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VIRGIN FORESTS OF THE EUROPEAN NORTH-EAST

This article outlines the issues of conditions and protection of virgin forests in the Komi Republic, it also includes silvicultural and mensuration characteristics of intact forest stands.

Key words: dark coniferous taiga, virgin forests, forest protection.

BACKGROUND

The Komi Republic is one of the regions in Russia where intact, undisturbed by human activities forests remained. The European North-East had more favorable conditions that differ from the neighboring regions in intensity of the territory development. The studied territory differs from the southern ones as it was less intensively used for agriculture and has got a less impact on the land structure as a result. Low harvesting volume for industrial needs in order to supply factories with charcoal and fire wood was typical for the republic, whereas in the southern regions of Russia and the Urals, for example, huge areas were used for charcoal production. Huge territories close to Arkhangelsk had been cut more intensively for a long period of time and there were selective cuts with lower quality trees left, non-commercial thin conifers left, aspen and birch stands. In spite of increase of timber harvesting volume in the Komi Republic since the 1930-ies, undisturbed intact areas nevertheless were left in the region.

Due to the rising interest to intact forests from both the scientists and public, well-illustrated publications that provide information about republican virgin forests and ways of their conservation have been recently published [1, 2, 3]. The main huge areas of intact forests in the Komi Republic are located on the western slope of the Ural Mountains, including some territories of the national park "Jugyd-Va" and Pechoro-Ilychsky nature reserve. In 1995 those territories were recognized unique and were included into the UNESCO list of the world cultural and natural heritage under the title "Virgin forests of Komi". Nature and flora of this nature reserved territory is well studied [1, 2, 3, 4, 5 etc.]. However most of research works provide geobotanical and floristic characteristics of plants, whereas there is lack of forests silvicultural and mensuration descriptions [6, 7, 8]. This scientific article outlines characteristics of the republican virgin forests and their dynamic processes that were made by traditional silvicultural and mensurational methods of research. Issues dealing with virgin forests description and conservation are also considered.

USED TERMS

In Russian and foreign literature researchers use alongside with the term “a virgin forest” other terms like “a native forest”, “primary forest”, “a spontaneous taiga”, “an intact forest”, “a frontier forest”, “a pristine forest”, “an unexploited forest”, etc. [9, 10, 11]. We are not going to describe in details all the above mentioned terms, will just make a note that they might be similar or have differences in meaning used by different authors. There is an opinion that some terms have not been completely worked out. In the definitions there is an element of evaluation of an anthropogenic impact on forests, there is a variability of terms, used for similar in meaning concepts. In some cases researchers analyze a possibility and a period of regeneration structure of the forest community after a temporary or complete restriction for the anthropogenic impact.

Analyses of the term definition “virgin forest” given by different authors and our own studies allow us to use a general concept, defining the subject matter of the notion: exception of any human impact on all stands composing a forest area (forest massif); impact of natural disasters (forest fires, windfalls, etc) on certain forest stands; and existence of virgin forest stand in the forest massif structure. Virgin forests - are stands that have been developed without any human impact and include no less than one generation of the edificatory species in the forest stand structure, have been formed without any natural disasters within the period of getting a mature age in the certain soil and climate conditions. In this article we use the term “a virgin forest” and “an intact forest” or other authors’ terms.

VIRGIN FORESTS IN THE SYSTEM OF NATURE PROTECTED AREAS AND FOREST FUND STRUCTURE OF THE KOMI REPUBLIC

According to the literature analysis, virgin forests communities of the Komi Republic are included in the system of nature protected areas (NPAs) [12, 13]. Nowadays nature protected areas are forests of “Pechoro-Ilychsky state nature biospheric reserve” (721, 3 thousand ha) and forests of the national park “Jugyd-Va” (1 891, 7 thousand ha). Besides on the territory of the Komi Republic there are 237 republican nature protected areas and more than 40 local (regional) NPAs. At that the most valuable territories are located on border of the north-west areal of Siberian cedar. In most cases these are intact by human activities forest massifs of dark coniferous taiga with cedar or remained parts of such type forest areas.

In the Komi Republic 40% of the forest covered area is classified as protected forests. Mostly these are territories with pretundra forests and protected forest belts along the rivers. Due to a special regime of forest management and use on these areas some virgin forests massifs remained. Mature and over-mature stands make more than 60 % of all forest covered area. Spruce, fir and pine stands were not cut on huge wetland areas and have composed overmature low density stands. The age structure of spruce stands is presented by more than 80% of mature and over-mature trees [14]. It is possible to assume that, the more mature and overmature stands and fewer young stands on the territory of a forest management unit area is, the higher is the probability of preserved virgin forests. In this regard forest management units' territories that border on the Ural range (Komsomolskoye, Pechoro-Ilychskoye, Vuktylskoye, Pechorskoye), the national park "Yugyd Va", and also northern forest management units' territories (Ust-Tsylemskoye, Izhemskoye, Usinskoye, Kadzheromskoye) are likely to have areas of preserved intact forests. The share of mature and overmature forests by the total forest covered area is more than 80 %. Indexes of Ukhtinskoye, Udorskoye, Pomozdinskoye, Meshchurskoye, Mezhdurechenskoye and Ertomskoye forest management units are also close to that figure. The probability of intact forests preservation in the southern forest management units (Letskoye, Priluzskoye, Kazhimskoye, Koygorodskoye, Syktyvkarskoye, Sysolskoye, Syktyvdinskoye, Kortkerosskoye, Aykinskoye) is lower, mature and over mature forests make 20-40 %.

Other forest management activities besides cuttings also influence intact forests preservation. In the northern regions, in the North-Polar Urals there is an exploration and production of liquid and gaseous hydrocarbon resources and mineral resources. Oil and gas pipelines cause some emergency situations. A high concentration of industrial production is in Vorkuta, Ukhta, Sosnogorsk and Syktyvkar industrial areas. Middle-Timan bauxite deposit is in process, it is a developing industrial area in the future.

Based on the aggregated impact estimation of logging and other forest management activities impact in the past, present and future development we can suppose that Komsomolskoe, Pechoro-Ilychskoe, Vuktylskoe and Pechorskoe forest management units, Pechoro-Ilychsky state nature biospheric reserve with its buffer zone and the national park "Yugyd Va" with its protection area are the most perspective for virgin forest researches and studies.

METHODOLOGY

The mensurational description of stands was made by traditional methods of mensurational description [15]. Forest types were defined according to V. N. Sukachev typology [16]. Site

indexes were defined according to the scale introduced by M. M. Orlov. For Komsomolsk forest management unit we have made a scale for visual mensuration of spruce in Mirtyllus-Sphagnum wet type of stand to conventional 40-years even aged stand (table1). Visual mensuration of age was made together with the direct estimation of age by means of an age drill. Age of cedar was determined individually. For big defective cedar trees the age was defined based on correlation between their diameter and a diameter increment.

Table 1. Scale for visual mensuration of spruce to conventional 40-years even aged stand

Height of the upper border zone of laminar and fissured bark, m	Stem diameter at a height of 1.3 m, cm						
	before 4	5-16	17-24	25-32	33-40	41-48	More than 48
less 0.5	41-80	81-120	-	-	-	-	-
0.6-1.5	41-80	81-120	81-120	121-160	-	-	-
1.6-2.5	41-80	81-120	121-160	121-160	121-160	161-200	-
2.6-3.5	81-120	121-160	121-160	121-160	121-160	161-200	-
3.6-4.5	-	121-160	161-200	161-200	161-200	161-200	201-240
4.6-6.5	-	161-200	161-200	161-200	161-200	161-200	201-240
6.6-8.0	-	-	201-240	201-240	201-240	201-240	201-240
more than 8.0	-	-	241-280	241-280	241-280	241-280	241-280

DISCUSSIONS OF THE RESEARCH RESULTS

Most of our researches were made in the Komsomolskoye forest management unit in the Komi Republic. The results of the mensurational description of virgin forests and natural regeneration characteristics made in the sample plots of this forest management unit are shown in tables 2, 3.

Virgin dark coniferous stands in the basin of the river Unja are mostly of a Mirtyllus-sphagnum wet type and a big fern forest type. Fir-spruce and fir-cedar-spruce stands with birch trees of a Mirtyllus-sphagnum forest type are located on the slopes of 1,5–4°. Stands have complicated two-three-storied levels. A wood storey density and the total wood stock differs in accordance to a stand tree species composition and a varied age. Spruce and fir are

predominating in the natural regeneration composition. The young growth is of the medium size (height 0,6-1,5 m) is predominating. The undergrowth is open and presented by mountain ashes and raspberries. One can find blueberries, *Equisetum sylvaticum* and sedge grass in the ground vegetation. The moss cover is presented mostly by *Polytrichum commune*, but there is also *Pleurozium schreberi*, *Hylocomium splendens* and *sphagnum* mosses.

Table 2. Stands characteristics of the experimental plots

Sample plot area	Indexes of the stand storey				Stands characteristics		
	Stand composition	Stock, m ³ ha ⁻¹	Height, m	Density	Age class	Site index	Forest type
10	I 8S2B	56	11.4	0.7	VI	V	S.b-fern.
	II 10Fir	19	7.4	0.2			
14	I 10Cd	302	21.2	0.8	XIV	IV	Cd MST
	II 10Fir	22	11.3	0.2			
	III 10S	26	6.8	0.6			
27	I 9S1B	83	13.4	0.5	VI	V	S MST
	II 10Fir	24	8.0	0.4			
28	I 7Cd3B	125	18.8	0.4	XII	IV	Cd MST
	II 7Fir3S	101	12.4	0.7			
30	I 10B	53	18.5	0.2	III	V	Fir MST
	II 7Fir3S unit Cd	93	9.4	1.1			
1(2)	I 8Cd(I)2B	159	21.6	0.5	XVI	IV	Cd MST.
	II 5S5Fir unit Cd(II)	70	9.8	0.8			
1(4)	I 10Cd(I)	54	22.0	0.1	V	V-Va	S MST.
	II 8S2B	76	12.1	0.6			
	III 10Fir unit Cd(II)	18	6.2	0.4			
1(1-4)	I 7Cd(I)3B	114	20.1	0.4	XIV	IV	Cd MST
	II 10S	77	11.5	0.4			
	III 10Fir unit Cd(II)	25	7.2	0.3			

Notice: S – spruce, Cd – cedar, Cd(I) – cedar of the first (the oldest) generation, Cd(II) – cedar of the second (the youngest) generation, Fir – fir, B – birch, b-fern. – big fern, MST – Mirtyllus-Sphagnum, I – the first storey, II – the second storey, III – the third storey.

Mixed dark coniferous stands of the big-fern forest type are located on the slopes of 3-6°. The sample plots stands have two storeys. Spruce and fir are predominating in natural regeneration. The young growth is of medium size (height of 0,6-1,5 m). The undergrowth is presented by mountain ashes, raspberries, prickly wild roses.

Table 3. Characteristics of regeneration on the experimental plots

Sample plot	Natural regeneration composition	Number of specimen (thousand units/ha ⁻¹) and size category				General density, thousand units/ha ⁻¹
		Spruce (S)	Fir (F)	Cedar (Cd)	Birch (B)	
10	5S5Cd	0.8m		0.8m		1.6
14	6F2S2Cd	0.8s	2.5s	0.8s		4.1
28	4F3B2S1Cd	2.0m	4.5m	0.5s	3.5m	10.5
30	6S2F2Cd	2.5s	0.8m	0.8s		4.1
1(2)	5F3S2Cd+B	3.8m	5.7m	2.2s	0.3s	12.0
1(4)	5F3S2Cd+B	3.3m	5.5m	1.9s	0.3s	11.0
1(2-4)	5S3S2Cd+B	3.6m	5.6m	2.0s	0.3s	11.5

Notice: l – big size young growth (more than 1,5 m height), m – medium (0,6-1,5 m),

s – small (less 0,5 m).

Ferns, *Equisetum sylvaticum*, sedge grass are predominating in the grass-subshrub composition. The moss-lichens cover is poorly developed. Micro rises are presented by *Pleurozium schreberi*, micro falls are presented by sphagnum mosses.

Calculations, based on trees count and defining the trees according to 4sm diameter classes and spruce conventional 40-years even aged stand show that the weighted average age of spruce is from 159 to 199 years. So the most frequently represented stands are 160-200 years old and that correlates with researches made by S. A. Dyrenkov [17].

Data of specimen distribution and spruce stock volume by age and thickness distribution prove the defined general regularity of tree species distribution by diameter class and age category. Spruce cenopopulations are represented by 4cm diameter class from seedlings to large-sized trees. Loss of growing forest exists in all diameter classes; it is the biggest among

young trees. In the distribution series according to diameter classes by the age of 160, there is a shift of maximum number of trees to the left from the middle. In some cases there is a row distribution break. These breaks could testify to the processes of the generation change.

Distribution of the total number of fir trees according to diameter classes is similar to spruce distribution; however the rows are more compact because of the shorter lifetime of fir trees in comparison to spruce. Spruce cenopopulations of conventional 40-years even-age generations of spruce are continuous from seedlings to the maximum age of 280 years (experimental plots 1(4), 1(1-4)). Spruce distribution for 40 years age classes can be represented by a broken line. In this case the youngest age classes are represented by thousands, the oldest age classes – by dozens, and middle age classes – by hundreds of trees. Spruce trees distribution by age classes is well reflected by polynomials of the 4-th stage and the higher ones. Spruce wood stock volume according to generations is distributed by the curve which is close to a normal distribution curve.

In the process of predomination of one tree specie to another, change of generations of the main forest making tree species the habit of the stand also changes, as well as its form (vertical structure). On the first stage of the age development in dark coniferous stands of a *Mirtyllus sphagnum* forest type (the stage of the upper storey decomposition and spruce predomination in the total wood stock volume of the spruce stand) one or two-storey stands are formed. The first storey is composed by birch and spruce trees, the second (if any) by fir. The first storey height is 11-12 m. For this stage the most of dead wood stock volume are typical. Stems of spruce and fir distribution by diameter classes at this stage can be characterized by the positive asymmetry ($A = 0,62-0,93$) and platykurtosis ($E = -0,63 - -0,13$).

In the second stage of the age development in dark coniferous stands (regenerating stage) two-storey stands are formed. The first storey height is 16-17 m, the second – about half of the first storey height. The first storey is composed by spruce and birch, the second by fir and cedar tree species. The total stand stock volume is increasing approximately by 20 % compared to the stand stock volume at the Ist stage. At the same time dead wood stock volume is decreasing to an average indicator value ($46 \text{ m}^3/\text{ha}$) for I – IV stages of development. General distribution of curves of spruce and fir stems by diameter classes does not differ a lot for the I stage of age development of a dark coniferous forest. For spruce and fir the asymmetry index (A) is described by a positive value ($0,72-0,85$), and platykurtosis (E) – negative ($-0,52 - -0,32$).

The III development stage (stage of culmination of the total stand volume and cedar predominance in a stand) is characterized by complication of a stand form, which comes out in two- and three-storey stands. The first storey height is more than 20 m. Cedar is in the first storey, the second one is composed by spruce or fir, spruce with fir or birch, the third by fir and spruce. The total stand stock volume is 200 m³/ha or is more than that. At the same time dead wood stock volume is decreasing and is 20-21 m³/ha. As in the I and II stages of dark coniferous forest development, in the III stage spruce and fir distribution by diameter classes stage has a positive asymmetry ($A = 0,87-0,75$) and platykurtosis ($E = -0,04- -0,56$).

In the IV development stage (stage of over mature and overstorey decay in the stand) the two- and three-storey vertical structure of the stands is preserved. Composition, height of a storey in stands, stands' stock and dead wood stock are close to the stands in the II development stage. Characteristics of skewness ($A = 0,78-0,89$) and steepness ($E = -0,37 - -0,19$) of the distribution curves of spruce and fir stems by diameter classes are close to such stands in the II development stage of dark coniferous forest. Therefore a general thing in the form of curves in the I and IV development stages is a positive asymmetry which appears in a crown curve displacement to the left from the center of distribution and platykurtosis testifying the fact of flat-toppedness of variation curves. A remarkable similarity of the spruce and fir distribution curves by diameter classes is in accordance to a displacement of the frequencies maximum to the left from the centre of the row for comparatively young generations and to falling character of diameter classes distribution (or another mensurational indicator, in average increasing in age) number of trees, composing a sustainable in dynamics cenopopulations [17].

The completed researches show the importance of study of a unique natural phenomenon - virgin taiga forests. Based on the structure study and dynamic of the intact by human activities forest ecosystems researches one can identify a stand to belong to a category of virgin forests, to prove that such forest areas should be considered as nature protected areas, to forecast the condition of remained virgin forests for the nearest future and long-term perspective.

CONCLUSION

The Komi Republic has huge areas of virgin forests that are also included in the structure of nature protected areas. Our researches allow us to consider that virgin dark coniferous stands

of a Mirtyllus-sphagnum forest type in the south-eastern parts of the Komi Republic have achieved a sustainable state (moving equilibrium), this is kept by a continuous stands regeneration with young trees and replacement of spruce, fir, cedar that leads to a frequent predomination of cedar and vice versa. Quantitative characteristics that can testify to that fact are: an average available stand stock $170-180 \text{ m}^3\text{ha}^{-1}$, variance of this level is 17-24%, spruce average age through the stock volume of conventional even age 40- years generations is 160-200 years.

In the process of changes in predomination of one tree specie to another, change of generations of the main forest making tree species the habit of the stand also changes, as well as its form (vertical structure). There are 4 stages of age development of dark coniferous Mirtyllus-sphagnum forest type stands. In the I stage there is an overstorey decomposition and spruce predominates in the total wood stock volume, the II stage can be called regeneration, the III stage is a culmination of the total wood stock volume and cedar predomination in the stock. The IV stage is an over mature stage and overstorey decomposition.

Based on the fulfilled researches we have suggested to consider the possibility to enlarge the territory of Pechoro-Ilychsky nature biospheric reserve and to include forest areas between the rivers Unja and Pechora in the west and the eastern slope of Vysokaya Parma to the category of mountain forests. Practical implementation of the above suggestions contributes to virgin forests conservation in the south-eastern regions of the Komi Republic where there are huge areas of intact dark coniferous taiga forests that differ in a comparatively high productivity and a rich tree species composition in comparison to the northern and western territories of the republic.

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