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Araştırma Makalesi/Research Article

Changes of Trees Regeneration Diversity in Main and Secondary Roads of Hyrcanian Forests, Iran

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ABSTRACT: Forest roads are directions in natural habitats that used to transport wood products, secondary forest products and recreation. Constructing forest roads is one of the factors in ecological changes can affect tree regeneration diversity and species composition. This study assessed trees regeneration diversity from main and secondary forest roads edge to forest interior. Sixteen transects were considered in main and secondary forest roads (8 transects in main and 8 transects in secondary roads). Nine plots (5×20 m) established in distances 0, 5, 10, 15, 20, 30, 45, 60, and 100 m in both sides of the roads (down and fill slopes). To evaluate diversity of trees regeneration, Simpson diversity index and Margalef richness were used. Results showed that diversity indices significantly different in main and secondary forest roads and different distances. Trees regeneration increase in forest interior in both roads. Minimizing road density is essential to preserve diversity and sustainability of forest resources. Results suggest the necessity of using environmentally sound forest road construction principles and techniques to mitigate negative environmental impacts.

Key words: Diversity, Forest roads, Richness, Simpson diversity index.

İran Hyrcanian Ormanları Ana ve İkincil Yollarındaki Ağaç Yenilenme Çeşitliliğindeki Değişiklikler

ÖZET: Orman yolları, ahşap ürünleri ve ikincil orman ürünlerini taşımak için kullanılan ve rekreasyon amaçlı doğal habitatlara giden yönlendir. Orman yollarının yapılması, ağaç rejenerasyon çeşitliliğini ve tür kompozisyonu etkileyebilecek ekolojik değişiklikler faktörlerden birisidir. Bu çalışmada, ana ve ikincil orman yollarından orman iç kenarlarına kadar ağaçlar rejenerasyon çeşitliliği değerlendirilmiştir. Ana ve tali orman yollarında on altı bölge (ana yollarda 8 bölge ve tali yollarda 8 bölge) dikkate alınmıştır. Yolların her iki tarafından (aşağı ve yukarı yamaçlarda) 0, 5, 10, 15, 20, 30, 45, 60 ve 100 m mesafelerde dokuz parsel (5 × 20 m) oluşturulmuştur. Ağaçlar rejenerasyon çeşitliliğini değerlendirmek amacı ile Simpson çeşitlilik indeksi ve Margalef zenginliği kullanılmıştır. Sonuçlar, çeşitlilik indekslerinin ana ve ikincil orman yolları ve farklı mesafelerde önemli ölçüde farklı olduğunu göstermiştir. Ağaç rejenerasyonu her iki yolda da orman içine doğru artmıştır. Yol yoğunluğunu en aza indirmek, çeşitliliği ve orman kaynaklarının sürdürülebilirliği korumak için esastır. Sonuçlar, olumsuz çevresel etkilerini azaltmak için çevreye duyarlı orman yolu yapım ilkeleri ve teknikleri kullanılması gerekliliğini göstermektedir.

Anahtar kelimeler: Çeşitlilik, Orman yolları, Zenginlik, Simpson çeşitlilik indeksi.

Introduction

Forest road is one of the essential means to access forest for timber harvesting, forestry projects, fire protection and recreation. Constructing road has been known as a major cause of degradation of forests; but has an outstanding performance on human life (Forman and Alexander, 1998; Watkins et al., 2003). Such activities affect quantity and quality of composition, structure, and biodiversity of trees regeneration (Flory and Clay, 2009; Spooner et al., 2004). Tree regeneration in managed forests is essential for stability of wood production. Structure of forest roads makes changes in biotic and abiotic parts of environment. Compaction and soil displacement around the roads will reduce natural regeneration of forests due to road constructing. Hence, identification of tree regeneration in roadsides can be effective in increasing stability of soil around forest roads. This process can be used in bioengineering methods to stabilize road edges. Therefore, this paper aims to study different factors affecting diversity and tree regeneration of roadside and their effect on soil strength and stability.

Effects of forest roads on tree regeneration diversity have been studied widely all around the world. The results of Lotfalian et al. (2012) and Najafi et al. (2012) showed that light tolerant species were seen along the road especially on road verge. Species of *Acer* sp. was found to be on the side of the road and *Fagus orientalis* was increased with distance from the road. Hosseini (2010) indicated that regeneration of *Diospyrus lotus* in 0-10 m is more than 10-15 m. Also regeneration combination in interval of 10-15 m is much richer than 0-10 m. Guariguata and Dupuy (1997), assessed tree regeneration on the edge of forest roads in the mountains of Costa Rica. They concluded that tree regeneration density in roadside is low because of compaction and low fertility of soils, so light demanding species are present in this area. Buckley et al. (2003) evaluated impacts of haul roads and skid trails on understory vegetation richness and composition. They reported that understory plant richness was significantly greater in haul roads than in skid trails and forest. This forest has a long history of forest management and in this study we sought to answer the following question:

- Do the main and secondary forest roads have a significant effect on the surrounding tree regeneration?

Materials and Methods

Site Description

The study site is a Kheyrud Forest and is located in northern Iran, 7 km Noswhahr, Mazandaran province. This forest is deciduous forest. Specific study area (Namkhane) covers about 1083 ha and the elevation ranges from 350 to 1350 m above sea level. Namkhane has been divided in to 27 districts, 5 districts have been considered as protective ones due to high gradients. The road length is 15.8 km and road density is 20 m/ha. Range of rainfall in this district is 1300-1600 mm. Growing season in this region is about 270 days, and it begins in late March, with average daily temperatures about 10 ° C and completed in mid-December.

Field measurements

To eliminate effect of forest type, all transects were located in hornbeam–beech forest type as dominant forest type of study area. Set a 100-meter buffer in both sides of main and secondary forest roads and continued up to 100 meters from road edge to forest interior. Numbers of sixteen transects were established perpendicular to the axis of forest roads in both fill and down slope (8 transects on main roads and 8 on secondary roads). Nine plots (5×20m) were established parallel to the road at 0 (road edge), 5, 10, 15, 20, 30, 45, 60 and 100 m. Regeneration abundance was recorded (Appendix) in each plot (Londo 1976). Data were collected in two stages: in summer of 2012 (September), and spring of 2013 (April).

Data analysis

For comparing, tree regeneration diversity in main and secondary forest roads, fill and down slope, Simpson's diversity index and Margalef's richness was used. The indices calculated as follow:

$$D = 1 - \sum_{i=1}^{S} \left[\frac{n_i - (n_i - 1)}{N(N-1)} \right] \quad (1)$$

where D is Simpson diversity index, S number of species, n_i is the number of entities belonging to the i^{th} type and N is the total number of entities in the dataset.

$$I = \frac{S-1}{log_e N} \quad (2)$$

where I is Margalef richness index, S is the number of data types in the sample and N is the total size of the sample.

Past 2.12 software was used to calculate each of these indicators. Finally, two-way ANOVA was used for data analyzing by using SPSS 20 software to examine variation in main and secondary forest roads in both fill and down slope.

Results

Simpson index

Analyzing Simpson diversity index shows that there is a significant difference between main and secondary forest roads, down and fill slops, and distances from road verge to forest interior, respectively ($F = 10.04$, $P < 0.05$; $F = 7.42$, $P < 0.05$; $F = 52.67$, $P < 0.05$). The Simpson index increase in main and secondary roads when we lose sight of the road edges in both cut and fill slopes (Figure 1).

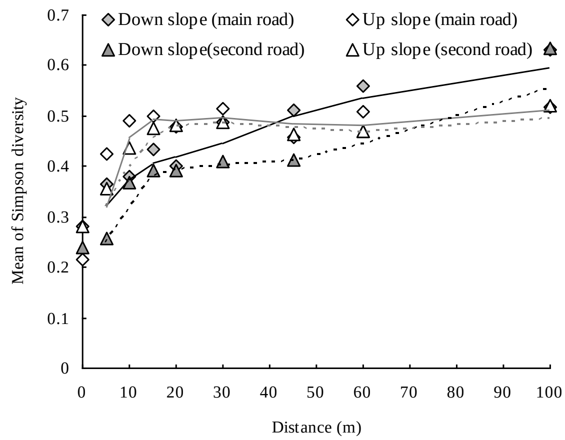

Figure 1. Simpson index in main and secondary forest roads in both cut and fill slopes. Different lines show the trend of changes in tree regeneration diversity for cut and fill slopes of different roads.

Margalef index

The results of two-way ANOVA for Margalef richness index in main and secondary forest roads showed that there is significant differences between different roads and different distances from forest roads edge, respectively ($F = 39.66$, $P < 0.05$; $F = 107.46$, $P < 0.05$). Figure 2 shows that with increasing distance from the edge of the road, value of index rises.

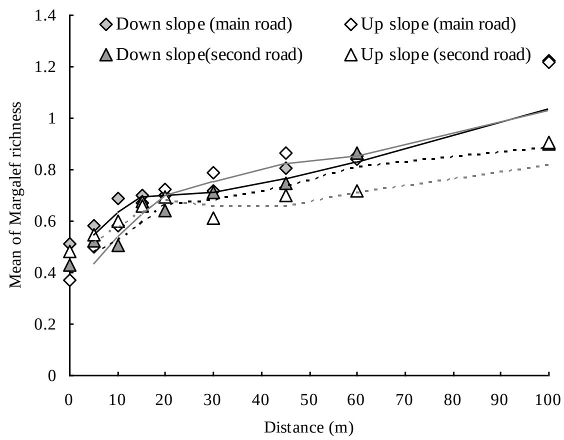

Figure 2. Margalef index in main and secondary forest roads in both cut and fill slopes. Different lines show the trend of changes in tree regeneration richness for cut and fill slopes of different roads.

Discussion

According to the obtained results, type of forest road affect amount of Simpson diversity index and Margalef richness index that may be due to leave secondary forest roads after harvesting operations. These roads were left for a long time. Establishing tree regeneration depends on dispersal, germination and competitiveness of seeds (Cavallin and Vasseur, 2008). Species on shoulders of roads use more energy to absorb more nutrients and moisture because moisture and nutrients is low (Tilman, 1988), so regeneration and growth of seeds can be a limited. Because of better conditions in forest interior, diversity and richness in forest increases and these conditions provide establishing seeds. Present results are the same as other research's results (Karim and Mallik, 2008; Avon et al., 2010, 2013; Hosseini, 2010; Sheng-Lan Zeng, 2011; Lotfalian et al., 2012; Najafi et al., 2012), they stated that distance from a road verge impacts on the diversity and richness. Canopy removal, low moisture and nutrients in roads verge due to high temperature and sunlight, limited establishment and survival of their regeneration (Pinard et al., 1996). According to the results (Figures 1 and 2) biodiversity of tree regeneration within forest is more. grazing of livestock and compacting soil is another reason for the lack of regeneration in roads (Barchuk et al. 1998). Percentage of light demanding species decreases with distance from the road, while shade tolerant species tend to be present in forest interior. Presence of *Acer velutinum*, *Alnus glotinusa*, and *Ulmus glabra* in the side of the roads indicates that light demanding species more frequent along the road towards the forest interior. These results are consistent with the findings of Delgado et al. (2007). Forest road edges have higher temperatures, lower relative humidity and higher wind shear encounter (Didham and Lawton, 1999; Laurance, 1997). A combination of the above factors can reduce the growth and survival of trees regeneration.

Conclusion

Analysis of tree regeneration diversity indicates that distance from road verge affects richness and species diversity in both main and secondary. Road verges are unsuitable places so less regeneration was seen in road side. Light demanding trees such as *Acer velutinum*, *Alnus glotinusa*, and *Ulmus glabra* were seen in road verges because more competitive in such places than shade tolerant trees such as *Fagus orientalis*. In fact, forest interior due to closed and dense canopy has different conditions than the margin of roads and these factors led to development and distribution of tree regeneration in the forest away from the road. Constructing forest roads cause soil compaction so reduces regeneration of the forest. Thus identify trees regeneration status around the road sides be effective in increasing the stability of soils. In summary road presence and its function, draw researchers and managers to challenge because forest ecosystems are complex and routes that pass through the landscape that affect their performance at local and regional scales.

Appendix. List of tree regeneration species on main and secondary forest roads of study site

Species Name
Fagus orientalis
Carpinus betulus
Acer velotinum
Acer cappadocicum
Ulmus glabra
Frangula alnus
Tilia begonifolia

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