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Marginal Effects of Rural Roads and Irrigation Canals on Woody and Non-woody Species Composition

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Abstract

Across the northern rural regions of Iran, gardens and farmlands are being fragmented into smaller and smaller patches by rural roads network with significant edge effects on plant species composition and abundance. In this study the presence of different plant species was recorded in ninety 1 1 m plots on nine 100 m transects at the edge of terrene rural roads with irrigation canal and without irrigation canal. Thirty seven plant species were identified in the 9 transects surveyed. Twenty six (or 70.3%) of those species were occurred near the irrigation canal (Transect 2 and 3). Rubus hyrcanus Juz (more than 80% in visually) were observed on transect 3 of roadside with irrigation canal because of light availability and high soil moisture. *Ulmus carpinifolia* Borkh., *Quercus castaneifolia* C. A. Mey., *Pterocarya fraxinifolia* (Lam.) Spach., *Parrotia persica* C.A.M., *Zelkova carpinifolia* (pall.) Dipp. And *Albizia julibrissin* (Willd) Benth were the unique species which were found near the irrigation canal especially on transect 2. These species are the final survivors of Hyrcanian forests in rural area which were conserved from the human damages. Plant species richness at the edge of rural road with irrigation canal (37 species) was more than the edge of rural road without irrigation canal (17 species), but the cover value was similar to each other. *Punica granatum* L. was the more frequent species (more than 80%) on the both side of rural road (transect 2 and 3) without irrigation canal.

Key words: Edge . Iran . Irrigation canal . Plant composition . Rural road

INTRODUCTION

Rural roads are the base of social and economical activities. These types of roads are built to provide easy access to the gardens, farmlands and community places. In Iran, the rural population is about 23 million and the total length of urban and interurban roads including highways, main and secondary roads is approximately 75000 km [13]. In addition, the total length of rural roads network in this country is more than 150000 km which 72000 km of them have been asphalted. Approximately 100000 km of these roads was constructed after Iranian Islamic revolution 1979 [13].

Rural transportation infrastructure affects the structure of edge ecosystems, the dynamics of ecosystem function, and has direct effects on ecosystem components, especially their plant species composition. However, transportation systems, and more specifically, rural and forest roads, have a wide variety of primary, or direct, ecological effects as well as secondary, or indirect, ecological effects on the landscapes that they penetrate [3].

The patterns of plant species diversity in herbaceous vegetation subjected to various human activities were studied in most of the landscape elements in a rural area of central Japan [7]. Accumulated number of species increased in a stepwise pattern along the DCA axis 1, in which the dominant plant life-forms were replaced from annuals, to perennials and perennials/tree-saplings depending on different management regimes. The unique species which were confined to a certain management regime were identified in each site. Among four types of management regime, mowing sites had most abundant unique, rare species specially adapted to regular cutting. It is suggested that maintaining such traditional mown sites is important to conserve the unique biodiversity of the studied area [7].

Road development is a primary mechanism of fragmentation, removing original land cover, creating edge habitat, altering landscape structure and function, and increasing access for humans [14]. Across the rural regions, gardens and farmlands are being fragmented into smaller and smaller patches by rural roads network, with significant effects on plant species composition and abundance. The minor rural road network is an important part of the landscape structure. It sustains all agricultural activities by connecting farms and fields, market or processing industries (output) and input resources. Roads and their adjoining verges are important elements of the ecological infrastructure and influence landscape-ecological patterns and processes [9, 11].

Initial road failure is indicated when the drivers complain about pot holes, surface rutting and roughness. The wheel ruts frequency and dimensions were investigated by Parsakhoo and Hosseini [10] found that the ruts length and area were affected by longitudinal gradient of rural roads in Denji Kola village of Iran. Moreover, the effects of geographical aspect on ruts length, ruts width and ruts area was significant. The objective of this study was to evaluate the edge effects of rural roads (with irrigation canal and without irrigation canal) on woody and non-woody plants species composition in a northern village in Iran.

MATERIAL AND METHOD

Site description

This research was conducted In the spring of 2010 in Denji Kola village of Ghaem Shahr (36°21' to 36°38' N and 52°43' to 53°3' E), Mazandaran province, Iran. Average annual precipitation and temperature in this area are 724.9 mm and 16.7 °C, respectively [10]. Elevation at see level ranges from 64 to 98 m. During the rainy season months, the bare soil of the terrene rural roads in our study area become waterlogged and impassible, because there are little or no facilities for surface or subsurface drainage. A terrene road is a type of small rural unpaved road connecting areas of farmland in hilly areas [2]. During the dry season months, dust raised by the wheels of passing vehicles becomes a major environmental and health hazard. The rural roads were under traffic by different types of machines in sandy clay loam soil.

Data collection

The plant species composition was identified at the edge of unpaved rural roads with irrigation canal and without irrigation canal. The irrigation canal is a ditch which directs water to the farmlands. At the edge of rural roads with irrigation canal we sampled 3 transects at the distances from the roadside into the garden 0, 2 and 5 m and in other side we sampled 2 transect at the distances from the roadside into the garden 0 and 2 m. At the both sides of rural roads without irrigation canal we sampled 4 transect at the distances from the roadside into the garden 0 and 2 m. In each of the 100 m transect which was parallel to the road edge, ten 1×1 m plots were randomly placed and in each plot the presence of plant species was recorded. Ten 1×1 m plots appeared adequate to detect at least 95% of species present in each transect.

RESULTS AND DISCUSSION

Plant invasions are often more common near roads and in young habitats than in interior and mature habitats [5]. Thirty seven plant species were identified in the 9 transects surveyed (Table 1). Twenty six (or 70.3%) of those species were occurred near the irrigation canal (Transect 2 and 3). In this study, *Rubus hyrcanus* Juz were observed on transect 3 of roadside with irrigation canal because of light availability, high soil moisture and nutrient content. *Ulmus carpinifolia* Borkh., *Quercus castaneifolia* C. A. Mey., *Pterocarya fraxinifolia* (Lam.) Spach., *Parrotia persica* C.A.M., *Zelkova carpinifolia* (pall.) Dipp. And *Albizia julibrissin* (Willd) Benth were the unique species which were found near the irrigation canal especially on transect 2. These species are the final survivors of Hyrcanian forest in rural region which were conserved from the human damage (Table 2). Karim and Mallik [6] found that floristic zonation along roadsides is a function of roadside microtopography, substrate type and environmental gradients created by the road building process. Several native plants, such as *Empetrum nigrum, Juniperus communis, Vaccinium angustifolium, Trifolium repens*, and *Anaphalis margaritaceae* are naturally abundant in side slopes and possess autecological attributes such as low stature, widespread above- and below-ground parts, and drought tolerance. Presence of these desirable properties and their perennial habit make them excellent candidates for roadside revegetation in Karim and Mallik [6] study area.

Rural roads are integral part of rural development and it stimulates overall development by providing access to economic and social infrastructure and facilities. In order to avoid the problems associated with rural road development, it is advisable to prepare a rural road plan by building strong database, which consists of village level information and road inventory details. GIS supports multiple views of data and yet provide integration that would minimize redundancy and maintain data integrity and security [12]. The rural road system conditions the development perspectives of agriculture and recreation, as well as some possibilities of agriculture related preservation of scenery and nature [11].

The relationship between densities of invasive exotic shrubs, distance to road, and successional age of the forest was investigated in 14 forested sites throughout central and southern Indiana. Densities of four of seven exotic shrub species declined with increasing distance to the nearest road across all successional ages. Greater densities of exotic shrubs were found in young and mid-successional forests than mature forests. However, there was no interaction between distance to road and forest age, suggesting that the role of roads in the invasion process does not change across forest successional ages [4].

Species richness at the edge of rural road with irrigation canal (37 plant species) was more than the rural road without irrigation canal (17 plant species), but the cover value was similar to each other. *Punica granatum* L. was the more frequent species on transect 4 of the edge of rural road with irrigation canal and on transect 2 and 3 of the edge of rural road without irrigation canal (Table 2). The shape of road cross section with irrigation canal affects the drainage and hydraulic behavior of runoff. So the soil moisture in different parts of road edge changes

Table 1. Presence of plant species on 100 meter transects along rural road with irrigation canal

Plant Species	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5
Trees					
Citrus aurantium	×	-	-	-	×
Citrus aurantium var. deliciosa	×	-	-	-	×
Citrus aurantium var. amara	×	-	-	-	×
Parrotia persica C.A.M.	-	×	-	-	-
Quercus castaneifolia C. A. Mey.	-	×	-	-	-
Pterocarya fraxinifolia (Lam.) Spach.	-	×	-	-	-
Zelkova carpinifolia (pall.) Dipp.	-	×	-	-	-
Populus nigra	-	×	-	×	-
Ailanthus altissima	-	-	×	×	-
Albizia julibrissin (Willd) Benth.	-	×	-	-	-
Ulmus carpinifolia Borkh.	-	×	-	×	-
Juglans regia L.	-	×	×	×	-
Ficus carica L.	-	×	-	×	-
Prunus divaricata Ledeb.	-	×	-	×	×
Morus alba L.	×	-	-	×	×
Melia azaderaeh L.	-	×	-	-	-
Shrubs					
Mespilus germanica L.	-	×	-	-	-
Crataegus oxycantha	-	-	×	-	-
Punica granatum	-	×	-	×	-
Herbs					
Mentha sativa	×	-	-	-	×
Convolvulus arvensis	-	×	-	×	-
Lamium album	×	-	-	-	×
Potentilla reptens	×	-	×	-	×
Oxalis corniculatum	×	-	-	-	×
Calystegia sepium	-	×	-	×	-
Rubus hyrcanus Juz.	-	-	×	×	-
Asplenium filix femina	-	×	×	-	-
Sombocus ebulus -	-	×	-	-	
Circium arvens	-	-	×	×	-
Thurgenia sp.	-	-	-	×	×
Urtica dioica	-	-	-	×	-
Rynchocorus elephans	-	-	×	-	-
Melissa sp.	×	-	-	-	×
Grasses					
Pheleum peratens	×	-	×	×	×
Poa annua	×	-	×	×	×
Gasteridium sp.	×	×	×	×	×
Berachypodium silvaticum	-	-	-	×	-

× and - Indicate presence and absence of plant species, respectively.

from one place to another place which this can alter plant community. Edge effects of Tenerife laurel forest road on plant species richness, plant composition and litter production was studied in Canary Islands' forests. Effects of anthropogenic corridors on vegetation differed between paved roads and unpaved trails. Opportunistic species (shade intolerant) dominated road edges, but composition differed among all sites. Multivariate analysis revealed convergence in species composition along the corridor-interior gradient. For trails, both species richness and litter production did not differ significantly between edge and interior. Road edge effects on vegetation were detectable only within the first 10 m towards the interior. This suggests that the main effects of roads and trails on species richness are limited to the immediate edge of the laurel forest. Litter fall along road edges was half that of the interior [1].

Koukoura et al. [8] showed that drought tolerant species of all plant life forms had high survival percentages and contributed significantly to the vegetation cover at the end of the growing season. Drought tolerance and the existence of rhizomes benefited the establishment ability of grass species. The best adapted species were the grasses *Agropyrum cristatum* L., *Bromus inermis* Leyss., *Dactylis glomerata* L. and *Festuca valesiaca* Schleich, the legume *Medicago sativa* L. and the forb *Sanguisorba minor* Scop.

Soil erosion is the dominating factor of damaging terrene roads in rural areas worldwide. The results of the field tests of anti-erosion and maintenance techniques on terrene rural roads in China showed that soil erosion on unpaved terrene roads with no vegetation is more than that of roads with grass pavement in the same situation. Roads with *Bromus inermis, Elymus sibiricus, Elymus, Poa annua* can bear traffic loads up to 300 vehicles per year. The cost of grass road construction is less than that of stone roads, with maintenance costs averaging 60.97% less than that of non-grass terrene roads. So, grass roads can fill the gap between paved and unpaved roads in areas with sloping terrain and low traffic volumes (rural countryside) and thus minimize the level of soil erosion, landscape damage and other environment problems [2].

The effects of road construction are more apparent on downslope than upslope. Also, the effect range is more on downslope than on upslope. Soil remediation is mainly related to effect extent of road construction, road service time, vegetation restoration, soil organic matter and soil total nitrogen, among which, road construction is the most important factor. When vegetation coverage can be restored to 30% of the original condition, soil quality can be remedied to 44% of the original condition after 10 years, indicating that soil fertility remediation is rather difficult once it is destroyed [15]. Several naturally occurring plants with desirable properties have been found to colonize in different roadside microhabitats. Plant species can be selected from this naturally occurring species pool for revegetation of respective roadside microhabitats. For example, despite the poor moisture and organic matter content, plant species, such as *Trifolium repens* have successfully colonized and dominated the side slope.

CONCLUSIONS

In this study, 70.3% species ([Number of plant species near the irrigation canal total number of species in study area] × 100) were occurred near the irrigation canal. *Rubus hyrcanus* Juz with 80% coverage were observed on roadside with irrigation canal because of light availability and high soil moisture. *Ulmus carpinifolia* Borkh., *Quercus castaneifolia* C. A. Mey., *Pterocarya fraxinifolia* (Lam.) Spach., *Parrotia persica* C.A.M., *Zelkova carpinifolia* (pall.) Dipp. And *Albizia julibrissin* (Willd) Benth were the unique species which were found near the irrigation canal especially on transect 2. These species are the final survivors of Hyrcanian forests in rural area which were conserved from the human damages. Plant species richness at the edge of rural road with irrigation canal was more than the edge of rural road without irrigation canal, but the cover value was similar to each other. *Punica granatum* L. was the more frequent species on the both side of rural road without irrigation canal.

Table 2. Presence of plant species on 100 meter transects along rural road without irrigation canal

Plant Species	Transect 1	Transect 2	Transect 3	Transect 4
Trees				
Citrus aurantium	×	-	-	×
Citrus aurantium var. deliciosa	×	-	-	×
Citrus aurantium var. amara	×	-	-	×
Juglans regia L.	-	×	×	-
Ficus carica L.	-	×	×	-
Ulmus carpinifolia Borkh.	-	×	×	-
Shrubs				
Punica granatum L.	-	×	×	-
Herbs				
Circium arvens	-	×	×	-
Asplenium filix femina	-	×	×	-
Rubus hyrcanus Juz.	-	×	×	-
Convolvulus arvensis	×	×	×	×
Urtica dioica	-	×	×	-
Thurgenia sp.	×	-	-	×
Grasses				
Pheleum peratens	×	-	-	×
Poa annua	×	-	-	×
Gasteridium sp.	×	×	×	×
Berachypodium silvaticum	-	×	×	-

× and - Indicate presence and absence of plant species, respectively.

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