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*Full Length Research Paper*

# Effect of the standard clearing limit of forest road right-of-way on stand stock growth: Case study of Vaston forests, Hyrcanian zone

**Ali Sorkhi*, Seyed Ataollah, Hoseini, Majid Lotfalian and Aidin Parsakhoo**

Department of Forestry, Faculty of Natural Resources, Sari Agricultural Sciences and Natural Resources University, Mazandaran, Iran.

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**Forest roads must be constructed according to the technical standards and guidelines published by the scientific organizations. The main aims of this research was to compare the standard clearing limit with existence status and assess the effects of the application of improper clearing limit on forest stock growth. In this research the standard design of clearing limit was determined based on soil texture and hillside gradient. Slope steepness map were obtained from DEM. 17 clearing limit samples were taken for each of the slope classes. The soil samples number were determined according to the length of roads which have passed from each slope classes. Results showed that the difference between the standard and existing clearing limit in secondary forest road was significantly higher than that in main forest road. Difference between stand volume decrease in standard and existing clearing limit in silt soil was significantly more than that in silt clay and clay soils. The difference between standard and existing clearing limit as well as the difference between standard and existing trees stock growth in different slope classes and soil sub-units was significant. Difference between stand volume increased significantly as difference between standard and existing clearing limit.**

**Key words:** Forest road, clearing limit, right-of-way, stock growth, standard design.

## INTRODUCTION

Forest roads are necessary for emergency forest management (Potočnik et al., 2008) like timber harvesting, recreation, fire control and etc. During the construction project of a forest road, the standard design must be carried out on the ground to achieve the desired road with minimal impact on environment (Hosseini, 2010). Sometimes the standard design cannot be useful for determining clearing limit of forest roads (Tunay and Melemez, 2004).

These standards are often ignored by executives. In some cases when the standard design of roads is considered, the vegetative characteristics of edge stands determine the real clearing limit of roads (Parsakhoo et al., 2009). Moreover, tree markers avoid from cutting valuable trees on sensitive points such as cut slopes and fill slopes to preserve them as genetic sources. So when the planner and executors want to determine forest road right-of-way should attend to the natural condition.

One of the negative effects of roads is the loss of forest area due to their construction in the forest environment. The proliferation of human-made clearings may have important impacts on wildlife populations (Laurance et al., 2004). The clearance of a forest road cross-section affects both the forest and the road (Potočnik et al., 2008). One of the first steps in forest road construction is clearing trees. At this phase, trees and other large vegetation within the right-of-way boundaries should be felled and bucked. In addition hazardous snags and unsafe trees adjacent to the right-of way should also be felled (LeDoux, 2004).

Forest road right-of-way is the width of a strip in forest

*Corresponding author. E-mail: alisorkhi65@gmail.com. Tel:+989111293747.

which is clear-cut for road construction. The width of this strip is variable in different types of roads (Sarikhani and Majnonian, 1994). The clearing limit of road depends on hillside gradient, trees height, tree species, regional climate, direction of wind blowing, slope direction and bedrock type (Potočnik et al., 2008).

The use of reinforced soil enables steeper slopes to be utilized for road construction, with a consequent reduction in the width of right-of-way. In forest areas the initial approach to clearing the site involve removing from the right-of-way trees, hedges, underbrush, other vegetation and rubbish (O'Flaherty, 2007). Typically, right-of-way clearing and subsequent thinning of roadside vegetation during the operation phase exposes habitats near the road to the drying effect of winds and the sun, which may eliminate favorable germination and growing conditions for certain plant species surprisingly far from the road cut itself (Rajvanshi et al., 2001).

Road right-of-ways need to be as wide as possible to allow sun drying of the roadway after rainfall (Schiess and Whitaker, 1986). While there may be some merit in this viewpoint, particularly in heavy clay soil conditions, most of the problems in achieving a stabilized road surface can usually be attributed to poor water management, lack of adequate compaction, and inadequate surfacing of the road (Klassen, 2006). One of the important factors in forest road construction phases is cost analysis of clearing limit. The clearing and piling cost can be calculated by estimating the number of hectares of right of way to be cleared and piled per kilometer of road (Sessions, 2007). The clearing and piling. Most studies of large-scale linear clearings in roads and power lines have focused on determining their effects on the distribution and abundance of wildlife species in the adjacent habitat. Moreover many studies have been conducted about the technical parameters of clearing limit, whereas the influence of clearing limit on vegetative parameters has not been. So, this study attempts to compare the standard clearing limit with existence status and assess the effects of the application of improper clearing limit on forest stock growth including trees density and volume per hectare.

## MATERIALS AND METHODS

### Study area

Vaston forest with an area of 1611 ha is located in watershed number 71 and in north of Iran. The latitude, longitude and elevation ranges of this forest are 36° 02′ 18″ to 36° 18′ 13″ N and 53° 06′ 52″ to 53° 10′ 55″ E and 300-1010 m at sea level, respectively. The main woody species in Vaston are *Fagus orientalis Lipsky*, *Ulmus glabra* Huds, *Acer velutinum* Boiss, *Carpinus betulus*, *Parottia persica* and *Alnus subcordata L*. The dominant species in our research area is *Fagus orientalis Lipsky*. Herbaceous vegetation in the forest encompasses Asperula (*Asprula odorata*), Ferfion (*Ephorbia sp.*), Metumeti (*Hypericum androseamum*) and fern (*Polystichum sp*.). The study area includes 27 compartments and 17.2 km forest roads. These roads were planned only based on hillside slope parameter and then constructed in year of 1993. The mean annual air temperature is 17.1°C. The region receives 724 mm of precipitation annually. The forest type in the study area is deciduous uneven aged irregular mixed forest dominated by beech and horn-beam. In these forests, cutting regime and silvicultural method were selection system and cuts were done as group-selection and single-tree selection. In our study area the general slope of the hillside is less than 30% (Anonymous, 2004) (Figure 1).

The bedrock is marl, calcareous sandstone and limestone. The forest has three types of soil consisting of non-developed randzin, forest washed brown soil and forest brown soil. The study area has three soil sub-unit consisting of 1.5.2 soil sub-unit 2.5.2 soil sub-unit and 1.5.3 soil sub-unit. The bedrock origin in 1.5.2 sub-unit is marnlime and sandstone lime; Soil type in 2.5.2 sub-unit is brown waterworn with calcic lyer and the bedrock origin in it is lime, sand lime and siltymarn; The bedrock origin in 1.5.3 sub-unit is lime, marn, siltyand limestone (Figure 2).

### Data collection

Road routes were also collected with track mode by GPS MAP 76CSX. The standard design of clearing limit was determined based on soil texture and hillside gradient (Sarikhani and Majnonian, 1994). For produce slope steepness map digital elevation model (DEM) was generated from 1:25000 map 2d 3d in GIS software (Arc Map 9.3) and from surface analysis. The slope map divided in seven classes; from 10% slope to 60% divided in sex classes and from 60% to maximum slope divide in one class (Sarikhani and Majnonian, 1994) (Figure 3).

According to soil map and forestry plan booklet data the digital layer of soil sub-units were produced. The track status of road in different slope classes of soil sub-units was determined by overlaying road map and soil sub-unit map. To be able to investigate the effects of soil texture on determining standard clearing limit of road right of way, the soil samples number were determined according to the length of roads which have passed from each slope classes. According to this approach 39 samples were taken to analyse soil texture. After determining soil texture, appropriate cut and fill slopes were appointed for each soil texture. Appropriate cut and fill slopes determination was based on soil stability. In this research roadbed width was spotted 7.5 m for main road and 5.5 m for secondary road ((Sarikhani and Majnonian, 1994). Then 17 clearing limit samples were taken for each of the slope classes. AutoCAD 2010 software was used to design the map of clearing limit in road right of way. Number of trees per hectare and stand volume per hectare was extracted from the forestry plan booklet. The study was established as a randomized complete block design with two type blocks (slope classes and soil type) and treatments (main road, secondary road and soil sub-units). All data were subjected to analysis of variance (ANOVA) using the GLM procedure in SAS software (SAS Institute Inc. 2000). Wherever treatment effects were significant the Duncan test at probability level of 5% was carried out to compare the means. The graphs drawing were done in excel software.

## RESULTS AND DISCUSSION

The fill and cut hillsides appropriate slope for each soil type of road route in our study area show at Table 1 (standard table).

Soil texture along forest road were divided into three groups, clay, silty-clay and silty soils. The standard clearing limit for clay soil was determined 8.5 m. For

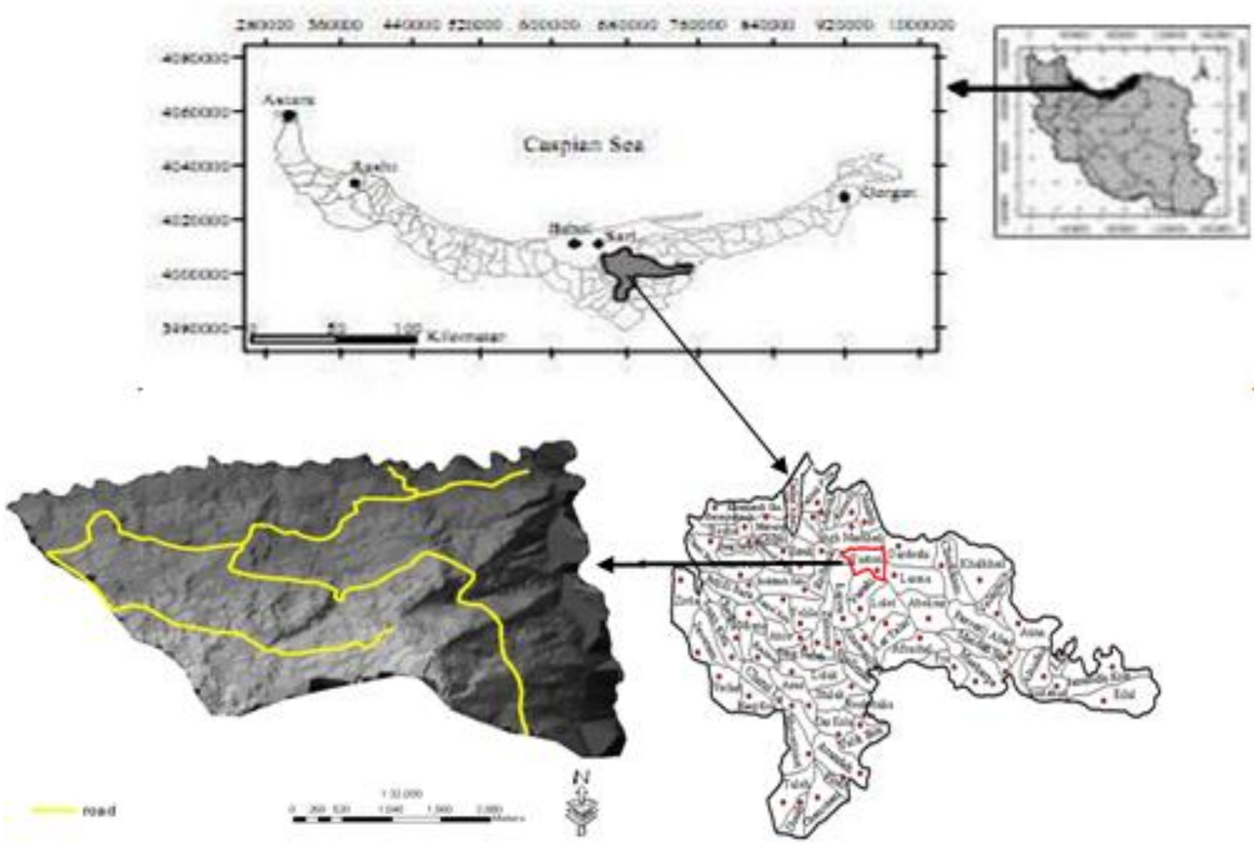


**Figure 1.** The geographical position of the study area.

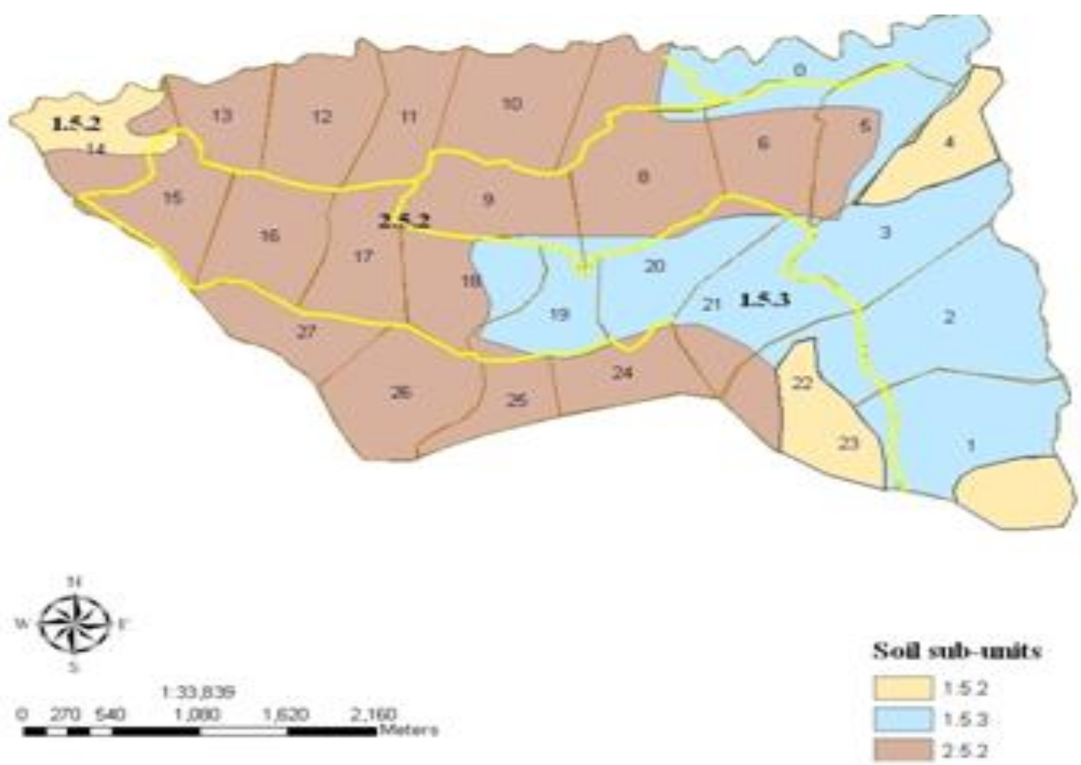


**Figure 2.** The map of soil sub-units in study area.

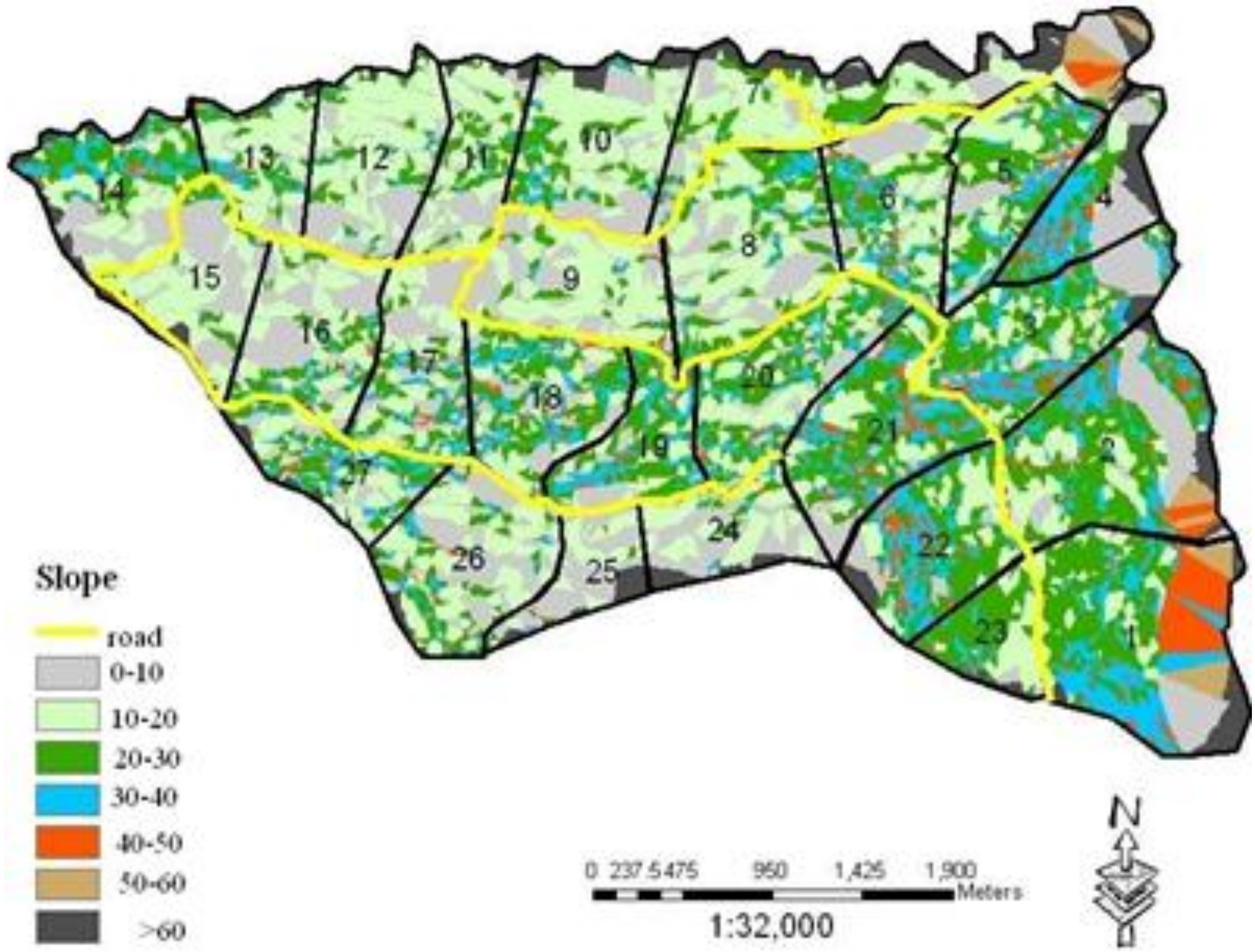


**Figure 3.** The map of slope classes in study area.

**Table 1.** Fill and cut hillsides appropriate slope for each soil type of road route.

| Soil texture \ Determined slope | Cut slpe (%) | Fill slope (%) |
|---|---|---|
| CL (clay) | 66 | 70 to 80 |
| SL (silty-loam) | 60 to 70 | 80 |
| SCL (silty-clay) | 50 | 80 |

silty-clay and silty soils the standard clearing limit was determined 10.5 m. The present study clearly demonstrated that the difference between standard and existing clearing limit were influenced not only by the road type but also by the soil sub-units. Nevertheless, the effects of independent parameters on existing clearing limit were not statistically significant. There were significant differences between the standard and existing trees stock growth (density and volume per hectare) in response to road type and soil sub-units (Table 2).

The difference between standard and existing clearing limit in secondary forest road was significantly higher than that in main forest road. Moreover the difference between standard and existing trees stock growth in

**Table 2.** Analysis of variance for the clearing limit and stock growth parameters.

| Parameter | Source | DF | SS | MS | F value | Pr > F |
|---|---|---|---|---|---|---|
| Existing clearing limit (ECL) | Road | 1 | 11.62 | 11.62 | 1.06 | $0.33^{ns}$ |
| | Soil sub-units | 2 | 11.19 | 5.59 | 0.51 | $0.62^{ns}$ |
| | Slope | 6 | 73.09 | 12.18 | 1.11 | $0.43^{ns}$ |
| | Soil texture | 2 | 2.51 | 1.25 | 0.11 | $0.89^{ns}$ |
| Difference between standard and existing clearing limit (DSEC) | Road | 1 | 6.54 | 6.54 | 5.25 | $0.05^{*}$ |
| | Soil sub-units | 2 | 16.90 | 8.45 | 6.78 | $0.01^{**}$ |
| | Slope | 6 | 19.05 | 3.17 | 2.55 | $0.11^{ns}$ |
| | Soil texture | 2 | 2.27 | 1.14 | 0.91 | $0.43^{ns}$ |
| Difference between standard and existing trees density (DSED) | Road | 1 | 164279.9 | 164279.9 | 5.62 | $0.04^{*}$ |
| | Soil sub-units | 2 | 448494.1 | 224247.0 | 7.67 | $0.01^{**}$ |
| | Slope | 6 | 539680.0 | 89946.7 | 3.08 | $0.07^{ns}$ |
| | Soil texture | 2 | 212523.9 | 106261.9 | 3.64 | $0.07^{ns}$ |
| Difference between standard and existing trees volume (DSEV) | Road | 1 | 491595.1 | 491595.1 | 6.98 | $0.03^{*}$ |
| | Soil sub-units | 2 | 1127618.4 | 563809.2 | 8.00 | $0.01^{**}$ |
| | Slope | 6 | 1401543.9 | 233590.7 | 3.32 | $0.06^{ns}$ |
| | Soil texture | 2 | 126060.1 | 63030.1 | 0.89 | $0.45^{ns}$ |

*****: Significant at probability level of 5%, ******: significant at probability level of 1%, ns: non-significant, DF: degree of freedom, SS: sum square, MS: mean square, F value: F quantity, Pr>F: significant level.

secondary forest road was significantly higher than that in main forest road. The difference between standard and existing trees density in silt soil was significantly more than that in silt clay and clay soils. The difference between standard and existing clearing limit as well as the difference between standard and existing trees stock growth in different slope classes and soil sub-units was significant (Table 3).

Kachenderfier (1970) suggested that the road width in steep slopes must be constructed less than that in gentle slopes to reduce earth working width and clearing area. This may cause decrease in fill slope length and increase erosion rate (Artour et al., 1998). If the clearing limit is determined less than standard design, the road structure would damaged by the dangerous and troublous trees. Besides, if the clearing limit is determined more than standard design, the trees growth at the edge of forest road would decrease by weather warming and cold (Mirzaei, 2004). Results showed that there was no significant relationship between difference of standard and existing clearing limit and existing clearing limit ($p>0.05$; $r = 0.005$). There was no significant relationship between difference of standard and existing trees density and existing clearing limit ($p>0.05$; $r = -0.084$). Difference between standard and existing trees volume increased significantly as difference between standard and existing trees density increased ($P<0.01$; $r=0.839$) (Table 4).

## Conclusions

Increasing the clearing limit of forest road increases the amount of environmental damages and sediment yield from earth working area to ditch through soil creep, sheet wash and slumping.

**Table 3.** Comparison of the means of parameters in different classes based on Duncan's multiple range tests.

| Source | Classes | Existing clearing limit (ECL) | Difference between standard and existing clearing limit (DSEC) | Difference between standard and existing trees density (DSED) | Difference between standard and existing trees volume (DSEV) |
|---|---|---|---|---|---|
| Road | Main road | 23.54$^{A}$ | 0.35$^{B}$ | 89.50$^{B}$ | 107.10$^{B}$ |
| | Secondary road | 19.88$^{A}$ | 1.11$^{A}$ | 228.40$^{A}$ | 304.70$^{A}$ |
| Slope (%) | 0 to 10 | 18.15$^{A}$ | 0.67A$^{B}$ | 117.4BA$^{C}$ | 181.3B$^{A}$ |
| | 10 to 20 | 19.55$^{A}$ | 2.75$^{A}$ | 482.4$^{A}$ | 723.2$^{A}$ |
| | 20 to 30 | 24.46$^{A}$ | 1.07A$^{B}$ | 173.5$^{BAC}$ | 321.2$^{BA}$ |
| | 30 to 40 | 18.05$^{A}$ | 0.30A$^{B}$ | 416.9$^{BA}$ | 88.7$^{B}$ |
| | 40 to 50 | 19.14$^{A}$ | 0.17$^{B}$ | 28.4$^{C}$ | 46.0$^{B}$ |
| | 50 to60 | 20.11$^{A}$ | 0.04$^{B}$ | 4.7$^{C}$ | 10.9$^{B}$ |
| | More than 60 | 22.65$^{A}$ | 0.48A$^{B}$ | 79.5$^{BC}$ | 153.6$^{BA}$ |
| Soil sub-units | 1.5.2 | 19.00$^{A}$ | 0.08$^{A}$ | 15.20$^{B}$ | 26.00$^{B}$ |
| | 2.5.2 | 19.37$^{A}$ | 1.75A$^{B}$ | 381.90$^{A}$ | 458.00$^{A}$ |
| | 1.5.3 | 21.60$^{A}$ | 0.75$^{B}$ | 143.30$^{AB}$ | 221.70$^{AB}$ |
| | | | 1.34$^{A}$ | 239.3$^{B}$ | 357.7$^{A}$ |
| Soil type | CL (clay) | 19.45$^{A}$ | 0.75$^{A}$ | 121.1$^{B}$ | 218.5$^{A}$ |
| | SCL(silty clay) | 21.57$^{A}$ | 0.33$^{A}$ | 786.8$^{A}$ | 96.0$^{A}$ |
| | SL(silty loam) | 17.76$^{A}$ | | | |

In a same column, values with same superscript are not significantly different at 5% level based on Duncan's test.

**Table 4.** Pearson correlation coefficients among dependent variables.

| No. | Variables | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 1 | Existing clearing limit | 1 | | | |
| 2 | Difference between standard and existing clearing limit | 0.005 | 1 | | |
| 3 | Difference between standard and existing trees density | -0.084 | 0.841*** | 1 | |
| 4 | Difference between standard and existing trees volume | 0.026 | 0.996*** | 0.839*** | 1 |

*****: is significant at probability level of 0.1%.

This study proved that the difference between standard and existing clearing limit were affected not only by the road type but also by the soil sub-units. The difference between standard and existing clearing limit in secondary forest road was significantly more than that in main forest road. Difference between standard and existing trees volume increased as difference between standard and existing trees density increased.

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