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Full Length Research Paper

Marginal effects of rural roads and irrigation canals on woody and non-woody species composition

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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 (70.3%) of those species occurred near the irrigation canal (Transects 2 and 3). *Rubus hyrcanus* Juz (more than 80% in visually) were observed on transect 3 of the roadside with irrigation canal because of the availability of light 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 that were found close to the irrigation canal especially on transect. These species are the final survivors of Hyrcanian forests in rural area that were protected from 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 most frequent species (more than 80%) on 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 (Rezaei, 2009). In addition, the total length of rural roads network in this country is more than 150000 km in which 72000 km of them have been asphalted. Approximately 100000 km of these roads was construc-ted after Iranian Islamic revolution, 1979 (Rezaei, 2009).

Rural transportation infrastructure affects the structure of edge ecosystems, the dynamics of ecosystem function, and has direct effects on ecosystem compo-nents, especially on 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 (Coffin, 2007).

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 (Kitazawa and Ohsawa, 2002). Accumu-lated 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 manage-ment 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 the most abundant unique and 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 (Kitazawa and Ohsawa, 2002).

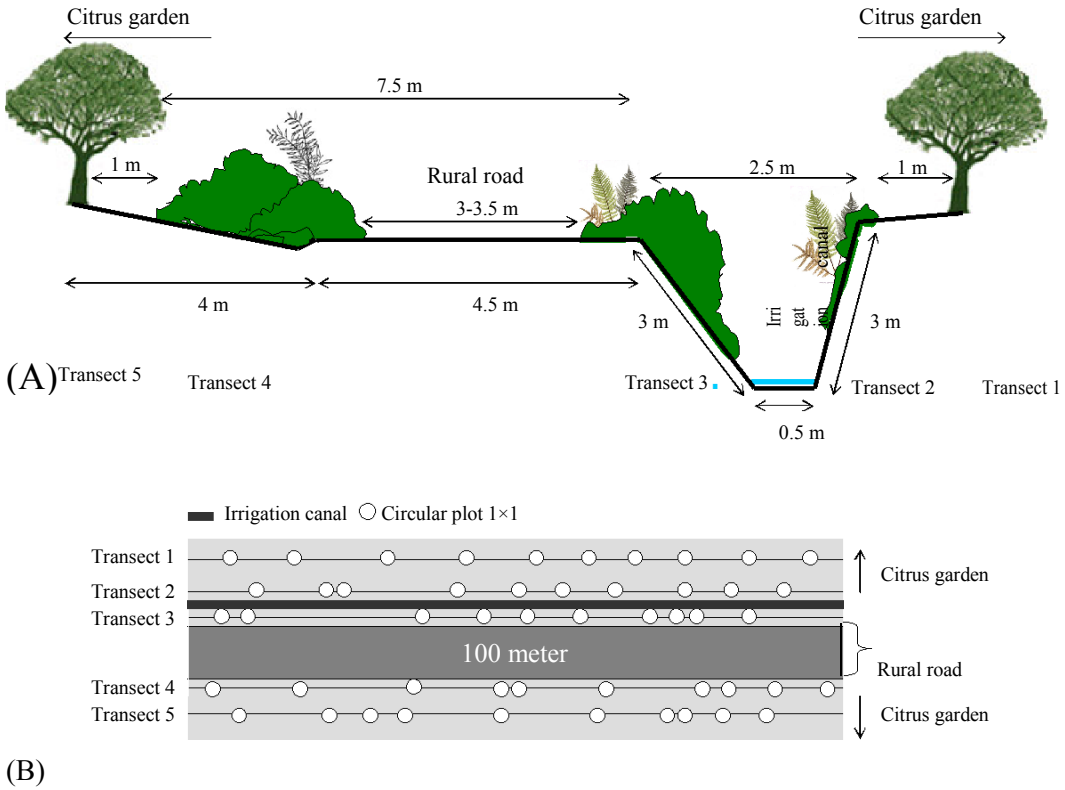

Figure 1. (A) Schematic of terrene rural road with irrigation canal and (B) map of sampling design.

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 (Saunders et al., 2002). 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 (Michels and Jaarsma, 1988; Pauwels and Gulinck, 2000).

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 (2009), who 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 were 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.

MATERIALS AND METHODS

Site description

This research was conducted 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 (Parsakhoo and Hosseini, 2009). Elevation at sea level ranges from 64 to 98 m.

During the months of rainy season, the bare soils 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 (Cao et al., 2006) During the months of dry season, 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

During spring in 2009, the plant species composition was identified at the edge of unpaved rural roads with 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 distances from the roadside into the garden 0 and 2 m (Figure 1). At the both sides of rural roads without irrigation canal, we sampled 4 transect at distances from the roadside into the garden 0 and 2 m (Figure 2) . 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

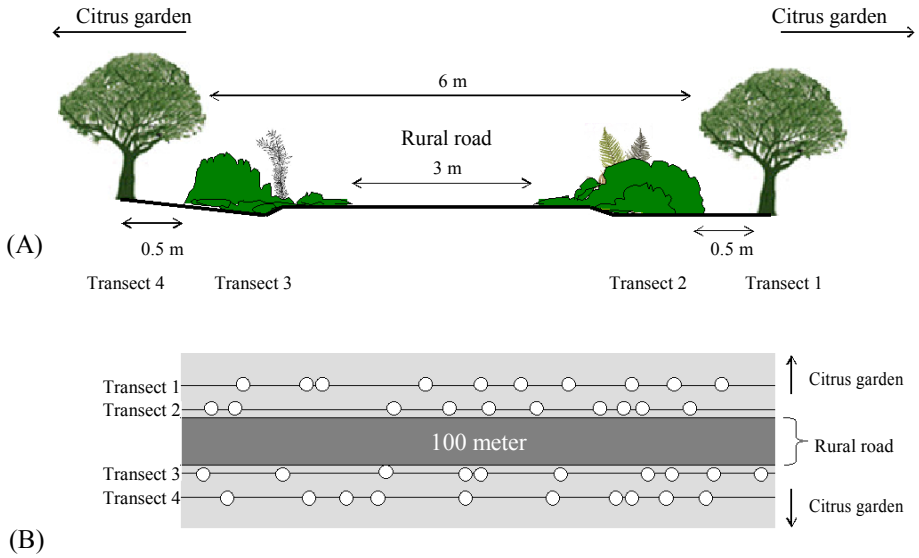

Figure 2. (A) Schematic of terrene rural road without irrigation canal and (B) map of sampling design.

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 DISSCUSSION

Thirty seven plant species were identified in the 9 transects surveyed (Table 1). Twenty six (70.3%) of the species occurred close to the irrigation canal (Transects 2 and 3). In this study, *Rubus hyrcanus* Juz were observed on transect 3 of roadside with irrigation canal because of the availability of light, 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 close to the irrigation canal especially on transect 2. These species are the final survivors of Hyrcanian forest in rural region which were conserved from human damage (Table 1).

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 provide integration that would minimize redundancy and maintain data integrity and security (Rao et al., 2003). 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 (Pauwels and Gulinck, 2000).

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 most frequent species on transect 4 of the edge of rural road with irrigation canal and on transects 2 and 3 of the edge of rural road without irrigation canal (Table 2). The shape of the 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 from one place to another and this can alter plant community.

Koukoura et al. (2007) 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* and *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,

Table 1. Presence of plant species on 100 m 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.	-	×	-	-	-
P. fraxinifolia (Lam.) Spach.	-	×	-	-	-
Z. carpinifolia (pall.) Dipp.	-	×	-	-	-
Populus nigra	-	×	-	×	-
Ailanthus altissima	-	-	×	×	-
A. julibrissin (Willd) Benth.	-	×	-	-	-
U. carpinifolia Borkh.	-	×	-	×	-
Juglans regia L.	-	×	×	×	-
Ficus carica L.	-	×	-	×	-
Prunus divaricata Ledeb.	-	×	-	×	×
Morus alba L.	×	-	-	×	×
Melia azaderaeh L.	-	×	-	-	-
Shrubs					
Mespilus germanica L.	-	×	-	-	-
Crataegus oxycantha	-	-	×	-	-
P. granatum	-	×	-	×	-
Herbs					
Mentha sativa	×	-	-	-	×
Convolvulus arvensis	-	×	-	×	-
Lamium album	×	-	-	-	×
Potentilla reptens	×	-	×	-	×
Oxalis corniculatum	×	-	-	-	×
Calystegia sepium	-	×	-	×	-
R. hyrcanus Juz.	-	-	×	×	-
Asplenium filix femina	-	×	×	-	-
Sombocus ebulus	-	-	×	-	-
Circium arvens	-	-	×	×	-
Thurgenia sp.	-	-	-	×	×
Urtica dioica	-	-	-	×	-
Rynchocorus elephans	-	-	×	-	-
Melissa sp.	×	-	-	-	×
Grasses					
Pheleum peratens	×	-	×	×	×
P. annua	×	-	×	×	×
Gasteridium sp.	×	×	×	×	×
Berachypodium silvaticum	-	-	-	×	-

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

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.	-	×	×	-
U. carpinifolia Borkh.	-	×	×	-
Shrubs				
P. granatum L.	-	×	×	-
Herbs				
Circium arvens	-	×	×	-
Asplenium filix femina	-	×	×	-
R. hyrcanus Juz.	-	×	×	-
Convolvulus arvensis	×	×	×	×
Urtica dioica	-	×	×	-
Thurgenia sp.	×	-	-	×
Grasses				
Pheleum peratens	×	-	-	×
P. annua	×	-	-	×
Gasteridium sp.	×	×	×	×
Berachypodium silvaticum	-	×	×	-

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

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 (Cao et al., 2006).

Conclusion

In this study, 70.3% species ([Number of plant species near the irrigation canal ÷ total number of species in the study area] × 100) occurred close to the irrigation canal. *R. hyrcanus* Juz with 80% coverage were observed on roadside with irrigation canal because of light availability and high soil moisture. *U. carpinifolia* Borkh., *Q. castaneifolia* C. A. Mey., *P. fraxinifolia* (Lam.) Spach., *P. persica* C.A.M., *Z. carpinifolia* (pall.) Dipp. and *A. julibrissin* (Willd) Benth were the unique species that were found close to the irrigation canal especially on transect 2. These species are the final survivors of Hyrcanian forests in rural area that 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.

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