A COMPARATIVE ANALYSIS OF FOREST ENGINEERS' OPINIONS ON FOREST ROAD CONSTRUCTION IN TÜRKIYE

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Abstract. This study aims to compare the perspectives of academics and forest engineers in the public on the impact of forest road construction on forest ecosystems. Two expert groups were involved in the study, including 163 forest engineers working in public institutions and 121 academics in Türkiye. A survey consisting of 20 statements was given to expert groups and evaluated with a 5-point Likert scale. Cronbach's alpha coefficients were calculated for academics, forest engineers, and all experts as 0.764, 0.693, and 0.718, respectively. As a result of the MANOVA analysis, the awareness of the academics on the environmental impact of roads varies according to age (Wilk' Lambda = .015, $p < .05$) and work experience (Wilk' Lambda = .003, $p < .05$) and however, no variation was observed related to gender (Wilk' Lambda = .574, $p > .05$). It was found that the awareness of forest engineers working in the sector did not differ according to their demographic characteristics. However, it was found that there was a statistically significant difference between the mean scores of awareness of the environmental impact of roads among the expert groups (Wilk' Lambda = .706, $p < .05$). According to results of the chi-square test, while there was a difference in 16 statements ($p < 0.05$), it was determined that there were only 4 statements that showed no differences ($p > 0.05$).
Keywords: *environmental impacts, road damage, habitat loss, forest ecosystem, Likert*

Introduction

Industrial development, global warming, unplanned land use, and unregulated population growth, that began with the Industrial Revolution, have caused significant disruptions to the world's ecological balance. In this regard, the 2019 report of the United Nations Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) emphasized that approximately 75% of terrestrial ecosystems have been significantly changed, 66% of oceans are experiencing increasing cumulative impacts, and over 85% of wetlands have been significantly degraded by human activities (IPBES, 2019). However, it was revealed that there was an average 69% decrease in mammal, bird, amphibian, reptile, and fish populations monitored between 1970 and 2018 in the Global Living Planet Index Report published only three years after this report (WWF, 2022). The fact that the extent of ecosystem destruction negatively affects all living forms, including humans, has accelerated the actions of societies to reduce or eliminate these adverse effects. For this reason, since the Second Industrial Revolution, various regulations have been initiated regarding the environmental impact of all activities at national and international scales (Hsu, 2014; Kurdoğlu, 2008).

Forests, one of the most destroyed ecosystems, are in great demand for environmental, economic, and social services (Winkel et al., 2022; Tadesse et al., 2022). An intervention in any element of the ecosystem to meet these demands may cause the order of all resources in the basin to change. Mountain forests, defined as sensitive ecosystems in the Rio Convention's Agenda 21, have been identified as priority areas that need to be protected in terms of hosting freshwater resources and biodiversity and

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providing services such as cultural heritage, tourism, and recreation (United Nations, 2011). While 27% of the world's forests are in mountainous areas (Romeo et al., 2020), the proportion in Türkiye is as high as 50%. The high percentage of mountain forests and the ecological impact of all forestry activities, especially road construction, be implemented in these areas.

Forest management consists of many different activities, such as the establishment of forests, silviculture, maintenance, fighting against forest pests (such as wildfires and insects), forest road construction, logging, water conservation, wildlife improvement, and recreation (Soulis et al., 2015; Rahbarisisakht et al., 2021; Lisboa et al. 2022). Kolkos et al., 2023). A well-planned forest road network, built using environmentally friendly methods and to appropriate standards, is needed for the transportation of material, machinery or labor, primary/secondary transportation, timber harvesting, silviculture, recreation, and forest firefighting (Badea and Apostol, 2020; de Gomes et al., 2021; Thompson et al., 2021). In addition, these roads are one of the main needs of villagers living in interaction with the forest ecosystem to sustain their daily lives (Kantartzis et al., 2021) and can provide socio-economic benefits. Due to the demand for forest resources in Türkiye, industrial timber harvesting increased from 19.1 million m^3 in 2018 to 25.5 million m^3 in 2022 (GDF, 2022a). Intensified logging, transportation, and storage activities have led to an increased need for new road networks. In addition, new roads are also needed to access the 782 thousand hectares of land allocated for mining, housing, hydroelectric power plants (HEPs), power lines, dog kennels, garages, agricultural areas, or tourism facilities (GDF, 2022b).

While Türkiye ranked 99th out of 180 countries in the Yale Environmental Performance Index (EPI) in the category of biodiversity and habitat protection in 2020, it dropped to 178th in 2022 due to major and irreversible deforestation (EPI, 2022). For this reason, as a result of increasing public pressure, contradictions arising from resource use are frequently experienced in Türkiye. One of the most controversial issues is forest road construction. While economic costs are primarily considered during the planning phase of forest roads, ecological impacts are rarely considered. Roads can easily be routed through ecosystems in sensitive areas to make them cheaper. These careless practices ultimately cause great environmental damage to the forest ecosystem. Today, the importance of protecting forests by determining the impacts of forestry activities on the ecosystem has revealed the need for sustainable forest management (Augustynczik et al., 2020; Thomas et al., 2022). Sustainable forest management clearly shows the need to construct forest roads according to their intended use and take into account their ecological effects (Scandari and Hosseini, 2011; Ünver and Kurdoğlu, 2021). In recent years, society has become more aware of determining and minimizing the impacts of interventions and infrastructure applications on forest ecosystems (Escobedo et al., 2019; Kazama et al., 2021; Reddiar and Osti, 2022). Today, various policies and strategies for forest protection are being developed, and the types and sizes of technical projects that may be allowed to be implemented in the forest are being determined (Maier et al., 2021). There is always a dilemma arising from the nature of the work between forest road construction and protecting forest health. Therefore, the ecological impacts of road construction have an important place in forest management as a subcategory of conflict management. This study aimed to compare the perspectives of forest engineers working in the public/sector and academics on the effects of road construction on the forest ecosystem. Thus, it will be revealed to what extent the environmental impacts of forest road construction are accepted by both professional groups.

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Environmental damages of forest road constructions

Historically, the negative impacts of roads on the forest ecosystem have often been ignored, although they are much more intense than the effects of other land cover changes (Ziegler et al., 2004). Zoker et al. (2022) stated that due to road construction with machines in Sierra Leone, many living organisms are in danger of extinction or have moved away from their natural habitats. The ecological impacts of forest roads can be classified into two groups: biotic impacts and abiotic impacts. Moreover, there are also indirect impacts caused by human access to the forest or other reasons. It is known that the fragmentation caused by forest roads leads to changes in the ecological balance of the forest ecosystem (Eker and Acar, 2005) and causes some indirect damage to the forest (*Fig. 1*).

Vegetation	Soil	Water	Wildlife	Indirect impacts
• Loss of area • Habitat loss • Biodiversity change • Tree and sapling damage/death • Species decline • Wind corridor	• Erosion • Landslide • Rockfall • Yield loss	• Water pollution • Sedimentation • Changes in groundwater and surface water flows • Decline of aquatic life	• Movement Prohibition • Barrier effect • Conduct disorder • Change of living space • Death by traffic accident	• Smuggling • Hunting • Grazing • Fire • Change in land use • Sensitivity to insect or invasive species

Figure 1. *Classification of ecological impacts of forest roads*

Biotic impacts

In many studies on road construction using heavy construction equipment, various damages, such as habitat loss, degradation, corridor effect, loss of biodiversity, death, fragmentation, barrier effect, modified hydrology, soil erosion, the quality of forest soil, water resources and behavioral differentiation, occur in the living elements of the forest ecosystem (Avon et al., 2010; Li et al., 2014; Madadi et al., 2017; Abbasi et al., 2022).

Vegetation

All herbaceous and woody species along the route of the road are harvested during the construction of a forest road. This causes significant changes in abiotic factors such as microclimate, the amount of light, humidity, evapotranspiration, and wind (Bazyari et al., 2014; Deljouei et al., 2018). Changing abiotic effects through forest roads can create suitable environments for invasive plant species in the area (Fallahchai et al., 2018; Karatas, 2019; Zamani et al., 2019). Additionally, the fast-growing and light-friendly species can significantly change biodiversity on the roadside (Li et al., 2022; Arjmand et al., 2023). The forest road routes can have various effects, including habitat losses, alteration of plant movement patterns, and expansion of roadside impacts into the forest (Picchio et al., 2018). Spruce (*Picea orientalis* L.), the native tree species of Turkey's Eastern Black Sea Region, is sensitive to abiotic factors such as wind and temperature. Damages such as windfall and sunburn may occur in the fragmentation of the stand and the opened areas. Ips spp. species have caused significant damage to spruce forests, which have been weakened physiologically as a result of interventions such as forest road construction in the last 50 years.

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Since it is difficult and expensive to store the excavation resulting from road construction, most of the material is dumped on the slope, and all the vegetation on the slope, including trees, is damaged. As a result, most of the woody material, from tall trees to saplings, is broken, disintegrated, or completely disappeared. Contrary to popular belief, the destruction caused by road construction is quite large. Kurdoğlu (2015) calculated that approximately 11,700,000 m^3 (21,060,000 tons) of excavation would be generated in the construction of a newly built 10 m wide and 100 km long road in an area with a 70% slope in northeastern Türkiye. Considering that approximately 1000 km of roads have been built in the same region since 2015, the magnitude of the excavation and, therefore, the destruction is better understood. Parsakhoo and Hosseini (2009) determined that approximately half of the trees nearly 6 m of the road were damaged bark peeling (7%), crown loss (13%), and breakage or dismantling (30%) during road construction. In addition, it was revealed that approximately 87% of the young saplings with diameters ranging from 2.5 to 7.5 cm were damaged by the crawler bulldozer during the excavation works. Damage to saplings that ensure the sustainability of the forest and produce the products of the coming years is an important economic and ecological loss.

Wildlife

Forest roads have various effects that can lead to the extinction of wildlife in the area. Effects of new road construction and the existence of roads on wildlife vary depending on the type of road and animal species. The main interactions between wildlife and roads are wildlife mobility and behavior, widening the gap between habitats, and the contrast created by the barrier effect with adjacent habitats. Fragmentation has an impact on wildlife, which is known to cause effects such as the barrier effect, traffic-related mortality, behavioral disorders, inability to access food or water resources, and exposure to traffic-related pollutants and noise (Boston, 2016; Gonçalves et al., 2018; Mohammed et al., 2022). Additionally, forest roads can reduce interactions between wildlife populations, causing harm such as limitation of gene flow, inbreeding, depression, wildlife movement, disrupting metapopulation dynamics, vulnerability to random stochastic events, land use change, and devastating impact on endangered animals (Hanski, 2011; Lagos et al., 2012; Mech and Chesh, 2014; Shi et al., 2018). Naturally, there is a negative relationship between the density of forest roads and animal species. In Europe, most wildlife deaths occur on the roads that divide the animals' habitats so that they disperse from their birth areas, or during the mobility during the breeding season. Many studies have shown that forest roads are ecological traps that cause wild animals to be exposed to vehicle collisions (Milton et al., 2015; Kioko et al., 2015). On the other hand, Çağlar (2008) determined that 58% of the noise level generated by blasting in forest road construction was at a level that would negatively affect wildlife, as wild animals are disturbed by noise above 130 dB.

Abiotic impacts

It is known that roads affect some abiotic factors such as water, soil, microclimate conditions, noise, wind, and light.

Water

Human-induced changes in vegetation, soil, and topography cause significant changes in watershed hydrology and the hydrological response of degraded areas

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(Kastridis, 2020). This situation can negatively affect several biogeochemical processes in the forest ecosystem (Ramos-Scharrón, 2010). Accordingly, it has been emphasized that in some cases, the impacts of roads on the ecosystem can be greater than other known destructive activities (Cuo et al., 2008). The main causes of road-related pollution in water resources are material flowing into the water from slopes, ditches, or road surfaces. Construction work can affect soil density, landscape, and surface and groundwater flow. As a result, roads can cause water recharge to be restricted, water quality to decrease, and drinking water to become contaminated. In many studies, the excavated soil that flows down the slope during road construction and reaches streambeds negatively affects water quality (Ramos-Scharrón, 2017; Ramos-Scharrón and LaFevor, 2018). There is a significant increase in sedimentation and peak flows, especially in watersheds with dense road networks (Jordán-López et al., 2009). The severity and extent of the damage to the water resources are directly proportional to the length of the roads under construction and the amount of excavation (Connors et al., 2014). In addition, the disposal of excavated material into streams affects the aquatic ecosystem. It can also cause mortality, reduction in food quality, habitat degradation, eutrophication, and forced migration.

Soil

Forest soil, which is the primary habitat for the biological activities of flora and fauna, is undoubtedly one of the most important components of the natural environment. Adverse changes in soil properties and the geomorphological and hydrological behavior of slopes after extreme rainfall, soil erosion (Mahmoudzadeh, 2007; Sui et al., 2008), mass movements, and an increase in landslides (McAdoo et al., 2018; Froude and Petley, 2018) may cause this. During forest road construction, some physical properties of the soil changed such as depth, water holding capacity, soil density, infiltration, nutrient continent, and soil compaction. Parsakhoo et al. (2010) found that removing vegetation and excavating the topsoil in the road construction area significantly increased the occurrence of soil loss in the area. It has also been determined that soil compaction on slopes and road surfaces causes various negative effects on some physical properties of the soil (Aust et al., 2011). These changes in soil properties cause the migration of fertile topsoil, increased erosion (Fu et al., 2010; Jordán-López, 2009), and decreased habitat productivity. Laurance (2013), who made the most dramatic statement on this issue, stated that the most practical and cheapest way to protect important ecosystems is to keep roads out of mountainous areas.

Materials and methods

This study was carried out on two expert groups consisting of academic forest engineers and forest engineers working in the sector in Türkiye. In the expert group consisting of forest engineers working in the sector, forest engineers work in the General Directorate of Nature Conservation and National Parks, General Directorate of Forestry, and Forestry Research Institute. The expert group includes academics working in the departments of forest engineering of 12 universities in Türkiye (Istanbul University Cerrahpaşa, Karadeniz Technical University, Artvin Çoruh, Kastamonu, Düzce, Bartın, Çankırı Karatekin, Maraş Sütçü Imam, Isparta Applied Sciences, Izmir Katip Celebi, Bursa Technical University, and Karabük).

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The population size of academics in forest engineering departments was determined as 376 people from the websites of the relevant institutions. The required sample size for the group of academic experts was calculated using *Equation 1* (Hamioğlu, 2006).

$$n = \frac{N.t^2.p.(1-p)}{d^2.(N-1)+t^2.p.q} \quad \text{(Eq.1)}$$

Here, n is the number of individuals to be sampled, N is the main population size, t is the theoretical value in the t-table at a certain level of significance (1.96 for 95% confidence), p is the Frequency of occurrence of the event (probability of occurrence) (0.5), d: the sampling error (10%) that is accepted according to the frequency of occurrence of the event. With this equation, the number of academics in forest engineering to be reached within the scope of the study was calculated as 77 people. The sample size of forest engineers working in practice was calculated using the sample size determination formula for large universes in *Equation 2* (Singh and Masuku, 2014).

$$n = \frac{t^2.p.(1-p)}{d^2} \quad \text{(Eq.2)}$$

The number of forest engineers working in the sector to be reached was calculated as 96 people using *Equation 2*. To determine the perspectives of practicing forest engineers and academics on the environmental impact of road construction on the forest ecosystem, a survey was prepared based on a literature review, field observations, and practitioners' opinions. The survey consists of two main parts: the demographic characteristics section (3 questions) and the evaluation section. Many statements were put forward during the preparation of the survey used in the study. Then, the evaluation section consisting of 20 statements was finalized as a result of preliminary interviews with the expert group (7 academics, 5 forest management chiefs, and 3 private forest engineers). The statements include the necessity, the practices in construction, functions, the social problems created, and the effects on the environment of the forest roads.

The forest engineers in the expert groups were asked to express their attitudes by selecting one of the following options: "strongly disagree (1), disagree (2), undecided (3), agree (4), strongly agree (5)" regarding the necessity and environmental damage of forest road construction. Participants were also asked about their demographic characteristics, including age (years), gender (female/male), and length of work experience (years). The survey developed for the scope of the study was applied to a total of 284 forest engineers, 121 academics, and 163 forest engineers in public institutions in 2022.

Statistical analysis

The survey data were analyzed using the Statistical Package for the Social Sciences (SPSS) 20.0 package program. Cronbach's alpha values were calculated to determine the reliability levels of the statements explaining the independent variables. Normal distribution assessments were made by first applying the Kolmogorov-Smirnov test to the data, and it was determined that the data did not have a normal distribution at the 95% confidence level ($p < 0.05$). The demographic characteristics of the expert groups and their opinions on the statements were evaluated using frequency analysis. In

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addition, the demographic characteristics of the experts and their awareness of the environmental impact of forest roads were compared using the MANOVA analysis. The chi-square test was used to analyze whether there was a statistical difference between the opinions of the two expert groups on the statements.

Results and discussion

The study is based on the hypothesis that academicians and forest engineers working in the sector have different perspectives on the environmental damage of forest roads. Within the scope of the study, the proportional distributions (%) of the demographic characteristics of two groups of experts, consisting of forest engineers working in the sector in which the survey was conducted and academic forest engineers, were determined by frequency analysis (*Table 1*).

Table 1. *Proportional distribution of participants' demographic characteristics*

Demographical features	Classes	Forest engineers (FE)		Academics	
		Number of participants	Sample (%)	Number of participants	Sample (%)
Gender	Male	113	69.3	93	76.9
	Female	50	30.7	28	23.1
Age (year)	21-35	57	35.0	28	23.1
	36-50	74	45.4	66	54.5
	51-65	32	19.6	27	22.3
Experience (year)	1-5	43	26.4	13	10.7
	6-10	33	20.2	15	12.4
	11-20	42	25.8	34	28.1
	> 20	45	27.6	59	48.8

As seen in *Table 1*, while 57.4% of the experts in the target groups are forest engineers working in the sector, 42.6% are academics. While 30.7% of the experts in the group of forest engineers working in the sector are women, only 23.1% of the academics are women. Nearly half of the engineers participating in both expert groups are in the 36-50 age class. While the work experience of forest engineers in the sector is closely distributed in each class, approximately half of the academics have more than 20 years of work experience.

A total of 284 experts in both expert groups were asked to evaluate 20 statements on the environmental damage caused by forest road construction and to express their opinions on a 5-point Likert scale. As a result of the reliability analysis applied to the opinions of the expert groups, Cronbach's alpha coefficients were determined to be 0.764, 0.693, and 0.718 for academics, forest engineers in the sector, and all experts, respectively. The proportional distribution (%) of the expert's opinions on the statements was determined by frequency analysis (*Table 2*).

As seen in *Table 2*, it is seen that the majority of engineers in both expert groups disagreed with half of the statements in the survey (S1, S3, S4, S5, S8, S11, S14, S16, S17, and S20). In addition, while most forest engineers in the sector disagreed with 30% of the statements (S6, S9, S10, S12, S13, and S15), the majority of academics agreed.

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Table 2. *Proportional (%) distribution of the responses given to the statements*

No	Strongly disagree (1)		Disagree (2)		Undecided (3)		Agree (4)		Strongly agree (5)	
	****FE**	**Acad.**	**FE**	**Acad.**	**FE**	**Acad.**	**FE**	**Acad.**	**FE**	**Acad.**
S1	3.1	0.8	3.1	1.7	0.6	0.0	23.3	16.5	69.9	81.0
S2	10.4	7.4	28.2	40.5	6.1	9.9	31.9	26.4	23.3	15.7
S3	11.0	24.8	34.4	40.5	11.7	18.2	30.1	14.9	12.9	1.7
S4	2.5	1.7	0.0	0.8	1.8	0.0	16.6	29.8	79.1	67.8
S5	6.7	14.9	11.7	21.5	16.6	20.7	41.7	29.8	23.3	13.2
S6	9.2	4.1	35.6	19.0	9.8	7.4	27.6	45.5	17.8	24.0
S7	11.0	0.8	17.8	9.9	11.7	7.4	33.1	37.2	26.4	44.6
S8	4.9	4.1	31.3	12.4	3.1	5.0	42.3	46.3	18.4	32.2
S9	6.7	1.7	41.1	21.5	7.4	13.2	30.7	46.3	14.1	17.4
S10	9.8	4.1	40.5	19.0	9.2	19.8	31.9	42.1	8.6	14.9
S11	11.0	0.8	44.8	38.0	10.4	19.8	26.4	33.9	7.4	7.4
S12	9.2	0.8	53.4	24.8	7.4	17.4	24.5	45.5	5.5	11.6
S13	10.4	0.0	38.0	14.9	16.6	22.3	28.2	47.9	6.7	14.9
S14	3.1	0.8	20.2	11.6	17.2	19.0	47.2	46.3	12.3	22.3
S15	6.1	0.0	38.7	19.0	16.0	20.7	29.4	49.6	9.8	10.7
S16	6.7	0.8	46.0	31.4	17.8	33.1	21.5	30.6	8.0	4.1
S17	16.0	33.9	33.7	40.5	14.7	12.4	25.8	9.9	9.8	3.3
S18	41.1	55.4	43.6	35.5	2.5	1.7	6.7	3.3	6.1	4.1
S19	12.9	5.8	20.2	9.9	14.1	20.7	31.9	31.4	20.9	32.2
S20	22.7	28.1	47.9	52.1	6.1	9.9	18.4	9.1	4.9	0.8

*No: Numbers of statements asked in the survey. These are given in *Table 3*

Within the scope of the study, the arithmetic means of the expert groups' opinions on the statements between 1 and 5 were calculated (*Table 3*).

As seen in *Tables 2* and *3*, only nine of all statements (45%) subject to the study was rated in the same class by both the expert groups. In addition, three of them (15%) were rated higher by engineers in the sector, while eight of them (40%) were rated higher by academics.

Consistent with the literature, both of the expert groups clearly stated that "forest roads are necessary", "forest fires facilitate firefighting", and "sufficient environmental protection measures were not taken during forest road construction".

While forest engineers in the sector stated that they agreed (30.9%) with the statement "forest roads are ecologically beneficial", academics stated that they disagreed (40.5%). This may be because forest engineers working in the public sector are reluctant to express their opinions about the ecological consequences of roads built by the public in public forests. The same fear does not exist among academics due to the working environment and type of employment. Engineers working in the public sector lack the necessary ecological knowledge, which is a very worrying situation.

Both expert groups said they "agree" in the same way with the proposition "Greenway develops tourism". While forest engineers in the forestry sector said they "agree" (31.9%) with the proposition "Construction of green roads will cause the urbanization and sale of plateaus and winter pastures", academicians expressed a sharper opinion as "definitely agree" (32.2%).

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Table 3. *Average scores of the responses to the statements*

	Statements	Score	
		Academics	Engineers
S1	Forest roads are required	4.75	4.54
S2	Forest roads are ecologically beneficial	3.02	3.29
S3	Adequate environmental protection measures are taken in the construction of forest roads	2.28	2.99
S4	Forest roads make firefighting easier	4.61	4.70
S5	*Greenroad develops tourism	3.05	3.63
S6	Forest road networks cause fragmentation	3.66	3.09
S7	Environmental Impact Assessment (EIA) is required for road construction	4.15	3.43
S8	Harvesting the trees on the road route causes erosion	3.90	3.38
S9	Forest road construction negatively affects the forest ecologically	3.56	3.04
S10	Environmental sensitivities are not considered in forest road construction	3.45	2.89
S11	Forest road construction causes habitat loss	3.09	2.74
S12	Fragmentation reduces plant and animal diversity	3.42	2.64
S13	Forest road construction changes some properties of forest soil	3.63	2.83
S14	The fill slope is heavily damaged during forest road construction	3.78	3.45
S15	Road construction negatively impacts water quality and aquatic life	3.52	2.98
S16	Forest road construction increases insect and fungal invasion	3.06	2.78
S17	Fragmentation does not create an ecological problem in the forest	2.08	2.80
S18	Blasting activities do not negatively affect the ecosystem and living elements	1.65	1.93
S19	Greenroad offers the opportunity to develop and sell plateaus and winter pastures	3.74	3.28
S20	Road density does not affect the increase in illegal hunting and security problems	2.02	2.35

*Greenroad: It is a road called Greenroad, planned by the state, connecting mountain settlements and plateaus to be perceived as environmentally friendly. It is not a greenway

While forest engineers working in the forestry sector did not agree with “Forest road networks cause fragmentation”, “forest road construction negatively affects the forest ecologically”, “environmental sensitivities are not taken into account in forest road construction”, “fragmentation reduces plant and animal diversity” “road construction changes some properties of forest soil” and “road construction negatively affects water quality and aquatic life”, academics agreed with them. It is thought that this situation is due to the lack of technical and ecological knowledge of forest engineers working in the sector.

An interesting result is that while forest engineers in the sector disagree (46.0%) with the statement that “forest road construction increases the risk of insects and fungi in the area”, academics remain undecided (33.1%). However, it is known that the wounds on trees caused by excavation rolling down the slope during road construction make trees susceptible to harmful insects and can cause pathogen infestations in the area (Dickie and Reich, 2005). In addition, insect density and dead trees on newly opened road routes were observed to be much more common than in forest parts without roads. It is assumed that this situation arises from the fact that forest engineers working in public forestry organizations want to avoid management pressure.

Both forest engineers in the sector (47.9%) and academics (52.1%) stated that they did not agree with the statement that “road density does not affect the increase of illegal hunting and security problems”. Roads have made it easier for people to access forests, which has been linked to various security problems, such as poaching, grazing, deforestation, smuggling, and human-caused fires. Road transportation has made it easier to reach wildlife, forests, and plateau houses, especially during the winter months

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when inspection is difficult, and there has been an increase in the amount of poaching and illegal logging. This news is constantly mentioned in the press (URL 1, 2023).

The two expert groups’ awareness of the environmental impact of forest roads according to gender, age, and work experience was compared using the MANOVA analysis (*Table 4*).

Table 4. *Manova analysis results*

Effects		Value	F	df	Error df	Sig.
Academic_Age	Pillai’s Trace	.531	1.806	40.000	200.000	.004
	Wilks’ Lambda	.525	1.880[b]	40.000	198.000	**.003**
	Hotelling’s Trace	.797	1.953	40.000	196.000	.001
	Roy’s Largest Root	.627	3.137[c]	20.000	100.000	.000
Academic_Gender	Pillai’s Trace	.154	.912[b]	20.000	100.000	.574
	Wilks’ Lambda	.846	.912[b]	20.000	100.000	.574
	Hotelling’s Trace	.182	.912[b]	20.000	100.000	.574
	Roy’s Largest Root	.182	.912[b]	20.000	100.000	.574
Academic_Experience	Pillai’s Trace	.664	1.420	60.000	300.000	.031
	Wilks’ Lambda	.450	1.501	60.000	293.213	**.015**
	Hotelling’s Trace	.985	1.588	60.000	290.000	.007
	Roy’s Largest Root	.685	3.424[c]	20.000	100.000	.000
*FE_Age	Pillai’s Trace	.324	1.374	40.000	284.000	.075
	Wilks’ Lambda	.701	1.371[b]	40.000	282.000	.076
	Hotelling’s Trace	.391	1.368	40.000	280.000	.078
	Roy’s Largest Root	.243	1.724[c]	20.000	142.000	.036
FE_Gender	Pillai’s Trace	.176	1.512[b]	20.000	142.000	.086
	Wilks’ Lambda	.824	1.512[b]	20.000	142.000	.086
	Hotelling’s Trace	.213	1.512[b]	20.000	142.000	.086
	Roy’s Largest Root	.213	1.512[b]	20.000	142.000	.086
FE_ Experience	Pillai’s Trace	.460	1.285	60.000	426.000	.085
	Wilks’ Lambda	.601	1.297	60.000	418.518	.077
	Hotelling’s Trace	.566	1.308	60.000	416.000	.071
	Roy’s Largest Root	.260	1.845[c]	20.000	142.000	.021

*FE: Forest Engineer working in the public institutions

As seen in *Table 4*, academics’ awareness of the environmental impact of roads depends on age (Wilk’ Lambda = .015, F = 1.501; p < .05) and work experience (Wilk’ Lambda = .003, F = 1.880; p < .05), but not on gender (Wilk’ Lambda = .574, F = 1.371; p > .05). Among forest engineers working in the sector, their awareness of the environmental impact of roads had no difference age (Wilk’ Lambda = .076, F = 1.512; p > .05), gender (Wilk’ Lambda = .086, F = .912; p > .05), and experience (Wilk’ Lambda = .071, F = 1.297; p > .05). However, it was determined that there was a statistically significant difference between the means of the expert groups’ awareness of the environmental impact of roads (Wilk’ Lambda = .706, F = 5.478; p < .05). Whether there was a statistical difference between the opinions of the expert groups on the statements was analyzed with the Chi-square test (*Table 5*).

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Table 5. *Chi-square test results comparing the awareness of the expert groups*

Statements		Value	df	Asymptotic significance (2-sided)
Forest roads are required	Pearson Chi-Square	5.659[a]	4	.226
	Likelihood Ratio	6.280	4	.179
	Linear-by-Linear Association	4.857	1	.028
Forest roads are ecologically beneficial	Pearson Chi-Square	7.792[a]	4	.099
	Likelihood Ratio	7.809	4	.099
	Linear-by-Linear Association	2.848	1	.091
Adequate environmental protection measures are taken in the construction of forest roads	Pearson Chi-Square	28.129[a]	4	.000
	Likelihood Ratio	30.684	4	.000
	Linear-by-Linear Association	23.296	1	.000
Forest roads make firefighting easier	Pearson Chi-Square	10.439[a]	4	.034
	Likelihood Ratio	11.838	4	.019
	Linear-by-Linear Association	1.027	1	.311
Greenroad develops tourism	Pearson Chi-Square	15.799[a]	4	.003
	Likelihood Ratio	15.879	4	.003
	Linear-by-Linear Association	15.175	1	.000
Forest road networks cause fragmentation	Pearson Chi-Square	17.249[a]	4	.002
	Likelihood Ratio	17.620	4	.001
	Linear-by-Linear Association	13.803	1	.000
Environmental Impact Assessment (EIA) is required for road construction	Pearson Chi-Square	23.451[a]	5	.000
	Likelihood Ratio	26.897	5	.000
	Linear-by-Linear Association	22.340	1	.000
Harvesting the trees on the road route causes erosion	Pearson Chi-Square	17.108[a]	4	.002
	Likelihood Ratio	17.836	4	.001
	Linear-by-Linear Association	12.796	1	.000
Forest road construction negatively affects the forest ecologically	Pearson Chi-Square	19.524[a]	4	.001
	Likelihood Ratio	20.341	4	.000
	Linear-by-Linear Association	13.003	1	.000
Environmental sensitivities are not considered in forest road construction	Pearson Chi-Square	23.425a	4	.000
	Likelihood Ratio	24.102	4	.000
	Linear-by-Linear Association	15.249	1	.000
Forest road construction causes habitat loss	Pearson Chi-Square	16.562a	4	.002
	Likelihood Ratio	19.506	4	.001
	Linear-by-Linear Association	6.614	1	.010
Fragmentation reduces plant and animal diversity	Pearson Chi-Square	40.606a	4	.000
	Likelihood Ratio	43.413	4	.000
	Linear-by-Linear Association	32.801	1	.000
Forest road construction changes some properties of forest soil	Pearson Chi-Square	38.652a	4	.000
	Likelihood Ratio	45.718	4	.000
	Linear-by-Linear Association	35.109	1	.000
The fill slope is heavily damaged during forest road construction	Pearson Chi-Square	9.186a	4	.057
	Likelihood Ratio	9.449	4	.051
	Linear-by-Linear Association	7.002	1	.008
Road construction negatively impacts water quality and aquatic life	Pearson Chi-Square	24.595a	4	.000
	Likelihood Ratio	28.637	4	.000
	Linear-by-Linear Association	16.931	1	.000
Forest road construction increases insect and fungal invasion	Pearson Chi-Square	20.040a	4	.000
	Likelihood Ratio	21.358	4	.000
	Linear-by-Linear Association	5.055	1	.025
Fragmentation does not create an ecological problem in the forest	Pearson Chi-Square	23.961a	4	.000
	Likelihood Ratio	24.956	4	.000
	Linear-by-Linear Association	23.198	1	.000

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Blasting activities do not negatively affect the ecosystem and living elements	Pearson Chi-Square	6.406a	4	.171
	Likelihood Ratio	6.490	4	.165
	Linear-by-Linear Association	4.727	1	.030
Greenroad offers the opportunity to develop and sell plateaus and winter pastures	Pearson Chi-Square	13.487a	4	.009
	Likelihood Ratio	13.895	4	.008
	Linear-by-Linear Association	9.055	1	.003
Road density does not affect the increase in illegal hunting and security problems	Pearson Chi-Square	10.165a	4	.038
	Likelihood Ratio	11.022	4	.026
	Linear-by-Linear Association	6.377	1	.012

As seen in *Table 5,* there is no difference for four statements ($p > 0.05$), which are, only “forest roads are necessary for forestry activities”, “forest roads provide various ecological benefits”, “during forest road construction, the embankment is often severely damaged”, and “explosive substance ecosystem and living elements”.

Conclusion

Although the concept of sustainability in forestry has been used constantly in recent years, this study has revealed that traditional practices and the pressure to maximize commodity production are important obstacles to the implementation of more nature-friendly and more responsible rules. Although the employees of the public forestry organization were more cautious about the new road works, they, like the academic participants, still said that the roads were damaged. Understandably, they are concerned that it will cause problems such as environmental degradation, illegal hunting, and security.

It has been emphasized in many studies that road networks have various ecological effects on ecosystems, such as hydrology, habitat loss, land fragmentation, pollution, noise, barrier effect, death, or behavioral disturbance of wildlife. However, in this study, it was observed that similar statements were made by academic staff and those working in the public forestry organization (whose living conditions depend entirely on the income provided by the public): Namely, While forest engineers working in the public sector did not participate to “widespread forest road networks causing fragmentation”, “the forest is negatively affected ecologically”, “environmental sensitivities are still not taken into account”, “fragmentation reduces plant and animal diversity”, “changes some properties of forest soil” and “negative effects on water quality and aquatic life”, the academics agreed. These evaluation results also show that the ongoing road construction frenzy cannot be easily abandoned in the forestry routine.

In the literature, the necessity of conducting EIA applications for forest roads is clearly emphasized, and the main criteria that can be used in applications are presented. Furthermore, it has been stated that separate EIA projects should be carried out for each area due to the different impacts of different construction projects on natural resources (Falahatkar et al., 2010; Jaafari et al., 2011; Enache et al., 2012), although there are no forests in Türkiye. EIA reports are not required for roads, nor even for more extensive road networks such as the Greenroad in the high mountains. However, within the scope of this study, while the majority of forest engineers in the public sector responded “agree” to the statement “EIA is required for forest road construction”, the majority of academics made similar evaluations as “definitely agree”. It is possible to see these responses as wanting road construction to be at least somewhat environmentally friendly. Indeed, although it is prohibited by all relevant legislation, excavation material is thrown down the slope during road construction, and the destruction of the entire slope and the loss of forest area is not taken into account. EIA will at least be able to prevent this arbitrary practice. Therefore, the uncontrolled dumping of excavation material down the slope should be strictly avoided. In addition, roads create wind corridors, cause an increase in fractures and landslides, trigger surface runoff and erosion, restrict the right to live by disturbing wildlife as a result of intense pressure on pristine natural areas due to transportation, and add additional debt to the national economy due to road construction and maintenance costs" (GDF, 2008).

While the Greenroad construction has been continuing, construction in the mountain forests and plateaus also continues. However, the exemption of hundreds of kilometers of greenway activities from the environmental impact assessment (EIA) process makes it impossible to evaluate negative ecological and social impacts. Because the people who carry out these constructions continue their work and maximize their profits, exempt from all legal and environmental controls. As a result, many activities that should be environmentally friendly cause serious environmental problems.

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