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Several Key Points in Territorial Ecological Restoration

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Abstract

The coupled Human-Natural System thinking is considered as an important theoretical basis for territorial ecological restoration. The relationships between ecological space, production space, and living space show three evolution stages in territorial governance: coordinated arrangement, systematic governance, and human-nature harmony. In this regard, coupled Human-Natural System research is necessary to set the perspectives of coupling indicators, coupling hierarchies, coupling effects and coupling models to identify the primary evaluation indicators, delineate hierarchical nested regions, decouple the spatio-temporal relationship of socialecological effects, and develop human-natural coupling models, so as to systematically support the territorial ecological restoration and facilitate the national and regional high-quality development.

Keywords

coupled Human-Natural System, ecological restoration stage, coordinated arrangement, systematic governance, humannature harmony

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Abstract: The thinking of coupled human-natural system is considered as an important theoretical basis for territorial ecological restoration. The relationship between ecological space, production space, and living space shows three evolution stages in territorial governance: coordinated arrangement, systematic governance, and human–nature harmony. In this regard, the research on coupled human-natural system is necessary to set the perspectives of coupling indicators, coupling hierarchies, coupling effects, and coupling models to identify the primary evaluation indicators, delineate hierarchical nested regions, decouple the spatio-temporal relationship of social-ecological effects, and develop human-natural coupling models, so as to systematically support the territorial ecological restoration and facilitate the national and regional high-quality development.

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Ecological restoration refers to the process of repairing the ecosystems that have been degraded or destroyed, which aims to restore the structure and functions of ecosystems and improve their services^[1]. Territorial space, as the carrier of human activities, is composed of ecosystem, humans, and their interactions^[2]. The previous studies on ecological restoration in China mostly focused on single ecological elements (e.g., water and soil) or natural processes (e.g., water and soil loss) while failed to resolve underlying problems. Therefore, the thinking of territorial ecological restoration has been proposed, with emphases on systematicness, integrity, and comprehensiveness^[3]. Guided by the thinkings of ecological civilization construction, such as coordinating systematic governance of mountains, rivers, forests, farmlands, lakes and grasslands, implementing integrated ecological protection and restoration of mountains, rivers, forests, farmlands, lakes, and grasslands, and clear waters and green mountains are as valuable as mountains of gold and silver, the theory and methodology of territorial ecological restoration have been constantly improved. Such improvement is manifested by shifting of subjects of ecological protection and restoration from natural elements to social-ecological elements, of the scale from local ecosystem to multi-scale ecological security pattern, and of the goal from ecosystem structure and function optimization to ecological well-being improvement^[3,4].

Territorial space is a typical space carrier of the

human–nature system, and the thinking of coupled human-natural system is considered as an important theoretical basis for territorial ecological restoration^[4–6]. However, the available studies mainly elucidate the theoretical connotation of territorial ecological restoration based on the thinking of coupled human-natural system. These studies fail to expound the effective application of coupled human-natural system in guiding territorial ecological restoration and to develop the method of deepening the research of coupled human-natural system according to the demand of territorial ecological restoration. In this study, the key points of territorial ecological restoration were elucidated and the corresponding research contents were put forward based on the theory of coupled human-natural system.

1 Evolution stages of territorial ecological restoration

Territorial space, the spatial integration of natural elements (mountains, rivers, forests, farmlands, lakes, grasslands, deserts, and sea) and social elements (cities, villages, roads, and mines), has the compound functions of production, living, and ecology. With the requirements of territorial space optimization for efficient production space, suitable living space, and beautiful ecological space, the correct understanding of production space, living space, and ecological

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space has been taken as the theoretical basis for the development and protection of territorial space^[7,8]. The identification of the relationship between ecological space, production space and living space, as well as the strategic positioning of territorial ecological restoration, is the prerequisite of the relevant planning and management.

The relationships between ecological space, production space, and living space show three evolution stages in territorial governance: coordinated arrangement, systematic governance, and human–nature harmony (Fig. 1). Coordinated arrangement: With the focuses on environment carrying capacity under the background of ecological space occupation and environmental degradation^[9], it intends to reduce the consumption of ecological products and services by human beings through delineating the boundary of production, living, and ecological space with a series of ecological protection and pollution control policies in the case of territorial space over-exploitation. Systematic governance: On the basis of in-depth understanding of the spatial influence of natural elements and social elements and their feedback paths, it tries to form a cognition of territorial space system with the subject of territorial complex and guide natural restoration of the ecosystem by artificial assistance^[10], thus coordinating the systematic governance of mountains, rivers, forests, farmlands, lakes and grasslands^[11]. Human-nature harmony: Along with the construction of a strong, prosperous and beautiful China with blue sky, green land, beautiful mountains and clear rivers^[12], it aims to promote the positive succession and coordinated development of human-nature system under the interaction and mutual penetration between social system and ecosystem^[13]. The integration of production and living space into ecological space forms a territorial ecological security pattern for green development, thus promoting the human–nature harmony.

The systematic governance of mountains, rivers, forests,

farmlands, lakes, and grasslands is at the second stage of territorial ecological restoration, the goal of which is to optimize the coordinated arrangement of natural elements based on appropriate artificial support. At this stage (a link between past and future) of territorial ecological restoration, the foundation of ecological protection and the geographic cognition of ecological space at the first stage need to be consolidated, and meanwhile the green development should be oriented for the coupling of social-ecological elements at the third stage.

2 Key points in territorial ecological restoration

(1) For coordinated arrangement, we need to determine the key regions of territorial ecological protection and restoration to safeguard the boundary of ecological security. Considering the misalignment of ecological security boundary with administrative boundary, and the province crossing of large-scale geographic units (important ecological security barriers), territorial ecological restoration should clarify the strategic pattern of national ecological security^[14]. In the National Plan for Developing Functional Zones published on June 8, 2011, the ecological security strategic pattern based on Two Barriers and Three Belts (Qinghai-Tibet Plateau Ecological Barrier, Loess Plateau-Sichuan-Yunnan Ecological Barrier, Northeast Forest Belt, Northern Desertification Prevention Belt, and Southern Hilly Belt) was proposed, which have formed an elementary contour of overall ecological security. The difference between barrier and belt is reflected in not only spatial pattern but also ecosystem structure and function. Ecological barrier, with complex ecosystem structure and landscape pattern, can provide diverse ecological functions and services. Ecological belt, generally dominated by a certain type of ecosystem, can provide single or primary ecological functions and services.

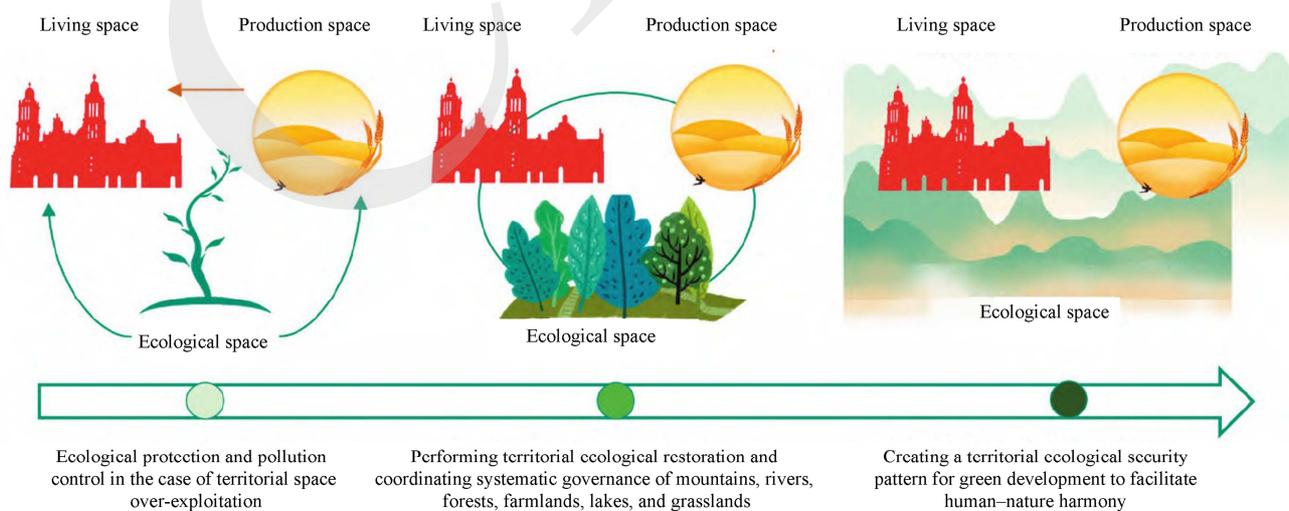


Fig. 1 Evolution stage of spatio-temporal ecological restoration

During the “14th Five-Year Plan” period, China’s ecological security strategic pattern should be advanced from “freehand brushwork” to “elaborate-style painting.” That is, the ecological security pattern should be refined during the development of functional zones. The formed basic framework of ecological security pattern will guide the general arrangement of territorial ecological restoration. For example, the Loess Plateau-Sichuan-Yunnan Ecological Barrier is separated by Qinling Mountains between the south and the north. Qinba Mountains have outstanding ecological functions such as biodiversity maintenance, water conservation and climate regulation, being worthy of protection and restoration as a territorial ecological security barrier. Next, in view of the green development strategy of the Yangtze River Economic Belt, it is urgent to discuss the ecological protection and restoration of lakes and wetlands in the middle and lower reaches of the Yangtze River. Furthermore, the coastal zones, as the lifelines of marine economic development, have suffered from the shrinkage of natural coastlines and degradation of environment in recent years. The inclusion of coastal zone protection into the territorial ecological security pattern will provide greater support for overall ecological restoration from the perspective of land and marine development in a coordinated way. With the ecological restoration in the northern farming-pastoral transitional zone and southern karst area, it is recommended to implement Yanshan Mountain-Taihang Mountain ecological protection and restoration, and construct the green corridor along the Beijing-Hangzhou Grand Canal. The construction of several north-south corridors connecting the ecological barriers and ecological belts will form a national ecological security pattern of barriers-belts-corridors.

(2) For systematic governance, it is necessary to deeply study the interactions of ecosystem with natural elements including mountains, rivers, forests, farmlands, lakes, grasslands and deserts, and then determine the ecological protection and restoration methods according to local conditions for improving the quality and stability of ecosystems. Ecological protection and restoration can be carried out from the perspectives of conserving specific species or habitats, protecting regional ecology, restoring destroyed ecosystems, and rebuilding the ecosystem incapable of self-restoration. In humid and semi-humid areas with mild damage, the restoration can be rapidly achieved by the prevention of artificial disturbance in regional ecological space. However, in arid and semi-arid zones with slow succession of natural ecosystems, artificial restoration or ecological reconstruction should be performed through the planting of shrubs, trees or herbs. It is worth noting that mountains, rivers, forests, farmlands, lakes, grasslands, and deserts are highly associated at the landscape scale^[15]. The increase in vegetation coverage in the arid areas can change the water circulation, while the restriction threshold of soil water and underground water on the stability of ecosystems in arid areas remains uncertain. Therefore, it is necessary to keep in mind that greener

terrestrial ecosystem is not definitely to be better. The artificial ecological restoration and reconstruction of territorial space should insist on the principle of taking quality and stability as priorities according to geographic rule. On the basis of clarifying the plant suitability as well as the interactions and environmental effects of natural elements in local places, we can determine the restoration methods and the spatial allocation modes of mountains, rivers, forests, farmlands, lakes, and deserts conforming to local geographic conditions.

(3) For human–nature harmony, the integration of ecological restoration with economic, social, and cultural construction will optimize the pattern of territorial space and improve the well-being of the people, thus promoting the green transformation of economic and social development. Territorial ecological restoration is not limited to ecosystems, but involves social elements such as cities, farmlands, and industrial and mining areas. The purpose of ecological security is to maintain and improve well-being of the people while keeping the functions of ecosystem. Therefore, the well-being of the people can reflect the purpose and benefits of territorial ecological restoration from the demand side^[16]. An important mission of territorial ecological restoration is to supply high-quality ecological products and improve the well-being of the people. China’s current territorial ecological restoration has laid a solid ecological basis for regional green development through the arrangement of restoration projects for mountains, rivers, forests, farmlands, lakes and grasslands. On the basis of continuous promotion of these projects, efforts should be made to strengthen the core position of territorial ecological restoration in the improvement of farmland production and ecological function for rural ecological revitalization, the improvement of urban ecological quality in the context of new urbanization, and the construction of green mines with energy revolution in the future. It is required to fully integrate ecological civilization construction into political, cultural, economic and social construction from the perspective of optimizing the pattern of territorial space.

3 Strengthening of the research on coupled human-natural system to support territorial ecological restoration

The protection, restoration, and reconstruction of ecosystem via territorial ecological restoration can guide the improvement of ecosystem quality and stability and keeping of ecological security, which directly interprets the concept of clear rivers and green mountains are as valuable as mountains of gold and silver. Since China has vast territory with diverse ecosystems and large difference in social development levels, the in-depth understanding of human–nature relationship in different regions is the scientific prerequisite for territorial ecological restoration and human–nature harmony. According to the requirements of high-quality development,

revealing the coupling of geographic environment with human activities from the following four aspects will lay a solid foundation for territorial ecological restoration.

(1) The driving mechanism of ecosystem degradation needs to be revealed based on ecological and social coupling indicators for the determination of ecological restoration standard system. On one hand, ecosystem degradation is generally caused by the combined actions of climate changes and human activities, the contributions of which vary in different regions. If attention is only attached to the degradation process and spatial pattern rather than the driving mechanism, the restoration will merely resolve specific problems while cannot realize prevention at the source^[17]. In ecological restoration, prevention at the source is to separately optimize one or more natural and social indicators dominating ecosystem degradation through decoupling. On the other hand, the indicators for evaluating the quality and stability of ecosystem contribute to regional ecological security in different ways. For the establishment of the ecological restoration standard system, we need to comprehensively consider multiple goals such as the conservation of biodiversity and supply of ecological products in specific regions, and select the indicators with the greatest impact on ecological security for evaluation^[18].

(2) Key restoration regions should be identified based on biogeographical elements and ecological functions. Ecological and social elements coexist in the same geographical unit which may be an ecosystem, landscape, basin or region in terms of space, as well as an element, structure, and function in terms of attribute^[19]. Ecological restoration should consider the spatial nesting and attribute hierarchy. Therefore, it is essential to comprehensively understand the territorial space based on geographic zoning. In view of the cascading between ecological restoration, ecosystem services and human well-being, we can take climate changes and socio-economic indicators as external variables and employ the nesting method of biogeographical zoning and ecological functional zoning to form the interference-induced ecosystem degradation system, biogeographic attributes-based biodiversity conservation system, and ecological function enhancement multi-hierarchical indicator system, thus determining the zoning scheme^[20]. At the same time, the identification of key regions for territorial ecological restoration can maintain the stability of ecosystem and supply ecological products.

(3) The regional balance or collaboration of the production, living and ecological functions of territorial ecological restoration should be understood from the perspective of spatio-temporal flow. The ecological and social effects of territorial ecological restoration are diverse and interactive and feature spatio-temporal flow, which can be interpreted by the telecoupling framework (sending, receiving, and spill-over systems) in the theory of coupled human-natural system^[21]. The telecoupling framework has been modified to the metacoupling framework. Specifically, pericoupling and

intracoupling have been supplemented to the telecoupling framework^[22]. Territorial ecological restoration in the metacoupling framework should quantitatively identify the neighborhood and remote responses of production, living and ecological functions on the basis of local effect evaluation, thus providing a comprehensive basis for the evaluation of restoration performance.

(4) The coupling model of human–nature system should be developed for predicting the support of ecological restoration to sustainable development. The current research on Earth surface system is transferring from multielement perspective to systematic perspective with the support of big data and artificial intelligence^[23]. The future research on human–nature relationship will focus on the simulation of complex human–nature system and sustainable development system^[24]. Data matching and path recognition of geographical environment and human activities are still the keys to the simulation^[25]. Therefore, it is urgent to develop a human–nature coupling model based on the mechanism of sustainable development, and give full play of it to the site selection, sequential arrangement, project selection, performance evaluation, and decision-making coordination for territorial ecological restoration, which will facilitate the national and regional high-quality development.

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