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[Research]

Residual trees injury assessment after selective cutting in broadleaf forest in Shafaroud

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ABSTRACT
In the Shafaroud forest, logging operation is generally performed by using selective cutting methods. Chainsaw and cable skidder are two main forest machines for harvesting of this forest. However, forest harvesting operations result in serious residual stand damage during felling, winching and skidding operations in this forest. Residual stand damage resulting from selective cutting was assessed on Avardim district in the Shafaroud forest in the north of Iran. Logging operation was performed by chainsaw and cable skidder. To gain benefit of directional felling, Landing and skid trail was planned prior to felling. Study area was cruised using 14 random sampling plots centered on transect lines uniformly distributed throughout the harvested area. Study results indicate majority of the injuries that occurred belong to the skidding and winching stage and the bole portion of tree (> 1m). Beech trees were injured more than trees of other species, and the mean area of injury was 290.3 cm^2. Investigation on felling error showed that 40% of felled trees were at an angle of about 45-70 degrees with skidding direction, therefore felling crew could not lead the felled trees toward the skid trails. Increase felling error made the remaining trees more susceptible to injuries. This research indicated that preliminary planning of skid trail prior to felling is not a sufficient measure to minimize residual stand damage but proper training of crew is essential to insure a good performance of the operation. Felling crew should be not only trained and experienced workers but also aware of the value of residual crop trees, and the importance of minimizing stand damage if uneven-aged stand management practices are to be successful

Keywords: *Residual trees, Injury, Felling, Skidding, Winching.*

INTRODUCTION
Impact on residual stand after forest harvesting continues to be a concern of forest managers responsible for implementing single tree selection harvests in the Caspian forests of Iran. Impact may be limited to broken branches in the crown, skinned bark and exposed sapwood, root damage or any of what can result in decreased vigor and quality, or the damage may be severe enough to destroy the tree. When a tree is injured, certain physiological changes and cell differentiation occurs in the area surrounding the injury and the injury usually becomes sealed off from the rest of the tree (Shigo, 1966). Most decay and defect problems in trees originate in and spread from some kind of injury, and the impact of these injuries is likely to increase with time (Carvell, 1984). The intensity and type of bole damage; the susceptibility of the tree species present; and the rate of injury healing (which may be indirectly related to discoloration or linked to sources of decay) are also important considerations. Residual stand damage is a natural prospect of selective cutting, but the level of damage should be minimized to assure future product quality. Hosseini et al., (2000) pointed out the significance of injury to

forest trees due to logging operations in the Caspian forest. His study showed that 17.5% of regeneration was damaged (i.e. injured or broken) by skidding operations in a shelterwood system, while another study put the equivalent damage level at 14.5% (Alahie, 1997). Naghdi et al (2009) reported damage levels of 19.04% to trees in a single tree selection harvesting operation in the northern forest in Mazandaran province, while Nikooy (2007) and Naghdi (2006) reported damage levels as high as 13.6% of all remaining trees after logging operations in natural forests in the west of the Guilan Province. Last emphasis of Forest, Watershed and Range Organization of Iran (FWRO) on planning skid trail prior to felling and directional cutting during the harvesting of the Caspian forest demands that foresters examine the impact of current hardwood logging practices. This paper reports on felling, winching and skidding damage to residual stand trees for forest areas where individual-tree selection harvesting according to FWRO recopies was carried out.

The objectives of this study were as follows:

1- Better understanding of damages caused by harvesting to the residual stand and possible ways to reduce the negative impacts.
2- Examination of the stand damages by considering different factors including logging stages, tree species, location, size, and type of damages.

Material and methods

Data were collected from compartment 39 of Avardim district in the Shafaroud Forest (N 48°56'25″, E37°32'30″). This section of Shafaroud forest is characterized by acidic (igneous and metamorphic) parent rocks and light, semi-deep fully drained soils (Sagheb Talebi et al., 2004). The topography consists of ridges with moderate to steep slopes ranging from 10 to 60%. The forest is dominated by beech (*Fagus orientalis*) with an admixture of other hardwoods such as alder (*Alnus subcordata*), hornbeam (*Carpinus betulus*) and maple (*Acer platanoides*). It has an area of 42 hectares with an average elevation of 1125meters, ground slope 45% and stand volume $195.66\,{}^{m^3}\!/_{ha}$. Trees to be harvested on the compartment were marked by Iranian Division of forestry plan supervision office in the Shafaroud Forest using a combination of individual-tree selection methods. Harvested area was logged by the Shafaroud Forest Company using chainsaws for felling, and cable skidder for moving cut to length logs to the landing area. Landing areas and skid trails were designated by FWRO foresters according to FRWO instruction for planning of them. The logging contractor had no prior knowledge that this tract would be evaluated for residual stand damage. A general field cruise was conducted that included a component to measure logging damage to residual trees. Compartment was cruised using random sampling; a total of 14 temporary marked 0.1 hectare plots centered on transect lines uniformly distributed throughout the study area. Transect lines were spaced 200 meters apart, and plot centers were placed 150 meter apart along the transect lines. This sampling design approximated a 3.33 sampling intensity. Data collected included harvesting stage (felling, winching or skidding) species, DBH (Diameter Breast Height), damage on the tree, location of damage on the tree as (> 1 m, 1-2 m, and > 2 m) and injury size (width, length, and area). The severity of the injury was recorded in the bark, wood and top injury classes.

Results and discussion

Totally, 395 trees were sampled comprising 73.4% beech (n =290), 3.3% maple (n =13), 2% hornborn (n=8) and 21.3% alder (n=84) (Table 1). The breakdown of damage by species was 17.2% for beech, 39.8% for maple, 28.6% for hornborn, and 21.1% for alder (Table 2). In total, 78 of the sampled trees (19.7%) showed damage, with an average of 0.7 scare (damage to cambium) and 0.4 gouges (damage to sapwood) per tree. The average damage size per tree was 290.31 cm^2 (minimum of 16.0 cm^2; maximum of 3200.2 cm^2). On average, 57.1% of the damage on a tree occurred within less than 1 meter of ground level.

Table 1. The summary of tree species in the sample plots

Sample plot	Beech	Maple	Hornbeam	Alder	Total
1	33	1	1	0	35
2	27	0	1	14	42
3	0	0	0	0	0
4	25	0	1	3	29
5	30	0	0	1	31
6	28	2	0	4	34
7	23	0	0	8	31
8	1	0	0	18	19
9	38	2	1	3	44
10	28	0	0	22	50
11	20	0	0	2	22
12	13	3	0	4	20
13	21	2	2	0	25
14	3	3	2	5	13
Total	290	13	8	84	395

Table 2. Summary of injured tree specious in sample plots

Sample plot	Beech	Maple	Hornbeam	Alder	Total
1	0	0	0	0	0
2	6	0	0	2	8
3	0	0	0	0	0
4	7	1	0	1	9
5	6	0	0	0	6
6	3	2	0	4	9
7	0	0	0	0	0
8	6	0	1	4	11
9	4	1	0	0	5
10	5	0	0	4	9
11	6	0	0	2	8
12	0	0	0	0	0
13	4	1	0	0	5
14	3	0	0	5	8
Total	50	5	1	22	78

Logging process

The numbers of stand damages occurring during the felling; winching and skidding operations were 14, 40 and 37, respectively (Table 3). Results showed that the number of injured trees during winching and skidding operations increased in comparison with felling ($p<0.05$).

During winching and skidding operations, the majority of the damage (53%, 48%) also occurred within 1 meter of the centerline them. Planning skid trail prior to felling does not help in directional felling because felling crew could not fall trees to predetermined directions (Figure 1). In order to minimize felling injuries, directional felling must be applied considering the skid trails. Measuring felling error showed about 80% of felled trees had felling errors of more than 45° (Fig 1).

Tree diameter and species damaged

Injury to stems was most common for trees in the 10 to 30 centimeter dbh class; 37 trees (47.4%) in this class were injured. For the 30 to 50 centimeter, 50 to 70 and more than 70 centimeter classes, tree damage occurred more frequently than the frequency of that diameter class in the remaining stand. The 10 to 30 centimeter diameter classes had a lower frequency of damage than its frequency on incidence in the stand (Figure2). In agreement to this finding, previous studies have reported that remaining stand damage is usually concentrated in the lower diameter classes (Mirarab, 2007; Naghdi *et al*. 2009).

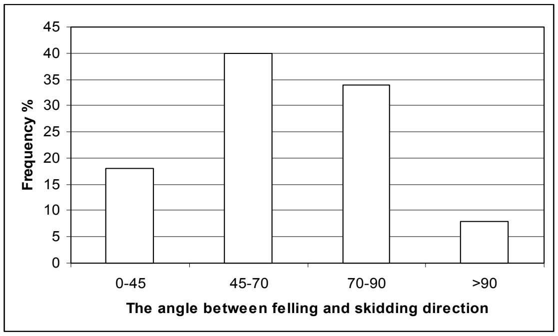

Fig 1. Frequency of felling error in the study area.

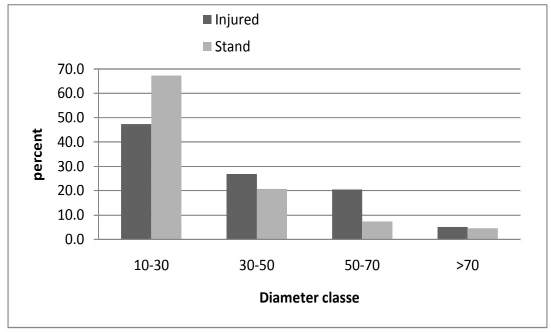

Fig 2. Damage by DBH classes.

Beech trees were injured more than other species found in this stand. The results indicated that the percentage of injured trees for beech, maple, hornbeam and alder trees was 28%, 38%, 12% and 26% respectively (Table 2). High density of beech trees make them more exposed to injury than other species in study area.

Damage location

Most of the injuries in all trees were observed on the first 1 meters of the bole above the stump. 62% of the remaining injured trees showed injuries in this location and 38 % of injuries were scraped where the bark was removed. All of damage below 2 meters height was caused by winching and skidding. This study showed that damage to remaining trees in harvesting operations were generally caused during extraction of logs. Naghdi et al. (2009) found out that in uneven-aged stands harvested by selective cutting only 34.5 % of all injuries were situated higher than 2 meters, and over 65.5 % of the trees were damaged at 2 meters height from the ground. Comparatively, Hosseini (1995) reported that 82.5 % of the damage to the remaining trees in uneven age stands was below 2 meters height on the stem.

Size of damages

The effect of exposed sapwood impact on remaining tree quality is well documented, and depends on the severity of the injury. Previous studies showed individual injuries with area less than 100 cm^2 are likely to be caused more than the others (Naghdi et al., 2009). Exposed cambium injuries will become callous and produce some decay in the butt log, but the damaged trees will rarely die because of these injuries. For this study, 45% of the injury sizes were less than 100 cm^2 size (Figure 3), and the overall average size of tree injuries for the study area was 290.31 cm^2 (Table 3). In a study in the Asalem Forest on 25-50% slopes, Nikooy (2007) reported that more than 28% of the residual trees had no injuries exceeding 1000 cm^2 in size. In felling operations, the injury length was greater than the width because felled trees strike parallel to stem of remaining trees and adhesion of bark and wood is weak in this position on trees.

The width of injury in skidding was larger than the others because of frequent contact between skidded logs and remaining trees. Study of Yilmaz and Akay (2008) in a forest of Turkey showed similar results. The most important pathological consequence of mechanical damage to standing trees is development in injury of decay. The majority of hardwood trees such as beech, hornbeam and alder are susceptible to injury infection and variations in injury infection frequency could be attributed to factors such as difference in size, position of injury on a tree and season of injury (Vasiliauskas, 2001).

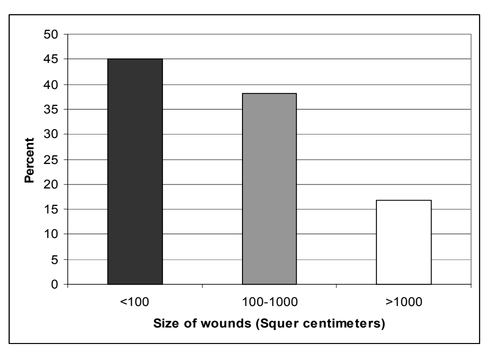

Fig 3. Percent of injuries size classes for the study area

Type of damage

Damage to remaining trees on the site showed in overall size classes, damage to cambium was more than sapwood (Table 4). About 62% (56 damages) of injuries occurred on the bark of trees, results in cambium exposed and 38% (35) of damages were injured sapwood.

Table 3. Statistical summary on the size of the injuries

Forest harvesting process	Number of injuries	Average value ±SE		
		Width (cm)	Length (cm)	Area (cm2)
Felling	14	5.21±1.86	22.11±6.23	115.19±53.64
Winching	40	10.27±2.21	25.55±9.65	262.40±70.24
Skidding	37	19.31±1.64	23.84±8.66	460.35±81.36
Total	91	13.67±2.01	24.32±4.55	290.31±64.21

Table 4. The summary of stand damage at different steps of logging, location, dimension and type of damage

Sample plot	Location			Type		Logging stage			Total
	<1m	1-2M	>2m	Cambium	Sapwood	Felling	Winching	Skidding	
1	0	0	0	0	0	0	0	0	0
2	7	1	0	4	4	2	4	2	8
3	0	0	0	0	0	0	0	0	0
4	4	3	1	3	5	1	4	3	8
5	3	2	2	4	3	1	3	3	7
6	6	5	3	7	7	2	5	7	14
7	0	0	0	0	0	0	0	0	0
8	8	3	2	9	4	2	7	4	13
9	5	3	1	5	3	1	2	5	8
10	6	3	1	7	3	2	4	4	10
11	5	2	1	4	4	1	3	4	8
12	0	0	0	0	0	0	0	0	0
13	4	1	2	6	1	1	4	2	7
14	4	3	1	7	1	1	4	3	8
Total	52	26	14	56	35	14	40	37	91

Logging damage resulting in exposed sapwood is a key factor in lowering butt-log quality (Solgi and Najafi, 2007). It is known that larger and deeper injures are more likely to be colonized by fungi. In general, 60-100 % of injuries inflicted on trees produce decay. Therefore, there is a high proportion of damaged trees in managed forest stands; injury-caused decay fungi may form a significant part of the community of wood inhabiting fungi (Vasiliauskas, 2001). Intensive damage to bark of trees results in growth losses in damaged trees and sometimes these can seriously offset the gains from cutting (Wästerlund, 1992).

Conclusions

Study of felling, winching and skidding during the harvesting operation with chain saw and cable skidder gave the opportunity not only to assess the amount of damage to remaining trees but also to classify the damage by harvesting process, tree species, location, size and type of damage. The effect of these factors on stem injuries should be well understood for planning proper harvesting operations with the least damage. Results of this study indicated that not only is proper planning of skid trail prior felling an essential stage of forest harvesting, but also the ability of felling crew for falling trees toward planned skid trail is necessary. Naghdi (2006) and Nikooy (2007) reported that skid trail planning before felling can reduce impact of residual stand after harvesting but results of this study indicated that ability of felling crew is also important. In our study, skid trail planning before beginning the felling operations did not decrease damage to residual forest stand in comparison to the study of Nikooy (2007) and Naghdi (2006). This research indicated that preliminary planning of skid trail prior to felling is not enough to minimize residual stand damage because ability of felling crew is also important. Sustainable harvesting from forest needs trained and experienced felling crew that should be aware of the value of residual trees and the importance of minimizing stand damages. Close supervision of harvesting especially felling by the forest manager and forest supervisor is essential to avoid damage to potential crop trees.

REFERENCES

Alahie, H. (1997) The study of skidding in the Hyrcanian Forest of Iran. Tehran University, Iran.

FRWO. (2006) Instructions for planning of landing and skid trail. Forest Harvesting Office. pp. 35.

Hosseini, M. (1995). Harvesting operations in the northern forest of Iran. *Forest and Range Mag.,* **25,** 28-32.

Hosseini, S.M., Majnonian, B., Nieuwenhuis, M. (2000) Damage to natural regeneration in the Hyrcanian forests of Iran, a comparison of two typical timber extraction operations. *J. For. Eng.* **11,** 63-72.

Mirarab, J. (2007) Study the transect sampling method in estimating the standing trees damages caused by skidders. (Case study: Kheyroud Forest). Master thesis, Tehran University, Tehran, pp. 92. (in Persian)

Naghdi, R. 2006. Investigation and comparison of two harvesting systems: tree length and cut-to-length method in order to optimize road network planning in Neka, Iran. Ph.D thesis, Tarbiat Modares University.Tehran, pp. 177. (in Persian).

Naghdi, R. Bagheri, I. Taheri, K. Akef, M. (2009) Residual stand damage during cut to length harvesting method in Shafaroud forest of Guilan province. *Iranian J of Env Sci*: **60 (3),** 931-947.

Nikooy, M. (2007). Production optimization and reduction impact on forest by preparing harvest planning in Nav, Iran. Doctoral thesis, Tehran University, pp. 165.

Shigo, A.L. (1984) How to assess the defect status of a stand. Northern. *J. Appl. For.* **10(9),** 41-49.

Sagheb-Talebi, Kh., Sajedi, T. and Yazdian, F. (2003) Forests of Iran. Research Institute of

Forests and Rangeland. Technical Publication No. 339, pp. 28.

Solgi, A. Najafi, A. (2007) Investigating of residual tree damage during ground-based skidding. Pakistan. *J. Biol. Sci*., **10,** 1755-1758.

Vasiliauskas, R. (2001) Damage to trees due to forestry operations and its pathological significance in temperate forest: a literature review. *Forestry* , **74(4**), 319–336.

Wästerlund, I. (1992) Extent and causes of site damage to forestry traffic. *Scandinavian J. For. Res.* **7**, 135-142.

Yilmaz, M., Akay A. (2008) Stand damage of a selection cutting system in an uneven aged mixed forest of Cimendagi Kahramanmaras - Turkey. *Int. J. of Natural and Eng. Sci.* **2(1),** 77-82.

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بررسی خسارات وارده به درختان ناشی از برش تک‌گزینی در جنگل‌های پهن‌برگ حوزه شفارود

م. نیکوی، ر. رشیدی و گ. کوچکی

چکیده

عملیات بهره‌برداری در جنگل‌های شفارود عموماً بوسیله برش تک‌گزینی انجام می‌گردد و اره‌موتوری و اسکیدر دو ماشین اصلی برای بهره‌برداری از این جنگل‌ها می‌باشند. به هر حال عملیات بهره‌برداری جنگل منتج به خسارات جدی در هنگام قطع، کشیدن و خروج چوب در این جنگل‌ها می‌گردد. در این مطالعه خسارات وارده به درختان ناشی از برش تک گزینی در سری آواردیم جنگل شفارود در شمال ایران مورد ارزیابی قرار گرفت. قطع درختان توسط اره‌موتوری و خروج آن بوسیله اسکیدر چوبکشی انجام گرفت. برای رسیدن به مزایای قطع‌هدایت، مسیرهای چوبکشی و دپوها قبل از قطع طراحی گردیدند. ۱۴ پلات دایره‌ای شکل بر روی خطوط ترانسکت که به تصادفی سیستماتیک در کل جنگل پراکنده شده بود، مورد ارزیابی قرار گرفت. نتایج مطالعه نشان داد که بیشتر خسارات وارده به درختان در اثر عملیات کشیدن و خروج چوب‌آلات و به قسمت انتهایی تنه درختان(کمتر از یک متر) وارد گردید. بیشتر درختان آسیب‌دیده راش با متوسط اندازه زخم‌هایی به اندازه ۲۹۰/۳ سانتی‌مترمربع بودند. مطالعه خطای قطع نشان داد که ۴۰ درصد از درختان قطع شده زاویه ای ۷۰–۴۵ درجه نسبت به مسیرهای چوبکشی داشتند و گروه نتوانست درختان را به سمت مسیرهای چوبکشی بیاندازد. افزایش خطای قطع، درختان باقیمانده را در معرض آسیب بیشتری قرار داد. این مطالعه نشان داد که طراحی مسیرهای چوبکشی و دپوها قبل از قطع درختان به تنهایی برای کاهش آسیب وارده به توده سرپا کافی نیست و آموزش گروههای قطع برای انجام مناسب عملیات بهره‌برداری ضروری می‌باشد. برای موفقیت انجام عملیات بهره‌برداری در مدیریت جنگل‌های ناهمسال، گروههای قطع باید متشکل از کارگران آموزش دیده و باتجربه‌ای باشند که از ارزش توده باقیمانده جنگل و اهمیت کاهش صدمات وارده به توده سرپا آگاه باشند.