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# THE ANALYSIS OF THE VOLUME OF LOGGING RESIDUE IN FINAL FELLINGS IN PINE STANDS

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**Abstract.** The aim of the work was to determine which part of biomass remains in the forest in the form of so-called logging residue. In order to achieve the result, the analysis of wood volume harvested in the final felling was carried out, and the total volume was broken down into different parts of trees. Furthermore, to estimate the wood volume of the forest stand, on each of the experimental plots 10 model trees were chosen based on Draudt method. Assuming that the thickness of wood acquired from forest is bigger than 4 cm, it is possible to assume that the part of biomass which remains in the forest in the form of the branches and conifer needles ranges from 10% to 12% of general amount of biomass.

**Key words:** biomass, felling site remains, the log volume of forest stand

## INTRODUCTION

Preparing the soil for regeneration after the harvesting of wood assortments in the final felling of pine tree stands, requires previous utilization of the logging residue. This biomass in the form of branches, needles as well as tops of the trees must be removed from the felling site, because it makes difficult and sometimes impossible to carry out the regeneration operations. There are many methods to remove the arbomass remaining on the felling site.

In the light of the carried out examinations and analyses, as well as considering the present trends in search for the renewable sources of energy, the significance of logging residue has grown meaningfully. From the natural point of view, leaving arbomass behind on clear cut areas is desirable because this material is a valuable source of nutrients for the new generation of forest [Lim and Cousebs 1986, Rehfuess 1981, Gornowicz et al. 2000].

From the other point of view, growing awareness of the necessity of more rational shaping of the relation economy – environment influences the seeking and implementing the alternative sources of energy as an alternative for these which are leading nowa-

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days. [Anon 1998, Kubiak et al. 1989, Asikainen 1998]. According to all estimates the world demand for the energy will have tripled by 2060 [Marutzky and Seeger 1999, Helberg 2000]. Therefore biomass as the source of the energy replacing fossil fuels is gaining significance [Košelev and Švedov 1998, Lönner et al. 1998, Goglia et al. 2000].

Taking the above mentioned arguments into account, the thickness of pine tree stands has been established, with the distinction which part of it consists of felling states remains.

## THE METHODS

### Research area

Research areas were localised on the area of the Forest District Dąbrowa, which is the part of the Regional Directorate of National Forests in Toruń. The field tests were carried out in adult pine stands, growing on the same forest sites: the fresh coniferous forest site. The field work was conducted in spring and summer and the research areas were situated on flat terrain.

### Measurement of biometric features

The first stage of the work, was to define the basic biometric features of tree stands, growing on the experimental areas. In order to gather the necessary data the breast height diameters of all trees were measured. The measurements were made in 1 cm accuracy classes, from two directions: NS and EW. The arithmetic average from two measurements was adopted as the real diameter of the tree.

Every second tree was measured regarding its height, which was made with the help of the altimeter of Blume-Leisa with the accuracy up to 0.5 m. Based on the Kraft classification each of the trees growing on the experimental areas was assigned a biosocial position.

The choice of model trees was based on Draudt method. The number of model trees, falling into each thickness grade, was proportional to the number of trees in each thickness grade. Following previosusly mentioned methods the 10 model trees were chosen on each area. They were marked, felled on a big cloth sheet and delimbed. The conducted measurements of the biomass of trees created the basis for determining the mass of each part of the tree.

### Measurements of the biomass of model trees

After cutting and delimbing the volumes of the following tree parts were measured:

- stemwood up to the thickness of 7 cm in the thinner end,
- branches with thickness above 4 cm,
- branches without needles up to the thickness of 4 cm,
- twigs without needles.

Wood and branches were weighed on the decimal balance with the accuracy up to 0.5 kg. Twigs with needles were weighed with the accuracy up to 0.1 kg. In order to determine the mass of the needles a 2 kg sample was taken weighed with the approximation to 0.001 kg. With the same accuracy the mass of the needles obtained from these twigs was determined. Quotients of these quantities calculated on the basis of samples constituted spare factors, according to which mass of new conifer needles was established for the entire tree. Mass of twigs with needles after reducing conifer needles against established mass was ranked among general mass of branches.

The measurement of mass of modelling trees allowed to calculate mass of tree stands on appointed areas which next enabled to establish what part of biomass remained on the research area.

## RESULTS

### Measurement of the biomass

An overall description of pine tree stands on the research areas was presented in Table 1. Age of tree stands on the examined areas, ranged between 90 and 135 years. The youngest tree stand, 90 years old, occurred on the area no. III while the oldest – on the area no. I.

Table 1. Characteristics of tree stands on analysed areas
Tabela 1. Charakterystyka drzewostanów na powierzchniach badawczych

| Specification<br>Wyszczególnienie | Unit of measure<br>Jednostka miary | Analysed areas – Powierzchnie badawcze | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII |
| Age of forest stand<br>Wiek drzewostanu | years<br>lata | 135 | 106 | 90 | 120 | 106 | 110 | 106 | 101 |
| Average breast height diameter<br>Średnia pierśnica | cm | 31 | 29 | 24 | 33 | 29 | 29 | 27 | 26 |
| Average height<br>Średnia wysokość | m | 29 | 29 | 18 | 21 | 25 | 24 | 19 | 20 |
| Number of trees on 1 ha<br>Liczba drzew na 1 ha | no.<br>szt. | 122 | 398 | 657 | 302 | 220 | 398 | 489 | 554 |

The average breast height diameter on areas ranged form 24 to 33 cm. The average height ranged from 18 m (surface no. III) up to 29 m (surfaces no. I and II). Considerable differences during the conducted research were noticed in the number of trees, found in research areas, in terms of 1 ha. On the area no. I there was the smallest amount of trees, only 122 pieces, while the highest amount or trees – 657 – occurred on the area no. III and there were the trees with the lowest average thickness of all trees growing on the analysed areas.

### Characteristics of the size of biomass on each research area

In accordance with the Draudt method the sample trees were selected in order to establish the amount of biomass on the research areas.

Average mass of the aboveground part of trees was 243.2 t per 1 ha (Table 2). The lowest value was noticed on the surface no. I, where 67.8 t of biomass was on 1 ha. It constituted almost 20% of biomass which appeared on the surface no. VIII where analyses carried out showed the biggest biomass amount – 340.8 t.

Table 2. Results of the measurement of the fresh biomass divided in tree parts, t/ha
Tabela 2. Wyniki pomiaru biomasy w stanie świeżym z podziałem na poszczególne części, t/ha

| Analysed area Powierzchnia badawcza | Total mass Łączna masa | Stemwood Drewno strzały | Branches > 4 cm Gałęzie > 4 cm | Branches < 4 cm Gałęzie < 4 cm | Conifer needles Igliwie |
|---|---|---|---|---|---|
| I | 67.8 | 56.9 | 4.5 | 2.6 | 3.8 |
| II | 264.3 | 222.0 | 12.9 | 12.9 | 16.5 |
| III | 208.6 | 173.9 | 11.1 | 10.2 | 13.4 |
| IV | 313.7 | 263.9 | 15.2 | 16.7 | 17.8 |
| V | 122.4 | 101.5 | 5.5 | 6.4 | 8.9 |
| VI | 313.8 | 270.2 | 15.1 | 14.2 | 14.2 |
| VII | 314.4 | 265.2 | 14.5 | 14.7 | 20.1 |
| VIII | 340.8 | 287.6 | 14.4 | 18.9 | 19.8 |
| Average Średnia | 243.2 | 205.1 | 11.7 | 12.1 | 14.3 |

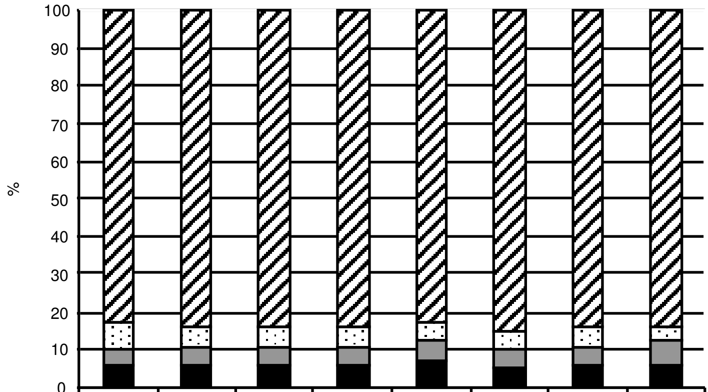
Number of trees falling per one hectare had some influence on diversification of the thickness of biomass from the analysed areas. On the area no. I, where the lowest thickness of biomass was demonstrated, 122 trees occurred on the area of one hectare. It was the lowest amount of trees among all areas which were examined. However, on the area with the biggest thickness of the biomass of trees there were almost five times more trees (554 pcs.).

The height of trees and the average breast height diameter on explored surfaces had also influence on the log volume of the biomass. It is important that on area III, where the number of trees per one hectare was the biggest (657 pcs.), there was not the biggest amount of biomass. The log volume of biomass on this area was lower by about 39% compared with the area no. VIII, where there was the highest amount of biomass per one hectare demonstrated. However, the trees growing on this area had the average log volume about 8% and average height about 10% higher compared with the surface no. III. Also differences were noticed in the share of marked parts of trees whitin the general amount of biomass of the analysed areas. This share was distributed unequally into each of the analysed parts.

Definitely the biggest part of the tree mass was the stemwood and its bark. Average share of stemwood ranged from 56.9 to 287.6 t/ha. The biggest share of stemwood in the tree mass was noticed on the area no. VI, it was 85%. However, the smallest share (83%) was demonstrated on the surface no. V (Fig. 1). On average on the analysed areas the participation of the stemwood amounted to around 205.1 t/ha.

Conifer needles got considerable share among the remaining part of biomass, varied from 3.8 up to 20.1 t/ha. The lowest amount of conifer needles was found on area no. I and the biggest on no. VII. Per one hectare there were 20.1 t of biomass, what amounted to 6% in the whole amount of mass of the trees on the analysed area. There was on average 14.3 t biomass in the shape of conifer needles on 1 ha of the analysed area.

Mass of the branches up to 4 cm of thicknesses which remained on the clear cut area amounted to 12.1 t on average. The biggest amount was on the area no. VIII – 18.9 t. In the case of the branches above 4 cm of the thickness, their mass varied from 4.5 up to




| | area I pow. I | area II pow. II | area III pow. III | area IV pow. IV | area V pow. V | area VI pow. VI | area VII pow. VII | area VIII pow. VIII |
|---|---|---|---|---|---|---|---|---|
| stemwood drewno strzały | 83 | 84 | 84 | 84 | 83 | 85 | 84 | 84 |
| branches > 4 cm gałęzie > 4 cm | 7 | 5 | 5 | 5 | 5 | 5 | 5 | 4 |
| branches < 4 cm gałęzie < 4 cm | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 6 |
| needels igliwie | 6 | 6 | 6 | 6 | 7 | 5 | 6 | 6 |

Fig. 1. Percentage structure of fresh biomass on the analysed areas
Rys. 1. Procentowa struktura biomasy w stanie świeżym na powierzchniach badawczych

15.5 t/ha. On the basis of the carried out analyses it was stated, that on average 11.7 t of biomass falls to one hectare of the analysed area, that is on average about 18% less compared with conifer needles. Assuming that the density of the fresh pine wood amounts to 0.8 g/cm$^3$ [Trendelenburg et al. 1955], log volume of the branches thicker than 4 cm acquired from trees growing on the area of 1 ha might be estimated at the level of 14.6 m$^3$. The branches constituted about 5% of total mass of the overground part of the tree.

## SUMMARY

To sum up, it should be stated that the biggest share in biomass on the analysed areas had the stemwood (84%), and then branches (10%) and needles (6%). Assuming that the wood taken away from forest is at least 4 cm thick, the part of biomass in the form of branches thinner than 4 cm, which was left behind in the forest, varied between 4 and 6% of the total tree volume. By adding the needles to this amount, the average amount of biomass left behind on the analysed areas would reach 10% to 12% of the total biomass. It means that on average 26.4 t per 1 ha of fresh biomass was left. This material nowadays is mainly crushed and left behind on the surface of the felling sites, supplying the forest soil with nutrients. It is also getting more and more popular to chip or bundle the logging residues and use the product as fuel in the energy production.

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## ANALIZA MIĄŻSZOŚCI POZOSTAŁOŚCI ZRĘBOWYCH W DRZEWOSTANACH SOSNOWYCH

**Streszczenie.** W celu ustalenia ilości biomasy pozostającej w lesie w postaci tzw. pozostałości zrębowych przeprowadzono analizę miąższości rębnego drzewostanu sosnowego z rozbiciem na poszczególne części drzew. Aby określić miąższości drzewostanu, na każdej z badanych powierzchni wybrano 10 drzew modelowych, wykorzystując metodę Draudta. Przeprowadzona analiza wykazała, iż największy udział w biomasie na powierzchniach poddanych analizie miało drewno strzały, a następnie w kolejności gałęzie i igliwie. Zakładając, iż pozyskujemy z lasu drewno o grubości powyżej 4 cm, można przyjąć, że ta część biomasy, która pozostaje w lesie w postaci gałęzi o grubości poniżej 4 cm oraz igliwie zawierała się w przedziale od 10% do 12% ogólnej ilości biomasy.

**Słowa kluczowe:** biomasa, pozostałości zrębowe, miąższość drzewostanu

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