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Identification of Ecological Connectivity for Brown Bears: Example of Malatya Province

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Abstract

Increasing population, industrialization and use of agricultural land in the world results in devastation and fragmentation of natural areas, and thus the wild life is threatened. Especially big carnivorous animals are influenced heavily by this situation. They are vulnerable due to the need for wide areas for habitation, low reproduction rates, huge body size and the fact that they are perceived as threats by people because of their predatory characteristics. Therefore, these species should be considered as a priority in protection strategies.
Connectivity is one of the tools used for preventing the mentioned devastation created by human activities and enabling protection of the habitats of mentioned species. An umbrella species, big carnivorous brown bear (*Ursus arctos* L) is tackled in the study which is found in the natural landscape of Malatya province. The purpose of the study is to identify their habitats via Geographical Information Systems and ensure ecological connectivity among habitats. Similar studies are examined as examples within the applied model in this context and they are transferred to the field. The mobility among reproduction and population areas of the brown bears is provided by the to-be-established ecological networks, while they are protected from isolation and spatial losses.

Keywords: Brown bear (*Ursus arctos* L), ecological connectivity, habitat model, Malatya, Turkey

INTRODUCTION

Within densely populated landscapes, human activities generally deprived wild animals and plants of their natural habitats while restricting the carnivore (for instance; the bears) to reach their habitats (Posillico et al. 2004). In addition to this, the carnivores have a vulnerable structure due to their need for a bigger living space, their low fertility rate and ravenousness (Fernández, 2014). For the last two centuries large carnivore populations became widely extinct largely depending on increasing human population (Fernández, 2014). The disappearance of the predators is generally considered worrisome, since majority of the ecosystems are controlled top-down (Dorresteijn, 2013).

For this reason, habitats of the large carnivore should first be identified so that the so called extinction could be prevented by finding connections among separated habitats. The bears tackled in this study are one of the most varied groups of the large mammals. Their habitats include a large area extending to the Ecuadorian rainforest, desert steppe, poles and meadows (Figure 1). They feed on various resources such as plant roots and leaves, fruits, insects, larva, eggs and fish (Servheen, 1998). The Bear are generalist and opportunistic species which have a bigger adaptation to different habitat types and to human activities (Favilli, 2013).

Figure 1 *General distribution of bear species throughout the World (Servheen, 1998)*

Protection of the bears with a wide range of habitats and food sources will also pave the way for the protection of many other species. The bears no matter where they exist are a significant sign for the ecosystem health. Therefore, the bears can be at the center of ecosystem protection (Servheen, 1998). Connectivity is one of the tools used for preventing deteriorations in the ecological systems (Favilli, 2013). It should be handled as species focused and determined as per each animal species (Merriam, 1991). For this reason, brown bear was selected as the study subject due to its higher ecologic tolerance and top level of the food pyramid convenient for a top down control in line with the data obtained from IUCN 2016. The aim of this study is to identify the habitats of the brown bear (*Ursus arctos L)* and to specify the possible connectivity routs among these habitats.

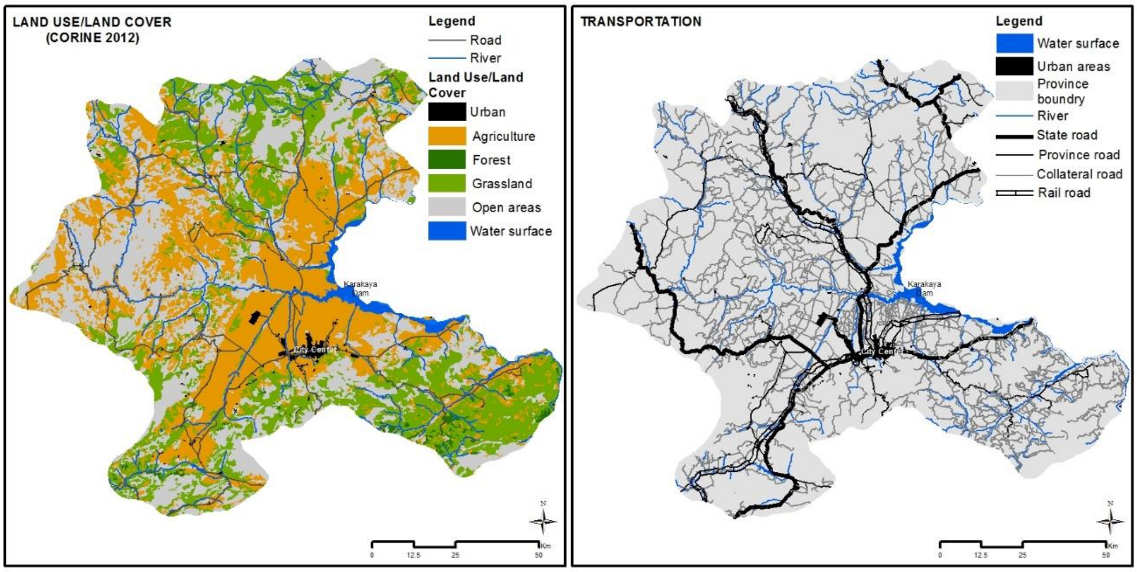
MATERIALS and METHODS

The main material of this study is Malatya province. Malatya is positioned in the Eastern Anatolia Region between 35 54' - 39 03' North latitudes and 38 45' - 39 08' East longitudes (Anonymous, 2011). It is surrounded by Elazığ and Diyarbakır on the East, by Adıyaman on the South, by Kahramanmaraş on the West, by Sivas and Erzincan on the North (Figure 2) (Kaymaz, 2014).

Figure 2 *Location map*

In this study, CORINE land use/land cover data prepared by the European Commission in 2012 was used (http://land.copernicus.eu, 2016). The transportation and topographic maps used in this study are obtained from various government agencies as part of PEYZAJ-44 project (Şahin, 2013). The transportation collected from this so called project was obtained from Directorate General of Highways while the topographic maps were taken from General Command of Cartography.

Agricultural lands are placed densely in the distance between the city center and Karakaya Damn. The forests cover a small portion of the province and the general outlook includes grassland and open areas (Figure 3a). There are two significant transportation lines placed in the land of study. First one is the highway numbered 300-23 connecting East with the West. The second one is the railway starting from Sivas. This line is separated into two at the center of Malatya as one line reaches to Adıyaman and the other line ends in Karakaya Dam Lake. Railway transportation generally shows similarity with the highway transportation (Şahin, 2013) (Figure 3b)



a *b*

Figure 3 *Land use/land cover (Kaymaz, 2014) and tranportaton (Şahin, 2013)*

The gradient ranges between 0-30 degrees on the study area (Figure 4a). The height ranges between 540-2690 m. The height of the land between Karakaya damn and city center changes between 540-1000 m and the elevation increases as we go to the west of the province (Figure 4b)

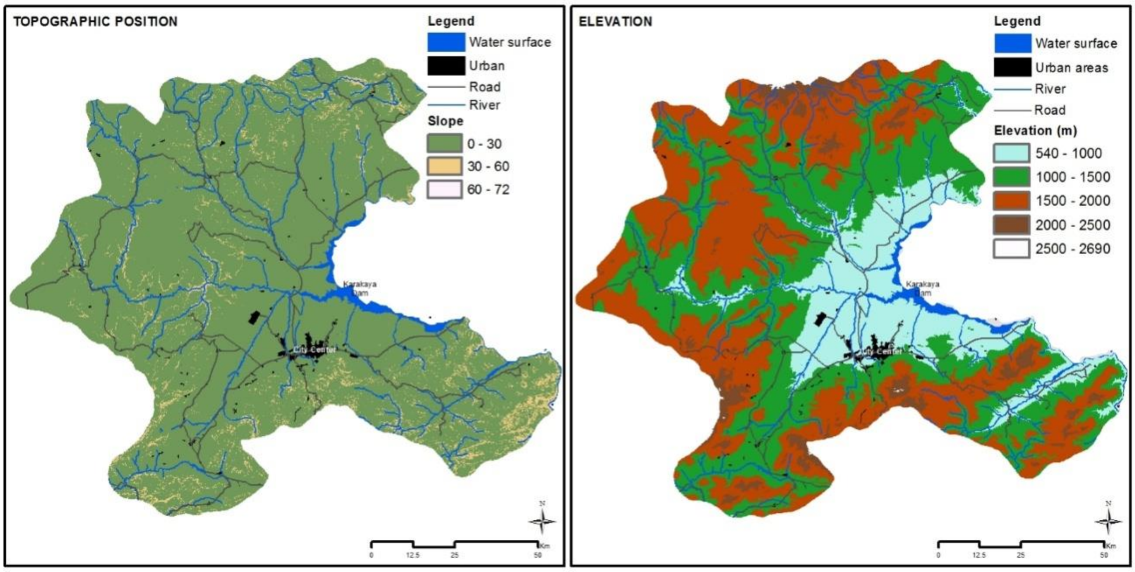


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Figure 4 *Topographic position and elevation*

The study which aims to find some ecological connections regarding the brown bear consists of two phases. In the first phase, the database give in table 1 and conformity ratios were used in order to find species specific lands by identifying the appropriate habitats via Corridor Designer tool. In the second phase the affiliated lines between specified habitats were identified by Linkage Mapper tool (Figure 5).

In this study the appropriate habitats for the brown bear (*Ursus arctos* L) were identified by making use of the study called BioREGIO Carpathians Advanced Tools and Methodologies Adopted GIS Model Design For Deriving Ecological Corridors (2013). In this study the umbrella types were specified and the data regarding CORINE land use/land cover, distance to roads weight, topographic posıtıon, elevation, and distance to human impact facilities were used in order to identify appropriate living spaces for these species. For finding habitat lands CorridorDesigner tool was used. The data regarding identification of habitats for the brown bear (*Ursus arctos* L) was availed from the so called study.

Table 1 *Data, weight and scores (Favilli, 2013).*

	Classes	**Weight**	**Summer Scores (% suitability)**	**Winter Scores (% suitability)**
Land Cover	Forest	30%	100	75
	Grassland		50	50
	Open areas		50	50
	Water bodies		25	25
	Agriculture		25	25
	Urban		0	0
Topographic Posıtıon	Bottom-gentle (0-30)	30%	50	75
	Steep (30-60)		100	50
	Ridge top (60-90)		25	0
Distance to Human Impact Facilities	0-100 m	10%	0	0
	100-500 m		50	50
	500-1000 m		100	100
	> 1000 m		100	100
Elevation	0-500	10%	50	50
	500-1000		75	75
	1000-1500		100	100
	1500-2000		100	50
	2000-2500		100	0
	>2500		50	0
Distance to Roads Weight	0-50 m	20%	0	25
	50-200 m		50	50
	>200 m		100	100

In this study, Linkage Mapper (McRae and Kavanagh 2016) tool was used for identifying possible ecologically connected routes among the habitats found with the help of CorridorDesigner tool. The tool creates the connected routes by using self-space and resistance surface. The resistance surface should be evaluated by the consumed energy, hardship or risk of death (Favilli, 2013; McRae and Kavanagh 2016). The habitats determined as mentioned above, are handled as self-spaces. The resistance surface is specified by the method taken from (Favilli, 2013). The human foot prints effect (Woolmer, 2008) and hemeroby degrees (Walz and Stein 2014) were used to calculate resistance values in this method (Favilli, 2013)

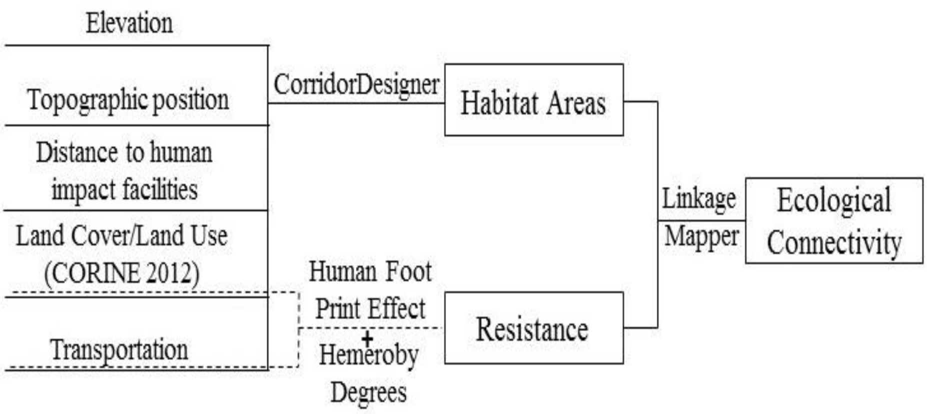

Figure 5 *Flow chart*

RESULTS and DISCUSSION

The habitats of summer and winter seasons were studied separately. However, the analysis of the winter season (figure 6a) fragmentation was not identified in population habitats. Therefore, only summer season (figure 6b) was included. In the light of the data displayed on Table 1, the species specific habitats found by the method taken from (Favilli, 2013). The areas found on the study area are transitional areas feeding and population areas. (Figure 6a, Figure 6b).

As a result of the analysis made feeding and population areas have a fragmented nature. Particularly, the agricultural lands and human impact facilities are candidate for being transitional habitats.

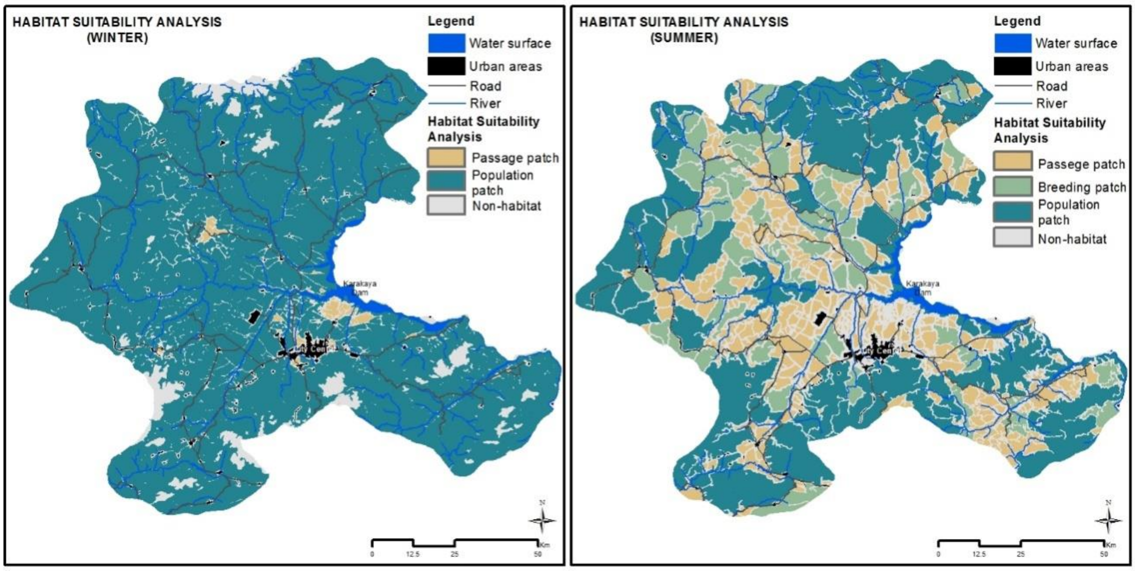

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Figure 6 *Habitat suitabilty analysis (Favilli, 2013)*

In this study, the resistance value of the area must be known so that the possible ecological connectivity routes between self-spaces can be identified. In this regard, the method taken from (Doğan, 2016) was applied to learn the resistance degree of the land. The resistance values determined by this method ranged between 1 and 100. As the value closes to 100, the resistance increases (Favilli, 2013) (Figure 7). The resistance value is the highest particularly around highways, settlements and their surroundings while the lowest in natural lands (Favilli, 2013).

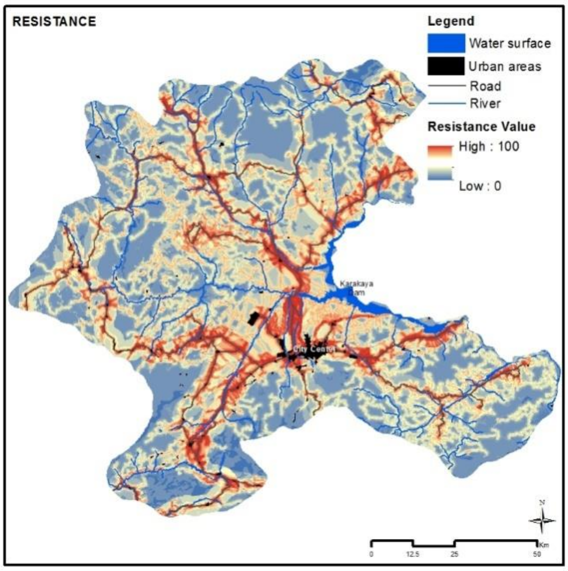

Figure 7 *Resistance layer*

In this study, the possible connectivity routes were identified with the help of Linkage Mapper tool by using the specified habitats (self-spaces) and resistance value (Figure 8). The broadness of the routes is one of the most important topics while idetifiying connectivity routes in ecological protection focused studies. According to the studies and the models, large corridors show the direct movement of the animals among the stains and their rate of movement increase (Hennings and Soll 2010). The broadness changes from species to species. The minimum broadness of corridor for the brown bear is 2-5 km (Favilli, 2013). Most of the possible connectivity routes mentioned in this study pass through agricultural lands. For this reason, the broadness is specified as 2 km.

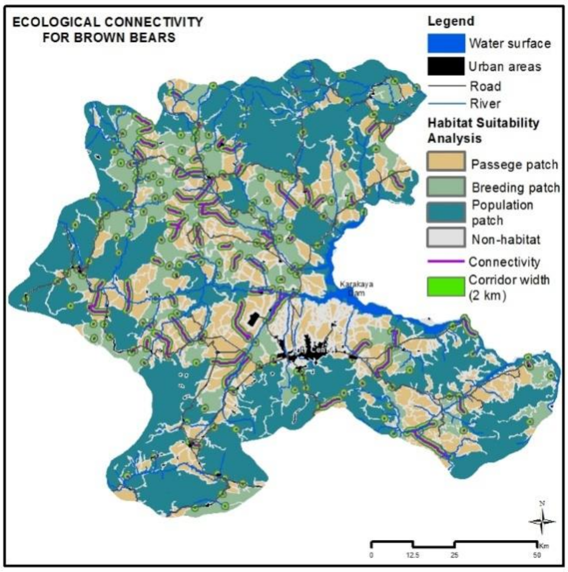

Figure 8 *Ecological Connectivity for Brown Bears*

CONCLUSION

Ecological connectivity is a crucial element for sustainability of the ecological processes and systems. Particularly in high scale and species focused studies, we must be able to specify habitats by means of models. This depends on the integration of ecological data with the modeling process (Fernández, 2012). The model used as part of this study is actually the result of such process. It is important to determine connectivity according to species in ecological connectivity studies. However, it is not that easy to determine connectivity routes for every species and to apply this to the site. Therefore, indicator species are designated for such studies and connectivity routes are specified as to these species. The indicator species are selected among primary consumer as well as among large predators positioned on top of the food pyramid.In this study, brown bear was used as an indicator species due to the high habitat diversity as well as high tolerance, because protection of the bears and their habitats will also provide protection for the habitats of many other species (Servheen, 1998).

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