

## 渭河流域生态安全格局的多情景分析与优化策略\*

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**摘要:**【目标】多年来, 渭河流域一直在努力在生态保护和经济增长之间取得平衡。构建生态安全格局 (Ecological Security Pattern, ESP) 对于确保生态安全 (Ecological Security, ES) 至关重要。【方法】本研究采用多目标规划 (Multi-objective Programming, MOP) 与斑块生成土地利用模拟 (Patch-generating Land Use Simulation, PLUS) 模型相结合的方法, 预测了 2040 年在三种不同情景下的土地利用变化 (Land Use Change, LUCC)。利用电路理论, 我们生成了生态走廊, 并确定了关键的生态节点, 从而对渭河流域内的生态安全格局进行了比较分析。【结果】主要结果表明: (1) 生态保护 (Ecological Protection, EP) 情景中, 林地、草地和水域的比例最高, 表明生态环境最优。相反, 在经济发展 (Economic Development, ED) 情景中, 建设用地的比例最高, 尤其是在城市快速扩张方面表现得尤为明显。自然发展 (Natural Development, ND) 情景则呈现出更为均衡的变化, 与历史趋势紧密相连。(2) 在生态保护情景中, 生态源区面积为 13,856.70 平方公里, 拥有最大且最完整的斑块面积。在经济发展情景中, 已确定的生态源斑块呈现出碎片化和分散化的特点, 总面积为 8,018.82 平方公里。自然发展情景中的生态源区与 2020 年的实际情况最为相似, 面积为 8,474.99 平方公里。(3) 生态保护情景中的景观破碎度最小。经济发展情景呈现出更为复杂的走廊模式, 阻碍了物种和能量流动效率。自然发展情景与 2020 年的实际分布更为相似。保护和恢复关键生态节点, 确保生态源的完整性和连通性, 对于各种情景下的生态安全格局优化至关重要。【结论】综合所有结果, 我们将渭河流域的空间格局划分为“三区、三带、一中心”; 并为生态保护提供战略建议, 以促进当地生态和社会经济的可持续发展。

**关键词:** 多情景; 生态安全格局; 土地利用变化; 电路理论; 渭河流域

## Multi-Scenario Analysis and Optimization Strategy of Ecological Security Pattern in the Weihe River Basin

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**Abstract:** 【Objective】 For many years, the Weihe River Basin (WRB) has struggled to achieve a balance between ecological protection and economic growth. Constructing an Ecological Security Pattern (ESP) is extremely important for ensuring ecological security (ES). 【Method】 This study employed a coupling of multi-objective programming (MOP) and the patch-generating land use simulation (PLUS) model to project land use change (LUCC) in 2040 across three scenarios. Leveraging circuit theory, we generated ecological corridors and identified key ecological nodes, enabling a comparative analysis of ESPs within the WRB. 【Result】 The main results showed that: (1) The Ecological Protection (EP) scenario showed the highest proportions of forestland, grassland, and water, indicating an optimal ecological environment. Conversely, the Economic Development (ED) scenario features the greatest proportion of construction land, particularly evident in the rapid urban expansion. The Natural Development (ND) scenario exhibits a more balanced change, aligning closely with historical trends. (2) The ecological source areas in the EP scenario is 13,856.70 km<sup>2</sup>, with the largest and most intact patch area. The ecological source patches that have been identified in the ED scenario exhibit fragmentation and dispersion, encompassing a total area of 8,018.82 km<sup>2</sup>. The ecological source areas in the ND scenario is most similar to the actual situation in 2020, encompassing 8,474.99 km<sup>2</sup>. (3) The EP scenario demonstrates minimal landscape fragmentation. The ED scenario presents a more intricate corridor pattern, hindering species and energy flow efficiency. The ND scenario is more similar to the actual distribution in 2020. Protecting and restoring key ecological nodes, and ensuring the integrity and connectivity of

ecological sources are crucial for ESP optimization in various scenarios. **【Conclusion】** Combining all results, we categorize the WRB's spatial pattern into "three zones, three belts, and one center" and offer strategic suggestions for ecological preservation, promoting sustainable local ecological and socioeconomic development.

**Keywords:** multi-scenario; ecological security pattern; land use change; circuit theory; Weihe River Basin