Habitat Evaluation of Japanese Black Bear using GIS

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Abstract: In this research, GIS based evaluation methods were applied to habitats of Japanese black bear (Ursus thibetanus japonicus Schlegel) in northern Honshu. The study area was divided into 828 small watershed units, and five GIS indexes, Vegetation Type（V.T.）, Extent of Forest Cover (E.F.C.) Slope Incline (S.I), Average Altitude (A.A.) and Road Density(R.D.), were used to evaluate each watershed unit in terms of suitability as black bear habitat. In addition, Interspersion and Juxtaposition spatial indices were calculated for each watershed unit. The results clearly identified the regions with the most suitable habitats, indicating that this methodology is suitable for application to various environmental planning efforts, such as regional development master plans, project-specific environmental impact assessments, species management plans and biodiversity conservation plans.

Keyword: black bear, GIS, habitat, evaluation, biodiversity

1. Introduction

The Japanese black bear, an endemic subspecies of the Asiatic black bear, is listed as threatened local population by the Japanese Ministry of Environment. Although protected, the bear is thought to be effected by factors such as loss, fragmentation and isolation of habitat, as well as illegal hunting and pest extermination. Various research (e.g., Hanson & Urban, 1992, McIntyre, 1995, etc.）have shown that landscape patterns influence individual organisms and populations. In addition, evaluations of habitat obtained in this manner can have practical applications (Rickers et al, 1995). In this study, the habitat of the black bear in the Tohoku Region was analyzed by applying GIS indexes, as well as spatial diversity analysis, to small watershed units. The object of the study was to determine if these techniques are suitable to practical application in regional environmental and species management planning.

2. Methodology

1) Study Area

Miyagi Prefecture, about 7300km^2 in area, is located along the Pacific Ocean side of the Tohoku Region in northern Honshu, Japan, between 37°00' and 50'39° north latitude, and 140°20' and 141°40' east longitude. The prefecture includes high, steep mountains along the western boundary, hills along the northeastern coast, and lowlands with abundant rice paddies and marshes in the center.

2) Habitat Suitability Analysis

The study area was divided into 828 small watersheds. Geographic information system (GIS) was used to analyze each watershed based on five indexes; Vegetation Type（V.T.）, Extent of Forest Cover (E.F.C.) Slope Incline (S.I), Average Altitude (A.A.) and Road Density(R.D.). These indexes were then correlated with field data on black bear distribution compiled by the Natural Environment Research Center (March 1994), and the HIS (Habitat Suitability Index) model (U.S.Fish and Wildlife Service, 1987) was utilized to rate each category within the indexes on a scale of 1 (highest suitability) to 4 (lowest suitability). The categories in each index, along with the rate of black bear habitation derived from the field data, and Habitat Suitability Rating (HSR) are shown below.

＜Index 1 Vegetation Type (V.T.) ＞

V. T.	Black Bear Confirmation Rate. (%)	Habitat Suitability Rating
beech forest, oak forest (Quercus mongolica)	35<	**1**
conifer plantation, shrub forest, oak woodland (Q. serrata)	25〜35	**2**
grassland, deciduous broad-leaved forest, coniferous forest.	15〜25	**3**
other	15>	**4**

＜Index 2 Extent of Forest Cover (E.F.C.)＞

E.F.C.(%)	Inhabiting Confirmation Rate. (%)	Habitat Suitability Rating
85<	30<	**1**
55〜85	20〜30	**2**
35〜55	10〜20	**3**
35>	10>	**4**

＜Index 3 Slope Incline (S.I)＞

S.I. (°)	Inhabiting Confirmation Rate. (%)	Habitat Suitability Rating
20〜35	30〜40	**1**
10〜20	15〜30	**2**
35>	15〜30	**3**
10<	15>	**4**

＜Index 4 Average Altitude (A.A.)＞

A.A. (m)	Inhabiting Confirmation Rate. (%)	Habitat Suitability Rating
500～700	60<	**1**
300～500 700～1400	40～60	**2**
150～300 1400～1500	20～40	**3**
150>, 1500<	20>	**4**

＜Index 5 Road Density(R.D.)ratio of road length/ small watershed unit area＞

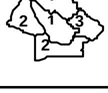
R.D.	Habitat Suitability Rating
0～0.05	**1**
0.05～0.1	**2**
0.1～0.15	**3**
0.15<	**4**

3) Spatial Diversity Analysis

A spatial diversity index was used to measure horizontal diversity between small watersheds,. This technique, which uses measurements of I_s (Interspersion) and J_x (Juxtaposition) as components of spatial diversity, was described by Mead et al. (1981), and is considered to be the most effective index for quantitative and qualitative evaluation of habitats (J.Heinen & G.H.Cross, 1983).

In this technique, calculations were originally implemented using raster (Clevenger et al. 1997, Clark et al. 1993). In this research, however, the calculations were based on polygons, represented by the small watershed units. Comparisons of these two calculation methods are shown in the following tables.

	Interspersion Using Raster
Original Calculation Method 1 2 2 4 1 1 1 3 3	the letters 1, 2, 3and 4 represent the small watershed evaluation categories, 5=total number of changes recorded between adjacent units 8=total possible number of changes Interspersion calculated as Is=5/8=0.625

	Interspersion Using Polygons
Calculation Method in this study 	Isp=3/4=0.75 3=different polygon 4=total polygons

	Juxtaposition(Jx) Using Raster
Original Calculation Method	EdgetypesQuantity*¹Quality*²Total 1/1 4 0.8 3.2 1/2 3 0.6 1.8 1/3 3 0.4 1.2 1/4 2 0.2 0.4 12 6.6 in this example 1;Jx=6.6/12.0=0.55 *¹: diagonal edges only count as 1, either vertical or horizontal edges count as 2. *²: various edge combinations can be assigned relative weight factors ranging from 0 to 1.

	Juxtaposition(Jx) Using Polygons
Calculation Method in this study	Quantitative: If Adjacency distance between 2 polygons is greater than the mean distance (centroidpolygon perimeter/polygon number), it counts as 2. If smaller, then n the value, it counts as 1. Qualitative: Various edge combinations can be assigned relative weight factors ranging from 0 to 1.

Edge weighting factors used in the calculation of juxtaposition were arbitrarily assigned using Table-1.

Table-1 Edge weighting factors assigned for calculation of juxtaposition in this research.

		Evaluation rating of center cell or polygon			
		1	**2**	**3**	**4**
Eval. rating of adjacent cells or polygons	**1**	0.8	0.6	0.4	0.2
	2	0.6	0.6	0.4	0.2
	3	0.4	0.4	0.4	0.2
	4	0.2	0.2	0.2	0.2

3. Results

1) Habitat Suitability Analysis

The five Habitat Suitability Ratings were added together to produce an Overall Suitability Rating score for each small watershed unit. The total scores were then rated as 1(5-7 total score), 2(8-11), 3 (12-15)and 4 (16-20). The distribution of watersheds by Overall Habitat Suitability Rating is shown in Fig.-1.

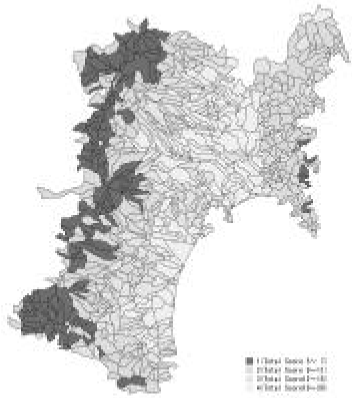


Fig.-1 Overall Habitat Suitability Rating for 828 Small Watershed Units

2) Spatial Diversity Analysis

The Degrees of Interspersion and Juxtaposition for the small watershed units is shown in Fig.-2 and Fig.-3 respectively.

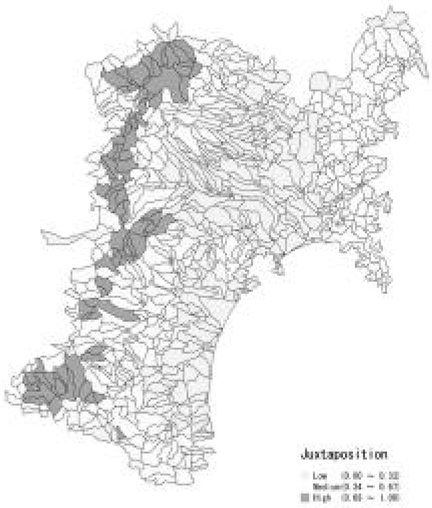


Fig.-2 Degrees of Juxtaposition

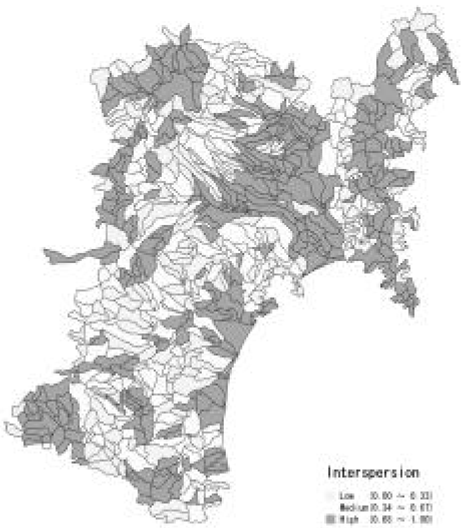


Fig.-3 Degrees of Interspersion

4. Discussion

As can be seen in Fig. -1, small watershed units with highest habitat suitability (Overall Rating of 1) are concentrated along the western mountain ridge. In addition, good habitat (Overall Rating of 1 or 2) are also found along the mountain slopes, and in the hills along the northeastern coast. The lowlands, on the other hand, show much lower suitability. Analysis of spatial diversity showed that even among the western mountains, where many high suitability watershed units were concentrated, there were still some units with high interspersion scores, indicating that they are isolated. On the other hand, the juxtaposition results indicate that many of the highly suitable watershed units have good connectivity. This research demonstrated that GIS analysis of habitat suitability is a convenient tool for evaluating habitat suitability over a wide area, and that the results can be quickly incorporated into regional environment and species management plans.

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