

# Research on Biodiversity and Ecological Environment Cycle: Interaction and Balance Mechanisms

Xiche Ye<sup>1\*</sup>

<sup>1</sup> Wuhan Haidian Foreign Language Shiyan School, Wuhan, China

**Abstract.** Biodiversity and ecological environment cycling are two closely related aspects in nature which maintain the balance of the Earth's life system through a series of complex interactions. Biodiversity, which refers to the richness of biological species and genetic diversity, provides multiple functions for ecosystems, including material cycling, energy flow, disease control, and more. The ecological environment cycle refers to the flow and redistribution of elements such as water, carbon, and nitrogen in the environment. These natural cycles play a crucial supporting role in maintaining biodiversity. Conversely, the level of biodiversity directly affects the efficiency and stability of element cycling. Currently, due to the impact of human activities, the ecological environment is facing unprecedented threats, and the rapid decline of biodiversity has exacerbated the vulnerability of the environmental cycling system. Therefore, understanding the interaction and balance mechanism between biodiversity and ecological environment cycling is of great significance for human beings in formulating sustainable management and protection strategies.

## 1 Introduction

In the vast web of life on Earth, biodiversity and ecological cycles form two crucial and interdependent frameworks. Biodiversity can be defined as the diversity and variation at the individual, population, species, and ecosystem levels. It is not just a colorful display of the biological world but the foundation for the health, stability, and productivity of the entire ecosystem. The ecological environment cycle includes global biogeochemical processes such as the water cycle, carbon cycle, and nitrogen cycle, which play a crucial role in regulating the Earth's environment, supporting biological activities, and maintaining biodiversity. The interaction between these two systems determines the structure and function of the ecosystem, the amount of pressure it can withstand, and the strength of its resilience.

## 2 The Interaction Between Biodiversity and Ecological Environment Cycling

### 2.1 The Impact of Biodiversity on Ecological Environment Cycling

#### 2.1.1 The Impact of Species Diversity on Ecosystem Function

Species diversity is one of the most significant dimensions of biodiversity, playing a crucial role in maintaining ecosystem functions. Ecosystems with high species diversity often exhibit higher productivity and

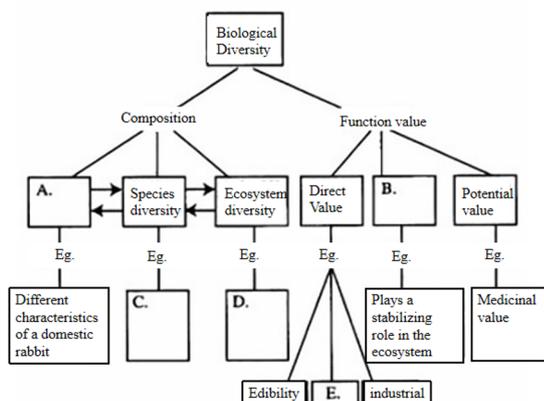
stronger stability. A diverse combination of species can improve the structure of the food web, enhance energy conversion efficiency, and optimize material cycling. For example, in multi-species grasslands, the complementary role of plants can more effectively utilize soil nutrients and water and resist pests and diseases through mutual promotion.[1] High species diversity can also increase the filling of ecological niches, reduce resource competition, promote the rate and efficiency of nutrient cycling within ecosystems, and further enhance underground storage of carbon and nitrogen. In addition, systems with higher species diversity have stronger resistance to external disturbances and self-healing abilities. This, in turn, maintains species diversity itself by promoting the stable operation of the ecological environment cycle, forming a virtuous cycle.

#### 2.1.2 Relationship Between Genetic Diversity and Ecosystem Adaptability

Genetic diversity, which refers to the differences in genetic characteristics between individuals within a single species, is another key aspect of biodiversity. It is crucial for the adaptability of species and their contribution to ecosystem function.[2] The high genetic diversity within a species can enhance its adaptability to environmental changes and improve its survival ability and reproductive success rate. For example, changing environmental conditions requires plants to have different adaptive traits, such as root depth, leaf size, or shade tolerance. A species with rich genetic diversity is more likely to contain genetic variations that survive

\* Corresponding author: [yexiche2007@outlok.com](mailto:yexiche2007@outlok.com)

under specific environmental conditions. High genetic diversity can also prevent the accumulation of harmful genes and provide a wider range of ecological services. When the ecological environment cycle changes, this inherent reserve of variation can help species adapt faster, ensuring the continuity and stability of ecosystem functions. As shown in Figure 1:



**Fig. 1.** Ecosystem diversity

### 2.1.3 The Regulatory Role of Ecosystem Diversity in Global Climate

Ecosystem diversity, including biodiversity and diversity of ecosystem types, has a significant regulatory effect on global climate. Various biological communities, such as forests, wetlands, grasslands, and coral reefs, play a role in regulating atmospheric temperature humidity and mitigating climate change. For example, tropical rainforests, through their dense vegetation cover, can effectively absorb carbon dioxide and produce oxygen, serving as an important "carbon sink" on Earth and slowing down the process of global warming. Wetland ecosystems regulate the water cycle and filter out pollutants through their unique hydrological processes, playing a role in purifying the air. The interactions between different ecosystems can also affect the local to global water vapor cycle, thereby regulating regional and global climate. In the context of global climate change, protecting ecosystem diversity has become one of the important strategies to avoid extreme climate events and maintain the balance of the entire Earth's environment.[3]

## 2.2 The Impact of Ecological Environment Cycle on Biodiversity

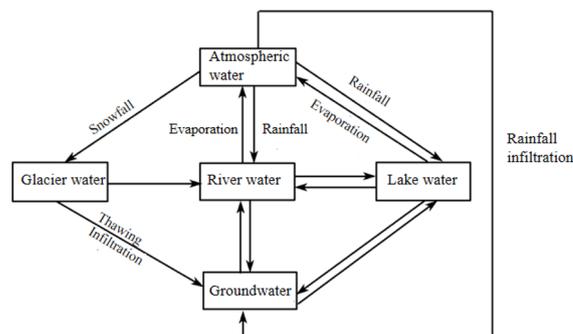
### 2.2.1 The Impact of Climate Change on Biological Distribution and Species Survival

Climate is a key determinant of biodiversity, directly affecting the distribution and behavior of organisms by controlling natural variables such as temperature, precipitation, and seasonal patterns. Climate change, especially global warming caused by the greenhouse effect, is altering the habitats suitable for living organisms, forcing many species to migrate or adapt. Some species may find new habitats, while others may

face extinction risks due to the inability to adapt quickly or hindered migration. The increase in extreme weather events, such as drought, heat waves, and rainstorms, also poses a threat to ecosystem structure and species survival. These events may disrupt the survival environment of species, affect the stability of the food chain, and even disrupt the reproductive cycles of certain key species. Therefore, the impact of climate change on the distribution of organisms is not limited to a single species but involves the entire ecosystem, which may lead to an overall decrease in biodiversity and damage to ecosystem functions.[4]

### 2.2.2 The Impact of Water Cycle Changes on Ecosystem Structure and Function

The water cycle is one of the most important ecological cycles on Earth, which transfers water between the atmosphere, surface, and underground through evaporation, precipitation, runoff, and other forms. Changes in the water cycle, whether caused by natural factors or human intervention, can have profound impacts on ecosystems.[5] For example, reduced precipitation or higher evaporation rates may lead to wetlands drying up, affecting species diversity and the structure of biological communities. Changes in water sources can also affect the distribution and availability of water quality in ecosystems, thereby affecting the growth, reproduction, and survival of organisms. In some arid or semi-arid regions, water is a scarce resource, and subtle changes in the water cycle can have a significant impact on ecosystems, leading to the reduction or even disappearance of specific species. Therefore, maintaining a healthy water cycle is crucial for preserving biodiversity and the diverse functions of ecosystems. As shown in Figure 2:



**Fig. 2.** Supply relationship of land water bodies

### 2.2.3 The Interrelationship Between Nutrient Cycling and Biodiversity

Nutrient cycling, especially the cycling of key elements such as carbon, nitrogen, and phosphorus, is the foundation for supporting ecosystem biodiversity. The effective circulation of nutrients ensures the flow of energy and the exchange of substances within and between ecosystems, thereby maintaining biodiversity. There are complex interdependent relationships between different trophic levels in an ecosystem, which

promote the transformation of nutrients from one form to another and their subsequent recycling. For example, plants convert inorganic carbon into organic matter, consumers (such as insects, birds, and mammals) consume the plant to obtain energy, and decomposers (such as fungi and bacteria) break down this organic matter, releasing nutrients for the plant to use again. When nutrient cycling is disrupted, such as nitrogen cycling imbalance caused by excessive fertilization, biodiversity will be negatively affected. Excessive nutrient intake may lead to overgrowth of certain species, inhibiting or excluding others, ultimately resulting in a decrease in biodiversity. Therefore, the maintenance of ecosystem health and sustainability requires the coexistence of balanced nutrient cycling and biodiversity.

### 3 The Balance Mechanism Between Biodiversity and Ecological Environment Cycle

#### 3.1 Natural Equilibrium Mechanism

There are a series of natural balance mechanisms between biodiversity and ecological environment cycling, which maintain the stability and productivity of ecosystems by regulating and promoting interactions. Firstly, competition and predation between species maintain the balance of species quantity and distribution. The structure of this food chain and food web can moderately suppress the excessive growth of certain species, thereby maintaining the diversity of the ecosystem. Secondly, the complementary functions brought by diversity promote the effective use of internal resources in ecosystems, enhance the resilience of ecosystems to external disturbances, and accelerate the restoration process of ecosystems.[6] In addition, ecosystems maintain critical functions through the redundancy inherent in genetic diversity. Even if some species are threatened by environmental changes, other species can fill their ecological niches to ensure that ecological services are not lost. In addition, species adaptability and migration ability are also part of natural balance mechanisms that allow biological populations to survive and evolve under climate and environmental changes. Overall, these natural balance mechanisms collectively construct a complex and resilient ecological network, ensuring the health and sustainable productivity of the entire ecosystem.

#### 3.2 Human Interference and Disruption of Balance Mechanisms

Human activities have had a wide-ranging and profound impact on the balance between biodiversity and ecological cycles. Land development, agricultural expansion, deforestation, and pollution emissions in the process of urbanization directly lead to the fragmentation of habitats and the destruction of biological communities. These disturbances disrupt the natural balance mechanism, leading to a decrease in species numbers and even extinction.[7] For example, the temperature rise and precipitation pattern changes caused by climate change have seriously affected the ecological niche and migration patterns of species, weakening the steady-state maintenance ability within the ecosystem. Human factors such as pollution and excessive use of fertilizers and pesticides may lead to excessive nutrient intake, disrupt nutrient and energy cycles, and further have negative effects on biodiversity, such as causing algal blooms and disrupting the balance of aquatic ecosystems. The abuse of natural resources and the development beyond the carrying capacity of nature by humans have exacerbated the loss of biodiversity and disrupted the natural balance of the ecological environment cycle.

#### 3.3 Strategies for Restoring and Rebuilding Balance Mechanisms

In order to address the damage caused by human activities to the natural balance mechanism, it is necessary to adopt practical and effective restoration and reconstruction strategies. Firstly, establishing nature reserves and biological corridors is a fundamental means of restoring species diversity and natural ecological cycles. Developing strict protection policies and reasonable land use planning can mitigate habitat destruction and biodiversity loss. Secondly, rebuilding ecosystem functions, such as replanting forests, restoring wetlands, and other measures, can enhance the self-purification capacity of ecosystems and help maintain biodiversity. In addition, promoting ecological agriculture and sustainable resource management methods, reducing the use of fertilizers and pesticides, and adjusting planting structures can improve nutrient cycling and reduce human pressure on the ecological environment. Furthermore, through public education and awareness raising, enhancing the attention and participation of all sectors of society in nature conservation is also the key to ensuring long-term sustainability. Through these comprehensive strategies, natural balance mechanisms can be gradually restored and rebuilt, promoting the harmonious coexistence of biodiversity and ecological environment cycles. As shown in Table 1:

**Table 1.** Strategies for restoring and rebuilding natural balance mechanisms

Policy category	Concrete measure	Goal and effect
Establish a protection mechanism	Establish nature reserves and biological corridors	Restoring species diversity and natural ecological cycles
	Develop strict protection policies	

	Reasonable land use planning	Reduce habitat destruction and biodiversity loss
Rebuilding the ecosystem	Replanting forests	Strengthening the self-purification capacity of ecosystems
	Restoration of wetlands	Maintain biodiversity
Public education and awareness	Public education	Enhance the emphasis on nature conservation
	Consciousness raising	Promote participation from all sectors of society

## 4 Case Study

### 4.1 Biodiversity and Ecological Environment Cycle in Typical Ecosystems: The Amazon Rainforest

The Amazon rainforest is the largest tropical rainforest in the world, covering nearly half of the rainforest area on Earth. It is known as the "lung of the earth" due to its rich biodiversity and impact on global ecological cycles. The biodiversity of the Amazon rainforest is demonstrated by its over 3000 tree species, consisting of at least 40 billion trees and about 10% of the world's known species. The existence of these species constructs a complex food web that not only supports regional biodiversity but also has profound impacts on global carbon cycling and climate regulation.[8]

The interaction between biodiversity and ecological environment cycling in the Amazon rainforest is mainly reflected in the following aspects:

The high biodiversity of rainforests directly enhances the carbon storage capacity of ecosystems. A large number of trees and plants absorb carbon dioxide from the atmosphere through photosynthesis, convert it into biomass, and store carbon in their trunks, leaves, and roots. These large accumulations of carbon have slowed down the rise in global temperature and played a crucial role in combating global warming.

This ecosystem plays a crucial role in the water cycle. Through the so-called "aerial rivers" system, the water vapor released by this forest has a significant impact on precipitation patterns in South America and can even affect the climate of other continents far away. The Amazon River and its numerous tributaries also provide a source of life for the organisms in the region.

The complex nutrient cycle in rainforests is crucial for the health of ecosystems. The decomposers on the rainforest floor, such as fungi and bacteria, break down organic matter, such as fallen leaves and lignin, releasing nutrients back into the soil for plants to reuse. This process maintains abundant soil nutrients, giving the forest sustained growth momentum.

Unfortunately, the Amazon rainforest is facing serious threats. Human activities such as logging, mining, and agricultural expansion have led to extensive deforestation and destruction, not only weakening the carbon storage capacity and biodiversity of this ecosystem but also causing long-term impacts on its water and nutrient cycles. The destruction of forests also

affects regional and global climate, leading to reduced precipitation and more extreme weather conditions.

The example of the Amazon rainforest clearly demonstrates the close relationship between biodiversity and ecological cycles. It emphasizes the need for us to take timely action to protect and maintain this precious natural resource so that it can continue to contribute to global ecological security and human well-being. By reducing carbon emissions, strictly implementing protective measures, and promoting sustainable development, we can provide a path for the restoration and sustainability of this and other ecosystems.

### 4.2 Biodiversity and Ecological Environment Cycling Changes Under Human Interference

The Great Barrier Reef in Australia is the world's largest coral reef group and a complex ecosystem with extremely high biodiversity. The Great Barrier Reef supports thousands of marine species, including various corals, fish, turtles, sharks, dolphins, and seabirds. However, in recent decades, due to climate change and other human disturbances, the biodiversity and ecological cycle of the Great Barrier Reef have been greatly affected.

The rise in seawater temperature caused by global warming is one of the main reasons for coral bleaching in the Great Barrier Reef. As seawater temperatures rise, algae that coexist with corals are repelled, causing corals to lose their color and primary source of energy. Whitened corals are susceptible to disease infections and may eventually die due to a lack of sufficient nutrition without recovery. The massive death of corals has had a serious impact on their own living environment and other organisms that rely on it, leading to the destruction of the biodiversity and ecological structure of the entire coral reef.

Human overfishing and illegal fishing activities disrupt the natural balance of the food web, affecting the flow of matter and energy in coral reef ecosystems, reducing the number of key species, and ultimately damaging the resilience of coral reefs. The improper use of fertilizers and pesticides has also caused serious nutrient pollution problems in the Great Barrier Reef due to land runoff. Excessive nutrients, especially nitrogen and phosphorus, promote the overgrowth of algae, forming algal blooms and depriving other organisms of light and oxygen, further threatening the health of coral reefs. The development of coastlines and the extraction of active fossil fuels in the Great Barrier Reef region have caused water turbidity and sediment

deposition, which affects the growth and reproduction of corals and their ability to obtain light. Ocean acidification is another issue caused by rising levels of carbon dioxide in the atmosphere, which increases the acidity of seawater and affects the ability of corals and other marine organisms to use calcium carbonate to construct shells and bones.

## 5 Conclusions

Through in-depth analysis of the interaction between biodiversity and ecological environment cycles, as well as case studies of different ecosystems worldwide, we can draw several important conclusions. Firstly, maintaining biodiversity is crucial for enhancing the stability of ecosystems and improving their productivity. The diverse species provide the foundation for the structure of the food web, increasing the ecosystem's resistance and self-healing ability in the face of external disturbances. In addition, biodiversity influences global climate patterns through various pathways, including supporting the Earth's critical carbon, water, and nutrient cycles. However, human activities have profoundly altered this natural balance, causing damage to many ecosystems and putting species at risk of extinction.

Therefore, it is urgent to restore and rebuild the balance mechanism between biodiversity and the ecological environment cycle. This requires us to take immediate and effective actions, such as establishing protected areas, promoting ecological agriculture and sustainable resource management, and raising public awareness of environmental protection. For affected ecosystems such as the Amazon rainforest and the Great Barrier Reef, specific protection and restoration measures need to be designed to address the threats they face. Only through global cooperation and strengthened environmental policies can we ensure the health and sustainability of the natural world, providing a sustainable environment for current and future human societies as well as all living beings on Earth.

## References

1. Naeem S, Loreau M, Inchausti P. Biodiversity and ecosystem functioning: the emergence of a synthetic ecological framework[J]. *Biodiversity and ecosystem functioning: synthesis and perspectives*, 2002: 3-11.
2. Solan M, Batty P, Bulling M T, et al. How biodiversity affects ecosystem processes: implications for ecological revolutions and benthic ecosystem function[J]. *Aquatic Biology*, 2008, 2(3): 289-301.
3. Boero F, Bonsdorff E. A conceptual framework for marine biodiversity and ecosystem functioning[J]. *Marine Ecology*, 2007, 28: 134-145.
4. Lawton J H. The role of species in ecosystems: aspects of ecological complexity and biological diversity[M]//*Biodiversity: an ecological perspective*. New York, NY: Springer New York, 1997: 215-228.
5. Fjeldsaå J, Lovett J C. Biodiversity and environmental stability[J]. *Biodiversity & Conservation*, 1997, 6: 315-323.
6. Boero F, Belmonte G, Bussotti S, et al. From biodiversity and ecosystem functioning to the roots of ecological complexity[J]. *Ecological Complexity*, 2004, 1(2): 101-109.
7. De Graaff M A, Adkins J, Kardol P, et al. A meta-analysis of soil biodiversity impacts on the carbon cycle[J]. *Soil*, 2015, 1(1): 257-271.
8. Folke C, Holling C S, Perrings C. Biological diversity, ecosystems, and the human scale[J]. *Ecological applications*, 1996, 6(4): 1018-1024.