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ENVIRONMENTAL ESTIMATION OF MECHANIZED TECHNOLOGIES FOR REGENERATIVE CUTS IN MOUNTAINOUS CONDITIONS

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Abstract

An environmental estimation is made of regenerative cuts in mountain beech (*Fagus sylvatica* L.) stands, based on a motormanual prime processing and transportation by wheel cable skidders. After the mechanized regenerative cuts, about one-third of the residual trees are damaged, fortunately most of them superficially. Predominantly the tree roots and stems are damaged. Inside the stands, the number of damaged trees is smaller, whereas around the skid roads almost half of the trees are damaged. In the first case, the residual trees are damaged by the felled trees (mainly higher than the first 1 m of the stem). In the second case the damages are caused by the skidded stems. The results show that the percentage of damaged understorey is about 16.89%, icncluding 80% of it recoverable. To reduce tree damages along the skid roads and especially those along the curves, it is advisable to use some protective devices for prevention. To minimize the damages on the understorey it is necessary to use protective X-devices, diverting rollers and cones on the front of the logs. It is advisable to improve the professional skills of the loggers and to introduce effective stimulations for environmentally-sound logging operations.

Key words: regenerative cuts, motormanual prime processing, wheel skidder, damages, residual stand.

Introduction

The negative impact of regenerative motormanual cuts on forests is focused on 3 directions: damages on the residual trees, damages on the understorey, and forest soil compaction. For our forests the effects mentioned above are extremely unfavorable, because of the protective function and mountainous location of the major part of the Bulgarian forests. The number and size of damages caused by logging operations depend on the tree species, age, season, type and cutting intensity, location, logging technology and system of machines. The timber harvested in Bulgaria is extracted predominantely by wheel tractors. The choice of proper logging technology according to certain natural and productive conditions is made by comparative analysis based on economic as well as environmental criteria.

The aim of the present study is to make an environmental estimation of mechanized logging technologies for regenerative cuts in order to find out the reasons for damages and the ways to reduce their impact on wood quality.

Background

Despite the increased understanding of environmentally-sound logging, the number of studies in this field is limited. The problems are discussed not very carefully and studies cited are from countries with different logging technologies (Baev et al. 1985, Mateev et al. 1986). According to many authors cited by Schütz (1990), 33% of the residual stands have damages greater than 10 cm^2 after thinnings in Switzerland and that leads to a danger of wood destruction. The Scandinavian authors (Saarilahti 1999, 2000, 2003; Wästerlund 1994) report mainly about the damages caused by the interaction between tractor wheels and forest soils during cut-to-length (CTL) logging operations. The share of damaged trees in Czech Republic using CTL technologies and system of machines ranges between 1.50 and 2.38% (Dvořák 2005). According to Ferenčik et al. (2008) the negative effect of the CTL technology in Slovakia is expressed as tree damages (not heigher than 1 m) of 25% of the residual stands on the average. A comparative study between motormanual and fully mechanized logging concerning the size of residual stand damages, made by Košir (2008), shows that in the first case the number of damaged trees is greater and later on these damages make the stand structure worse.

In Bulgaria Dinev (2003) studied the effect of different thinning technologies on the damages of residual stands. To reduce stand damages and facilitate timber extraction, proper felling directions must be kept, consistent with skid roads. On areas with high tree stand density, a crosscutting of stems into stem sections is recommended, although that the technology is being modified. The skid roads must be with proper width and suitable curves, consistent with the stem length. The use of protective devices for residual trees along the road curves is recommended for reducing the damages (Georgiev and Stoilov 2007).

We could conclude that the effect of different logging technologies and machines on residual stands in the modern logging practice in Bulgaria is a live question.

Objects and Methods

Damages were classified by their depth (superficial and deep), as well as by their location on the stems (root, stem or both root and stem) (Meng 1978). The aim was to find out the cause of damages – fallen trees, skidder equipment or tree load, as well as unsuitable curves or width of skid roads. The understorey damages were classified as bended, raw and broken (i.e. irretrievable damages).

In the Petrohan Training and Experimental Forestry Enterprise at the University of Forestry, located in the West Balkan Mountains, six test areas (TA) in two compartments were marked. The skidding operations were made by means of a LKT-81T double drum wheel cable skidder.

TA1 (compartment No 94, area 0.4875 ha) and TA2 (subcompartment No 19b, area 0.1407 ha) were intended for estimating the damages inside the residual stands. TA3 (compartment No 94, length of 130 m) and TA4 (subcompartment No 19b, 65 m long) were strips of the trees located at 1 m spacing along the skid roads (the latter 4 m wide) intended to specify damages caused by skidding. TA5 and TA6 with areas of 24 m^2 and 14 m^2 respectively, were located in compartment No 94 and were intended for determining understorey damages. In subcompartment No 19b no natural regeneration was observed.

Results and Discussion

The data analysis of test areas shows that 93 out of 305 remaining trees (i.e. 30.49%) were damaged during the regenerative cuts (see Fig. 1). The injuries of 28 damaged trees (30.11%) were deep (under bark). On TA2 two of the damaged trees were broken at a height of 5 m and 6 m respectively, and a third tree was partly uprooted and bent. The most damaged trees were at 1 m distance along the skid roads: on TA3 that were 63.33% of all the trees, and on TA4 – 35.14%.

Root damages

The share of trees with damaged roots in the residual stands of the studied test areas is large – 34.41%. The dimensions of tree damages in cm^2 are shown in Fig. 2. On TA1 root damages with areas over 100 cm^2 (46.15%) were prevailing. Damages with areas smaller than 10 cm^2 were not found. The damages were caused by trees extracted by the skidder winch as well as by other skidder equipment. All root damages on TA2 were with areas over 100 cm^2 and were also caused by ex-

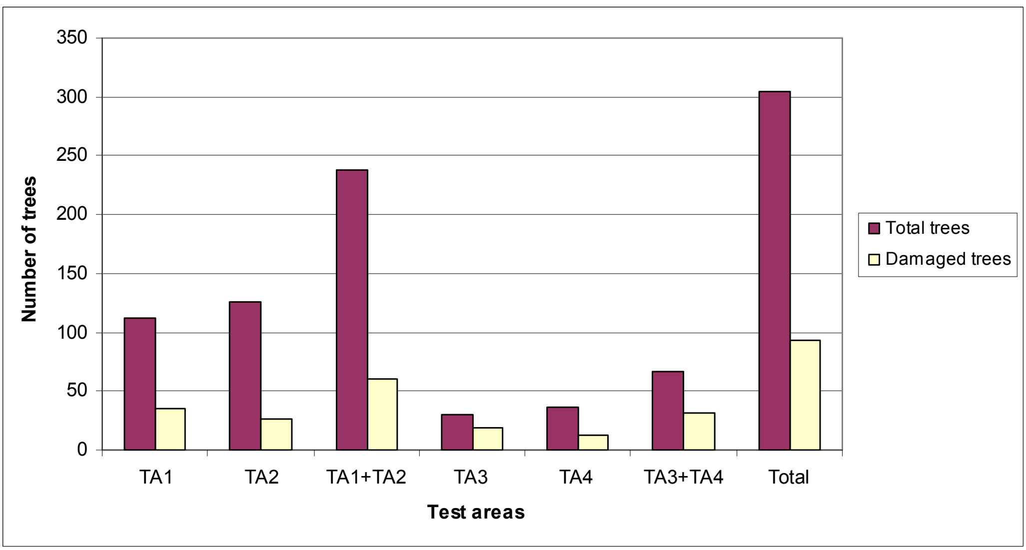

Fig. 1. Total number of trees and number of the damaged ones.

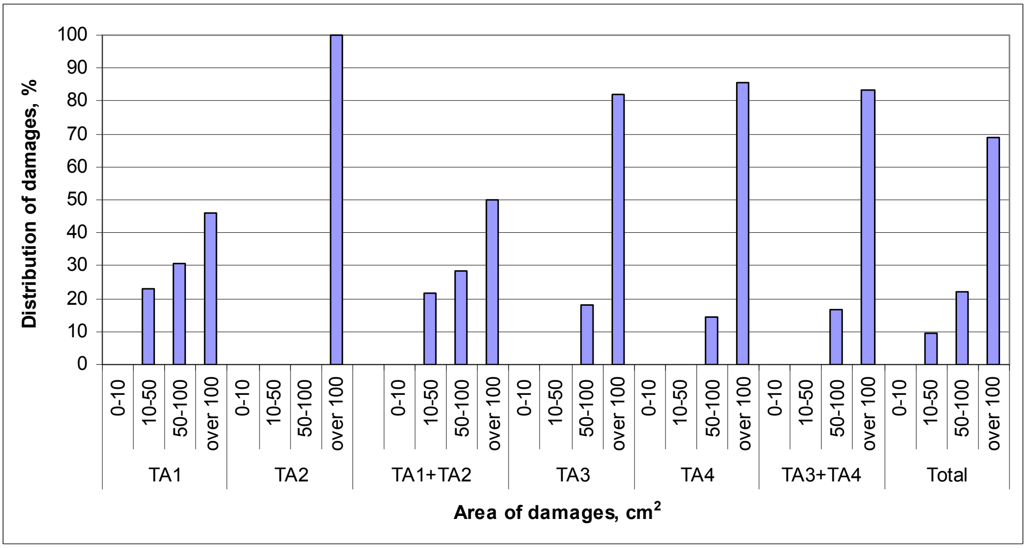

Fig. 2. Distribution of root damages by area.

tracted trees and the skidder equipment. Generally, inside the stands (TA1 and TA2) large size damages prevailed.

The share of root damages along the skid roads was very large: on TA3 and TA4 the damages with areas over 100 cm^2 (83.33%) were prevailing. Here the root damages were caused by the skidded long stems, especially along the curves.

The summary for both of the studied stands shows that the percentage of root damages of the residual trees over 100 cm^2 is the largest – 68.75%. In both of the stands the roots of 32 out of 305 residual trees (10.49%) were damaged, i.e. every tenth tree.

Stem damages

The distribution of stem damages by height is shown in Fig. 3. If damages are caused by the skidder equipment during the bunching of wood materials we could assume that they were up to 1 m above the ground surface, whereas the damages higher than 1 m were caused by the trees felled nearby.

On TA1 nearly 2/3 of the stem damages were located up to a height of 1 m, therefore they were caused by the arch and the cable winch, as well as by the extracted stem sections. All the rest of the damages were caused by wrong felling directions, respectively by the thick branches and stems of felled trees in that case. Inside both of the stands (i.e. on TA1 and TA2) on the average 46.35% of stem damages lower than 1 m were caused by stem sections extracted to the skidder and the skidder equipment, whereas 53.65% of the damages were caused by the felled trees.

The distribution of stem damages by area is shown in Fig. 4. If we classify the damages into two groups – up to 500 cm^2 and over 500 cm^2, the first group includes 87.5% of the damages on TA1 and only 36% of these on TA2. Therefore, the damages on the residual trees on TA2 were more serious and the stand was

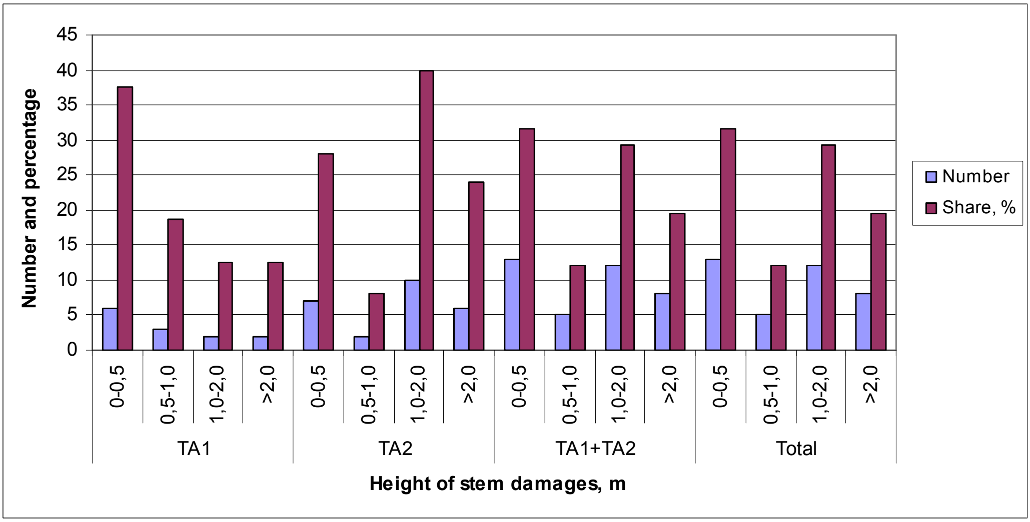

Fig. 3. Distribution of stem damages by height.

in danger. Generally, the areas of damages on TA1 and TA2 were approximately equally distributed in the ranges 0–100 cm^2, 100–500 cm^2 and 500–1000 cm^2, whereas the damages with areas over 1000 cm^2 were not numerous – 17.07%.

Concurrent root and stem damages

The distribution of that type of damages is illustrated in Fig. 5. On TA2 there were no concurrent root and stem damages.

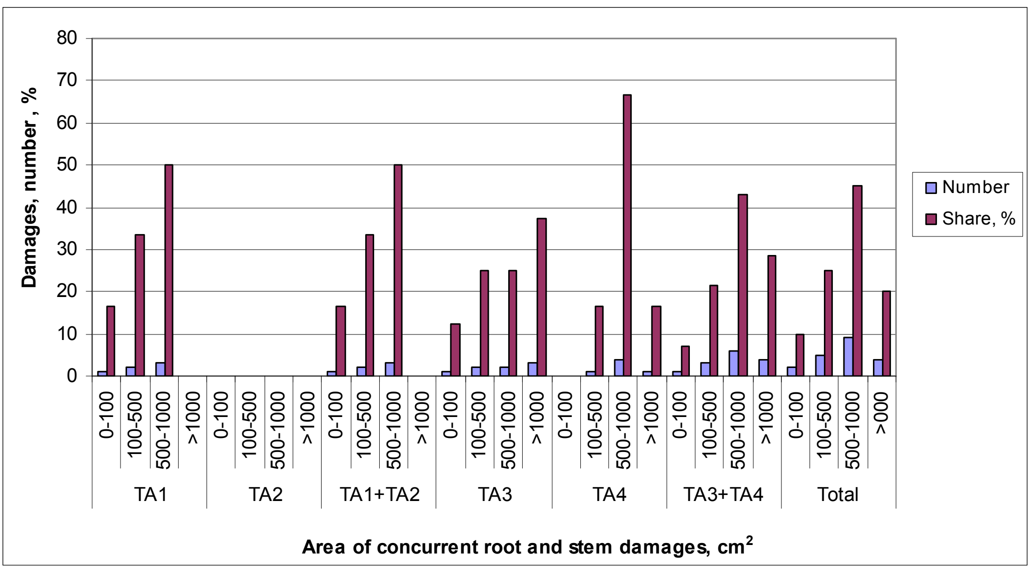

Fig. 4. Distribution of stem damages by area.

On TA1 66.67% of the damages at a height lower than 1 m were caused by the skidder equipment and the bunched stem sections, whereas 16.67% of them were caused by the felled trees. The most numerous concurrent root and stem damages of the residual stands on TA3 and TA4 were at a height of 0.5–1.0 m – 60%, whereas these at heights of 0–0.5 m and 1–2 m were relatively equally distributed – 20% each group. The damages were entirely caused by the skidded stem sections.

It is seen from Fig. 6, that large damages prevail, therefore the health of trees is in danger. On TA1 50% of the damages were with areas of 500–1000 cm^2 and there were no damages larger than 1000 cm^2. On TA2 no concurrent root and stem damages were found. Along the skid roads, damages with areas of 500–1000 cm^2 dominated (42.86%), followed by these over 1000 cm^2 (28.57%).

Understorey damages

Results show that on TA5 and TA6 16.89% of the understorey was damaged. Fortunately, the greatest part of the damaged understorey (80%) was raw, i.e. recoverable, while the rest was broken (see Fig. 7). As mentioned previously, in subcompartment 19b there was no natural regeneration and test areas were not placed there.

Conclusions

After the regenerative cuts in the studied stands 30.49% of the residual stands were damaged, fortunately 69.89% of them – injured superficially. The damaged residual trees in both of the stands were distributed by parts of tree as follows: root damages – 34.41%, stems damages – 44.09%, and concurrent root and stem damages – 21.5%. Inside

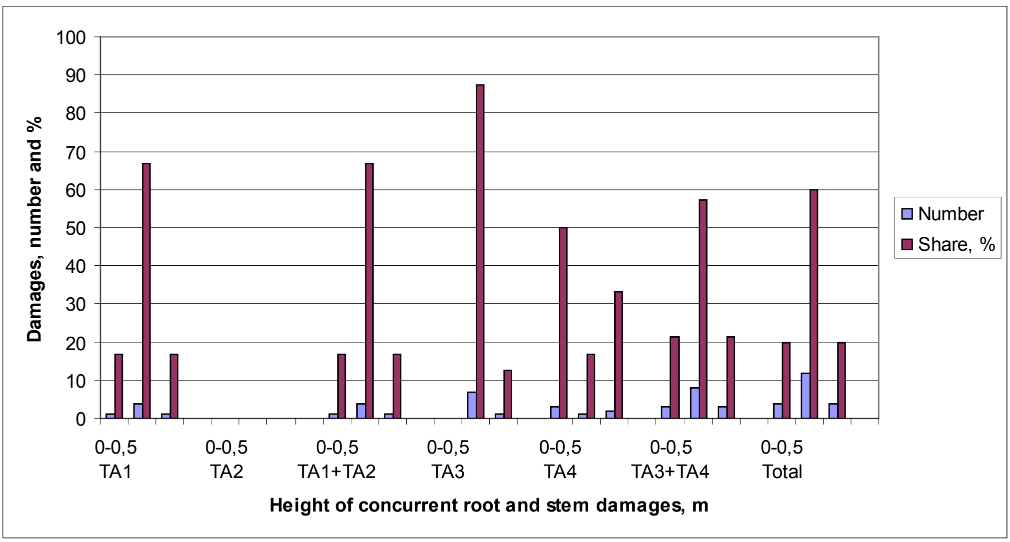

Fig. 5. Distribution of concurrent root and stem damages by height.

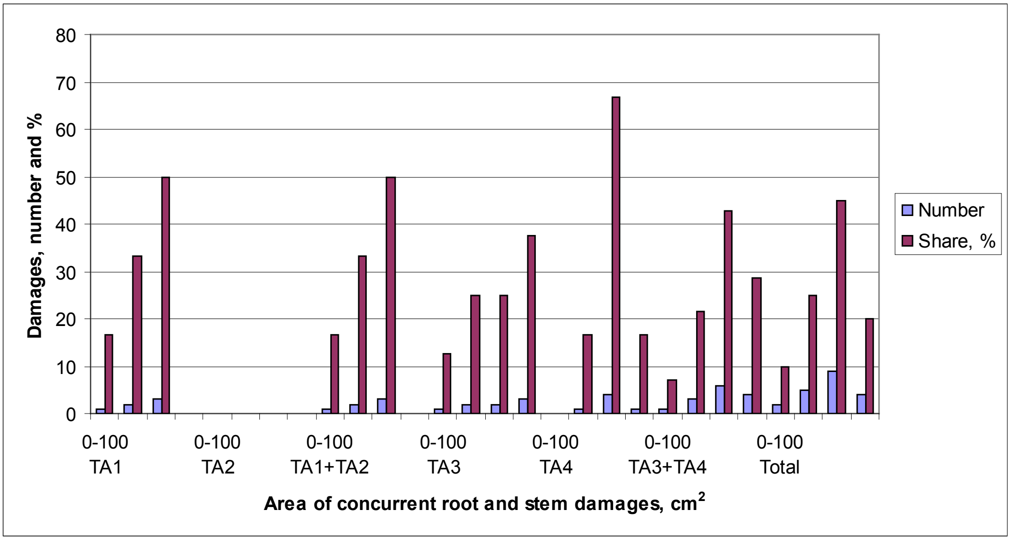

Fig. 6. Distribution of concurrent root and stem damages by area.

the stands the damaged trees were 25.94%, 75.60% out of which – superficially.

The most numerous damages were the stem damages – 70.93%, followed by the root damages – 20.5% and the concurrent root and stem damages – 8.57%.

During the transportation the semi-suspended stem sections injured almost

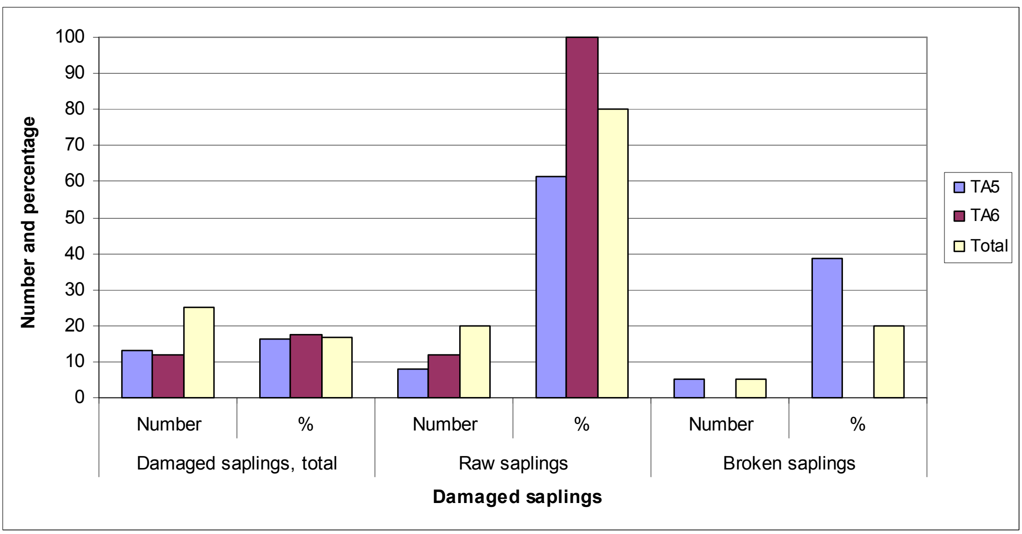

Fig. 7. Distribution of the understorey damages.

half of residual trees along the skid roads (47.76%), 59.38% of them – superficially and 40.63% – deeply. The damages were predominately root damages (56.25%), the rest (43.75%) were concurrent root and stem damages.

Inside the stands, 50% of the root damages were with areas over 100 cm^2, whereas along the skid roads – 83.33% were larger than 100 cm^2. In the first case the damages were caused by the stem sections during the bunching, in the second case – by the load during the skidding to the landing. The tree stem damages were mainly at a height over 1 m (53.66%) and with areas over 1000 cm^2 (56.10%). These damages were located only inside the stands and they were caused by unproperly directed felled trees which interlaced with the residual trees. This additionally increased the tree stem damages within the final prostration of the trees and lead to critical situations concerning the logger safety.

The concurrent root and stem damages inside the stands were predominately with areas of 500–1000 cm^2 (50%) and at a height of 0.5–1 m (66.67%), whereas along the skid roads damages of over 500 cm^2 (71.43%) and at a height up to 1 m (78.67%) were prevailing. In the first case as mentioned above the damages were caused by the bunching and in the second case – by the skidded loads.

The damaged understorey saplings were 16.89% of the total, 20% of which being broken and the rest – recoverable.

Therefore, significant damages on the residual trees and the understorey in the studied stands were caused by the skidded stems. To reduce stand damages, an adequate felling direction is required, consistent with the skid roads and a proper bunching direction as well. In high density stands some cutting of the long stems is recommended that means certain changes of the logging technology. To reduce tree damages along the skid roads and especially those along the curves it is advisable to use some protective devices for prevention. To reduce the understorey and soil damages it is necessary to use protective cones on the front part of the logs.

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