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Annals of Biological Research, 2012, 3 (4):1700-1703
(http://scholarsresearchlibrary.com/archive.html)

ISSN 0976-1233
CODEN (USA): ABRNBW

Effect of Forest Roads on Adjacent Tree Regeneration in a Mountainous Forest

Akbar Najafi [1], Mehdi Torabi[1], Abbas-Ali Nowbakht[2], Mehran Moafi[2], Alireza Eslami[3], Bahman Sotoudeh Foumani[4]

[1]*Tarbiat Modares University, Faculty of Natural Resources and Marine Sciences, Department of Forest Science, Noor, IRAN*
[2]*Department of Forestry, Faculty of Natural Resource, University of Mazandarn, Sari, Iran*
[3]*Department of Natural Resources, Rasht Branch, Islamic Azad University, Rasht, Iran*
[4]*Young Researcher's Club- Islamic Azad University, Rasht Branch, Rasht, Iran*

ABSTRACT

The estimation of the road effects on the adjacent tree regeneration particularly composition and density is useful to understand changes induced by the road network on ecosystems. In this study the effects of forest roads (5.5 m width) were evaluated on adjacent tree regeneration in plots that located on transects running from edge roads to 40m to the interior in the Hyrcanian mountainous forests of Iran. Mean of adjacent tree regeneration under height 150cm and 5 cm diameter was compared in the circle shape plots with various distances from the road edges (2.5, 7.5, 15, 25, 35m). The results revealed that some species which were benefited from increased light and disturbed soils were established in plots near the forest roads. Also results suggested that construction of roads in forest may cause establishment light demanding species specially for light loved species such as Acer sp (Maple) were more present close to the road edges and density of shade loved (demands) species such as Fagus orientalis (Beech) increased with distance from the road. Density of tree regeneration changes significantly persisted for 7.5 m distance. Most number of regeneration was observed in the plots with distance of 7.5 m from road edge.

Keywords: Road margin, Road ecology, Road edge, Tree regeneration, Soil disturbance.

INTRODUCTION

Forest roads are necessary for a variety of activities including timber management, wildlife management, recreation, fire management, insect break thorough and pathogens [6, 19, 10]. These structures create micro and meso-climatic changes and probably contribute to global macroclimate change, through variation of the received sun radiation, wind regimes, moisture and temperature [17, 28]. Forest roads remove or disturb large areas through indirect effects that accumulate and interact at higher scales [7, 13, 29, 14]. Forest destruction by roads causes progressive vegetation degradation, with the new open spaces being concealed by shrubs, bracken ferns and numerous introduced Mediterranean elements [23]. Numerous exotic plants are increasingly colonizing forest road edges. Probably, microclimatic changes produced in the zone of road edge effect are favoring the spreading of exotics outward the road surface [12, 9]. Tree regeneration is fundamental to the sustainability of timber production in naturally managed forests. Soil compaction and topsoil displacement in the surrounding environment due to road construction is responsible for decreased potential of establishment and subsequent growth of tree regeneration in some forests [4, 15, 27]. Identification of tree regeneration situation in the adjacent forest roads in various distances from road edge is first step to understand road influence on ecosystem structure and dynamics for land managers;

responsible for managing invasive plant species to maintain the integrity of biological communities in fragmented habitats. The aims of this paper are first; to investigate whether the density and composition of adjacent regeneration along forest roads can be influenced from some changes in environmental conditions and second; to compare the density and composition of tree regeneration along forest roads to interior of 40m forest from road edge.

MATERIALS AND METHODS

Study area

The study area was located in the Chamestan forest in Mazandaran province, north of Iran, between 36º22' and 36º27'35"N, latitudes and 52°2'30" and 52°7'30"E longitudes and covers an area of 2500ha. Annual mean rainfall was 803 mm, with wet months between September and February, and a dry season, from April to August. Altitude ranged from 700 to 850m. Soil was with silt-clay-loam and clay-loam textures. Dominant tree species in the adjacent of roads were reported *Alnus glotinosa, Acer sp, Fagus orientalis, Carpinus betulus, Zelkova carpinifolia, Quercus castanifolia* and a few number of *parrotia persica* trees. All roads segments width was 5.5m and whole the area had same traffic.

Experimental design and data collection

To investigate the influence of the roads on the adjacent regeneration, regeneration was sampled in the different plots along six transects that were situated perpendicular to the road. Each transects extended 40m on either side of the road and had five plots at 2.5, 7.5, 15, 25 and 35m distances. In order to minimize the influence of topographic landscape controls on local microclimate, sampling was restricted to sites with followed requisites: (1) as similar elevation as possible (altitudinal limits between transects: forest, 700–850 m; maximum altitudinal range in which forest develop: 900 m), (2) similar aspect (all hillsides in Chamestan forest, were selected N, NW or NE, (3) low variation in micro topography (e.g. absence of large boulders or rocks) and slope, (4) similar corridor width 5.5m in all road segments and straight in shape and (5) no overlapping with other linear infrastructures such as fire breaks, power line corridors, habitation areas or areas of strong relief (i.e. deep ravines or slopes). With these restrictions, in late of August and early September, transects were constructed at right angle from the road edge to 40m to the forest interior and between up-slope and down-slope directions from the road. The first transect was selected accidentally at Chamestan region and other transects were selected at least one tree length far away from previous transect. The edge was considered as the outeral limit of the artificial road surface. Five circle shape sampling plots were placed with an area of 12.56m^2 and along each transect all tree regeneration height 150cm and 5cm diameter (D.B.H.) were measured under at the following distances from road edge: 2.5, 7.5, 15, 25 and 35m (Fig.1). Tree regeneration densities, were averaged over the six plots in each distance and the resultant means were used in data analysis. A two-way analysis of variance (ANOVA) was used to test for differences in tree regeneration mean among various tree species and distances from road edge.

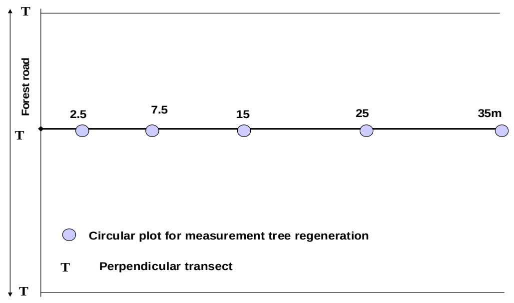

Fig 1- Sampling points on the adjacent forest road

RESULTS

Figure 2, illustrates the mean number of tree regeneration in the different distances from road edge. There is no significant difference between mean of tree regeneration in 2.5, 15, 25 and 35m distances from road edge. The least density of tree regeneration can be observed in first plots of adjacent forest roads in 2.5m distance. Also, this figure revealed that the most density of tree regeneration located in plots with 7.5 m distance from road edge and decreased from 7.5m distance to later to the interior forest.

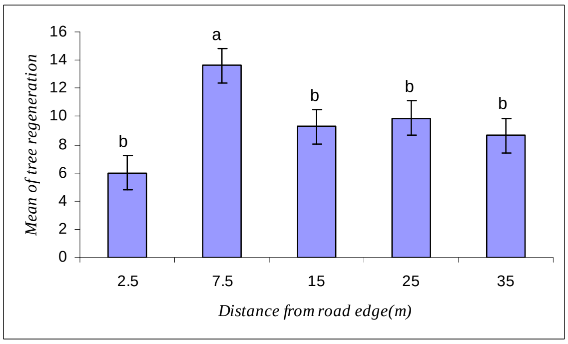

Fig 2- Mean number of tree regeneration in different distances from road edge. Within each distances group, means with the same letters are not significantly different at α= 0.05 level.

Regeneration mean of various species in different distances of road edge can be observed in Table1. Generally, results showed that mean of tree regeneration for some species (e.g. *Alnus glotinosa* and *Acer sp,* Table 1) and small seeded species (e.g. *Murus alba* and *Ficus carica*, Table 1) were most extent in close distances to forest road especially in 7.5 and 2.5m distances respectively. In addition, regeneration of two species; *Murus alba* and *Ficus carica* were observed only in first distance from road edge. Whereas mean number of shade-demand species regeneration (*Fagus orientalis*) significantly was increased to the interior of forest. Also semi loved-light species (*Carpinus betulus* and *Parotia persica*) were higher in intermediate distances (15, 25m) from road edge. The highest regeneration of shade and light demand species (*Fagus orientalis* and *Acer sp*, respectively) was observed in 7.5 m distance from road age.

Table 1- Mean number of regeneration for various species in different distances from road edge. Comparison among distances conducted by (ANOVA) test. Mean with same letter within rows are not significantly different at α= 0.05

Tree species	Distances from road edge (m)				
Acer sp	2.57b	5.3a	1c	0.2c	0.03c
Alnus glotinosa	0.4ab	0.57a	0.1b	0.0b	0.0b
Parotia persica	0.37b	1.07ab	1.38a	1.53a	1.13ab
Carpinus betulus	0.07b	1.17a	1.4a	1.3a	0.43ab
Fagus orientalis	1.17b	2.63ab	3.37ab	5.83a	6.17a
Ficus carica	0.1	0.0	0.0	0.0	0.0
Morus alba	0.2a	0.0b	0.0b	0.0b	0.0b

DISCUSSION

From figure1, it is obviously recognizable that mean of tree regeneration is at least in 2.5 m distance from road edge in comparison with other distances. This can be explained by road construction events which may have partly or totally destroyed a population, therefore removing all evidence of previous recruitment events. The frequency and severity of disturbance events may have prevented recruitment [22]. All plots in 2.5m distance were located in shoulder and have lower moisture content compared to the other microhabitats that reached this result in their researches [21]. Germination and growth of seeds depend on moisture and environmental conditions such as light availability [16] that act as environment barriers and affect the establishment of non native plants [3]. On the other hand, compaction of soil and highest soil bulk density and no detectable organic matter depth were recorded in the shoulder [21]. Soil compaction at the level found in the present study may generally impede root growth, especially in dry soils [2]. Problems with establishment of regeneration of many species in 2.5 m distance appear to be related to problems with competing vegetation and compacted soil [30]. Dense cover of competing vegetation in the first plots near the road edge, particularly (*Rubus hyrcanus* and *Sambucus ebulus*) account for the low densities of tree regeneration observed on these sites. Competing vegetation at ground level may be responsible for some regeneration failure [5]. There was a notable absence of tree regeneration in all of the sampling plots in the 2.5m distance from road edge, specially for loved–shade species , for example *Fagus orientalis* (fig 2). In these distances, road construction and tree cutting along forest roads, increased light on the ground level. Most density of regeneration was observed in plots with 7.5m distances from road edge because on that distance, the situation was natural and competitor species were less with increasing of distance from road edge. (Fig1). Frequency of exotic plants decreased with distance from road edge to interior forest [20]. Also compaction of soil was less in 7.5 m distance compared to 2.5m distance, whereas moisture content was more. Also [21] reclaimed this issue in their researches. In the plots located in 7.5m distance from road edge, light and semi light demand species invade and concentrate in this zone. It appears that high levels of disturbance in conjunction with increased resources of light and moisture, often results in high–density populations along narrow road verges [22], especially for 7.5m distance with less soil compaction. Regeneration of some small-seed species such as *Ficus carica* and *Morus alba* were observed only in plots in the first 2.5 m distances (Fig2). Light–tolerant species that would be expected to be benefit from the soil disturbance and seedbed preparation caused by road construction of operations, as well as the increased light from partial canopy removal and control of understory plant competitors [8] reported successful regeneration following strip clear cutting in the Peruvian Amazon. Also [30] observed that the regeneration of free-standing tree species also was enhanced on areas with soil disturbance. In the neo-tropics, these studies are supported by observations that regeneration of high-value species, such as *macrophylla* are depended on seedbed preparation and or release of competition created by such large disturbances as fire and hurricanes [18] or river meanders [24]. The availability of seed in the various distances may be also being an important factor determining the success or failure of regeneration of some commercial tree species. Light-demand species such as *Acer sp* would likely benefit from a strip cutting system specially those using that create soil scarification near seed trees. However, the general lack of regeneration of all other species on all sites regardless of soil disturbance or light environment created by harvesting indicates the need for post harvest competition control treatments to establish and or liberate commercial tree regeneration [11] especially for distances near the road edge. Some species such as *Acer sp* benefited from increased light intensities on plots near the forest road. Other species benefited from low densities of competing vegetation on plots in 2.5 m distance with compacted soils. Soil disturbance from road construction may also promote recruitment by alleviating soil compaction and increasing moisture infiltrating [1, 25]. Finally, the intensive and frequent road construction events may exceed natural disturbance regime and some relevant effects which may take decades for a population to fully recover from [26].

Acknowledgment
We would like to thank the staffs from Mazandaran Forests and Watershed Management Bureau at Sari, Iran for their help.

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