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Research on the Construction of Protection Corridors for Endangered Species under Urban Green Space System Planning

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Abstract: Urban internal green spaces are predominantly distributed as scattered patches, exhibiting significant spatial disparities. The ongoing process of urban construction further fragments the natural environments upon which rare flora and fauna depend. This research focuses on the correlation between urban green spaces and biological habitats, systematically outlining comprehensive implementation methodologies for ecological corridors, encompassing site selection, overall layout, environmental restoration, and routine management. By leveraging spatial structure adjustments, vegetation and micro-habitat modifications, coupled with zonal management and dynamic monitoring approaches, the establishment of a connected ecological network offers a viable technical solution for the conservation and survival of rare species in urban areas.

Keywords: urban green space system; endangered species; conservation corridor; habitat connectivity; ecological network

Introduction

The urbanization process has fragmented once contiguous natural habitats into isolated green patches, nearly severing the pathways for population exchange among endangered species. Although urban green spaces are increasing in quantity, they often fall short of effectively supporting the needs of species migration and dispersal at an ecological functional level. The lack of continuous corridors between green patches impedes genetic exchange among populations and heightens the risk of local extinctions. Incorporating conservation corridors into the planning framework of green space systems, and reconstructing migration pathways for endangered species based on spatial patterns, has become a pressing practical issue in urban ecological development.

1. Analysis of Urban Green Space System and Spatial Requirements for Endangered Species

1.1 Spatial Pattern Characteristics of Urban Green Space Systems

Urban green spaces exhibit pronounced distribution disparities within city limits. Buildings and transportation networks carve these spaces into fragmented parcels, with limited ecological connectivity between them.

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The size, shape, and linkage of green patches directly impact the movement range and migration corridors for wildlife within urban areas. While overall urban green coverage often meets quantitative targets, imbalanced layout remains widespread—newer districts enjoy abundant green resources, whereas older urban areas suffer from scarce and scattered green spaces, resulting in marked fragmentation of ecological areas [1]. Concurrently, urban planting schemes tend to lack diversity; landscape construction relies heavily on introduced ornamental tree species, diminishing the proportion of local native flora, which in turn struggles to meet the survival needs of indigenous rare wildlife. Such development practices merely enhance visual appeal without fostering interconnected ecological functions among green patches, ultimately failing to build continuous and intact habitats for urban biodiversity.

1.2 Current Status of Fragmentation in Endangered Species Habitats

Urbanization continuously encroaches upon and fragments the native habitats of endangered species. Built-up areas, transportation routes, and artificial barriers create hard separations, dividing once-connected natural habitats into scattered, isolated patches, restricting species' movement and disrupting gene flow between different populations. Habitat fragmentation alters the microclimate at patch edges, increasing light intensity, intensifying temperature fluctuations, and reducing air humidity, making conditions unsuitable for species adapted to stable interior habitats. The smaller the habitat patch, the more pronounced the edge effects, leading to a steady decline in population viability. Currently, the habitats of urban endangered species are severely fragmented, with the remaining habitat patches lacking effective ecological connectivity corridors.

1.3 Spatial Requirements for Dispersal and Migration of Endangered Species

Endangered species rely on the movement and exchange of individuals between various habitat patches to maintain normal population reproduction. Different animal species exhibit distinct activity patterns and varying tolerance levels to environmental conditions and human disturbances along migration routes. Ground-dwelling species depend on surface vegetation cover for movement, while arboreal species require continuous canopy layers to ensure their activity range. During breeding stages, species often expand their activity ranges significantly, making it necessary for ecological corridor planning to account for this maximum radius of movement. Urban ecological corridors are often located near transportation routes and human activity areas, where vehicle traffic, nighttime lighting, and human presence can all hinder species' normal movement.

1.4 Matching of Green Space Patches and Species Survival Suitability

The current urban green space conditions are insufficient to adequately support the normal settlement and reproduction of regional endangered flora and fauna. The biological capacity of green spaces depends on multiple factors, including local food supply, nesting sites, and spaces for evading predators. Only green spaces with diverse vegetation structures and compatibility with local ecological food chains can provide ideal living conditions for endangered species. Many urban green spaces predominantly consist of artificial lawns and non-native ornamental plants. The ecological functions of such greening forms are significantly weaker compared to natural green spaces composed of native vegetation.

2. Corridor Siting and Network Structure Design

2.1 Corridor Node Identification and Source Area Screening

To establish an ecological corridor network, the first step is to complete the selection of habitat source areas. Patches capable of serving as core nodes in the network must possess stable biological populations and consistently meet the needs of species reproduction and growth. During on-site selection, decisions are primarily made based on a comprehensive evaluation of three criteria: patch area, vegetation growth status, and the intensity of human disturbance [2]. Patches with small areas or those severely impacted by human development are unlikely to ensure long-term species survival and should therefore be excluded from the source area scope. Stepping-stone patches, due to their limited size, cannot independently sustain populations, but they can connect various core source areas. The distribution density and mutual distance of such patches directly influence the overall effectiveness of cross-regional species movement. Habitat conditions within patches also require significant consideration. Areas with rich vegetation layers and diverse habitat types can support far more species than patches with a homogeneous environmental structure. The spatial arrangement of core source areas and stepping-stone patches forms the basic framework of ecological corridors. The rationality of node selection profoundly impacts individual exchanges among endangered species and the outward expansion of populations.

2.2 Corridor Path Planning and Resistance Surface Construction

Quantitative analysis of spatial resistance to species migration serves as the core basis for scientifically delineating corridor pathways. Different land cover types exhibit distinct barrier effects on biological movement: major urban roads and dense building clusters create high-intensity migration barriers, whereas forests, waterfront green spaces, and low-density development areas present relatively lower migration resistance. By integrating multiple disturbance factors—such as road traffic volume, building density, nighttime light radiation, and frequency of human activities—and conducting spatial overlay analysis, a continuous resistance model can be developed to accurately reflect the difficulty of species migration across a region. The planning of corridor pathways relies on this resistance model to identify routes between source areas that minimize cumulative resistance loss, thereby effectively avoiding zones of high disturbance and high resistance.

2.3 Corridor Network Topology Optimization

An independent corridor struggles to fully realize its connectivity value. When multiple corridors interconnect to form a network system, they can enrich the travel paths for species migration. When conducting topological optimization work, it is essential to balance ecological value with long-term management costs. A layout that is too dense will increase land consumption and management burdens, while a sparse layout may lead to gaps in ecological connectivity. A circular layout demonstrates stronger resilience to external disturbances than a tree-like layout; even if a local segment is damaged, connectivity can be maintained via alternative routes. Connection points within the network are particularly critical—damage to these points can disrupt the overall ecological structure. Adding backup channels between points can enhance the stability of the entire network.

2.4 Determination of Corridor Width and Buffer Strip Scale

The width planning of ecological corridors primarily considers the movement patterns of the target species. Corridors with insufficient width can only provide basic greening, while strong edge disturbances hinder biological migration. Species of varying sizes have different spatial requirements; large mammals require significantly larger passage areas compared to birds or amphibians. Designing buffer zones on both sides of the corridor can mitigate the impact of urban development and human activities on the internal habitat. The width of buffer zones should be flexibly determined based on the degree of site development, with wider buffers near roads and commercial areas, and narrower ones near residential zones. Only by scientifically managing these spatial parameters can ecological corridors sustainably fulfill their ecological functions [3].

3. Corridor Ecological Function Cultivation and Habitat Restoration

3.1 Corridor Vegetation Community Configuration and Structure Construction

Priority should be given to native plants in the creation of corridor vegetation, establishing multi-layered communities that integrate trees, shrubs, and herbaceous plants. Local trees with expansive canopies are selected to form the upper vegetation layer, connecting canopy spaces to meet the needs of arboreal animals. In the middle layer, clustered shrubs are arranged, utilizing their dense growth to create habitats and shelter for terrestrial organisms. The lower layer is planted with shade-tolerant and drought-resistant herbaceous plants to stabilize the surface soil and reduce soil erosion. This stratified layout accommodates the survival and activities of various species. By combining evergreen and deciduous plants according to seasonal changes, a continuous supply of natural food resources such as flowers, fruits, and nectar sources is ensured, preventing gaps in food availability due to seasonal shifts and maintaining the stable operation of the corridor ecosystem.

3.2 Microhabitat Creation Technology within Corridors

Diverse microhabitats are key to enhancing the ecological carrying capacity of corridors. By developing small constructed wetlands in existing low-lying areas along the corridor, foraging and breeding spaces can be created for amphibians and waterfowl. Using locally sourced deadwood and stones to construct log pile habitats supports the survival and activity of insects and small reptiles. Exposed sandy and rocky areas should be appropriately preserved on sun-facing slopes to accommodate the activity and thermoregulation needs of ground-dwelling organisms. These various habitats should be distributed in a dispersed manner to prevent concentrated arrangements from compressing the range of biological activity. Ponds and wetlands do not need to be deliberately expanded in area; maintaining natural wet-dry water level fluctuations aligns with the growth habits of local species. Reasonable control of the distance between habitats ensures continuous and unobstructed migration pathways for organisms.

3.3 Ecological Integration Treatment of Corridor and Surrounding Green Spaces

The design of the transition between ecological corridors and the adjacent green spaces significantly impacts the settlement and movement of organisms. Removing rigid vertical barriers and replacing them with gentle slopes and graded vegetation can mitigate the passage obstacles created by topographic differences. Planting native shrubs at corridor entrances helps guide organisms inward through vegetation screening. The plant species in the transition zone should align with those within the corridor to prevent ecological disconnection due to community differences. Along the corridor edges adjacent to residential areas, incorporating low hedges and noise-reducing plants can reduce the impact of human activities and facilitate the integration of corridors into the urban green space ecosystem.

3.4 Corridor Connectivity Barrier Mitigation Measures

Internal roads, solid fences, and artificial ditches within the city are the primary obstacles that disrupt corridor connectivity. To address road barriers, ecological overpasses or underground animal culverts can be constructed to enhance passage conditions. The dimensions of these facilities should align with the activity characteristics of target species, and the interior walls of culverts should be roughened to accommodate small organisms for climbing passage. For solid fences, modifications such as creating openings at the base or replacing them with permeable green barriers can be implemented to open up biological pathways, thereby eliminating the impact of artificial structures on the fragmentation of ecological corridors.

4. Long-term Management and Adaptive Regulation Mechanism for 4 Corridors

4.1 Layout of the Corridor Ecological Monitoring Indicator System

To conduct a quantitative analysis of the operational effectiveness of ecological corridors, it is essential to establish a stratified and categorized monitoring indicator framework. On-site observations primarily focus on three key areas: biological communities, vegetation growth conditions, and soil conditions. For key protected species, long-term records are maintained on activity frequency and population size changes [4]. Vegetation surveys emphasize calculating the proportion of native plant species to curb the expansion of invasive species. Soil testing involves continuous monitoring of fluctuations in two core parameters: organic matter content and bulk density. Monitoring points are evenly distributed along the corridor route, with intensified sampling in core habitats of species and transit nodes. The observational data accumulated over the long term can clearly reflect the operational status of the corridor ecosystem.

4.2 Corridor Anthropogenic Disturbance Prevention, Control, and Management Zoning

Ecological corridors traverse various functional zones of the city, and different segments experience varying intensities of human disturbance. Management and maintenance efforts must implement zoning control modes. Core protected areas strictly limit all types of human activities, opening only for scientific research and surveys during specific periods. In buffer zones, low-intensity recreational and leisure activities can be moderately developed. By delineating clear activity boundaries, human intrusion into the corridor's core ecological areas is avoided. Different management zones rely on vegetation buffer zones or topographic elevation differences to achieve physical separation, effectively blocking the transmission of disturbances between zones and ensuring the stability of the internal ecological environment within the corridor.

4.3 Corridor Vegetation Succession Guidance and Dynamic Maintenance

After the corridor vegetation is established, its structure will change along the direction of natural succession. The goal of management is not to freeze the vegetation in its initial state but to guide the succession toward a direction that favors the survival of target species. During the early succession stage, rapidly expanding invasive herbaceous plants should be promptly removed to create space for the colonization of native woody plants. In the mid-succession stage, over-dense tree layers need to be thinned to maintain understory light and promote the development of shrub and herb layers. In the late succession stage, a certain proportion of standing dead trees and fallen logs should be retained to provide habitats for wood-decay-dependent species.

4.4 Corridor Function Decline Warning and Structural Adjustment

The weakening of ecological corridor functions often stems from changes in the surrounding environment or the gradual degradation of internal plant communities. During field observations, once the frequency of target species declines continuously and the population size falls below the survival threshold, early warning signals should be promptly issued. Staff systematically analyze various influencing factors, distinguishing issues such as structural fragmentation, vegetation degradation, and excessive human activities. Based on actual problems, restoration efforts are carried out—reopening blocked segments to ensure spatial connectivity, supplementing native plants and clearing invasive species to improve the growth environment, and strictly managing buffer zones to reduce external impacts. Fieldwork adheres to a low-disturbance approach, avoiding large-scale engineering projects that could cause new harm to existing biological communities.

Conclusion

Urban green conservation corridors should not be viewed merely as ordinary green passages; their construction and operation encompass the entire process, from habitat selection and route planning to ecological environment creation and routine management. The key to achieving effective connectivity in corridors lies in organizing the overall layout and defining appropriate widths. Implementing zoned management measures, combined with regular dynamic maintenance, serves as crucial support for sustaining the ecological effectiveness of corridors. All tasks are interconnected and must be coordinated comprehensively to ensure the long-term, stable survival of rare flora and fauna within urban areas.

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