

Research Progress and Trend of Ecological Restoration of Land Space

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Abstract

The implementation of ecological restoration of land and space is an important way to promote ecological protection and restoration, build an ecological civilization and a beautiful China, and accelerate the development of modernization in the new era. In recent years, the ecological environment has been deteriorating due to the acceleration of urbanization, the rapid warming of the global climate and the external interference of human activities. The ecological restoration of land and space is imminent, and people are paying more and more attention to this issue, especially in the fields of academia, ecology and environmental science, and some progress and results have been made. In this study, the concepts related to ecological restoration were identified, the research on ecological restoration of land space at home and abroad was systematically sorted out, and the important trends of ecological restoration research on land and space were analyzed.

Keywords

Ecological Restoration; Ecological Restoration of Land and Space; Research Progress; Research Trends.

1. Introduction

Ecosystems provide humans, providing supply services, climate regulation, cultural services, support services and other ecological, social and economic services⁰. However, with the continuous expansion of human activities and the acceleration of industrialization, rapid economic development has brought prosperity to cities, but also brought huge negative impacts to the global ecosystem, such as large-scale degradation of ecosystems, reduction of global biodiversity, and increasingly serious anthropogenic pollution, which have greatly damaged the structure and function of ecosystems, and the sustainable development of human beings is facing severe challenges.

To address these issues, ecological restoration emerged as a discipline that aims to assist in the restoration of degraded, damaged, or destroyed ecosystems[2]. In addition, ecological restoration plays an important role in slowing down ecosystem degradation, enhancing ecosystem services, improving the relationship between humans and nature, and resisting future environmental changes. It is an important means to improve the quality of ecosystems and maintain ecological security, and is gradually becoming an important political issue and priority in the global environment, and is widely included in the natural resource management framework and sustainable development strategy[3,4]. At the beginning of the 20th century, some European and American countries carried out reasonable protection and utilization of damaged mountain, forest, and grassland resources, and the research work on ecological restoration began[5]. Since then, with the development of landscape ecology and restoration ecology, various physical, chemical, biological and composite ecological restoration technologies have gradually emerged and been improved. In the 21st century, the United Nations has formalized a 10-year plan for ecosystem restoration, which has promoted large-

scale restoration of damaged ecosystems. At present, ecological restoration has become a hot issue of concern to the international community at home and abroad, and it is also a core issue of global ecological and environmental governance[6].

Since 2020, a number of international organizations, including the International Union for Conservation of Nature (IUCN) and the United Nations, have issued many laws and regulations related to the protection of nature or biodiversity, all of which aim to promote the great idea of harmonious coexistence between man and nature. In order to achieve high-quality and sustainable development, the 18th National Congress of the Communist Party of China elevated the construction of ecological civilization to the strategic height of "five-in-one", and constantly emphasized the systematic governance of ecosystems. Under the guidance of the concept of the management of mountains, rivers, forests, fields, lakes, grasslands and sands, and the concept that lucid waters and lush mountains are invaluable assets, the ecological restoration of land and space has become a national strategic deployment. In 2020, the Central Committee for Comprehensively Deepening Reform adopted the Master Plan for Major Projects for the Protection and Restoration of National Important Ecosystems (2021-2035), further emphasizing the adherence to the new development concept. Coordinate the integrated protection and restoration of mountains, rivers, forests, fields, lakes and grasslands, focus on improving the self-repair capacity of ecosystems, promote the overall improvement of the quality of natural ecosystems and the overall enhancement of the supply capacity of ecological products, and reach a consensus on nature-based solutions that are generally recognized by the international community. The report of the 20th National Congress of the Communist Party of China pointed out that respecting nature, conforming to nature, and protecting nature are the inherent requirements of building a modern socialist country in an all-round way. In addition, the report stresses that we need to promote the construction of a beautiful China, adhere to the integrated protection and systematic management of mountains, rivers, forests, fields, lakes, grasslands and sands, and promote ecological priority, conservation and intensive, green and low-carbon development. It can be seen that there is a strong demand for ecological restoration at home and abroad[7]. Based on this, this study summarizes the relevant concepts, significance, and research trends at home and abroad of land space ecological restoration, and analyzes its research trends, in order to provide reference or broaden ideas for the research and practice of land space ecological restoration.

2. Identification of Related Concepts

2.1. Ecological Restoration

Ecological restoration originated from the use and management of various resources in nature by human beings a hundred years ago. The term "ecological restoration" appears in restoration ecology, and there is no unified definition. In a narrow sense, ecological restoration refers to the process of helping to restore degraded, damaged, or damaged ecosystems[8]. In a broad sense, ecological restoration has a more positive and extensive connotation. That is, to stop human disturbance of the ecosystem to reduce the compound pressure, rely on the self-regulation and self-organization ability of the ecosystem to make it evolve in an orderly direction, or use the self-recovery ability of the ecosystem, supplemented by artificial measures, to gradually restore the damaged ecosystem or promote the development of the ecosystem to a virtuous cycle. In short, the object of ecological restoration is the natural or semi-natural ecosystem disturbed by the external environment, and the restoration methods include natural restoration, artificial restoration and other types, and the ultimate goal is to achieve the harmonious development of man and nature.

2.2. Extension of Ecological Restoration

Ecological restoration, ecological protection and ecological reconstruction are three important aspects of the current ecological environment construction, which are interrelated and have their own priorities and goals.

Ecological restoration refers to the process of actively restoring the areas that have occurred or are about to suffer ecological damage to a healthy state under the premise of protection. Including the restoration of soil, water, vegetation and other aspects, the ultimate goal is to improve the stability of the ecosystem, restore the original function of the ecosystem, and realize the harmonious development of man and nature.

Ecological protection refers to the act of taking a series of measures to protect the ecosystem from damage. Including the formulation and implementation of relevant laws and regulations, environmental education, etc., focusing on prevention and protection, its goal is mainly to maintain the integrity of the ecosystem structure and the sustainability of functions, to avoid disturbance to the ecosystem, is passive management.

Ecological reconstruction refers to the process of reconstructing ecosystems that have undergone significant changes under human intervention. This change may be caused by natural disasters, land changes, environmental pollution, etc., and its goal is to reshape the structure and function of the ecosystem, artificially create or promote the development of the ecosystem.

The restoration subjects of ecological restoration include nature and people, while the restoration subjects of ecological protection and ecological reconstruction are generally people. Ecological restoration can reflect people's enthusiasm more than ecological protection, and has more extensive applicability than ecological reconstruction, which plays an important role in ensuring the existence of lucid waters and lush mountains and maintaining the safety and stability of various natural ecosystems[4].

2.3. Ecological Restoration of Land and Space

With the emergence of the political term territorial space, other new professional terms have been derived, and the combination of ecological restoration and territorial space is expressed as ecological restoration of territorial space[9]. At present, there is no unified understanding of the concept of land space restoration. Cao Yu et al[10]believed that the ecological restoration of land space is to take the damaged or destroyed ecosystem as the object in a more macro spatial scale, and gradually develop the structure, process, function and service of the ecosystem facing the ecological crisis through various measures such as spatial structure adjustment and optimization of land elements, human intervention, and ecological engineering and technical restoration at the medium and macro scale. Peng Jian et al[11]believed that the concept of ecological restoration of land space is the inheritance and development of the concept of ecological restoration, and it is defined as the process of optimizing the development pattern of land space and improving the quality of ecological environment through various remediation and restoration measures, taking the concept of ecological restoration of mountains, rivers, forests, fields, lakes, grasses and mines as the starting point. The above two perspectives are the two authoritative definitions of ecological restoration of land space, both of which emphasize the improvement of the function and structure of the entire ecosystem through systematic management and restoration of damaged ecosystems[12].

There is a difference between the ecological restoration of land space and the traditional ecological restoration. Firstly, the ecological restoration of land space expands the concept to the whole country, facing a more macro space, and pays more attention to the integrity, systematization and internal laws of the ecosystem; secondly, the object of restoration gradually changes from the natural ecosystem to the human-land composite system, and the scale extends from local environmental improvement to the protection and restoration of the

whole ecosystem. Based on the concept of "mountains, rivers, forests, fields, lakes, grasslands and sands", the ecological restoration of land space helps the ecosystem move in the right direction by optimizing and adjusting the structure of land elements and taking appropriate human interventions. In order to achieve the harmonious coexistence of man and nature, it is necessary to interdisciplinarily integrate, and experts in multiple fields should work together to tackle key problems, and use ecological theory and holistic thinking to solve the contradictions and problems between development and protection [6,9].

2.4. The Significance of Research on Ecological Restoration of Land Space

At present, the problem of deterioration of the ecological environment has become a global problem, which seriously restricts the development of human civilization. The research goal of ecological restoration of land and space is to restore damaged ecosystems, maintain their normal ecological functions, enhance the resistance and stability of ecosystems to natural disasters, improve the carbon sink capacity of ecosystems, and further improve environmental quality. The research on ecological restoration of land space is helpful to optimize and adjust the spatial pattern of land space, promote the coordinated development of various spatial elements such as ecology, agriculture and towns, and improve the quality and efficiency of land space development. It will help to promote the construction of ecological civilization and sustainable development, improve the level of national and regional ecological security, and also help promote the development of the ecological environment in a benign direction, so as to promote the balance between the ecological environment and economic development. In short, the research on ecological restoration of land space has important theoretical and practical significance, and is of great significance for protecting the ecological environment, promoting sustainable development, and improving the quality of human living environment.

3. Research Progress at Home and Abroad

From the perspective of the development of human civilization, the research on land ecological restoration has a history of hundreds of years, and it also occupies a key position in the rapid development of human society [13]. However, the in-depth analysis and research time of the academic community on the research problems of land ecological restoration is still relatively short, and it is still in the early stage of research. At present, the research on land ecological restoration has not yet formed a complete system, and it has always been in a relatively scattered state. It was not until 1980 that foreign scholars began to systematically study this problem, but at that time, the issue of land ecological restoration was only studied as a branch of ecology [14]. With the continuous advancement of research, great achievements have been made in the problem of land ecological restoration.

3.1. Research and Practice of Ecological Restoration Abroad

The research on ecological restoration of land and space is developed from the traditional research on ecological restoration, and the research on ecological restoration in foreign countries began in Europe and the United States in the early 20th century [7], mainly focusing on small-scale ecological elements. For example, Liere et al. [15] used a combination of ecological restoration technologies to restore lake ecosystems. Edwards et al. [16] applied bioremediation measures to river restoration, using the biological characteristics of algae to increase floodplain connectivity and habitat complexity. Maleki et al. [17] proposed the use of artificial neural networks for wetland ecosystem restoration. Turrión et al. [18] used innovative restoration techniques to rehabilitate the mine to restore its plant communities and ecosystem functions. It can be seen that the focus of ecological restoration measures in foreign countries is at the micro technical level, and the research on the ecological restoration of the entire ecosystem in the region at the macro level is still relatively lacking.

In addition, some successful engineering practice cases have been formed abroad. As the green lung of Manhattan, Central Park in New York has become a "freshener" for the city to show the "beauty of rural scenery". Springs Park is a world-class park converted from a landfill, with the concept of a "living landscape" that symbolizes the rebirth of New York City from the ashes, with typical projects including restoring large habitats, organizing diverse activities, and creating a multi-layered transportation system[19]. Brazil's "savanna" has been protected and restored, with planned burning of invasive grasses and ploughing of soils, the establishment of seed collection networks, regular field surveys of potential landscape plants, and propagation experiments[20]. Japan's Awaji Dream Stage is a successful practice of mine rehabilitation, taking steps to cut the slope to form a slope that can accommodate buildings and landscapes. The staggered terrace is designed to cover the roof of the building with vegetation, and the largest mining platform is designed as an amphitheater, and the smaller platform is introduced into a water ditch to set up a staggered square flower bed[19].

3.2. Research and Practice of Ecological Restoration in China

Research on ecological restoration in China started late, but the development speed is very fast. In the 50s of the 20th century, China began long-term positioning observation and ecological restoration research and practice in the degraded slopes of South China and the Horqin Sandy Land in the north[21]. Since the 70s of the 20th century, a large number of restoration and reconstruction work has been carried out in some ecologically fragile areas and degraded ecosystems in some waters, and many successful restoration models have been formed, such as the construction of the Three-North Shelterbelt, the comprehensive management of soil erosion areas on the Loess Plateau, and the comprehensive management of desertified land in Inner Mongolia[22]. In 2020, the development of the pilot project for the ecological protection and restoration of mountains, rivers, forests, fields, lakes and grasses reflects the national ecological security strategic barrier with "two screens and three belts" as the framework, and the concept of the overall protection of mountains, rivers, forests, fields, lakes and grasses has gradually taken root in the hearts of the people, and a new path of global governance has been initially explored, and experience in carrying out ecological protection and restoration projects in a holistic and systematic manner has been accumulated[23]. In 2020, the relevant national plan for ecosystem protection and restoration clearly stated the main goals of promoting the protection and restoration of natural ecosystems such as forests, grasslands, deserts, rivers, lakes, wetlands, and oceans by 2035, as well as the overall layout, key tasks, major projects and policy measures for the integrated protection and restoration of mountains, rivers, forests, fields, lakes and grasslands. This is a guiding plan for promoting major projects for the protection and restoration of important ecosystems in the country at present and in the future, and an important way to meet the growing needs of the people for a beautiful ecological environment, which is of great strategic significance for building a beautiful China, promoting the construction of ecological civilization, and realizing the sustainable development of the Chinese nation[24].

At the level of theoretical research, the Chinese research team has also achieved rich research results. From natural ecological restoration to human-land composite ecological restoration, there are sufficient research foundations and breakthrough achievements[25]. It mainly includes: comprehensive land remediation and ecological restoration, comprehensive water pollution control and water environment remediation technology, urban brownfield and waste land transformation and regeneration, mining area geological environment treatment, pollution remediation, land reclamation, tailings and other solid waste comprehensive utilization, plant landscape and ecological restoration design, heavy metal contaminated soil phytoremediation technology, etc[26-28]. After decades of exploration of different ecosystems

such as forests, wetlands, and rivers, a relatively mature system of ecological restoration theories and technical methods has been formed.

Generally speaking, the current research on ecological restoration by scholars at home and abroad mainly focuses on the study of regional single ecological environment problems and single ecosystem restoration, and the research scale is biased towards microscopic. Ecological restoration of land space tends to be macro-scale restoration, but most of the current related research focuses on concept definition and content exploration. Moreover, the existing strategies of ecological restoration of land and space are still limited to the original research framework of ecological restoration, which is difficult to reflect the requirements of "systematic restoration and comprehensive management" of ecological restoration of land and space, resulting in unsatisfactory restoration effects. Therefore, it is urgent to explore more effective strategies for ecological protection and restoration of land and space from the perspective of overall ecosystem protection and restoration.

4. Research Trends of Ecological Restoration of Land Space

In the early stage of land ecological restoration research in China, there were many aspects, including environmental management, vegetation protection, water environment management, ecological restoration, and ecosystems, which became a hot topic in land ecological restoration research at that time[29]. Since 2005, China has gradually focused on ecosystem research, because some problems of land ecosystem destruction that appeared in the early stage have not been well solved. By 2011, according to the growth of global population and the change of consumption, the research focus shifted to ecosystem services, and through the study of ecosystem services, the sustainable use of resources and the ecological restoration of land were promoted. Around 2015, climate change became the focus of research again, and in the past two years, the focus of research has shifted to forest restoration.

Based on the hot changes of land ecological restoration research at home and abroad, multi-level systematic coordination will become the main development trend in the future land ecological restoration work. Compared with other industries, the land ecological restoration work itself has certain particularities, which cannot be solved by the market, and the restoration cost is high, which determines that the land ecological restoration work is not a problem that can be solved in one field, and it needs to be systematically and comprehensively coordinated.

5. Conclusion

As an important part of ecosystem protection, land ecological restoration research has a history of hundreds of years. From an overall point of view, the research on land ecological restoration has attracted more and more attention from all walks of life, but it is still in its infancy. This also reflects the fact that the real problems such as the increasing population, the worsening of the pollution problem, and the change of the climate have reached a very serious point, and it is precisely because of this that the research work of land ecological restoration is of great significance for the improvement of the global ecological environment. At this stage, there are still deficiencies in the research work of land ecological restoration in China, which greatly restricts the development of land ecological restoration. In the long run, the ecological restoration of land and space is a difficult project. It not only requires the participation of multiple industries and subjects, but also the integration of theoretical knowledge and practical experience, the use of multidisciplinary knowledge, the strength of the whole country, and the action of all the people to achieve the grand goal of "Beautiful China" set by China. In addition, it is necessary to continuously update and improve the policies and mechanisms of land and space ecological restoration, and continue to deepen the research on ecosystem restoration

theory, scientific and technological innovation, project capital investment, exchange and cooperation, etc., so as to promote the development of land ecological restoration and provide strong support for the protection of global ecosystems.

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