The Republican Unitary Enterprise "Belgosles"
The project "Development of the forestry sector in the Republic of Belarus "
GEF / World Bank TFOA 1173

APPROVED by
First Deputy of
Minister of Forestry
A.A.Kulik

REPORT

contract № BFDP/GEF/SSS/15/20-02/16 dated 05.03.2016
component 3: activities 3.1.1.2. and 3.1.2.2.; №02-2/15
Modernization of forest monitoring system of the Republic of Belarus

Stage №1. Description of conditions, objectives and assignment scope according to the technical project. Operating procedures.

EXECUTOR:
CEO of
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Minsk 2016

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General provisions

Recently much attention has been paid to the problem of climate changes in the international community. These changes influence flora and fauna. To slow down these processes there are made researches of possibilities of forest adjustment to forest ecosystem changes under the influence of anthropogenic factors.

Forest monitoring is a system of observation, evaluation and forecast of the state and dynamics of forest fund with the aim of public administration in the area of use, protection of forest fund and reproduction of forests and increase of their ecological functions.

Forest health monitoring is held since 1989 in the Republic of Belarus. The Ministry of Forestry entrusts RUE «BELGOSLES» with the function of central forest monitoring management which performs forest monitoring works through international cooperation program ICP Forests. Forest monitoring is a component of forest monitoring system within the National Environmental Monitoring System which includes 1450 permanent accounting items (PAI) and 80 permanent sample plots (PSP), equally distributed throughout the country. Over 40 000 trees are explored according to this method.

The main aim of holding forest monitoring is to get information for assessment of the current state of the main forest-forming timber species of the republic, forest ecosystems, to prepare the forecast changes under the current levels of exploitation and influence of anthropogenic, natural factors and information support of management, design and technological solutions in the area of ecological safety, reconstruction, conservation and rational use of forest soil fertility, biological and landscape diversity, habitat-forming forest properties.

Forest stands and individual components of forest fund (plantation story, timber species, staddle, auxiliary species, ground vegetation, ground and others)are the objects of forest health monitoring.

Nowadays forest monitoring is realized in following directions:

- general forest health under the influence of air solution (forest health monitoring);
- forest health under the influence of destructive insects and diseases (forest pathology);
- forest health under the influence of reclamation (eco-reclamation monitoring of ameliorative wooded lands)

Monitoring statistics is included into public database in which you can find the information about environmental health and influence on it.

In December, 2015 it was necessary to revise all laws and regulations in accordance with the code of regulations. It happened because of the adoption of the newest Forest Code in the Republic of Belarus. Also it is necessary to improve regulatory, legal and technical bases regarding the system of forest monitoring. When developing the recommendations for improvement the forest monitoring system of the Republic of Belarus it is necessary to take into account the international practice of environmental monitoring.

The aim of the assignment

The development of the Republic of Belarus forest monitoring system is the main aim of job execution based on international experience, improving the quality of observations of forests, introduction of new technologies, proven in developed countries in order to ensure the operational implementation, if necessary, such forestry activities and other measures that will contribute to minimize the negative effects that influence the forest fund as a result of climate change and economic activities, as well as the development of recommendations to improve the regulatory, legal and technical bases on forest monitoring in Belarus.

Assignment scope

The scope and the work schedule is given in table 1.1

Scheduled plan of work delivery on the subject
«The development of the Republic of Belarus forest monitoring system»

Table 1.1.

Work Stage	Execution period
1. Analysis of the dynamics of the main qualitative and quantitative indicators characterizing the state of the forest fund of the Republic of Belarus in the last ten years	18.04.2016 - 01.05.2016
2. Monitoring analysis of state and transformation of forest fund under the influence of changing climatic conditions, economic activities during the last ten years	01.05.2016 - 01.06.2016
3. Addressing the problematic issues of existing forest monitoring system with all stakeholders, piling-up of such material and its analysis. Allocated operations:	
a. Carrying out of survey (questionnaire) of forestries, RUE "Belgosles" the Ministry of Forestry, and other stakeholders in order to identify problematic issues of existing forest monitoring system; data processing;	01.06.2016 - 01.07.2016
b. Arch and analysis for the following storage of findings with the possibility of carrying out the sampling and data analysis according to the request	01.07.2016 - 15.07.2016
c. analysis and comparison of findings from different data sources regarding the problematic issues of existing forest monitoring system	15.07.2016 - 01.08.2016
4. Inquiry of international experience of forest monitoring organization (in terms of certain leading countries in the area of forest management, such as Finland, Sweden, Czech Republic, and at least two other countries with the choice of the country for review). Allocated works:	
a. preparation of positive and negative aspects of organization and forest monitoring in other countries (with selection of countries for review);\	01.08.2016 - 15.08.2016
b. analysis generation of the main achievements of international experience in the area of forest monitoring (technologies, methods, techniques) in terms of certain countries (with selection of countries for review);	15.08.2016 - 01.09.2016
5. Development of the improving proposals of monitoring system in the Republic of Belarus in order to minimize the negative impact of changing climatic conditions and economic activities on forest health. Allocated works:	

Table 1.1. (continued)

Work Stage	Execution period
a. development of improving proposals of methodology in forest monitoring, which provides more detailed forest monitoring in forest areas with more significant changes of forest health under the influence of external factors;	01.09.2016 - 15.10.2016
b. development of proposals for optimizing the number of observations;	01.09.2016 - 01.11.2016
c. development of proposals for optimizing the number of observation points ;	01.09.2016 - 01.11.2016
d. development of proposals for simplifying the methods of observation and technology in the areas of forest fund that are less susceptible to the influence of external and internal factors and according to which the dynamics of change the forest health is negligible.	01.09.2016 - 01.11.2016
6. Development of improving proposals of regulatory, legal and technical framework in the question of forest monitoring.	01.11.2016- 15.12.2016

The procedure of assignment

Customer - Ministry of Forestry of the Republic of Belarus.

Customer representative - Export and Production Republican Unitary Enterprise "Bellesexport".

Organization Executive - Forest Inventory Republican Unitary Enterprise (RUE) "Belgosles".

Organization Executive in consultation with the customer and the customer's representative forms working group (consultants) among its employees to carry out all the works which are described in Table. 1 and appoints a consultant-coordinator of the working group.

Consultant Coordinator distributes works independently within a group.

Each of the stages of the work is issued by the report, the final report is issued at the end of the work.

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Modernization of forest monitoring system of the Republic of Belarus

Stage №2. Analysis of the dynamics of the main qualitative and quantitative indicators characterizing the state forest fund of the Republic of Belarus over the last 10 years.

EXECUTOR:
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Annotation

Industrial use of wood increases every year. At the same time we must remember that forest is not only the wood for fuel and stuff production. Forest is lungs of our planet, a source of clean water, it protects the ground from water and wind erosion, makes nutrition of rivers by subsoil waters better, protects the roads from snow banks and many other things. And, of course, forest – is one of the best and picturesque places for rest.

In this report you can find the characteristic of forest fund of the Republic of Belarus. We represented the breakdown of forests along the territory of the republic, the breakdown of lands, covered with forest in terms of their types, according to location and the functions, making by forests and specifications of wood exploitation, and also we showed the division of forests on groups and categories of protection.

We have prepared the analysis of all the changes which happened in 2006 – 2015, the main qualitative and quantitative indicators characterizing the state forest fund. These are such indicators as area of forest land in the context of species and age groups, species and age structure of forests, reserve forests in the context of households and age groups, the average fullness of plantations by species group, average age, average change in stock, forestation.

The report consists of 16 pages; it contains 8 pictures and 3 tables.

Analysis of the dynamics of the main qualitative and quantitative indicators characterizing the state forest fund of the Republic of Belarus over the last 10 years.

Industrial use of wood increases every year. At the same time we must remember that forest is not only the wood for fuel and stuff production. Forest is lungs of our planet, a source of clean water, it protects the ground from water and wind erosion, makes nutrition of rivers by subsoil waters better, protects the roads from snow banks and many other things. And, of course, forest – is one of the best and picturesque places for rest.

At present (as at 01.01.2016) the lands of the forest fund of the Republic of Belarus occupied 9549,2 thousand hectares, or makes up 40% of land of the Republic. Out of that, 8239,8 thousand hectares of land are covered by forests. The total stock of wood is estimated at 1739,9 million m^3. The percentage of the forest cover of the Republic at the same time made up 39,7%.

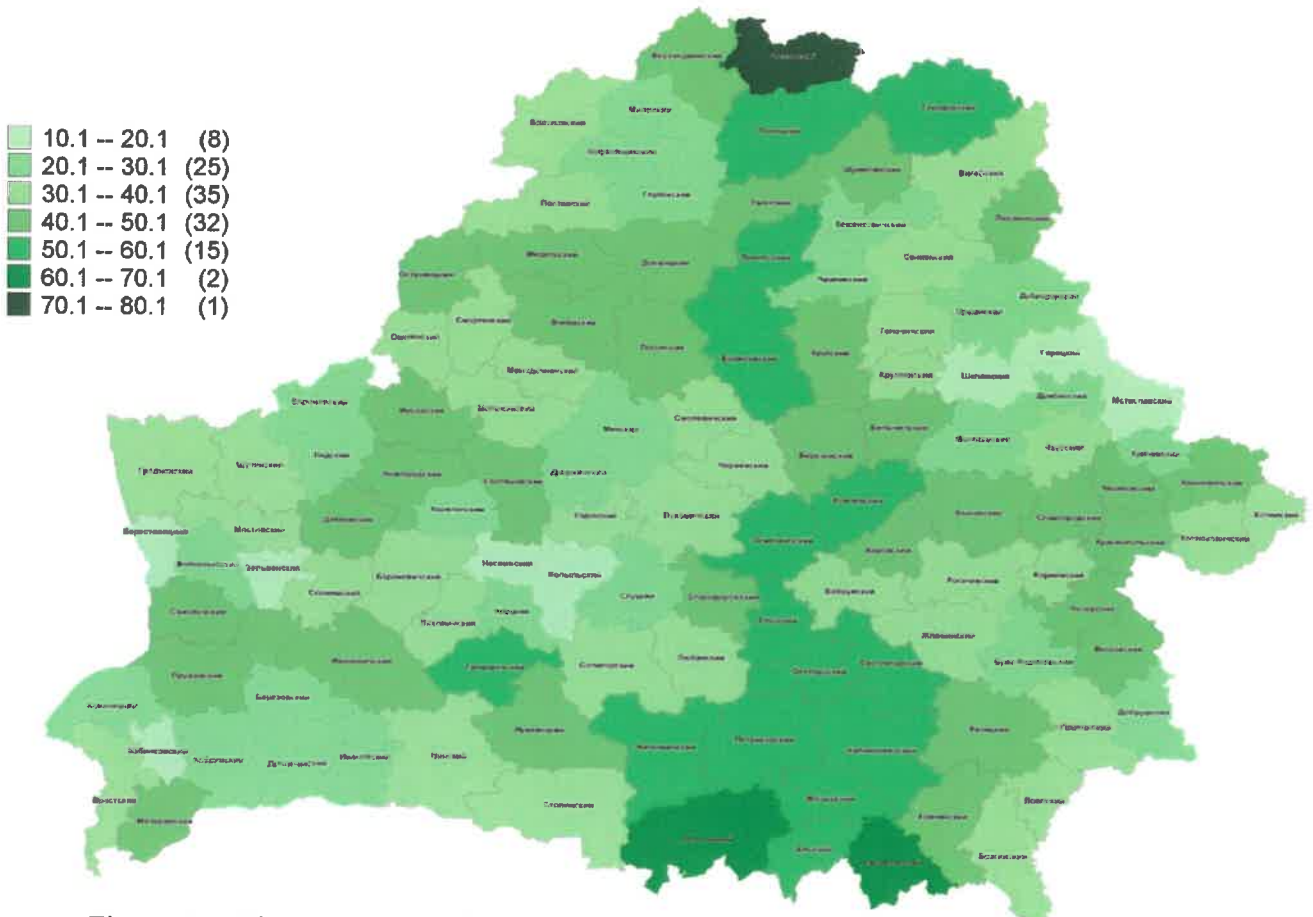

Figure 2.1. The percentage of the forest cover of the administrative-territorial units of the Republic of Belarus

Allocation of the forests all over the territory of the Republic is not even. The percentage of the forest cover of the administrative-territorial units is shown on Figure 2.1. So a minimal forest coverage is seen in Nesvizh district, Minsk region – 11,1%, and a maximal – in Rossony district, Vitebsk region – 71,2%. The forest coverage of the country's regions is as follows:

- Brest region – 36,2%;
- Vitebsk region – 40,3%;
- Grodno region – 35,1%;
- Gomel region – 46,9%;
- Minsk region – 38,3%;

- Mogilev region – 37,8%.

In accordance with economic, environmental, scientific, historical, cultural and social value of forest funds, its location and functions performed by these forests and established forest management regime forests are divided into the following groups and categories of protection.

Division of forests into groups and categories of protection

Table 2.1.

Forest groups and categories of protection	Area, ha
Forests of the I group:	
Forests of reserved areas	301290
Forests of national parks	348990
Forests of nature moments of national significance	1855
Municipal forests	9456
Parts of recreational forests in green zones	254079
Forests of the 1st – 2d sanitary protection zone of water supply sources	14083
Forests of the 1st – 2d sanitary protection zone of health resorts	27360
Forests of reserves of national significance	746668
Protective forests belts along railroad lines	135695
Protective forest belts along republican roads	189329
Forests of the 3d sanitary protection zone of health resorts	17175
Parts of forestry in green zones	1340414
Forbidden forest belts on the banks of water bodies	1602752
Total group 1	4989146
Forests of the II group:	
Commercial forests	4560017

More than half of (*52,3%*) the republican forests are designed primarily to perform protective, recreation and health-improving, social and environmental functions. These are forests located around settlements and resorts, along the roads and railways, around rivers and brooks, lakes, within the borders of specially protected zones.

The most represented types of the forests in the republic are mossy, myrtillus, oxalis and bracken. In total area of these forest types made up 66% of all land covered by forests (*table 2.2.*). A forest type consolidates lands characterized by common forest site type, i.e. indices of wetness, soil fertility, flowage of groundwater, etc., by homogeneous silvicultural characters - with similar stand development, their similar sustainability and producing capacity. Site conditions explanated throughout the territory of the forest fund provide a reasonably good potential producing capacity of forest stands. Thus high-productive forests (*Ib – I capacity classes*) occupy 4584634 ha or 55,7% of lands covered by forest, average-productive (*II – IV capacity classes*) occupy 3388617 ha or 41,1% of lands covered by forest and low-productive (*V – Vb capacity classes*) occupy 266532 ha or 3,2% of lands covered by forest. Low-productive plantings are mainly represented by pine and birch tree forests, growing on high moors mainly in a sedge-sphagnum and sphagnum forest types, as well as on dry sands in a lichen forests.

Forest types distribution of lands covered by forest

Table 2.2.

Forest type	Core forest forming species							
	pine	spruce	oak	birch	black alder	aspen	other	total
Lichen	20338			104			7	20449
Ericetal	187538			9298			32	196868
Vaccinium	12371	1358		1239		125	12	15105
Mossy	1687705	34048		56742		1074	147	1779716
Bracken	829618	94795	26747	213149		12580	5380	1182269
Oxalis	207115	417960	134586	317406	15211	74991	50001	1217271
Myrtillus	665336	154527	54069	362749		20464	2414	1259559
Longmossy	195459	12413		190620		4288	393	403173
Ledum	110035						6	110041
Sedge	61163	2029		173618	168233		36540	441583
Sphagnum	9987			229			2	10218
Sedge-sphagnum	148207	247		27508			53	176015
Aegopodium		20594	26012	57931	22335	38468	89398	254738
Nettle		2427	3216	28879	85804	4796	4997	130119
Ferny		21137	9424	322602	169046	18625	45283	586117
Near-brook herbal	7959	3261		43589		2056	380	57245
Hairgrass			1747				3	1750
Near-brook inundated			10341				13	10354
Grass inundated			9006				3	9009
Alder inundated			4118				17	4135
Ashen inundated			352				4	356
Wide-grass inundated			1704					1704
Inundated			2642				5193	7835
Marshy and mixed herbs							136	136
Spirea					200177		19152	219329
Sedge-herbal				93164			132	93296
Ferny-marsh				10097	30643		105	40845
Iris family					5448		21	5469
Willow coppice				613	2521		1831	4965
Grasses							113	113
Total on a nationwide	**4142831**	**764796**	**283964**	**1909537**	**699418**	**177467**	**261768**	**8239780**

As can be seen from the figure 2.2, the forest funds indices dynamics from 2006 to 2015 shows mainly positive trends. Thus for the last 10 years in consequence of cession of low-productive farmlands area of forest fund lands increased by 134,9 thousand hectares or 1,4%. Reduction of the total area of the state forest fund (relative to past years) was seen only in 2007 and was mainly related to the confiscation of non-forest lands occupied by gas pipelines, oil pipelines, overhead and cable transmission facilities, lines of communication and other lands. Forest lands increased by 187,9 thousand hectares or 2,2% mainly due to accepted lands, and also due to creation of the forests on non-forest lands of the forest fund. During this period area of lands covered by forest increased by 356,1 thousand hectares. As a result, with increasing area of lands covered by forest, there was an increase of forest cover percent from 38% in 2006 to 39,7% in 2015.

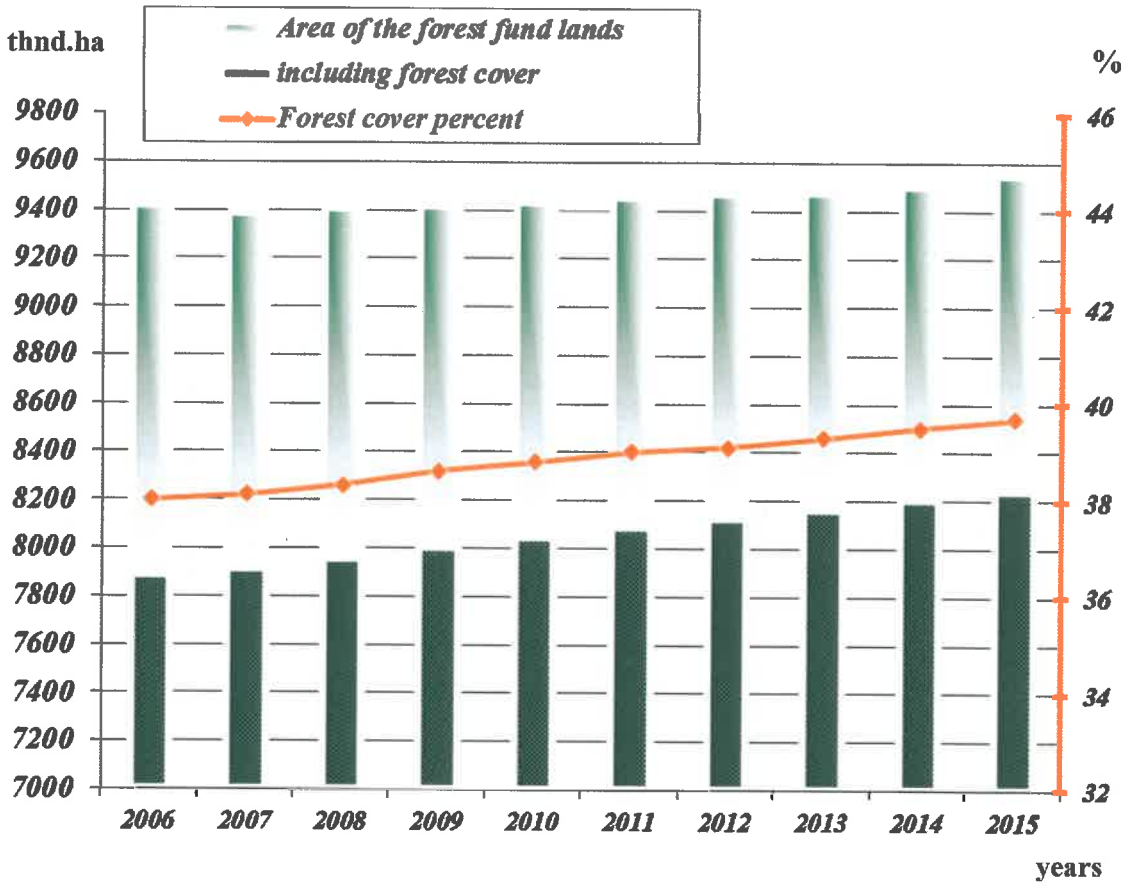

Figure 2.2. Forest fund lands dynamics

As revealed by the figure 2.3, increase of the area of lands covered by forest has come from the all three-species group. Area of coniferous forests during this period has increased by 204,4 thousand hectares, including increase of plantings with a prevalence of pine trees by 180,9 thousand hectares, spruce by 22,7 thousand hectares. Furthermore, area of soft-wooded plantings increased by 144,8 thousands hectares, including increase of birch, aspen and black alder plantings by 122,3, 16 and 26,5 thousand hectares, respectively. Area of hard-wood plantings increased by 6,9 thousand hectares, including increase of oak plantings by 6 thousand hectares. During the same period area of plantings with a prevalence of ash-trees and speckled alder has declined by 5,8 and 9,7 thousand hectares, respectively.

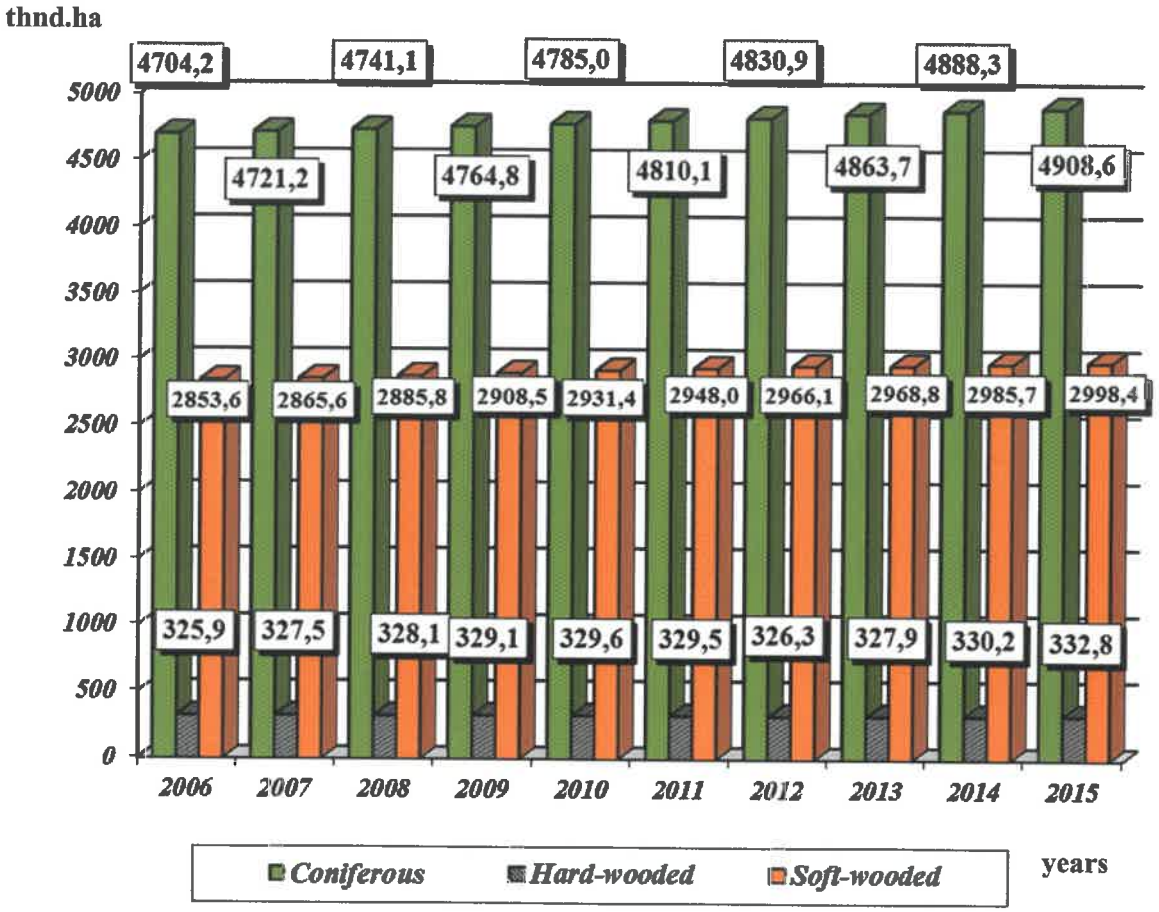

Figure 2.3 Lands covered by forest distribution by species group dynamics

Coniferous plantings dominate in the Republic of Belarus. In 2015 they occupied 59,6% of area covered by forest. Coniferous plantings dominate in all regions, except Vitebsk, where, in contrast, dominate soft-wooded plantings, growing in 52% of the area covered by forest. Soft-wooded plantings has occupied 36.4% of the area covered by forest. Hard-wooded plantings has occupied a relatively small area, and accounted for only 4.0% of the area covered by forest. Their main area is located in the south of the republic. Moreover, almost half of the area of hard-wooded plantings (44%) is located in the territory of Gomel region.

The distribution of plants (species group) throughout the administrative regions of the Republic of Belarus is shown on Figure 2.4.

More than half of the state forests are presented by a predominance of pine-tree plantings *(Figure 2.4.)*. According to the share of participation in the forest species composition pine-tree forests are quite equally represented in all regions of the country.

Plantings with a predominance of birch are represented mainly by European birch (74%). A quarter of all birch trees (26%) constitute white birch, dedicated mainly to the bottom and intermediate moors with varying degrees of watering. More than half of the area of birch forests are located in Vitebsk and Gomel region. In addition, throughout the territory of Vitebsk region birch occupies nearly a third of the lands covered by forest.

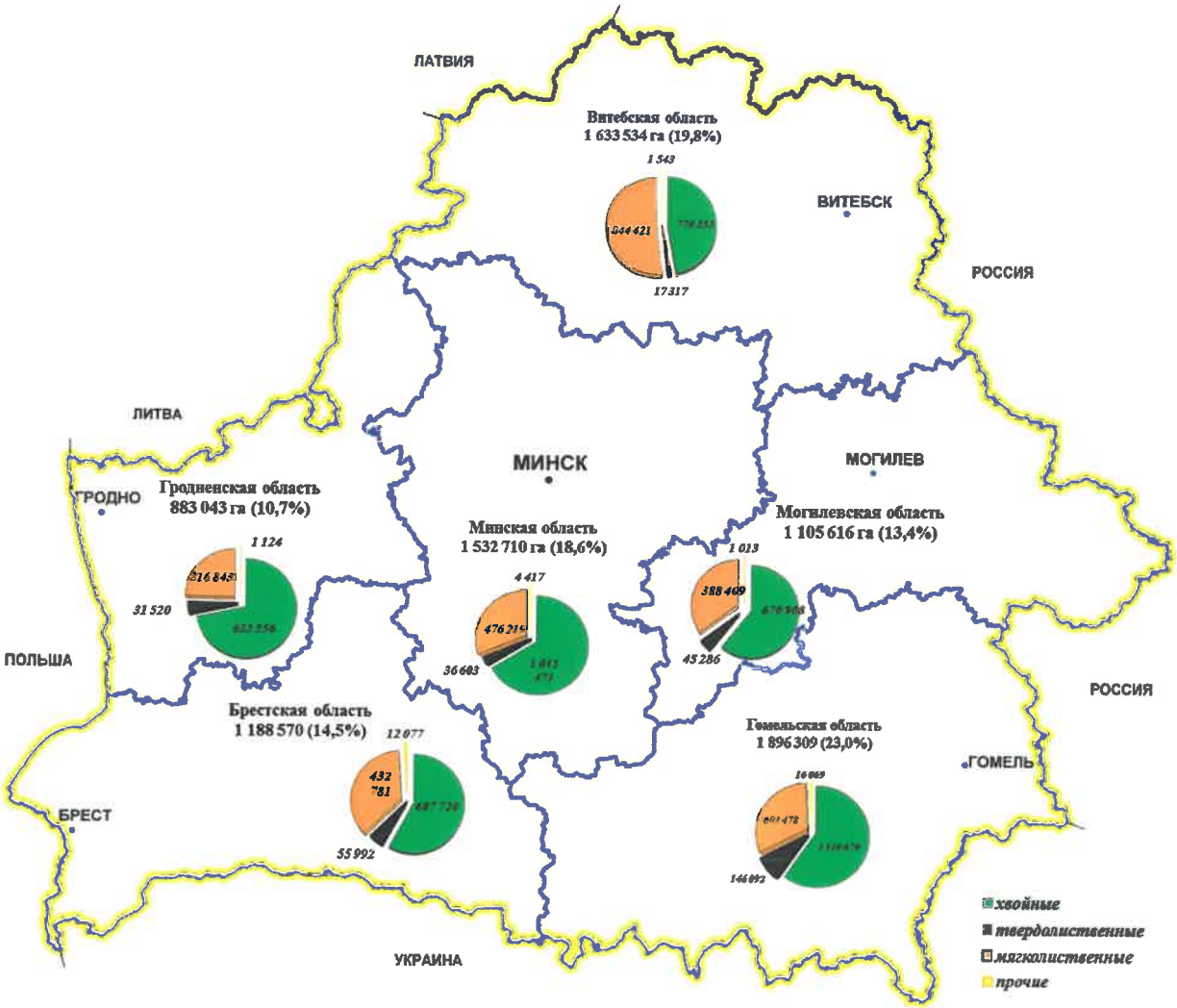

Figure 2.4. The distribution of plants throughout the administrative regions of the Republic of Belarus

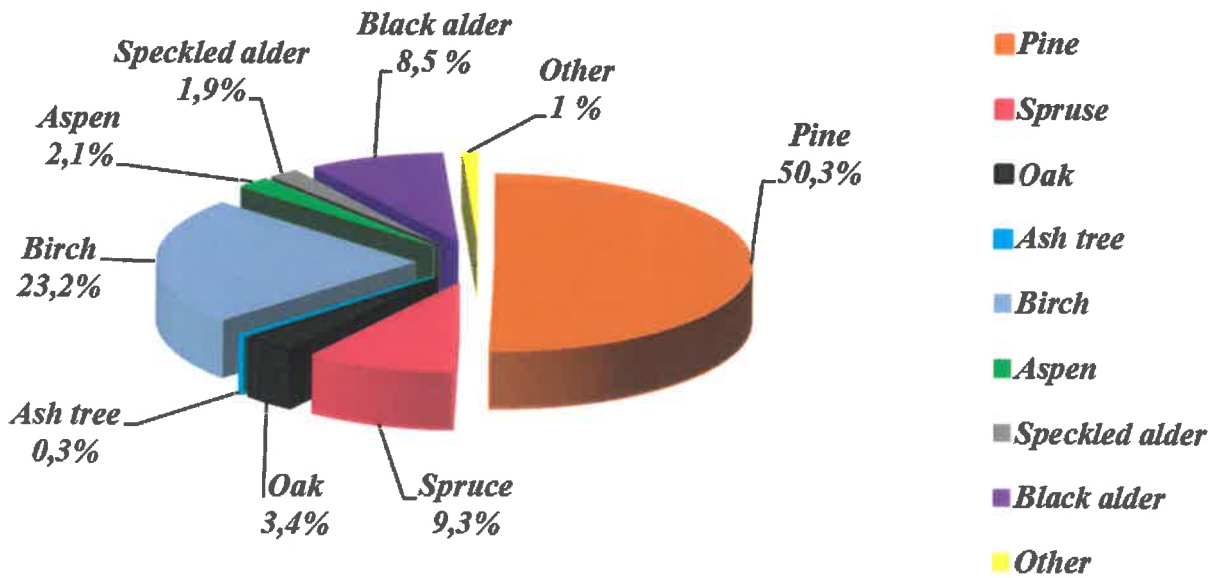

Figure 2.5. Specie composition of the forest stands in the Republic of Belarus

Forest plantings with a domination of spruce on the occupied area stand on the third place. Most of them are concentrated in Vitebsk, Minsk and Mogilev region. The southern boundary of the spruce continuous enlargement passes around the edge of the Polesye.

Black alder plantings domination can be seen mainly on the lowland moors throughout the country, but their main areas are also concentrated in Polesye.

Forest stands with a domination of oak occupy rather small area. Almost half of the oak forests are concentrated in Gomel region.

As result of natural growth, redistribution of forest plantings by age groups is coming. Age group is a classificaton unit of plantings distribution by age stages of growth and development throughout the life cycle reflecting their biological and economic specifics. From 2006 to 2015 there was an increase in the area of mature and maturing plantings and decrease in the area of middle aged and young plantings. *(figure 2.6.)*.

During the period in quiestion area of mature and overmature forests grew by 348,9 thousand hectares and leveled off at around 1,1 million hectares in 2015. Mature and overmature plantings are forest stands that have reached the age of the highest increase in targets merchantable assortment stock and are fitting for cutting till the gradual deterioration of their technical qualities and till the excess of loss of growing forest over wood increase. Maturing plantings are forest stands with specified economic and technical qualitative characters of stands, that still haven't reached the age of maturity. During the period under consideration area of maturing forests increased by 426,9 thousand hectares and reached 1,9 million hectares.

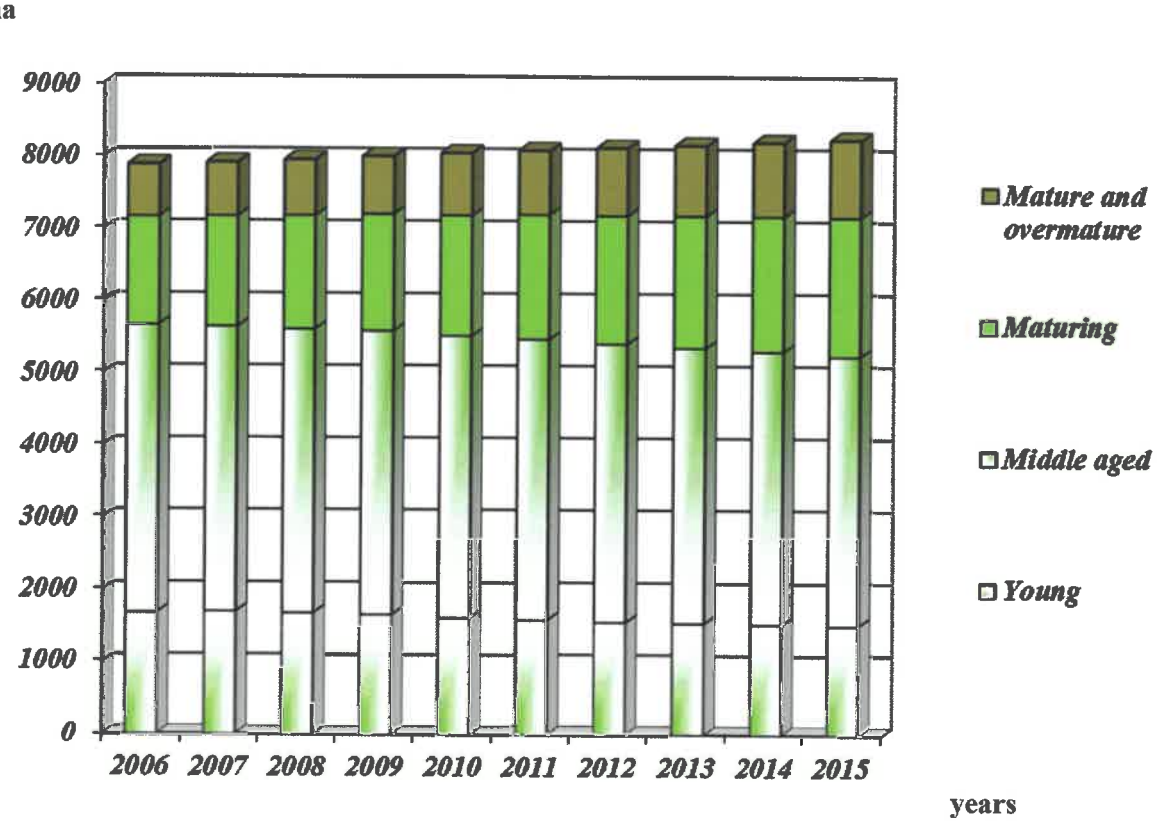

Figure 2.6. Forest planings dynamics by groups of age

At the same time there was a dicrease in the area of young plantings of 64,5 thousand hectares and in 2015 young stands covered an area of 1,5 million hectares. Young plantings are

the most strongly growing stands from the young age, when they are formed into the forest (period of thickening) till the process of trees natural status differentiation.

Reduction of the area of young plantings resulted from decrease in the area of creation forests on non-forest lands, in comparison with the post-war period, as well as from relatively small share of cutting mature and overmature stands, and creation instead of the young's.

Area of middle-aged plantings decreased by 55,2 thousand hectares and in 2015 reached 3,7 million hectares. The group of middle-aged plantings is made up of stands after the young age till they reached the age of maturing stands. Plantings of this age period are characterized by intensive diameter growth with some reduction in height growth. Middle-aged plantings are mainly stands being created intensively in the post-war period. Despite the reduction of their area in the period under review, middle-aged stands continue to outweigh in the age structure of forest plantings *(figure 2.7)*.

Thus the current age structure is far from being optimal. According to the scientists the state age structure should be as follows: young should occupy 36% of the area covered by forest, middle-aged – 33%, maturing – 16% and mature – 15%.

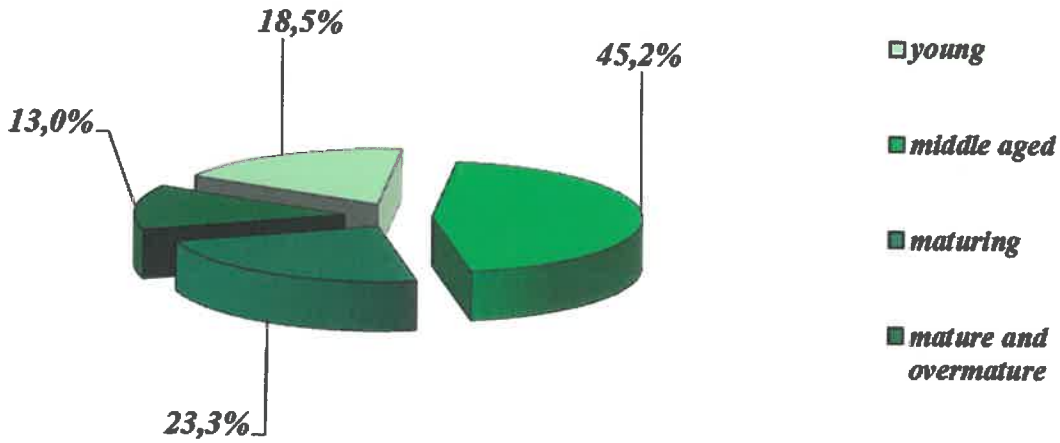

Figure 2.7. Age structure of the forest plantings

Over the past 10 years total stock of the forest plantings increased by 272,6 million m^3 or by 18,6% and made up to 1739,9 million m^3. Average change in stock was 3,9 m^3/ha (in 2006 - 3,6 m^3/ha). There was an increase of forest stock avereage of all species group: average stock of coniferous plantings increased from 207 to 236 m^3/ha, hard-wooded from 164 to 177 m^3/ha, soft-wooded from 156 to 175 m^3/ha.

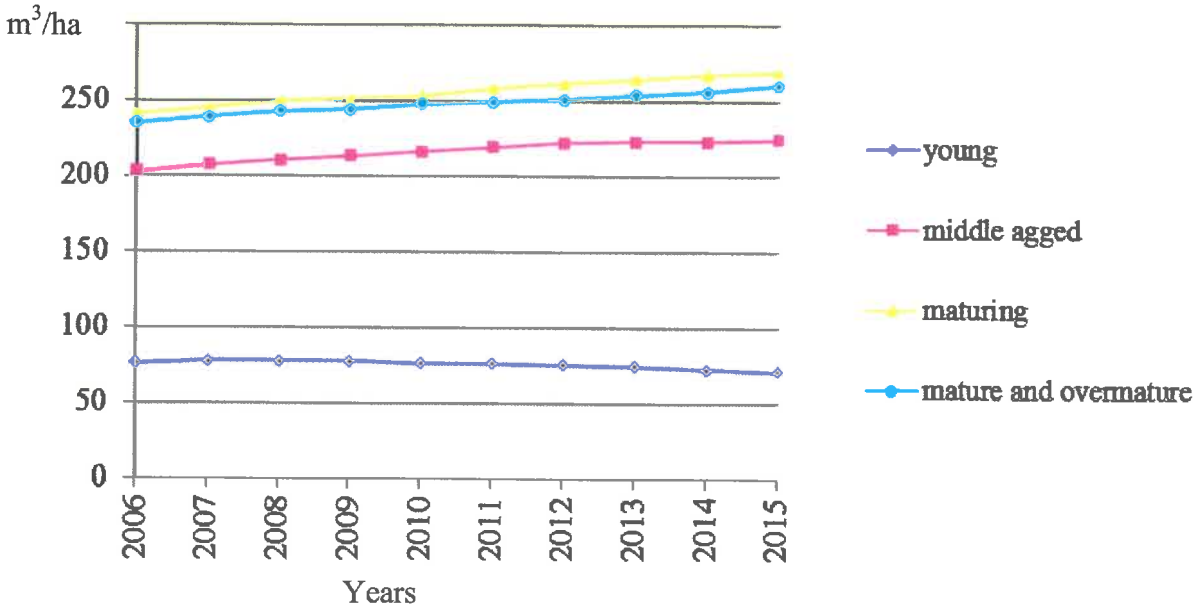

Figure 2.8. Forest stock average changes by groups of age

From 2006 to 2015, the average stock of the forest plantings of most age groups, except young stands, rises annyally *(figure 2.8)*. During this period in middle-aged plantings this indicator increased by 21 m^3/ha, in maruring by 28 m^3/ha, in mature and overmature by 25 m^3/ha.

Avereage stock of mature and overmature plantings per 1 hectare is less in relation to the stock of maturing stands mainly because of partial final cutting (gradual and selective) in mature and overmature confireous stands, which are followed by the cutting of a certain amount of woodstock. Since area of partial final cutting rises annually *(point 2, figure 2.1.)*, the difference in average stocks of plantings per 1 hectare of this age groups rises too.

Decrease of average stock of young planings during the ten-year period of 5 m^3/ha resulted mainly from the transfer of a large stand part from the 2d age class to the category of middle-aged. Consequently, there was an average age and stock per 1 ha of young plantings decrease.

During the period in question, average plantings age increased by 4 years and reached 55 years. Besides average age of coniferous and soft-wooded stands increased by 3 years, leveled off at 61 and 43 respectively, and of hard-wooded plantings by 4 years, and lined up with 70 year. Also there was an increase in average stand density from 0,69 to 0,71. In the group of coniferous plantings the average stand density increased by 0,03, and in the group of hard and soft-wooded stands by 0,01.

Conclusions

Thus, over the past ten years in the state forest funds taken place mainly positive changes of qualitative and quantitative indicators characterizing state of the forest fund. However, the decrease of the autochthonous ashen stands area raises concerns. In addition, there is a significant increase of the area of soft-wooded plantings and of uneven age structure of forests.

Dynamics of the main qualitative and quantitative indicators characterizing the state of the forest fund of the Republic of Belarus over the past ten years is presented in table 2.3.

Dynamics of the main qualitative and quantitative indicators characterizing the state forest fund from 2006 to 2015.

Table 2.3

Indices	Units of measure	Years										Changes 2006-2015	
		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	+,-	%
Area of forest fund lands	thnd.ha	9414,3	9385,6	9404,7	9416,7	9432,7	9455,1	9468,6	9477,2	9499,5	9549,2	+134,9	+1,4
inc. forest lands	thnd.ha	8506,0	8532,0	8560,6	8598,2	8624,9	8612,1	8633,5	8651,3	8672,1	8693,9	+187,9	+2,2
inc. lands covered by forest	thnd.ha	7883,7	7914,3	7955,0	8002,4	8046,0	8087,6	8123,3	8160,4	8204,2	8239,8	+356,1	+4,5
Where:													
- coniferous	thnd.ha	4704,2	4721,2	4741,1	4764,8	4785,0	4810,1	4830,9	4863,7	4888,3	4908,6	+204,4	+4,3
- hard-wooded	thnd.ha	325,9	327,5	328,1	329,1	329,6	329,5	326,3	327,9	330,2	332,8	+6,9	+2,1
- soft-wooded	thnd.ha	2853,6	2865,6	2885,8	2908,5	2931,4	2948,0	2966,1	2968,8	2985,7	2998,4	+144,8	+5,1
Young, total	thnd.ha	1685,6	1697,7	1678,3	1656,7	1623,6	1595,0	1557,9	1545,0	1540,7	1521,1	-64,5	-9,8
- coniferous	thnd.ha	1040,9	1054,2	1039,3	1026,6	1005,8	995,9	982,0	989,1	990,3	984,6	-56,3	-5,4
- hard-wooded	thnd.ha	77,8	80,0	79,8	78,9	78,5	76,0	73,8	74,2	75,4	78,0	+0,2	+0,3
- soft-wooded	thnd.ha	566,9	563,5	559,2	551,2	539,3	523,1	502,1	481,7	475,0	458,5	-08,4	-19,1
Middle-aged, total	thnd.ha	3979,9	3945,2	3928,7	3928,2	3894,3	3879,6	3852,6	3812,1	3770,0	3724,7	-55,2	-6,4
- coniferous	thnd.ha	2386,4	2353,9	2343,2	2336,6	2319,9	2306,8	2286,0	2254,8	2212,1	2169,1	-17,3	-9,1
- hard-wooded	thnd.ha	170,8	169,0	169,4	172,6	171,0	173,0	170,8	171,5	171,0	168,5	-2,3	-1,3
- soft-wooded	thnd.ha	1422,7	1422,3	1416,1	1419,0	1403,4	1399,8	1395,8	1385,8	1386,9	1387,1	-35,6	-2,5
Maturing. total	thnd.ha	1495,5	1527,8	1570,7	1613,1	1664,4	1722,7	1774,0	1826,5	1867,3	1922,4	+426,9	+28,5
- coniferous	thnd.ha	967,4	990,3	1019,1	1047,5	1078,0	1113,6	1146,0	1182,7	1221,6	1259,0	+291,6	+30,1
- hard-wooded	thnd.ha	34,8	34,7	33,8	32,7	33,5	36,0	35,5	35,9	35,9	35,2	+0,4	+1,1
- soft-wooded	thnd.ha	493,3	502,8	517,8	532,9	552,9	573,1	592,5	607,9	609,8	628,2	+134,9	+27,3
Mature and overmature, total	thnd.ha	722,7	743,6	777,3	804,4	863,7	890,3	938,8	976,8	1026,2	1071,6	+348,9	+48,3
- coniferous	thnd.ha	309,5	322,8	339,5	354,1	381,3	393,8	416,9	437,1	464,3	495,9	+186,4	+60,2
- hard-wooded	thnd.ha	42,5	43,8	45,1	44,9	46,6	44,5	46,2	46,3	47,9	51,1	+8,6	+20,2
- soft-wooded	thnd.ha	370,7	377,0	392,7	405,4	435,8	452,0	475,7	493,4	514,0	524,6	+153,9	+41,5

Indices	Units of measure	Years										Changes 2006-2015	
		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	+,-	%
Forest cover percent	%	38,0	38,1	38,3	38,6	38,8	39,0	39,1	39,3	39,5	39,7	+1,7	+4,5
Specie composition of forest lands:													
Pine tree	thnd.ha	3961,9	3977,5	3993,5	4016,7	4034,8	4059,4	4080,6	4109,6	4128,7	4142,8	+180,9	+4,6
	%	50,3	50,3	50,2	50,2	50,2	50,2	50,3	50,4	50,3	50,3	0	0,0
Spruce	thnd.ha	742,1	743,5	747,3	747,9	749,8	750,3	749,8	753,6	758,9	764,8	+22,7	+3,1
	%	9,4	9,4	9,4	9,3	9,3	9,3	9,2	9,2	9,3	9,3	-0,1	-1,1
Oak	thnd.ha	278,0	279,6	280,2	281,1	281,8	281,6	277,8	278,7	281,1	284,0	+6	+2,2
	%	3,5	3,5	3,5	3,5	3,5	3,5	3,4	3,4	3,4	3,4	-0,1	-2,9
Ash tree	thnd.ha	29,1	28,8	28,4	28,2	27,2	26,2	25,6	25,5	24,6	23,3	-5,8	-19,9
	%	0,4	0,4	0,4	0,4	0,3	0,3	0,3	0,3	0,3	0,3	-0,1	-25,0
Birch	thnd.ha	1787,2	1805,6	1819,6	1834,4	1852,7	1866,2	1881,7	1886,6	1899,5	1909,5	+122,3	+6,8
	%	22,7	22,8	22,9	22,9	23,0	23,1	23,2	23,1	23,1	23,2	+0,5	+2,2
Aspen	thnd.ha	161,5	163,8	168,3	168,7	171,4	172,6	173,2	171,3	173,7	177,5	+16	+9,9
	%	2,0	2,1	2,1	2,1	2,1	2,1	2,1	2,1	2,1	2,1	+0,1	+5,0
Speckled alder	thnd.ha	167,2	166,5	166,4	165,9	165,8	164,2	162,9	162,0	161,4	157,5	-9,7	-5,8
	%	2,1	2,1	2,1	2,1	2,1	2,0	2,0	2,0	2,0	1,9	-0,2	-9,5
Black alder	thnd.ha	672,9	675,2	680,2	685,2	689,4	692,1	694,5	694,7	697,1	699,4	+26,5	+3,9
	%	8,5	8,5	8,6	8,6	8,6	8,6	8,5	8,5	8,5	8,5	0	0,0
Other	thnd.ha	83,8	73,8	71,1	74,3	73,1	75,0	77,2	78,4	79,2	81,0	-2,8	-3,3
	%	1,1	0,9	0,9	0,9	0,9	0,9	1,0	1,0	1,0	1,0	-0,1	-9,1
Total stock of forest stands, inc.:	mln.m^3	1467,3	1498,1	1535,6	1566,1	1598,2	1635,6	1669,3	1692,7	1714,3	1739,9	+272,6	+18,6
- coniferous	mln.m^3	975,6	997,7	1024,9	1046,6	1068,2	1092,9	1115,5	1131,2	1144,6	1160,8	+185,2	+19,0
- hard-wooded	mln.m^3	53,6	54,1	54,6	55,6	56,2	57,2	57,3	58,0	58,5	59,0	+5,4	+10,1
- soft-wooded	mln.m^3	438,1	446,3	456,1	463,9	473,8	485,5	496,5	503,5	511,2	520,1	+82	+18,7

Indices	Units of measure	Years										Changes 2006-2015	
		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	+,-	%
Young, total	mln.m^3	127,8	130,4	128,9	127,4	123,8	120,6	116,7	113,8	111,0	107,6	-20,2	-15,8
- coniferous	mln.m^3	99,4	101,7	100,0	98,3	95,0	92,2	88,9	86,8	84,3	81,6	-17,8	-17,9
- hard-wooded	mln.m^3	5,2	5,4	5,3	5,3	5,2	5,0	4,8	4,8	4,7	4,8	-0,4	-7,7
- soft-wooded	mln.m^3	23,2	23,3	23,6	23,8	23,6	23,4	23,0	22,2	22,0	21,2	-2	-8,6
Middle-aged, total	mln.m^3	808,9	815,8	826,3	836,8	839,4	848,9	853,8	849,5	842,6	835,5	+26,6	+3,3
- coniferous	mln.m^3	551,7	557,6	567,6	575,2	580,2	587,2	591,3	588,2	580,8	574,3	+22,6	+4,1
- hard-wooded	mln.m^3	30,4	30,6	31,2	32,1	32,0	33,0	33,0	33,4	33,6	33,4	+3	+9,9
- soft-wooded	mln.m^3	226,8	227,6	227,5	229,5	227,2	228,7	229,5	227,9	228,2	227,8	+1	+0,4
Maturing, total	mln.m^3	360,7	374,4	391,7	405,2	421,1	444,2	463,0	481,3	497,7	517,7	+157	+43,5
- coniferous	mln.m^3	247,4	257,3	270,7	281,3	292,6	308,7	322,7	336,9	351,1	366,2	+118,8	+48,0
- hard-wooded	mln.m^3	7,6	7,4	7,2	7,1	7,4	8,1	8,0	8,1	8,2	8,0	+0,4	+5,3
- soft-wooded	mln.m^3	105,7	109,7	113,8	116,8	121,1	127,4	132,3	136,3	138,4	143,5	+37,8	+35,8
Mature and overmature, total	mln.m^3	169,9	177,5	188,7	196,7	213,9	221,9	235,8	248,1	263,0	279,1	+109,2	+64,3
- coniferous	mln.m^3	77,1	81,1	86,6	91,8	100,4	104,8	112,6	119,3	128,4	138,7	+61,6	+79,9
- hard-wooded	mln.m^3	10,4	10,7	10,9	11,1	11,6	11,1	11,5	11,7	12,0	12,8	+2,4	+23,1
- soft-wooded	mln.m^3	82,4	85,7	91,2	93,8	101,9	106,0	111,7	117,1	122,6	127,6	+45,2	+54,9
Averagw stock:		186	189	193	196	199	202	205	207	209	211	+25	+13,4
- coniferous	m^3/ha	207	211	216	220	223	227	231	233	234	236	+29	+14,0
- hard-wooded	m^3/ha	164	165	167	169	170	174	176	177	177	177	+13	+7,9
- soft-wooded	m^3/ha	156	158	160	161	163	167	169	171	173	175	+19	+12,2
Young	m^3/ha	76	77	77	77	76	76	75	74	72	71	-5	-6,6
- coniferous	m^3/ha	96	96	96	96	94	93	91	88	85	83	-13	-13,5
- hard-wooded	m^3/ha	66	67	66	67	67	66	65	64	63	61	-5	-7,6
- soft-wooded	m^3/ha	41	41	42	43	44	45	46	46	46	46	+5	+12,2
Middle-aged	m^3/ha	203	207	210	213	216	219	222	223	223	224	+21	+10,3

Indices	Units of measure	Years										Changes 2006-2015	
		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	+,-	%
- coniferous	m^3/ha	231	237	242	246	250	255	259	261	263	265	+34	+14,7
- hard-wooded	m^3/ha	178	181	184	186	187	191	193	195	196	198	+20	+11,2
- soft-wooded	m^3/ha	160	160	161	162	162	164	164	165	165	164	+4	+2,5
Maturing	m^3/ha	241	245	249	251	253	258	261	264	267	269	+28	+11,6
- coniferous	m^3/ha	256	260	266	269	271	277	282	285	287	291	+35	+13,7
- hard-wooded	m^3/ha	217	214	213	218	221	223	225	227	228	229	+12	+5,5
- soft-wooded	m^3/ha	214	217	220	220	219	222	223	224	227	228	+14	+6,5
Mature and overmature	m^3/ha	235	239	243	244	248	249	251	254	256	260	+25	+10,6
- coniferous	m^3/ha	249	251	255	259	263	266	270	273	277	280	+31	+12,4
- hard-wooded	m^3/ha	244	243	244	247	248	251	249	251	251	250	+6	+2,5
- soft-wooded	m^3/ha	244	245	249	251	252	253	253	254	255	259	+15	+6,1
Average age:	years	51	51	51	52	52	53	53	54	54	55	+4	+7,8
- coniferous	years	57	57	58	59	59	59	60	60	60	61	+4	+7,0
- hard-wooded	years	66	66	66	68	68	68	69	69	70	70	+4	+6,1
- soft-wooded	years	40	40	40	41	41	41	42	42	43	43	+3	+7,5
Average change in stock:	m^3/ha	3,6	3,7	3,8	3,8	3,8	3,9	3,9	3,9	3,9	3,9	+0,3	+8,3
- coniferous	m^3/ha	3,6	3,7	3,8	3,7	3,8	3,9	3,9	3,9	3,9	3,9	+0,3	+8,3
- hard-wooded	m^3/ha	2,5	2,5	2,5	2,5	2,5	2,6	2,5	2,6	2,6	2,5	0	0,0
- soft-wooded	m^3/ha	3,9	4,0	4,0	4,0	4,0	4,0	4,0	4,1	4,0	4,1	+0,2	+5,1
Average fullness:		0,69	0,69	0,70	0,70	0,70	0,71	0,71	0,71	0,71	0,71	+0,02	+2,9
- coniferous		0,70	0,71	0,71	0,71	0,72	0,72	0,73	0,73	0,73	0,73	+0,03	+4,3
- hard-wooded		0,65	0,65	0,65	0,65	0,66	0,66	0,66	0,66	0,66	0,66	+0,01	+1,5
- soft-wooded		0,68	0,68	0,68	0,68	0,68	0,68	0,68	0,69	0,69	0,69	+0,01	+1,5

Annex A

REPUBLIC OF BELARUS
FORESTRY DEVELOPMENT PROJECT

GEF/THE WORLD BANK

TF0A1173
TERMS OF REFERENCE AND SCOPE OF SERVICES 02-2/15

Project Component 3: Capacity Building for Sustainable Forest Management

Project Activity 3.1.1.2 and 3.1.2.2: 'Improvement of the national legislation and the regulatory technical framework of the forestry sector with account of principles of sustainable forest management and use, practice of implementation thereof, and international experience' and 'Consolidation and publication of recommendations on applying the experience of forest management abroad'

Objective: To improve the system of monitoring in the Republic of Belarus taking into account international experience, to improve the quality of observations of the state of forests, introduction of new technologies, which showed to good advantage in developed countries in order to ensure rapid implementation, where appropriate, of such forestry activities and other measures that will help to minimize the negative consequences that affect the forest fund as a result of climate change and economic activity.

1. Background

Belarusian Forestry Development Project builds on the World Bank experience in the Belarusian forest sector since the mid 1990s through the first Forestry Development Project completed in 2002 (rated satisfactory), phases I and II of the European Neighborhood and Partnership Instrument (ENPI) East Countries Forest Law Enforcement and Governance (FLEG) Program (2008-2012, 2012-2017) and the Forest Sector Policy Note prepared in 2013.

The Project Development Objective is to enhance silvicultural management and reforestation and afforestation, increase the use of felling residues and improve the public good contribution from forests in targeted forest areas.

Project component 3: Capacity Building for Sustainable Forest Management provides for the implementation of Project activities 3.1.1.2: 'Improvement of the national legislation and the regulatory technical framework of the forestry sector with account of principles of sustainable forest management and use, practice of implementation thereof, and international experience' and 3.1.2.2: 'Consolidation and publication of recommendations on applying the experience of forest management abroad'.

Forest monitoring has been carried out in Belarus since 1989 by specialized service of the Ministry of Forestry on the basis of the National Raster Network according to the pan-European technology. National forest monitoring network includes 1 450 permanent

registration points (PRP) and 80 permanent sample plots (PSP), which are evenly distributed throughout the country.

This assignment within the Project activities 3.1.1.2 is aimed at developing of an improved system and review of directions of forest monitoring after the change of forest legislation and the adoption for the new Forest Code of the Republic of Belarus.

In recent years more and more attention is paid to the issues of climate change and therefore to the dynamic of changes in the plant and animal world. The international community is trying to prevent or at least to slow down these processes, however, we now stand at the threshold of the changes that humanity will live in the next century. Forest monitoring will be carried out with a view to study the possibility of adaptation of forest vegetation to changing conditions, both in natural forests and those that are under the human control with respect to practices that take into account the factor of climate change.

2. Tasks

The Consultant will undertake the following tasks:

1) analyze the dynamics of the main qualitative and quantitative indicators characterizing the state of the forest fund of the Republic of Belarus in the last ten years;
2) analyze the monitoring of the state and transformation of the forest fund of the republic under the influence of changing climatic conditions, economic activity in the dynamics of the last ten years;
3) identify and study together with all concerned parties problematic issues of the existing forest monitoring system, data storage of this material and its analysis. Allocated works:
    a. implementation of a survey (questionnaire) of the forestry enterprises, RUE "Belgosles", Ministry of Forestry and other concerned parties to identify problematic issues of the existing system of forest monitoring system; processing of the received data;
    b. generalization of a survey (questionnaire) data and its storage for the possibility of sampling and analyzing at the request of;
    c. analysis and comparison of data from different sources regarding problematic issues of the existing forest monitoring system;
4) prepare a desktop review of international experience in the field of organization and carrying out of forest monitoring (in terms of individual countries-leaders in the area of forest monitoring such as Finland, Sweden, Czech Republic and at least two others, giving arguments for the selection of the countries). Allocated works:
    a. preparation of a review of the positive and negative aspects of the organization and carrying out of forest monitoring in above mentioned countries. The study does not involve trips to the selected countries;

b. preparation of an analysis of the major achievements of the international best practices in the field of forest monitoring (technologies, methods, techniques);

5) develop proposals to improve the forest monitoring system in the Republic of Belarus in order to minimize the negative impact of changing climate conditions and economic activity on the state of forest fund. Allocated works:

   a. development of the proposals to improve the methodology of forest monitoring providing more detailed monitoring of forests in the forest areas with a significant change in the state of forests under the influence of external factors;

   b. development of the proposals to optimize the number of observations;

   c. development of the proposals to optimize the number of observation points;

   d. development of the proposals for simplifying of the observation methods and technology in forest areas, which are less affected by external and internal factors and where the dynamics of change in the state of forests is low.

6) develop proposals to improve the legal and technical framework for forest monitoring

3. Work schedule

Stages	Due date*
to analyze the dynamics of the main qualitative and quantitative indicators characterizing the state of the forest fund of the Republic of Belarus in the last ten years;	4 weeks
to analyze the monitoring of the state and transformation of the forest fund of the republic under the influence of changing climatic conditions, economic activity in the dynamics of the last ten years;	6 weeks
to study together with all concerned parties problematic issues of the existing forest monitoring system, accumulation of this material and its analysis. Allocated works:	
implementation of a survey (questionnaire) of the forestry enterprises, RUE "Belgosles", Ministry of Forestry and other concerned parties to identify problematic issues of the existing system of forest monitoring system; processing of the received data;	12 weeks
generalization of a survey (questionnaire) data and its storage for the possibility of sampling and analysing at the request of;	14 weeks
analysis and comparison of data from different sources regarding problematic issues of the existing forest monitoring system;	20 weeks

Stages	Due date*
to prepare a desktop review of international experience in the field of organization and carrying out of forest monitoring (in terms of individual countries-leaders in the area of forest monitoring such as Finland, Sweden, Czech Republic and at least two others, giving arguments for the selection of the countries). Allocated works:	
preparation of a review of the positive and negative aspects of the organization and carrying out of forest monitoring in other countries (with arguments for selected countries for review);	25 weeks
preparation of an analysis of the major achievements in the field of forest monitoring (technologies, methods, techniques) in terms of individual countries (giving arguments for the selection of the countries for review);	30 weeks
to develop proposals to improve the forest monitoring system in the Republic of Belarus in order to minimize the negative impact of changing climate conditions and economic activity on the state of forest fund. Allocated works:	
development of the proposals to improve the methodology of forest monitoring providing more detailed monitoring of forests in the forest areas with a significant change in the state of forests under the influence of external factors;	20 weeks
development of the proposals to optimize the number of observations;	25 weeks
development of the proposals to optimize the number of observation points;	30 weeks
development of the proposals for simplifying of the observation methods and technology in forest areas, which are less affected by external and internal factors and where the dynamics of change in the state of forests is low.	30 weeks
to develop proposals to improve the legal and technical framework for forest monitoring	30 weeks

*specified in terms of weeks from signing the contract

4. Reporting Requirements

All reports will be considered at the meeting of the Coordination Council on the implementation of the GEF grant and accepted by the majority decision, then the report will be sent for approval to the Project Task Team Leader World Bank Andrew Michael Mitchell (TTL). The consultant will liaise with (i) Leu Fedarovich, Project Management Unit in UE 'Bellesexport' (PMU), and (ii) the World Bank project team in Minsk (Elena Klochan);

The Consultant shall provide the PMU in UE 'Bellesexport' with the following reports:

1. the inception report which contains a short description of the background, purpose and scope of the assignment according to the ToR and how the consultant will implement the contract;

2. analysis of the dynamics of the main qualitative and quantitative indicators characterizing the state of the forest fund of the Republic of Belarus in the last ten years;

3. analysis of the monitoring of the state and transformation of the forest fund of the republic under the influence of changing climatic conditions, economic activity in the dynamics of the last ten years;

4. analysis of the problematic issues of the existing forest monitoring system, which among other things includes:

   a. report on the survey (questionnaire) of the forestry enterprises, RUE "Belgosles", Ministry of Forestry and other concerned parties to identify problematic issues of the existing system of forest monitoring system. Results of the survey (questionnaire) shall be presented in a form of tables and diagrams;

   b. generalization of a survey (questionnaire) data and its storage for the possibility of sampling and analyzing at the request of;

   c. analysis including comparison of data from different sources, data on problematic issues of the existing forest monitoring system;

5. review of international experience in the field of organization and carrying out of forest monitoring (in terms of individual countries-leaders in the area of forest monitoring such as Finland, Sweden, Czech Republic and at least two others, giving arguments for the selection of the countries), including:

   a. review of the positive and negative aspects of the organization and carrying out of forest monitoring in these countries;

   b. analysis of the major achievements of the international best practices in the field of forest monitoring (technologies, methods, techniques);

6. description of proposals to improve the forest monitoring system in the Republic of Belarus in order to minimize the negative impact of changing climate conditions and economic activity on the state of forest fund, which among other things includes:

   a. proposals to improve the methodology of forest monitoring providing more detailed monitoring of forests in the forest areas with a significant change in the state of forests under the influence of external factors;

   b. proposals to optimize the number of observations;

   c. proposals to optimize the number of observation points;

   d. proposals for simplifying of the observation methods and technology in forest areas, which are less affected by external and internal factors and where the dynamics of change in the state of forests is low;

7. proposals to improve the legal and technical framework for forest monitoring.

All draft and final versions of documents shall be provided to the PMU in UE "Bellesexport" in 2 printed copies and in electronic form in Russian/Belarusian and English. The inception report and draft final reports will be presented at a workshop where the concerned parties will be presented. The final versions of these reports will take into account the comments received from the PMU, the Coordination Council on the implementation of the GEF grant, the World Bank and feedback received during the workshops.

Final reports must be submitted on A4 paper, typed with single spacing, in any font equivalent to Times New Roman size 12 pt.

5. Time Schedule

The assignment will be undertaken under a lump-sum individual contract. The Scope of Work shall be performed over CY 2016. The assignment will require 210 days. The duration of work is approximately 30 weeks from the date of contract signing. Schedule for execution and submission of reports is in accordance with paragraph 3 'Work schedule'.

6. Qualifications Required

Qualification requirements are not produced. As long as only RUE "Belgosles" possesses the qualifications necessary and the experience of exceptional worth for the assignment the "single source selection method" will be used to select the consultant.

The Republican Unitary Enterprise "Belgosles"
The project "Development of the forestry sector in the Republic of Belarus "
GEF / World Bank TFOA 1173

APPROVED by
First Deputy of
Minister of Forestry
A.A.Kulik

REPORT

contract № BFDP / GEF / SSS / 15 / 20-02 / 16 dated 05.03.2016
Component 3: activities 3.1.1.2. and 3.1.2.2 .; №02-2 / 15
Modernization of forest monitoring system of the Republic of Belarus

Stage 3. Analysis and monitoring of status and transformation of the country Forest resources due to the impacts of changing climatic conditions and economic activity trends over past ten years

EXECUTOR:
CEO of
The Republican Unitary
Enterprise "Belgosles"
A.A.Kozak

Minsk 2016

CONTENTS

Annotation

There are two opposite processes constantly taking place in forestry. One process aims at increasing of the forest area whereas the second one reduces its area. The decrease of forest area occurs during the planned felling or the timber harvesting and other felling also in order to liquidate the consequences of adverse natural and anthropogenic impacts.

This report provides an analysis of forest resource status monitoring and transformation in the Republic of Belarus due to the impacts of changing climatic conditions and economic activity. The dynamics over past ten years of forest felling in terms of their types: clean felling, gradual ones and others. The reasons for carrying out other fellings in the forests as a result of forest plantations mortality under the influence of adverse weather conditions, and as a result of forest fires are reviewed in this report. It also provides data on the creation area of new forests over the past ten years.

The report comprise 11 pages, 6 pictures and 1 table.

Analysis and monitoring of status and transformation of the country forest resources due to the impacts of changing climatic conditions and economic activity trends over past ten years

Belarus is located in the moderate latitudes of the Northern hemisphere on a hilly plain, virtually in the center of Europe. The climate is transitional from maritime to continental, moderatecontinental. The fundamental climate-forming factor is the impact of the Atlanticocean. The air masses coming from the west bring cloudy and rainy weather in summer and significant warming and thaw in winter. The influenceof the ocean is waningwith the advance to the east wherecontinental climate enhances.

The average annual temperature in Belarus is + 5.8 ° C. Temperature is gradually increased in the direction from north-east of the republic to the south and south-west. In the north-east of Vitebsk region average annual air temperature is 4.5? C and in the extreme southwest of the Brest region it exceeds 7? C.The average temperature of the warmest month (July) is 17,8? C, the coldest one (January) is -6,7? Con the average country level.

As for precipitation Belarus belongs to areas of sufficient moisture. Climate rate of annual rainfall is 656 mm. Rainfall is uneven on the territory of the country. The general annual rate of precipitation depends on the terrain and is mostly 600-650 mm in the lowlands of the republic and 650-700 mm in the plains and hills region. In the warm season which lasts from April to October precipitation contribute to 70% of annual norm. The total number of days with precipitation (0.1 mm or more) varies from 145 in the south-east to 195 in the western elevated plains.

The wind conditions over the territory republic is stipulated by the general circulation of the atmosphere. In winter period, winds of the southwest quarter are prevailingand in summer period are of north-west one. The average annual wind velocity in the openareas is 4 m / s and in low relief ones is about 3 m / s. In some areasstrength of wind reaches 10-15 m / s, every 5 years up to 15-20 m / sannually.

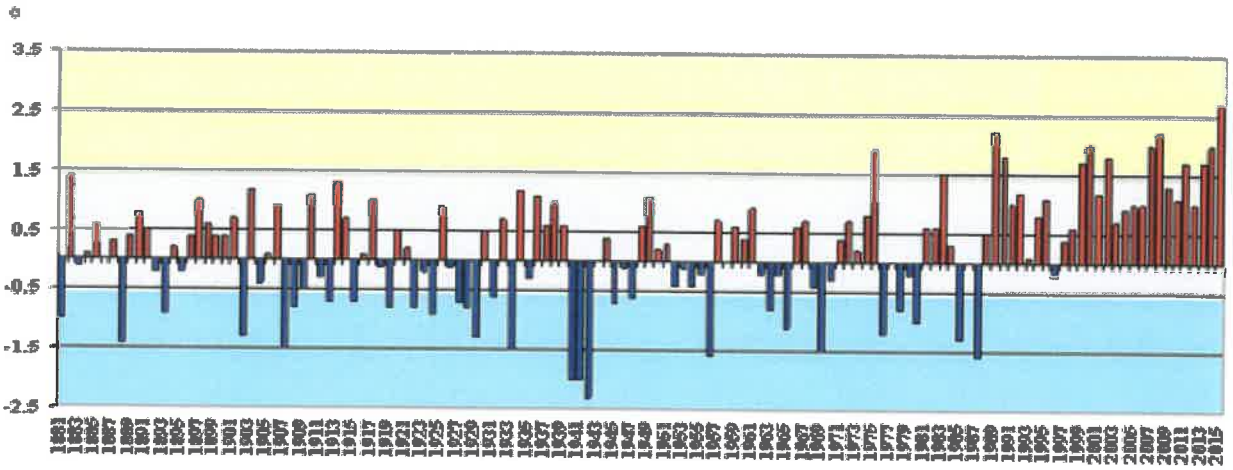

Figure 3.1 Average annual temperature deviation from a climatic norm (+5.8° C) on the territory of Belarus.

Instrumental observation of the weather phenomena in the country commenced in 1891. During the period of observation,periods ofwarmthwere repeatedly followed by a sharp cold snap. But the most significant climate change turned out to be apparent in the late 1980s (*Figure* 3.1). Thepeculiarityof the present warming is not only in its unprecedented duration but also in a higher temperature rate thatexceeded climatic norm by 1.1 ° C. It is noteworthy that the increase in temperature rate has occurred in almost every month with the exception of November.

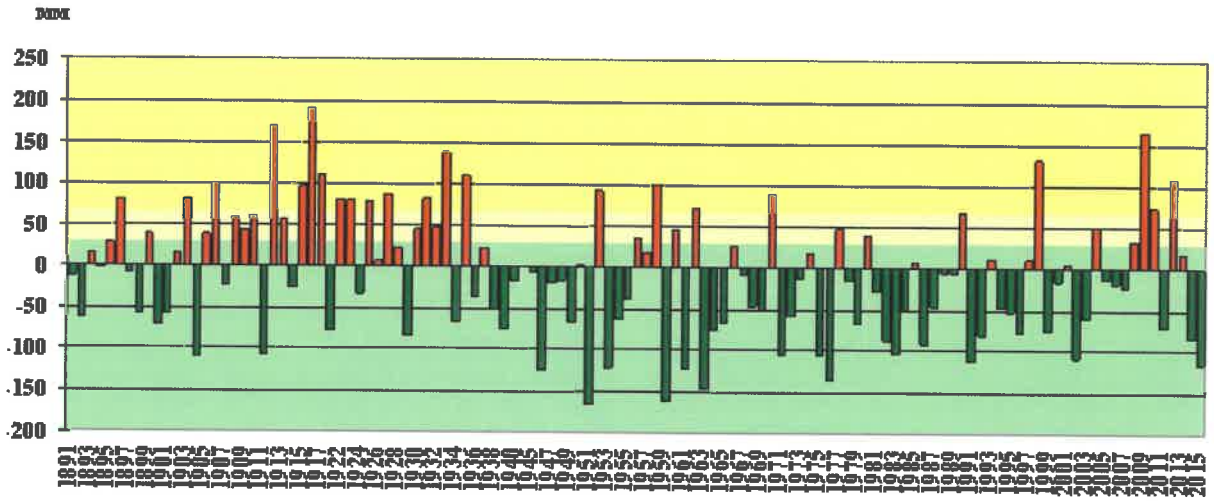

Figure 3.2 Average precipitation amount deviation from a climatic norm (656 mm) on the territory of Belarus.

The amount of rainfall in the country since the late 1980s has slightly changed. In addition to the mentioned period,irregularity of precipitation hasincreased within a year as for particular years (see Figure 3.2). The reduction of the amount of rainfall and its irregularity especially when combined with high-temperature leads to the drought hazard. Droughts of varying intensity were observed in a number of regions of the country in 1992, 1993, 1994, 1995, 1996, 1999, 2000, 2002, 2003, 2004, 2007, 2010, 2011, 2012, 2013, 2014,2015. Recurrence of droughts for this period was twice frequent in comparison to the previous years.

The peculiarity of climate change in Belarus is aggravation of extreme weather hazards. According to the data of National MeteorologicalCenter,from 10 to 30 cases of severe weather phenomenaare annually registered in Belarus. Their number does not increase but in the wake of climate change the intensity of severe weather phenomenaintensifies

Approximately 80% of all cases of severe weather phenomena fall on the warm period of the year, and most of them are of local nature. However weather phenomena like frost, very strong winds, including gusts, heavy rain, large amounts of snow, extreme fire danger, in some years, covering a substantial part of the territory of Belarus.

Strong winds (gusts) and fires causethe greatest damage to the forestry. Since 2004, the area of plantations affected by the wind became significantly more than in previous years. In previous years a large area of forests affected by windwere only observed in 1997. Since 2004, windfalls were observed almost every year. The most frequent they were in 2005-2006 and in 2009-2010. During these years in some places wind gusts reached 25-27 m / s.

The process forest dieback is considered to be one of the most obvious effects of climate change. The important role in it played both the climatic anomalies and the number of pest outbreaks.

According to forest pathology monitoring over the past ten years as a result of the impact of various climatic factors8.8 thousand hectares of forestry in averageperish each year. In 2015, the maximum number of perishedplantationareawas registered in recent years (Figure 3.3).

Figure 3.3 Dieback forest plantations trends in the republican forestry [1]

The mainforest perishcause were adverse weather conditions. Because of their affects to the annual average plantation dieback was 6.6 thousand hectares, or three-quarters of the affectedplantations. Thearea of spruce forests, withered because of the effects of stem pests is also included into the area of forest killed by adverse weather conditions, except for the death of the windfall, windbreak, snowbreak, etc. The drying of spruce forests because of stem pestsvital activity (mainly bark beetle) is included in the group of plants killed by adverse weather conditions, because the pests feed by the stem of weakened trees and adverse effects are the secondary cause leading to forestry dieback.

In the period from 2006 to 2009, the area of plantations, perishing from the adverse weather conditions was significantly lower than in subsequent years. At the same time in 2010 was registered the maximum plantation area of perished trees due to thisgroup of factors. In that year, only windfall and windbreakhave affected more than 6 thousand hectares of forest. After 2010, plantations areas perishing from adverse weather conditions in general were decreasing annually. However, in 2015, their area was still significantly greater than 2006-2009 and it is caused mainly diebackof spruce forest. The spruce dieback has resumed after abnormally high

[1] Total dieback plantations
Dieback due to adverse weather conditions
Dieback due to forest fires accordingly

summer temperatures and lack of precipitation in 2010, when the drought was observed in the east of the country where the spruce forests occupy large areas. The existence of windfall wood also contributed to multiplication of bark beetle after wind squalls of 28 July and 8 August 2010 when because of the wind in varying degreesforests of 75 out of 95 timber enterprises of the republic were affected. Areasof spruceplantations damaged by stem pests,continuous salvage felling in the past five years comprise more than half of plantation area perishing from adverse weather conditions.

The weather conditions are followed byforest diseases as mostlyinfluential on forestplantations and affect more than 700 hectares of forest or 8% of the total area of diebackforestryeach year. The most common disease is pine fungus. This is stipulatedby the predominance of pine forests as part of a high proportion of pine plantations raised on land that fell out of agricultural use, quarries, landfills, etc. where typical forest soil has not yet formed.

Forest fires have a negative impact on the status and dynamics of the forest ecological systems,they worsen the qualitative composition of forest and inflict material and ecological damage. The major causes of fires in spring is burning of dry grass and household trash and in summer is careless handling of fire when visiting the forest by the population.

Climate change increases the fire season which in some areas can last for a month. Fast drying of last year's grass and peat bogs after winters with little snow contributes to the occurrence of forest fires and their active spread. Over the past ten years each year from fires perished on average. 1.1 thousandhectares of forest.Most fire hazardsturned out to be in the year of 2015, when fire destroyed nearly 6 thousand hectares of forest plantations. In August and September due to the hot and dry weather in most parts of the Brest and Grodno region, in some areas and the rest of the country anextreme fire danger arose in the woods up5, the highest degree of fire danger scale. In this regard, fire hearths increased rapidly and forest fires spread over a significant area. More than half of the plantationsareas,destroyed by fire, was in the south on the border with Ukraine territories. Fires were mostly transboundary and came from the Ukrainian territory. The complexity of extinguishing these fires has been associated with the presence in the border area of large forest areas and a lack of a developed road network, as well as a large number of inaccessible forest wetlands and marshes.

Changes in climatic conditions directly or indirectly (*through a change in the groundwater level, the multiplication of forest pests and worsening of disease*) have a negative effect on forestry. It should be noted that the tree species rather slowly adapt to rapid changing growing conditions. According to the foreststatus monitoring data small-leaved forestsamong which the most stable isblack alderare more resistant to adverse environmental factors. Black alder in comparison with other species of wood has a maximum share of trees with no signs of waning(*see Figure 3.4*). It also has a minimum share of much weakened and drying trees.

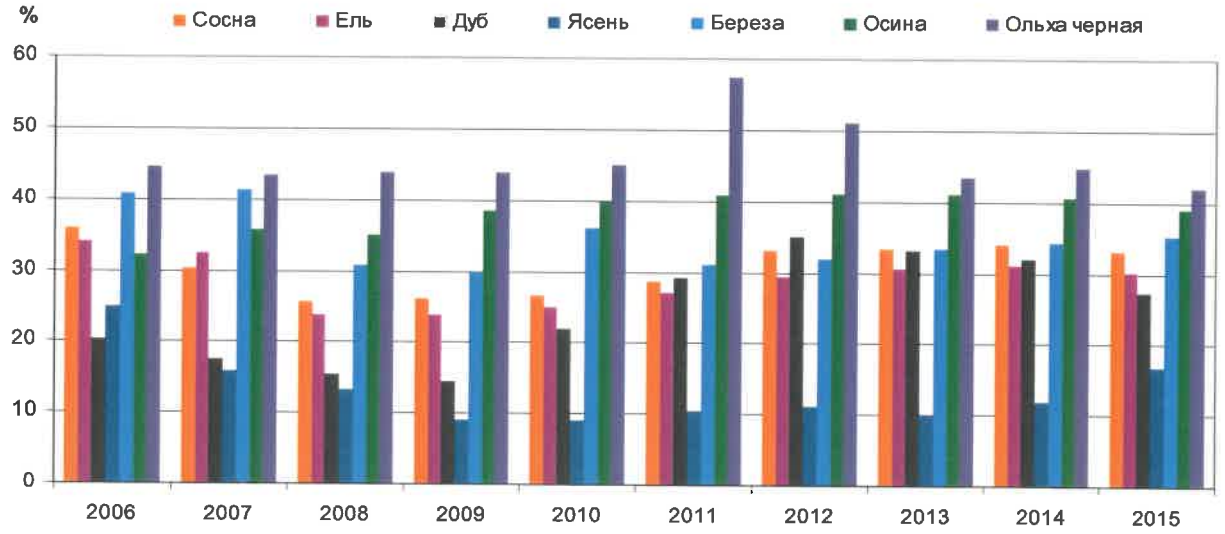

Figure 3.4 Major forest-forming wood species not possessing signs of dieback trends Pine Spruce Oak Ash Birch Aspen Alder accordingly

Reference: When monitoring the status of forest tree resistance to stress effects and the ability to fully permeatethe life cycle was determined by the state of crowns assessment. Crown condition integrates a set complex of abiotic and biotic, internal and external impacts on a tree, and thus, the fullyintegrated approach to the overall state of a particular tree or after relevant averaging, the whole area or tree species.

Formations of oak and ash forestsin particular were least resistant to changing climatic conditions. These tree species have not only the lowest proportion of trees that do not have signs of dieback but at the same time have the highest proportion of severely weakened and dieback trees. In recent years the overall number of oak was restored, the state of ash remains weak.

The weakening of the trees leads to a reduction of their entomological andPhyto-resistance. Oak and ash being the most weakened tree species have a large share of trees with visible lesions at external examination (*Table 3.1*). A significant proportion of damaged aspens areaffected by the fact that more than half of the observed trees are older more than 60 years, there are overmature. Resistance of trees to adverse factors decreases with the increase in age. Aspen mostly affected by a false aspen tinder. These pore fungi affect the central (core) of a treeand for a long time exist on the infected tree without external worsening of its condition.

Percentage distribution of the trees with the presence of damage

(*Average for the past ten years*)

Table3.1

Damaging factors	Wood species						
	Pine	Spruce	Oak	Ash	Birch	Aspen	Alder
Pest insects	0,1	1,1	6,4	-	1,2	4,5	9,8
Diseases	3,1	5,4	17,3	42,6	2,2	24,2	2,8
Not identified	0,3	1,6	2,9	6,1	1,8	1,0	0,8
Other	5,2	9,6	5,3	0,8	8,6	3,9	1,4
Total	8,7	17,7	31,9	49,5	13,8	33,6	14,8

Diseases of tree species are the main cause of damage to the majority of tree species. This is caused by the stability and the duration of the existence of points of damage, as a result, in the course of time it leads to the accumulation of damaged plantations. Growing trees are damaged mainly by fungal diseases more rarely by bacterial and viral ones. Fungal diseases of forestry are infectious diseases caused by harmful fungi. In the forest biocenoses, along with relatively large and pileate and polypore fungi, there are many types of microscopic parasitic and saprophytic fungi destroying roots, trunks, branches, as well as damaging the leaves and pine needles. These species of fungi are widespread and cause enormous damage to forestry. Beside aspen ash and oak trees are also often damaged by phytopathogenic fungi. Estimated ash plantations are damaged mainly byhoney agaric, oak ones by microscopic fungi that destroy treetrunks.

Damageof growing trees caused mainly by vital activity of leaf-eating insects, however, not all insects have a significant impact on the trees. For example, among black alders was annually registered a fairly large proportion of the trees damaged by insects mostly by alder leaf beetle. Typically, the proportion of the trees was two or more times greater than the proportion of other tree species, damaged by leaf-eating insects. However, the mass defoliation was not

observed. Most insects eat no more than 15% of the foliageof trees. The oak wasmost significantly affected. In 2002-2003. foliage on the trees was almost completely gnawed, mainly by caterpillar moths in some plantations. As a result of the annual strong defoliation,part of the trees died and the remaining part was weakened.It took years to restore the previous state of the oak plantations. Currently oak status has much improved, however, in spite of the improvement, oak occupies the second place mostly after ash as most defoliated tree species.

Quite a large proportion of trees damaged by factors, classified as other, mainly caused by the direct influence of anthropogenic activity and abiotic factors. In percentagetermsbirch and spruce are mostlymechanically damaged. In most cases they have been damaged in a slight degree. Birch mostly damaged by tapping of treesby the population, and spruce as a result of conduction offorest management activities.

Under the influence of economic activities in the forestry two opposite processesconstantly take place. One process aims at increasing of the forest area, the second onereduces their area. The decrease of forest area occurs during the planned felling (*felling of mature and over-mature stands*) for the timber harvest, cutting paths for different communications, clearing space for industrial enterprises and other purposes.

Figure 3.5 The republican forestry plantations trends according to type of felling.[2]

Currently, clear-felling is predominanttype of felling (*Figure 3.5*). Over the past ten years on average 20.3 thousand hectares of forest was felled by clear-felling annually. Clear-cut is a procedure when in a particular area all the trees are cut downin a short time usually for a period not exceeding a year. The biological basis for the use of clear-felling is the presence of even-

[2] The area of major clear-felling
Area of gradual major felling
Area of plantations cut for other purposes accordingly

aged stands in nature. These fellings correspond to the nature of light-demanding woods.Natural and forest regeneration by anthropogenic ispossibleafter clear-cuts. However, these fellings cause significant changes in forest conditions, in the light, thermal and hydrological conditions. In this regard, clear-cuts can greatly change ground and underground composition conditions of post-felling forests.

Annually at an average of 4.3 thousand hectares of forest were felled gradually. When gradual felling takes place in a certain area,timber stand is cut down in severalstages: from twoto four. Full cutting stand is carried out in the last stage. Period of plantations felling usually does not exceed the age class, i.e., 20 years. In the process of felling the old stand is completely removed and issteep-sided coeval young forest stands in the felling area. The positive side of gradual fellings is in maintaining of wooded covered state, and thereby to ensure water protection and soil conservation by forest, creation of favorable conditions for the protection of its natural regeneration. The fellings help to increase the forest area of natural regeneration as more acceptable from an environmental point of view. Over the past ten years, the area ofgradual cuts was increasing annuallyand amounted to 17% of the total felling area.

In the forest reserve also annual clearing of forest plantations takes place for thepurposes of road construction, constructions of utilities and other facilities, prospecting and exploration of mineral resources, for industrial and other purposes. Over the past ten years for the purpose of clearing forest areas at an average 7.7 thousand hectares of forest werefelled annually. Moreover, the area of cleared areas as a whole has being increased every year. Since 2006, when the minimalarea was cleared, till 2015 areaof clear-cut territories has almost doubled.

The increase in forest area is made in natural, by anthropogenic and combined ways. For the shortening of forest regeneration terms, as well as the resumption of areas with finewood species, forest enterprises carry out planting of forest samplings. In fact it is active (*using anthropogenic activity*) form of reforestation. Creation of forest plantations is carried out by planting or seeding. Planting is made with planting material: seedlings, samplings, grafts and sowing with seeds of trees and shrubs. However, about one third of the area of forest plantations is created with plantsbreeding.Mainlymixed plantingswith higher biological stability and performance are created.

Over the past ten years the average area of anthropogenic reforestation on non-forested lands covered 21.8 thousand hectares, and afforestation -- 6.6 hectares. Anthropogenic reforestation is planting of forest plantations on land which previouslyused to be under forest (*felling, clearing and so on.),*reforestation isplanting of forests on land that previously wasnot under forest (*arable and meadow land*). During this period, most plantations were created in 2006, and the least of all in 2012 (*Figure 3.6*). In general, over the past five years, the areas taken by anthropogenic reforestation and afforestation were smaller than that ones in previous years. This is related to the decrease in land area, which is suitable for creation of plantations.

Reduction of area suitable for artificial reforestation is mainly due to the fact that large areas of clear-felling are replaced by discontinuous forms of fellings (*gradual and selective*). As a consequence, seeding and planting of forest plantations in these areas are replaced by natural regeneration. Natural regeneration in these areas is carried out actively and it is aimed at accelerating the process. Activities are conducted by preparing the soil environment favorable for acception of wood seeds, undergrowth preservation of commercially valuable speciesofwood.

Reduction of theafforestation area is stipulated by two reasons: reduction of the areaof agriculturallow productivity land passed to the forest reserve and a decrease in arable and meadow land on the territory of the forest reserve. Over the past ten years, the area of arable and

meadow lands in the territory of the forest reserve, decreased three and a half times (*from 45.1 to 12.7 thousand hectares*). These lands were mainly plantedwith forest species.

Figure 3.6 Anthropogenic forest regeneration and forestation trend[3]

Over the pastten years as a result of the planned felling of the forest, forest plantations area of the republican forest reserve has decreased by 280 thousand hectares, including 77 thousand hectares of forest plantations that were cleared for usage of these sites for other purposes. During the same period from adverse climatic factors were destroyed 165 thousand hectares of forest. For the shortening of forest regeneration terms and renewal of areas of economically valuable tree species to 284 thousand hectareswere created newanthropogenicforest plantations.

Conclusions

For the whole country the transformation of the forest reserve over past ten years had a positive trend.After an increase in the total area of forest land by 135 thousand hectares of forested lands increased by 356 thousand hectares. Increasing of the area of forested land to a large extent connected with economic activities of forestry institutions and happened due to transfer to non-closed forest plantations and forest plantations and areas conducted with facilitation to natural renewal. As a result of economic activity significantly decreased areaof not forested land including area decreaseof burnt and dead stands from 10.2 to 6.9 thousand hectares.

[3] Anthropogenic reforestation
Forest regeneration accordingly

The Ministry of Forestry of the Republic of Belarus
RUE «BELGOSLES»
Forestry Development Project of the Republic of Belarus
GEF/WORLD BANK TFOA 1173

Approved by
The First Deputy
Minister of Forestry
A.A.Kulik

REPORT

under the contract № BFDP/GEF/SSS/15/20-02/16 for 05.03.2016
on component 3: arrangements 3.1.1.2. and 3.1.2.2.; №02-2/15
Development of the forest monitoring system of the Republic of Belarus

Phase №4. The analysis of addressing the issue of current forest monitoring system

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General Director
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A.A.Kozak

Minsk 2017

CONTENTS

Annotation

Damage and death of plantations are constantly observed under the influence of various natural and climatic factors in the forest fund. Forest monitoring system of the Republic is functioned to get the actual information about forest health and forecast changes.

This report presents the results of questioning of legal entities, which are managing the forestry, and also organizations and agencies which hold forest monitoring and use its results. You can find the procedure of holding of three separate directions in forest monitoring. What concerns the disaster at the Chernobyl Atomic Electric Power Station, there is information about radiation monitoring in the report. The analysis is done and all the questions of current monitoring system are decided.

The volume of the report is 16 pages and it contains 3 figures and 1 table.

The testing (questioning) of forestry enterprise, RUE «BELGOSLES», Ministry of Forestry, and other concerns of current forest monitoring system

Forest monitoring is carried out according to the Regulation of forest and environmental monitoring procedure within the National system and their data usage. It was approved by a decree of the Council of Ministers № 1036 of August, 2007 (*as amended by the decree of the Council of Ministers № 835 of June, 10, 2008, № 762 of August, 29, 2013*). Forest monitoring is carried out by the Ministry of Forestry and is held in the following directions:

- general forest condition, also under the influence of air pollution (*forest health monitoring*)
- forest condition under the influence of harmful insects and diseases (*forest pathological monitoring*);
- forest condition under the influence of reclamation works (*environmental and ameliorative monitoring of reclaimed wooded lands*).

Nowadays forest monitoring system functions in such a way that all legal entities, which are conducting forestry, are held the state forest fund monitoring. This fund is handed over for usage and the received primary monitoring data is submitted for further processing to specialized organizations which are responsible for forest monitoring activities. The structure of the current forest monitoring system is shown in Figure 4.3.

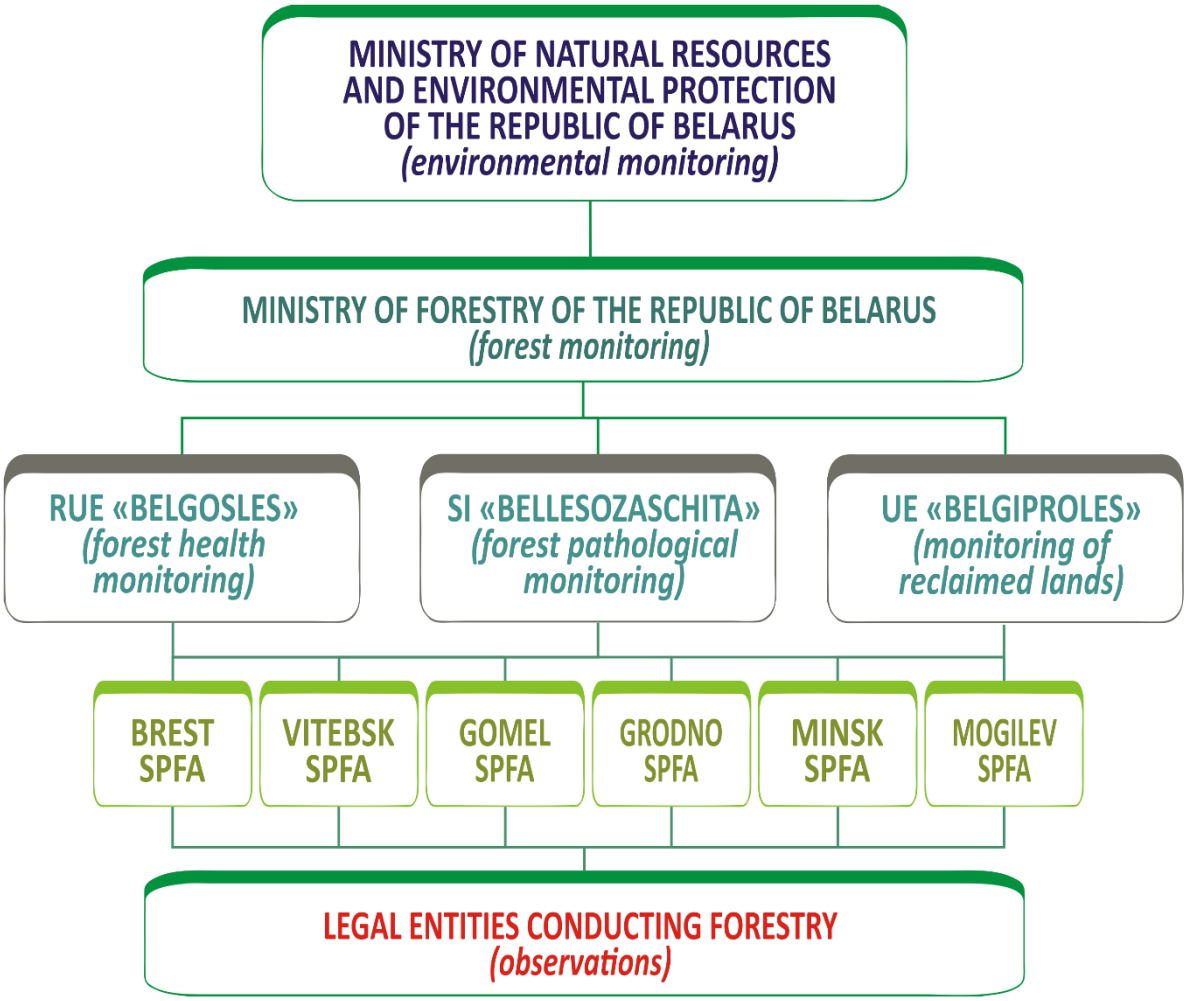


Figure 4.3. The structure of the current forest monitoring system as part of the National Environmental Monitoring System (SPFA – state production forestry association)

Forest health monitoring

The Instruction of the forest health monitoring structure is confirmed by the degree of Ministry of Forestry of the Republic of Belarus № 41 of December, 30, 2008.

The detection of negative processes, affecting the forests, as well as assessment of the current state of forests and the forecast of its changes at existing levels of exploitation and the impact of anthropogenic and natural factors are the aims of forest health monitoring.

Afforestation and individual components of forest fund are the objects of forest health monitoring (main stand, woody species, undergrowth, underbrush, soil vegetation, soil and others).

Monitoring is based on regular surveys of observation points, organized in the forest fund of the republic. The observation points are laid out on a network of 16 × 16 kilometers (transnational network) and 8 × 8 and 4 × 4 kilometers (national network). Generally, over 402 and 443 observation points of transnational network were laid out in 1990. The observation points of national network were laid out from 1990 till 1999 at regularly scheduled times over the years. 592 observation points are laid out on the network 8 × 8 and 487 points on the network 4×4 km. In total, over 1522 observation points were laid out for monitoring. However, starting from 2007, the observation points are located only on the transnational network because of bad financing.

In 1996, 83 permanent inventory plots were laid out in the plantations of the most important (main) woody species, in the most common conditions of the site. It was made to establish the cause-effect relationships of anthropogenic influence and other unfavorable environmental factors on the forests. The observations were held till 2012.

Forest health monitoring is carried out by the forest management republican unitary enterprise "Belgosles" (hereinafter - RUE "Belgosles"). Until 2012, RUE "Belgosles" performed the whole range of works: methodical maintenance of work, observation and processing of primary data obtained at observation points, conducting of database of forest health monitoring, storage and presentation of environmental information about forest health, forest health survey. Starting from 2012, the observations and submission of primary data to RUE "Belgosles" are carried out by legal entities, leading forestry. It is happened because of the lack of budget funds for the implementation of monitoring.

Forest pathological monitoring

The procedure of conducting the forest pathological monitoring is defined in TCP 252-2010 (02080) "The procedure of forest pathological monitoring of the forest fund" approved and enacted by the Ministry of Forestry of the Republic of Belarus No. 18, dated July 29, 2010.

Identification of forest areas, damaged by diseases and drying up under the influence of natural and anthropogenic factors; obtaining of the information on the forest pathological and sanitary condition, spreading and developing of pests; analyzing of pathological processes; forecasting of their development; assessing of possible negative consequences; planning and implementing of effective forest-protection and forestry activities, taking into account the environmental and economic feasibility are the aims of forest pathological monitoring.

Forest plantations, forest cultures before transferring them to forest-covered lands, forest-free lands, intended for reforestation, forest nurseries, if necessary, non-forest lands, planned for afforestation, as well as associated ecological groups and types of pests and diseases, which do harm to forestry are the objects of forest pathological monitoring.

Forest pathological monitoring is carried out within the boundaries of forest fund plots of legal entities leading forestry. In this regard, the legal entity, leading forestry, is accepted as a point of observation of forest pathological monitoring. The state institution «Belleszashchita» (hereinafter – SI «Belleszashchita») protects and monitors the forest, carries out methodological guidance and organization of forest pathological monitoring.

Forest pathological monitoring is based on the use of forest pathological service and forest pathological surveys. There are different types of forest pathological service in the forest fund of the republic: general visual, reconnoitring, detailed and pheromone services.

General visual service is carried out continuously for timely detection and signaling of damage of the forest fund by harmful organisms and other unfavorable environmental factors. The management of the general service is attached to the forest rangers. Forest rangers verify the correctness of the messages, specify the area of forest pathological object, establish the kind and extent of damage (ocular) and its reasons. After it they outline the necessary measures and inform the legal entity which is leading forestry.

The reconnoitring service is carried out in warm season. It represents a system of visual service for the most dangerous types of harmful forest insects and diseases or their groups (needle-eating, leaf-eating or secondary insects, root and stem rots, forest culture and young growth diseases, forest nurseries and others) in order to identify the signs of the focus of mass reproduction of pests and spread of forest diseases in early stages. The reconnoitring service is planned, first of all, for those harmful organisms, which focus of disease was noted in the plantations over the last years, and in their absence - taking into account the presence of plantations which are potential reserves by their characteristics. The reconnoitring service is organized by the specialist of forest protection of a legal entity, leading forestry. It is carried out by forest masters and assistants of forest rangers under the direct control of forest rangers.

The detailed service is also carried out in warm season. And it represents a system of detailed surveys and long-term observations for the dynamics of stand condition, the populations of harmful insects, the spread of forest diseases on constant routing, sample plots, observation sites. The detailed service is organized by the specialist of forest protection of a legal entity, leading forestry, and also by the specialists of overhead organizations - State Forestry Production Associations (hereinafter SFPA) and SI «BELLESZASHCHITA».

Pheromone service is carried out within the timeframes, established by the recommendations on the use of pheromones for a particular type of insects. The main aim of this type of service is to control the number of pests, to monitor their dynamics, and to limit the number of stem pests.

Pheromone service is carried out in the places of chronic weakening of plantations and in the plantations with excess of mortality. The traps with pheromone are placed in special areas of pheromone service in order to control the number of needle-eating and leaf-eating insects. In that area (taking into account the biology of pests) the imago of harmful insects is recorded. This type of service is organized by the specialist of forest protection of a legal entity, leading forestry, or forest workers under their control.

Forest pathological monitoring is a special forest examination which is planned every year. It is conducted to identify the focus of pests and diseases; other pathological lesions of the forest, the forest pathological and sanitary conditions of forest plantations. The materials of forest pathological monitoring are based on planning and carrying out of forestry and forest protection measures.

According to the organizational forms and tasks, forest pathological monitoring is subdivided into inventory, expeditionary, aerovisual, current and forest pathological examinations.

Inventory and expeditionary examinations are held by RUE "Belgosles". Inventory examinations are carried out in the process of conducting forest management fieldworks, expeditionary examinations - if it is necessary, by a specialized forest pathological party.

Aerovisual examination of forests is used if the forests are damaged by hurricanes, fires, etc.

Current examinations are carried out by the officials of Forestry. These examinations are held every year and even more often if there is information about unfavorable condition of the forest fund. At the same time, the duration of the forest pathological examination should not exceed 20 days from the date of getting information. A legal entity, leading forestry, may cause

highly qualified specialists (experts) for forest pathological expertise if there will be difficulties in establishing the causes of the emergence and assessment of pest and disease outbreaks, in determining the species of pests that caused damage to forests and in deciding the question about forest protection measures.

Environmental and ameliorative monitoring of reclaimed wooded lands

The procedure of environmental and ameliorative monitoring of reclaimed wooded lands is determined by the Instruction of the organization and management of environmental and ameliorative monitoring of reclaimed wooded lands, approved by the Ministry of Forestry Committee of the Council of Ministers of the Republic of Belarus No. 21 of December 20, 2001.

The assessment and forecast of changes in forest growth conditions, depending on the parameters of the drainage network, development of recommendations for forest management are the aims of environmental and ameliorative monitoring of reclaimed wooded lands.

Forest ranges, soil, soiled water, forest drainage and irrigation systems are the objects of environmental and ameliorative monitoring of reclaimed wooded lands.

In order to conduct monitoring, 13 stations were established from 1999 to 2004. They were based on geobotanical subzones and forest districts and included 19 index plots (from 1 to 3 index plots for station).

Environmental and ameliorative monitoring of reclaimed wooded lands is carried out by the design and survey Republican unitary enterprise "Belgiproles" (hereinafter – UE "Belgiproles"). It was made the whole complex of works: planning and organization of monitoring, methodological support of work performance, observation and processing of primary data, database support of forest health monitoring, storage and presentation of environmental information about forest health in reclaimed lands. Starting from 2009, forest health monitoring under the influence of reclamation works is not held because of the termination of budgetary financing.

Radiation pollution of the environment as the result of Chernobyl disaster is a significant environmental problem in Belarus. Radiation monitoring is held in order to assess and forecast the radiation situation in the country. SI «Belleszashchita» performs radiation monitoring in terms of groundshine within the boundaries of forest lands. Forest radiation monitoring is carried out within the framework of radiation monitoring. It is controlled by the Ministry of Natural Resources and Environmental Protection (hereinafter - the Ministry of Natural Resources).

For reference: during the period between 1986 and 2015 the area of the territory of the republic with a level of soil pollution with cesium-137 above 37 kBq / m2 (1 Ci / km2) due to natural physical processes and human activities decreased in 1.7 times. In January 1, 2015 the area has become 2790 thousand hectares or 13,4% from the total area. It happened because of the natural physical processes (radioactive decay of radionuclides, horizontal and upright migration, weathering and airborne processes) and human activities. The area of the forest fund with a soil contamination density of cesium-137 more than 1 Ci / km2 as of 2015 amounted to 1,669 thousand hectares or 17.6% of the total area of the forest fund.

Over 89 observation points were laid by SI «Belleszashchita» in order to conduct radiation monitoring in the forests which are exposed by radioactive pollution. The level of soil pollution, trees of the main stage (wood, bark, branches, needles and leaves), undergrowth, underbrush, live ground cover and mushrooms with cesium-137 is controlled on these points.

The density of soil pollution decreases in the result of natural radioactive decay of cesium-137 and redistribution of the radionuclide in the components of forest ecosystems. In this regard, SI «Belleszashchita» controls the radiation situation on the territory of the forest fund every year.

A questionnaire was prepared in order to study the problematic issues of the current forest monitoring system. In electronic form, it was sent to all legal entities, leading forestry, as well as to other organizations and agencies which are related to forest monitoring and / or the use of its results (a total of 130 organizations).

40% of the interviewed respondents took part in the questionnaire: 45 legal entities, leading forestry (from 118), 6 organizations (out of 10 to which the questionnaires were sent) and 1 agency (out of 2 to which the questionnaires were sent). The respondent's answers are summarized in table 4.1 for the possibility of sampling and analysis of the results of questionnaire.

The results of questionnaire on the issue of forest monitoring

Table 4.1

The name of organizations completed the questionnaire	Does forest health cause a fear in the Republic of Belarus?	In Your opinion is it necessary to hold forest monitoring?	Do you use forest monitoring data personally in your professional activities and (or) is it used in your organization?	Does your organization perform forest monitoring work?				In your opinion, is it necessary to carry out the above listed directions of monitoring? If "Not", then which directions can be avoided?	In your opinion, what additional monitoring directions should be conducted in the forests? Explain the answer.	Is your organization interacting with institutes responsible for organization of forest monitoring management (RUE "Belgosles", SI «Belleszashchita», UE "Belgiproles")?If «not», then In which areas is it organized not enough?	Does your organization have any problems in making observations?? If «Yes», what problems?	Have you ever seen the experience of forest monitoring in other countries? If "Yes", then, in your opinion, what countries experience is most suitable for forest monitoring in the Republic of Belarus?	What recommendations do you have for improving the forest monitoring system in the Republic of Belarus?
				Forest health monitoring (FHM)	Forest pathological monitoring (PM)	Environmental and ameliorative monitoring of reclaimed wooded lands (EAM)	Radiation monitoring (RM)						
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Baranovichskiy forestry	no	yes	yes	yes	yes	no	no	no EAM, PM	-	yes	no	no	no
Brestskiy forestry	yes	yes	yes	yes	yes	no	no	no FHM, EAM, PM	-	yes	yes	no	observations of FHM should be carried out by RUE "Belgosles"
Drogichin forestry	no	yes	yes	yes	yes	no	no	yes	-	yes	no	no	no
Luninets forestry	yes	yes	yes	yes	yes	yes	yes	yes	-	yes	no	no	no
Maloritskiy forestry	no	yes	yes	yes	yes	no	no	yes	-	yes	no	no	no
Pinskiy forestry	yes	yes	yes	yes	yes	yes	yes	yes	-	yes	no	no	no
Polesye forestry	no	yes	yes	no	yes	no	no	yes	-	yes	no	no	no
Pryzhanskiy forestry	yes	yes	yes	yes	yes	no	no	yes	-	yes	no	no	observations should be carried out by RUE "Belgosles" SI «Belleszashchita», UE "Belgiproles"
Begomlskiy forestry	no	yes	yes	yes	yes	no	no	yes	-	yes	no	no	no
Beshenkovichskiy forestry	no	yes	yes	yes	yes	no	no	yes	-	yes	no	no	no

Table continuation 4.1

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Bogyshevichskiy forestry	no	yes	no	yes	yes	no	no	yes	-	yes	no	no	no
Verhnedzvinskiy forestry	no	yes	no	yes	yes	no	no	yes	-	no	yes lack of experience on this issue	no	no
Glubokskiy forestry	yes	yes	no	yes	yes	no	no	yes	-	yes	no	no	no
Disniyskiy forestry	yes	yes	yes	yes	yes	no	no	yes	-	yes	no	no	no
Dretunskiy forestry	no	yes	yes	no	yes	no	no	yes	-	yes	no	no	no
Polotskiy forestry	no	yes	yes	yes	yes	no	no	yes	-	yes	no	no	no
Postavskiy forestry	yes	yes	yes	yes	yes	no	no	yes	-	yes	no	no	no
Rossonskiy forestry	no	yes	yes	yes	yes	no	no	yes	-	yes	no	no	observations should be carried out by RUE "Belgosles" SI «Belleszashchita», UE "Belgiproles"
Vasilevichskiy forestry	yes	yes	yes	yes	yes	no	no	yes	-	yes	no	no	no
Mozyrskiy forestry	yes	yes	yes	yes	yes	no	yes	yes	-	yes	no	no	To hold courses in increasing knowledge and improving skills of forest monitoring
Petrikovskiy forestry	yes	yes	yes	yes	yes	no	no	yes	-	yes	no	no	no
Rogachevskiy forestry	no	yes	no	yes	yes	no	yes	yes	-	yes	no	no	no
Svetlogorskiy forestry	yes	yes	yes	yes	yes	no	yes	yes	-	yes	no	no	no
Hrodnenskiy SFPA	yes	yes	yes	yes	yes	no	yes	yes	-	yes	yes absence of specialists	no	no
Volkovysskiy forestry	yes	yes	no	yes	yes	no	no	yes	-	yes	no	no	no
Hrodnenskiy forestry	yes	yes	yes	yes	yes	no	no	yes	-	yes	no	no	no
Dyatlovskiy forestry	yes	yes	yes	yes	yes	no	no	yes	-	yes	no	no	no
Lidskiy forestry	no	yes	no	yes	yes	да	no	yes	-	yes	no	no	no
Ostrovetskiy forestry	no	yes	yes	yes	yes	no	no	yes	-	yes	no	no	to carry out monitoring once in 5 years
Slonimskiy forestry	no	yes	yes	yes	yes	no	no	no EAM, PM	-	yes	no	no	no
Slutskiy forestry	no	yes	yes	yes	yes	no	no	yes	-	yes	no	no	no
Starodorozhskiy forestry	yes	yes	yes	yes	yes	yes	no	yes	-	yes	no	no	To study the foreign experience of monitoring and practically introduce it into forestry
Stolbtsovskiy experimental forestry	no	yes	yes	yes	yes	no	yes	yes	forest fire monitoring	yes	no	no	Forest fire monitoring is urgent because of changing climatic conditions

Table continuation 4.1

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mogilevskiy SFPA	yes	yes	yes	yes	yes	no	yes	yes	-	yes	no	no	To move to a system of remote forest monitoring
Belynichskiy forestry	no	yes	yes	yes	yes	no	yes	yes	-	yes	no	no	no
Bobruyskiy forestry	no	yes	yes	yes	yes	no	no	yes	-	yes	no	no	no
Byhovskiy forestry	yes	yes	yes	yes	yes	no	yes	yes	-	yes	yes lack of experience on this issue	no	no
Glusskiy forestry	yes	yes	yes	yes	yes	no	no	yes	-	yes	no	no	no
Klimovichskiy forestry	yes	yes	yes	yes	yes	no	yes	yes	-	yes	no	no	To move to a system of remote forest monitoring
Krasnopolskiy forestry	no	yes	yes	yes	yes	no	yes	yes	-	yes	no	no	no
Osipovichskiy forestry	yes	yes	нет	yes	yes	no	no	yes	-	yes	yes lack of experience on this issue	no	observations of FHM should be carried out by RUE "Belgosles"
Chausskiy forestry	yes	yes	yes	yes	yes	no	yes	yes	-	yes	no	no	no
Cherikovskiy forestry	yes	yes	yes	yes	yes	no	yes	no EAM	-	yes	yes lack of experience on this issue	no	no
The Korenevskaya experimental forestry base of the National Academy of Sciences of Belarus	no	yes	yes	no	yes	no	no	yes	-	yes	no	no	no
Negorelskiy Forestry	no	yes	yes	no	yes	no	no	yes	-	yes	no	no	no
SFPA «Teterinskoye»	no	yes	yes	yes	yes	no	no	yes	-	yes	no	no	no
RUE "Belgosles"	yes	yes	yes	yes	yes	no	no	no EAM	-	-	no	yes	budgetary financing of forest monitoring activities, FHM observations should be carried out by a minimum number of specially trained staff
UE "Belgiproles"	no	yes	yes	no	no	yes	no	yes	-	-	no	no	no
Forest Institute of the National Academy of Sciences of Belarus	no	yes	yes	yes	yes	yes	yes	yes	Forest genetic diversity monitoring	yes	no	Russia, Poland	while carrying out of FHM, to monitor the genetic diversity of forests on the basis of molecular genetic marking

Table continuation 4.1

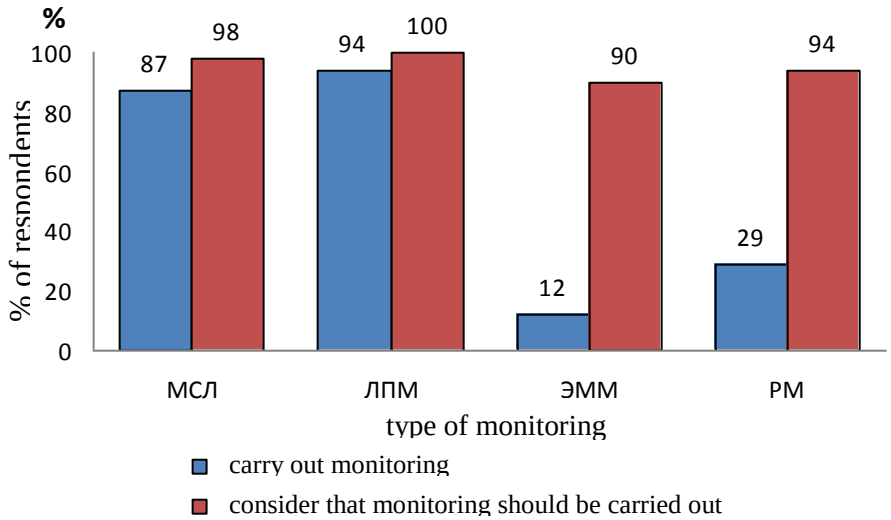
1	2	3	4	5	6	7	8	9	10	11	12	13	14
The National Park «Belovezhskaya Pushcha»	yes	yes	yes	yes	yes	no	no	yes	resume within the framework of the International Cooperative Program ICP Forests on the permanent sample plots	no (a necessity for closer cooperation in the field of GIS technologies)	yes problems with a shortage of workers, material and technical supply and financing	ICP Forest of European countries, FHM – USA.	budgetary funding for FHM management on the entire existing network of observation points. For qualitative performance of the work, the observations should be carried out by the specialists of RUE "Belgosles"
Belarusian State Technological University	нет	yes	yes	no	no	no	no	yes	Forest monitoring on sustainable forest management in the context of climate change and anthropogenic impact	-	-	yes	to include into the forest monitoring system a new direction "Forest monitoring on sustainable forest management in the context of climate change and anthropogenic impact"
The Ministry of Natural Resources and Environmental Protection	yes	yes	yes	no	no	no	no	yes	-	yes	-	-	to increase the number of observation points around industrial-hazardous (anthropogenic) facilities in order to determine the harmful impact of anthropogenic factors on the environment more accurately

Summary and data received analysis

Forest health of the Republic of Belarus does not cause any fears among the half of the respondents who took part in the questionnaire. At the same time, all respondents, both inside the country and on a global level, believe that forest monitoring needs to be carried out. They think so because of the various reasons, which are related to the forest health.

Forest pathological monitoring and state forest monitoring are the main directions of forest monitoring (Picture 4.1). Over 94 % of respondents do the work which is associated with forest pathological monitoring. Also these works are carried out by all legal entities, leading forestry. All respondents consider that forest pathological monitoring should be carried out.

91% of legal entities, leading forestry, are carried out in forest state monitoring. They took part in the questionnaire. In general, the observation points of forest health monitoring are laid on the territory of the forest fund by 93% of legal entities, leading forestry. Some respondents consider that forest health monitoring can not be carried out. But if it will be carried out, then specialists of a specialized enterprise should conduct it.



Picture 4.1 The distribution of respondents who monitor forests and their opinion about the practicability of conducting separate monitoring directions

A relatively small number of respondents conducts radiation monitoring. These are mainly legal entities, leading forestry and organizations, the forest fund of which is located on the territory exposed to radiation pollution as a result of the Chernobyl disaster.

Environmental and ameliorative monitoring of reclaimed wooded lands is carried out on separate forestry establishments. The observation points (stations) are laid in that territory.

A smaller number of respondents voted for these two directions of monitoring. At the same time, it should be noticed that those legal entities, in the territory of which monitoring in these directions are not carried out, offer not to conduct radiation monitoring and environmental and ameliorative monitoring of reclaimed wooded lands. RUE «BELGOSLES» share such opinion.

In general, 96% of respondents expressed their support for the preservation of the current forest monitoring system.

In addition, there are proposals not only to reduce the number of forest monitoring directions, but also to increase their number. It is proposed to conduct additionally the new directions of forest monitoring:

- Belarusian State Technological University consider that it is necessary to add the direction: "Forest monitoring on sustainable forest management in the context of

climate changes and anthropogenic impact" in the forest monitoring system of the Republic of Belarus;

- " Stolbtsovskiy Experimental Forestry" considers that it is necessary to carry out "Forest fire Monitoring" because of the changes in climatic conditions in the territory of the republic.

Concerning the proposals of the above mentioned institutions, we can say the following:

- the proposal of the Belarusian State Technological University is partially realized and regulated by the legislation. Forest management in the republic is carried out through forest management projects. These projects are developed for a ten-year period. They are compulsorily passed state ecological expertise and contain an in-depth analysis of forest changes in the result of economic activity. The procedure of carrying out forest management in the Republic is established by the articles 35, 36 of the Forestry Code of the Republic of Belarus.

- the proposal of " Stolbtsovskiy Experimental Forestry" about the necessity of carrying out forest fire monitoring is actual. Nowadays, the legal entities, leading forestry and their overhead organizations are keeping the Forest Fire Register in order to control all the forest fires. The information which is recorded in this register is not enough for complete monitoring. The list of fixed indicators should be significantly expanded. In particular, it is necessary to note the cause and the source of the fires. In case of fire on the territory of the forest fund, it is necessary to mark the number of the division, the forest type, stand composition and the age of stand in the source of the fire. The fire area must be described by two indicators: the entire area covered by the fires and the area of plantations that died in a result of the fire.

Forest fire monitoring can be carried out as a separate type of observation within the framework of one of the directions of forest monitoring. It does not take a significant amount of financial resources to organize forest fire monitoring because the accounting of forest fires is held at the present time.

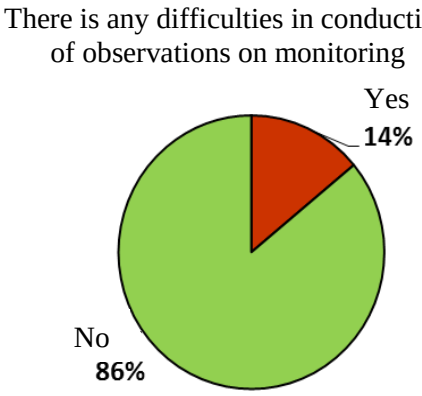
We can also mention the other suggestions, regarding the current forest monitoring system:

- The Ministry of Natural Resources proposes to increase the number of observation points around industrial-hazardous (anthropogenic) facilities in order to determine the harmful impact of anthropogenic factors on the environment more accurately;
- The national park «Belovezhskaya Pushcha» proposes to resume observations at permanent inventory plots (level II according to the classification of ICP Forests). The State Forest Institute "Forest Institute of the National Academy of Sciences of the Republic of Belarus" proposes further monitoring of the genetic diversity of forests on the basis of molecular genetic spotting at permanent inventory plots.

Concerning the proposals of the Ministry of Natural Resources and above mentioned institutions, we can say the following:

- the proposal of the Ministry of Natural Resources refers to a change in the methodology of forest monitoring and it should be resolved between the Ministry of Natural Resources and the Ministry of Forestry in the working order;
- the proposals of the national park «Belovezhskaya Pushcha» and the State Forest Institute "Forest Institute of the National Academy of Sciences of the Republic of Belarus" are unacceptable at the present time. Specially qualified specialists should carry out measurements, observations and select samples at permanent inventory plots. They should perform analyzes of selected samples in specialized laboratories. A significant amount of financial resources is required to carry out all these works. Budget financing is not provided for the work at permanent inventory plots until 2020. At the same time, in the connection with the observed climate changes and increased human impacts on forests, the resumption of observations at the permanent inventory plots is urgent and it is necessary to find financing for these works.

The problematic issues of the current forest monitoring system were also found in the result of the questionnaire on forest monitoring of the Republic of Belarus. A significant number of legal entities find difficulties in conducting of forest monitoring system (picture 4.2).



Picture 4.2. Distribution of legal entities having difficulties in conducting of field observations on forest monitoring

When the legal entities conduct field observations on forest monitoring, they face with the problem: the lack of practical skills of their employees. According to the results of the survey, the final results of forest monitoring are not used by 16% of legal entities, leading forestry. As a consequence, a significant number of legal entities have no motivation to obtain primary data on monitoring of proper quality. Most of all it applies to those types of observations, the final results of which are obtained by the statistical method. The specialists of RUE "Belgosles" and SI «Belleszashchita» confirmed a representation of a significant number of unreliable primary monitoring data by legal entities. They carry out the measures to determine the reliability of primary data from legal entities, leading forestry.

Analysis, including data received from different sources, in the matter of the concerns of current forest monitoring system

Financing is the main problematic issue of forest monitoring organization. Nowadays, the legal entities, leading forestry, are carried out forest health monitoring for their own financial resources. There was a proposal from legal entities that the part of the field observations on forest monitoring should be carried out by specialized organizations with highly qualified specialists. They should hold it because of the different financial costs and organizational problems (education of employees, transport support of performed works).

According to this proposal, it is necessary to mention that monitoring observations were assigned to legal entities leading forestry because there is no budgetary financing for the implementation of these works by specialized organizations.

For reference: While forest health monitoring the main costs fall on the field observations. It is necessary to form three specially trained groups with two performers (6 people in total) for carrying out field observations of forest health monitoring by the specialists of RUE "Belgosles". Each group should be provided with motor transport, fuel and lubricants, driver. Thus, in 2017, the specialists of RUE "Belgosles" need over 150 thousand Belarusian rubles (79 thousand dollars) for conducting the whole complex of forest health monitoring on a common-European network (field observations, cameral treatment of primary data, maintenance of a database). In 2016 only 19 771 rubles (10.4 thousand dollars) were given from the government budget.

The measures of forest monitoring are the costs of leading forestry. Meeting expenses for forest monitoring, in accordance with the legislation, should be carried out by legal entities leading forestry, at the expense of funds coming to them from payments for forest use and from the sale of forest products received in the implementation of forest management measures. The lack of motivation and use of the results obtained in the course of economic activity is the second important issue. Not all legal entities leading forestry use forest monitoring data in the process of

economic activity in full scale. If, according to the results of forest pathological monitoring, the legal entities, leading forestry, perform forest management measures and maintain the condition of the plantations in a proper sanitary condition, then the monitoring data of the forest health are practically not used. They are more interested in scientific and educational institutions, the Ministry of Natural Resources and Environmental Protection (Information and Analytical Center of the National System of Environmental Monitoring in the Republic of Belarus).

There are not enough good specialists who conduct field observations on forest health monitoring. And it affects negatively the quality of the received data. It also should be mentioned that the list of indicators to be determined is small, according to these types of observations. At the same time, due to the small amount of work on the territory of the forest fund of a single legal entity, the acquisition by their employees of any practical skills to perform these works is impossible. To obtain high-quality primary data, field observations should be carried out on the territory of all the forest fund by a small number of specially trained specialists.

The Ministry of Forestry of the Republic of Belarus
RUE «BELGOSLES»
Forestry Development Project of the Republic of Belarus
GEF/WORLD BANK TFOA 1173

REPORT

under the contract № BFDP/GEF/SSS/15/20-02/16 for 05.03.2016
on component 3: arrangements 3.1.1.2. and 3.1.2.2.; №02-2/15
Development of the forest monitoring system of the Republic of Belarus

Stage №5. The review of international experience in the field of organizational systems and forest monitoring

EXECUTOR
General Director
RUE "Belgosles"
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Minsk 2016

CONTENTS

Annotation

Monitoring of forest health provides getting environmental information for the current state of the main wood species of forests and other components of forest ecosystems, forest ecosystems as a whole, also produces the forecasts of changes in current levels of exploitation and impact of anthropogenic and natural factors as well as information support of management, design and technology solutions in the field of ecological safety, rehabilitation, conservation and sustainable use of forest soil fertility, biological and landscape diversity, habitat-forming properties of forests.

In this report you can find the review of international experience in the field of organizational systems and forest monitoring holding.

We have chosen the countries-leaders in realization of such project and countries-neighbors which are the most similar in its forest conditions such as Czech Republic, the Republic of Finland, the Republic of Sweden, the Russian Federation and the Republic of Poland for study of positive and negative aspects of organizing and conducting of forest monitoring.

We have made an analysis of the main achievement in monitoring (technology, methods, and techniques) and estimated the possibility of using these directions in the Republic of Belarus.

The report consists of 21 pages and contains 5 figures.

The review of positive and negative aspects of organizing and conducting forest monitoring in the Czech Republic, the Republic of Finland, the Republic of Sweden, the Russian Federation and the Republic of Poland.

Czech Republic.

1. Forest health monitoring.

In 1985-1987 the Czech Republic was one of the first countries who had created the program of international cooperation in the monitoring and assessment of the impact of air pollution on forests (ICP Forests).

The first 106 study plots in the Czech Republic were established in 1987 according to the European network of 16x16 km. In 1991 8x8 km network was established with the 334 sample plots in the other regions of the country.

Nowadays there are 306 permanent study plots (PSP), which are situated in the 16 x 16 km systematic network, and separate 8x8 network components. These components are evenly distributed throughout the territory of the Czech Republic in accordance with the interests of each breed in the composition of the forests of the Republic and they form a national monitoring of forest condition **Level I** Network. The components are located in the woods from 150 m to 1100 m above sea level, and each year 28 species of forest trees are estimated in different age groups. In 2015 more then 11000 trees were surveyed.

Species composition and PSP I level layout is shown in the figure 5.1.

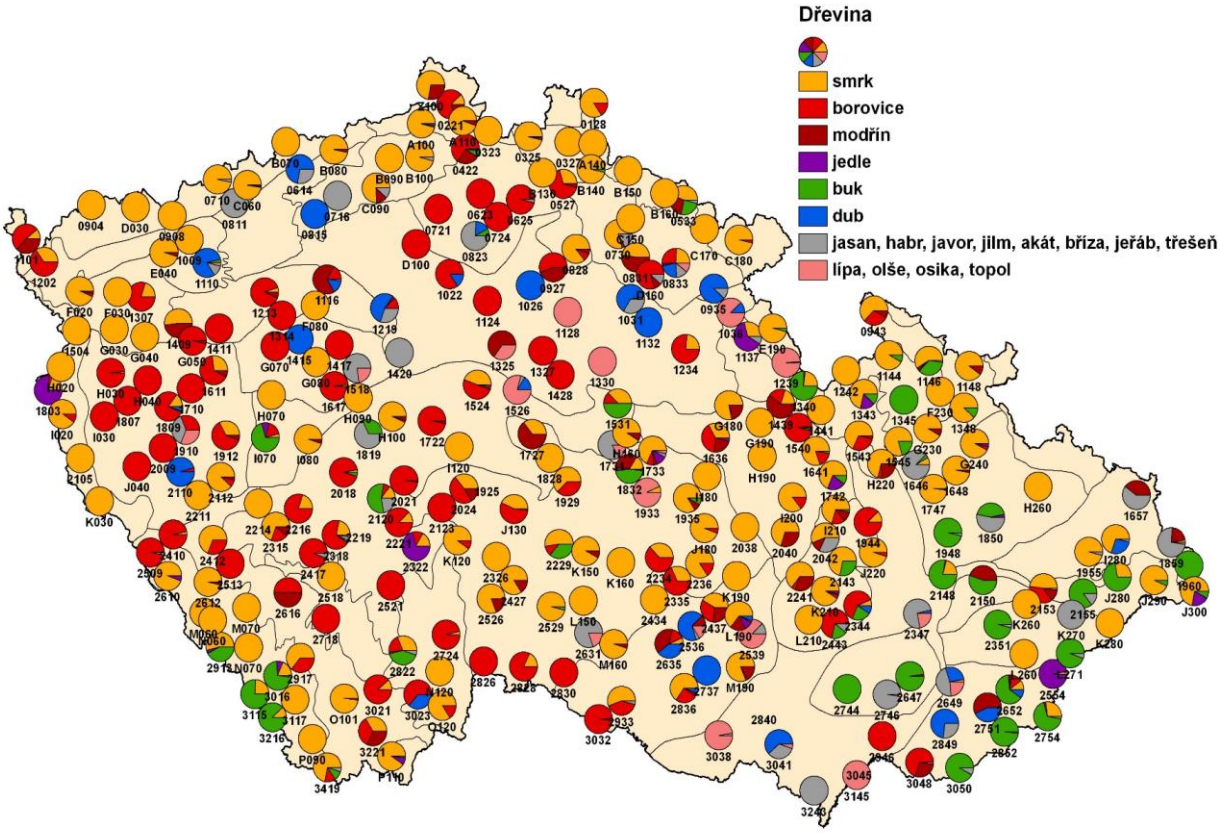

Figure 5.1. Allocation of PSP I level.

Status of the trees on the PSP is estimated according to the level of defoliation, defined as relative loss of assimilative instrument in the crown of trees in comparison with healthy trees growing in the same environmental conditions. This loss is mainly due to unfavorable changes in forest ecosystems as a result of prolonged and excessive presence of various pollutants (SO_2, NO_x, O_3, dust, etc.).

Spruce

15 % 35% 55%

Beech

Figure 5.2. Forest assessment (% of defoliation)

The program ICP was maintained and well-funded by the European Union. It made an opportunity to organize the creation and conduct intensive monitoring of forest ecosystems - monitoring of the **II level**.

There are 16 PSP for detailed forest state value and environmental factors which have am impact on it. PSP were gradually laid in 1994, the most recent changes took place in 2004 after the implementation of the National Forestry program (NFP), in order to cover the main species of trees in area of their natural habitat (spruce - 50%, pine 20%, oak - 10%, 10% beech, the others - 10%).

Nowadays, the Intensive forest ecosystem monitoring program is currently financed by the funds, provided by the Ministry of Agriculture. Before this situation most of funds were provided by the European Union as the part of the project Forest Focus (2003-2008) and LIFE + и FutMon (2009-2011). Some events are financed by the Ministry of Environment.

Observation and assessment of PSP indicators is carried out in accordance with the approved Guidelines on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the impact of air pollution on forests. The main criterias are:

- assessment of crones (defoliation);
- state assessment of forest soils;
- soil moisture and hygroscopicity of the soil;
- chemical analyzes of assimilation organs;
- plant growth;

- precipitation;
- weather conditions;
- assessment of biodiversity and terrestrial vegetation;
- phenological observations;
- air quality assessment;
- collection and assessment of plant mortality.

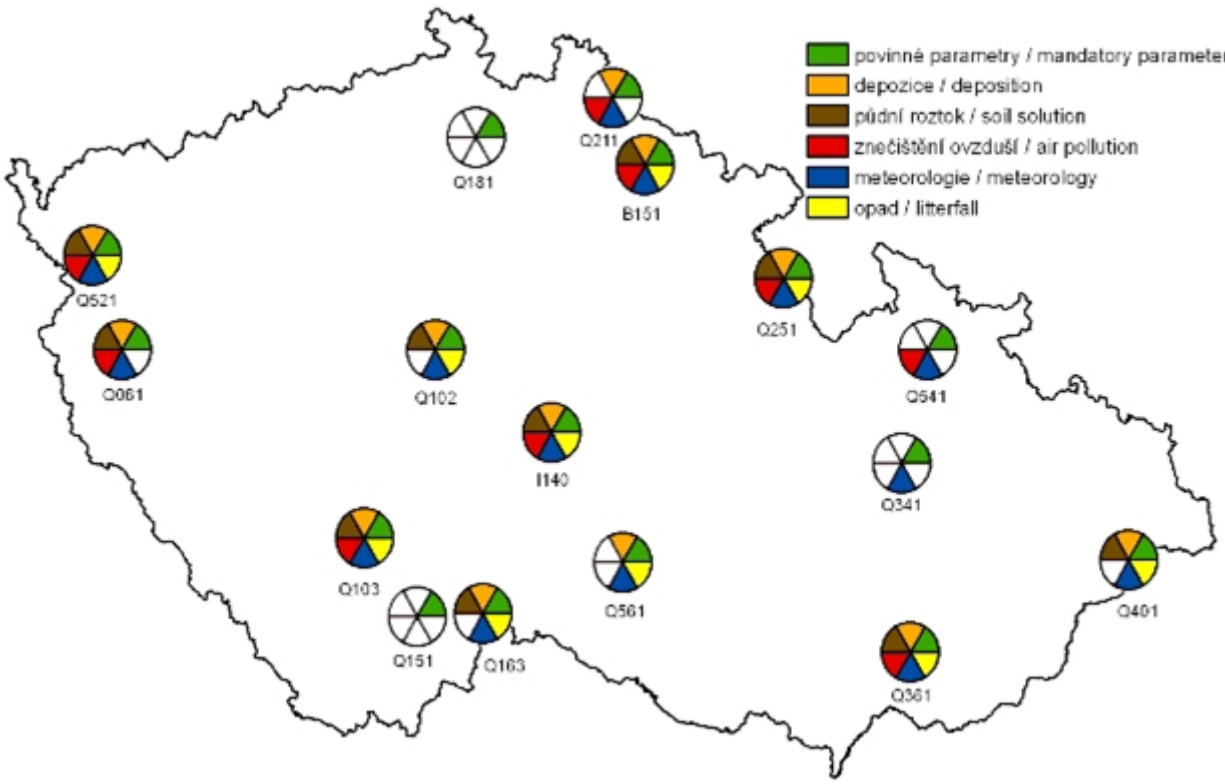

Figure 5.3. Allocation of PSP II level and test items.

The aim of forest health monitoring is, on the one hand, to collect information about the spatial and temporal changes in the forests on a European scale, and on the other hand, to study the reasons of current damage forests, with particular emphasis on critical loads and levels of air pollution.

2. The project FutMon.

The project FutMon was a part of intensive monitoring of forest ecosystems and was held in 2009-2011, funded by EU, and financed by the public funds of the Ministry of Agriculture of the Czech Republic since 2012.

The project provided the same methodology over the whole territory of EU in order to evaluate different forest characteristics and environmental factors. The existing intensive monitoring of forest ecosystems in FutMon project is limited to the certain areas with a full range of analyzed characteristics (there are 14 provinces and 16 PSP national networks in the international database of the Czech Republic). The complex measurements have been carried out in these areas, corresponding ICP Forests program.

The purpose of the FutMon project was to continue the forest health monitoring in the systematic manner in the network areas according to the methods in different European

countries. The types of assessment were divided into four target areas with various intensity of researches:

IM1 - the main directions of intensive monitoring.

D1 - tree vitality and adaptation.

D2 – nutrient cycle and critical loads.

D3 – water cycle.

The system «intensive monitoring of forest ecosystems» is IM1 concept. It was introduced as a part ICP Forests program in 1994. The creation of an intensive monitoring program was a natural reaction to the fact that the overall forest monitoring is carried out in Europe using the same methodology. However, there was not enough information for analysis of causes of forest health. With this view, 16 PSP were laid in 14 regions for getting more information about forest health, nature and anthropogenic factors of the environment which are influenced it.

The detailed survey of tree crowns, soil analysis once every 10 years, observation for assimilation of organs of woody plants (is held once every two years), assessment of forest growth in five year, all these parameters are included into the "required settings" of intensive monitoring from the beginning. Optional (non-required) settings are: assessment of soil solution, assessment of pollution load, phenological observations, assessment of plant mortality and others. These observations are carried out on 10% of the total number of PSP.

Identification of the main indicators of tree viability is the aim of D1 direction. Survival assessment indicators (surviving trees, number of deaths), functional indicators (for example, growth and regeneration, carbon deposition) and indicators of resistance to stress (for example, sensitivity to changes, flexibility, the ability to compete with neighboring trees) are included into traditional parameters of defoliation. These parameters are tracked on 4^{th} PSP of intensive monitoring.

The aim of D2 events was to develop the methods of nutrient cycle monitoring and evaluating of critical loads in forest ecosystems, including the starting materials in the form of deposits, their consumption of trees and other plants.

Intensive monitoring was supplemented by the next analyzed indicators: control of the quantity and chemical characteristics of litter, more intensive screening of assimilation organs sample (analysis of 4 years old butcher) from pine trees, estimate of standing crop and nutrient reserves in the ground part of the plants.

D3 direction was focused on the hydrological functions of forests. The aim was to provide a basis for the development of water balance models of forest ecosystems. This direction monitored the weather data parameters, assessment of water in the soil, phenological observations, evaluation of tree growth, biotic damage and assessment of tree health. Moreover, the direction was completed by the assessment and measurement of certain parameters: soil temperature, soil moisture and water potential of soil, precipitation.

3. Monitoring of harmful substances in forest ecosystems.

Monitoring of harmful substances in forest ecosystems (VULHM) is held for assessing the content of heavy metals in mushrooms since 1988. Monitoring is directed to the detection of heavy metals (Cd, Cr, Cu, Hg, Ni, Pb, Zn, Mn), in selected samples for the determination of polycyclic aromatic hydrocarbons, organochlorine pesticides and polychlorinated biphenyls.

It is carried out by analyzing the samples of edible mushrooms and berries which are collected in the forests in summer and autumn months.

4. Forest pathological monitoring.

Forest pathological monitoring is held on the first level of PSP monitoring under the forest health assessment.

5. National inventory (NFI).

Forest inventory is a statistical method, which is used to describe the characteristics of the forest. The main principle of the inventory is repeated studies that are carried out on specialized sample plots. The remote investigation method of the Earth surface plays a big role in it. The results of national inventory are comprised on rather big areas: republic, region, typological forest area. The statistics which was obtained as a result of inventory is described not only by specific number, but also by the limits of prescribed accuracy. The collection of exact information about forest ranges is the main aim of inventory and it depends on human factor.

The first cycle of forest inventory was held in Czech Republic in 2001-2004, in the result of which 14 220 sample plots were held. Afterwards, the processing of results was carried out, and the system of inventory was undated in the area of unification of forest terms and definitions of the international classification.

The second cycle of inventory was held in 2011-2015. Data volume was expanded and statistics of remote sensing of earth's surface began to be used. In the result of researches, the network of the first cycle of inventory was used and at the same time the new cycle of sample plots was laid.

The third cycle of forest inventory has already projected and it lasted from 2016 till 2020. The establishment of sample plots is a main innovation of this cycle and it will be held not only in the forests. In such a way it changes forest inventory into the general inventory of landscapes in Czech Republic.

The inventory is based on the method which is formed by the theory of probability and mathematical statistics. The basis of the second cycle inventory is a network with cell 0,5 x 0,5 km. A sample plot is selected randomly in each square. There are 315 249 plots in the cycle. A larger network with 1,0 x 1,0 km is created on the basis of this network. We have 78 856 plots of such size, they conducted the more extensive collection of indicators than on the plots of small network. In all these areas the method of distance study of the earth's surface is used, the indicators are collected on the basis of photogrammetric analysis of aerial photographs. There is a process of data collection (over 39 454) on the plots of 2,0 x 2,0 km network in condition that these plots are referred to the forest territory. Forest inventory groups move to all the plots, where the rates are determined by instrumental method, for which laser rangefinders, altimeters, electronic caliper, waterproof computer with special software, GPS receivers are used. A square with 51 meters side is laid at the heart of the plot, it is divided into sectors and collected forest taxation indices. A number of narrow rectangular plots - transects - for the determination of the dead (lying timber) is getting through the sample plot. The plots of 4,0 x 4,0 cell form the last stage– the largest network, where the soil and forest pathology examination is added to the definition of a variety of forest taxation. All the sample plots are registered in nature on the quiet.

Forestry and Game Management Research Institute is a legal entity which performs research projects in the area of forest management, including monitoring of forest health, monitoring of harmful substances in forest ecosystems, forest pathological monitoring. It is a participant of FutMon project.

The Institute is also engaged in providing expert advice and other services for the government and forest owners. The institute, according to its principal activities, conducts researches at the expense of public funds. Now, the Institute employs over 100 people.

The assessment of forest health and plantations is carried out on the subjective assessment of the specialist performing the observation data. In this regard, if we want to ensure an identical approach to the visual definition of crown defoliation assessment, we should carry out a group of experts who are constantly performing this work.

The Institute of Forest Management «Brandis-nad-Labem» **(Ústav pro hospodářskou úpravu lesů Brandýs nad Labem)** is state forest structural enterprise which obeys the Ministry of Agriculture of Czech Republic. Nowadays, the enterprise is working over the all territory of Czech Republic and has 9 branch companies which are situated in different regions of the country, the staff number is 428. The main activity of the company is a national forest inventory.

The Republic of Finland

Forest monitoring

Finland is the richest with the forest resources country in Europe. The forests cover 76 % of the territory – 26 millions ha (*taking into account the low-productive forests*). Besides, you can see sparsely forested territories, forestless opened bogs and rocky surfaces and also 3 millions ha, in the result of which the area is 29 millions ha and it is 86 % of the territory of the country.

National forest policy in Finland is based on the traditional forest family ownership. There are over 60 % of the forests in family ownership. More than 9 % of the forests are in the private property of enterprises and companies of forest industry. Over 5 % of the forests are in the private property of churches, communities and other structures like this. The government owns only 26% of the forests. They are mainly situated in the north of the country. Almost half of them belong to protected environmentally natural areas.

National forest inventory of Finland is a system of forest monitoring. It is realized by «Metla» (National Forest Inventory Finland), which is subordinate to the Ministry of Agriculture and Forestry of Finland. Finland is one of the first countries in the world which holds a national forest inventory, based on a statistical sample (*1921-1924 years.*). Private forestry is relatively small in size because there is a large number of private forest owners (*currently more than 630 thousand*). On average, agriculture accounts over 30 hectares of forest. It is extremely difficult to bring together scattered in time and space materials of the devices of many forest owners in a single state accounting. In this regard, forest inventory is held by the statistical method. It is carried out by a plurality of tabs clusters (groups) of sample plots which are equally spaced around the forest fund (Figure). Sample plots are circular areas of constant radius. The radius of the plots depends on the age of the plants and their completeness. The sample plots are permanent because they give more reliable information about forest dynamics. The examination of sample plots is held simultaneously across the whole country and is being completed within 5 years. More than 70 thousand sample plots have been changed when the last forest inventory was held (2009-2013 years). In addition to the land data satellite images are used (Landsat TM or ETM+) and digital maps including digital elevated maps.

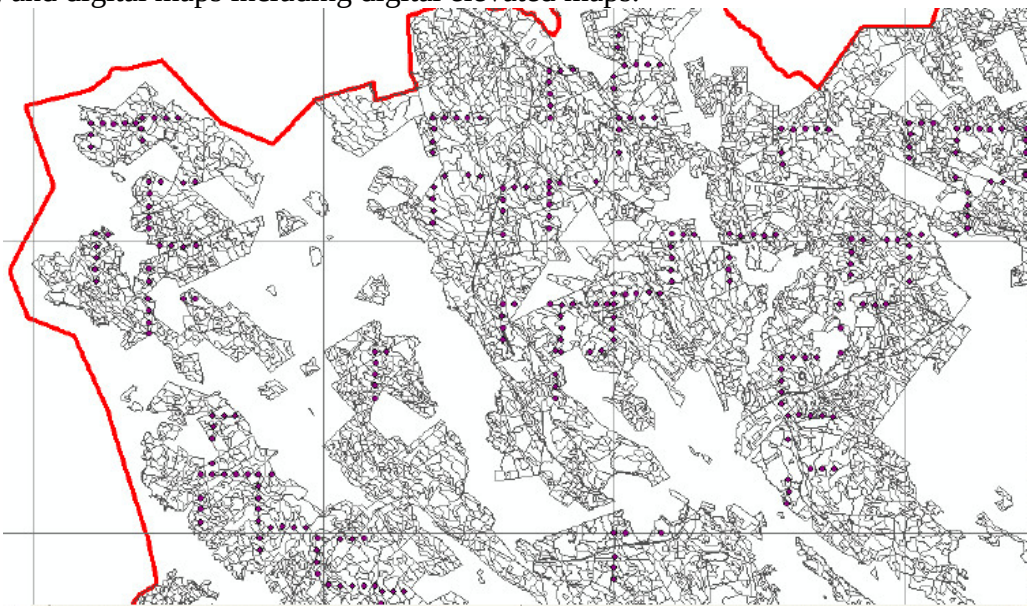

Figure 5.4. The arrangement plan of sample plots in conducting of forest inventories

During the National Forest Inventory we receive the information about:
- forest resources – about the volume, growth and the wood quality;

- the structure of land use and forest ownership;
- requirement in forest management activities;
- forest health;
- forest biodiversity;
- carbon sinks in the forests and their changes.

13 forest Centers do field works on forest inventory. Forest Centers also conduct forest management, but forest management is separated from the state inventory. According to the results of field forest inventory materials, high resolution satellite images, laser scanning of the area and other data sources, using special computer programs, Forest Centers provide the forest management of all the forests, both private and public. It also provides information to all operational business activities in the forests. Forest database is updated in accordance with the current state at least twice a year.

The Republic of Sweden.

Forest monitoring

The forest area used for the production of timber and pulpwood comprise 22.9 million hectares in Sweden. Part of the forest area is owned by several large companies, whereas the other part is divided into more than 200 000 private plots.

Information on all of these forest resources is essential on several levels:

- governing bodies need a summary of all forest owners;
- the owners need more detailed information on their forest plots to produce forest management plans;
- at the level of plantings, information on the forest area is regularly required, where the planned cuttings are or have been recently taken place.

Forest monitoring is carried out in Sweden within the framework of the state program of monitoring and comprehensive evaluation of national forest resources. New remote sensing methods are being currently actively introduced to the integrated forest resource assessment:

- state forest monitoring using satellite data;
- area laser scanning;
- forests mapping using unmanned aerial vehicles.

The Swedish Forest Agency and the Swedish government program for forest inventory in recent years have effectively used optical satellite imagery medium resolution system from Landsat or SPOT satellites. Since 1999, the Forestry Agency annually receives satellite images of the entire Swedish forests territory.

Analysis of the forests dynamics is carried out on the basis of relatively calibrated images, which are used as spectral pixel standards for "forest" pattern. The annual summer survey has been carried out in recent years on the entire territory of Sweden with SPOT satellites to perform this monitoring project. The obtained imagery database can be effectively used to solve other forestry issues: for example, to estimate the parameters of plantations through the joint analysis of images and plots of the land data.

1. Swedish national forest inventory program

Forest inventory project of the Swedish national program is based on a systematic description of the annual field plots across Sweden. The purpose of the project is to collect reliable statistics of 31 provinces (or on parts of the provinces), using the average five-year periods results of surveys on field plots. Test plots are arranged in groups on the sides of the square; each group consists of either 6 (12) temporary circular platforms with radius of 7 m or 8 permanent circular plots of 10 m radius. Surveys are conducted in Sweden at approximately 5,300 permanent and 3,500 temporary plots every year. Permanent plots are re-examined every

5-10 years. The coordinates of test areas are defined by GPS from 1996, which allows further share characteristics of trees and plots characteristics.

In order to share the plots NFI data and Landsat satellite data a range of multiple software products by name **Munin** was developed. As a first step, the plots data are used for pre-processing of satellite data. Local geometric error is modeled between satellite data and each test area, and then the model basis of most probable values of the pixels are selected. Furthermore, data plots, and the image data are used together to determine the parameters and orthocorrection to compensate for the haze in the images. The first application experience of software products Munin was to classify all forest land in Sweden with the release of the seven classes of forest vegetation. This work was carried out by the Swedish Agricultural University in 2002-2003 under a contract with the Swedish Ordnance Survey, and the results were used to compile the national Swedish and European data base on land types (landscape). A total of 50 shots by Landsat ETM + and 34,000 plots were used. Classification of forests was conducted by the method of maximum likelihood calibration, which used a priori probabilities. Classification of Landsat pixels of each frame is repeated as long as the occurrence of each class of forest land in the photo do not match the occurrence of the same class in the NFI plots for a given frame.

2. kNN-classification by the nearest neighbor method

Pictures Landsat ETM + and test areas used for the above-mentioned classification of land types, have also been used to create a state database on Forests with the Finnish version of the method of kNN - variants of the nearest neighbor method.

The first database "kNN Sweden" was created on the basis of a series of pictures dating back from about 2000. This database is available as a raster product with an estimate for each pixel: the total stock of trunks, trunks stock by species, age of plants and trees of medium height. The calculation of these parameters was performed for all the pixels defined as "forest", in accordance with the topographic map with scale of 1: 1 000 000. The creation of a database for all of Sweden forest land with usage of this software requires approximately one man-year including the processing of all data and quality control.

There is also a version of the database kNN, where the original data is generalized using proprietary segmentation module to display similar characteristics plantings. While the accuracy of kNN product on the pixel level can be quite low, the accuracy level of aggregate sites is quite acceptable for many applications. Typically, the accuracy of trunks reserve estimation is about 60% at the pixel level, 40% at the level of plants and 15% for generalized plots larger than 100 hectares. Since the correlation between the optical satellite data and serried plantations is quite low, kNN classification method underestimates the trunks reserve in productive plantations. On the other hand, the trunks reserve in sparse or young forests can be overrated. kNN data base used by the forestry authorities and environmental protection, as well as the tax management for review of data on forest resources in large areas. It is also used in many research projects, such as the modeling of different types of habitats; as input for modeling the dynamics of the landscape, and in addition (with multi-temporal images), to analyze the areas affected by the hurricane.

In 2006, a new version of the national database kNN data using SPOT satellite images dating from the summer of 2005 is created. Test plots generalization is currently used as a standard operating procedure. Test results show that the average square error of the reserve assessment (general trunks reserve, pine, spruce and hardwoods reserve, as well as the trees biomass) can be reduced on the province level by generalization of data using images of Landsat ETM +. In this case estimation error is reduced by 10-30% compared to the accuracy that is obtained only on the field data. Generalization of data proved itself as a comprehensive and effective method of combination of satellite imagery and test plots NFI. As a result of this method, most of the problems that lead to inaccurate estimates are eliminated, making it difficult to achieve using other approaches.

3. Lazer scanning

Since 1991, Remote Probing Laboratory (often in collaboration with the Swedish Defense Research Agency - FOI) has been working on the use of laser scanning forests. Two main methods of forest inventory based on laser scanning are developed. With the use of low density laser data registration (about 1 laser pulse per m2), statistical relationships between measurements on the field areas and the characteristics of the data received from the laser can be identified. Thus, the identified patterns of the statistical distribution of tree height (in percentage) can be then used in all the plantations, where laser scanning was carried out. This method provides a average square error of trunks reserve assessment of 10-15%).

Commercial use of laser measurements for forest inventory was carried out for the first time in Norway. The first industrial trial in Sweden was conducted in 2003, when an area of 5,000 hectares laser was examined with a laser. Average square error on a stand level was 14% for the trunk reserve, 5% for the height of the trees, and 9% for the average diameter. A totally different approach is laser scanning at a density sufficient to produce a plurality of laser pulses on a tree - to identify separate trees, which requires a density of about 5 pulses per m2 and more. Such an information is mainly obtained by conducting research from a helicopter nowadays but technical development enabling receiving data laser transmitter with a very high density from an aircraft with fixed wing represents a promising option for future forest surveys on industrial scale. The contribution to this development is the growing use of focal plan technology, which involves many sensor elements for recording return signal from each laser pulse. One such study was conducted in Sweden in a forest with a predominance of softwood. It was possible to identify more than 70% of all trees with the help of a laser high-density sensor, which in total amounted to more than 90% on the trunk reserve. The height of the trees and the diameter of the crown were also detected automatically and both indicators with an accuracy of 0.6 m. Using the characteristics of tree crowns, automatically derived from laser scanner data, it was possible to divide the pine and spruce with an accuracy of 95%.

Remote Probing Laboratory is also working on trunk diameter distribution estimate with usage of a laser sensor of high density laser data segmentation plants on images. On-board VHF Radar - CARABAS system of Swedish Defence Research Agency and Ericsson Microwave Systems have developed a system of CARABAS, which possesses a unique synthetic aperture radar. Currently, there is only one such system, however, the development of new systems for civil use is actively discussed. Since CARABAS works with radar waves 3 - 15 m in the VHF, radar signal penetrates the forest canopy and is reflected mainly from earth and tree trunks. Long implementation experience of CARABAS system in Sweden has identified good opportunities of SAR VHF to determine the trunks reserve in boreal forests. Typically, the average square error in determining the inventory of plots level is about 20%.No signal concentration in dense Swedish forest stands was not observed compared to an optical capture. Optical satellite data, however, correlate better inventory with trunk reserve at values up to about 100 m3 / ha, in comparison to the data produced by CARABAS system. Thus, the best results were obtained by joint use of these two data sources when estimates from optical images were given greater weight in minor reserves, and data CARABAS with major reserves. It was also shown that the trees felled by the wind, compared to growing trees often provide a stronger radar return signal and its other texture, which usually reveals windfall trunks under the canopy of the remaining trees. Currently, mapping territory with usage of CARABAS system is carried out in the southern part of Sweden in an area of 15,000 km2, which was affected by a hurricane. The purpose of this work is the identification of windfall trunks, which can cause a pests outbreak.

4. Plots mapping using unmanned aerial vehicles

Clear cuts in the Swedish forests are assigned to the forest at the age of approximately 100 years. Major forest companies carry out a special logging inventory to create the database,

which can be used for the selection and cutting the trees needed by the industry at the exact moment. Currently, such forest inventories are based entirely on field studies, and there is a need to develop and use more remote sensing methods. Furthermore, after the clear felling it is necessary to examine the area for planning reforestation, as well as for the planning of environmental measures. In future it is also needed to monitor the young trees resumption progress, as well as to determine the time and venue of sanitary clear cuts. Common requirement in developing specific survey techniques is that such surveys should be carried out at a certain time in specific plantations scattered throughout the territory. Photos of fresh continuous logging sites are often made today in Sweden with small aircraft and digital medium-format cameras. In future, time and money-saving option may be the use of unmanned aerial vehicles (UAVs) with cameras or other sensors, which may be steered to target by the foresters.

The Russian Federation.

Grounding the choice of the country

The forest are a in the Russian Federation is more than 809 million ha. Percentage of forest land makes about 49%. Also taking into account near-boarder location of the Russian Federation, historically general approaches to the forest management, the recent fundamental reformation of forest management and the federal property on forests was the basis to consider the organization and carry out the forest lands monitoring of the Russian Federation.

Forest monitoring

Forest monitoring of the Russian Federation is a system of observation, evaluation and forecast of the state and dynamics of the forest funds for the purpose of public administration in the area of use, preservation, protection of forest funds and reproduction of forests and increase of their ecological functions. Monitoring is a subsystem of a unified system of state environmental monitoring (the state environmental monitoring).

The main goals of the state forest monitoring system:

- the ability of making multi-factor decisions on state forest management through the establishment of specialized information flows;
- making different urgency forecasts of forests ecological state and development, the development of possible spatiotemporal patterns of their usage, the development of processes in specific forest areas with account of natural and anthropogenic factors scenario.

Information support of state forest management in the state forest monitoring system is carried out for the following purposes:

- to develop strategies for socio-economic development of the Russian Federation and their subjects and the evaluation of their results;
- to develop a public policy for forest relations;
- to develop a federal and regional programs of the forestry, to assess their effectiveness;
- to forecast an emergency situations of natural and man-made disasters;
- to develop measures to recover forest health;
- to establish links between changing in the forest conditions and negative impacts on forests;
- to develop an adequate and informed decisions on prevention negative impact on forests;
- to assess of the effectiveness of interventions.

Certain types of forest monitoring in the state forest monitoring system act as their subsystems, with the object of monitoring (in any form of forest monitoring) is a forest area.

The procedure for monitoring of forests is established by national forest legislation. The current Forest Code of the Russian Federation establishes the following types of forest monitoring.

1. State monitoring of forest reproduction (Art. 61.1 of the Forest Code of the Russian Federation).

The monitoring of forest reproduction is carried out in order to assess compliance with forest legislation while using forest areas, identifying forest areas with the illegal use of forests and the calculate the indicative amount of damage from illegal forest use.

Forest reproduction monitoring includes:

- assessment of the changes of the area of land occupied by forests;
- identification of land not occupied by forests and require reforestation;
- assessment of forestry characteristics for reproduction of forests;
- assessment of the characteristics used in the reproduction of forests, seeds of forest plants and planting material of forest plants (seedlings);
- evaluation the effectiveness of reforestation.

Monitoring is carried out by observation of the reproduction of forests with using of ground, air, or space vehicles, as well as by collecting and analyzing information on reproduction of forests from sources (State Forest Register, statistical information and reporting in the field of forestry, the state inventory of forests data, state forest pathology data monitoring, forest plans of the Russian Federation entities, forest regulations forest areas (parks), the design documentation for the reproduction and development of forests).

Monitoring the reproduction of forests by conducting special surveys using aircraft or space vehicles (hereinafter - the remote monitoring) include aerospace, aviation photography and aerovisual survey.

The remote monitoring is used for:

- assessment of changes of the area of land occupied by forests(including those due to natural overgrowing with forest vegetation);
- identification of land not occupied by forests and require reforestation, including as a result of negative impacts on forests (droughts, fires, flooding, windfalls, damage by pests and other natural and human factors);
- assessment of forestry characteristics for reproduction of forests.

Monitoring the reforestation with using ground assets is implemented to assess the characteristics used in the reproduction of forests, seeds of forest plants and planting material of forest plants (seedlings). They are carried out on transport and available land areas, in respect of which there is no relevant information, and in case, if the information obtained from remote monitoring for reforestation, do not allow to carry out the assessment of forest stand characteristics in the reproduction of forests, or the assessment of the characteristics used in the reproduction of forests, seeds of forest plants and planting material of forest plants.

While conducting special surveys to assess the characteristics of forest stands in reproduction of forests in order to clarify the causes of the inadequate (including health) state of artificial plantations are being taken measures of assessment the volume and quality of outputs of creation and care for such plantations, assessing the state of the soil, as well as research the origin of the used seed and planting material, including genetic methods.

The result of monitoring is the analytical information (data, scheme, thematic forest, as well as digital, maps) in the form of annual report on the monitoring of reproduction of forests in the Russian Federation, analytical information about forest plantations indicators in forest reproduction and annual forecast of changes in their status, as well as analytical information on the subjects of the Russian Federation about the activities in the field of forest seed.

2. Forest fire danger and forest fires monitoring (art. 53.2 of the Forest Code of the Russian Federation).

The purpose of this monitoring is:

- concurrent detection and effective extinguishment of forest fires;

- forest fire trainings, fire-fighting machinery and equipment maneuvering in accordance with the inter-regional plan of maneuvering.

The objective of forest fire danger and forest fires monitoring is prediction and evaluation forest fire danger and the development of forest fires, the detection and registration of forest fires, monitoring their progress, the forest fire danger forest fires control.

Forest fire danger and forest fires monitoring includes:

- observation over forest fire danger and forest fires
- the organization of the system of detection and tracking of forest fires, monitoring system of their development with the use of ground, air, or space vehicles;
- the organization of forest patrols;
- forest fire messages acceptance and accounting, and also population and fire department warning about forest fire danger and forest fires by specialized monitoring service.

In the implementation of forest fire danger and forest fires monitoring are held:

- visual observations (ground patrols),
-meteorological observation in order to obtain information about fire hazard class,
- observation with the use of early detection system (fire tower, camera, thermal camera and others).

3. Forest health monitoring (art. 56 of the Forest Code of the Russian Federation).

The purpose of forest health monitoring is timely detection, assessment and forecast of changes in forest health status for management in the field of protection of forests from pests.

The main tasks are the timely detection of the poor state of forests and identifying the causes of damage (lesion), the weakening and forest destruction, development forecast of pathological processes and phenomena in the forests, as well as the assessment of their possible consequences.

Methods of implementing state forest health monitoring are:

- regular ground observations of sanitary and forest health state;
- selective monitoring of pest populations;
- remote sensing observations of sanitary and forest health state;
- selective ground observations of sanitary and forest health state;
- pest harborage area inventory;
- expeditionary survey;
- assessment of sanitary and forest health state.

As a result of conducting forest health monitoring are prepared:

- register of weakened, damaged and dead forest areas in the context of forestry and forest parks (monthly);
- register of forest areas, on which are recommended measures for the protection of forests in the context of forestry and forest parks (monthly);
- register of pest harborage area, classified as quarantine (quarterly);
- forecast of forest health and sanitary state of the Russian Federation (twice a year);
- plan of action for the localization and liquidation of pest harborage area (each year before 1 November of the current year) ;
- overview of the forest health and sanitary status of the Russian Federation subjects, and in Russia in general (annually before 1 May of the following year).

Within the forest health monitoring are held:

- regular ground observations (at least 30 main species of trees on a permanent observation point) on a selective basis;
- assessment of population-based indicators on model objects (trees, branches, litter)of a permanent observation point;
- monitoring the number of insect populations - forest pests in the harborage area;
- by eye forest pathology taxation with enumeration on the routes and temporary sample plots;

- expeditionary observation with the length of the route: solid - 16 km per 100 ha, sample - 1,000 km on 1 million ha.

4. Forest radiation situation monitoring (art. 58 of the Forest Code of the Russian Federation).

Forest radiation situation monitoring is aimed at the implementation of forest protection from contamination by radioactive substances. Their tasks include:

- establishing and clarifying zones of radioactive contamination;
- radiation control of forest resources;
- creation conditions for safety using of forest land contaminated areas based on radiation monitoring of forest resources;
-development of preventive and rehabilitation activities in the areas of forest radioactive contamination.

In monitoring the radiation situation in forests are performed:

- regular ground observations at stationary sites (1-hectare area) on a selective basis;
- quarterly survey with selection collective soil samples (5 cores soil samples);
- sampling of timber and non-timber forest resources in forest areas.

In the Russian Federation, there are 4-level management of forest monitoring: global, federal, regional and local.

At the global level, or worldwide, forest monitoring are included in the system of international relations, under the responsibility of the Russian Government.

At the federal level, the Federal Forestry Agency is responsible for carrying out forest healthy monitoring and monitoring of the radiation situation in forests on forest land, in all the forests of the Russian Federation - remote monitoring of the use of forests within the state forest inventory. On the lands of specially protected natural territories, and defense and security lands responsible for carrying out forest monitoring (except remote monitoring of the use of forests) are respectively the Ministry of Natural Resources of Russia and the Russian Ministry of Defense.

At the regional level, forest fire danger and forest fires monitoring is held by the Russian Federation subjects and forestry departments in the federal districts provide assistance in carrying out works on forest monitoring.

At the local level, forest health and forest radiation monitoring is held by affiliated organizations of Federal State-Funded Institution "Roslesozashchita" with accredited radiologic laboratory, remote forest monitoring - Federal State-Funded Institution"Roslesinforg" (based on the results of tender procedures), forest fire danger and forest fires monitoring - specialized agencies of the Russian Federation subjects.

Each type of forest monitoring is characterized by its zoning plans.

For conducting the forest fire danger and forest fires monitoring allocate patrol zone son land, air and two-space levels and classes of natural forest fire risks (total - 5) and classes of fire danger in forests, depending on weather conditions (total - 5).

In providing forest health monitoring is provided zoning on weak, average and strong threats of forest pathology, forest and forest protection areas, also stratification of forests for carrying out ground works is held.

Forest radiation monitoring is carried out with taking into account geo referencing of the objects of accidents (Chernobyl NPP accident, "Kyshtym" accident, nuclear testing site at the Semipalatinsk Polygon, zone of radioactive contamination on soil contamination density by cesium-137 and strontium-90.

The methods and amount of work for conducting the forest monitoring vary with account of problems solved at the same time.

In performing forest monitoring, taking into account significant amount of work, is widely used space-based information with different spatial resolution images. Thus, in

performing forest fire danger and forest fires monitoring for the forest fire detection with fixation thermo-spots are used space images with a resolution of less than 100 m.

To define smokiness from the forest fires zones are usedspace images with a resolution of50 - 100 m, to clarify the burned area, for assessing the damage passed by fire forest plantations - with a resolution of 10-30 m.

In performing forest monitoring depending on areas availability are used space images with a resolution of 2 to 60 m, for remote monitoring of forest use – not less than 5 m.

The great value in the forest monitoring work methods has space information on a specific territory incoming periodicity, which varies from several times a day –if detected forest fires (forest fire danger and forest fires monitoring) to once a year - if detected illegal felling (remote monitoring of forest use). In performing forest fire danger and forest fires monitoring and forest health monitoring aerial work are done. Therefore, air-forest pathology taxation carried out from a height of 400 – 500 m with fly length of 1000-2500 km per 1 million ha of the covered area.

Ground methods of forest monitoring includes observations at permanent monitoring stations, plots, look-out towers, routes; expeditionary surveys; sampling; counts the number of insect pests.

In accordance with given tasks forest monitoring output documentation also has its own specifics. The forest monitoring output documents are reports, surveys, forecasts, estimates, various forms, statements, registration cards, maps.

The aim of the state forest monitoring system is functioning of interconnected forest monitoring system as part of the state environmental monitoring for the operational support of various levels of government management of comprehensive relevant information about the state of forests.

Operating scenario of state forest monitoring includes the following steps: source data acquisition (materials of forest management, the state forest inventory, remote sensing, government and industry statistical reports, the state forest ledger), routine observation, data acquisition, data maintenance, consolidation and analysis of information, the assessment of the actual state and prediction of changes, proposals (recommendations) on the prevention of negative impacts.

Final state forest monitoring results come in a unified forestry action data automation for consolidated managerial decision-making, planning and organization of work, evaluation the effectiveness of implemented activities. In addition, based on it will be held the preparation of an annual report of the forest state by the subject of the Russian Federation and in the whole of the Russian Federation.

For reference: In 2015, it was first held state reforestation monitoring in the Russian Federation. To conduct the state reforestation monitoring was requested to the Russian Center for Forest Protection (Federal State-Funded Institution "Rosleszaschita"). Monitoring is carried out in several directions. Experts analyzed the dynamics of change in the area of land occupied by forests. Monitoring data showed a decrease in the area occupied by forest plantations of 0.5 million hectares.

The Republic of Poland.

Grounding the choice of the country

The Republic of Poland is one of the leaders in Europe in terms of forests – 29,4% of the total area of the country, which is 9,1 million ha, most of them – 7,6 million ha is state-owned. The predominant species are pine - 64.3%, which is the result of industrial demand for wood of this breed. The average age of trees is 60 years.

The high percentage of forestland, the predominance of conifers causes the selection of the Republic of Poland to study the experience of conducting forest monitoring.

Forest monitoring

The main organizers of the forest monitoring in the Republic of Poland are:

- General Directorate of the Forests.
- Department of Forestry and Environment of the Minister of Environmental Protection, Natural Resources and Forestry.
- Main Inspectorate of Environmental Protection.
- The National Fund of Environmental Protection and Water Management.

The main principals are:

- Scientific-Research Institute of Forestry.

The international cooperation:

- ICP-Forest (International Coordination Centre), Germany.

The goals and objectives

- Determination of spatial differentiation of forest health.
- Monitoring changes in in the state of forest health in time.
- The analysis of cause-effect relationships between forest health and the biotic and abiotic environmental factors.
- Development of short-term forecasts of changes in the state of forest health.
- To gather information about the status of forests used in the development of forest policy and environmental policy.
- To fulfil obligations of the Convention on Long-range Transboundary Air Pollution, Biodiversity Convention and the resolution of the Pan-European Ministerial Conference on the Protection of Forests in Europe.
- To provide information for government, public and administrative units of the State Forests.

Methods of monitoring

Ongoing monitoring in the areas of the first order.

Observation and measurement are carried out once a year. The object of observation are the morphological features of trees at the permanent sample plots:

- defoliation;
- dechromation;
- the number of needles;
- the size of the leaves or needles;
- growth;
- the intensity of seeding;
- the intensity of flowering;
- type of crown thinning;
- the proportion of dead branches.

Dendrometric measurement:

- measurement of the diameter at breast height of trees thicker than 7 cm.

The identify symptoms of damage, their situation, extent and causes:

- a description of the symptoms of damage, their location with a precise indication of possible causes of damage;

-classification of the damage and its location in the crown, based on the code system.

Ongoing monitoring in the areas of second-order.

Periodic measurements:

- analysis of the chemical composition of pine needles or leaves (every 4 years);
- assessment of species diversity of undergrowth (every 5 years);
- measurement of thickness and volume growth of forest stands (every 5 years).

Non-periodic measurement:

- Investigations of soil - chemical properties of the soil typology, grain composition, physical properties.

Ongoing monitoring on intensive monitoring plots.

Measurements on a monthly basis:

- quantitative and qualitative study of precipitation;
- quantitative and qualitative study of the soil;
- quantitative and qualitative research on the outdoor rain;
- a study of air quality of SO 2, NO 2.

Continuous measurement:

-measurement of meteorological parameters;

On growth plot health tree condition is being evaluated on the basis of several morphological features of the crown. Particular attention is paid to the assessment of defoliation and discoloration of leaves or needles, which is held at 5% of the trees. At 5% of the samples re-evaluated defoliation is carried out by experts. The collected results are used to compare the conformity assessment of defoliation made by the experts and the control group.

The results of defoliation and dechromation assessment are combined and classified:

- Class 0 - 0 to 10% • - no defoliation;
- Class 1 - from 11 to 25% - light defoliation (warning level);
- Class 2 - from 26 to 60% - the average defoliation;
- Class 3 - over 60% - a strong defoliation;
- Class 4 - adeadtree.

Also, evaluation is divided into groups of classes: Classes 1-3, 2-3, 2-4, 3-4. This separation is carried out in the framework of the International Co-operative Program on Assessment and Monitoring of Air Pollution Effects on Forests operating - ICP Forest.

Dechromation and defoliation evaluation results are also added and divided into equal intervals in the range of 0 to 100% with 10% accuracy.

When laying study plots, all trees should be classified according to the I-III Kraftclass. In subsequent years, some trees may change their biosocial position.

Defoliation - determined with an accuracy of 5%.

Dechromation - determined with an accuracy of 5%.

Measurement of tree diameter at breast height is carried out with an accuracy of 1 mm.

Shading crown:

- Head significantly obscured (or in physical contact) on one side;
- Head significantly obscured (or in physical contact) from both sides;
- Head significantly obscured (or in physical contact) on three sides;
- Head is much obscured (or in physical contact) with four sides;
- Head free of shading.

Visibility of head is measured at 6-point scale: full visibility of the head, the head partially visible, a large part of the head is visible, the lower part of the head is visible, visible contour head and head are invisible.

The number of needles is counted by the number of needles in the middle of the head.

The length of the needles, or size of the leaves - is taken into account the nominal length of the needles, or size of the leaves in the middle of the head: is shortened or reduced, the normal state, extends or increases.

The proportions of shoot growth –growth of shoots in the upper part of the head is estimated: the main shoot growth higher than the growth of side shoots, the main shoot growth equal to the increase of lateral shoots, the main shoot growth less than the growth of side shoots.

Percentage of dead branches - upper part of the crown is estimated primarily: not dead branches, single dead branches (10%), from 11% to 50% of the dead branches, of more than 50% of the dead branches.

Surveillance Network of the first order

Surveillance network of the monitoring of national forest of I order relies on a system of large-scale forest inventory, which was founded within the framework of the European network ICP Forest.The reference point was the point with coordinates: latitude - 50 ° 15'15N, longitude - 09 ° 47'06 "E, starting from which the accounting items were laid out in a network of 16 km x 16 km. This network for national forest monitoring has been sealed to 8 × 8 km, besides large-scale network forest inventory at a density of 4 x 4 km is laid.

At each point in the network inventory are installed L-shaped routes (paths) in which every 200 meters five test areas are laid out (Figure 5.5.). Numbering of plots within the route (1, 2, 3, 4, 5) is locked, remain unchanged even when one or more sites of the route is beyond the forest. In each of the distributed network paths 8 x 8 km established one of the forest monitoring points.

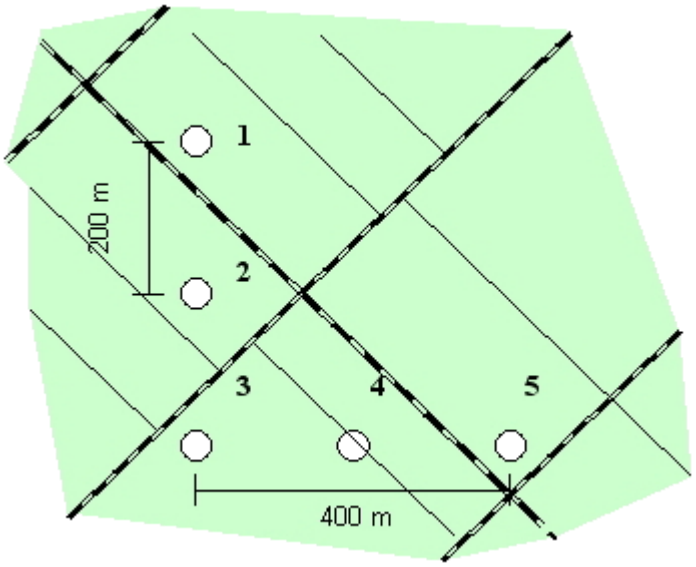

Figure 5.5. The numbering of plots within the tract

These items are suitable for measurement only if their focus is on the territory included in the land register as forest area and lands for reforestation or relating to the natural heritage. If it turns out that the location of the plots in the planning was considered on the lands of the forest fund and the actual location was outside the forest, on the site is not carried out any measurement. If the central region falls on non-forest lands, forest-monitoring item is set in one of the remaining test points of a route designed for inventory purposes, falling on forested land. The point is selected from the first point satisfying the following order: # 2, # 4, # 1, # 5. Location of observation points will be constant. (even in the future, when the central point will occupy the forest land). At the site select 20 ruling trees (I-III classes of Kraft classification), growing close to the center. The site, with the planting of 20 years, is an active platform on which observations are conducted. The site, which falls in the I forest stand age class and in forestlands not covered by forest, etc. are called the waiting area, where the measurement will take place after the age of 21 years old. In the network of 16 x 16 km there are 586 sites and in the network of 8 x 8 km - 2200. Paragraphs surveillance are identified on the basis of geographical coordinates and the observed trees are determined by measuring the distance and bearing from the center of the site.

Surveillance Network of the second order

148 permanent observation points of the II order were established in stands of pine and spruce at the age of 50-60 years old, oak and birch trees at the age of 70-90 years for two in 56 of the 59 forest growing regions of Poland. In some areas with large forest growing, was established 3 points. On accounting points of the second order are observed about 400-450 trees, on the site like a square or rectangle with the known length of the sides and angles of a quadrilateral, which allow us to determine its size.

Ongoing monitoring on intensive monitoring plots

Ongoing monitoring on intensive monitoring plotsare the link between forest monitoring system for integrated environmental monitoring and supervision for the purpose of research and development programs aimed at the analysis of the functioning of forest ecosystems to changes in environmental conditions. In total, there are 12 observation points of intensive monitoring, which are located in nature reserves and protected areas of Poland.

b. Analysis of the main achievements of the international best practices in the field of monitoring (technology, methods, techniques).

In the Czech Republic forest health monitoring is conducted on a pan-European network ICP Forest on permanent sample plots located over the systematic network of 16 x 16 km, as well as some parts of the network 8 x 8 km.

Forest ecosystem monitoring programs are currently financed from the provided by the Ministry of Agriculture and some of the activities are financed by the Ministry of Environment.

National Forest Inventory can be considered as an integral part of the forest monitoring in the Czech Republic. It is a statistical method used to describe the characteristics of the forest. The main principle of the inventory is repeated studies that are carried out on specialized study plots. The main purpose of the inventory is to collect accurate data on forest plantations.

The status of forests monitoring, monitoring of harmful substances in forest ecosystems, forest health monitoring exercise State Research Institute for Forestry and Hunting (**Forestry and Game Management Research Institute**).Given that the assessment of wood and planting state made on a subjective evaluation of the specialist performing the surveillance data to provide an identical approach to the visual definition of performance evaluation conducted by a team of experts that is constantly performing this work.

State Forest Inventory Enterprise "Brandysnad Labem» (**Ústav pro hospodářskou úpravu lesů Brandýs nad Labem**) conducts National Forest Inventory from the funds financed by the Ministry of Agriculture of the Czech Republic.

Carrying out forest monitoring at a systematic network in parallel with the National Forest Inventory is a good method to obtain reliable information on the state of forests and their characteristics. Funding of the work carried out by the state provides accurate data at the national level.

The advantage of the Finnish forest monitoring system is the possibility of a significant amount of inventory of forest owners, ownership of which is small area and presented in a groups of allotment of complex geometric shapes, and a relatively small inventory repetition interval, which is five years.

At the same time the emergence and spread of forest pests and diseases monitoring is held annually based on the results of notification of forest damage provided by the Forest Centre, Forest Service and Forest associations. National inventory is held by the State Forest Research Institute «Metla», which is subordinate to the Ministry of Agriculture and Forestry of Finland.

The drawback of forest monitoring system is relatively high cost of the work. According to expert estimates of Russian experts estimated cost of works on the national inventory of forests in Finland is about $ 6 per 1 ha.

Forest monitoring in Sweden is currently being implemented under the state monitoring program, and a comprehensive assessment of national forest resources.

In the implementation of the state program is widely used the latest methods and technologies of forest inventory using satellite images, laser scanning technology, unmanned aerial vehicles. The main emphasis in the national program of forest inventory is on determination of the parameters of taxation: the total stock of trunks, trunks stock by species, age, average height, diameter, density of stands. Under the state program is conducted an inventory of trees felled by wind and windfalls from hurricanes.

State program monitoring and inventory of national forest resources in Sweden is a comprehensive program aimed at the full definition as taxation characteristics of forest stands, and the environmental and economic aspects of forest management, at the design of forest management and reforestation, as well as control of forest management activities.

Forest resources inventory system is fundamentally different from the inventory system used in the Republic of Belarus. Therefore, to borrow some aspects of a comprehensive monitoring program and assessment of forest resources in Sweden for monitoring the forests of Belarus is very problematic, and inappropriate.

The only thing to draw attention at is a study of the experience of laser scanning inventory of individual trees felled by wind and windfalls as a result of the hurricane.

Given the huge territory of the Russian Federation in conducting forest monitoring noted a number of specific moments.

The main direction of forest monitoring in the Russian Federation is the forest reproduction monitoring, conducted to assess compliance with forest legislation with using of forest areas, to identify forest areas with the illegal use of forests and to calculate the indicative amount of damage from illegal use of forests. For these purposes, remote surveillance, including space and aviation shooting, are mainly used.

These directions are not relevant for the Republic of Belarus because of precisely built centralized governance structure of the forest management and a large number of regulatory authorities.

In the Republic of Poland forest monitoring are the following positive aspects:

Forest monitoring is carried out in accordance with the program and methods of ICP Forest, which provides the unification of the results obtained in the framework of monitoring the state of forest health, including the state of the environment in the whole Europe;

Forest monitoring is carried out by experts of scientific research institute of forestry, which provides high-quality and uniform execution of works on monitoring forest condition at the counting posts, as well as the processing and provision of the results to the interested organizations;

Monitoring points are linked to a national network of large-scale inventory of forests in Poland, which making easier to bookmark and support up to date, also allows you to link the results of the monitoring data with the results of forest inventory.

Ministry of Forestry of the Republic of Belarus
RUE "Belgosles"
Forestry Development Project of the Republic of Belarus
GEF/The World Bank TFOA 1173

Approved by
The First Deputy
Minister of Forestry
A.A.Kulik

REPORT

under the contract № BFDP/GEF/SSS/15/20-02/16 for 05.03.2016
on component 3: arrangements 3.1.1.2. and 3.1.2.2.; №02-2/15
Development of the forest monitoring system of the Republic of Belarus

Phase №6. Description of proposals to improve the monitoring system in the Republic of Belarus in order to minimize the negative impact of changing climatic conditions and economic activities on the condition of the forest fund

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Minsk 2017

Contents chart

Annotation

An effective forest protection system is functioning in Belarus, including monitoring of the state of forests and, based on its results, planning and implementing a set of preventive, protective and sanitary measures.

In this report, proposals have been made to improve the current forest monitoring system in the Republic of Belarus. Proposals are made to optimize the quantity of observations and the quantity of observation stations. Proposals have been made to improve the methods of monitoring the state of forests, providing for a differentiated approach to the scope of forest fund surveys, depending on the degree of threat to the forest damage.

The volume of the report is 10 pages and contains 2 figures and 3 tables.

Proposals to improve the methodology of the forest monitoring, providing for a more detailed monitoring of forests in those areas of the forest fund with a more significant change in the state of forests under the influence of external factors

The maintenance of the state forest cadastre, based on the forest management materials, combined with the timely introduction of current changes in the forest fund, provides information on:

- forest resources - wood and non-timber;
- forest owners;
- categories of forests and land types;
- restoration and cultivation of forests;
- forest biodiversity.

The maintenance of the state forest cadastre provides up-to-date information both the lower consumer grade (forestry establishments, corporate bodies) and the highest one - forest statistics at the state level. At the same time, maintaining the state forest cadastre does not allow to obtain up-to-date information on the sanitary and forest pathology state of forests and the forecast of its changes. To solve this problem, forest monitoring is conducted.

Taking into account the economic and ecological features of the republic, the most optimal system, in our opinion, is the two-level forest monitoring system, which provides not only timely detection of negative processes affecting forests, but also planning and implementation of effective environmental and forest protection measures.

The first level of monitoring is a one-time annual survey of trial plots that are evenly spaced in the forest fund. The purpose of the first - level monitoring is to obtain generalized data on the health status of the forests (forest vitality), to identify the negative factors affecting forests, to predict their changes at existing levels of exploitation and of the impact of anthropogenic and natural factors. Since the first level of monitoring is performed by a statistical method, at least two technological conditions need to be met in order to obtain sufficiently accurate data. The first is the randomness of the sample, which is provided by placing trial plots on the accepted regular network. Regular networks of trial plots are the simplest and most understandable way to organize the selection of 'model' trees with a relatively large area according to strict and unambiguous rules. The use of regular networks is analogous to the widely used in taxation mechanical selection of trees to the sample (for example, every 5th tree in the studied plantation is selected), which provides random sampling with sufficient accuracy. The second is the minimum sample size required to obtain accurate results. In a simplified form, it is expressed in the area of forests per one trial plot in order to ensure an acceptable accuracy of the identification of indicators. Fulfillment of these conditions will make it possible to consider the sample as representative, and the findings on the state of forests in the given territory will be statistically justified.

Maintenance of the first level of monitoring is ensured by the state of forests monitoring. Monitoring of the state of forests is carried out by examining plantations on permanent test plots (observation points) located on a regular network. The location of the observation points surveyed in 2016 and the predominant tree species are shown in Figure 6.1.

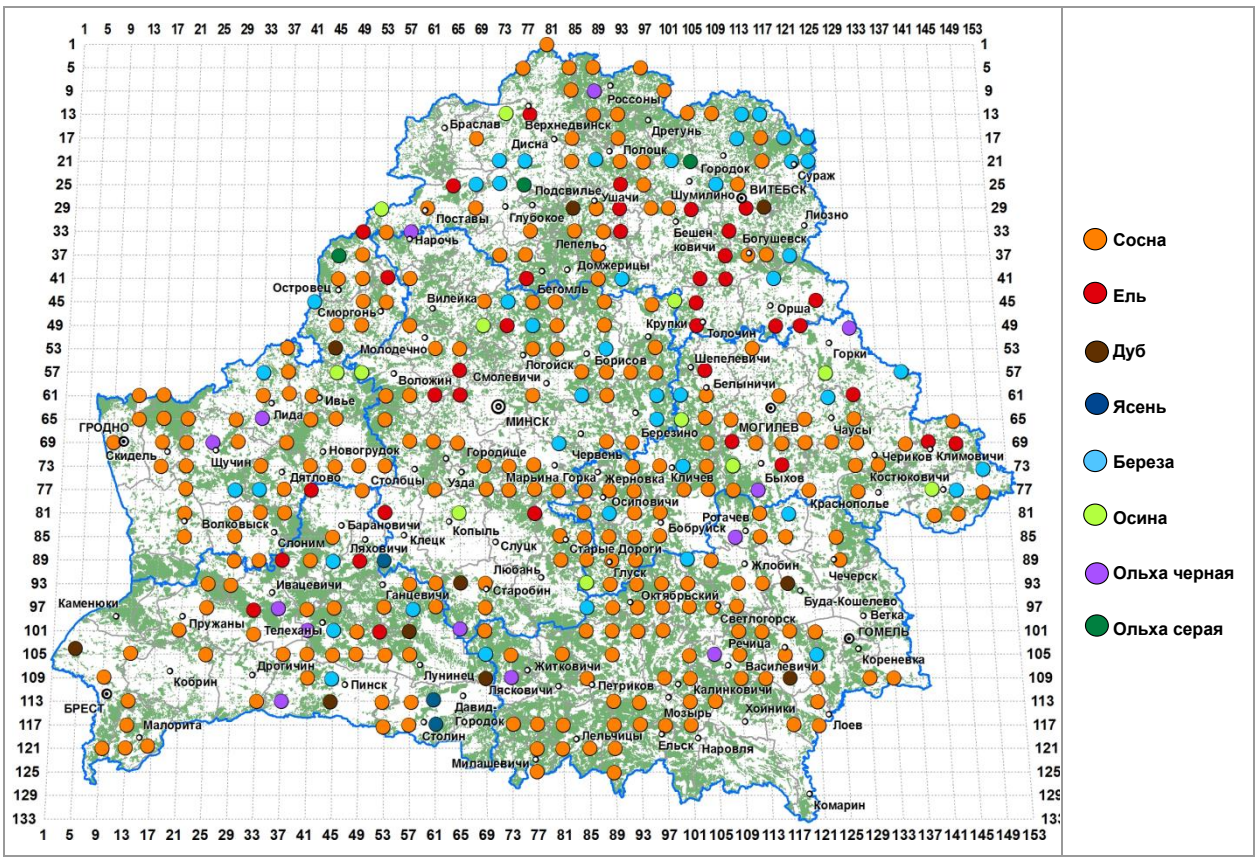

Figure 6.1. Observation points surveyed in 2016 and the predominant tree species

Monitoring is carried out on the basis of the I level technology of monitoring according to the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests. (ICP Forests). The determination of the condition of the surveyed plantations is based on the use of the bioindication method, which takes into account the morphological changes in the trees. The most important visual signs of damage to trees are the density and color of the crown, the presence and proportion of shrunken branches in the crown, the state of the cortex. Based on these indicators is determined the life condition of trees. For early detection of negative factors, affecting forests, in addition to bioindication signs of tree conditions, visible damage to trees by various factors (agents) and the extent of the damage to various parts of the tree are determined.

The second level of monitoring is a permanent survey of the forest fund in order to identify areas of forests that are drying up under the influence of natural and anthropogenic factors, identify locus of harmful and dangerous diseases, monitor their development and distribution, evaluate and predict pathological processes. On the basis of these data, it is necessary to justify and develop an economic and ecological system of forest protection measures, including preventive (organization and technical, forestry, sanitary) and active protective and exterminating measures.

Maintenance of the second level of monitoring is provided by forest health monitoring. The forest health monitoring is complex. It represents a system for the state of forests monitoring and making decisions on the planning and implementation of effective forest protection and forestry measures.

Observation points of the forest health monitoring are the forest fund of legal entities, leading forestry. The location of observation points (legal entities leading forestry) is shown in Figure 6.2.

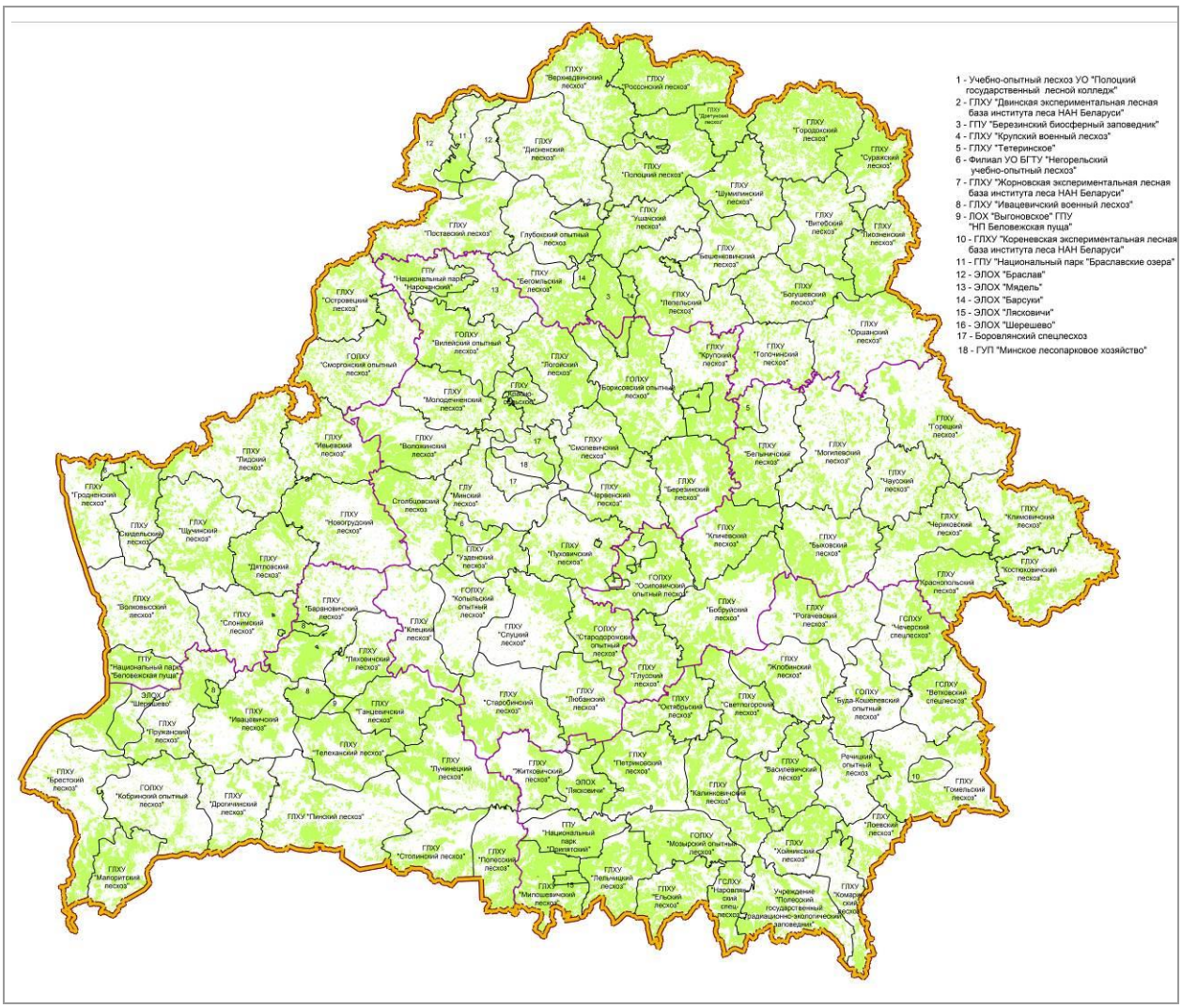

Figure 6.2. Observation points of the forest health monitoring

Forest health monitoring is carried out by:

- general visual control to identify signs of pest and disease outbreaks, of the sanitary conditions of forests, other objects;

- reconnaissance control in the areas of plantations specific to the occurrence of outbreaks, with annual observations of the occurrence, spread of pests and an ocular assessment of the number of pests and damage to plantations;

- detailed control at the permanent points of registration, fixed-route passageways with permanent points of registration on them (route-ecological method of control), at the permanent trial areas, which are used to keep detailed records of the number of pests and diseases of forests, long-term observations of variations of the sanitary and forest pathological condition of plantations;

- pheromone control of harmful insects, allowing to identify the pest outbreaks at an early stage of their formation;

- forest pathology research of the forest fund that allow to identify and take into account focus of pests and diseases, other pathological damage of the forest and establish the causes of their damage.

In places where pathogenic factors are concentrated should be envisaged more detailed monitoring of forests. The primary objects of observation during the second level of monitoring should be forests in the zones of technogenic pollution affected by natural disasters, fires, harmful insects, diseases and other unfavorable factors.

Proposals to optimize the quantity of observations

According to the results of the questionnaire survey, the smallest number of respondents was in favor of conducting ecological and meliorative monitoring of meliorated forest lands. This is explained by the fact that large-scale drainage of the forest land in the Republic of Belarus was carried out mainly during the period from 1966 to 1990. Currently, in the forest fund, the area covered by the forests of meliorated land is 236.5 thousand hectares. Due to the length of the melioration, the process of adapting forests to the changing conditions of growing on these lands has basically been completed. The selection of the most stable individuals and breeds took place on the meliorated lands, as well as the structural adjustment of the communities was made. As a consequence, the condition of the standing trees on these lands has stabilized. In connection with the stabilization of the state of plantations on meliorated lands, and also taking into account the economic condition of the republic, it is not proposed to carry out ecological and meliorative monitoring of reclaimed forest lands.

When monitoring the state of forests, observation points are inspected once a year. If the periodicity of surveys is reduced to once in two years or more, it is impossible to find out in advance the negative factors affecting the forests. In this case, it will be possible only to determine the actual sanitary condition of the forests at the time of the surveys, that is, it will be impossible to achieve the very purpose of this type of monitoring.

In order to optimize the number of observations, it is suggested not to conduct observations on specially equipped test plots (ICP Forests II level monitoring) during the state of forests monitoring. Taking into account the economic peculiarities of the republic, a substantial amount of funding is needed to carry out these works, but no budgetary financing is provided for the implementation of these works until 2020.

When conducting the forest health monitoring, the number of observations for each legal entity leading forestry should be based on the distribution of the forest fund in zones of forest pathology threat, in accordance with the forest pathology zoning of the Republic of Belarus. Thus, in the forest health monitoring, the optimization of the number of observations can be achieved by reducing the amount of observations in relatively safe areas of the forest fund.

Proposals to optimize the quantity of observation stations

Since 1987, the Republic of Belarus is a party to the UN Convention on Long-Range Transboundary Air Pollution (CLRTAP) and within its framework – the participant in the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests. (ICP Forest). For conducting the international forest monitoring in 1989, a pan-European bio-indicator grid with vertical and horizontal lines located 16 km *(with a cell size of 16 × 16 km)* was broken up throughout the country. The appearance of a raster grid with a cell size of 16 × 16 km is shown in Figure 6.1. In 1990, observation points were laid on forest lands at the intersections of the lines of this grid. In subsequent years *(from 1991 to 2011)*, an additional laying of observation points on a 16 × 16 km grid was carried out, as well as to obtain more accurate information on the state of Belarus' forests, the observation points were placed on a national raster grid with a cell size of 8 × 8 and 4 × 4 km. The number of observation points laid on the pan-European grid of 16 × 16 km, in the context of the years of the tabulation, is given in Table 6.1.

Table 6.1

Establishment of the observation points on a pan-European raster grid

Year of establishment	1990	1991	1992	1993	1995	1998	2000	2009	2010	2011	Total
Number of points, pcs	402	2	1	2	14	5	1	3	4	9	443

In 2011, the total number of established observation points on the pan-European and national grid was 1,522 points. In connection with the natural growth of forests, part of the mature plantings was cut down for logging, part of the plantations was died from the impact of unfavorable climatic factors, as a result, in 2016, there were 1415 points of observation. The number of points of observation laid and existing in 2016 in the context of the establishment networks is given in Table 6.2.

Table 6.2

Distribution of observation points by establishment networks

Network of observation points	Established, p	Died, p	Existed, p
pan-European (*16x16 км*)	443	42	401
national (*8x8 км*)	592	37	555
national (*4x4 км*)	487	28	459
Total	1522	107	1415

According to the results of a survey of plantations at observation points, it is established that the forests on the territory of the republic are sufficiently resistant to the effects of unfavorable environmental factors. In addition, the survey of points located on the pan-European grid provides an acceptable accuracy in determining the indicators of the forest state. Survey on this raster grid allows to provide objective conclusions about development of the plantations under investigation, their damage in time *(during the observation period)* and in space - on the territory of the republic or the region.

In order to optimize the number of observation points, while conducting state forest montoring it is suggested to monitor only at points located on a pan-European grid.

On the national network of observation points (8 × 8 km and 4 × 4 km), it is necessary to conduct observations, if necessary, on the state of timber species that are unstable to changing climatic conditions. In particular, degradation of the ashen forests is observed on the territory of the republic. Estimated ash is affected mainly by necrosis of branches. The drying up of the branches of an ash tree is caused by a dangerous infectious disease, which is called the flat-headed growth or halaric necrosis. A significant proportion of trees affected by halaric necrosis is associated with the susceptibility of the common ash to the invasive fungus *Hymenoscyphus fraxineus*. Halaric necrosis usually develops in conjunction with root damage with armillariasis (honey fungus), which leads to rapid death of trees. Since the proportion of ash forests in the forest composition of the republic is small, only 0.3%, then observations of their condition should be carried out on the entire existing network of observation points.

Proposals to facilitate the methodology of observations and technology on the forest fund plots, which are less susceptible to the influence of external and internal factors and for which the dynamics of changes in the state of forests is negligible

Belarus has an integrated forest protection system, including forest healthy monitoring and a set of preventive, protective and sanitary measures. However, while conducting forest health monitoring are not fully taken into account occurrence of locus of pests and forest diseases, the degree of their damage, the volume of death of stands, the extent of forest protection measures carried out in the outbreaks, the trends and forecasts of the spread of pests and forest diseases. In particular, in carrying out all types of forest health surveillance is not observed a differentiated approach to observations, depending on the degree of threat to forest damage. All types of forest health surveillances, as a rule, are conducted throughout the forest fund of the republic for all pests and diseases of the forest. Such an approach substantially increases the labor input for conducting forest health monitoring, significantly reduces the effectiveness of the measures taken to identify, calculate and assess the impact of the most

important natural and anthropogenic factors on the viability and productivity of the forest plantations.

Possibilities of mass reproduction and intensity of impact on forests of harmful pathological organisms are determined by a complex of natural and climatic factors that directly or indirectly affect the forest pathological and sanitary state of forests. In this regard, forest health surveillance in different regions of the country is economically expedient to implement differentially, taking into account the degree of threat to damage to forests by harmful organisms. The assignment of forest fund plots to zones of forest pathological threat for each type of pest or disease should be carried out in accordance with the forest pathological zoning of the Republic of Belarus.

The recommended number of reconnaissance, detailed and pheromone surveillance for species of pests and diseases, depending on the zones of forest pathological threat, is given in Table 6.3.

For reference: The work on forest pathological zoning of the forest fund of Belarus was carried out by a group of specialists from the State Institution "Bellesozaschita" in 2014-2016. The allocation of forest pathological areas was carried out within the boundaries of forest fund plots of legal entities, forestry or their groups. A total of 90 forest pathological areas of prevalence and harmfulness of forest pests and diseases for Belarus have been identified and characterized. The most widespread and harmful species of forest pests and diseases, capable of causing outbreaks of mass reproduction and causing economically perceptible damage, were the objects of forest pathological zoning. Subsequently, the objects of forest pathological zoning can changed in one direction or another depending on the newly emerged quarantine species of pests and pathogens or the termination of observations of zoned species for one reason or another.

Table 6.3

Regulations for forest pathology research, depending on the zones of forest pathological threat

<table>
<tr><th rowspan="2">№</th><th rowspan="2">Threat zone</th><th colspan="3">Types of supervision</th></tr>
<tr><th>reconnaissance</th><th>detailed</th><th>pheromone</th></tr>
<tr><td>1</td><td>strong</td><td>It is carried out in each forestry department, where locus of a pest or disease of the forest are marked, but not less than 6 plots on the territory of a legal forest entity that leads forestry</td><td rowspan="3">Detailed surveillance of pests and diseases is carried out on the existing network of detailed supervision: permanent trial plots, permanent routings, permanent counting points and detailed surveys of locus</td><td>At least 3 traps in the forest area, in which pest outbreaks are noted, but not less than 9 traps on the territory of the legal entity that leads the forestry</td></tr>
<tr><td>2</td><td>average</td><td>It is carried out in each forestry department, where locus of a pest or disease of the forest are marked, but not less than 3 plots on the territory of a legal entity that leads forestry</td></tr>
<tr><td>3</td><td>weak</td><td>There are at least 3 sites in the territory of the legal entity that are conducting forestry</td><td>Establish at least 9 traps on the territory of the legal entity that leads the forestry</td></tr>
<tr><td>4</td><td>minimal</td><td colspan="3">Reconnaissance, detailed and pheromone surveillance are conducted when detecting locus.</td></tr>
</table>

Conducting of the forest health monitoring with considering forest pathological zoning, allow all types of surveillance to be carried out in accordance with the needs of specific regions and observing objects located on their territory. It will make it possible to monitor the state of populations of harmful forest organisms that are most threatening for a particular region, and to organize their identification at an early stage of the emergence of locus of mass reproduction. As a result, will be created conditions for the possibility of limiting economic damage from the vital activity of harmful forest organisms on a minimal area, preventing their possible spreading in significant areas

The differentiated regime of conducting forest health surveillance will allow optimizing the costs of collecting and analyzing the necessary amount of information for assessing the status of populations of harmful organisms.

When conducting forest health monitoring, it is also necessary to envisage a new type of forest health surveillance - supervision of quarantine species. Carrying out this type of supervision will help to protect the forest fund from the invasion of alien species of pests.

The supervision of quarantine species is confirmed by the single quarantine phytosanitary requirements of the Eurasian Economic Union. The implementation of measures to identify the quarantine objects and fight against them on the territory of the Union is the responsibility of the partner countries.

The Ministry of Forestry of the Republic of Belarus
RUE «BELGOSLES»
Forestry Development Project of the Republic of Belarus
GEF/WORLD BANK TFOA 1173

REPORT

under the contract № BFDP/GEF/SSS/15/20-02/16 for 05.03.2016
on component 3: arrangements 3.1.1.2. and 3.1.2.2.; №02-2/15
Development of the forest monitoring system of the Republic of Belarus

Stage №7. The proposals for improving the regulatory legal and technical framework for forest monitoring

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Minsk 2017

Annotation

Forest monitoring in the National environmental monitoring system in the Republic of Belarus is defined in article 97 of the Forestry code of the Republic of Belarus. Forest monitoring of Belarus is carried out in accordance with the Regulation «On the procedure of forest monitoring and use of data» and other legal regulations.

This report contains proposals to improve the regulatory legal for forest monitoring forest monitoring of the Republic of Belarus, proposals to improve and technical framework for forest pathology monitoring and forest health monitoring.

The report consists of 6 pages and contains 1 figure, 1 table.

The proposals for improving the regulatory legal and technical framework for forest monitoring.

One possible way of effective functioning of forest monitoring is improving the existing system of forest monitoring.

To evaluate the health of forests on reclaimed lands in the country since from 1999 began to be monitoring of reclaimed forest lands. Regular observations were made to assess the statusmelioration systems, evaluation and forecast of changes of forest conditions depending on the parameters of the drainage network and the duration of drainage, development of recommendations for executing forest management activities. For monitoring, based on the geobotanical subzones and forest counties, was laid down 13 observation points. In the Republic was organized by local monitoring the condition of forests on reclaimed forest lands.

Large-scale draining of forest lands was carried out mainly in the period from 1966 to 1990 and now the process of adaptation of forests to changing conditions of growth on these lands was completed. The selection of the most resistant wood species occurred on the reclaimed lands and therefore there was a restructuring of forest communities. As a result, the health of the forest planting on these lands has stabilized. In connection with the stable health of forests on drained lands, it is proposed not to carry out monitoring of reclaimed forest lands.

In this case, forest monitoring of the Republic of Belarus can be represented as follows (figure 7.1):

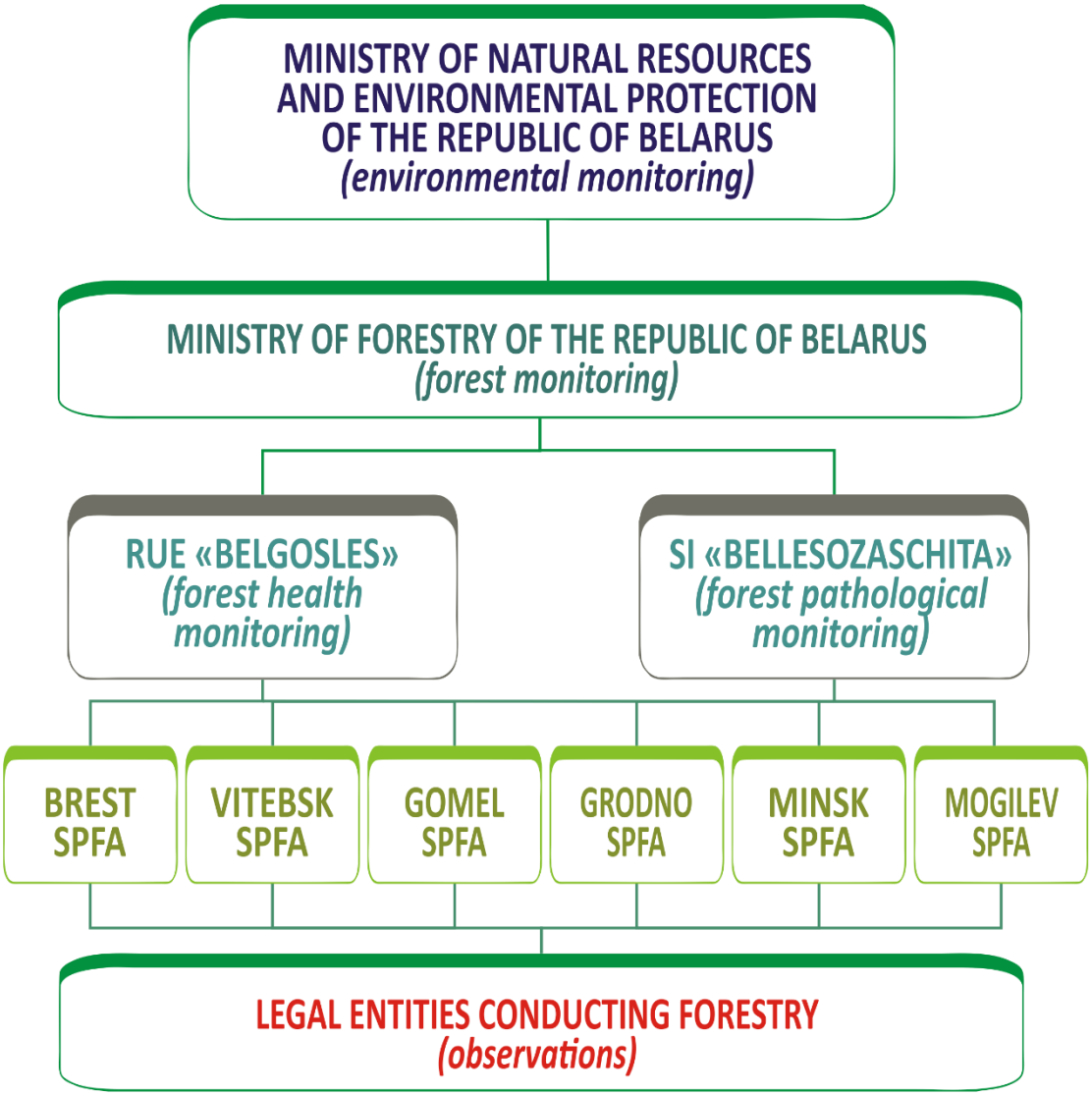

Figure 7.1. The structure of the forest monitoring system as a part of the National environmental monitoring system (SPFA – state production forestry association).

More efficient forest monitoring and reduce monitoring costs can also be achieved by making changes in the organization of monitoring and methodology of work.

The procedure of forest monitoring and its particular types is regulated by legal regulations and technical normative legal acts of the Republic of Belarus. A list of these legislative acts and legal regulations, which should be modified, shown in table 7.1.

Table 7.1. The list of legal regulations and technical normative legal acts, which define the procedure of forest monitoring

№	Legal regulation, technical normative legal act	Approved	Proposals
1	Forest code of the Republic of Belarus	dated 24.12.2015 №332-З	-
2	The regulation on the National environmental monitoring system in the Republic of Belarus	Resolution of the Council of Ministers of the Republic of Belarus dated 14.07.2003 № 949	-
3	The regulation on the procedure forest monitoring as a part of the National environmental monitoring system of the Republic of Belarus and use of data	Resolution of the Council of Ministers of the Republic of Belarus dated 15.08.2007 № 1036	develop a new resolution
4	The instruction on exchange of information in the National environmental monitoring system in the Republic of Belarus	Decree of the Ministry of Natural Resources and Environmental Protection dated 28.12.2004 № 43	-
5	The instruction on the procedure of maintaining the state register of observation points of the National environmental monitoring system in the Republic of Belarus	Decree of the Ministry of Natural Resources and Environmental Protection dated 17.12.2008 № 119	-
6	The regulation on the Information and Analytical Center for Forest Monitoring of the National environmental monitoring system in the Republic of Belarus	Order of the Ministry of forestry dated 02.11.2012. № 287	to make changes
7	The technical code of common practice "The procedure for forest pathological monitoring of the forest fund"	Decree of the Ministry of forestry dated 29.07.2010 № 18	to make changes
8	The instruction on the procedure of forest monitoring	Decree of the Ministry of forestry dated 30.12.2008 № 41	cancel
9	Methodology for organizing and conducting works on the forest health monitoring in the Republic of Belarus	Order of the Ministry of forestry dated 30.12.2008 № 332	develop technical code of common practice

Note: Other regulations and technical normative legal acts in the field of forest monitoring (orders of the Ministry of Forestry and other government regulators related to forest monitoring) should bring in line with changes in the regulatory framework.

Regulations on the procedure forest monitoring as a part of the National environmental monitoring system of the Republic of Belarus and use of data (hereinafter – Regulation on forest monitoring) is one of the main acts of legislation that should be set rules of carrying out monitoring of forests in general and certain types of forest monitoring. Currently, the procedure of forest monitoring shall be prescribed by other regulatory legal acts. To resolve this discrepancy, as well as other reasons, it is proposed to develop a new Regulation on forest monitoring, which should be included the following main proposals:

– in connection with the stable health of plantings on drained lands, and also in order to optimize the costs of forest monitoring, exclude from the types of forest monitoring of reclaimed forest lands;

– identify specific specialized organizations responsible for implementing types of forest monitoring: methodical support of the work, processing and analysis of data obtained from legal entities conducting forestry, providing information on monitoring and solving other problems;

– in order to resolving the issue of forest health monitoring, determine that those responsible for their conduct and submission of primary or generalized data of monitoring are legal entities conducting forestry;

– in order to obtain information on the health of the forest fund of the appropriate quality, establish the procedure for carrying out types of forest monitoring, including periodicity and specific dates for observations and reporting of monitoring data to specialized organizations.

In order to optimize the costs of collecting and analyzing information to assess the impact of the most important natural and anthropogenic factors on the vitality and productivity of forests, it is necessary to modify the Regulation on the Information and Analytical Center for Forest Monitoring of the National Environmental Monitoring System in the Republic of Belarus.

The Information and Analytical Center for Forest Monitoring should work in the specialized State Institution for the Protection and Monitoring of Forests "Bellezoszaschita" (hereinafter - the State Institution "Bellesozaschita"). The work of the information and analytical center for forest monitoring in the State Institution "Bellezoshchita" is justified by the fact that this institution carries out the main type of forest monitoring – forest pathological monitoring. When conducting forest pathological monitoring, the health of the forest fund is constantly monitored and set of preventive, protective and sanitary measures for forest protection is planned also analytical information and statistical reporting are prepared annually.

The procedure for forest pathological monitoring is carried out in accordance with the technical code of common practice "Procedure for forest pathological monitoring of the forest fund" (hereinafter – TCP 252-2010 (02080)).

In the TCP 252-2010 (02080) it is proposed to make the following main additions:

– in order to optimize the costs of forest pathological surveillance, as well as to improve the efficiency of measures taken to protect forests from adverse environmental factors, determine the volumes of reconnaissance, detailed and pheromone surveillance, depending on zones of forest pathological threat established in accordance with forest pathological zoning of the Republic of Belarus;

– to implement the single quarantine phytosanitary requirements of the Eurasian Economic Union to prevent the penetration of alien species of pests into the territory of the Union, add a section with the methodology for conducting a new type of forest pathological surveillance – supervision of quarantine species.

The procedure for forest health monitoring is determined by the Instruction on the procedure for forest health monitoring (hereinafter - the Instruction) and the Methodology for organizing and conducting works on the forest health monitoring in the Republic of Belarus (hereinafter - the Methodology).

The main provisions of the Instruction – the regulation on forest health monitoring, are proposed to state in a new version of regulation on forest monitoring. In the new version of regulation on forest monitoring, it is also necessary to reflect the procedure for conducting a survey of plantations at observation points by legal entities conducting forestry. After the approval of this Regulation for the settlement of legal issues of monitoring, it is necessary to cancel the above Instruction.

The Forestry Republican Unitary Enterprise «Belgoles» developed the methodology for organizing and carrying out forest health monitoring in the Republic of Belarus. In order to extend the observation methodology to all organizations which carry out forest monitoring activities (legal entities conducting forestry), it is necessary to develop the technical code of

common practice “The procedure for forest monitoring” (hereinafter - TCP). After approval of this TCP, it is necessary to cancel the above Methodology.

When carrying out forest monitoring activities, it is important to obtain primary monitoring data of appropriate quality. Improve the quality of primary data of monitoring is necessary by improving the theoretical and practical skills of performers. Training performers at the Republican Center for Advanced Training of Leaders and Forestry Specialists can achieve the solution of this problem.

The application of all proposals to improve the regulatory legal and technical framework for forest monitoring of the Republic of Belarus will allow optimizing the costs of forest monitoring, improving the efficiency and quality of the information of forest health and the measures taken to protect forests. As a result, conditions will be created to reduce the economic damage from the impact on forests of adverse natural and anthropogenic factors.