BIO Web of Conferences **215**, 03003 (2026) https://doi.org/10.1051/bioconf/202621503003
RENA 2025

Wood raw materials obtained from intermediate-use cuttings in Azerbaijan's beech forests and possibilities of their complex uses

Aydin Yakhyayev [1], *Kemala* Yusifova [2], *Tariyel* Jafarov [2], *Ulviyya* Karimova-Japharova [1], *Shahbaz* Shiraliyev [1]

[1]Western Caspian University, Baku, AZ 1001, Istiqlaliyyet ave. 31, Azerbaijan.
[2] Azerbaijan University of Architecture and Construction, Baku, AZ 1073, A. Sultanova street, 13 Azerbaijan.

Abstract: The article examines the volume, harvesting, transportation, and integrated utilization of wood raw materials obtained from intermediate cuttings in beech (*Fagus orientalis*) forests of Azerbaijan. For this purpose, experimental sites were established for each thinning regime as well as for selective sanitary cuttings. Each site was subdivided into 7–10 compartments, resulting in a total of 43 sample plots with a combined area of 26 hectares. The results of the logging operations indicated that the total volume of harvested wood raw material amounted to 508.16 m³ (19.6 m³/ha), of which 53.1% was classified as merchantable timber, 28.0% as industrial (technological) wood, and 18.9% as fuelwood (green wood). To ensure the continuous collection and delivery of harvested timber in full volume, maps were developed in the forested areas of the northeastern Greater Caucasus. Two to three intermediate collection points were established in eight directions, each extending 40-50 km. Each collection point was designed to collect wood raw materials located within a 15-20 km radius. The article also explored the potential for the integrated use of low-quality wood and wood waste in the production of wood-based panel materials and bioactive substances.

1 Introduction

Wood is the main forest product, a widely used natural material in various industries and human activities. Its resources have the unique ability to continuously renew themselves. At the same time, the growing demand for timber products increases the timber shortage, access to its natural resources becomes more difficult, and its quality characteristics deteriorate. This is typical for all sparsely forested countries, including the Republic of Azerbaijan, where final felling in forests has been suspended since 1991. Only intermediate cutting was permitted [5, 6].

In this study, the selection of the research object within the beech forests of the Greater Caucasus was determined by the widespread distribution of this species, which accounts for 31.7% of the forested area and more than 50% of the total growing stock. As the dominant forest-forming species, beech plays a crucial role in maintaining ecological stability and ecosystem balance in the region. [13].

In the system of forest felling from the point of view of environmental safety, an important component is the implementation of intermediate felling. In this regard, their works showed that the main requirements for an environmentally safe system of intermediate felling are the same as for the main felling carried out in the forests of Belarus [1, 35, 36].

As is well known, intermediate fellings are aimed at forming target (primary) stands, i.e., obtaining a commercially desirable stand. Improving environmentally oriented intermediate fellings requires a higher level of silvicultural, ecological, and technological implementation. However, in the Republic, these logging operations are not carried out consistently and promptly [2, 12, 22]. In practice, these logging operations were carried out using a technological scheme partial use of timber, skidding long logs or tree trunks, as well as large branches. Small and medium-sized branches and tree tops were cut off at the stump and left in the forest to rot in small piles. Some of the resulting waste was used to make containers or for fuel. The rest remained in the warehouse, polluting the environment [3, 10, 23]..

The concentration of this waste varies between the logging site and the lower logging yard, and together they account for 30-40% of the timber harvested. To successfully plan the efficient use of this secondary raw material, it is necessary to know the volume of waste generated during logging operations and primary wood processing at each concentration point [11, 20].

As can be seen, the region's utilization of wood raw materials is very low, compared to 80-90% of the total utilization in developed countries. Limiting factors to the increased use of low-quality wood and wood waste include the lack of imperfections in technical equipment for logging, transportation, and processing. and the lack of experience and production facilities for integrated wood processing in the Republic [18, 25].

Other factors limiting the use of low-quality wood and wood waste include the spread of forests: in mountainous areas, in remote areas with difficult terrain, in small territories, etc [8, 26].

In their work, I.S. Geles and M.A. Korzhova examined the potential for using intermediate-use wood raw materials in hard-to-reach forest areas of the Ural region [30]. Their research recommended the use of small-diameter wood in the production of pulp and semi-finished fiber products.

In his work, Obed Asamoah drew attention to the ongoing illegal logging in the forests of the Republic of Ghana. He noted that the annual increase in deforestation is accompanied by the generation of large quantities of wood waste, which remains unused [3].

In this regard, Yushkevich M.V. and Khodorovich A.I., in their works studying intermediate forest use in the system of ecological safety of forest cuttings, showed that the main requirements for an ecologically safe system of intermediate cuttings are the same as for final cuttings in the forests of Belarus [35].

In another study, Marek Wieruszewski *et al.* noted that one of the key factors influencing the overall balance of wood pulp resources is the form and quality of wood material that cannot be further processed by mechanical methods. To assess the impact of this material, the authors analyzed the relationship between the availability of wood biomass resources and the conditions of wood harvesting and processing in Poland. [28].

To study the aforementioned issues of using low-quality wood and wood waste, including: determining the volume of waste raw materials generated, organizing the collection and delivery of these raw materials to collection points; and establishing the main directions for the integrated processing of these types of wood raw materials, research was conducted [16, 17].

The objective of this study, conducted in the forests of the Greater Caucasus, is to quantify the volumes generated during intermediate cuttings and to identify the principal directions for the integrated utilization of harvested wood raw materials. To achieve this objective, the following tasks were addressed:

1. To determine the volume and structural composition of wood raw materials obtained from intermediate cuttings and subsequent wood processing.

2. To develop a schematic map for the collection and transportation of low-quality wood and wood residues generated during intermediate cuttings to collection points or lower storage sites.
3. To identify the main pathways for the integrated utilization of wood raw materials derived from intermediate cuttings and wood processing.

2. Research Objects and Methods

Geography and Natural Conditions. To address the objectives, field studies were conducted in forest stands of the Guba Forest Region of the Greater Caucasus Mountains from 2022 to 2024. The geographic coordinates of the region are 41°21'11"/48°30'47" (Fig. 1). These forest areas are dominated by mountain-forest brown soils [34] with average annual temperatures ranging from 8.6 to 11.9°C and annual precipitation ranging from 570 to 694 mm [24, 25].

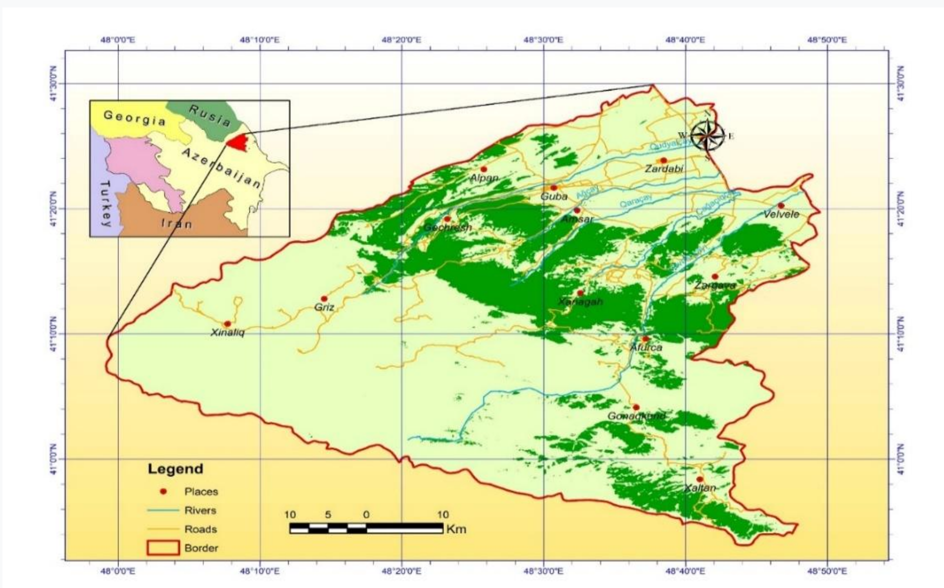

Fig. 1. Schematic map of the Guba forest district

Selection and characterization of sample plots. The volume and compositional structure of wood raw materials obtained from intermediate cuttings were assessed in beech stands within the Alpansky Forest District of the Guba Forestry Enterprise. For this purpose, for each type of thinning and selective sanitary cutting, one plot was allocated, dividing them into 7-10 sections, where test plots (PP with an area of 0.55-0.60 hectares) were laid out. The selection, description, and processing of averaged data for the selected sections were carried out using well-known methods [14, 28] and the methodological guidelines of [32, 29].

Assessment of the volume and compositional structure of wood raw materials obtained from intermediate cuttings. All types of thinning were conducted in August-September

2022-2023, with selective sanitary logging in October 2024. Forest felling was carried out using the assortment-length technology and full utilization of the harvested wood raw material. When developing logging sites, a self-propelled cable-skidding unit was used with a lopper, a gasoline-powered saw, a small-sized wheeled tractor and horse-drawn transport [19, 26].

Following tree felling, the removal of branches, limbs, and tops, and the cutting of long logs into timber, all harvested wood at the logging site was transported to the lower storage area at the base of the mountains. At this location, the wood was systematically sorted into distinct categories [4, 21]. When calculating the volume of wood waste per 1000 m3 of harvested wood raw materials, the formula [15, 37] for each species was determined. m^3.

$$P = \sum_{i=1}^{k} a_i \, b_i \, \frac{C_i}{1000} \quad ,$$

here, P – volume of cutting waste, m^3; a_i - share of wood raw materials $_i$ - species in the formula of species composition of forest stands, m^3; b_i - weighted average standard for the output of this type of waste; $_i$ - species m^3 ; k – number of tree species in the plantings; C_i - weighted average standards for the output of crown elements for each tree species, m^3.

Depending on the diameter, commercial timber was divided into 3 size-quality groups: large - 24 cm and more (at the lower end); medium - from 14 to 23 cm; small - from 6 to 13 cm [12, 29].

Development of a collection and transportation map for wood raw materials. Study sites were selected in the beech forests of the Greater Caucasus, encompassing stands within the Yalama, Gusar, Guba, Shabran, and Gilezin Forest Districts. Collection points were planned for these sites, and a map was developed based on this [37, 27]. When compiling the map-scheme, a GIS program (ArcGIS10.2.2) was used [9].

In identifying the principal pathways for the integrated utilization of wood raw materials obtained from intermediate cuttings, the standard schemes proposed by [32] were employed.

3. Research Results

The results of the assessment of the volume and structural composition of harvested wood materials by felling type were as follows:

During the clearing of stands composed of the main forest-forming valuable species (PP-1 to PP-7) and the clearing of young stands representing the future forest composition (PP-8 to PP-15), the majority of the harvested raw material consisted of technical green wood, ranging from 55.4% to 68.1%, and small-sized wood in the form of brushwood, accounting for 31.9% to 37.5%.

In contrast, during the thinning of plantations (PP-16 to PP-25), which primarily involved the felling of trunks of valuable species, a marked increase in the yield of merchantable timber was observed, reaching 53.2%—an increase of 7.5-fold. Within this category, large-sized timber accounted for 11.0%, medium-sized timber 29.1%, and small-sized timber 59.9%. Concurrently, the yield of technological wood remained at approximately 30%, while the proportion of technical green wood decreased to 17.6%, representing a 3.9-fold reduction.

In the thinnings conducted to enhance the growth of valuable species (PP-26 to PP-35), the majority of the harvested raw material comprised merchantable timber, accounting for 66.6% of the total yield. Within the size categories, large timber predominated at 39.2%, while the yields of medium and small timber were both approximately 30%. Compared to earlier thinning operations, the proportions of technological wood and technical green timber decreased to 21.9% and 11.5%, respectively.

In selective sanitary fellings (PP-36 to PP-43), merchantable timber predominated, accounting for 62.2% of the harvested volume, while industrial green timber represented the lowest proportion at 8.5%. Within the commercial timber category, large-sized timber constituted 52.4%, and medium-sized timber 29.9%. The yield of technological (processable) wood remained approximately 30%.

Overall, intermediate felling operations produced 508.16 m³ of wood (19.7 m³/ha). The distribution of the harvested material by category was as follows: merchantable timber – 53.1% (10.5 m³/ha), technological wood – 28.0% (5.5 m³/ha), and technical green wood – 18.9% (3.7 m³/ha). The total yield of merchantable timber amounted to 269.88 m³. By size class, it was distributed as large timber – 38.6% (4.0 m³/ha), medium timber – 29.6% (3.1 m³/ha), and small timber – 31.8% (3.3 m³/ha) (Fig. 2a, b).

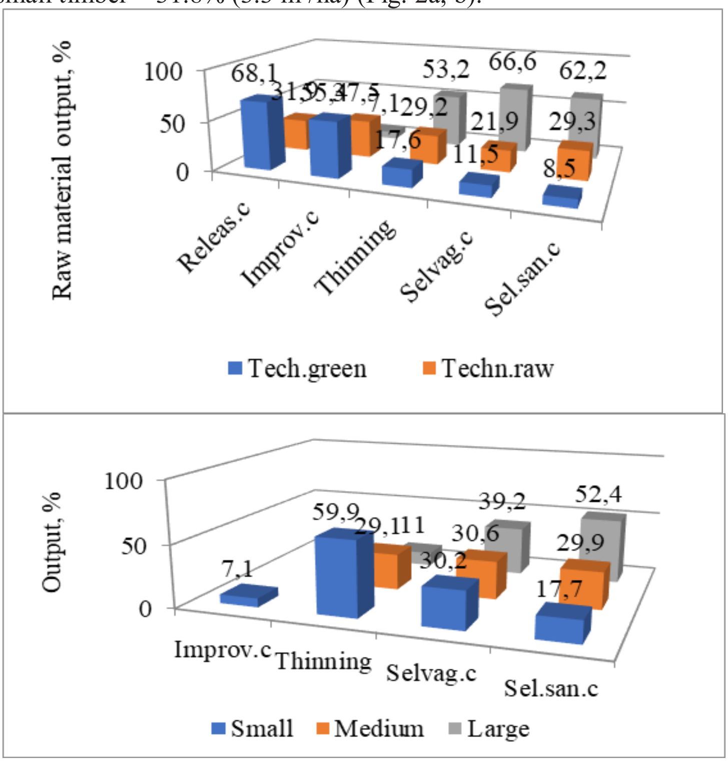

Fig. 2. Distribution of harvested wood: (a) by raw material category; (b) merchantable timber by size class.

In accordance with the task set for the collection and delivery of harvested wood raw materials to the timber processing point, we have planned to organize 2-3 collection points in 8 areas of the enterprise's forest areas. The length of each route is planned to be 40-50 km [26, 38]. Each point is designed to collect wood raw materials located within a 15-20 km radius, based on which a map has been created (Fig. 3).

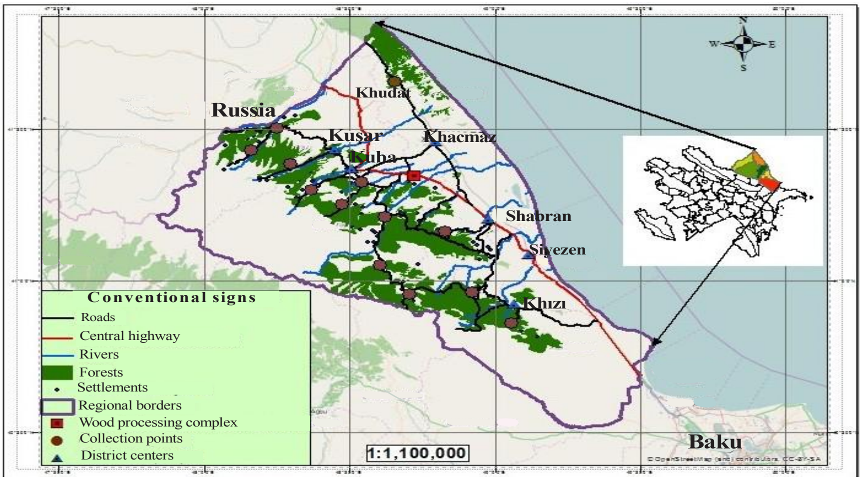

Fig. 3. Schematic map of loading points and the wood processing complex in the forest areas of the Greater Caucasus.

The transportation of sorted wood raw materials from collection points to the timber processing plant is planned to be carried out by self-loading timber trucks up to 8 m long [7].

4. Discussion

In thinnings, the marked increase in merchantable timber yield to 53.2% (a 7.5-fold rise) is attributed to the preservation of the second canopy layer and the upper canopy of the stands. During thinning, an increase in the yield of large-sized timber to 39.2%, including commercial timber up to 66.6%, is explained by the increase in the age and wood stock of the stands. During selective sanitary felling, the elevated yield of merchantable timber (62.2%) was largely influenced by the large tree dimensions and the species composition of the stands [31].

Consequently, during intermediate felling, the distribution of wood raw material categories was as follows: merchantable timber – 53.1%, technological wood – 28.0%, and technical green wood – 18.9% (Fig. 2a). The work also established that there is a fairly close relationship between the age of the stands and the yield of commercial timber and technological raw materials (R2 = 0.683-0.881), and the relationship between age and technical greenery is very weak (R2 = 0.224). There is also a fairly close relationship between the age and the timber stock of stands and the yields of large and medium-sized commercial timber (R2 = 0.745-0.874), and a very weak relationship with small timber (R2 = 0.112-0.133) [9].

The analysis indicates that, of the total harvested wood raw material volume (508.16 m^3) intended for national economic use, only 36.2%—in the form of large and medium-sized timber—is effectively utilized. The remaining 63.8%, consisting of small-sized, low-quality wood and logging residues, is either partially used as firewood—representing inefficient utilization—or is entirely left to decompose or is burned. It has been established that this portion of wood raw materials can be directed toward two main applications: the production of wood-based materials and the extraction of biologically active substances [33].

5. Conclusions

1. It was determined that intermediate felling in beech forests yielded 19.7 m³/ha of wood raw material, of which 10.5 m³/ha was merchantable timber, 5.5 m³/ha was technological wood, and 3.7 m³/ha consisted of technical green wood.
2. Approximately two-thirds of the harvested wood raw materials comprised low-quality wood and logging residues, a portion of which is used as firewood, while the remainder is left to decompose, contributing to environmental pollution.
3. A schematic map for the collection and transportation of wood raw materials harvested during intermediate felling in the Guba Forest District was developed.
4. The principal pathways for the utilization of low-quality wood and logging residues obtained from intermediate felling were identified, including the production of wood-based materials and biologically active compounds.

References

1. A.Kozuch, J. Banas, The dynamics of beech roundwood prices in selected Centr. Europe. Mark. For. **11(9):** 902, (2020)

2. A. Atik, B. Yilmaz, Factore affecting industrial wood material production yield in Turkeys natural beech forests. Ann. For. Res. **57 (1):** 149-162, (2014)

3. A. Obed, K. Suvi, A. Jones, T. Ebo, B. Dastan, M. Charles, P. Ari. Assessing wood waste by timber industry as a contributing factor to deforestation in Ghana. Forests, **11(9):**939. (2020)

4. P Araman, D Hindman, M. Fwinn, Characterization and potential recycling of home building wood waste. Research Gate, January. 129-138. (2010).

5. A.Yakhyaev, E.Safarova, Structure and volumes of wood raw materials received from thinning in the beech forests of the Greater Caucasus, For. Inform. **4**, 73-80. (2015) (in Russian)

6. A.Yakhyaev, On the use of raw wood materials of the forests of Azerbaijan. Proceedings of Inst. Botany NAS of Azerbaijan. **Vol. XXV**:118-122. (2004). (in Azerbaijan)

7. A.Yakhyaev, Features of the use of raw wood of beech forests of the Greater Caucasus. Bulletin of the Kazan SAU. **2 (36)**, 164-168. (2015). (in Russian)

8. A.Yakhyaev, E.Safarova, The current state of the stock and use of raw woody materials in the Forests of Azerbaijan. Collection of scientific works of the Institute of Dendrology NAS of Azerbaijan. 73-81. (2015). (in Azerbaijan)

9. A.Yakhyaev, Y.T. Abiyev, Organizational-technological features of the use of raw wood materials obtained from intermediate cuttings in beech forests of the Greater Caucasus//For. Journ. **1(17)**, 197-206. (2015). (in Russian)

10. A.Yakhyayev, Thinning in beech-hornbeam young forests of the north-eastern slope of the Greater Caucasus within Azerbaijan. Vestnik BSAU. **1**, 91-95. (2014). (in Russian)

11. A.Yakhyayev, V.Farzaliyev, Results of complex felling in beech-hornbeam plantations of the Greater Caucasus within Azerbaijan. Sib. For. Journ. **3**, 140-149. (2014). (in Russian)

12. A.Yakhyayev, Regulatory framework for thinning in beech plantations of the Greater Caucasus. News of OGAU. Orenburg. No. 2, 10-13. (2015). (in Russian)

13. A.Yakhyayev. Ecological and silvicultural features of the formation and use of beech stands in the Guba forest region of the Greater Caucasus. Abstract of the dissertation of the doctor of Ecology. Baku, 28. (2022).

14. B.Baqinskiy. Forest taxation. QSTU, Gomel. 123-167. (2018). (in Russian)

15. Collection of methods for calculating waste generation volumes. St. Petersburg. 22-26. (2004). (in Russian)

16. S. Coulibaly, F-M Zahui et. Al, Assment of wood waste management in timber industries in the forest areas of Man and Daloa (Cote d'Ivoire). Scient. Journ. of Envir. Sci. **10 (2),** 349-364. (2021)

17. N.Elginoz, J. Blokland, S. Safarian et. al. Wood waste recycling in Sweden.Industrial, Environmental, Sosial, and Economic Challenges and Benefits. Sustainability. **(16) 5933**. 1-17. (2024)

18. F. Berger, F. Gauvin, H. J. Brouwers. The recycling potential of wood waste into wood-wool/cement composite. Construction and Building materials. **(260).** 119786. (2020)

19. Forest policy and strategy of Ukraine: assessment, problems and ways to solve them. Regional program "ENPI EAST FLEG" Киев. 132. (2014). (in Russian)

20. G.N. Malkov, N.N. Popov. State and problems of forest management in the North Caucasus.Forestry. No. 1:16-19. (1992). (in Russian)

21. https://www.activestudy.info/kompleksnaya-pererabotka-lesnoj-rastitelnosti/

22. https://www.britannica.com/science/wood-plant-tissue/Harvesting-of-wood/

23. https://www.activestudy.info/ekonomicheskie-osnovy-rubok-uxoda-za-lesom/

24. https://azerbaijan.az/ru/related-information/17

25. https://method.meteorf.ru/publ/tr/tr383/htm/03.htm

26. I. Oriqorev. Development of hard-to-reach logging sites. Wood. RU. **2,** Moscow. 38-42. (2009). (in Russian)

27. I. Grigorev, F. Svojkin. The mastering of hard-to-reach forests .Wood. RU. **4**, Moscow. 72-74. (2011). (in Russian)

28. I. Qriqorev. Wood shredding. Wood. RU. **2**, 84-89. (2014). (in Russian)

29. I. Kotlyarov. Thinning and their role in the structure of forest management. Forestry. **5**, 27-28. (1989). (in Russian)

30. I.Geles and M.Korjova. Resources of intermediate use of forests and some directions for their use. Lesnoy Vestnik. Krasnoyarsk. 2: 10-15. (2008). (in Russian)

31. K.Asadov, F.Mammadov, S.Sadykhova. Dendrology and Forests of the North Eastern Part of the Greater Caucasus. Baku Uni. Press., 98-122. (2008). (in Azerbaijan)

32. K. Smelevsky. What can be done from waste. Wood Ru. No. 1: 90-94 (2011). (in Russian)

33. M. Lotfalian, S. Peyrov, K. Adeli, T. Pentek. Determination of Optimal Distribution and Transportation Network: Wood Transportation in Iran. Croat. Journ. Forest engin. **(43) 2**, 313-327. (2022)

34. M.Salayev, M.R. Babayev. Morphogenetic profiles of soils in Azerbaijan. Inst. Soil Sciences NAS Azerbaijan, 26- 91. (2004). (in Azerbaijan)

35. M.V. Yushkevich and A.I. Xodorovich. Intermediate use in the system of environmental safety of forest felling. Scientific News BSTU. 200-204. (2002). (in Russian)

36. O. Bouriaud, A. Don, I. Janssens, G. Marin, E. Schulze. Effects of forest management on biomass stacks in Romanian beech forests. For. ecosyst. **6:19**. (2019)

37. S. Gensurik. Use and reproduction of forest resources of the Ukrainian SSR. Kiev. 312. (1986). (in Russian)

38. V. Patyakin, E.Salminen, et. al. Forest exploitation. (Moskva. "Academy", 320, 2006). (in Russian)