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Ecological effects of forest roads on plant species diversity in Caspian forests of Iran

Mir Mozaffar Fallahchai [a,*], Katayoun Haghverdi [b], Mohammad Sadegh Mojaddam [c]

[a] Department of Forestry, Lahijan Branch, Islamic Azad University, Lahijan, Iran
[b] College of Agriculture and Natural Resources, Karaj Branch, Islamic Azad University, Karaj, Iran
[c] Lahijan Branch, Islamic Azad University, Lahijan, Iran

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ABSTRACT

Current research includes the effects of asphalt forest roads on changes of plant cover and tree regeneration from asphalt forest roads edges towards its inner parts in two compartments of Nave Asalem forests located in the north of Iran. For this reason, in each side of road, 6 sample plots (20 m × 20 m) were established for measuring plant species diversity. In each sample plot, ground vegetation and tree regeneration were assessed within nine 2 × 2 m micro plots. In total, 12 sample plots and 108 μ plots were established. Results indicated that the road positions were effective on plant species diversity. The highest diversity and evenness indices value were observed down of the road compared to the up of the road position for herbal and tree regeneration layers. The same results were found also for herbal richness indices. Up of road position had the greatest value of richness indices in comparison to the other road position for tree regeneration layer. Also, the results showed that diversity, richness, and evenness indices were decreased with the increasing of distance from the road side for herbs and tree regeneration layers. This study indicated that roads can increase plant biodiversity; that is, tree regeneration density.

1. Introduction

The Hyrcanian forests are one of the last remnants of natural deciduous forests in the world. This ancient forest provides habitats to a unique set of flora and fauna. Native and endangered tree species include Caspian honey locust (*Gleditschia caspica* Desf.), false walnut (*Pterocarya fraxinifolia* Land. (Spach.)), ironwood (*Parrotia persica* C.A.M.), Siberian elm (Zelkova *carpinifolia* (Pall.) Dipp), box tree (*Buxus hyrcana* Pojark) and a few conifer species such as yew (*Taxus baccata* L.) and oriental arbor-vitae (*Thuja orientalis* L.) [1,2]. The high species diversity in the region has given rise to various plant communities. One of the most important tree and shrub communities in the Hyrcanian zone are Beech forests. Beech forests account for approximately 17.6% of the total forest area, 30% of the standing volume, and 23.6% of the stem number in the Hyrcanian forests in Iran [3]. Nave Asalem forests are one of the most important beech forests of Iran with high species diversity, so to protect biodiversity for future forest management is an important task that is dealt in detail here.

The assessment and monitoring of biodiversity has recently emerged as one of the main global environmental concerns. Consequently, a thorough treatment of the influences of human interventions on biodiversity is to be included in the procedure of Environmental Impact Assessment (EIA), as recommended by the Convention on Biological Diversity: "each Contracting Party should introduce appropriate procedures requiring environmental impact assessment of its proposed projects that are likely to have significant adverse impact on biological diversity" [4]. Road construction and maintenance are one of the most widespread anthropogenic activities that have occurred over the past centuries [5,6]. The impact of roads on local biodiversity largely leads to changes in species composition, especially regarding the variability in the abundance of herbal and woody species [7,8]. Although corridors have been implemented with the assumption that they will increase biodiversity, not enough research has been done to come to a solid conclusion [9]. The construction and improvement of roads of all types sometimes leads, directly or indirectly, to significant loss or degradation of natural habitats and increased wildlife mortality. As a result, road projects frequently pose conflicts with biodiversity conservation objectives. The challenge for people who plan, build, and maintain roads is to reconcile the improvement of transportation infrastructure with the need to avoid serious damage to natural habitats and biodiversity. Transportation corridors have not traditionally been focused on in conservation issues until Cilliers and Bredenkamp [10] discussed the role of railway as dispersal corridor for species between fragmented natural areas. Roads have been the most widespread forms of the natural landscape during the past centuries; correspondingly, the value of road as a corridor, changing the isolation degree of animals and plant populations in fragmented landscape, should also be attended. Using of road to preserve local biodiversity has been an area of considerable debate over the past two decades. Proponents argue

* Corresponding author.
E-mail address: Fallahchai@liau.ac.ir (M.M. Fallahchai).

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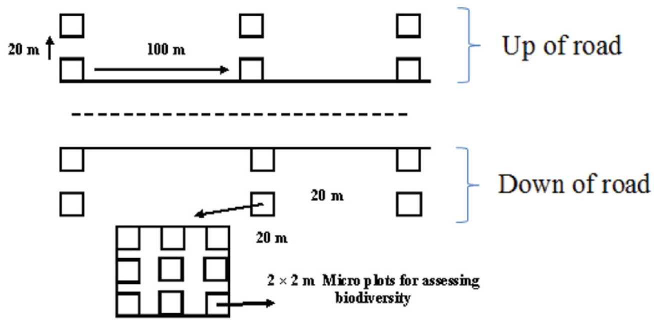

Fig. 1. Sampling method in up/down of road positions.

that roads act as conduits, facilitating the movement of individuals between isolated patches of remnant habitat, thereby promoting gene flow, reducing population fluctuations, and decreasing extinction risks. Therefore, roadside is sometimes considered as the last favorable refuge for plant species in many fragmented agricultural areas, such as *Eucalyptus* and *Acacia* [11].

In general, roadsides are more disturbed, drier, and warmer [12]. Hence, fast-growing species such as *Alnus*, *Rubus*, and so forth will be established around forest roads [13]. Tree cutting for making of roads are due to increasing of light amounts and also photosynthesis activities in below strata [14]. Light intensity and also temperature will be reduced from edge to inner of forest, whether the moisture amounts will be increased [15,16]. Fields with opening of canopy cover are more invaded by exotic species and light-demanding species [17]. The environmental influences of forest roads were categorized into abiotic and biotic. For abiotic conditions, the effects of roads on hydrology, geomorphology, natural disturbances and edaphic features have been studied [18,19]. In a pine forest, Delgado et al. [16] detected a highly significant gradient of soil temperature along asphalt roads and also a significant light gradient for both asphalt and unpaved roads. The biotic outputs are divided into genetic parameters, plant and wildlife population situations [20].

Forest roads make edge effects on plant communities through fragmenting habitats and introducing different disturbances [7,8,21]. These effects may vary with the width of roads as well as the geometry of road cross sections [22]. Solar radiation, soil moisture content, and soil temperature in gaps created by forest roads are significantly greater than adjacent closed canopy plots [23]. Zhou, et al. [24] found that wide and narrow roads have different edge effects. For wide roads, plant diversity and soil moisture tend to increase, but herbaceous biomass tends to decrease from the road edge to the forest interior. In fact, the plant diversity was increased following soil properties' changes in gaps and roadside plots compared to forest plots [25]. In spite of extensive studies about forest road ecology in temperate broadleaf mixed forests, few studies have been conducted in the Hyrcanian Mixed Forests Eco region of Northern Iran [26–28]. However, the Hyrcanian forests are unique Arcto-Tertiary forests, where several tree genera (i.e., Pterocarya, Albizia, Parrotia, or Gleditsia) survived the last ice age [29]. Approximately 60% of Iranian forests have been managed since the early 1970s, and the ecological effects of forest roads on herbaceous diversity have a recent history. This pattern is in contrast with other temperate forests considered in road ecology literature, which have a longer management history (at least 100 years; [30,31]). The aim of the current study is to assess the effects of forest roads on biodiversity of herbal species and also tree regeneration in northern Iran.

2. Materials and methods

2.1. Area of study

This research has been conducted in the compartments 49 and 50 of district 2 of Nave Asalem forests located in water catchment 7 in Guilan province, north of Iran (Between 37° 37′ 23″, 37° 42′ 31″ northern latitude, 48° 44′ 26″, 48° 49′ 58″ eastern longitude). The maximum elevation is 1300 m. Minimum temperature (−7 °C) and the highest temperature (41 °C) were recorded, respectively. Mean annual precipitation of the study area were from 1024 to 1254 mm at the Hashtpar city metrological station, which is 30 km far from the study surface. The soils are semi-deep to deep, moderately well drained. The texture of soil is silty-sand with the pH of 5 to 6.2 [32].

2.2. Road selection

For this study, asphalt roads with length of >1 km that had been built about ten years ago were selected in two compartments of Nave Asalem forests. The same conditions existed according to topography, slope, and direction for studied compartments. In each side of the road (up and down of road; see Fig. 1), 6 sample plots (20 m × 20 m) were established for measuring plant species diversity [33]. 3 sample plots in the road edges with a 100 m distance from each other, and 3 more ones in parallel to them with a 20 m distance from the sample plots located in the road edges were established. In each sample plot, ground vegetation and tree regeneration were assessed within nine 2 × 2 m micro plots (Fig. 1) Mesdaghi [33]. In total, 12 sample plots and 108 μ plots were established in the studied compartments to recording of herbal

Table 1
Floristic list of herbal and tree regeneration layers in study area.

Number	Herbal species		Tree species regeneration	
	Road edge	Inside forest	Road edge	Inside forest
1	*Voila odorata* L.	*Voila odorata* L.	*Fagus orientalis* Lipsky	*Fagus orientalis* Lipsky
2	*Oplimenus undulatifolis* L.	*Oplimenus undulatifolis* L.	*Carpinus betulus* L.	*Carpinus betulus* L.
3	*Rubus hyrcanus*	*Rubus hyrcanus*	*Parrotia persica* (DC.) C.A. Meyer.	*Tilia begonifolia*
4	*Lalium temulentum*	*Lalium temulentum*	*Acer velutinum* Boiss	
5	*Dryopteris pallida*	*Dryopteris pallida*	*Alnus subcordata* (L.) Gaertn.	
6	*Pteridium aquilinum* L.	*Pteridium aquilinum* L.		
7	*Carex hordeistichos*	*Carex hordeistichos*		
8	*Juncus rigidus* Desf.	*Carex plantuginea*		
9	*Polygonum hydropiper*	*Carex hirta*		
10	*Geum urbanum*	*Solanum kiesseritzkii* C.A.M		
11	*Rumex sanguinus*			
12	*Prunella vulgaris*			
13	*Campanula patula*			
14	*Stellaria media*			
15	*Agrostis stolonifera*			
16	*Plantago major*			
17	*Trifolium repens*			
18	*Taraxacum officinale*			

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