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Comparison of Right-of-way in Mountainous and Valley Forest Roads

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ABSTRACT

The aesthetic quality of hyrcanian forest roadsides is influenced by a number of factors. Among these factors are right-of-way width, earth working (cut and fill slopes), adjacent land use, topography and existing vegetation. The main objectives of this study were to comparison of right-of-way in mountainous and valley forest roads. For this purpose, were measured real right of way and earth working limit using laser rangefinder and mapping index for each road. Results showed, there was significant difference between the earth working limit and real right of way in valley and mountainous forest roads ($P< 0.05$). Also, was found significant linear relationship, with equation of $Y = 0.249X + 2.202$ ($R^2 = 0.69$) between range slope and real right of way in mountainous forest road. The rate of earth working limit and real right of way increased with increasing range slope. Horizontal curve radius has an important effect on geometric design of road. So that, the rate of earth work limit decreased with increasing horizontal curve radius. Also, there was a significant linear relationship between horizontal curve radius and real right of way in mountainous ($R^2 = 0.65$) and valley ($R^2 = 0.49$) forest roads. According to results, right of way and earth working limit should be carefully selected, not only to minimize the total road cost but also to reduce the environmental impact and to improve driver safety.

Keywords: Mountainous and valley forest roads, Right of way, Earth woking limit, Horizontal curve radius

1. Introduction

Hyrcanian forest areas are approximately 1.8 million hectare (Nosrati, 1994). The aesthetic quality of hyrcanian forest roadsides is influenced by a number of factors. Among these factors are right-of-way width, earth working limit (cut and fill slopes), adjacent land use, topography and existing vegetation. Plant species composition in clearing limit of forest roads depend on several physical and biological factors involving canopy closure, edaphic and micro climatic factors, intensive growth of advanced regeneration before the stand disturbance, and species colonization (Arriaga, 2000). A mistake in planning a road, such as ignoring the effects of environmental and other parameters leads not only to the waste of public investment but also to adverse environmental impacts and increase maintenance costs (Heralt, 2002). After designing cross sections and vertical alignments and calculating earthwork volume, the trees which have located in right-of-way limitation are marked and then are felled. In other words, right-of-way felling involves cutting down and bucking the trees in the right-of-way.In addition hazardous snags and unsafe trees adjacent to the right-of way should also be felled at this time. The right of way is opened by chainsaw operator and depend on several factors involving range steep, tree height, species, climate condition, wind direction, range direction, altitude and type of bedrock (Potocnik et al 2008). According to

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forest ecosystem conditions in Hyrcanian forests, the fixed numbers can not be useful for determining forest roads right-of-way. Also, these numbers are frequently ignored by the executives and road constructors in order to preserve valuable trees and avoid cutting these trees on sensitive points such as cut slopes and fill slopes. In some cases that roads right-of-way is considered based on standard numbers, the vegetative characteristics of edge stands is determinant of real forest roads right-of-way (Parsakhoo et al 2009).

The clearing of trees, shrubs, low vegetation and organic material from the soil surface should be delayed until the threat of erosion from the disturbed areas is minimal. The general recommendation is that "all snags, danger trees, loose rocks, stumps or other unstable material shall be removed or cleared for a safe distance back from roadsides or roadside banks when they present a hazard to users of roadways", and that "brush foliage or debris which would obstruct the view of a vehicle operator on roadway intersections or on sharp curves shall be cleared and all possible precautions shall be taken to relieve the hazard of such conditions (Wenger, 1984).

The center line of a road consists of a series of straight lines connected by curves. Horizontal curves on all forest roads will be laid out as the arc of a circle having a pre-selected radius. For best alignment, the largest radius possible should be selected, consistent with topographic limitations and the economics of construction (Arriaga, 2000). For this reason, the minimum radius of horizontal curve in forest road is 16 meter that depend on several factors involving design speed, topographic conditions, soil conditions, limits of super elevation, length of timber truck carrying, length of timber, financial resources, importance of forest and environmental conservation and maximum of longitudinal slope (Sarikhani and Majnonian, 1994). The road right-of-way width is typically much wider than the clearing width. Real right of way are determined according to the number of trees per unit area and the form of Stands in forest roads (LeDoux, 2004). Also, in steep slopes with low potential for vegetative, right of way should be determined according to silviculture operations (Lugo and Gucinski, 2000). Roads cause soil compaction on the road itself and due to road building activities in adjacent areas (Bolling and Walker, 2000 & Guariguata and Dupuy, 1997). Soil compaction influences the succession of vegetation communities developing on roadsides or abandoned roads as increased compaction, commonly suppresses plant growth.

Sedlak (1985) stated that standard width of right of way for slope classes 30-40, 40-50, 50-60 and 60-70, are 11, 13, 15 and 19, respectively. Potocnik (2003) The width of a forest road clearance and tree species are probably the most important factors. Rock base and terrain slope were analysed as some of the factors that impact the road formation width and basic rocks shows that limestone is the was concluded that road formation width could increase up to 80 percent on steeper terrain and 20 percent less solid rock base regardless the terrain slope. It varies between 5.4 m (solid rock base, gentle slope) and 11.4 m (soft rock base. Steep slope). Parsakhoo et al (2009) showed that the mean width of real right-of-way in type A (Fageto-carpinetum with 155 stem per hectare and crown cover 75 percent) and B (Fageto-carpinetum with 175 stem per hectare and crown cover 85 percent) were 15.10 and 14.21, respectively.

2. Problem Statement

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The main objectives of this study were to (i) comparison of right-of-way in mountainous and valley forest roads and (ii) investigate some factors affecting on real right of way and earth work in Hyrcanian Forest.

3. Materials and Methods

3.1 Description of the Study Area

Table 1: Sites characteristics (Berenjestanak and Pashakola)

Forest road	Geographical position	Slope(%)	Above sea level (m)
Berijestanak (V)	36° 33′ to 36° 35′ N 52° 26′ to 52° 34′ E	5 – 70	290 - 560
Pashakola(M)	36° 23′ to 36° 26′ N 52° 09′ to 52° 19′ E	5 – 85	1040 – 1720

Note: (V) = Valley forest road ; (M) = mountainous forest road

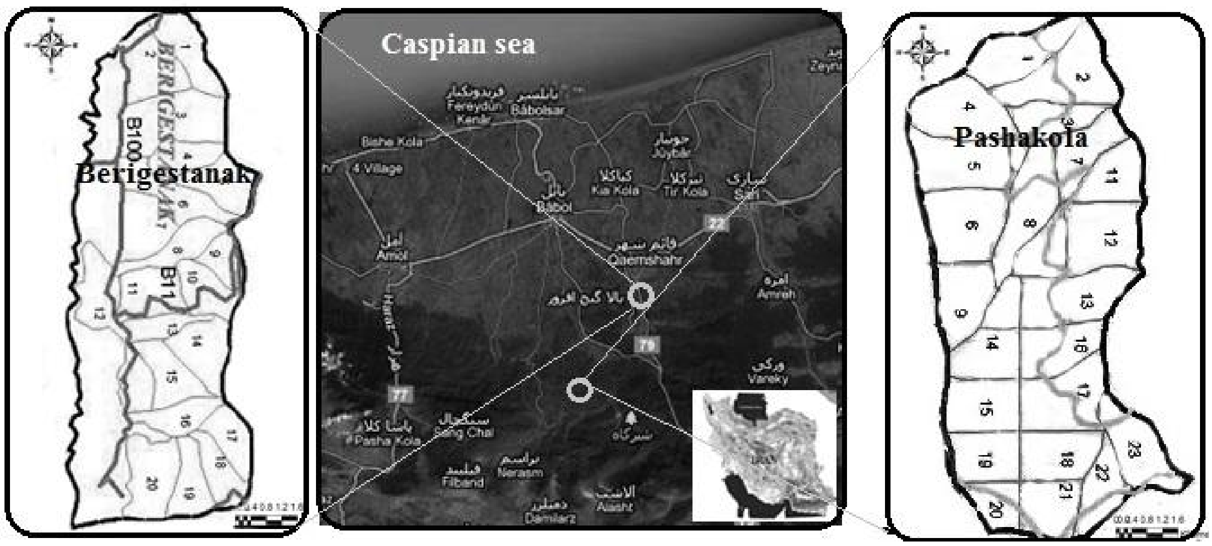

Figure 1: Map and geographical location of study area

3.2 Data collection

To comparison of mountainous and valley forest roads were measured steep ranges, horizontal curve radius, real right of way and earth working limit for each road. For this purpose, steep ranges were measured using clinometer. Gradient was divided into four classes involving 30-40, 40-50, 50-60 and 60-70 percent. Then, 20 random samples were measured for each class. Earth working limit and real right of way in place of each transect with the method that is shown in figure (2) were measured using laser rangefinder and mapping index. In order to assess the impact of horizontal curve on earth working limit and real right of way, was chosen 28 horizontal curve. Radius of each curve were measured using meter and was divided into 4 classes involving 15-25, 25-35, 35-45 and more than 45 meter. Then, curve classes were compared using statistical tests.

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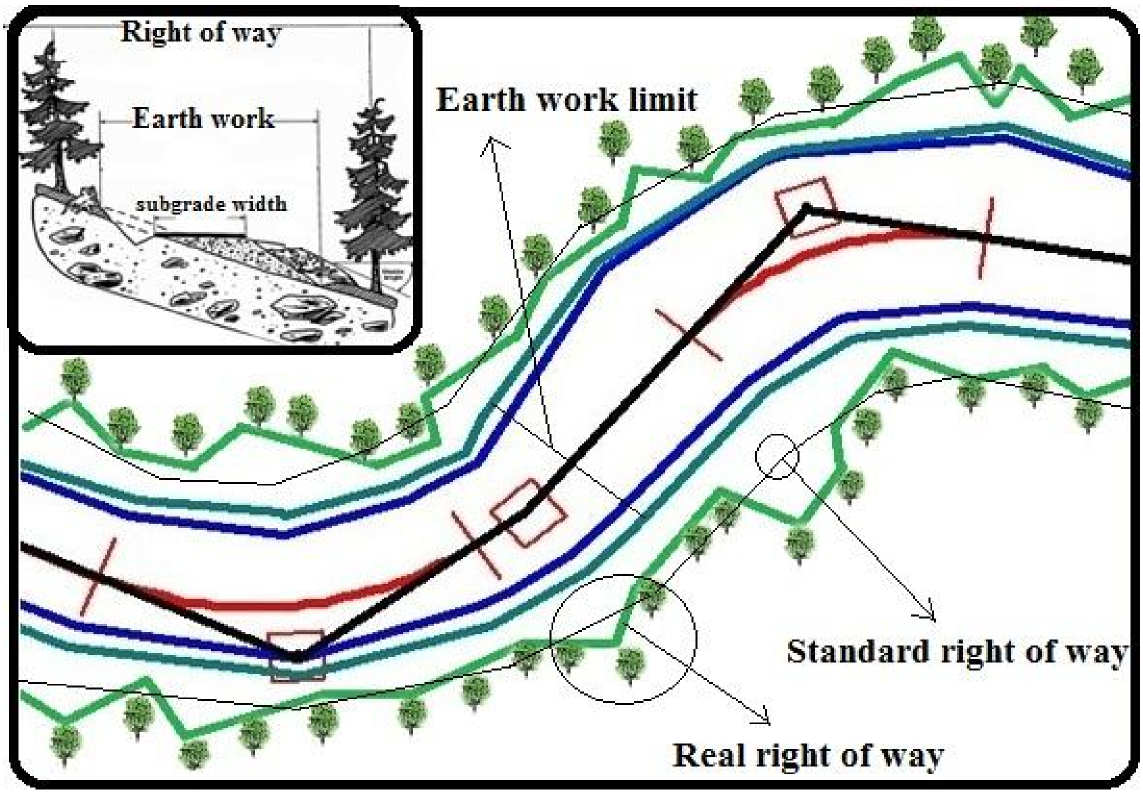

Figure 2: Measurement method of real right-of-way and earth work limit

3.3 Data Analysis

Data were analyzed based on complete randomize block design using SAS software. The means were compared using *ANOVA*(for forest road type), *Univariate Linear Analysis* (for statistical comparison of horizontal curve radius, earth working limit and real right of way) and *Tukey HSD* test.

4. Results and Discussions

4.1 Effect of forest road type on real right of way and earth work limit

Soil properties and soil structure directly influence the growth and survival of vegetation communities. Consequently, any alterations to natural soil characteristics due to roads construction will affect vegetation communities in roadside areas. However, the degree of impact on soil will vary according to the road features (Donaldson and Bennett, 2004). Results showed the rate of real right of way in valley forest road is more than mountainous forest road. So that, there was significant difference between the real right of way of valley and mountainous forest roads ($P< 0.05$). Type of plant species has a great impact on real right of way (Parsakhoo et al 2009). In the study area (mountainous road) presence of alder along the forest roads can reduce real right of way.

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Figure 3: Real right of way in mountainous (M) and valley (V) forest roads

Table 2: ANOVA for statistically comparsion of real right of way and earth working limit in mountainous and valley forest roads

Treatment	DF	SS	MS	F
Earth working limit	1	19.2	19.2	6.9*
Real right of way	1	114.5	114.5	11.3*

Note: DF = Degree of freedom; SS = Sum of squares of error; MS = Mean square; F = Value calculated by dividing MS source with MS error in SAS software ; * = Significant in probability level of 5 %

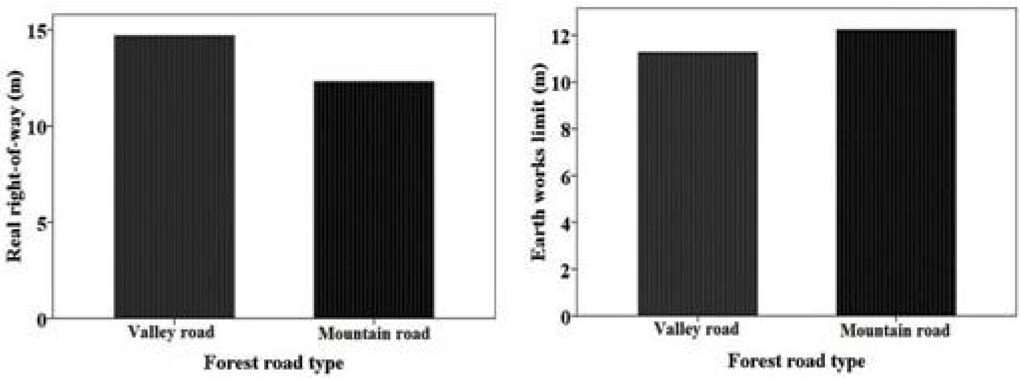

Figure 4: Comparsion of real right of way and earth work limit in mountainous and valley forest roads

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Alder tree is one of the most important species that appear in edge of road sides because of highlight nutrient or energy requirements and soil miosture in edge environment (Stohlgern and Banelt, 2003). Due to the ability of these species to settle on the compact soil and poor drainage, probability of presence these species is high on the steep slopes and difficult vegetative conditions of mountainous areas. For this reason, the real right of way in mountainous roads are less than valley roads. road construction activities using excavator have advantages in long run due to reducing damages on forest ecosystem, biodiversity, and forest soil (Haanshus, 1998). Erdas (1986) it was indicated that excavator should be used in construction activities on steep terrains to reduce environmental impacts. Bayoglu (1986) suggested that bulldozers should be used in the forested areas with less than 40 percent ground slope, while excavators should be preferred when the slope is greater than 40 percent. Results indicated the rate of earth working limit in mountainous forest road is more than valley forest road. Also, was found significant difference between the earth working limit of valley and mountainous forest roads ($P< 0.05$). Due to increasing road safety in mountainous areas, the earth working limit will be considered further. Also, earth working limit increased with using bulldozer instead excavator to create cut and fill slopes in steep slopes. So that, For this reason in the study area (mountainous road) , the earth working limit increased.

4.2 Effect of range slope on real right of way and earth working limit

Table 3: Effect of range slope on real right of way and earth work limit in mountainous and valley roads

Slope classes(%) / Treatment	30 – 40	40 – 50	50 – 60	60 – 70
Real right of way (V)	10.7 [c]	13.4 [b]	15.1 [b]	19.6 [a*]
Real right of way (M)	10.3 [c]	11 [b]	12.5 [b]	15.5 [a*]
Earth work limit (V)	9.6 [c]	10.5 [bc]	11.7 [b]	13.3 [a*]
Earth work limit (M)	11 [c]	11.7 [bc]	12.7 [ab]	13.6 [a*]

Note: * means followed by different lower-case letters are significantly different at probability level of 95% ; V = Valley forest road ; M = Mountainous forest road

Vegetation cover diminishes the effect of rainfall and steepy topography on erosion. Vegetation reduces total rainfall, rainfall intensity, and rain drop impact through interception, and decreases runoff velocity and erosive power. On steep slopes due to leaching of surface soil and instability of trees seeds, by cutting number of trees, biological production is reduced (Mohajer, 2007). So that, a significant linear relationship, with equation of $Y=0.249X+ 2.202$ ($R^2 = 0.69$) was found between range slope and real right of way in mountainous forest road. Also, there was this relationship with equation of $Y = 0.15X + 4.76$ ($R^2 = 0.5$) for valley forest road. In mountainous areas due to the stability of cut slopes (Rock), right of way are considered less than valley forest road (Sarikhani and Majnonian, 1994). Also, due to exist steep slope (slope 5:1, 3:2) in mountainous roads, real right of way because of infestation of chomophyte plants is reduced. Consideration should be given to the necessity for roadway drying, as well as to the safety, cost and aesthetics of rights-of-way. Fill slope plays an important role on overall aesthetic value of road templates (Akay et al 2007). The mean cut-slope heights for gradient classes of 0-15, 15-30, 30-60 and over 60 percent were estimated as 0.75, 1.5, 3 and 7.5 m, respectively (Akay et al 2008). Results showed that there was

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significant diffence between earth working limit in slope classes more than 50 percent ($P<0.05$). Also, the rate of earth work limit increased with increasing range slope. The reason for this, is lack of accuracy of construction machinery to construct cut and fill slope on steep slopes.

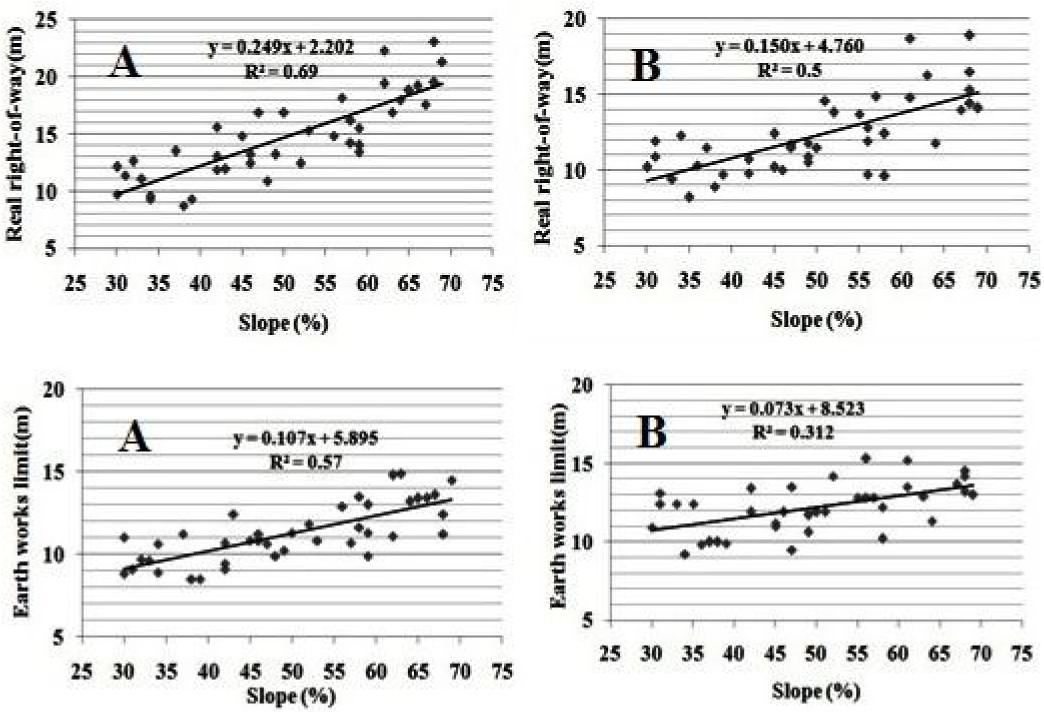

Figure 5: Relationship between slope, real right of way and earth work limit in mountainous and valley roads, A = Mountainous forest road; B = Valley forest road

Effect of horizontal curve radius on real right of way and earth work limit

Table 4: Effect of curve radius on real right of way and earth work limit in mountainous and valley roads

Curve radius(m) / Treatment	15 – 25	25 – 35	35 – 45	X > 45
Real right of way (V)	11.2^{c}	13.1^{bc}	14.4^{ab}	16.8^{a*}
Real right of way (M)	9.4^{b}	10.9^{b}	13.6^{a}	15.6^{a*}
Earth work limit (V)	12.4^{a*}	11.1^{ab}	10.6^{ab}	9.8^{b}
Earth work limit (M)	13.6^{a*}	11.7^{ab}	11.4^{ab}	10.9^{b}

Note: * means followed by different lower-case letters are significantly different at probability level of 95%; V = Valley forest road; M = Mountainous forest road

Horizontal curve radius has an important influence in determining the right of way. The radius of horizontal curve should be chosen according to the construction site (Sarikhani and Majnonian, 1994). Disproportion of radius with transportation condition increases the damages to roadside. So that, results indicated, the rate of real right of way increased with increasing horizontal curve radius. Select of improper radius for horizontal curve (exceed limit) increases destruction of vegetation and soil compaction. There for, real right of way increased with increasing horizontal curve radius. Horizontal sight restrictions may be caused by retaining walls, cut slopes, trees, etc. on the inside of curves. A height of 2 feet (0.61 Meter) can be used as the midpoint of the sight line where the cut slope usually obstructs sight (Narimani, 2001). Brushing of the road clearing width should be carried out for vegetation control and to provide safe sight distances. For example, potential hazards exist where brush limits visibility at the inside of a curve or at bridge approaches,or where heavy snow loads on roadside trees may cause the trees to bend over the road surface, restricting use of the road and creating a safety hazard (Wenger, 1984). Result showed, the rate of earth work limit decreased with increasing horizontal curve radius. So that, a significant inverse relationship was found between horizontal curve radius and earth work limit in mountainous (R^2 = 0.28) and valley (R^2 = 0.39) forest road. In the horizontal curve with low radius, widening and suitable width on curve for revolve is required, thus earth working limit increased. Also, if the culvert is located within a horizontal curve, extra road width to accommodate side tracking of logging trucks is required (Zwirn, 2002).

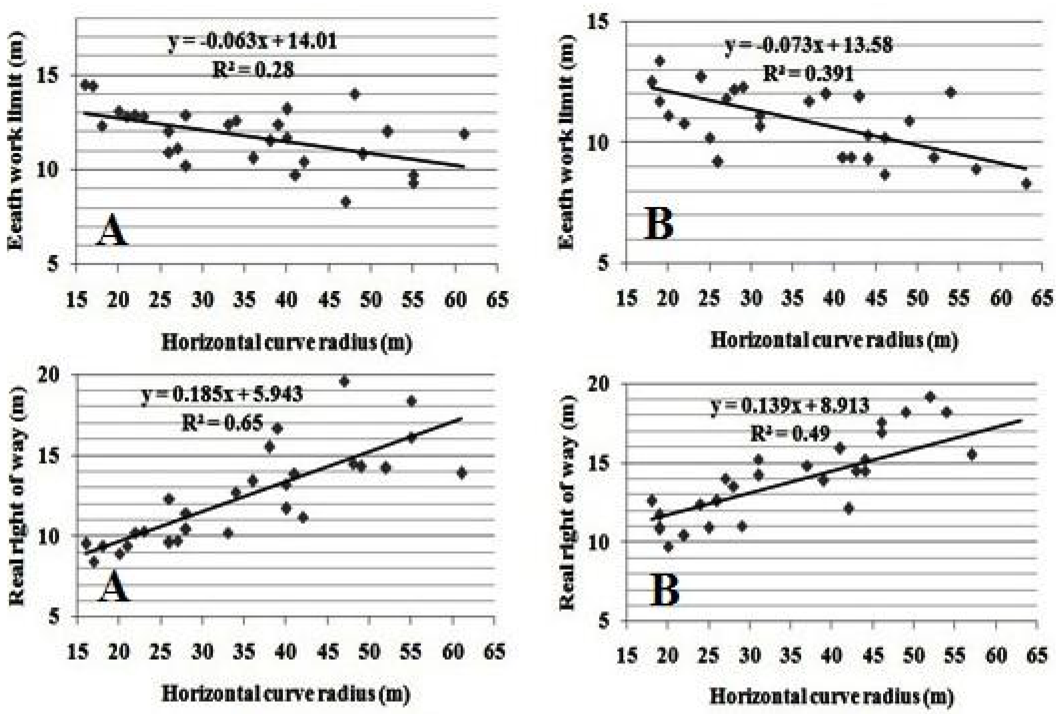

Figure 6: Relationship between horizontal curve radius, real right of way and earth working limit in mountainous and valley forest roads, A = Mountainous forest road; B = Valley forest road

5. Conclusion

The forest road right of way and earth working limit should be carefully selected, not only to minimize the total road cost but also to reduce the environmental impact and to improve driver safety. In order to prevent environmental damage and driver safety, following cases is recommended:

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1. For protecting natural environment the equipped and powerful excavators must be preferred to bulldozers, especially for determining right of way and earth working limit in steep terrains.
2. If there are doubts about a tree's stability, that tree should be removed.
3. Width of the right-of-way to clearing should be determined by the class of the road being constructed, and the topography.
4. The engineer or construction supervisor must ensure that all trees marked for removal is actually removed.
5. In mountainous areas, clearing should be kept minimum to prevent soil erosion. When working close to waterways, it may be necessary to take precautions to prevent sediment from washing into streams, such as installation of silt traps or silt screens.
6. Any stumps which will have their root system compromised by the cut-bank should be removed. The engineer or operator must determine if these stumps will eventually end up sliding into the road or side drain, creating a maintenance problem.
7. Determination of right of way in location of horizontal curve must be done according to the widening, width on curve and horizontal curve radius.

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