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Soil destruction investigation due to logging (felling and skidding): A case study: Neka Choob Forest Lands, North of Iran

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Abstract

Forest harvesting includes felling, gathering the wood from the stump to landing near the skid road and transporting to the yard and finally exports to the market. These activities effect on natural environment's stability because in the whole procedure was used heavy and semi heavy machines that causes damages to the forest. Soil compaction is one of the most important of these damages influence in regeneration, tree growth and erosion of forest soil. This study performed in Series 2 Part 2 Neka - Zalemrod and investigated the effects on soil in consequence of forest harvesting. 0-10 and 10-20 cm depths in the soil samples by standard cylinders were taken and measured. First, the data follow a normal distribution were conducted data analysis with SPSS software and paired t-test was performed. Comparison showed significant difference between the density and moisture content of soil before and after winching and skidding.

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Introduction

Forest harvesting makes a relationship between biological production and wood industrial production sector. Usually after forest harvesting operations, effects on soil degradation can be seen and the works of skidding machines are more remarkable include compaction, wheel and log track. Compaction reduces soil infiltration and increases runoff and on the other hand prevents the growth of roots and other vegetation is weakened. Wheels and log track on long routes with steep slopes flows rainwater and causes soil erosion (Lotfalian, 1996). Soil compaction on different habitats of forest has direct and immediate impact on the soil physical properties. These changes often have impacts on the soil physical, chemical and biological phenomenon. When soil is compacted, the soil resistance increases but porosity and weathering, water holding capacity and soil permeability to water and air decrease. Forest soil compaction often arises from harvesting machines and other forestry machinery transportation.

It is an economic necessity for harvesting machineries to work during the year regardless of the interaction of climate and soil, these machineries force a lot of weight into the soil. The result of such forces into the soil is the change and damage on the soil structure that often appears like compaction.
Lotfalian *et al* (1996) reviewed the effects of Taf skidder in the Patom series of Kheyroudkenar forest and concluded that soil compaction increases with the number of transportation but soil compaction increase is reduced with each extra transportation. In this study 21 times of transportation was conducted and the maximum soil compaction occurred on wheel path and on 21st traffic.

Daghestani *et al* (2005) studied the effects of group cut on the physical properties of forest soils in the Nam-Khaneh series of Kheyroudkenar forests in Noshahr area and reached the conclusion that soil density at a depth of 0-5 cm felling plot due to cutting and skidding operation was 8% more than voucher plot but on lower density there was no significant difference. In addition, soil porosity at 0-5 cm depths of felling plot was 12% lower than the voucher plot. Mechanical strength of the soil increased by 17% in felling plot and its permeability has been reduced by 47%. Humidity and moisture measuring and the percentage of moisture change, indicate that in the depth of 0-5 cm in addition to moisture, the humidity is higher than the bottom of the soil.

Tavankar *et al* (2009) have studied effects of skidding on regeneration and soil compaction in ground skidding systems of Asalem forests in Gilan Province. The survey results showed that forest soil bulk density at a surface depth of 10 cm is increased by 74.15% in harvested area and 35.61% in skidding routes in comparison with voucher areas.

Jourgholami and Majouian (2010) in their study entitled “Forest soil compaction and erosion resulted from wood extract with a rubber-wheeled skidder" have concluded that the control location (voucher or compacted), depth, path slope, mutual relationship between control locations and slope, control location and depth had a significant effect on the soil bulk density. In the flat paths, soil density in the depth of 0-10 cm had a 30.2% rise, in 10-20 cm 17% and in 20-30 cm 15.3%. In The upward skidding (10%slope) soil density in the surface layer (0-10 cm) has had the maximum increase (41.8%). In the downward skidding with 10 and 20 percent slope no significant difference was observed in the soil density increase of surface layer.

Burger *et al* (1985) in a study of Virginia forests showed that soil density increases to a depth of 6 cm due to skidder transport but at a depth of 15 - 21cm there was no change in density.

In Turkey Makineci *et al* (2006) studied the effects of skidding machinery on forest soil in Fir forested plantation and concluded that skidding dramatically reduces forest grass plantation in skidding paths and soil compaction r skidding increases the fine soil weight and bulk density and decreases pores and balanced moisture of soil on skidding path.

The objective of this study is to measure soil bulk density changes, moisture and changes in soil texture due to harvesting.

Methods and materials

Study area

This study was performed in Parcel 9 and 24 in Neka-choob Company areas of Series 2 Part 2.

Parcel No. 9 is known as Gavazn-Kheyl forest with an area of 40.5 Hectares and harvested area of 26 Hectares. Minimum and maximum altitudes from sea level are 580 and 710 meters respectively. Type of rock is marl, limestone and marl silt. Soil type is Pseudogley brown with podzolic red. Soil texture is heavy and its depth is more than 100 cm.

Parcel No. 24 is known as Kooran-Goli has an area of 60.3 hectares with the harvested area of 56.3 hectares. Minimum and maximum altitudes from sea level are 750 and 1060 meters, respectively. Type of rock is marl, limestone and marl silt. Soil type is brown washed with calcic horizon in the north and forest brown limestone in the southern part and soil texture on surface is slightly heavy but in depth it is heavier. Soil depth is110 cm and the permeability of soil in above horizon are medium.

Methods

To check for soil damage a systematic random sampling was used. For this purpose, circle form pieces of samples were used. Number of sample according to the relationship between total area of parcel and total area of plots for Parcel 9 and 24 was calculated as 10. Network Dimension was calculated as 250 × 250 m. Then the network was put on the map, and GPS was coordinated into the map and the locations for soil sampling were identified. Because the aim was to evaluate harvesting damages, sampling had to be done once after cut and once after wood extract. For this purpose the first stage of sampling was conducted in August and the second phase in late September. After determining the desired plot and specifying the range of the plot after cleaning took place, in 0-10 and 10-20 cm depth, by the standard cylinder (8 cm diameter and 10 cm height) soil samples was removed. In fact 20 of Parcel 9 and 20 of Parcel 24 (10 samples from 0-10 depth cm and 10 samples from of 10-20 cm depth) had to be removed but because 5 plots were exposed to arable, bramble and grassland a total of 15 plots remained. Thus the total number of samples collected to determine soil density and moisture content is 60 samples (30 samples after cutting and 30 samples after skidding).

Soil bulk density samples were calculated by obtaining sample weight (w), using a standard scale with a precision of 0.1 g and plots volume (v) with respect to the diameter and height of the cylinder, that the method of calculating is shown in the below formula.

$$W = \frac{w}{v} \gamma$$

Soil moisture was measured in proportion to the dry soil volume. First, moisture measurement container is weighed (w1), and then some moist soils representative of desired soils were placed into a container and weighed (w2). After weighing, the moist soil container was placed in an electric oven until water was completely evaporated, usually 24 hours is enough to do it, then it has to be weighed again (w3) and soil moisture content was determined according to the following formula:

$$\varpi = \frac{w2-w1}{w3-w1} \times 100$$

Soil particles diameter, soil particles percentage of parcels 9 and 24 and 6 soil samples were measured randomly. This test was performed by the hydrometer method and desired plots soil texture was determined by the soil texture triangle.

Results

To compare the data, the data follow of a normal distribution was evaluated by chi-square test. Then by using a paired t-test (t Test) the mean dry soil density and moisture content was compared in 0-10 and 10-20 cm depths. SPSS software was used for the test. The data showed normal results. After data analysis it is observed

that in all of these factors, after cutting operations and wood extract both parcels had significant difference at 95% and 99% (p=0.00) The factors are presented in Table 1.

Table 1. Dry soil density ANOVA and moisture content at two studied depths.

Source	Mean	Std. Deviation	*t*	*sig*	*df*
soil density Depth 0-10	0/18267	0/06352	-11/137	0/000	14
soil density Depth 10-20	0/22476	0/27625	-3/150	0/007	14
moisture content Depth 0-10	2/446	16/245	-5/833	0/000	14
moisture content Depth 10-20	8/0166	3/108	-9/988	0/000	14

Moisture content

The moisture content at 0-10 and 10-20 cm depths after cutting and wood extract is given in Table 2. which reflects an increase in both depths, following wood extract.

Table 2. Percentage of moisture in 15 plots after cutting and extracting at two depths of 0-10 and 10-20 cm.

Depth 10-20 cm		Depth 0-10 cm		Plot
After Extract	After Felling	After Extract	After Felling	
26/3	23/04	23/2	23/5	Voucher
19/6	15/2	53/02	19/3	1
19/8	12/5	29/9	23/4	2
22/9	16/1	48/4	7/16	3
28/8	19/6	49/7	20/7	4
22/1	12/1	31/2	10/7	5
31/2	25/4	43/2	19/2	6
26/5	20/2	40/2	28	7
27/5	22/9	35/7	19/3	8
34/1	27/5	33/6	18/2	9
24/9	17/2	70/8	18/07	10
21/6	13/5	32/9	26/9	11
23/2	6/35	80/5	22/6	12
32/2	20/9	29/8	25/6	13
30/7	24/6	37/6	13/7	14
29/6	20/5	40	15/8	15

Soil Texture

According to The hydrometer tests, the percentage of deposited particles on a specified length of time in all 4 sample plots after cutting and wood extracting was measured and then using the soil texture triangle, type of soil texture was determined according to Table 3.

Soil bulk density samples are harvested to calculate the bulk density of the soil at depths of 0-10 and 10-20 cm after cutting and wood extract. Soil density in both two studied depths has increased after wood extract (Fig.1.).

Table3. Percentage of soil particles and tissue of four sample plots.

Texture		**clay**		**slit**		**sand**		**Plot**
After Extract	After Felling	After Extract	After Felling	After Extract	After Felling	After Extract	After Felling	
Sa.L	*Si.L*	7	12	43	50	48	38	**19**
Si.L	*Loam*	13	10	53	39	34	51	**22**
Sa.L	*Loam*	10	10	37	46	53	44	**36**
Loam	*Si.L*	16	20	36	57	48	23	**37**

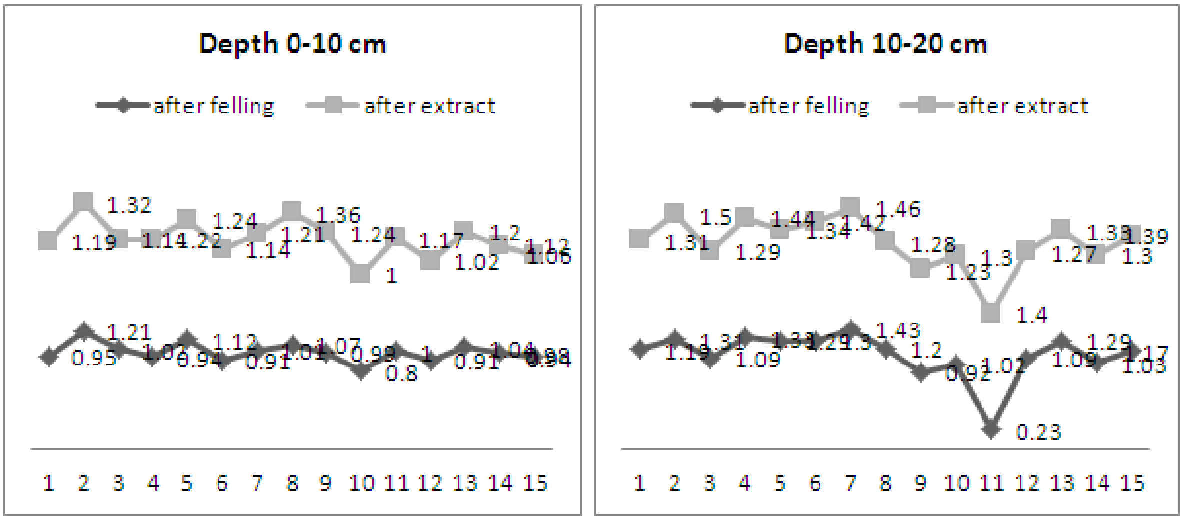

Fig. 1. Soil bulk density in 15 plots at the 0-10 and 10-20 cm depths after cutting and wood extract.

Conclusion and Discussion

The results show that Soil bulk density after wood extract operations have raised significantly. Since the force to soil causes soil particles shift and compaction, soil particles are bound to each other and subsequent weight gain occurs. This trend is also observed in this study which is consistent with the results of Tavankar *et al* (2009), Jourgholami and Majnounian (2010), Burger (1985) Makineci (2006) studies.However, given that the dry soil density is consistent with soil type and moisture, this level may vary in different locations with different soil.

For texture factor, given that no significant changes in soil texture is seen in other studies, changes in soil texture of this study is due to severe raining and flood on area and a huge pile of soil shift.

According to the results after wood extract more moisture in the soil samples at 0-10 and 10-20 cm depths were observed. The result of factor is also consistent with the research results of other studies. Daghestani *et al* in 2005 concluded that soil moisture due to cutting and skidding operation at a depth of 0-5 cm is higher than the lower depths of the soil. As we know, water from the soil, causes soil Slippery and adhering the surrounding soil particles to each other. Deibi *et al* in 2008 concluded that the impact of more soil moisture is caused by factors such as machinery weight, the size of the wheel or tire pressure. Even with 2 or 3 percent change in the amount of moisture, the soil may be severely damaged.

Given that most fine roots absorbing water and nutrients are in the soil surface layers where the most compaction occurs, there are several important ways to reduce the soil disturbance and compaction. Given that compaction amount has direct relationship with the number of traffic, the most obvious way is to reduce it. For this purpose the number of skidding paths should be increased to prevent repeatedly wood extract. At first glance it appears the number of paths increase causes more damages on forest but consequently because of the limits and threshold of destruction, normal reconstruction of paths is easier and faster. Multiplicity of travel in one path causing excessive soil compaction which prevents revitalization and damages soil surface humus.

Choosing paths with negative slope, compaction and destruction of soil in areas with negative slope, are less than regions with positive slope, and the reason is the lower power consumption and less pressure on the soil.

Selecting the appropriate time, given that the maximum soil compaction is obtained at optimum moisture content, is important. if the soil moisture is more or less than this amount, soil will not be compacted to its maximum due to the fact that in moisture content below the optimum, the friction between soil particles is much higher and it prevents soil from being compacted and in higher moisture content water in the voids prevents soil compaction and filling the empty spaces by the soil particles. So the best time to travel on the ground in order to compact the soil is when the soil moisture is too far from the optimum moisture content.

To wind down the tires reduces soil compaction also flat or dual tires increase the contact area and the friction. Also the use of chains for rubber wheeled machines makes an average of less force into the ground.

The most practical way to reduce the effects of soil compaction is the establishment of a permanent network of skidder paths, reconstruction and restoration of pathways by seeding and planting after skidding operations.

Another important concept is to avoid machine transportation when the soil is moist and soil moisture is close and skidding paths design and limiting machines to transport on these paths, is another way to reduce erosion and compaction of soil.

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