Identifying Priority Areas for County-Level Biodiversity Conservation Based on Ecological Security Patterns: A Case Study of Burqin County (Postprint)

Authors: Yan Xiaomei, Hongwei Wang, Luo Kui, Dong Kangning, Guo Ruijie, Zheng Xudong

Date: 2025-04-21T16:13:24+00:00

Abstract

Ecological security constitutes a critical safeguard for human security and survival. In recent years, the continuous reduction of biological habitats has rendered ecological issues increasingly prominent. The construction of ecological security patterns represents an effective approach to biodiversity conservation. Burqin County, Xinjiang, was selected as the study area. The InVEST and PLUS models were employed to analyze and predict the spatiotemporal evolution characteristics of habitat quality and identify ecological source areas in Burqin County from 2000 to 2030. Circuit theory was utilized to determine the spatial extent of ecological corridors and key areas for biodiversity conservation. Optimal ecological corridor widths were selected for ecological protection zones of varying priorities, and differentiated protection strategies were proposed. The results indicate: (1) From 2000 to 2020, the habitat quality in Burqin County remained at a medium level, with an average habitat quality index of 0.4978, exhibiting an overall trend of initial decline followed by a slight increase; from 2020 to 2030, the habitat quality index in Burqin County continues to increase. (2) The study identified 1059.83 km^2 of ecological source areas, 684.26 km^2 of construction source areas, 69 ecological corridors, and 42 ecological pinch points in Burqin County; based on the resistance threshold points during the expansion of the two types of source areas, the study area was partitioned into distinct ecological protection zones and their conservation priorities were established, which were subsequently refined using data on important ecological protection sites in Xinjiang. (3) Based on wildlife species within different zones, optimal-width ecological corridors were selected and their spatial extents were determined, ultimately proposing a three-dimensional ecological differentiated protection strategy to provide references for county-level ecological protection

and regional development.

Full Text

Preamble

ARID LAND GEOGRAPHY Vol. 48 No. 4 Apr. 2025

Determining Priority Areas for County-Level Biodiversity Conservation Based on Ecological Security Patterns: A Case Study of Burqin County

YAN Xiaomei[1],[2], WANG Hongwei[1],[2], LUO Kui[3], DONG Kangning[1],[2], GUO Ruijie[1],[2], ZHENG Xudong[1],[2]

[1]School of Geography and Remote Sensing Science, Xinjiang University, Urumqi 830017, Xinjiang, China
[2]Xinjiang Key Laboratory of Oasis Ecology, Urumqi 830017, Xinjiang, China
[3]Institute of International Rivers and Ecological Security, Yunnan University, Kunming 650091, Yunnan, China

---

Abstract

Ecological security is fundamental to human well-being and long-term sustainability. However, the ongoing degradation of biological habitats has intensified ecological challenges, highlighting the urgent need for effective biodiversity conservation strategies. This study examines Burqin County in Xinjiang, China, to develop an ecological security framework by analyzing habitat quality dynamics and identifying priority conservation areas. Using the InVEST and PLUS models, we evaluated the spatiotemporal evolution of habitat quality from 2000 to 2030 and mapped ecological source areas. Circuit theory was applied to delineate ecological corridors, ecological pinch points, and key biodiversity conservation zones. Based on optimal corridor widths and conservation priorities, differentiated protection strategies were proposed. The key findings are as follows: (1) From 2000 to 2020, habitat quality in Burqin County remained at a moderate level, with an average habitat quality index of 0.4978. The trend initially showed a decline, followed by slight recovery, while projections indicate a continuous improvement in habitat quality from 2020 to 2030. (2) The study identified 1059.83 km^2 of ecological source areas, 684.26 km^2 of construction source areas, 69 ecological corridors, and 42 ecological pinch points. Resistance thresholds during source area expansion were used to partition the region into distinct ecological protection zones with prioritized conservation levels. These results were cross-validated with data from Xinjiang' s significant ecological protection areas. (3) Zone-specific ecological corridor widths were determined by considering the spatial distribution of wildlife species, ensuring accurate delineation of their extents. (4) Finally, three-dimensional differentiated protection strategies were proposed based on the priority protection areas, providing a reference for county-level ecological conservation and regional development.

Keywords: habitat quality; ecological corridors; ecological security pattern; ecological reserve; differentiated protection strategy

1. Introduction

With ongoing urbanization and modernization, human disturbance to ecosystems has intensified, leading to ecological instability, biodiversity loss, global warming, and deteriorating air quality. These ecological security issues have significantly hindered the coordinated development of socio-economic and environmental systems. In response, the "14th Five-Year Plan for Territorial Space Ecological Restoration in Xinjiang Uygur Autonomous Region" emphasizes the need to accurately identify existing ecological problems and select the most appropriate ecological protection and restoration measures based on Xinjiang' s landscape patterns and current ecological conditions. The report of the 20th National Congress of the Communist Party of China further stresses the need to comprehensively strengthen ecological environmental protection and build a solid ecological security pattern. The Convention on Biological Diversity also notes that progress in global biodiversity conservation and effective management remains limited. Consequently, determining optimal ecological protection areas, establishing conservation priorities under different management scenarios, and proposing effective management recommendations have become critical challenges.

Constructing ecological security patterns represents an effective approach to reconciling the conflict between regional development and ecological conservation. This approach has evolved into a standard research paradigm involving "identifying ecological sources, constructing ecological corridors, and extracting ecological nodes." Ecological sources refer to habitat patches with high ecological capacity that play crucial roles in regional ecosystems, while ecological corridors—first proposed in the early 20th century based on connectivity theory—are channels connecting major habitat patches to facilitate the flow of species, genes, energy, and materials. Recent studies have predominantly used the minimum cumulative resistance model to construct ecological corridors, but this method cannot explicitly define the spatial extent of corridors or identify critical nodes. Determining the spatial range of ecological corridors has gradually become a research focus. To transform corridors into landscape entities with spatial dimensions, scholars have attempted various methods to define corridor width. However, existing studies often treat ecological corridors as homogeneous landscapes and determine width based on corridor type and construction purpose, neglecting local impacts and the specific biological species requiring protection.

Priority protection areas are specific regions with rich species diversity, and their identification is key to biodiversity conservation and sustainable development.

Current approaches primarily rely on biodiversity hotspots and gap analysis, but some identified priority areas include regions with significant human impact, which is detrimental to ecological conservation. Ecological security patterns can help exclude anthropogenic influences when establishing priority protection areas, thereby constructing networks that maintain regional ecosystem integrity and ecological process continuity. This study establishes a coherent biological flow network based on ecological corridor spatial range identification to determine priority areas for ecosystem conservation and achieve effective regulation of ecological processes.

This research focuses on Burqin County, Xinjiang, using the InVEST model and circuit theory to analyze habitat quality spatiotemporal evolution from 2000 to 2030, identify ecological source areas, determine ecological corridor spatial extents and key biodiversity conservation zones based on local biological characteristics, delineate optimal corridor widths for different priority zones, and propose differentiated protection strategies. The objective is to provide a scientific basis for future ecological conservation and planning at the county level.

1.1 Study Area

Burqin County is located in the Altay Prefecture of Xinjiang Uygur Autonomous Region, covering a total area of 10,500 km^2. It borders Mongolia, Russia, and Kazakhstan, with a border length of 171.8 km. The county features diverse ecosystem types and hosts numerous national first- and second-class protected animal species. The terrain slopes from northeast to southwest, showing a north-high-south-low pattern, with a longer north-south axis and narrower east-west width [Figure 1: see original paper]. The ecological environment is complex and fragile, facing issues such as land desertification and soil erosion, making it an appropriate study area for analyzing habitat quality evolution and identifying priority conservation areas based on ecological security patterns.

1.2 Data Sources

Meteorological data (precipitation, temperature, relative humidity, and potential evapotranspiration) were obtained from the National Earth System Science Data Center. LANDSAT series remote sensing satellite data were processed through the Google Earth Engine cloud computing platform (including cloud removal, cloud shadow removal, and stripe misalignment correction). Population density data were sourced from WorldPop. Grazing intensity data were obtained from the National Ecological Science Data Center. Road data were acquired from the Geographic Remote Sensing Ecological Network. Land use data were provided by the Resources and Environmental Sciences Center of the Chinese Academy of Sciences. Slope and elevation data products were obtained from the Geospatial Data Cloud website. Socio-economic data were collected from the Burqin County People' s Government official website. Important ecological protection area data were sourced from the Xinjiang Department of Natural Resources. All spatial data were unified to a spatial resolution of 30 m and projected using the Krasovsky 1940 Albers coordinate system.

1.3 Research Methods

The research framework is illustrated in [Figure 2: see original paper]. The InVEST model was used to measure habitat quality in the study area from 2000 to 2030, thereby identifying ecological source areas in Burqin County. Urban land units were selected as construction source areas. Minimum cumulative resistance surfaces were constructed, and circuit theory was applied to determine ecological corridors. Based on the different resistance values of ecological and construction source area expansion, ecological protection zones with different priorities were delineated. According to the landscape heterogeneity and key protected species in each zone, optimal ecological corridor widths and priority conservation and restoration areas were determined. The ecological security pattern construction results were integrated into differentiated restoration modes to formulate tailored ecological protection strategies for different priority zones, thereby enhancing the efficiency of regional ecological conservation measures.

1.3.1 Source Area Identification

This study utilized the Habitat Quality module of the InVEST model to simulate the impact of land use type changes on regional ecosystem service functions and generate visualized habitat quality assessment results. The calculation formula is as follows [25]:

$$Q_{xj} = H_j \left(1 - \frac{D_{xj}^z}{D_{xj}^z + k^z}\right)$$

where Q_{xj} represents the habitat quality index of grid cell x in land cover type j; H_j is the habitat suitability of land cover type j; D_{xj} is the habitat degradation degree of grid cell x in habitat type j, with a relative habitat suitability score of 1; k is the half-saturation constant, taken as half of the maximum degradation degree (obtained from model calculation); and z is a normalization constant, set to 2.5.

By reviewing relevant literature [26-27], this study determined the maximum impact distances and weights of 5 threat sources, combined with current land use status and referenced similar study area literature [28-29] to determine the sensitivity of different land types (Table 1, Table 2). Finally, areas with excellent habitat quality and area no less than 2 km^2 were selected as ecological source areas, while construction land patches no less than 2 km^2 were selected as construction source areas [30].

1.3.2 Land Use Simulation

The PLUS model is a rule-mining framework based on land expansion analysis strategy (CARS) with multi-type random seed mechanisms, capable of deeply investigating factors causing land use change and dynamically simulating such changes over time and space [31]. This study referenced existing literature [32-33] and selected 7 socio-economic factors: population density, roads, grazing intensity, distance to construction land, elevation, annual average temperature, annual average precipitation, potential evapotranspiration, and relative humidity as driving factors. Based on a natural development scenario, habitat quality in 2030 was explored. This scenario focuses only on land use changes caused by human and natural processes, thereby maximizing the continuation of established development trends and maintaining historical land use change patterns. The land use demand predictions for 2030 were based on Markov chain predictions using land use data from 2000 to 2020. The simulated land use map for 2030 was validated against the actual 2020 land use map, yielding a Kappa coefficient of 0.87, indicating high accuracy and meeting simulation requirements.

1.3.3 Resistance Surface Construction

The spatial distribution of various land types is relatively dispersed, creating resistance for ecological flow processes, with ecological source area expansion experiencing varying resistance levels across different regions. This study established resistance surfaces using a comprehensive index method [34], calculated as:

$$Z = \sum_{i=1}^{n} W_i \times A_i$$

where Z is the comprehensive resistance value; W_i is the weight of resistance factor i; A_i is the score of resistance factor i; and n is the number of resistance factors.

By referencing relevant literature [35-36] and considering the actual conditions of Burqin County, this study selected 8 resistance factors highly correlated with both ecological and construction source area expansion processes, using the same resistance factor system for both. The natural breaks method was used to determine classification criteria for each resistance factor, and the analytic hierarchy process determined each factor’ s weight (Table 3).

1.3.4 Ecological Protection Zoning

Ecological protection zoning can achieve higher conservation efficiency at lower cost. The minimum cumulative resistance values for both source types were calculated separately. Based on the relationship between resistance difference values and grid cell counts, the resistance threshold method [28,33] was applied as the ecological protection zoning standard. When a certain expansion process passes a mutation point, the resistance difference value changes abruptly, allowing land before and after the mutation point to be classified as different types. The relationship between resistance difference values and grid cell counts was statistically analyzed to partition ecological protection zones in Burqin County. The calculation formula is:

$$R = R_{\text{生态}} - R_{\text{建设}}$$

where R is the minimum cumulative resistance difference; $R_{\text{生态}}$ is the minimum cumulative resistance value for ecological source area expansion; and $R_{\text{建设}}$ is the minimum cumulative resistance value for construction source area expansion.

1.3.5 Ecological Corridor and Pinch Point Identification

Circuit theory models assume that during species migration from source areas, different landscape surfaces (i.e., different resistance values) generate different current densities. This method can simulate biological migration routes between ecological sources through current direction and determine ecological corridor spatial extents by measuring cumulative current values [37]. This study used the Linkage Mapper tool to identify ecological corridor directions, with corridor ranges determined by cumulative current values. The Circuitscape open-source program was then used in multi-pair-one mode to connect different ecological sources, inputting current sequentially to other sources for flow iteration, identifying areas with the highest cumulative current density in corridors as ecological pinch points. Corridor width selection was based on relevant references [38-39], with different widths selected for target protected species in different regions.

2 Results

2.1 Spatiotemporal Evolution of Habitat Quality

From 2000 to 2020, the average habitat quality indices for Burqin County were 0.4978, 0.4953, and 0.4978, respectively, indicating moderate habitat quality with an overall trend of initial decline followed by slight improvement. During the study period, the proportion of areas with general habitat quality increased rapidly from 38.45% to 42.31%. Poor and very poor habitat quality areas showed a slight decline after 2015, while good and excellent areas gradually increased, demonstrating an overall improving trend. Under the natural development scenario, grassland area continued to increase from 2020 to 2030, while the expansion rate of unused land decreased, with the average habitat quality index rising to 0.5032.

Spatially, habitat quality in Burqin County shows significant spatial variation, with a pattern of high quality in the central region and low quality at the northern and southern ends. Better habitat quality areas are mainly distributed in the northern and central mountainous regions, where land use types are primarily forest, grassland, and water bodies with high vegetation coverage. The southern oasis region mostly exhibits moderate and poor habitat quality, with land use types including cultivated land, construction land, and some unused land, where human development activities cause certain disturbances. Very poor habitat quality areas are mainly distributed in the northern desert region and southern urban development zone, dominated by bare land and construction land. Overall, the spatial pattern of habitat quality in Burqin County is primarily influenced by land cover types, showing distinct spatial differences [FIGURE:3, FIGURE:4].

2.2 Ecological Security Pattern Construction

2.2.1 Source Area Identification This study selected ecological source areas totaling 1059.83 km^2, accounting for 10.09% of Burqin County' s total area. The main land use types are forest, grassland, and water body, including major forest patches, wetlands, and nature reserves within the study area, showing a "more in the north, less in the south" spatial pattern. Different land use types have different ecological conservation levels, indicating that land use type is an important factor affecting ecological source selection. Construction source areas of 684.26 km^2 were selected, accounting for 6.52% of the county area, concentrated in the southern part of Burqin County as the township construction zone [Figure 5: see original paper].

2.2.2 Resistance Surface Construction Ecological flows encounter different obstacles when passing through various land types, with ecological and construction source area expansion having different resistance surfaces [Figure 6: see original paper]. In Burqin County' s ecological expansion resistance surface, the minimum value is 1 and the maximum is 100. The northern region is a medium-low resistance area for ecological expansion, with large water bodies and forest lands, while the southern region is mostly high resistance as a dense township construction area. The construction expansion resistance surface shows the opposite distribution, with minimum resistance of 1 and maximum of 100, consistent with the assignment in Table 3. Landscape connectivity is disrupted by bare land in the north and construction land in the south, with high resistance values in both areas hindering species movement and normal ecological processes.

2.2.3 Ecological Corridor Identification Identifying ecological corridors is crucial in ecological security patterns, maintaining landscape connectivity between source areas while preserving species dispersal for biodiversity conservation. This study identified 69 ecological corridors, classified as important or potential ecological corridors. There are 10 important ecological corridors with a total length of 724.54 km, including 4 corridors under 10 km, 3 between 10-20 km, and 3 between 20-60 km, with the longest reaching 354.34 km. Potential ecological corridors total 59.92 km. Ecological corridors connect ecological sources to meet the needs of ecological flow movement and energy transfer. Northern ecological sources are densely distributed while southern sources are sparse, resulting in more short important corridors in the north connecting nearby sources, and longer important corridors linking central and southern sources to enhance connectivity of central patches.

Ecological pinch points are critical corridor areas that serve as stepping stones for biological flow of birds and small mammals. Red high-value areas of cumulative current represent these stepping stones, with this study identifying 42 ecological stepping stones covering 13.79 km^2, relatively evenly distributed across Burqin County.

When constructing ecological corridors, source-to-source cumulative current values were calculated to determine corridor spatial extents. Corridor thresholds were set at 30 m, 38.39 m, 50.73 m, and 976.96 m, corresponding to average widths of 17.59 m, 30.75 m, 461.62 m, and 53.89 m, respectively, yielding different corridor width distributions [Figure 7: see original paper]. Corridor width significantly impacts ecological function—excessively wide corridors result in low current density and increased predation risk, while overly narrow corridors create edge effects that reduce edge and interior species numbers. Large wildlife typically requires larger activity areas and thus wider corridors.

2.3 Determining Ecological Priority Protection Areas

Establishing protection zones can reduce habitat loss and protect biodiversity. Different priority ecological protection zones were delineated based on minimum cumulative resistance differences from the two source area expansions. Areas with negative resistance difference values were classified as ecological function key zones, located in northern Burqin County. According to Xinjiang' s important ecological protection area data, the main protected species in this zone include argali, red deer, moose, forest musk deer, snow leopard, sable, purple marten, and lynx. Based on relevant literature and these key species, a corridor threshold of 976.96 m was selected, with a maximum width of 461.62 m to accommodate large mammal movement.

Using the resistance threshold method, the ecological function key zone was further subdivided into ecological core zones and ecological optimization zones. Ecological core zones account for the highest proportion at 32.18%, serving as first-level ecological protection areas and priority conservation zones that are critical for maintaining ecosystem functions and ensuring ecological security. This zone should adhere to bottom-line thinking, with land planning focusing on national reserves and other ecological lands to maximize ecosystem service values. Ecological optimization zones account for 23.98%, serving as second-level ecological protection areas with relatively good ecological quality that primarily buffer and protect the ecological core zones while optimizing nearby areas.

Areas with positive resistance difference values were classified as ecological function conservation zones, located in southern Burqin County. According to Xinjiang' s important ecological protection area data, the key species requiring protection in this zone are rock ptarmigan and Dalmatian pelican. Based on relevant literature and these species, a corridor threshold of 53.89 m was selected, with a maximum width of 15.37 m to accommodate bird and small animal movement. This zone was further subdivided into ecological transition zones and ecological restoration zones. Ecological transition zones account for 32.02%, serving as third-level ecological protection areas with lower ecological security levels as reserve areas for cultivated land and urban expansion, featuring intensive human activities. Development should be planned reasonably to avoid important ecological protection areas. Ecological restoration zones account for the smallest proportion at 11.82%, serving as fourth-level ecological protection areas for urban construction, farmland reclamation, and residential expansion, with extremely low ecological security levels requiring attention to ecological restoration and protection during development [Figure 8: see original paper].

When determining biological corridor spatial extents, the impact of width on land use structure and ecological landscape pattern distribution must be considered. Examining surrounding landscape structure and function can enhance ecological network stability and sustainability while ensuring corridor construction does not excessively impact residents or infrastructure within the width range, thereby avoiding unnecessary interference and excessive social cost consumption. To verify corridor feasibility, land cover maps were overlaid to analyze the proportion of each land use type within corridors [Figure 9: see original paper]. The results show that construction land and cultivated land occupy small proportions, while forest, grassland, and water body occupy large areas, confirming the feasibility of the proposed corridor widths and ranges.

2.4 Differentiated Protection Strategies

Based on the four ecological protection zones with different priorities, three-dimensional differentiated protection strategies were proposed from the perspective of efficient ecological conservation and coordinated economic development. The ecological core zone is the priority protection area located in the northern high-altitude region, featuring two major lakes (Akkule Lake and Kanas Lake) with crucial ecological conservation functions. Although habitat quality is high and human activities are minimal, soil erosion and grassland degradation have resulted in extensive bare land, sand, and Gobi. Conservation and restoration funds should be prioritized for this zone, combining natural recovery with artificial assistance (e.g., vegetation replanting, erosion control) to protect ecological sources. Corridor construction faces low resistance and cost, requiring protection and monitoring to prevent land degradation from damaging corridors. For ecological pinch points, priority should be given to ecological barrier construction and vegetation restoration to ensure functional stability. Natural protection core areas should be strictly controlled, with some severely degraded areas closed for forest regeneration.

The ecological optimization zone is located in medium-high altitude areas with large grasslands and fragmented forest lands, primarily used for grazing. This zone provides a buffer for ecological core zones and should focus on improving livestock breeding efficiency and scientific pasture management to prevent overgrazing from damaging corridors. Although ecological sources and corridors experience human interference, measures such as local closure, grassland restoration, and vegetation reestablishment in degraded forest lands can gradually restore ecological functions. Ecological pinch points require special protection through buffer zone establishment and reduced human activity intensity.

The ecological transition zone is located in medium altitude areas with extensive cultivated and unused lands experiencing rapid development. Facing higher ecological risks due to more human activities than the optimization zone, this zone should improve cultivated land utilization and plan ecological protection land by combining ecological red lines with ecological sources. Ecological source protection can be achieved through farmland ecological buffer belts to form small but stable sources. With poor ecological foundations, corridors should be planned through width reduction and green buffer belts to ensure normal biological flow. Ecological pinch points require refined management; although small in area, their degradation or loss would affect overall corridor connectivity. Therefore, corresponding ecological buffers must be established, law enforcement strengthened, and regulations improved to strictly prohibit any occupation of pinch points.

The ecological restoration zone consists mainly of cultivated and construction land with intensive human activities, fragmented ecological land, and low altitude. Green infrastructure should be vigorously developed to maintain existing habitat quality levels while ensuring orderly township economic development. Ecological source protection primarily relies on planning and protection of semi-natural ecosystems such as parks and suburban green spaces to provide limited ecological habitats. Corridors in this zone are relatively narrow, requiring embedded or artificial corridor solutions such as urban greenways and rooftop greening to achieve local connectivity. Ecological pinch points require the most urgent restoration measures—once fragmented, immediate recovery actions are needed to prevent serious impacts on regional ecosystem connectivity. Measures can include constructing ecological bridges across roads and installing biological passage culverts to reduce human interference.

3 Discussion

Ecological protection zone delineation is a critical step in implementing differentiated ecosystem conservation policies. Given limited investment in ecological protection and restoration, comprehensive protection is unrealistic. This study partitions protection zones based on ecological security patterns to clarify conservation objectives and restoration priorities for different priority areas, achieving greater ecological benefits with smaller investments. The study uses InVEST and ArcGIS 10.6 Linkage Mapper tools to construct Burqin County' s ecological security pattern. However, the PLUS model' s driving factors are influenced by data availability. Future work should integrate more land use change influencing factors to improve simulation accuracy. Due to data limitations, not all relevant factors were considered in constructing the ecological security pattern. Future research should enrich resistance surface indicators, such as socio-economic factors and existing green infrastructure.

4 Conclusion

This study comprehensively analyzed habitat quality spatiotemporal evolution in Burqin County from 2000 to 2030 using the InVEST model, identified ecological source areas, determined optimal ecological corridor widths based on circuit theory and local biological characteristics, constructed ecological security patterns by integrating resistance thresholds from ecological and construction source expansions, delineated different protection zones with prioritized conservation levels, and proposed three-dimensional differentiated protection strategies based on priority zones. The main conclusions are:

(1) The average habitat quality indices for Burqin County from 2000 to 2020 were 0.4978, 0.4953, and 0.4978, respectively, remaining at a moderate level with an overall improving trend. Spatially, habitat quality shows significant variation with a central-high, north-south-low pattern.

(2) The study identified 1059.83 km^2 of ecological source areas and 684.26 km^2 of construction source areas, showing a "more in the north, less in the south" pattern. A total of 69 ecological corridors were identified, including 10 important corridors (724.54 km total length) and 59 potential corridors (354.34 km total length). Forty-two ecological stepping stones were extracted, covering 13.79 km^2 with relatively even distribution.

(3) For the northern ecological function key zone, a corridor threshold of 976.96 m was selected (maximum width 461.62 m) for large mammal movement. For the southern ecological function conservation zone, a threshold of 53.89 m was selected (maximum width 15.37 m) for bird and small animal movement. The zones were further subdivided into ecological core zones (32.18%, first-level), ecological optimization zones (23.98%, second-level), ecological transition zones (32.02%, third-level), and ecological restoration zones (11.82%, fourth-level).

(4) Considering Burqin County' s geographical location and socio-economic conditions, three-dimensional differentiated protection strategies were proposed from the perspective of efficient ecological conservation and coordinated economic development, providing optimization recommendations for Burqin County' s ecological layout.

References

[1] Li Tao, Gong Yabo, Ge Jianzhai, et al. Construction of urban landscape ecological security pattern based on circuit theory: A case study of Hengyang City,

Hunan Province, China[J]. Chinese Journal of Applied Ecology, 2021, 32(7): 2555-2564.

[2] Zhang Xiaodong, Zhao Zhipeng, Zhao Yinxin, et al. Landscape ecological risk assessment and ecological security pattern optimization construction in Yinchuan City[J]. Arid Land Geography, 2022, 45(5): 1626-1636.

[3] Herath H, Halwatura R U, Jayasingh G Y. Evaluation of green infrastructure effects on tropical Sri Lankan urban context as an urban heat island adaptation strategy[J]. Urban Forestry & Urban Greening, 2018, 29: 212-222.

[4] Lewis A C. The changing face of urban air pollution[J]. Science, 2018, 359: 744-745.

[5] Zhai Tianlin, Wang Jing, Jin Zhifeng, et al. Change and correlation analysis of the supply demand pattern of ecosystem services in the Yangtze River Economic Belt[J]. Acta Ecologica Sinica, 2019, 39(15): 5414-5424.

[6] Li Xinqi, Wang Yongjia, Xu Tao. Overall consideration on ecological monitoring works of Xinjiang Uygur Autonomous Region during the 14th year plan period[J]. Arid Environmental Monitoring, 2020, 34(4): 187-192.

[7] Pan Jinghu, Wang Yun. Ecological security evaluation and ecological pattern optimization in Taolai River Basin based on CVOR and circuit theory[J]. Acta Ecologica Sinica, 2021, 41(7): 2582-2595.

[8] Sun Feng, Zhang Jinhe, Wang Peijia, et al. Construction and evaluation of urban ecological security pattern: A case study of Suzhou City[J]. Geographical Research, 2021, 40(9): 2476-2493.

[9] Zhang Y, Li X B, Song W. Determinants of cropland abandonment at the parcel, household and village levels in mountain areas of China: A multi level analysis[J]. Land Use Policy, 2014, 41: 186-196.

[10] Zhu Qi, Yuan Quan, Yu Dapao, et al. Construction of ecological security network of northeast China forest belt based on the circuit theory[J]. Chinese Journal of Ecology, 2021, 40(11): 3463-3473.

[11] Daniela T M, Luciano C J F, Eduarda S M, et al. Delimitation of ecological corridors between conservation units in the Brazilian cerrado using a GIS and AHP approach[J]. Ecological Indicators, 2020, 115: 106440.

[12] Reed F, Noss. Corridors in real landscapes: A reply to Simberloff and Cox[J]. Conservation Biology, 1987, 1(2): 159-164.

[13] Liu Z, Lin Y L, Bruno D M, et al. Heterogeneous landscapes of urban greenways in Shenzhen: Traffic impact, corridor width and land use[J]. Urban Forestry & Urban Greening, 2020, 55: 126785.

[14] Hou Q, Du Y, Dong W, et al. Smart city oriented ecological corridor layout of Sanshui River Basin in arid area of Loess Plateau[J]. Sustainable Energy Technologies and Assessments, 2021, 44: 100993.

[15] Zhang L, Fu B, Lü Y, et al. Balancing multiple ecosystem services in conservation priority setting[J]. Landscape Ecology, 2015, 30: 1-15.

[16] Myer N. Threatened biotas: Hot spots in tropical forests[J]. Environmentalist, 1988, 8(3): 187-208.

[17] Wilson E O, Peter F M. Monitoring biological diversity for setting priorities in conservation[M]. Washington: National Academy Press, 1988.

[18] Yang R, Cao Y, Hou S Y, et al. Cost effective priorities for the expansion of global terrestrial protected areas: Setting post 2020 global and national targets[J]. Science Advance, 2020, 6(37): eabc3436.

[19] Wei Q Q, Halike A, Yao K X, et al. Construction and optimization of ecological security pattern in Ebinur Lake Basin based on MS-MCR models[J]. Ecological Indicators, 2022, 138: 108857.

[20] Huang X, Wang H, Shan L, et al. Constructing and optimizing urban ecological network in the context of rapid urbanization for improving landscape connectivity[J]. Ecological Indicators, 2021, 132: 108319.

[21] Chen Nannan, Kang Shuaizhi, Zhao Yonghua, et al. Construction of ecological network in Qinling Mountains of Shaanxi, China based on MSPA and MCR model[J]. Chinese Journal of Applied Ecology, 2021, 32(5): 1545-1553.

[22] Secretariat of the Convention on Biological Diversity. Global biodiversity outlook 5[R]. Montreal: Secretariat of the Convention on Biological Diversity, 2020.

[23] Li Hongqing, Yang Yu, Zhang Junhong. Construction of ecological security pattern in Shannan Wide Valley Basin of Yarlung Zangbo River[J]. Arid Land Geography, 2023, 46(9): 1503-1513.

[24] Fan Ying, Wang Hongwei, Yang Shengtian, et al. Identification of ecological protection crucial areas in Altay Prefecture based on habitat quality and ecological security pattern[J]. Acta Ecologica Sinica, 2021, 41(19): 7614-7626.

[25] Richard S, Rebecca C K, Spencer W, et al. InVEST3.14.3. User guide: Integrated valuation of environmental services and tradeoffs[M]. Stanford: The Natural Capital Project, 2021.

[26] Gao Qingyan, Pan Yujun, Liu Hua. Spatial temporal evolution of habitat quality in the Dali Bai Autonomous Prefecture based on the InVEST model[J]. Journal of Ecology and Rural Environment, 2021, 37(3): 402-408.

[27] Hu Feng, Zhang Yan, Guo Yu, et al. Spatial and temporal changes in land use and habitat quality in the Weihe River Basin based on the PLUS and InVEST models and predictions[J]. Arid Land Geography, 2022, 45(4): 1125-1136.

[28] Ma Yaxiong. Construction of ecological security pattern in loess hilly region based on habitat quality: Take Lanzhou City as an example[D]. Lanzhou:

Northwest Normal University, 2021.

[29] Knaapen J P, Scheffer M, Harms B. Estimating habitat isolation in landscape planning[J]. Landscape and Urban Planning, 1992, 23(1): 1-16.

[30] Hao Yue, Zhang Na, Du Yajuan, et al. Construction of ecological security pattern based on habitat quality in Tang County, Hebei, China[J]. Chinese Journal of Applied Ecology, 2019, 30(3): 1015-1024.

[31] Dong K N, Wang H W, Luo K, et al. The use of an optimized grey multi objective programming PLUS model for multi scenario simulation of land use in the Weigan Kuche River oasis, China[J]. Land, 2024, 13(6): 802.

[32] Zhang Xiaoyao, Zhang Xiao, Li Donghua, et al. Multi scenario simulation of the impact of urban land use change on ecosystem service value in Shenzhen[J]. Acta Ecologica Sinica, 2022, 42(6): 2086-2097.

[33] Yuan Zhengzheng, Wang Qiuhong, Wang Yong, et al. Impacts of land use change on ecosystem health in Chongqing under multi scenario[J]. Acta Ecologica Sinica, 2023, 43(20): 8279-8291.

[34] Luo K, Wang H W, Yan X M, et al. Integrating CVOR and circuit theory models to construct and reconstruct ecological networks: A case study from the Tacheng Emin Basin, China[J]. Ecological Indicators, 2024, 165: 112170.

[35] Song Lili, Qin Mingzhou. Identification of ecological corridors and its importance by integrating circuit theory[J]. Chinese Journal of Applied Ecology, 2016, 27(10): 3344-3352.

[36] Zhu Qiang, Yu Kongjian, Li Dihua. The width of ecological corridor in landscape planning[J]. Acta Ecologica Sinica, 2005, 25(9): 2406-2412.

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv —Machine translation. Verify with original.