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RESOURCES OF WOODY PLANTS OF NORTH CAUCASUS BEECH FORESTS

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ABSTRACT

The aim of this study is to investigate material and monetary valuation of forest resources in the beech forests of the North Caucasus. The plots were selected in the Central part of the North Caucasus, on the territory of the Republic of North Ossetia-Alania (Kartcinsky ridge), between 1200-1350 m above sea level. Two objects are located on the northern macroslopes and two on the southern macroslope. The characteristics of phytocenoses on the experimental plots were established based on the results of a continuous enumeration of trees on a test area of 50x100 m. The number of undergrowth and undergrbrush, their composition and distribution by height groups, are established on circular areas of 10 m^2. The average wood volume is about 300 m^3/ha, and the average stand density is 248 trees per 1 hctare. The average number of undergrowth is 8988 per hectare, and underbrush 1998 per hectare. The average height of the young generation is 0.65 m, and the undergrowth is 0.86 m. The weight of one plant of average height in the air-dry state is 0.24 kg for undergrowth and 0.55 kg for undergrbrush. Phytomass of undergrowth and underbrush by species was set by weighing in a fresh and air-dry state. Prices for all types of wood resources used average market prices as of 2019. The main income can be obtained from the sale of wood – about 650 thousand RUB/ha. Undergrowth and underbrush can give in a total about 43 thousand RUB/ha. At the same time, the period of maturation for the harvest of beech and related species is 100-140 years. During this period, it can be carried out about 15-20 harvests of undergrowth and underbrush, which together can generate income comparable to the amount from the sale of wood.

Keywords: *The North Caucasus, the components of forest phytocenosis, the resources of the beech forests.*

INTRODUCTION

Mountain forests are special natural formations with many important ecological functions. One of these functions is there recource potential. The resource potential of mountain forests is often much more diverse than lowland forests. Moreover, that potentials are very heterogeneous due to the growing conditions, and that is well illustrated by mountain forests of the North Caucasus. (Albegov, 2001; Bazaev *et al*., 2008; Gryazkin *et al*., 2013; Khetagurov, Gryazkin, 2013; Khetagurov *et al.*, 2018; Bazaev *et al*., 2019). In this regard, one of the most important tasks of forestry is to organize the rational use of all available forest resources, taking into account their ability to reproduce itselves.

Mountain forests of the North Caucasus are represented by different tree species and the dominant forest community edificator is beech (Albegov, 2001; Bazaev *et al*., 2008; Andrew *et al.*, 2006; Gryazkin *et al*., 2019). Potential reserves of even the main types of forest resources in the current Forest Code of Russian Federation, have not yet been fully established. For the last 100 years, mainly wood has been extracted from the forest fund in North Caucasus, and value of other recources were underestimated (Khetagurov and Gryazkin, 2013; Development Strategy ..., 2018; Global Forest Resources ..., 2001; Wong *et al.*, 2001). Several attempts have already been made to comprehensively assess resource potencials in the diffrent forest ecosystems (Lebedev *et al.*, 2013; Gryazkin *et al.*, 2013; Khetagurov and Gryazkin, 2013; Khetagurov *et al.*, 2018; Bílek *et al.*, 2009; Bazaev *et al.*, 2019; Gryazkin *et al.*, 2019). Such researches were also undertaken in mountain forests in the North Caucasus (Bazaev *et al.*, 2008; Gryazkin *et al*., 2013; Khetagurov, Gryazkin, 2013; Khetagurov *et al.*, 2018; Bazaev *et al.*, 2019; Gryazkin *et al*., 2019; Gryazkin *et al.*, 2019), but the data of total availability and value of some resources are still inconclusive. The aim of this study is to investigate material and monetary valuation of forest resources in the beech forests of the North Caucasus.

MATERIAL AND METHODS

Investigation included stands with a predominance of beech in the first vegetation floor. The experimental plots are located between 1200-1350 m above sea level (Kartsinsky ridge, North Ossetia). In North Ossetia, beech grows between 600 to 2000 m above see level, on slopes of different aspects and different steepness. In total, four experimental plots have been selected, two on the northern macroslope of the Kartsinsky ridge (objects 1 and 2) and two on the southern macroslope (objects 3 and 4). The general characteristics of the research plots are presented in Table 1.

Table 1. General characteristics of research plots

Object number	Macroslope	Elevation (m)	Slope steepness, degrees	Slope aspect
1.	North	1250	15-20	NE
2.	North	1350	30-45	NE
3.	South	1300	15	SW
4.	South	1200	25-35	SW

Experimental plots are represented by two types of phytocenoses - *Fagetum festucosum* (plots 1 and 2) and *Fagetum asperulosum* (plots 3 and 4). In the structure of the first vegetation floor, at least 80% is represented by beech and hornbeam, while in the second floor, share of these species was 90-100%. The participation of other species in the composition of forest stands is less than 10-20 % (Table 2).

Table 2. Taxation characteristics of forest stands at the research plots

Plot No.	Stand composition by vegetation layers	Total number of trees (ex./ha)	Average		Relative density	Volume (m^3/ha)	Stand age	Bonitet class
			Diameter (cm)	Height (m)				
1	6B 3Hb 1Mn + L, Ag	269	38	23	0,84	306	90	II
	8B 2Hb	46	9	12	0,12	17	30	
2	6Hb 4B +Mn, Ash	251	38	21	0,81	262	80	II
	10B	29	11	13	0,11	18	30	
3	4B 4Hb 2O + Ab, As, Mn	180	47	20	0,93	263	80	II
	6B 3Hb 1Mn	16	12	10	0,10	3	40	
4	4B 4Hb 2Mn + Ab, Pe	148	52	23	0,86	313	90	II
	7B 2Hb 1Mn	52	13	12	0,28	19	40	

Notes. 1. The top line is the first vegetation layer of the stand, the bottom line is the second layer. 2. List of abbreviations: B= Beech, Hb = Hornbeam, Pe = Pear, O = Oak, Mn = Norway maple, L = Linden, Ag = Gray Alder, Ab = Black Alder, As = Aspen, Ash= Ash.

Taxation inventory of forest stands at the experimental plots was carried out in accordance with the accepted methodology in forestry and forest management. For this purpose, experimental plots of a standard size - 0.5 hectares each - were laid at each experimental stand. Wood volume by species and its structure was estimated after a continuous enumeration of each tree on the plots by using reference books (Standards for forest taxation, 1992 and Standards for forest taxation for RF, 1995). Counting the number of undergrowth and underbrush, estimation of their composition and distribution by height groups, was carried out on circular areas of 10 m^2 (Gryazkin, 1999). There were at least 30 circular areas at each experimental plot which ensured statistically acceptable accuracy of the experimental work.

The phytomass of undergrowth's and underbrush's branches was determined by weighing their mass in wet state (in field conditions) and air dry state (in laboratory conditions). In material and monetary valuation there were used average market prices in Russian Federation for all types of forest resources (prices for 2019).

Occurrence, projective cover, and species composition of the groundcover were determined on the same circular areas of 10 m^2. The dominant species in composition of the groundcover was *Anemone ranunculoides L.*, *Rubus hirtus Waldst. et Kit*., *Stellaria media (L.) Vill.*, *Athyrium distentifolium Tauschex Opiz*., *Urtica dioica L*., *Matteucia struthiopteris (L.) Tod*., *Galium odoratum (L.) Scop*. and *Festuca gigantea (L.) Vill*. The projective cover for the absolute majority of herbaceous species, as a rule, does not exceed 5%. The list of herbaceous plants that accompanying the beech (*Fagus orientalis Lipsky*) and berry yew (*Taxus baccata L*.) are included in the database developed with the participation of the authors (Bazaev *et al.*, 2016).

RESULTS AND DISCUSSION

Timber is the most demanded forest resource, as it was in the past. At the same time, other forest resources are used partially and insufficiently only. For example, undergrowth, underbrush and groundcover were rarely used, and that was noted by many researchers (Bazaev *et al*., 2008; Gryazkin *et al.*, 2020; Gryazkin *et al.*, 2019; Bílek *et al*., 2009; Andrew *et al*., 2006). For the material and monetary assessment of wood products at the experimental plots a continuous enumeration of trees of all species, starting from 6 cm diameter, was carried out. Wood volume reserves at the research plots are mainly represented by beech and hornbeam. The participation of other species in the composition of stand in the upper vegetation floor is less than 10%. Table 3 shows the distribution of wood volume by species in the first (upper) floor of forest stands.

Table 3. Wood volume at experimental plots by different species (m^3/ha)

Forest-forming species	Experimental plots				Average volume (m^3/ha)
	1	2	3	4	
Beech	200	137	117	147	150.3
Hornbeam	91.7	140	95	118	111.2
Pear	-	-	-	2.0	0.5
Oak	-	-	50	-	12.5
Norway maple	29.0	1.4	1.3	63	23.7
Linden	1.3	-	-	-	0.3
Alder gray	1.0	-	-	-	0.2
Alder black	-	-	1.4	2.0	0.8
Aspen	-	-	1.3	-	0.3
Ash	-	1.6	-	-	0.4
Total	323	280	266	322	297.8

Average composition of forest stands in experimental plots is 49 Beech, 38 Hornbeam, 8 Norway maple, 4 Oak + Pear, Linden, Gray Alder, Black Alder, Aspen, and the average wood volume is 297.8 m^3/ha. The structure of wood products by species is presented in Table 4.

Table 4. Distribution of wood volume by species and marketability categories (m^3/ha)

Stand-forming species	Wood volume by product categories			Total volume
	Sawlog	Semi-sawlog	Firewood	
Beech	92.2	37.1	21.0	150.3
Hornbeam	74.6	25.6	11.0	111.2
Pear	0.3	0.1	0.1	0.5
Oak	7.5	2.9	2.1	12.5
Norway maple	13.8	6.3	3.6	23.7
Linden	0.1	0.1	0.1	0.3
Alder gray	-	0.1	0.1	0.2
Alder black	0.4	0.2	0.2	0.8
Aspen	-	0.2	0.1	0.3
Ash	0.2	0.1	0.1	0.4
Total	189.1	64.7	31.9	297.8

Growing conditions for beech between 1200-1350 m above sea level are characterized by excess moisture, lack of heat and lack of illumination. These unfavorable factors primarily affect the tree species of the second stand's floor such as hornbeam. For these reasons, the most intense tree mortality is observed in the second floor of a stands (Table 5).

Table 5. Number of dry trees on experimental plots (m^3/ha)

Plot number - Elevation (m, above see level)	Beech	Hornbeam	Maple	Oak	Total
1-1250	33	14	2	-	49
2-1350	7	28	-	-	35
3-1300	16	24	1	1	42
4-1200	23	17	2	-	42
Average	19.7	20.8	1.3	0.2	42.0
Percentage of dry trees in total growing volume %	11.6	15.8	5.2	1.6	12.4

The high proportion of dry trees at the experimental plots (on average more than 12%) indicates a deterioration in the sanitary condition of forest stands. Hornbeam and beech in these forest areas require selective sanitary cuts.

The distribution of trees by different timber categories was carried out using the reference book Standards for Forest Taxation (1992). Timber prices are differentiated by assortment. The dominant share of wood volume per hectare is represented by beech wood, the cost of oak, pear and ash wood to the price of beech was conditionally accepted: sawlog – 3000 RUB/m^3, balance wood – 1800 RUB/m^3, and firewood – 1000 RUB/m^3.

Wood of other species - aspen, linden, alder can be sold at the price of hornbeam: sawlog –2500 RUB/m^3, balance wood – 1400 RUB/m^3, and firewood – 800 RUB/m^3.

The calculation results and the total cost of wood by categories of marketability are presented in the Table 6.

Table 6. Timber cost by marketability category RUB/ha

Forest-forming species	Timber categories			Total
	Sawlog	Balance	Firewood	
Beech	276600	66780	21000	364380
Hornbeam	186500	35840	8800	231140
Pear	900	180	100	1180
Oak	22500	5220	2100	29820
Norway maple	41400	11340	3600	56340
Linden	250	140	80	470
Alder gray	-	140	80	220
Alder black	1000	280	160	1440
Aspen	-	280	80	360
Ясень Ash	600	180	100	880
Total	492850	120380	36100	649330

Stands with a predominance of beech in the composition have great potential, which in current prices reaches 650 thousand RUB/ha. More than 76% of this amount is the cost of high-quality wood materials - sawlogs.

Table 7 presents data on the composition and number of undergrowth and underbrush. The undergrowth on the plots consists of the same forest-forming species as the stands in the upper floors. The underbrush consists of 7 different species that were discovered on the plots. Undergrowth and underbrush are sources for wood-chemistry industry (pulp and paper) and animal food. In addition, undergrowth and underbrush can be used to make brooms, panicles, etc.

Table 7. Composition and number of undergrowth and underbrush on experimental pots

Plot number	Undergrowth and underbrush composition	Number/ha
1	Undergrowth – 84Pe 9B 7Mn Underbrush – 54Bar Euo 46Elb	12563 2281
2	Undergrowth – 79Pe 14Mn 6B 1Ash + Ulm Underbrush – 51Euo 25Cur 14Bar 6Mas 4Hsu	9239 1461
3	Undergrowth – 70Pe 21Mn 5Ash 2B 1Ab 1Pe +L, As Underbrush – 60Haz 24Bar 5Ros 11Mas	5775 1250
4	Undergrowth – 50Mn 41Pe 9B + An, Ash Underbrush – 69Bar 19Euo 12Mas	8375 2600

List of abbreviations: Bar = Barberry, Euo = Euonymus, Elb = Elderberry, Wbe = Wolfberry, Pe = pear, Hsu = Honeysuckle, Haz = Hazel, Mas = Mountain ash, Cur = Currant, Bch = Bird cherry, Che = cherry, Ros = Rose hips

The height structure of the undergrowth is very heterogenic; and it changes significantly on the different plots. The category of small undergrowth (up to 0.5 m) prevails. The average number of undergrowth on the experimental plot is 8988 per hectare. The average height of the undergrowth is 0.65 cm, and the air-dry weight of one plant of this height is 0.24 kg.

In summer, undergrowth and underbrush can be used to produce animal food, by harvesting branch collected in the form of bunches about 1 m long and about 10 cm in diameter at the tying site. An average about 30 plants is needed to make this kind of a bunch. For this purpose, it can be used only small and medium-sized plants (up to 1.5 m). The average price for branch bunch is 60 RUB/bunch. Any species can be used as animal feed, except Berry yew. All parts of Berry yew are poisonous. In addition, this species is in the Red Book of the Russian Federation.

Undergrowth and underbrush can be used as raw material for wood destination, as well. The cost of one ton of such raw material is 6500/RUB.

The large undergrowth and underbrush (brushwood, 10% of the total) is used for the construction of hedges and as small ornamental material. The cost of a bunch of 10 plants is on average 15 RUB. Based on the number of undergrowth by species and its distribution by height groups, it is possible to determine the output of marketable products (Table 8).

Table 8. Output of marketable products from undergrowth

Name of product	Undergrowth (number/ha)	Number of finished products	Revenues from sales (RUB/ha)
Branch feed (number/ha)	8988	300	18000
Panicles (90% of the total undergrowth) (number/ha)	8098	405	14175
Brushwood (10% of the total), (bunches/ha)	899	45	675
Wood greenery for destination (T)	8988	2 157	14020
Total without wood = greenery	-	-	32850
Total without branch feed	-	-	28870

The underbrush, as well as the undergrowth, is not uniform both in composition and in height. This vegetation floor of phytocenoses with predominance of beech is represented by 7 species of shrubs. The average composition of the undergrowth is 37 Barberry, 31 Euonymus, 19 Hazel, 8 Mountain ash, 3 Currant, and 2 Rose hips. The average number is 1898 per hectare. The distribution by height groups is 50% small, 40% medium and the remaining 10% is large. The average height is 0.86 m, and the weight of one plant in air-dry state is 0.55 kg. From the underbrush, as well as from the undergrowth, in the summer period it is possible to harvest branch fodder in the form of bunches about 1 m long and about 10 cm in diameter at the tying site. For producing of one feed bunch average 25 plants from the underbrush (its average height is slightly higher than the average height of the undergrowth) is needed. The average price for bunch is 60 RUB/bunch. Based on the number of underbrush and its distribution by height groups, it is possible to determine the output of marketable products (Table 9).

Table 9. Output of marketable products from the underbrush

Name of product	Undergrowth (number/ha)	Number of finished products	Revenues from sales (RUB/ha)
Branch feed (number/ha)	1898	76	4560
Panicles (90% of the total undergrowth) (number/ha)	1708	85	2975
Brushwood (10% of the total) (bunches/ha)	190	19	285
Wood greenery for destination (T)	1898	1 044	6786
Total without wood greenery	-	-	7820
Total without branch feed	-	-	10046

The amount of incomes from the sale of the underbrush is less than from the undergrowth. However, due to the greater mass of one plant of underbrush it gives more revenue than the same wood products of undergrowth. At the same time,

labor costs for harvesting the undergrbrush is less, because the average height of the underbrush is greater than the average height of the undergrowth.

CONCLUSION

The resources of the forest found, concentrated in the stand, undergrowth and underbrush, can bring the maximum total income of about 700 000 RUB/ha. The share of timber is 650 000, and undergrowth and underbrush 43 000 RUB/ha. The final results are highly dependent on the number of trees, undergrowth and underbrush, as well as on the composition of the tree species and the total wood volume. Under the canopy of a stands with predominance of beech, the composition and reserves of the lower vegetation floors (undergrowth and underbrush) can be recovered in 5-8 years, and by active care of stands this time can be shortened. Logging of mature beech and related species can be carried out once in 100-140 years, depending on the forest type category. Consequently, during the period of maturation of beech, it can be carried out about 15-20 harvests of undergrowth and underbrush, which together can generate income comparable to the amount from the sale of wood. Complete removal of undergrowth and underbrush does not reduce the water-regulating and soil-protecting properties of beech stands, and it is without environmental risks. The positive effect can be manifested in the improvement of conditions for self-renewal of some forest-forming species, because removal of undergrowth and underbrush excludes competition from these vegetation floors of the phytocenosis.

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