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Study on functional division optimizing of Kuankuoshui national nature reserve based on resistance surface analysis

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Functional division of nature reserve is the region set for the protected object. For optimizing and adjusting it, we selected Kuankuoshui national nature reserve as research area. This research utilized 5 ecological sources as research objects, which included 4 types of animals (*Phasianidae, Cervidae, Felidae* and Primate) and *Fagus lucida* woods, and the used resistance factors containing altitude, slope, landscape type and rock bare rate defined the distribution pattern of the resistance surface. The complex strategic points were identified by combining the statistics and superposition of the ecological corridors. The results showed that the resistance surface model gives excellent simulation of the potential biodistribution; classical function zoning may protect the ecological source and strategic points at saddle points except for strategic points at intersections, multiple strategic points at intersections and multiple ecological corridors. On the basis of the research results suggestions are put forward for the functional division adjustment, three-dimensional ecological corridor construction measures and management measures on time.

Key words: Nature reserve, Ecological source, Division into districts, Ecological corridor, Strategic points

INTRODUCTION

With the development of society, the human interference ability is gradually strengthened, which has resulted in the gradually increased degree of fragmentation of natural habitat. Habitat segregation leads to faster extinction and increased loss of biodiversity [1]. As a sanctuary for endangered species, the importance of the function of biodiversity protection has been brought into play, and the nature reserve has come into being. The circle structure of nature reserve – functional zoning is the basis for the implementation of management and protection, for scientific and rational functional zoning can effectively protect and utilize all kinds of resources in nature reserves. In the current way of development, construction of roads, farmland cultivation and tourism activities exist in protected areas, which will to some extent affect the function of protected areas, the formation of linear gallery landscape types, cutting and interference of roads to some biological habitats. For different kinds of living things, habitat suitability evaluation as a potential biological distribution area is necessary. Including it in a higher-level reserve area is beneficial to biodiversity protection and achieves the purpose of establishment of protected areas. Ecological corridors for biological diffusion of different types of organisms can help reasonable planning and construction of protected areas, so as to break the restrictions on biological habitats. The core problem of corridor protection is to control or maintain the ecological process on the surface through some location or part of the space, this location / part is the landscape strategic point [2], and the establishment of the resistance zone of biological migration / diffusion in the region can better identify corridors between birth sources.

The natural function zoning districts are usually divided based on simple data statistics, human experience, and existing habitat for protected objects, while there is less consideration of potential distribution, suitability, biological diffusion corridors and complex problems [3-6]. With the development of landscape ecology theory and the development of GIS technology, there is a new way of studying and dividing the functional zoning [7]. This paper intends to carry out multiple analysis on diffusion, resistance and ecological corridors of 5 types of ecological sources, current functional zoning in Kuankuoshui nature reserve, so as to find out the insufficiency of functional zoning, and provide a scientific basis for the construction of rational functional zoning.

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EXPERIMENTAL

Research area overview

Kuankuoshui nature reserve is located in north Suiyang County of Zunyi city of Guizhou Province, the geographic coordinates are: east longitude of 107°02′42″-107°13′26″, north latitude of 28°08′23″-28°19′10″; it extends about 19 km from east to west and has a depth of about 20 km in the north and south. It belongs to the humid subtropical monsoon climate. The mountains belonging to the protected area are undulating, and the annual temperature on the raised upland is relatively low. The cloud cover time is long and the sunshine time is short, which has the characteristics of low-altitude mountain humid climate, the annual average temperature is 11.7-15.2 ºC, annual precipitation is 1300-1350 mm. There are over 200 days with rainfall≥0.1mm, and the annual average relative humidity is high (more than 82%). It is the only remaining evergreen deciduous broad-leaved mixed forest in the eastern section of the Da Lou mountain range in Guizhou province, including the ancient plants remaining from the Tertiary period – primary forest, secondary forest, artificial forest, bamboo forest and shrub forest based on *Fagus lucida* forest. Furong River and its main streams, Qingxi River, Yangyan River, Chiwei stream and other river valleys form a steep ravine valley; there are typical landscapes such as primeval forests and karst caves on karst landform. There are favorable water and heat conditions, geological soil conditions and forest ecosystems in the reserve area, which provide a favorable habitat for the growth and breeding of wild animals and plants of forest, therefore, rich biodiversity has been formed in the reserve.

Research method

Research data were used to establish a 2.5 m resolution digital elevation model (DEM) by using vectorization 1:1 topographic map, and slope data were obtained based on DEM calculations. The 2015 remote sensing image (GF-1, China) was used to interpret land use type as landscape type data; what is more, rock bare rate data in the second type forest resources survey database of 2015 were used. We built up 4 resistance layers where the slope division was: 0-5º, 5-15º, 15-25º, 25-35º, 35-45º and >45º, divided in 6 grades of slope in total. The altitude division was: <700m, 700-800m, 800-900m, 900-1000m, 1000-1100m, 1100-1200m, 1200-1300m, 1300-1400m, 1400-1500m and >1500m, a total of 10 altitude classes. The rock bare rate data division was: 0-10%, 10-20%, 20-30%, 30-40%, 40-50%, 50-60% and >60%, a total of 7 levels. The landscape types were divided into 9 types including residential areas, farmland, evergreen coniferous forests, deciduous broad-leaved forests, evergreen shrubs, evergreen broad-leaved forests, deciduous shrubs, water bodies and roads. The study selected 5 biological groups of more accurate and comprehensive distribution of animals that contain *Phasianidae* (*Syrmaticus ellioti*, *Tragopan satyra*, *Chrysolophus pictus* and *Phasianus colchicus*), *Cervidae* (*Muntiacus reevesi*, *Elaphodus cephalophus*), *Felidae* (*Prionailurus bengalensis*, *Viverra zibetha*), Primate (*Trachypithecus francoisi*), and *Fagus lucida* in the nature reserve as ecological source. The resistance surfaces of Kuangkuoshui nature reserve were established and analyzed according to the grade division, and the ecological sources of the different biological groups investigated in the reserve were counted and superimposed to identify compound strategic points. Based on the types and quantities of interchange corridors, a more important strategic point of interchange was explored, and multiple corridors in some areas were combined to form compound corridor. All calculations, analyses and drawings in this study were conducted with ArcGIS 10.2.

RESULTS ANALYSIS

Distribution pattern of different resistance surfaces

According to the classification factors of different resistance layers, the distribution pattern of different resistance levels in the Kuankuoshui nature reserve was constructed (Figure 1). In elevation resistance surface distribution, the altitude range is between 649.2-1758.9m, the protection area is mainly at 1200-1600m, 1600-1800m high altitude mainly distributes in the middle of the reserve, 600-1000m' s low elevation mainly distributes in the edge of the reserve; In slope resistance surface distribution, in the west, there are deep karst peak clusters with the tributary of the Tang River and its right bank ("V" type valley and gorge), in the east, there are watershed, and northwest to southeast of the karst valley, and in the middle, there are three ridges, Daping ridge, Jinlin Mountain – Tianping ridge, and Pijiapo ridge, relatively flat areas are between the high altitude ridges, and inside human settlements. The resistance surface distribution of landscape types is based on evergreen broad-leaved forest, followed by evergreen coniferous forest, deciduous broad-leaved forest, and large farmland area; while in rock detachment rate resistance surface distribution, the rock cover rate is very low on the whole, and high distribution areas of exposed rock distribute on both sides of canyon and valley, and the karst geomorphic area in the West.

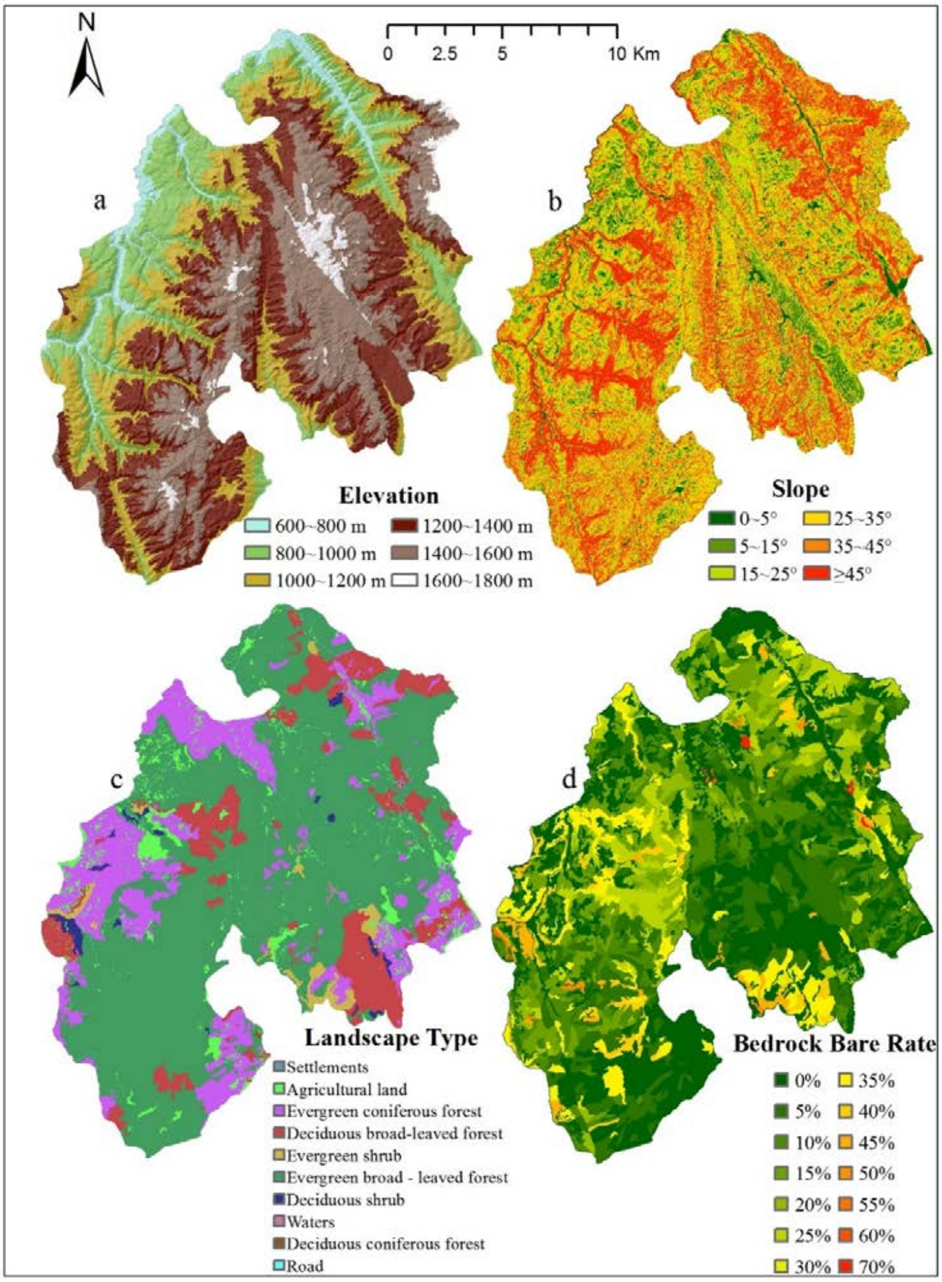

Fig. 1. Distribution pattern of different resistance surface in Kuankuoshui nature reserve

Different ecological source areas of Kuankuoshui Nature Reserve survey were recorded; combining with the analysis of bio-diffusion ecological corridor, we identified the strategic points of structure type of the landscape ecology [2]. The identified strategic points were superimposed on different functional partitions of the Kuankuoshui nature reserve, statistical results (Table 1) indicated that: in quantitative distribution of ecological sources, the core area > experimentation area > buffer zone, the proportion of the core area was 42.3%; in quantitative distribution of saddle strategy points, core area > buffer area > experimentation area, and the proportion of the core area was 56.9%.

Table 1 Status of protected strategic points.

Functional areas	Ecological source		Saddle strategy points		Interchange strategic points		Total	
	Quantity	Proportion	Quantity	Proportion	Quantity	Proportion	Quantity	Proportion
Core area	19	42.3%	29	56.9%	15	48.4%	44	53.7%
Buffer area	13	25.0%	12	23.5%	6	19.4%	18	22.0%
Experimental Area	17	32.7%	10	19.6%	10	32.3%	20	24.4%
Total	52	-	41	-	31	-	82	-

The proportion of buffer and experimentation area was relatively low; while in quantitative distribution of strategic points at interchange, core area > experimentation area > buffer zone, the core area accounted for more than 50%, the proportion of experimentation area in the buffer zone was very small. On the whole, half of the strategic points were in the core area, and compared to the conservation status of ecological resources, the proportion of strategic points falling in the core functional areas was higher; according to the types of strategic points, the proportion of strategic points at the core area of the interchange was lower than that of the saddle strategy points, the proportion in experimentation area was relatively high (32.3%), that is, in the present functional zoning, the saddle strategy points could get better protection than the intersection strategy points, and the convergence strategic points had not been well protected.

CONCLUSION AND RECOMMENDATIONS

In view of the 5 biological groups of more accurate and comprehensive distribution of rare and endangered animals pheasants (Elliots pheasant, tragopan temminckii, Chrysolo phuspictus and necked pheasant) in the nature reserve, Felidae (leopard cat, zibet), Primates (Francois monkey) and *Fagus lucida* under protection in the Kuankuoshui reserve, the distribution patterns of resistance levels of 4 factors of elevation, slope, landscape type and bare bedrock were used for analysis, and combined with functional zoning of protected areas. It was found that all kinds of ecological resources and landscape strategic points in the reserve had not been optimally protected, and relative to the source and the saddle ecological strategy points, the strategic points in junction, the strategic points in compound interchange and compound ecological corridors had not been better protected.

According to the protection status of the reserved area, suggestions on improving the protection efficiency were put forward from two aspects of the protection function zone adjustment and the artificial biological corridor construction. The function zoning of the south of the core area of the reserve can be adjusted, so that more landscape strategic points, compound junction strategic points and compound corridors can be included in the buffer zone, so as to achieve a higher level of protection. Planning and construction of important corridors of compound forest corridor landscape could help isolated island habitats to link together, so as to reduce wildlife dispersal resistance and increase wildlife activity and dispersal surfaces.

We should abandon the idea of plain planning and build a three-dimensional functional area, and build complex artificial passages on important strategic points and corridors. Taking into account the barrier and interference of roads to the landscape, ecological highway tunnels and ecological bridges and biological channels can be built in the important terrain, so that people and creatures make their way separately, which can reduce the interference of human activities. Meanwhile, scientific studies of long-term succession of plant communities, location observation, monitoring of animal migration and channel selection can be conducted in the passageway.

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