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THE LOGGING IMPACT ON THE SEEDLINGS FROM LOGGING SITES IN SOUTHWESTERN ROMANIA

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Abstract

From thinning to regeneration works, stand management works, can only be applied through logging, which become a vector of maintaining biodiversity through forest regeneration, but also a vector of reducing it, through the damage it causes to forest ecosystem and to seedlings. This paper analyzes the impact of logging works on the seedlings and its biodiversity in 96 sample plots located in 24 wood harvesting sites in southwestern Romania (8 logging sites for each relief form). The impact of logging works on the seedlings was studied by analyzing the evolution of seedlings damages and the impact of these damages on their further development, but also by analyzing the composition of the installed seedlings and comparing it with the composition of the exploited tree. The highest degree of seedling damage was recorded at final cuttings. The most accelerated seedling healing pattern was recorded for barkings. We have observed a maintaining diversity of species after logging that can lead, to a stable diversity of the species from the stand. The obtained results were discussed and compared with other researches in the field, highlighting the most important aspects observed.

***Key words**: logging works; logging technology; damages; regeneration areas.*

INTRODUCTION

The prejudice in forest exploitation is a change in the natural state of the soil, seedlings, and trees caused by logging that adversely affects the further development of forest ecosystems. It follows that not all negative influence in the process of logging on trees, soil or seedlings when it is to be promoted is prejudice.

Due to the damages brought to the natural seedlings in the forest exploitation process, the success of the natural regenerations can be reduced by 20-70% (Giurgiu, 1995). However, the impact of logging on the seedlings can also be indirect by impoverishing and destroying the soil and excessive compaction, especially on collection routes, that can hinder or prevent seed germination. Direct damage to the seedling is also common near the collection routes, especially in specimens with a height of 30-80 cm (Dămăceanu, 1976).

The tolerability threshold of the seedlings in the forestry works is clearly established in Order no. 1540/2011 for the approval of the instructions regarding the terms, modalities and periods of collection, removal and transport of the wood material (art. 15, paragraph 1). "In the case of treatments that promote natural regeneration, it is not a prejudice, the destruction or damage of the seedlings as a result of the normal development of the logging process within the maximum limit of 8% of the area with seedlings, provided in the minutes of handing over the logging site, in the case of cuttings for developing or enlarging regeneration areas, and not more than 12% in the case of final cuts or connection cuts (Ord. nr. 1540/2011). From all technological processes of the entire logging process, most of seedling's damages are produced in technological process of wood harvesting (Chisăliţă et al., 2018).

The negative effects of logging on the seedlings can be minimized in areas with optimal climatic and vegetation conditions. Thus, experiments which consisted in well-watered conditions of beach seedlings from south-western Romania, resulted in higher plant height and higher leaf number, suggesting higher plant growth potential (Cocozza et al., 2016). Similar studies indicate a high drought sensitivity for beech seedlings populations from south-western Romania (Bolte et al., 2016).

The hypothesis of this study is that the damage caused to the seedlings through logging only affects in the short term their further development and does not negatively influence the diversity of species in the future stand. In addition to the field observations that preceded and support the assumption, this hypothesis it is also supported by data from the literature, showing that total seedlings alongside the collection routes were surveyed (Badraghi et al., 2015).

The purpose of the paper is to analyze the impact of logging on seedlings in logging sites in southwestern Romania. This goal has been achieved by meeting the following objectives:

- Analysis of the damages brought to the seedling by studying the injury indexes;
- Analysis of the dynamics of seedlings damages;
- Analysis of the diversity of species from seedlings by comparing it with the diversity of the species from the logged stand.

MATERIALS AND METHODS

This paper analyzes the impact of logging on seedlings in 24 logging sites from southwest Romania, Caraş-Severin County with 8 replicates for each relief form, and 6 replicates for different regeneration works, constitutes on variants as follow:

V1 - logging sites with thinning works with two replicates on each relief form;

V2 - logging sites with works for opening regeneration areas - cutting I of progressive treatment and gardening cutting – with two replicates on each relief form;

V3 - logging sites with works for enlarging regeneration areas - cutting II and III of progressive treatment - with two replicates on each relief form;

V4 - logging sites with works for connecting regeneration areas - last cutting from progressive treatment - with two replicates on each relief form.

Field works have been realized in forest departments from Caraş-Severin forest directorate as Băile Herculane, Bocşa Montană, Bocşa Română, Moldova Nouă, Văliug, and in Caransebeş experimental base administrated by National Institute for Research and Development in Forestry "Marin Drăcea".

In each logging site, seedlings have been investigated in 4 circular sample plots of 5 m^2 each, located on each cardinal direction, at 10 m distance from a fix point from the middle logging site. Having into consideration all 24 logging sites, seedlings have been investigated in 96 sample plots, totalizing 480 m^2.

We have evaluated species diversity in the analyzed plots by evaluating the seedling population and species diversity compared with the composition of the exploited stand.

Seedling damages have been evaluated at a distance of two vegetation seasons, in 2019 and 2021.

Damages identified at seedlings level have been classified using a classification adapted from literature (Knežević et al., 2018; Ciubotaru, 1998) as follow: galling (damages without affecting cambium), barking (bark removing up to the wood), splintering (removing a part of the bark and the wood), breaking (branches or trunk), uprooting (total or partial).

For each seedling sample area, we noted the position of the center of the circular sample area evaluated (using FieldMap system or polar coordinates), the maximum seedling height (measured with measuring tape), the type of regeneration, the number of samples below 0.5 m in height, the number of samples between 0.5 and 1.3 m tall, the number of samples over 1.3 m tall, the percentage of usable seedlings, the species represented among the damaged seedlings identified, the percent-age of damaged seedlings by species, and the types of damage by species.

The evaluation of the injuries and damage done to seedlings through logging was performed by determining damage indexes. Damage indexes for seedlings involve correlating the number of damaged samples by damage type and version to the total number of samples from the sample area. We have evaluated seedling injuries and damage by creating seedling damage indexes that report the correlation between the number of damaged samples and the seed-ling coverage degree of the sample surfaces (expressed in percentages), using the following formula 1:

$$i = \frac{N_V}{A_S} \qquad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where: i - seedling damage index;

N_V - number of damaged seedlings from the sample surfaces;

A_S - seedling coverage in the sample surfaces, expressed in percentages.

The indexes presented and used to interpret the results were calculated as weighted averages based on the number of injuries of each type.

For seedlings, the damage dynamic was analyzed as a relationship between the number of samples that were healed, in the process of healing, dead, or without evident change (obtained during the reevaluation) and the initial number obtained from surfaces with seedlings.

RESULTS AND DISCUSSIONS

The damage indexes represent a quantification of the number of damaged specimens from the seedling in relation to the total seedlings cover, allowing the assessment of the seedling surfaces from the point of view of the damage caused to the seedling and the comparison from this point of view of the studied variants.

Important seedling injuries were caused progressively by wood mass exploitation works (Table 1).

Thus, the damage index increases as the work done over the stand's life increases.

The lowest values were found in thinning, where the purpose of the works was not to obtain usable seedlings.

The stand's damage index increases with the surfaces occupied by seedlings when different treatments are applied.

The highest values were thus obtained in final cuttings (Table 1).

Table 1. Seedling damage indexes on damage types in the studied versions

Version	Relief form	Damage index				
		General damage index	galling	barking	splintering	breaking
V1 - Thinning	plain	0	0	0	0	0
	hill	0	0	0	0	0
	mountain	0,145	0	0,055	0,036	0,055
Total V1		0,048	0	0,018	0,012	0,018
V2 - Progressive I or Transformation towards gardening	plain	0,29	0	0,14	0	0,14
	hill	1,33	0	0,67	0	0,67
	mountain	0,033	0,011	0,022	0	0,000
Total V2		0,551	0,004	0,277	0	0,270
V3 - Progressive 2 or 3	plain	1,29	0	0,57	0	0,71
	hill	1	0	0,43	0	0,57
	mountain	0,015	0	0,015	0	0
Total V3		0,768	0	0,338	0	0,427
V4 - Final cutting	plain	0,86	0	0,86	0	0
	hill	2,89	0,11	1,22	0	1,56
	mountain	0,311	0,089	0,178	0	0,044
Total V4		1,354	0,066	0,753	0	0,535
TOTAL		2,722	0,070	1,387	0,012	1,250

According to the calculated damage indexes, the highest damage degree is found in V4-Final cutting. The same indexes show us that seedling damage is higher in hills than in plains, especially when compared with mountains (Figure 1).

It was also observed that many samples have healed while the majority of those that are still damaged are healing.

These mending samples present bark growth at the level of the barked area and sprouts on broken samples.

All gallings and splintered samples have completely healed, as well as 73% of the barked ones and 42% of the broken ones.

The most accelerated seedling healing pattern was recorded for barkings with a slope value of -30 in the plot representing the healing dynamic (Figure 2). A sustained healing pattern was also observed for breakages, where the majority presented sprouts. Thus, the negative impact of forest exploitation work on seedlings weakens over time, and most samples recover in a short period.

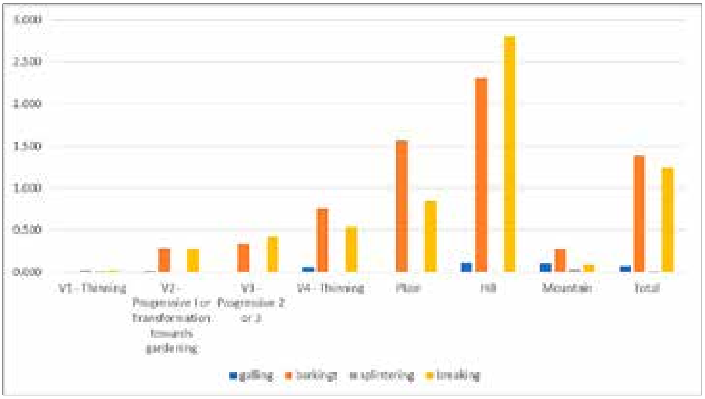

Figure 1. Seedling damage indexes from the analyzed versions

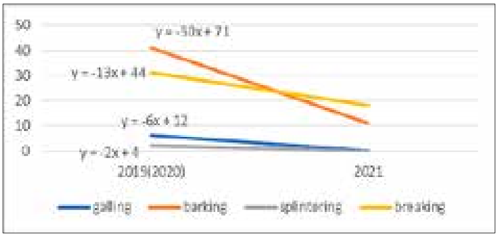

Figure 2. Dynamic of seedling damages on their type

In thinnings (Figure 3a), although the work is not intended to regenerate the stand, seedlings were identified and the composition was more varied than that of the existing stand. Species such as maple, elm, field maple, or ash are found in significant percentages among the seedling species, although these represented a very low percentage of the exploited stand in the DT category.

In opening eyes works from V2 (Progressive I or gardening transformations) (Figure 3b), only field maple and ash appear in significant percentages in the seedling species composition that were not part of the exploited stand.

Pine, sorb, and hawthorn were found in significant percentages among the species that diversify the seedling composition in stands where enlargement works for regeneration loci were performed (Progressive II or III from version V3) (Figure 3c).

For final cuttings (version V4) (Figure 3d), the seedling composition has diversified through the appearance of high percentages of elm, goat willow, field maple, and oak.

In the surfaces from the analyzed versions, the majority of injuries that were observed initially are now healed or healing. These results are supported by other studies concerning seedling recovery that have shown that seedlings damaged during logging for species such as Douglas fir could recover in 3 years (Tesch et al., 1990). However, studies have shown that seed-lings have grown 40% slower on tractor roads than in regeneration gaps (Howlett et al., 2003).

The lack of a negative influence of forest exploitation on biodiversity at the tree level is best demonstrated by seedlings. If we consider the increased number of species represented among seedlings, as shown above, we can predict a future increase of biodiversity at the tree level in the future stand. Some studies show that where forest species are represented by advanced and abundant regeneration, impact logging alone could be sufficient to sustain biodiversity areas. This applies as long as exploitation intensities are moderate and cutting cycles are long (Putz et al., 2008).

The same authors affirm that forest area biodiversity can decline if the techniques used are not silviculturally appropriate and where substantial crown openings are necessary, including soil perturbation. Sometimes, environmentalists and even ecologists wrongly equate only the forest structure before cutting with good management, failing to consider the newly obtained structure (Putz et al., 2008).

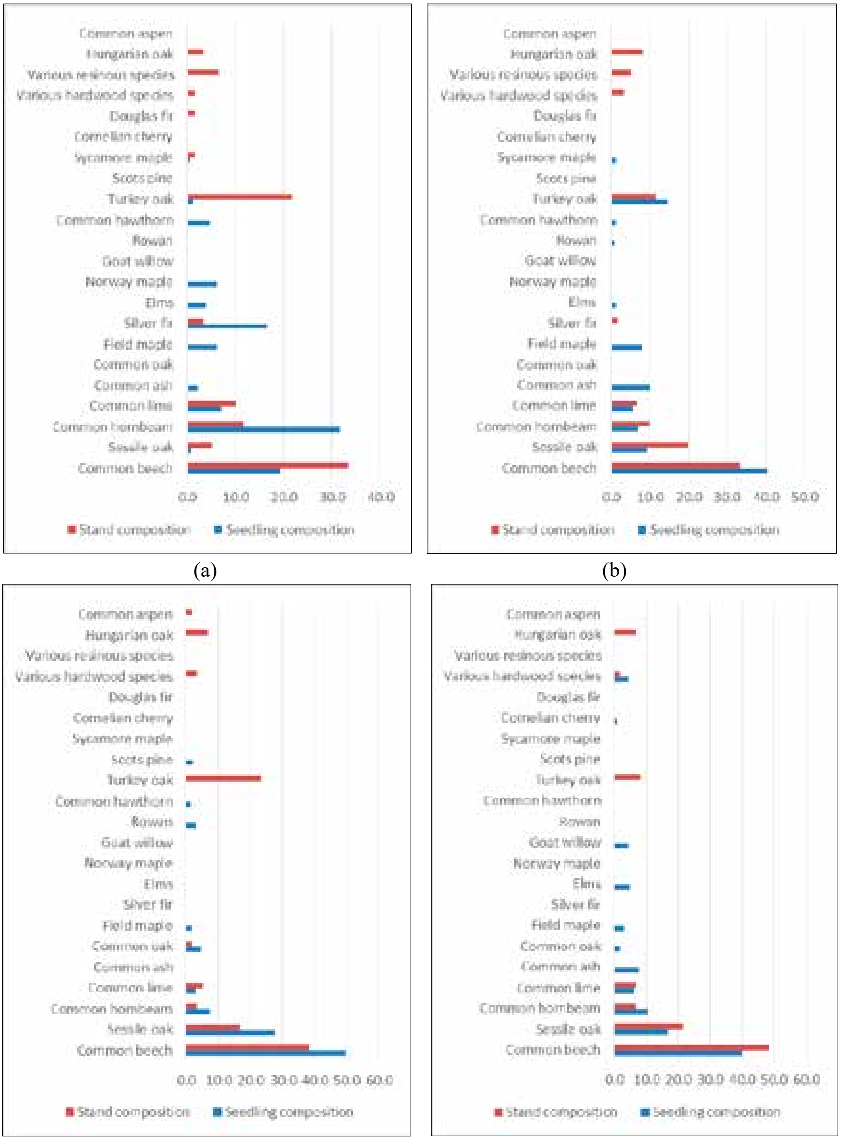

Figure 3. Species and seedling participation percentage in stand composition (a - V1 Thinning; b - V2 Progressive 1 and Gardening transformations c - V3 Progressive 2 or 3; d - V4 Final cutting)

The results of analyzing species diversity of seedling and composition compared with the composition of the exploited stand show that the species present in the exploited stand were also found in the new seedlings in most versions. Similar results show that selective forest exploitation represents a low threat for tree diversity as most of the species found in primary forests seem to be able to persist in exploited forests (Wilcove et al. 2013). However, other studies have shown that natural and anthropic disturbances, such as logging, decrease species richness and diversity. In this case, the exploited stands were not able to recover their diversity even after 150 years. This is correlated only with the presence of invasive species, which is not the case for our study (Brown and Gurevitch, 2004). An increase of species richness (pioneer trees, liana, and shrubs) 10 years post-logging is also mentioned by other authors among the biodiversity benefits of forest exploitation, together with increasing sub-stand density and in-creasing moss diversity. However, moss diversity decreases up to 40 years after logging (Putz et al., 2000).

CONCLUSIONS

In seedlings, all galling and splintered samples have healed completely, as well as 73% of the barked ones and 42% of the broken ones. This demonstrates the diminishing negative effect of logging on seedlings in a short period, as many samples are capable of a full recovery.
If we compare seedling and stand composition, we can observe a maintaining diversity of species after logging. If this diversification remains as the future stand grows, the new seedling composition can lead to a stable diversity of the species from the stand.
The results obtained by analyzing the impact of exploitation work on seedlings in this study, discussed and compared with results from other similar studies, show that forest exploitation can be considered a vector of maintaining biodiversity through forest regeneration. This situation applies as long as works are executed by respecting certain measures for protecting the forest ecosystem as well as by the applied silvicultural works.

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