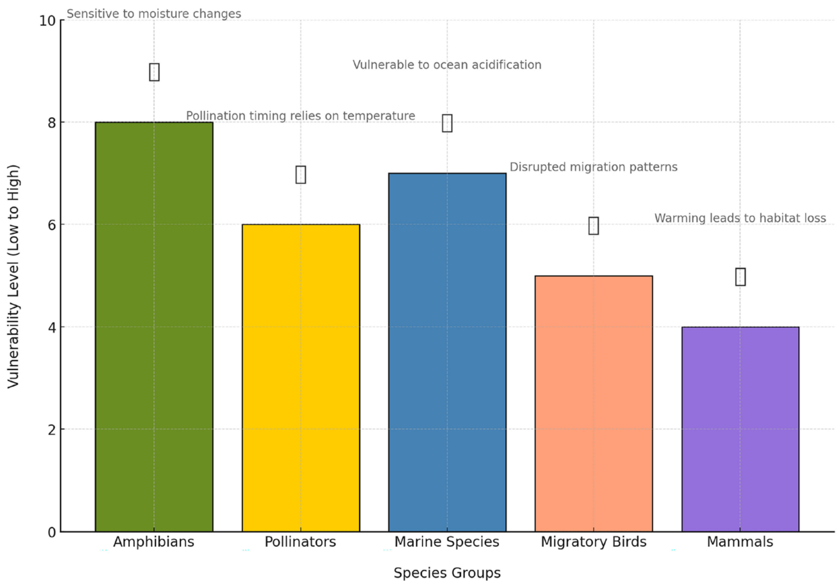

Fig 6 | Climate change vulnerability by species group

native to Southeast Asia, has invaded parts of Europe and North America, creating health hazards by transmitting diseases such as dengue and chikungunya. In aquatic ecosystems, rising temperatures have facilitated the invasion of zebra mussels in North America. These mussels clog water intake pipes, outcompete native mussels, and alter nutrient dynamics by filtering large volumes of water, thereby preventing native plankton-dependent species from receiving crucial nourishment. The spread of the zebra mussel epitomizes ecological and economic issues; thus, industry and municipalities have sometimes made costly efforts toward management.

Ecosystem Imbalance

Invasive species disrupt food webs, nutrient cycles, and interactions among species in ecosystems. Typically having no natural predators or competitors, they can increase unchecked and put excessive pressure on native species biodiversity. For instance, the brown tree snake was introduced to Guam, resulting in the extinction of most native bird species; these birds were important for seed dispersal and thus affected the reproduction of native plant species dependent on them. This loss has cascading effects, including among flora and other fauna that depend on the affected resources.

Invasive species can significantly alter nutrient cycles. Nitrogen-fixing invasive plants, for instance, enhance soil nutrients in North American grasslands, creating conditions more favorable to other non-native species than to natives adapted to poor soil conditions. This disrupts the balance of the ecosystem and homogenization, where nutrient-loving invasives dominate the landscape.

Invasive grasses, such as cheatgrass in the western U.S., increase fire frequency and perpetuate the dominance of fire-adapted species, further disrupting native ecosystems.

Altered Species Interactions

Spread and climate change-induced disruptions of species interactions generally destabilize the ecosystem and biodiversity. The relationship between mutualism is very prone to interference, where the two species mutually benefit. An instance is that pollinators depend on the exact time flowering plants bloom. Because of this, changes brought about by the climate might interrupt these interactions; poor pollination due to disrupted flowering times reduces pollination and plant reproduction, eventually decreasing food sources available for other animals.[11] Similarly, environmental change alters predator-prey dynamics. Polar bears rely on stable Arctic ice platforms from which to hunt seals. The early melting of this ice puts polar bears into using more energy to search for food, thereby cutting their survival rates. In freshwater systems of North America, the invasive northern snakehead considered a highly aggressive predator of native fish-lead to food web disruptions through native population depletions, hence causing ecosystem imbalance. Resource competition is heightened as invasive species replace native species. In freshwater systems, for example, invasive carp monopolize the plankton resources native fish species can feed on; in terrestrial systems, invasive plants superior in adaptation to a changed climate outcompete native vegetation for light and mineral resources, worsening habitat quality and food sources native animals depend upon.

Conservation efforts focused on controlling harmful species and promoting native biodiversity are critical for maintaining ecosystem resilience in the face of climate change.

Conservation Strategies and Policy Responses

Adaptation and Mitigation Strategies

An approach to the biodiversity crisis involves taking the step of being proactive in balancing adaptation and mitigation. Adaptation keeps ecosystems and species in changed conditions of the environment to maintain continuity over essential ecological functionalities. Habitat restoration remains one of the major adaptation tools that focuses on restoring degraded ecosystems by reintroducing natural water circulation or other means of revitalizing such a degraded ecosystem and uprooting harmful intrusive plant species. Everglades Restoration Project is going on very actively within the United States territory, bringing about tremendous outcomes concerning wetland recovery in the case of biodiversity.

Protected areas are fundamental to the protection of key habitats. So far, roughly 15% of terrestrial and 7% of marine areas are protected, but this needs to be extended if biodiversity under climate change is to be conserved.[12] The connection of protected areas through wildlife corridors supports species migration and genetic diversity, enabling animals to move across fragmented landscapes. In Africa, the Kavango-Zambezi Transfrontier Conservation Area crosses several countries, allowing species such as elephants and big cats to roam freely, building up biodiversity and resilience.

Among other mitigation strategies, reducing greenhouse gas emissions is very important to keep abrasion at a slower pace and lessen the impacts of climate change on biodiversity. Carbon is greatly sequestered in forests, wetlands, and peatlands. Forest ecosystems are estimated to sequester 2.4 billion tons of carbon yearly so that reforestation can be one of the most high-impact interventions. Cover cropping and no-till farming in regenerative agricultural methods improve the condition of soils to store more carbon, create different habitats, and reinforce biodiversity.

Global Policy Initiatives

Global policy frameworks form the foundation of concerted action on climate and biodiversity. While focused on climate change, the Paris Agreement under the UNFCCC supports biodiversity through calls for countries to reduce greenhouse gas emissions due to deforestation and forest degradation via programs like REDD+. Successes with reduced Amazonian deforestation demonstrate how climate policy supports biodiversity goals in Brazil.[13] The Convention on Biological Diversity addresses biodiversity directly through the CBD, promoting the sustainable use of ecosystems and the fair sharing of its benefits. It presents ambitious targets for reducing habitat loss and enhancing protected area coverage consistent with the Aichi Targets. Looking ahead, the Convention's post-2020 Global Biodiversity Framework aims to integrate biodiversity into national policies, setting new targets to conserve 30% of land and ocean by 2030.

Community and Indigenous Conservation Efforts

The role of indigenous communities in conservation is essential, as they have long practiced sustainable environmental management. Recognizing the effectiveness of community-led conservation is crucial; for example, indigenous lands comprise approximately a quarter of the world's land area and hold 80% of the remaining biodiversity. The Amazon is home to various indigenous groups that effectively manage the forest density by employing controlled burning techniques to mitigate the risk of wildfires. Research indicates that forests managed by indigenous peoples typically experience lower deforestation rates. This highlights the effectiveness of traditional management practices in maintaining ecosystem resilience amid climatic stress.

Examples of Indigenous-led conservation exist around the world. In Canada, Inuit communities collaborate with scientists to monitor marine ecosystems in the Arctic, adapting conservation approaches to reflect Indigenous knowledge and scientific data. Similarly, New Zealand's Māori community manages natural reserves by blending cultural practices with environmental stewardship, exemplifying effective biodiversity protection.[14]

Integrated Conservation and Development Plans

The primary goal of an Integrated Conservation and Development Plan is to harmonize biodiversity conservation with the needs of local communities ICDPs. Conversely, they offer livelihood opportunities that mitigate activities leading to environmental degradation and are, therefore, largely in harmony with nature. In Costa Rica, for example, ecotourism in hotspots like Manuel Antonio National Park generates income among the locals by conserving the place's natural habitat. In high-deforestation countries, the ICDPs support sustainable agriculture, such as agroforestry, whereby trees are grown among the crops. Agroforestry prevents soil erosion, stores carbon, and offers habitat for wildlife. Thus, it is a viable alternative to such destructive uses. For instance, under an agroforestry model, vanilla farming has reduced deforestation while increasing incomes locally in Madagascar- a clear example of how conservation and poverty reduction go hand in hand.[15]

Future Directions and Emerging Research Needs

Predictive Models

Climate change, and thus its acceleration, gives predictive models significance when considering biodiversity outcomes. Predictive modeling simulates several climatic scenarios and the probable impacts on the distribution of species, ecosystem functioning, and species interactions. Past climate data and projections made using species distribution models show shocking trends in the predicted northward migration of boreal species and shrinking habitats for polar species. However, most of the current models suffer from a lack of available data, especially for tropical rainforests and deep ocean areas. They are poorly parameterized to represent the complexity of ecosystem interactions. New machine learning approaches are improving model predictions by integrating real-time data, making better predictions of biodiversity change at regional and global scales. Ecosystem-level models also provide insight into changing food webs and species interactions. For example, studies of Arctic ecosystems have projected that decreased ice cover due to global warming would significantly impact the food chain and animals that rely on polar environments. This requires enhanced data collection and interdisciplinary work from ecologists, climate scientists, and data analysts, enabling proactive conservation planning according to likely scenarios.

Innovative Conservation Technologies

Technological innovations are progressively transforming the landscape of biodiversity conservation, encompassing aspects from monitoring and protection to restoration. Although it is currently in the experimental stages, genetic engineering holds the promise to enhance the resilience of some species. Scientists are testing genetic modifications in corals to increase their tolerance to higher temperatures and acidification to potentially prevent coral bleaching. While promising, such manipulation raises several red flags concerning ethical concerns and ecological risks, such as the potential spread of modified organisms to wild relatives, thus affecting natural gene pools. Combined with a responsible attitude, genetic engineering can offer new perspectives in biodiversity conservation under conditions of environmental stress.

Satellite and drone technology has transformed the monitoring of habitats through high-resolution data on deforestation, changes in land use, and distribution of species. Multispectral satellite imaging detects vegetation health and habitat degradation, thus allowing timely intervention in problem areas. In Brazil, such satellite monitoring helps to unmask illegal land-clearing sites, making it easier to protect the precious Amazon rainforest. Drones also make wildlife surveillance possible in parts of the most remote regions for tracking animal populations-from elephants moving across African savannas to colonies of penguins in Antarctica.

AI further enhances these technologies by automating data analysis to provide timely insights into ecosystem health and trends.

Identified Research Gaps

Despite these technological advances, some critical gaps exist in understanding biodiversity and climate change. One of the major areas involves cryptic biodiversity or hidden genetic diversity within morphologically similar species. Although cryptic species play unique roles in ecosystems, they generally remain unconsidered in conservation efforts. Further genetic analysis and molecular techniques would be required for such species identification, which may reveal previously unrecognized ecological interactions and conservation priorities. Another nascent field is research involving genetic adaptation mechanisms in response to climate change. Among the few species that already show adaptive traits, such as drought resistance in flora, the genetic basis for such adaptation is unknown, especially in long-generation trees. It identifies genes connected with climate resilience that could provide trends on conservation, allowing more efficient and preferential protection of populations with higher adaptive potential. In this respect, if the Atlantic salmon populations are more adapted to cool water, they can become critical in warm conditions. Furthermore, Bourret et al.[16] found that besides the deeply studied ecosystems of the world, deep-sea and some forest biomes will need urgent scientific research. In those places, truly unique species thrive under very harsh conditions. Such biodiversity knowledge is still extremely scarce. The potential to broaden these studies could lead to the discovery of new species or insights related to ecological resilience, which may contribute significantly to the comprehensive conservation of organisms.

The Need for Interdisciplinary Approaches

Such a complex relationship between climate change and biodiversity requires an interdisciplinary approach from ecologists and geneticists to climate scientists, policymakers, and sociologists. For example, climate scientists provide data on changing conditions, while ecologists assess how these changes impact species and ecosystems. Geneticists contribute insights into the adaptive capacities of species, while policymakers translate scientific findings into actionable regulations for biodiversity protection.[17–22] An interdisciplinary approach enables ecosystem-based management, for which ecological and socioeconomic factors are all considered in conservation planning. The management of coral reefs under climate stress could also include coral restoration techniques, reduction of pollutants, and proper tourism practices, requiring inputs over a wide range of fields. In the case of migratory species, such as the monarch butterfly, there is a requirement for ecological understanding of the species, securing habitat corridors through connectivity, and integrating local communities toward the cause, calling for integrated cross-sector efforts. With the increasing interconnectedness of climate and biodiversity challenges, interdisciplinary frameworks are fundamental to building resilient ecosystems that can survive future environmental stresses. Any effective conservation will be rightly based on the integration of science. Technology and socioeconomic considerations thereby form the bedrock for sustainable biodiversity conservation.[22–30]

Conclusion

Climate change is an unparalleled threat to global biodiversity through altering ecosystems and putting innumerable species at risk. This review highlighted the significant impacts of rising temperatures, extreme weather events, ocean acidification, and changes in habitat that collectively threaten the survival of species and compromise ecosystem services essential for human well-being, such as food security, water purification, and climate regulation. These challenges require multiple approaches: habitat restoration, expansion of protected areas, better land management, and reduction of greenhouse gas emissions.[31–40]

Global initiatives, such as the Paris Agreement, and conservation frameworks, like the Convention on Biological Diversity, are very important in mobilizing international efforts. Furthermore, these processes are key to Indigenous community involvement, advanced technologies, and innovative conservation practices. Predictive models will be used, interdisciplinary research will be promoted, and future collaborative conservation strategies will be fostered to protect biodiversity.[40–45]

Prioritization of biodiversity includes the interest of saving nature's heritage from further degradation or destruction and providing a road to a secure future that is insurably durable and resilient for Earth's life continuum. This requires intense international cooperation where informed policy would involve commitments toward effectively integrating scientific contributions with community awareness for the sustainability of a changing environmental spectrum.

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