



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

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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 m² 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 develop, 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 m² 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)

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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

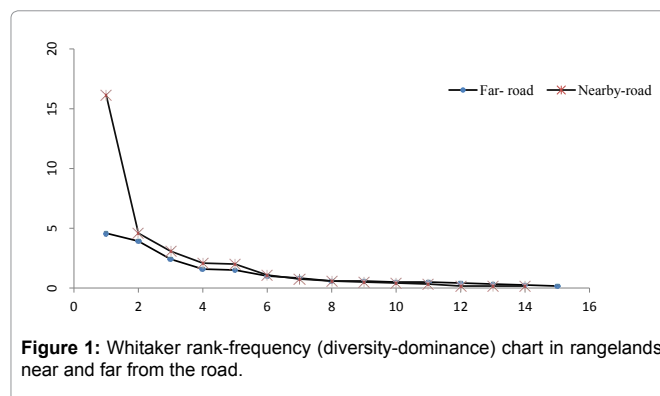


Figure 1: Whitaker rank-frequency (diversity-dominance) chart in rangelands near and far from the road.

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

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.

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 quadrat 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

Table 2: 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/m ²)			Canopy cover (%)			Density (No/m ²)		
	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.

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