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Grid Method Applied for Establishing the Ecological and Natural Map: A Review Based on Results of Surveys of Endangered Mammals

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ABSTRACT

We analyzed data of endangered mammals in the 1st grade zone of the Ecological and Natural Map of Korea that were obtained through 202 field surveys over six years. Five endangered mammal species were identified including otters, long-tailed gorals, martens, leopard cats, and flying squirrels. The total number of habitat traces collected was 918, of which 897 traces (97.7%) were excrement types. The total surveyed distance was 697.7 km and there were 2,184 grids of 250×250 m each. Of these grids, 441 or 20.2% were confirmed as habitats of endangered mammals. Moreover, we analyzed results of repeated surveys in the same area by converting them into individual one-time surveys, accounting for 23.1% of the total area. The flying squirrel showed a low correlation with the frequency of field surveys but showed many habitats in a specific season. Leopard cats and martens were correlated with the frequency of field surveys. Results of analysis confirm that the grid method used for establishing the Ecological and Natural Map is unsuitable for the habitat division of flying squirrels, otters, leopard cats, and martens, and it does not reflect the actual habitats of these four species. Therefore, we propose that the concept of the habitat grid of species must be reevaluated and improved, specifically for endangered mammals.

Keywords: Assessment habitat, Development pressure, Statistics, Trace

Introduction

A system termed the Ecological and Natural Map is stipulated in the laws of the Ministry of Environment of Korea (MOE, 2016). This system evaluates the entire country based on vegetation, endangered species, wetlands, and topography, and classifies it into three grades. The 1st grade is a zone in which the natural environment is good, and 2nd grade is a zone in which the natural environment is maintained to some extent. Other areas are classified as 3rd grade (Ahn *et al.*, 2015; Lee *et al.*, 2019a).

According to the regulations of the Ministry of Environment Act, vegetation, topography, wetlands, etc. are divided into polygonal planes by drawing lines on the surface of the map. In addition, the habitat of endangered wildlife is specified by the Ministry of Environment as a 1st grade Ecological and Natural Map composed of square grids of 250×250 m (Lee *et al.*, 2019a).

Korea has a high demand for land development. The 1st grade zone of the Ecological and Natural Map is

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demarcated for the protection of nature. Although it is not legally stipulated, the 1st grade zone is unlikely to proceed toward the planning stage of land development. Therefore, individuals or groups who wish to develop land in this zone are raising objections on the classification of the Ecological and Natural Map to the Ministry of Environment. When the Ministry of Environment receives such an application for changing the grade specified in the Ecological and Natural Map, it inspects the site, checks and readjusts the grade, and notifies the applicant. Most of the zones for which objections are raised are very close to the development area (Jung *et al.*, 2017). Most of these objections aim to downgrade parts of the Ecological and Natural Map for developmental activities.

The grade adjustment of zones is mainly determined by vegetation. Usually, the grade determined by the evaluation of vegetation or topography is unlikely to change. In contrast, places designated as 1st grade in the animal habitat grid based on endangered wildlife are likely to be changed to lower grades. Mammals are the most commonly used taxon among habitats of endangered species for grading.

Traces of excrement can confirm mammalian inhabitants, and in particular, endangered species such as Amur leopard cat (*Prionailurus bengalensis euptilurus* Elliot, 1871), Amur yellow-throated marten (*Martes flavigula borealis* Radde, 1862), common otter (*Lutra lutra chinensis* Gray, 1837), long-tailed goral (*Naemorhedus caudatus* Milne-Edwards, 1867), and Siberian flying squirrel (*Pteromys volans* Linnaeus, 1758) are widely used because the excrement traces are clearly distinguishable.

We analyzed and summarized the statistical significance and characteristics of data obtained from surveys of the habitat of endangered mammals in the 1st grade zone for which objections were filed against the grading of the Ecological and Natural Map.

Materials and Methods

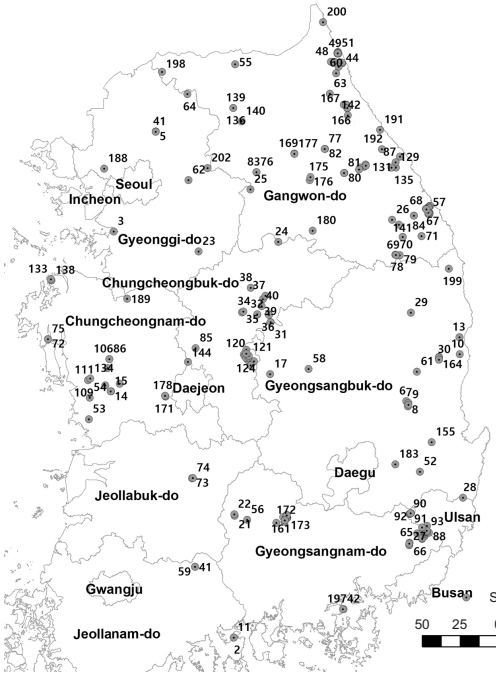
Survey area and methods

The researcher surveyed all the survey sites on foot. All survey routes were saved as GPS information. All information on habitat traces that was confirmed during the field survey was recorded. The researcher recorded the coordinates of the point where the habitat traces of endangered species (excrement, footprint, etc.) were identified. In the case of scats such as those of Amur leopard cat, Amur yellow-throated marten, and common otter, earlier and new observations were recorded as separate coordinates (Lee *et al.*, 2019a). In the case of the dropping of the Siberian flying squirrel, the coordinates were recorded for each tree, regardless of the quantity of excrement.

The survey area is shown in Fig. 1. The study area consists of 202 survey areas, including forests and rivers across the country, for which objections were raised against the classification of the 1st grade zone in the Ecological and Natural Map during the past six years.

Data analysis

We analyzed data obtained through 202 field surveys collected over six years (2014-2019). The survey tracks were numbered from 1 to 202 according to the order of



Region	2014	2015	2016	2017	2018	2019	Total
Gangwon-do		13		13	1		27
Gyeonggi-do	2	3		9	3	3	20
Gyeongsangnam-do		14	6	20	31	6	77
Gyeongsangbuk-do	4	1	2			2	9
Ulsan	7	5	1		4	2	19
Jeollanam-do		5	2	21	6	8	42
Jeollabuk-do				2			2
Chungcheongnam-do	2	1	1				4
Chungcheongbuk-do		1				1	2
Total	15	43	12	65	45	22	202

Fig. 1. A map of the survey area in Korea. The number on the map is the serial number for the analysis area, and the number sequence is year and date. The numbers in the table indicate the number of surveyed areas by year. A total of 202 survey areas were used for the analysis.

the survey days (Fig. 1). The 202 field survey tracks and the animal habitat grid map (250×250 m grid, hereafter referred to as species grid or grid) provided by the Ministry of Environment were superimposed to extract the grids that overlapped each other. If the survey track crossed the grid or passed at least a part of it, it was included in data. For example, Fig. 2 shows the survey result for the most extensive area among the 202 field survey cases. In the grids extracted as analysis data, the number of survey tracks corresponding to each grid was inserted as additional data and the number of grids included per survey track was calculated. In addition, the number of corresponding survey tracks was assigned to the coordinates of the habitat traces of endangered wildlife collected by field surveys and added to the endangered species identification information for each survey case.

Using this data, we performed statistical analyses such as identification frequency and the number of grids per survey distance for endangered mammals. Among the analysis areas, those in which objections were repeatedly entered were included, and the number of each survey was also numbered. Data were analyzed separately. Furthermore, we treated the overlapped grid as one grid for retrieving information on a plane. If the accumulated habitat traces were included in the same grid, they were treated as one grid to organize data. We then analyzed the entire grid and the habitat grid of the endangered species using these data.

Results

Statistical analysis of the number of endangered species in habitat traces

Five species of endangered wildlife mammals, including otters, long-tailed gorals, martens, leopard cats, and flying squirrels were identified during the 202 field surveys and normality was confirmed (P<0.005). The number of habitat traces was 918, and they were classified by type (Table 1). The species with the most and fewest habitat traces were leopard cats and long-tailed gorals, respectively. The species with various habitat types was marten. Footprints, claw marks, excrement, feeding traces, and hairs confirmed the habitat of martens. Of the 360 habitat traces of leopard cats, 357 were scats, and the proportion of excrement was very high in all otters, martens, and flying squirrels. Out of the 918 habitat traces, the type of excrement accounted for 897 (97.7%). In other words, these five species were mostly confirmed by the presence or absence of excrement.

The frequency of monthly traces was analyzed based on excrement traces of each species as follows (Fig. 3). Most field surveys were conducted in June and November, but it was confirmed that the actual number of excreta traces for each species differed slightly based on the frequency of the survey. The number of excrement traces was high in April, May, and June for the flying squirrel, but this number was high in November for martens. A positive correlation between the number of habitat traces and survey frequency was observed for leopard cats. However, the number of traces was relatively high in January, March,

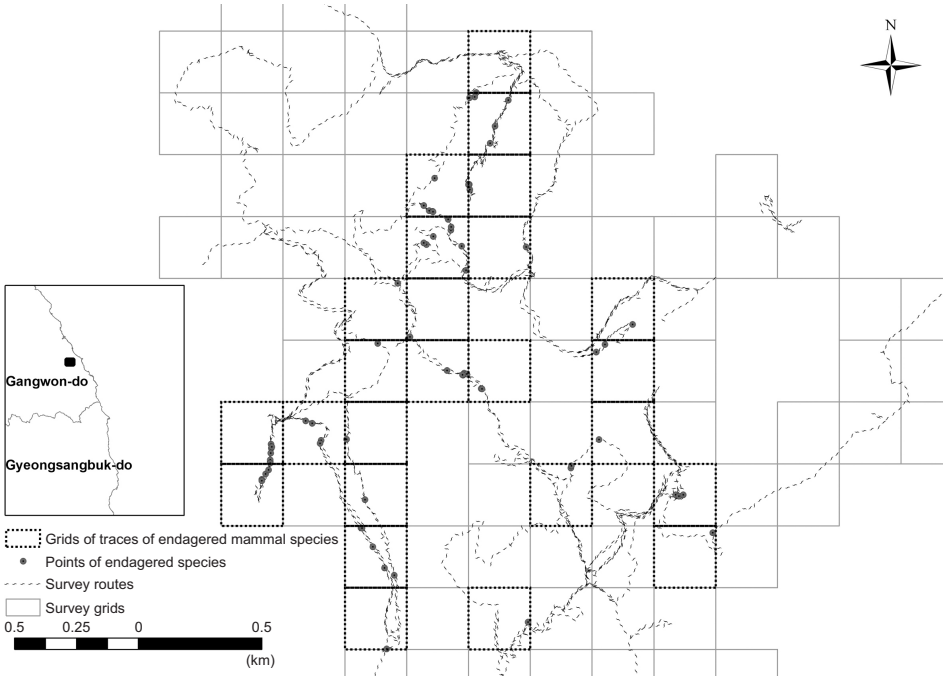


Fig. 2. Sample map of survey track, points, and grids of Ecological and Natural Map.

Table 1. Classification of trace types for each endangered mammal

Traces	Otter	Goral	Marten	Leopard cat	Flying squirrel	Sum
Appearance	-	-	-	-	1	1
Footprint	5	-	1	3	-	9
Claw mark	-	-	1	-	-	1
Excrement	103	1	164	357	272	897
Horn mark	-	6	-	-	-	6
Feeding sign	-	-	2	-	-	2
Hair	-	-	1	-	1	2
Sum	108	7	169	360	274	918

–, not available.

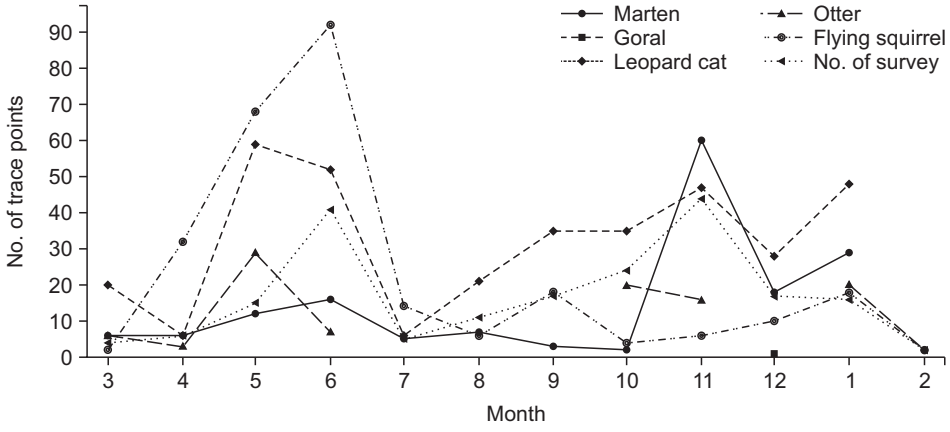


Fig. 3. The monthly plot of excrement traces points to endangered mammals.

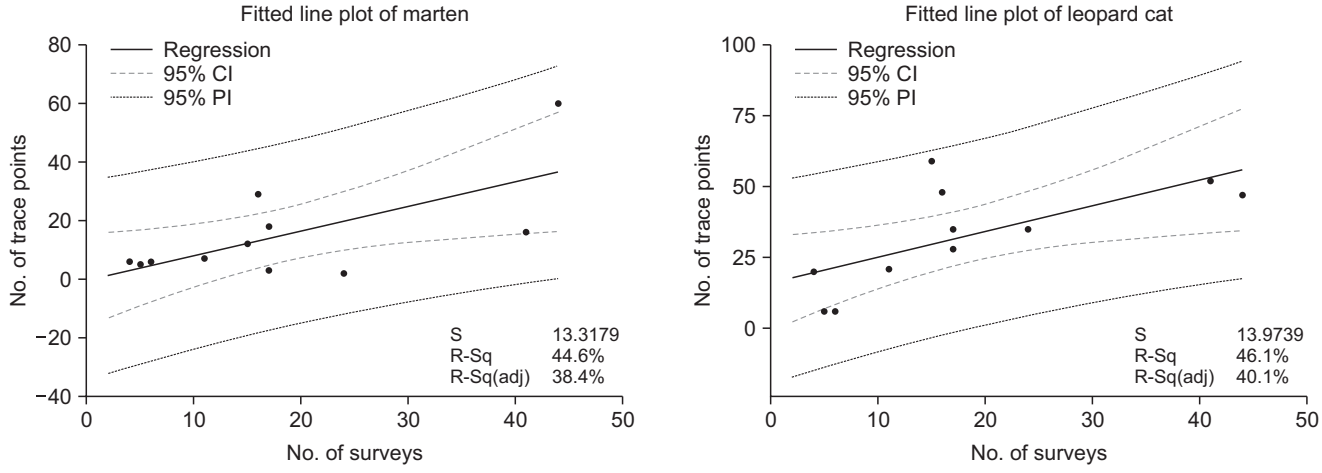


Fig. 4. Regression line plots of the marten and the leopard cat. CI, confidence interval; PI, prediction interval; adj, adjusted.

August, September, and December when the number of surveys was less. The number of otter excrement traces did not appear to correlate with survey frequency. Excrement of the long-tailed goral was identified only once and hence, it was excluded from the analysis.

Results of the correlation analysis between survey frequency and habitat traces for each of the four species show no significant correlation for flying squirrels (r=0.39, P=0.21) and otters (r=0.284, P=0.496) and a significant correlation for martens (r=0.667, r^2=0.446, P=0.025) and leopard cats (r=0.679, r^2=0.461, P=0.022). However, the coefficient of determination was slightly low; therefore,

the linearity of the survey frequency was weak. Nevertheless, it was found that the higher the survey frequency, the higher the number of habitat traces (Fig. 4). This result indicates a temporal characteristic indicating that the flying squirrel leaves traces of excretion. In other words, there is a high possibility of a specific season when the excrement of flying squirrels is confirmed. This indicates that the survey results may vary depending on the season and date of the field survey of the flying squirrel. In the case of otters, the excretion points were not uniformly distributed or they excreted in rough places.

In other words, numerous otter scats can be identified in one survey, and even if the number of surveys is high, the number of traces may be low. Results for leopard cats and martens show that the correlation between the frequency of surveys may be the leading cause of their wide range of habitat activities. Therefore, it seems unreasonable to designate only a tiny grid with confirmed excrement as the habitat grid for these two species.

Statistical analysis of survey distance and grid

The total survey distance covered during the 202 surveys was 697.7 km (Table 2) with an average distance of 3.5 km and a trimmed average of 3.1 km. The shortest survey distance was 100 m, the longest was 26.7 km, the median distance was 2.4 km, and the distance corresponding to 75% of the quartile was 4.6 km. Most survey distances did not exceed 5 km. When these tracks were overlapped with the grid, a total of 2,184 grids were produced, with an average of 10.8 (truncated average of 9.5) grids. In one survey, the number of grids for the shortest survey track was one and the number for the longest survey track was 61. The median value was approximately seven grids, and the number of grids corresponding to 75% of the quartile was approximately 14. This is similar to the statistical results obtained for the object area (Jung *et al.*, 2017).

Most of the objections to the designation of the 1st grade zone in the Ecological and Natural Map were pertaining to the fact that most of the habitat grids of

Table 2. Statistics on survey distances and the number of grids

Statistics	Distance of surveys (km)	No. of all grids	No. of grids with traces
Sum	697.7	2,184 (1,626*)	441 (375*)
Mean	3.5	10.8	3.0
Trim mean	3.1	9.5	2.7
Minimum	0.1	1	1
Median	2.4	7	2
Q3	4.6	14	4
Maximum	26.7	61	16
Mode	-	2	1
No. for mode	-	25	46
Total count	202	202	146

–, not available.
*The number in parentheses is the number of grids on the plane when ignoring the repeated survey area.

Table 3. Statistics on the number of coordinates of endangered species identified in each survey

Statistics	Otter	Goral	Marten	Leopard cat	Flying squirrel
Sum of points	108	7	169	360	274
Sum of grids	25	3	48	102	46
Mean	4.3	2.3	3.5	3.5	6.0
Trim mean	3.9	-	3.1	3.1	4.86
Maximum	17	5	19	17	43
Mode	2	1	1	1	1
No. for mode	6	2	15	34	9
Median	3	1	2	2	3

–, not available.

endangered wild animals are approximately only one grid. Endangered wild mammals were found in 441 grids, which accounted for 20.2% of the total grids. Approximately 23.1% of accumulated values were converted to information on the plane for repeated surveys in the same area. Table 3 shows the statistics of the number of grids, including points where the habitat of each endangered mammalian species was identified. Although the grid number and average of each species are different, the mode is only two for otters and one for all other species.

Tables 2 and 3 show that even if we examine a place that has already been designated as a 1st grade zone in the Ecological and Natural Map, the rate of confirmation of the habitat of endangered species is only approximately 20% of that area. This proves that despite the wide range of habitat activities of these five species, the grid of the Ecological and Natural Map was calculated very narrowly. In other words, it shows that only one grid is often identified in most areas. A study reported the tendency to reevaluate the Ecological and Natural Map, particularly with respect to areas for which of objections were raised, to a lower grade than in the past (Jung *et al.*, 2017). This study confirms that the grades of the evaluations that reflect results of the endangered mammal survey were further lowered. In other words, the species grid of the Ecological and Natural Map did not reflect the habitats of endangered mammals realistically.

Discussion

Number of habitat traces and species grid

Analysis of survey data obtained from 202 surveys over six years lead to the following implications. When field research was conducted in the 1st grade zone of the Ecological and Natural Map, most of the habitat traces of endangered species were excreta, and a only a low number of excreta was observed each time. Only a 250×250 m grid can be maintained as a grid that represents the 1st grade zone using the present form of trace points under current rules. However, results of our analysis question whether such rules can reflect the habitats of endangered species.

A study reported that the habitat of flying squirrels was 0.599 km^2 (59.9 ha) for males and 0.083 km^2 (8.3 ha) for females (Taulman & Smith, 2004). The habitat for long-tailed gorals was reported at approximately 1.38±0.24 km^2 (Cho *et al.*, 2015), and these two species are known to have very narrow habitats. However, the current grid of the Ecological and Natural Map (0.0625 km^2) is small, even though it reflects the narrow habitats of these two species. In addition, a previous study reported that otters, martens, and leopard cats have a wide range of activities. The otter's movement distance is approximately 15 km, the habitat area of the marten is approximately 32.2±12.9 km^2, and the habitat area of the leopard cat is 3.69±1.34 km^2 in rural areas. It is reported that the movement distance of the Iriomote cat (*Prionailurus bengalensis iriomotensis*) is 1.9 to 3.2 km (Choi *et al.*, 2012; Erlinge, 1967; Schmidt *et al.*, 2003).

The number of habitat traces of wild animals is proportional to the survey distance, and leopard cats and martens are no exception (Lee *et al.*, 2019a; b). It seems unreasonable to maintain only tiny grids in which excrement has been confirmed as extensive habitats of these species. In addition, there is weak evidence to support that only places where excrement is confirmed are essential habitats. In particular, in a study that repeatedly examined the same location, it was confirmed that leopard cats excreted in the active route of the habitat area, and not just in one place (Lee *et al.*, 2019a). It is clear that martens and otters also have a leopard cat-like excretion habit, even if scientifically collected data are insufficient.

This species grid concept was postulated, approximately in 2007 through consultation with specialists, by taxa and is used as a determinant of habitats till date. In the past, owing to limitations of data collection and analysis, the ecological characteristics of taxa were not well known; therefore, the concept of a species grid would have been introduced as the best option. However, many ecological studies on each major species are being conducted, and various data are being collected; therefore, it is necessary to improve habitat determinants based on quantitative and qualitative data.

Therefore, a re-discussion on the species grid is required. A total of 267 endangered species have been identified in Korea (MOE, 2016). It is necessary to organize and analyze only those of these species that are frequently applied to evaluate zoning of the Ecological and Natural Map. A re-discussion on the wide range of activities of species is essential for endangered species such as martens, leopard cats, and otters. It is desirable to exclude species, whose ecology is well known, from the concept of the species grid and use the habitat concept instead. Research data that can establish specific places as habitats for most endangered species is still lacking, and further research is required in this direction. Connecting intermediate grids sandwiched between grids in which excrement was found can improve the accuracy of the use of the grid-type geographic unit for evaluation. Among the many endangered species, habitat assessments of otter, marten, and leopard cat can be improved as many researchers have collected adequate data.

Author Contributions

YKK collected and analyzed data and wrote the original draft. JBL analyzed data and reviewed and edited the draft. SJL, JSC, and HL participated in the fieldwork. The

authors read and approved the final manuscript.

Conflict of Interest

The authors declare that they have no competing interests.

Acknowledgments

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