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Editorial

A New Advance on the Improvement of Forest Ecosystem Functions in the Karst Desertification Control

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Abstract: In recent years, after the implementation of large-scale ecological restoration projects, karst areas in the South China Karst have become global "greening" hot spots. However, the biodiversity, ecosystem quality, and security patterns in karst areas are still severely affected. The reason for this is that despite the execution of karst desertification control projects, the lag mechanism of forest ecosystem functions and services is still unclear. Therefore, we analyze the progress in the research related to desertification control and the improvement of regional forest ecosystem function through a systematic literature review approach. The results show that the major landmarks achieved so far include the following aspects: based on the karst desertification control area, we have elucidated the driving factors of forest ecosystem change, discovered the ecological security pattern of landscape optimization and reconstruction, revealed the internal mechanism of forest system structure optimization and stability enhancement, overcome the technical constraints of forest water–fertilizer coupling, introduced a strategy for regulating functional traits to improve the growth and development of vegetation, proposed strategies to enhance carbon sequestration in forests and the efficiency of microbial carbon use, and created models and paths to realize the value of forest products. The key scientific issues to be addressed in the future mainly comprise the following: the effects of spatial heterogeneity on forest ecosystems, disturbances in landscape reconfiguration caused by human activities, the work mechanisms of the combination and configuration of the niche in structural optimization, the response of species configuration to the water cycle, the coupled relationship between biodiversity and soil properties, the screening and construction of the plant germplasm resource base, the functional trade-offs/synergistic mechanisms of karst forest ecosystems, the creation of policies for forest product in terms of rights, trading, and compensation, and systematic research on the extended industrial chain of forest ecosystems, its service potential, and so on.

Keywords: structural optimization; water and fertilizer regulation; functional improvement; forests ecosystem; karst desertification control

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1. Introduction

Forests are the largest terrestrial ecosystem in the world and an important component in maintaining human survival and development [1]. Forest ecosystem functions (FEP) provide goods and services directly or indirectly to human society, and these include raw materials, water conservation, soil retention, carbon sequestration, climate regulation, nutrient cycling, biodiversity, and cultural aesthetics [2,3]. Since the Industrial Revolution, the rapid development of the socioeconomic situation has been accompanied by problems such as dramatic population growth, environmental degradation, and resource depletion. Simultaneously, the transformation of forests and grasslands into agricultural or construction land has directly altered the structure and function of ecosystems, leading to a decline in biodiversity. In order to achieve the fifteenth goal among the United Nations Sustainable

Development Goals (SDGs), i.e., to sustainably manage forests, combat desertification, and halt and reverse land degradation, research on identifying the factors underlying changes in the functioning of forest ecosystems is imminent [4]. However, there are fewer studies integrating the interrelationships between environmental factors, human activities, policy implementation, and ecosystem functioning, while the drivers of changes in forest ecosystem functioning in karst areas are also currently unknown.

Karst areas account for about a fifth of the global land area, of which the South China Karst (SCK), centered in Guizhou, is an ecologically fragile area of the largest distribution and the richest geomorphological types [5]. In the past, the combined effects of a fragile natural environment and irrational human economic activities have led to frequent soil erosion, the degradation of vegetation cover, and increased poverty [6,7]. Due to the unique hydrological structure of the karst region, it provides a safe source of fresh water for approximately 25 percent of the world's population. Therefore, curbing the expansion of desertification has become a common and understated challenge that must be faced globally [8]. At the beginning of the 20th century, China launched a large-scale ecological management project of converting farmland back into forests and grasslands to rapidly increase vegetation coverage [9]. Today, the South China Karst has become a global "greening" hot spot. Meanwhile, the regional ecological environment has also introduced new problems, from "ecological cancer" to "green desert", and the lag in forest ecosystem services and functional degradation in rocky desertification control areas are particularly severe. Related studies have shown that the scientific planting of agroforestry can effectively improve soil fertility, improve water resource utilization, and restore biodiversity [10,11]. Therefore, human activities (regional scale) and planting structures (field scale) in karst areas may be important factors that alter the functionality of forest ecosystems.

The body of research on optimizing the structure and enhancing the function of forest ecosystems is currently rapidly growing. However, the mechanisms of their functional enhancement are still unclear, and the interrelationships between ecosystem functions and natural factors, human activities, and policy implementation still need to be further explored. Analyzing the functional traits and soil responses under different forest planting modes, the impact of human activities on forest ecosystem functions, and strategies for improving the supply capacity of different forest ecological products can help in the restoration of forest ecosystems in karst areas.

We adopt a systematic literature review method to (i) clarify the factors influencing the functional decline of forest ecosystems in karst desertification control areas; (ii) summarize the major landmark achievements in improving the functionality of forest ecosystems; (iii) propose key scientific issues to be addressed in the study of functional systems in karst forest ecosystems to provide a scientific basis for consolidating the effectiveness of desertification control and improving the quality of forest ecosystems in karst areas.

2. Major Landmark Achievements

2.1. Via Studies on the Spatiotemporal Evolution of Forest Ecosystem Value in Ecologically Fragile Karst Areas, It Is Clarified That the Decline in Ecosystem Function under Desertification Control Is Influenced by Factors Such as Policy Implementation and Human Intervention, Improving the New Understanding of Forest Ecosystem Restoration

The contradiction between the supply and demand of forest ecosystem functions and human social activities is particularly prominent [12], and it is urgent to carry out research on the evaluation of regional forest ecosystem functions. The traditional evaluation protocol is to calculate the static value based on the equivalent factor method [13], but the trend of large-scale time changes is still unclear. With scientific technological innovation and the combination of remote sensing technology and socio-economic data, a comprehensive evaluation framework was designed to accurately analyze the spatiotemporal evolution of forest ecosystem service value and the response of land use in the past 20 years [14]. This indicates that the driving factors are land use changes caused by returning farmland to forests, immigration and relocation, and artificial intervention, effectively alleviating the contradiction between forest ecosystem functions and human survival and development.

2.2. Through Research on the Reconstruction of Ecological Landscape Security Patterns and Rural Landscape Restoration in Desertification Control, Current Regional Forests and Rural Landscapes Are Found to Have High Fragility and Weak Anti-Interference Abilities, Providing a Reference for Landscape Planning and the Layout of Environmental Protection

Karst areas have high landscape fragility and weak anti-interference ability. Therefore, a framework for evaluating rural landscape restoration was constructed from the perspectives of ecology, engineering, and socio-culture, and the constraints of disaster resistance and village cultural values were analyzed [15]. A multi-dimensional plan for the transformation and adjustment of village ecosystem structure to promote the restoration of landscape elasticity and the improvement of production functions was proposed. At the same time, based on the GIS technology analysis of the importance, vulnerability, and connectivity of regional ecological functions, the overlay analysis of the ecosystem service value in Guanling County was conducted to obtain the ecological corridor planning plan [16], which effectively promotes the formation of regional ecological landscape security patterns.

2.3. Via Studying the Physiological Characteristics of Forest Planting Structure in Rocky Desertification Control, It Is Revealed That Optimizing Forest System Structure Can Enhance the Adaptability of Vegetation and Efficiency of Nutrient Utilization, and Expand the Research Perspectives on Improving Ecosystem Stability

The optimization of forest structure and the improvement of stability are key concerns in the field of ecology, and are also important components in the process of karst desertification control. These not only directly improve the genetic and species diversity of forests, but also change the elements of nutrients in different forest stand structures, promoting the enhancement of ecosystem functions. Kong et al. [17] systematically reviewed the interrelationships between the structure, functional characteristics, and biodiversity of forest ecosystems, indicating that different plant physiological characteristics and levels of nutrient utilization efficiency can effectively improve soil quality under forests. Therefore, the spatial optimization of karst forests (such as sparse forests, agroforestry, and intercropping between forests and grasses) directly determines the process and functional utility of the ecosystem. According to the ecological niche, appropriate allocation should be conducted for individual characteristics within and between species (such as light preference, drought tolerance, and calcium preference). This is not only an important means to support the mutually beneficial coexistence of species, but also an important measure to maintain system stability and enrich diversity. Jiang et al. [18] constructed a stability evaluation system based on forest structure and functional indicators using a comprehensive evaluation method, and found a positive correlation between stability and biodiversity, while also identifying the subjective wishes of farmers. In summary, optimizing the species structure of forest stands is an important means toward improving the nutritional structure of ecosystems and enhancing their stability; it also acts as an important foundation on which to enhance ecosystem functions, therefore promoting ecological restoration in desertification areas.

2.4. By Studying the Response Relationship between the Forest Water Cycle and Soil Fertility in Desertification Control, We Have Overcome the Technical Limitations of Water–Fertilizer Coupling, Including Effective Water Resource Utilization and Carbon and Nitrogen Leakage, Helping to Improve Levels of System Productivity

Karst areas are two-dimensional and three-dimensional geomorphic structures of the surface and underground, and scientific water and fertilizer regulation technology is an important tool with which to improve ecological imbalance and promote sustainable agricultural development. Regional niche drought and seasonal water scarcity stress make it difficult for agriculture and forestry to develop healthily. Therefore, selecting suitable drought-resistant tree species and crops for mixed sowing, and regulating water infiltration and organic matter decomposition rates under forests and farmland, is an effective measure to improve the function of karst desertification ecosystem. Wu et al. [19] compared different agroforestry ecosystems, and based on the perspective of physiological complementary characteristics, demonstrated that composition of scientific species changes the effectiveness of water resource conversion and weakens water evaporation. Fan et al. [20] analyzed the water content of forest xylem and soil using stable isotope methods, indicating that scientifically combining species with physiological and ecological characteristics is an effective method to reduce interspecific competition. The increase in effective water absorption efficiency is an important manifestation of species symbiosis and changes in adaptability. Hu et al. [21] analyzed the response of changes in carbon and nitrogen content in karst springs to soil leakage, indicating that carbon and nitrogen loss can reduce forest ecosystem function. As the level of desertification increases, the carbon and nitrogen content in karst springs decreases. The increase in carbon and nitrogen content in karst spring water indirectly reflects the benign development of soil thickness, vegetation coverage, and litter. When the soil's water holding and storage capacity increases, the continuous fluidity of its spring water increases. Zhu et al. [22] believe that the stability of soil aggregates is highly sensitive to surface vegetation succession and plays an important role as an indicator of soil quality. Therefore, analyzing the response relationship between different vegetation patterns and soil aggregates indicates that as the complexity of vegetation types increases, soil particle size changes increase, changing soil stability, erosion resistance, and soil nutrients. In summary, in-depth research on water and fertilizer regulation technology has improved ecosystem functions and promoted the overall improvement of regional forest ecosystem quality.

2.5. Via Studies on the Changes in the Carbon Sequestration Function of Forest Ecosystems in Desertification Areas, Strategies Have Been Proposed to Enhance Forest Carbon Sequestration and Microbial Carbon Use Efficiency, Which Can Help Regulate the Climate Conditions of Small Niches

Hu et al. [23] explored *Eriobotrya japonica.* and peanut from the perspective of intercropping between foresters and farmers, and the results showed that loquat yields and soil properties were significantly improved, while emissions of carbon monoxide, methane, and other gases were significantly reduced. Wu et al. [24] analyzed the microbial environment in the topsoil and subsoil of root nodules of the endangered species *Abies fanjingshanensis* using a fungal and bacterial symbiotic network method, indicating that the soil microbial carbon sequestration function in forest environments is an important characteristic of plant growth and development. The important reason for the death of *Abies fanjingshanensis* is the decrease in microbial carbon use efficiency (CUE). Forest management and decision-makers should appropriately add exogenous biochar and nitrogen fertilizer.

2.6. By Studying the Cascading Framework of "Forest—Soil—Microbiota" in Desertification Areas, Strategies Have Been Proposed to Effectively Improve the Soil Microbial Environment, the Soil Nutrient Status, and Vegetation Growth and Development via the Regulation of Functional Traits, Which Can Help Diminish the Contradiction between Forest Ecosystem Function and Human Intervention

The current karst desertification control forest ecosystem is facing functional lag challenges such as biodiversity decline, limited material circulation, and declining supply capacity. Therefore, many scholars have explored strategies for enhancing the functionality of forest ecosystems in desertification control from the perspective of the "forest—soil—microbiota" cascade framework. Yu et al. [11] conducted a comparative study on the functional traits of leaves and roots of *Z. planispinum* 'Dintanensis' and *Z. amatum* 'Novemfolius' during the seedling stage, and the results showed significant differences in structural, nutritional, and physiological traits between the two types of tree species. *Z. planispinum* 'Dintanensis' demonstrates stronger resource utilization efficiency, preservation, and resistance to pests and diseases in response to extreme environments, as well as constructing strong defense and adaptation mechanisms through secondary metabolites and developed fine roots. This indicates that the introduction of excellent varieties has improved the forest ecosystem function of karst rocky desertification control, and it is urgent to build a germplasm resource bank and explore scientific seedling cultivation techniques. On the one hand, utilizing mutually beneficial symbiotic relationships within species can enhance crop yield, quality, and disease and pest resistance, and improve soil environments. At the same time, a reasonable planting ratio of *Z. planispinum* not only effectively enriches biodiversity, but also enhances the utilization of space, resources, and ecosystem functions. For example, the mixed planting of *Z. planispinum* and *L. japonica* can effectively regulate the soil microbial environment, nutrient status, and growth and development via the production of litter and root secreta. At the same time, it can promote the accumulation of amino acids and the formation of special flavors, improving product quality [25]. On the other hand, via a comparison of the response of leaf functional traits and soil characteristics of *Z. planispinum* 'Dintanensis' with those of different planting structures, it was found that the mixed planting of *Z. Planispinum* and *S. Tonkinensi* has a good effect. Meanwhile, *S. tonkinensi* promoted the growth of *Z. planispinum* by regulating the N content of microorganisms, and also effectively regulated its tolerance to the cold and barren conditions [10].

2.7. Through Research on the Supply Capacity and Value Realization of Ecological Products for Desertification Control, Strategies for Enhancing Product Supply Capacity, Value-Accounting Systems, Implementation Models, and Paths Have Been Created, Which Contribute to the Adjustment of the Characteristic Regional Forest Industry Structure

Master Plan for Major Projects for the Protection and Restoration of Important National Ecosystems (2021–2035) clearly points out the national strategy for improving supply capacity, and realizing the value of ecological products, which is of great significance for promoting rural revitalization in desertification control areas. The work of Yang et al. [26] is based on the research framework of "time change—content division—distribution areas—key scientific questions to be addressed". Based on the five perspectives of the connotation and extension, supply, value accounting, value realization, and ecological industry of ecological products, we aim to improve the functionality of forest ecological systems by enhancing the supply capacity of forest ecological products, improving the compensation mechanism for ecological services, and coordinating development strategies for ecological services and ecological industries. In addition, Yang et al. [27] also shifted their research focus to the management of agroforestry ecosystems in karst desertification, presenting the significant contribution of agricultural forest ecosystems in enriching biodiversity, improving supply capacity, and increasing farmers' economic incomes. In summary, the sustainable economic development model of promoting ecological industrialization and industrial ecology in karst areas not only effectively helps to identify the functions of agricultural and forest ecosystems, but also greatly mitigates the livelihood problems experienced by farmers and diminishes the contradiction between people and land.

3. Key Scientific Issues to Be Addressed

3.1. Regarding the Scientific Issue of the Spatiotemporal Evolution Differences in Forest Ecosystem Values under Different Environmental Factors in Desertification Control, Elucidating the Impact of Regional Spatial Heterogeneity on Forest Ecosystem Quality Can Provide a Basis for the Accurate Evaluation of Forest Ecosystem Values at Different Levels of Rocky Desertification

The evaluation of forest ecosystem service value for karst desertification control is currently in the development stage [14]. However, there are still many limitations in terms of the evaluation system, methods, and accuracy, such as significant differences in altitude, slope, and climate conditions in the study area. The price fluctuations of various service functions are large, making it difficult to accurately evaluate the spatiotemporal differences in the value of forest ecosystem services. Therefore, in the future, it is necessary to ensure that more rigorous research is conducted on the internal mechanisms of the factors that affect the functions of forest ecosystems with different levels of desertification and environmental factors.

3.2. The Key Scientific Issues in Constructing a Framework for Rural Landscape Restoration Assessment from the Ecological, Engineering, and Socio-Cultural Perspectives of Desertification Control Are Identified, and the Underlying Mechanisms of Poverty, Population Migration, and Cultural Invasion in Landscape Safety Patterns Are Discovered, Providing New Insights for Optimizing the Natural and Social Landscape Configuration in Karst Areas

There are significant differences between the level of karst desertification and the spatial distribution of forest ecosystem function utility in South China Karst. Previous research results have only qualitatively analyzed the impact of a series of ecological restoration policies, such as returning farmland to forests, immigration and relocation, and promoting the development of the forestry industry. Integrating GIS and RS technologies to quantitatively analyze the driving factors of ecosystem changes has become a trend [15,16]. Therefore, further research is needed on the impact of landscape functional zoning, population migration, and rural cultural decline on ecosystem changes. Strengthening the construction of ecological corridors between regions in the future, in so doing overcoming regional population loss and external interference, is beneficial for the reconstruction of regional forest landscape patches.

3.3. To Address the Key Scientific Issues Related to the Differential Effects of Different Niches and Forest Types in Desertification Control, This Study Aims to Reveal the Internal Mechanism of Improving Forest Ecosystem Structure and Stability, and Provide a Forest Ecosystem Optimization Plan That Transforms Quantity in to Quality for Karst Areas

The structure of forest ecosystems determines their functions and changes the processes and services. Under the strong intervention of ecological restoration projects, rapid vegetation restoration has led to the dilemma of regional ecosystem singularity, biodiversity decline, and functional deterioration. With the increasing awareness of the inseparable relationship between the quality of the ecological environment and the development of economic health, understanding how the effects of niche and forest type combinations affect system structure and stability is the key to improving regional landscape functions [17,18]. In the future, it is necessary to continue to enhance the cultivation of forest species and the study of the inherent relationships between inter-species material circulation, energy flow, and information transmission in the ecosystem process, in order to improve the overall resilience of the ecosystem.

3.4. In Response to the Key Scientific Issue of Obstructions to Effective Water Resource Circulation in Forest Ecosystems under Desertification Control, Revealing the Internal Mechanism of Forest Species Allocation and Climate on the Conversion of Atmospheric Precipitation into Soil Water Efficiency Can Lay the Foundation for Improving the Productivity of Karst Forestry and Crops

The soil layer in karst desertification environments is relatively thin, with a high degree of soil erosion, and there is a seasonal lack of soil moisture for a long duration. Studying the transformation of atmospheric precipitation into soil water, mitigating surface erosion (transpiration inhibition; litter interception), and underground leakage can enhance the relative stability and anti-interference effect of overlying forest ecosystems [19]. At the same time, the combination of different forest types with complementary ecological characteristics can improve the efficiency of effective water absorption and the adaptability of effective vegetation [20]. Therefore, future research on karst desertification areas needs to explore the impact of different water source cycling mechanisms on vegetation growth and development.

3.5. To Address the Key Scientific Issues of Soil Fertility Conservation under the Desertification Control of Forests, the Response Mechanisms of Complex Plant Types and Soil Characteristics Must Be Revealed, and Technical Support for Element Supplementation and Soil Fertility Regulation in Karst Forests Must Be Provided

The objectives of realizing high-quality development and sustainably managing of understory soil in karst desertification control areas have not yet been fully achieved. Further research is needed on the configuration of lithophyte communities, biodiversity restoration techniques, and soil fertility optimization scheduling. There is still a need to increase the robustness of technological research on the elemental supplementation of water resources, control of carbon and nitrogen leakage, and improvement of soil fertility (aggregates, carbon and nitrogen absorption) [21,22]. Therefore, in the future, more attention should be accorded to the effects of endogenous water, carbon and nitrogen cycling, nutrient accumulation, and vegetation adaptability in the region. Not only must we analyze the differences in different environmental factors from a field perspective, but we must also conduct in-depth research from a micro-perspective, combining plant nutrient differences, moss crust characteristics, soil microbial activities, and other factors to improve regional forest ecological environments through utilizing multi-scale, multi perspective, and diversified integrated technologies.

3.6. Aiming at the Key Scientific Objectives of Improving Soil Microbial Environments, Soil Nutrient Status, and Vegetation Growth and Development through Enhancing the Functional Characteristics of Different Vegetation Types in Rocky Desertification Control, This Paper Proposes the Construction of Germplasm Resource Banks and Vegetation Adaptability Enhancement Strategies, Which Can Help Improve the Functionality of Karst Forest Ecosystems

The rate of element transfer, material cycling, and environmental factors in different areas of vegetation in karst regions are closely related. Due to the significant differences in the utilization of nitrogen and phosphorus by leaves and roots of artificial forests, it directly leads to differences in the direction of vegetation growth and development in response to extreme environments [11]. Therefore, in the future, it is not only necessary to consider the impact of physiological activities such as those of roots, stems, and leaves on microbial and extracellular enzyme activities, but also to construct germplasm resource banks and vegetation adaptability enhancement strategies to prevent the major risks faced by karst forest ecosystems in the future.

3.7. To Address the Key Scientific Issue of the Difficulty in Consolidating the Effectiveness of Desertification Caused by Rapid Vegetation Restoration, Revealing the Balance/Synergy Mechanism of Karst Forest Ecosystem Functions Can Help Alleviate the Supply Demand Contradiction of Forest Ecological Products in Desertification Areas

The rapid restoration of vegetation in karst areas has caused repeated problems in terms of the effectiveness of rocky desertification control. Analyzing the interrelationships between plant functional traits (roots, stems, and leaves), soil physicochemical properties (pH, carbon and nitrogen, enzyme activity, etc.), and microorganisms (population quantity, community structure, etc.) is imperative to proposing relevant improvement strategies [10,25]. For example, improving organic structure of soil plant ecological adaptability of plants, increasing the effective water and nutrient absorption of plants, and clarifying the functional balance/synergistic mechanisms of karst forest ecosystems are beneficial for enhancing the supply capacity of forest products (increasing ecological product quality).

3.8. To Address the Key Scientific Issues of Unclear Paths for Realizing the Value of Forest Ecological Products in the Desertification Control, the Establishment of a Forest Ecological Product Property Rights System, Asset List, and Ecological Compensation Mechanism Can Help Coordinate the Coupling of Karst Ecological Protection and Restoration with Ecological Industries

The ecological, social, and economic benefits of forests and agroforestry ecosystems in karst areas must be evaluated. Based on the current progress in regional ecological restoration and its own advantages, future efforts must include further cultivating, developing, and expanding characteristic forest products, as well as building a trading platform to promote the value realization of forest products. Therefore, it is necessary to improve the path, mechanism, and model for realizing the value of forest ecological products, among which ecological compensation is an important way to achieve the value of ecological products. At the same time, it is necessary to build a fully integrated ecological industry system, for example via enhancing the supply capacity of forest ecological products, the value realization path, the ecological industry chain, and comprehensive desertification control [26,27].

3.9. Focusing on the Layout of the Forest Wellness Industry for Desertification Control in the Context of the Era of Great Health, We Systematically Study the Extended Industrial Chain and Service Potential of Forest Ecosystems, and Identify the New Highlights of the Tourism Economy under the New Normal

Select desertification areas with good ecological tourism infrastructure and location advantages fully utilize local forest wellness industry policies and layouts, combine their existing vegetation, and screen species that combine aspects of both ecology and economy [28–30] to study and construct an extended industrial chain of forest ecosystems from the perspectives of germplasm protection, research experience, wellness tourism, and medication and food therapy, in order to achieve an integrated leisure and health service system of forestry–tourism–rehabilitation, as well as the sustainable and healthy development of ecosystem restoration work in desertification areas.

4. Conclusions and Prospect

Through a systematic literature review of all articles in this Special Issue on karst desertification control forest ecosystem, it was found that significant progress has been achieved in the current research on the improvement of forest ecosystem function, driving factors, and regional ecological environment restoration in karst desertification control.

(1) Major landmark achievements and elucidations: we clarified that the decline in ecosystem function in desertification control is influenced by factors such as policy implementation and human intervention, which can improve the new understanding of forest ecosystem restoration; we discovered the strong fragility and weak anti-interference ability of current forest and rural landscapes, providing a reference for landscape planning and layouts for karst environmental protection; we revealed that optimizing the structure of forest systems can enhance the adaptability and nutrient utilization efficiency of vegetation, and expand the research perspective of optimizing the structure and stability of ecosystems; we overcome the technological limitations of water–fertilizer coupling, including effective water resource utilization and carbon and nitrogen leakage, contributing to the levels of climate and system productivity in niches; strategies have been proposed to effectively improve soil microbial environments, soil nutrient status, and vegetation growth and development via the regulation of functional traits, which can help alleviate the contradiction between forest ecosystem function and human intervention; strategies have been proposed to enhance forest carbon sequestration and microbial carbon use efficiency, which can help regulate niche climate conditions; we create strategies to enhance the capacity of product supply, a value accounting system, implementation models, and paths, which contribute to the structural adjustment of the characteristic forest industry.

(2) Key scientific issues and prospects: clarifying the impact of spatial heterogeneity in desertification control on the quality of forest ecosystems can provide a basis for the precise evaluation of the value of forest ecosystems with different levels of desertification; discovering the inherent mechanisms of poverty, population migration, and cultural invasion affecting the landscape security pattern, providing new insights for optimizing the allocation of natural and social landscapes; revealing the internal mechanism of improving the structure and stability of forest ecosystems, which can provide optimization plans for forest ecosystems that transition from quantity to quality; revealing the internal mechanism of forest species allocation and climate on the conversion of atmospheric precipitation into soil water efficiency, which can lay the foundation for improving the productivity of forestry and crops; revealing the response mechanism of complex types of forest plants and soil characteristics, providing technical support for element supplementation in forest water and soil fertility regulation; proposing strategies for building germplasm resource banks and enhancing vegetation adaptability, which can help enhance the functionality of forest ecosystems; revealing the balance/synergy mechanism of forest ecosystem functions, which can help alleviate the supply–demand contradiction of forest ecological products; creating

a forest ecological product property rights system, asset inventory, and ecological compensation mechanism, which is conducive to the coupling and coordination of ecological protection and restoration with ecological industries; systematically studying the layout of forest wellness industry and creating new prospects for the tourism economy under the new normal.

Although this Special Issue systematically summarizes the interrelationships between the structure, function, and services of forest ecosystems for karst desertification control, it is still necessary to expand the neglected research on evaluation methods, technologies, and strategies. This Special Issue has made significant contributions to forest desertification control prevention in achieving the 15th United Nations Sustainable Development Goal (SDG). We hope to encourage more efforts to be made in this direction and sincerely thank all the contributors for their hard work and contributions.

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References

1. Mather, A. Global Forest Resources Assessment 2000 Main Report. *Land Use Policy* **2003**, *20*, 195. [CrossRef]
2. Costanza, R. Economic growth, carrying capacity, and the environment. *Ecol. Econ.* **1995**, *15*, 89–90. [CrossRef]
3. He, C.; Xing, K.; Chi, Y.; Song, S.; Fang, J.; He, S. Effect of landscape type change on spatial and temporal evolution of ecological assets in a karst plateau-mountain area. *Int. J. Environ. Res. Public Health* **2022**, *19*, 4477. [CrossRef]
4. Zhang, S.H.; Xiong, K.N.; Qin, Y.; Min, X.Y.; Xiao, J. Evolution and determinants of ecosystem services: Insights from South China karst. *Ecol. Indic.* **2021**, *133*, 108437. [CrossRef]
5. Xiong, K.N.; Li, J.; Long, M.Z. Features of soil and water loss and key issues in demonstration areas for combating karst rocky desertification. *Acta Geogr. Sin.* **2012**, *67*, 878–888.
6. Yang, Q.; Jiang, Z.; Yuan, D.; Ma, Z.; Xie, Y. Temporal and spatial changes of karst rocky desertification in ecological reconstruction region of Southwest China. *Environ. Earth Sci.* **2014**, *72*, 4483–4489. [CrossRef]
7. Xiong, K.N.; Chi, Y.K. The problems in southern China karst ecosystem in southern of China and its countermeasures. *Ecol. Econ.* **2015**, *31*, 23–30.
8. Ford, D.C.; Williams, P.W. *Karst Hydrogeology and Emorphology*; Wiley: Chichester, UK, 2007.
9. Trac, C.J.; Harrell, S.; Hinckley, T.M.; Henck, A.C. Reforestation programs in southwest China: Reported success, observed failure, and the reasons why? *J. Mt. Sci.* **2007**, *4*, 275–292. [CrossRef]
10. Li, Y.; Yu, Y.; Song, Y. Leaf functional traits of Zanthoxylum planispinum 'Dintanensis' plantations with different planting combinations and their responses to soil. *Forests* **2023**, *14*, 468. [CrossRef]
11. Yu, Y.; Song, Y.; Li, Y. Seedling survival strategies of Zanthoxylum planispinum 'Dintanensis' and Zanthoxylum amatum 'Novemfolius', based on functional traits in karst desertification control. *Forests* **2023**, *14*, 386. [CrossRef]
12. Maeler, K.G.; Aniyar, S.; Jansson, A. Accounting for ecosystem services as a way to understand the requirements for sustainable development. *Proc. Natl. Acad. Sci. USA* **2008**, *105*, 9501–9506. [CrossRef] [PubMed]
13. Xie, G.D.; Zhang, C.X.; Zhen, L.; Zhang, L. Dynamic changes in the value of China's ecosystem services. *Ecosyst. Serv.* **2017**, *26*, 146–154. [CrossRef]
14. Zhou, Z.; Zhang, L.; Wu, T.; Luo, D.; Wu, L.; Chen, Q.; Feng, Q. Changes in ecosystem service values of forests in southwest China's karst regions from 2001–2020. *Forests* **2023**, *14*, 1534. [CrossRef]
15. Ying, B.; Li, S.; Xiong, K.; Hou, Y.; Liu, T.; Sun, R. Research on the resilience assessment of rural landscapes in the context of karst rocky desertification control: A case study of Fanhua village in Guizhou province. *Forests* **2023**, *14*, 733. [CrossRef]
16. Ying, B.; Liu, T.; Ke, L.; Xiong, K.; Li, S.; Sun, R.; Zhu, F. Identifying the landscape security pattern in karst rocky desertification area based on ecosystem services and ecological sensitivity: A case study of Guanling county, Guizhou province. *Forests* **2023**, *14*, 613. [CrossRef]
17. Kong, L.; Xiong, K.; Zhang, S.; Zhang, Y.; Deng, X. Review on driving factors of ecosystem services: Its enlightenment for the improvement of forest ecosystem functions in karst desertification control. *Forests* **2023**, *14*, 582. [CrossRef]

18. Jiang, S.; Xiong, K.; Xiao, J.; Yang, Y.; Huang, Y.; Wu, Z. Agroforestry ecosystem structure and the stability improvement strategy in control of karst desertification. *Forests* **2023**, *14*, 845. [CrossRef]
19. Wu, Q.; Xiong, K.; Li, R.; Xiao, J. Farmland Hydrology Cycle and Agronomic Measures in Agroforestry for the Efficient Utilization of Water Resources under Karst Desertification Environments. *Forests* **2023**, *14*, 453. [CrossRef]
20. Fan, B.; Xiong, K.; Liu, Z. Forest Plant Water Utilization and the Eco-Hydrological Regulation in the Karst Desertification Control Drainage Area. *Forests* **2023**, *14*, 747. [CrossRef]
21. Hu, C.; Liu, Z.; Xiong, K.; Lyu, X.; Li, Y.; Zhang, R. Temporal and Spatial Variations in Carbon/Nitrogen Output in the Karst Critical Zone and Its Response to the Forest Ecosystem of Karst Desertification Control. *Forests* **2023**, *14*, 1121. [CrossRef]
22. Zhu, D.; Yang, Q.; Zhao, Y.; Cao, Z.; Han, Y.; Li, R.; Ni, J.; Wu, Z. Afforestation Influences Soil Aggregate Stability by Regulating Aggregate Transformation in Karst Rocky Desertification Areas. *Forests* **2023**, *14*, 1356. [CrossRef]
23. Hu, T.; Xiong, K.; Wang, J. Intercropping Peanut under Forests Can Reduce Soil N_2O Emissions in Karst Desertification Control. *Forests* **2023**, *14*, 1652. [CrossRef]
24. Wu, X.; Zhang, Z.; Zhang, J.; Liu, Y.; Luo, W.; Mou, G.; Huang, X. Multiple factors jointly lead to the lower soil microbial carbon use efficiency of Abies fanjingshanensis in a typical subtropical forest in southwest China. *Forests* **2023**, *14*, 1716. [CrossRef]
25. Li, Y.; Yu, Y.; Song, Y.; Wei, C. Influence of different planting combinations on the amino acid concentration in pericarp of Zanthoxylum planispinum 'Dintanensis' and soil. *Forests* **2023**, *14*, 843. [CrossRef]
26. Yang, B.; Zhang, Y.; Xiong, K.; Huang, H.; Yang, Y. A Review of eco-product value realization and eco-industry with enlightenment toward the forest ecosystem services in karst ecological restoration. *Forests* **2023**, *14*, 729. [CrossRef]
27. Yang, Y.; Xiong, K.; Huang, H.; Xiao, J.; Yang, B.; Zhang, Y. A Commented review of eco-product value realization and ecological industry and its enlightenment for agroforestry ecosystem services in the karst ecological restoration. *Forests* **2023**, *14*, 448. [CrossRef]
28. Li, X.; Wang, X.H.; Qiang, W.; Zheng, H.J.; ShangGuan, L.Y.; Zhang, M.S. Transcriptome revealing the dual regulatory mechanism of ethylene on the rhynchophylline and isorhynchophylline in *Uncaria rhynchophylla*. *J. Plant Res.* **2022**, *135*, 485. [CrossRef]
29. Wang, X.H.; Li, X.; Qiang, W.; Yu, X.S.; Zheng, H.J.; Zhang, M.S. Comparative transcriptome analysis revealed the molecular mechanism of the effect of light intensity on the accumulation of rhynchophylline and isorhynchophylline in *Uncaria rhynchophylla*. *Physiol. Mol. Biol. Plants* **2022**, *28*, 315. [CrossRef]
30. Li, X.; Zhang, M.S.; Zhao, L.Q.; Ling-hu, Q.Q.; Xu, G. The study on interacting factors and functions of *GASA6* in *Jatropha curcas* L. *BMC Plant Biol.* **2023**, *23*, 99. [CrossRef]