International Journal of Natural and Engineering Sciences 2 (1): 77-82, 2008
ISSN: 1307-1149, www.nobel.gen.tr

Stand Damage of a Selection Cutting System in an Uneven Aged Mixed Forest of Çimendağı in Kahramanmaras-Turkey

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Received: September 12, 2007
Accepted: November 30, 2007

Abstract

In the uneven-aged mixed forests, logging operation is generally performed by using selection cutting method. However, logging activities result in serious residual stand damages during felling and skidding operations in these stands. Therefore, the effects of main factors on stand damage should be well understood by the logging managers to plan proper logging operations with minimum damage. In this study, the residual stand damages from a logging operation was studied in an uneven-aged mixed forest to examine the main factors (i.e. logging stages, tree species, and location, size, and type) affecting stand damages. Then, some of the suggestions and practices that can be implemented during logging operations to reduce stand damage were presented.

Keywords: Residual damage, mixed stands, logging, felling, skidding,

INTRODUCTION

In managing forest resources, one of the most desirable stand types in terms of sustaining the biodiversity is uneven-aged mixed forests where many tree and shrub species can live together with harmony. The uneven-aged mixed forests are highly resistant against biotic and abiotic agents and they provide rich gene combinations and genetic variations [14, 8, 18]. Besides, they improve the visual quality and aesthetic value of the forest stand.

In uneven-aged mixed forest, forest managers mostly apply selection system which ensures and sustains uneven-aged forests, consisting of single trees or group of trees with various age, height, and diameter classes [7]. In selection system, the stand is divided into cutting blocks and each block is periodically (e.g. period of 10 years in Turkey) treated by implementing either single tree selection cutting or group selection cutting method [7]. The single tree selection cutting favors growth of shade tolerant species (e.g. fir, beech, spruce) while group selection favors the regeneration of light demanding species (e.g. pines). In mixed forest containing both shade tolerant and light demanding species, group selection cutting should be applied. After implementing selection cutting method, the natural regeneration can occur in the open areas where trees are extracted.

In applying selection cutting method, inadequate and poor logging operations (i.e. felling and skidding) may cause serious damages on residual stands due to existence of various tree species with different age classes. In uneven-aged forests, the amount of residual stand damages after logging is more than within even-aged forests [9]. The injured residual trees loss considerable amount of timber volume and economical value, and they become more vulnerable to insect and fungus attacks. Furthermore, damaging young trees results in a long term impact on regeneration process of uneven-aged mixed forests. Besides, uneven-aged forests require frequent silvicultural treatments that of even-aged forests [22]. Therefore, when executing a logging activity as a tool of implementing silvicultural treatments [19] in uneven-aged mixed forests, special felling and skidding operations should be performed to minimize residual stand damage and to secure natural regeneration process [21]. It should be noted that applying special techniques in selection cutting to reduce stand damage may increase the cost of logging activities [15].

To reduce stand damage in uneven-aged mixed forests during selection cutting operations, felling directions should be predetermined, road networks should be well planned, loggers and operators should be experienced and adequately trained, skidding distance should be kept shorter, and natural logging residuals (i.e. slash materials) should be bunched in the woods [5, 23, 13, 10, 21, 6, 2, 12, 20]. To reduce stand damage, the type of selection cutting method (i.e. single tree selection cutting or group selection cutting) should be also determined carefully by considering local stand characteristics. According to Stokes et al. [25], number of injured trees in using group selection method (e.g. average 37.5 tree/ha) is more than that of using single tree selection method (e.g. average 29.8 tree/ha).

In mountainous terrains, selection cutting is highly preferable to reduce damages on residual trees as well as end-products. In some parts of the world, chute system is widely used to extract timber in steep terrains. For example, wooden chute system has been used for over 200 years in China. In steep terrain, the chutes should be located diagonal to the contours while they should be perpendicular in gentle terrains [1]. The average yarding distance in chute system varies from 200-1000 m in the ground slope of 45-60%.

In order to determine the most appropriate logging activity with minimum stand damage, stages of logging operation (i.e. felling and skidding) should be well analyzed in terms of their

Table 1. The summary of stand damages based on variable factors including logging stages, tree species, and location, size, and type of damages.

Sample Plots	Slope (%)	Residual Trees	Extracted Trees	Trees Species			Damages								Total
							Location			Type			Logging Stage		
				Fir	Pine	Cedar	<0.30 m	0.30-1.3 m	>1.3 m	Bark	Wood	Top	Felling	Skidding	
1	50	33	4	9	0	0	6	4	4	8	5	1	7	7	14
2	35	45	7	4	0	0	4	1	0	2	3	0	1	4	5
3	40	46	3	1	0	1	2	0	0	2	0	0	0	2	2
4	35	41	5	0	1	0	0	1	0	1	0	0	1	0	1
5	40	22	4	3	3	0	6	0	1	3	4	0	2	5	7
6	35	37	3	7	0	0	4	3	0	4	3	0	2	5	7
7	45	36	4	7	0	1	8	4	0	10	2	0	1	11	12
8	30	45	4	0	0	0	0	0	0	0	0	0	0	0	0
9	45	22	4	0	0	0	0	0	0	0	0	0	0	0	0
10	35	26	3	3	0	0	3	1	0	0	4	0	1	3	4
11	55	26	5	3	0	0	1	2	0	1	2	0	1	2	3
12	50	23	3	0	2	0	1	1	0	1	1	0	1	1	2
	TOTAL	402	49	37	6	2	35	17	5	32	24	1	17	40	57

potential for causing residual stand damage [11]. In this study, a logging operation conducted in an uneven-aged mixed forest was studied to examine the stand damages by considering variable factors including logging stages, tree species, and location, size, and type of damages.

MATERIAL AND METHODS

Study Area and Stand Characteristics

Study area of 50 ha is located in Çimendağı forest which is in the boundaries of Hartlap Forest Enterprise Chief in Regional Forest Directorate of Kahramanmaraş (Figure 1). In the study area, average elevation and ground slope are 1450 m and 40%, respectively. The study area consists of an uneven-aged mixed forest where fir and pine (*Pinus nigra*) are dominant trees with scattered cedar trees and very rare junipers and poplar trees. The average site index in the study area is determined as the medium site class.

In the study area, the tree diameter classes in the study area showed an irregular distribution. The number of mature trees with large diameter classes was more than the optimum numbers. The forest was multistoried with very dense overstory and relatively rare understory. However, the forest tends to return into a single-storied stand due to about 100% crown closure, which leads to scarcity of sufficient gaps to receive light for natural regeneration of light-demanding trees including pine and cedar. The litter layer under the stands dominated by pine was measured as 5-10 cm while it was measured as 1-2 cm under the stands of fir trees. Besides, the litters under the pine were drier and more loosely.

Figure 1. Geographical location of the study area in Turkey

Logging Operation

In order to ensure sustainability of uneven-aged mixed forest, selection system has been applied by performing single tree selection cutting operations within 10 years intervals. These selection cutting operations include several silvicultural treatments such as thinning, intermediate cutting, harvesting, and natural regeneration cutting. In the logging operation, trees were first fallen by using chainsaw and then transported to the landing areas by using animal (mule), manpower, and tractor. Approximately 10% of the timber (49 trees) was extracted during the operation. The total timber production was about 464 m^3 in which two third of the yield was from fir and one third was from pine.

Measuring Residual Stand Damage

To analyze stand damages after logging operations, 12 round-shaped sample plots with 400 m^2 area were randomly selected from the study area. Total of 402 residual trees with breast height diameter of 8 cm or great were considered in data collection. The number of fir, pine, cedar, and other tress were 198 (49%), 163 (41%), 31 (8%), and 10 (2%), respectively.

The stand damages on trees were examined by considering variable factors including logging stages (felling or skidding), tree species (fir, pine, and cedar), and location (stump level: 0-0.3 m, stem: 0.3-1.3 m, upper-stem: 1.3 m and higher), size (width, lenght, and area), and type of damages (bark, wood, and top injuries).

RESULTS AND DISCUSSION

Logging Stages

The results indicated that 57 stand damages were counted on 45 injured residual trees due to the logging operation in the sample plots (Table 1). The number of stand damages occurred during the felling and skidding operations were 17 and 40, respectively (Figure 2).

Figure 2. The view of stand damages due to felling (left) and skidding (right) operations.

Therefore, one felling injury was occurred for felling of 3 trees (49/17). To minimize felling injuries, directional felling must be applied considering skidding trails [2]. Besides, extracted trees should be pruned before felling where it is necessary [24].

In the study area, three sample plots were located over the main skidding trails. The number of skidding injuries in those specific plots was significantly greater than injuries in the other plots (Figure 3). There were 33 residual stand damages were detected over the skidding trails. Therefore, the average number of stand damages occurred in the plots located over the skidding trails was about 11 (33/3), while the number of damages in the other plots was about 3 (24/9). To reduce skidding damages, skidding trails must be predetermined by considering ground slope, terrain conditions, vegetation density, and harvesting intensity [5]. Besides, straight skid trails should be designed to prevent damages on the trees next to the skid trails [16].

Tree Species

The results indicated that the number of injured fir, pine, and cedar trees were 37, 6, and 2, respectively (Table 1). The percentages of injured trees were 19% (37/198), 4% (6/163), and 7% (2/31) for fir, pine, and cedar trees, respectively. The fir trees received the highest number of damages because their bark thicknesses are relatively thinner than that of pine and cedar trees. Besides, almost all of the felling injuries were detected on firs and cedars since they have dense brunches on lower stem, comparing with pines which have brunches only on upper stem due to natural pruning.

Figure 3. Damaged trees over the skidding trail.

The pine trees were injured during the skidding operation due to impacts of moving logs on butt section and lower section of the stems. In general, skidding injuries could not penetrate deep into the wood and cambium due to thick barks of pines. However, when the logs roll down or move uncontrollably on dry and loosely litters under the pine dominated stands, they hit the stems in very high speed and caused injuries on barks and wood. Considering that four out of six injuries on the pine were on the wood, one can say that loggers lost control of the logs and they hit the trees with very high speed. To reduce skidding damages, loggers should be experienced and well trained for effective and preservative skidding operations in uneven-aged mixed forest.

Damage Location

The results indicated that the percentages of damages on stump level, stem level, and upper-level are 61% (35 injuries), 30% (17 injuries), and 9% (5 injuries), respectively (Figure 4). All of the damages on stump level were caused by skidding operation. However, on the stem level, 5 out of 17 damages were occurred due to skidding operation, while felling operation caused 12 injuries. The damages on upper stem level were caused by felling operation. When skidding damages occur on stump level, biotic agents such as fungus and insects easily attack wood through injuries, especially which close to the ground [4]. Therefore, injured trees infected by fungus and insects become subject to considerable amount of value loss in long run (Figure 5).

Han and Kellogg [16] suggested that artificial tree protection rigging such as rub pads should be used to prevent damage on stump and stems. Besides, small size slash material can be located around the lower tree parts to provide a protection layer. Stumps height should be low since high stumps on skid trials can force skidder to move around the stump, which leads to damages on the trees along the skid trial.

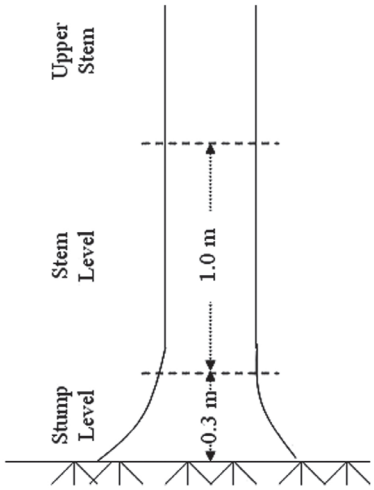

Figure 4. Tree sections indicating the damage location classes.

Figure 5. Blue-stain defects discoloring the woods after the stand damage.

Damage Sizes

The size of the damages was evaluated by considering average width, length, and area of the injury. The results indicated that damage sizes vary depending on the logging stages (Table 2). The statistical analysis showed that the average width and length of the damages due to felling operation was 8.31 cm and 28.94 cm, respectively. Since vertical felling direction is parallel to the tree stem, damage length was generally greater than damage width in felling operation (Figure 6).

Table 2. Statistical summary about size of the damages.

Logging Stages	Number of Injuries	Average Values ± SE		
		Width (cm)	Length (cm)	Area (cm^2)
Felling	16	8.31 ± 2.16	28.94 ± 8.26	376,19 ± 198,48
Skidding	40	10.87 ± 1.30	19.08 ± 2.27	307,70 ± 67,75
Total	56	10.14 ± 1.12	21.89 ± 2.88	328,82 ± 70,90

Figure 6. Thinner and longer stand damage on firs due to felling operation.

During skidding operation, the average damage width and length was found to be 10.87 cm and 19.08 cm, respectively. In skidding operation, larger damage widths occurred due to frequent contacts between skidded logs and residual trees. However, the average damage length in skidding operation was smaller than that of felling.

The damage size can be the most significant factor of deterioration. Aho et al. [3] reported that the larger injuries results in more and rapid deterioration process. The studies indicated that wider and shorter injuries can cause more volume loss than that of thinner and longer injuries [28]. Besides, wider injuries can reduce the diameter growth. Isomaki and Kallio [17] reported that damage widths of 5-10 cm and 17-35 cm reduced the diameter growth by 10% and 35%, respectively. Furthermore, recovery from the wider injuries takes longer period of time than of thinner and longer injuries [26].

In Turkey, the number of injuries and damage sizes are considerably high because logging operations are mostly performed during summer season. However, extracting timber during winter season can dramatically reduce the amount and size of the residual damages [27].

Damage Types

The results indicated that about 56.14% (32 damages) of the injuries occurred on tree barks, resulted in cambium exposed. About 42.11% (24 damages) of the damages was seen to be stem or wood injuries. Only 1.75% (1 damage) of the injuries resulted in broken tops. The results also indicated that 4 out of 24 wood injuries occurred in pines, while rest of the wood injuries was encountered in firs [28]. Residual trees with wood injuries become more vulnerable to insect and fungus attacks. The average depth of the injuries on the wood was estimated to be 2.70 ± 0.38 mm.

Isomaki and Kallio [17] indicated that the depth and size of the injuries on the wood greatly affect the diameter growth. They reported that diameter growth can be reduced by 10% and 20% due to surface injuries and deep wood injuries, respectively.

CONCLUSIONS

The residual stand damages from a logging operation was studied in an uneven-aged mixed forest to examine the effects of various factors such as logging stages, tree species, and location, size, and type of damages. In an uneven-aged mixed forest, timber extraction is generally performed by selection cutting method which may cause serious stand damages during felling and skidding operations. Therefore, the effects of specified factors on stand damage should be well understood to plan proper logging operations with minimum damage. The logging managers should implement directional felling techniques and pre-determine straight skidding trails before entering the stand. In extracting timber from a stand consisting of trees with thinner barks (i.e. firs), logging operations should be carried out with extra precautions. Tree protection tools (i.e. rub pads) should be used to reduce damages on stump level and stem level sections. In felling and skidding operations, damage size should be kept as small as possible to minimize potential deterioration on wood due to attacks of biotic agents. The loggers should be well educated about the important functions of uneven-aged mixed forests in sustainability of forest ecosystem. Then, these adequately trained and supervised loggers should be employed in selection cutting operations to reduce stand damage. Finally, adequate logging activities should be applied as a tool of silvicultural treatment in maintaining and ensuring the significant value and functions of uneven-aged mixed forest.

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