Original Scientific paper
10.7251/AGREN2502021G
UDC 630(470)

STRUCTURE AND RESERVES OF RESOURCES IN SPRUCE FORESTS OF NORTHWESTERN RUSSIA

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ABSTRACT

The data on the species composition and productivity of the main forest resources are presented using the example of a region in the north-west of Russia. The subject of research is wood and non-wood resources of highly productive spruce forests. A comprehensive assessment of the main forest resources based on field data has been carried out. The wood reserves and volumes of non-timber forest products have been estimated - tree bark, tree greens, twig food, plants that have resource value as parts of the living ground cover. The valuation of different types of raw materials deposited in the forest ecosystem has been carried out. It has been established that the main part of the site's resources are non-timber forest products. The share of timber in total amount of income ranges from 32 to 40%. Calculations show that the integrated harvesting of diverse forest resources can significantly reduce costs. This eliminates multiple visits to the forest area, which increases the conservation and sustainability of the ecosystem. When harvesting the available resources in winter, the income received will be 19% lower. The forest phytocenosis can undoubtedly be called a multifunctional natural factory, unique, first of all, because its products are ecologically clean and can be created without human participation and without any expenses. Such a factory produces not only wood, but also many other types of raw materials.

Keywords: *forest fund, spruce forest, forest raw materials, species composition, valuation.*

INTRODUCTION

Forest resources are being studied more and more often by scientists from all over the world. The interest to them is conditioned not only by their value as natural exhaustible resources, but also by their poorly studied property of self-renewal. In addition, the most important property of most types of forest resources is the short cycle of full regeneration, i.e. the same forest area can be harvested annually without damaging the forest ecosystem (Vu Van Hung et al., 2016; Gryazkin et al., 2017;

Samsonova et al., 2017; Khetagurov et al., 2018; Gryazkin et al., 2019; Gryazkin et al., 2019).

There are many publications on the diversity, importance and reserves of forest resources, but they are mostly expert estimates on species diversity and approximate stocks of certain types of forest resources (Egoshina et al, 2005; Nekrasova, 2006;Cherkasov et al., 2006; Baginsky et al., 2007; Veprikova et al., 2012; Maznaya, 2016; Khetagurov et al, 2018; Lung, 2001; Peter et al., 2003; Vasilev et al., 2003; Ajay, et al., 2005; Sharashkinetal., 2005; Nygrenetal., 2006; Liuetal., 2011; Kidaneetal., 2014; Enescu, 2017; Cioacă, Enescu, 2018).

One of the most valuable products of the forest fund is birch sap and sap of other tree species (Vu Van Hung et al., 2016; Gryazkin et al., 2022; Gryazkin et al., 2023; Khetagurov et al., 2023). Today, a variety of birch bark products are widely used (Nekrasova, 2006; Veprikova et al., 2012; Gryazkin et al., 2019). Honey-bearing plants are often in the field of researchers' attention (Samsonova et al., 2017; Gryazkin et al., 2019; Gryazkin et al., 2022; Gavrilova et al., 2023; Paramonov et al., 2023).

The use of medicinal and food plants occupies a special place in the general problem of harvesting forest resources both in Russia and in other countries (Wild useful plants..., 2001; Egoshina et al. 2005; Maznaya, 2016; Gryazkin et al., 2019; Mahmood et al., 2013; Kidaneet al., 2014; Enescu, 2017; Enescu et al., 2018). Attempts have been made to quantitatively and qualitatively assess the recreational resources of forest ecosystems (Voskoboynikova and Ivonin, 2017; Gryazkin et al., 2017; Kochkin, 2019; Vasilev et al., 2003).

An important direction for the rational use of the diversity of forest resources is integrated forest management, when several types of raw materials are harvested in one and the same forest area during one entry into the forest (Complex Productivity..., 2007; Khetagurov et al., 2018; Gryazkin et al., 2019; Nygren et al., 2006; Liu et al., 2011; Kidane et al., 2014; Enescu, 2017; Cioacă, Enescu, 2018; Gryazkin et al., 2019). Multi-purpose use of forest resources – the basis for preserving the resource base.

A new direction of integrated use of forest ecosystem resources is the creation of so-called "agroforestry farms". Such farms produce not only agricultural products, but also many types of forest products (World Forestry Congress, 2003; Sharashkin et al., 2005; Andrew et al., 2006).

The main problem of modern forest management practice is the lack of a universal methodology for assessing yields and stocks of various products, the lack of systematized data by region and forest conditions (Cherkasov et al., 2006; Samsonova et al., 2017; Gryazkin et al., 2019; Global Forest Resources Assessment, 2001; Nygren et al., 2006; Kidane et al., 2014).

The purpose of the work is a comprehensive assessment of wood and non-wood resources deposited in the forest fund on the example of a separate region in Northwestern Russia.

MATERIAL AND METHODS

The most productive spruce forests growing in northwestern Russia (Saint-Petersburg and Leningrad region) were selected as the objects of the study. These forest types belong to the greenmoss group of assotiations and are represented by bilberry-greenmoss (mirtyllus type) and bilberry-woodsour-greenmoss (oxalis type) assotiations. Such ecosystems predominate in the forest fund of the Leningrad region. The main characteristics of the experimental forest sites are presented in Table 1.

Table 1. Characteristics of the forest stands on the objects of study
(Abbreviations of tree species: Ns – Norway spruce (*Picea abies* (L.) H. Karst.), Sp – Scots pine (*Pinus silvestris* L.), Wb – white birch (*Betula pubescens* Ehrh.), Ea – European aspen (*Populus tremula* L.), Ga – grey alder (*Alnus incana* L. Moench)

Stand characteristics	Quantitative indicators by objects of study	
Spruce forest type	Oxalis type	Myrtillus type
Composition, %	84Ns8Wb6Ea2Sp	68Ns12Wb10Ga6Sp4Ea
Relative completeness	0,8	0,6
Canopy closure, %	0,84	0,64
Average age, years	88	95
Average diameter, cm	29,1	26,8
Average height, m	27,9	25,0
Bonitet class	I	II
Trunk wood stock, m^3/ha	375	244

The wood stocks of all species within the stand were determined by means of tree numeration. Earlier publications analyzed data on the phytomass of birch and spruce (Gryazkin,1999; Gryazkin et al., 2019).

In each forest type under study, 5 square-shaped sample plots of 50 m^2 were laid out. Within these plots, stocks of resource species were determined, along with berry yields. For this purpose, circular survey plots with a radius of 1.785 m (10 m^2) were used according to the original methodology (Gryazkin et al., 1999). 48 counting plots were laid in each experimental plot. In each square plot, all species of living ground cover, undergrowth and understorey were counted to determine occurrence and projective cover. Height, vital state, abundance and composition of undergrowth and understorey were determined. Stocks of marketable plant species were determined by cuttings. Berry yields were determined by single picking during their ripening period. Wholesale prices for resource types are given in accordance with the prices for 2021. Prices for medicinal herbs and medicinal raw materials were obtained through the official program - Search and order of medicines in pharmacies of St. Petersburg and Leningrad region, Information service "EKMI". Prices for berries were taken as average market prices, and for technical raw materials – from procurement offices on "agroserver.ru". Average prices of LLC "TransLes" and LLC "HasslacherLes" were used for timber.

RESULTS AND DISCUSSION

Forest products are environmentally friendly products If in specialised shops eco-products are sold products obtained with the use of special technologies, with the investment of large amounts of labour and money, then in forest ecosystems clean products are formed without human participation, without any expenses. A forest area is literally a unique production, a multifunctional natural factory. Such a factory produces not only wood, but also many other raw materials.

The data in Table 1 reflect the different taxation characteristics as well as the species composition of the experimental plots: it can be seen that the stands have a mixed composition and are represented by different species. The number of trees by species and their main characteristics are shown in Table 2.

Table 2. Main characteristics of wood species at experimental sites

Tree species	Number of trees, pcs/ha		Dm, cm		Hm, m		M, m^3/ha	
	Oxalis type	Myrtillus type	Oxalis type	Myrtillus type	Oxalis type	Myrtillus type	Oxalis type	Myrtillus type
Betula pubescens Ehrh.	32	47	27,9	26,8	25,3	23,0	20	31
Picea abies (L.) H.Karst	365	245	28,2	25,3	27,7	26,2	250	165
Alnus incana (L.) Moench	-	95	-	19,2	-	17,8	-	24
Populus tremula L.	20	12	30,6	30,0	27,9	25,8	99	15
Pinus sylvestris L.	5	16	29,7	32,7	28,1	25,5	6	17
Total	422	403	-	-	-	-	375	244

It has been established that the total stock of wood, taking into account the tree species and class of marketability, allows to get income from 201 thousand rubles/ha to 248 thousand rubles/ha (Table 2). At the same time with timber harvesting it is possible to harvest bark of tree species. Bark can be used to produce tar and its derivatives (aspen and birch), tannins (spruce, alder) and dyes (alder). On average, the share of spruce bark from the total volume of the trunk is 12.5 %. Taking into account the average density of bark (310 kg/m3), in these spruce forests it is possible to harvest from 7383 to 8344 kg/ha. The volume of alder bark is set according to the standards for spruce bark. In total it is possible to get from 406065 to 522410 rubles/ha from bark sales. Average prices for tanning raw material by species differ slightly, so the same price for bark of all tree species was used in the calculations.

Aspen bark is used for leather tanning, fodder additives (aspen fat), tar, composting raw material. The maximum profitability from the sale of aspen bark - raw material for tar, costing 110 rubles/kg (average price from procurement companies). Realization of aspen bark gives revenue from 46860 to 53170 rubles/ha.

It is known that the mass of birch bark on one trunk of birch, on average, is 3.732 kg (Gryazkin et al., 2019). The wholesale price of 1 kg of birch bark is equal to 230 rubles. Birch bark harvested in a spruce forest (with birch participation in the composition of the stand from 8 to 12 % by stock) can be sold for 32550-40343 rubles/ha. When processing model birch trees, it was found that one birch tree has an average of 32 branches in its crown. In the summer period, when harvesting wood, after cutting off limbs and branches, it is possible to make birch brooms. On one broom, on average, two branches are used, so from one birch tree you can make 16 brooms. The average price of one broom is 90 rubles. The total cost of such products will be from 31670 to 45120 rub./ha in spruce forest.

When harvesting wood in winter, you can collect birch buds from birch branches, which are used as a medicinal raw materials. One birch branch has an average of 350 buds. The mass of 1000 buds is 49.3±6.4 g. The number of buds is approximately equal to the number of leaves. The cost of birch buds is 700 rubles/kg, and the cost of all harvested raw materials will be from 15422 to 18130 rubles/ha.

After harvesting the buds, birch branches can be used to make panicles for household needs. On average, three branches are consumed to make one broom. The average price of one broom is 52 rubles. The total amount of revenue can range from 21271 to 25540 rubles/ha. A valuable raw material for obtaining a variety of biologically active products is woody greenery - shoots with leaves or needles. According to the data published earlier (Gryazkin, 1999), the crown of one spruce tree contains on average 43.1 kg of woody greenery, and one pine tree - 14.0 kg. The total stocks of woody greenery are: in the oxalis type of spruce forest – 15732 kg of spruce and 74 kg of pine, in the myrtillus type of spruce forest - 10473 kg of spruce and 224 kg of pine. The cost of 1 ton of woody greenery averages 6.9 thousand/rub. The total cost of woody greenery of pine and spruce in the oxalis spruce forest is 109061 rubles/ha, and in the myrtillus spruce forest - 73809 rubles/ha.

The undergrowth under the canopy of stands is also a source of raw materials and resources that participate in the formation of the upper storey. The composition of undergrowth is represented by the following species (Table 3).

Table 3. Species composition and number of young trees at experimental sites, pcs/ha

Tree species	Oxalis type	Myrtillus type
Betula pubescens Ehrh.	33	8
Picea abies (L.) H.Karst	1436	2357
Acer platanoides L.	358	-
Alnus incana (L.) Moench	702	919
Populus tremula L.	660	60
Pinus sylvestris L.	8	4
Total	3197	3348

The phytomass accumulated in the undergrowth (Table 3) can be used as twig fodder (deciduous species), or as raw material for production of vitamin meal (coniferous species). Taking into account the number of deciduous undergrowth (from 993 to 1686 specimens/ha), its average height (1.2 m) and average weight of one plant (0.36 kg), the total stock of twig fodder from undergrowth will be from 357 to 907 kg/ha. The twig fodder can be sold at the price of 1910 rubles/t, therefore, the total cost of twig fodder from undergrowth growing under the canopy of spruce forests will be from 682 to 1732 rubles/ha.

Coniferous undergrowth is a raw material for producing greenery. The average weight of woody greens in one plant is 0.63 kg. The total reserves of woody greens accumulated by the undergrowth ranges from 910 to 1488 kg/ha. Sales of woody greens from the undergrowth additionally gives from 6279 to 10267 rubles/ha.

The understory under the canopy of spruce forests is represented by *Daphne mezereum* L., *Lonicera xylosteum* L., *Salix caprea* L., *Viburnum opulus* L., *Frangula alnus* Mill., *Sorbus aucuparia* L.. The number of understory on the experimental plots ranges from 3073 to 3595 pcs/ha. The number of understory by species is given in Table 4.

Table 4. Species composition and number of undergrowth under the canopy of stands, pcs/ ha

Species	Oxalis type	Myrtillus type
Daphne mezereum L.	132	11
Lonicera xylosteum L.	132	248
Salix caprea L.	67	335
Viburnum opulus L.	614	23
Frangula alnus Mill.	774	492
Sorbus aucuparia L.	1876	1987
Total	3595	3073

Both undergrowth and undergrowth can be used as twig fodder in equal proportion (Table 4). Taking into account the total number of plants suitable for twig fodder - 2571 and 2689 eq/ha, the average height of the undergrowth (1.9 m) and the average mass of twig fodder per plant (0.66 kg), the total phytomass will be from 1697 to 1775 kg/ha. The total sum from realization of twig fodder from undergrowth species will be 3241 and 3390 rubles/ha.

The living ground cover under the canopy of highly productive spruce forests is represented by herbaceous plants, shrubs, semi-shrubs and mosses. A total of 30 species of herbaceous-shrub vegetation were identified. Of these, 18 species are of resource importance. Food plants include 11 species, including berry plants – 5. Medicinal plants – 17, technical species (containing tannins and dyes) – 3, honey-bearing plants – 16 species.

In compliance with the established rules (Rules for harvesting..., 2020), food and medicinal plants can be harvested in the experimental sites in the following amounts Table 5 (kg/ha per season).

Table 5. Species composition and reserves of resource plants under the canopy of stands

Species	Reserves, kg/ha	Value, rubles/ha
Vaccínium vítis-idaéa L.	110	12100
Veronica officinalis L.,	21	2310
Anemone nemorosa L.	19	2090
Geranium sylvaticum L.	20	2200
Geum urbanum L.	18	1980
Angelica sylvestris L.	61	6710
Hypericum maculatum Crantz.	9	990
Fragaria vesca L.	8	880
Chamaenerion angustifolium L.	26	2860
Oxalis acetosella Kuntze	24	2640
Rúbus saxátilis L.	70	7700
Convallaria majalis L.	18	1980
Potentilla erecta (L.) Raeusch.	11	1210
Rubus idaeus L.	64	7040
Melampyrum nemorosum L.	12	1320
Pulmonária obscúra Dumort.	20	2200
Aegopodium podagraria L.	56	6160
Vaccínium myrtíllus L.	288	31680
Total	855	94050

Prices for food, medicinal and raw plants vary from 50 to 160 rubles/kg. For all plant species we used the average value of 110 rubles/kg in our calculations. The total income from the sale of medicinal plants can average 94050 rubles/ha.

Under the canopy of spruce forests the yield of the presented berry species is average. *Rúbus saxátilis* L.and *Vaccínium myrtíllus* L. are more abundant, respectively 14.1 and 47.3 kg/ha. Under these conditions yield of *Vaccínium vítis-idaéa* L. is about 8.9 kg/ha, and yield of Fragaria vesca L. – 2.2 kg/ha (Table 6).

Table 6. Berry yield in experimental sites, kg / ha

Name of species	Value, rubles/kg	Yield, kg/ha	Total value, rubles/kg
Vaccínium vítis-idaéa L.	290	8,9	2581
Fragaria vesca L.	680	2,2	1496
Rúbus saxátilis L.	290	14,1	4089
Vaccínium myrtíllus L.	410	47,3	19393
Total	-	72,5	27559

The total value of all types of berries that can be harvested in spruce forests averages 27559 rubles/ha.

In general, taking into account the reserves and yields of the main types of resources and the season of harvesting, a forest area with a predominance of spruce in the composition of the stand can bring substantial income (Table 7).

Table 7. Income from the sale of forest resources during complex harvesting, rub./ha under integrated harvesting

Types of resources	Winter	Summer
Wood	224500	224500
Birch buds	16776	-
Birch brooms	-	38395
Birch	36446	36446
Bark for tanning	116059	116059
Aspen bark	50015	50015
Twig fodder from trees	-	4448
Twig fodder from undergrowth	-	1207
Twig fodder from undergrowth	-	3241
Brooms from felling residues	23406	-
Woody greenery (stand of trees)	93435	93435
Woody greens (undergrowth)	8273	8273
Medicinal and food plants	-	97350
Berries	-	27559
Total	568910	700928
Share of timber sales, %	39.5	32.0

CONCLUSION

The results of the calculations based on real field data show that integrated harvesting of diverse forest resources can significantly reduce costs. This eliminates multiple visits to the forest area, which increases the conservation and sustainability of the ecosystem. Winter harvesting of forest resources brings 19 % less income, but it allows to increase the employment of the population in the winter period, which is important for the population of remote settlements and villages of the forest zone.

The cost of harvesting any type of raw material in the forest is always high and this explains the reason for the slow involvement of various forest products in the commodity turnover. With the integrated utilization of forest area resources, the economic performance of this activity improves significantly. Harvesting and processing of a wide range of forest by-products can be profitable. The above data show that the main part of the forest area resources is not timber, but non-timber resources, or forest by-products. The share of wood in the total income is, depending on the season of the year, 32-40 %.

REFERENCES

Weiss A. A. Average percentage of bark of Siberian spruce trees (Picea obovata L.) according to normative reference materials // Research in the field of natural Sciences. 2015. No. 1 [Electronic resource]. URL: http://science.snauka.ru/2015/01/8961 (accessed: 07.02.2019). (In Russ.).

Veprikova, E. V., Tereshchenko E. A., Chesnokov N. V., Kuznetsov B. N. [et al.] Use of birch bark and birch bark for obtaining sorption materials / / Journal of the Siberian Federal University. Chemistry. - 2012. - Vol. 5. - No. 2. - P. 178-188. (In Russ.).

Voskoboynikova I. V., Ivonin B. M. Justification of permissible recreational loads in the forests of the Western Caucasus // News of higher educational institutions. Forest magazine. – 2017. – № 1 (335). – C. 64-72. (In Russ.).

Gryazkin A.V. Structural organization of phytocenoses of the southern taiga (on the example of spruce forests of the green-Mosh group of forest types). Saint Petersburg: Spbglta, 1999, 136 p. (In Russ.).

Gryazkin A.V., Belyaeva N. V., Vanjurak G. V., Wu Van Hung. Variability of thickness and mass of birch bark along the length of the trunk // University news. Forest Magazine. 2019. No. 2. - Pp. 54-61. (Izv.). studies'. institutions'). DOI: 10.17238/issn0536-1036.2019.2.32. (In Russ.).

Gryazkin A.V., Lyubimov A.V., Samsonova I. D., Khetagurov H. M., Hung Wu Wang. SAP productivity of birch depending on the number of cutting channels // Agrarian scientific journal. 2017. No. 6. - P. 7-10. (In Russ.).

Wild useful plants of Russia / Responsible editors A. L. Budantsev, E. E. Lesiovskaya. Saint Petersburg: SPKHFA, 2001, 663 p. (In Russ.).

Egoshina T. L., Kolupaeva K. G., Rychkova N. N., Skopin A. E., scriabina A. A. Resources of Vaccinium vitis-idaea L. in the Kirov region. Message 1. Biological features and reserves / / Rast. resources. 2005. Vol. 41. Issue 1. Pp. 72-82. (In Russ.).

Complex productivity of forest Fund lands: monograph / V. F. Baginsky [et al.]; edited by V. F. Baginsky. - Gomel: F. Skarina state University, 2007, 295 p. (In Russ.).

Kurlovich L. E., Nikolaev G. V., Cherkasov A. F. and others. Manual on accounting and assessment of secondary forest resources and products of secondary forest management. - Moscow: VNIILM, - 2003. - 315 p. (In Russ.).

Lebedev Yu. V., Lebedev M. Yu., Neklyudov I. A. Complex assessment of the forests of the Urals and Western Siberia / / Lesnoy Vestnik. - 2013. - № 4. - Pp. 172-176. (In Russ.).

Maznaya E. A. Structure and productivity of aboveground phytomass of coenopopulations of Vaccinium myrtillus L. and Vaccinium vitis-idaea L. in pine forests of shrub-lichen (Kola Peninsula) / / Rast. resources. 2016. Vol. 37. Issue 1. P. 15-22. (In Russ.).

Nekrasova V.B. Therapeutic and prophylactic means from tree biomass. Saint Petersburg: publishing house of the Polytechnic University, 2006, 192 p. (In Russ.).

Samsonova I.D., Gryazkin A.V., Do V. T., Syrnikov I. A., vu V. H. Potential honey-bearing resources of the forest Fund of the Leningrad region // Beekeeping. 2017. No. 3. Pp. 25-28. (In Russ.).

Khetagurov Kh. M., Gryazkin A.V., Gutal M. M., Feklistov P. A. On the issue of effective use of resources of high-altitude maple trees of the Caucasus // Sustainable development of mountain territories. Vladikavkaz, 2018. - № 2(6). - Pp. 373-382. DOI: 10.21177/1998-4502-2018-10-3-373-382. (In Russ.).

Hung, V. V., Khetagurov, H. M., Kochkin, A. A., and others. Intensity of birch SAP release depending on the trunk diameter and crown habitus // Agrarian scientific journal. – 2016. – no. 10. – Pp. 46-49. (In Russ.).

Cherkasov A. F., Mironov K. A., Shutov V. V. non-Wood forest resources of the Kostroma region: wild fruits and berries, medicinal plants and mushrooms. - Kostroma: Kostroma technological University, 2006, 250 p. (In Russ.).

Shmatkov N.M. Non-Wood forest resources – human health and health of the economy of forest areas // Byul. Center for environmental policy of Russia "On the way to sustainable development of Russia". - 2004. - № 28. - P. 17-19. (In Russ.).

Ajay Kumar Mahapatra and D.D. Tewari. Importance of non-timber forest products in the economic valuation of dry decidious forests of India. Forest Policy and Economics. 2005. Vol. 7(3): pp. 455-467.

Andrew D. Scott, James A. Burger and Barbara Crane. Expanding site productivity research to sustain non-timber forest functions // Forest Ecology and Management. 2006. Vol. 227(1- 2): p. 185- 192.

Cioacă, L., Enescu, C.M., What is the potential of Tulcea County as regards the non-wood forest products? Current Trends in Natural Sciences 2018. 7(13): 30-37.

Enescu C.M., Which are the most important non-wood forest products in the case of Ialomița County? AgroLife Scientific Journal. - 2017. 6 (1): 98-103.

Enescu, C.M., Dincă, L., Crișan, V., The most important non-wood forest products from Prahova County. Revista Pădurilor. - 2018. 1: 45-51.

FAO. Report of the expert consultation on non-wood forest products, Yogyakarta, Indonesia, 1727 January 1995. Non-Wood Forest Products 3. - Rome.

Global Forest Resources Assessment. FAO Forestry Paper 140. – Rome: Food and Agriculture Organization. 2001. http://www.fao.org/forestry/fo/fra/ [Geo-2-416].

Gryazkin A., Bespalova V., Samsonova I., Belyaeva N. et al. Potential reserves and development of non-wood forest resources. IOP Conference Series: Earth and Environmental Science. - 2019. - № 316 (https://iopscience.iop.org/issue/1755-1315/316/1). DOI https://doi.org/10.1088/1755-1315/316/1/012007. // Published under licence by IOP Publishing Ltd IOP Conference Series: Earth and Environmental Science, Volume 316, conference 1. 2019. Volume 316. Previous issue. Next issue IV scientific-technical conference "Forests of Russia: policy, industry, science and education" 22–24 May 2019, St. Petersburg, Russia.

Kidane, B., van der Maesen, L. J. G., van Andel, T., & Asfaw, Z. Ethnoveterinary medicinal plants used by the Maale and Ari ethnic communities in southern Ethiopia. Journal of Ethnopharmacology, 2014.153 (1): pp. 274–282.

Kremen, C., Niles, J.O., Dalton, M.G., Daily, G.C., Ehrlich, P.R., Fay, J.P., Grewal, D. and Guillery, R.P. (2000). Economic Incentives for Rain Forest Conservation Across Scales. Science, 9 June 2000, - pp. 1828-2832.

Liu T.X., Zhang S. W. Agroforestry Systems in Northen Temperate Zone and Productive Perspectives// Advanced Materials Research. 2011. Vol. 304. Pp. 253-258.

Lung N.N. The status of forest resources in Vietnam: matter of environment, economy, society and resolutions // Journal of Agriculture and Rural Development. - 2001. - № 12. - pp. 891-893.

Mahmood A, Mahmood A, Malik RN, Shinwari ZK. Indigenous knowledge of medicinal plants from Gujranwala district, Pakistan // Journal of Ethnopharmacology. - 2013. – 148. – pp. 714-723.

Nygren A., C. Lacuna-Richman, K. Keinänen and L. Alsa. Ecological, Socio-Cultural, Economic and Political Factors Influencing the Contribution of NonTimber Forest Products: Case Studies from Honduras and the Philippines // Small-scale Forest Economics, Management and Policy, - 2006. - 5(2): 249-269.

Peter C.B., Gordon M., James R.U. Non-timber forest products from the Canadian boreal forest: An exploration of aboriginal opportunities // Journal of Forest Economics. - 2003. - Vol. 9(2). – pp. 75-96.

Sharashkin L., Gold M., and Barham E. Ecofarming and agroforestry for self-reliance: small-scale, sustainable growing practices in Russia. In: Proceedings of the Association for Temperate Agroforestry Conference, June 12-15, 2005, Rochester, Minnesota. 2005. – P. 39-42.

Syampungani S., Chirwa P.W., Akinnifesi F.K., Ajayi O.C. The potential of using agroforestry as a win-win solution to climate change mitigation and adaptation and meeting food security challenges in Southern Africa //Agric J. 2010. №.5. Pp.80-88.

Vasilev Z.; Markov I.; Jambazova M. Methodology for economic evaluation and commercialization of environmental services provided to the population in protected recreational forests. (Bulgaria)] // Science Of Gorata. - 2003. - T. 40. - N 1. - pp. 3-32.

Gryazkin, A.V. Sap productivity of birch trees : A book for forestry specialists, university students studying in the field of Forestry / A.V. Gryazkin, V. V. Hung, Ch. Ch. Thanh. – The second edition, stereotypical. – Saint Petersburg : 'Lan' Publishing House, 2023. – 148 p. – ISBN 978-5-507-45730-4. – EDN ZOKDBF.

Features of the structure of young trees formed on the sites of forest crops / O. I. Gavrilova, A.V. Gryazkin, K. A. Pak [et al.] // Coniferous boreal zones. - 2023. – Vol. 41, No. 2. – pp. 133-138. – DOI 10.53374/1993-0135-2023-2-133-138. – EDN BBPYRM.

A comprehensive assessment of the raw materials of birch forest areas / A.V. Gryazkin, T. Ch. Chan, H. V. Wang [et al.] // News of Higher educational institutions. Forest Magazine. – 2022. – № 1(385). – Pp. 23-35. – DOI 10.37482/0536-1036-2022-1-23-35. – EDN CXVKFD.

Kochkin, A. A. The influence of intensive recreation on the dynamics of the state of the lower tiers of forest phytocenoses : specialty 06.03.02 "Forestry, forest management and forest taxation" : dissertation for the degree of Candidate of agricultural Sciences / Kochkin Alexander Andreevich, 2019. – 137 p. – EDN KCIWEC.

Tapping of beech, hornbeam, walnut and alder / H. M. Khetagurov, I. A. Nikolaev, A.V. Gryazkin, A. B. Bazaev // Improving the efficiency of the forest complex : Materials of the Ninth All-Russian National Scientific and Practical Conference with in-ternational participation, Petrozavodsk, May 02, 2023. – Petrozavodsk: Petrozavodsk State University, 2023. – pp. 175-177. – EDN QTXWBK.

Order of the Ministry of Natural Resources of the Russian Federation dated 07/28/2020 No. 496 "On approval of the Rules for harvesting and collecting non-wood forest resources" (Registered with the Ministry of Justice of the Russian Federation on 12/16/2020 No. 61508)

https://www.researchgate.net/publication/323115707_XII_World_Forestry_Congress

Certificate of state registration of the database No. 2023624311 Russian Federation. Resources of the Heather family on the North-West of the Russian Federation : No. 2023624311 : application 28.11.2023 : publ. 01.12.2023 / S. G. Paramonov, A.V. Gryazkin, L. K. Voldaev ; applicant Federal State Budgetary Educational Institution of Higher Education "St. Petersburg State Forestry University named after S.M. Kirov". – EDN TRNYWV.