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COMPUTER-AIDED ASSESSMENT OF SOIL DAMAGE CAUSED BY WOOD EXTRACTION

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Abstract. The aim of the study was enhancing the efficiency and accuracy of the method developed by Dyrness [1965] for the visual assessment of soil damage caused by wood extraction. The results achieved with the computer-aided and traditional version of the method were compared and used as a basis of the optimal wood extraction method. The computer processing of digital photographs involved the use of CorelDRAW 11, Auto-CAD R14 and Solid Edge V17 computer programmes. The proposed procedure providing support to the visual assessment of soil damage produces more reliable results. According to the performed assessment, the double horse skidding, resulting in the smallest disturbance area and causing the smallest soil compaction, proved to be most environment-friendly wood extraction method.

Key words: wood extraction, soil damage, methods, mountain forest

INTRODUCTION

Current production of wood in Poland reaches about 34 million cubic meters [Mały rocznik... 2009]. Wood extraction causes arising damages to the soil. For years, research has been carried out on technologies of production, application of which, would cause possibly low level of damage in the forest environment.

One of the elements that is being damaged in the forest environment is soil. Uncovering, moving and kneading the soil during the transportation of wood is yet intensified by the erosion. Therefore in mountain forests, which are particularly vulnerable to this phenomenon, the aim should be to reduce damages of soil through introducing accurate skidding technologies.

The aim of the study is to propose the way enhancing the accuracy of the method developed by Dryness [1965] for the visual assessment of soil damage at the nodal points, which with some modifications was commonly used in our country [Dudek 2009, Giefing 1990, Gil et al. 1987, Kulak 2005, Sosnowski 1999]. Also to compare the research results obtained using both methods, and which were carried out on equal-sized

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research areas, and on the basis of those results to indicate the technology that is the least detrimental to the soil.

MATERIAL AND METHODS

The research was based in mountain forests of south-eastern Poland. The examined areas were established in the mountain forest habitat (LG) in precutting stands (TPP) and final cut stands (sylvicultural-cutting method IV d), in the Dukla Forestry, Rymanów Forestry and Wetlina Forestry. The research was carried out using commonly used skidding equipment, i.e. a specialized forest articulated tractor of skidder type (LKT 80), an agricultural tractor (MTZ 82), a mobile cable crane (Latrix 3T) and a horse team (2-horse). In the precutting stands, there was no second method used for assessment of soil damage caused by a mobile cable crane, because it was developed by the author in the later period of the research.

Condition of the soil damage was defined at nodal points which resulted from imposition of the grid of 10 m-side squares on each examined area (dimensions 100×40 m). Measurement of the soil damage, caused by wood extraction, was performed in two ways:

– visual assessment of the soil damages at the nodal points
– based on digital photographs of the plots (of 1 square meter area, placed on the nodal point) showing the soil damages, and the computer processing (proposed by the author of this study improvement of the method).

For the assessment of damages there was used the scale of the following damage degrees developed by Dryness [1965] and modified by Sosnowski [1999]:

1) undamaged soil; mulch undisturbed, no signs of pressure
2) slightly damaged soil; mixed with mulch or covers the mulch with the layer up to 5 cm thick
3) deeply damaged soil; soil surface removed, deeper layers exposed, surface of the soil rarely covered with mulch
4) tamped soil; evident signs of tamping by a skidding vehicle or a load.

Additionally, in the mentioned nodal points there were measurement plots established using (made from wood earlier) a square frame of 1 m-side. They were designated so that the nodal point was placed at the crosscut point of the diagonals of the frame imposed. This resulted in 55 plots on each examined area. The plots were assessed in terms of the soil condition using the method proposed by the author of this study. In that phase of research the plots, on which soil damages were found, were photographed with digital camera Canon PowerShot A510. At the further stage of the research the photographs were computer – processed. The other plots remained undamaged.

Using the first method, i.e. the visual assessment of soil damage at nodal points, the points with the same degree of soil damage were summed up (amount of spot damages in degrees). Afterwards, there was calculated the percentage of the soil damage degrees.

The method suggested by the author, i.e. digital photographs of the plots and computer processing, enables to assess the degree of the soil damage basing, not on the measurements taken from the points, but basing on the plots placed on them (area of 1 square meter). As a result of processing the photographs there were obtained the areas affected by the particular degrees of soil damage. Next, the areas of damage were summed up – for each degree separately – from all of the plots. Basing on that there was calculated the percentage of each degree of soil damage in the area, where the wood extraction was being performed, with use of the technologies mentioned above.

Computer processing of the digital photographs was carried out using three kinds of engineering software, i.e. CorelDRAW 11, AutoCAD R14 and Solid Edge V17. There is also a possibility to use the mentioned software in different available versions, however the versions have to be compatible.

First of the abovementioned software allows to set an area designated by a square frame of a 1 m side, and the area of damage within the borders of the square frame, the plot with 1 square meter area. For this purpose, there needs to be imported the photo (Fig. 1), a JPG file, into the software (most digital cameras nowadays performs photos in this format), and then select the rectangle tool from the tools and set the frame area. Then, using another available tool, the area of the cataloged damage needs to be outlined (Fig. 2). After completing the operations the changes need to be saved converting the file type to DWG AutoCAD. In the dialog box that appears there needs to found and selected the version of the used software – in this case Auto CAD R14 is selected from the list. Bitmaps are exported as JPEG files.

Fig. 1. Picture of soil damage caused by skidding tractor LKT 80
Rys. 1. Zdjęcie szkody powstałej w glebie w czasie zrywki drewna ciągnikiem LKT 80

In Auto CAD the side of the square needs to be dimensioned (i.e. the frame used in research), identifying its actual size. To be able to do this the previously saved file needs to be opened by choosing the system of measurement – metric. From the top toolbar, the “Zoom Realtime” tool needs to be selected, and after clicking a right mouse button the “Zoom Extens” is to be selected to display the open drawing, in its entirety, on the screen. Then, using the “Snap to Endpoint” tool, available on the top toolbar, the side of the square is dimensioned. The result, which is displayed on the monitor, is expressed in millimeters. In the further phase, the required value (in this case 1000 mm) needs to be divided by the achieved result. From the side toolbar select “Scale” and set

Fig. 2. Picture elaborated in CorelDRAW 11
Rys. 2. Zdjęcie po obróbce w programie CorelDRAW 11

the entire image, then press the enter key, and click inside the drawing and enter the result of the quotient, and then press the enter key again. Then the image needs to be displayed on the screen (Fig. 3), in a described above way, and dimensioned again in order to eliminate the error bigger than accepted by the researcher. For the research, there was accepted a limit of 5% deviation from the linear value equal to 1000 mm. After completing the tasks the changes need to be saved.

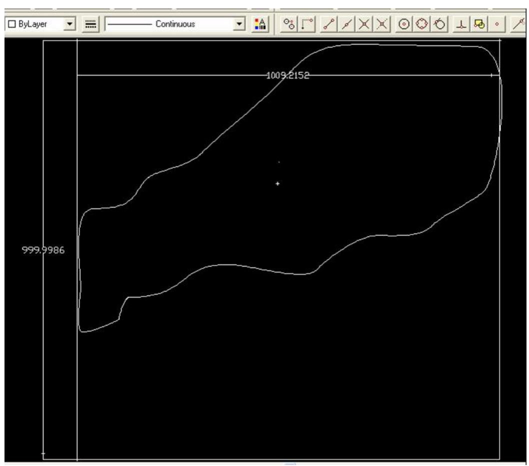

Fig. 3. Picture elaborated in AutoCAD R14
Rys. 3. Zdjęcie po obróbce w programie AutoCAD R14

Then the saved file needs to be opened in Solid Edge V17. In the dialog box that appears, on the General tab, the option "Normal.dft" is selected. The value of the scale needs to be changed relevantly to display the area result in mm^2 and next the "Measure Area" tool needs to be selected, and then click on the field value of which you want to know. The value is automatically displayed on the screen (Fig. 4). In order to eliminate

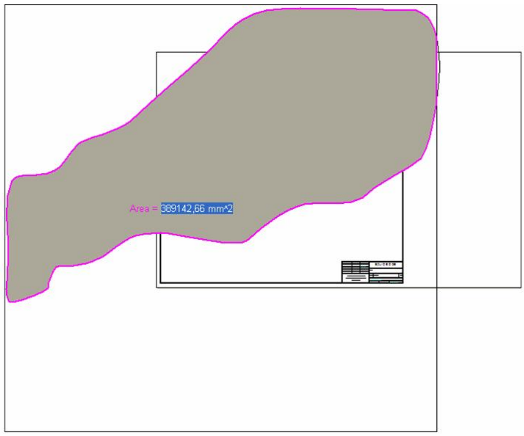

Fig. 4. Final image visualized by Solid Edge V17 with the disturbed part of the plot highlighted
Rys. 4. Końcowy obraz zdjęcia wyświetlony w programie Solid Edge V17 – po obróbce w trzech programach – z wyświetloną powierzchnią szkody glebowej

the error of determining the area of damage, greater than 5%, a check needs to be performed at this point (by clicking the field designated by the sides of the square, and then in the field of the damage; the sum of the fields should – with precision of 5% – equal to 1,000,000 mm^2).

Full computer processing of a single photography, the result of which is obtaining the area affected by soil damage that is formed by wood extraction, takes about 5 minutes.

The described method for determining an area of regular and non-regular shaped figures, whose image was recorded using a digital camera in JPEG format, may be used on a larger scale in research carried out in other scientific disciplines.

RESULTS AND DISCUSSION

Damage of the stand was being defined after completion of wood harvesting works. Hence, on areas, where the wood extraction was performed using the long wood system and the short wood system, the examined level of damage in the stand refers to two skidding technologies (skidding technology of long wood and short wood S2). The examined technologies were grouped by the name of the skidding equipment as follows:

- Horse: 2-horse team (skidding of long wood) + 2-horse team with a cart (Forwarding of wood S2)
- MTZ: agricultural tractor 82 with windlass (skidding of long wood) + MTZ agricultural tractor 82 with a cart or dray without drive (Forwarding of wood S2)
- LKT: specialized forest articulated tractor LKT 80 with windlass (skidding of long wood) + LKT 80, with driven dray or MTZ 82, driven dray (Forwarding of wood S2)
- Latrix: a mobile cable crane Latrix 3T skidding of long wood.

Soil damage caused by wood extraction, performed using various technologies – defined in two methods described in the methodology, is specified, in terms of use of the stand, in Tables 1 and 2.

Table 1. Soil damage in precutting stands
Tabela 1. Uszkodzenia gleby w drzewostanach trzebieżowych (TPP)

Degree of soil damage Stopień uszkodzenia gleby	Timber skidding, % – Technologia zrywki, %							
	LKT		MTZ		Larix		koń – horse	
	method 1 metoda 1	method 2 metoda 2	method 1 metoda 1	method 2 metoda 2	method 1 metoda 1	method 2 metoda 2	method 1 metoda 1	method 2 metoda 2
1. Undamaged soil 1. Niezakłócona	78.18	84.64	72.73	79.27	78.18	–	78.18	87.35
2. Slightly damaged soil 2. Lekko zniszczona	3.64	2.39	7.27	4.10	9.09	–	5.45	2.51
3. Deeply damaged soil 3. Głęboko zniszczona	5.45	3.32	3.64	2.34	1.82	–	9.09	3.47
4. Tamped soil 4. Ubita	12.73	9.65	16.36	14.29	10.91	–	7.27	6.67

Table 2. Soil damage in final cut stands
Tabela 2. Uszkodzenia gleby w drzewostanach rębnych (rębnia IV d)

Degree of soil damage Stopień uszkodzenia gleby	Timber skidding, % – Technologia zrywki, %							
	LKT		MTZ		Larix		koń – horse	
	method 1 metoda 1	method 2 metoda 2	method 1 metoda 1	method 2 metoda 2	method 1 metoda 1	method 2 metoda 2	method 1 metoda 1	method 2 metoda 2
1. Undamaged soil 1. Niezakłócona	70.91	77.59	81.82	87.21	78.18	86.69	85.45	90.36
2. Slightly damaged soil 2. Lekko zniszczona	16.36	9.15	9.09	4.91	14.55	7.91	5.45	2.21
3. Deeply damaged soil 3. Głęboko zniszczona	1.82	1.33	0	0	0	0	5.45	2.30
4. Tamped soil 4. Ubita	10.91	11.93	9.09	7.88	7.27	5.40	3.64	5.13

The comparison of the research results, carried out the way of the visual assessment at nodal points (method 1), with those carried out the way of digital photography of plots and computer processing (method 2) proved (Table 1 and 2) that the total area of soil, damaged from wood extraction using the examined technologies in both categories of use, measured by the second method is smaller. Whereas the proportions of apportionment of damage in classes remain the same, except for horse skidding. Using the method of visual assessment at nodal points the horse skidding with 2 – horse team was found to have caused the largest percentage of 3-class damage – the soil deeply damaged. While, the use of the second of the methods indicates tamped soil (4-degree) as the most frequent type of damage as a result of horse skidding. This is due to the large unit pressure of the horse, and the fact that the horse team moves across the entire area of skidding. It should however be noted here that among the examined technologies, it is horse skidding that has the least impact on soil compaction.

Assuming that the method based on use of grater research material, and that the use of the apparatus gives more objective results – for further analysis, there were used the results obtained the way of digital photography of plots and computer processing.

The analysis of Table 1 shows that in the precutting stands (the TPP) the total area of damaged soil (degrees 2-4) was grater by 5% when using the agricultural tractor than the specialized tractor of skidder type.

The smallest area of soil damaged from skidding was observed when using the 2--horse team. Moreover, the horse skidding led to the smallest soil compaction, despite the fact that it was performed by dragging.

The mentioned results support the argument that greater soil damage of a surface size is caused by skidding equipment of less maneuverability (agricultural tractor). In addition, more serious damage to soil quality – including tamping – is caused by higher unit pressure (also agricultural tractor).

By wood extraction in final cut stands (Table 2) approximately 13% of the soil area was damaged using a mobile cable crane, or an agricultural tractor, and 22% using the skidder.

The smallest area of damage to the soil (10%) was recorded using 2-horse team. Moreover, applying 2-horse team or a cable crane for skidding resulted in the smallest size of tamped soil area (5%). This kind of damage is the most dangerous for the destruction of forest (4 degree of damage). Thus, the horse team or a cable crane caused 1.5 times less of soil compaction than using agricultural tractor and 2.2 times less than using the skidding tractor LKT 80th.

The occurrence of tamped soil is particularly disadvantageous on the slopes, as it increases the flow of water from rainfall and thaw. The effect of this phenomenon is not only the loss of water, but also the degradation and soil erosion, and increased risk of flooding, especially after the intense and short rainfall. How serious is soil compaction together with its consequence, i.e. increased density consistence, which is the cause of its further damage (especially on the slope) as proved by other researchers.

Maciaszek and Zwydak [1992] in their experiments carried out in Beskid Śląski and Beskid found that exceeding of the critical value of soil density consistence (> 1.35 t/m) causes that the runoff equals on average 70-80% of rain water. Moreover, the mentioned density consistence of the soil, recorded on the skidding trail of the first rank, exceeded the critical value limiting the development of plants.

Similar results were obtained by Peřina and Sach [1986], through examining the final cut stands in the Czech Karkonosze Mountains and the Beskidy Mountains in terms of the impact of wood extraction on water erosion – using a mobile cable crane, a horse team and an agricultural tractor.

On the area of comparison with an intact grass cover on slopes, with a slope of 15-20 degrees there was found 1-6% flow of rainwater, which did not cause erosion. On tracks where the extraction was performed using tractors the flow of rain water down the tamped soil reached 95%.

Kulak and Barszcz [2008] proved that the least detrimental to soil skidding technique – which was expressed in percentage of damaged soil area – is horse skidding

(11.88%), more (15.03%) is applying three skidding techniques on the same area of extraction (a horse, a tractor of skidder type and agricultural tractor) and the most (18%) the tractor LKT 80th. The authors carried out the research in beech-fir final cut stands growing in the Lwyż św. habitat.

The research carried out in this study confirms the arguments of the mentioned authors that wood extraction performed with a mobile cable crane or horse team causes less damage than using tractors.

CONCLUSIONS

1. The method of assessing the soil damage caused by wood extraction has been improved by the author of the study by using, for this purpose, digital photography and computer processing. Application of this modification, supporting the visual assessment of the quality of damaged soil by computer technology, provides more reliable test results. It is hoped that the improvement will be used in other studies in the future.
2. The study proved that double horse skidding, comparing with tractors, causes much less damage, as evidenced by the smallest area of damaged soil and the least soil compaction.
3. Due to the fact that the horse skidding is systematically decreasing in Poland, it should endeavoured to replace it – particularly in the mountain forests, where protected forests dominate – with equipment like a mobile cable crane (eg. Latrix type). It is compared with tractor skidding, the least detrimental wood extraction method.

REFERENCES

Dudek T., 2009. Ocena wybranych technologii zrywki drewna w lasach górskich [Assessment of wood extraction technologies in mountainous forests]. KULiD UR Kraków [typesctript; in Polish].

Dyrness C.T., 1965. Soil surface condition following tractor and high-lead logging in the Oregon Cascades. J. Forestry 4, 67-74.

Giefing D.F., 1990. Wpływ pozyskiwania i transportu drewna w cięciach przedrębnych na szkody i jakość techniczną pozostających drzewostanów sosnowych [Influence of wood extraction and transportation in precutting stands on damages and technical quality of the remaining pine stands]. In: Mat. Konf. Reakcja ekosystemów leśnych i ich elementów składowych na antropopresję. Wyd. SGGW-AR Warszawa, 52-59 [in Polish].

Gil. W., Sosnowski J., Stanibuła S., 1987. Szkody wyrządzane przy zrywce drewna przez ciągniki Tree Farmer C-5D oraz Ursus C-328 [Damage caused by wood extraction performed with theTree Farmer C-5D and Ursus C-328 skidding tractors]. Zesz. Nauk. AR Krak. 215, 107--119 [in Polish].

Kulak D., 2005. Wpływ technologii pozyskiwania drewna na rozmiar uszkodzeń roślinności dolnych warstw lasu i górnych poziomów gleby [Influence of wood extraction technologies on the scale of damages to the lower layers of forest and the upper levels of soil]. KULiD UR Kraków [typescript; in Polish].

Kulak D., Barszcz A., 2008. Wpływ wybranych środków zrywkowych na uszkodzenia gleby w rębnych drzewostanach bukowo-jodłowych [The impact of selected skidding techniques on soil damage in beech-fir bimber stands]. Sylwan 12, 20-28 [in Polish].

Maciaszek W., Zwydak M., 1992. Wpływ zrywki drewna na degradację górskich gleb leśnych [Influence of wood extraction on degradation of mountain forest soils]. Zesz. Nauk. AR Krak. 269, 29-44 [in Polish].
Mały rocznik statystyczny Polski [Concise statistical yearbook of Poland] 2009. GUS Warszawa [in Polish].
Peřina V., Sach F., 1986. Možnosti sniženi eroze půdy na obnovnich sečich. Lesn. Pr. 2, 61-65.
Sosnowski J., 1999. Przydatność kolejki linowej Larix 550 do zrywki drewna z trzebieży w górach [Usefulness of the Larix 550 mobile cable crane for wood extraction in precutting stands of mountain forests]. Sylwan 12, 21-34 [in Polish].

WSPOMAGANIE TECHNIKĄ KOMPUTEROWĄ WZROKOWEJ OCENY USZKODZEŃ GLEBY PRZY ZRYWCE DREWNA

Streszczenie. Celem pracy jest zaproponowanie użycia techniki komputerowej do zwiększenia dokładności – opracowanej przez Dyrnessa [1965] i stosowanej w naszym kraju – metody wzrokowej oceny uszkodzeń gleby na skutek zrywki drewna, a następnie porównanie otrzymanych (z użyciem obu metod) wyników badań i na tej podstawie wskazanie technologii najmniej uszkadzających glebę. Komputerową obróbką fotografii cyfrowych wykonano z użyciem trzech programów inżynierskich, tj. CorelDRAW 11, AutoCAD R14 oraz Solid Edge V17. Zastosowanie wspomnianej modyfikacji, umożliwiającej wspomaganie oceny wzrokowej jakości uszkodzeń gleby przez technikę elektroniczną, zapewnia uzyskanie obiektywniejszych wyników badań. Na postawie przeprowadzonych badań wykazano, że zrywka zaprzęgiem dwukonnym jest najbardziej proekologiczna spośród badanych technologii, czego dowodem jest najmniejsza powierzchnia z glebą uszkodzoną oraz najmniejsze ubicie gleby.

Słowa kluczowe: zrywka drewna, uszkodzenia gleby, metodyka, lasy górskie

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