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Road effect on diameter growth of trees in Caspian forests of Iran

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ABSTRACT

Forest roads are the most important elements of forestry projects, the management, supervision, care, and only access way to the forest for mechanized harvesting and using other services of forests. The aim of this study was to compare the current annual increment of basal area in different distances from the road in northern forests of Iran. For this purpose, 50 plots were established in 5 distance classes (0-10, 10-20, 20-30, 30-40, and 40-50 m) on the 10 perpendicular transects to the forest road. In each plot current annual increment of basal area of 6 trees were measured by trunk core samples. Results of ANOVA test showed that there is no significant difference among the current annual increment of basal area in different distance classes from the roads. The results also showed that with increasing of distance from the roads into forest interior, current annual increment of basal area were reduced. The UNIANOVA test showed that there was a significant difference between interaction distance classes and diameter classes on current annual ring and diameter increment ($p = 0.00$).

Key words: Adjacent Stand, Increment of Basal Area, Transect, Tree Diameter Growth.

INTRODUCTION

The management of forests is integrally connected with the ability to access the stand via strip roads. The presence of which is crucial to the effective and balanced management of stands. Creating strip roads is an interference within an ecosystem which may lead to the creation of side effects characterized by a change in the tree microclimate as well as a disruption in the growth and development of trees and it may even lead to the disruption of the integrity of the stand ecosystem (Buckley *et al*. 2003; Delgado *et al*. 2007; Bembenek *et al*. 2013). The strip road in forest ecosystems cause the reduction and redistribution of organic matter, changes in plant cover, organic layer and soil properties, and modification of microclimate (Buckley *et al*. 2003). Roads cause soil disturbance on the road itself and due to road building activities in adjacent areas (Bolling & Walker 2000). Soil disturbance can be relatively high, adversely affecting tree growth over the cross section of the skid road (Yilmaz *et al*. 2010). Disturbances can extend variable distances beyond the road gap (Delgado *et al*. 2007) and microclimate edge effects have been shown to extend to the surrounding habitats from only a few meters up to hundreds of meters (Forman *et al*. 2002). Mader (1987) reported that changes in plant and animal diversity occur up to 30 m from the road edge into the adjacent forest. Yilmaz *et al.* (2010) was investigated the skid road effects on annual ring widths and diameter increment of fir trees in Turkey. The results showed that tree growth and increment on the undisturbed area was greater (about 60%) than the skid road. Edge effects can reduce the area of interior habitat by changing species composition, temperature, moisture, light availability and wind speed (Chen *et al*. 1999; Euskirchen *et al*. 2001; Delgado *et al*. 2007). The reaction of the trees to the creation of strip roads can be different depending on age and species (Bembenek *et al.* 2013). Light is a crucial resource for trees growth (Muth & Bazzaz 2002). The natural reaction of trees to increasing of sun light is increased growth. This can be seen as an excessive average rate of growth. Many factors influence trees growth along roadside, including site characteristics (such as slope, aspect, elevation, moisture, soil properties, and microclimatic factors), and stand characteristics (such as species composition, stand age, live crown proportion, crown cover, stocking, and overall health). Of course, the increasing of light can lead to defects in the structure of the tree *(*Bembenek *et al. 2013)*. The felling of trees in order to make a strip road creates better growing conditions for adjacent vegetation. The decrease in competition among trees along the edge may results in larger crowns, increased diameter growth, and thereby, increased volume. Unfortunately, yet little attention has been paid to the associated edge effects of roads in the landscapes in which they are embedded. Therefore, the estimation of the road edge effect for trees growth is a useful tool to assess the amount of territory that is functionally affected by the road network (Forman & Deblinger 2000). The aim of this study was to compare the current annual increment of basal area in different distances from the road in the northern forests of Iran.

MATERIALS AND METHODS

Study area

This research was conducted in June 2012 in the Shenrood forest, Guilan Province, northern Iran (36° 59'N and 37° 1'N and 50° 3'E and 50° 7'E). The study area was composed of deciduous trees dominated by oriental beech, *Fagus orientalis* Lipsky, and common hornbeam, *Carpinus betulus* L. along with Caucasian alder, *Alnus subcordata* (C.A.M) and chestnut-leaved oak, *Quercus castaneifolia* (C.A. Mey) as companion species, with a canopy cover of 85%, a stand density of 180 trees.ha^{-1}, an average stand basal area of 14.94 m^2.ha^{-1}, and an average height of 21.83 m. The elevation of the study area is between 700-1000 m above sea level with and an average annual rainfall of 1200 mm recorded at the closest national weather station. The maximum mean monthly rainfall of 120 mm usually occurs in October, while the minimum of 25 mm occurs in August. The mean annual temperature is 15 ^{o} C, with the lowest values in February. The management in the district is mixed un-even aged high forest, with single and group selective cutting regime. Forest roads are categorized as permanently main forest roads used for trucking, with an average width of 6.5 m, longitudinal slope 3 to 8% and current forest road density is 11.46 m.ha^{-1}. Ground skidding using wheeled cable skidders (Timber Jack 450C, 174 hp and 12 tn) is the most common method of wood extraction in this mountainous, uneven aged hardwood forest. The soil class of our study area was classified as Cambisol according to the World Reference Base (WRB). The study site was established in mature forest on a clay loam soil. The average depth of soil to the bedrock ranged from 60 to 90 cm. This area is susceptible to erosion due to their steep mountainous conditions, heavy rainfall, and marl and limey sandstone sediments. Marls, due to their special constitution (35% lime and 65% clay), have low infiltration capacities and thus are susceptible to intense run-off and erosion. Soil protection and productivity are problematic on such sites.

Methods

In this study, transects were constructed at right angle from the road edge to the forest interior. In total, 10 transects were established in the study area (5 in upslope, and 5 in downslope). Transects were set up perpendicular to the road, and extended from the road edge to 50 m into the forest interior with 50 m distance between those. Finally, 50 plots (5 m × 50 m) were established in five points on the transects at distances of 10, 20, 30, 40 and 50 m from the road edge into the forest interior as plot center (Fig. 1). In each plot, dbh, tree height and trunk core samples were measured using steel increment borer. At each plot, six trees were examined. The core samples were selected in the direction that was perpendicular to the area slope. Five diameter classes were determined including: Class 1: 30 cm; Class 2: 35 cm; Class 3: 40 cm; Class 4: 45 cm; and Class 5: 50 cm. Tree core samples were dried in paper roles for a couple of days and glued onto wooden laths with two grooves of 5 mm. The cores were sanded with fine sandpaper until the rings were visible under a magnifying glass. Parts of the cores with very dense rings were cut with a sharp knife and brushed with powder to make the rings clearer. Annual ring widths and bark thicknesses of tree core samples were measured to within 0.007 μm accuracy. Annual ring growth values were calculated by averaging ring widths from those cores. We multiplied by two the annual tree ring widths to calculate dbh growth and increment values.

Statistical Analysis

One-way and Two-way ANOVA tests were used to assess the significance of observed differences in average basal area increment under different distances from the forest roads, different tree diameter classes, and to assess the significance of interaction effects.

One-way ANOVA (significance test criterion $\alpha \leq 0.05$) was performed on the data, and Tukey's HSD test was used to compare the basal area increment among the five distance from forest road and five diameter classes (main effects). All statistical calculations were performed using SPSS version 11.5.

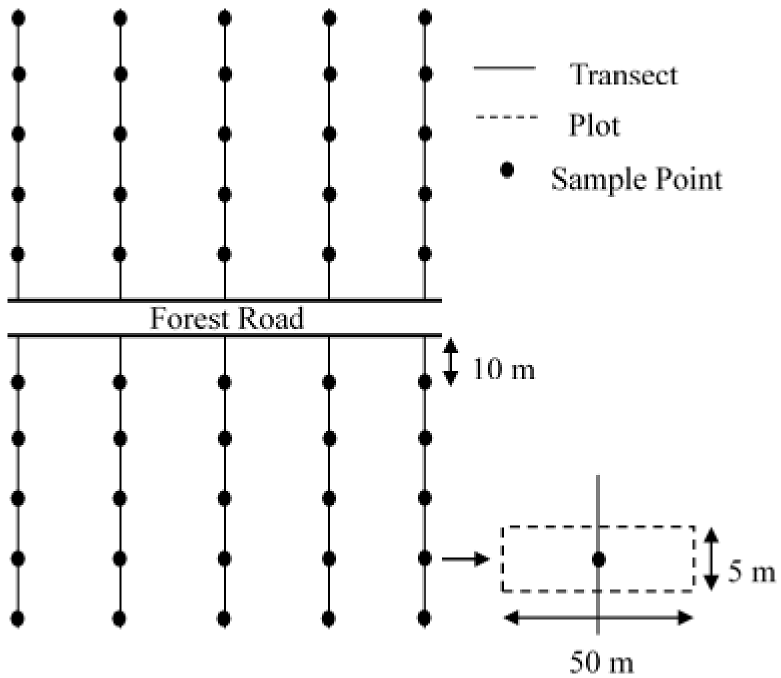


Fig. 1. Sketch of the treatment set-up with the location of the sample point and the plots.

RESULTS AND DISCUSSION

Basal area increment

The analysis of variance (ANOVA) tests showed that there was no statistical significant difference among the current annual basal area increment in different distance classes from the roads (Table 1). Results showed that by increasing the distance from the roads, the current annual basal area increment was reduced. The highest annual basal area increment was measured in the distance class of 0-10 m, while the lowest was measured in the class of 40-50 m (Fig. 2).

The results of ANOVA test showed that there is a significant difference between the averaged current annual basal area increments in different diameter classes (Table 2). So that, current annual basal area increment was increased by increasing the diameter classes. The highest basal area increment was found in fifth diameter class (50 cm), while the lowest was found in the first one (25 cm) (Fig. 3).

The results of UNIANOVA test showed that there is a significant difference in interaction between distance and diameter classes on the current annual basal area increment. The results are shown in Table 3.

Table 1. Results of ANOVA test for basal area increment in different distances from the forest roads.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	40.65	4	10.16	0.47	0.76[ns]
Within Groups	978.77	45	21.75		
Total	1019.42	49			

ns: Not significant at the 0.05 probability level.

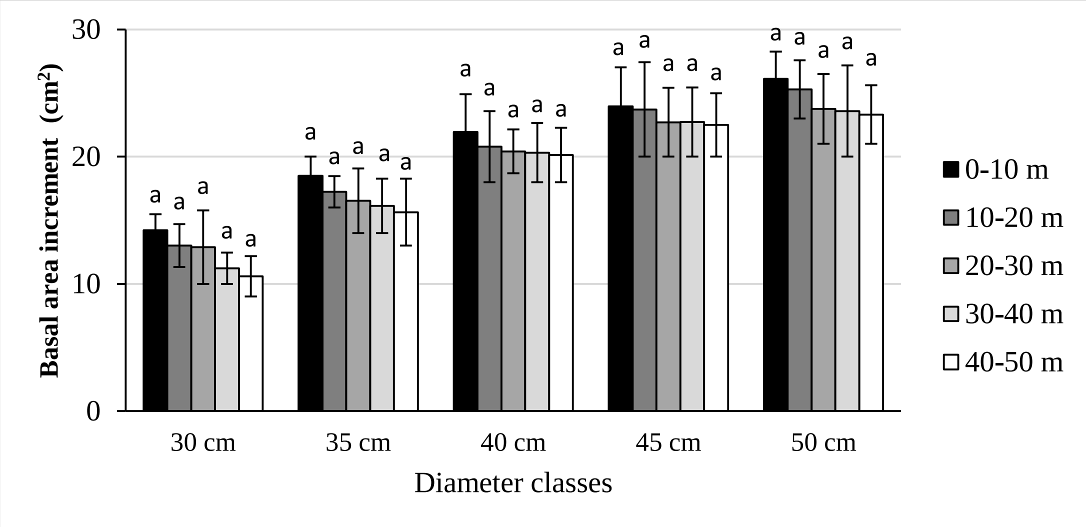


Fig 2. Basal area increment in the different diameter classes.

Table 2. Results of basal area increment compared for each distance classes.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	965.30	4	241.32	200.66	0.000*
Within Groups	54.12	45	1.20		
Total	1019.42	49			

Marked by an asterisk: statistically significant at the 0.05 probability level.

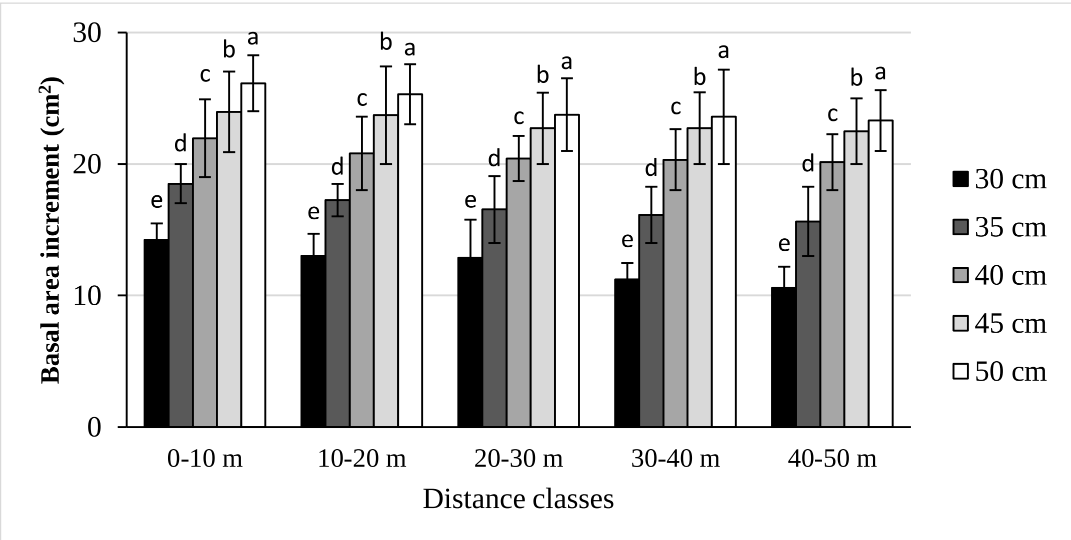


Fig. 3. The basal area increment in different distance classes.

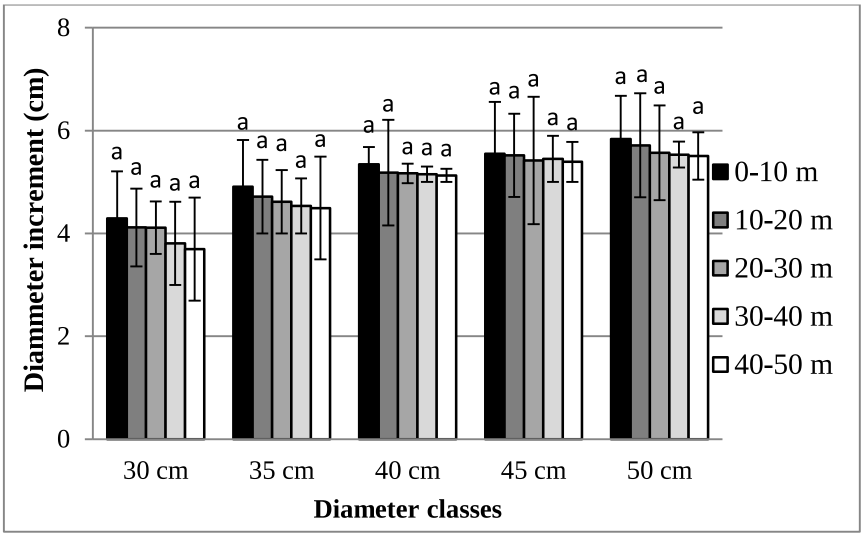
Table 3. Results of interaction between distance and diameter classes on the current annual basal area increment.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1539.39[a]	24	64.14	337.08	0.000*
Intercept	28824.38	1	28824.38	151479.56	0.000*
Distance	61.33	4	15.33	80.58	0.000*
Diameter	1467.57	4	366.89	1928.11	0.000*
Distance * Diameter	10.50	16	0.66	3.45	0.000*
Error	9.51	50	0.19		
Total	30373.29	75			
Corrected Total	1548.91	74			

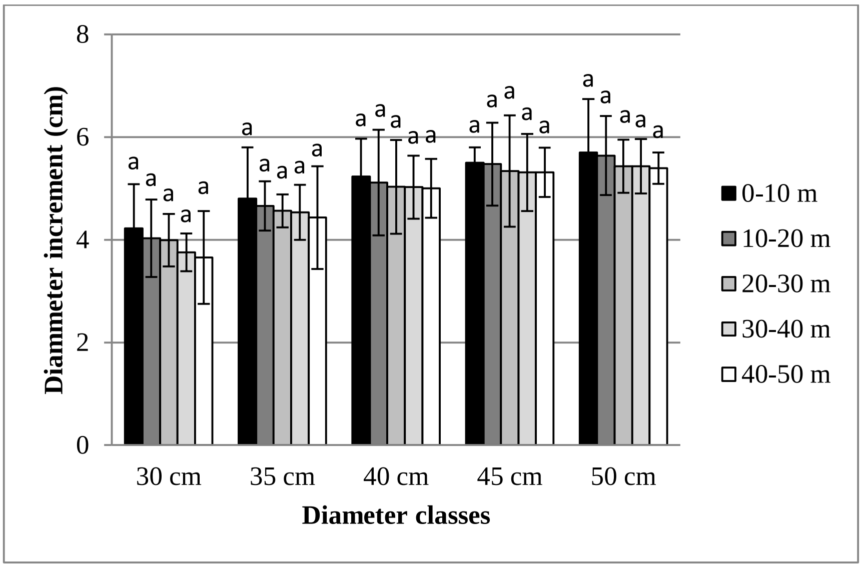
Marked by an asterisk: statistically significant at the 0.05 probability level.

Diameter increment

The results showed that there is no significant difference among the current annual diameter increment in different distance classes from the roads. The results showed that with increasing distance from roads the current annual diameter increment were reduced in the both slope (uphill, Fig. 4a; and downhill, Fig. 4b). In other words, the higher diameter increment was observed in the distance class of 0-10 m, while the lower found in the class of 40-50 m from the road (Fig. 4).



(a)

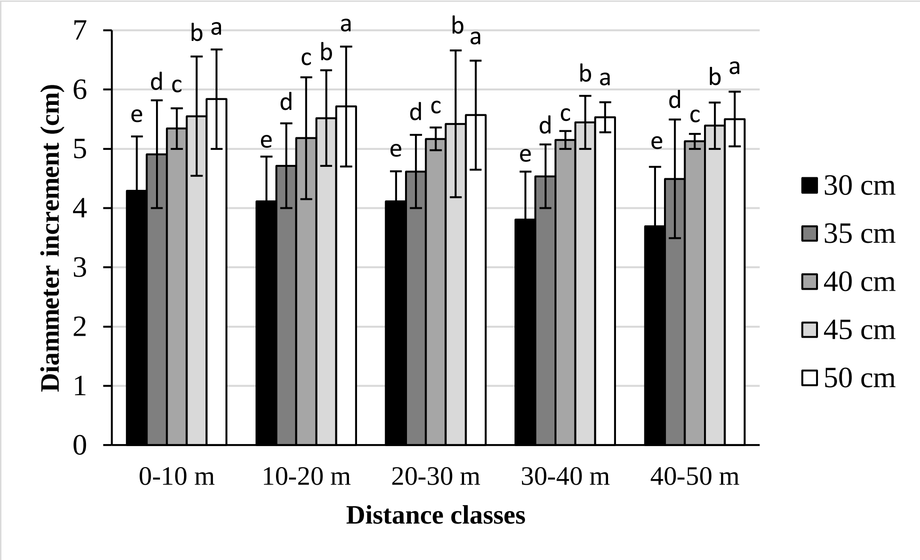


(b)

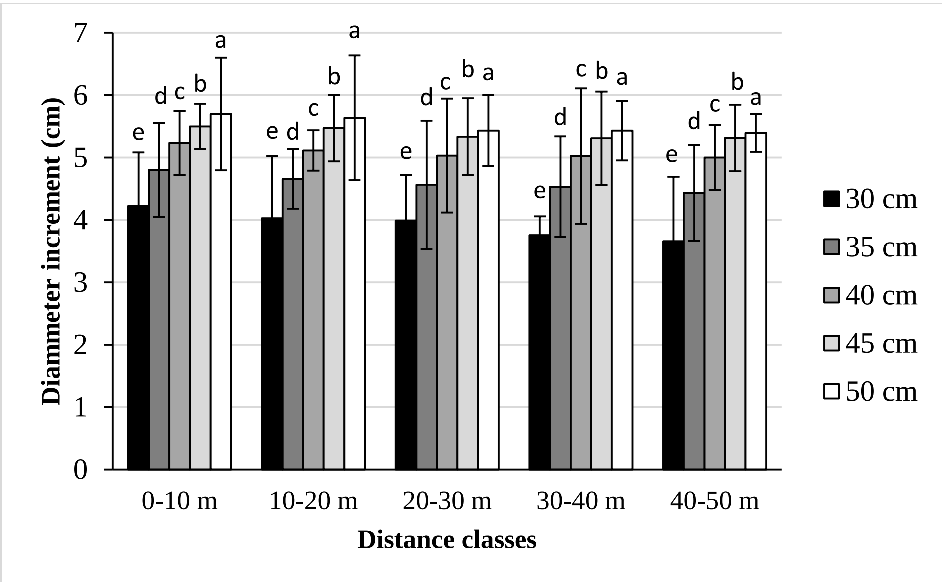
Fig. 4. Diameter increment in the different diameter classes. a) Uphill slope, and b) downhill slope.

The comparison between current annual diameter increment and different diameter classes showed significant difference (One-way ANOVA, p≤0.5) (Table 1). Also the results showed that current annual diameter increment was increased by increasing in diameter classes.

The higher diameter increment was found in the fifth diameter class (50 cm) while the lower found in the first one (25 cm) (Fig. 5).



(a)



(b)

Fig. 5. Diameter Increment in different diameter classes. a) Uphill slope, and b) downhill slope.

This research was investigated road effects of the different distance and diameter classes on the current annual basal area increment in a mixed beech stand in the northern forests of Iran. There was no significant difference among the current annual basal area increment and diameter growth in different distances from forest road (Table 1). The averaged current annual basal area increment was reduced in five distance classes (0-10, 10-20, 20-30, 30-40 and 40-50 m into forest interior) respectively (Fig. 2). The reason for the increasing of basal area increment by decreasing trees distance from the forest road was receiving more sunlight to them, due to forest canopy opening in forest road. According to Kramer (1936) increasing roadside trees growing (diameter) within 8 meters far from road, has been enough to offset the decline in growth of felled trees on the road, which also approved by Cohen *et al.* (1983) and Mirzaei (2004). Shahnazari (2006) stated that the difference of stock between roadside and adjacent stands was about 31.54 m^3 and showed that after road construction and opening the site (increasing light), increasing of volume in roadside stands was about 3.15 m^3 per year. Mirzaei (2004) stated that the growing basal area of trees in two 5-years (5 years after and 5 years before the road construction) was 6.11% and 14.35% respectively.

In this study, the results of ANOVA test showed that there was a significant difference between the current annual basal area increments in the different diameter classes (Table 2). The results showed that by increasing the diameter classes, the averaged current annual basal area increment was increased. The results of interaction among distance and diameter classes on the current annual basal area increment showed that there was a significant difference (Table 3). Cancino (2005) measured 9 to 25 m impact zone influenced by the road. McDonald and Urban (2004) showed that at the distance of 5 m from the road, the average canopy cover is 5% lower than it is averagely inside the stand but the average of increasing growth (dbh) in this distance for all species were more than its value for inner parts and with increasing distance from the road, increment change trend remained constant. Yilmaz *et al.* (2010) showed that tree growth and increment on the undisturbed area was greater (about 60%) than the skid road in the forests of Turkey.

CONCLUSION

Road construction requires the allocation of part of surface to the earthwork. So undoubtedly some potential of actual production will be reduced. However, the growing of trees bordering the road can reduce the volume increment percentage of felled trees on the way. The results of the study regarding to annual increase in basal area compared with distance from road revealed that the increasing the distance from the road, the reducing the annual growth rate of trees. In other words, the highest level of basal area has been found at 10 meters away from the road. As shown in Fig. 4, trees with high diameter in the edge of forest roads have higher rate of annual growth in term of basal area. In other words, at different distances from the road, trees with a diameter of 50 cm had higher rate of annual growth in basal area compared to trees with a diameter of 30 cm.

Finally, this study showed that forest roads have a great impact, directly or indirectly, on the surrounding environment.

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تاثیر جاده برروی میزان رویش قطری درختان راش در جنگل‌های هیرکانی ایران

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چکیده

جاده‌های جنگلی یکی از مولفه‌های مهم طرح‌های جنگل‌داری برای مدیریت و حمایت جنگل و هم‌چنین تنها ابزار دسترسی به جنگل برای عملیات بهره‌بردای به روش مکانیزه هستند. این تحقیق به منظور مقایسه رویش سالیانه سطح مقطع درختان در فواصل مختلف از جاده‌ها در جنگل‌های شمال ایران انجام شد. برای رسیدن به این هدف، درختان ۵۰ پلات در ۵ کلاسه فاصله از جاده (۱۰-۰، ۲۰-۱۰، ۳۰-۲۰، ۴۰-۳۰ و ۵۰-۴۰) مورد اندازه‌گیری قرار گرفت. در هر پلات رویش سالیانه سطح مقطع محاسبه شد. نتایج به دست آمده نشان داد که با افزایش فاصله از جاده میزان رویش سطح مقطع کاهش پیدا کرد، هم‌چنین بین کلاسه‌های مخلتف فاصله از جاده و میزان رویش اختلاف معنی‌دار وجود دارد. نتایج آزمون UNIANOVA نشان داد که بین فواصل مختلف از جاده و رویش جاری سالیانه کلاسه‌های قطری احتلاف معنی دار است($p=0.00$).

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