Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 3, No. 2, p. 10-16, 2013
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Plant species recovery and natural tree regeneration on skid trails in the Hyrcanian forests of Iran

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Article published on February 18, 2013

Key words: Logging, skid trail, regeneration, species importance value, species diversity.

Abstract

In the ground based logging operation construction of skid trails are need to transport logs from felling areas to road side landings. In this research plant species recovery rate and natural tree regeneration on the skid trails with different time of construction (1980, 1990, 2000 and 2010) were investigated in the Hyrcanian forests of Iran. Plant recovery rate including coverage, height, diversity and species importance value were measured and noted on each skid trail by systematic sample plots and were analyzed by ANOVA and Duncan test. Results showed plant coverage, number of species and plant height on the skid trails were increased by increasing of skid trails construction ages. After 10 years from logging operation only 2 species of tree regeneration (*Alnus subcordata* and *Acer velutinum*) were established on the skid trails. Also, after 30 years from skid trail construction and logging operation only 7 species of tree regeneration were established on the skid trails that were seedling and small sapling stages. *Sambacus ebulus* had the most species importance value on the skid trails with 1 and 10 years old, whereas, on the skid trails with 20 and 30 years old *Rubus caesus* had the most species importance value. Post harvest operations are necessary to limit soil erosion and conservation plant species diversity in these forests.

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Introduction

Skid trails are using in ground based logging operation to transport trees, logs, and other forest products from the woods to a deck, landing or roadside by skidders. Forest soils can be detrimentally impacted by timber harvest operations using skidders (Miller *et al.*, 1996; Curran *et al.*, 2005). Potential ecological impacts of roads and skid trails have received a great deal of attention in recent years (Forman, 2000; Curran *et al.*, 2005). Forest soil maintenance is a key factor for sustaining productive forests (Curran *et al.*, 2005). Ground based logging operation can lead to soil compaction, soil displacement, increase runoff, cause deep ruts and erosion (Clayton, 1990; Pinard *et al.*, 2000; Miller *et al.*, 2010). Harvest activities that compact soils limit the effective rooting depth of plants by restricting access to water and nutrients and reducing gaseous exchange (Gomez *et al.*, 2002). Heninger *et al.* (2002) reported reductions in mean annual height growth of 24% in Douglas-fir four years post establishment on skid trails relative to logged areas adjacent to skid trails. Miller *et al.* (1996) reported an initial decline in the growth of Douglas-fir, Sitka spruce and western hemlock on primary skid trails. Erosion and mass flow are natural processes occurring on all landscapes, but the rate and extent of erosion can be increased by forest management activities (Grigal, 2000). Establishing vegetative cover on the skid trails reduces soil erosion and prevents offsite sediment. Effects of roads on forest plant communities are less well documented. The increased light levels in the forest under storey after selection cutting, road and skid trail construction usually result in the sudden occurrence of many herbaceous and woody pioneer species (Pinard *et al.*, 1996; Cochrane and Schultze 1999; Pinard *et al.*, 2000). The conservation of biological diversity is one of the goals of ecologically sustainable forestry (lindenmayer *et al.*, 2000). Biodiversity includes diversity at the genetic, species, landscape and ecosystem level (Noss and Cooperrider, 1994). Species diversity is known equal to biodiversity that is limited to diversity in local or regional surface (Krebs, 1998). In contrast, species diversity considers the number and frequency of the species present (Pretzsch, 2009). Plant species diversity is an important part of forest biodiversity. Hyrcanian forests of Iran are located in the north of Iran and south coast of Caspian Sea, also known as the Caspian forests. These forests are suitable habitats for a variety of hardwood species such as beech, hornbeam, oak, maple, alder, and encompass various forest types including 80 woody species. The current forest harvesting method in these forests is mainly selective cutting. Chainsaw and cable skidder are two main logging machines for tree felling and timber extraction in these forests. The main objectives of this study are to investigate plant recovery (coverage, compositions, height and diversity) on skid trails with different construction time in the hyrcanian forests of Iran.

Material and methods

Study area

The study area is located in Nav watershed forest area in the north of Iran. The Nav watershed is located between 37° 38' 34" to 37° 42' 21" N and 48° 48' 44" to 48° 52' 30" E, and 950 m to 1750 m above sea level. The mean annual precipitation is approximately 1050 mm and the mean annual temperature is 8.7° C. The original vegetation of this area is uneven aged mixed forest dominated by *Fagus orientalis* and *Carpinus betulus*, with companion species *Alnus subcordata*, *Acer velutinum, Acer cappadocicum, Ulmus glabra and Tilia rubra*. The management method and logging system in these forests is single selection cutting and ground based logging.

Collection and analysis of data

In this research four skid trails whit different construction time (1980, 1990, 2000 and 2010) were selected and plant recovery rates (coverage, compositions, height and diversity) on the skid trails were measured and identified. For this reason on each skid trail 15 sample plots with an area of 10 m^2 and with 10 m distance were layout systematically with random start point. In each sample plot, species, coverage and height of plants were identified

and measured. Density, frequency and dominance and their relative measures for each species were calculated. Species importance value (SIV) for each specious was calculated by summing the relative values of Density, frequency and dominance (Ganesh *et al*., 1996; Krebs, 1998). The species diversity index was computed using the Shannon – Wiener information function (Shannon and Wiener, 1963) as: $H' = -\Sigma n_i/n \log_2 n_i/n$, where n_i was the SIV of a species and n was the sum of total SIV of all species. Differences in mean values of the plants coverage, height and species diversity on skid trails with different construction time were determined by analysis of variance (ANOVA) and Duncan tests using SPSS 19.0 software.

Table 1. Plant Species Importance Value (SIV) on the skid trails.

Plant species	Time of skid trail construction			
Herbaceous	**1980**	**1990**	**2000**	**2010**
Aspelnium adiantum nigrum L.	7.4	6.0	11.7	-
Asperula odorata	8.1	5.8	5.0	21.8
Calamintha grandiflora L.	6.9	6.0	10.2	18.6
Carex aqutiformis L.	7.0	5.6	11.0	17.0
Cyclamen coum Miller.	11.5	12.0	14.5	21.6
Euphorbia amygdaloides L.	7.9	4.5	-	-
Galium rotundifolium L.	8.2	5.0	10.3	21.0
Heraceluum persicum Desf.	8.3	8.0	17.7	13.6
Hypericum androsaemum L.	11.0	10.4	15.0	26.5
Hypericum perforatum L.	10.1	8.0	-	-
Mentha sylvestris L.	12.4	8.4	18.8	10.3
Oplismenus undulatifolius	7.7	5.9	15.6	14.6
Petasites hybridus L.	3.1	-	-	-
Plantago major L.	3.4	-	7.0	6.6
Polygonum polygonoides L.	9.7	10.0	10.7	17.0
Potentilla reptans L.	9.1	9.1	13.1	20.1
Primula heterocharoma Staff.	8.2	10.2	20.6	20.2
Pteridium aquilinum L.	7.9	4.7	18.9	-
Ranunculus arvensis L.	10.2	8.0	-	-
Rubus caesus L.	51.5	83.2	26.1	20.4
Rumex conglomerates Murr.	7.7	10.0	-	-
Sambacus ebulus L.	35.3	51.2	44.9	50.7
Smilax excelsa L.	8.1	8.0	-	-
Urtica dioica L.	9.0	9.5	17.6	-
Viola alba Bess.	8.7	-	-	-
Tree regeneration				
Acer velutinum Boiss.	3.0	1.8	2.1	-
Acer cappadocicum Gled.	2.8	1.2	-	-
Alnus subcordata C. A. Mey.	7.3	4.2	4.2	-
Carpinus betulus L.	3.2	1.1	-	-
Fagus orientalis Lipsky.	2.7	1.1	-	-
Mespilus germanica L.	1.1	-	-	-
Vaccinium microphylla Willd.	1.5	1.1	-	-
Total	**300**	**300**	**300**	**300**

Table 2. Analysis of variance for effect of time of skid trail construction on plant coverage, height and species diversity.

		SS	df	Ms	F	Sig.
Plant coverage	Between groups	39112.5	3	13037.5	203.87	0.000
	Within groups	3581.2	56	63.95		
	Total	42693.7	59			
Plant height	Between groups	252787.1	3	84262.4	834.54	0.000
	Within groups	5654.2	56	100.97		
	Total	258441.3	59			
Plant species diversity	Between groups	0.442	3	0.147	24.44	0.000
	Within groups	0.337	56	0.006		
	Total	0.779	59			

Results and discussion

A total 25 herbaceous species and 7 tree species were recorded on the skid trails that the most number of herbaceous and tree species were recorded on the skid trail that construction time was 1980 (Table 1).

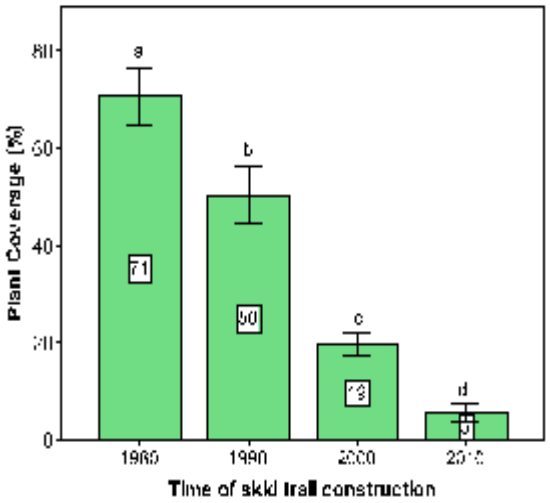

Fig. 1. Plant coverage on skid trails (Different letters among time of skid trail construction indicates statistically significant differences ($p < 0.05$)).

After one year of skid trail construction and logging operation 15 herbaceous species were established on the skid trails and not found tree regeneration (Table 1). Four herbaceous plants (*Sambacus ebulus, Rubus caesus*, *Primula heterocharoma* and *Potentilla reptans)* have highest SIV after one year skid trail construction and logging operation. The maple (*Acer velutinum*) and alder (*Alnus subcordata*) were the first trees that regeneration of them established on the skid trail that construction time was 2000 (Table 1). The results indicated that number of plant species on the skid trails increased with increasing of skid trail construction ages. *Sambacus ebulus* had the most species importance value on the skid trails that construction time was 2010 and 2000, but on the skid trails of 20 and 30 years old (construction time 1990 and 1980) *Rubus caesus* (83.2 and 51.5) had the most species importance value (Table 1). After 30 years from logging operation 7 woody species were established on the skid trail and *Alnus subcordata* had the most species importance value. Maple (*Acer velutinum, Acer cappadocicum*) and alder (*Alnus subcordata*) are light demanding trees and pioneer woody species in Hyrcanian forests. The increased light levels in the forest understorey after selective logging usually result in the sudden occurrence of many herbaceous and woody pioneer species (Cochrane and Schultze 1999; Fredericksen and Mostacedo 2000; Pinard *et al.* 2000).

The results indicated that plant coverage on the skid trails increased by increasing of skid trail construction ages (Fig. 1). Similar results have been reported in other areas of Hyrcanian forest (Lotfalian and Bahmani, 2011). The Average of plant coverage on the skid trails of 1, 10, 20 and 30 years old were measured 5, 19, 50, and 71 percent. One-way ANOVA showed that these averages of plant coverage have statistical different at $\alpha=0.001$ (Table 2). The plant coverage is a main ecological factor that limit soil erosion rate from the skid trails.

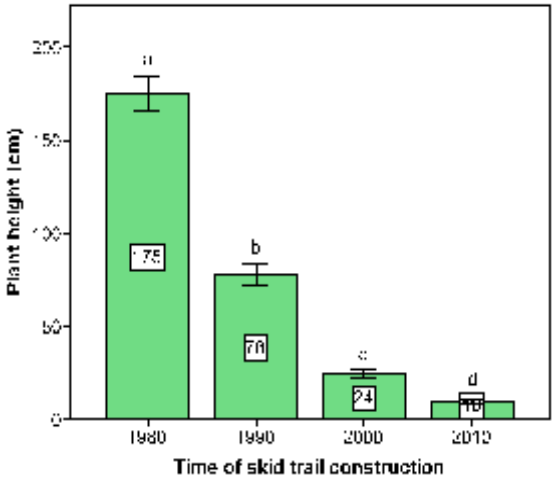

Fig. 2. Plant height on skid trails (Different letters among time of skid trail construction indicates statistically significant differences ($p < 0.05$).

In this research plant heights were measured on the skid trails and results showed that plant heights increased with increasing of skid trail construction ages (Fig. 2). The Average of plant height on the skid trails of 1, 10, 20 and 30 years old were measured 10, 24, 78, and 175 cm. One-way ANOVA showed that this averages of plant height have statistical different at $\alpha=0.001$ (Table 2).

Skid trails with 20 years old had the most value of plant species diversity and skid trails with 30 years old had the minimum value of plant species diversity

(Fig 3). The Shannon – Wiener index value of plant species diversity on the skid trails with 1, 10, 20 and 30 years old were 1.11, 1.05, 1.25 and 1.03. One-way ANOVA showed that these averages of plant species diversity have statistical different at α=0.001 (Table 2). Duncan test showed that mean of plant species diversity values on the skid trails with 20 years old (construction time is 1990) was statistically higher than skid trails with 1, 10 and 30 years old. But not was statistical different between means of plant species diversity values on the skid trails with 1 and 10 years old (Fig. 3). Species diversity often increases following timber harvest because of invasion by plants that thrive in disturbed areas.

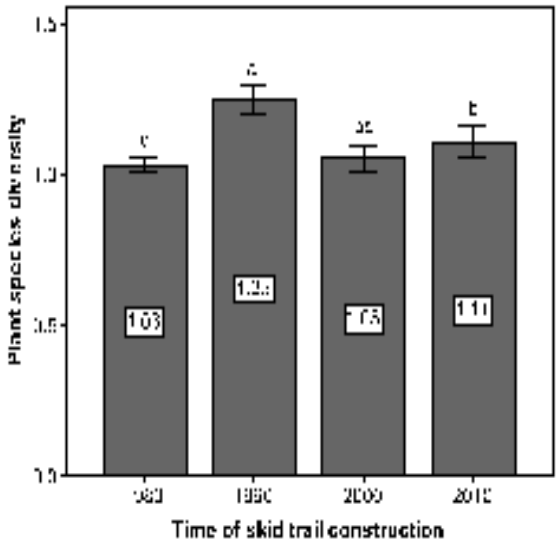

Fig. 3. Plant species diversity on skid trails (Different letters among time of skid trail construction indicates statistically significant differences ($p < 0.05$)).

Conclusion

In this research plant coverage, height and species diversity were studied on the skid trails with different construction time (1980, 1990, 2000 and 2010) in the Hyrcanian forests in the North of Iran. Results indicated that with increasing of skid trail construction age plant coverage and plant height were increased significantly on the skid trails. The most percentage of plant coverage and plant height was observed on the oldest skid trail. If skid trails not properly constructed are considered a major source of erosion from forest lands. Factors controlling erosion on the skid trails include slope length and steepness, precipitation intensity duration, infiltration rate, soil texture, geomorphology and soil cover (Elliott and Hall, 1997, Robichaud *et al.*, 2007). Plant coverage is a main ecological factor to limiting soil erosion on the skid trails. When vegetation and forest litter soil coverage is removed through management activities, the roughness of the soil surface is decreased and thus facilitates increased water flow along the soil surface (Troeh *et al.*, 1999). The soils on the skid trails about 35.6% are compacted by logging operation than undisturbed areas after selection cutting in the Northern forests of Iran (Tavankar et. al., 2009). The soil erosion rate on the compacted and without plant cover soils such as skid trails is faster and more than undisturbed areas (Williamson and Neilsen, 2000; Grigal, 2000). Soils recover from compaction at varying rates. Surface compaction may recover after some time, but compaction at depth in the mineral soil may take decades or longer to return to pre harvest conditions (Powers *et al.* 2005). Establishing vegetative cover on the skid trails reduces soil erosion. Results of this study showed that after 30 years from skid trail construction and logging operation plant coverage on the skid trails were 71% and number of woody species regeneration were 7 species that these measures are less than undisturbed and natural stands. Management and maintenance of forest roads and skid trails are essential elements to mitigate erosion (Akbarimehr and Naghdi, 2012). It is important to develop a forest management plan before any timber harvest occurs. Skid trails should be well planned to help minimize damage to residual trees and reduce erosion. Planning of skid trails without sharp turns and use gradual curves are important ways to reduce soil erosion. Rehabilitation of skid trails after finishing skidding operation by construction drainage are essential to reduce the quantity of runoff and to minimize then soil erosion (Croke *et al.* 2001; Grace and Clinton 2007). Installation water bars and brush barriers on skid trails after skidding activities is

necessary to control and capture runoff and ensure soil stabilization. The cross drains should be spaced less than 25 m apart on skid trails sloping 10-15 degrees (Putz, 1994).

The results of this study showed that after one year from logging operation only herbaceous species were established on the skid trails and tree regeneration could not established. After 30 years from skid trail construction and logging operation only 7 species of tree regeneration were found on the skid trails that were seedling and sapling stages, whereas, density and number of tree species in the undisturbed areas were more than skid trails. Properly planned and applied logging operation will minimize adverse impacts on the environment. Poor forest management practices contribute to decline or loss of biodiversity. Forest management plan should describe both short and long term management goals and how to maintain forest productivity. Post harvest operations such as Installation water bars and brush barriers on skid trails, construction of drains across skid trails and seeded to grass, replanting and fertilization of severely compacted soils are practices that can be useful to maintain forest biodiversity.

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