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Evaluation of Forest Road Networks Located in Karadeniz Technical University Research and Practice Forest

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Abstract

Forest roads are in mutual interaction with many factors such as technical, economic and environmental requirements. The evaluation of forest roads network has been clarified by considering issues such as the accessibility to forest, the cost of transportation and impact on the environment. In this study, evaluation of future usage of existing forest roads have been aimed with taken into account to all tasks in accordance with the sustainable forestry objectives. To reach this goal, previously developed forest road evaluation and grading method was tested in Karadeniz Technical University (KTU) Research and Practice Forest. The total road length in the study area was 107+371 km which contained 27 road segments. All forest roads in the study area were classified into four quality classes (Class I: very good; Class II: good; Class III: bad; Class IV: very bad) for the future use. After evaluating the forest road network, it was found that 50.51% of the road was classified as Class II, while 31.09% and 18.39% were classified as Class I and Class III, respectively. The results indicated that there was no road segment under Class IV. The results suggested that the forest road network of the KTU Research and Practice Forest was sufficient in general regarding with the sustainable forestry goals. However, about 20% of the road was found to be in bad quality status. It can be concluded that it is necessary to implement urgent road repair in these segments based on forest road evaluation and grading method. Thus, it would be very useful to implement the road evaluation process described in this study in redesigning stage of forest road networks.

Keywords: Forest roads, Road classes, Evaluation of forest roads, KTU

1. Introduction

Forest roads are the most important substructures for utilization of forests that are renewable natural resource. It is necessary to establish the road networks to ensure the sustainable management of forest resources. Forest road planning is constrained by many factors such as technical, economic and environmental requirements.

The most important function of forest roads is to serve for transportation of forest products as well as for all other forestry operations. As an example, almost all of the forest transportation is made with logging trucks on forest roads in Turkey.

"Forest access is essential to achieve forest management goals. Access requirements are dependent on management goals, geographic location, harvest methods utilized, and other on-site factors. Forest management, timber removal, recreation, and fire protection, as well as other activities, are all heavily, if not totally, dependent on road access into the forest. In this sense needs a careful planning with the objective of minimizing the necessary cost" (Mac Donagh, 2007). According to these approaches, the forest roads classifications should be made based on the interests of the user groups.

Different planning approaches have been used in many studies where optimum planning goals are considered such as minimization of transportation cost, road distance, or travel time. In addition to this, goal programing like genetic algorithm and network analysis integrated with GIS have been used in some studies (Martin, et al., 2001; Greulich, 2002; Huang et al., 2006; Pentek et al., 2007).

Energy consumption, costs and road surface parameters have been taken in to consideration in some recent studies (Wolf, 1996; Saari et al., 2007). Numerical measurements are used in estimation of the future transport problems for traditional transport planning and decision making (Fouracre et al., 2006). One of the most common methods is the dynamic shortest path method implemented on transport problems (Ahuja et al., 2002).

In Turkey, the evaluation of the existing roads is being made of first priority according to 292 numbered edict of General Directorate of Forestry for forest road

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network planning. Whether convenient for forestry services or not, the previously constructed forest road are subject to investigation according to their location, routes, side slopes, width, and curves. Roads with required standards are included into the new road network plans. On the other hands, roads which cannot be improved (including major repairs) are completely abandoned and excluded from the forest road network plan (GDF, 2008).

Comparing with similar evaluation studies conducted in other countries, it can be seen that many other factors are being also considered in forest road network evaluations. Some of these factors are topographic features, harvesting methods and the forest structures etc. Besides, forest management practices, recreational activities, fire control etc. are only possible with the access to the forest through forest road network. Moreover, the forest roads serve to local people for trading, health, education and other social activities. Thus, the important functions should be also considered in evaluation of forest roads.

In previous studies conducted on the forest road network planning in Turkey, researchers mainly focused on the determination of the impact, management and functional criteria. In those studies, forest roads were evaluated based on limited number of factors such as road intervals, road density values, etc. (Demir, 2007).

In this study, evaluation of future usage of existing forest roads was performed by considering all tasks in according to the sustainable forestry objectives. To achieve this goal, an evaluation system which has been previously developed was tested in a study area. All forest roads in the study area were identified and evaluated for the future use.

2. Materials and methods

KTU Research and Practice Forest at the Macka Forest Management Directorate in the Trabzon Regional Directorate of Forestry, was selected as the study. The study area covered the total land of 5990.03 ha. KTU Research and Practice Forest consisted of 94 forest compartments. In the area, 24 different stand types are located in the area of 4277.12 ha. There is also a range land of 114.56 ha in the study area. Total land of villages and agricultural areas are 1598.65 ha.

Length of the total existing road is 181+404 km at the study area. The length of Trabzon-Gumushane state highway coded E-97, situated in the road network, is 9+754 km. The length of 61-65 coded former Trabzon-Gumushane state highway is 10+746 km. The total length of rural roads is 53+428 km in the study area. The total length of forest roads in the study area is 107+371 km. Forest roads in the study area are in Type B standard secondary roads (Figure 1).

Forest products derived from the research area are transported to the Esiroglu forest warehouse which is 8 + 840 km far away from the town of Macka. To produce the data needed for research, road network plan, forest management plan, and topographic maps were obtained from the forestry directorate. Google Erath images of the area have been used to overlay the digital maps on.

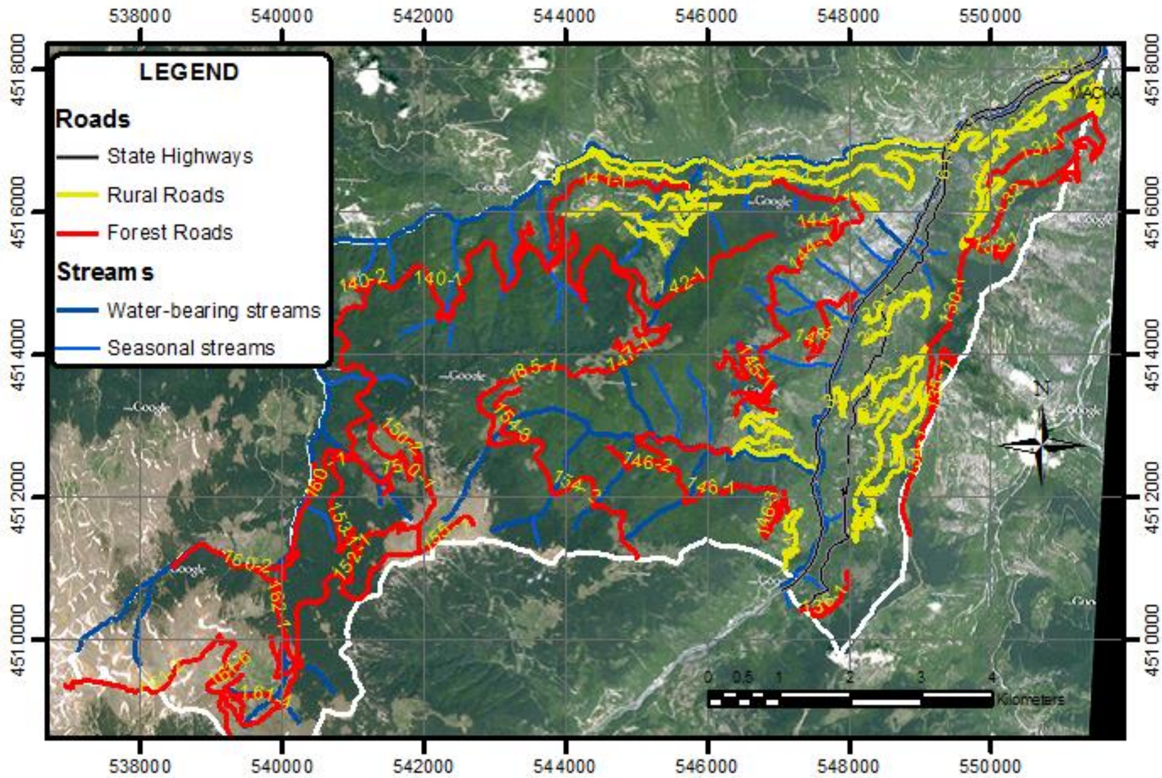

Figure 1. Illustration showing the points where soil samples were taken in the study site

Fieldwork was conducted for the inventory of forest roads information. Existing maps in relation to the field have been digitized and organized in Geographic Information System database prior to the fieldwork. Location information of each road segment was obtained by using GPS (Global Positioning System) receiver and then added on a 1/25000 scaled digital standard topographic maps. For each road section, road slope, road width, superstructure condition, status of structures and embankment slopes (excavation and backfilling) were recorded. Each road feature was recorded and numbered as a GPS waypoint and recorded with video camera.

The measurements and records, carried out with GPS receiver, have been checked and completed by usage of satellite images, derived from Google Earth software. The forest compartments and stand types along each road segment were determined by the usage of digital maps.

All roads within the study area were configured as a link of network database using ArcGIS network module. Searching the shortest connection route between any two or more points in the area, length and alignment information was obtained by the use of this network database.

Then, the road evaluation table, which was previously developed by Gumus (2009), was used for evaluating the roads (Table 1). Gumus (2009) implemented AHP method for constitution of this table. In AHP method, the order of significance of the factors to be used in evaluation was determined based on opinion of an expert group from stakeholders. The road value for each factor was obtained based on indicator scores and the important rates.

Finally, each road segment was classified in four classes based on the total score value suggested by Acar and Unver (2007). Those classes and ranges of scores were given in the Table 2. In this table, road grading status are;

Class I refers to roads with the ideal situation longevity in every respect,

Class II refers to roads with the good condition which do not require urgent repair,

Class III refers to roads in poor condition and need urgent repairs,

Class IV refers to roads in very poor condition requiring urgent major repairs or decommissioned roads those have to be abandonment.

3. Results and Discussion

Forest roads, designated by the General Directorate of Forestry, were evaluated by the existing road code numbers in a sample study area. The total length of forest road network was 107 + 371 km consisting of 27 road segments. Evaluation and grading of the roads has been performed based on the evaluation factors specified in Table 1. During the process, each road segment was evaluated individually.

The result for 130 coded road segment was provided as an example to give an idea of the evaluation process. This road segment is located between Ortakoy Village and Mollaismailli District. The total length of the road was 1 + 659 km and the vertical gradient was calculated as 10.3 % (Figure 2). The sample road segment enables access to the compartment numbered 37, which consisted of spruce forest, pine and other coniferous, plantation area and coppice forest. In addition, it provides access to agricultural areas as a transportation facility for local people from nearby villages. It is a hillside road with gravel surface and approximately 300 m far from the main ridge. The average slope of the hillside is calculated as 59.7%. The shortest path from this sample road to Macka (4 + 968 km) follows 26 and 27 coded village roads and 61-65 coded state highway. The total distance from the midpoint of the road to Esiroglu forest warehouse was computed as 14+550 km.

The information obtained from evaluations process above was then combined with road technical data summarized in Table 3. Finally, Table 1 was used to evaluate forest roads. As an example, a total road value score was 85 for 130 code number road segment. According to the road grading table, it is classified as Class I status. Thus, this road segment can be used with the annual maintenance.

When considering all forest road network, the length of roads were 54+237 km, 33+385 km, and 19+724 km for Class II, Class I, and Class III in the study area. However, there was no road segment within Class IV.

According to the evaluations of the forest roads, the roads coded 130, 131, 132, 134, 135, 140, and 141 were classified as Class I. The average road score was calculated as 92.92. Longitudinal slopes of these roads are within the defined limit and have enough superstructure and drainage structures. These roads have continuous access features and low transport expenditures. Whereas, the roads are located on steep side slopes areas and have some soil erosion and landslide risks.

The roads coded with 133, 136, 137, 142, 144, 145, 146, 147, 148, 150, 151, 152, 153, and 154 were classified as Class II. The average road score was found to be 71.48. Longitudinal slopes are close to upper slope limit (12%) at some road segments. Also, some segments have some superstructure and drainage structure deficiencies. Roads also provide some contribution to eco-tourism, inter-city transportation and transportation for local people. Even though these roads were in good status, the annual maintenance of these roads should not be neglected.

Table 1. Descriptive statistics (mean and standard deviation) related to soil physical and chemical properties

Forest Range Headquarters		Forest enterprises			
Local forest office		Serial			
Road code		Name			
Length		Longitudinal slope			
Construction year		Average side slopes			
Other features:					
Evaluation factors	Indicator	Indicator score	Road score	Importance rate (%)	Road value (score x rate)
Longitudinal slope (Transportation quality and safety) (%)	0 - 1.9	50		12.73	
	2 - 8.9	100			
	9-12	90			
	12.01-20	30			
	20.01 < ..	0			
	Adverse slope	0			
Superstructure	Asphalt	100		6.89	
	Concrete	100			
	Stabilize	90			
	Soil	50			
	Damaged	20			
Necessity of drainage structures	Adequate	100		5.71	
	Cross concrete	90			
	Concrete pipe	70			
	Culvert	50			
	Bridge	30			
	Walls	20			
Continuous access	10- 12 month	100		5.17	
	8- 10 month	70			
	6- 8 month	50			
	less than 6 month	0			
Transportation expenditures (TRY/m^3)	1 - 10	100		3.94	
	11 – 20	80			
	21 – 30	50			
	Over 30	20			
Fire protection (possibilities of accessing and linking)	Wide range forest and rural settlement areas	100		12.37	
	Only forest areas	80			
	Only rural settlement and agricultural areas	70			
	Blind roads	0			
Partition or destruction of importance forest lands	No affect	100		8.49	
	Relatively negative effect on stand type	20 - 80			
Soil erosion and water quality problems	No effect	100		11.45	
	Effective	50			
Risk of landslides by high side slopes (%)	Flat and low side slope terrain (0 – 33)	100		12.55	
	Sloping and upright terrain (34-65)	50			
	Steep terrain (Upper than 66)	0			
Affect to stream bodies	No negative effect	60 - 100		5.97	
	Effect to profile narrowing	0 - 59			
Partition or destruction of wildlife habitats	No effect	60 - 100		5.63	
	Effective	0 - 59			
Suitability for forestry activities (opening-up rate %)	81 – 100	100		2.64	
	61 – 80	70			
	0 – 60	50			
Suitability for security aimed usage (army and police)	Suitable	100		6.45	
	Unsuitable	0			
				Total Road Value Score	

Table 2. Road grading status of forest roads according to the road score

Grading Status	Explanation	Total Score
I. Class	Very good roads	81-100
II. Class	Good roads	61-80
III. Class	Bad roads	30-60
IV. Class	Very bad road	< 30

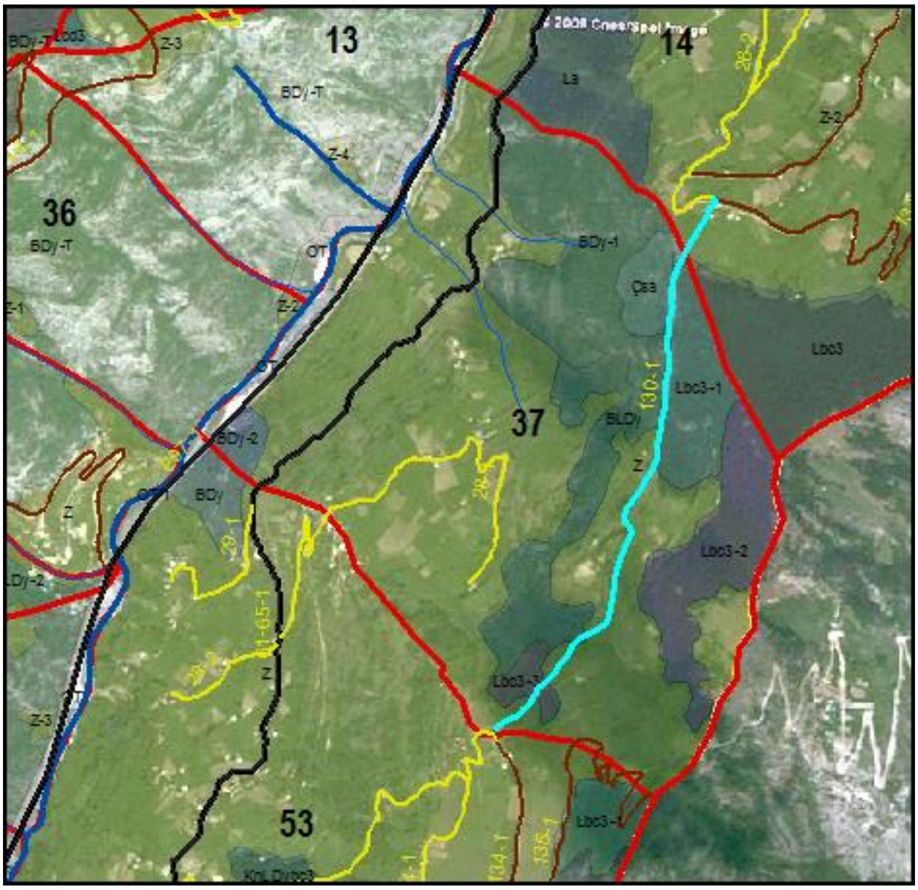

Figure 2. 130 coded forest road segment

Table 3. A part of evaluation table for forest road network

Code number	Subcode number	Type*	Road Name	Road slope (%)	Length (m)	Side slope (%)	Distance to Macka (m)	Route to reach Macka (road code numbers)	Distance to the Esiroglu forest warehouse (m)	Accessed compartment
130	1	3	Ortakoy-Mollaismailli	10.3	1659	59.7	4880	26-1, 26-2, 27-3, 27-1, 61-65	14549	37, 14
131	1	3	Ortakoy	3.4	2086	47.5	3910	26-1, 27-3, 27-1, 61-65	13793	1, 2
132	1	3	Ortakoy	1	933	41	4550	26-2, 26-1, 27-3, 27-1, 61-65	13857	14, 2, 1
132	2	3	Ortakoy-Kozagac	11	1686	70	3755	27-1, 61-65	13438	1
132	3	3	Ortakoy	9	981	36	5445	132-2, 27-1, 61-65	14776	1
132	1	3	Ortakoy	1	992	41	4500	26-2, 26-1, 27-3, 27-1, 61-65	13836	14,2
132	1	3	Ortakoy	11	356	41	4550	26-2, 26-1, 27-3, 27-1, 61-65	13568	14, 2
133	1	3	Ortakoy	12.1	1223	39.3	4880	26-2, 26-1, 27-3, 27-1, 61-65	14331	14
134	1	3	Mollaismailli -Naldoken hill	5	2819	37	6520	130-1, 26-1, 26-2, 27-3, 27-1, 61-65	16770	53, 54
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

* 1: High way, 2: Village roads, 3: Forest roads.

The roads codded with 155, 160, 161, 162, 163, and 185 were classified as Class III. The average road score was calculated as 57.94. Some of these road segments have very high road gradient of up to 24.7%. These roads are subject to lack of superstructures and drainage structures. It was determined that Class III roads are generally located on mountainous areas where the skidding and cable logging distances were up to 1000 m. Due to severe climate conditions, these roads do not provide continuous access to the forest areas for transportation, fire protection, security purposes. These roads are in poor condition and need urgent repairs to complete the technical limitations.

4. Conclusion

The forest road network of the KTU Research and Practice Forest were evaluated by using road evaluation and grading method. The total length of forest road network was 107+371 km consisting of 27 road segments. It was also found that 50.51% of the road was classified as Class II, while 31.09% and 18.39% were classified as Class I and Class III, respectively. The results indicated that there was no road segment under Class IV.

In general, road network was found to be capable for sustainable forestry goals. However, some road segments were not capable especially in sections within the productive forest areas. Even though road spacing of 500 m is required for current forest planning policies, the average skidding distances were calculated as over 1000 m in some parts of the study area. Therefore, the ratio of the accessibility was found to be quite low in the region.

It was also found that some roads are subject to excessive longitudinal slope, cut/fill slope failures, lack of superstructure and drainage structure, sediment yield to stream channels, and incapable of continuous access. Finally, these unfavorable factors resulted in lower road value scores in the evaluation process. As a result, it can be concluded that it would be critical to implement the road evaluation and grading process described in this study in redesigning of forest road networks.

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