MINISTRY OF FORESTRY OF THE REPUBLIC OF BELARUS
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"BELLESOZASCHITA"

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Component 3: Capacity Building for Sustainable Forest Management

Project activity 3.4.1: Improvement of methods of obtaining the information regarding the radiation situation in forests

Final report containing the information about implementation results of the "RadForInfo" information module in the three Forestry Enterprises (Vetka Special Forestry Enterprise, Gomel Forestry Enterprise, and Cherikov Forestry Enterprise), elaboration and publication of the brochure "User Guide for RadForInfo Information Module", training seminars

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Abbreviations

MoF	Ministry of Forestry of the Republic of Belarus
^{137}Cs	Cesium-137 radionuclide (half-life is 30 years)
DER	Gamma radiation dose equivalent rate (microSv/h)
Zone I	Radioactive contamination zone with soil contamination density of Cesium-137 37-185 kBq / m^2 (1-5 Ci/km^2)
Zone II	Zone of radioactive contamination with soil contamination density of Cesium-137 185-555 kBq / m^2 (5-15 Ci/km^2)
Zone III	Zone of radioactive contamination with soil contamination density of Cesium-137 555-1480 kBq / m^2 (15-40 Ci/km^2)
RPL/Forestry-2001	Republican Permissible Levels of Cesium-137 content in wood, wood products and wood materials, other non-food forest products
RPL-99	Republican Permissible Levels of Cesium-137 and Strontium-90 radionuclides content in food products and drinking water
IS "RadFor"	Information System "Radioactive contamination of forests. RadFor"
IS "RadForView"	Information system "Radioactive contamination of forests. RadForView" (peripheral version for Forestry Enterprises)
GIS	Geographic Information System
TFC	Type of forest conditions (conditions of soil fertility and moisture)
COT	Coefficient of Cesium-137 transfer from soil to plants
RCD	Radiation control department
Forestry Enterprise	State Forestry Enterprise
Special Forestry Enterprise	State Special Forestry Enterprise
Experimental Forestry Enterprise	State Experimental Forestry Enterprise
Forestry	State Forestry Enterprise Unit
SFPA	State Forestry Production Association
FC	Forest compartment
UE "GeoInformation Systems" of NAS	Scientific and Engineering Republican Unitary Enterprise "Geoinformation Systems" of the National Academy of Sciences of Belarus
RC	Radiation conditions
DB	Database
NRA	Normative Regulatory Act
TNRA	Technical Normative Regulatory Act
TCEP	Technical Code of Established Practice

Executive Summary

1. The subject of the study is forest fund areas contaminated due to the Chernobyl disaster, a support information system for taking a decision on forest management based on the compliance with radiation safety standards. As of October 10, 2020, the forest fund area of the Ministry of Forestry of the Republic of Belarus (hereinafter referred to as the MoF) in zones of radioactive contamination is 1274.5 thousand hectares or 15.09% of the total forest area.

2. The aim of the work is to implement the GeoInformation service "RadForInfo" into work of Forestry Enterprises with the forest fund territories in the radioactive contamination zones. This module was created to ensure the convenience and efficiency of decision-making process on forest management (forest felling) in zones of radioactive contamination, primarily with a high density of ^{137}Cs soil contamination (hereinafter referred to as the soil contamination density) from 15 to 40 Ci / km^2 (zone III).

3. The capabilities of the "RadForInfo" module are directly related to the volume of indicators on the radiation conditions in forests, which are contained in the databases of the IS "RadFor". Window "RadForInfo" opens when you select the GIS "RadForInfo" item in the "Base" menu. GIS "RadForInfo" has two functional parts. (i) Informational, displaying data from the "Radiation conditions" and "Forest Products" databases and calculated values. (ii) Cartographic, allowing the users to control the display, adjust the map layers, as well as graphically display the current and forecast information on the density of the ^{137}Cs soil contamination and on the ^{137}Cs content in wood in forest compartments of a given Forestry.

4. The functions of the GeoInformation service "RadForInfo" were tested by the specialists of the "Bellesozashchita" Enterprise in close contact with the developers. The necessary corrections and adjustments were promptly made. The installation discs with a new map service, MapX software and explanations for their installation in the radiation control departments of Forestry Enterprises were prepared to conduct a pilot check of "RadForInfo".

5. In October 2020, a pilot check was carried out in three organizations – Vetka Special Forestry Enterprise, Gomel Forestry Enterprise, and Cherikov Forestry Enterprise. The GeoInformation service "RadForInfo" was installed, the personnel of the radiation control departments (hereinafter referred to as RCD) were trained, the performance of functions was jointly checked, and the task of self-checking the functions of the new service was set.

6. Pilot check of the GIS "RadForInfo" as a whole and its components separately showed positive results and confirmed the compliance of the developed functions with the requirements formed in terms of reference. Possible options for the interpretation of the predicted values are considered and the factors influencing the calculation results are determined. The determining factors are the accuracy and relevance of data on the results of radioactive contamination control. The RDC specialists discussed the issues of the practical application of the web service, noted the clarity and complexity of the information presentation, which makes it possible to assess quickly the possibility and necessity of carrying out work on the clarification of the radiation conditions, radiation survey and demarcation of cutting areas.

7. A brochure "User Guide for RadForInfo GeoInformation service" has been developed and produced. For the convenience and ease of functions use by specialists of Forestry Enterprises the auxiliary visual materials have been prepared.

8. Training seminars were held for specialists responsible for radioactive contamination control, forest management in the Gomel and Mogilev SFPAs. Radiological engineers and technicians from 18 "contaminated" Forestry Enterprises, including from the territory in the III contamination zone, attended the seminars. Installation discs with loaded maps and "RadForInfo" cartographic service were prepared for each Forestry Enterprise. The presentation and visual training materials were created and provided to the Forestry Enterprises. The support

of the information module “RadForInfo” will be carried out by the specialists of the Enterprise “Bellesozashchita” and UE “Geoinformation Systems” of NAS within 2 years after installation in all Forestry Enterprises with the territories of radioactive contamination.

9. Information about the main work stages on the creation of the GeoInformation service "RadForInfo" such as conducting a pilot check in the Forestry Enterprises and training specialists of radiation control departments on the use of new functions, was regularly posted on the website of the "Bellesozashchita" Enterprise and in the Belarusian Forestry Newspaper (articles issued on August 28, November 11, and December 9, 2020).

1. Introduction

1. When conducting forestry in the territories of radioactive contamination, information on the radiation conditions which is stored in a systematic form in the databases of the Information System “Radioactive contamination of forests. RadFor”. The functions of the IS “RadFor” allow to receive documents with the results of radiation monitoring in the form of acts, statements, as well as Forestry maps. One radiation indicator is visualized on the maps viz assignment of a forest compartment to a zone of radioactive contamination.
2. During the research period, a significant amount of data on the ^{137}Cs content in wood has been accumulated, algorithms for calculating forecast levels have been elaborated that use the laws of radioactive decay (the half-life of ^{137}Cs is 30 years), as well as statistically reliable data on the intensity of transition of ^{137}Cs from soil to wood for the main forest-forming species in various forest conditions.
3. As ^{137}Cs decays, the soil contamination density and the area of forests in the contamination zones decrease. The same is observed for zone III (15–40 Ci / km^2) where for 20 years after the Chernobyl accident forest use was significantly limited – there were no felling and no forestry activities.
4. By 2020, the forest area in the zone III is 101.2 thousand ha, of which 10.12 thousand ha with ripe forest stands with a timber stock of 2 793.4 thousand cubic meters. According to preliminary estimates, up to 60% of ripe wood will meet the requirements of hygienic standards (RPL/Forestry-2001) – the content of ^{137}Cs will not exceed the permissible level (normatively “clean” wood).
5. For a prompt decision on forest use in areas with a high density of soil contamination (zone III) and cutting of ripe stands with normatively “clean” wood, it is necessary to use all radiation and forestry indicators in the complex with the possibility of their reflection on the maps for comparative analysis between forest compartments, sub-compartments and set of cutting areas.
6. Therefore, the problem of obtaining up-to-date information on safe forest management in “contaminated” areas, including the possibility of cutting in ripe stands and obtaining normatively “clean” wood in forest compartments in zone III, is currently relevant.
7. The problem of expanding forest use in areas with a soil contamination density of 15-40 Ci / km^2, a gradual return to traditional forestry methods, is significant for the Belarusian forest industry in terms of rehabilitation and restoration of forest infrastructure, forest health and, in general, improvement of the ecological situation.
8. To ensure the availability and convenience of obtaining information when making decisions on forest management, forest use in zones of radioactive contamination, as well as their planning for the long term, the extension of the IS “RadFor” function, and developing of the GeoInformation service “RadForInfo” are proposed. The capabilities of the “RadForInfo” service are directly related to the scope of indicators on the radiation conditions in forests that are contained in the IS “RadFor” databases. The use of “RadForInfo” will make it possible to simultaneously have all the radiation indicators for the forest compartment, both for the current period and in the future (on a given date), and to receive this information quickly using a map of the Forestry Enterprises.

9. The implementation of the measures proposed by the project meets the main goal and priorities of sustainable forestry, aimed at the rational use of forests in the territories of radioactive contamination.

2. Conducting a pilot check of the information service "RadForInfo"

10. The first stage of work included the development of the GeoInformation service "RadForInfo". A combined interactive map of each Forestry Enterprise was created with the connection to forest compartments and sub-compartments, the "RadForInfo" functions were developed to obtain information on the indicators of the radiation conditions at the present time and in the forecast for a given date on the basis of an interactive map, digital maps of Forestries with coloring of forest compartments by ^{137}Cs soil contamination density and ^{137}Cs content in wood. At the second stage, testing the developed service "RadForInfo" by "Bellesozaschita" specialists and pilot check in three Forestry Enterprises were carried out.

2.1. Testing of the functions of the GIS "RadForInfo"

11. Testing of the GeoInformation service "RadForInfo" was carried out by the specialists of the "Bellesozashchita" Enterprise in close contact with the developers of the UE "Geoinformation Systems" of NAS. In the process of testing, a number of proposals were made to improve the work of the GIS "RadForInfo". The system was supplemented with new functions, command buttons of the control panel, and algorithms for obtaining calculated values.

12. Successively, as new functions of the GIS "RadForInfo" appeared, work was carried out to test them (testing of functions on the Forestries example of the Forestry Enterprises). Since the map is the basis for the visualization of the information presented, special attention was paid to the functions of loading and setting the layers of digital maps to a topographic base.

13. Testing of GIS "RadForInfo" was carried out in four directions:

- Operation of the functions of the toolbar and command buttons (table 1, part I – "Command buttons and tools");
- Setting up map layers, forming thematic interactive maps of the Forestry Enterprises at the current moment and in the forecast for a given year (table 1, part II – "Interactive map").
- Information exchange and formation of the "Maps" system catalog to ensure the use of the web-based mapping service in the "RadForView" IS. Data export function (table 1, part III – "Information exchange").
- Checking the operation of calculation algorithms in the "Radiation factor" window.

14. Testing of all functions was carried out with each update of the executable (exe) files of the RadFor and RadForView programs, which ensure the operation of the GeoInformation service "RadForInfo" and the information system as a whole. Therefore, in addition to all the functions of "RadForInfo", the functions of information exchange between the peripheral versions of the IS and the host computer were tested.

15. While testing it is found that all the interconnections of the databases of the IS "RadFor" and maps, tools for viewing the map, an interface window with information on the indicators of the radiation conditions in each forest compartment, including forecast indicators, are stable. The function of visualization on the map of radioactive contamination levels changing over time (actual results of radiation survey and expected, predicted values) has been implemented.

16. GeoInformation service "RadForInfo" includes two main parts such as the combined interactive map and the interface module "Radiation factor", each of which performs certain functions and, in general, provides the necessary information at the user's request. The table shows (i) the content and main functions of "RadForInfo", (ii) the results of testing, (iii) the

results of checking the correspondence between the real behavior of the service and the tasks formed during the development of the project.

Table 1. Test results of the GeoInformation service “RadForInfo”

Function	Tested service components	Test results
Part I – “Command buttons and tools”. Formation of the toolbar and command buttons and their functions		
Formation of the toolbar (working with map layers, zooming in and out, moving the map around the window, obtaining information about objects, fixing the position and scale of the map, creating files in BMP and MapInfo format, applying and removing conventional symbols of sampling points, visualization and hiding of the soil sampling sites)	The control panel at the top of the map window consists of a toolbar and command buttons. The toolbar, consisting of buttons with the help of which the on-screen part of the interactive map and the map layers are controlled. Command buttons that control the formation of the subject of maps, including algorithms for calculating predicted values when presenting maps in the forecast for a given date. Captions of control buttons for maps and reports, as well as the correspondence of the names of the toolbar buttons and command buttons to the functions performed. The peculiarities of working with the map service and the availability of sufficient user experience were taken into account.	Revealed: inconsistency and lack of signatures of some buttons in the interlinear for the left and right keys; discrepancy between the names of some buttons and their function; difficult to understand name that should be simplified. Fixed names: “Map layers” on “Map layers / layers control”; “Coordinates of soil sampling sites / edit coordinates of soil sampling sites” to “Enter coordinates of soil sampling sites / delete, edit coordinates”; “Apply soil sampling sites / Clean” to “Show soil sampling sites / Hide icons”; “Colorize layers / compartments to clarify RC” to “Colorize the map / Select compartments to clarify RC”; “Clear layers” to “Clear map theme”
Adding, editing and deleting the coordinates of soil sampling points in forest areas during radiation survey. Visualization of sampling sites on the map using special icons	Toolbar button “Entering coordinates of soil sampling sites” with the right or left mouse button. Window “Coordinates of soil sampling site” in which latitude and longitude values are entered. Saving values in the database “Radiation conditions. Editing in “RadForInfo” if necessary Tool for drawing special “marks” -  places of soil sampling in a forest compartment on the map of the Forestry Enterprise (Forestry). Toolbar button for visualization of sampling sites,	After entering the latitude and longitude values, the saved data appears for viewing in the “Coordinates of the soil sampling site” window. When editing, new and previous coordinate values are presented in the field of view, which can be replaced using the “Save” function. The setting was made for the introduction and display of “icons” in a compartment - one icon per each.

Function	Tested service components	Test results
	toggled on with the left mouse button and off by the right one.	A special “icon” indicating the location of the sampling site in the compartment appears on the map at the user's request
Management of changing the subject of the map, the formation of the map for the selected subject. Management of the forecast calculation algorithm for the maps formation of the Forestry Enterprise	Command buttons for changing subject and creating a thematic map. Entering the forecast date into the map control panel window with the subsequent formation of a thematic map in the forecast for a given date	A check mark is placed in the window for changing the subject of the map; the map is formed in accordance with the selected subject. The date entered in the control panel window starts the forecast calculation algorithm. The map is formed in the forecast for a given date
Applying Zoom settings: to change the scale of the Forestry Enterprise map when viewed in the “RadForInfo” window; for display settings for MapX map layers depending on the scale when viewing Forestry Enterprise maps	Zoom adjustment window located on the bottom panel “RadForInfo”. Interconnections of the windows for changing the scale of the map and the window Zoom for numerical displaying. Map Layers toolbar button to customize the display of map layers Window for setting the minimum and maximum values of the Zoom value for each layer (as the map gets closer (enlarged), smaller objects will appear for viewing, and as it decreases, they will disappear so as not to overload the map with small details)	As you zoom in and out of the map using the top panel icons (+ and -), the Zoom value changes. The Forestry Enterprise map is scaled up and down when you manually enter the Zoom value and can be adjusted as needed. The minimum and maximum Zoom value set for each layer controls the display of map objects when it is farther and closer using scrolling or the buttons on the toolbar. When the image is reduced, small details are hidden in accordance with the specified Zoom parameters and do not interfere with viewing
Part II – “Interactive map” with reference to forest compartments and sub-compartments to provide information about the radiation conditions in the forest fund of the Forestry Enterprise and Forestry at the present time and in the forecast for a given date		
Loading (updating) layers of	Stages of loading maps in GIS “RadForInfo”	Loading of maps occurs through the removal

Function	Tested service components	Test results
digital maps on a cartographic basis in accordance with the materials of the new basic forest management	- Working with catalogs of layers of digital maps in MapInfo format - forming a system catalog “Maps”, which must be placed on disk “D” (this is how the path from “RadForInfo” to “Maps” is written); - Managing map layers through the service menu “Map Layers” (control panel) and adding necessary or removing unnecessary layers. Search for layers using codes that indicate belonging to Forestry Enterprises	and addition of layers of digital maps and is carried out in accordance with the results of the new basic forest management. Using the command buttons of the “Map layers” window, the layers of digital maps are loaded from the “Maps” folder into the GeoInformation service in the “TAB” format. The presence of codes belonging to Forestry Enterprises in the name of the layers simplifies the selection of map layers. Map layer management works without crashing.
Setting up the digital maps layers of the Forestry Enterprises in the “Map layers” and “layers control” windows to improve the quality of displaying vector objects in the specified parameters	Setting up digital map layers in the “Map layers” and “Layers control” windows. “Layers control” window. Verification and ordering the digital map layers by moving up or down to eliminate layer overlap when viewing the map. Window “Map layers”. Checking the settings of each individual layer by the parameters available for it - layer type, layer color, line thickness. Setting the image and selection parameters, and layer settings. Using codes when setting up layers of the Forestry Enterprises map (selecting the appropriate code)	The order of layers in the “Layers control” window is adjusted and saved by simultaneously pressing the “Map layers” menu and the “Ctrl” button on the keyboard The visualization of the map layer settings is absolutely the same. Objects of the “area object” layer type save and display color settings. Objects of the “topographic base” layer type save and display color settings and line width. Objects of the “compartments” and “sub-compartments” layer types save and display the settings for color, line width, and fonts.
Change of the maps subject by choice – “Density of the ^{137}Cs soil contamination” and “^{137}Cs content in wood”	Window for choosing the map subject “Density of the ^{137}Cs soil contamination” or “^{137}Cs content in wood” Thematic map obtained with the “Paint the map”	By placing a check mark in the upper panel of the window, the map subject can be selected. Automatic loading and coloring of the map layers on a given subject is carried out

Function	Tested service components	Test results
	tool – launching the processing of the layers. The speed of preparing a thematic map when setting a change of the subject, as well as when creating maps in a forecast for a given date Application of the schemes draft to form the maps and to use the algorithms for calculating the density of soil contamination with ^{137}Cs and the content of ^{137}Cs in wood	It takes up to 45 seconds to load a thematic map for the first time and up to 15 seconds to create the thematic map after subsequent changes in the subject, as well as when creating maps in a forecast for a given date. IS "RadFor" database, algorithms for calculating the density of the ^{137}Cs soil contamination, and the ^{137}Cs content in wood are used in accordance with the drafts.
Representation of forest compartments with color by zones of radioactive contamination in the ranges of contamination density in accordance with the legend at the current moment (results of the radiation survey)	Tool "Colorize the map" and the window for selecting the map subject "Density of the ^{137}Cs soil contamination" Connection of the map subject with the legend and the database - launching the mechanism for selecting the legend and the database, which underlie the formation of the thematic map. Correspondence of the map color to the values of 1^{37}Cs soil contamination density in the "Radiation conditions" database.	The map generation mechanism is convenient and easy to use. The map is formed correctly in accordance with the ranges of soil contamination density at the current moment. The colors of the forest compartments correspond to the values in the "Radiation conditions" database.
Representation of forest compartments with color by zones of radioactive contamination (ranges of the soil contamination density in accordance with the legend) for a given year (forecast of the density changes of the soil contamination)	Tools and windows for selecting the subject of the map "Density of the ^{137}Cs soil contamination" and entering the forecast date to start the algorithm for calculating the density of contamination. Tool "Colorize the map" to start calculating the predicted values of the soil contamination density for each forest compartment for a given year. Correspondence of the color of the forest compartments on the map to the calculated	The generated map and legend correspond to the chosen subject "Density of the ^{137}Cs soil contamination" The "Colorize the map" tool launches an algorithm for calculating predicted values and generating a map in the forecast for a given year. The colors of the forest compartments correspond to the calculated values in the

Function	Tested service components	Test results
	predicted values of the ^{137}Cs soil contamination density in the "Radiation conditions" database.	"Radiation conditions" database. The speed of data processing when forming a thematic map is sufficient.
Allocation of a group of forest compartments for radiation survey in order to clarify the radiation conditions (RC meaning soil contamination density) and refer to a zone with a lower soil contamination density	A map of the Forestry Enterprise with a color by zones of radioactive contamination in the forecast for a given date (date, year of clarification of the radiation conditions are entered by user). Tool "Color the map" (left mouse button). "Selection of compartments to clarify RC" (right mouse button). Compartments are being highlighted that will move to a zone with a lower contamination density due to radioactive decay, and are subject to clarification of the radiation conditions Changing the map subject at "^{137}Cs content in wood" keeping the selection of the compartments where the clarification of the radiation conditions on the specified date is planned	A map of the Forestry Enterprise has been compiled with coloring by zones of radioactive contamination in the forecast for the date of clarification of the radiation conditions. Compartments for specifying the radiation conditions are highlighted on the map with red shading. The convenience of viewing the soil contamination density in the adjacent forest compartments, analyzing the conditions and making a decision on updating the RC is provided. Keeping the selection of the compartments when changing the subject of the map makes it possible to estimate the levels of ^{137}Cs content in wood and the correspondence for the analysis of RC
Representation of forest compartments colored by the content of ^{137}Cs in wood (average for all species) with gradation by levels (ranges of the specific activity of ^{137}Cs in wood in accordance with the legend) at the present time	Thematic map window. The command button for selecting a map subject launches the mechanism for selecting a legend and a database that are used to form the map. Legend for using the map. Map with coloring of forest compartments by ^{137}Cs content in wood.	The mechanism for generating the map is convenient and easy to use. DB "Forest Products" of the IS "RadFor" and calculation algorithms are applied correctly. The map is formed correctly at the current moment and in accordance with the ranges of specific activity of ^{137}Cs in wood.

Function	Tested service components	Test results
(results of the radiation survey)	DB “Forest products” of the IS “RadFor”. Using the algorithm for obtaining the average value of the specific activity of ^{137}Cs in wood in a forest compartment for coloring the map.	The colors of the forest compartments correspond to the legend and the calculated values obtained when checking the algorithm in the “Forest products” database. The speed of data processing when forming a thematic map is sufficient.
Representation of forest compartments colored by ^{137}Cs content in wood (average for all species) with gradation by levels (ranges of specific activity of ^{137}Cs in wood in accordance with the legend) for a given year (forecast of changes in specific activity of ^{137}Cs)	Thematic map window. The command button for selecting the subject of the map and the window for entering the forecast date, which launch the mechanism for selecting the legend and the database that are used to generate the map. The tool “Colorize the map”, which starts the function of calculating the predicted values of the specific activity of ^{137}Cs in wood for each forest compartment for a given year. Legend for using the map. Forecast map with coloring of forest compartments by ^{137}Cs content in wood.	DB “Radiation conditions” and “Forest products” of the IS “RadFor” and calculation algorithms are applied correctly. The colors of the forest compartments correspond to the legend and the calculated values obtained when checking the algorithm in the databases “Radiation conditions” and “Forest products”. The data processing speed when forming a thematic map is good.
Receipt and printout of a report with a list of forest compartments for radiation survey for a year of the clarification of the radiation conditions (assignment to a zone with a lower soil contamination density)	Forecast map of ^{137}Cs soil contamination density with selected forest compartments to clarify the radiation conditions. Report with a list of forest compartments to clarify the radiation conditions.	The report generator is working correctly. The data comes from the database and provides up-to-date and predictive information necessary for planning work to clarify the radiation conditions. The report is displayed on the screen, printed to the printer on paper.

Function	Tested service components	Test results
Printout of the image of thematic maps of Forestries (Forestry Enterprises), fragments of forest compartments with division by sub-compartments, formed using the functions of the GIS "RadForInfo"	The "Create BMP" button provides unloading of the map window and the formation of a file with subsequent printing. The "Print screen" function also allows to capture an image and print. The "Save map layers" button launches the function of generating a file in MapInfo format.	The generated BMP file displays the map of the RadForInfo window and gives a satisfactory image quality. The file, generated in MapInfo format, opens up the ability to work in more detail with map layers and get high quality images.
Part III – "Information exchange". Data export and import functions. Formation of the system catalog "Maps" to ensure the use of the web-map service in the IS "RadForView"		
Information exchange between IS "RadFor" and peripheral versions of IS "RadForView". Export of data from the IS "RadFor" to obtain the folder "RADFOR". Importing data from the "RADFOR" folder into the IS "RadForView". Creation of the "Maps" catalog by sequential export of data from the IS "RadFor" and the import of the data of the "RADFOR" folder into the IS "RadForView"	New versions of executable (exe) files for the programs "RadFor" and "RadForView", which ensure the operation of the information system. Programs "RadFor" and "RadForView" with new (exe) files. The window for exporting data from the IS "RadFor" and obtaining the folder "RADFOR". Folder "RADFOR" for importing data with new program components for updating. Data import window for selecting a new component with digital maps – "RadForInfo data" System catalogs IS "RadFor" and "RadForView" System folder "Maps" with catalogs (maps and topographic base)	IS "RadFor" and "RadForView" are launched using new (exe) files When exporting data from the IS "RadFor" to download the data, you should select the component "Forest products". At the same time, new catalogs with files for data updating are successfully formed in the "RADFOR" upload folder. The function of importing data from the "RADFOR" folder into the IS "RadForView" passes without errors. New "strucles" files are added to the DBF catalog. "CatalogList", "mapslayers", "MapsMetka" are added to the User catalog As a result of the import, a new system folder "Maps" with catalogs (maps and topographic base) is formed on the disk "D".

Function	Tested service components	Test results
Data export from the peripheral version of the IS “RadForView” Data import into the IS “RadFor”, including the coordinates of the soil sampling sites when clarifying the radiation conditions on the territory of the forest fund	The “View” folder, created during the data export, which includes new database components - the “User” catalog with files containing the coordinates of the soil sampling sites when clarifying the radiation conditions on the territory of the forest fund. The window “Data import into the Radiation conditions database” for selecting the components of the “View” folder when importing data into the IS “RadFor” by checking the “Sampling sites” Interactive map of the Forestry Enterprise in the “RadForInfo” window. Command button of the toolbar – “Show soil sampling sites” and “Coordinates of soil sampling sites”	As a result of data export from the IS “RadForView”, a folder “View” is formed where there is a folder “User” with attached files: mapsmetka.cdx; mapsmetka.dbf. In the data import window, 2 new fields “Sampling sites” have appeared. After saving the data, the coordinates of the soil sampling sites appear in the IS “RadFor” database. In the “RadForInfo” window, the map displays on demand the icons and coordinates of the soil sampling sites, marked during the work to clarify the radiation conditions.
Possibility of using a web-mapping service in the Geoportal of the Land Information System	The button of the function “Save map layers”, which is located in the toolbar, provides unloading and saving of the map layers in MapInfo format.	Maps in MapInfo format can be used to load a thematic layer into a web-mapping service in the Geoportal of the Land Information System.
Part IV - interface module “Radiation factor” for presenting detailed information about the radiation conditions in the forest compartment, sub-compartment at the present time and in the forecast for a given date. The name of the Forestry, Forestry Enterprise, forest compartment is entered by the user manually or by highlighting the forest compartment on the interactive map		
Section 1: Receiving the information about radioactive contamination of the territory of the forest	The value of the soil contamination density on the date of the radiation survey; The year in which the forest compartment will move to a zone with a lower soil contamination	The value of the soil contamination density and dose rate correspond to the DB “Radiation conditions” The calculated values of the forecast of the soil contamination density and the average annual

Function	Tested service components	Test results
compartment in automatic mode	density; Predicted values of soil contamination density for a given date (date, year are entered by user); The dose rate in micro Sieverts per hour (μSv/h) and the average annual radiation dose in milli Sieverts per year (mSv/year) at the date of the radiation survey	radiation dose correspond to the calculation formulas laid down in the program, the external radiation dose is calculated for 2000 working hours per year (all working hours during the year)
Section 2: Receiving the information on the ^{137}Cs content in wood in a forest compartment in automatic mode	The values of the specific activity of ^{137}Cs in wood by species and categories of technical suitability (commercial timber and fuelwood) in sub-compartments; The content of ^{137}Cs in wood is average for all species in the forest compartment in a certain period of time (from and to, date, year are entered by user); The content of ^{137}Cs in wood is average for all species in the forest compartment in the forecast for a given date (date, year are entered by user).	The values of the specific activity of ^{137}Cs in wood correspond to the "Forest products" database; the average value for all species is calculated taking into account the specified period. The predicted value of the ^{137}Cs content in wood is calculated taking into account the forecast date and corresponds to the calculation formula laid down in the program.
Section 3: Receiving the information on the content of ^{137}Cs in wood in sub-compartment in automatic mode	Sub-compartment, tree species (reference book), audit period range (from and to, date, year) are entered by user ^{137}Cs content in wood Coefficient of ^{137}Cs transfer from soil to wood Content of ^{137}Cs in wood of the selected species in the forecast for a given date (date, year are entered by user)	The ^{137}Cs content and the coefficient of ^{137}Cs transfer from soil to wood averaged for the selected species are calculated taking into account the number of values in the audit period. The predicted value of the ^{137}Cs content in the wood species is calculated taking into account the forecast date and corresponds to the calculation formula laid down in the program

Function	Tested service components	Test results
Information on paper	Printout of the “Radiation factor” interface module with information on the indicators of the radiation conditions	All information of the “Radiation Factor” module is displayed on the screen, printed on a printer

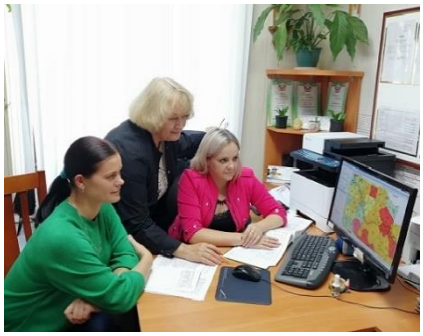
17. Based on the results of testing the GIS “RadForInfo”, the necessary corrections and adjustments, both functional and editorial, were promptly made. Functional corrections are (i) the reflection of the number of the compartments, (ii) highlighting and preserving the shading of the selected compartments when changing subjects, (iii) the unity of information on the screen and in printed form, (iv) printing out the “Radiation factor” window. Editorial corrections are the names of function buttons and units of measurement.

18. To configure and successfully operate the “RadForInfo” service, the necessary technical characteristics of personal computers (PCs) and the availability of the office programs were determined. To view the maps, the “MapX” program must be installed on the PC. For its installation on the PCs of the Forestry Enterprises, boot disks and a description (memo) for installing “MapX” are prepared.

19. To conduct a pilot check of “RadForInfo” in Forestry Enterprises, the installation discs with a new map service, MapX program and explanations for their installation on a PC in the radiation control departments, and auxiliary tables for checking functions were prepared.

20. On October 6-8, 2020, specialists of the department of the forest radiation monitoring of the “Bellesozashchita” Enterprise carried out a pilot check of the GeoInformation service “RadForInfo” in the Gomel Forestry Enterprise and the Vetka Special Forestry Enterprise of the Gomel SFPA. On October 13-15, 2020, it was done in the Cherikov Forestry Enterprise of the Mogilev SFPA. The GIS "RadForInfo" was installed in the radiation control departments of the Forestry Enterprises. Training of employees was carried out and the performance of the functions of a new GeoInformation module was checked directly for the Forestries of the Forestry Enterprises.

Figure 1. Specialists training of the radiation control departments of the Forestry Enterprises



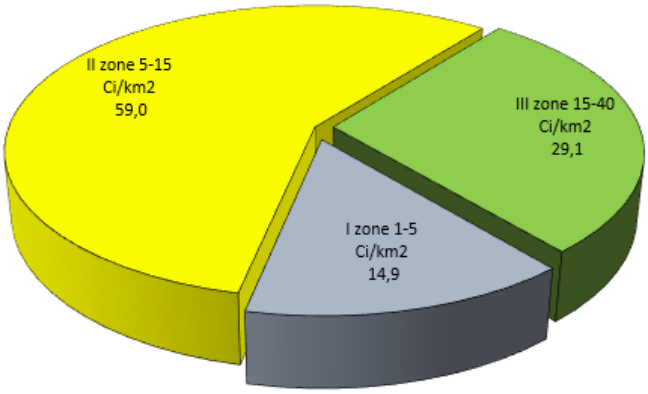
21. To check and compare the indicators of the radiation conditions in the windows of the interface module “Radiation factor” and in the databases of the IS “RadForView” the auxiliary tables have been prepared for independent work and the acquisition of skills in working with the GIS “RadForInfo”. Auxiliary tables included three blocks of the checked parameters: (i) the soil contamination density in forest compartments at present and in the forecast, (ii) the year of transition to the zone with a lower soil contamination density, (iii) the average content of ^{137}Cs in wood in a forest compartment in a certain period and forecast for a given date, (iv) the ^{137}Cs content in wood of the selected species as of the date of the radiation survey (within the audit period), (v) the transition coefficient, (vi) the ^{137}Cs content in wood of the selected species in the forecast for the given date.

2.2. Vetka Special Forestry Enterprise, pilot check

22. Vetka State Special Forestry Enterprise takes the first position in terms of the severity of radioactive contamination out of 44 Forestry Enterprises of the Ministry of Forestry with forest fund territories assigned to contamination zones. The forest fund of the Vetka Special Forestry

Enterprise has a total area of 102.9 thousand hectares. The area of 14.88 thousand hectares or 14.5% is assigned to zone I (from 1 to 5 Ci / km^2). The area of 58.95 thousand hectares (57.2%) is assigned to zone II (from 5 to 15 Ci / km^2). The area of 29.1 thousand hectares (28.3%) is assigned to zone III (from 15 to 40 Ci / km^2) (Fig. 2).

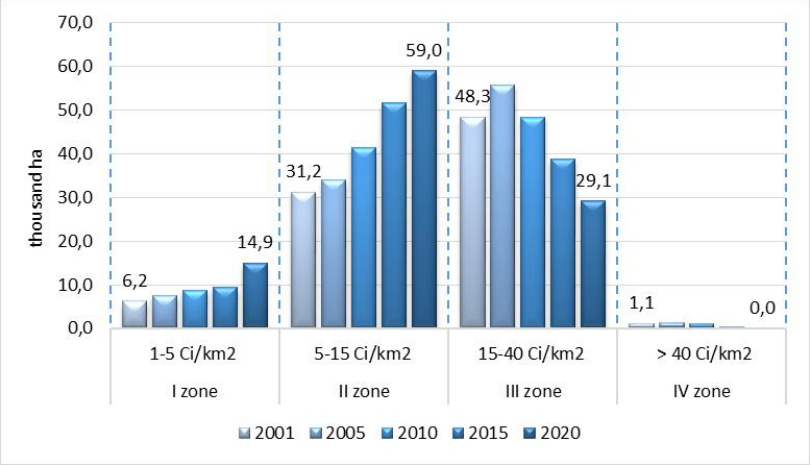
Figure 2. Distribution of the territory by zones of radioactive contamination. 2020



The source: IS "RadFor"

23. The distribution of forest fund territories by the degree of radioactive contamination changes over time. During the period from 2001 to 2020, the area of the I zone increased by 2.4 times and the II zone – by 1.9 times, the area in zone III decreased by 40% and is absent in zone IV (40 Ci / km^2 and more) (Fig. 3). The assignment of the territory to the zones of radioactive contamination is carried out based on the results of a radiation survey, radiometric measurements, and determination of the average, minimum and maximum value, of the soil contamination density with ^{137}Cs in the forest compartment.

Figure 3. Change in the area of the contamination zones from 2001 to 2020.

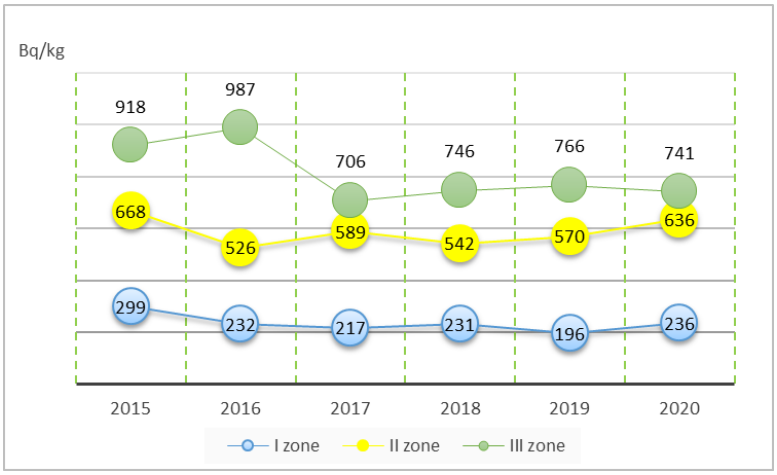


The source: IS "RadFor"

When calculating the predicted levels of ^{137}Cs in wood in the GIS "RadForInfo" the average value of the soil contamination density in the forest compartment is used.

24. Due to the significant proportion of the forests in zones II and III, the average levels of ^{137}Cs in wood are quite high – over 700 Bq / kg in zone III and up to 600 Bq / kg in zone II. With such a content of ^{137}Cs in wood, its use is limited. For example, for the construction of walls of residential buildings or as fuel (fuelwood, wood for the manufacture of chips, fuel pellets) wood with a permissible level of 740 Bq / kg can be used. Figure 4 shows the average levels of ^{137}Cs in wood, found during the radiation survey of cutting areas in 2015-2020 in various contaminated zones.

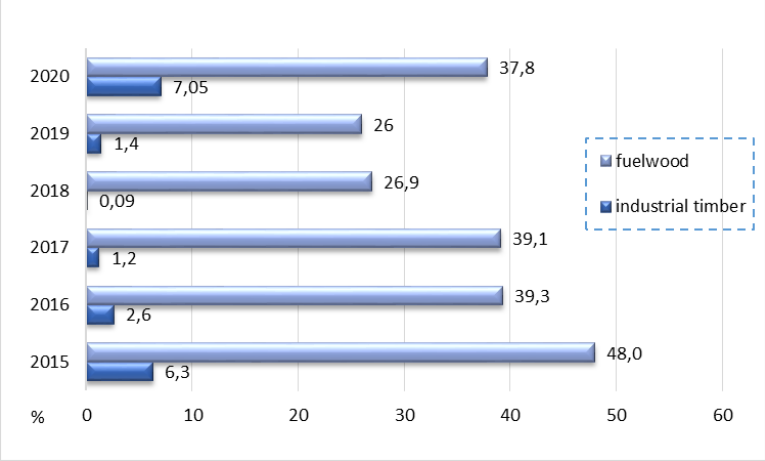
Figure 4. Average values of the ^{137}Cs content in wood in the contaminated zones. Vetka Special Forestry Enterprise, 2015-2020



The source: IS "RadFor"

The specific weight of the controlled wood samples exceeding the permissible levels of ^{137}Cs, taking into account the direction of the harvested wood usage, reaches 40% for fuelwood, and up to 7% for commercial timber (Fig. 5).

Figure 5. Exceeding the permissible level of ^{137}Cs content in wood. Vetka Special Forestry Enterprise, 2015-2020



The source: IS "RadFor"

25. On average, on the territory of the forest fund of the Special Forestry Enterprise, tree species can be arranged as the accumulation of ^{137}Cs increases in the following row: birch → pine → aspen → oak → alder → spruce. At the same time, on the territory of each Forestry, this distribution will have its own form, since in this case the peculiarities of the growing conditions are taken into account. The estimation of the degree of ^{137}Cs wood contamination of various species is carried out according to the value of the transfer coefficient calculated as the ratio of the specific activity of ^{137}Cs in wood to the surface activity of ^{137}Cs in the soil at the place of its examination and sampling. Table 2 shows the average values of the coefficients of the ^{137}Cs transfer from soil to wood of the main forest-forming species in the territories of the forest fund of four Forestry of the Vetka Special Forestry Enterprise.

Table 2. Coefficients of ^{137}Cs transfer to wood. Vetka Special Forestry Enterprise

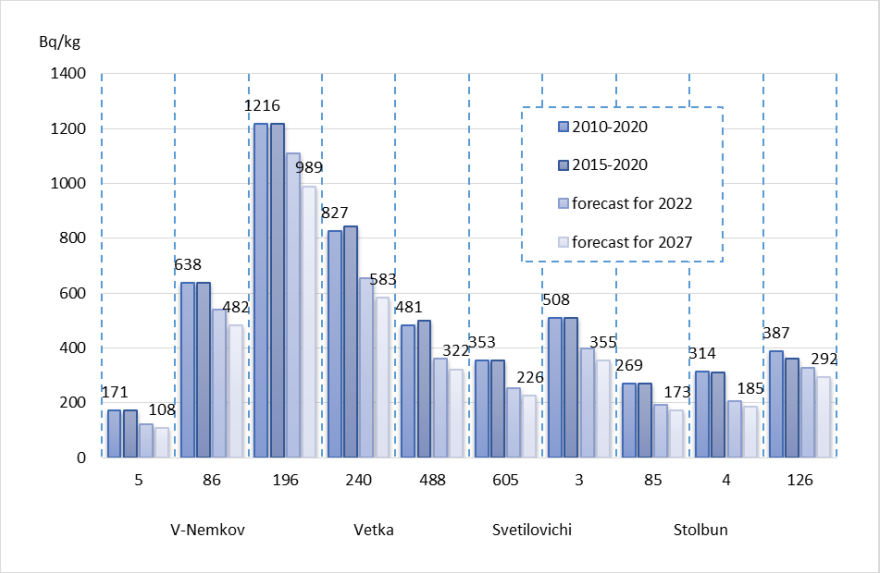
Forestry name	Pine	Birch	Spruce	Aspen	Alder	Oak	All species
Veliko-Nemkov	1.49	1.31	1.72	1.59	1.67	2.32	1.48
Vetka	1.53	1.35	1.91	1.39	1.79	1.38	1.51
Svetilovichi	1.33	1.08	1.49	1.23	1.34	1.34	1.26
Stolbun	1.53	1.08		2.02	1.54	1.25	1.53

The transfer coefficients are used at a preliminary stage (prior to the radiation survey in order to demark the cutting areas to felling) to determine the possibility of harvesting the normatively "clean" wood.

26. The radiation control department (RCD) is organized and operates in the Special Forestry Enterprise. Its specialists have been using the IS “RadForView” (peripheral version of the IS “RadFor”) in their work since 2009 for the last 11 years. A GeoInformation service “RadForInfo” was installed in the RCD. A pilot check of the service functions, the presentation of all embedded parameters on the map and the interface window “Radiation factor” was conducted. A random check of the reliability of indicators of the radiation conditions in the forest compartment, sub-compartment was carried out. In total, in 4 Forestries the 26 forest compartments and 36 sub-compartments were checked in the range of the soil contamination density from 2.1 to 23.2 Ci / km^2.

27. During the check, no deviations were found between the indicators of the radiation conditions in the "Radiation factor" interface window and the samples from the "Radiation conditions" and "Forest products" databases for the corresponding forest compartments of the Forestries. Comparison of actual for a certain period and predicted levels of ^{137}Cs content in wood showed a stable decrease in wood contamination with the radionuclide over time (Fig. 6).

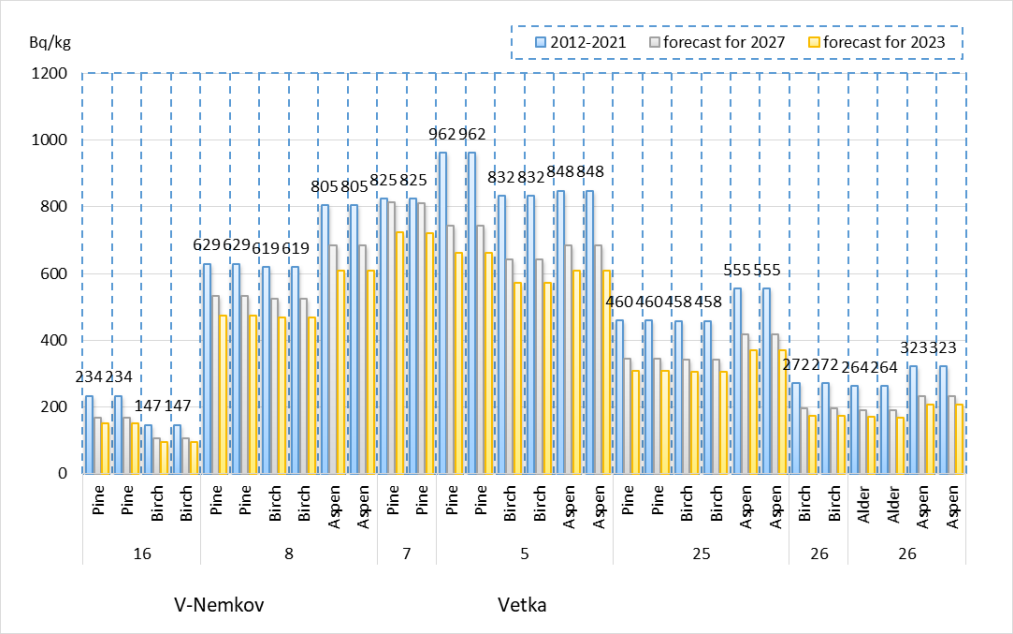
Figure 6. The “RadForInfo” check. Information on the average content of ^{137}Cs in wood in the forest compartments of the Forestry. Vetka Special Forestry Enterprise



The source: IS “RadFor” and GIS “RadForInfo”

The matching of the 137Cs content values in the wood of each species in the sub-compartments presented in the GIS "RadForInfo" and samples from the "RadFor" databases was established.

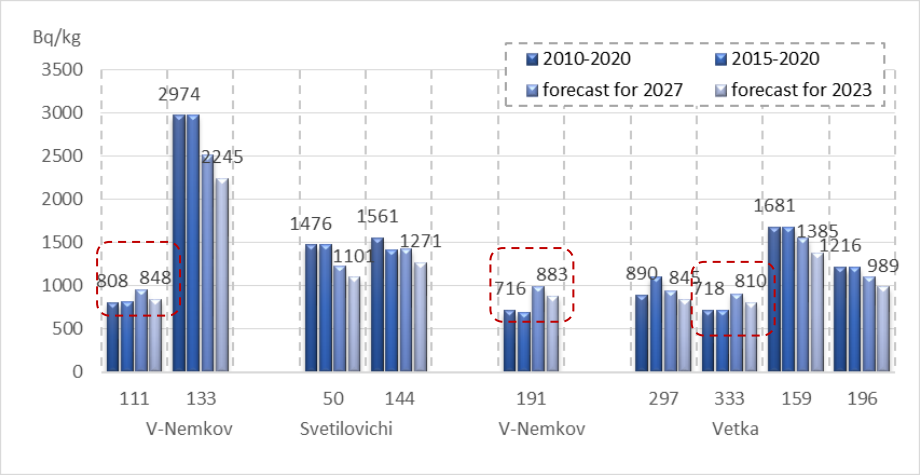
Figure 7. The “RadForInfo” check. Information on the average content of ^{137}Cs in wood by species the forest compartments of the Forestry. Vetka Special Forestry Enterprise



The source: IS “RadFor” and GIS “RadForInfo”

28. In zone III, a comparison of the actual (as of the date of the survey of the cutting areas) and predicted values of ^{137}Cs content in wood in forest compartments in Forestries showed that in some cases the predicted values are higher than the actual ones by 5-38%.

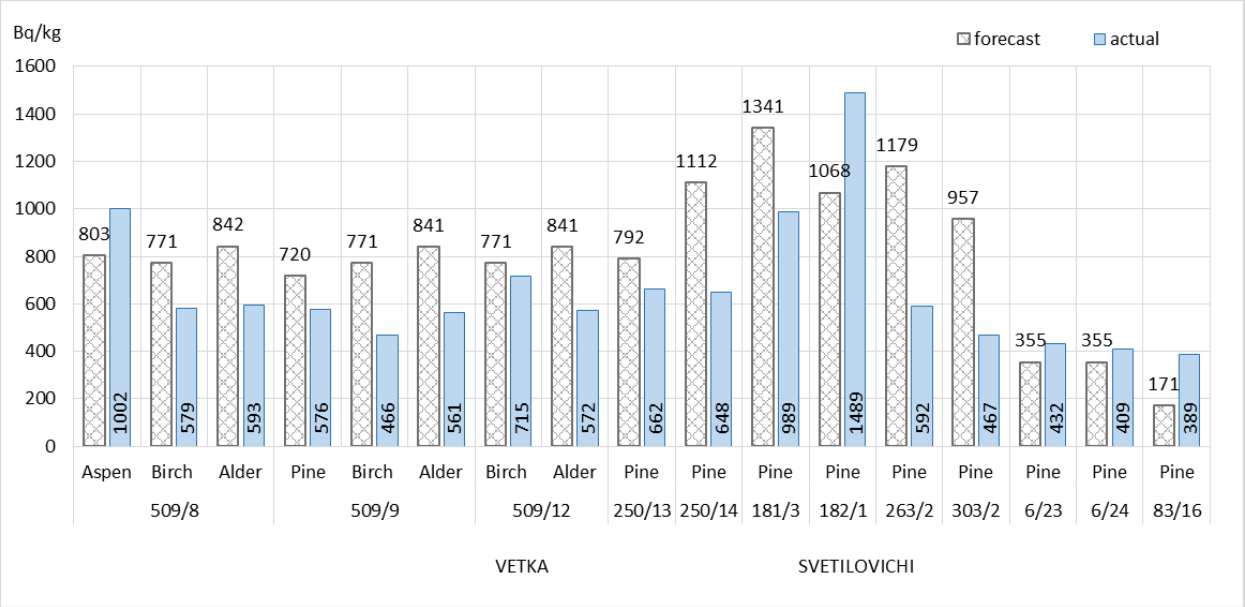
Figure 8. The “RadForInfo” check. Information on the average content of ^{137}Cs in wood in the forest compartment in zone III



The source: IS “RadFor” and GIS “RadForInfo”

29. Comparison of the results of radiation survey of 15 cutting areas in 9 forest compartments of three Forestries: Veliko-Nemkov, Vetka, Svetilovichi (October 2020) with the values of the predicted ^{137}Cs content levels in wood, calculated in the GIS "RadForInfo". When comparing the actual and predicted values of the specific activity of ^{137}Cs in wood of various species in the sub-compartments, differences were found both upward and downward.

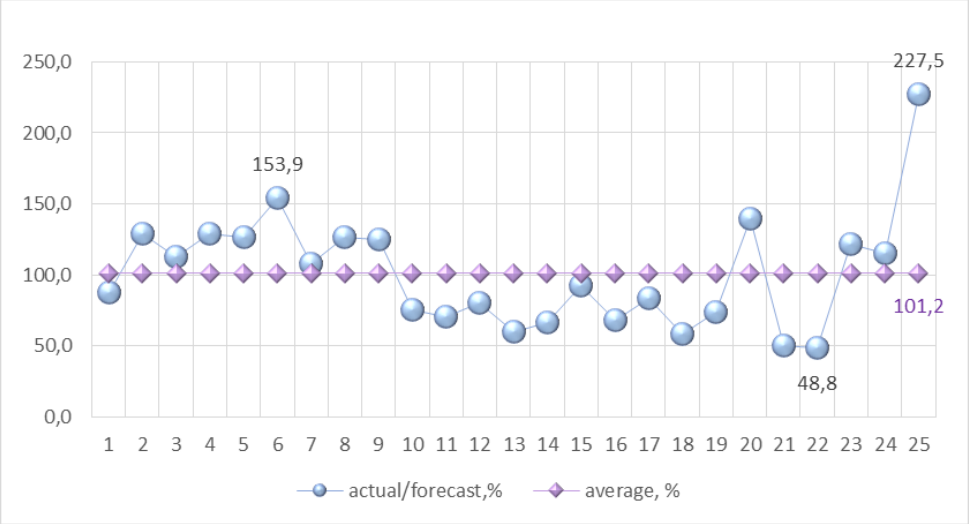
Figure 9. The “RadForInfo” check. Actual and predicted values of ^{137}Cs content in wood by species in the sub-compartments



The source: IS “RadFor” and GIS “RadForInfo”

There were no significant differences between the actual values and the predicted ones, calculated based on a different data sample: (i) data from the sub-compartments (2 cases), (ii) forest compartments (20 cases), and (iii) Forestries (3 cases). The standard deviation of the actual and forecast values on the example of the sample made was 40.2% with an average value of 101.2%. The majority (92.7%) of the ratio actual / forecast values are close to 1. Figure 10 shows that the actual values may be higher than the forecast 1.5-2.3 times, while the average difference does not exceed 8%, and the spread from the average is 40%.

Figure 10. The “RadForInfo” check. The ratio of actual values of ^{137}Cs content in wood to predicted values (species in the sub-compartment)



The source: IS “RadFor” and GIS “RadForInfo”

Analysis of actual and predicted average for all species values of the ^{137}Cs specific activity in wood in the forest compartment showed a smaller difference than in the sub-compartments (by 1.5-1.7 times).

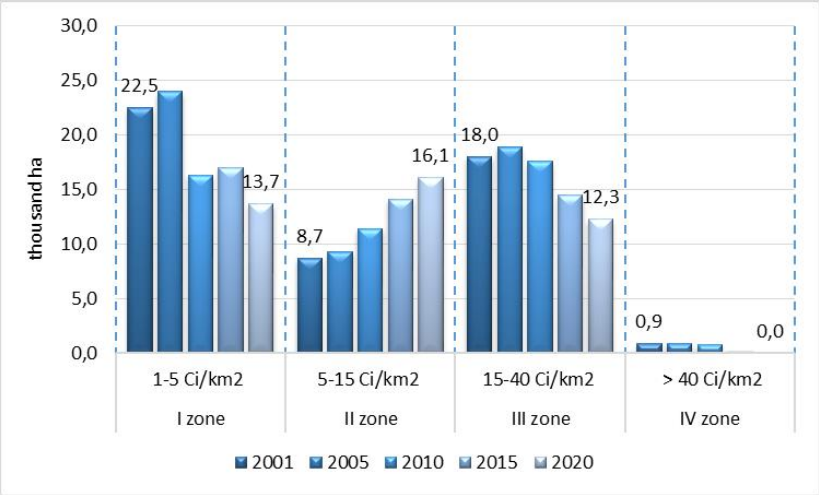
30. **Summary.** The pilot check of the GIS "RadForInfo" showed positive results. The RCD specialists successfully mastered the GIS "RadForInfo". The issues of practical application were considered on the spot. Indicators of the radiation conditions on the map and in the "Radiation factor" window of the GIS "RadForInfo", the predicted values of the soil contamination density

are identical to the data in the databases and reports of the IS "RadFor". The calculations of the average and predicted ^{137}Cs content in wood, the transfer coefficients correspond to the formulas. Comparison of the actual and predicted values of ^{137}Cs content in wood showed their sufficient convergence. The clarity and complexity of the presentation of information make it possible to assess quickly the radiation indicators, the possibility and necessity of carrying out work to clarify the radiation conditions, radiation survey and the demarcation of the cutting areas.

2.3. Gomel Forestry Enterprise, pilot check

31. Gomel Forestry Enterprise takes the first position in terms of the severity of radioactive contamination out of 44 Forestry Enterprises of the Ministry of Forestry with forest fund territories assigned to zones. At the same time, the area of the forest fund in the III zone, amounting to 12.27 thousand hectares, is in third place after the Vetka Special Forestry Enterprise and the Krasnopolie Forestry Enterprise. The area assigned to the contamination zones is 42.1 thousand hectares, or 36% of the total area as of November 1, 2020; Figure 13 shows its change by zones over time. Over the past 10 years, the area of zone I has decreased by 1.6 and zone III by 1.47 times, while it has increased in zone II by 1.9 times due to the transfer of part of the forest compartments from zone III due to a decrease in soil contamination density to values of 14.94 Ci / km^2 and less. Almost one-third of the "contaminated" forests of the Forestry Enterprise (29.2%) belong to the III zone (in 2000 - 35.9%).

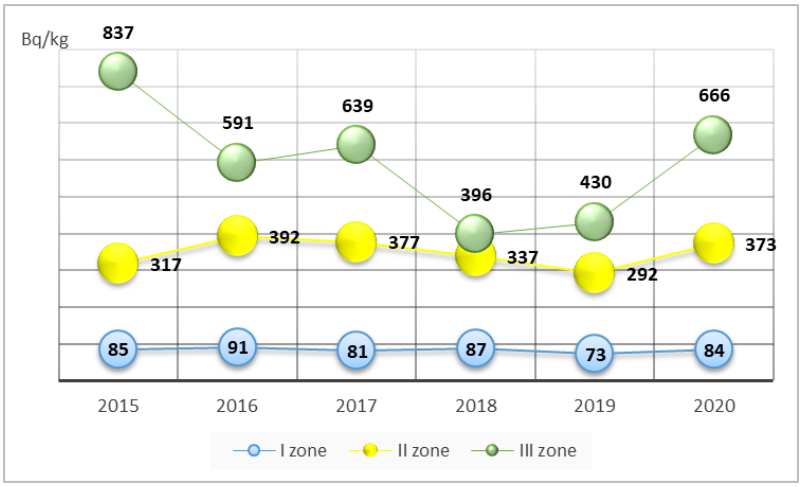
Figure 11. Change in the area of the contamination zones from 2001 to 2020. Gomel Forestry Enterprise



The source: IS “RadFor”

32. Average ^{137}Cs content in wood in zone III are 600 Bq / kg, in zone II - 350 Bq / kg. The maximum value of the specific activity of ^{137}Cs in commercial timber did not exceed 2200 Bq / kg (2019-2020). Figure 14 shows that in the last 6 years in zones I and II, all wood corresponded to the permissible levels, was used without restrictions on the radiation factor.

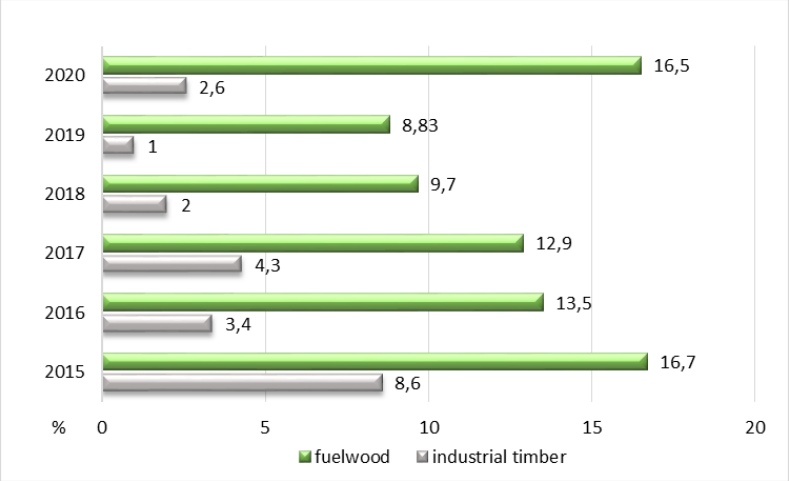
Figure 12. Average ^{137}Cs content in wood in contamination zones. Gomel Forestry Enterprise, 2015-2020



The source: IS "RadFor"

The specific weight of controlled wood samples exceeding the permissible levels of ^{137}Cs content during 2019-2020 is 8.8-16.5% for fuelwood, and 1-2.6% for commercial timber.

Figure 13. Exceeding the permissible level of ^{137}Cs content in wood. Gomel Forestry Enterprise, 2015-2020



The source: IS "RadFor"

33. On the territory of the forestry fund of the Forestry Enteprise, tree species can be arranged as the accumulation of ^{137}Cs increases in the following row: birch → pine → alder → aspen → oak. Table 3 shows the average values of the coefficients of the ^{137}Cs transfer of from soil to wood of the main forest-forming species in the territories of the forest fund of 5 Forestries of the Gomel Forestry Enterprise.

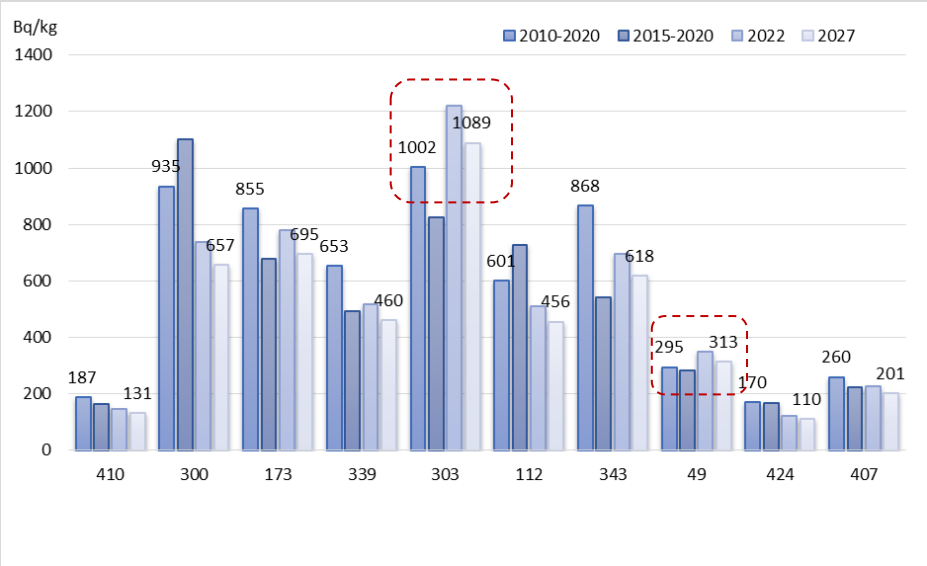
Table 3. Coefficients of ^{137}Cs transfer to wood. Gomel Forestry Enterprise

Forestry name	Pine	Birch	Spruce	Aspen	Alder	Oak	All species
Dobrush	1.04	1.07	1.08	1.67	1.22	1.67	1.24
Priborsk	1.23	1.00		0.92	0.89	1.34	1.07
Romanovichi	0.95	1.06		1.3	1.33	1.15	1.07
Terehovka	1.09	1.01		1.21	1.35	1.32	1.08
Shabrin	0.49	0.51	0.35	0.67	0.55	0.61	0.54

34. The GeoInformation service “RadForInfo” was installed in the radiation control department of the Gomel Forestry Enterprise. A pilot check of the service functions and presentation of all the parameters on the map and the “Radiation factor” interface window was conducted. A random check of the reliability of indicators of the radiation conditions in the forest compartment, sub-compartment was carried out. 28 sub-compartments in the 29 compartments in the range of soil contamination density from 1.5 to 25.4 Ci / km^2 in 3 Forestries were checked.

35. During the GIS check, no deviations were found between the indicators of radiation conditions in the "Radiation factor" interface window and the samples from the "Radiation conditions" and "Forest products" databases for the corresponding forest compartments of the Forestries. Comparison of the actual for a certain period and the predicted levels of ^{137}Cs in wood showed a logical decrease in wood radionuclide contamination over time, with the exception of several forest compartments assigned to zone III in Dobrush Forestry, one of the three checked Forestries.

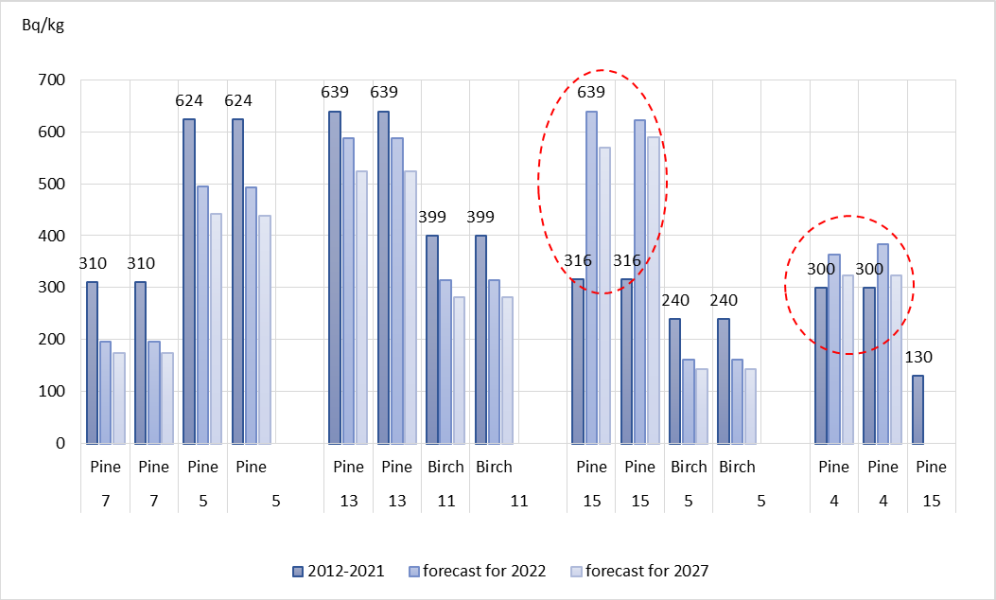
Figure 14. The “RadForInfo” check. Information on the ^{137}Cs content in wood in forest compartments. Dobrush Forestry, Gomel Forestry Enterprise



The source: IS “RadFor” and GIS “RadForInfo”

The predicted values of ^{137}Cs content in wood of various species are higher than the real values for the previous 10 years and were found in the sub-compartments in the forest compartments of zone III in the Dobrush Forestry.

Figure 15. The “RadForInfo” check. Information on the ^{137}Cs content in tree species in the sub-compartments. Dobrush Forestry, Gomel Forestry Enterprise



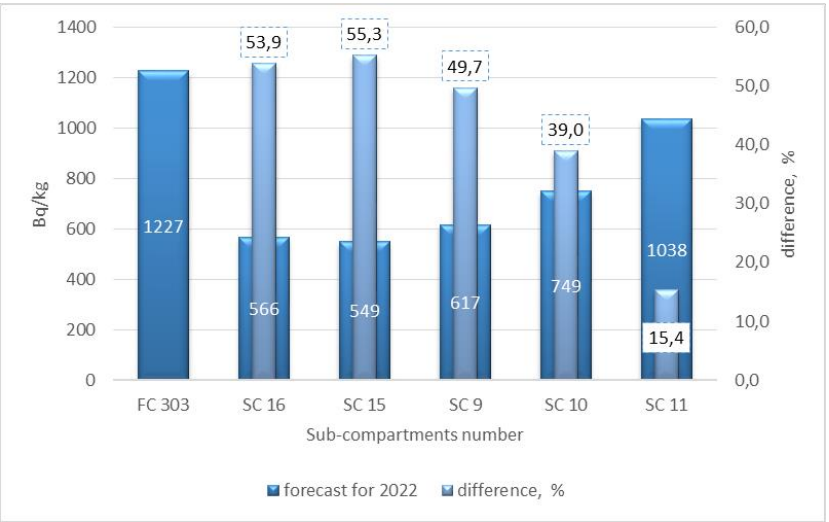
The source: IS “RadFor” and GIS “RadForInfo”

36. To explain the predicted values of ^{137}Cs content in wood, exceeding the real ones, the analysis of the average density of the soil contamination in the forest compartment and sub-compartment was carried out. During the audit period (for the Gomel Forestry Enterprise from 2012 to 2021), 3 cutting areas were surveyed in the 303 forest compartments of the Dobrush Forestry in 2016 and 2 cutting areas in 2019.The forest compartment was surveyed in 2009. Soil contamination densities in cutting areas (sub-compartments) were 15-55% less than in the forest compartment. The content of ^{137}Cs in wood corresponded to these density values and was 316 Bq / kg averaged for pine and 825 Bq / kg for all species in the 303 forest compartments. When calculating the predicted level of ^{137}Cs content in wood, the forecast of the soil contamination density in the forest compartment is used, and if the density is higher than at the surveyed cutting areas, the value of specific activity in the future (as of a given date) is higher than in the previous period. On average, the soil contamination density in the sub-compartments was less than in the forest compartment by 42.3%, and as a result, the forecast of ^{137}Cs content in wood was overestimated.

Table 4. Contamination density at the cutting areas

Sub-compartment (SC)	Survey year	Soil contamination density, Ci/km^2			Difference from average cont.density in FC, %
		Actual	Forecast for 2022	Forecast for 2027	
303 Forest compartments (FC)	2009	36.5	27.4	24.5	0
SC 13	2010	36.5	27.4	24.5	0
SC 15	2010	36,5	27.4	24.5	0
SC 21	2010	36.5	27.4	24.5	0
SC 16	2016	14.0	12.6	11.3	53.9
SC 15	2016	13.6	12.3	11.0	55.2
SC 9	2016	15.2	13.8	12.3	49.7
SC 10	2019	17.4	16.7	15.1	39.0
SC 11	2019	24.1	23.2	20.9	15.4

Figure 16. The difference between the predicted values of ^{137}Cs content in wood in 2022 in the sub-compartments from the average in the forest compartment. Dobrush Forestry

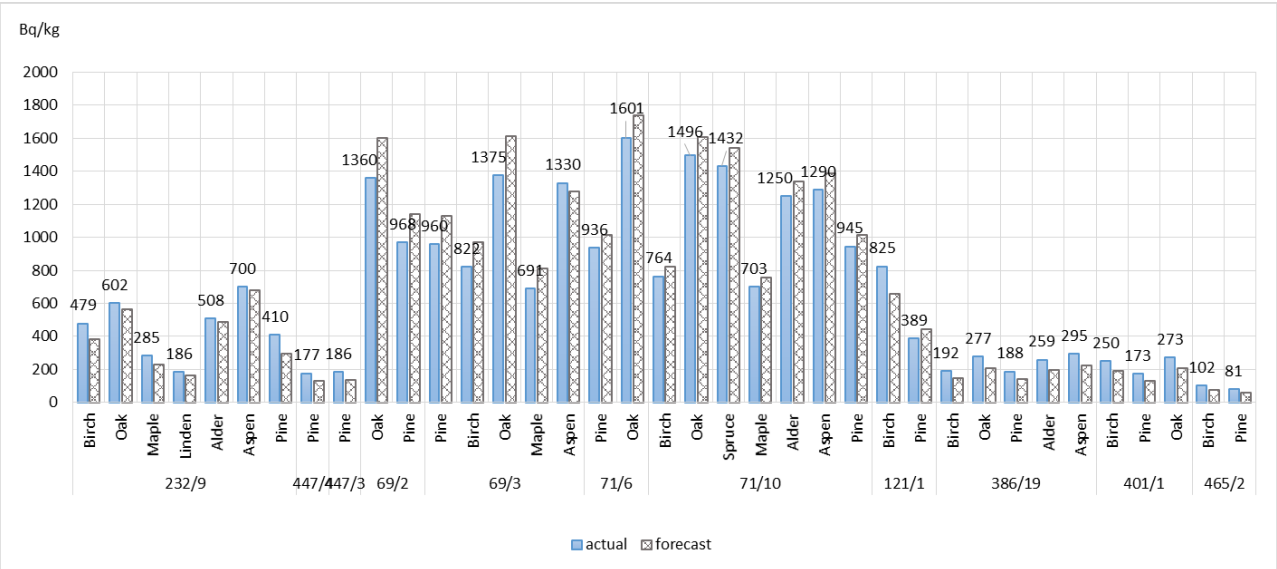


The source: IS “RadFor”

Thus, the calculated predicted value may be higher if the soil contamination density in the forest compartment used in the calculations is higher than in the sub-compartment (at the cutting area). The maximum matching between predicted and actual values will be in the case of the same indicators of soil contamination density in the forest compartment and the sub-compartment. Clarification of the radiation conditions in the compartments in zone III, some of which were surveyed more than 10 years ago (2008-2009), will lead to more reliable results.

37. Comparison of the results of radiation survey of 13 cutting areas in 10 forest compartments of Dobrush and Shabrin Forestries (July-October 2020) with the values of predicted levels of ^{137}Cs in wood calculated in GIS "RadForInfo" was done. When comparing the actual and predicted values of the specific activity of ^{137}Cs in wood of various species in the sub-compartments, upward and downward differences were found. As a rule, at high content of ^{137}Cs in wood (from 700 to 1600 Bq / kg), the calculated predicted values are higher than the actual ones.

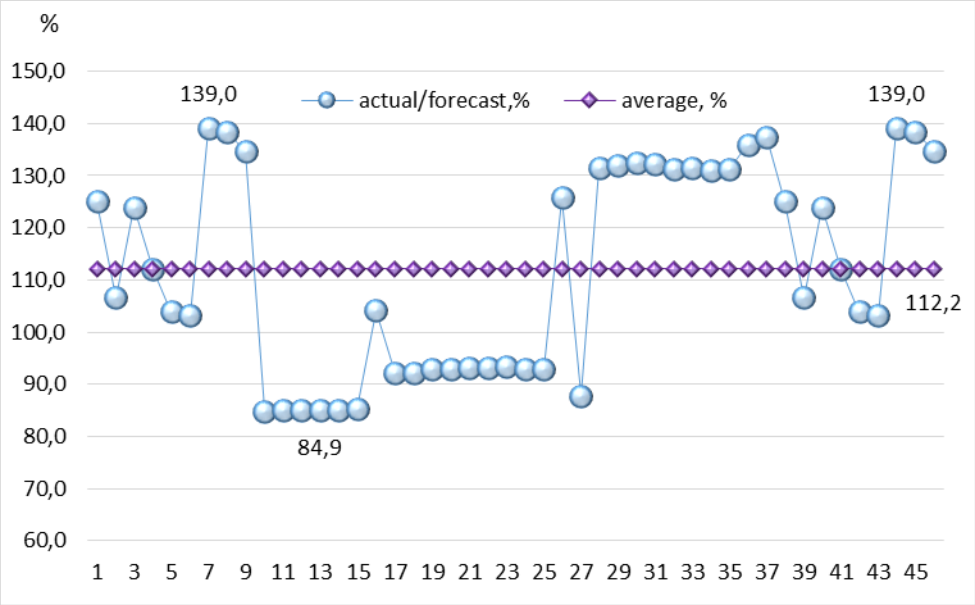
Figure 17. The “RadForInfo” check. Actual and predicted values of ^{137}Cs content in wood (species in the sub-compartments). Dobrush Forestry



The source: IS “RadFor” and GIS “RadForInfo”

The actual ^{137}Cs content in wood differed on average by 12% (maximum 39%) from the predicted one calculated based on the previously obtained results of a survey of the cutting areas in forest compartments. 33% of the actual values were less than the predicted ones (15 out of 46 values). The standard deviation of the actual and predicted values for the sample made was 19.8%.

Figure 18. The "RadForInfo" check. Difference between actual values of ^{137}Cs content in wood and predicted values (species in sub-compartments). Dobrush Forestry



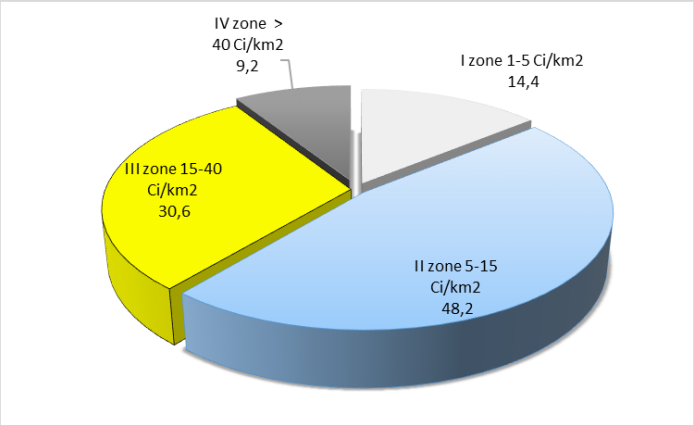
The source: IS "RadFor" and GIS "RadForInfo"

38. **Summary.** The pilot check of the GIS "RadForInfo" as a whole and its components separately showed positive results, confirmed the compliance of the developed functions with the requirements formed in terms of reference. Possible options for the interpretation of predicted values are considered. The factors influencing the calculation results are determined, the most important of which is the accuracy and relevance of data on the radioactive contamination control results. The RCD specialists discussed the issues of the practical application of the web service, noted the clarity and complexity of the presentation of information, which makes it possible to assess quickly the possibility and necessity of carrying out work to clarify the radiation conditions, radiation survey, and demarcation of the cutting areas.

2.4. Cherikov Forestry Enterprise, pilot check

39. Cherikov Forestry Enterprise takes the fifth position in terms of the severity of radioactive contamination out of 44 Forestry Enterprises of the Ministry of Forestry with forest fund territories assigned to zones. The forest fund of the Cherikov Forestry Enterprise has a total area of 102.4 thousand hectares. The area of 48.2 thousand hectares or 47% of the total is assigned to zone I (from 1 to 5 Ci / km2). 30.63 thousand hectares (30%) are assigned to II (from 5 to 15 Ci / km2). 9.24 thousand hectares (9%) are assigned to III (from 15 to 40 Ci / km2). The area of forests assigned to the contamination zones is 88.0 thousand hectares or 86% of the total. Zone III includes 10% of all "contaminated" forests of the Forestry Enterprise.

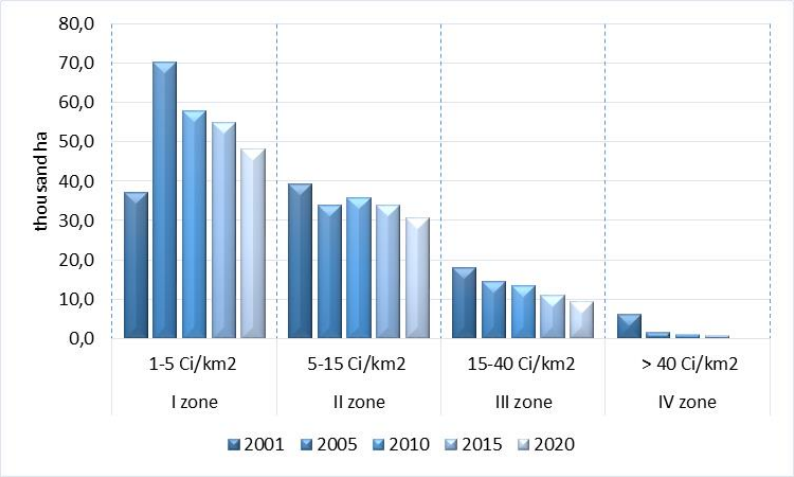
Figure 19. Distribution of the territory by zones of radioactive contamination. Cherikov Forestry Enterprise, 2020



The source: IS "RadFor"

40. Over the past 10 years, the area of zone II (by 22%) and zone III has decreased by almost 2 times, while it has increased in zone I (by 23%) due to the transition of part of the forest compartments from zone II due to a decrease in soil contamination density to values of 4.94 Ci / km^2 and less. Since 2010, there has been a steady decrease in the area in each zone of radioactive contamination due to the balance of the number of forest compartments that "left" one zone and "passed" into another and the absence of significant land volumes acceptance.

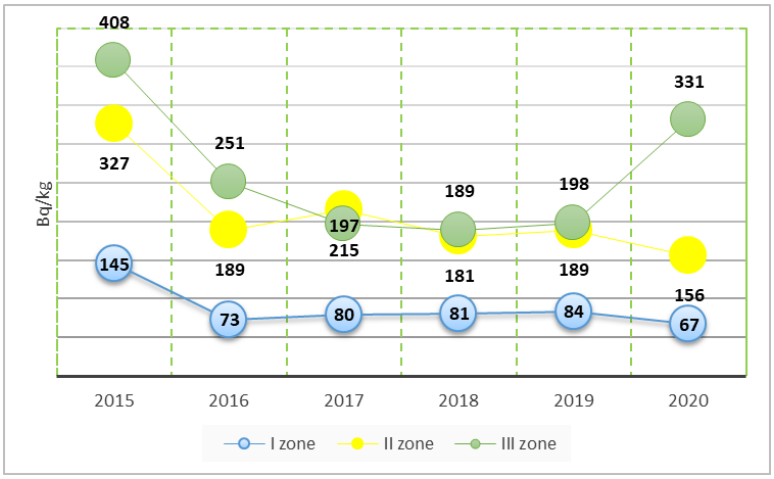
Figure 20. Changes in the area of contamination zones from 2001 to 2020. Cherikov Forestry Enterprise



The source: IS "RadFor"

41. During the last 5 years, the average levels of ^{137}Cs in wood in zone III are not more than 410 Bq / kg with a maximum value of 5000 Bq / kg, in II zone - 350 Bq / kg. Compared to the Vetka and Gomel Forestry Enterprises, the ^{137}Cs wood contamination in the forests of the Cherikov Forestry Enterprise is lower both in absolute values and in the specific weight of wood that exceeds the permissible levels, which is associated with the remoteness from the accident site and the soil characteristics of the region.

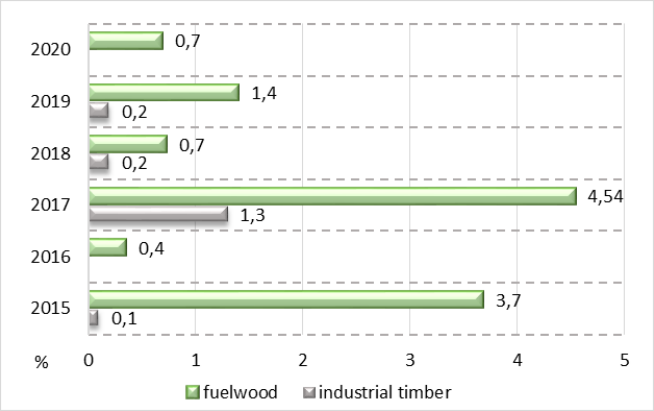
Figure 21. Average content of ^{137}Cs in wood in the contaminated zones. Cherikov Forestry Enterprise, 2015-2020



The source: IS "RadFor"

Thus, the specific weight of controlled wood samples exceeding the permissible levels of ^{137}Cs during 2019-2020 is 1.4-0.7% for fuelwood, 0.2% for commercial timber.

Figure 22. Exceeding the permissible level of ^{137}Cs content in wood. Cherikov Forestry Enterprise, 2015-2020



The source: IS "RadFor"

42. On the territory of the forestry fund of the Forestry Enterprise, tree species can be arranged as the accumulation of ^{137}Cs increases in the following row: pine → birch → spruce → aspen → alder → oak. Table 5 shows the average values of the coefficients of the 137Cs transfer of from soil to wood of the main forest-forming species in the territories of the forest fund of 8 Forestries of the Cherikov Forestry Enterprise.

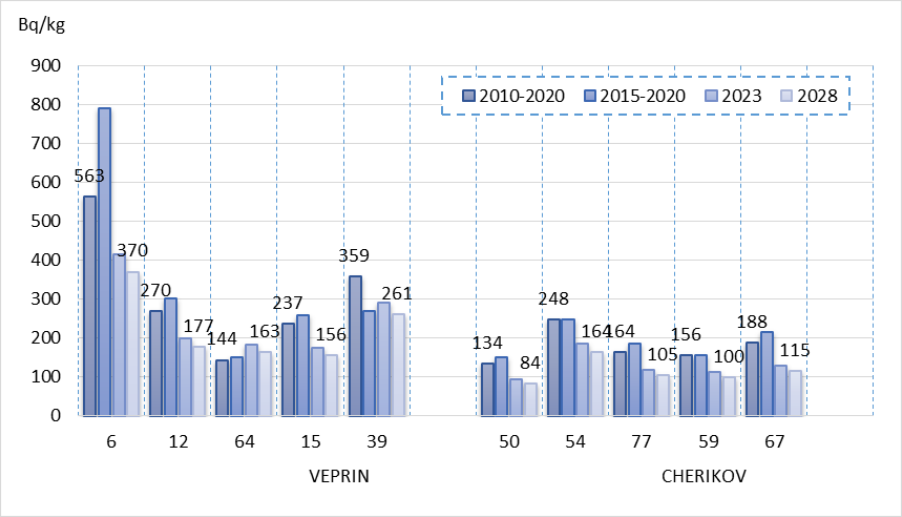
Table 5. Coefficients of ^{137}Cs transfer to wood. Cherikov Forestry Enterprise

Forestry name	Pine	Birch	Spruce	Aspen	Alder	Oak	All species
Veprin	0.77	0.78	0.84	0.93	0.97	1.22	0.92
Veremeiki	1.29	1.30	1.51	1.66	1.40	1.81	1.50
Gizhenka	0.77	0.81	0.93	0.91	1.09	0.99	0.92
Ezery	0.67	0.79	0.78	0.91	0.99	1.14	0.88
Lesnaya	0.60	0.70	0.66	0.70	0.80	0.66	0.69
Limensk	0.89	1.04	1.18	1.12	1.27	1.48	1.16
Slavgorod	0.65	0.78	0.71	0.81	0.82	0.81	0.76
Cherikov	0.64	0.78	0.81	0.76	1.31	0.88	0.86

43. A GeoInformation service “RadForInfo” was installed in the radiation control department of the Forestry Enterprise. A pilot check of the service functions and the presentation of all parameters on the map and interface window “Radiation factor” was done. The reliability of the indicators of radiation conditions in 7 Forestries (35 sub-compartments in 35 forest compartments in the range of soil contamination density from 1.7 to 14.5 Ci / km^2) was checked selectively.

44. During the GIS check, no deviations between the indicators of the radiation conditions in the “Radiation factor” interface window and the samples from the “Radiation situation” and “Forest Products” databases for the corresponding forest compartments of the Forestry were found. Comparison of actual for a certain period and predicted levels of ^{137}Cs content in wood showed a logical decrease in wood radionuclide contamination over time.

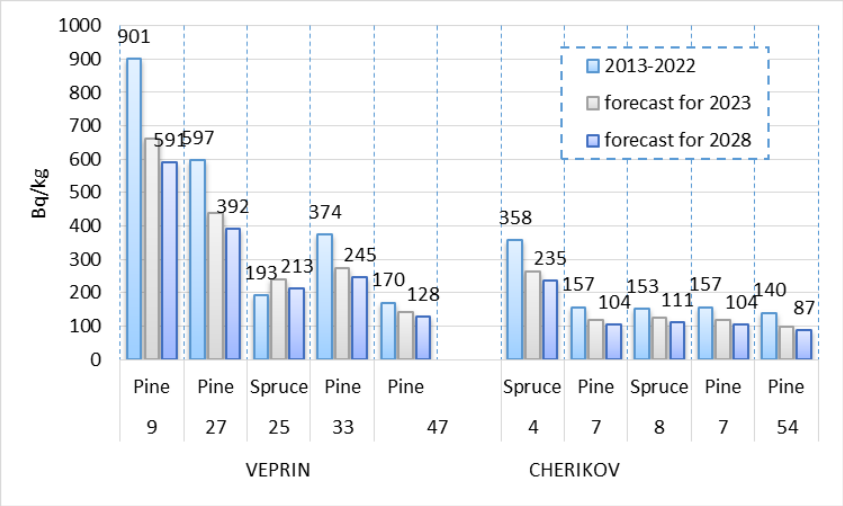
Figure 23. The “RadForInfo” check. Information on the content of 137Cs in wood in forest areas. Veprin and Cherikov Forestry



The source: IS “RadFor” and GIS “RadForInfo”

The matching of the ^{137}Cs content values in the wood of each species in the sub-compartments presented in the GIS "RadForInfo" and samples from the IS "RadFor" databases was established.

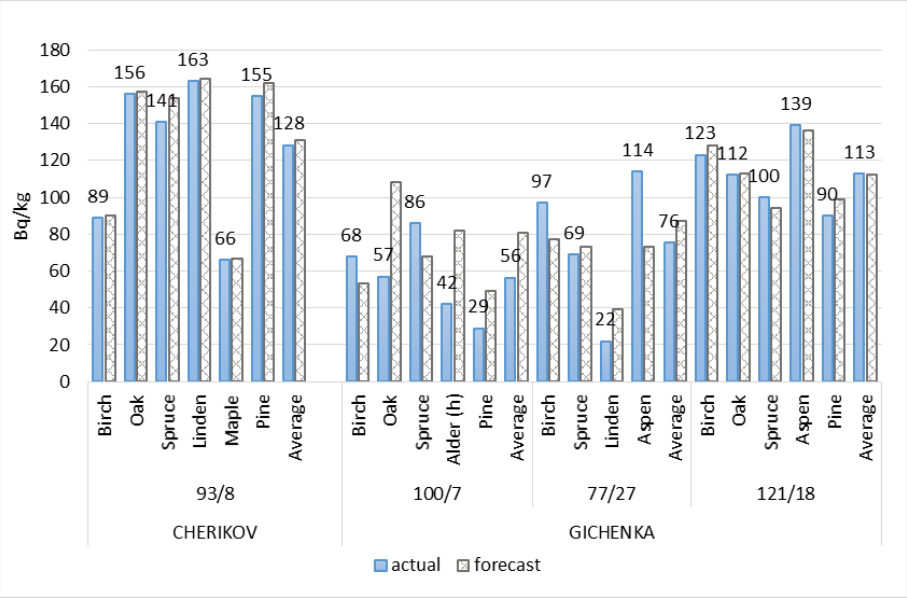
Figure 24. The “RadForInfo” check. Information on the content of ^{137}Cs in tree species in the sub-compartments. Veprin and Cherikov Forestries



The source: IS “RadFor” and GIS “RadForInfo”

45. Comparison of the results of the radiation survey of the 16 cutting areas in the 15 forest compartments of Gizhenka, Lesnaya, Slavgorod, and Cherikov Forestries (October 2020) with the values of predicted ^{137}Cs levels in wood calculated in the GIS "RadForInfo" was carried out. When comparing the actual and predicted values of the specific activity of ^{137}Cs in wood of various species in the sub-compartments, it was found that most (70%) of the predicted values exceed the actual ones.

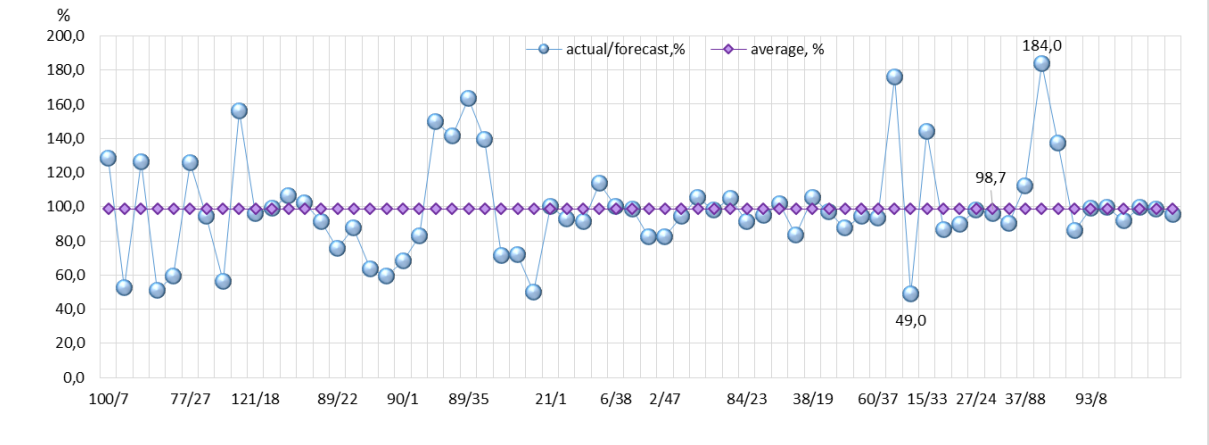
Figure 25. The "RadForInfo" check. Actual and predicted values of ^{137}Cs content in wood (species the sub-compartments)



The source: IS "RadFor" and GIS "RadForInfo"

On average, the difference between the actual and predicted values of the specific activity of ^{137}Cs in wood of various species in the sub-compartments does not exceed 6%. The maximum difference for a particular species can be significant (84%). The mean and median values of the fact / forecast ratio for this sample (66 values) are close to 1, the standard deviation from the mean is 28.7%, which confirms the sufficient reliability of the predicted values calculated in the GIS "RadForInfo".

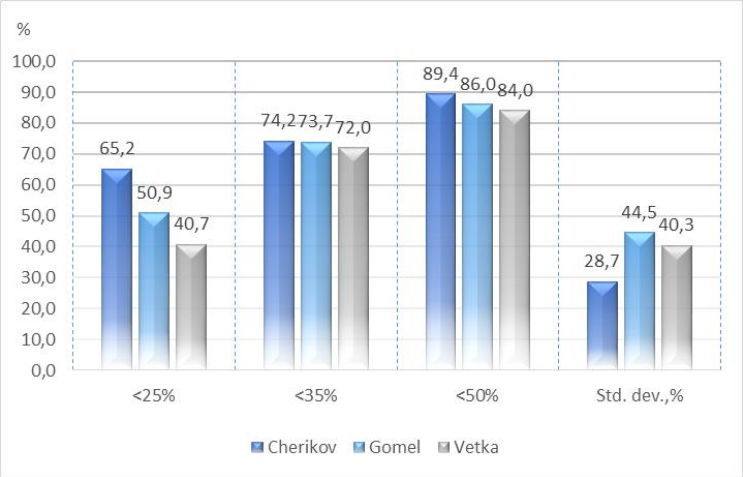
Figure 26. The "RadForInfo" check. Difference between actual values of ^{137}Cs content in wood and predicted values (species in the sub-compartments).



The source: IS "RadFor" and GIS "RadForInfo"

46. Comparison of the results of the pilot check in the Cherikov Forestry Enterprise with the rest shows the highest reliability of the calculated forecast values, which is explained by the representativeness of the data due to the smaller area in zone III, mosaic radioactive contamination, and lower transfer coefficients. So, in the Cherikov Forestry Enterprise, the main part of the forecast values (74%) differs less than 35% from the actual ones, while the spread from the average actual / forecast ratio is less than 30%.

Figure 27. The specific weight of the actual values of ^{137}Cs content in wood with a deviation from the predicted by 25%, 35% and 50% in 3 Forestry Enterprises (148 values)



The source: IS “RadFor” and GIS “RadForInfo”

47. **Summary.** The pilot check of the GIS “RadForInfo” as a whole and its components separately showed positive results, confirmed the compliance of the developed functions with the requirements formed in terms of reference. In most forest compartments (> 80 %) of the Cherikov Forestry Enterprises there is information on the ^{137}Cs content in wood, which ensures the completeness of cartography on this subject. Not so significant (compared with the territories of the “near” zone) gradients of the soil contamination density within the forest compartment make it possible to determine the predicted levels more accurately. The RCD specialists discussed the issues of the practical application of the web service, noted the clarity and complexity of the presentation of information, which makes it possible to assess quickly the possibility and necessity of carrying out work to clarify the radiation conditions, radiation survey, and demarcation of the cutting areas.

3. Create and publish a brochure “User Guide for RadForInfo Information Module”

3.1 “RadForInfo” revision based on the results of testing by “Bellesozashchita” specialists and pilot check in Forestry Enterprises

48. During the revision of the Geoinformation service “RadForInfo”, some functions were corrected, using of which led to the software errors identified in the testing of the IS "RadFor". New functions that make it possible to present the information promptly from the “Forest products” database in the form of calculated values of the ^{137}Cs specific activity in products (Bq / kg) and the ^{137}Cs coefficient of transfer, as well as a new form of a report with printing, have been developed.

49. As a result of testing the toolbar organization of the GIS “RadForInfo” window, shortcomings in the design of buttons were revealed. Due to the discrepancy or lack of signatures of some buttons in the interlinear for the left and right keys, the names in the taskbar have been corrected: (i) “Map layers” to “Map layers / layers control”; (ii) “Coordinates of soil sampling sites / edit coordinates of soil sampling sites” to “Enter coordinates of soil sampling sites / delete,

edit coordinates"; (iii) "Apply soil sampling sites / Clean" to "Show soil sampling sites / Hide icons"; (iv) "Colorize layers / compartments to clarify RC" to "Colorize map / Select compartments to clarify RC"; (v) "Clear layers" to "Clear map subject".

50. A setting for the introduction and display of "icons" indicating the soil sampling sites in the forest compartment during the radiation survey was made. A limitation on the number of characters per compartment when entering the coordinates of soil sampling sites was set. The function allows to add and save only one icon per forest compartment.

51. During the testing, problems with the operation of functions providing information exchange between the IS "RadFor" and peripheral versions of the IS "RadForView" were identified: when importing data into the IS "RadForView" using the "RADFOR" folder, a program error appeared when loading data and forming a map in the "GeoInformation service RadForInfo" window. The data export function providing the formation of the catalogs of the "RADFOR" folder and import, and update of the IS "RadForView" was improved. The folder "RADFOR" includes catalogs that allow generating automatically the system catalog "Maps", which is necessary to run the RadForView program on a new exe-file and generate interactive maps of the Forestry Enterprises in the RadForInfo window. As a result of repeated testing, when exporting data from the IS "RadFor", the "RADFOR" folder is formed where catalogs with files for updating are successfully formed. The function of importing data from the "RADFOR" folder into the IS "RadForView" is carried out with the formation of the "Maps" catalog. In the GIS "RadForInfo" window, a Forestry Enterprise map on a topographic basis is opened.

52. For the user's convenience, new functions have been developed in the DB "Forest Products" window, allowing calculating and presenting the average values of a specific activity (Bq / kg) and coefficient of the ^{137}Cs transfer for the selected type of product quickly. The function works automatically due to successive actions in the "Search" window, such as entering search parameters and selecting the "Find" button. As a result, two more values appear in the title bar of the DB "Forest Products" window next to the data showing the number of selected records (the number of sample rows), such as the average value of specific activity, which is calculated using the field "Specific activity, Bq / kg" and the average value of the ^{137}Cs transfer coefficient, which is calculated in the field "Transfer coefficient".

53. A new report form "Coefficients of ^{137}Cs transfer to wood in various types of forest conditions on the territory of the forest fund of Forestries" was developed. To do this, a button for launching the generator for a new report form had been added to the "Create report" window. This report can be obtained for a specified period. Fields for manual entry of the report generation period had been added to the "Report generation" window. To view the report, select the button "Coefficients of ^{137}Cs transfer to wood in various types of forest conditions on the territory of the forest fund of Forestries". The generated report can be viewed and printed in the "Report constructor" window

3.2 Elaboration and publication of the brochure "User Guide for RadForInfo Information Module"

54. The "RadForInfo" information module for obtaining data on the radiation conditions in forests based on cartographic materials is designed to provide information support and facilitate the availability and convenience of obtaining information when making decisions on the forest management in zones of radioactive contamination, as well as its planning from a long-term perspective. Application of the "RadForInfo" information module allows all the radiation indicators for the forest compartment to be available at the same time, both for the current period and in the future (for a given date), receiving this information promptly based on the maps of the Forestry Enterprises.

55. The information module allows the users to ensure interaction with information systems of Forestry Enterprises, generate complete, reliable and up-to-date information about the radiation conditions in forests using cartographic materials. The information module makes it possible to form integrated interactive maps of distinct Forestry Enterprises with reference to forest compartments and sub-compartments, as well as to receive information on the indicators of the radiation conditions at the present time and in the forecast for a given date with the coloring of forest compartments in accordance with data on the density of soil contamination with ^{137}Cs and the ^{137}Cs content in wood.

56. The "RadForInfo" information module for obtaining data on the radiation conditions in forests based on cartographic materials can operate and perform specified functions subject to the requirements for hardware, system and application software.

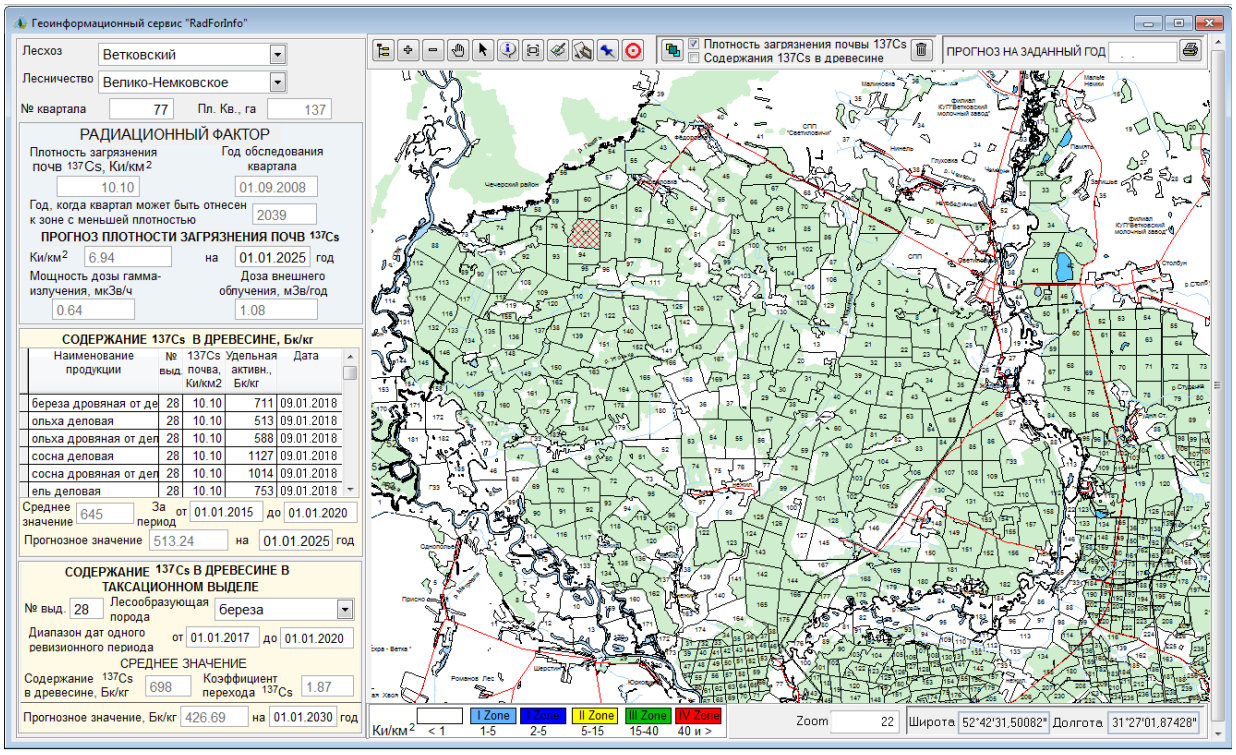
57. The information module for obtaining data on the radiation conditions in forests based on cartographic materials is a synthesis of a GeoInformation system, a database management and decision support systems.

58. The capabilities of the "RadForInfo" module are directly related to the volume of indicators on the radiation conditions in forests, which are contained in the databases of the IS "RadFor".

59. Figure 28 shows the window of the GIS "RadForInfo". This window opens when you select the "RadForInfo" GIS item in the "Base" menu. The window has two functional parts:

– Informational, displaying data from the "Radiation conditions" and "Forest Products" databases and calculated values.
– Cartographic, allowing the users to control the display, adjust the map layers, as well as graphically display the current and forecast information on the density of the ^{137}Cs soil contamination and on the ^{137}Cs content in wood in forest compartments of a given Forestry.

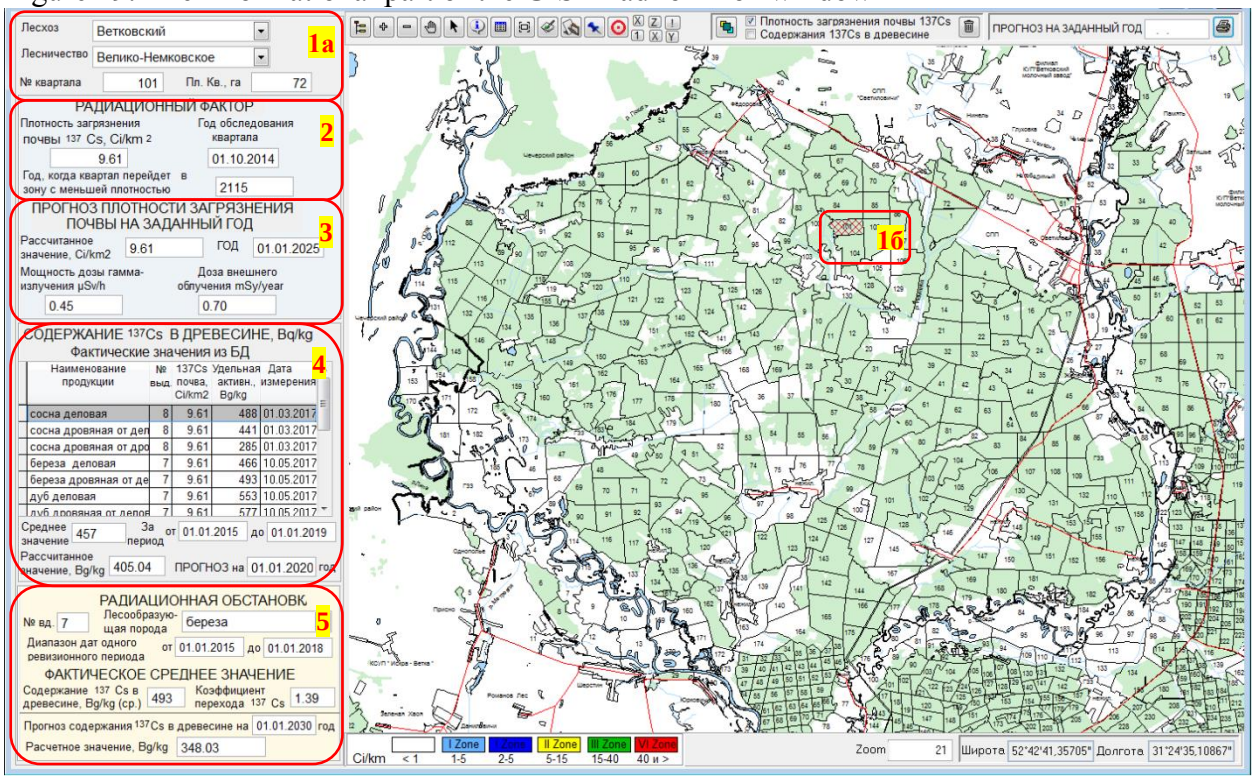
Figure 28. GIS "RadForInfo" window



The source: IS "RadFor" and GIS "RadForInfo"

60. Interaction with the system begins with the selection of the required Forestry Enterprise and Forestry. The selection can be made manually from the drop-down lists, as shown the callout 1a, or on the map, as shown in the callout 1b of the Figure 29.

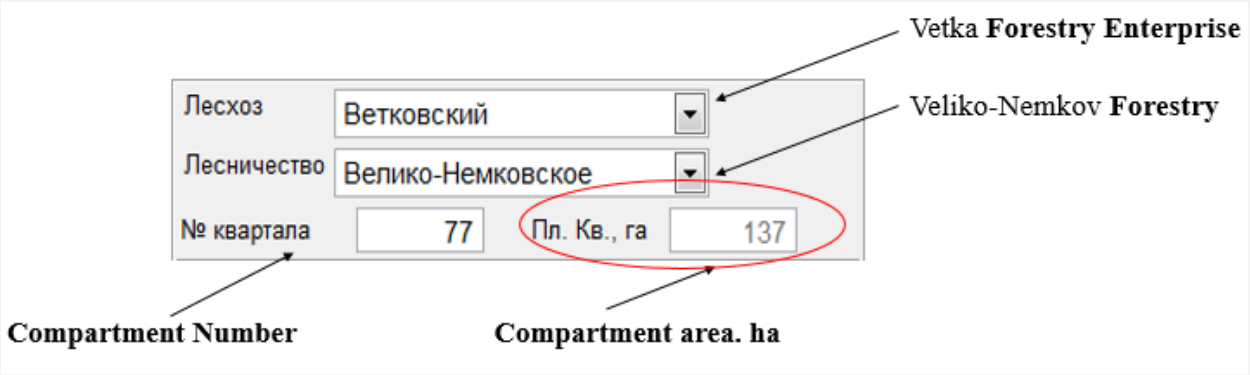
Figure 29. The informational part of the GIS "RadForInfo" window



The source: IS "RadFor" and GIS "RadForInfo"

61. After selecting on the map or manually, the Forestry Enterprise, Forestry, compartment number, and the values of the corresponding fields are automatically filled in with data from the database (Fig. 30-34)

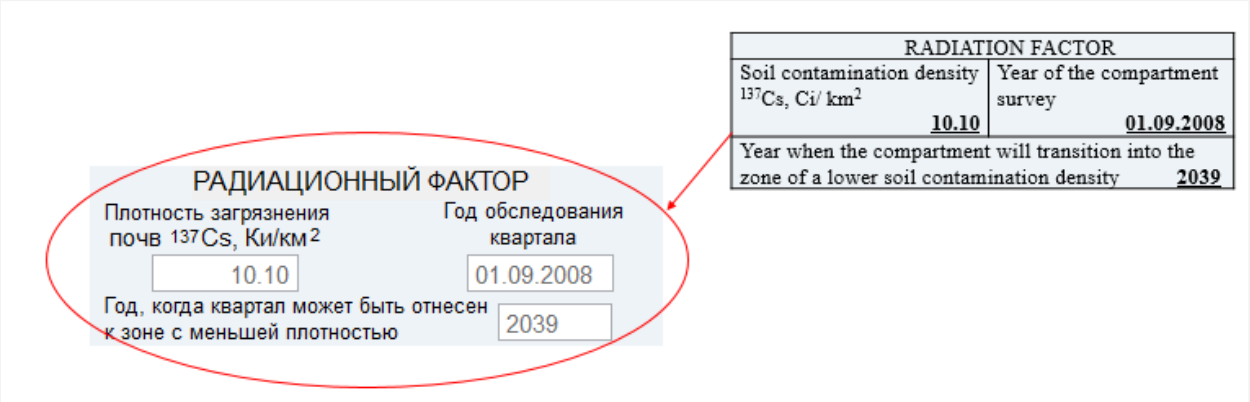
Figure 30. Automatic fill-in of the field "Compartment area, ha" with data from the database



The source: IS "RadFor" and GIS "RadForInfo"

62. In the "Radiation Factor" section, the values of the information fields "Soil contamination density with ^{137}Cs, Ci / km^2" and "Year of the compartment survey" are automatically filled in from the "Radiation conditions" database so that to calculate the value of the field "Year when the compartment will transition into the zone of a lower soil contamination density" (Fig. 31).

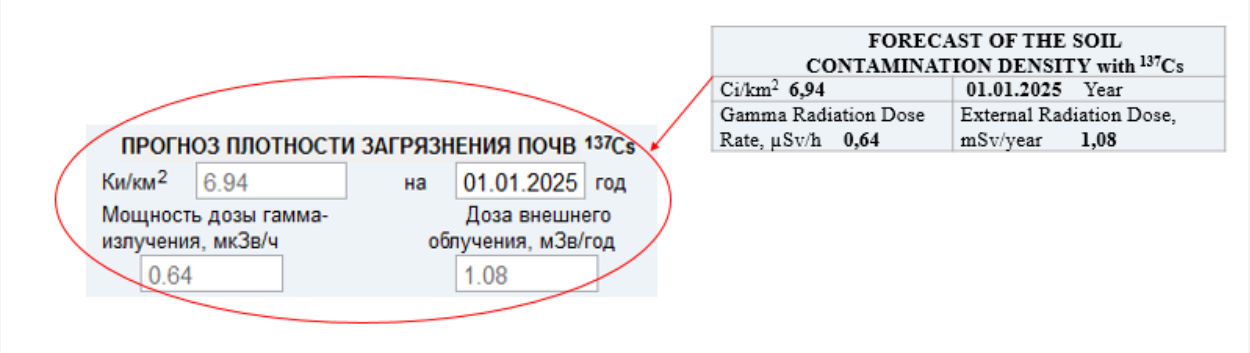
Figure 31. Automatic fill-in of the fields in the “Radiation Factor” form with the data from the database



The source: IS “RadFor” and GIS “RadForInfo”

63. In the section “Forecast of the soil contamination density with ^{137}Cs”, the specified date is entered in the “Year” field, for which the predicted value of the soil contamination density in “Ci / km^2” field is calculated. The value for the field “Gamma Radiation Dose Rate, µSv/h” is entered from the “Radiation conditions” database. The value in the field “External Radiation Dose, mSv/year” is calculated automatically (Fig. 32).

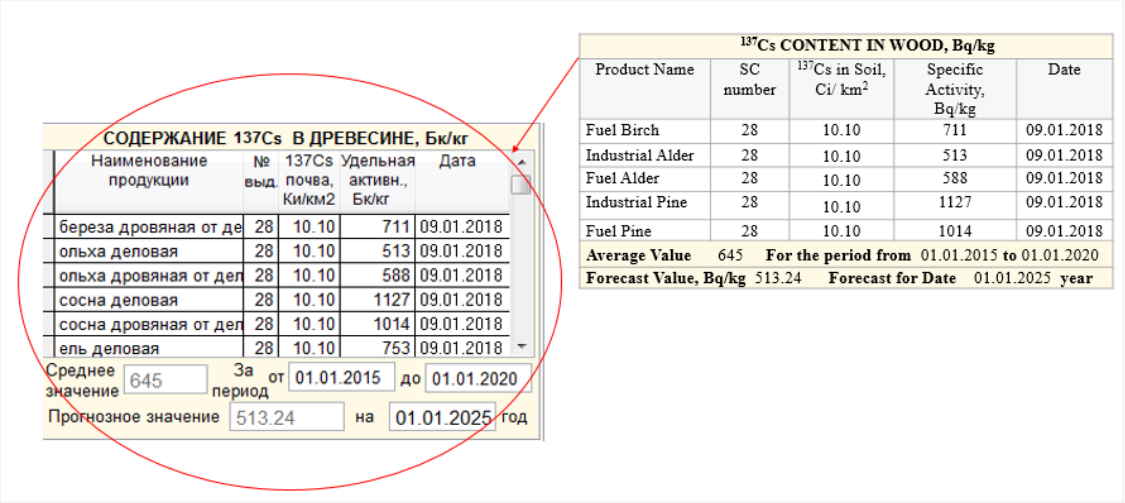
Figure 32. Automatic fill-in of the fields in the form “Forecast of the soil contamination density with ^{137}Cs” with the data from the database



The source: IS “RadFor” and GIS “RadForInfo”

64. In the section “^{137}Cs content in wood, Bq / kg”, the actual values of the “Product Name”, “SC number”, “^{137}Cs in soil, Ci / km^2”, “Specific activity, Bq / kg” and “Date” are filled in automatically from the database “Forest products”. When entering period for the selected compartment, the “Average value” is calculated. The field “Forecast value” of the specific activity of ^{137}Cs in wood for the selected compartment is calculated on the basis of the data from the “Radiation conditions” and “Forest products” databases (Fig. 33).

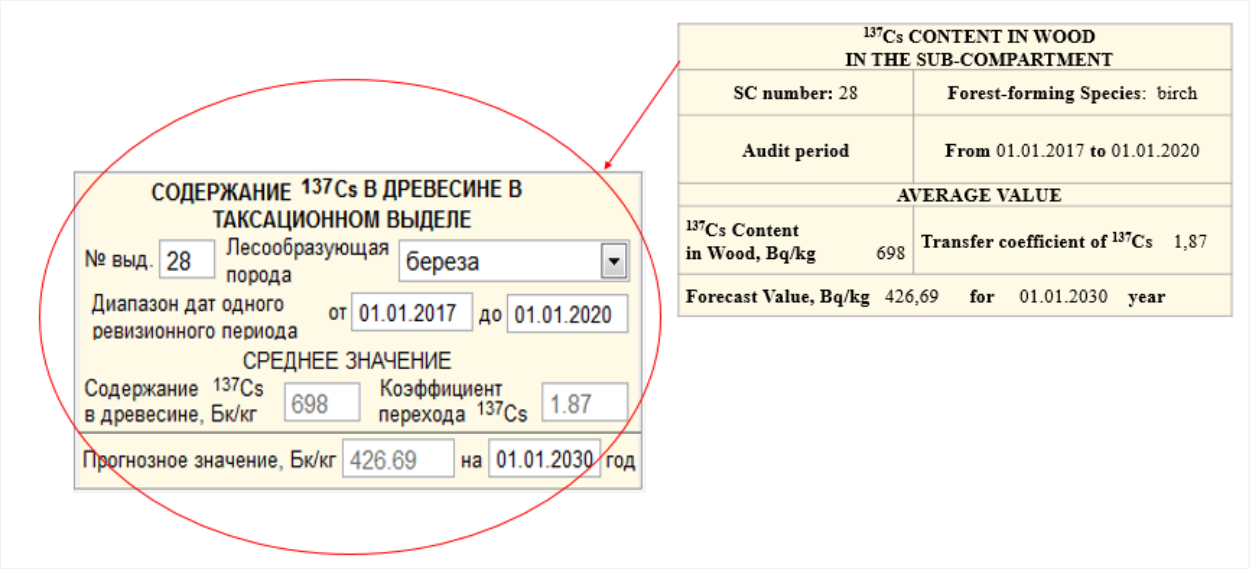
Figure 33. Automatic fill-in of the fields in the form "^{137}Cs content in wood, Bq / kg" with the data from the database



The source: IS "RadFor" and GIS "RadForInfo"

65. In the section "^{137}Cs content in wood in the sub-compartment", the value in the field "SC number" is either entered manually or selected on the map. After that, in the drop-down list of the main forest-forming species, the needed species is selected and the audit period of interest is set. In the field "^{137}Cs content in wood, Bq / kg", the average value of the specific activity for the selected species from the "Forest Products" database is automatically calculated and entered. In the field "Transfer coefficient of ^{137}Cs", the average value of the ^{137}Cs transfer coefficient for the selected species from the "Forest products" database is automatically calculated and entered (Fig. 34). When entering the year of interest in the "Year" field, the average value of the ^{137}Cs transfer coefficient from soil to wood for forest-forming species is calculated and entered into the "Forecast value, Bq / kg" field. The calculation is carried out in the "Transfer coefficient of ^{137}Cs" field from the "Forest Products" database only for the selected forest-forming species.

Figure 34. Automatic fill-in of the fields in the form "^{137}Cs content in wood in the sub-compartment" with the data from the database



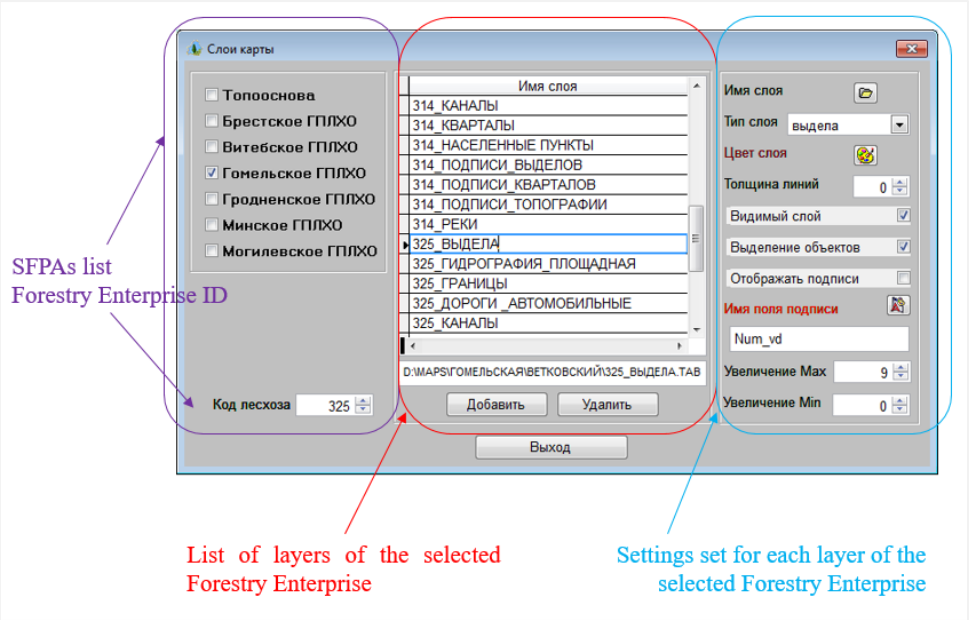
The source: IS "RadFor" and GIS "RadForInfo"

66. The cartographic part of the window contains a set of buttons for working with loaded map layers:

	Map layers / Manage layers / Ctrl - Saving the order of layers	to set up map layers (see subclause 4.1.2.1)
	Zoom in	to enlarge the scale of the map
	Zoom out	to reduce the scale of the map
	Move the Map	to drag and drop map layers in the window;
	Highlighting the compartments	to highlight compartments on the map
	Information	to obtain information about the selected object
	Restore position, scale / Remember position, scale	to restore the position and scale of the current map layers, and to save the position and scale of the current map layers
	Create BMP	to save the current image in a graphic BMP file
	Save map layers	to save a layer of compartments of the selected forestry section in MapInfo format
	Enter coordinates of the soil sampling sites / delete, edit coordinates	to open a window for entering coordinates of the soil sampling sites / to open a window for deleting, editing coordinates of soil sampling sites (see subclause 4.1.2.2)
	Show soil sampling sites / hide icons	to map the soil sampling sites for the selected Forestry Enterprise, Forestry / to erase the soil sampling marks on the map

67. When pressing the left mouse button in the area of the cartographic part of the GIS "RadForInfo" window, the "Map layers" window opens.
The working window is divided into three areas:
– SFPAs list and Forestry Enterprise ID;
– List of layers of the selected Forestry Enterprise;
– Settings set for each layer of the selected Forestry Enterprise.
68. In the first area, SFPA and Forestry Enterprise is selected for which the map layers and layer parameters are defined. The second area contains a list of layers and the full path to their storage. The third area contains tools for adjusting the layers (Fig. 35).

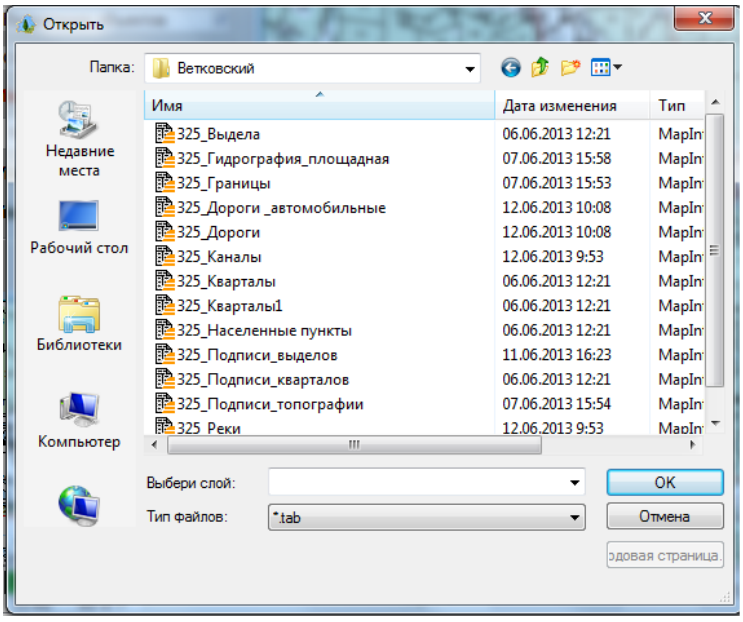
Figure 35. Representation of the data in the “Map layers” window



The source: GIS “RadForInfo”

69. Layers of digital maps are stored on disks in directories built on the principle of subfolders. For example, D: \ Maps \ Gomel \ Vetka\. Digital map layer settings are stored in \ User \ MapsLayers.dbf and \ User \ MapsLayers.cdx files. Layers for the current Forestry Enterprise are added when the “Add” button is clicked. This launches a standard “open” dialog box of the user’s file (Fig. 36). The current layer is deleted with the help of the “Delete” button.

Figure 36. The “Open” dialog box of the user’s file

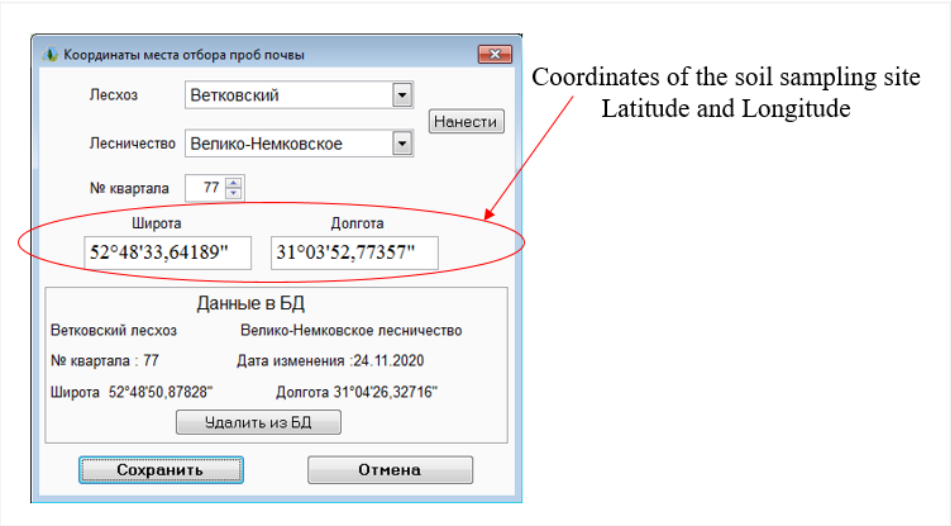


The source: GIS “RadForInfo”

70. Enter the coordinates of the soil sampling sites. When pressing left mouse button the cursor turns into a needle ( ) movable around the map. Pressing the left mouse button in the required place of the selected compartment opens the window “Coordinates of soil sampling site” (Fig. 37). In this case, the fields “Forestry Enterprise”, “Forestry”, “Compartment number”,

"Latitude", and "Longitude" will be filled in with the current values automatically. If the coordinates of the soil sampling site for the current compartment have already been entered into the database, these data will also be displayed in the active window.

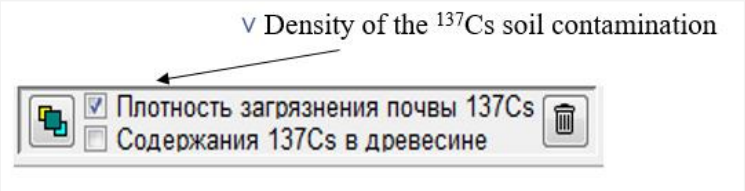
Figure 37. Representing the data in the "Coordinates of soil sampling site" window



The source: GIS "RadForInfo"

71. The developed software tool makes it possible to generate an up-to-date map of forest lands with coloring as to radioactive contamination zones on the date of survey of the forest compartments; to these ends, a checkbox "Density of the ^{137}Cs soil contamination" is enabled (Fig. 38).

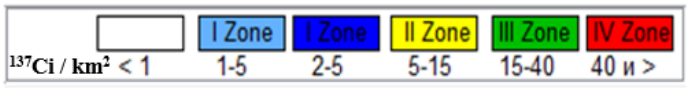
Figure 38. The control checkbox for applying thematic coloring



The source: GIS "RadForInfo"

72. In this case, in the lower part of the screen, the symbols for the color of the radioactive contamination zones are displayed (Fig. 39).

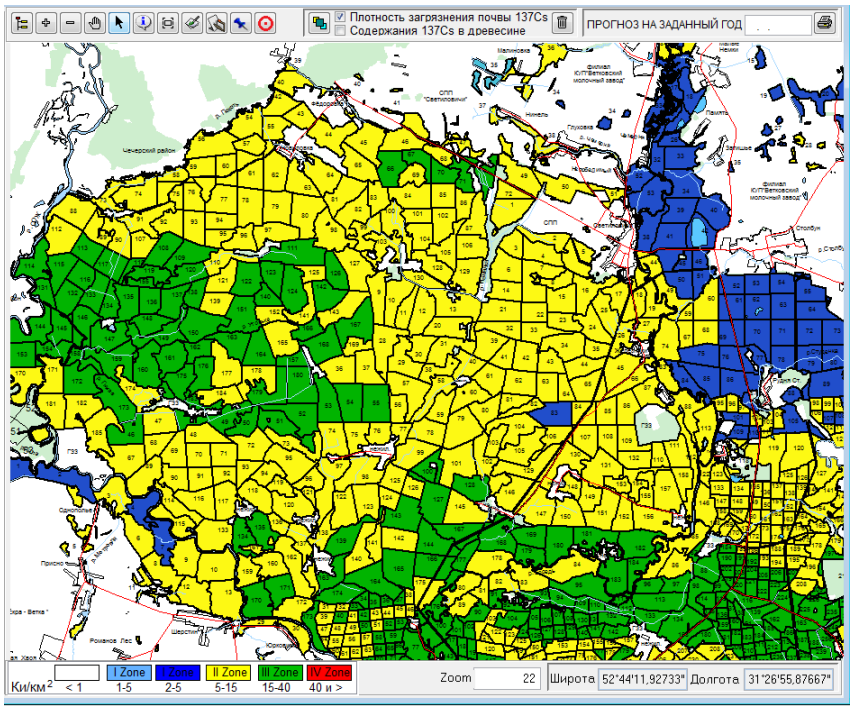
Figure 39. The map legend with thematic coloring



The source: GIS "RadForInfo"

73. After pressing the left mouse key on the "Colorize the map" button  , the compartments are colored in accordance with the values of the ^{137}Cs soil contamination density (Fig. 40).

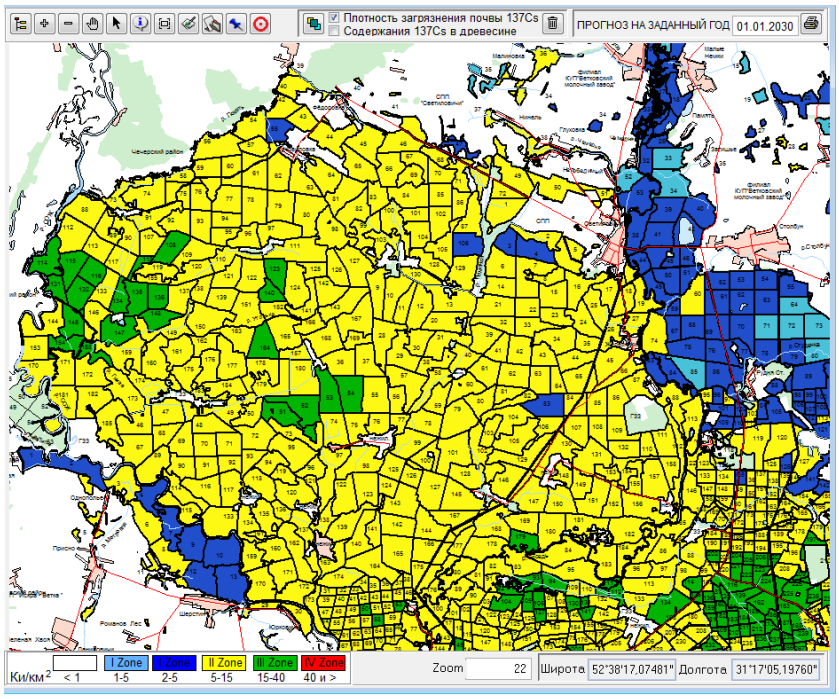
Figure 40. The compartments coloring according to the values of the ^{137}Cs soil contamination density



The source: GIS “RadForInfo”

74. The information module has made it feasible to form a forecast map of forest lands with the coloring of radioactive contamination zones for a given date, the value of which is entered in the “Forecast for a given year” field. An example of a map with colorized compartments according to the values of the ^{137}Cs soil contamination density for a given date is shown in Figure 41.

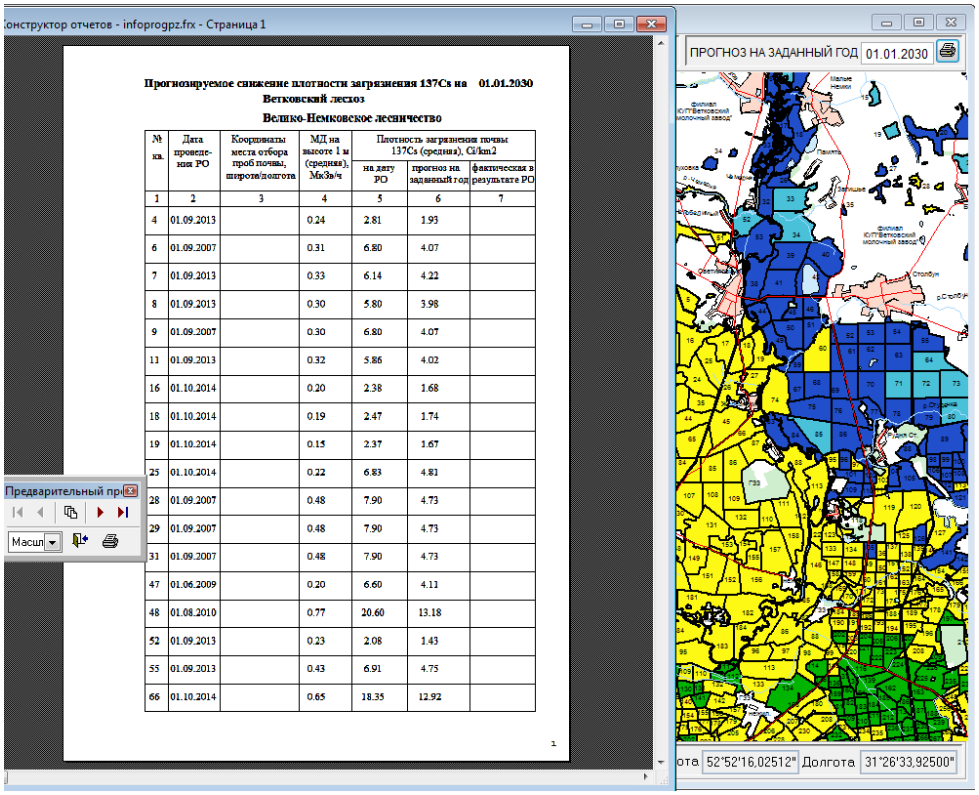
Figure 41. Forecast map with coloring of compartments according to the values of the ^{137}Cs soil contamination density



The source: GIS “RadForInfo”

75. After clicking the left mouse key on the button , the report “Predicted decrease in the ^{137}Cs contamination density” for a given date is generated, an example of which is shown in Figure 42.

Figure 42. Example of the “Predicted decrease in the ^{137}Cs contamination density” Report

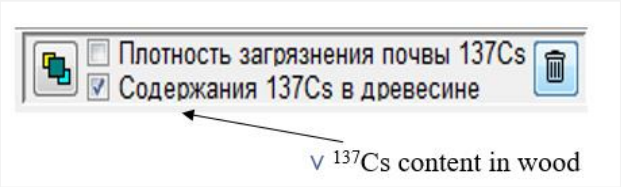


№ кв.	Дата проведе-ния РО	Координаты места отбора проб почвы, широта/долгота	МД на высоте 1 м (средняя), МкЗв/ч	Плотность загрязнения почвы 137Cs (средняя), Ci/km2		
				на дату РО	прогноз на заданный год	фактическая в результате РО
1	2	3	4	5	6	7
4	01.09.2013		0.24	2.81	1.93	
6	01.09.2007		0.31	6.80	4.07	
7	01.09.2013		0.33	6.14	4.22	
8	01.09.2013		0.30	5.80	3.98	
9	01.09.2007		0.30	6.80	4.07	
11	01.09.2013		0.32	5.86	4.02	
16	01.10.2014		0.20	2.38	1.68	
18	01.10.2014		0.19	2.47	1.74	
19	01.10.2014		0.15	2.37	1.67	
25	01.10.2014		0.22	6.83	4.81	
28	01.09.2007		0.48	7.90	4.73	
29	01.09.2007		0.48	7.90	4.73	
31	01.09.2007		0.48	7.90	4.73	
47	01.06.2009		0.20	6.60	4.11	
48	01.08.2010		0.77	20.60	13.18	
52	01.09.2013		0.23	2.08	1.43	
55	01.09.2013		0.43	6.91	4.75	
66	01.10.2014		0.65	18.35	12.92	

The source: GIS “RadForInfo”

76. The developed software tool makes it possible to generate an up-to-date map of forest lands with coloring according to the ^{137}Cs content in wood as of the date of survey of the forest compartments, for which a checkbox “^{137}Cs Content in wood” is enabled (Fig. 43).

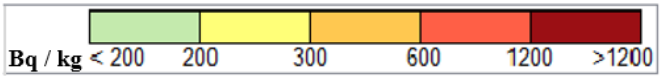
Figure 43. Control checkbox for applying thematic coloring



The source: GIS “RadForInfo”

77. In this case, in the lower part of the screen, the conventional coloring symbols are displayed according to the value of the ^{137}Cs content in wood (Fig. 44).

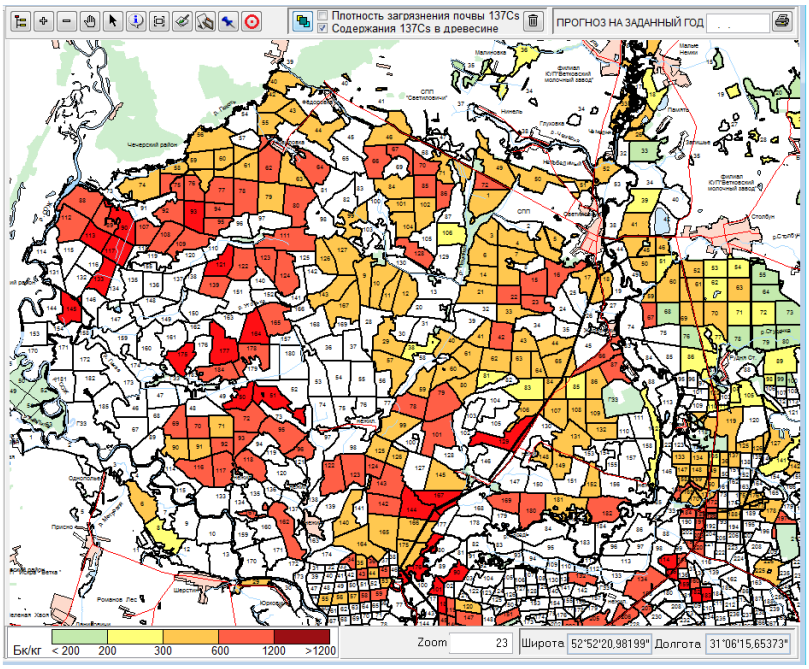
Figure 44. The legend to the map with thematic coloring



The source: GIS “RadForInfo”

78. After clicking the “Colorize Map” button  with the left mouse key, the compartments are colored according to the ^{137}Cs content in wood, as shown in Figure 45.

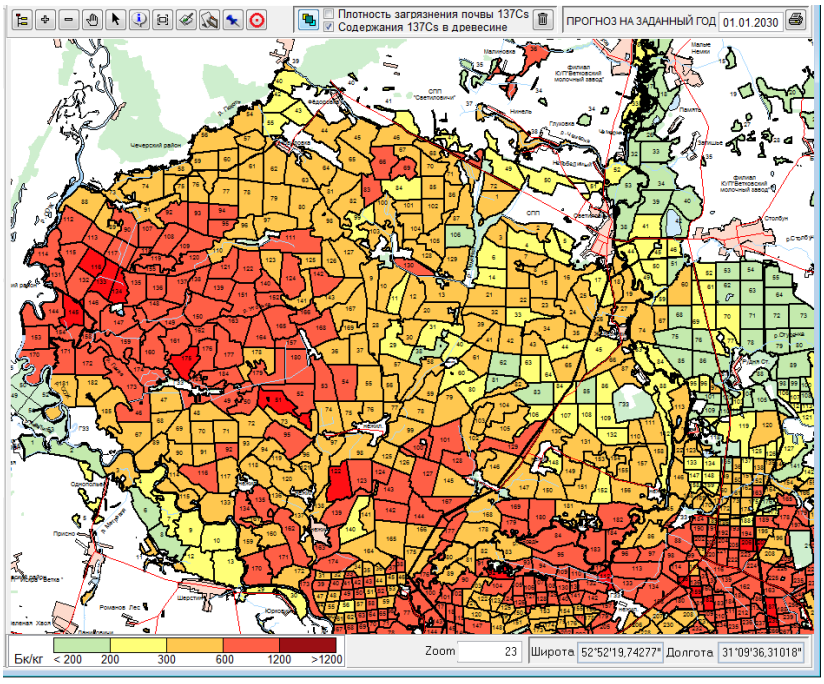
Figure 45. The compartments coloring according the ^{137}Cs content in wood



The source: GIS “RadForInfo”

79. The function of obtaining predicted values of ^{137}Cs content in wood is also supported (Fig. 46). In this case, the control operations are similar to those discussed above for obtaining thematic maps containing information on the zones of radioactive contamination.

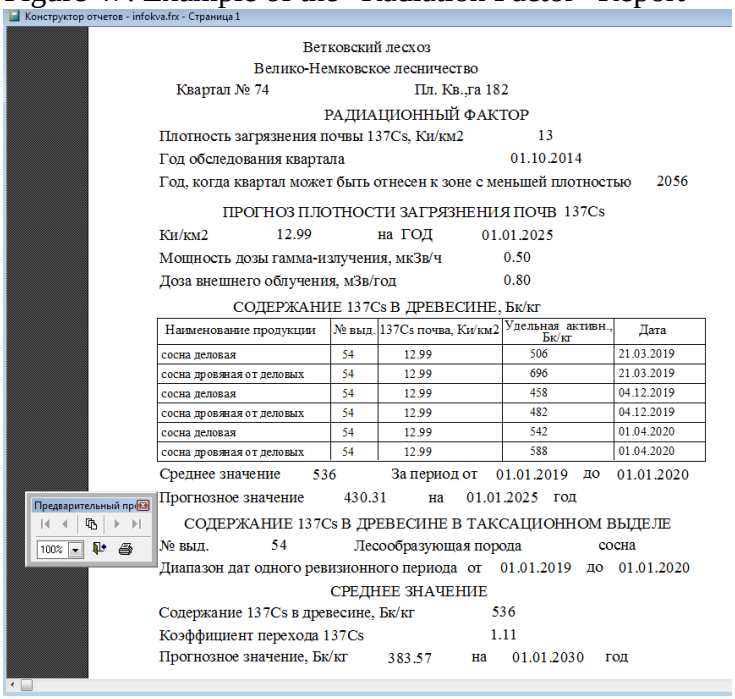
Figure 46. Forecast map with the compartments coloring according to the values of ^{137}Cs content in wood



The source: GIS “RadForInfo”

80. The view of the “Radiation Factor” report generated in this particular case for a given compartment is shown in Figure 47.

Figure 47. Example of the “Radiation Factor” Report



Конструктор отчетов - infokva.frx - Страница 1

Ветковский лесхоз
Велико-Немковское лесничество
Квартал № 74 Пл. Кв.,га 182

РАДИАЦИОННЫЙ ФАКТОР

Плотность загрязнения почвы 137Cs, Ки/км2 13
Год обследования квартала 01.10.2014
Год, когда квартал может быть отнесен к зоне с меньшей плотностью 2056

ПРОГНОЗ ПЛОТНОСТИ ЗАГРЯЗНЕНИЯ ПОЧВ 137Cs

Ки/км2 12.99 на ГОД 01.01.2025
Мощность дозы гамма-излучения, мкЗв/ч 0.50
Доза внешнего облучения, мЗв/год 0.80

СОДЕРЖАНИЕ 137Cs В ДРЕВЕСИНЕ, Бк/кг

Наименование продукции	№ выд.	137Cs почва, Ки/км2	Удельная активн., Бк/кг	Дата
сосна деловая	54	12.99	506	21.03.2019
сосна дровяная от деловых	54	12.99	696	21.03.2019
сосна деловая	54	12.99	458	04.12.2019
сосна дровяная от деловых	54	12.99	482	04.12.2019
сосна деловая	54	12.99	542	01.04.2020
сосна дровяная от деловых	54	12.99	588	01.04.2020

Среднее значение 536 За период от 01.01.2019 до 01.01.2020
Прогнозное значение 430.31 на 01.01.2025 год

Предварительный пр

СОДЕРЖАНИЕ 137Cs В ДРЕВЕСИНЕ В ТАКСАЦИОННОМ ВЫДЕЛЕ

№ выд. 54 Лесообразующая порода сосна
Диапазон дат одного ревизионного периода от 01.01.2019 до 01.01.2020

СРЕДНЕЕ ЗНАЧЕНИЕ

Содержание 137Cs в древесине, Бк/кг 536
Коэффициент перехода 137Cs 1.11
Прогнозное значение, Бк/кг 383.57 на 01.01.2030 год

The source: GIS “RadForInfo”

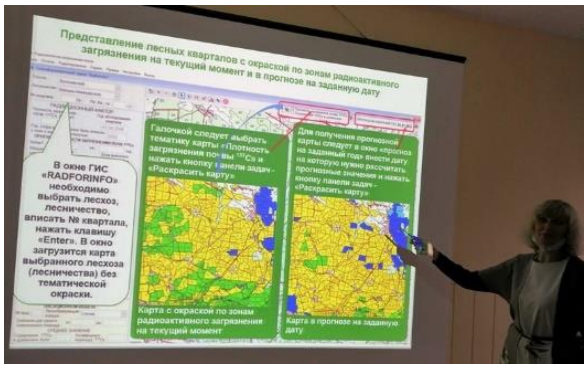
81. The full text of the User Guide for “RadForInfo” Information Module designed to obtain data on the radiation conditions in forests based on the cartographic materials is provided as a separate Appendix.

4. Training seminars for specialists responsible for radioactive contamination control and forest management of the Gomel and Mogilev State Forestry Production Association

82. In November, the Enterprise “Bellesozashchita” trained the specialists responsible for radioactive contamination control of the forest fund of the Forestry Enterprises of the Gomel and Mogilev SFPAs for 4 days. The training included theoretical and practical lessons on using the GIS “RadForInfo”, including individual ones, the development of auxiliary training materials, workshops and testing of the acquired knowledge.

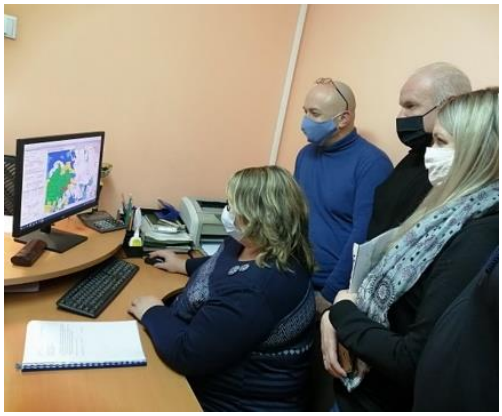
83. Presentation materials were prepared and presented on the following topics: (i) “GIS RadForInfo, functions and application procedure”, (ii) “IS RadFor, structure and functions”, (iii) “Quality of entering the results of radiation control into the RadForView databases, error analysis”, (iv) “Application of IS RadFor in the preparation of the information materials”.

Figure 48. Participants of the training seminar at the lecture on the use of the GIS “RadForInfo” functions, November 23, 2020.



84. Training was conducted for 22 radiological engineers and technicians from 18 Forestry Enterprises. The training was carried out individually with the specialists of each Forestry Enterprise; the “RadForInfo” functions were demonstrated using the cartography of a particular Forestry Enterprise and previously created databases with the results of radiation control.

Figure 49. Individual lessons, November 24-26, 2020



85. To ensure the effective use of the GIS “RadForInfo” functions for trainees, auxiliary materials such as leaflets were developed.

86. Installation of the GeoInformation service “RadForInfo” for the peripheral version of the IS “RadForView”. The leaflet describes the conditions that must be met for the successful installation of the “RadForView” and MapInfo MapX on computers with modern operating systems. Fragments of custom windows for data exchange are presented. The steps order that must be passed when installing MapX and downloading the new version to the user's computer has been determined.

87. Loading digital maps and managing layers. The leaflet describes the steps for downloading layers of digital maps using individual codes of Forestry Enterprises on the user's computer independently, including the case of damage to already loaded layers. Layer adjustment windows are displayed. The steps for setting up the properties of each layer separately are described step by step: (i) line thickness and color; (ii) visualization of displaying layers; (iii) choice of fonts and their sizes; (iv) setting the minimum and maximum zoom values to set the priorities of the layers when viewing interactive thematic maps of Forestry Enterprises.

88. Selection of a group of forest compartments for radiation survey to clarify the density of Cs-137 contamination and assigning to a zone with a lower soil contamination density. The command buttons of the menu, which are responsible for the functions of presenting thematic

maps of Forestry Enterprises in the forecast for a given date, are highlighted in the leaflet. Actions for the presentation on the map of the shaded forest compartments that, according to the forecast, can move to an area with a lower soil contamination density are indicated. The factors of the analysis for the selection of compartments are described. Obtaining a list of forest compartments for preparing a plan to clarify the radiation conditions on the territory of the forest fund and printing out the report. To visualize the sample result, an example report "Predicted decrease in the density of Cs-137 contamination" for the specified year is presented.

89. Entering the coordinates of the soil sampling sites during the radiation survey and their visualization on the map. The menu command buttons that allow opening the windows for adding, changing, and deleting the coordinates of soil sampling sites in a forest compartment, such as drawing icons of sampling sites, are highlighted in the leaflet. Actions when it is possible to view or hide plotted soil sampling sites recorded during the radiation survey of forest compartment on the interactive map of Forestry Enterprise are indicated.

90. Representation of forest compartments with color by zones of radioactive contamination and content of Cs-137 in wood at the current moment and in the forecast for a given date. The command buttons that allow enabling the subject choice for the map formation are highlighted in the leaflet. The arrow indicates the window for entering the forecast date, which launches the function of calculating the values of the soil Cs-137 contamination density and the specific activity of wood in the forecast for a given date. Fragments of window examples with thematic maps, colored at the current moment and in the forecast for a given date, are presented.

91. Methods of the information obtaining about the radiation conditions in the "Radiation factor" window for the selected forest compartment. The leaflet describes how information is presented. Using the menu arrow is the first way to select a compartment. A place specified for entering a query is the second way to select a compartment. The button "print" is highlighted, which provides the output of the received information for printing. The button control using the right and left keys giving different forms of reports is described. An example of the "Report Designer" window with filled fields of the "Radiation factor" window is presented. Examples of developed leaflets are shown in Figure 50.

Figure 50. Examples of leaflets (guidelines for visualizing sequential actions)

92. Maps for each Forestry Enterprise and separately with all Forestry Enterprises for the Gomel and Mogilev SFPAs were prepared. To ensure the functioning of the GIS "RadForInfo" in the Forestry Enterprises with the territories of radioactive contamination, it was carried out the following: (i) loading of 269 layers of digital maps for 23 Forestry Enterprises of the Gomel and Mogilev SFPAs into the IS "RadFor" for attaching to the topographic base and forming maps; (ii) setting the order, display, and zoom (max and min) for 269 layers of digital maps of the Forestry Enterprises of the Gomel and Mogilev SFPAs in the GIS "RadForInfo" window for setting priorities when viewing interactive thematic maps of the Forestry Enterprises; (iii) setting the properties (color and thickness of lines, type and size of fonts) of 269 layers of digital maps of the Forestry Enterprises of the Gomel and Mogilev SFPAs in the GIS "RadForInfo" window for optimal visualization of the generated thematic maps.

93. 29 electronic packages were prepared for updating the RadForview version. For this purpose, the export of data for 27 Forestry Enterprises and 2 SFPAs from IS “RadFor” was carried out. Electronic packages RADFOR with databases were formed, including customized digital maps of the Forestry Enterprises, databases, and new exe-files, which will ensure the update of peripheral versions of the IS “RadForview” and visualization of the digital maps.

94. The installation discs for MapInfo MapX software and a guide for installing on a PC in radiation control departments were prepared for 24 Forestry Enterprises and 2 SFPAs.

95. The folders with a set of leaflets on the use of the GIS “RadForInfo” functions, boot disks, and descriptions (memos) for installing “MapX”, a collection of presentations in electronic form were prepared for each participant of the training seminar. The version for the Forestry Enterprises of the GIS “RadForInfo” with maps of the Forestry Enterprises (by analogy with the “RadForView”) were uploaded to electronic carriers. Testing of trained radiation control specialists showed positive results.

Figure 51. Set of auxiliary materials, training wrap up, November 27, 2020.

96. In connection with the completion of the radiation survey and the receipt of the official data on the radioactive contamination of the forest fund in December 2020, it was decided to install and put into practice the GIS “RadForInfo” in January 2021.

97. Information about the main work stages on the creation of the GeoInformation service "RadForInfo" such as conducting a pilot check in the Forestry Enterprises and training specialists of radiation control departments on the use of new functions, was regularly posted on the website of the "Bellesozashchita" Enterprise and in the Belarusian Forestry Newspaper (articles issued on August 28, November 11, and December 9, 2020). The report on the development and capabilities of the GIS "RadForInfo" was presented at the scientific-practical seminar "Forest and radioactivity - 30 years of the creation of a radiation monitoring service in forestry", held on October 15-16 in the city of Novozybkov, Bryansk region, "Roslesozashchita".

Conclusions and suggestions

98. There is an improvement in the radiation conditions on the territories of the forest fund: (i) the forest area in the zones of radioactive contamination decreases to 2.0% per year (over the past 5 years by 141.0 thousand hectares), (ii) the dose rate decreases by 2.2%, (iii) the ^{137}Cs content in wood decreases by 2.35%. Positive changes are proposed to be taken into account and used for a gradual return to normal forest management conditions in the territories exposed to radioactive contamination, provided that radiation safety standards are met – the average annual radiation dose limit and permissible levels of ^{137}Cs in forest products are not exceeded.

99. To date, a significant amount of radiation control results has been accumulated in the databases "Radiation conditions" and "Forest products" of the IS "RadFor". There are digitized maps of the Forestry Enterprises with the selection of the compartments which allows expanding the IS "RadFor" capabilities and getting the additional service with the simultaneous presentation of all available indicators of the radiation conditions on the map and with details in tabular form. Such service was created and received the name GeoInformation service "RadForInfo" or abbreviated GIS "RadForInfo".

100. A combined interactive map with reference to forest compartments and sub-compartments was created in the GIS "RadForInfo". On this map, at the user's request, it is possible to obtain (i) the information about the assignment of forest compartments to zones of radioactive contamination (color by zone) at present and in the forecast for a given date, (ii) content of ^{137}Cs in wood (average for all species) within the forest compartment (color according to the established level) at the present and in the forecast.

101. GIS "RadForInfo" contains the interface part "Radiation factor", which combines all the radiation characteristics of the forest compartment: (i) the density of soil contamination with ^{137}Cs (fact, forecast, and date of transition to a zone of lower density); (ii) dose rate and dose of external radiation on the survey date; (iii) the average content of ^{137}Cs in wood in forest compartment (fact for the period of time, forecast); (iv) ^{137}Cs content in tree species in sub-compartment (fact for the audit period, transfer coefficient, and forecast).

102. The complex of indicators of the radiation conditions presented on the interactive map and the "Radiation factor" window allows obtaining comprehensive information about radioactive contamination in one forest compartment and the neighboring ones, comparing the contamination levels to make grounded decisions.

103. GIS "RadForInfo" ensures the efficiency of solving practical issues: (i) a radiation survey plan of forest compartments for the next year is automatically generated, which leads to timely clarification of the radiation conditions; (ii) the soil sampling sites in forest compartment and their coordinates are given, which allows them to be used in the next survey and thus to maintain the comparability of the results; (iii) predicted levels of ^{137}Cs content in wood are calculated, which helps to determine the need for a radiation survey of cutting areas and their demarcation for felling, as well as directions of wood use.

104. Testing and pilot check of the GIS "RadForInfo" and its components separately showed positive results, confirmed the compliance of the developed functions with the requirements formed in terms of reference. The interconnection with the IS "RadFor" databases is implemented. The predicted levels of the radioactive soil and wood contamination are calculated according to the laid down algorithms. The color of thematic maps is changed at the user's request. The sufficient reliability of the predicted levels of ^{137}Cs in wood is confirmed.

105. To work with the GIS "RadForInfo", training for specialists of radiation control departments from 18 Forestry Enterprises of the Gomel and Mogilev SFPAs was conducted. The training contained the theoretical and practical lessons, including individual ones, conducting workshops, and testing the knowledge gained. All participants received (i) a set of auxiliary

training materials on the use of GIS "RadForInfo" (leaflets, boot disks, and description of the "MapX" installation), (ii) versions for Forestry Enterprises of GIS "RadForInfo" with a topographic base and maps of Forestry Enterprises, (iii) a collection of presentations. The trained specialists have successfully passed the assessment. They gave a high estimation of the new web service, noted the clarity and complexity of the presentation of information, and determined practical application directions.

106. To ensure the effective operation of the GIS "RadForInfo", it is proposed to: (i) provide methodological and technical support for the cartographic service in the Forestry Enterprises; (ii) equip the RCD with the modern PCs with the parameters necessary for working with cartographic materials; (iii) install GIS "RadForInfo" in forestry departments and Forestries of the Forestry Enterprises, and conduct the technical training with specialists; (iv) conduct training on the use of the new service of specialists from the radiation control departments of the Brest, Grodno, and Minsk SFPAs.