

ANALYZE THE IMPACT OF HABITAT PATCHES ON WILDLIFE ROAD-KILL

S. Seok^a, J. Lee^{a,*}

^a Dept. of Geoinformatics, The University of Seoul, 163 Seoulsiripdaero, Seoul, South Korea – (rltk00, jlee@uos.ac.kr)

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ABSTRACT:

The ecosystem fragmentation due to transportation infrastructure causes a road-kill phenomenon. When making policies for mitigating road-kill it is important to select target-species in order to enhance its efficiency. However, many wildlife crossing structures have been questioned regarding their effectiveness due to lack of considerations such as target-species selection, site selection, management, etc. The purpose of this study is to analyse the impact of habitat patches on wildlife road-kill and to suggest that spatial location of habitat patches should be considered as one of the important factors when making policies for mitigating road-kill. Habitat patches were presumed from habitat variables and a suitability index on target-species that was chosen by literature review. The road-kill hotspot was calculated using Getis-Ord G_i^* . After that, we performed a correlation analysis between $G_i Z$ -score and the distance from habitat patches to the roads. As a result, there is a low negative correlation between two variables and it increases the $G_i Z$ -score if the habitat patches and the roads become closer.

1. INTRODUCTION

The ecosystem fragmentation due to transportation infrastructure causes a road-kill phenomenon. According to the report, after installing a wildlife crossing structure for amphibians in 2006, road-kill occurrence of amphibians declined from 986 cases (2006) to 71 cases (2012), by approximately 92% (Korea National Park Research Institute, 2013). In other words, when making policy for mitigating road-kill it is important to select target-species in order to enhance its efficiency.

In this paper, we are to grasp the relationship between road-kill hotspots and habitat patches, and we will suggest that spatial location of habitat patches should be considered as one of the important factors for mitigating road-kill. This paper is organized as follows; Section 2 reviews limitations in current research on mitigating wildlife road-kill, Section 3 proposes methodology of this study, and Section 4 describes the experimental implementation. The final section concludes with a discussion of future work.

2. LIMITATION OF CURRENT RESEARCH ON MITIGATING WILDLIFE ROAD-KILL

By its nature, the road-kill phenomenon occurred on the road, and the occurrence factor of road-kill varies from traffic to ecological factors such as traffic volume, operating speed, etc. (Choi, 2007). As mentioned previously, target-species is an important factor to increase efficiency of the wildlife crossing structure. Their ecological characteristics also reflect that. Park *et al.* (2012) attempted to identify a potential wildlife passage site for leopard cats (*Prionailurus bengalensis euptilura*) utilizing radio-tracking data captured during the four-month period and proposed suitable site for installing crossing structure (Park *et al.*, 2012). Besides that, many researchers have proposed to set up measure for mitigating wildlife road-kill through categorization of road-kill characteristics based on accumulated road-kill data over time such as types of road,

maximum speed limit, land use, etc. (Lee & Lee, 2006; Shin & Ahn, 2008, Choi *et al.*, 2012).

Such microscopic studies utilizing accumulated data have the advantage of more precise and reliable in analysis results. Nevertheless, since the data acquisition period is too long and the results are obtained within a single region, the scope of application is limited. With a view to improving such limitations, this paper proposes ways of identifying a correlation between habitat patches and road-kill hotspots in macro perspective. Because habitat patches of target-species can be repeatedly utilized in many regions, it has benefits compared with other approaches on the recyclability side.

3. METHODOLOGY

The purpose of this study is to analyse the impact of habitat patches on wildlife road-kill, so the entire procedure for analysis is summarized as follows;

Step 1: Presumption of Habitat Patches

Step 2: Correlation Analysis between Habitat Patches and Road-kill Hotspots

3.1 Presumption of Habitat Patches

For accurate presumption of habitat patches, it will be desired to utilize a well formulated Habitat Suitability Index (HSI). However, it is impossible to formulate HSI of all species existing on earth, and for such a reason, HSI has been formulated for endangered species or principal species.

In this paper, we determine a Habitat Variable (HV) and Suitability Index (SI) based on ecological characteristics of target-species, and then presume their habitat patches using a weighted overlay method in GIS. Here, weights-related to HVs are calculated by Rank Order Centroid (ROC) (Edward & Barron, 1994) (1) according to their priority.

* Corresponding author

$$w_i(ROC) = \frac{1}{n} \sum_{j=1}^n \frac{1}{j} \quad i = 1 \dots n \quad (1)$$

When HVs, SIs, and their weights are determined, it is classified into two-groups (suitable habitats and unsuitable habitats) using quantile classification after the weighted overlay model (Lee & Zarine Kemp, 1997) (2). After that, habitat patches of target-species are finally presumed from consideration of their territory.

$$v = \sum_{i=1}^M w_i u_i(x_i) \quad (2)$$

where $\sum_{i=1}^n W_i = 1$

w_i is the weighting associated with attribute i ,
 u_i [0, 1] is the utility function associated with attribute i ,
 x_i is the attribute (Suitability variable)

3.2 Correlation Analysis between Habitat Patches and Road-kill Hotspots

In this paper, we use Getis-Ord G_i^* (3) to calculate road-kill hotspots. To take advantage of road-kill spot data (POINT), the data are aggregated using grid (POLYGON), and then grid (cell) size is determined by one neighbor distance between the spot data. Finally, we performed a correlation analysis between G_i Z-score and the distance from the habitat patches to the roads.

$$G_i^*(d) = \frac{\sum_j W_{ij}(d)x_j - W_i^* \bar{x}^*}{s^* \{[(nS^*1i) - W_i^{*2}]/(n-1)\}^{1/2}} \quad (3)$$

where $w_{ij}(d)$ is the spatial weight vector with values for all cells,
 j is within distance d of target cell i ,
 w_i^* is the sum of weights,
 S_i^* is the sum of squared weights,
 s^* is the standard deviation of the data in the cells

4. EXPERIMENTAL IMPLEMENTATION

4.1 Research Area and Target-Species

Mt. Odae National Park, of all national parks in Korea, has the second highest road-kill rate (Korea National Park Research Institute, 2013). According to road-kill data collected April 2006 - June 2014, mammal accounted for the highest number of cases (479) followed by reptilia (225), amphibian (220), aves (159). Additionally, it is found that the Siberian Chipmunk from Korea (*Tamias sibiricus barberi*) has the highest proportion (70%, 334) of mammal road-kill cases. Therefore, we selected Mt. Odae National Park and the Siberian Chipmunk as the research area and target-species.

4.2 HSI Model for Siberian Chipmunk

The Siberian chipmunk (*Tamias sibiricus* Laxmann 1769) is distributed from north European and Siberian Russia to Sakhalin, including Korea and Japan (Hoffmann *et al.* 1993). Johnson and Jones (1955) classified the Siberian Chipmunk from the central and southern regions of Korea into a new

subspecies, *barberi* (Koh *et al.*, 2009).

HVs based on the ecological characteristics of the Siberian Chipmunk are summarized as follows; (1) Ground Coverage (GC), (2) Age Class (AC), (3) Diameter Class (DC), (4) Forest physiognomy (FP), (5) Distance from the Road (DfromR). Each HV is defined in the following section.

4.2.1 Ground Coverage: It is found that The Siberian chipmunk lives in a wide range of environmental conditions primarily covered by forests (Yoon *et al.*, 2004). Therefore, we determine fuzzy membership which has a negative sloped linear transformation with a using fuzzy logic. Any value above 100(m) will be assigned a 0.

4.2.2 Age-Class: The Siberian Chipmunk prefers short trees rather than tall trees (Yoon *et al.*, 2004). In this paper, we presume that the higher age-class trees have, the taller they are. Thus, SI of AC is classified as follow; class 1 (1), class 2 (0.8), class 3 (0.6), class 4 (0.4), class 5/6 (0.2), class 7 (0).

4.2.3 Diameter Class: Earlier research (Han *et al.*, 2009) found that a tree's height is related to diameter at breast height. Thus, SI of DC is classified as follow; class 1 (1), class 2 (0.8), class 3 (0.6).

4.2.4 Forest Physiognomy: It is found that the Siberian Chipmunk prefers coniferous forests rather than deciduous forests (Yoon, 1992). Thus, SI of FP is classified as follow; coniferous forests (1), mixed forest (0.8), broadleaved forest (0.6), non-stocked forest land (0.4), cultivated land (0.2), etc. (0).

4.2.5 Distance from the Roads: Earlier research (Road Environmental Research Institute, 1995) found that if the roads and forest are separated by over 400(m), road-kill of small mammals such as Japanese hare (*Lepus brachyurus*) and Japanese weasel (*Mustela itatsi*) has not occurred. Therefore, we determine fuzzy membership which has a positive sloped linear transformation with a using fuzzy logic. Any value above 400(m) will be assigned a 1.

4.2.6 Weights: With reference to a research study (Shin, 2013), weights to each habitat variables calculated by using ROC are determined as follow; (1) GC (0.46), (2) AC (0.26), (3) DC (0.15), (4) FP (0.09), (5) DfromR (0.04).

4.3 Presumption of Habitat Patches of the Siberian Chipmunk and Correlation Analysis

Figure 1 shows presumed habitat patches of the Siberian Chipmunk in Mt. Odae National Park. The patches include district where the many Siberian Chipmunks are observed in the 2004 survey (red box in Figure 1). In this area, national highway route 6 has more road-kill hotspots (222 spots) compared with local road route 446 (75 spots) and habitat patches is closer to route 6 than route 446.

The correlation coefficient between G_i Z-score and distance from habitat patches to the roads was -.281. After reclassifying variables based on maximum speed limit (km/h) (40, 50, 60, no speed limit), it showed different results in cases of the speed limit as 60 km/h (correlation coefficient = .518) and no speed limit (correlation coefficient = -0.072). Thus, the correlation coefficient increased to -.369 after analyzing the correlation between the two variables except for the zone of speed limit as 60 km/h and no speed limit. To summarize, there is a low negative correlation between the two variables and it increases

the *Gi* Z-score if the habitat patches and the roads become closer (Table 1). However, even though the distance is close, it is found that accident frequency rates are low in cases of the speed limit as 60 km/h or higher zones.

* $p < 0.05$

		Distance
<i>Gi</i> Z-Score	Correlation coefficient (whole)	-.281*
	Correlation coefficient (60 km/h)	.518*
	Correlation coefficient (no speed limit)	-0.072*
	Correlation coefficient (40 & 50 km/h)	-.369*

Table 1. Correlation coefficient between two variables

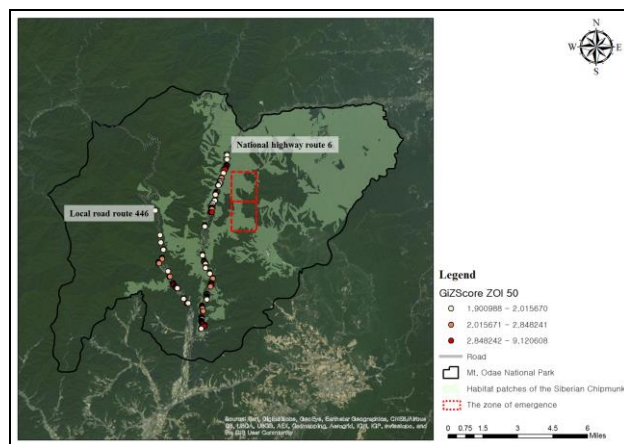


Figure 1. Habitat patches and Road-kill Hotspots of the Siberian Chipmunk in Mt. Odae National Park

5. CONCLUSION AND FUTURE WORK

The purpose of this study is to analyse the impact of habitat patches on wildlife road-kill. As a result, there is a low negative correlation between *Gi* Z-score and distance from habitat patches to the roads. Thus, it affects the *Gi* Z-score going up if the habitat patches and the roads become closer and suggests that spatial location of habitat patches should be considered as one of the important factors for mitigating road-kill.

As mentioned previously, for accurate presumption of habitat patches, it is desired to utilize well formulated HSI. HSI for the Siberian Chipmunk proposed in this paper is based on only literature review in research. In other words, quantitative analysis is required to validate presumed patches in this study.

In the next steps, we will need to consider additional data achieved through field survey about wildlife and habitat. It allows researcher to more precisely and easily presume the habitat patches in the field where it is hard to survey. Consequently, it will be effectively utilized as an important factor to presume dangerous stretch of road.

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