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Damage reduction of trunks of trees left for growing during selective felling

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Abstract. Forest management improvement is an important task, especially in the context of the development of forest areas with a depleted resource base. When carrying out non-clear cuttings, the main operation that has the greatest negative impact on the trees left for growing is skidding, during which trees located along the portage and, especially, at the turn, can receive damage, consisting in damage to the root system and trunk bark. It is possible to prevent damage to the trunks of trees left for growing by using fencing devices, which can be made from logging residues located in the cutting area, or from slabs obtained by sawing logs. The use of a protective device does not require large expenses due to the use of substandard wood; after skidding the devices can be easily removed and put on other trees.

1. Introduction

The advantage of selective successive felling is to ensure the continuity and sustainability of forest management, reducing the amount of artificial reforestation. However, their implementation is difficult due to the lack of special equipment and appropriate technologies that provide environmental and forestry requirements to logging machines and environmentally friendly technologies for logging operations.

Logging with the use of machinery can be carried out by different technological schemes [1,2], various types and collections of machines [3,4,5], and one of the main tasks that arise when performing hauling operations is the task of minimizing the harmful effects of logging equipment on natural environment (trees left for growing), especially during improvement felling [6]. Therefore, the main goal in terms of the environmental friendliness of the use of machinery and technology should be to ensure the maximum increase in labor productivity, providing the rational use of the entire tree biomass and the minimum machines impact on forest ecosystems.

The main trees damage that can affect their further viability and productivity can be divided into three groups (figure 1).

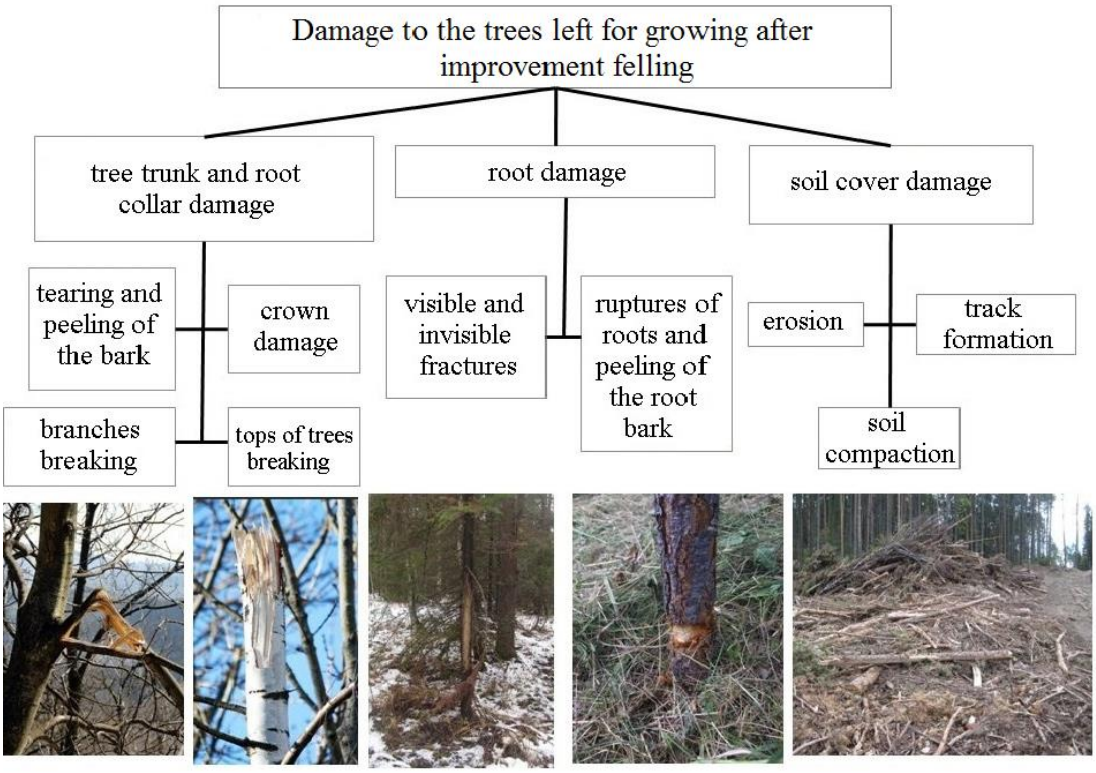

Figure 1. The main types of damage that negatively affect the further productivity of forest stands.

The purpose of the work is to identify factors that can reduce the harmful effects of skidding equipment on trees left for growing, during selective logging and to develop technological measures that ensure the solution of these problems.

2. Methodology

To reduce the harmful effects of logging equipment on forest stands, various methods are used. The greatest attention is paid to damage by logging equipment to the soil cover. In order to reduce this damage various technical and technological methods are used.

It should be noted that technical methods are aimed at reducing the degree of soil compaction and its mineralization (it covers 65-70% of the cleared area). To obtain a rational specific pressure on the soil (≈50 kPa), a number of technical solutions were developed. Some of them are used on wheeled vehicles and are aimed at changing the vehicles design, for example, using wide-profile ultra-low pressure tires (15-20 kPa) or installing wheels of the same size in pairs according to the “tandem” scheme with a drive for each of them, increasing cross-country ability in case of overcoming difficult areas, for example, the use of quick-release devices that allow their use if necessary (this group includes anti-skid chains of various designs, various options for elastic caterpillar belts) (figure 2). The use of the drive of each wheel (all-wheel drive) can increase the traction force up to 40%.

For tracked logging machines, to reduce pressure on the soil, track expanders are used, the number of track rollers is increased, their arrangement is changed, and not metal, but rubberized tracks are used [7].

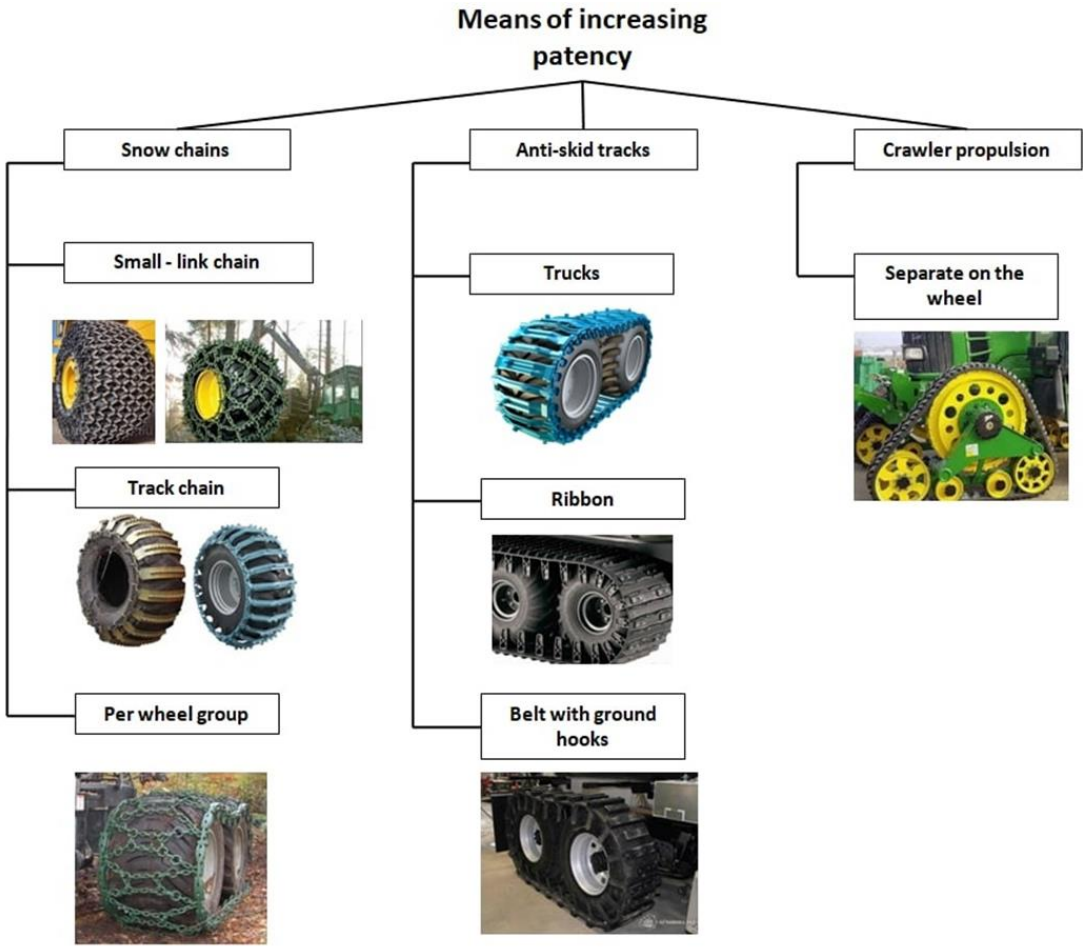

Figure 2. Means of cross-country ability increase of logging equipment.

When carrying out selective or sanitary cuttings, tree limbs are cut directly at the felling site, the tree-length logs are cut into assortments [8,9].

Skidding is carried out by various equipment, and according to the method of tree-length logs capturing and holding during movement, it can be divided into groups:

- skidding in a semi-suspended position on the suspension with the center of its rotation along the portage;
- skidding by dragging by means of a grip hinged on the skidding mechanism;
- skidding in a semi-suspended position using a flexible rope, with the point of its attachment (on the drum or block) not located on the longitudinal axis of the tree-length log being skidded;
- skidding by dragging with a rope with its attachment point (on a drum or block) located not on the longitudinal axis of the tree-length log [10].

The most gentle skidding method, but at the same time highly energy-consuming, is considered to be skidding in a completely suspended state [10].

It is possible to increase the safety of the soil cover, as well as the root system, from damage (especially in the warm season) through technical (figure 2) or technological solutions - strengthening the portage with logging residues.

Also, to reduce the harmful impact of skidding means on forest ecosystems, a non-rectilinear location of the skidding portage is possible, and, consequently, the movement of machines performing skidding

will be carried out along a curved route, allowing for the preservation of undergrowth [9, 11, 12]. However, the use of curved skidding routes, and, consequently, skidding, increases the likelihood of damage to tree trunks. This problem is relevant and noted by both Russian [8, 13] and foreign researchers, for example in Iran [14], USA [15,16,17], Indonesia [18] and some others [19, 20] (figure 3).

The current Timber Harvesting Rules determine that at the selective felling areas the number of damaged trees should not exceed 5% of the number left after felling, while damaged trees include the following trees:

- with a broken top;
- with a trunk inclination of more than 10°;
- with the crown damage more than 30% of its surface;
- with the trunk bark peeling more than 10% of the trunk circumference;
- with peeling and breakage of skeletal roots.

The main trees damage is the trunk bark peeling, which can be from 9% (in winter) to 14% (in summer) with tree-length log technology, and from 6% to 10% with assortment technology. The issue relevance of trees damage reduction during logging is also confirmed by foreign researchers. For example, the percentage of damaged trees during logging operations with ground skidding in the forests of northeastern California reached 23% [21], in the forests of Turkey 14% of the trees left were damaged during felling and skidding operations [23]. Other researchers also confirm the high percentage of tree damage (from 13 to 22%) [23-26].

Figure 3. Tree trunks damage during skidding.

3. Results

Reducing the tree trunks damage is one of the important tasks, as noted in a number of works by the authors [27, 28, 29, 30].

Reducing the trunks damage can be achieved by increasing the portage width, but it leads to the felling area increase and to decrease of the productive number of trees left for growing. On the other hand, modern technologies require a rectilinear portages arrangement [31, 32, 33].

To protect trees from damage, a universal, removable, dismountable and assembled protective device was developed [34], consisting of fencing elements; sections of the trunk part of thin, substandard wood or slabs (1.5 - 2 m long) can be used as such elements, they are fixed with flexible annealed wire (figure 4). Protective devices developed on the basis of this patent are shown in figure 5.

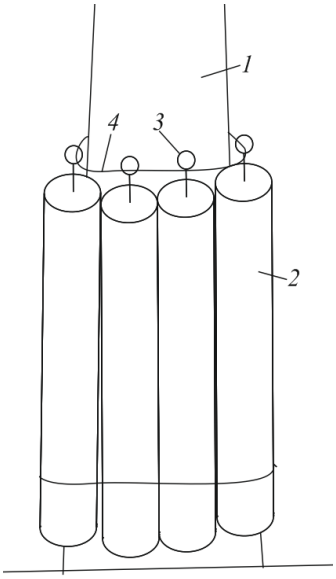

Figure 4. Tree trunk protection device installation scheme: 1 - tree trunk; 2 - elements of the fence; 3 - fastening (screws with a ring); 4 – wire.

a) b)

Figure 5. Options of a protection device mounted on a tree trunk: a - from logging residues; b - from slabs.

The damage protection technology of a tree trunk is as follows: trees whose trunks can be damaged during skidding are identified, then fencing elements are mounted around the trunks of these trees (they are previously prepared, cut either from logging residues or from slabs to the required length with screws with rings put in the upper end). An annealed wire or a cable with a diameter of 3-4 mm, longer than the diameter of a tree trunk, is put through the screw rings; a screw clamp is attached to one of their ends, the required length of the wire is adjusted using the second free end. This protective device allows

the use of a wire (or cable) with a lock for tree trunks of different diameters, achieving quick mounting around the tree trunk. After mounting the upper part of the protective device on the tree trunk and fixing it with a clamp, the same type of annealed wire (or cable) is tied and fixed with a clamp to its lower part, which makes it possible to increase the attachment reliability of the protective device and the structure rigidity. Such a solution allows, subsequently, to maintain the rigidity of the structure and to protect the tree trunk bark from damage when the tree trunk protected by the protective device is touched by the tree-length logs being skidded and by the equipment. When skidding is completed and the tree trunk needs no protection, the protective device is removed and can be put in another place.

4. Conclusion

Damage to the soil cover, as well as to the trees left for growing is done by trees skidding machines during logging operations.

To reduce the soil cover damage, various devices are used that reduce the specific pressure of machines on the soil - anti-skid chains and caterpillars.

There are still no technical and technological solutions to reduce damage to the trunks of trees left for growing, so it is advisable to use the protective device discussed in the article.

As an option, unused logging residues or slabs resulting from sawing logs can be used to make a protective device.

The proposed device, in addition to the damage preserving possibility of trees left for growing, allows for a curvilinear arrangement of skidding portages; which makes it possible to reduce the amount of cut areas, improve environmental friendliness and economic efficiency of forest management.

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References

[1] Zyryanov M, Medvedev S and Mokhirev A 2020 *J. of Appl. Eng. Sci.* **18** 15
[2] Mokhirev A, Rukomojnikov K, Gerasimova M and Medvedev S 2020 *J. of Appl. Eng. Sci.* **18** 500
[3] Rukomoinikov K, Mokhirev A, Burgonutdinov A, Kunitskaya O, Voronov R and Grigorev I 2021 *J. of Appl. Eng. Sci.* **19** 407
[4] Hertz E, Mekhrentsev A, Pobedinsky V, Terinov N and Urazova A 2021 *Forest J.* **1** 138-49
[5] Yakimovich S and Teterina M 2019 *IOP C. Ser. Earth Environ. Sci.* **272** 032026
[6] Bartenev I and Rodin S 2001 *Greening technologies and machines of the forestry complex* (Pushkino: VNIILM)
[7] Bartenev I and Drapalyuk M 2012 *Forestry J.* **1** 61-6
[8] Gerasimov Yu and Syunev V 1998 *Environmental optimization of technological processes and machines for logging (*Joensuu: Joensuu University Press)
[9] Hertz E 2004 *Forestry industry* **2** 13-4
[10] Hertz E and Zalesov S 2003 *Forestry* **5** 18-20
[11] Azarenok V, Hertz E, Zalesov S and Mekhrentsev A 2015 *Tree-length timber harvesting* (Ekaterinburg: Ural State Forestry University)
[12] Hertz E, Azarenok V and Livshits N 2002 *Forestry J.* **3** 44-8
[13] Vasyakin E and Dobrynin Y 2017 *News of the St. Petersburg Forestry Academy* **219** 120-32
[14] Tavankar F, Majnounian B and Bonyad A 2013 *J. of forest Sci.* **59** 196-203
[15] Bettinger P and Kellogg L 1993 *Forest Prod. J.* **43** 59-64
[16] Camp A 2002 *Western J. of Appl. Forestry* **17** 14-22
[17] Ficklin R, Dwyer J, Cutter B and Draper T 1997 Residual tree damage during selection cuts using two skidding system in the Missouri Ozarks *Proceedings of 11 th Central Hardwood Forest Conference. Columbia* ed Pallardy S G , Cecich R A, Garret H H, Johnson P S, 23.-26. March.

St. Paul, USDA Forest Service 36-46
[18] Iskandar H, Snook L K, Toma T, MacDicken K and Kanninen M 2006 *Forest Ecology and Management* **237** 83-93
[19] Majnounian B, Jourgholami M, Zobeiri M and Feghhi J 2009 *J. of Environmental Sci.* **7** 33-44
[20] Meadows J 1993 Logging damage to residual trees fol-lowing partial cutting in a green ash-sugarberry stand in the Mississippi Delta *Proceedings of the 9th Central Hard-wood Forest Conference* ed Gillespie A R, Parker G R, Pope P E, Rink G West Lafayette, 8-10. March 1993. St. Paul, USDA Forest Service: 248-60
[21] Hartsough B 2003 *Western j. of Appl. Forestry* **18** 133-42
[22] Yilmaz M and Akay A 2008 *Int. J. of Natural and Eng. Sci.* **2** 77-82
[23] Lotfalian M, Parsakho A and Majnounian B 2008 *J. of Env. Sci. and Technology* **10** 51-62
[24] Naghdi R, Bagheri I, Taheri K and Akef M 2009 *J. of Env. Sci.* **60** 931-47
[25] Tavankar F, Bonyad A, Majnounian B and Iranparast Bodaghi A 2010 *J. of Wood and Forest Sci. and Techn.* **17** 57-72
[26] Tavankar F, Bonyad A E and Majnounian B 2015 *Ecological Engineering* **83** 505-12
[27] Vadbolskaya Y Azarenok V 2014 *Forests of Russia and farming in them* **2** 32-4
[28] Bestuzhev A, Valyazhonkov V, Dobrynin Y, Ivanov V, Ivashchenko V and Kovalenko A 2012 *Systems. Methods. Technologies* **1** 167-72
[29] Bezgina Y, Gerc E, Ivanov V, Perepechina T, Terinov N and Urazova A 2015 *Forests of Russia and farming in them* **4** 12-22
[30] Zaikin A, Sivakov V and Sheveleva E 2019 *Forestry J.* **4** 200-11
[31] Pankratovich A, Protas P, Misuno Y, Chernetskaya N, Yumagulova V and Safin A 2023 *E3S Web of Conferences* **390** 03026
[32] Duhovnik A, Balabanova Y, Lushpaeva M, Gaiduk A and Nurullin A 2023 *E3S Web of Conf.* **390** 07043
[33] Dolmatov S, Makunina Y, Voinash S, Tikhonov E, Aksenov A, Alekseeva S and Parfenopulo G 2023 *E3S Web of Conf.* **390** 07045
[34] Zaikin A, Sivakov V and Polegotchenkov V Tree trunk protector Patent 181336 Russian Federation, IPC A01G 13/00; A01G 23/00, applicant and patent holder Bryansk State Engineering and Technology University. – No. 2018101818; application 17.01.2018; publ. 11.07.2018