Aesthetic Evaluations of Forest Road Templates

Abdullah E. AKAY* Mehmet PAK Nese YENILMEZ Hakan DEMIRBAG

KSU, Faculty of Forestry, Forest Engineering Department, 46060 Kahramanmaras, TURKEY

*Corresponding Author
e-mail: akay@ksu.edu.tr

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Abstract

Forest road construction is the most costly activity which requires physical, environmental, and social considerations. In recent years, there have been increasing public considerations about the visual quality of the road and roadside aesthetics. The visual quality of a road template mostly depends on state of the road surface, vegetation cover on the cut and fill slopes, and aesthetic along the roadside. In this study, the selected forest road sections from Kahramanmaras and Adiyaman regions were evaluated to assess the aesthetic of the forest road template. The number of photos were taken from the road templates and evaluated by the forestry students, considering forest road surface, cut-slope, fill-slope, and roadside. Then, statistical analysis indicated that existence of vegetation cover especially on the fill sections was the most significant factor affecting the overall aesthetic value for the selected road templates.

Keywords: Visual quality, low-volume roads, roadside vegetation, cut and fill slope

INTRODUCTION

Forest roads are essential structures in forest lands to provide access for management, afforestation, harvesting, transportation, protection, and recreation activities [1]. Forest roads are generally planned and constructed by considering physical, economical, and environmental requirements [2]. In constructing forest roads, forest surface and adjacent landscape along the roadway are mostly displaced due to removal of soil and vegetation cover, which then results in serious environmental impacts such as soil erosion and sediment yield to streams [3]. Forest road surface and roadside features (cut-slope and fill-slope) should be constructed in such a way that reduces these environmental impacts. The amount and quality of the surface material should be carefully selected and cut-slope and fill-slope areas should be immediately revegetated since natural re-vegetation can be extremely slow. These activities not only reduce environmental impacts but also enhance the beauty of the forest roads.

In last decade, visual quality of the forest road has been considered as one of the major factors in planning and constructing forest roads since improperly and poorly constructed forest roads can negatively affect the aesthetic value of the landscape [4]. Especially, the appearance of bare soil and stones on road surface and roadside features dramatically reduce the visual quality of the road template [5]. Previously constructed old forest roads with well established vegetation cover over the roadsides can provide better view than recently constructed forest roads with bare cut and fill slope areas. However, the visual quality of the road surface in old forest roads can be worse than the quality of the road surface in new forest roads due to long time usage.

A number of studies have been conducted to analyze the effect of forest road on aesthetic value of the landscape, considering unnatural topographic diversions, linear corridor formations, color and texture alterations, and light intensity changes. Existence of roadside vegetation was found to be one of the important factors to improve the visual quality of the landscape around the forest road [6]. Aesthetic value of the landscape is evaluated based on some indicator variables such as forest cover percentage, number of trees per unit area, ground cover percentage, landscape exposure, tree foliage height, distribution of bushes and other species, and ground color [4].

Previous studies have mostly evaluated the aesthetic value of the forest roads considering the outside harmony of the road (surrounding landscape) and road bands (road alignment). The aesthetic evaluations were generally depending on distant view observations. In this study, the visual quality of the internal harmony was assessed based on the road template elements such as forest road surface, cut-slope, and fill-slope, and roadside. The visual experiences of the near view observers were targeted in aesthetic evaluation procedure.

MATERIAL AND METHODS

Research Areas

The sample forest road sections were selected from four research areas. The first research area was located in KSU Baskonus Research and Application Forest in the city of Kahramanmaras, while other three research areas were located in forested areas in Alidag, Celikhan, and Karadag Districts in the city of Adiyaman (Figure 1). In the research forest, the dominant tree species were *Pinus brutia, Pinus nigra, Cedrus libani,* and *Abies cilicica*. The average ground elevation was 1165 m. In the research forest, there were county-maintained asphalt roads and gravel forest roads. In the other research areas, forest road sections were gravel roads and the dominant three species were *Pinus brutia* and *Quercus sp.* The average

Figure 1. Approximate locations of the research areas on the map of Turkey.

ground elevations were 694, 1388, and 950 m for the research areas in Alidag, Celikhan, and Karadag Districts, respectively.

Data Preparation

From the research areas, over 200 photo images of sample forest road sections were taken by a graduate student who was not informed about the study objectives to prevent possible bias in the data collection process. Images were taken by Kodak LS755 type digital camera with 5.0 Mega Pixels resolution. The data collection was performed in late spring and summer 2006. The images were taken at the day time (i.e. from 10.00 am and 15.00 pm) to have sufficient sun light. Then, all the images were stored into a portable computer and evaluated for pre-selection. For aesthetic evaluation, 32, 27, 25, and 30 images that represent the general characteristics of the research areas of Baskonus, Alidag, Celikhan, and Karadag were selected, respectively. The selected images consisted of 20-30 m long road sections and provided clear views of road template elements and roadside condition. The average side-slope in the research areas was from 15% to 30%.

Aesthetic Evaluation

In aesthetic evaluation of the forest road images, 60 senior forestry students ageing from 21 to 24 were surveyed. Firstly, the students were informed that it was aimed to evaluate the visual quality of the four specific road components including road surface, cut slope, fill slope, and roadside condition. Secondly, 8 warm up images were presented to define good and poor examples for each component. Figure 2 shows two examples of warm up images indicating good (left) and poor (right) road templates regarding visual quality. Then, selected forest road images were presented and the students were asked to assign a score from 1 to 5 (1 = very low, 2 = low, 3 = normal, 4 = high, and 5 = very high visual quality) for each component based on their personal sense of aesthetic quality. Total numbers of 114 images were presented to the student for 20 seconds each. The students were provided with a survey sheet in aesthetic evaluation process.

Figure 2. Two examples of warm up images indicating good (left) and poor (right) road templates regarding visual quality.

Statistical Analysis

The raw data obtained from the survey were reorganized for statistical analysis. For each research area, the Average Aesthetic Value (AAV) for each component (i.e. road surface, cut slope, fill slope, and roadside condition) was computed based on the total scores assigned to the images. Then, to estimate the overall aesthetic value of the road templates, the value of Average Visual Quality (AVQ) was assigned to each

research area by computing the average value for AAVs of four road components.

In statistical analysis, relationships between AAV of road components and AVQ were investigated for each research area by using a stepwise regression analysis. The correlation among the AAVs of road components was also examined for each research area by using Spearman's Nonparametric Correlation. In regression analysis, road components were defined as independent variables while AVQ was a dependent variable. SPSS 11.0 (Lead Tech., Illinois, USA) was used to perform statistical analysis.

RESULTS AND DISCUSSION

The summary of the regression analysis for each research area were indicated in Table 1. In Baskonus, two variables (Cut Slope and Fill Slope) were included into the regression model (Equation 1) in which about 45% of the variability in AVQ was explained:

$$AVQ = 1.408 + 0.289X_2 + 0.436X_3 \quad (1)$$

This model indicated that existence of vegetation cover on cut slope and fill slope areas was the most important factor on visual quality of the forest road template. McDonald and Litton also suggested that vegetation cover on roadsides improves the visual quality of the road [6]. Fill Slope variable with higher coefficient value suggested that Fill Slope had greater visual impact than that of Cut Slope in Baskonus. The results also indicated that the correlation between Cut Slope and Fill Slope was significant at the 0.01 level ($P = 0.003$).

In Alidag, three variables (Surface, Fill Slope, and Roadside) explained approximately 57% of the variability in AVQ based on the following regression model:

$$AVQ = 0.771 + 0.266X_1 + 0.370X_3 + 0.201X_4 \quad (2)$$

where Fill Slope had the greatest visual impact, followed by Surface and Roadside. Statistical results indicated that there was a significant correlation between Fill Slope and Roadside at the 0.01 level ($P = 0.002$), while significant correlation between Surface and Roadside was at the 0.05 level ($P = 0.039$). The results suggested that there was no significant correlation between Fill Slope and Surface.

In Celikhan, two variables (Fill Slope and Roadside) were included into the regression model (Equation 3) in which about 50% of the variability in AVQ was explained:

$$AVQ = 1.000 + 0.318X_3 + 0.364X_4 \quad (3)$$

This model indicated that roadside conditions and existence of vegetation cover on fill slope areas were the most important factors on visual quality of the forest road template. Roadside variable with higher coefficient value suggested that Roadside Condition had greater visual impact than that of Fill Slope in Celikhan. The results indicated that correlation between Fill Slope and Roadside was highly significant at the 0.01 level ($P = 0.0001$).

Table 1. The summary of the regression analysis.

	Coefficients	SE	F	R^2	*P*
Baskonus					
(Constant)	1.408	0.361			0.000
Cut Slope (X_2)	0.289	0.095	23.372	0.451	0.003
Fill Slope (X_3)	0.436	0.096			0.000
Alidag					
(Constant)	0.771	0.282			0.008
Surface (X_1)	0.266	0.092	24.986	0.572	0.006
Fill Slope (X_3)	0.370	0.072			0.000
Roadside (X_4)	0.201	0.081			0.016
Celikhan					
(Constant)	1.000	0.219			0.000
Fill Slope (X_3)	0.318	0.083	28.010	0.496	0.000
Roadside (X_4)	0.364	0.098			0.000
Karadag					
(Constant)	0.777	0.364			0.037
Surface (X_1)	0.243	0.091			0.010
Cut Slope (X_2)	0.311	0.080	21.198	0.607	0.000
Fill Slope (X_3)	0.203	0.096			0.039
Roadside (X_4)	0.185	0.082			0.028

In Karadag, all four variables (Surface, Cut Slope, Fill Slope, and Roadside) explained approximately 61% of the variability in AVQ based on the following regression model:

$$AVQ = 0.777 + 0.243X_1 + 0.311X_2 + 0.203X_3 + 0.185X_4 \quad (4)$$

where Cut Slope had the greatest visual impact, followed by Surface, Fill Slope, and Roadside. Statistical results indicated that there was a significant correlation between Fill Slope and Surface, Cut Slope and Surface, Roadside and Surface, and Cut Slope and Roadside at the 0.01 level. The significant correlation between Cut Slope and Fill Slope was at the 0.05 level ($P = 0.031$).

The results indicated that Fill Slope was included into the models. Therefore, Fill Slope was the most important factor that affects the visual quality of forest road template in selected research areas. Benson and Ulrich indicated that the appearance of bare soil and stones on road surface and roadside features (i.e. cut slope and fill slope) due to removal of vegetation cover can dramatically reduce the visual quality of the road template [5].

CONCLUSIONS

There has been an increasing interest in considering visual quality of the forest road in planning and constructing forest roads. In appropriately and poorly constructed forest roads can negatively affect the aesthetic value of the landscape. In this study, the visual quality of the internal harmony was investigated based on the road template elements including forest road surface, cut-slope, and fill-slope, and roadside condition. The visual experiences of the forestry students were evaluated by using over 200 images of forest road templates from four different research areas. The results from the statistical analysis indicated that regression models included Fill Slope and Cut Slope in Baskonus; Surface, Fill Slope, and Roadside in Alidag; and Fill Slope and Roadside in Celikhan, while all of the elements took place in the model in Karadag.

Having Fill Slope in regression models of all research areas indicated that visual quality of the Fill Slope plays an important role on overall aesthetic value of road templates. Therefore, roadside features of cut-slope and fill-slope areas should be immediately revegetated after road construction not only to enhance the beauty of the forest roads but also to reduce environmental impacts. In three research areas, roadside condition was effective on the visual quality of the forest road template. Thus, cleanness of the roadside condition should be maintained as long as road section is in use. The structural integrity of the road surface should be also sustained since Surface was one of the effective road template elements in two of the research areas.

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