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The effect of population shift on land cover change and illegal forest activities

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Abstract Interaction between humans and forests has always been strong. Wood has been at the core of all humankind's endeavors since the discovery of fire and learning how to fabricate it out of trees. The exploitation of forests has not been limited to the procurement of wood, but the concepts of sheltering, hunting, and protection have also been matured near or within the forests. This win-win situation intuitively attracted more and more people to this type of resource. As the human population has grown in forest villages, the pressure caused by the human on the forests has increased. Without active management of the forests, the situation has become so dire that uncontrolled and irregular utilization has started jeopardizing the existence of this resource. The objective of this study was to examine the changes in forest road, forestland cover, and forest crimes in the Daday Forest Enterprise (DFE) located in Kastamonu Regional Directorate of Forestry, Turkey. The results indicated that the population in 51 forest villages was decreased from 1975 to 1990. This decrease was also apparent in all villages across the region during the 1990–2000 period and continued decreasing in 45 villages during the 2000–2016 period. The forestland cover was 57% in 1975, 44% in 2000, and 57% in 2016 while the density in the forest road kept increasing. A noticeable decrease in the forest-related crimes was also determined, and the results showed that effective forest management, consciousness, and conservation policies stopped the deterioration.

Keywords Forest villages · Forestland cover · Forest crime · Population · Forest roads

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Introduction

The new era, which started with the Industrial Revolution and accelerated the development of market economy and technology, caused notable changes in the European population figures and living standards. This was when fossil fuel consumption rose incredibly. The interest since then has shifted from fossil fuels to renewable energy alternatives, which caused the pressure on forests and their derivatives. Although this pressure is positively correlated with the increase in the regional or global population (Demirbas 2001), the rising population is not always responsible for forest loss and forestland degradation (Mather and Needle 2000). It becomes possible to sustainably supply the demand of the population only by effectively managing the natural resources (Loucks 2000; Bayramoglu and Toksoy 2016; Oburger et al. 2016). In this context, many countries make considerable investments to the well-being of their forests and forest management activities. Forest operations require quite a big portion of such investments to meet infrastructural and superstructural necessities (Acar 2005). There are many studies conducted over the years to assess the effects of infrastructure activities performed to increase the effectiveness and productivity in forestry (Watkins et al. 2003). Some of these studies specifically dealt with the effects of forest roads on forest ecosystems (Nelson and Hellerstein 1997; Benitez-Lopez et al. 2010). Other factors such as technological advancements, market conditions, governmental policies, and administrative demands also play roles in these changes (Barbier et al. 2010). However, forest roads, which are considered indispensable infrastructural facilities in the forest management activities, comprehensive utilization of the forest resources (Demir 2007), and the exploitation of forested lands, are at the forefront of the changes seen in forests. While they may lead to changes in micro-climatic conditions such as solar radiation, temperature, humidity, and wind speed (Delgado et al. 2007), forest roads also cause alterations within uninterrupted forestlands by forming linear gaps (Spellerberg 1998; Spellerberg 2002; Laurance et al. 2009) and affecting vegetation (Gelbard and Belnap 2003), air quality (Trombulak and Frissell 2000), soil, pollutant deposition (Yli-Pelkonen et al. 2017), and wildlife (Forman et al. 2003; Coffin 2007).

In general, there are two known adverse effects of the forest roads on forests. First, they cause fragmentation (Forman and Alexander 1998, Fearnside 2007) and, second, unwillingly accessing pristine forestlands (Nagendra et al. 2003; Walker et al. 2013). Especially in the second scenario, human encroachment also starts to violate the forestlands. In any case, human intervention to forests is always known to occur after the inception of the forest roads (JJaeger et al. 2007; Selva et al. 2011; Valipour 2014). Various other studies were conducted on the effects of the roads on land use/land cover change, utilizing separate indicators such as "road density" and "distance from road." When the relationship between the road distance and the forests is investigated, the changes are found to be notable (Kumar et al. 2014; Xisheng et al. 2016).

The population shift from rural to urban is at a fast pace in Turkey as it is in other developing countries. The rate of the rural population compared to the urban population in Turkey in the 1930s was in favor of the rural by 75.8%. This rate decreased to 65.6% in the 1970s, 56.1% in the early 2000s, and came down to 24.5% in 2012 (Toksoy and Bayramoglu 2017). There are studies conducted to assess the effects of such demographic changes on Turkish forests (İnanç 2011; Sen et al. 2015). However, none of these studies shed light on the relationship between the forest roads and the socioeconomic changes observed.

The present study aimed to examine the effects of the shifting population trends and forest road expansion on the forest cover change and illegal forest activity (illegal logging, arson, land encroachment, etc.) rates, recorded by the Kastamonu Regional Directorate of Forestry (KRDF) in Kastamonu Province, Turkey.

Material and methods

This study was conducted at the Daday Forest Enterprise (DFE) of KRDF founded by the permission of the Turkish Forest Service in 1939. It includes seven forest directorates, the smallest administrative unit in Turkish forestry. DFE encompasses an overall area of 85,465 ha and has been certified by the Forest Stewardship Council (FSC) since 2012 (Fig. 1). A total of 60 forest villages within the administrative area of DFE were included in the analysis.

Both Landsat Multispectral Scanner (MSS) and Thematic Mapper (TM) images, dated 1975, 1990, 2000, and Operational Land Imager (OLI) 2016, ID # EMP190R31_2M19750509, ETP177R31_5T19870702, ELP177R031_7T20000713, and LC08_L1TP_177031_20160818_20170322_01_T1, respectively, national topographic maps, aerial photographs, and Google Earth images were used in the analysis. The satellite imagery was downloaded from the United States Geological Survey (USGS) Earth Explorer data portal (Earth Explorer 2019) (Fig. 2).

Image classification

The satellite images were first subjected to radiometric and geometric calibrations and classified to detect if a land cover change had occurred through the years. Erdas IMAGINE 2013 was used during the classification process. Three cover types were defined as forest, non-forest, and water. There are various methods in land

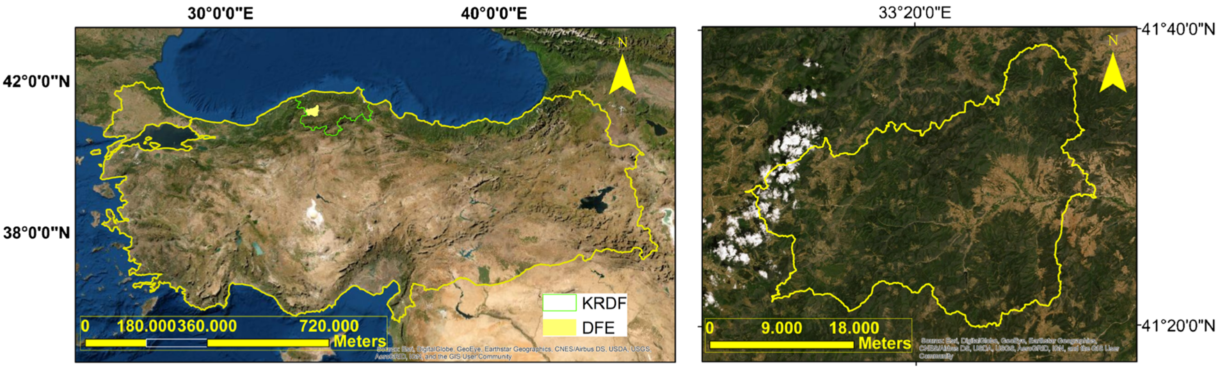

Fig. 1 Study area

cover classification including parallel pipes, cubic convolution, artificial neural networks, and maximum likelihood (Lillesand and Kiefer 2000). The maximum likelihood algorithm was preferred for the present study. The classification accuracies were checked through a random point check and kappa statistics. Cohen's kappa coefficient (*k*) was preferred to assess the suitability of the cross-comparison between the two evaluators (Fleiss et al. 1969). If the value of *k* found at the end, the test is 0; there is no suitability between the classified images and the reference data while < 0.4 refers to not enough performance, > 0.75 to good performance, and 1 to perfect performance (Mather 1999).

Forest road network delineation and interaction with classified images

The forest road networks constructed between the years 1990 and 2000 were delineated over 1/25,000 scaled topographical maps. Similarly, the 2016 coverage was digitized using ArcGIS. Since there was no topographic map, which would coincide with the 1975 image, the previous map coverage of 1960 was used instead to draft the earliest forest roads within the study area. The time difference between 1950 and 1975 was not deemed to create an ambiguity in the delineation of the forest roads simply because both the development and the growth were rather slow in Turkey during this period (Moravetz 1977). After the road coverages were materialized, 50-m segmented buffers were installed up to 400 m starting from the roadbed. The results of the image classifications in the raster format were converted to the vector format and were intersected with the forest road coverages across the years. This procedure was repeated in three of the four dates specified earlier. Since there was no reference map data to be used with the satellite image of 2000 and no reliable imagery on Google Earth was found (the poor quality of the old imagery on the medium did not allow generating the road coverage), the above procedure could not be applied to 2000 image.

Census data and the determination of forest crimes in the study area

The census results from the years of 1975, 1990, 2000, and 2016 regarding the forest villages were acquired from the Turkey Statistical Institute (TUIK 2018). In the calculation of the population growth rate (PGR), exponential function method (Kocaman 2002) was used. The actual PGR can be calculated using the exponential function of:

$$r = \frac{\log_e \frac{p_{t+n}}{p_t}}{n}$$

where:

r	population increase speed
P_{t+n}	the last census result
P_n	the previous census result
n	The number of years between the two census.

The arithmetic density was used in this study to calculate the population density. In addition, the forests and forestry-related crimes committed during the specified years were acquired from the DFE. The crime figures from the periods of 1979–1990, 1991–2000, and 2001–2016 were generated by averaging the numbers within the periods. All data for census, population densities, forest roads, forest crime, and forestland cover were analyzed by IBM SPSS Statistics 23.

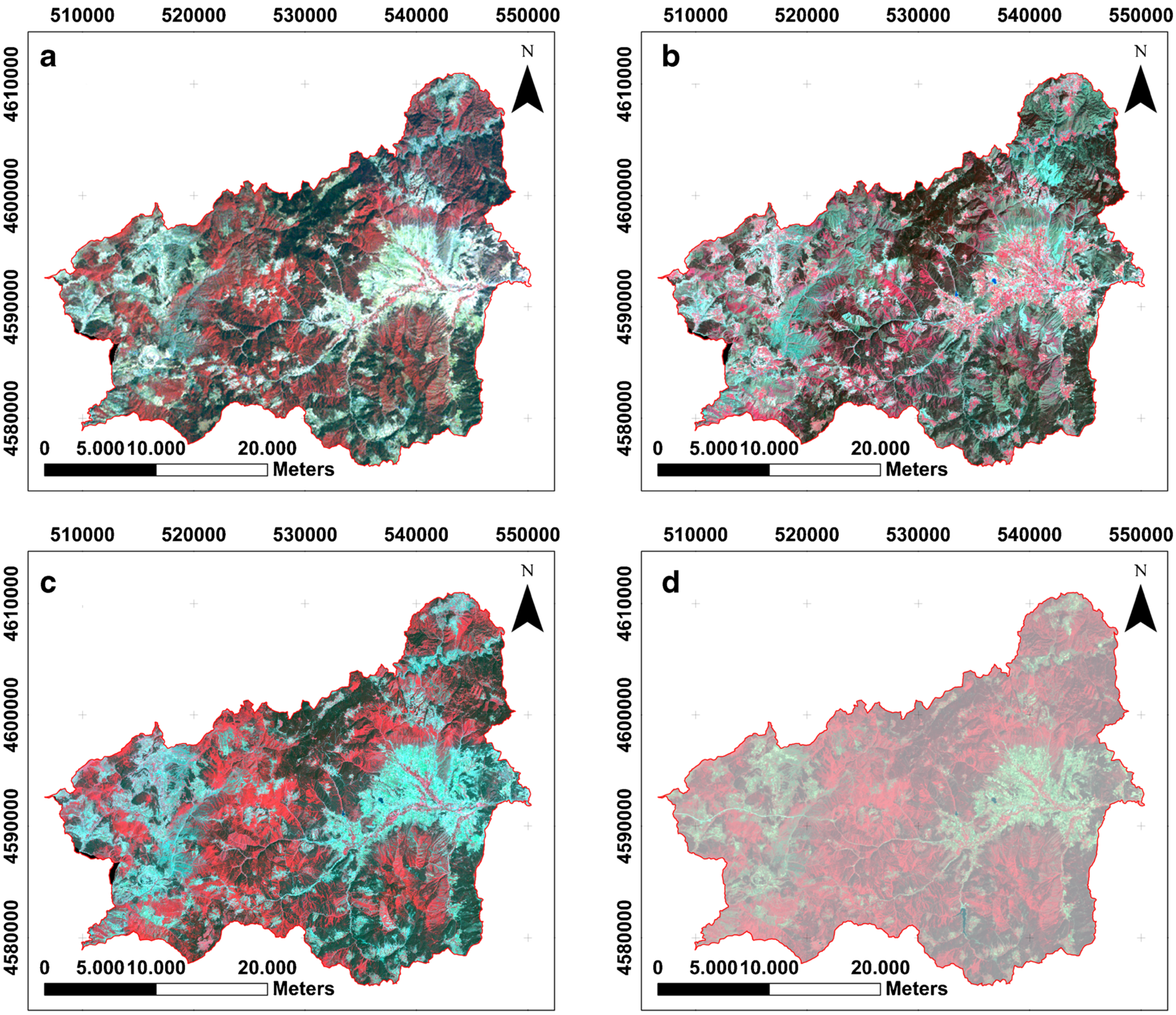

Fig. 2 **a** 1975 Landsat MSS satellite image, **b** 1990 Landsat TM satellite image, **c** 2000 Landsat TM satellite image, and **d** 2016 Landsat OLI satellite image

Results

Findings regarding the census data

Table 1 summarizes some descriptive statistics concerning the populations and arithmetic population densities from 60 forest villages scrutinized within the DFE in the years of 1975, 1990, 2000, and 2016. A decreasing tendency in the village populations occurred between 1975 and 2016 (Table 1). Friedman's test was used to detect whether the arithmetic population densities across the specified years differed or not. At least one particular year was determined to be significantly different from the others ($p < 0.01$). Additionally, Wilcoxon's signed-rank test showed that the population densities were significantly different in all specified years ($p < 0.01$)

Within the studied forest villages, PGR was determined for the 1975–1990 (period 1), 1990–2000 (period 2), and 2000–2016 (period 3) periods, and the summary statistics are given in Table 2. The population figures of 51 forest villages decreased while they increased in nine villages during period 1. The decrease speed was calculated as 0.0205 for period 1, 0.0538 for period 2, and 0.0202 for period 3. During period 1 when the population decrease was the highest, all the forest villages

Table 1 Some statistics for forest village populations and population densities

$n = 60$	Minimum	Maximum	Mean	Sum	Std. deviation
1975 population	70.00	580.00	228.0500	13,683.00	97.96063
1990 population	60.00	519.00	183.0667	10,984.00	85.56925
2000 population	30.00	308.00	109.2667	6556.00	55.57248
2016 population	30.00	206.00	89.5667	5374.00	35.51813
Arithmetical population density for 1975	0.04	2.40	0.3746	22.48	0.38215
Arithmetical population density for 1990	0.03	0.99	0.2841	17.05	0.24105
Arithmetical population density for 2000	0.02	0.52	0.1645	9.87	0.13768
Arithmetical population density for 2016	0.01	0.59	0.1610	9.66	0.15578

within the DFE showed a decreasing trend in the population figures. Such figures showed a stabilizing tendency in period 3, despite the fact that overall population continued to decrease.

The repeated measures ANOVA was used to test whether or not the annual PGR differed across the periods since the data distributions were normal. According to the results, at least one particular period was determined to be significantly different from the others ($p < 0.05$). Bonferroni's correction showed that the annual population increase speed was found to be statistically different for period 2 ($p < 0.05$) (Table 3).

Findings regarding the forest roads

Table 4 summarizes various statistics concerning the length of the forest roads and the forest road density within the DFE. The length of the forest roads was 2599 km in 1975. It increased to 2826 km in 1990 and 3625 km in 2016. Friedman's test was used to detect if the length of the forest roads across the specified years differed, and at least one particular year was determined to be significantly different from the others ($p < 0.05$). Additionally, Wilcoxon's signed-rank test showed that the length of all forest roads was significantly different in all the three years ($p < 0.05$) (Table 5).

The increases were observed in the road densities simply because the road lengths also increased. The repeated measures ANOVA was used to test if there is any difference in the road densities among the years 1975, 1990, and 2016 since the data distributions were normal. The results indicated that, at least, one particular year was determined to be significantly different from the others ($p < 0.05$). Bonferroni's correction showed that the road densities across the above-mentioned years were found to be statistically different from one another ($p < 0.05$) (Table 6).

Table 2 Summary statistics for village populations according to periods

	1975–1990		1990–2000		2000–2016	
	Villages with decreasing population ($n = 51$)	Villages with increasing population ($n = 9$)	Villages with decreasing population ($n = 60$)	Villages with increasing population ($n = 0$)	Villages with decreasing population ($n = 45$)	Villages with increasing population ($n = 15$)
Minimum	− 0.07	0.01	− 0.15	0.00	− 0.06	0.01
Maximum	0.01	0.06	− 0.01	0.00	0.01	0.07
Mean	− 0.0205	0.0145	− 0.0538	0.00	− 0.0202	0.0211
Std. deviation	0.01684	0.01888	0.02462	0.00	0.01324	0.02086

Table 3 Repeated measures ANOVA with Bonferroni's correction for population growth rate in periods

Pairwise comparisons

Measure: MEASURE_1

I Factor 1	*J* Factor 1	Mean difference (*I-J*)	Std. error	Sig.[a]	95% confidence interval for difference[a]	
					Lower bound	Upper bound
Period 1 PGR	Period 2 PGR	0.039*	0.004	0.001	0.028	0.049
	Period 3 PGR	− 0.005	0.004	0.679	− 0.016	0.005
Period 2 PGR	Period 1 PGR	− 0.039*	0.004	0.001	− 0.049	− 0.028
	Period 3 PGR	− 0.044*	0.005	0.001	− 0.057	− 0.030
Period 3 PGR	Period 1 PGR	0.005	0.004	0.679	− 0.005	0.016
	Period 2 PGR	0.044*	0.005	0.001	0.030	0.057

Based on estimated marginal means

*The mean difference is significant at the 0.05 level

[a] Adjustment for multiple comparisons: Bonferroni

Findings regarding the crime figures

The averages of the forest and forestry-related crime figures, which were acquired from the DFE, were calculated for each period. The Repeated Measure (ANOVA) was used to test whether or not the averages of the committed crime figures differed among the four periods. According to the results, at least one particular period was determined to be significantly different from the others ($p < 0.05$). Bonferroni's test showed that the averages of the committed crime figures across the above-mentioned periods were found to be statistically different from one another ($p < 0.05$) (Table 7).

Findings regarding the forestland cover (FLC)

The classification accuracies were checked through random point check and kappa statistics. In all the classified images, kappa statistics were > 90%, validating the near perfect results. The classified raster images were first vectorized, then were intersected with the demographic boundaries of the 60 studied forest villages. The summary statistics are given in Table 8. The percentage of the forestland cover in the studied villages was higher in 1975 than in other years in which the forestland cover kept decreasing, whereas it almost bounced back to the level of 1975 in 2016.

Friedman's test was used to detect if thepercentage of the forestland in the villages differed across the specified years, and at least one particular year was determined to be significantly different from the others ($p < 0.05$). Additionally, Wilcoxon's signed-rank test with a 95% assurance showed that the amount of the forest in the villages was significantly different from 1975 to 2016 ($p < 0.01$). The summary statistics are given in Table 9.

Table 4 Summary statistic for forest roads

N = 60	Minimum	Maximum	Sum	Mean	Std. deviation
1970 (road km)	1.76	117.53	2599.17	42.6093	32.19991
1990 (road km)	2.65	153.18	2826.38	46.3341	36.19088
2016 (road km)	5.72	177.42	3625.26	59.4305	46.93124
Road density_1970	0.02	0.05	2.15	0.0352	0.00721
Road density_1990	0.02	0.06	2.40	0.0393	0.00834
Road density_2016	0.02	0.23	3.36	0.0551	0.02919

Table 5 Wilcoxon's signed-rank test for forest roads (km)

	Test statistics[b]		
	1975 vs. 1990	1975 vs. 2016	1990 vs. 2016
Z	− 2.959[a]	− 5.337[a]	− 4.969[a]
Asymp. Sig. (2-tailed)	0.003	0.001	0.001

[a] Based on negative ranks

[b] Wilcoxon's signed-rank test

The buffer zones that were installed on the forest roads for all the three years were intersected with the amount of forestland cover in the villages. The buffer zones were investigated to see if a forest cover variation was significant across the years. The percentage of the forest cover within the first 50 m was independent for all the years. However, for 100, 150, 200, 250, and 350 buffer zones, the amount of forestland cover in the villages was statistically different in 1990 (Table 10).

The data for the buffer zones of 300 m and 400 m were not normally distributed. Friedman's test showed that at least 1 year was statistically different for the zones of 300 m and 400 m ($p < 0.05$). In addition, Wilcoxon's signed-rank test showed that both zones in terms of the amount of forest cover were significantly different for 1990 ($p < 0.05$). The summary statistics are given in Table 11.

Discussion and conclusion

In this study, the changing nature of the rural population in the forest villages, the expansion of forest roads, and crimes such as illegal logging, deliberate forest fires, and land use conversion were investigated, considering the forest cover change. It was obvious through the analysis that a decreasing trend was present in the forest village populations from 1975 to 2016, which noticeably peaked from 1990 to 2000. This trend was observed in all of the forest villages investigated in the present study. Although a forest village population stabilization was apparent especially during the last period, it is thought that the decreasing trend may steadily continue in the future. Bulut (2018) showed that the population of forest villages decreased continuously from the 1970s to 2016 in Kastamonu. This assumption, as well as the aging population of forest villages in Kastamonu, was also confirmed in other studies (Ozden and Bugday 2015). Although it may be unintentional, the decreasing and aging population also helped curb the crime figures. In addition, the land cover-land use routines were also affected. The forest and forestry-related crimes committed within the investigated forest villages drastically decreased. The increasing density of the forest roads, on the other hand, has helped facilitate the easy accessibility of the forest villagers to the cities and paved the way for migration patterns, leaving the formerly tilled fields unattended. Although they are valued tremendously in Turkey for the management, sociocultural, and recreation-related purposes, forest roads have

Table 6 Repeated measures ANOVA with Bonferroni's correction for road density

Pairwise comparisons

Measure: MEASURE_1

I	*J*	Mean difference (*I-J*)	Std. error	Sig.[a]	95% confidence interval for difference[a]	
					Lower bound	Upper bound
Road density_1975	Road density (km/area)_1990	− 0.004*	0.001	0.001	− 0.005	− 0.002
	Road density_2016	− 0.016*	0.002	0.001	− 0.022	− 0.011
Road density_1990	Road density_1975	0.004*	0.001	0.001	0.002	0.005
	Road density_2016	− 0.013*	0.002	0.001	− 0.017	− 0.008
Road density_2016	Road density_1975	0.016*	0.002	0.001	0.011	0.022
	Road density_1990	0.013*	0.002	0.001	0.008	0.017

Based on estimated marginal means

*The mean difference is significant at the 0.05 level

[a] Adjustment for multiple comparisons: Bonferroni

Table 7 The Repeated Measure ANOVA table with Bonferroni correction for forest crimes

Pairwise comparisons

Measure: MEASURE_1

I factor	*J* factor	Mean difference (*I-J*)	Std. error	Sig.[a]	95% confidence interval for difference[a]	
					Lower bound	Upper bound
Average number of crime conducted 1975–1990	Average number of crime conducted 1990–2000	− 0.458*	0.071	0.001	− 0.650	− 0.265
	Average number of crime conducted 2000–2016	1.014*	0.061	0.001	0.847	1.180
	Average number of crime conducted 1990–2016	0.455*	0.057	0.001	0.299	0.612
Average number of crime conducted 1990–2000	Average number of crime conducted 1975–1990	0.458*	0.071	0.001	0.265	0.650
	Average number of crime conducted 2000–2016	1.471*	0.059	0.001	1.311	1.631
	Average number of crime conducted 1990–2016	0.913*	0.035	0.001	0.817	1.009
Average number of crime conducted 2000–2016	Average number of crime conducted 1975–1990	− 1.014*	0.061	0.001	− 1.180	− 0.847
	Average number of crime conducted 1990–2000	− 1.471*	0.059	0.001	− 1.631	− 1.311
	Average number of crime conducted 1990–2016	− 0.558*	0.025	0.001	− 0.627	− 0.490
Average number of crime conducted 1990–2016	Average number of crime conducted 1975–1990	− 0.455*	0.057	0.001	− 0.612	− 0.299
	Average number of crime conducted 1990–2000	− 0.913*	0.035	0.001	− 1.009	− 0.817
	Average number of crime conducted 2000-2016	0.558*	0.025	0.001	0.490	0.627

Based on estimated marginal means

*The mean difference is significant at the 0.05 level

[a] Adjustment for multiple comparisons: Bonferroni

Table 8 Statistics for forestland cover

	Descriptive statistics					
	N	Minimum	Maximum	Mean		Std. deviation
	Statistic	Statistic	Statistic	Statistic	Std. error	Statistic
1975	60	0.01	0.95	0.5685	0.03865	0.29937
1990	60	0.07	0.87	0.4618	0.03299	0.25555
2000	60	0.01	0.85	0.4372	0.03712	0.28754
2016	60	0.06	0.92	0.5670	0.04084	0.31634
Valid *N* (listwise)	60					

Table 9 Wilcoxon's signed-rank test for forestland cover

	Test statistics[c]					
	(FLC) 1990–(FLC) 1975	(FLC) 2000–(FLC) 1975	(FLC) 2016–(FLC) 1975	(FLC) 2000–(FLC) 1990	(FLC) 2016–(FLC) 1990	(FLC) 2016–(FLC) 2000
Z	− 5.752[a]	− 6.685[a]	− .123[b]	− 2.777[a]	− 5.909[b]	− 6.542[b]
Asymp. Sig. (2-tailed)	0.000	0.000	0.902	0.005	0.000	0.000

[a] Based on positive ranks

[b] Based on negative ranks

[c] Wilcoxon's signed-rank test

started the erosion in the least expected places, fragmented the land, and facilitated poaching activity and alien species deep into the resources. Although the majority of the Turkish forest cover is on the treacherous mountain range, due to the objections from the forest villagers and the logging work force, the mechanization initiative has never taken hold in the country. Instead, the Turkish Forest Service has kept on building forest roads without ever considering the mentioned repercussions.

The shift observed in the forestland cover of the forest villages investigated in the study made sense under these following findings; while the forest villages studied were covered with forests with a rate of 57% in 1975, a decreasing tendency was observed up until 2000; then, the figures bounced back and have been recently stabilized around 57%. In another study conducted in the Trabzon Regional Directorate of Forestry (TRDF), Bayramoglu and Kadiogullari (2018) examined the land cover and deforestation trends because of the forest crimes and demographic shifts in Torul Forest Enterprise (TFE). Between 2005 and 2016, they revealed considerable changes in the temporal dynamics and related parameters of forest cover, and displayed a 3.26% increase. A 16,459-ha productive forest cover increase was reported by TFE. Pascarella et al. (2000) showed that after humans abandoned the agricultural activities in Puerto Rico in the period of 1937–1995, the forest cover rose to 60%. Similarly, Grau et al. (2003) further validated the previous conclusions by presenting the results of their study that the changing socioeconomic dynamics have helped the forest cover to increase from 10% in the 1940s to 40% around the turn of the century. The increasing forest cover was explained to be the result of forests' natural regeneration overpowering the abandoned lands left by the migrating people. When this situation is globally investigated, it is apparent that this situation is in Turkey and the countries mentioned above studies are limited. Siddiqui et al. (2004) showed that because of the rapidly increasing population figures and the changing of socioeconomic dynamics, approximately 100,000-ha forest area was lost between 1977 and 1998 in Pakistan. In another study, Miyamoto et al. (2014) examined the forest cover change from 1970 to 2010 in western Malaysia. They showed that during the 1970s and early 1980s, vast amounts of forest losses were reported, but the rate of the loss subsided considerably since then.

Considering the results given above, it can be said that habits regarding the land use dramatically changed as the population moved from rural areas to urban areas in Turkey as well. However, the older population has chosen to not abandon their lands. Since their capabilities for tending the land are limited, they stop cultivating every piece of land, which have been worked. Simultaneously, when the human pressure on the forests has been lifted, the crime figures have started decreasing, which, in turn, caused an increase in the forest cover. No matter how it occurs, the increase in forest cover is regarded as a positive sign in Turkey; however, the population decrease has also started eroding the abled-body workforce form in all kinds of forest/forestry-related jobs. Not only in forestry, but also in agriculture and husbandry, the population shift from rural to urban has started to hamper the strategic development agenda

Table 10 Repeated measures ANOVA with Bonferroni' correction for FLC in buffer zones

Pairwise comparisons

I Factor 1	*J* Factor 1	Mean difference (*I-J*)	Std. error	Sig.[a]	95% confidence interval for difference[a] Lower bound	Upper bound
50-m buffer zone (FLC) %						
1975_50-m buffer zone (FLC) %	1990_50-m buffer zone (FLC) %	0.147*	0.015	0.001	0.110	0.184
	2016_50-m buffer zone (FLC) %	0.057*	0.014	0.001	0.022	0.092
1990_50-m buffer zone (FLC) %	1975_50-m buffer zone (FLC) %	− 0.147*	0.015	0.001	− 0.184	− 0.110
	2016_50-m buffer zone (FLC) %	− 0.090*	0.016	0.001	− 0.129	− 0.051
2016_50-m buffer zone (FLC) %	1975_50-m buffer zone (FLC) %	− 0.057*	0.014	0.001	− 0.092	− 0.022
	1990_50-m buffer zone (FLC) %	0.090*	0.016	0.001	0.051	0.129
100-m buffer zone (FLC) %						
1975_100-m buffer zone (FLC) %	1990_100-m buffer zone (FLC) %	0.097*	0.014	0.001	0.062	0.133
	2016_100-m buffer zone (FLC) %	0.023	0.013	0.277	− 0.010	0.056
1990_100-m buffer zone (FLC)%	1975_100-m buffer zone (FLC) %	− 0.097*	0.014	0.001	− 0.133	− 0.062
	2016_1000-m buffer zone (FLC) %	− 0.074*	0.015	0.001	− 0.112	− 0.036
2016_100-m buffer zone (FLC) %	1975_100-m buffer zone (FLC) %	− 0.023	0.013	0.277	− 0.056	0.010
	1990_1000-m buffer zone (FLC) %	0.074*	0.015	0.001	0.036	0.112
150-m buffer zone (FLC) %						
1975_150-m buffer zone (FLC) %	1990_150-m buffer zone (FLC) %	0.079*	0.015	0.001	0.043	0.115
	2016_150-m buffer zone (FLC) areas %	0.018	0.012	0.427	− 0.012	0.048
1990_150-m buffer zone (FLC) %	1975_150-m buffer zone (FLC) %	− 0.079*	0.015	0.001	− 0.115	− 0.043
	2016_150-m buffer zone (FLC) %	− 0.061*	0.014	0.001	− 0.096	− 0.025
2016_150-m buffer zone (FLC) %	1975_150-m buffer zone (FLC) %	− 0.018	0.012	0.427	− 0.048	0.012
	1990_150-m buffer zone (FLC) %	0.061*	0.014	0.001	0.025	0.096
200-m buffer zone (FLC) %						
1975_200-m buffer zone (FLC) %	1990_200-m buffer zone (FLC) %	0.062*	0.015	0.001	0.025	0.099
	2016_200-m buffer zone (FLC) %e	0.010	0.013	1.000	− 0.023	0.042
1990_200-m buffer zone (FLC) %	1975_200-m buffer zone (FLC) %	− 0.062*	0.015	0.001	− 0.0099	− 0.025
	2016_200-m buffer zone (FLC) %e	− 0.052*	0.015	0.002	− 0.089	− 0.016
2016_200-m buffer zone (FLC) %e	1975_200-m buffer zone (FLC) %	− 0.010	0.013	1.000	− 0.042	0.023
	11990_200-m buffer zone (FLC) %	0.052*	0.015	0.002	0.016	0.089
250-m buffer zone (FLC) %						
1975_250-m buffer zone (FLC) %	1990_250-m buffer zone (FLC) %	0.062*	0.015	0.001	0.024	0.099
	2016_250-m buffer zone (FLC) %	0.004	0.015	1.000	− 0.033	0.041
1990_250-m buffer zone (FLC) %	1975_250-m buffer zone (FLC) %	− 0.062*	0.015	0.001	− 0.099	− 0.024
	2016_250-m buffer zone (FLC) %	− 0.058*	0.014	0.001	− 0.093	− 0.023
2016_250-m buffer zone (FLC) %	1975_250-m buffer zone (FLC) %	− 0.004	0.015	1.000	− 0.041	0.033
	1990_250-m buffer zone (FLC) %	0.058*	0.014	0.001	0.023	0.093
350-m buffer zone (FLC) %						
1975_350-m buffer zone (FLC) %	1990_350-m buffer zone (FLC) %	0.114*	0.028	0.001	0.046	0.183
	2016_350-m buffer zone (FLC) %	− 0.032	0.027	0.725	− 0.100	0.035
1990_350-m buffer zone (FLC) %	1975_350-m buffer zone (FLC) %	− 0.114*	0.028	0.001	− 0.183	− 0.046
	2016_350-m buffer zone (FLC) %	− 0.147*	0.029	0.001	− 0.217	− 0.076
2016_350-m buffer zone (FLC) %	1975_350-m buffer zone (FLC) %	0.032	0.027	0.725	− 0.035	0.100
	1990_350-m buffer zone (FLC) %	0.147*	0.029	0.001	0.076	0.217

Based on estimated marginal means

*The mean difference is significant at the 0.05 level

[a] Adjustment for multiple comparisons: Bonferroni

Table 11 Wilcoxon's sign-ranked test for FLC in buffer zones

	Test statistics[c]		
	1990_300-m buffer zone (FLC) %–1975_300-m buffer zone (FLC) %	2016_300-m buffer zone (FLC) areas %–1975_300-m buffer zone (FLC) %	2016_300-m buffer zone (FLC) %–1990_300-m buffer (FLC) %
Z	− 3.897[a]	− 0.891[b]	− 4.412[b]
Asymp. Sig. (2-tailed)	0.000	0.373	0.000
	1990_400-m buffer zone (FLC) %–1975_400-m buffer zone (FLC) %	2016_400-m buffer zone (FLC) areas %–1975_400-m buffer zone (FLC) %	2016_400-m buffer zone (FLC) %–1990_400-m buffer zone (FLC) %
Z	− 2.611[a]	− 1.355[b]	− 4.521[b]
Asymp. Sig. (2-tailed)	0.009	0.175	0.001

[a] Based on positive ranks

[b] Based on negative ranks

[c] Wilcoxon's signed-rank test

of the country as not enough people can participate in the workforce. In the present study supported by solid results, it is especially recommended that humans, no matter where they live, must be supported and developed in their hometowns, so the consciousness and conservation agendas can be established firmly.

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Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

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