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Research on the Role of Biodiversity in Protecting the Ecosystem Against Climate Change

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Abstract: As climate change intensifies, its impact on ecosystems has become increasingly severe, threatening the survival of various species and leading to habitat destruction, biodiversity loss, and ecosystem degradation. Biodiversity, encompassing the variety of life on Earth, plays a critical role in maintaining ecosystem stability, buffering against the effects of climate change, and enhancing ecosystem resilience. This study explores the multifaceted role of biodiversity in supporting ecosystem functionality amidst the challenges posed by climate change. By reviewing existing literature and case studies across different ecosystems, this research highlights biodiversity facilitates nutrient cycling and energy flow, which stabilizes the ecosystem, acts as a natural buffer against extreme weather events, and enhances ecosystem resilience by providing functional redundancy. The findings underscore the importance of biodiversity conservation as a strategy to mitigate the adverse effects of climate change and sustain the health and functionality of ecosystems worldwide.

Keywords: biodiversity, ecosystem, climate change, conservation.

1. Introduction

Biodiversity refers to various creatures on the earth, which contain different plants, animals, and microorganisms, as well as the genetic variation within these species and the ecosystem [1]. Nowadays, climate change has caused many problems to the ecosystem. Specifically, climate change has threatened the survival of terrestrial and aquatic creatures, damaged their habitat, and led to the depletion of forests, floods, droughts, and land degradation. For instance, the warming of seawater is causing stress to corals, mainly bleaching, which leads to a mass decline in corals. Additionally, the fluctuating weather causes issues for soil and humus formation, as well as biomass degradation due to decreased bacterial activity [2]. As the earth faces increasing pressures from climate change, the role of biodiversity in protecting ecosystems has never been more critical. This essay explores three aspects of the role of biodiversity: how biodiversity contributes to ecosystem stability, how it buffers ecosystems against the impact of climate change, and how biodiversity enhances ecosystem resilience by reviewing references related to the topic. This essay study can remind people of the importance of biodiversity in the ecosystem and the necessity for people to protect biodiversity. As climate change continues to pose significant threats to ecosystems worldwide, the conservation and enhancement of biodiversity must be prioritized as a key strategy for protecting and sustaining ecosystems in the long term.

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2. Ecosystem Stability

Biodiversity is crucial in maintaining ecological stability by ensuring the continuous operation of essential ecological processes such as nutrient cycling, productivity, and energy flow [3].

As climate change intensifies, ecosystems are increasingly subjected to stressors such as rising temperatures, changing precipitation patterns, and more frequent extreme weather events [4]. Biodiversity acts as a natural adjustor against these changes and helps maintain the ecosystem's stability. To be more specific, scientists have found that in dryland, plant diversity, particularly the diversity of leaf functional traits (SLA) and species richness, plays a significant role in the process of stabilizing the ecosystem. As shown in Figure 1, in areas with low aridity, functional diversity was found to be positively correlated with ecosystem stability, indicated by the variance in SLA [5]. This indicates that in the low arid environment, a higher diversity in plant resource-use strategies, such as differences between evergreen and deciduous species, allows ecosystems to respond more flexibly to environmental fluctuations, thereby enhancing stability.

This functional diversity is vital in the context of climate change because it enables ecosystems to absorb and adapt to varied climate conditions. For instance, when different plant species within an ecosystem have various strategies for water usage and nutrient absorbance. This can make the whole ecosystem more resilient to drought. For example, the Mediterranean Chaparral Ecosystem comprises a combination of deep-rooted and shallow-rooted plants. Deep-rooted species, like oaks, can access water stored underground, allowing them to survive even during prolonged dry periods. On the other hand, shallow-rooted shrubs, such as sagebrush, quickly absorb water from the surface soil during brief rainfalls [6]. Functional diversity of different species helps to ensure that all species in an ecosystem are not simultaneously affected by some factors, like climate change, thus maintaining overall ecosystem function.

The findings from global drylands demonstrate the stabilizing effects of plant diversity on ecosystem stability and emphasize the importance of biodiversity in building resilience to climate change. Through the functional diversity in less arid environments, biodiversity provides the necessary flexibility and redundancy that ecosystems need to adapt to the changing climate.

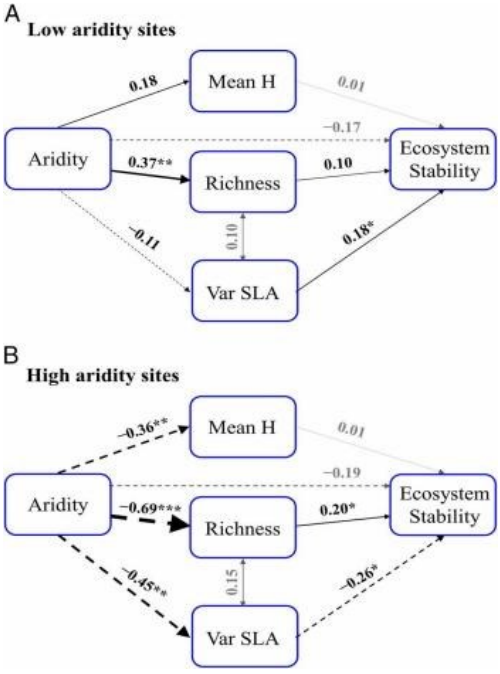

Figure 1: This picture shows the relationship between aridity, plant biodiversity, and residual variance of ecosystem stability from low and high aridity levels [5].

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3. Climate Change

One of the most significant ways biodiversity acts as a buffer against climate change is by alleviating the effects of extreme weather events. Diverse ecosystems are more resilient to extreme climates because they can maintain their functions even under stress [7]. As global warming intensifies, it leads to the pests' expansion, increased survival during winters, a higher number of generations, and an elevated risk of invasive species [8]. Some scientists utilize the United States Department of Agriculture (USDA) and found that forests with higher biodiversity are less likely to be affected by pests, which shows a dilution effect. This is because some specific pests, like monophagous pests, only eat one plant species in this scenario. Therefore, they will be affected mainly by biodiversity. Increasing biodiversity will reduce the frequency of pests meeting with suitable hosts [9].

Similarly, some coastal ecosystems, such as mangroves, are rich in species diversity and provide habitat for thousands of creatures [10]. Mangroves can act as a buffer to protect the ecosystem against global warming. For instance, Mauritius, an island nation, is highly affected by the rising sea level caused by global warming. However, Mauritius is now using mangroves to limit the threat caused by rising sea levels. Mangroves helped Mauritius absorb the energy of waves, reduce erosion, stabilize shorelines, and even decrease the impact of tsunamis [11].

Besides, recent research involving 46 experiments in Europe and North America has provided robust evidence that biodiversity consistently increases the resistance of ecosystem productivity to climate change, regardless of the event duration. These events were defined over timescales ranging from 3 months to 24 months, including both brief and intra-annual events and multi-year phenomena. The findings reveal that ecosystems with higher biodiversity experienced smaller proportional changes in productivity during these events, which shows the protective role of biodiversity against the adverse impacts of climate change [12].

In conclusion, biodiversity's protective role against the adverse effects of climate change is evident across diverse ecosystems. From forests that mitigate pest outbreaks through the dilution effect to coastal mangroves that shield shorelines from rising seas, biodiversity is key to ensuring they can withstand and adapt to adverse consequences caused by changing climates. The consistent findings further underscore the importance of preserving and enhancing biodiversity to serve as a buffer against climate change.

4. Ecosystem Resilience

Biodiversity plays a significant role in enhancing the resilience of ecosystems, particularly in the face of the challenges caused by climate change. As global temperatures rise and extreme weather events become more frequent and severe, the ability of ecosystems to remain stable and recover from disturbances is increasingly threatened. Through its comprehensive contributions, biodiversity provides the necessary mechanisms for improving ecosystem resilience.

One of the vital ways biodiversity enhances ecosystem resilience is through the presence of a diverse array of species that fulfill different ecological roles. Some researchers have grouped all species based on their ecosystem functions: decomposition, carbon sequestration, pollination, pest control, and cultural values. The presence of multiple species within these functional groups creates a 'portfolio' effect, where the overall stability of ecosystem services is maintained even when individual species fluctuate in abundance due to environmental changes. This redundancy among species—often referred to as functional redundancy—ensures that ecosystems can continue to function despite disturbances, thereby enhancing their resilience [13].

Recent analyses of biodiversity trends in Great Britain have revealed important insights into how different species groups contribute to ecosystem resilience. The study focused on native species present before 1970, as well as species that have arrived since then, primarily through human

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introduction. The findings indicate that for certain ecosystem functions, such as carbon sequestration and decomposition, the arrival of new species and the increase in native species have helped offset the declines in other species [13]. This suggests that these functions remain relatively robust, even in the face of broader biodiversity declines.

The study also explored the dynamics of species trends within specific functional subgroups, specifically, bees that pollinate oilseed rape and carabid beetles that provide pest control in wheat. The results showed no significant difference in the proportion of species showing positive or negative trends within these subgroups compared to the broader functional groups [13]. This finding suggests that the overall trends in biodiversity are broadly indicative of the resilience of more specific ecosystem functions, even under changing environmental conditions.

This study indicates the importance of maintaining biodiversity to enhance ecosystem resilience against climate change. While some ecosystem functions appear to be relatively resilient due to the arrival of new species and the increase in certain native species, others, particularly pollination and pest control, are at greater risk. The reason is that the decline in species richness within these critical functional groups reduces the portfolio effect and lowers functional redundancy, making these ecosystems more vulnerable to the impacts of climate change. This case shows the importance of protecting biodiversity and its role in improving ecosystem resilience.

5. Conclusion

In conclusion, biodiversity is a fundamental key that supports ecosystem stability, acts as a buffer against the adverse effects of climate change, and enhances the resilience of ecosystems. Specifically, biodiversity contributes to the robustness of ecosystems by maintaining essential ecological processes, reducing the impact of extreme weather events, and providing functional redundancy that ensures ecosystems can recover from disturbances. Through various examples, such as the stabilizing effect of plant diversity in drylands, the role of mangroves in protecting coastal regions, and the resilience of ecosystem functions in Great Britain, it is clear that preserving biodiversity is crucial for sustaining the health and functionality of our planet's ecosystems.

However, there is a limitation in that the examples and studies discussed focused on specific regions and ecosystems, which may not fully capture global diversity and complex interactions within different ecosystems. Therefore, the focus on various geographic regions and ecosystems to provide a more comprehensive view of the role of biodiversity is needed.

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