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ANNUAL RING GROWTH OF CASPIAN ALDER IN THE FOREST ROAD EDGES

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Abstract

Three northern forest sites of Iran viz., Neka, Paved; Amreh and Darabkola, unpaved roads were selected to determine the edge effects of forest roads on the annual ring growth of alder trees (*Alnus glutinosa*). The thickness of annual rings, bark and height of trees were measured. The sampled trees were located in upward and downward of roads along one kilometer length of road. Statistical method and sample selection with the fixed area were used to measure diameter and height of selected trees. Core samples of alder tree were taken by borer in order to investigate the effect of different conditions including road-making operations on thickness of annual rings and its bark. The result showed that the average growth of alder trees in the front edge of roads was less than those were in the back of the road. Average of bark growth in the front edge of road was less than that it in the back. Also, the result of this study revealed negative effect of the paved forest road was more than that of unpaved forest roads. The research showed that the growth of alder in the edge of forest roads (Neka, Amreh and Darabkola in northern forest of Iran) as a main factor and the given samples from either back or front of the roads as secondary factor were considered. Conclusion of this study revealed that the average annual growth of rings in paved road was less than those in unpaved roads.

Introduction

Roads have become a prominent landscape feature that we use daily and in almost every environment imaginable (Forman & Alexander, 1998). Yet little attention has been paid to the associated edge effects of roads in the landscapes in which they are embedded. Historically, researchers have limited their interest in the edges to borders between two different ecosystem types, such as forests and fields or clear cuts (Franklin & Forman, 1987), but interest in edges associated with power-line corridors and roads is increasing (Pickett & White, 1985; Luken *et al*., 1991; McIntyre & Lavorel, 1994; Reed *et al*., 1996).

Forest roads can be defined as ecosystems because they occupy ecological space (Hall *et al*., 1992). They have structure, support a specialized biota, exchange matter and energy with other ecosystems, and experience temporal change. Forest road ecosystems are built and maintained by people (Haber, 1990). Forest road ecosystem includes both the paved and unpaved rights of way and adjacent structure, including other infrastructure, ditches, drainage features, and other components that provide the means for vegetation to establish and provide habitat for associated plants and animals (Lugo & Gucinski, 2000). Furthermore, edge effects can reduce the area of interior habitat by changing species composition, temperature, moisture, light availability and wind speed (Gysel, 1951; Chen *et al*., 1992, 1995; Euskirchen *et al*., 2001). Edges often have higher species richness and greater numbers of exotic species (Ranney *et al*., 1981; Brothers & Spingarn, 1992), potentially altering ecosystem processes and functions such as productivity near the edge (Laurance *et al*., 1997). Changes in plant and animal diversity occurring up to 30 m from the road edge into the adjacent forest (Mader, 1987).

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Roads may be the first point of entry for exotic species into a new landscape. Road can also serve as a corridor along which plants move farther into the landscape (Greenberg *et al*., 1997; Lonsdale & Lane, 1994). Roadsides contain few regionally rare species but have relatively high plant species richness (Bennett, 1991). Disturbance-tolerant species predominate, especially with intensive management, adjacent to highways, and exotic species typically are common (Tyser & Worley, 1992).

Roads cause soil compaction on the road itself and due to road building activities in adjacent areas (Guariguata & Dupuy, 1997; Bolling & Walker, 2000). Soil compaction influences the succession of vegetation communities developing on roadsides or abandoned roads as increased compaction, commonly suppresses plant growth (Guariguata & Dupuy, 1997; Olander *et al*., 1998; Bolling & Walker, 2000). Compaction mainly affects plant root growth, soil water availability and percolation. Root growth decreases with reducing of soil density and soil oxygen infiltration (Schwab *et al*., 2004). The increasing use of heavy machinery is the major cause of soil and subsoil compaction (Horn *et al*., 2000).

Reduced growth of vegetation in roadfill habitats was related to increased soil compaction and decreased nitrogen availability and organic matter. These factors were also implicated in altered floristic composition of roadside communities, in which the abundance of monocot species was increased and the recruitment of natives significantly reduced (Olander *et al*., 1998). As soil compaction increased, the dry mass of shoots and roots, root length and P accumulation in shoots and roots decreased (Nadian *et al*., 2005). Grasses were more sensitive to this problem than leguminous plants (DaSilva & Rosolem, 2003). The least limiting water range index very useful in evaluating tree growth on disturbed soils in South Carolina because air–water balance and soil physical properties were important for explaining response of tree growth to compaction (Kelting *et al*., 2000).

We examined the edge effects of paved and unpaved forest roads within a hardwood landscape in the Mazandaran Natural Forest at the north of Iran. The objective of this study was to compare back and front annual wood ring and bark growth of alder (*Alnus glutinosa*) in front and back of the trees at upward and downward margin of paved and unpaved forest roads.

Materials and Methods

In order to investigate the edge effects of road, three sites (unpaved roads in Amreh, Darabkola and paved road in Neka forests) having the considered features were selected (Fig. 1). One of the features is the existence of forest road whether unpaved or paved road into the stand. So, the situation of these sites considering longitude, latitude and elevation above sea level is determined by GPS. All physiographical conditions in selected roads were the same (Table 1).

Sampling with fixed area plots: In this research, sampling area was circularly taken with 10,000 square meters within the above forest sites. The selected road had one km. There is a point on the road as a start point and a sign in the middle of the road with 50 meter distance from the start point. There was generally taken 10 plots in each road (Fig. 2).

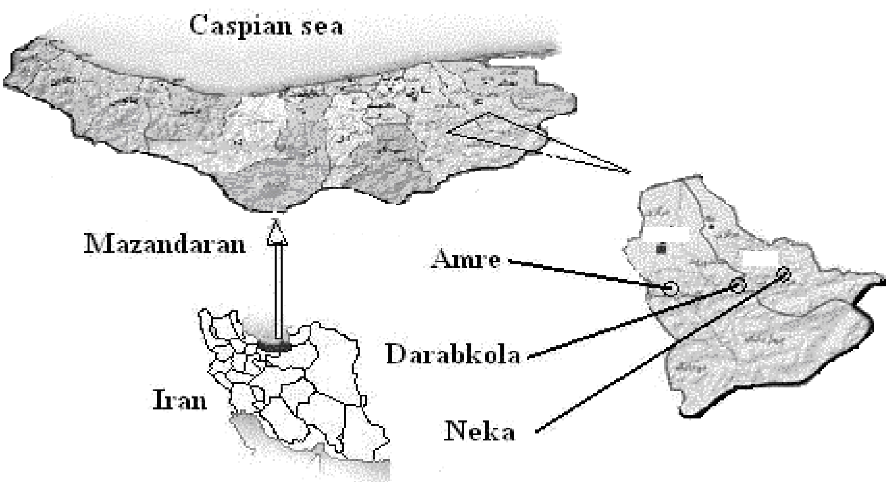

Fig. 1. Location of three research sites in this project (Neka, Amre and Darabkola).

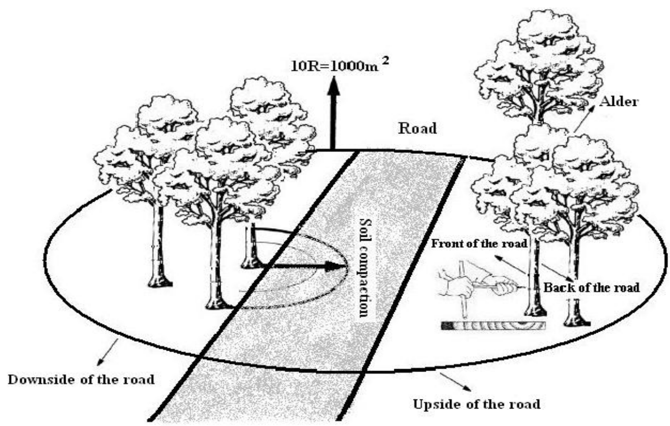

Fig. 2. Sampling design in each plot of ten selected plots in one kilometer of forest roads

Table 1. Sites characteristics (Amreh, Darabkola and Neka)

Forest road	Geographical position	Mean annual temperature range (˚C)	Mean annual precipitation (mm)	Slope (%)	Above sea level (m)
Amreh (Unpaved)	53˚ 55′ to 53˚ 85′ E 36˚ 27′ to 36˚ 25′N	4.2 - 27	848	5-80	260-813
Darabkola (Unpaved)	52˚ 14′ to 52˚ 31′ E 36 33 to 36˚ 34′ N	-3 - 28	750	5-70	300-874
Neka (Paved)	53˚ 30′ to 53˚ 44′ E 36˚ 23′to 36˚ 27′N	4.4 - 28	1110	5-75	290-883

There have been selected 20 trees in upside and 20 trees in downside into the plots. So, these trees could be in the over story and they were in the front of each other at the edge of roads too. Then the trees diameter at breast height (DBH) was measured. Two cores at DBH of trees (one from front of road and the other from back sides of the roads) were sampled. All feature of trees relating to the diameter, the bark thickness, the number, the plot, the direction of the road were measured (upside, downside, back or front of the roads) were labeled on the sampled trees. Eighty cores were taken from each site and generally 240 cores from the three sites. These cores were prepared by sand paper in the open air. After 60 minute washing in the white smith solution, they were dried in the open air and tree ring width was measured.

Data analysis: In completely randomized block design (CRBD) analysis of variance was done for tree rings in back, front, up and downsides of the roads (three sites as a block and growing rings, front and back of the roads as a core). The average thickness of annual rings for each core was determined and compared to each other. The comparisons of growth among the sites were carried out with Tukey test. The average of cores on the back and front and up and down of roads were compared in each tree with pair t-test at the SAS software.

Results

Annual tree ring growth comparison in the up and downside of roads (back and front of the roads) in two sites of Neka and Amreh has been drawn. There were no significant differences in Neka and Amreh roads, but it significantly differed in Darabkola road (Fig. 3). Comparison of average thickness of bark in the up and downside of the roads (back and front of the roads, separately) at the three sites was not statistically significant (Fig. 4).

The growth of alder in up and downside of the roads (back and front of the roads) at Neka (paved) and Amreh (unpaved) sites and also in Darabkola (unpaved) at the upside of the road was significant at 5% level (Fig. 5).

The growth of bark in the up and downside of the road (back and front sides of the road) at Darabkola and Neka sites were not significantly different by comparison with Amreh site in the downside of road (Fig. 6). Paved road of Neka with two unpaved road (Amreh and Darabkola) were compared and results showed that tree ring growth in Neka (paved road) was less than two other sites (unpaved roads) (Table 2, Fig. 7). Bark growth of alder trees in Amreh compared with two other roads showed less average growth (Table 3, Fig. 8).

Discussion

Trees damaged or stressed by road building through direct wounding of stems and roots, covering of roots with side castings or compacting of soil over roots (Shaw & Kile 1991). 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 & Bennett 2004). In our study, tree ring growth, with collected cores from front of road in down and upside and then back of road in down and upside (Fig. 2), in two sites of Neka and Amreh didn’t show any significant differences between these data (Fig. 3). This may have the existence of even conditions such as sunlight, moisture, soil compaction and other climate and edaphic factors. The growth of rings in three sites at downside of the road was less than that of upside. Since, firstly the sunlight in the upside of road was more and secondary the existence of ditch in the upside of the road caused to give more moisture to the cultivated pieces and to increase in the annual tree ring growth. This subject was also seen in Darabkola as it was in the result ($p=0.05$, Fig. 3).

Table 2. Analysis of variance of annual ring growth in the upside=U (back=B and front=F of the roads, together) and downside=D (back and front of the roads, together) and growth average of annual rings.

Dependent variables		Mean square	Error of variance	CV	R^2
Annual rings growth in the edge of the road	FD	1.21^{ns}	0.0459	17	0.26
	BD	1.29^{ns}	0.0521	17	0.35
Annual rings growth in the edge of the road	FU	1.36^{*}	0.0606	18	0.51
	BU	1.39^{ns}	0.0527	16	0.34
Annual rings growth in the edge of the road	FR	1.30^{***}	0.0160	9	0.56
	BR	1.36^{ns}	0.0209	10	0.37

Table 3. Analysis of variance of bark growth in the upside=U (Back=B and Front=F of the roads, together) and downside=D (back and front of the roads, together) and growth average of bark.

Dependent variables		Mean	Error of variance	CV	R^2
Bark growth in the edge of the road	FD	1.98	0.0735	13	0.59
	BD	1.92	0.1079	17	0.45
Bark growth in the edge of the road	FU	1.96	0.0554	12	0.66
	BU	1.98	0.0747	14	0.55
Bark growth in the edge of the road	FR	1.98	0.0435	11	0.68
	BR	1.97	0.05803	12	0.47

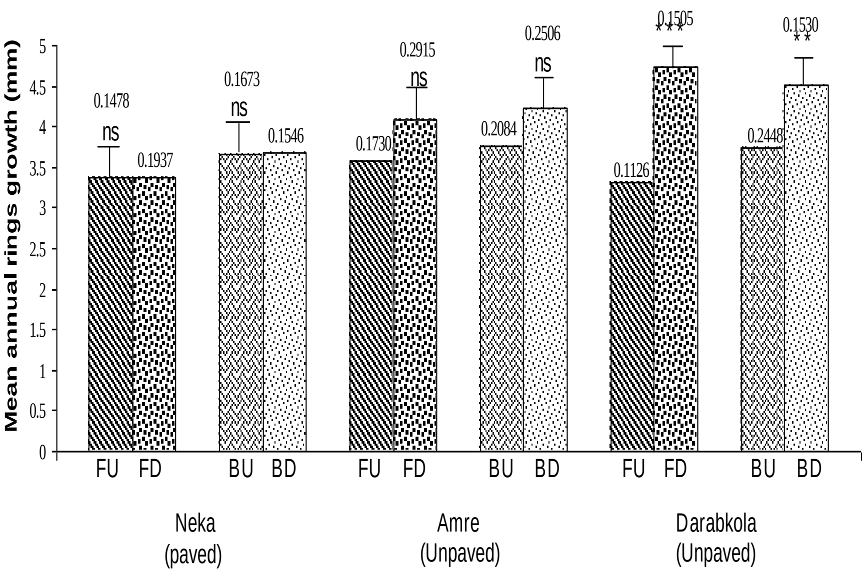

Fig. 3. Comparison of average growth of annual rings in the up and downside (front and back of the roads, separately); F, front of the road; U, upside of the road; B, back of the road; D, downside of the road; **, Significant in probability level of 1% ***; Significant in probability level of 0.1%; ns, without significant difference.

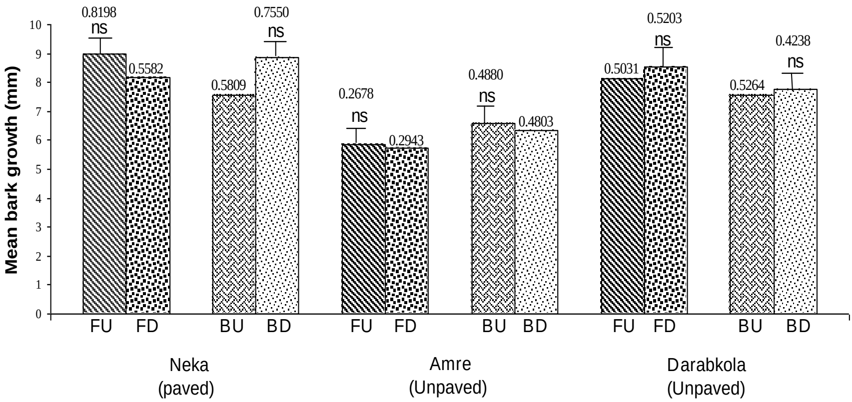

Fig. 4. Comparison of bark thickness in the up and downside of roads (Front and Back of the road, separately).

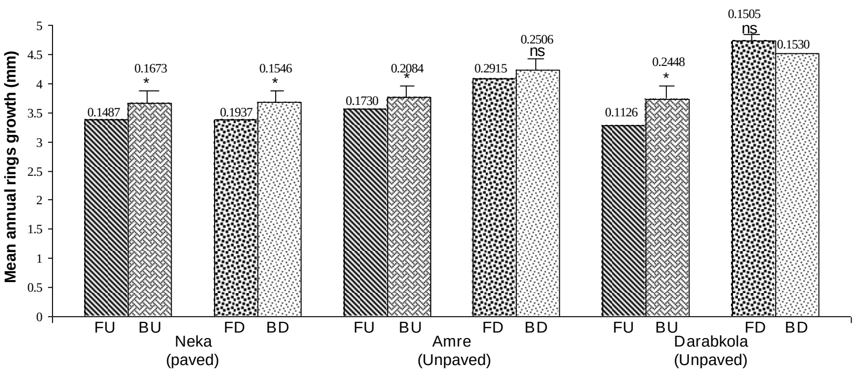

Fig. 5. Comparison of alder annual rings in the upside (back and front of the roads, together) and downside (back and front of the roads, together).

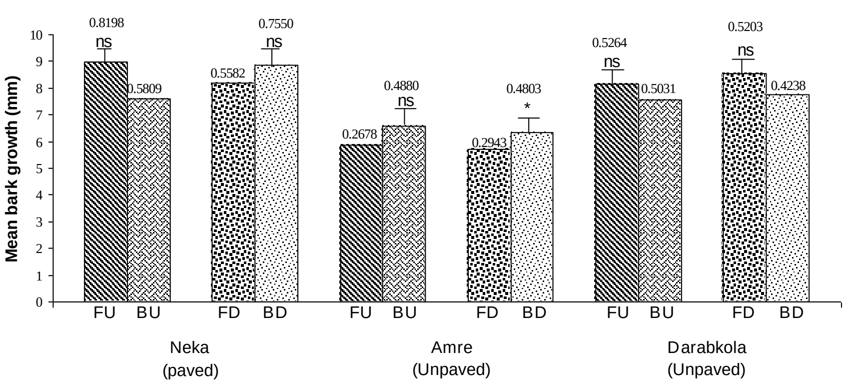

Fig. 6. Back growth in the upside (back and front of the roads, together) and downside (back and front of the rods, together).

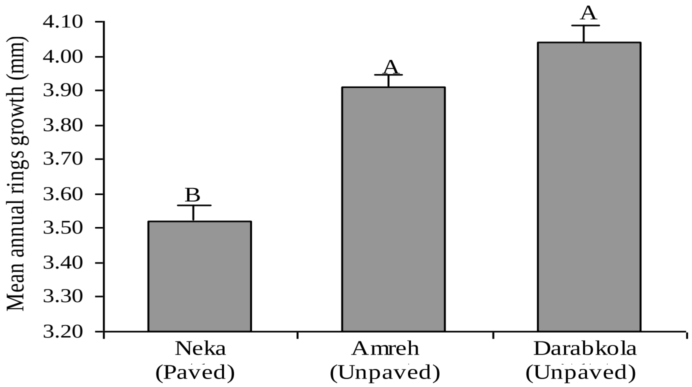

Fig. 7. Annual ring growth in Neka (paved) and Amreh and Darabkola (unpaved) roads.

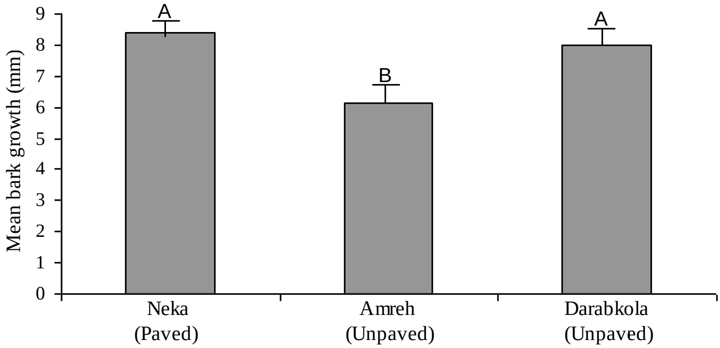

Fig. 8. Comparison of the growth average of bark in three sites (Neka, Amreh and Darabkola).

Bormann & Likens (1979) in their study showed that removing the canopy of trees causes to increase the effect of light intensity on surface of soil and analysis of organic matter. Greacen & Sands (1980) revealed that the soil compaction during removing operation and transportation are the main factor that increased soil density, decreased porosity and capacity of penetrating of soil. The soil structure changes in the soil make decreasing root growth as well as the growth rate and production of trees. Froehlich & McNabb (1984) described an inverse, linear relationship between bulk density and seedling height growth that was apparently independent of soil texture.

Tree roots and the soil surrounding them are an ecological composite of biotic and abiotic features. Compaction initiates many negative impacts in the soil including: decreases the volume of ecologically active space availability and tree root making ability, so made more shallow roots (Coder, 2000) that was concluded in our study when we compared the growth of annual rings at down and upside margins (back and opposite of the road) in the above areas. The existence of unidentical situation was different because of the compaction of soil since the soil of road building which caused to prevent developing and growing the annual rings roots of *Alnus subcordata*. In this study there was no significant difference by comparison of alder annual rings in the upside (back and front of the roads, together) and downside (back and front of the roads, together) in

Darabkola site (Fig. 5). Olander *et al*., (1998) proved that the decrease of plants growth depends on the soil compaction intensity and decrease ability of nitrogen absorption from organic matter. Soil compaction causes special biology which reacts in plants and usually decrease the water absorption by roots and some changes in the balance of nutrients and hormones in growing plants (Kwzlowski, 1999; Nadian *et al*., 2005).

In comparison of the bark growth of the downside (back and front of road) and upside (back and front of roads), didn't show a significant difference (Fig. 4); but a little difference which was observed, implied that being in the subject of shadow, the trunk of tree and much more soil moisture in back of the road causes the more growth of bark in front of the road compared with the back road growth (Fig. 6).

At unpaved roads, soil compaction is less observed compared with paved roads (Thomas *et al*., 2001). Thus the results of this study were focused on the annual ring growth of alder trees in paved road (Neka) and unpaved roads (Darabkoa & Amreh,). It showed the growth in paved road was less than that of unpaved roads (Table 2, Fig. 7). Bark growth was compared, so unpaved road of Amreh was less than Neka & Darabkola. The main reason was because of being young alder tree at the margins of road in this site (Table 3, Fig. 8).

In comparison with repetitive sample taken from all sites (front and back of road in up and downsides of all roads at three sites), it didn't show any significant differences. It showed that the sample was made correctly since the age of trees and generally the negative effect of paved forest roads was more than in diameter growth of alder trees at the margins of unpaved forest roads.

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