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Review on Land Ecosystem Health Assessment

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Abstract Land ecosystem is a unified whole formed by the interaction between natural elements and human activities in the earth surface system. With the increasingly serious eco-environmental problems, the health problems of land ecosystem have attracted more and more attention. In order to fully understand the development trends and achievements of land ecosystem health assessment at home and abroad, this paper reviews the literature on land ecological health assessment from four aspects: connotation, evaluation system, evaluation method and evaluation scale of land ecosystem health assessment.

Key words Land ecosystem health, Review, Land

1 Introduction

The theoretical research on land ecosystem health assessment started early in foreign countries, but there are few papers and achievements, and there is not a complete evaluation index. The research is more comprehensive in the fields of land quality evaluation, land potential evaluation and ecosystem service value. The pressure-state-response (PSR) model lays the foundation for land ecosystem health assessment. At present, there are a large number of documents and achievements in the evaluation of land ecosystem health in China, but there is not a clear definition and standard for its evaluation, and the evaluation methods are diversified. Flexible evaluation models and evaluation indicators should be established according to the characteristics of different regions, so as to provide a better scientific basis for the development of ecological civilization. To sum up, although the research on land ecosystem at home and abroad has gradually entered a new stage, the research methods tend to be diversified, the innovation and application of land science and technology have been further reflected, and the research has achieved rich results.

2 Research progress of land ecosystem health assessment

2.1 Content of domestic land ecosystem health assessment

The research contents of land ecosystem health in China are classified, which mainly include the following aspects.

2.1.1 Study on the connotation of land ecosystem health. There are many research achievements on land ecosystem health in China, but there is no consensus on the definition of land ecosystem health. Zeng Dehui believes that a healthy land ecosystem can not only maintain its own complexity but also meet the needs of human development, and summarizes the relationship between ecosystem health and the sustainable development of human society[1]. When studying Poyang Lake area in Jiangxi Province, Chen Meiqiu thought that the health of land ecosystem is that it can maintain its normal metabolism, has a good ability of recovery and self-maintenance, can alleviate the adverse shocks brought by the outside world and promote the healthy development of economy, society and human beings[2]. Han Mei *et al.* believe that a healthy land ecosystem means that the land resources and environment are in a balanced and sustainable state[3]. Liu Yanxu believes that land ecological health means that the structure and function of land ecosystem will not be threatened or damaged under the interference of regional economic development and human activities[4].

2.1.2 Study on the evaluation system of land ecosystem health. The selection of evaluation system determines whether the results of land ecosystem health assessment are objective and accurate. At present, domestic research mainly adopts "pressure-state-response" (PSR) model and "driving force-pressure-state-impact-response" (DPSIR) model. Among them, the PSR model is the most commonly used. He Xin *et al.* used the PSR model to analyze the temporal and spatial changes of land ecosystem health in Pinggu District of Beijing[5]. Gao Zhijie used the modified entropy method and obstacle degree model to diagnose the land ecosystem health of Sichuan Province[6]. Huo Ziwen *et al.* used PSR model to construct evaluation indicators to evaluate the ecosystem health of the ecological conservation area in northwest Beijing[7]. Based on PSR model and entropy method, Wang Tongda *et al.* discussed the spatio-temporal change trend of land ecosystem health in Shaanxi Province and the driving factors affecting land ecosystem health change[8]. With the deepening and expansion of the research, scholars further improve the original PSR model, and gradually use the DPSIR model to build an index evaluation system. Liu Yang uses DPSIR model to build an evaluation system from five aspects: driving force, pressure, state, impact and response to evaluate the security of land ecosystem in Kunming[9]. At present, some scholars further optimize on the basis of DPSIR

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model, and use DPSIR-TOPSIS compound model to construct index evaluation system to assess land ecosystem health. Xu Mei *et al.* use DPSIR-TOPSIS compound model to construct index evaluation system to assess the health status of land ecosystem in Hunan Province[10]. Based on DPSIR model, Gao Zhijie applied entropy-weight TOPSIS method to diagnose the health of land ecosystem in Jiangsu Province[11]. There are also a small number of scholars using other evaluation models, for example, Ma Shijun put forward the theory of "social-economic-natural complex ecosystem"[12], laying a foundation for the study of urban ecosystem health assessment in China and providing a strong theoretical basis for later scholars. In the selection of evaluation indicators, a unified standard has not yet been formed, and it mainly focuses on the natural growth rate of population, land reclamation rate, forest coverage and so on.

2.1.3 Study on the evaluation method of land ecosystem health. The main evaluation methods of land ecosystem health in China are mathematical model method, information model method and ecological model method. Mathematical model method is the most widely used in practice and develops in the direction of diversification. The main methods to determine the weight are principal component analysis, entropy weight, analytic hierarchy process and so on. Principal component analysis can transform multiple indicators into a few comprehensive indicators, so as to simplify the complex problems. Guo Qiong used principal component analysis to evaluate the health status of land ecosystem in Yuci District. Analytic hierarchy process (AHP), as a comprehensive evaluation method combining qualitative and quantitative analysis, can simplify complex problems. Li Lihong used AHP to evaluate the land health of Shandong Province[13], and put forward some suggestions for improvement. Compared with the AHP, entropy weight has the advantages of strong operability, can avoid the influence of subjective factors, and has a wide range of applications. Li Jiaqi *et al.* used entropy method to determine the weight to evaluate the health status of urban land ecosystem around Changsha, Zhuzhou and Xiangtan[14]. The information model method refers to the use of "3S" technology to combine thematic data with remote sensing data to evaluate the health status of regional land ecosystem from the grid scale. The GIS spatial superposition method with grid as the evaluation unit can make the evaluation results more accurate and the characteristics of spatial differentiation more obvious. The most commonly used method in the ecological model method is the ecological footprint method, which refers to the impact of a specific population on the environment under a certain level of technology and consumption, reflecting the health status of the land ecosystem through ecological carrying capacity and ecological deficit. Wei Liling applied the improved ecological footprint method to evaluate the land ecological health status of the urban agglomeration in the Fujian Triangle. Through the ecological pressure index, it was found that the ecological deficit in Xiamen was the most serious, which provided a scientific basis for the sustainable development of the urban agglomeration. On the whole, the domestic evaluation methods of land ecosystem health are becoming more and more perfect, in which mathematical model method and information model method are widely used in ecosystem evaluation because of their simplicity and scientificity. Because of the instantaneity of calculation results, the ecological model can only be based on static data for analysis, which can not reflect the future development trend, and has certain limitations in practical application. Therefore, this study uses the entropy weight method in the mathematical model method to calculate the index weight to ensure that the evaluation results are objective and accurate.

2.1.4 Study on the evaluation scale of land ecosystem health. The scale of land ecosystem health assessment can be divided into spatial scale and time scale. On the spatial scale, affected by the differences in regional land use and the continuity and difficulty of obtaining original data, the domestic land ecosystem health assessment areas focus on counties, provinces, local areas with special natural environment, urban agglomerations and other regions, while there are few studies on multi-scale and large-scale areas of cities, sub-urban agglomerations and urban agglomerations. On the time scale, the evaluation time span chosen by domestic scholars is mostly concentrated in 5 years and 10 years.

2.2 Content of domestic land ecosystem health assessment Foreign research on ecosystem health began as early as several centuries ago. James Hutton in Scotland put forward the concept of "natural health" and combined it with the ecosystem[15]. British Aldo Leopold put forward the concept of "land health", which believes that healthy land is occupied by human beings without destroying its own function, and it began to be applied to the diagnosis of "land diseases"[16]. Canadian Schaeffe proposed that ecosystem diseases mean that the organizational function of the ecosystem is damaged, the ability of self-maintenance is reduced, and ecosystem health means that there are no diseases in the ecosystem. Rapport defines the connotation of ecosystem health. He believes that healthy ecosystems are sustainable and stable, that is, ecosystems have the ability to maintain and renew themselves[17]. The classical literature written by two ecologists, Schaeffer and Rapport, laid the foundation for ecosystem research for later scholars. Ulanowicz put forward a deeper theory that: in the process of the development of an ecosystem, when the whole system is less restricted, its own ability or potential is enough to compete with the constraints, or through the ability to restore the ecosystem itself to the original state or close to the original state, and can maintain long-term stability, the ecosystem can be considered healthy[18]. In the late 1980s, the Organization for Economic Cooperation and Development (OECD) and the United Nations Environment Programme (UNEP) jointly put forward the environmental safety index model, namely the PSR model[19]. In the PSR system, the environmental problem is divided into three subsystems with different concepts but closely related to each other, and an appropriate index system is established to describe the relation-

ship between the human activity circle and the environmental system. Nowadays, the concept of unified ecological environment has been gradually formed and widely accepted, and the application of PSR model to land ecological health research has been widely recognized by scholars at home and abroad. On the basis of the PSR model, the European Environment Agency proposed the DPSIR model[20].

3 Review and prospect of land ecosystem health assessment

3.1 Review After decades of development, the research content of land ecosystem health assessment at home and abroad is gradually diversified, and there are increasing research results of evaluation system and evaluation indicators. The selection of ecosystem health evaluation indicators is also more scientific and comprehensive. In the empirical research, some scholars also increase the regional characteristic indicators according to local conditions, and the research objects are mainly concentrated in counties, provinces, special sensitive areas and so on. The rich research results provide some theoretical support and method reference for the related research in the future.

3.2 Prospect Although the academic research on the health of land ecosystem has been carried out in depth, there are still some shortcomings. First of all, the intervention of human factors can not be avoided when constructing the index system and determining the weight of factors, it increases the subjectivity of the evaluation results to a great extent, and the later research should reduce human intervention to ensure the objectivity of the results. Secondly, most of the existing studies choose county, provincial and special sensitive areas for health assessment, but there are few studies on the large-scale areas of urban agglomerations, and the subsequent studies should comprehensively consider various factors that affect regional ecosystem health and it is necessary to carry out more comprehensive research on land ecosystem health.

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