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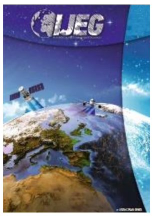

Determining the habitat fragmentation thru geoscience capabilities in Turkey: A case study of wildlife refuges

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ABSTRACT

Technical forest management started 180 years ago in Turkey, during which time there have been various approaches and policy changes. The primary objective of forestry has been considered as timber production, so the intangible benefits have never been given the proper attention they deserve. The majority of Turkey's wildlife has prospered within the forest ecosystems. This situation has gradually led to a change of status, so some forests and land areas have been reassigned with the conservation agendas as the primary purpose; however timber production has never slowed down. Thus, operational forestry practices, such as roading, logging, etc., have kept on exploiting these lands to their full extent despite their conservation statuses. In Turkey and anywhere else, since forestry has always evolved around extracting the timber out of the forest lands, the accessibility has long been provided, building roads to take related services to forested ecosystems. The remnants of these roads, along with the more standardized new ones can be found everywhere, regardless of the land status. Such expansion has resulted in habitat fragmentation emerging as a major threat for the protected areas. In this study, the expansion of all-weather and dry-weather accessible roads and suburban spread was examined in two adjacent, Ilgaz and Gavurdagi, wildlife refuges for the years of 1960, 1993, 2010 and 2019, relying heavily on the mapping, geographic information systems (GIS) and remote sensing. It was found that 275.5 km dry-weather roads in 1960 rose to 700 km in 2019, which meant 254% increase. Additionally, when the core along with the surrounding 3000 m buffer area was considered, 51 km all-weather roads in 1960 increased almost four and a half times by 2019. Suburban expansion was relatively stable inside the core area but had almost quadrupled within the surrounding areas, exposing the refuges to more people. These findings indicated that the wildlife habitats of Turkey are fragmented and under heavy human pressure.

1. INTRODUCTION

The geographic location of Turkey has allowed it to host a diverse flora and fauna, with the country being home to more than 10.000 species of plants, 32% of which are endemic, and around 1500 terrestrial and marine vertebrate species (URL-1, 2018).

Large-scale infrastructure works, such as highways and roads, crisscross the country at an ever-increasing rate, linking places and people, and facilitating commerce. Thus, these and many other measures that have been hastily imposed on Turkey in the name of development have caused habitat destruction and environmental degradation (Eken et al. 2016; Sekercioglu et al. 2011). The environment has long been conceptualized as dispensable in Turkey, so protective measures have had little effect on people's perception about the environmental conservation (Boluk and Mert 2015). Consequently, Turkey ranks 172nd out of 180 listed countries in the Environmental Performance Indexing (URL-2, 2018). The first national park was established for nature conservation in 1958. Since then, the number of national parks has increased to 46 as of 2019. There are also 81 "wildlife refuges" (WRs), or "wildlife development areas" as they are locally known.

There are a number of climatic zones in Turkey due to its unique positioning and varying

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topography, so the land covers also vary dramatically (Kaya and Raynal 2001), forming an ideal setting for vegetation growth and high levels of biodiversity. This is particularly true in the Western Black Sea Region (Yildiz et al. 2007), where the majority of the country's timber is produced. A number of objectives are associated with the management of forests and forest services but the primary goals are to sustainably manage the forest resources and generate tangible and intangible revenues via timber and non-timber sales, soil protection, water preservation, climate control, and recreation (Lundmark et al. 2014; Bekiroglu et al. 2015; Bussotti et al. 2015; Milodowski et al. 2015; Jones et al. 2018; Towerton et al. 2016; Suleiman et al. 2017; Won et al. 2017). The region provides perfect habitats for a range of wildlife, from big game animals such as elk (*Cervus elaphus*), roe deer (*Capreolus capreolus*), brown bear (*Ursus arctos*), wolf (*Canis lupus*), Eurasian lynx (*Lynx lynx*) and wildcat (*Felis silvestris*) through to smaller predators, rodents, and insect-eating mammals (Soyumert 2010; Erturk 2017). Consequently, eight WRs have been established in this region.

Both forestry and nature conservancy are managed within the same piece of land in the country. Forest Service (FS) is responsible for the administration, establishment, and upkeep of any type of forested land and primarily deals with the sustainable management of timber resources because 98% of all forests, covering 27% of the entire land area, are owned and managed for production by the state. Other governmental agencies are only allowed to function within the forests if the land(s) are reassigned with a function other than timber production. The General Directorate of Nature Conservation and National Parks (GDNCN), at this point, looks after the biodiversity and wildlife resources without altering the ecosystem dynamics within the land under their authority vested by the national constitution. The Department of Wildlife (DW) within GDNCN oversees all aspects, such as administration, decision-making, and on-site practices of the conservation areas in Turkey. This two-headed administration situation, FS vs. GDNCN, has created a dilemma in such wildlife conservation designated areas, in mind, because the notion of which value, forest management or wildlife conservation, should prevail, is still rather vague. Therefore, timber production continues unimpededly, and runs exclusively on forest roads because mechanization has not been effectively integrated into forest management in the country (Di Gironimo et al. 2015).

The road standards, i.e. type, slope, drainage requirements, etc., vary according to the designated purpose(s) of the land (production, afforestation, conservation, nature conservancy) (Demir and Hasdemir 2005), so their direct and indirect effects also vary considerably (Lugo and Gucinski 2000; Caliskan 2013). The planning, design, and implementation of roads for forest management are drafted in forest management plans (Akay et al. 2012; OGM 2008). However, haphazard applications of the same procedures to all forest lands could further worsen erosion and sedimentation, sub-surface water dispersals on slopes and edge phenomenon (Araujo et al. 2014; Al-Chokhachy et al. 2016; Edwards et al. 2016) and create unforeseeable new ones in the longer term (Fahrig 2002; Laurance and Balmford 2013). One of the most understood and studied side effects of roads is habitat fragmentation (Ortega and Capen 1999; Heilman Jr. et al. 2002; Liu et al. 2014; Amin and Fazal 2017), which involves the partitioning of an uninterrupted piece of land, a continuous habitat, into smaller pieces through either natural or anthropogenic processes (Skole and Tucker 1993; Forman et al. 2002). Habitat fragmentation naturally occurs because of climatic conditions, large water bodies, and mountain chains (Geffen at al. 2004; Bartakova et al. 2015; Machado et al. 2018). However, human induced development and management strategies can further exacerbate this to highly detrimental results (Crooks et al. 2017).

Two of these refuges, Ilgaz (OSIB 2012) and Gavurdagi (OSIB 2015), were the subjects of this particular study. Since both WRs have long been considered as prime regions for wildlife to live and prosper (Soyumert et al. 2019; Soyumert 2020), it is logical to think that habitat fragmentation would not be an issue if human interference has been kept to a minimum. These WRs were selected because the region was one of a couple heavily timber production oriented regions around the country, in which the first steps of wildlife oriented conservation efforts were introduced approximately 40 years ago (OSIB 2012). It was conceptualized that there was no better way than geoscience capabilities to backtrack how forest management has shaped these recently-status-changed-areas. Both were constitutionalized in 7 September 2005, (OSIB 2012; OSIB 2015). Turkey has come a long way since the 1960s. Infrastructure investments are vast, however what has been overlooked while doing all these, is wide open for researchers to delve into. Therefore, the aim of this study was to assess the level of habitat fragmentation caused by all-weather accessible roads (highways, hard-surface roads with two or more lanes and suburb / village access roads) and dry-weather accessible roads (including forest roads) linking the suburbs (forest villages) and these forests to major arteries, as well as the level of suburban expansion in and around these adjacent WRs.

2. MATERIAL and METHODS

2.1. Study Area

This study was conducted in Ilgaz and Gavurdagi WRs, which are located in Kastamonu, Turkey. These WRs lie adjacent to one another inside the "Region 10", shown as Region-X in Figure 1, which includes two national parks and six additional WRs. Region 10 also spans four other provinces, Sinop, Karabuk, Bartin, and Zonguldak, and comprises of a total area of 115458 ha (URL-3, 2018). Ilgaz and Gavurdagi WRs lie toward the south-central part of the Region 10, and encompass 26282 ha. The elevation ranges from 935 m at the southeastern tip of Gavurdagi WR to 2577 m at the western junction of the two WRs (Figure 1). The Ilgaz Mountain chain divides these WRs and create a distinctive climatic regime for the region, with semi-arid summers and cold winters (mean annual average temperature ~ 5.13°C, mean annual precipitation ~ 611.96 mm) (OSIB 2012). The evergreen vegetation that occurs here is dominated by stands of fir (*Abies nordmanniana* subsp. *equi-trojani*) and occasional Scots pine (*Pinus sylvestris*) in both pure and mixed groupings. Above 1800-2000 m, extensive alpine meadows stretch all the way to the highest reaches of Ilgaz WR. It was declared a no-hunting/breeding zone in 1981, primarily to safeguard elk and roe deer, and along with Gavurdagi was restructured as WRs in 2005 (OSIB 2015). Situated southeast of Ilgaz WR, Gavurdagi WR can be considered as the continuation of an already established elk habitat. Due to high altitude and rather treacherous topographical conditions, forest existence and the accompanying road building practices were low. Limited and scattered alpine meadows are found on the upper reaches of the WR. No forest village or neighborhood was reported inside the designated WR area. Untouched wilderness and none existent human activity were the driving forces behind its establishment as an extension to Ilgaz WR. Both WRs are on government property. The administration and development plans prepared for Ilgaz and Gavurdagi WRs listed more than 600 plant taxa in their combined area, 100 of which are endemic to Turkey and four of which are endemic to the Ilgaz Mountains. In addition to the target species elk and roe deer, the study area is home to 41 insect, 6 amphibian, 7 reptile, 15 mammal, and 77 bird species. Furthermore, 42 of the reported vertebrate species within the study area are currently protected by international conventions (OSIB 2012 and OSIB 2015). Thus, it is clear that the area is rich in both flora and fauna, and the principles of conservation have been identified and documented.

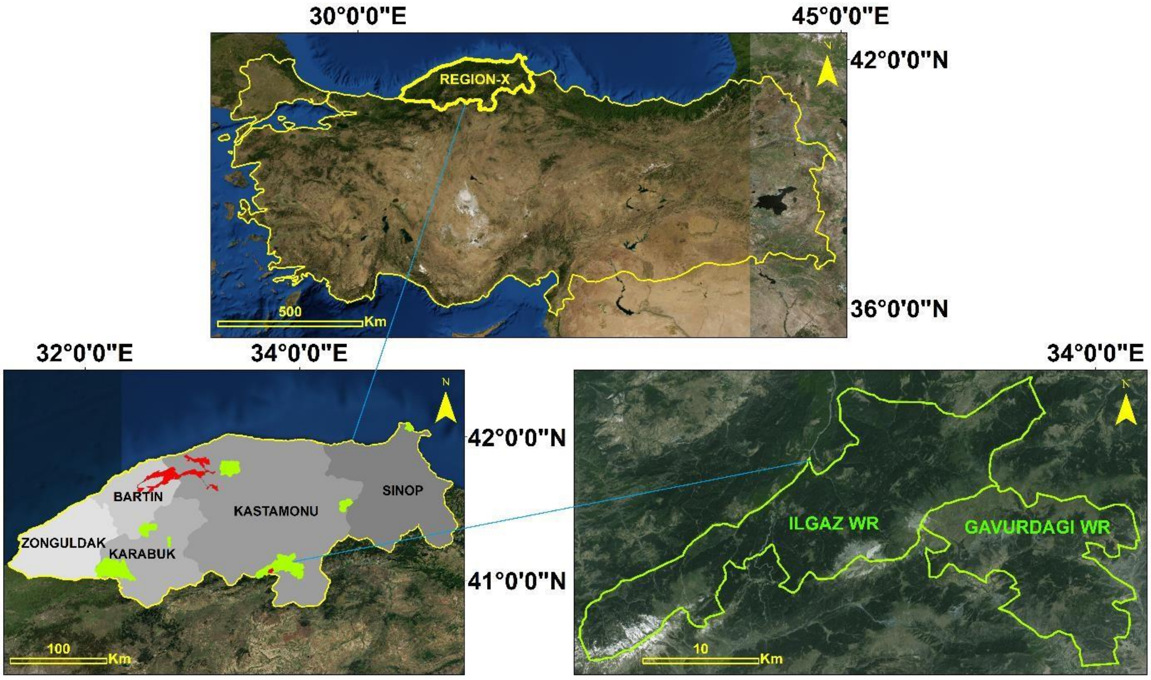

Figure 1. Location of the study area

2.2. Data Handling and Methodology

Standard raster topographical state maps at a scale of 1:25000 are at the core of many planning- and engineering-related endeavors in Turkey (Sefercik and Atesoglu 2013). Three sets of these maps (1960, 1993, and 2010) are currently in circulation. Complete stereoscopic aerial photo coverage was undertaken for 2 years prior to producing each set of maps. The mentioned scale was appropriated from the very beginning in 1960 for providing sufficient spatial resolution for denoting land characteristics such as linear features, neighborhoods and rooftops, and cover types (Le at al. 2016). They were preferred because national topographic map coverages have been the most dependable data sources for questioning the past. The vector data including Ilgaz and Gavurdagi WRs, along with all other conservation areas in Turkey, were obtained from the GDNCN open-access data portal (URL-3, 2018).

Both WRs and their immediate surroundings were then defined for each period using a total of 11 topographical maps and their matching aerial photographs, which included 10 black and white aerial photographs scaled to 1:50000 from 1955, 12 black and white aerial photographs scaled to 1:40000 from 1990, and 16 four-band-color infrared aerial photographs scaled to 1:5000 from 2008 (Figure 2). Since Ilgaz and Gavurdagi WRs are adjacent to each other, these analyses were made over their combined area, named as "the core area" hereafter for computational convenience.

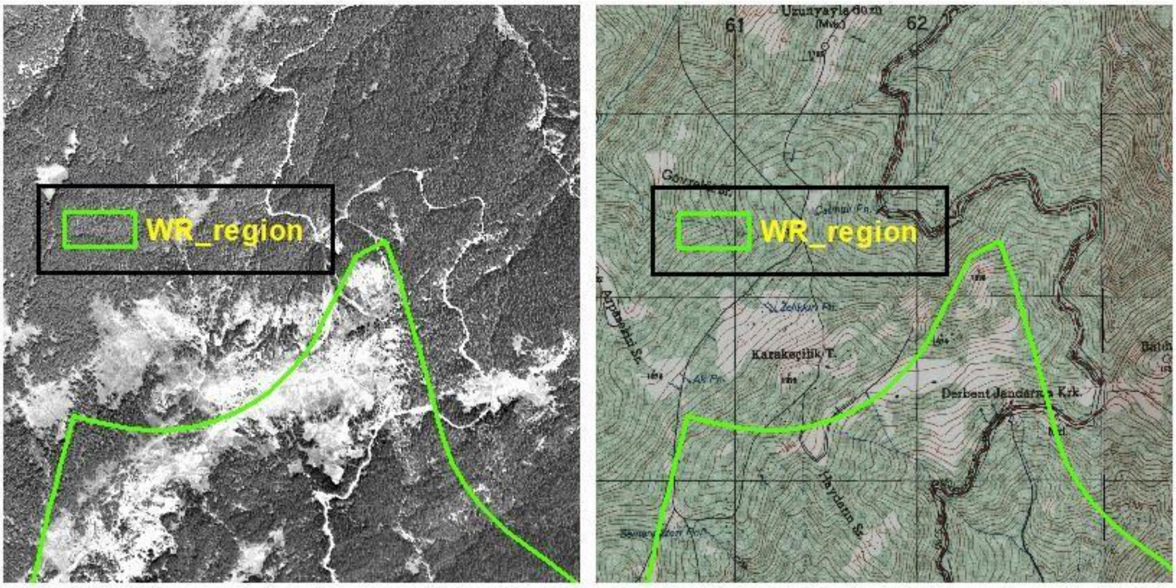

Figure 2. Aerial photograph dated 1955 and the corresponding topographical map dated 1960 (not to be scaled)

In the first part of data handling, the topographical maps were geo-referenced according to the abovementioned intervals to generate three separate coverages. The corresponding aerial photographs were then co-registered onto the registered maps and placed in their respective regions. Next, all-weather, dry-weather accessible roads and linear fashioned man-made marks, and house rooftops occurring within the neighborhoods were meticulously digitized through the coverages, while simultaneously cross-checking their validities through aerial photographs in AcrGIS-10.6 (Figure 2). This enabled us to draw every linearly fashioned man-made object within the core area and aggregate them as one coverage result measured in length through UTM projection. The majority of forest roads in the study area had a 3 to 4 m platform width which was bordered by a 0.5 to 1 m wide side ditch, and lacked surface material. However, as oppose to the procedure applied in this study, not all road-designated linear features on maps or in aerial photographs were considered in road density calculations in Turkey. Other government agencies like rural affairs, provincial governorships, state provinces bank, etc., also provide access to the regions and communities, which can be used all-year round. However, these additions do not count towards the calculation of road density in forest management by regulation (OGM 2008), even though they link to forest road networks and continue to fragment the area even further. Dry-weather roads were digitized within the core + 1000 m buffer area to establish continuity for further calculations. All-weather roads, on the other hand, were digitized, starting from behind 3000 m buffer area with the same intension and to see the bigger perspective (Figure 3). Road covered area percentage was calculated by multiplying the respected road lengths with 4 m in dry-weather, and with 6 m in all weather, and dividing them with the corresponding acreages, in three scenarios (Table 1 and Table 2). As the roads have been built, the intact habitat continuity has kept on dwindling. Thus, we wanted to see the number of such forest patches completely surrounded by roads in the forms of closed polygons both within the core + 1000 m buffer area, and within the core +3000 m buffer area. While digitizing both road types, all connections defined by point, end, edge and vertex snapping algorithm within and across the road type(s) were carefully placed to form and measure these closing polygons frequently named as patches (Hawbaker and Radeloff 2004). In the beginning, only the dry-weather roads were forming patches, enclosed area of which got smaller in every coverage period. However, as the time progressed, higher standard all-weather roads, too, started forming patches around the core area. Finally, decommissioned roads were removed and newly constructed roads were added along with any suburban expansion to create a fourth coverage for 2019 through the Google Earth Pro. This process was quick and efficient because the majority of roads from the 2010 coverage were usually identical and easily visible on the high-spatial-resolution imagery, thanks to the matching projection. As for the suburban expansion figures, each settlement was assigned with a location number to allow us to keep track of it over the coverage periods, along with the number of houses in the vicinity and the type of usage i.e., permanent or seasonal. The results were simplified in Figure 5. The second part of data handling dealt with the change detection of land cover types occurring inside the WRs. To determine whether there had been any visible change in the cover types, four Landsat images were classified. Landsat was chosen because more than 40 years of data were available, and the program was considered by many as having been at the pinnacle of Earth observation for over 45 years (Wulder and Masek 2012). The earliest Landsat image available for this region was from 1975 (USGS, 2020), thus, we were unable to reference any satellite image to the developing coverage of 1960. However, the time difference between the two data types was unlikely to have caused an issue since the development and growth were reported rather stagnant in Turkey between 1950 and 1975 (Moravetz 1977). A Landsat Multispectral Scanner (MSS) image from October 13th, 1975 was used. For the second, third, and fourth coverages, Landsat Thematic Mapper (TM) images from July 18th, 1993 and August 15th, 2009, and a Landsat Operational Land Imager (OLI) image from October 14th, 2019 were analyzed. Due to data availability and quality concerns, a 2009 image was acquired and analyzed for 2010 coverage. The frame locations were referenced using Landsat's old and new global reference grids and were acquired from the "Earth Explorer" data portal as path-190, row-31 for the MSS data and path-177, row-31 for the remaining data. Since the MSS data had a coarser spatial and spectral resolution, we opted to use three easily discernible classes: forest, non-forest and water (Haack et al. 1987). The sensor capabilities were more than enough for the intended task. (Amil 2018).

Supervised classification using a pixel based classification algorithm was then performed on all datasets (Karakus et al. 2017; Li et al. 2014) (Figure 6). ERDAS-2013 was used during the analyses.

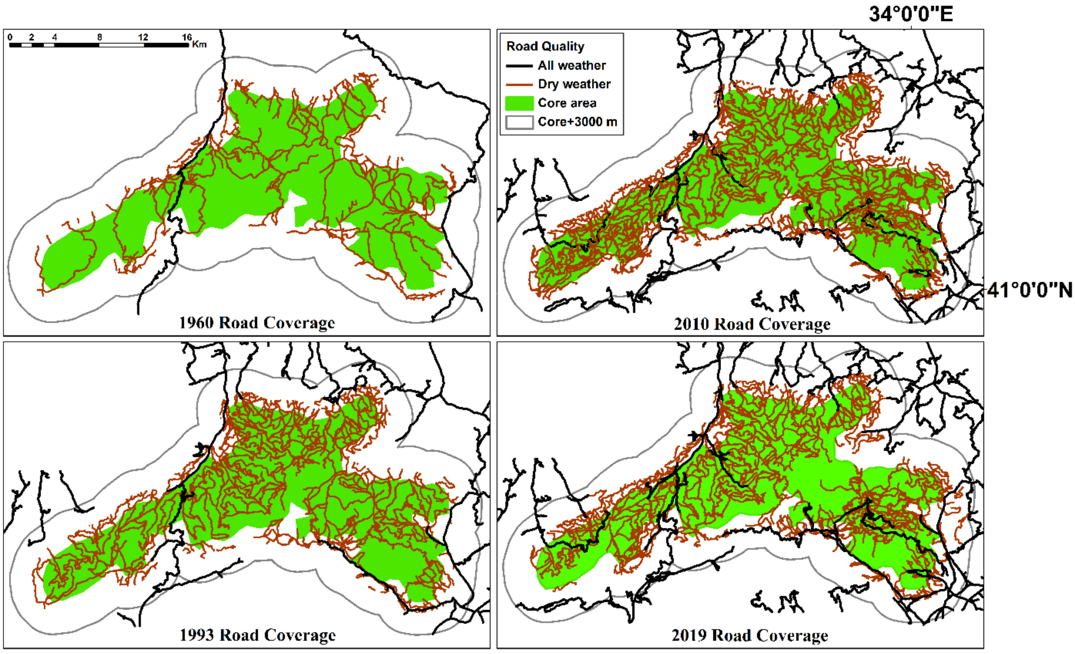

Figure 3. Road network in and around the core area from 1960 to 2019

3. RESULTS

3.1 Road Density Figures

Although it was impossible to trace the actual annual road construction figures, a simple calculation showed that an average of 10.8 km road was laid inside the core area per year for the first 33 years. The average rate of road development increased the following 17 years to approximately 15 km road built per year. As a result, the road density figures more than tripled and reached 3.4 km/km^2 in 2010 compared to a meager 1.1 km/km^2 in 1960. The more the road density, the more fragmented the forest area not constituting a suitable habitat for wildlife (Torres et al. 2016). The results showed that the length of both all-weather and dry-weather accessible roads increased dramatically from 1960 to 2019. The dry-weather road covered area percentage within the combined area of Ilgaz and Gavurdagi WRs (the core area) reached today's prescribed rate of 1% in 2019, and even further passed 1% within 1000 m buffer. The all-weather road covered area percentage, on the other hand, has steadily increased. The number of patches that are encircled by forest roads has also grown exponentially from 92 in 1960 to 245 in 1993, 457 in 2010, and 353 in 2019, which has served to divide the area into smaller patches. The patch sizes, on the other hand, have been shrinking, <1 to1912 ha in 1960, <1 to 970 ha in 1993, <1 to 890 ha in 2010, and <1 to 901 ha in 2019 when a 1000 m buffer was considered over the core area. Furthermore, all-weather roads have also started to completely encircle forest patches when a 3000 m buffer was considered over the core area, with patch sizes of 18 to 864 ha in 1993, <1 to 1464 ha in 2010, and <1 to

1463 ha in 2019. Consequently, the average patch size first decreased, then increased in both road types (Table 1 and Table 2). The study results yielded rather striking figures across the coverage periods showing that there was a dramatic increase in the road density of both all-weather and dry-weather roads. The decreasing numbers between 2010 and 2019 were due to decommissioning of the roads which had been laid before the establishments of both WRs. They were constructed everywhere regardless of the land cover or logging needs, thus when WRs were constıtutionalized after 2010, some of such roads did not surface in 2019.

3.2 Suburban Expansion Figures

Our study showed that both the combined area of Ilgaz and Gavurdagi WRs and their immediate surroundings have been subject to human settlement, a perfect example of which is seen in the bustling industrial sub-province of Tosya, which is still growing in the southeastern tip of the core area, today (Figure 4).

Although the town is outside the core area on municipal property and terms, its neighborhoods simply border the core area. Two types of settlement were present within and around the core area: permanent and seasonal. In 1960, there were two permanent villages with 55 houses inside the core area. In 1993, there was no additional permanent habitation within the core area, with the house count decreasing to 46. However, the number of houses increased to 65 in 2010 and to 74 in 2019. By contrast, seasonal habitation fluctuated during the study period because such settlements lacked legitimacy, thus were subjected to unexpected crackdowns by the authorities. Evaluation of a 1000 m buffer showed that there was an incredible increase in the number of permanent habitation around the villages and in the sub-province Tosya, which squeezed Gavurdagi WR from the southeastern tip of the core area. In this study, it was evident that there were more seasonal locations than permanent villages inside the core area (Figure 5 (a), whereas the opposite was true in the surrounding 1000 m buffer area (Figure 5 (b). WRs have systematically been squeezed from within and outside.

Table 1. Road statistics for the study area from 1960 to 1993

Coverage period	1960			1993		
Quality (all-weather (1) vs. dry-weather (2))	1	2	Total	1	2	Total
Road tally within core area* (km)	6.6	275.5	282.1	11.9	627.6	639.5
Road covered area % within core area (262.8 km²)	0.02	0.42		0.03	0.96	
Road tally within 1000 m buffer area (km)	16.7	199.7	216.4	40.3	302.1	342.5
Road covered area % within buffer area (128.8 km²)	0.08	0.62		0.19	0.94	
Road tally within 3000 m buffer area (km)	51	-	51	124.5	-	124.5
Road covered area % within buffer area (373.2 km²)	0.08			0.2		
Road density within the core area (km/km²)	0.02	1.05	1.07	0.04	2.4	2.4
within 1000 m buffer (km/km²)	0.13	1.55	1.68	0.3	2.4	2.7
within 3000 m buffer (km/km²)	0.14	-	0.14	0.3	-	0.3
Number of patches within the core area+1000 m	-	92	92	-	245	245
range of patch sizes (ha)	-	<1 to 912	-	-	<1 to 970	-
average patch size (ha)		112			88	
Number of patches within the core area+3000 m	-	-	-	3	-	-
range of patch sizes (ha)	-	-	-	18 to 864	-	-
average patch size (ha)				584		

Table 2. Road statistics for the study area from 2010 to 2019

Coverage period	2010			2019		
Quality (all-weather (1) vs. dry-weather (2))	1	2	Total	1	2	Total
Road tally within core area* (km)	72.9	828.8	901.7	72	700	772
Road covered area % within core area (262.8 km²)	0.17	1.26		0.16	1.07	
Road tally within 1000 m buffer area (km)	60.8	409.6	470.4	62.4	370	432.4
Road covered area % within buffer area (128.8 km²)	0.28	1.27		0.29	1.15	
Road tally within 3000 m buffer area (km)	216	-	216	222	-	222
Road covered area % within buffer area (373.2 km²)	0.35			0.36		
Road density within the core area (km/km²)	0.3	3.2	3.4	0.3	2.7	2.9
within 1000 m buffer (km/km²)	0.5	3.2	3.6	0.5	2.9	3.4
within 3000 m buffer (km/km²)	0.6	-	0.6	0.6	-	0.6
Number of patches within the core area+1000 m	-	457	457	-	353	353
range of patch sizes (ha)	-	<1 to 890	-	-	<1 to 910	-
average patch size (ha)		56			74	
Number of patches within the core area+3000 m	21	-	-	19	-	-
range of patch sizes (ha)	<1 to 1464	-	-	<1 to 1463	-	-
average patch size (ha)	287			338		

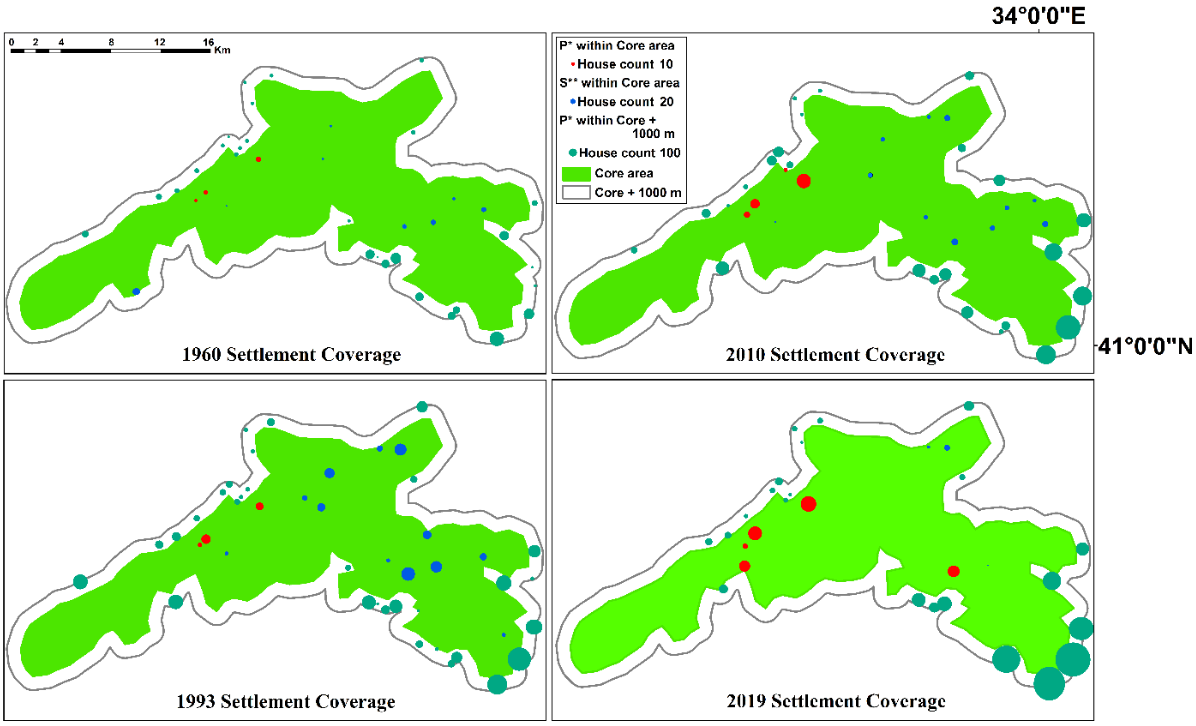

Figure 4. Settlement locations in and around the core area from 1960 to 2019 (*Permanent,** Seasonal)

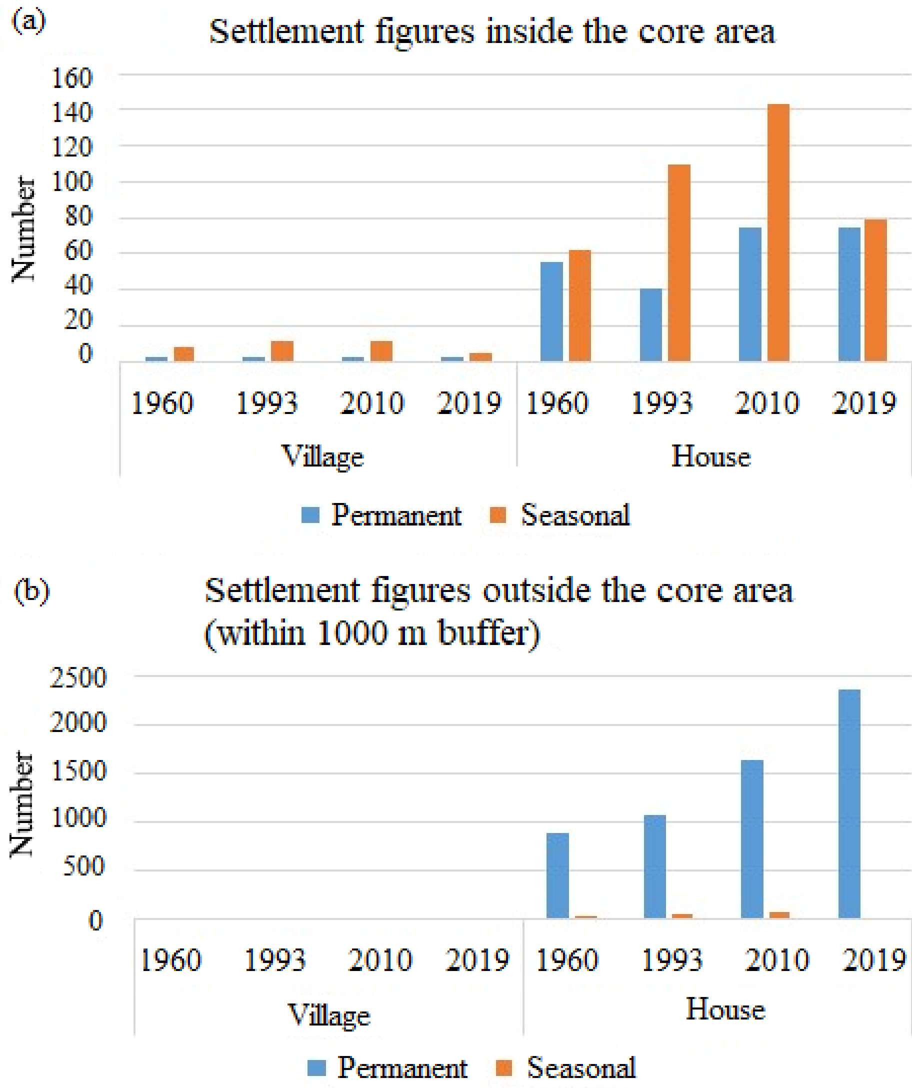

Figure 5. Settlement figures in and around the core area from 1960 to 2019

3.3 Change Detection Figures

The classification accuracies were high and the kappa statistics were meaningful in all years: 0.8665, 0.8324, 0.8164, and 0.8035 for the 1975, 1993, 2009, and 2019 images, respectively. No drastic change in land cover was apparent during the study period but a fluctuation in forest area was evident (Table 3). Forest cover within the core area was more than 75% in all years. A reservoir built during the 1980s started depositing water later that is why no water was discernable in 1975 image. It was determined that the amount of forest cover declined during the first interval but then recovered during the second interval, despite a continued increase in the number of roads being built. Forest roads first became evident in 1993, largely due to the fact that 1975 MSS image had a lower spatial resolution of 80 m compared to 30 m for the later periods utilizing TM data. Although the technology to extract such linear futures with efficiency has existed for some time (Bakirman and Gumusay 2020), there is a shortage of spreading it into the countryside. The total length of roads then decreased in 2009, despite more roads being present, because growing trees and tightening crowns began to obscure the roads underneath. Finally, the decrease in forest cover again in 2019 could be attributed to harvesting, and growing settlement expansions.

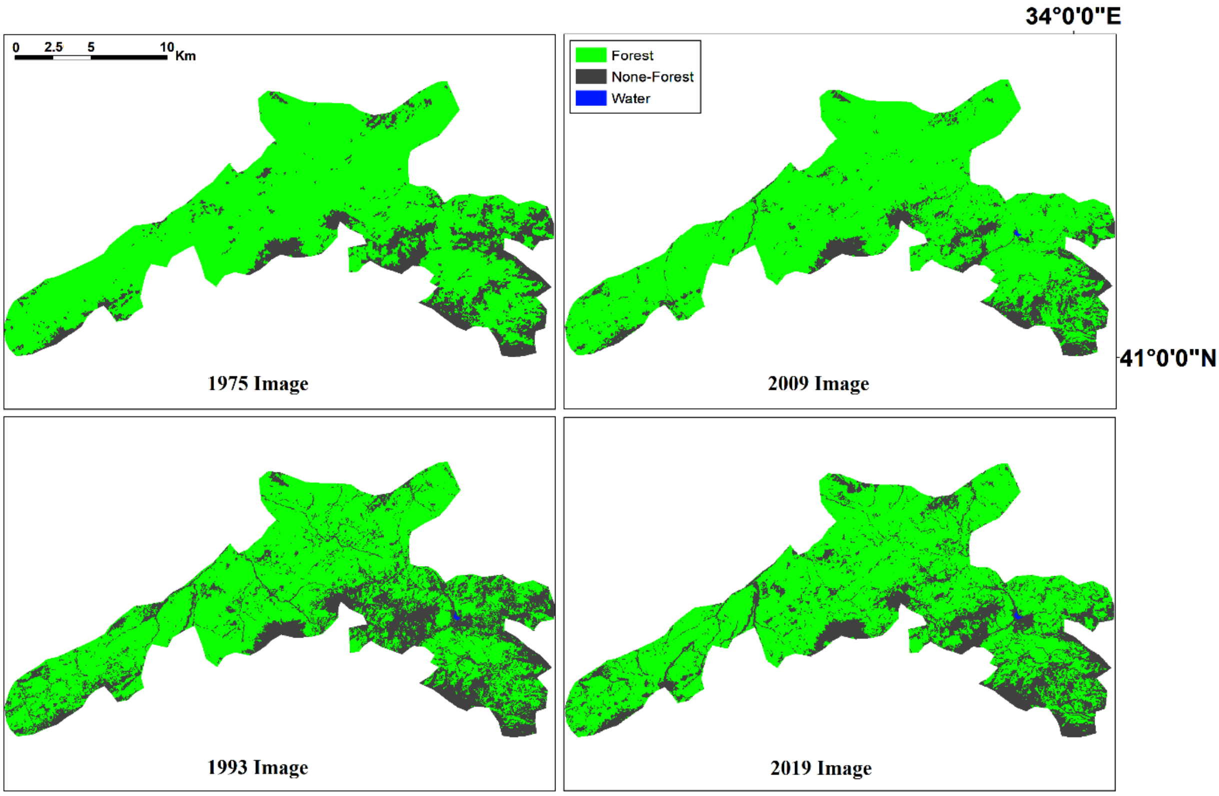

Figure 6. Classified images of the core area from 1975 to 2019

Table 3. Land-cover changes in the study area between 1975 and 2019

Coverage period	1975	1993	2009	2019
Forest (ha)	20785	19797	22577	21900
None-Forest (ha)	5497	6473	3694	5369
Water (reservoir) (ha)	0	12	11	13

4. DISCUSSION

Several studies have documented the importance of biodiversity (Gamfeldt et al. 2008; Christie et al. 2012; Evcin et al. 2019) and have discussed the factors that threaten the habitats (Jangi et al. 2019). However, in Turkey, there has been a lack of in-depth investigations validating these threats and showing what has actually happened to species within habitats, because the problem(s) has never been clearly defined to begin with.

Just as any other place on Earth, scattered rural settlement has occurred everywhere since the ancient times in Anatolia. Consequently, people have almost settled anywhere other than flood plains, extreme elevation, or broken topography. However, this type of sporadic habitation did not usually comply with the rules of later-time governmental legislations, which, in time, have always granted in concessions. People have traditionally constructed wooden dwellings at higher elevations, which they have temporarily moved to with their livestock to escape from the summer heat, leading to the formation of seasonal neighborhoods and transhumance inside state forests, on pastures, on high plateaus, etc. (Ocak 2016). The sites in which groups of such dwellings occurred always belonged to the state, primarily represented by the Forest Service in Turkey. The lack of restriction that people enjoyed in the past while erecting such neighborhoods has gradually vanished. The agencies governing the area(s)-region(s) have started monitoring and restricting the movement of people, particularly in conservation areas (Hanacek and Rodriguez-Labajos 2018).

Accessibility has always been of paramount importance for forest management in Turkey, with roads having been considered as the only option for managing the resource and transporting all related services to and from it. New roads have been added to the forest road network each year (Turk and Gumus 2017). The current forest road building notification has stated that no more than 1% of the total forest area could be used for road building, which is the accepted norm within the Turkish forest management practice, today. However, the same notification has also stated that the above mentioned rate should be applied even less in other types of functionality assigned forests (OGM 2008).

When the land is reassigned with a new agenda, one could anticipate that the footprints of past forest management practices would be somewhat remedied. As obvious from the results of this study, the situation did not materialize like this inside the core area because timber harvesting has continued. The conservation status has not changed the wrong-doing. Consequently, poaching is rampant, as the fines and sentencing do not act as deterrents, and policing is undermanned and ineffective.

It has previously been reported that small mammals avoid crossing forest roads, mainly due to various types of predation risks, so the presence of roads causes their home ranges to shrink, their existing habitat usage patterns to change, and population isolation to occur (Ascensao et al. 2017). Although roads and the resulting forest fragmentation do not have as great an effect on larger game animals as they do on smaller ones, they still have direct impacts in the form of vehicle collisions when there are high volumes of traffic (Litvaitis et al. 2015), increased mobility for human access (Bischof et al. 2017), and from the changing nature of the ecosystem services (Coffin 2007). Collisions involving bears, roe deer, wild boars, and occasional elk occur on the Kastamonu-Ankara intercity road that crosses Ilgaz WR in a north-northeast to south-southwest direction, especially in early winter and late spring months were reported (OSIB 2012) as higher.

It has been shown that underground or aboveground wildlife passages effectively mitigate these impacts and are frequently used by all sorts of animals, even insects (Martinig and Belangar-Smith 2016; Wang et al. 2018). However, no such passage exists inside the core area. A recent global study showed that habitat fragmentation is responsible for 13%-75% biodiversity loss and prevents ecosystem functions from occurring efficiently (Haddad et al. 2015). The study area has long been considered as a prime habitat for wildlife. Although the quality of a habitat can be considered as a primary indicator of species abundance, it is a rather weak indicator of the distribution and similarity of species (Dambros et al. 2015). There is not any published study looking into the effects of forest fragmentation on the quality and abundance of any species in Turkey.

Turkish legislation prohibits big game hunting for the general public, but according to inventories carried out by DW, issues licenses annually for harvesting a number elk, roe deer and wild boar. These licenses are rather expensive for rural people, so it is generally the international hunters applying for them. If no one applies, the tags are left. There is no "must be fulfilled" policy meaning that the animals are not required to be harvested. However, although these regulations seem appropriate and by the code, poaching continues, and is increasing. The Kastamonu sub-branch of DW has been recording the number of poaching cases in Region 10 since the beginning of 2000s. In the first 10 years, there were very few records of poaching, despite Kastamonu being a sizable province and 67% of its land area being covered by forests. However, there has been an increase in the number of poaching-related crimes annually since 2010, with cumulative figures of 15, 33, 52, 85, 69, 77, 119, 99, and 86 each year from 2010 to December 2019. However, these were only the documented cases of a much bigger problem.

Therefore, this many people residing in or around such habitats that are covered with such a large amount of road, on which they can both track the animals and flee from rangers, could be considered detrimental for the resources (Boston 2016).

The core area has long been considered as a pristine habitat for a large number of animals, ranging from big game animals to small mammals, birds, reptiles, and insects. However, no studies have investigated fragmentation and its effects on resident species in Turkey, so the current health, distribution, and stress level of these species are unknown. The results showing the road-building trend in Turkish forest habitats and the final assessment for 2019 are important as they show the current state of forest habitats in two, Ilgaz and Gavurdagi, of Turkey's WRs, and to emphasize the problem on these issues and provide a baseline for future research.

The data used in this study, are easily achievable for anywhere within Turkey, thus similar studies for other regions are sincerely encouraged to display the situation in sensitive areas.

5. CONCLUSION

Turkey lies between three bio-geographical regions (Euro-Siberia, Iran-Turania, and the Mediterranean) and forms a bridge between Europe and Asia, resulting in many things changing within short distances. The country is blessed with a rich biodiversity in terms of both its flora and fauna. However, this wealth is not receiving the attention it deserves because Turkey is trying to take its place among the developed countries of the world. This is a difficult ambition, and the sacrifices are being made, the functionalities of many things across the country are misleading and policing is insufficient. WRs in Turkey are under heavy human pressure, so it is unclear whether all of the documented species are in good standing. Thanks to the invaluable potential of mapping, remote sensing and GIS, this study has showed how fragmented the forest habitats are in Turkey, even in areas where least expected. This assertion must be taken seriously either to nullify the situation or to go deeper to investigate the health of the habitats in all dimensions. This study can be criticized as being a straight-forward mapping exercise, lacking novelty both in the approach and the analysis, however it is still an important work to show that nothing could be kept hidden when geo-science capabilities are utilized for the sake of environmental issues. If the forests would continue to be used for a number of causes, not only for timber production, it is important that the impacts of humans are kept to a bare minimum or eliminated to protect the biodiversity.

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