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ABSTRACT

of the dissertation submitted for the degree of Doctor of Sciences

ECOLOGICAL AND FORESTRY FEATURES OF THE FORMATION AND USAGE OF BEECH STANDS OF THE GREATER CAUCASUS (GUBA FOREST DISTRICT)

Specialty: **2426.01 – Ecology**
Field of science: **Agricultural science**

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INTRODUCTION

The urgency of the problem. Solving the issues of the reproduction and efficient use of the forest resources of the republic, taking into account the ecological and forestry characteristics, the main task of the farms is to increase the sustainable development and productivity of the forests and to meet the demand for the forest products and benefits of the national economy.

Beech forests make up 36% of the forested areas in Guba forest region of the Greater Caucasus and 50% of the total wood reserves, they are also important by performing water retention, soil protection and other ecological functions[1].

However, intensive and in many cases, unsystematic fellings carried out in gross violation of technology, unregulated grazing and other anthropogenic factors have led to the extreme thinning of beech forests, the formation of numerous clearings in forest areas, and weakening of natural regeneration processes. The raw wood obtained from such fellings was used partially and irrationally[2]. The volume of regeneration work carried out on the areas was insignificant and these works were not carried out in a timely manner and everywhere. As a result, 48,8% of beech forests in the forest region have been transformed into low-density stands and in many cases beech and oak, valuable tree species have been replaced by derived hornbeam stands. At the same time, their soil-protecting, water-retaining and other beneficial ecological-forestry properties have also weakened[3].

In order to solve this problem, a comprehensive approach is required to study the modern state of beech forests of the Greater

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[1] Məmmədov Q.Ş., Xəlilov M.E. Azərbaycanı meşələri / Q.Ş. Məmmədov, M.E. Xəlilov, - Bakı: Elm, - 2002, - 472 s

[2] Əmirov, F.Ə. Azərbaycan Respublikasının meşələri və meşə təsərrüfatı /F.Ə. Əmirov, -Bakı: Azərnəşr,-1997.-192 s.

[3] Яхьяев А.Б. Антропогенная динамика лесных массивов северо-восточных склонов Большого Кавказа // А.Б. Яхьяев, - Баку: Труд. Инст. Ботаники НАН Азерб., т. XXVII , - 2007. – с. 98-104.

Caucasus, their formation processes and the effective use of natural resources, etc. In this direction, a number of orders of the President of the Republic of Azerbaijan, including the National Program[4] for the restoration and increase of forests and forested areas and the Comprehensive Action Plan[5] for the improvement of the ecological situation in the Republic, have been issued. In general, in recent years, many measures have been taken by the State to protect and restore forest resources. However, the positive changes observed in the regional forests have been very few, which is explained by the lack of consistency of the measures taken and not covering all areas. The dissertation work is dedicated to the development of a system of scientifically based measures for studying the issues of their formation and efficient use, taking into account the ecological and forestry characteristics of beech groves of the Greater Caucasus. For this purpose, ecological and forestry characteristics of beech forests were studied by setting up more than 252 experimental plots in four farms of Guba forest district in 1996-2018 and by recording 7821 m of taxation process. On the basis of the conducted field and camera works, the necessary indicators for the evaluation of the ecological-forestry characteristics of the beech forests of the region were obtained.

The object and subject of the research: Beech forests in 4 forestries of the Guba forest district of the Greater Caucasus (Gusar, Guba, Shabran, Gilazi) were accepted as the research object. The subject of the research is the development of more advanced complex measures for the study of their formation processes and

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[4]Azərbaycan Respublikasında meşələrin bərpa edilməsi və artırılmasına dair Milli Proqramm // Azərbaycan Respublikası Prezidentinin 2003 – cı il 18 fevral tarixli Sərəncamı ilə təsdiq edilmişdir. – Bakı: - 2003

[5]Azərbaycan Respublikasında ekoloji vəziyyətin yaxşılaşdırılmasına dair 2006-2010 – cu illər üçün "Kompleks Tədbirlər Planı" // Azərbaycan Respublikası Prezidentinin 2006 – cı il 28 sentyabr tarixli Sərəncamı ilə təsdiq edilmişdir. – Bakı: - 2006.

usage characteristics based on the study of the vital conditions of beech trees in this region.

The subject of the research is the development of more advanced complex measures for the study of the formation processes and usage characteristics of beech stands based on the study of the vital conditions and appropriate evaluation of the beech stands of this region.

Purpose and objectives of research. The main goal of conducting research is to study the ecological-forestry properties of the formation processes of beech forests of the Greater Caucasus, increase their productivity and sustainable development. The research to be carried out for this purpose is aimed at solving the following issues:

- to study ecological-forestry features of age and size structure and annual growth of beech stands;
- to study ecological and forestry features of natural regeneration process of beech forests under the canopy and in clearings;
- to study ecological and forestry features of the qualitative variability of beech stands and stem wood;
- to determine ecological and forestry features of cleaning and regeneration felling in derived hornbeam and beech-hornbeam stands;
- to determine ecological and economic features of the efficient use of wood raw materials obtained from intermediate use fellings.

Research methods: Head-to-head counting of trees in the research area, mainly in experimental areas; methods of studying the effects of forest types, forest growing conditions and ecological factors on regeneration processes; method of determining the quality of tree stands, methods of recovery of natural beech groves by means of cleaning and complex fellings; mathematical-statistical methods and etc. were used.

The main provisions of the dissertation submitted for defense:

- Ecological and forestry features of the age and size structures and growth dynamics of beech stands in Guba forest region;

- Ecological and forestry features of natural regeneration processes under the canopy and in clearings of beech forests and technology of creation of beech plantations in the region;
- Ecological and forestry features of the qualitative state of beech stands and stem wood, as well as the material and commodity assessment of their wood reserve;
- Ecological and forestry features of improving cleaning and regeneration felling systems to be held in beech forests;
- Forestry and economic features of complex use of wood raw materials supplied from beech forests of the region.

Scientific novelty: On the basis of the conducted ecological-forestry-taxation studies, for the first time we have established:

- Disturbed, natural and virgin stands are distributed in beech forests of Guba forest region, which are also related to the relative-multiple-aged and cyclic-multiple-aged types of age structure;
- Successful natural regeneration of beech stands occurs: under canopy of stand at 0,60-0,75 crown closure; in clearings up to 25 m from the forest wall, the presence of subsidiary species in the composition of regenerated stands increases with the change of these conditions;
- As the forest growth conditions deteriorates from D_{2-3} to C_{1-2}, the quality of beech stands degrades and the degree of damage decreases from healthy to very weak category as well as with an increase in age over 240 years, useful output of commercial wood from trunks affected by fungal diseases decreases by 62,7%;
- It is possible to regenarate natural beech groves of the region by applying 2-4 times cleaning and combined individual and group selection fellings in derived hornbeam and beech-hornbeam stands;

Practical relevance. The practical relevance of the dissertation work consists of the following:

- in economic activities, the determination of age (with a 60-year rank) and size (with a diameter of 20 cm) boundaries of beech trees by age generations in four ranges;

- in compilation of a table of the growth course of beech stands by quality and forest types in 100-240 year old age limits;
- in development of technology for creating beech plantations in mountainous conditions with methods of sowing and planting;
- in compilation of the assortment and commodity table of the wood reserves of beech stands;
- in the development of an improved program for cleaning fellings and a system for regeneration fellings to be implemented in beech stands;
- in selection of technological schemes and appropriate machine systems to be applied for cleaning and combined individual and group selection fellings in beech stands;
- in development of map-scheme of the location of points for the collection, transportation, primary processing of wood raw materials supplied in beech stands and technological scheme of complex processing enterprise for transformation of this raw material into finished product.

Realization of research results. The main results of the dissertation work were used in development of a system of activities in the farms of the region and programs to increase the sustainability and productivity of beech stands, including in forest inventory.

The developed methodological approaches were used in the development of growth tables of beech stands and tables for material assessment of their wood raw materials and commodity structure as well as program for the rational use of supplied raw wood.

Technologies developed for creating beech plantations, programs for cleaning felling and systems for regeneration felling, technologies for felling operations with appropriate machine systems, maps for the collection and delivery of wood raw materials, as well as technological schemes for processing wood raw materials with the release of finished products in the farms of the Guba forest region of Greater Caucasus are accepted for the implementation.

On the basis of research materials, methodological guidelines such as “On conducting cleaning fellings in beech forests”, “On the creation of oriental beech plantations in the Greater Caucasus” were developed and

presented to the farms of the region. The research materials were also used by the author in the preparation of textbooks entitled "Fundamentals of Forestry" and "Supply of Forest Materials".

Approbation of work. The main provisions of the dissertation work were presented in a number of republican and international conferences (Baku 2001, 2005, 2013, 2016, Tbilisi 2013, Bishkek 2014, Moscow 2014) and scientific-practical (Baku 2010, 2016) conferences, as well as at the scientific seminars of the Central Botanical Garden of ANAS (2014- 2017) and Forestry Scientific Research Institute of MENR (2010-2016).

Published works. On the basis of the materials of the dissertation work, 48 scientific works, including 38 scientific articles, 10 theses materials were published.

The name of the organization where the work is performed: Azerbaijan University of Architecture and Construction.

Scope and structure of work. The dissertation consists of 370 pages, an introduction compiled with the author's research results, 8 chapters, 24 figures, 79 tables, general results and recommendations, including 574867 thousand signs and a list of literature with 326 titles and appendices. In the additional part of the dissertation, the classification scheme of tree plants, as well as the species composition of trees and tree-shrub plants distributed in the Guba mountain massifs are provided.

GENERAL CHARACTERISTICS OF THE WORK

Chapter I. Natural conditions of the Guba forest region of the greater caucasus

This chapter provides a description of the main elements of the zoning classifications of the region's relief and forests. According to the above classifications, the region belongs to the Guba forest district of the

Greater Caucasu[67]. The forest fund of this region is 130426 ha, of which 116912 ha are forested areas, and beech forests make up 36% (42088 ha) of this area. The map-scheme of Guba forest district is given in figure 1.

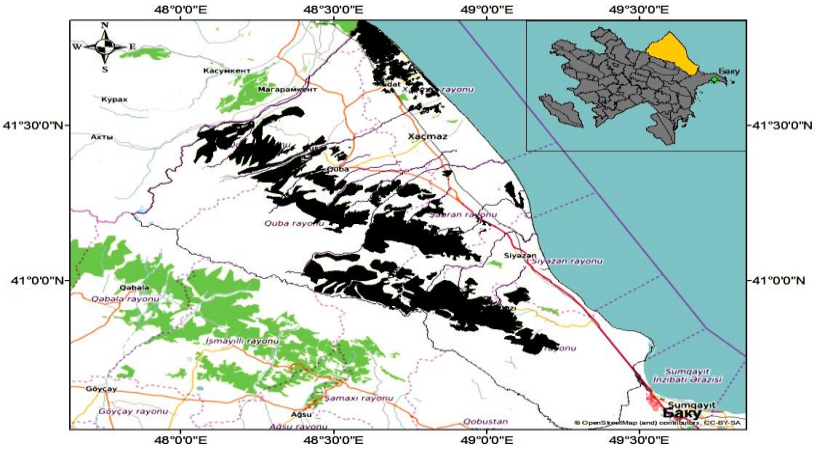

Fig. 1. Map-scheme of the Guba forest region of the Greater Caucasus

The description of the hydrological conditions of the given district gives the main characteristics of the glaciers[8] and snow cover of the region, the density of the hydrological network and the hydrological indicators[9]of the main rivers of the region. In this part, according to the region's climatic conditions, the characteristics of the climate types and moisture zones[10] in the region, as well as the average annual temperature, the total of positive temperatures in the year, air humidity and

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[6] Прилипко, Л.И. Лесная растительность Азербайджана / Л.И. Прилипко, - Баку: Изд-во АН АзССР, - 1954. - 488 с.

[7] Сафаров И.С., Олисаев В.А. Леса Кавказа: Социально-экологические функции / И.С. Сафаров, В.А. Олисаев, – Владикавказ: ИР, - 1991. – 270 с

[8] İsmayılov F.M., İsmayılov F.F. Azərbaycanda melorasiya və su təsərrüfatı tikintiləri / F.M. İsmayılov, F.F. İsmayılov, - Bakı: Təhsil NPM, - 2009. 560 s.

[9] Рустамов С.Г., Кашкай Р.М. Водные ресурсы Азерб. ССР / С.Г. Рустамов, Р.М. Кашкай , - Баку: Елм, - 1989. – 184 с.

[10] Эйюбов А.Д., Гаджиев Г.А. Климатические запасы Азерб. ССР / А.Д. Эйюбов, Г.А. Гаджиев, - Баку: Элм, - 1984. – 132 с.

atmospheric precipitation indicators were recorded. It was determined that climatic factors shall be changed in the following limits for the normal development of oriental beech in its natural habitat:

dryness factor – 0,8-2,4; amount of precipitation – 400-1000 mm; duration of the vegetation period – 131-248 days; average annual temperature – 7-13^{0}C; sum of positive temperatures per year – over 800 hours; humidity coefficient Md – more than 0.45.

Mainly mountain-forest brown soils are spread under the beech forests of the Greater Caucasus. These soils are mainly divided into the following subtypes due to the variety of ecological and geographical conditions in which they are spread: unsaturated brown mountain-forest soils; typical brown mountain-forest soils; residual carbonaceous brown mountain-forest soils; steppe brown mountain-forest soils. Diagnostic indicators[11] of these soils are given in the dissertation.

In the forests of the research region 58 species of trees, 109 species of shrubs, and 5 species of semi-shrubs are distributed, which are mainly formed in the lower, middle and upper mountain-forest zones[12]

Chapter II. Forestry-ecological characteristics of oriental beech and beech forests of Guba forest region and their economic importance

This chapter contains materials about the origin[13] of the oriental beech, its distribution in the region, and bioecological characteristics. The description of forest growth conditions of oriental beech was carried out according to the types of forests distributed in the research region. The

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[11] Бабаев М.Р. Современная классификация почвы Азербайджана / М.Р. Бабаев, - Баку: Элм, - 2006. – 340 с.

[12] Əsədov K.S., Məmmədov F.M., Sadıxova S.Ə. Böyük Qafqazın şimali-şərq hissəsinin dendroflorası və meşələri / K.S. Əsədov, F.M. Məmmədov, S.Ə. Sadıxova, - Bakı: BDU, - 2008. – 274 s

[13] Гросгейм А.А. Растительный покров Кавказа / А.А. Гросгейм, - Москва: Изд. Моск. общ-ва испыт. природы, - 1948. – 265 с.

forestry-taxation characteristics[14] of beech forests are compiled according to the plans-projects of the farms of the forest district given in the form of a table. In the description[15] of the economic importance of beech forests, it has been shown that they play a major role in maintaining the ecological balance in nature due to their high environment-forming capacity, as well as in meeting the demand for wood raw materials of the national economy

Chapter III. Program, objects and methodology and experimental materials of researches

Studies were conducted in 4 farms of Guba forest district in 1996-2018. During the expeditions, 252 ecological-forestry records of beech forests were carried out in field and cameral conditions.

In the course of the expeditions, the generally accepted methodology for taxation accounting[16] of forests, the methodology for studying forest regeneration processes[17], the methodology for determining the vital conditions[18] of tree stands, and the methodology for carrying out intermediate fellings were basically applied

Type machine systems used in mountainous conditions for the design of the machine system applied in felling work and typical technological schemes in the development of the technological scheme of the complex processing enterprise[19].

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[14] Təsərrüfatların 1988-2003 – cü illər üçün Plan-Layihələri / - Bakı: ETEN – nin Meşə quruluşu idarəsi,-2003. – 186 s.

[15] Яхьяев А.Б. Об использовании древесного сырья лесов Азербайджана // А.Б. Яхьяев, - Баку: Труды Инст. Ботаники НАН Азерб., т. XXV, - 2004. – с. 118-122 .

[16] Анучин Н.П. Лесная таксация / Н.П Анучин, - Москва: Лесн. пром-сть, - 1982. – 552 с.

[17] Калуцкий К.К., Мальцев М.П., Молотков П.И. Буковые леса СССР и введение хозяйства в них / К.К. Калуцкий, М.П. Мальцев, П.И. Молотков, - Москва: Лесн. пром-сть, - 1972. – 198 с.

[18] Алексеев В.А. Диагностика жизненного состояния деревьев и древостоев // В.А. Алексеев, - Москва: Лесоведение, - 1989. №4, - с. 51-57.

[19] Смелевский К. Что можно сделать из отходов // К. Смелевский , - Москва: Дерево RU деловой журнал по деревообработке, - 2011. №1, - с. 90-94

Chapter IV. Ecological-forestry characteristics of the structure, annual growth and productivity of beech stands in the Guba forest region

In this chapter, the research results of the ecological-forestry characteristics of the structure, annual growth and productivity of the beech stands of the Guba forest region are provided.

Ecological and forestry features of the age structure of beech stands. It was determined that, depending on the ecological and forestry features of the beech stands distributed in the Guba forest region, their ages vary in the ranges of 41-300 years and 101-420 years, and according to the classification scheme for types of age structure, they belong to multiple-aged stands, the generations of which vary in groups[20]. However, the differences in the composition and formation processes of these forest areas manifests itself in different ways in the structure of taxation. Thus, the age of trees in a natural thickness class of 48 cm varies from 81 to 300 years, and the diameter of trees in X age class varies from 16 cm to 68 cm. The same situation is observed in other thickness and age classes.

Considering the forestry-biological features of oriental beech in the dissertation, the distribution of the total number of trees by age generations and diameter groups can be presented as follows[21]:

- ***by age generations*** - undergrowth (3-60 age) – 21,7 %; young (61-120 age) – 34,2 %; in ripening (121-180 age) – 25,5 %; mature (181-240 age) – 14,0 %; overmature – more than 240 years old – 4,6 %.

- ***by diameter groups*** – I group – chest diameter more than 68 cm

[20] Яхьяев А.Б., Халилов Е.В., Бадалов Г.А. Практика и особенности выделения возрастных групп в изучении структуры буковых древостоев // А.Б. Яхьяев, Е.В. Халилов., Г.А. Бадалов, - Баку: Экоенергетика. Науч.-техн. Журнал, - 2011. №4, - с. 35-45.

[21] Яхьяев А.Б., Мамедова Г.А., Меликов А,А. Возрастная структура буковых древостоев северо-восточных склонов Большого Кавказа // А.Б. Яхьяев, Г.А Мамедова, А,А. Меликов, - Баку: Изв. НАН Азерб., сер. биол. науки, т. 66, - 2011. № 3, - с. 112-116.

(2.1%); II group – 48-64cm (11,5 %); III group – 24-44cm (27,9 %); IV group – 8-20 cm (58,5 %).

Ecological and forestry features of the age structure of beech stands of different categories. The results of the study are shown in Table 1. As can be seen, although all the studied stands are multiple-aged, the amplitude of their age fluctuations is not the same and depends on the age of the stand and forest types and also differ in the altitudinal distribution in the mountain slopes. Thus, despite the fact that the average age of stand in sq. 15 is 50 years, the fluctuations of trees ages were from 21 to 180 years. Similarly, average age in sq. 55 was 122 years, and fluctuations in age changed from 41 to 340 years. Of the stands studied, the lowest multiple-aged was recorded in the stands distributed in sq.15 and sq.123. The maximum number of trees in these stands falls on age classes III and IV, respectively. The wider amplitude of age fluctuations was observed at sq.55. The maximum number of trees in this stand falls on age class VI. The amplitude of age fluctuations was 1-18 years in young stands, 15-50 years in middle-aged stands, and 20-116 years in ripening and mature stands[22].

The distribution ranges of tree ages by natural thickness classes were as follows on quarters: qr.15 - 0,5-2,6; qr.27 - 0,3-3,8; qr.30 - 0,4-3,2; qr.55 - 0,4-2,8; qr.123 - 0,5-3,4. Variation value of tree ages in the studied forest area was v = 27 - 38 % in forb forest types, v = 51 - 57 % in fern covered forest type.

As a result of the research, it was determined that modern beech forest areas of Guba forest region consist of 40-50% - disturbed, 30-40% - natural and 10-20% - virgin stands according to the degree of thinning. According to the distribution area relative-multiple-aged stands

[22]Яхьяев А.Б. Возрастная и размерная структура буковых насаждений северо-восточных склонов Большого Кавказа // А.Б. Яхьяев, - Баку: Ландшафтная архитектура в ботанических садах и дендропарках. Матер. V межд. конф., - 2013. – с. 323-332

predominate in disturbed and natural beech forest areas, and cyclic-multiple-aged ones in virgin forest areas[23].

Table 1

Age structure of beech stands

Age classes	Number of trees by quarters, %												Age generations
	Sq. 15		Sq. 27		Sq. 30		Sq. 55		Sq. 123		general		
	pcs	%	pcs	%	pcs	%	pcs	%	pcs	%	pcs	%	
II	34	36,3	68	5,2	92	11,6			166	30,6	360	11,5	
III	22	23,6	139	10,6	130	16,3	18	4,8	120	22,0	429	13,7	72,0% young
IV	16	17,4	239	18,2	186	23,4	45	11,7	89	16,3	575	18,4	
V	10	12,2	265	20,2	123	15,4	70	18,3	56	10,3	524	16,8	
VI	5	5,3	184	14,0	85	10,6	48	12,5	39	7,2	361	11,6	
VII	1	1,2	126	6,6	35	4,3	15	4,0	20	3,7	197	6,3	19,5% in ripening
VIII	3	3,1	102	13,6	72	9,1	49	12,7	37	6,9	263	8,4	
IX	1	0,9	76	6,0	30	3,8	33	8,6	11	2,1	151	4,8	7,3% mature
X			52	4,0	34	4,3	24	6,2	5	0,9	115	3,7	
XI			37	2,9	9	1, 2	30	7,7			76	2,4	
XII			16	1,2			20	5,3			36	1,2	1,2% overmature
XIII			6	0,5			11	3,0			17	0,5	
XIV							14	3,5			14	0,4	
XV							5	1,2			5	0,2	
XVI							-	-			-	-	
XVII							2	0,5			2	0,1	
Total:	92	100	1310	100	796	100	384	100	543	100	3125	100	

Ecological and forestry features of the size structure of beech stands.

Structure of beech stands by diameter. According to the results of the research (Fig. 2), it was determined that as the age structure of beech stands becomes more complex from relative-multiple-aged to cyclic- multiple-aged, the place of the mean tree shifts from 0,5-0,6 to 0,9-1 towards large-sized trees on natural thickness class. With an increase in the diameter of the mean tree, the range of distribution row of trees by thickness: decreases from 0,4-3,3 natural distribution row by thickness in low-density and relative uneven-aged stands with an average diameter of 12-20 cm to the 0,4-1,8 natural distribution row by thickness

[23] Яхьяев А.Б. Строение буковых древостоев северо-восточных склонов Большого Кавказа // А.Б. Яхьяев, - Баку: Труд. ЦБ Сада НАН Азерб., т. VIII, - 2011. – с. 185-193

in middle-density and cyclic uneven-aged stands with an average diameter of 48-56 cm[24].

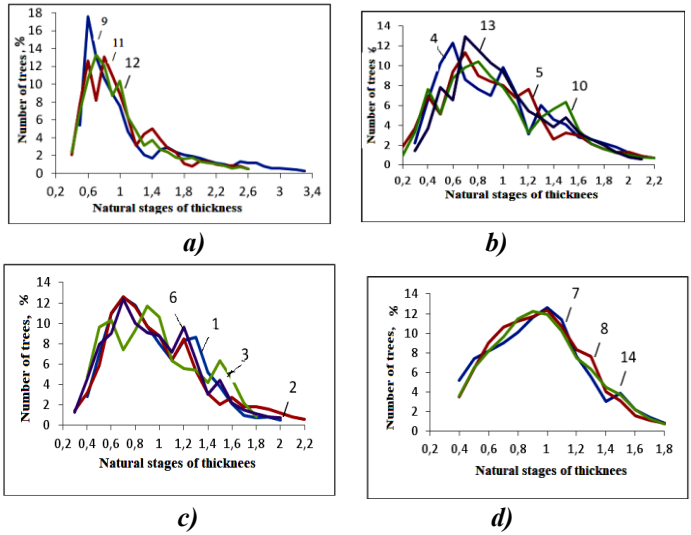


Fig. 2. Distribution of trees on natural thickness classes: a) in young stands with an average diameter of 12-20 cm; b) in middle-aged stands with an average diameter of 24-32 cm; c) in ripening stands with an average diameter of 36-44 cm; in mature stands with an average diameter of 48-56 cm; 1-14 – order number of experimental plots.

It was determined from the calculations that a greater number of trees was concentrated in the central natural thickness classes (0,7-1,3) in comparison with the outer classes. Coefficient of variation of the number of trees in the central classes: decreases from 38,6-45,4% in relative-multiple-aged young stands with an average diameter of 12-20 cm to 16,9-25,5% in cyclic-multiple-aged mature stands with an average diameter of 48-56 cm. It was determined that the place of the mean tree is

[24] Яхьяев А.Б., Мустафаев М.Г., Рефили Ш.Ф. Строение буковых древостоев по толщине // А.Б Яхьяев, М.Г. Мустафаев, Ш.Ф. Рефили, - Баку: Прогресивные технологии в области архитектуры, строительства и транспорта, Матер. науч.-прак. конф., - 2016. – с. 82-88

located in the range of 57,6 - 59,6% of the thinnest thickness class, respectively, according to the specified diameter groups and age types.

The distribution of trees by shown diameter groups and natural thickness classes of age generations is expressed by equations of dependence of the third degree. The equation of constraints of distributions and their main statistical indicators are presented in Table 2.

Table 2

Equation of constraints and statistical indicators of distribution rows of beech trees by diameter

Diameter groups, cm	Equation of dependence	R^2	Mean values		
			A	E	v %
12-20	$У_{c.} = 2{,}71x^3 - 12{,}80x^2 + 13{,}17x + 4{,}37$	0,680	+ 1,46	+ 0,98	45,2
24-32	$У_{ory} = 8{,}61x^3 - 37{,}18x^2 + 43{,}11x - 6{,}11$	0,932	+ 0,81	+ 1,22	46,4
36-44	$У_{y.o} = 21{,}47x^3 - 86{,}59x^2 + 100{,}07x - 24{,}24$	0,961	+ 0,19	- 0,29	42,1
48-56	$У_{y} = 16{,}27x^3 - 67{,}02x^2 + 77{,}55x - 16{,}83$	0,880	- 0,08	- 1,42	40,7

It was determined that with an increase in the average diameter of stands, the kurtosis of the distribution row decreases from (+0,98) in low-density young stands with an average diameter of 12-20 cm to (-1,42) medium-density mature stands with an average diameter of 48-56 cm. The asymmetry of these stands by diameter groups and age generations also decreases from +1,46 to –0,08 respectively.

Structure of beech trees in height. The structure of stands by height was studied by determining the correlation between the diameter of beech trunk and their height (Fig. 3).

The distribution of beech trees in forests by their height is distinguished by their diversity in different ages and diameter groups. During the experiments, the fluctuation range of the height rows of tree by the thickness class was as follows: 0,5-1,8 in low-density stands with an average diameter of 12-20 cm, 0,3-1,5 in low-density stands with an average diameter of 24-32 cm, 0,5-1,3 in middle-density stands with an average diameter of 36-44 cm, 0,7-1,2 in middle-density stands with an average diameter of 48-56 cm.

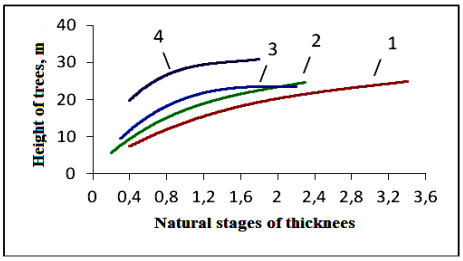


Fig. 3. Distribution of beech trees on height rows in natural thickness classes:1 – in young stands with an average diameter of 12-20 cm; 2 – in middle-aged stands with an average diameter of 24-32 cm; 3 –in ripening stands with an average diameter of 36-44 cm; 4 – in mature stands with an average diameter of 48-56 cm.

The equation of constraints of distribution of trees by height rows with corresponding relative diameters and the main statistical indicators of these relations are given in Table 3.

Table 3

Equation of constraints of distribution rows of beech trees by height and their statistical indicators

Diameter groups, cm	Equation of constraints	R^2	Mean values		
			A	E	v %
12-20	$У_c = 0{,}45x^3 - 4{,}20\ x^2 + 15{,}87\ x + 1{,}71$	0,998	- 0,68	- 0,66	26,1
24-32	$У_{or.y} = 1{,}49\ x^3 - 9{,}33x^2 + 23{,}71\ x + 1{,}33$	0,999	- 0,74	- 0,55	32,2
36-44	$У_{y.o} = 2{,}40\ x^3 - 15{,}15\ x^2 + 31{,}88\ x + 1{,}22$	0,999	- 1,25	+ 0,56	19,2
48-56	$У_y = 5{,}79x^3 - 26{,}51\ x^2 + 42{,}31\ x + 6{,}80$	0,999	- 1,23	+ 0,71	11,5

In young stands, the amplitude of height fluctuations on 0,4-1,0 natural thickness classes varied within 1,4-0,8 m, and in classes 1,1-1,8 within 0,8-0,2 m. In mature stands, these indicators were 1,2-0,7 and 0,5-0,2 m, respectively. The coefficient of height variation in these stands varied from 11,5% to 32,2%.

Ecological and forestry features of growth and productivity of beech trees.

Growth features of beech stands. Low- and medium-density beech stands are widespread in the Guba forest region, and their period in the first tier ends at the age of 100-120. Therefore, in order to compile experimental growth tables of beech stands, the age limit of stands in the region has been accepted as 100-240 years.

Graphs for height growth of beech stands distributed in fern, dead

and grass-covered forest types were established (Fig. 4). This allowed us using materials from stands of adjacent forest types with the same quality in terms of productivity in compiling growth tables.

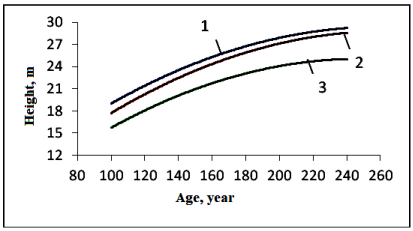


Fig. 4. Growth curves of beech stands in II quality class by average heights: 1 – in fern covered beech groves; 2 – in dead covered beech groves; 3 –in grass covered beech groves

The growth tables compiled for stands with II and III quality class on forest types are given in Table 4,5 of the dissertation work. Calculation of elements in the compilation of growth tables was carried out in accordance with the methodical instructions of N.P.Anuchin (1982) and N.I.Ismayilov (2011)[25].

Annual growth characteristics of beech stands. The calculation of annual growth is based on determining the volume of the trunks of trees of different ages by 10-year periods or by age classes. The current annual growth of trees by volume (n+10) was calculated by the following formula in the age interval.

$$Z^{car} = \sum G(Hf) - \sum g(hf),$$

here Z^{car} – annual growth of stand by volume, m^3; $\sum G$, $\sum g$ – the sum of the cross-sectional areas of the trees in the different thickness classes now and n years ago; *(Hf)* and *(hf)* – form height of the trees in the thickness classes, now and n years ago.

The calculation of the average annual quantities of current annual growth of beech stands by forest types is given in Table 4 in age groups.

[25] İsmayılov N.İ. Azərbaycan Respublikası ağac cinslərinin həcm cədvəlləri / N.İ. İsmayılov, - Bakı: ETSN, - 2011. c. I, - 242 s

Table 4

Calculation on current annual growths of beech stands by forest types

No. experiment field	Age groups of trees												Total in 1 ha		
	young			In ripening			mature			overmature			annual growth		growth power (P_v)
	annual growth		growth power (P_v),	annual growth		growth power (P_v)	annual growth		growth power (P_v)	annual growth		growth power (P_v)			
	m^3	%		m^3	%		m^3	%		m^3	%		m^3	%	
In beech groves with grass cover															
1	0,815	12,9	3,15	3,59	56,8	1,74	1,69	26,7	1,13	0,23	3,6	0,64	6,33	100	2,10
2	1,99	35,9	3,05	2,78	50,2	1,75	0,77	13,9	0,89	-	-	-	5,54	100	2,50
3	1,68	27,0	2,82	2,79	44,8	1,94	1,69	27,2	1,57	0,06	1,0	1,04	6,22	100	1,96
mean value	1,65	29,0	3,07	3,12	51,6	1,79	1,49	24,0	1,22	0,19	3,0	0,73	5,95	100	2,26
In beech groves with fern cover															
4	0,06	1,6	2,90	1,41	37,6	1,65	2,06	54,9	1,23	0,22	5,9	0,66	3,75	100	1,48
5	0,07	1,9	3,35	0,90	25,2	1,99	2,25	62,8	1,48	0,36	101	0,75	3,58	100	1,70
6	0,63	17,1	3,13	1,50	40,8	1,98	1,55	42,1	1,24	-	-	-	3,68	100	2,18
mean value	0,57	15,5	3,13	1,39	37,7	1,90	1,97	53,8	1,32	0,30	8,4	0,71	3,68	100	1,90

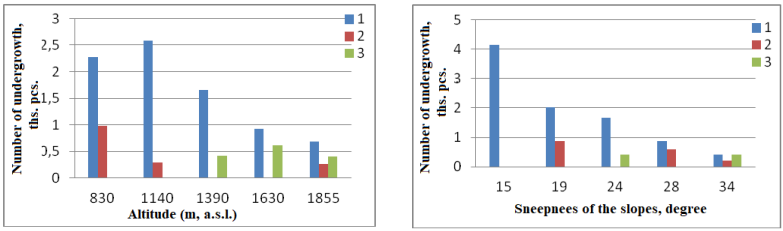
As can be seen from the values in Table 4, the current annual growth of stem wood (Z^{car}) is 6,33 m^3/ha in beech groves with grass cover and 3,75 m^3/ha in beech groves with fern cover. This shows that the current annual growth is directly dependent on the ecological and forestry features of the stand. The lowest annual growth was recorded in the overmature part of the stands. The obtained values allow to estimate the annual growth of the indicated age groups in terms of growth energy (P_v). With increasing age in beech forests with grass cover, the current annual growth increases first in the group of young stands (1,65 m^3/ha) and middle-aged (3,12 m^3/ha), and then gradually decreases to 0,19 m^3/ha in the group of overmature trees[26].

[26]Яхьяев А.Б. Прирост и отпад буковых древостоев северо-восточныхсклонов Большого Кавказа // А.Б. Яхьяев, - Баку: Труд. ЦБ Сада НАН Азерб., т. X, - 2012. № 1, – с. 76-82

Chapter V. Ecological-forestry characteristics of regeneration processes of beech groves of Guba forest region

This chapter presents the results of research on ecological and forestry features of regeneration processes in beech stands of Guba forest region.

Impact of ecological factors on reforestation processes. In this study, the issues of natural regeneration of beech forest stands were studied depending on the height of their distribution areas, steepness and exposure of the slopes. Studies have shown that the number and quality characteristics of beech undergrowths, which are formed by the increase in altitude from 830 m to 1855 m above sea level, also change[27]. Thus, the total number of undergrowths decreases 2,4 times, the presence of beech in their composition from 90% to 50%, and the presence of other species - mainly mountain maple and oriental oak - increases to 50% (Fig. 5). It was found that in such conditions, the average diameter of the root collar of undergrowths increases by 19,8%, while the average height, on the contrary, decreases to 23,0%.



a ***b)***

Fig. 5. Changes in the number of undergrowths depend*i*ng on the height distribution above sea level (a), the steepness of the slopes (b): 1 - beech; 2 - hornbeam; 3 - other species

[27] Садыхова С.А., Сафарова Е.П., Яхьяев А.В. Возобновление букняков северо-восточных склонов Болшого Кавказа // С.А. Садыхова, Е.П. Сафарова, А.В.Яхьяев, - Баку: Труды Инст. Ботаники НАН Азерб. т. XXXV, - 2015. – с. 80-85

In order to study the regeneration processes in the beech forests of the study area depending on the steepness and exposure of the slopes, experiments were carried out on the slopes increasing from 15^0 to 34^0 by steepness and in beech groves distributed in the northern and north-eastern exposures. The results of research show that the total number of undergrowths in all types of forests and exposures with an increase in slope inclination, decreases by more than 4 times, which is explained by the deterioration of soil and hydrological conditions of these forest stands. The highest number of undergrowths is observed in the north-eastern exposure and on slopes with a steepness of up to 15^0. It was found that as the steepness of slope increases, the share of beech in the composition of undergrowth decreases to 40%, and on such slopes, large specimens of beech predominate.

Influence of coenotic factors on regeneration processes. The results of experiments conducted in the research area (Figure 6) show that the number of undergrowths in beech forests with a density of 0,2-0,3 is gradually increasing. This trend is gradually decreasing in forest areas with a density over 0,55-0,60. In forest areas with a density of 0,65 and above, a sharp decline[28] in beech undergrowths is observed. It has been established that natural regeneration is better in medium-density (0,45-0,60) beech forests in which canopy closure degree varies in the range of 0,60-0,70.

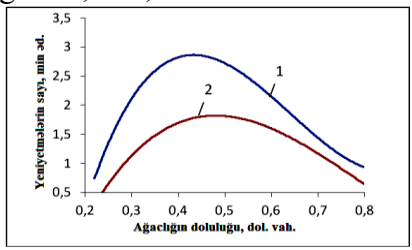


Fig. 6. Changing the number of undergrowths depending on the density of forest areas: 1 - the total number of undergrowths; 2 - number of beech undergrowths

[28] Яхьяев А.Б., Халилов Е.В. Влияние ценотических факторов на возобновительные процессы букняков Большого Кавказа // - Баку: Аграрная наука Азербайджана, - 2015. № 4, - с. 91-94

The rate of illumination of the tiers under the canopy has a great impact on the course of natural regeneration in beech forests. The average of illumination under the canopy is about 500-600 lux, which allows the process of photosynthesis to continue. On the other hand, the inequality of the canopy closure degree in the stands leads to alternating (2-3 hours) – flecking illumination, as a result of which the illumination under the canopy increases to 2-3 thousand lux. This, in turn, allows undergrowths in the forest area to develop in the medium illumination conditions created under an canopy. At the same time, it was determined that under the canopy of beech forests with a density of 0,45-0,60, illumination conditions are created that ensure the intensive development of undergrowths.

Regeneration of beech forests depending on forest type. Important indicators of natural regeneration under the canopy of beech forests and in the felling areas include the number of undergrowths and their distribution in the area. The best natural regeneration in terms of the number of undergrowths in the beech groves of Guba forest region was recorded in the pure and mixed beech groves distributed in humid umbrella-leaved- forb and dead-cover forest types. The number of undergrowths of different ages in these forest areas varies from 2,5 to 3,4 thousand pcs./ha, which is considered successful for the natural regeneration of beech groves and their sustainable development.

The weakest natural regeneration in the beech forest areas of this region is recorded in pure and mixed beech groves distributed in wet forest types with fern cover as 1,3-1,7 thousand pcs./hectare. This is explained by physiological dryness of soils in the specified forest growing conditions, as well as the continuance of drought in the second half of summer[29]. In dry beech groves with grass cover, natural regeneration

[29] Гурбанов Е.М., Яхьяев А.Б., Сафарова Э.П. Возобновление букняков Большого Кавказа в зависимости от типа леса // - Баку: Вестник Бакинского Университета. сер. ест. науки, - 2016. №1, - с. 94-102

(1,8-2,2 thousand pcs./ha) was found to be relatively weak. The low-density of the studied forest areas (0,45-0,55) promotes better regeneration and development of the hornbeam, which in turn leads to the formation of hornbeam and beech-hornbeam derived trees in the region.

The vital conditions of undergrowths in the process of natural regeneration are assessed mainly by the number of reliable specimens in the forest area. In the studied forest areas, undergrowths of such categories range widely: from 0,04 thousand pcs./ha in subalpine forest types, to 2,5 thousand pcs./ha in umbrella-leaved-forb forest types. The typological determination of reliable categories of beech undergrowths confirms that the best regeneration supply is occupied by umbrella-leaved-forb and dead-covered beech groves up to 1,1-2,5 thousand pcs/ha, the next places are shared by beech groves with grass cover - 0,6-1,1 thousand pcs./ha, beech groves with fern cover - 0,07-0,2 thousand pcs./ha and subalpine beech groves with 0,04 thousand pcs/ha.

Percentage of distribution of undergrowths on areas by forest types was also determined in the stands of the experimental areas. The highest distribution percent was studied to be in umbrella-leaved-forb beech groves within 73-84%. This figure was 60-72% in dead-covered beech groves, 55-60% in beech groves with grass cover, 32-41% with fern cover and 16-21% in subalpine beech groves (Fig. 7).

Natural regeneration of large windows and clearings of beech stands. During the experiments conducted in the study area, the method of spatial analysis was used to study the natural regeneration taking place in large windows and clearings. Here, counting of tree species were made on 10x10 m plots located in transects (4-6 in each transects of 5 experimental site. The transects are located in the area starting from the forest wall to the end of the distribution area of the regenerated young stand or to the relief elements here (Fig. 8).

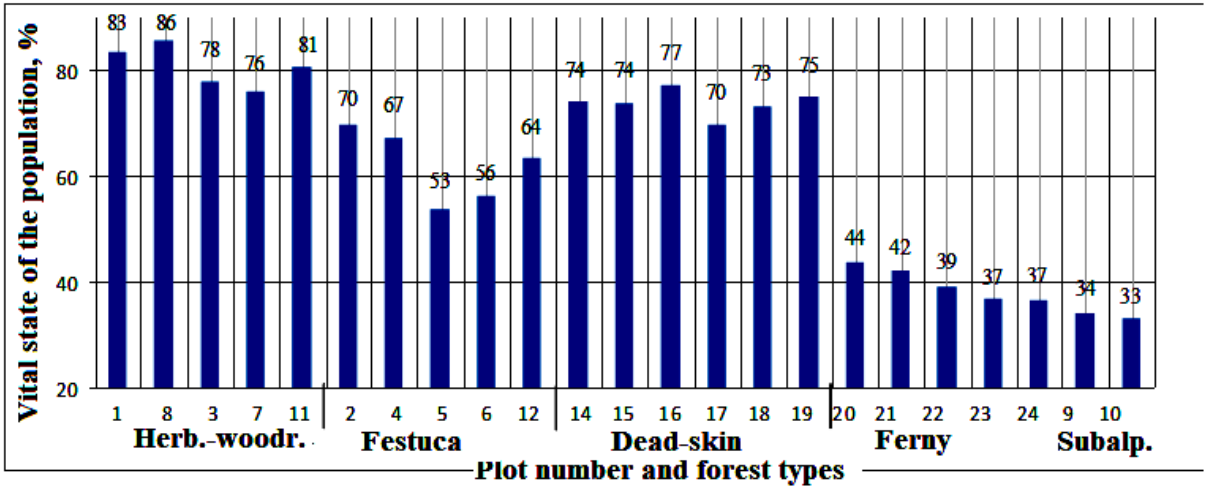


Fig. 7. Vitalitet structure of undergrowths

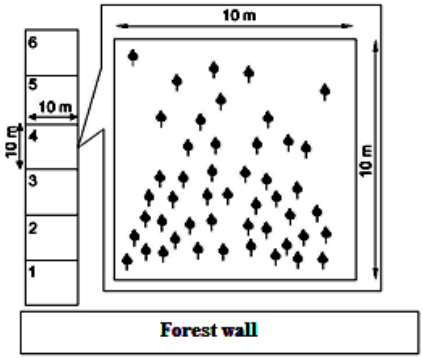
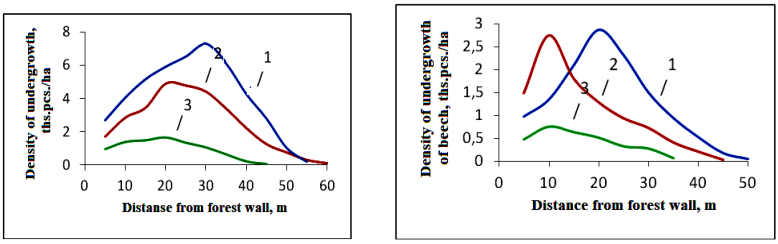


Fig. 8. Scheme of field studies of natural regeneration in clearings of beech forests

Analysis of the obtained figures (Fig. 9) showed that natural regeneration in the studied areas is proceeding successfully at a distance of 0-25 (30) m from the forest wall, where the protective role of the forest wall is important[30]. As a result, natural beech formations are formed in the composition of young generation after a certain period of time, and when they reach middle age, they begin to freely perform the protective functions of the forest. As the distance from the forest wall is more than 30 m, the regeneration process gradually weakens. Here, beech undergrowths are found singly, that is as the distance increases, only hornbeam, birch, elm, aspen and other species are found in the composition of stand in the area, which also form derived hornbeam, birch, beech-hornbeam or hornbeam-maple stands.

[30] Yakhyayev A.B., Farzaliyev V.S., Safarova E.P. The reforestation of the Greater Caucasus forests meadowand the glades //A.B.Yakhyayev, V.S. Farzaliyev, E.P Safarova, - Germany: Eastern European Scientific Journal, - 2015. No 6, - pp. 20-26.



a) *b)*

Fig. 9. Dynamics of the distribution of the number of undergrowths in the large windows and clearings of beech forests, depending on the growing conditions: a) the total number of undergrowths, b) the number of beech undergrowths; 1 – in wettish conditions with forb cover, 2 - in wettish conditions with grass cover, 3 - in wet conditions with fern cover

Artificial regeneration works in beech forests. During the studies in the beech forests of Guba forest region, afforestations in large windows up to 30 m wide were carried out on the site areas of 1x1 and 1x2 m by a sowing method. In clearings more than 30 m wide, in strips measuring 4,5-6,0x24-36 m, afforestations were carried out by planting method. A simple method – shovel was used here, terraces were not prepared on the mountain slopes, as well as the soils of the site and strip areas were partially processed. The layout of planting materials on tree species is presented in Fig.10.

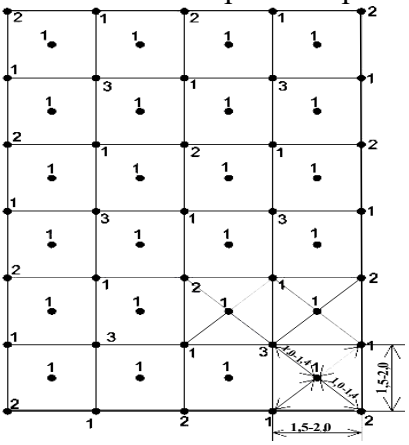


Fig. 10. Scheme of mixing of planting materials by tree species: 1 – beech; 2 – hornbeam (mountain birch); 3 – ash tree (oriental oak)

Studies have shown that the total number of seedlings formed in 5-year plantings created by the sowing method and the share of beech, as well as the assessment of the success of artificial regeneration, changed as follows, depending on forest growth conditions conditions: Total number of seedlings in wettish forest types with forb (MN_hT) was 3,49-4,20 thousand pcs/ha, the presence of beech in the composition- 5,0-6,4 units, regeneration success of beech forests - good; in plantings created in wettish forest types with grass cover (TN_hT) these indicators were 2,36-2,79 thousand pcs/ha, 2,7-3,7 units, respectively, - very weak; in wet forest types with forb (MNT) this indicator was an average of 1,92 thousand pcs/ha, 4,3 units, - very weak[31].

The number of beech specimens in the 5-year plantings created by the sowing method in the study area, the presence of beech in the composition and the assessment of the success of regeneration were as follows in different forest growth conditions (Fig. 11): The number of beech samples in the plantings created under MN_hT conditions is 1,83-2,15 thousand pcs/ha, the presence of beeches in the composition is 6,6-6,7 units, the success of artificial regeneration is rated as good; The number of beech samples in the plantings created under TN_hT conditions is 1,56-2,02 thousand pcs/ha, the presence of beeches in the composition is 6,5-6,8 units, the success of artificial regeneration is rated as good[32].

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[31]Yakhyayev A.B., Farzaliyev V.S. Reforestation in beech forest of the Greater Caucasus // A.B. Yakhyayev, V.S. Farzaliyev, - Poland: Journal SYLWAN, - 2017. 161(7), - pp. 181-198

[32] Yakhyayev A.B., Farzaliyev V.S., Seyfullayev F.S. Results of silvicultural treatments conducted in beech forest of Azerbaijan // A.B. Yakhyayev, V.S. Farzaliyev, F.S. Seyfullayev, - Czech: Journal of Forest Science, 64 (9). – 2018. pp. 394-401.

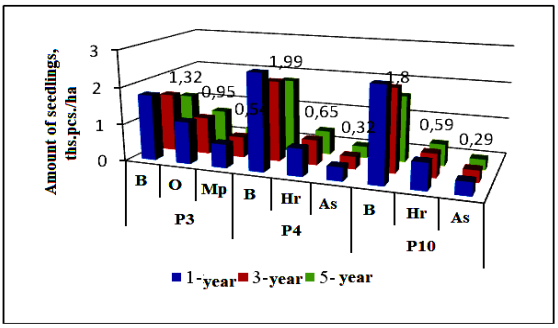


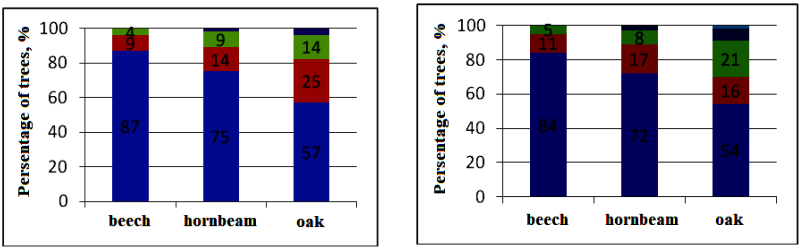
Fig. 11. Dynamics of change of the number of tree species in the created plantings by years

Chapter VI. Ecological-forestry characteristics of the quality and felling ages of beech stands of Guba forest region

The chapter presents the results of studies on the ecological and forestry features of quality and felling age of beech trees in the Guba forest region.

Ecological and forestry features of the vital condition of beech stands. The study of defoliation of tree crowns revealed that the damage of the leaves on the crown of stand consisting of mainly beech hornbeam and oak varies within 76-96%, 60-87% and 55-61% and classified as damage class 1 (Fig. 12,a). The number of beech trees in the 2nd damage class is 1,6 times less than hornbeam trees and 2,8 times less than oak trees. It was noted that the number of beech trees in the 3rd damage class decreased to 4%, while the damaged hornbeam trees amounted to 9% and oak trees - 14%. Trees with deciduousness from 61% to 100% are very rare and are found only in forests distributed in dryish forest types with grass cover[33].

[33] Яхьяев А.Б., Сафарова Э.П., Сейфуллаев Ф.С. Современное состояние буковых древостоев // А.Б. Яхьяев, Э.П. Сафарова, Ф.С. Сейфуллаев, - Баку: Известия НАН Азерб., сер. биол. науки, - 2017. № 1, - с. 74-78



a) *b)*

Fig. 12. Indicators of defoliation of crowns of trees by species (a) and dechromation of leaves (b)

A study of the vital state of beech, hornbeam and oak trees according to the degree of leaf dechromation showed that the number of healthy trees predominates in the stands. Healthy trees were found to be 84%, 72% and 54%, respectively, in their total number by species (Fig. 12, b). The number of trees with yellowing leaves in the crown in the 2nd damage class was 11% in beech trees, 17% in hornbeam trees and 16% in oak trees.

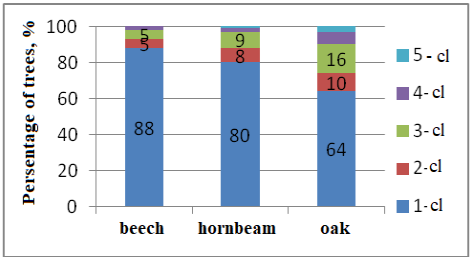


Fig. 13. Distribution of tree species according to the class of damage, depending on the number of dry branches in the crown

The study of trees by the number of dry branches showed that in dead-cover beech groves the basis of stands are trees of the 1st damage class (the number of dry branches in the crown is up to 10%). The average value of healthy trees in this damage class was 92% in beeches and 82% in hornbeams (Fig. 13).

In beech forests distributed in forest types with grass cover, the main part of the trees also belongs to the 1st damage class according to the number of dry branches in the canopy. Here, on average,

healthy trees are distributed by species as follows: beech trees - 88%, hornbeam trees - 80% and oak trees - 64%. In forest type with grass cover the total share of tree species in the 2nd damage class was 5-10%, and 2-7% in the 4th damage class[34]. It was determined that the stands in the studied forests are characterized by the damage index as follows: dead-covered beech groves (*i* =0,32-0,38)- healthy; forb beech groves (*i* = 0,55-1,46) - weakened; grass-covered beech groves (*i*=1,64-2,92) - very weakened.

Forestry features of the impact of rot on the quality of beech wood. As a result of the research, it was determined that the trees infected with fungal diseases were distributed by forest types as follows: in dead-cover beech groves–15,2%; in forb fern-covered beech groves–12,6%; in grass-covered beech groves–8,5%. The total number of trees infected with fungal diseases in the studied forests was on average 11,9% (Table 5).

Table 5

Characteristics of trees infected with fungal diseases

Age class	Number of infected trees, pcs./%	Average values of tree indicators						
		height, m	diameter, sm	volume, m^3	height of crown attachment, m	number of fruiting body, pcs.	the height of attachment of fruiting body, m	height of attachment of upper fruiting body, m
V-VI	19 / 2,7	17,1	19,6	0,248	9,8	1,2	1,3	1,6
VII – VIII	55 / 7,8	18,3	27,4	0,658	11,7	2,0	2,1	2,5
IX -X	97/16,5	20,1	38,7	1,586	13,8	3,5	2,4	3,7
XI – XII	129/35,8	21,6	46,5	2,579	14,9	4,1	2,9	4,2
XIII and above	79/37,2	23,4	58,3	4,611	16,0	4,2	3,4	4,4

It was revealed that trees are affected by fungal diseases at the age of 80-120 years. Here, the average height of the attachment of

[34] Яхьяев А.Б., Сафарова Э.П., Садыхова С.А. Распространение сучьев в древесине бука восточного // А.Б. Яхьяев, Э.П. Сафарова, С.А. Садыхова, - Баку: Труды Инст. Ботаники НАН Азерб., т. XXXVI, - 2016. – с. 25-29.

tree crowns to the trunk was 9,8 m, and the height of the upper fruiting body of the fungus was 1,6m. As the age of the trees increases by 260 years or more, the average height of the attachment of crown to the trunk and the height of the upper fruiting body of the fungus increase to 16,0 m and 4,4 m, respectively. At the same time, the average height of attachment of fruiting body of the fungus to the trunk increases from 1,3 m to 3,4 m, as well as their number from 1,2 pcs. up to 4,2 pcs[35].

According to the results of the study (Fig. 13), it was determined that the average value of height of rot spread increase from 1,47 m in middle-aged trees up to 6,43 m in overmature trees. The volume of rot increases from 2,5% to 13,3% of the volume of mean tree, respectively.

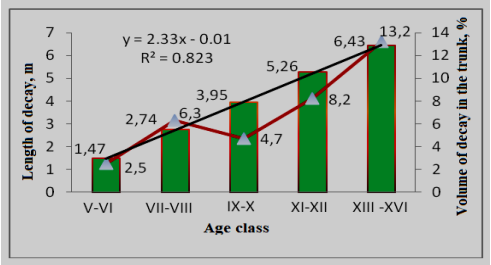


Fig. 14. Dependency graphs between the age classes of trees and height and volume of rot spread

Also, with age, the height of the upper fruiting body increases from 1,25 m to 5,02 m, respectively, and the volume of the trunk part with rot increases from 16,8% to 48,0%. At the same time, the diameter of rot on the stump of cut trees also increases from 8,15 cm to 32,70 cm. Based on the values obtained, it was determined that the actual output of commercial wood from mean tree with rot decreased

[35]Yakhyayev A.B., Farzaliyev V.S., Safarova E.P. Distribution of stem decay in the beech trees of the Azerbaijan and its impact on the output of commercial wood // A.B. Yakhyayev, V.S. Farzaliyev, E.P. Safarova, - China: Journal of Forestry Research. Vol.30, – 2019. No 3, - pp. 1023-1028.

from 1,6 times in middle-aged to 4,2 times in overmature stands compared to the estimated one (Tab. 6).

Mathematical models of the dependence of the output of commercial wood on the distribution of rot in the trunk by age class groups of beech stands were also developed.

Table 6

Output of commercial wood depending on the age of the trees

Age class	Volume of models, m^3	Mean values of output of commercial wood				Equation of constraints of output of commercial wood with the height of rot spread in age classes	Indicators	
		estimated		factual				
		m^3	%	m^3	%		R^2	r
V – VI	0,231	0,0977	40,8	0,0589	25,1	$P_{iş} = 1,892L_r^2 – 9,820\ L_r + 34,39$	0,251	- 0,458
VII – VIII	0,359	0,1843	49,5	0,0923	24,0	$P_{iş} = 1,369L_r^2 – 10,84\ L_r + 42,55$	0,181	- 0,409
IX – X	1,203	0,6779	56,4	0,2647	22,1	$P_{iş} = - 0,084L_r^2 – 2,708\ L_r + 34,17$	0,241	- 0,491
XI – XII	1,659	1,0208	61,4	0,3039	19,2	$P_{iş} = 0,244L_r^2 – 4,730\ L_r + 36,93$	0,338	- 0,575
XIII and above	3,106	1,9705	62,7	0,4506	14,8	$P_{iş} = 0,251L_r^2 – 4,003\ L_r + 29,65$	0,173	- 0,353

Note: P_{com} – output of commercial wood, %; L_r –height of rot spread in the trunk, m

Forestry features of the impact of knots on the quality of beech wood. The study revealed that tree trunks with the longest enclosed knot are found in the dead-covered beech groves with an average value of 15,08 m (58,4%), smallest length in beech groves with grass cover - 10,61 m (51,3%). The number of live knots in beech forests varies from 18 to 32 pcs., and the number of dry knots from 5 to 11 pcs. By thickness, knots with a diameter of 3-4 (2,8-3,5) cm predominate at the junction with the trunk. It should be noted that as the diameter of the trees increases, the size of the knots also increases.

The analysis of the location of the knots on the sections of height of the trunk determined that the number of live knots increases in all forest types as the height of the trunk increases. For every 1 m of the last section, 2,1 piece knots fall in beech groves with grass cover and up to 3,0 knots in forbs. The largest number of dry knots was recorded in the last section - 0,3 pcs/1m. The ratio of the number of dry knots on the trunk to live knots varies within about 1:5.

Forestry features of material assessment of beech stands. For material assessment of stands a scale of height category was established within middle thickness classes (24-64 cm). The interval between height categories is adopted to be 2-3 m, ie 10% of the average height of the majority of stands allocated for felling. When constructing the scale of height categories, growth of individual trees by height and diameter were determined by multifactorial calculations. In accordance with the optimal function of the growth, a new scale[36] of height categories was established (Fig. 15).

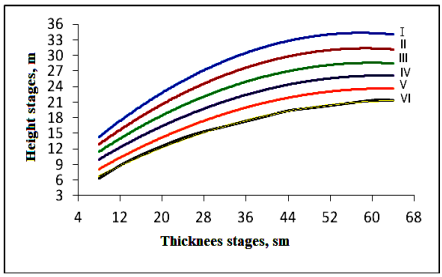


Fig. 15. Change of heights of stands by height categories I-VI.

The number of height categories is determined by the coverage of all the height and diameter ratios studied. When determining the volume of the trunks by thickness classes, a formula that takes into account their cross-sectional area, height and form factor was used.

$$V_{ij} = \frac{10^{-4}}{4} \cdot \pi \cdot d_{1 \cdot ai}^{2} \cdot h_{ij} \cdot f_i ,$$

here i - index of thickness class, $i =$ 1 - n (n – total number of thickness classes); j- height category.

The volume of beech trunks is divided into commercial, firewood and waste categories. Commercial wood, in turn, is divided

[36] Yakhyayev A.B. Definition of the assortment structure of the beech trees in the north-eastern slope of the Great Caucasus in Azerbaijan // A.B. Yakhyayev, - Georgiya: Annals of agrarian science. Vol. 12, – 2014. № 4, - pp. 1-7.

into large, medium and small wood according to the size categories on the basis of DUIST 9462-88 standard. Based on the selected height categories and value of form factor all volume-forming (P) elements of trunks with relative quantities (commercial wood, technological wood, firewood and waste) were calculated by the following formulas.

$$P_{ji} = \frac{V_{ji}}{V_{cT}^{e \cdot k}} \cdot 100; \quad P_{Tex} = \frac{V_{Tex}}{V_{cT}^{e \cdot k}} \cdot 100;$$

$$P_{\partial p} = \frac{V_{\partial p}}{V_{cT}^{e \cdot k}} \cdot 100; \qquad P_{ws} = 100 - \left(\sum_{i=1\delta}^{4 \cdot 3} \sum_{j=1} P_{ji} + P_{Tex} + P_{\partial p} \right),$$

Here V_{ji} - the volume of the commercial part of the trunk, m^3; $V_{cT}^{e \cdot k}$ - volume of trunk in bark, m^3; V_{Tex} - volume of the technological part of the trunk, m^3; $V_{\partial p}$ - volume of wood part of trunk, m^3; P_{ws} – volume of waste, m^3.

To determine the output of commercial wood from beech trunks, mathematical models for height categories were developed, which are also characterized by a high coefficient of determination. Correlation between taxation characteristics - the output of the commercial wood by thickness classes is characterized as inversely weak at the II and III height categories. The value of the correlation coefficient of firewood and waste outputs is also assessed as weak (Table 7)

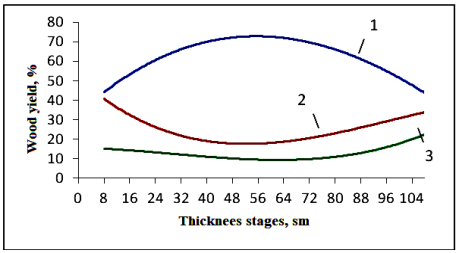
Table 7

Output models of volume-forming elements of trunks

Height categories	Mathematical models	r	R^2
II	$P_{com} = 2E\text{-}05x^3 - 0{,}015x^2 + 1{,}503x + 33{,}04$	- 0,074	0,921
	$P_{wood} = -7E\text{-}05x^3 + 0{,}019x^2 - 1{,}473x + 51{,}40$	- 0,049	0,852
	$P_{was} = 4E\text{-}05x^3 - 0{,}003x^2 - 0{,}029x + 15{,}54$	0,316	0,982
III	$P_{com}^1 = 0{,}0003x^3 - 0{,}052x^2 + 3{,}224x + 8{,}01$	- 0,428	0,962
	$P_{wood}^1 = -0{,}000x^3 + 0{,}041x^2 - 2{,}413x + 60{,}60$	0,376	0,938
	$P_{was}^1 = -4E\text{-}05x^3 + 0{,}012x^2 - 0{,}823x + 31{,}50$	0,493	0,934

The data obtained, expressed as a percentage of the total stock, were aligned graphically (Fig. 16) and presented in the form of a ta-

ble of material evaluation of trees, which are presented in the dissertation.



Fig/ 16. Distribution of volume-forming parameters of the trunk trees of the II discharges of heights: 1 - commercial wood; 2 - firewood; 3 - waste

Based on the material assessment of the stands, it was determined that the main wood reserves of beech stands are concentrated in 28-72 cm thickness classes. Maximum output of commercial wood is achieved in thickness classes of 64-68cm in the II height category with 71,3-71,6% output, in thickness classes of 44-48cm with 67,3-67,8% output in the III height category. The volume of firewood and waste generated in these groups of thickness class will be the smallest: firewood - 19,4-19,5% and16,3-17,3%; waste - 9,0-9,2% and 15,9-15,4%.

Forest-ecological features of determining the felling age in beech stands. Based on the biology and ecological function of the oriental beech, but also taking into account the direction of the economy to the cultivation of certain assortments, ecological-economic maturity age[37] of 200-240 years was determined for medium and high-yielding stands of I and II quality class and 160-200 years for low- and medium-density stands of III and IV quality class. Within the indicated age limits, it is advisable to carry out appropriate reforestation fellings with the repetition of one age class, i.e. every 20 years (Table 8).

[37]Яхьяев А.Б. Эколого-экономическая спелость буковых древостоев // А.Б. Яхьяев, - Баку: Труды ЦБ Сада НАН Азерб., т. XIV . – 2016. – с. 117-121.

Table 8
Felling ages of beech stands by ecological and economic maturity

Quality class of trees	Maturity and felling age of trees						
	natural	technical according to the categories of size			ecological		
		large	medium	large, medium	CO_2 bsorption	Separation of O_2	absorption of dust
I -II	240 years and above	181 – 220	161-200	161-220	141 – 180	141 – 180	141 – 180
III - IV	180 years and above	201- 240	181-220	181-240	161-200	161 - 200	141 - 180

Chapter VII. Ecological-forestry characteristics of cleaning and regeneration fellings in beech stands of Guba forest region

This chapter presents the results of research on the ecological and forestry features of cleaning and regeneration fellings in the beech forests of Guba forest region.

Ecological and forestry features of cleaning felling in beech-hornbeam derived forests were studied in 9-12 and 18-22-years-old young stands with 2-4 units of beech in the composition. Two-stage cleaning fellings were carried out with an intensity of 8% to 52% for 10 years and accounting of trees was carried out four times in 20 years. Here, fellings were carried out mainly by the upper method - with the selection of fast-growing species from the first tier and by combined method - freeing the beech from the oppressive influence of the upper and lower canopies of subsidiary species[38].

Based on the results of the research, in order to regenerate natural beech forests in the region, it is proposed to conduct heavy thinning in the young stands of beech-hornbeam forests with repetition every 5-7 years: in the age range of 9–12 years stands with felling in two steps up to 60%; in the age range of 18-22 years old stands up to 50% of stock of stands.

[38] Яхьяев А.Б. Рубки ухода в буково-грабовых молодняках северо-восточного склона Большого Кавказа в пределах Азербайджана // А.Б. Яхьяев, - Уфа: Вестник БГАУ, - 2014. №1, - с. 91-95.

Ecological and forestry features of improving the regimes of cleaning felling in beech forests. In order to regenerate the natural beech forests in the region, a more improved base for the implementation of all form of cleaning fellings by working circle has been developed taking into account the current regulatory framework, forest management materials, and the results of our research on beech forests. These working circles include seed plantations distributed in the northern and southern exposures of mountain slopes with a density of 0,4-1,0 and I-IV quality class. Here, all beech forests are divided into low (BLd), medium (BMd) and high-density (BHd) stands according to their productivity. Within each working circle, these forests are divided into those common in the northern and southern exposures, by steepness – common in slopes with a steepness of up to 20^0 and more than 20^0 and by the composition of stands - participation of 8-10 units and 5-7 units of beechs[39]. The main output parameters of this improved regulatory framework include indicators such as canopy closure degree of young generation before and after cleaning fellings, intensity and frequency of fellings in beechs forests. In the end, for each variant, prediction composition according to final felling age of forests was determined. The dissertation presents an improved program of cleaning fellings conducted in beech forests (Table 7.2).

Ecological and forestry features of improvement and implementation of the system of regeneration felling in beech stands. As it is known, all mountain forests of Azerbaijan belong to the I group, ie they must be subjected to special felling regimes, and the wood raw material to be supplied from such forests is of secondary importance. Therefore, in the beech forests of this region, regeneration fellings in the form of selection fellings are most acceptable, which are permissible in stands common in slopes of the northern exposure with a steepness up to 30^0 and on the southern - up to 25^0. The slopes of the northern exposure

[39]Яхьяев А.Б. Нормативная база проведения рубки ухода в буковых насаждениях Большого Кавказа // А.Б. Яхьяев, - Оренбург: Известия ОГАУ, - 2015. № 2, - с. 10-13.

with a steepness of more than 30^0, southern - 25^0 belong to especially protective areas where only sanitary-secondary fellings are allowed.

On the basis of the analysis of the selection fellings, as well as the condition and distribution of beech forests in the Greater Caucasus, the following forms of regeneration fellings were recommended in the dissertation. These felling forms are divided into economic groups of forest types, the degrees of steepness of mountain slopes and their main purpose (Table 9).

Ecological and forestry features of combined individual and group selection felling in derived beech-hornbeam stands. The results of the experiment shown that after 2-step combined individual and group selection fellings, the wood reserves of beech in the stand increased by 2,0-2,6 times. At the same time, the wood reserves of the hornbeam which is considered to be subsidiary species decreased by 30-49%. Despite intensive regeneration after 2 procedures of combined individual and group selection felling, beech was represented by 4-5 units in the composition of stands[40]. Therefore, for the sustainable formation of natural beech and hornbeam-beech forests, it is proposed to conduct 2-3 rounds of combined individual and group selection fellings in the derived hornbeam and beech-hornbeam forest areas depending on the initial share of beech in the composition.

During combined individual and group selection felling, it was proposed to bring the share of beech in the composition of young generation to 4-6 units by cleaning fellings. It should also be borne in mind that more than 60% of the trees that emerge in the first tier (in the newly formed part of the tier) after fellings should be beech[41].

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[40] Яхьяев А.Б., Фарзалиев В.С. Результаты комплексных рубок в буково-грабовых насаждениях Большого Кавказа в пределах Азербайджана // А.Б. Яхьяев, В.С Фарзалиев, - Красноярск: Сибирский лесной журнал, - 2014. № 3, - с. 140-149 .

[41] Yakhyayev A.B., Gurbanov E.M., Farzaliyev V.S., Seyfullayev F.S. The regeneration of Oriental beech (*Fagus orientalis* Lipsky) share in the secondary hornbeam stands using the complex cutting // A.B. Yakhyayev, E.M. Gurbanov, V.S. Farzaliyev, F.S. Seyfullayev, - Czech: Journal of Forest Science, 67, - 2021 (1), - pp. 12-20.

Table 9

Recommended forms of regeneration fellings by economic groups of forest types

Economic groups of forest types (index of types)	The steepness of the slopes	Primary purpose of forest type groups	Main regeneration felling forms
Pure and mixed low-density (0.4 - 0.5) beech forests F - C_2, C_3; F – $Д_2, Д_3$; VF – C_2, C_3; VF – $Д_2$; PF – C_2; GF – C_2, C_3; GF – $Д_2$; AgF – C_3; QtF – C_3; TzF – C_2; AgVF – C_2; PVF – C_2; GVF – C_2; QlVF – C_3; TzVF – C_2.	Up to 20^0	Water-regulating and soil-protective forests, Recreational-protective forests	combined individual and group selection felling
	$21 - 30^0$	Soil-protective-water-retaining forests	Combined individual and group selection felling
	More than 30^0	Soil-protective-water-retaining forests	Sanitary-secondary felling
Pure (associated species up to 2 units) medium-density (0,6 – 0,7) beech forests F – C_2, C_3; F – $Д_2, Д_3$; VF – C_2, C_3; VF – $Д_2, Д_3$.	More than 20^0	Water-regulating and soil-protective forests, Recreational-protective forests	Combined individual and group selection felling Voluntary-selective felling
	$21 - 30^0$	Soil-protective-water-retaining forests	Combined individual and group selection felling
	More than 30^0	Soil-protective-water-retaining forests	Sanitary-secondary felling
Mixed (associated species more than 2 units) medium-density (0,6 – 0,7) beech forests VF – C_2, C_3; VF – $Д_2, Д_3$; PVF – C_2, C_3; PVF – $Д_2$; GVF – C_2; AgVF – C_2, C_3; QlVF – C_3.	Up to 20^0	Water-regulating and soil-protective forests, Recreational-protective forests	Combined individual and group selection felling Voluntary-selective felling
	$21 - 30^0$	Soil-protective-water-retaining forests	Combined individual and group selection felling
	More than 30^0	Soil-protective-water-retaining forests	Sanitary-secondary felling
Pure and mixed high-density (0,8 – 1,0) beech forests F – C_2; VF – C_2, C_3; VF – $Д_3$.	Up to 20^0	Water-regulating and soil-protective forests	Voluntary-selective felling Group selection felling
	$21 - 30^0$	Soil-protective-water-retaining forests	Combined individual and group selection felling
	More than 30^0	Soil-protective-water-retaining forests	Sanitary-secondary felling

Forestry-technological features of intermediate use fellings in beech stands. In the studies, cleaning felling and combined individual and group selection felling forms were done with an intensity of 5,5-14,6% according to the sectoral method and wood reserves. For the purpose of carrying out intermediate use fellings, we have proposed a technological scheme based on a self-propelled cable hauler (SCTU) which is intended for the development of felling areas in mountainous condition and partial or full use of the supplied wood (fig.17).

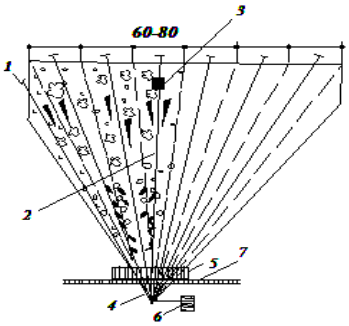

Fig. 17. Technological scheme for the development of felling areas using cable hauler for intermediate use felling: 1 – rear block; 2 – running skyline; 3 – carriage; 4 – drive; 5, 6 - receiving and loading point, respectively; 7 – haulage road.

In the experiments, felling areas are divided into sectors with a width of 60-80 m in the upper part in the longitudinal direction of the slopes. At the same time, for easy performance of work, these sectors were also divided into blocks with a width of 50-60 m and they adjoin the cable installation route at an acute angle ($30–40^0$) with an upward slope[42]. The haulage route under the carrying cable (pulling-load lifting) and with a width of 1,5-2,0m was laid in the middle of the sectors (blocks). These haulage routes are also placed sequentially in the subsequent felling areas.

[42] Яхьяев А.Б., Грязькин А.В. Особенности выборочных рубок в буковых лесах Большого Кавказа // А.Б. Яхьяев, А.В. Грязькин, - Саратов: Вестник Саратовского Госагроуниверситета им. Н.И. Вавилова, - 2014. № 11, - с. 47-52.

When developing felling areas, cut-to-length technology and machine systems consisting of BP – GT+miniTT – SCTU – TTk were used. In the experiments, intermediate collecting points with an area of 1,5-2,0 ha were located on the side of the main roads of regional importance. The main indicator of the quality of fellings was the degree of damage to forests, which was also found to be within the permissible limits in the experimental areas.

Chapter VIII. Forestry-economic characteristics of the use of firewood raw materials of beech groves of Guba forest region

This chapter presents the results of a study of forestry and economic features of the use of wood raw materials from beech forests of Guba forest region.

Structure and volume of raw wood obtained from cleaning fellings. According to the materials of forest inventory for 1992-2003 years in the forest management of the Guba forest district, fellings were held at 0,6% of the area in young stands, 9,5-12,9 m^3 of wood raw material was supplied from each 1 ha, of which the liquid wood amounted to 7-9 m^3. As can be seen, the volume of forestry work was very low, and the supplied wood raw material was not fully used[43].

In the farms of the region, thinning felling form was carried out in 0,3-0,4% of this total area and 10,6-12,4 m^3 of wood raw material was obtained from 1 ha. The share of increment fellings accounted for 4/5 of the total share of cleaning fellings (by area - 70-80%) and 16,7-2,.6m^3 of wood raw material was supplied from 1 ha. Small- and medium-sized assortments with limited scope of application were prepared from this raw material.

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[43] Яхьяев А.Б., Сафарова Э.П. Структура и объемы древесного сырья полученного от рубок ухода в буковых лесах Большого Кавказа // А.Б. Яхьяев, Э.П. Сафарова, - Москва: Лесохозяйственная информация. ВНИИЛМ, - 2014. № 4, - с. 73-80.

Felling wastes also plays an important role in increasing the volume of wood raw materials. These wastes are generated in large quantities in felling areas and they are still used inefficiently. To solve this problem, it is important to know the amount of waste generated which is calculated per 1000 m^3 of supplied raw wood in m^3 by the following formula.

$$P = \sum_{i=1}^{k} a_i b_i \frac{c_i}{100} ,$$

here: P – volume of felling wastes, m^3 ; a_i – in the composition of the stand i – share of wood raw material of the species, m^3; b_i - according to the given waste form i – the average normative output of the species, m^3; k - number of tree species in the composition of forest areas; C_i–average normative output of crown elements for each tree species, m^3

Material assessment of wood raw materials obtained from intermediate use fellings and main directions of their use. In the forest management of Guba forest region, only intermediate use fellings are carried out, which is the main source of raw wood. The volume of fine and small wood raw materials obtained in the form of secondary and cleaning felling is very small, and in the summer months this raw material is dominated by technical green. Its volume first increases, reaches a maximum in final cleaning felling forms (1,31t/ha) and stabilizes in subsequent felling forms. Similar dynamics is typical for technological chips, the maximum volume of which (2,56 m^3/ha) is formed during final felling form (Table 10)

Table 10

Volumes of raw wood obtained in cleaning felling

Category of wood raw materials	Average values of volumes of raw wood obtained in cleaning felling				Total
	secondary	final	thinning	increment felling	
Commercial wood, m^3	- / -	0,13 / 130	4,0 / 4000	6,94 / 6940	11,07/ 11070
Technological raw materials, m^3	1,47 / 1470	2,56 / 2560	2,18 / 2180	2,15 / 2150	8,36 / 8360
Technical green, t	1,07 / 1070	1,31 / 1310	0,69 / 690	0,68 / 680	3,75 / 3750

Note: in numerator - volumes calculated per 1 hectare; in the denominator - volumes calculated per 1000 hectares.

In the composition of wood raw obtained from thinning felling form, small-sized, ie fine and medium-sized commercial wood (58,2%) prevailed, and the technical green was within 10% of the total volume. Large-sized wood was obtained mainly from increment fellings (35,1% commercial), but the share of medium (28,5%) and small woods (36,4%) obtained from small-sized trees was also significantly higher. The volume of technical green in the increment felling did not exceed 7% of the total volume of wood raw materials obtained. During the selection-sanitary fellings, 15,30 m^3/ha of raw wood was supplied, of which 10,43 m^3/ha is commercial wood, 3,82 m^3/ha - technological raw material and 0,76 t/ha - technical green.

In recent decades, door blocks, parquet block, decorative veneer, elements of wooden stairs, wooden boxes, pallets and other products have been mainly used in the country. Therefore, during the experiments, we focused on commercial wood assortments intended for the manufacture of these products. Commercial wood was distributed by size categories and into required assortments, the resulting volumes of wood were presented in Table 11.

Table 11

Assortment distribution of commercial wood

Commercial wood categories	Plank timber, m^3	Veneer log, m^3	Parquet log, m^3	Tare log, m^3	Other raw form, m^3
Large	2,45	1,35	1,41	0,53	0,61
Medium	1,29	1,28	2,93	2,22	0,48
General	3,74	2,63	4,34	2,75	1,09

Another direction in the rational use of wood and the expansion of its raw material base is the involvement of small-sized and low-quality wood and felling waste in the production. According to world experience, felling waste is divided into two main fractions: to wood-fibre mass suitable for use in the production of wood-based panels and in bioenergy; 2) For wood greens suitable for obtaining a number of valuable biologically active substances for therapeutic-prophylactic and other purposes, as well as for use in the supply of fodder to livestock. It was determined that there is an appropriate initial technical and technological base for the involvement of

felling, in general wood wastes in production and their efficient use in the Republic and the steps taken in this direction can give impetus to the production of materials[44].

Organizational and technological features of using wood raw materials obtained from intermediate use felling. The use of non-waste technologies is a very important direction for improving the efficiency of forestry production, solving a number of complex environmental issues, rational use of local forest resources, and mobile management of farm collectives.

For this purpose, in order to deliver the wood raw materials supplied from the forests to the wood processing point in a full, uninterrupted and partially sorted state, it is planned to organize collecting points in 8 directions (with a length of 40-50 km) with 2-3 points each in the main forest areas of the region. These collecting points are designed to collect wood raw material supplied from forest massifs within a radius of 15-20 km. The main directions for the collection and transportation of wood raw materials, the planned locations of collecting points and wood processing complex in the study area are shown in the map developed in accordance with the GIS program (Fig. 18).

It is planned to separate the wood raw materials transported to the collecting points into size and quality groups and collect them in piles. Illiquid wood raw was compacted, tied with multi-turn slings in a volume of up to 2 st. m^3 and stacked in piles. Transportation of sorted wood raw materials from the collecting points to the processing complex is carried out by self-loading log trucks. The complex processing plant is planned to be located near the city of Guba and in an area close to the intersection of the central highway of the region and Garachay.

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[44] Яхьяев А.Б. Особенности использования древесного сырья буковых лесов Большого Кавказа // А.Б. Яхьяев, - Казан: Вестник Казанского ГАУ, - 2015. №2 (36) - с. 164-168.

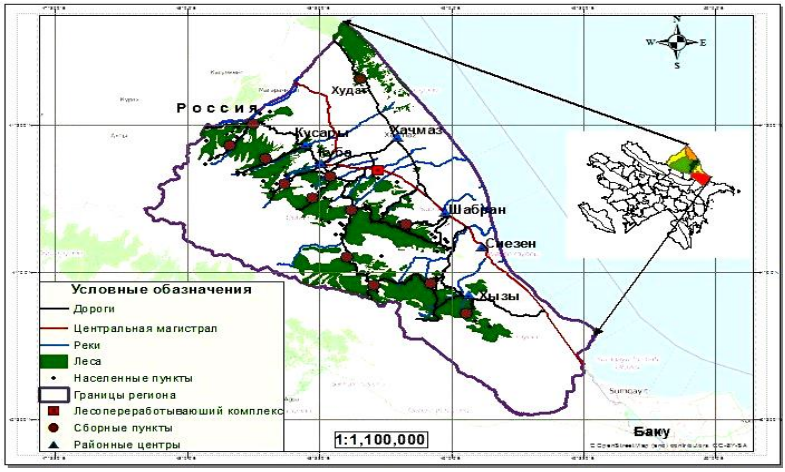

Fig.18. Map of location of collecting points and processing complex

It is planned to establish the following production areas at the complex processing establishments[45]: sawmill-parquet-tare; small commodity products; industrial chips; technical green. The dissertation presents the scheme of technological processes of the complex processing enterprise producing the finished product in these directions (fig. 19).

Ecological and forestry features of the organization of intensive forestry in the forests of the Greater Caucasus. The main task for the future development of forestry in the region is to improve the methods and technologies of forest growing, as well as

[45]Яхьяев А.Б., Абиев Ю.Т. Организационно-технологические особенности использования древесного сырья, полученного от рубок промежуточного пользования в буковых лесах Большого Кавказа // А.Б. Яхьяев, Ю.Т. Абиев, - Воронеж: Лесотехнический журнал. – 2015. №1 (17), - с. 197-206.

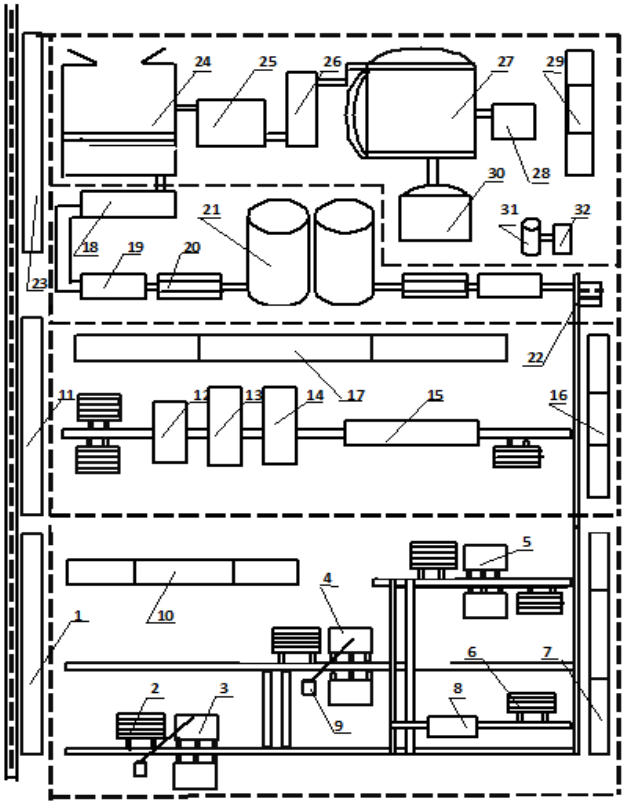

Fig. 19. Technological scheme of the wood processing complex for the production of finished products: 1 - commercial wood yard; 2 - a stack of round assortments; 3 - module of large-sized assortments of the 1st row; 4 - module of medium and short assortments and slabbing of the II row; 5 - module of tare logging; 6 - lumber pile; 7 - lumber yard; 8 - lumber processing center; 9 - waste bin; 10 - auxiliary facilities. 11 - timber yard for small-sized and low quality wood; 12 – module of blanks supply; 13 - module for generating base surfaces; 14 - module for longitudinal dividing of a semi finished product; 15 - finished lumber receiving module; 16 - workshop for the production of small-scale products; 17 – warehouse for small-scale products. 18 - container for non-standard timber; 19 - chipper; 20 - sorting plant; 21 – chip bin; 22 - storage for the slab. 23 - green timber yard; 24 - separation plant of green mass and wood part; 25 - bunker of green mass; 26 - preparatory division of green mass; 27 - capacity for the extraction of 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.

to stabilize the use of forests, ie to intensify them[46]. In general, the intensification means reduction in the unit costs of labour and means per unit of final products (in forest-growing – per 1 m^3 of mature wood and unit of non-wood product), as well as the improvement of useful functions of forests. Such an organization of farms makes it possible to use forest resources more fully and rationally in the forest territory assigned to it based on the principles of sustainable use. Such enterprises include complex forestry enterprises, which are widely applied in cedar forests of Ural and coniferous and broad-leaved forests of the Carpathians.

In order to intensify forestry in the region, the dissertation proposed to establish complex forestry enterprises that perform the functions of forestry, timber industry and additional use of forests. In this case, it is recommended to keep the specific weight of the areas of activities of this enterprise in the following ratios: forestry activities – 30-40%; timber industry activities – 45-55 %; additional use activities of forests – 15-20%.

CONCLUSIONS

Based on the research, the following conclusions and recommendations were made:

1. According to the degree of thinning, modern beech stands of Guba forest region of the Greater Caucasus consists of: 40-50% - disturbed; 30-40% - natural; 10-20% - virgin stands. Taking into account the ecological and forestry features of these stands, it was proposed to group the age and size boundaries of trees by age generations in economic activities as follows: in young stands – 61-120 age (diameter 8-20 cm); in ripening stands – 121-180 age (diameter 24-44cm); mature stands –

[46]Яхьяев А.Б., Гарибов Дж. А., Алиева Н.И. Особенности организации интенсивных хозяйств в лесах Большого Кавказа // А.Б. Яхьяев, Дж. А. Гарибов, Н.И. Алиева, - Баку: Науч. труды АзАСУ, - 2014. № 2, - с. 90-96.

181-240 age (diameter 48-64 cm); overmature stands – 241 years and more (diameter 68 cm and more).

2. Depending on the forest growth conditions, beech groves are successfully restored under the canopy cover of beech stands with canopy closure degree of 0,60-0,75 and in open areas up to 25 m from the forest wall, however, with the decrease in canopy closure degree and the increase in the distance from the forest wall, the presence of subsidiary species in the regenerated stands increases, resulting in the formation of derived forests in the area.
3. Depending on the ecological and forestry features of the area, it is recommended to create a beech plantation with partial treatment of soil and their arrangement in a staggered order across the slopes: in large windows at a distance of up to 30 m from the forest wall, by sowing method with areas of 1x1m and 1x2 m; in clearings by planting methods in stripes with 4,5-6,0 x 24-36 m in size.
4. Depending on the forest growth conditions, the state of beech stands according to the damage index of forest stand was assessed as follows: dead-cover forest types (i=0,32-0,38) - healthy; forest type with forb (i=0,55-1,46) – weakened; forest type with grass-cover (i=1,64-2,92) – severely weakened. According to the actual output of the commercial part of the beech trunks infected with fungal diseases, the quality of wood was determined to decrease from 1,6 times in young stands to 4,2 times in overmature ones.
5. According to the material assessment table, the maximum output of commercial wood is 71,3-71,6% on 64-68 cm thickness classes in II category of heights. According to the assortment tables, the maximum output of the assortments at this category of height is determined as follows: sawn material timber– 45,5-48,6% on 72-76 cm thickness classes; veneer block –19,7-19,8 % on 48-52 cm thickness classes; parquet block –12,8-13,5 % on 36-40 cm thickness classes.

6. Depending on the ecological and forestry features, in order to regenerate natural beech groves, it is proposed to carry out two-times cleaning fellings in derived hornbeam and beech-hornbeam stands of the young generation, at intervals of 5-7 years and with an intensity of 50-60%. In order to regenerate derived stands, it is proposed to carry out combined individual and group selection felling in the northern exposures in 2-3 steps and on the southern exposures in 3-4 steps. It is envisaged to carry out selection felling with an intensity of 10-30% on wood reserve and cleaning felling with an intensity of 20-40% on the number of trees with a return period of 10-20 years.
7. Taking into account the water-retaining-protective functions of beech stands, it is proposed to carry out combined individual and group selection and cleaning fellings by applying a sectoral method, which is intended for partial or full use of the supplied wood volume in mountainous conditions with complex relief elements. During these fellings, it is planned to use cut-to-length technology and a system of machines BP – GT+miniTTk – SCTU – TTk.
8. The total volume and structure of wood raw material obtained from intermediate use felling carried out in beech forests of Guba forest region is determined as follows: volume – 23,08 m^3/ha, commercial wood – 11,07 m^3/ha, technological raw materials – 8,36 m^3/ha, technical green – 3,75 t/ha. Main directions for the use of this raw material were established as follows: - sawmilling-wood working and production of wood slabs, as well as for the manufacture of biologically active products for therapeutic and other purposes and etc.
9. Taking into account the ecological and forestry features the distribution of beech forests in the region, in order to make full use of the supplied wood raw material, it was proposed to establish 14 intermediate collecting points in 8 directions of the region for the collection and transportation of this raw material to the processing complex. For the rational use of

supplied wood raw materials, a technological scheme of a complex processing enterprise which envisages the production of finished products in four areas has been developed.

10. In order to intensify the activities of forestry in the country, it is proposed to establish complex forest enterprises that perform the functions of forestry, timber industry and additional use of forests. It was considered expedient to maintain the specific weight of these activities in the following ratios: forest management activities - 30-40%; timber industry activities - 45-55%; activities on additional use of forests - 15-20%.

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