Long-term Effects of Logging Damages on Quality of Residual Trees in the Asalem Nav Forest

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Introduction

Chainsaw and cable skidder are two main logging machines for wood harvesting in the Caspian forests. Selection cutting is the main silvicultural method in these forests. Harvesting in the Caspian forests has the potential to damage the trees that are left standing. Damages to residual trees during the selection cutting operation may decrease the quality of residual trees and increase stand mortality through insect and disease infestation. The wounds can cause stem deformity and significant losses of the final crop volume and value. The wound characteristics such as size, location, and intensity are the main factors that influence on the future quality of damaged trees. Logging damages to the residual trees increase as the time passes. The literature review shows that minor damage to the stem of residual trees during logging operation can have a major impact on the final stand volume as future saw logs. In the Caspian forests, many studies focused on the primary logging damage (immediately after logging operation) and a few studies were done on the secondary logging damage (after years). The objective of this research was to study the condition of logging wounds on residual trees after 12 years elapsed in the Caspian forests.

Materials and methods

The study was carried out in two adjacent compartments (35 and 42) of the district No., one of Nav watershed in Guilan province in the Caspian forest 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. The elevation of the study area is ranged from 1350 to 1600 m and the mean of annual precipitation and temperature are approximately 950 mm and 9.1°C, respectively. The original vegetation of this area is an uneven-aged mixed forest and is dominantly covered by *Fagus orientalis* and *Carpinus betulus* stands. These compartments selectively logged by ground-based logging operation during December and January of 2000. The characteristics of wounds (size, intensity, and location) on the residual trees were measured immediately after logging operation. The condition of wounds was restudied after 12 years from logging operation in the year of 2012.

Results and discussion

The results of this study showed that 67.1% of wounds were closed and 32.8% of the damaged trees were not able to improve their wounds. About 4.2 percent of wounds caused to tree mortality as shown in Table 1.

Table 1. The condition of wounds after 12 years from logging damage in the study area

Frequency	Condition of wounds			
	Closed	Open	Decayed	Tree destroyed
Number	194	52	31	12
Percentage	67.1	18.0	10.7	4.2

Table 2 shows the condition of wounds on the trees with different diameters at breast height (dbh). The trees of dbh < 40 cm are more sensitive to logging wounds so that 58.4% of damaged trees of dbh < 20 cm and 10.5% of damaged trees with a dbh of 21-40 cm caused to tree mortality.

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Table 2. The condition of wounds on the trees with different diameter at breast height (dbh)

Tree dbh (cm)	Wound condition							
	Closed		Open		Decayed		Tree destroyed	
	N	%	N	%	N	%	N	%
< 20	1	8.3	1	8.3	3	25.0	7	58.4
21 - 40	34	89.5	0	0	0	0	4	10.5
41 - 60	89	92.7	4	4.1	2	2.1	1	1.0
61 - 80	49	70.0	13	18.6	8	11.4	0	0
>81	21	28.7	34	46.6	18	24.7	0	0

The effect of wound characteristics (size, intensity and location) on its future condition was studied and the results were shown in Table 3. Our study indicated that the wounds near the ground have a greater incidence of decay compared to the higher wounds. The wound size is one of the most important characteristics related to decay. The results showed the wounds in sizes <25 cm^2 had the most ability of healing. The bark squeezed intensity of bole wounds didn't caused to tree mortality; while about 8.3% of wood-damaged intensity of bole wounds caused to tree mortality and 19.8 % of them caused to wood decayed (Table 3). Overall, results of this study indicated any major wound located in the lower section of the tree have the potential to greatly reduce the quantity and quality of the future wood product by causing stain or decay in the high-value butt log.

Table 3. The condition of wounds in the different wound characteristics

Wound characteristics	Wound condition							
	Closed		Open		Decayed		Tree destroyed	
	N	%	N	%	N	%	N	%
Size								
< 25	116	90.6	9	7.0	3	2.4	0	0
26-100	74	70.5	29	27.6	2	1.9	0	0
101-1000	4	11.8	12	35.3	15	44.1	3	8.8
>1001	0	0	2	9.1	11	50.0	9	40.9
Intensity								
Bark squeezed	60	88.2	8	11.8	0	0	0	0
Bark removed	79	79.0	12	12.0	7	7.0	2	2.0
Wood damaged	55	45.5	32	24.6	24	19.8	10	8.3
Location								
Root	4	19.1	10	47.6	5	23.8	2	9.5
<1 m	73	60.4	20	16.5	20	16.5	8	6.6
1 – 2 m	53	69.8	19	25.0	3	3.9	1	1.3
>2 m	64	90.2	2	2.8	4	5.6	1	1.4

Table 4 presents the results of Chi square test for the effect of tree dbh and wound characteristics on the wounds condition. These results showed that the dbh of trees and wound characteristics (size, intensity, and location) have significant effect on wounds condition (Table 4).

Table 4. The results of Chi square test for the effect of tree dbh and wound characteristics on the wounds condition

Factor	Df	Chi Square Value	P-Value
Tree dbh	12	208.3	0.00**
Wound size	9	227.6	0.00**
Wound intensity	6	52.9	0.00**
Wound location	9	50.2	0.00**

** Significant at $\alpha = 0.05$.

Conclusion

The results of this study showed that logging damage to stand can be reduced substantially. To achieve sustainable forest management, the main requirements are minimization of the logging damages. In the context of selection cutting management, minimizing logging damage to residual trees must therefore remain a major

objective. In order to minimize felling damage, directional felling must be applied considering the skid trails. Pre-harvest planning and identifying the winching area before logging operation can reduce damage to the stand in the Caspian forests.

Keywords: logging damage, selection method, residual stand, bole injury, Nav forest.