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Resource evaluation of lower layers of vegetation under the canopy of a beech tree

A V Gryazkin^{1*}, M M Gutal², N V Belyaeva¹, V V Bespalova¹, I A Kazi¹, H Vu Van¹

¹Saint-Petersburg State Forest Technical University, 5 Institutskiy Lane, St. Petersburg 194021, Russian Federation ² University of East Sarajevo. Vuka Karadžiæa 30, Lukavica 71123, Federation of Bosnia and Herzegovina

*Corresponding email: lesovod@bk.ru

Abstract. The object of research – new growth and undergrowth under the canopy of growing stocks with predomination of a beech tree as the first and the second storeys. Our work objective - monetization of tree resources deposited with new growth and undergrowth of beech forests of North Caucasus. The structure of the new growth and the undergrowth is not uniform in height and composition, it varies essentially among the subjects of research. The mean number of the new growth is 8988 pcs/ha and of the undergrowth - 1998 exemplars/ha. The mean height of the new growth is 0.65 m, of the undergrowth -0.86 m. The mass of one plant of the mean height in the air-dry condition is equal to 0.24 kg for the new growth and 0.55 kg for the undergrowth. The income amount from sales of the undergrowth is less than from the new growth. While the maximum total income from sales of the new growth and undergrowth phytomass may be about 43 ths/ha. Final results depend significantly on the structure by height, on the composition and the number of the new growth and the undergrowth.

1. Introduction

Forest ecosystems represent an inexhaustible source of raw material and not raw material resources, because the full ranges of resources, with rare exception, are self-restoring. The other feature of forest resources lies in the fact that this is ecologically safe products. In the absolutely most cases, during forest management in the RF, chemical substances of different purpose are not applied [1-3]. It follows that all components of forest ecosystems are developed in the natural medium.

The most widespread type of raw materials commonly used for centuries is timber. And large-scale timber is harvested in the most cases [2-9]. Forest thinners, new growth, undergrowth are rarely used, as a result they are lost on researchers. But sometimes stocks of raw materials in these forest components may be considerable. Owing to other components of forest ecosystems, proceeds can exceed the total amount from sales of timber by several times [2, 5-11].

Publications of the last decades speak for the increasing interest in forest resources [1, 2, 5-8, 10, 12, 13]. Many countries give information on the use of novel products whose source is the forest resource [2, 5-8, 10, 11, 13]. Therefore the problem of the rational use of variable forest resources is of increasing current interest. Reliable estimate of the species composition and stocks of any kind of

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resources – a complex task and its solution requires efforts of specialists as well as organizations, states.

Our work objective – monetization of tree resources deposited with new growth and undergrowth of beech forests of North Caucasus.

2. Methods and Materials

The object of research – the most common types of beech forests. This is growing stocks in conditions of the middle belt of the beech forest growth in the North Caucasus central part. The height above the sea level is equal to 1200-1350 m (Kartsinsky range of mountains, the RNO-Alania). Two objects on the northern macro-slope (objects 1 and 2) and two objects – on the southern macro-slope (objects 3 and 4). Taxation characteristic of growing stocks on experimental plots is presented in table 1.

Growing stocks are represented by 80-90-year beech forests with different part of horn-beech and other species in composition. Such phytocenoses are widespread at heights of 1200-1350 m above the sea level, on slopes from 15 to 45 degrees. Growing stocks on objects of research are two-storeyed, beech trees being predominant in both storeys in composition (4-10 units). The forest site type is C2-D2. The forest type – beech oat forest (objects 1 and 2) and beech barley forest (objects 3 and 4).

The first storey of growing stocks has relative density 0.81-0.93 and the second storey – far below, only 0.10-0.28. The mean diameter of the first storey is equal to 38-52 cm, the mean height is 20-23 m, the standing crop – 262-313 m³/ha. The capacity class – the second. The standing crop and all other characteristics of the second storey are fewer across the experimental plots [14]. Growing stocks selected for research have been formed on dark-brown forest soils. Fragments of carbonate rocks occur locally on the surface and in the upper soil levels.

r r			Mean		0.		
Numbe of objec	Composition of growing stock by storeys ^a	Quantity of trees, pcs/ha	D, cm	H, m	Relative density	Stock, m ³ /ha	Age, years
1	6Eb 3Eh 1Nm single Sl, Ga	269	38	23	0.84	306	90
	8 Eb 2 Eh	46	9	12	0.12	17	30
2	6Eh 4Eb single Nm	251	38	21	0.81	262	80
	10Eb	29	11	13	0.11	18	30
3	4Eb 4Eh 2Eo single Ba, Ea, Nm	180	47	20	0.93	263	80
	6Eb 3 Eh 1 Nm	16	12	10	0.10	3	40
4	4Eb 4Eh 2 Nm single Ba	148	52	23	0.86	313	90
	7Eb 2Eh 1 Nm	52	13	12	0.28	19	40
9							

Table 1. Taxation characteristic of growing stocks on objects of research.

^aThe upper line – the first storey of growing stock, the lower line – the second storey.

^bAbbreviations of tree species: Ba - Black alder (*Alnus glutinosa* (L.) Gaerth.), Ea - European aspen (*Populus tremula* L.), Eb - Eastern beech (*Fagus orientalis* Lipsky), Eh - European hornbeam (*Carpinus betulus* L.), Eo - European oak (*Quercus robur* L.), Ga - Grey alder (*Alnus incana* (L.) Moench), Nm - Norway maple (*Acer platanoides* L.), Sl - Small-leaved lime (*Tilia cordata* Mill.).

The main characteristics of the growing stock are established based on the results of the complete enumeration of trees on the growth plot of standard size (0.5 ha). Timber resources of all species were established measuring the tree height and stem diameter in accordance with recommendations of [4].

Species composition of the forest live cover varies by experimental plots but common species predominate. Typically there occur anemone (*Anemone ranunculoides* L.), blackberry (*Rubus platyphyllos* C.Koch), winter-weed (*Stellaria media* (L.) Vill.), female fern (*Athyrium distentifolium* Tausch ex Opiz), great nettle (*Urtica dioica* L.), ostrich fern (*Matteucia struthiopteris* (L.) Tod.). Projective cover for the absolute majority of species, as a rule, is no larger than 5%. Occurence, projective cover and species composition were determined on round areas 1.785 m in radius [14]. Their quantity on each object, depending on conditions, varied from 30 to 40. The list of plants

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subtending common yew (*Taxus baccata* L.) and beech tree (*Fagus orientalis* Lipsky) is included in the data base developed involving authors [15].

The number, composition, distribution by height groups of the new growth and undergrowth were established during performance of accounting works on the same round areas by 10 m^2 on which characteristics of the forest live cover were determined.

The new growth and undergrowth phytomass by species was determined by weighing raw (in field conditions) and air-dry (in laboratory conditions) states. Prices by all resource categories were used as average market ones as of 2019.

3. Results and Discussion

The part of commercial forests in the Russian Federation is about 611 mln ha (more than 53% of forest reserve land). The raw materials base for harvesting various forest resources is located on the immense territory under different forest conditions. Forests of Caucasus hold a special place, because, in addition to raw and environment-forming functions, they perform also soil-protecting functions supporting valuable forests against erosion.

The main component of the forest ecosystem – the growing stock. Until the present time, timber is the most demanded resource. Other forest components remain untapped or are not used at all. Among untapped structural elements of forest ecosystems – new growth and undergrowth, which is being noted by both native and foreign researchers [2, 9, 8, 12, 16]. However identified stocks of valuable raw materials and non-timber products are concentrated here.

Table 2 presents data on composition of the main storeys of phytocenosis and the number of trees, new growth and undergrowth. In most cases, the new growth of research objects consists of the same forest species as growing stocks of the both storeys. As a part of the undergrowth, 7 species of shrubs occur.

No. of	Composition of growing stock by storeys and new growth ^a	Number
object		spc/ha
1	I storey – 6Eb 3 Eh 1Nm single Sl, Ga	38
	II storey – 8 Eb 2Eh	46
	New growth – 84Eh 9Eb 7Nm	12563
	Undergrowth – 54Es 46Ed	2281
2	I storey – 6Eh 4Eb single Nm	251
	II storey – 10Eb	29
	New growth – 79Eh 14 Nm 6Eb 1F single E	9239
	Undergrowth - 51Ed 25Cu 14Es 6Ro 4Hs	1461
3	I storey – 4Eb 4Eh 2Eo + Ba, Ea, Nm	180
	II storey – 6Eb 3Eh 1Nm	16
	New growth - 70Eh 21Nm 5F 2Eb 1Ba 1Ep single Sl, Ea	5775
	Undergrowth - 60Ch 24Es 5Br 11Ro	1250
4	I storey – 4Eb 4Eh 2Nm single Ba	148
	II storey – 7Eb 2Eh 1Nm	52
	New growth – 50Nm 41Eh 9Eb single Ba, F	8375
	Undergrowth – 69Es 19Ed 12Ro	2600

Table 2. Composition and numbers of trees, new growth and undergrowth by objects of research.

^aAbbreviations of tree species, under story and new growth: Ba - Black alder (*Alnus glutinosa* (L.) Gaerth.), E- Elm (*Ulmus* sp.), Ea - European aspen (*Populus tremula* L.), Eb - Eastern beech (*Fagus orientalis* Lipsky), Eh - European hornbeam (*Carpinus betulus* L.), Eo - European oak (*Quercus robur* L.), F - ash (*Fraxinus excelsior* L.), Nm - Norway maple (*Acer platanoides* L.), Sl - Small-leaved lime (*Tilia cordata* Mill.), Ga - Grey alder (*Alnus incana* (L.) Moench), Es - European spindle (Euonymus europaeus L.), Ep - European pear (*Pyrus communis* L.), Ed - Elder (*Sambucus* sp.), Hs - honeysuckle (*Lonicera* L.), Ro- rowan (*Sorbus aucuparia* L.), Cu - currant (*Ribes* sp.), Ch-common filbert (*Corylus avellana* L.), Br - brier (*Rosa* sp.).

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New growth and undergrowth represent sources of raw materials for forest chemistry (tree foliage) and sources of feed supplies (woody forage in case of the stable keeping of live stock). In addition, the new growth and undergrowth can be used for making switches, duster brushes and fences.

As can be seen from the table, the composition of new growth is not always determined by the composition of growing stock. Predominance of beech tree in composition of growing stock does not guarantee its predominance in composition of new growth, for instance objects of 1, 3 and 4. The structure of new growth by height is not uniform; it varies significantly just as the composition among the objects of research. Small new growth prevails (up to 0.5 m). The mean number of new growth is 8988 pcs/ha. The mean height of the new growth is 0.65 cm, air-dry mass of one plant of such height is 0.24 kg.

In summer, it is possible to harvest from new growth and undergrowth woody forage in the form of bundles about 1 m long and about 10 cm in diameter at the fastening place. To make such a bundle, the average number of 30 plants is used. For this purpose, small and mean in height plants up to 1.5 m are used. During winter harvest duster brushes are binded from new growth and undergrowth (raw material consumption -20 plants). Mean price of woody forage is 60 rubles for a bundle and 35 rubles for a duster brush. For harvesting woody forage and duster brushes it is possible to use any species. Common yew is the exception. All parts of this plant are toxic and besides of that species is in the Red Book of the RF.

Upon the availability of demand, new growth and undergrowth may be used as tree foliage – raw materials for small forest chemistry. Price of one ton of such raw materials is 6.5 thsd rub.

Large in height new growth and undergrowth (chat-wood, 10% from total number) are used for building fences and as small fabricating material. Price of a bundle from 10 long rods is on average 15 rubles. Based on the number of new growth by species and its distribution by height groups, it is possible to determine the commercial yield, table 3.

Product description	New growth number, pcs/ha	Number of end products	Proceeds from sales, rub/ha
Woody forage	8988	300	18000
Duster brushes	8098	405	14175
Chat-wood	899	45	675
Tree foliage,	8988	2.157	14020
Total, without tree foliage	-	-	32850
Total, without woody forage	-	-	28870

Table 5. Commercial vield from new grow	vth.
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Undergrowth, just as new growth, is not uniform both in composition and in height. This storey of beech phytocenoses is presented by 7 species of bushes. Averaged composition of the undergrowth – 37 Es 31Ed 12Ch 8Ro 7Cu 3Hs 2Br. The mean number – 1898 pcs/ha. Distribution by height groups: 50% – small, 40% – medium and the rest 10% – large. The mean height is 0.86 m, the mass of one plant in air-dry state – 0.55 kg.

In summer, it is possible to harvest woody forage in the form of bundles 1m in length and about 10 cm in diameter at the fastening place. The making of such bundle requires on the average 25 plants from the undergrowth, because the undergrowth mean height is somewhat more than the new growth mean height. During winter harvest, it is possible to make duster brushes from the undergrowth just as from the new growth (consumption of raw materials -20 plants). Mean price of woody forage is 60 rubles for one bundle and for a duster brush -35 rubles.

Based on the number of undergrowth and its distribution by height groups, it is possible to determine the commercial yield, table 4.

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	2	e	
Product description	New growth	Number of end	Proceeds from
	number, pcs/ha	products	sales, rub/ha
Woody forage, pcs/ha	1898	76	4560
Duster brushes	1708	85	2975
Chat-wood	190	19	285
Tree foliage, t	1898	1.044	6786
Total, without tree foliage	-	-	7820
Total, without woody forage	-	-	10046

Гable 4.	Commercial	yield f	rom und	ergrowth.
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The income amount from sales of the undergrowth is less than from the new growth, however owing to the more mass of one plant, raw materials in the form of tree foliage from the undergrowth gives more income than woody forage.

4. Conclusion

Thus, resources of a forest plot concentrated in the new growth and the undergrowth may bring max total income of around 43 thsd/ha. In case of other variants of the use of these raw materials, the income amount will be less than 37 thsd/ha. The final results significantly depend on the number of new growth and undergrowth as well as on the structure by height, on composition of tree species. Prime costs of raw materials harvest will depend on specified indices as well.

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