INTEGRATING GIS AND REMOTE SENSING FOR EVALUATION AND MONITORING OF SIKA DEER HABITAT ON KINKAZAN ISLAND, NORTHERN JAPAN

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ABSTRACT

The methodology of wildlife management using GIS and remote sensing was examined on Kinkazan Island, northern Japan. The habitat of Sika deer (*Cervus nippon*) was analyzed and the procedure of evaluation and monitoring of the island landscapes as deer habitat was examined. The census of Sika deer was conducted in the winter of 1990 and the distribution was mapped. ARC/INFO and ERDAS IMAGINE were used to analyze landscape characteristics and the distribution pattern of Sika deer. Vegetation cover was analyzed using Landsat TM data of April 1990. Five vegetation types, i.e., Forest-1 (conifer forests), Forest-2 (mixed forests), Forest-3 (deciduous broadleaved forests), Grass (*Miscanthus sinensis* or *Zoysia japonica* communities) and Bare ground were distinguished. A large number of deer were found in Grass type. The distribution pattern of Sika deer in relation to habitat characteristics was examined. The management framework of the island ecosystem was discussed.

1. INTRODUCTION

Geographic information systems (GIS) and remote sensing are powerful technologies for collecting, handling and analyzing spatial data. They are now indispensable to natural resources management. We examined the methodology of natural resources management, especially wildlife management using GIS and remote sensing.

Kinkazan Island is a small island situated on the Pacific side of northern Japan. The island's ecosystem has been well conserved due to the religious significance of the Koganeyama shrine. Many Sika deer (*Cervus nippon*) inhabit the island, mainly as a result of the absence of predators and the prohibition of hunting. The density of deer is as high as 60 per km^2, which results in remarkable effects on the plant communities (Takatsuki & Gorai, 1994). Two main problems of the island ecosystem are recognized: The first is overpopulation of Sika deer and the second is the degradation of plant communities caused by the heavy grazing of Sika deer. A mass-mortality of Sika deer occurred in the spring of 1984 (Takatsuki *et al.*, 1994) and the windfall of many trees was observed in the spring of 1994.

2. METHOD

We analyzed landscape characteristics of Sika deer habitat using remotely sensed data (Landsat TM data) and GIS. ARC/INFO and ERDAS IMAGINE were utilized to analyze landform characteristics, landcover and the distribution pattern of Sika deer. We digitized contour lines in each 10 m and made a base map (1/25000). The landform features (altitude, inclination and aspect) were analyzed using the ARC/INFO GRID module. Altitude was divided into 10 classes with an interval of 50 m. Inclination was recorded in 10 classes and aspect was recorded in 8 classes. Vegetation cover was classified by ISODATA clustering using Landsat TM data of 11th April 1990.

The census of Sika deer was conducted in the winter of 1990 and was mapped. The location of the deer finding points were digitized into the base map and ARC point coverage of the deer distribution was then created. The relationships between deer distribution and landscape characteristics were determined.

3. RESULTS AND DISCUSSION

3.1 Landscape characteristics

The Landsat TM image of the island is shown in Figure 1. Five landcover types were classified by ISODATA clustering using TM data without band 6 based on aerial photographs and ground survey data as ground truth data (Figure 2). The vegetation of Forest-1 type is composed of conifer trees (*Pinus densiflora* and *Abies firma*). The Forest-2 type is the mixed forest of conifers and deciduous broadleaved trees. The Forest-3 type is the deciduous broadleaved forest which consists of *Fagus crenata* and *Carpinus tschonoskii* etc. The Grass type vegetation is composed of *Miscanthus sinensis* or *Zoysia japonica*.

Contour, slope and aspect maps of the island are shown in Figures 3, 4 and 5. The gentle landform is widely extended to the eastern part, northern and western parts. South facing areas are dominated in the western side of the island and north facing areas are found in the eastern side.

3.2 Distribution of Sika deer

We input the locations of the points where deer were found, then, overlayed the above mentioned topographic layers (contour, slope, aspect) and the landcover layer (Figure 7). The number of finding points and deer of each category are summarized in Tables 1-4. A large group (123 individuals) of Sika deer was found at the grassland near the Koganeyama Shrine. Apart from this group, many deer were frequently found at the Forest-3 type vegetation (deciduous broadleaved forest), that is at 100-200 m in altitude and on the east - southeast facing slope.

Table 1. Number of deer found in each landcover type.

Landcover	# points	# deer	area (ha)	#deer/100ha
Forest1	38	71	468.54	15.15
Forest2	26	36	268.20	13.42
Forest3	22	34	139.05	24.45
Grass	8	128	94.41	135.58
Bare	1	2	53.82	3.72
	95	271	1024.02	26.46

Table 2. Number of deer found in each altitude class.

Altitude (m)	# points	# deer	area (ha)	#deer/100ha
0-50	5	125	178.65	69.97
-100	13	20	241.02	8.30
-150	23	49	182.61	26.83
-200	26	46	158.40	29.04
-250	17	16	117.99	13.56
-300	8	12	78.57	15.27
-350	3	3	44.82	6.69
-400	0	0	22.41	0.00
400<	0	0	0.09	0.00
	95	271	1024.56	26.45

Table 3. Number of deer found in each slope class.

Inclination	# points	# deer	area (ha)	#deer/100ha
0 - 5	0	0	0.27	0.00
5 -	15	28	160.11	17.49
10 -	31	50	295.11	16.94
15 -	28	137	241.47	56.74
20 -	11	19	142.74	13.31
25 -	5	4	84.78	4.72
30 -	2	26	47.97	54.20
35 -	2	4	25.47	15.70
40 -	1	3	26.10	11.49
	95	271	1024.02	26.46

Table 4. Number of deer found at each aspect.

Aspect	# points	# deer	area (ha)	#deer/100ha
Flat	0	0	0.27	0.00
N	17	22	174.51	12.61
NE	6	11	119.43	9.21
E	8	35	109.53	31.95
SE	15	28	125.19	22.37
S	20	30	175.14	17.13
SW	7	14	99.36	14.09
W	5	8	91.71	8.72
NW	17	123	128.88	95.44
	95	271	1024.02	26.46

3.3 Evaluation and monitoring of Sika deer habitat

Sika deer of this island were found at the highest frequency at Grass type vegetation, followed by Forest-3 type (deciduous broadleaved forests). According to the former study of habitat selection by Sika deer on Kinkazan Island (Takatsuki, 1983), Sika deer preferred the *Zoysia japonica* community and the *Pleioblastus chino* community, followed by the *Miscanthus sinensis* community and deciduous broadleaved forests, and preferred least the evergreen conifer forests. The tendency mentioned above was confirmed by this study.
To monitor the distribution and the abundance of deer over time, it is necessary to handle vegetation changes and to build a model for spatial distribution of them (Buckland & Elston, 1993; Norton & Possingham, 1993). Figure 8 shows the schematic representation of Sika deer habitat model. The development of the model will be examined to manage the deer population. The difference between two scenes of Landsat TM data is illustrated in Figure 6, which represents the degradation of vegetation caused by overgrazing of Sika deer. The Gap analysis project has recently started in USA (Scott *et al.*, 1993). It is the geographic approach to protection biodiversity using GIS and remote sensing. The application of the Gap analysis is necessary to manage the island ecosystem.

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