Ecological zone Evaluated in Natural Reserve by GIS

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***Abstract*—**As a special area of nature ecosystem, Nature Reserve is the core area to protect biodiversity, and an important part of government environment policy. Taking Beijing Labagoumen Nature Reserve as studying area, supported by multi-data resource as Digital Elevation Model and geo-spatial data, also spatial analyst technology including GIS and RS, which make expert knowledge related to spatial raster to express spatial raster's importance according its eco-attribute to make eco-evaluation index raster or layer, three and four level of eco- evaluation in this nature reserve was got through multi-layer raster map algebra operation based on multi-factor weighted model by using spatial analyst module of ArcGis9.x released by ESRI. It shows a balance to protect and develop resource in Nature Reserve.

Keywords- Nature Reserve; Spatial analyst; Eco-evaluation of fitness

I. INTRODUCTION

Reserve refers to some certain kinds of land or ocean administered through the application of law or other effective methods aimed at maintaining biodiversity, natu-ral resources and relevant cultural resources[1,2]. Natural reserve can be mainly classified into three branches, namely specific eco-system reserve, biological species reserve and natural relics reserve. It is a lively natural museum, natural resource warehouse, birth and storage place of natural eco-system and biological species[3].

Beijing Labagoumen Natural Reserve locates in the north of Labagoumen Town, North of Beijing, which lies in the warm temperate and semi-humid monsoon climate zone. It is also located in the transition area between Northern China mountainous climate and Inner Mongolia grassland climate. It is the main part of ecology barrier of Northern Beijing, as well as a typical area of biodiversity in mountain-forest type. Labamen Town, where the natural reserve lies, is a poverty stricken rural area, So, considering the economic and social functions of the natural reserve, applying infor-mation analysis technology including RS and GIS, a research on ecological fitness zone in Labagoumen Natural Reserve is conducted, with the aim to classify the func-tions of the partitions inside the reserve, and make the protection area and utilization area match for nature geographic and ecology environment..

II. RESEARCH ADVANCE AND RESEARCH METHOD CHOSEN

A. Relevant research advance

Ecological function division refers to the spatial distribution rule that divide the ecological functions according to natural and civil index system such as natural geo-graphical environmental factor, ecological environmental factor and sensitivity[4],etc.. The theory and method include qualitative analysis, matrix clustering, quantitative model merging by step based on expert knowledge[5], final classification matrix, matrix clustering methods based on economic value exploit and ecological value service, methods of ecological fitness evaluation on the basis of theory of landscape ecology plan, all of these above methods are completed through the application of natural geographic environmental index and social economic index into algorithm of mathematical analysis and statistical.

Compared to plain and lowland, the environment of typical upper mid mountain has many attributes of its own essence. The environment of mountainous area shows its complexity in vertical zonal rule and non zonal rule of the main factors in the mountain. And the uncertain of the environment in the mountain depends on the in-stability of mountain natural environment, surface coverage [6]. The comprehensive evaluation of a natural reserve consists of ecologic evaluation, social economic evaluation and effective management evaluation[7], and ecologic evaluation plays a key role in the protection and exploit of the reserve. The most frequently used indexes includes diversity, rarity, nature attribute, representative, educational value, human threaten, vulnerability, abundance of species, land effectiveness [4,5,7-9], etc..

Natural reserve of mountain-forest type comparatively has two types of ecologic process, namely vertical ecologic process and horizontal ecologic process. The former evolves in a certain unit of an area, and its evolvement reflects the distribution of the resources it relies on, as to the ecologic process between the plants and animals living in a certain area unit. Taking the mode of multi-layer bread as an example of fitness analysis model [10-13]; Horizontal process refers to alteration between surface raster units, such as animal activity and migration, spatial diffusion of ecologic interference and disaster (insect pests or fire, etc.). The most frequently used models are gravity model, potential model, tree seed diffusion model[14,15], pest diffusion model and fire spread model[16]. All the models above are expressed by analysis of potential surface[17], trend surface or MCR(minimum cumulative resistance) [18].

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B. Research method

To summarize what has been mentioned above, the research methods of the re-searchers before are about more indexes and figures, it is not enough to emphasize on ecological process and attribute. Further more, the application of GIS in ecology and society still has a long way to go. So it is of great theoretical and realistic significance to determine the ecologic fitness zone in spatial distribution by applying GIS spatial analysis, through integrating the knowledge of ecology and geography into the map layer.

1. Foundation of natural reserve eco-attribute database based on GIS

Joining different latitude, different aspect, different slope, different spatial position of ecosystem in a natural reserve. Then integrating it with geographic information system spatial database will make it convenient to analyze and evaluate the key ecologic areas on the basis of ecologic character.

2. Factor weight determination on the basis of AHP

Analytic Hierarchy Process, or AHP, was first proposed by Satty, American operation research expert in the early 1970s. It is a method that makes decisions avoiding subjective influence.

The evaluation index applies the method integrating AHP and expertise to make comparisons between the index of 1-9degree, to judge the matrix, and to testify the consistency, thus guaranteeing the logical validity of the index. Then, the data calculated by the above method is filled into the unit of the spatial raster, by which the significance degree of the eco-attribute can be shown in the raster, thus making it possible to analyze the overlying layer by GIS spatial analysis (ArcGis9.x).

3. Multi-factor weighted layer evaluation model based on GIS

The evaluation fitness of Labagoumen Natural Reserve is based on the key section of eco-attribute, different value and weight of different spatial section shows different importance on basis of its eco-attribute. To changes natural factors, eco-attribute factors and interference factors into map layers in GIS, and give factors value according Table six, making analysis and on factors layer in Arcgis9.x with the application of evaluation model of GIS(formula (1)). The meaning expressed in different results of the factors is as follows-- an arrangement of high score to low score of the natural factors means that the natural character is sinking gradually; as to the ecological attribute factors, it means that the condition of the ecologic attributes evolves from a good condition to a worse condition; and as to the interference factors, it shows a gradually stronger interference. The evaluation adopts the following model:

$$Yi = f(x) = f\left\{ \sum_{\substack{i=1,\, j=1 \\ m=1, n=1}}^{k} (Ei \times wi + Ai \times wj + Rm \times wm) \right\} \quad (1)$$

In this formula, i,j, m, n means evaluation unit; k stands for the maximum in the evaluation unit; Yi means the fitness degree score in evaluation unit i; f(x) refers to evaluation function. Ei, Ai, Rm stands for the evaluation unit score of natural envi-ronmental factor, ecologic attribute factor and interference factor respectively, wi, wj, vm stands for their weight. Ecologic fitness zone of Beijing Labagoumen Natural Reserve

C. Selection of evaluation index

The ecologic fitness evaluation index system of Labamen Natural Reserve is founded on the basis of its specific condition and the research of the researchers before[10,19-21]. Each index is divided into 5 degrees, according to which the index significance will be scored, and the scores are related with the data in the spatial raster. See table six.

1. Natural environment factor

The research area is the middle or small size protective area which to protect the type of land forest eco-system, where the landform and surface coverage type are the two main factors influencing landscape ecological differentiation. So, we choose altitude, slope, aspect and valley as major natural factors. The statistics of natural factors in Labagoumen Natural Reserve is in the following chart.

TABLE I. STATISTICS OF NATURE FACTORS OF RESEARCH AREA

latitude(m)		***Slope(°)***		***Aspect(°)***	
Minimum	435.5	Minimum	0	Minimum	0
Maximum	1687.6	Maximum	45.45	Maximum	360
Average	848.4	Average	23.7	Average	178.7
Standard	235.4	Standard	10.4	Standard	103.3

The protected community in the natural reserve mainly locate between the altitude between 800m and 1200m, the residential area and arable land locates basically below the altitude of 500m, there is no residents in the area where the slope angle is bigger than 20°. However, such a place is favorable for the growing of Mongolian oak. On the basis of the above and considering the integrity of landform combination and local slope degree standard, slope is divided into 5 degrees, namely, S1:<10°; S2:10～15°; S3:15～25°; S4:25～35°; S5:>35°

Weight of natural environment index as: Latitude,0.4; Aslope position,0.3; Exposure,0.2; Fluctuation degree,0.1.

Slope weight as below: S1:<10,2; S2:10～15°,3; S3:15～25°,5; S4:25～35°,3; S5:>35,4.

Elevation weight and value as: >1200m, 0.2230,4; 1200-800m, 0.4054,5; 800-700m, 0.1782, 3; 700-600m, 0.0912, 2; <600m, 0.0572, 1.

All result based on AHP has been testified and passed .

2. Ecological attribute index

There exist three types of forest eco-systems in Labagoumen Natural Reserve, see fig 1. 1st is low mountain broadleaf belt, 2nd is middle-low mountain oak pine forest belt, This belt is a main part of forest distribution. 3rd is Middle-high birch forest. In the three forest eco-system of this research region, ecological attribute's weight of the belt two is lower than belt one and belt three. And belt 4th does not exist in the Nature Reserve. Assign the value of eco-logical attribute and weigh to the spatial raster related with

the different eco-community, and join the pitch with ecological attribute and weigh assigned. It is layer of factor of ecological attribute.

3. Interference factors

It mainly refers to human disturbance, such as the road, watershed system and the expansion of residential area in the reserve.

Road: As a linear landscape unit, road has different influence on eco-system[22,23]. Forman[24,25,17] found that the influential area of the road is 19 times of the area of itself on the ecological functions of road, and the influenced area of ecological factor is beyond 100 meters, some to1000meters, the average is around 600 meters. Liu Chaomin etc.[25-27] determined the influence range of railway and main road as 2000 meters, and the secondary road 1000 meters. Labagoumen Natural Reserve has 4 degrees of transportation systems, namely, national road, town road, country road and mountain passage, and national road is the largest influence resource of the reserve.

River: Labagoumen Natural Reserve is the water gathering area of Tanghe River, and its river rank is realized through hydrological analysis of ArcGis9.x spatial analysis model. Residential area has a relatively low altitude, the banks of the river are the main residential area. It is not only the reflection of the side effect imposed on the natural environment by human activity, but also a representation of the self purification of the river. The layer of impact on the environment forms by buffering the roads.

Residential spot: Most village of Labagoumen Natural Reserve scatter along the valleys, roads or the rivers. The influential range mainly relates to the area, distribution, industrial structure, spatial distribution of the residential spot. The primary buffer area is near to the center of residential spot, here we take 100 meter, that is to say, within 100 meters of the residential spot is the area where the residents use most frequently. Secondary buffer area is further from the residential spot than the primary buffer area, and it is not so frequently used as the primary buffer area, here 200 meters is determined, that is to say, in the area 100m to 200 m far from the residential spot, the frequency of the resident activity is lower than the area within 100 m from the residential spot. Here we take 200 m as the first level impact buffering of town settlements, and second level, buffer value of 400m.

D. Raster weighted calculation and result formation

Ecological fitness evaluation is a comprehensive evaluation based on regional natural eco-system and ecological interference, after the layering of the evaluation indexes, the experiment is conducted by selecting altitude, land formation, aspect, slope position and valley as natural factors; selecting the ecological characters such as di-versity, Naturalness, representative, vulnerability as the main calculating factors. After correlating the above with the data in the raster, the data will be used after up-date. Selecting human activity factors, river system and road as main interference resource, calculating the data by the application of ArcGis 9.x spatial analysis model, select analyzing Resolution of 25×25. See appendix map behind for result: three and four level map of Eco-protection and developing. See figure 2. Three and four level map of Eco-protection and developing.

III. CONCLUSION AND SUGGESTION

The case study include computer spatial information process and analyzing technology, evaluating ecological fitness of Labagoumen Natural Reserve by correlating the evaluation index and weight with spatial data into raster unit. On the basis of DEM, fundamental natural geographic spatial data and expertise knowledge, thus providing a spatial reference for eco-tourism, scientific experiment, herbal plant fostering of the reserve. Meanwhile, it also provides reference for the foundation of small middle scale natural reserve or regional.

Today, harmony of the protection and exploit of natural reserve will become important. In order to materialize the function of protection and reasonable exploitation, the key factor is the recognition and extraction of ecological section, so the application of GIS, RS and the precision of spatial multi-resource data and expertise is the main factors to confirm the reserve resource, ecological resource and usable resource. The ecological fitness evaluation in this case may not be generally applied, for different natural reserves have different indicating factor system. At meantime, The division of natural reserve should breakthrough the limit of administrative division. The partition should be divided according to the distribution rules of natural geographic region, middle scale and small scale.

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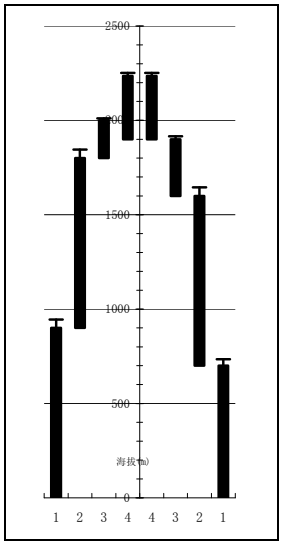

1：Low hill deciduous- broadleaf-shrub- shrub and grass belt.

In this belt , such secondary deciduous broad-leaved shrub is superior as herehd shrub, prunus armeniaca shrub and shrub land etc.

2：Mid-mountain lower part of the pine and oak forest belt

This belt is the major part of the forest which East-liaoning's oak forest,Chinese pine forest, Secondary davidiana，Birch forest, Bicolor Lespedeza shrub and Meadowsweet shrub exist especially in Shady slope.

3：Mid-mountain Upper birch forest belt

Poplar-birch mixed ecosystem

4：Peak Meadow belt

See only above 1900m.

Figure 1. Distribution map of mountain plant in Beijing

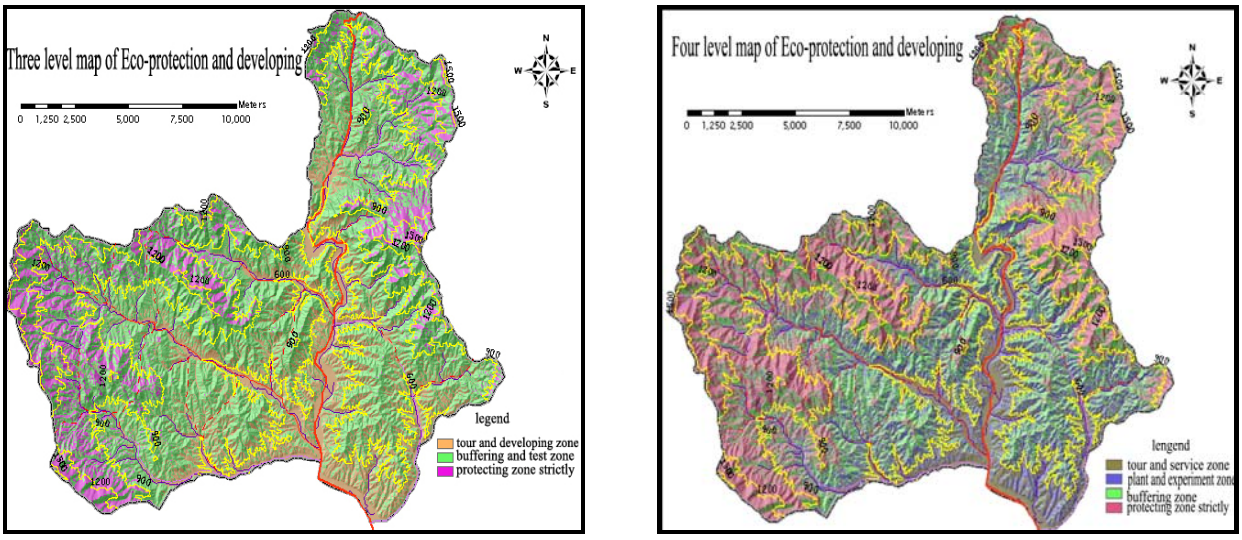

Figure 2. Three and four level map of Eco-protection and developing

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