Rashtian, Vegetos 2016, 29:3
DOI: 10.5958/2229-4473.2016.00063.X

Vegetos- An International Journal of Plant Research

Research Article A SCITECHNOL JOURNAL

Effects of Dirt roads on Vegetation and Diversity in Arid Rangelands (Case Study: Aliabad Pyshkoh of Yazd, Iran)

Anahita Rashtian*

Abstract

Since the road are considered as one of sustainable development indicators and many rural dusty roads are passed through rangelands, the effect of road networks on rangeland ecosystems is so important. In order to investigate the effects of roads, two regions were determined; one around the road, from the edge of road to 5 m and the other far from it, from 5 to 20 m. 10 transects of 50 m and 40 random plots of 1 m^2 were placed on each transect on each site and some vegetation characteristics were measured in Ali Abad Pishkuh rangelands in Yazd province. The results showed that road changes vegetation composition, production, and canopy cover percentage. So, grass production and canopy cover were decreased near the road. Important value of shrubs was declined near the road while it was increased in terms of grasses. Richness, evenness and diversity indices were reduced and distribution pattern moved to clumped. These factors indicate that plant communities moves less stable and they are crossed boundaries of ecological threshold around the road. Therefore, it is suggested that rural dusty roads construction should be with more study and proper reclamation.

Keywords

Rural road; Vegetation characteristics; Important value; Diversity indices

Introduction

In order to develope, human (directly or indirectly) has made many changes to natural ecosystems. Several studies indicate that the structure of plant communities is largely influenced by human factors [1]. Thus, human activities cause extensive changes in the environment. Roads and highways are like vital artery of a society; if they are not developed, social and economic sustainable development will be disrupted. On the other hand, improper road construction, as one of destroyer factors of natural resources, is proposed as one of watershed main problems [2]. Recognition and proper management of plant communities can make a balance between transportation quality and environment conservation.

During road construction, a large area of forests and rangelands are destroyed along the edge of road and a lot of stones and soils are moved. Environment, rangelands and forests degradation rates depend on different factors such as road type, topography, geologic formations and soil sensitivity [3].

The stages of road infrastructure can cause to remove some sensitive and less resistant species. The roads also cause changing microclimate, light regime, soil bulk density, pH and organic matters, microtopography, hydrologic regime, sedimentation and starting sensations [4,5,6]. Roads can increase plants density by establishing fast-growing and preferential species. Plants in the roadside grow more than other plants [7,8]. Many non-native or invasive species and even woody plants may accumulate at the edge of road [9,10]. Some species reproduction also decreases due to increasing traffic, soil compaction and reducing soil penetration [11]. People and vehicle movement can cause water, soil and air pollution and finally remove some species [12]; all these factors change species composition and diversity [13,14]; the effects of road decrease by getting away from it [15].

Quality of road construction effects on vegetation changes so that roads with more quality have more effects on vegetation dynamics [16]. This situation depends on railroad type, transport corridors or road and its superstructure characteristics such as paved or dusty roads [17,18], because the heat which absorbed by superstructure stuff during a day, emits to the atmosphere to the form of infrared waves and cause to create a heat island around roads corridors [17]. This situation changes according to the amount of road effect, vegetation density and its diversity [18,19,20]. The effects of road on plant communities can be seen up to 20 meters or even 60 meters far from the road in forests [21] but plant communities changes are significant to 5 meters in savannas or shrublands [22].

One of sustainable development indicators is to maintain natural resources for future generations [23]. According to this and the fact that the length of Iran road networks is 15137 km that the amount of 76749 km is paved and 37114 km is dusty [24], in this paper the effect of rural roads were investigated on vegetation characteristics and rangeland resources.

Materials and Methods

This study was conducted in Ali Abad Pishkuh steppe rangelands of Yazd province. These rangelands are located at 31° 39′ 01″ north latitude and 53° 47′ 09″ east longitude with annual precipitation of 212 mm. The average altitude is 2300 meters above sea level.

Firstly, the study area was determined using topographic maps and during field investigation, two regions were determined; one around the road, from the edge of road to 5 m and the other far from the road, from 5 to 20 m. some parameters such as canopy cover percentage, production, density, diversity and evenness were measured. Depending on vegetation type and condition, 10 transects of 50 m and 100 random plots of 1 m^2 were placed on each transect on each site and along 5 km of the road. Appropriate numbers of plots were calculated using statistical method. Species type, number of species, canopy cover and production were measured in each plot. The data was analyzed using T-test. Species important value was also determined using equation (1) [25].

Important value = relative frequency + relative dominance + relative density equation (1)

***Corresponding author:** Anahita Rashtian, Department of Soil science, Yazd Univeristy, University Blvd., Safayieh, Yazd, Iran, Tel: 035-31232817; E-mail: arashtian@yazd.ac.ir

Received: May 30, 2016 **Accepted:** July 09, 2016 **Published:** July 14, 2016

This index ranges from 0 to 300 and to show that as a coefficient, it was divided in 300. When it moves closer to 1, shows the species importance in the ecosystem and that species has a determinant role in species composition or ecological conditions prevailing in the region. It also has an important role in this species establishment. So species changes are important to interpret ecological conditions in the region. *EXCEL* and *MINITAB* software was used to analyze the data.

Some indices such as Jackknife (richness index), Simpson and Smith Wilson (evenness indices), Shannon Wiener and Brillion (diversity indices) were used to calculate diversity and richness. Differences between plant communities were determined using Tukey test.

Dispersion (variance/mean ratio), Morisita and Standardized Morisita indices were also used to determine species distribution [26].

Results and Discussion

Table 1 shows significant difference between the two regions in terms of production, density and canopy cover percentage ($p<0.05$), with production demonstrating a significant decrease in the rangelands near the road while density and canopy cover percentage have increased significantly.

In order to study the effect of roads on plant composition more precisely, plants were divided into three palatability classes and production, canopy cover and density of each palatability class were examined. The production of high palatable (Class I) species and the species with average palatability (Class II) has a significant reduction while canopy cover percentage of class I and production and canopy cover of class III species are higher in rangelands near the road (Table 2).

According to the results of the above table, shrubs production statistical analysis indicates a significant difference between two regions and it has decreased significantly, while grasses and forbs have had a significant increase in terms of canopy cover percentage and density in rangelands near the road. So, the road has caused shrubs reduction and grasses and forbs increase in plant composition around the road.

To determine important value of each life form, relative density, dominance and frequency were calculated. Important value of different life forms has shown in Table 4.

According to Table 5, important values of perennial and annual plants were investigated in rangelands near and far from the road.

Differences were detected between regions near the road and far from it, in terms of shrubs and forbs important value ($p<0.05$). In regions near the road, shrubs important value has reduced but this factor has increased in terms of forbs. It means that the road has caused favorable conditions for forbs growth. Important value of annuals has also increased significantly. This indicates that conditions have improved for annuals, but important value of perennial plants which play an important role in sustainability of rangeland ecosystems, has decreased.

Some indices such as Jackknife (richness index), Simpson and Smith Wilson (evenness indices) and Shannon Wiener and Brillion (diversity indices) were used to determine species diversity and richness and the effects of road on them. The results are shown in Figure 1.

Species richness index has a significant difference between the two communities. Richness in the plant community near the road has decreased significantly compared to the other. Plant communities far from the road have more evenness and diversity. Road construction has caused evenness and diversity reduction.

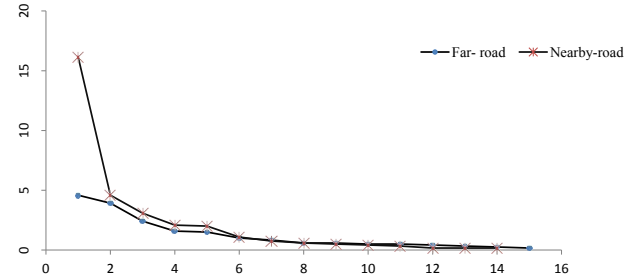

Figure 1: Whitaker rank-frequency (diversity-dominance) chart in rangelands near and far from the road.

Table 1: Investigated indices of rangelands near the road and far from it.

Paved region	Production (gr)	Canopy cover (%)	Density
Near rangelands	2.4 ± 28	4.2 ± 29.9	2.3 ± 32.1
Far rangelands	3.1 ± 38.3	3 ± 18.5	1.8 ± 19.17
P value	*0.017	* 0.039	*0.021

According to Table 2, richness, evenness and diversity indices have a significant reduction in rangelands near the road ($p<0.05$).

In order to recognize the complex structure of communities, Whitaker rank-frequency (diversity-dominance) chart was used. So, several species frequencies are so high in the community close to the road and it shows evenness reduction. The community far from the road has more evenness and there is also more species richness due to higher tension of the curve. Shorter length of curve indicates less species richness in the community near the road. Species distribution pattern is logarithmic in the two communities. This kind of distribution indicates that there are many species with low frequency. The number of species with high frequency is low. There are also immature communities with low species diversity.

Distribution pattern of different life forms was determined using quadrate distribution indices such as dispersion (variance/mean ratio), Morisita and Standardized Morisita indices (Table 6).

According to the results of Table 7, distribution pattern of shrubs, grasses and forbs are uniform on the basis of all indices in the rangelands far from the road. But based on Morisita and Standardized Morisita indices, there is clumped distribution pattern in rangelands near the road.

Discussion

The results showed that road causes to change plant composition, production and canopy cover percentage so that production decreased around the road. One of reasons can be reduction of perennial species density due to vehicles traffic, their pollution, waterways redirecting and finally more erosion. Decreasing canopy cover percentage can also cause more erosion. These results were also confirmed by Bolling [27], Coffin [12] and Liu et al. [15].

According to Tables 2 and 4, shrubs production and important value has decreased near the road while forbs and grasses important value, density and canopy cover percentage have increased. It seems that these species especially annuals are more opportunistic species [28]. They occupy open spaces (that is created in order to develop

doi: 10.5958/2229-4473.2016.00063.X

Table2: Production, canopy cover percentage and density of different palatable classes in rangelands near and far from the road

Region	Production			Canopy cover			Density		
	Class I	Class II	ClassIII	Class I	Class II	ClassIII	Class I	Class II	ClassIII
Near of road	1.25+0.7	15.4 ± 19.7	1.7 ± 5.8	0.75 ± 0.2	14 ± 21.3	1.8 ± 5.8	0.91+ 0.5	13.7 ± 25	2.4 ± 6
Far of road	2.9 ± 4	11.2 ± 28.2	2.8 ± 3.3	0.9 ± 1.58	11.2 ± 15	1.1 ± 2	1.2 ± 4.9	10.4 ± 27.4	2.1 ± 3.5
P value	0.01 **	0.044*	*0.05	0.031*	0.232 ns	0.024*	0.001**	0.639 ns	0.182 ns

Table 3: Production and canopy cover percentage of different life forms in rangelands near and far from the road. Plant composition was also evaluated on the bases of life forms.

Region	Production (gr/m²)			Canopy cover (%)			Density (No/m²)		
	Shrub	Forb	Grass	Shrub	Forb	Grass	Shrub	Forb	Grass
Near of road	1.4 ± 5.9	2.3 ± 13.08	1.3 ± 8.75	0.66 ± 8	1.2 ± 13.83	1.5 ± 6.58	0.7 ± 3.5	1.6 ± 8.83	4.1 ± 19.8
Far of road	3.3 ± 18.8	2.5 ± 8.33	1.1 ± 8.58	3.4 ± 9.42	1.5 ± 5.92	0.8 ± 4.58	0.75 ± 5.75	0.83 ± 3.75	1.9 ± 10.1
P value	** 0.004	0.179 ns	0.062 ns	0.725	* 0.02	*0.03	0.41	*0.012	*0.04

Table 4: Important value of different life forms in rangelands near and far from the road.

Region	Important value		
	Shrub	Forb	Grass
Near of road	11 ± 57.2	10 ± 139.1	9.3 ± 103.7
Far of road	14 ± 128.4	8 ± 76.2	8.3 ± 99.6
P value	** 0.001	**0.002	0.748 ns

Table 5: Important values of perennial and annual plants in rangelands near and far from the road

Region	Important value	
	Perennial	Annual
Near of road	10 ± 179.8	10 ± 120.2
Far of road	7.1 ± 242.7	7.7 ± 57.3
P value	** 0.000	** 0.000

Table 6: Richness, evenness and diversity indices in rangelands near and far from the road.

Region	Richness	Evenness		Diversity		
	Jackknife	Simpson	Wilson	Simpson	Shannon Wiener	Brillion
Near of road	0.91 ± 14.9	0.3 ± 0.695	0.05 ± 0.4	0.315 ± 0.09	0.22 ± 2.27	0.15 ± 2.067
Far of road	0.78 ± 17.8	0.2 ± 0.820	0.16 ± 0.5	0.08 ± 0.521	0.32 ± 2.77	0.22 ± 2.418
P value	* 0.046	*0.017	ns 0.143	* 0.022	*0.047	*0.04

Table 7: Distribution index of different life forms in rangelands near and far from the road.

Distribution index		Near rangelands		Far rangelands	
		Calculated number	Distribution pattern	Calculated number	Distribution pattern
Shrub	Ratio	0.61	Uniform	0.62	Uniform
	Morisita	0.71	Uniform	1.013	Clumped
	Standardized Morisita	0.62	Clumped	0.636-	Uniform
Grass	Ratio	0.74	Uniform	0.93	Uniform
	Morisita	1.42	Clumped	0.388	Uniform
	Standardized Morisita	0.616-	Uniform	0.264-	Uniform
Forb	Ratio	0.63	Uniform	0.69	Uniform
	Morisita	1.013	Clumped	0.363	Uniform
	Standardized Morisita	0.664-	Uniform	-0.264	Uniform
Total	Ratio	0.54	Uniform	0.39	Uniform
	Morisita	1.19	Clumped	0.98	Uniform
	Standardized Morisita	0.508	Clumped	0.845-	Uniform

roads) around the roads quickly while shrubs couldn't occupy this space or niche because of their growth speed and lower establishment. Studies by Hayasakaa et al. [29] support this connection. They investigated plant communities' changes near rural and urban roads and found that there are invasive plants (Astraceae family) and grasses near the road more than other plants.

Plant community richness near the road is less than the rangeland far from the road and road construction has caused to remove some plant species; it is obvious in Whitaker rank-frequency chart. Plant communities' evenness has reduced near the road and Simpson index and the curve slope shows this fact. Species diversity is higher far from the road that corresponds with the results of studies by Bowering et al. [27,30], Khodadad and Sepehry [2] and Marcantonio et al. [31] but the study by Najafi et al. [32], who have studied forest cover diversity, doesn't confirm this. Distribution patterns of different life forms have become clumped that its reason can be the effect of microtopography due to road construction and changing soil water regime near the

road. These results were also confirmed by Tormo et al. [33], who found that soil water regime and plant species types effect rangelands restoration near the road, and Neher et al. [5], who declared that microtopography factor and water flows influence plant composition.

Therefore, due to higher sensitivity of arid and semi-arid vegetation, it is recommended to do any road construction and development according to its environmental consequences. It is also better to restore vegetation properly and at the same time to cause the least damage to natural resources adjacent to it.

Reference

1. Garcia M, Montane F, Pique J, Retana J (2007) Overstory structure and topographic gradients determining diversity and abundance of understory shrub species in temperate forests in spain. Forest Ecology and Management 242: 391-406.
2. Khodadad A, Sepehry A (2012) Investigating the way of managing vegetation in roadside (case study; edge of kouhikheyl-behenmir road). Iranian Journal of Natural Resources 65: 367-377.
3. Nekooimehr M, Rafatnia N, Raisian R, Jahanbazi H, Talebi M, et al. (2006) Impact of road construction on forest destruction in bazoft region. Iranian Journal of Forest and Poplar Research 14: 228-243.
4. Karim MN, Mallik AU (2008) Roadside revegetation by native plants I. roadside microhabitats, floristic zonation and species traits. Ecol Eng 32: 222-237.
5. Neher DA, Asmussen D, Lovell ST (2013) Roads in northern hardwood forests affect adjacent plant communities and soil chemistry in proportion to the maintained roadside area. Science of the total environment 449: 320-327.
6. Venkatram A, Isakov V, Thoma E, Baldauf R (2007) Analysis of air quality data near roadways using a dispersion model. Atmos Environ 41: 9481-9497.
7. Megahan WF (1988) Effects of forest roads on watershed function in mountainous areas. Proceedings 335-348.
8. Parsakhoo A, Jalilvand H, Hosseini SA, Sheikhi M (2008) Effect of asphalted and earthy forest roads on stock growth of edge and adjacent stands. Journal Agriculture Science Natural Resource 15: 10-17.
9. Hansen MJ, Clevenger AP (2005) The influence of disturbance and habitat on the presence of non-native plant species along transport corridors. Biol Conserv 125: 249-259.
10. Smit IPJ, Asner GP (2012) Roads increase woody cover under varying geological, rainfall and fire regimes in African savanna. Journal of Arid Environments 80: 74-80
11. Belinchon R, Martinez I, Escudero A, Aragon G, Valladares F (2007) Edge effects on epiphytic communities in a mediterranean quercus pyrenaica forest. Veg Sc Journal 18: 81-90.
12. Coffin AW (2007) From roadkill to road ecology: A review of the ecological effects of roads. Journal of Transport Geography 15: 396-406.
13. Bowering M, LeMay V, Marshal P (2006) Effects of forest road on the growth of adjacent lodgeopole pine trees. Journal For Res 36: 919-929.
14. Parendes LA, Jones JA (2000) Role of light availability and dispersal mechanisms in invasion of exotic plants roads and streams. Conserv Biol 14: 64-75.
15. Liu Sh, Deng L, Zhao Q, DeGloria SD, Dong S (2011) Effects of road network on vegetation pattern in xishuangbanna, yunnan province, southwest china, transportation research Part D: transport and environment 16: 591-594.
16. Bogren J, Gustavsson T (1991) Nocturnal air and road surface temperature variations in complex terrain Int. Journal Climatol 11: 443-455.
17. Dickinson MB, Whigham DF, Hermann SM (2000) Tree regeneration in felling and natural tree fall disturbances in a semi deciduous tropical forest in mexico. Ecol Manag 134: 1-3.
18. Buckley DS, Crow TR, Nauertz EA, Schulz KE (2003) Influences of skid trails and haul roads on under story plant richness and composition in managed forest lands capes in upper michigan, USA. Ecol Manag 175: 509-520.
19. Avon C, Dumas Y, Bergès L (20f13) Management practices increase the impact of roads on plant communities in forests. Biological Conservation 159: 24-31.
20. Gatto M (1995) Sustainability: is it a well-defined concept. Ecological society of America 5: 1181-1183.
21. Bakhtiari S (2012) Atlas roads of iran 2012, institute of geographically and cartography 312 pages (in persian).
22. Huang D, Wang K, Wu WL (2007) Dynamics of soil physical and chemical properties and vegetation succession characteristics during grassland desertification under sheep grazing in an agro-pastoral transition zone in northern china. Journal Arid Environ 70: 120-123.
23. Azarnivand H, Zare-chahouki MA (2011) Rangeland ecology.
24. Bolling JD, Walker LR (2000) Plant and soil recovery along a series of abandoned desert roads. Journal of Arid Environments 46: 1-24
25. Hayasakaa D, Akasakaa M, Miyauchi, D, Elgene B, Boxc, O, et al. (2012) Qualitative variation in roadside weed vegetation along an urban-rural road gradient. Flora 207: 126-132.
26. Shahsavari A (2008) The study of some wild and cultivate plants in hammedan city. Iranian Journal of Biology 21: 712-722.
27. Bolling JD, Walker LR (2000) Plant and soil recovery along a series of abandoned desert roads. Journal of Arid Environments 46: 1-24.
28. Lamont BB, Whitten VA, Witkowski ETF, Rees RG, Enright NJ (1994) Region and local (road verge) effects on size and fecundity in Banksia menziesii. Aust. Journal Ecol 19: 19.
29. Hayasakaa D, Akasakaa M, Miyauchi, D, Elgene, B, Boxc, O, et al. (2012) Qualitative variation in roadside weed vegetation along an urban–rural road gradient. Flora 207: 126-132.
30. May RM (1975) Patterns of species abundance and diversity. Harvard University Press, Cambridge, MA, 81-120.
31. Marcantonio M, Rocchini D, Geri F, Bacaro G, Amici V (2013) Biodiversity, roads, & landscape fragmentation: two mediterranean cases. Applied Geography 42: 63-72
32. Najafi A, Hossieni SM, Ezzati S, Torabi M, Fakhari MA (2011) Comparison of regeneration and biodiversity of trees on cut and fill edges of forest road (case study: chamestan and lavige sdforests, noor). Journal of Wood & Forest Science and Technology 17: 132-159.
33. Tormo J, Fayos P, Bochet E (2008) Relative importance of plant traits and ecological filters in road embankment revegetation under semiarid mediterranean conditions. ecological engineering 33: 258–264.

Author Affiliations

Top

Department of Soil science, Yazd Univeristy, University Blvd., Safayieh, Yazd, Iran