Assessment of the volume of harvested wood in accordance with the vital state of wood species

I Konovalova* and E Lelekova

Competence Center “Use of biological resources”, Vyatka State University, 36 Moscovskay Street, 610000, Kirov, Russian Federation

*E-mail: usrl2061@vyatsu.ru

Abstract. During selective felling on the territory of 3.9 ha, 181 m$^3$ of wood, 35% of which is dead wood. Among them, pine (16 m$^3$), spruce (27 m$^3$), birch (8 m$^3$) and aspen (12 m$^3$) were found. The volume of cut viable wood was 118 m$^3$, including 50 m$^3$ of pine, 44 m$^3$ of spruce, 14 m$^3$ of birch and 10 m$^3$ of aspen. The values obtained do not exceed the forest declaration data. To determine the stumps from dead coniferous trees, the following criteria were tested: complete or partial absence of bark, the presence of traces of the vital activity of insect pests and abundance wood dust. Species-specific criteria are proposed: in pine – the presence of rot of the peripheral part of the wood, brown color of sapwood and bast; spruce – the presence of heart rot and wood destroying fungi. In deciduous species, the main criterion for isolating stumps from dead trees has been tested – the presence of wood-destroying fungi, in aspen – heart rot caused by tinder fungi. We recommend using these criteria to resolve legal claims against forest users in the removal and assessment of harvested wood.

1. Introduction

In forest ecosystems as a result of intraspecific competitive relations, natural wood dieback is observed [1]. Dead wood is an important component of the global carbon cycle and plays a key role in the functioning and maintenance of forest biological diversity [2–5, 6]. It is a habitat for mosses, some vascular plants, fungi and many animals [7]. To maintain the populations of these organisms, according to a number of authors [5], the volume of dead wood in the forest range should be maintained at the level of 50 m$^3$/ha.

Massive wood dieback is now reported, especially in boreal forests around the world. The main reason for this phenomenon is considered to be climate warming, which entailed hydrological changes, such as early spring melting of snow and prolongation of summer drought [8, 9]. In connection with the increase in the volume of dead wood attempts are being made to take an inventory and determine the value as a raw material [7, 10].

In our country in accordance with the Rules of Sanitary Safety in Forests [11] dead wood as well as wood affected by dangerous diseases and pests are primarily subject to felling, because they are sources of infections of dangerous diseases and reserves of pests. As part of maintaining sanitary and fire safety in forests such wood is selected and marked during the withdrawal of wood cutting areas along with wood for felling. However, within the framework of forestry legislation [12], the intensity of felling is determined by the stand of wood cut from the forest range not taking dead wood into account.

According to the Rules of wood harvesting [13], specially trained fellers can carry out felling without preliminary selection and marking of wood to be felled. In this case, especially in ripe forest
stands and old-growth forest stands, where the proportion of dead wood is quite large, the total volume of harvested wood may exceed the data of the forest declaration. To establish the volumes of damp-growing and dead wood collected as well as the fact of violation of forest legislation an assessment of the quality (vital) state of stumps left after the forestry activities is required. It is known that the decomposition rate of stumps is limited by the species composition of the stand, temperature, moisture content, and the content of mineral elements in the tissues of the tree [1, 5]. Therefore, to determine the state of stumps, it is necessary to develop criteria for the quality characteristics of harvested wood.

The purpose of this study is to establish the species composition and qualitative condition of stumps after selective logging on the territory of the forest plot in one of the forestry of the Kirov region, to determine the volume of viable trees and dead wood collected in the context of wood species and the presence of violation of the forest legislation.

2. Materials and methods

Stumps left after selective logging of the wood in a plot with an area of 3.9 hectares served as the material for the study. In the course of field studies, the stumps were recounted and their species composition was determined taking into account such morphological features as the structure of the bark (if any) and wood substance. For the subsequent calculation of the actually felled volume of the wood in the section of wood species, measurements of stump diameters in forest swaths and logging roads of the forest plot were carried out. Measurements were made with the tree caliper “Haglog Mantax Black” 65 cm in two mutually perpendicular directions. The extreme even number visible on the caliper was taken as the diameter of the stump. The obtained data were transferred from the height of the stump to the height of 1.3 m, using the list of wood, felled forest stands.

According to the quality the stumps were characterized as "viable", i.e. left after felling of viable trees that are not susceptible to diseases and pests of the forest, do not have signs of damage; and "dead", i.e. at the time of felling the tree was dead, standing on the root, the wood was dead, and the bark was partially or completely fallen.

It is known that mechanical properties of wood in the process of wood drying out decrease as a result of decomposition processes under the influence of wood-destroying fungi and insect pests [9, 14]. Therefore, dead wood stumps also included stumps with clear signs of damage by wood destroying fungi and insect pests and, as a result, decomposing stumps.

According to the data of literary sources [15–17] and the results of our own researches, morphological features of the stump of viable trees were considered: the integrity of the bark along the entire circular curve of the saw cut (with the exception of individual stumps located on logging roads and having lost the bark or part of it as a result of logging of tree stems or logging residues); tight fit of the bark to the wood of the stump; lack of entry and exit holes for insect pests; yellow-white color of the bast (on the fresh cut); hard, unstructured wood without signs of softness and looseness; the extent of annual rings (especially in conifers).

For the dead-wood stump the following was recorded: the absence of bark on most of the saw cut; the presence of species-specific traces of the vital activity of insect pests (entry holes in the bark, mother and larval gallery) and abundant worm dust; abnormal (from brown to black) color of the bast; the absence of resin on the inner surface of the saw cut in conifers; weak extent of annual rings (even in conifers); wood defects in the form of anomalous color due to the activity of destructive fungi; wormholes, fruiting bodies of wood-destroying fungi.

Field studies were accompanied by photographic materials, on which the general view of logging roads, forest swaths, logging residues, individual stumps of deciduous and coniferous species of various qualitative states were recorded. At the final stage of the work, the actually cut volume of viable and dead wood (in the bark) was calculated in the context of wood species. For this, the volume of the trunk of a certain thickness step was multiplied by the number of stumps in this step for each rock. The thickness step for each stump was determined by its diameter at a height of 1.3 m according to the table of the list of trees, felled forest stands. The data on the diameters of all stumps that were found in the plot were entered into this table. The number of stumps for each step of thickness was
calculated automatically in the table. This number, as well as the volume of the trunk, was used to determine the actually cut volume of wood for each species. The volume of the trunk in the bark is the exact number that is indicated for each species in the assortment and commodity tables for the forests of the central and southern regions of the European part of the Russian Soviet Federative Socialist Republic (RSFSR) [18] for the III category of heights established in the plantation under study.

3. Results and discussion
As part of the expertise carried out in October 2020, the forest range of the forest plot of one of the forestries located in the Kirov region was examined. According to the technological map of logging operations, the area of the wood cutting area is 3.9 hectares, the species composition of the forest range is 5 Pine 3 Spruce 2 Birch + Aspen + Fir, density is 0.7, the average stand of wood is 229 m³/ha.

In the summer of 2019, selective logging of ripe forest and old-growth forest stands with the intensity of 20% was carried out. The harvesting was carried out without preliminary selection and marking of the wood to be felled by specially trained forest fellers, which does not contradict the regulatory documents [13].

According to the forest declaration data, the volume of the wood to be harvested is 200 m³, including 95 m³ of pine, 54 m³ of fir, 3 m³ of silver-fir, 37 m³ of birch, 2 m³ of linden, 9 m³ of aspen.

In the course of field studies, the stumps were counted on the main logging road and four forest swath logging roads, as well as in forest swaths between logging roads.

It should be noted that field works was carried out in conditions of freshly fallen snow no more than 3 cm thick, which did not interfere with the detection, measurement and identification of stumps by species and quality condition.

A total of 259 stumps were counted, of which 147 were found on the logging roads, 112 in forest swaths. They are identified by species as pine (61 pcs.), fir (138 pcs.), birch (32 pcs.) and aspen (28 pcs.). The share of stumps from conifers prevails over deciduous ones and amounts to 77%. In general, half (53%) of the detected stumps were identified as fir. The share of pine is 24%, birch – 12%, aspen – 11%.

Most of the stumps (140 pcs.) are identified as remaining after felling of viable trees and 119 stumps from dead wood. More than half (64%) of the latter are represented by dead fir, 17% – pine, 11% – aspen, 8% – birch. Among pine, birch and aspen viable trees prevail, among fir there is more dead wood.

Pine stumps identified as dead wood often lacked bark, had entry and exit holes, larval galleries of insect pests, worm dust, decay of the peripheral part of the wood and other characteristic features. The renewed cuts of stumps from viable and dead pine have shown that, along with external signs, their difference is the condition of the wood. Pine sapwood is dense, usually yellowish or pale pink in color. The color and structure of wood and bast of the stump remaining after the saw cut of a viable tree is preserved. The sapwood and bast of the dead wood are brownish and become looser (figure 1).

Figure 1. Pine stump saw cut: (a) viable; (b) dead-wood.
Dead-fir stumps, studied in the course of field works, are noted by the presence of larval galleries, partial or complete absence of bark, the presence of fly-out holes of insect pests, fruiting bodies of wood-destroying fungi, core decay of varying degrees of development, up to the formation of hollows and complete wood destruction (figure 2).

![Figure 2. Dead-fir stumps with: (a) larval galleries; (b) fly-out holes of insect pests and fruiting bodies of wood-destroying fungi; (c) formed hollow.](image)

Viable stumps were more common among birch stumps. Stumps damaged by wood destroying fungi, putrefactive diseases, including rotten ones (figure 3) were considered dead-wood. A part (46%) of aspen stumps were identified as dead. The predominant defect in wood of this species is core decay caused by tinder fungi, the fruit bodies of which were also found on many of the examined stumps. During the field works, stumps left after felling of multistem aspens were found (figure 3).

![Figure 3. Deciduous species stumps: (a) viable birch; (b) dead birch; (c) dead aspen.](image)

It should be noted that among the logging residues on logging roads, along with tree branches, as well as near some stumps, whole or sawn to pieces logs of various types of dead wood were found (figure 4). This wood as illiquid was left on the territory of the forest plot for decay.

The total volume of wood felled in the forest plot (in bark) is 181 m³, among which 66 m³ of pine, 71 m³ of fir, 22 m³ of birch and 22 m³ of aspen were identified. In the total volume of collected wood, 63 m³ (35%) is dead wood (table 1). 101 m³ of wood (in bark) was harvested on logging roads, of which 26% (26 m³) is dead wood. A smaller volume of wood (in bark) was collected in forest swaths –
80 m$^3$, of which 46% (37 m$^3$) was dead wood. Dead wood makes up 54% of all aspen, 38% of fir, 36% of birch and 24% of pine wood.

It should be noted that a larger volume of dead wood was collected from forest swaths compared to logging roads, which contributes to an improvement in the sanitary state of the forest range as a whole.

### Table 1. The volume of harvested viable and dead wood (in bark).

| Data            | Fir, m$^3$ | Pine, m$^3$ | Birch, m$^3$ | Aspen, m$^3$ |
|-----------------|------------|-------------|--------------|--------------|
|                 | Viable     | Dead        | Viable       | Dead         | Viable      | Dead         |
| Logging road    | 34         | 14          | 25           | 3            | 13          | 8            | 3            | 1            |
| Forest swath    | 10         | 13          | 25           | 13           | 1           | 0            | 7            | 11           |
| Total           | 44         | 27          | 50           | 16           | 14          | 8            | 10           | 12           |
| Forest use report | 57    | –           | 95           | –            | 39          | –            | 9            | –            |

Thus, the volume of harvested viable wood (in bark) was 118 m$^3$. This value does not exceed the data (200 m$^3$) of the forest declaration. In the context of wood species, the values of the volumes of felled pine, fir and birch wood also do not exceed the declared ones (table 1). The volume of aspen wood (in bark) is exceeded by 11%, which, in accordance with the guidelines for the allocation and taxation of cutting areas in forests of the Russian Federation [19], is considered within the framework of the permissible discrepancy between the forest declaration data and the actual data for individual species, determined at the rate of 12%. The fact of violation of forestry legislation on exceeding the volume of collected wood was not revealed.

### 4. Conclusion

As a result of selective felling of ripe forest stands and old-growth forest stands in 2019 from the above forest plot, coniferous (fir, pine) and deciduous (birch, aspen) woods were collected. The cut volume of wood (in bark) was 181 m$^3$. 101 m$^3$ of wood was harvested on logging roads, 80 m$^3$ in
To determine the stumps from dead coniferous trees, the following criteria were tested: complete or partial absence of bark, the presence of traces of the vital activity of insect pests (entry holes in the bark, mother and larval gallery) and abundance worm dust. In addition, to identify stumps from dead pine trees, we suggest using such criteria as the presence of rot of the peripheral part of the wood, abnormal (brown) color of sapwood and bast; in spruce – the presence of pith rot and fruiting bodies of wood-destroying fungi. In deciduous species, the main criterion for isolating stumps from dead trees has been tested – the presence of wood-destroying fungi, in aspen – heart rot caused by tinder fungi. We recommend using these criteria to resolve legal claims against forest users in the removal and assessment of harvested wood.

References

[1] Mukhortova L V, Kirdyanov A V, Myglan V S and Guggenberger G 2009 Wood transformation in dead-standing trees in the forest-tundra of Central Siberia. Biology bulletin 36(1) 58 doi: 10.1134/S1062359009010099
[2] Reid C M, Foggo A and Speight M 1996 Dead wood in the Caledonian pine forest. Forestry 69 275 doi: 10.1093/forestry/69.3.275
[3] Stone J, Parminter J, Arsenault A, Manning T, Densmore N, Davis G and MacKinnon A 2002 Dead Tree Management in British Columbia. Proc. Int. Symp. on the ecology and management of dead wood in western forests November 2–4, 1999 Reno, Nevada USDA Forest Service Gen. Tech. Rep. PSW-GTR-181 Albany, California pp. 849–862
[4] Hararuk O, Kurz W A and Didion M 2020 Dynamics of dead wood decay in Swiss forests. Forest Ecosystems 7 36 https://doi.org/10.1186/s40663-020-00248-x
[5] Martin A R, Domke G M, Doraisami M and Thomas S C 2021 Carbon fractions in the world’s dead wood. Nature communications 12 889 https://doi.org/10.1038/s41467-021-21149-9
[6] Jonsson B G, Kruys N and Ranius T 2005 Ecology of species living on dead wood – Lessons for dead wood management. Silva Fennica 39(2) 290 doi: 10.14214/sf.390
[7] Adamowicz K, Jaszczyk R, Kuźmiński R, Łabędzki A, Łakomy P, Mazur A, Starosta-Grala M, Szramka H, Turski M and Zientarski J 2015 An attempt at valuation of wood from dead trees in polish forests. Acta Sci. Pol. 14(1) 5 doi: 10.17306/J.AFW.2015.1.1
[8] Birdsey R and Pan Y 2011 Ecology: Drought and dead trees. Nature climate change 1(9) 444 doi: 10.1038/nclimate1298
[9] Marchenko N V, Novitsky S V, Mazurchuk S M 2019 Constructional lumber from wood of pine dead trees. Ukrainian journal of forest and wood science 10(4) 103 https://doi.org/10.31548/forest2019.04.103
[10] Woodall C W, Verkerk H, Rondeux J and Stahl G 2009 Who’s counting dead wood? EFI News 2 12
[11] Rules of sanitary safety in forests: approved by Decree of the Government of the Russian Federation No. 607 of May 20, 2017 (Standard, Moscow)
[12] Methodological recommendations for the State forest inventory: approved by Order of the Federal Forestry Agency No. 472 of November 10, 2011 (as amended on March 15, 2018) (Standard, Moscow)
[13] Rules of wood harvesting and features of wood harvesting in forest areas, forest parks specified in Article 23 of the Forest Code of the Russian Federation: Approved by Order No. 474 of September 13, 2016 (as amended on January 11, 2017) (Standard, Moscow)
[14] Birkemoe T, Jacobsen R M, Sverdrup-Thygeson A and Biedermann P H W 2018 Insect-fungus interactions in dead wood systems. Saproxylic Insects 12 377 doi: 10.1007/978-3-319-75937-1_12
[15] Lykova I A and Sergaeva G A 2015 Establishing the category of tree vitality and the causes of big tree failure (based on forensic casework). Theory and Practice of Forensic Science 4(40) 46 [in Russian]

[16] Schweingruber F H, Börner A and Schulze E-D 2008 Decay of Dead Wood Atlas of Woody Plant Stems 12 204 doi: 10.1007/3-540-32525-5_13

[17] Shortle W C and Dudzik K R 2012 Wood decay in living and dead trees: a pictorial overview Gen. Tech Rep. NRS-97 (Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station) p 30

[18] Assortment and commodity tables for forests of the central and southern regions of the European part of the Russian Soviet Federative Socialist Republic (RSFSR): approved by the Chairman of the State Forestry Agency of the USSR A. I. Zverev, order No. 258 dated 23.12.1986 (Standard, Moscow)

[19] Instructions on the allocation and taxation of cutting areas in the forests of the Russian Federation: approved by Order of the Federal Forestry Service of the Russian Federation No. 155 of June 15, 1993 (Standard, Moscow)