Ecological Network Construction in Arid Regions: A Case Study of Gaochang District, Turpan City (Postprint)

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Abstract

Taking Gaochang District of Turpan City as an example, this study utilized 2015 Landsat data to classify the green space landscape into seven types through the Morphological Spatial Pattern Analysis (MSPA) method. Core areas and bridge areas, which play important roles in ecological network construction, were then extracted from the MSPA landscape types for connectivity evaluation, and "source areas" were selected based on the results. The minimum path method was employed to establish potential ecological corridors in the study area. The results show that the ecological network in this study area consists of 26 potential corridors, which are mostly distributed in the southern part of the study area, and the number of potential corridors is relatively small. These findings can provide reference and basis for ecological network construction research in arid regions and have certain referential significance.

Full Text

Preamble

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Development of Ecological Network in Arid Area: A Case Study in Gaochang District, Turpan City

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Abstract:
In this study, land use maps of Gaochang District, Turpan, Xinjiang were obtained using supervised classification based on remote sensing images from 2015. Morphological Spatial Pattern Analysis (MSPA) was employed to classify green space landscapes into seven types using forest and grassland data from the land use maps. Core areas and bridging areas, which play important roles in ecological network construction, were extracted to evaluate their connectivity degrees. During this process, the minimum path method was used to establish potential ecological corridors in the study area. The results showed that the ecological network in the study area consisted of 26 potential corridors, which were mostly located in the southern part of the region where potential corridors were relatively sparse. The ecological network was not perfect and required further optimization and improvement. These research results could provide reference for ecological network construction in highly fragmented areas and other arid regions.

Keywords: morphological spatial pattern analysis (MSPA); landscape connectivity; least-cost path; ecological network; Gaochang District; Turpan

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2 Data and Methods

2.1 Data Sources

The primary data sources included: (1) Landsat 8 OLI imagery (30 m resolution, bands 1-7, 30) from October 2015, with cloud cover less than 3%, obtained from the Geospatial Data Cloud; (2) a Digital Elevation Model (DEM) at 30 m resolution.

2.2 Methods

Preprocessing of remote sensing images, including radiometric calibration and atmospheric correction, was conducted using ENVI software. Supervised classification was performed to extract land use information, with classification accuracy assessed using a Kappa coefficient of 0.84. The land use map was resampled to 30 m × 30 m resolution [FIGURE 1(b)]. Land use types were categorized into five classes: forest land, grassland, cropland, water bodies, and construction land. Forest and grassland were further classified as ecological land, with forest land subdivided into dense forest and sparse forest for subsequent analysis.

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3 Results

3.1 MSPA-Based Landscape Classification

MSPA analysis classifies green space landscapes into seven types based on structural connectivity, including core, patch, and corridor categories. The "guidos" software was used for MSPA analysis, with a 30 m × 30 m grid cell as the foreground element and eight-neighbor connectivity rule. The analysis identified different landscape pattern types [TABLE 3].

TABLE 3 shows the area statistics of different green space landscape types:
- Core area: 9,015.93 hm² (34.34%)
- Patch area: 3,683.07 hm² (14.03%)
- Corridor area: 6,295.95 hm² (23.98%)
- Edge area: 703.89 hm² (2.69%)
- Perforated area: 2,974.14 hm² (11.33%)
- Branch area: 335.07 hm² (1.28%)

The core area represents large, contiguous green patches that serve as crucial habitats. The corridor area facilitates species movement and material flow between patches.

3.1.2 Classification of Source, Core, and Bridging Areas

Based on the MSPA results, source areas, core areas, and bridging areas were classified. The Confor software was used to calculate landscape metrics. Resistance values were assigned to different landscape types based on their permeability to species movement [TABLE 4]. The resistance values ranged from 1 (lowest resistance) to 80 (highest resistance), with water bodies assigned the lowest resistance and construction land the highest.

TABLE 4 Resistance values of different landscape types:
- Water bodies: 1
- Forest land: 5-15
- Grassland: 10-20
- Cropland: 20-60
- Construction land: 80

The minimum cumulative resistance model was used to identify potential ecological corridors. The cost distance and cost path tools in ArcGIS were applied to generate corridors connecting core areas.

3.2 Evaluation of Ecological Network Connectivity

The connectivity level of the ecological network was evaluated using network metrics including the index, index, and index [TABLE 5]. The formulas are:

Where:
- L represents the number of corridors
- V represents the number of nodes
- L represents the maximum possible number of corridors

The results showed:
- index: 0.29, indicating relatively low network development
- index: 1.44, suggesting moderate connectivity between nodes
- index: 0.54, reflecting that the network utilized about half of the possible connections

The ecological network comprised 26 potential corridors with a total length of 15,793 m. The average corridor length was 102 m, with the longest reaching 157 m. The network density was relatively low, particularly in the northern and central parts of the study area.

Discussion

The MSPA analysis revealed that the ecological network in Gaochang District was incomplete, with insufficient corridors to connect all core areas. The southern region showed better connectivity due to the presence of the main river corridor and dense forest patches. In contrast, the northern and central areas, dominated by cropland and construction land, exhibited poor connectivity.

The resistance surface analysis indicated that water bodies and forest lands provided the best movement pathways for species, while construction land and major roads created significant barriers. The current network structure suggests that conservation efforts should focus on: (1) protecting existing core habitats in the southern mountainous area; (2) establishing new corridors in the northern agricultural zone; (3) creating stepping-stone patches to reduce isolation; and (4) mitigating barrier effects of roads and urban areas.

The study demonstrates that combining MSPA with least-cost path analysis provides an effective framework for ecological network planning in arid regions. However, the analysis did not consider temporal dynamics or species-specific dispersal abilities, which should be addressed in future research. The results can inform land use planning and biodiversity conservation strategies in Gaochang District and similar arid environments.

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