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Full Length Research Paper

Plants canopy coverage at the edge of main communications network in Hyrcanian forests

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To investigate the plants canopy coverage on cut and fill slopes of Lat Talar forest roads in Hyrcanian zone, the systematic randomize sampling method with 60 parallelogram shape plots was used. Within each plot the herbaceous plants and regeneration of woody species were recognized and their canopy coverage was recorded in %. Results showed that the canopy coverage of herbaceous plants and regeneration on cut and fill slopes were 7.2 and 28.4%, respectively. *Rubus hyrcanus* L. had more canopy coverage at the edge of forest roads as compared with other species. Canopy coverage on fill and cut slopes with angles of 25 - 35°and 45 - 55° was more than angels of 35 - 45° and 55 - 65°, respectively. Reducing the cut slope angle is necessary for increasing the plant cover, as it was on the fill slopes.

Key words: Vegetation, canopy coverage, road edges, Hyrcanian forests.

INTRODUCTION

The cut and fill slope angle of the road, largely deter-mines soil stability, because both natural and artificially seeded vegetation rarely become permanently esta-blished on steep slopes, those with 100% slope or grea-ter (Lewis, 2000). Although seeds will often germinate on steep slopes, seedlings wash out when surface runoff and raindrops detach surface soil particles. Some natural revegetation on such cut and fill slopes occurs when mats of litter containing roots of woody and herbaceous plants break away from the top of the bank, lodge and take root on the slope below. Only after many years, however, when erosion at the top of the bank has reduced the % slope, does natural vegetation from seed become permanently established (Morschel, 2004).

The influence of transportation corridors on the frequency of non-native plant largely is due to factors associated with habitat characteristics (Acar, 2003; Hansen and Clevenger, 2005). Habitat type, altered disturbance regimes and intentionally introduced non-native species are essential to consider when describing the impact of non-native species on native plant communities along all types of transportation corridors (Pauchard and Alaback, 2006; Delgado et al., 2007).

Several authors have observed the pattern of roadside plant communities (Lausi and Nimis, 1985; Ullman et al., 1995). They recognized zonation of plant communities across the road corridor with specific biophysical characteristics and floristic composition (Olander et al., 1998; Cilliers and Bredenkamp, 2000). They also reported that soil moisture, organic matter content, bulk density, pH and light regime change significantly within the narrow width of the road corridor, affecting plant community com-position (Karim and Mallik, 2008; Hamed, 2008).

Bochet et al. (2005) studied the effect of slope conditions on vegetation cover and plant species composition near Valencia (East Spain). Results of this study indicated that the main factors influencing vegetation variables on road slopes were the angle, type and aspect of the slope. Vegetation was almost completely lacking on road cuts with slopes of > 45°. On gentler slopes, vegetation cover was 44 - 78% on road fills according to the aspect, whereas it did not reach 10% in any case on road cuts. The type and aspect of the slope also determined species composition, differences in the organic matter con-

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Table 1. Similarity and biodiversity indices.

Similarity index	Formula	Biodiversity index	Formula
Jaccard	$J = \frac{a}{a+b+c}$	Shannon	$H' = P_i \, Ln P_i$
		Simpson	$\lambda = 1 - \frac{n_i (n_i - 1)}{N (N - 1)}$
		Brillouin	$H = \frac{1}{N} Log \frac{N!}{N_1! N_2 ! \ldots N_S !}$

tent, soil available Π and water content existed between road fills and road cuts. However, the environmental conditions of the slopes were more limiting for plant colonization. The short duration of available water in the soil with respect to soil water potential proved to be a limiting factor to plant germination and establishment on road cuts and south-facing slopes, as well as the low soil fertility in the case of road cuts (Elseroad et al., 2003; Truscott et al., 2005).

Cao et al. (2006) showed that where the slope of the terrain was between 0° and 5° the average survival rate of planted grass over the 5 years was 94.69% compared to 82.64% when the slope of the terrain was more than 12.5°. Among grass species, *A. cristatum* showed the best performance with an average survival rate of 95.68% on slopes steeper than 12.5°. Soil moisture, or-ganic matter content, bulk density, pH and light regime change significantly within the narrow width of the road corridor and affecting plant community composition.

The research carried out by Cerdà et al. (2007) at the eastern Spain showed that the vegetation cover in under construction road is always lower than 7% during winter and 2% during summer for average values. But, the vegetation cover values were respectively 37 and 42% (summer and winter) and 46.4 and 54.8% which demonstrate the slow vegetation recovery after 10 years and the lowest vegetation cover during summer.

Koukoura et al. (2007) studied the ability of different types of plants to become established on the road sides of the Egnatia highway, Thessaloniki, Greece. The results showed that drought tolerant species of all plant life forms had high survival % 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* (koukoura et al.,2007)

The aims of this study were to assess the plants canopy coverage on cut and fill slopes after one year from road construction in Lat Taler forest of Iran. Our results suggest that roads have associated effects that alter embankments conditions, plants biodiversity and abundance Some of these vegetations are invader and expanse to the interior forest and damage to seedlings or saplings (Table 1).

MATERIALS AND METHODS

Site description

The focus of this study is a 2 km, secondary unpaved road that was built by the company of wood and paper industry in March 2006 to provide access to the Lat Talar forest compartments. Lat Talar site with an area of 2020 hectare was located in watershed number of 71 in Hyrcanian forest of Iran. The experimental road sections were located in northern aspect of compartments C_{22} (81 ha), C_{24} (70.7 ha) and C_{25} (42.81 ha) of this *Fagetum* forests with an elevation of 800 - 1000 m. a. s. l. (latitude 53 ˚9 40 to 53 ˚13 55 E and longi-tude 36 ˚12 55 to 36 ˚15 45 N). Average annual precipitation for the period 1973 - 1998 was 635 mm (Anonymous, 1994). The area has a mid moist and cold to very moist climate. Soils texture is dominated by deep loams and clay loam. These soils are snippet textured, bad drained and have low organic matter content. The bedrock is typically marl, marl lime and limestone.

Collection of field data

This study was conducted in August 2007. Sampling was carried out in the ground vegetation immediately adjacent to the road edge. Also, to determine the effects of cut and fill slopes gradient on canopy coverage, the cut slopes was classified into classes of 45 - 55° and 55 - 65° and the fill slopes was classified into classes of 25 - 35° and 35 - 45°. Our sampling scheme was based on a 3 transects with a length of 400 m which were systematic randomly located parallel to the road edge. 2 transects were placed on cut and fill slopes. The same sampling design (third transect) was used as the control plots in distance of 150 m from the corridor edge. Each transects included of 3 parallelogram shape plots with a size of 15 m^2 and distances of 20 m from each other. Plots were divided in to 15, 1 × 1 m^2 subplots to increase the accuracy of canopy coverage estimation. Within each subplot, the herbaceous plants and regeneration of woody species were recognized and their canopy coverage was recorded.

Data analysis

The study was established as a randomized complete block design with 4 blocks (slope gradient) and 2 treatments (cut and fill slopes). The equation for the model of a randomized complete-block design is as follows:

$$Y_{ij} = \mu + \tau_i + \beta_j + \beta_{\tau ij} + \varepsilon_{ij}$$

Table 2. Embankment effects on vegetation canopy coverage.

F	MS	SS	df	Treatments
19.64^{***}	4494.4	4494.4	1	Embankment types
2.39^{ns}	547.6	547.6	1	Embankment gradient
0.06^{ns}	14.4	14.4	1	Embankment type and gradient
1.27^{ns}	291.38	2622.4	9	Block
0.53^{ns}	122.04	1098.4	9	Embankment gradient and block
1.78^{ns}	293.07	2637.6	9	Embankment type and bloc

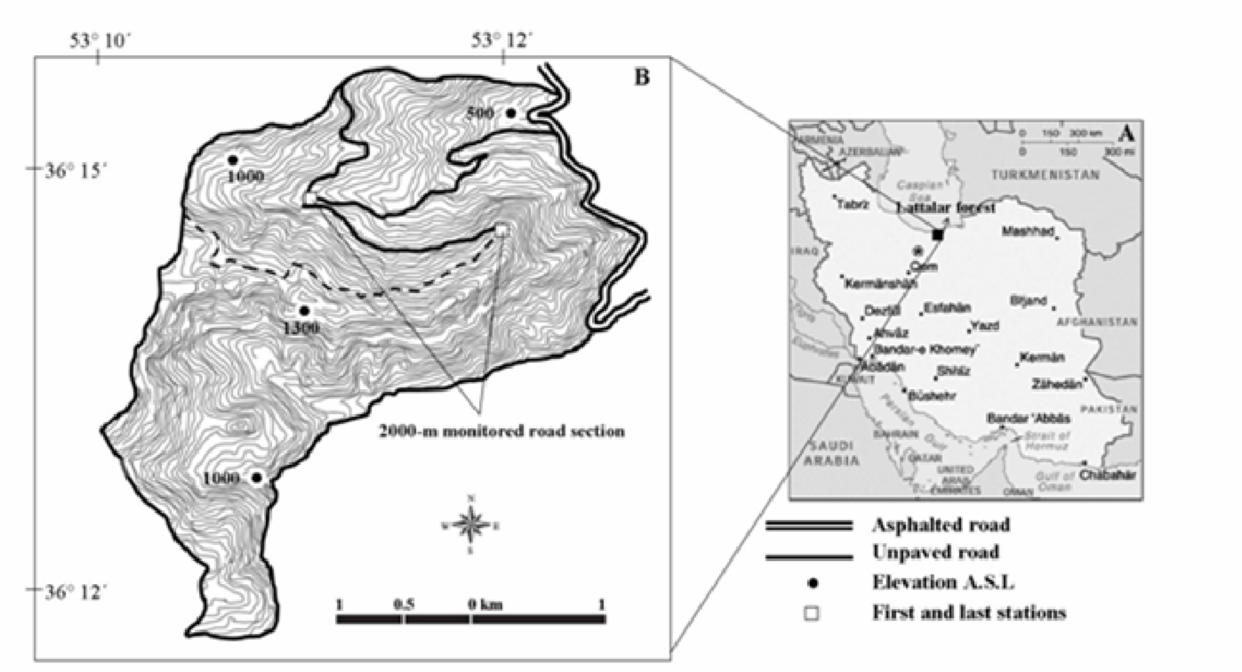

Figure 1. Comparisons of fills and cut slopes vegetation cover in different slope classes.

Where: Y_{ij} is the response of treatment i in replication j , μ is the overall mean, $_i$ is the treatment effect of the i^{th} treatment, $_j$ is replication effect of the j^{th} replication, $_{ij}$ is a replication x treatment interaction effect or plot error and $_{ij}$ is experimental error (South and Vanderschaaf, 2003).

Data were analyzed using the ANOVA procedure provided by the SAS software. When the analysis was statistically significant, the SNK test for separation of means was performed. Statistical signify-cance was judged at $P < 0.05$.

RESULTS AND DISCUSSION

Results showed that the embankment type had significant effect on canopy coverage of herbaceous plants and regeneration of woody species ($P = 0.0007$). But no significant differences were observed for canopy coverage in different slope gradients (Table 2).

Canopy coverage on fill slopes with angles of 25 - 35° and cut slopes with angles 45 - 55° was more than angles of 35 - 45° (fill slope) and 55 - 65° (cut slope), respectively. ($P = 0.06$). The canopy coverage on cut and fill slopes were 7.2% and 28.4%, respectively (Figure 1).

The characteristics of the embankments are not suitable for their resistance. The slope angle of the road bank on the uphill side determines soil stability, because both natural and artificially seeded vegetation rarely be-come permanently established on steep slopes, those with 45° slope or greater. Although seeds will often ger-minate on cut slopes, seedlings wash out when surface runoff and raindrops detach surface (Bochet et al., 2005).

Rubus hyrcanus with coverage of 3.2% was more concentrated on road embankments than control plots. *Cardamine pratensis* author with coverage of 0.02% was less concentrated on cut and fill slopes plots than other species. Overall, we found 19 herbaceous and 3 woody species on forest road embankments (Table 3). 20 herbaceous plants and 4 seedlings of woody species were observed in control plots which were located in adjacent compartments. Mean canopy coverage in control plots

Table 2. Embankment effects on vegetation canopy coverage.

F	MS	SS	df	Treatments
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0.53^{ns}	122.04	1098.4	9	Embankment gradient and block
1.78^{ns}	293.07	2637.6	9	Embankment type and bloc

Table 3. Species occurrence in sampling plots on road embankments.

(%)	Scientific name	no	(%)	Scientific name	no
0.95	*Polypodium auidinum*	12	0.25	*Oplismenus undulatifolius* (Ard)P.Beauv	1
1.78	*Carex silvatica L.*	13	0.02	*Cardamine pratensis* (L.) Cranty	2
0.76	*Asperula odorata L.*	14	0.99	*Ceterach officinalis* Lam. *et* DC.	3
0.32	*Lamium album L.*	15	0.10	*Primula heterochroma* Stapf.	4
0.49	*Acer insigne*	16	0.75	*Euphorbia amygdaloides L.*	5
0.11	*Acer laetum*	17	2.22	*Hypericum androsaemum L.*	6
0.46	*Diospyrus lotus*	18	3.20	*Rubus hyrcanus L.*	7
0.30	*Oplismenus sp.*	19	0.60	*Hedera helix L.*	8
0.75	*Tussilago* (*Tourn.*) *L.*	20	0.35	*Ruscus hyrcanus Woron*	9
1.46	*Salvia glutinosa*	21	0.03	*Phyllitis scolopendrium* (*L.*) *Newm*	10
0.56	*Viola odorata L.*	22	1.35	*Solanum* (*Tourn.*) *L.*	11

Table 4. Herbaceous plants in control plots.

Family	Scientific name	no	Family	Scientific name	no
Gramineae	*Oplismenus sp.*	11	Aspleniaceae	*Ceterach officinalis*	1
Araliaceae	*Hedera helix L.*	12	Gramineae	*Oplismenus undulatifolius P.B.*	2
Violaceae	*Viola odorata L.*	13	Primulaceae	*Cyclamen europaeum L.*	3
Cyperaceae	*Carex silvatica L.*	14	Primulaceae	*Primula heterochroma Stapf.*	4
Saxifragaceae	*Ribes qrossularia*	15	Hypericaceae	*Hypericum androsaemum L.*	5
Lamiaceae	*Lamium album L.*	16	Saniculaceae	*Semicolon europaea L.*	6
Gramineae	*Gramineae*	17	Hypolepidaceae	*Polypodium auidinum.*	7
Rubiaceae	*Asperula odorata*	18	Leguminosae	*Trifolium repens L.*	8
Equisetaceae	*Equisetum sp L.*	19	Euphorbiaceae	*Euphorbia amygdaloides L.*	9
Salviniaceae	*Salvia glutinosa L.*	20	Asparaginaceae	*Ruscus hyrcanus Woron.*	10

Table 5. Regeneration of woody species in control plots.

Scientific name	no	Scientific name	no
Diospyros lotus L.	3	*Carpinus betulus L.*	1
Parrotia persica C.A.M	4	*Fagus orientalis*	2

control plots was 45 - 55% (Tables 4 and 5).

High concentrations of non-native species have been observed near transportation corridors, suggesting that corridor edges acts microhabitats for many non-native species (Hansen and Clevenger, 2005). The impact of these species on habitats adjacent to corridors may extend far beyond the corridor edge (Pauchard and Alaback, 2006). Habitats along roads had equal frequencies

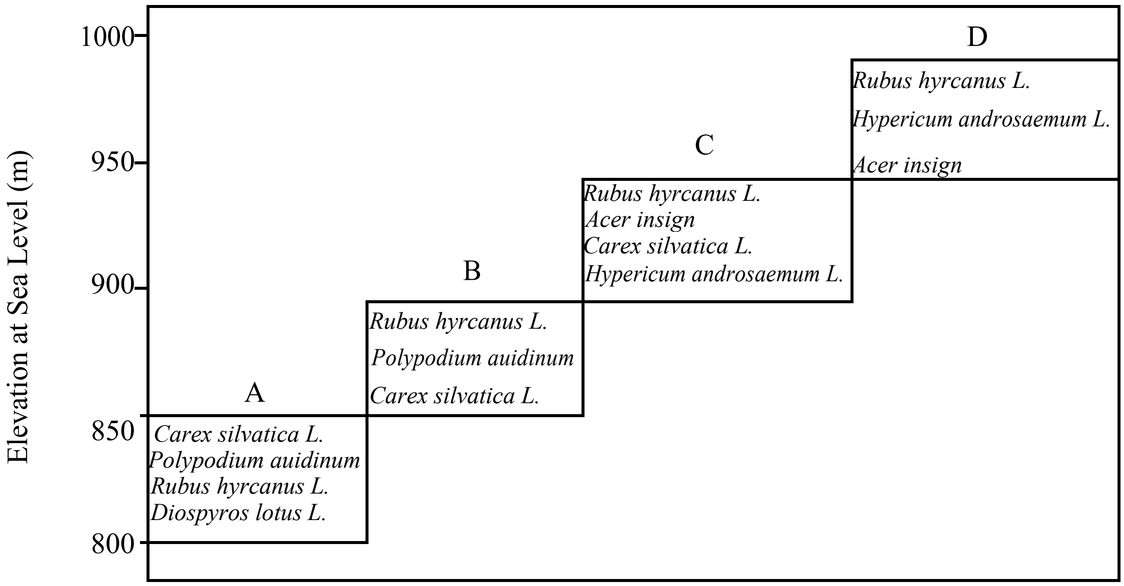

Figure 2. Distribution of plant species in different elevation classes at sea level in Lat Talar forests.

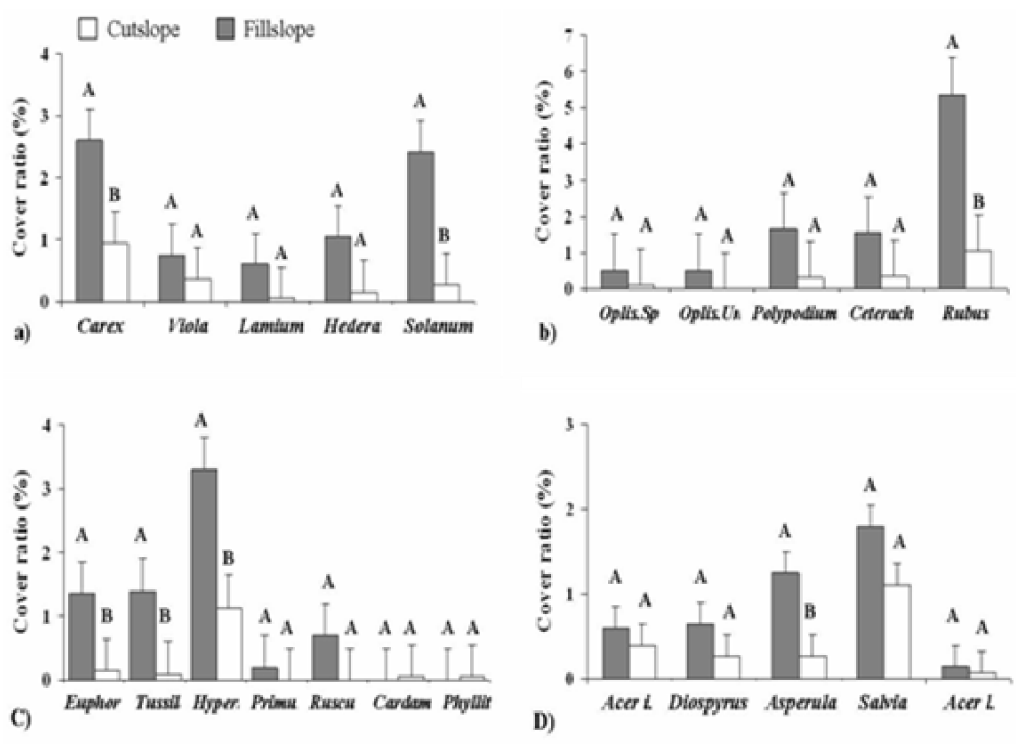

Figure 3. Comparisons of plant species coverage ratio on forest road cut and fill slopes.

of total non-native plant species, but had significantly higher frequencies than respective control sites. Our results agree with results from previous studies, where transportation corridors had high abundance of non-native plants (Truscott et al., 2005) (Figure 2).

Carex silvatica L., *Solanum* sp., *Rubus hyrcanus* L., *Asperula odorata* L, *Euphorbia amygdaloides* L., *Hypericum androsaemum* L. and *Tussilago which 1 Yes* (Tourn.) L. canopy coverage on fill slopes was much more than that of cutslopes at probability of 5% (Figure 3a, b, c, d).

Carex silvatica L., *Viola odorata* L. and *Rubus hyrcanus*

Table 6. Vegetation canopy coverage in different slope classes (mean ± S.D).

Fill slope gradient (degree)		Cut slope gradient (degree)		Plant species
35 - 45	25 - 35	55 - 65	45 - 55	
0.00[a] ± 0.00	1.00[a] ± 0.13	0.00[a] ± 0.00	0.00[a] ± 0.00	*Oplismenus undulatifolius* (Ard)
0.20[a] ± 0.06	1.00[a] ± 0.16	0.00[a] ± 0.00	0.00[a] ± 0.00	*Oplismenus* sp.
0.80[a] ± 0.01	0.70[a] ± 0.08	0.20[a] ± 0.06	0.55[a] ± 0.03	*Viola odorata* L.
0.00[a] ± 0.00	0.40[a] ± 0.01	0.00[a] ± 0.00	0.00[a] ± 0.00	*Primula heterochroma* Stapf
0.00[a] ± 0.00	1.20[a] ± 0.01	0.00[a] ± 0.00	0.10[a] ± 0.02	*Lamium a*L*bum* L.
3.00[a] ± 0.92	3.60[a] ± 0.20	0.30[b] ± 0.03	1.98[ab] ± 0.14	*Hypericum androsaemum* L.
5.75[a] ± 0.87	5.00[a] ± 0.41	0.62[b] ± 0.03	1.41[b] ± 0.39	*Rubus hyrcanus* L.
0.80[a] ± 0.04	1.30[a] ± 0.58	0.17[a] ± 0.07	0.15[a] ± 0.06	*Hedera helix* L.
0.00[b] ± 0.00	1.40[a] ± 0.35	0.00[b] ± 0.00	0.00[b] ± 0.00	*Ruscus hyrcanus* Woron
0.00[a] ± 0.00	0.00[a] ± 0.00	0.00[a] ± 0.00	0.10[a] ± 0.02	*Phyllitis scolopendrium* (L.)
2.35[a] ± 0.19	2.50[a] ± 0.19	0.12[b] ± 0.05	0.43[b] ± 0.03	*Solanum* (*Tourn.*) L.
1.70[a] ± 0.37	1.60[a] ± 0.06	0.00[a] ± 0.00	0.65[a] ± 0.03	*Polypodium auidinum*
3.20[ab] ± 0.62	2.00[a] ± 0.07	0.70[b] ± 0.06	1.20[ab] ± 0.23	*Carex silvatica* L.
0.90[a] ± 0.01	1.60[a] ± 0.49	0.00[a] ± 0.00	0.52[a] ± 0.03	*Asperula odorata* L.
1.10[a] ± 0.08	1.60[a] ± 0.07	0.10[a] ± 0.02	0.20[a] ± 0.03	*Euphorbia amygdaloides* L.
0.40[a] ± 0.01	0.80 [a] ± 0.03	0.20[a] ± 0.06	0.57[a] ± 0.07	*Acer insigne*
0.00[a] ± 0.00	0.30[a] ± 0.05	0.15[a] ± 0.09	0.00[a] ± 0.00	*Acer laetum*
0.40[a] ± 0.04	0.90[a] ± 0.02	0.43[a] ± 0.06	0.10[a] ± 0.01	*Diospyrus lotus*
0.00[a] ± 0.00	0.00[a] ± 0.00	0.00[a] ± 0.00	0.10[a] ± 0.06	*Cardamine pratensis* (L.) cranty
0.80[b] ± 0.01	2.00[a] ± 0.65	0.10[b] ± 0.05	0.10[b] ± 0.03	*Tussilago* (*Tourn.*) L.
0.90[b] ± 0.08	2.70[a] ± 0.16	1.00[b] ± 0.14	1.22[b] ± 0.01	*Salvia glutinosa*
2.00[a] ± 0.11	1.10[a] ± 0.04	0.00[a] ± 0.05	0.70[a] ± 0.03	*Ceterach officinalis* Lam. et DC.

L. coverage in fill slope class of 35 - 45° was more than other classes, while canopy coverage on slope class of 55- 65° was less than other classes (Table 6). Cao et al. (2006) showed that where the slope of the terrain was between 0 and 5° the average survival rate of planted grass over the 5 years was 94.69% compared to 82.64% when the slope of the terrain was more than 12.5°. So, plants survival and consequently its canopy coverage decreased with increasing the cut slope angle.

The main reasons for the presence of non-native species along transportation corridors are often altered disturbance regimes at the edges, such as physical disturbance of soil and vegetation during construction (Ullman et al., 1995), altered light conditions (Delgado et al., 2007), as well as intentionally introduced plants on corridor edges (Pauchard and Alaback, 2006).

Cardamine pratensis (L.) Cranty, *Tussilago species*? (Tourn.) L, *Phyllitis scolopendrium* (L.) Newm, *Rubus hyrcanus* L. and *Solanum species* (Tourn.) L. was only observed on road embankments, whereas *Trifolium repens* L. and *Gramineae* (*Poa annua L*) were only discovered on control plots.

Decrease in biodiversity associated with canopy closure is especially pronounced in stands of adjacent roads (Wallace and Good, 1995; Ferris et al., 2000), whereas the additional habitats and species supported within open within open spaces such as forest road's embankments serve to increase biodiversity at the scale of the forest and possibly the landscape. For this reason, maintenance of open space within Hyrcanian commercial forests has been proposed as one method for biodiversity enhancement of commercial forests (Smith et al., 2007; Husain et al., 2008).

In a row, means with the same letters are not significantly different at 5% level based on SNK test

Conclusion

Dominant plants from other microhabitats can also be suggested to revegetate side slopes, especially those species with high competitive ability and allelopathic potential to reduce the invasion of exotic species. For example, *Trifolium repens* L. and Gramineae species are dominant plants, has high competitive ability and allelopathic properties that may reduce invasion of exotic plants in the side slope. Although, the autecological properties of this species have not been studied in the present study, it has potential for side slope revegetation because of its rapid vegetative growth (Sarikhani and Majnonian, 1994; Koukoura et al., 2007; Karim and Mallik, 2008). Further comprehensive studies using similar approaches will make significant contributions in developing guidelines for roadside revegetation with native plants. Bioengineering is another method that protects and establishes the fill and cut slopes (Lewis, 2000). Roads supported a greater diversity of plants as a result of variation in topographic features and the management of roadside vegetation should take this into account. Road maintenance should avoid disturbance of marginal vegetation as far as possible, for example cleaning drains only when necessary. Mechanical clearance of roadside scrub for safety purposes would be preferable to herbicide use.

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