FEATURES OF THE COMPLEX USE OF WOOD RAW MATERIALS OBTAINED FROM INTERMEDIATE CUTTINGS IN THE BEECH FORESTS OF AZERBAIJAN

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Abstract: The article is devoted to the study of the issue of the complex use of wood raw materials obtained from intermediate use cuttings in the beech forests of Azerbaijan. In this regard, it was necessary to establish the volume and structure of the resulting wood raw materials. For this purpose, one sample areas was allocated for each type of care cuttings and selective-sanitary cuttings with separation of its 7-10 section where plots are laid. A total of 43 plots were laid with a total area of 26 hectares. Cuttings were carried out with intensity of 7.0-18.3%. The total volume of wood raw materials harvested was 508.16 m^3 (19.6 m^3/ha) including commercial wood - 53.1%, technological raw materials - 28.0%, technical greens (fitomass) - 18.9%. In turn, commercial wood in the amount of 269.88 m3 by size categories was distributed as follows: large - 38.6%, medium - 29.6%, small - 31.8%. Mathematical models of yield of categories wood raw materials depending on age and wood stock of forests have also been derived from the work. The article also indicates the possibilities of rational use of these raw materials and developed the corresponding technological scheme of the wood-processing complex for the production of finished products.

Keywords: wood raw materials, intermediate use cuttings, beech forests, commercial wood, technical greens, low-quality roundwood, felling waste, technological scheme.

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Received: 26 December 2023; **Accepted:** 18 February 2024; **Published:** 30 March 2024

DOI: 10.54414/ZKFX6288

Introduction:

In the forest of the Republic in the past, unsystem cuttings, forest pasture, agricultural use and other anthropogenic effects have led to a state of exhaustion and upset, as a result of which their productivity and sustainability have decreased. Therefore, since 2000 in all farms it is allowed to carry out only cuttings of care cutting and selective-sanitary cuttings. During these cuttings commercial and low-quality wood is harvested and felling waste is generated in large volumes in the form of small sticks, boughs, branches, tops, stubs, roots, etc. (Yakhyaev, 2004; Yakhyaev, 2015).

In the forestry practice of Azerbaijan, assortment technologies used with partial use of harvested wood raw materials. Felling waste and low-quality roundwood generated in felling areas, as well as sawmill waste generated at primary processing points of roundwood are partly used for firewood. The rest, including the small waste, is collected in a heap and left to rot (Yakhyaev and Safarova, 2015).

As can be seen, the low-quality wood and felling waste obtained from felling and primary processing of wood raw materials have not yet found effective production use (Yakhyaev and Abiyev, 2015). Here, the main constraints are the lack and imperfections of technical means available to enterprises for harvesting, transportation and processing, as well as the form of organization of forestry and logging production

in farms. and the Republic as a whole. On the other hand, the use of waste-free technologies in a sparsely wooded Republic is a priority for increasing the efficiency of forestry production (Gensurik, 1986).

The purpose of this work is: 1. Determination of the volume and structure of wood raw materials obtained from intermediate use cuttings, 2. Identification of the possibility of complex use of wood raw materials obtained from intermediate use cuttings in the production bases of the Republic, 3. Development of a technological scheme for complex use of wood raw materials obtained from intermediate use cuttings of finished products.

Objects and Methods of Research:

The research was carried out on the forests of the Alpan forest area of the Guba Forestry (41º21/ N, 48^{0}30/ E) region of Azerbaijan. Mountain-forest brown soils are mainly distributed in the research area. Here, the average annual temperature varies between 8,6-11.9 ºC, the annual precipitation is 570-694 mm. For this purpose, one sample areas was allocated for each type of care cuttings and selective-sanitary cuttings with its division into 7-10 sections, where plots are laid (PP with area of 0.55-0.65 ha). The plots were allocated by age groups to the appropriate types of care, and the sections - to the related forestry-taxation indicators of plantings. At the same time, the requirements of the regional standarts (OST 56-69-83: 1983) and the methodological instructions of L.B. Mahatadze and I.D. Popov (1965) in fescue and herbaceous forest types with a stand density of 0,62-0,78 (Table 1).

Table 1. Material evaluation of raw wood materials obtained from cutting intermediate.

Plot No	Composition by number	Averageage, (year)	Stand density	Stand volume, (m^3. ha^{-1})	Type of cuttings	Intense thinning, %	Total volumes of raw wood materials					
							commercial, m^3				techn. raw m^3/%	tech. green t / %
							large	medium	small	general		
P1-7	60Be40Hb+As+Mp	23,3	0,79	27,9	release cut.	13,6	-	-	-	-	8,87/31,9	18,96/68,1
P8-15	50Be40Hb10Mp+O	40,9	0,78	53,1	improve cut.	11,3	-	-	3,41	3,41/7,1	18,16/37,5	26,83/55,4
P16-25	50Be40Hb10O+Mp	63,3	0,77	92,9	thinning	10,8	5,81	15,43	31,71	52,95/53,2	29,06/29,2	17,47/17,6
P26-35	70Be20Hb10Mp	103,6	0,73	171,3	selvage cut.	9,1	40,33	31,49	31,04	102,9/66,6	33,95/21,9	17,7/11,5
P36-43	90Be10Hb+O+Mp	127,3	0,69	213,3	sel.-san. cut.	10,7	57,95	33,07	19,66	110,7/62,2	52,08/29,3	15,19/8,5
Total raw wood materials		-	-	-		-	104,09	79,97	85,82	269,88/53,1	142,1/28.0	96,15/18,9

Be – beech (*Fagus orientalis* Lipsky); Hb – hornbeam (*Carpinus caucasica* A. Grossh.); Ac – acer (*Acer platanoides* Lipsky); Mp – maple (*Fraxinus excelsior* Lipsky); O – oak (*Quercus iberica* Stev.).

All types of care cuttings were carried out in August-September, selective-sanitary cuttings in October 2014-2016, by the help of the Guba Forestry enterprise with the use of assortment technology and the full use of harvested wood raw materials. As a system of machines, gas-powered saws, horse transportation (in less accessible places) and a TDT-55 tractor (Russian) used.

After the felling trees, clearing them of boughs, branches and tops, as well as crosscutting of long whiplash into assortments were carried out. The whole wood mass collected on the area cuttings was transported to the feet of the mountains to the lower timber yard. At the

end of each type of cuttings, the areas was cleaned from cuttings residues with cutting and spreading over the whole area (Grokhovsky, et al, 1980; Grunyansky and Tupytsya 1972).

In the lower timber yard, the wood delivered was sorted into separate categories of raw materials. Commercial wood was classified by diameter into three dimensional-qualitative groups of assortments: small 6-13 cm (in the upper end without bark); medium -14-24 cm, large - 26 cm and above (Atrokhin and Ievin, 1985). Non-commercial wood was conditionally divided into two groups: technological raw materials - trees with a diameter at a height of 1.3 m to 6 cm, as well as boughs, branches thicker than 0.8 cm, small sticks and other weight waste; technical greens - branches up to 0.8 cm thick with leaves (https://www.activestudy.info/kompleksnaya-pererabotka-lesnoj-rastitelnosti/). Allocated categories of wood raw materials were taxed: technical greens – by weight method; technological raw materials –with raum meters (https://www.britannica.com/science/wood-plant-tissue/Harvesting-of-wood/). Commercial wood accounting was carried out on the basis of volumetric tables of the corresponding species (Gensurik, 1986, Gagoshidze, 1979).

In order to identify the possibilities of complex use of harvested wood raw materials in the Republican production bases, statistical data of leading companies of forest and wood-working industry of the Azerbaijan were used. At the same time, their technological capabilities and interests of the domestic market were taken into account (statistics 2012-2020).

In the development of the technological scheme of the wood-processing complex, the corresponding typical technological schemes of D.K. Verhov and Y.V. Shelgunova (1981), recommendations of K. Smelevsky (2011) developed for the complex use of harvested wood raw materials (Malkov and Popov,1992) were used.

Results:

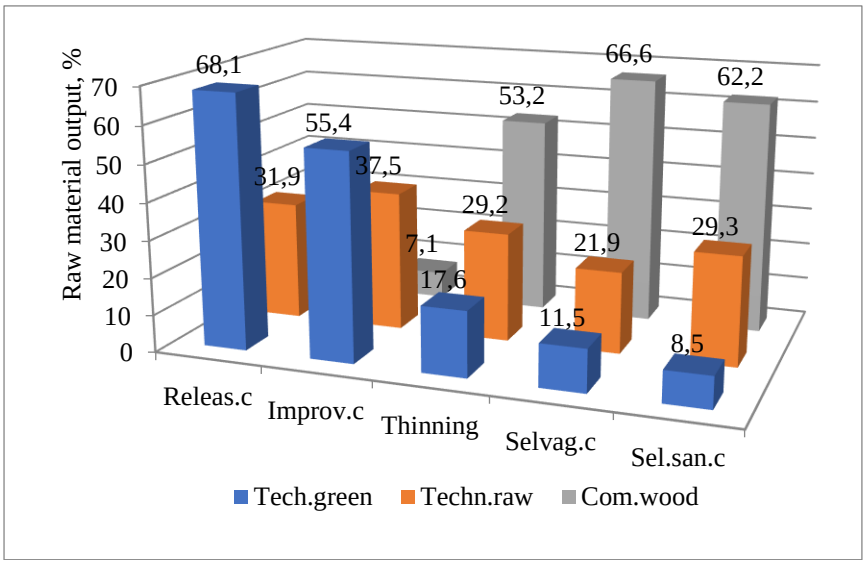
The results obtained to determine the volume and structure of harvested wood raw materials by type of cutting were as follows: In the process of release cutting (P-1 - P-7) of valuable species and improvement cutting (P-8 - P-15) of the young composition of future stands, the main mass of the raw materials was technical greens (55.4-68.1%) and small-dimensional wood in the form of small sticks (31.9-37.5%).

During thinning of plantings (P-16 - P-25), carried out in order to form stems trees of valuable species, there was a sharp increase in the output of commercial wood to 53.2% (7.5 times), in which a large category - 11.0%, medium -29.1%, small - 59.9%. At the same time, the output of technological raw materials remained at the level of 30%, and technical greens decreased to 17.6% (3.9 times).

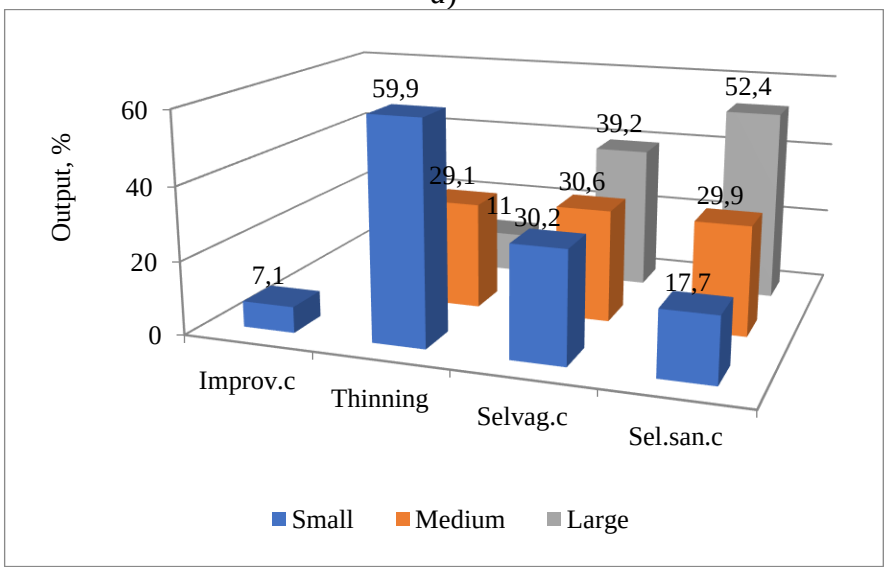
In the selvage cuttings (P-26-P-35), carried out in order to increase the growth of valuable species, the main mass of the harvested raw materials was commercial wood - 66.6%. By size category, it consists mainly of large wood (39.2%), and the output of medium and small wood were at 30%. The output of technological raw materials and technical greens decreased to 21.9% and 11.5%, respectively, compared to similar values in thinning.

Selective-sanitary cuttings (P-36-P-43) in the harvested raw materials were dominated by the output of commercial wood (62.2%), the lowest output was observed in technical greens (8.5%). The main mass of commercial wood was large (52.4%) and medium (29.9%) wood. The output of the technological raw materials was about 30%.

Analysing the obtained data, it can be noted that 508.16m3 (19.7m3/ha) wood raw materials were harvested in intermediate use cuttings. While the output of certain categories was: 53.1% (10.5 m^3/ha) - commercial wood; 28.0% (5.5 m^3/ha) - technological raw materials; 18.9% (3.7 m^3/ha) - technical greens. In turn, the total output of commercial wood was 269.88 m^3. The size categories are divided into large -38.6% (4.0 m^3/ha), medium - 29.6% (3.1 m^3/ha) and small wood -31.8% (3.3 m^3/ha) wood (Figure 1 *a*, *b*).



a)



b)

Figure 1. Distribution: a) – harvested volume by category of raw materials, b) - commercial wood by size categories.

The use of the obtained data removed the mathematical models showing an output of categories of wood raw materials depending on an age and also an output of commercial wood on categories of large-size depending on an age and a wood stock of plantings (table. 2)

From the derived mathematical models, it can be seen, between an age of plantings and to output of commercial wood and technological raw materials exists close connection. Since the value of the reliability of the approximation is more than 68% (R^2 = 0.774-0.880). and the connection of age with technical greenery is very weak (R^2 = 0.224). Between an age and a wood stock of plantings and with output of large and medium category of commercial wood rather close connection (R^2 = 0.745-0.874), with small wood - very weak is also observed (R^2 = 0.112-0.133). In this case, a great influence, for certain, features of selection and cutting of the chosen trees, a share and the pedigree list of a thin log in planting, etc. had on an output of small wood the size of stems and boughs (Yakhyaev, Safarova, 2015).

Table 2. Established mathematical models.

Name of category	Percent of output	Mathematical model	R^2	r
By categories of raw materials				
Commercial wood	53.1	$P_{com} = 0.135A – 3.839$,	0.881	0.938
Technological raw	28.0	$P_{tech/r} = 0.039A + 0.443$,	0.683	0.826
Technical greens	18.9	$P_{tech/g} = - 0.010A + 2.991$	0.224	-0.473
By size categories commercial wood				
Large wood	38.6	$P_{l.} = 0.088A – 4.736$,	0.847	0.920
		$P_{l.} = 0.047M – 3.588$,	0.874	0.935
Medium wood	29.6	$P_{m.} = 0.035A - 0.504$,	0.745	0.863
		$P_{m.} = 0.020M – 0.204$,	0.854	0.924
Small wood	31.8	$P_{s.} = - 0.009A+3.775$,	0.133	-0.365
		$P_{s.} = - 0.004M + 3.591$,	0.112	-0.334

P_{com}, $P_{tech./r}$, $P_{tech/g}$, P_l , $P_{m.}$, P_s – output of commercial wood, technological raw, technical green, large, medium, small wood, m^3; A – average age of plantings, year; M – stand volume of plantings, m^3. ha^{-1}.

As is known, the main goal of timber production in the world is to increase the volume of output of the products by 1 m3 of harvested raw materials (Grigoryev and Svojkin, 2011). In the forestry practice of our republic, on the example of our data, only 36.2% of the harvested total volume (508.16m3) of wood raw materials for the needs of the national economy in the form of large and medium wood is used. The remaining 63.8% raw materials in the form of small and low-quality wood and felling waste are either partially used for firewood, i.e. irrational, or burned or left for decay at all. On the other hand, in the existing technological bases in the Republic, this part of wood raw materials can be used in two directions: 1) for wood fibrous mass suitable for use in wood board production and bioenergy; 2) technical green mass suitable for obtaining a number of valuable biologically active products of therapeutic-preventive, fodder and other purpose. To mean, wood raw materials harvested during intermediate use cuttings in our forests are in demand, and there are prospects for its complex use in the Republic.

For this purpose we have developed a technological scheme of the wood - processing complex with the output of finished products (Figure 2). In this complex it is planned to organize the following production sites: sawing-parquet-tare; small tickers; technological spill; technical greens.

As raw material for the sawing-parquet-tare site is round timber with diameter of 16 cm and higher, length of more than 2 m. Here it is planned to produce standard lumber for woodworking and furniture industries, billets for the manufacture of parquet, agricultural boxes and pallets. In the small tickers site, it is planned to use thin log and low-quality round timber with a diameter of 6 to 16 cm and a length of more than 1 m. In this site it is planned to produce a wide range of strict and profiled lumber intended for the special market - Do it yourself (DIY).

The products of this group include parts and products for the design and arrangement of special purpose objects.

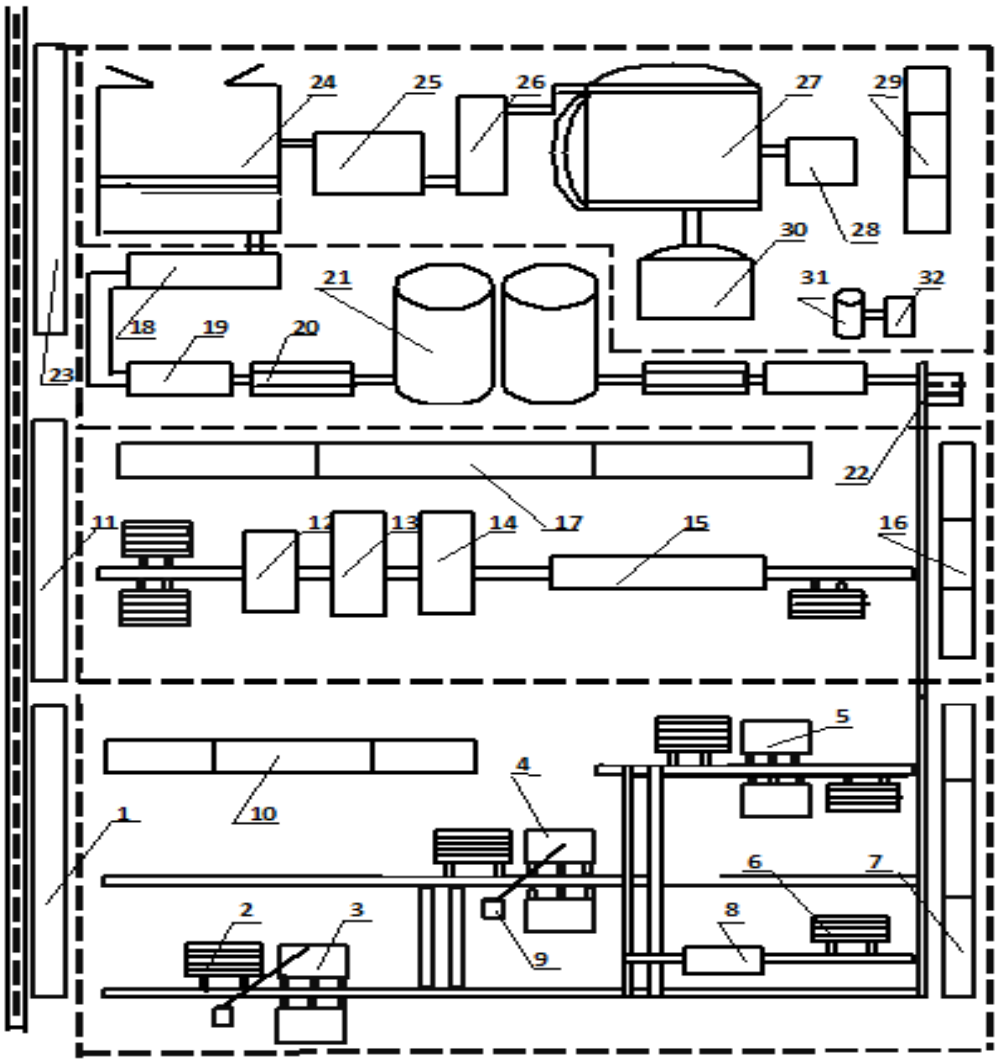


Fig. 2. Technological scheme of the wood-processing complex: 1 - commercial timber yard; 2 - a stack of round assortments; 3 - module of large-sized assortments of the 1st row; 4 - module of medium and short assortments of the II row; 5 - module of container blanks; 6 - lumber stack; 7 - lumber warehouse; 8 - lumber processing center; 9 - waste bin; 10 - auxiliary facilities; 11 - timber yard for small-sized and low quality wood; 12 - billet feeding module; 13 - module for generating explicit base surfaces; 14 - module for longitudinal dividing of a semi-finished product; 15 - ready lumber receiving module; 16 - workshop for the production of tickers; 17 – warehouse for tickers products. 18 - bunker for non-conditioned wood; 19 - chipper; 20 - sorting plant; 21 - bunker for chips; 22 - storage for the slab. 23 - green timber yard; 24 - separating plant of green mass and wood part; 25 - bunker of green mass; 26 - preparatory department of green mass; 27 - capacity for extracting green mass; 28 - bunker of green mass after extraction; 29 - capacity of the solution of the extracted substances; 30 - finished products warehouse; 31 - fuel waste bunker; 32 - gas generator.

Raw materials for the site of receiving technological spill are felling waste, waste of sawing and woodworking sites of a wood-processing complex, firewood and low-quality stem wood. The technological spill are planned to be used mainly in the production of wood boards. Branches up to 0.8 cm thick are used in the technical green processing site with leaves.

Products of technical greens as a natural product are intended to be used for industrial and agricultural purposes.

Discussion:

During the release cutting and improvement cutting technical greenery prevails in the structure of harvested wood raw materials in the volume of 0.729 t/ha, reaching a maximum value of 1.03 t/ha during the improvement cutting. And with subsequent types of care cutting, this indicator is slightly decreasing and stabilized (Table 1). This was mainly due to the timing of these cutting (by the autumn) and the age structure of these stands. A similar dynamics is characteristic of the concentration of technological raw materials, the maximum volume of which is formed during thinning (1.18 m^3/ha) and selvage cuttings (1.31 m^3/ha).

Carried out in the beech forests of the North Caucasus care cutting the mass of technical greens was similar to our indicators (Kotlyarov, 1989) and on the mixed (beech-spruce) forests of the Carpathian Mountains of Ukraine, the yield of technical greenery during release cutting and improvement cutting amounted to 1.51 t/ha and 3.22 t/ha, and in thinning and selvage cutting corresponded to our indicators. In these types of cutting, the yield of technological raw materials in the Carpathian forests was 1.24 and 2.29 m^3/ha, respectively. Both categories of wood raw material obtained in the Carpathian forests were mainly associated with the mixed composition, age structure and stand density of the young generation of these plantings (Kosyakov and Prokopchuk, 1979).

During the improvement cutting, commercial wood is obtained in a small category and in an insignificant volume (0.13 m^3/ha), and a sharp increase in this wood is observed in thinning (2.04 m^3/ha). This was due to care cutting in the second layer and on the upper canopy of plantings, where mainly small-sized trees and trees of medium and small numbers of large sizes are common.

With selvage cutting, an increase in the yield of commercial wood to 3.96 m^3/ha, including large-sized wood up to 1.55 m^3/ha, is explained relatively high age of plantings. During selective-sanitary felling, the predominance of commercial timber output (4.26 m^3/ha) was greatly influ-enced by the condition and size of damaged trees and the species composition of these plantings.

In our experience of forest care, 19.54 m^3 of raw wood were removed from one hectare of which commercial wood was 10.38 m^3/ha. Of this volume of commercial wood, 4.34 m^3/ha was classified as large, 3.08 m^3/ha of the middle category, which was associated with their purpose in the production of parquet products, small goods and in the arrangement of cultural and household facilities, the products of which are mainly characterized by small sizes and lower quality requirements (Yakhyaev, Safarova, 2015). Where as, in the North Caucasus, the volume of raw wood materials harvested during intermediate cutting amounted to 13.7-13.9 m^3, including commercial wood - up to 10 m^3 (Kotlyarov, 1989). In the Ukrainian forests, these indicators were respectively: 25-30 m^3/ha and 10-15 m^3/ha (Forest policy Ukraini, 2014).

As you can see, during care cutting, mainly large and medium categories of commercial wood are harvested, which is associated with the spread in the beech forests of the region of a sufficiently large number of trees of ripe and overmature age. This situation indicates that in the past, in the developed beech forests, care cutting was carried out not in a timely manner, and not in a high quality, which is typical for all forests in the region. This makes it necessary to develop and apply a comprehensive program for intermediate cutting in all forests of the Republic.

As noted above, in the Republic, 63.8% of timber harvested during intermediate cutting in the form of low-size and low-quality wood and felling waste are used partially and irrationally. This situation is also found in countries where timber production is poorly developed (Atik and Yilmaz, 2014; Obed, et al, 2020). On the other hand, the needs of the Republic for timber industry products are mainly provided through foreign delivery. In the last decade in the world market, prices for forest products, including beech, have a tendency to increase (Anna and Jan, 2020; Bouriaud, et al, 2019), which makes

the issue of the integrated use of wood raw materials harvested during intermediate cutting in our forests an urgent task. For this purpose, the technological scheme of the wood-processing complex developed by us includes four production sites that produce finished products for the domestic market (https://www.activestudy.info/ekonomicheskie-osnovy-rubok-uxoda-za-lesom/). When developing the technological scheme, we took into account the peculiarities of the raw material base, communications, market needs, a technological base in the republic for processing these categories of wood raw materials, as well as typical technological schemes in forestry practices of nearby regions (Yakhyaev and Abiyev, 2015). The wood-processing complex is planned to be located in the northern region of the Republic, where more than 100 thousand hectares of the region's forests will serve as a raw material base.

Conclusion:

1. It is established that, during cuttings of the intermediate use in beechen forests 19.7 m^3/ha of wood raw materials of which 10.5 m^3/ha commercial wood, 5.5 m^3/ha made technological raw materials and 3.7 m^3/ha of technical greens were harvested.
2. Mathematical models are obtained, describing the regularities of the output of categories of wood raw materials and commercial wood dependence on age and wood stock of plantings.
3. It has been established that about 2/3 of the harvested wood raw material belongs to low-quality wood and wood waste, which is partially used for firewood, and the rest is left for decay.
4. For the integrated use of harvested wood raw materials, a technological scheme of the wood-processing complex with the output of finished products has been developed, in which it is planned to organize the following production sites: sawing-parquet-tare; tickers; technological spill; technical greens.

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