RESEARCH ACTIVITIES OF THE POLESIE STATE RADIATION ECOLOGICAL RESERVE

PSRER address:
Ul. Tereshkovoj, 7
247618 Khoiniki,
Gomel region, BELARUS
Fax: +375 2346 452 40
E-mail: zapovednik@tut.by
Web: http://www.zapovednik.by

Maksim KUDZIN
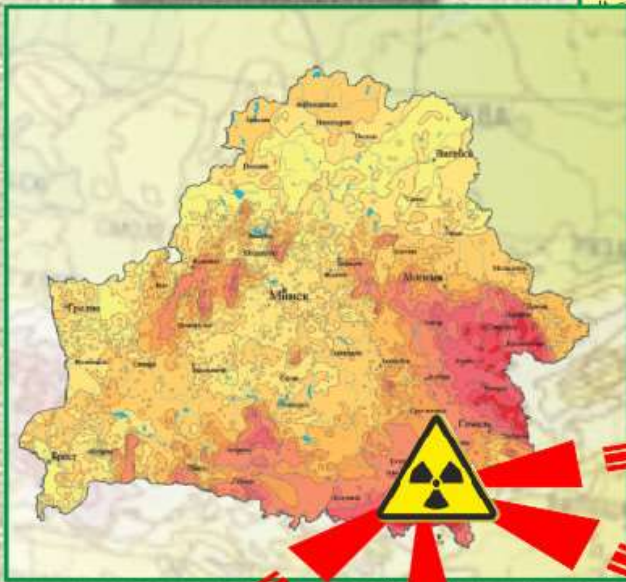
Deputy director on scientific work, Ph.D

Natural decay of radionuclides

plutonium-241 = 144 years

americium-241 = 4 320 years

**strontium-90 = 285 years,
cesium-137 = 300 years,
plutonium-239 > 240 000 years**

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*Due to **americium-241**, the total alpha activity of transuranium elements will be growing further up, reaching its maximum in **2056.***

Main areas of PSRER activity

- implementation of special preventive measures and actions against transition of radionuclides and secondary contamination of nearby areas;

- environmental management and maintenance of a specific mode of the use of natural resources according to the functional and radiation-ecological zoning of the territory;

- protection of forests and agricultural lands against wildfires, pests and diseases;

- implementation of basic measures to maintain hydrological conditions on previously drained lands;

- support of natural development of ecosystems, afforestation of lands affected by water and wind erosion, preservation of biological diversity of animal and plant life;

- radiation control and monitoring;

- experimental research on radiation and ecological monitoring of the environment, animal and plant life;

- testing of recovery and remediation measures and techniques.

Map-scheme
of distribution of the territory of Polessky state radiation-ecological
reserve on forestry
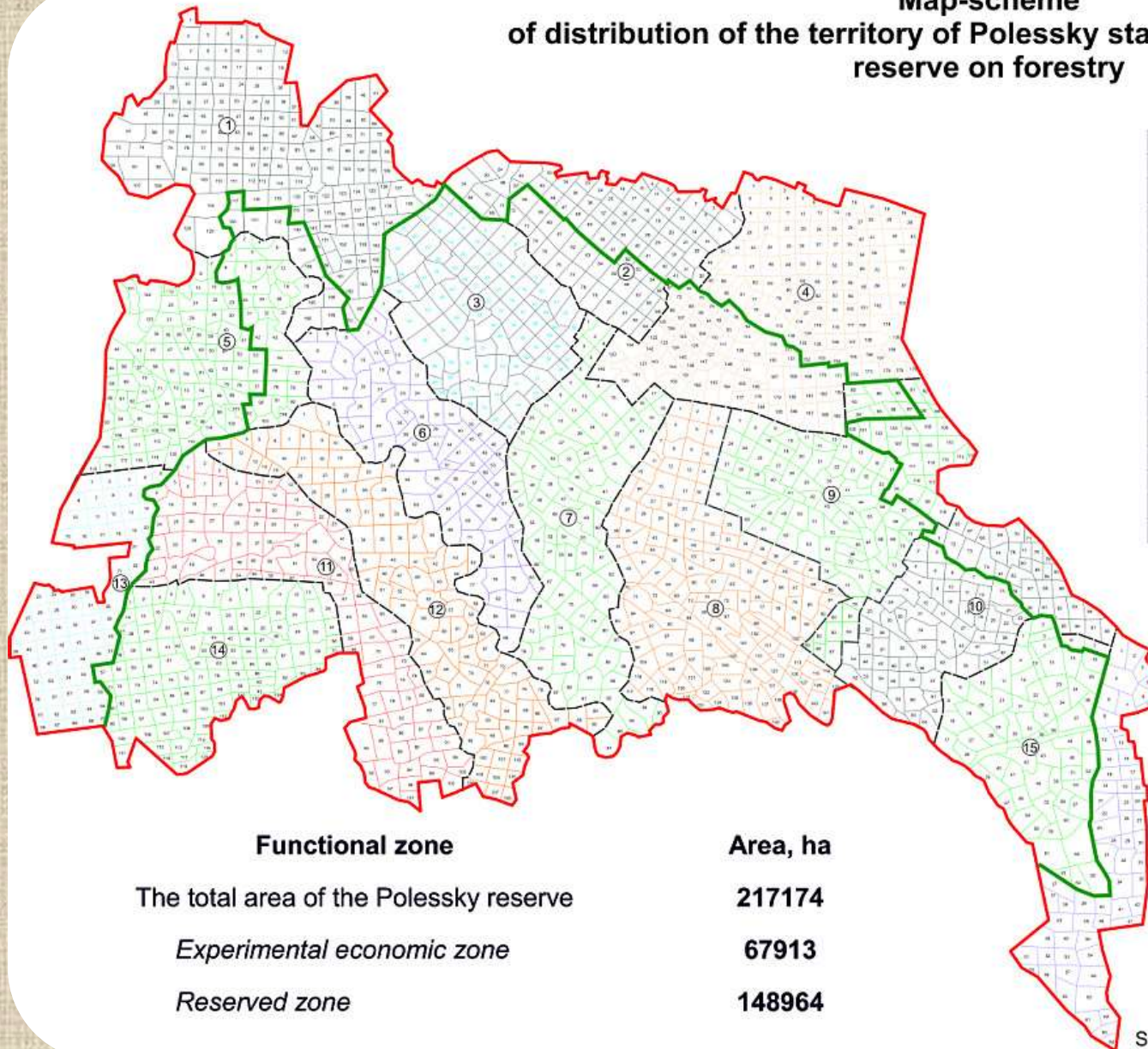
	Forestries
①	Tulgovichskoe
②	Vorotetskoe
③	Novopokrovskoe
④	Bogushevskove
⑤	Verbovichtskoe
⑥	Orevichskoe
⑦	Babchinskoe
⑧	Radinskoe
⑨	Verchneslobodskoe
⑩	Kryukovskoe
⑪	Dernovichtskoe
⑫	Pripyatskoe
⑬	Hilchanskoe
⑭	Partizanskoe
⑮	Kolybanskoe
⑯	Chikalovichskoe

Functional zone	Area, ha
The total area of the Polessky reserve	217174
Experimental economic zone	67913
Reserved zone	148964

Scale 1 : 100 000

4

Map-scheme
functional zoning and location of the disposal points of waste
decontamination and temporary storage "Masany" in the territory Polessky
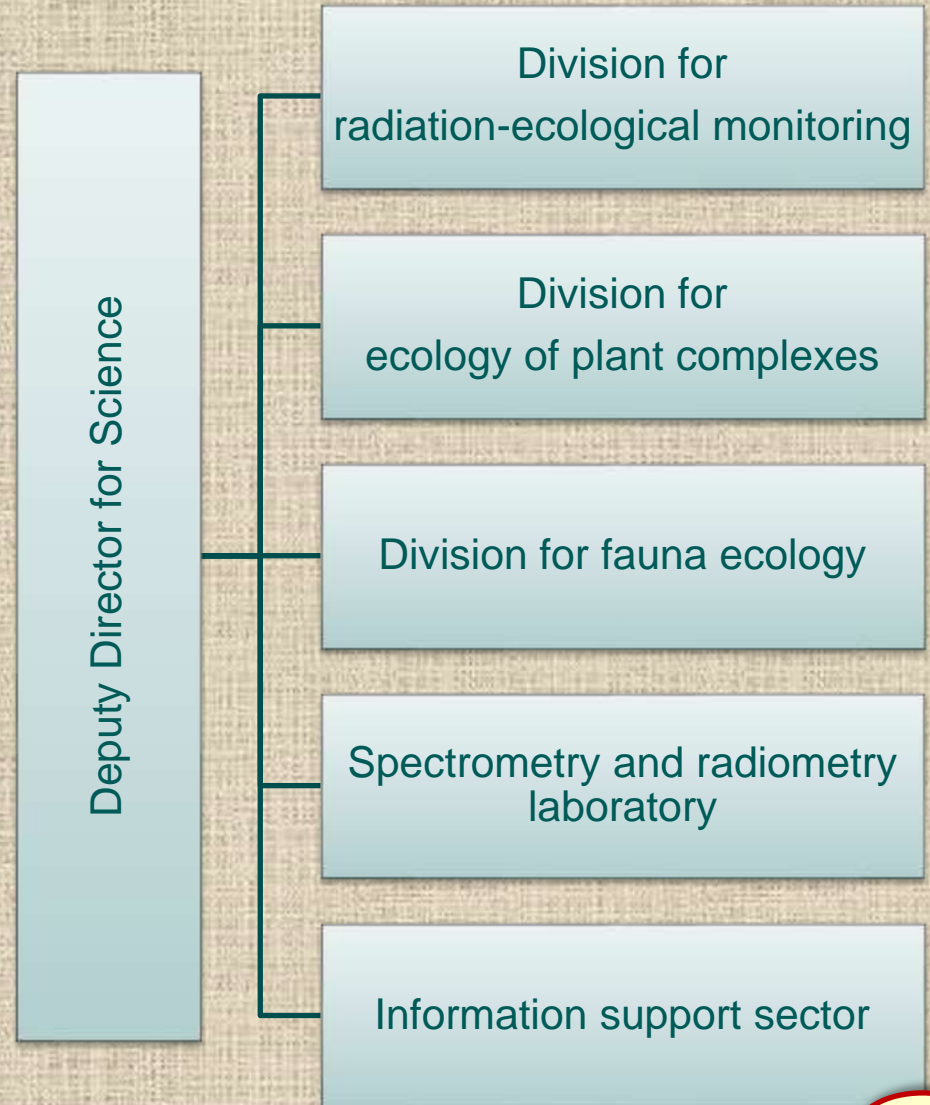state radiation-ecological reserve

Experimental economic zone

Experimental economic zone

Reserved zone

PBDW III category

PBDW II category

PBDW I category

PTS «Masany»

Functional zone	Area, ha
The total area of the Polessky reserve	217174
Experimental economic zone	67913
Reserved zone	148964

Scale 1 : 100 000

5
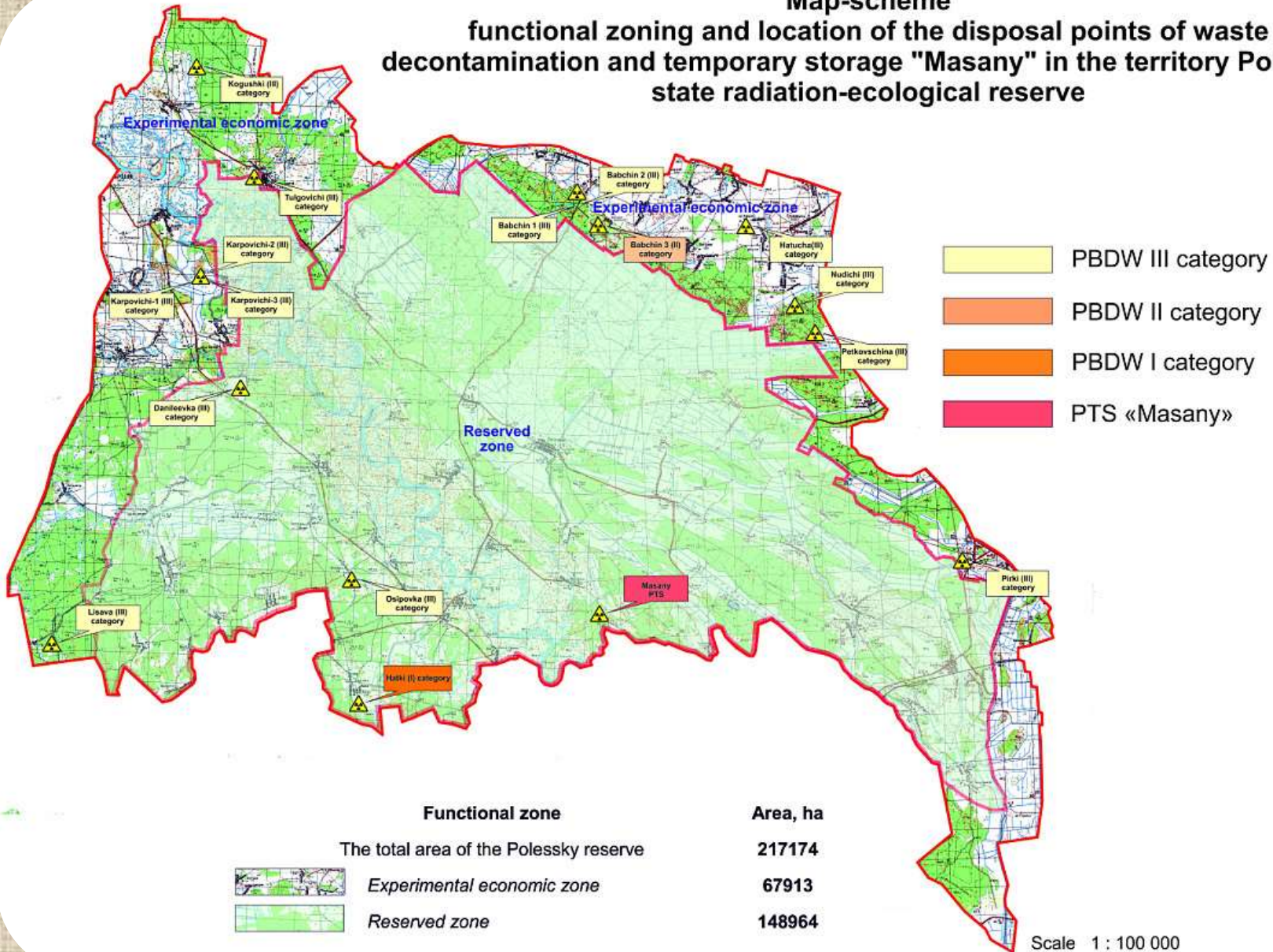
THE STRUCTURE OF PSRER RESEARCH DEPARTMENT

Research-administrative building

Sanitary-amenities building

Deputy Director for Science

- Division for radiation-ecological monitoring
- Division for ecology of plant complexes
- Division for fauna ecology
- Spectrometry and radiometry laboratory
- Information support sector

Since its first days of creation PSRER had been involved in an extended variety of R&D activities including the following five-year research projects:

✓ 1991-1995 – studying the dynamics of accumulation of radionuclides in the most important representatives of flora and fauna to be able to predict the time of their 'clearance' to the safe levels;

✓ 1996-2000 – elaborating scientific principles of preservation and development of natural complexes in PSRER;

✓ 2001-2005 – studying structural-functional state and dynamics of natural territorial complexes;

✓ 2006-2010 – monitoring various components of terrestrial and water ecosystems in the context of radioactive contamination and removed anthropogenic impact;

✓ 2011-2015 – studying water systems, forest-plant complexes, and animal life, and the dynamics of various processes behind radiation-ecological situation in the exclusion and resettlement zones;

✓ 2016-2020 – studying anthropogenic-free biogeocenoses and radiation-ecological conditions determined by radioactive fallouts (involving transuranium elements) in the near area around the ChNPP.

✓ 2021-2025 гг. – radiation-ecological aspects of the current state of ecosystems of the exclusion zone and their components.

Implementation of research projects	Number of projects
- within the framework of state and interstate programs	21
- within the framework of international cooperation	17
- within the framework of technical assistance projects	3

The number of published articles of scientific staff in scientific journals and publications in the period from 2007 to 2021

The name of the indicator	Всего
The number of published articles in scientific journals and publications – total, units	607
Number of published books (monograph) - total, units	9
The number of publications included in scientometric databases, including:	102
Web of Science – total, units	8
Scopus – total, units	10
Russian Science Citation Index – total, units	84

RADIATION-ECOLOGICAL MONITORING DIVISION

Objectives: assess the regularities of migration and accumulation behaviour of radionuclides in different chains of terrestrial and aquatic ecosystems, prediction of the radiation situation development in the exclusion zone in the long term

Tasks:

✓ study the parameters of lateral migration of ^{137}Cs, ^{90}Sr, ^{241}Am in the exclusion zone based on the type concentration gradients' formation;

✓ study the regularities of vertical redistribution of radionuclides in soils and the moisture regimes of basic plant formations in the exclusion zone, and establish the accumulation specifics;

✓ study the accumulation dynamics of ^{137}Cs, ^{90}Sr, ^{241}Am in potential food products of natural biogeocenoses;

✓ study the migration regularities of radionuclides in aquatic ecosystems (soils of water collection areas, bottom sediments, water, macrophytes, shellfish, fish) depending on the water basin type in the exclusion zone;

✓ assess the fluctuations in accumulation of ^{137}Cs, ^{90}Sr by water plants of reservoirs;

✓ give prediction estimates of radioactive contamination in muscle tissues of fish in water basins of the exclusion zones;

✓ analyze the dynamics and forecast the changes of ambient dose rates in permanent monitoring points in the exclusion zone;

✓ assess the weather regime in the exclusion zone and how it changes over time.

Test sites of the Department of radiation-ecological monitoring:
Study of the radionuclide lateral migration, dynamics of dose rate and
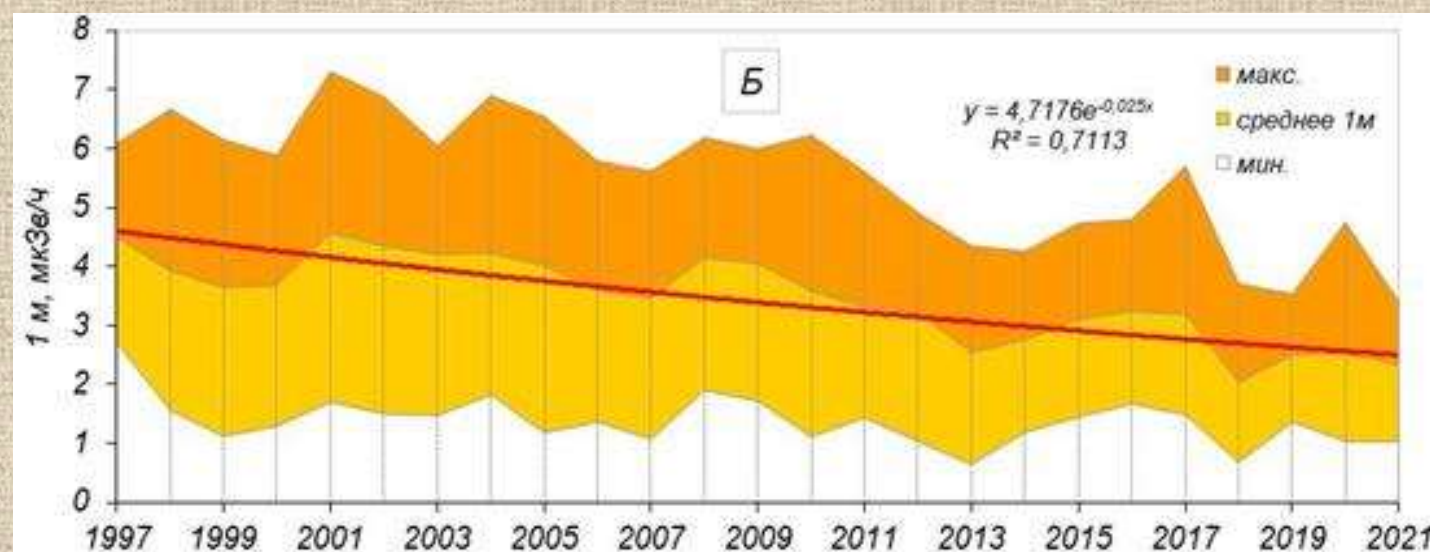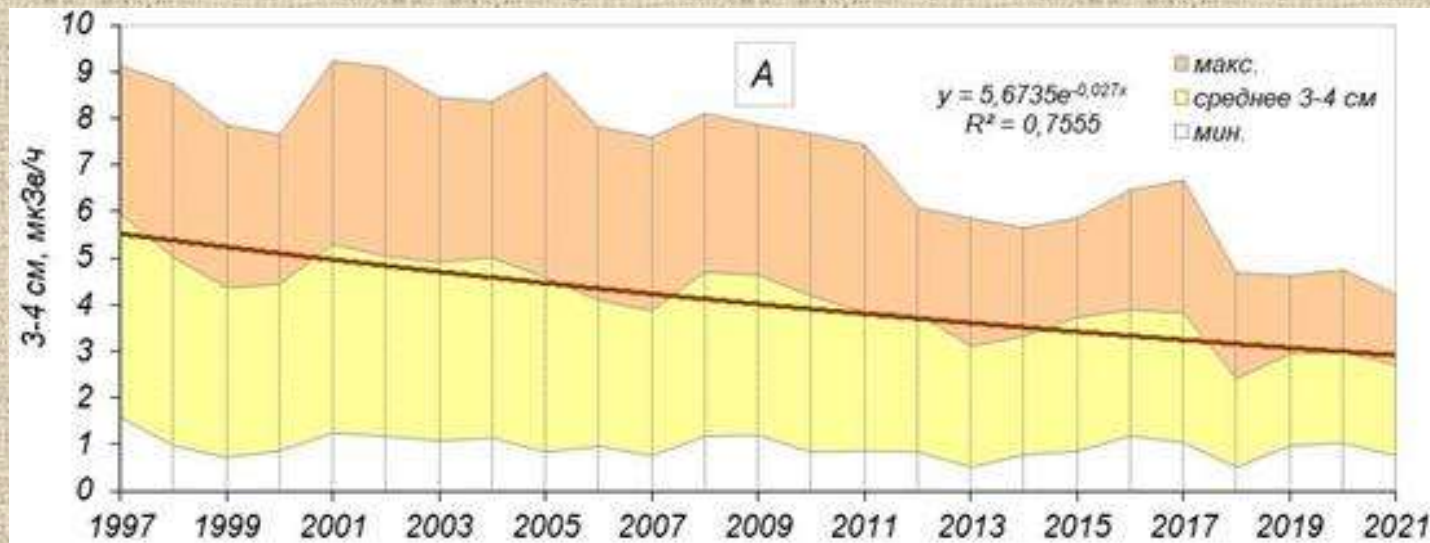**contamination density and radionuclide accumulation by living soil cover**
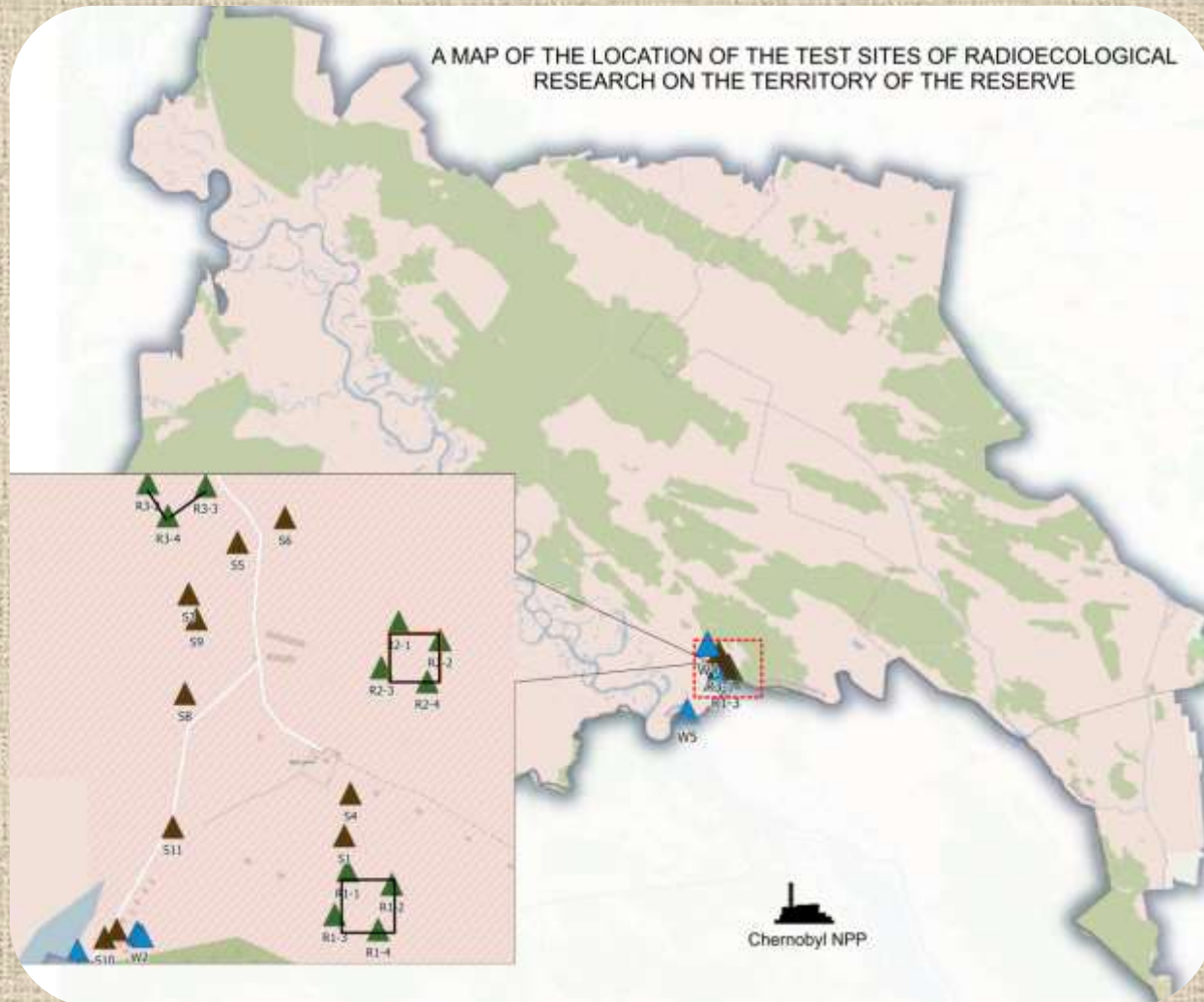
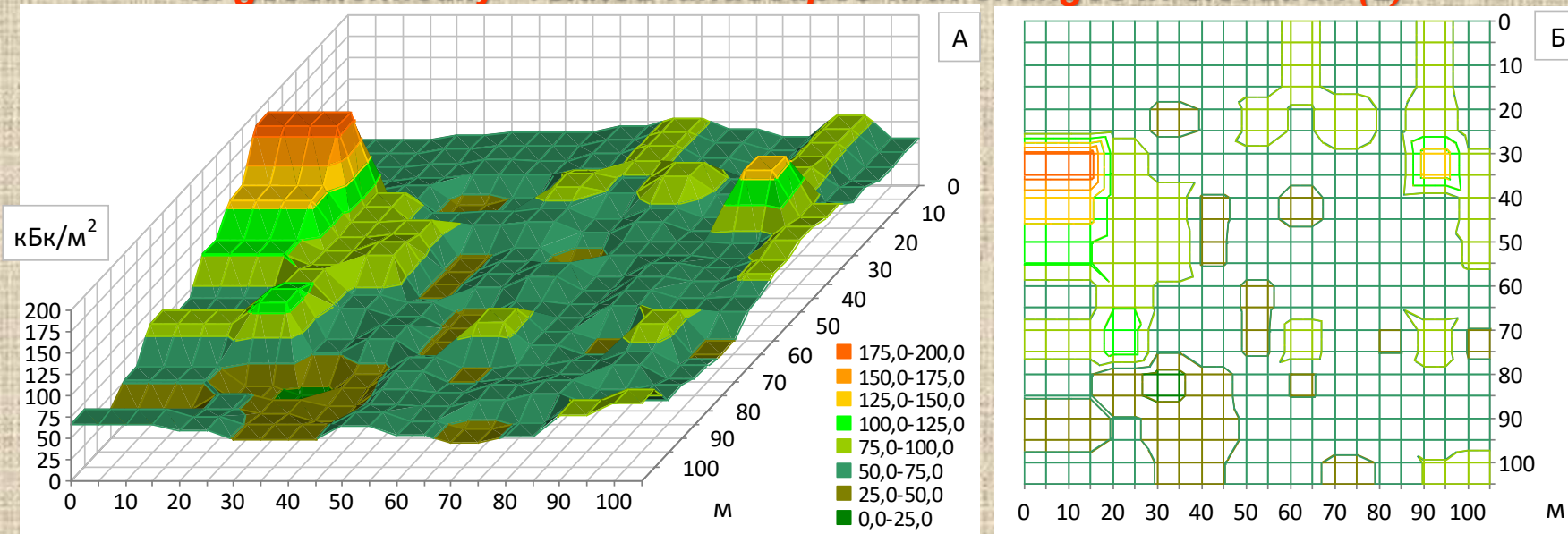A MAP OF THE LOCATION OF THE TEST SITES OF RADIOECOLOGICAL RESEARCH ON THE TERRITORY OF THE RESERVE

Ambient dose rates in measuring points of PSRER monitoring network, microSv/hour

Lateral migration of ^{137}Cs, ^{90}Sr, ^{241}Am in the surface layer of soil i in geochemically –related landscapes with changes in elevation (2)

Lateral distribution of ^{241}Am on the surface of experimental area "Yaseva Gora"
(А – surface histogram, Б – view from above), kBq/m^2
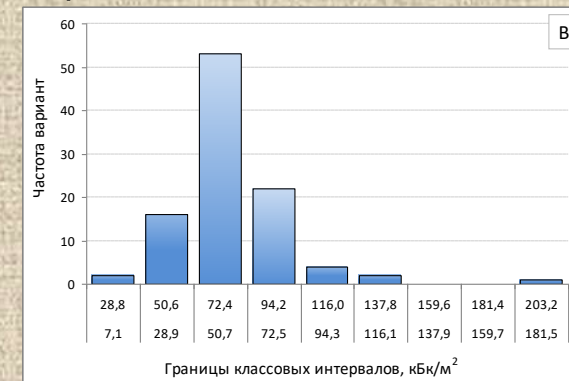
Values distribution histograms of ^{137}Cs (А), ^{90}Sr (Б), ^{241}Am (В) in the surface soil layer
of the experimental area, kBq/m^2

SPECTROMETRY AND RADIOMETRY LABORATORY

Objectives of research: study the processes of accumulation of transuranium elements and ^{90}Sr in biogeocenoses of the Belarusian part of the ChNPP exclusion zone

Tasks:

✓ enhance the measuring proceedings for determining $^{238\text{-}240}$Pu, ^{241}Am and ^{90}Sr in environmental samples with high organic matter contents;

✓ determine the densities of soil contamination in the areas of plant and animal sampling;

✓ study the transfer processes into grain crops (barley, rye, triticale, oats) and other grasses grown in the PSRER;

✓ determine the content of TUE on organs and tissues of the wild boar and other wild animals, and find the links between the findings of research and radioactive contamination of the environment;

✓ study the transfer of ^{90}Sr in wood of trees grown in the PSRER experimental-economic area.

Test sites studied in the framework of the project
"Advanced In-situ Gamma Spectrometry Field Activity - Chernobyl (GAMFAC)."
Participants: Norwegian Radiation Protection Authority, Swedish Defence Research
Agency, Danish Emergency Management Agency, Stirling University (Scotland), Icelandic
Radiation Protection Authority (2015)

A MAP OF THE LOCATION OF THE TEST SITES OF RADIOECOLOGICAL RESEARCH ON THE TERRITORY OF THE RESERVE
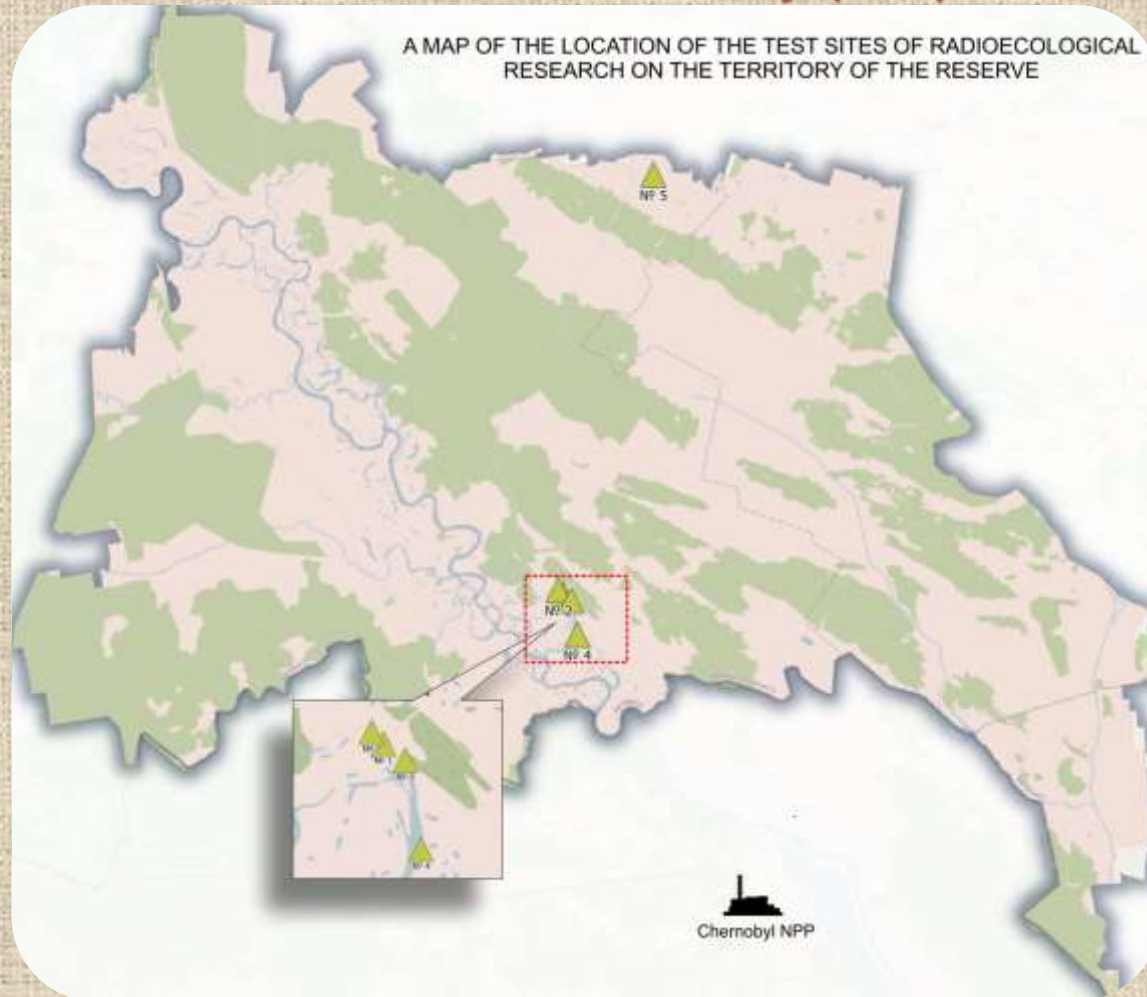
The lab is accredited for measuring:

- ✓ specific activity of ^{137}Cs in food samples, agricultural raw materials and feedstuffs, drinking water, soil, bottom sediments, surface water, non-food forest products;
- ✓ specific activity of ^{90}Sr in agricultural raw materials and feedstuffs, foodstuffs, soil, bottom sediments, surface water, samples of flora and fauna;
- ✓ specific activity of ^{241}Am in soil and bottom sediments;
- ✓ specific activity of $^{238\text{-}240}$Pu in soil, bottom sediments, surface water, samples of flora and fauna;
- ✓ ambient dose rate, surface beta-radiation.

The scope of accreditation also includes sampling of forest food and non-food products.

The lab is a regular participant of interlaboratory comparison exercises

The credibility of analytical data provided by the spectrometry and radiometry lab is confirmed by its performance in the interlab proficiency exercises.

Some of the latest tests include:

- ✓ Gomel Centre for Standardization, Metrology and Certification 2017 Inter-Laboratory Comparison Exercise on determination of specific activity of cesium-137;
- ✓ World Wide Proficiency Test IAEA-TEL-2017-03 on determination of anthropogenic and natural radionuclides in water, milk powder and Ca-carbonate of natural origin. The samples provided in this exercise contained cesium-137, strontium-90, barium-133, and several gamma-emitters.

Within the framework of the cooperation project Within the framework of the cooperation project with the IAEA BYE/9/024 received **mobile radiological laboratory**
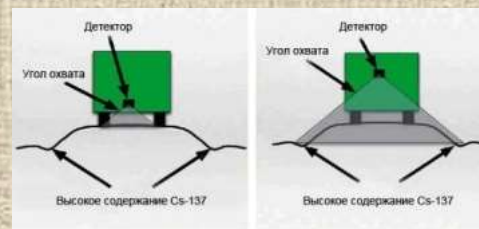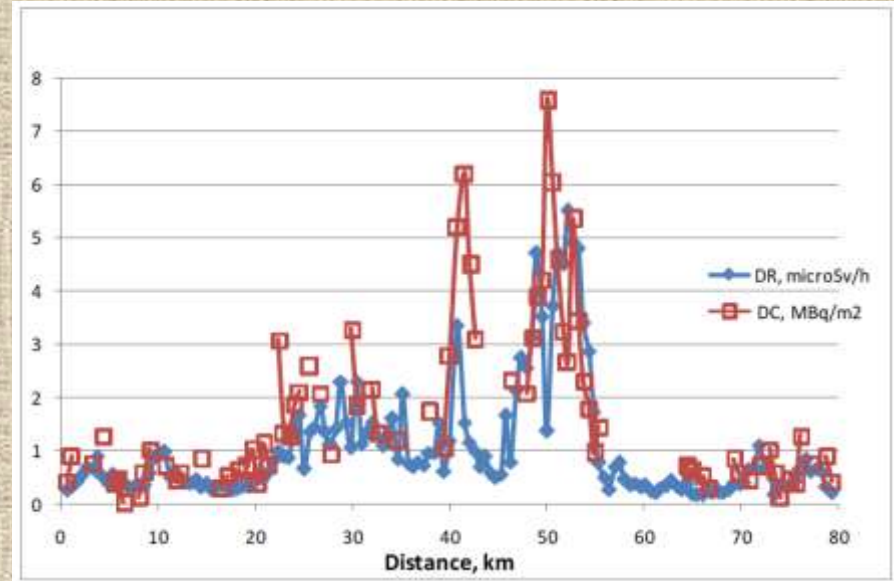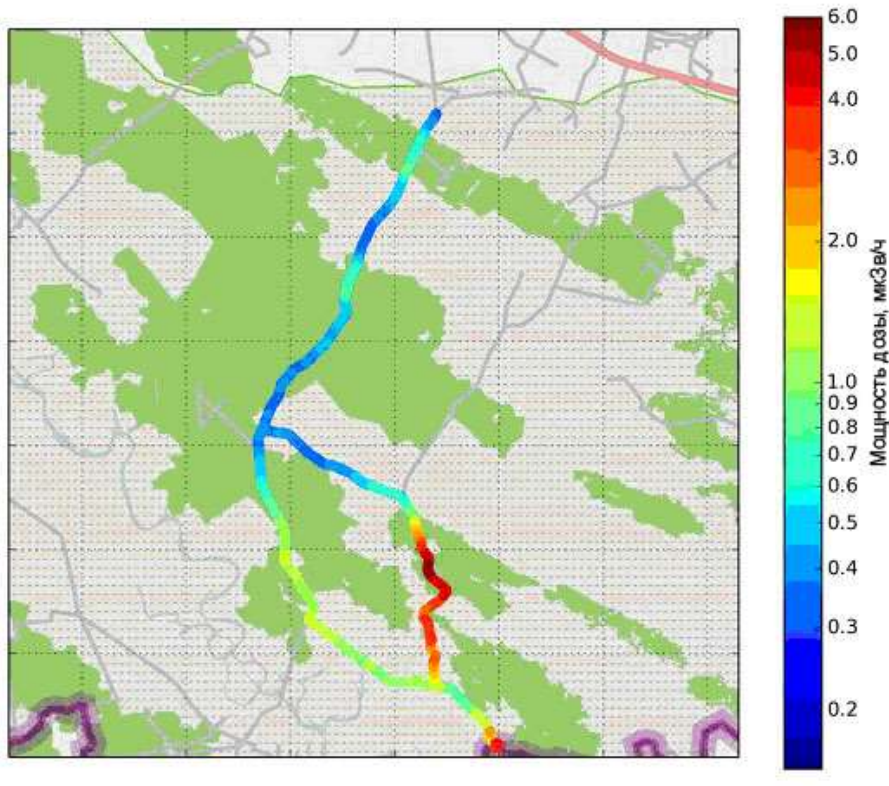

The laboratory staff was trained by the manufacturing company LLC "Polimaster" on practical methods of working with the equipment.

The identifier of radionuclides with spectroscopic capabilities was obtained «**SPIR-Ace with GenieXPort» with software S573 ISOCS**».
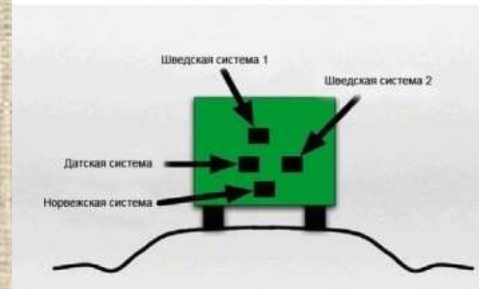
Determining the levels of ^{137}Cs contamination of the territory and ambient dose rates by car-borne dosimeters and spectrometers

The dose rate values on the road calculated with a correction factor SDI, microSv/hour; measured by Swedish teams

*Comparison between the dose rates measured along the road in a moving vehicle and ^{137}Cs contamination levels*

Positioning of detectors in a vehicle

The share of $^{239+240}$Pu in the matrix of fuel particles of the samples of soil and bottom deposit s

The concentration of fuel particles:

$3,3 \times 10^4$ kg^{-1} (9×10^6 m^{-2}) – in the most contaminated areas

$8,6$ kg^{-1} ($2,2 \times 10^2$ m^{-2}) – closer to the PSRER outer borders

The degree of fuel particle degradation is 88 ± 6 % in soil, and 60 ± 25 % in bottom deposits.
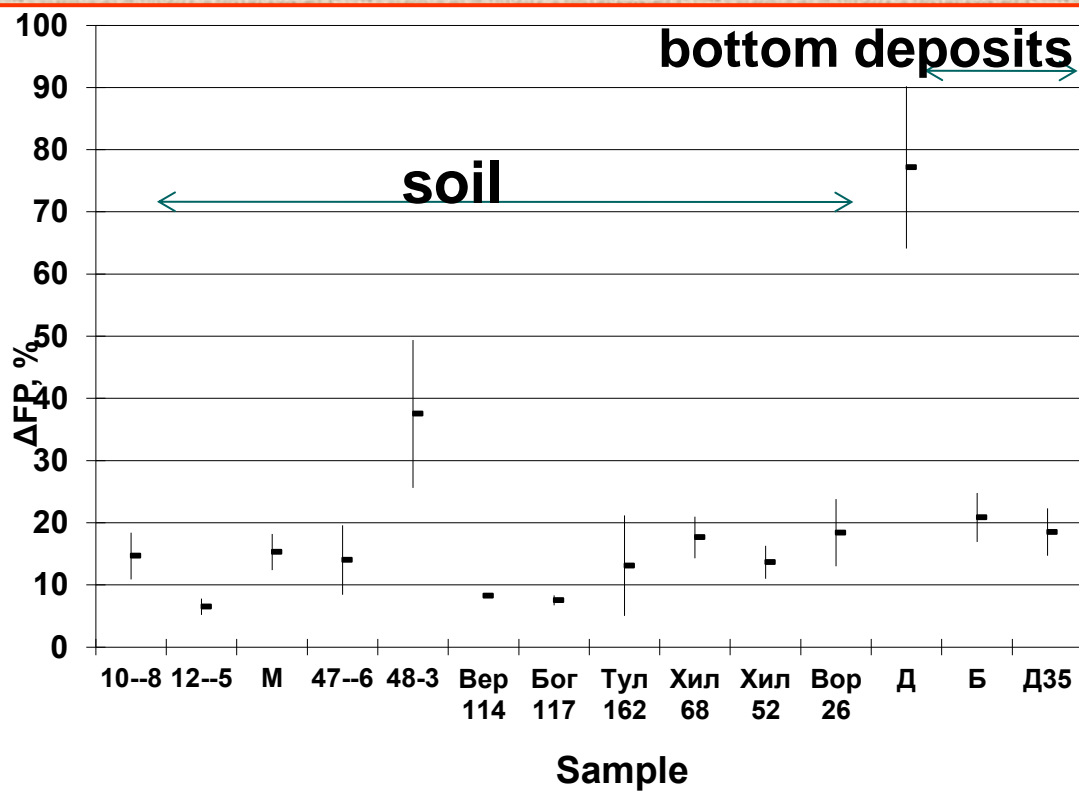
Size: 1–15 mkm

Density: 10^2–10^3 particles per cm^2

Dissolution time: ≤ 14 years

Activity:

Sr – $1,2 \times 10^{12}$ Bq/kg

Pu - 2×10^{10} Bq/kg

Am – $8,7 \times 10^8$ Bq/kg

The biggest share of Pu activity in the matrix of fuel particles falls upon bottom sediments of the lake Perstok. Low particle degradation is explained by low oxygen concentration at the bottom of the lake

ECOLOGY OF PLANT COMPLEXES DIVISION

Objectives: study the forest-formation processes on forest and non-forest lands, natural forest reproduction, growth of forest plantations in the Belarusian part of the ChNPP exclusion zone

Tasks:
- ✓ keep track and give estimates of the changes of the PSRER forest resources in the post-Chernobyl period ;
- ✓ study the course of natural reproduction in the main forest areas;
- ✓ study the course of natural forest reproduction on former agricultural lands;
- ✓ characterize the natural reproduction of forest plantations and orchard trees in former inhabited villages;
- ✓ study and estimate the results of artificial afforestation on former agricultural lands in the post-Chernobyl period;
- ✓ carry out radiation-ecological monitoring of the key forest formations;
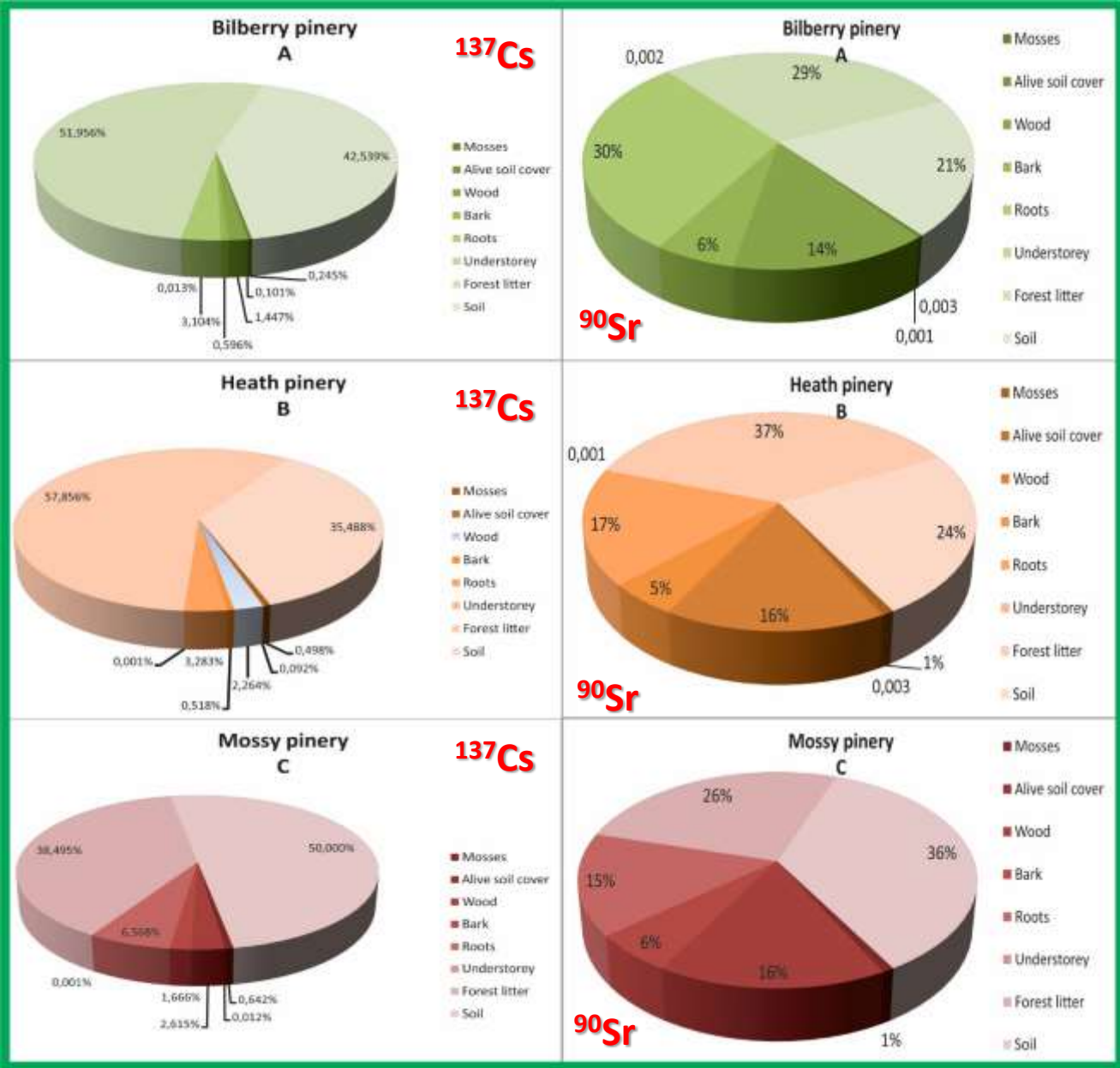- ✓ assure continuous floristic research.

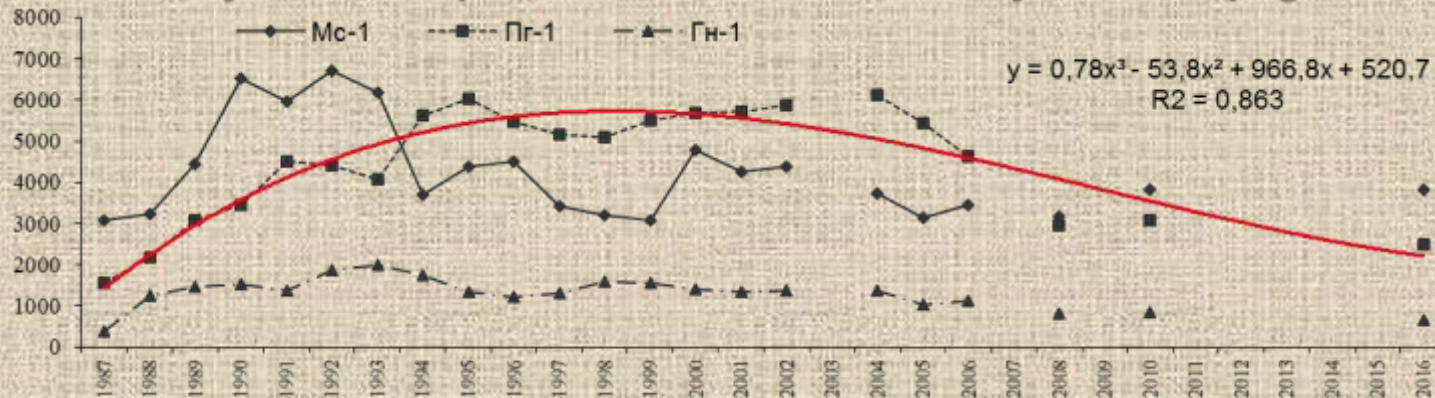## Test sites of the Department of ecology of vegetative complexes

A MAP OF THE LOCATION OF THE TEST SITES OF RADIOECOLOGICAL RESEARCH ON THE TERRITORY OF THE RESERVE
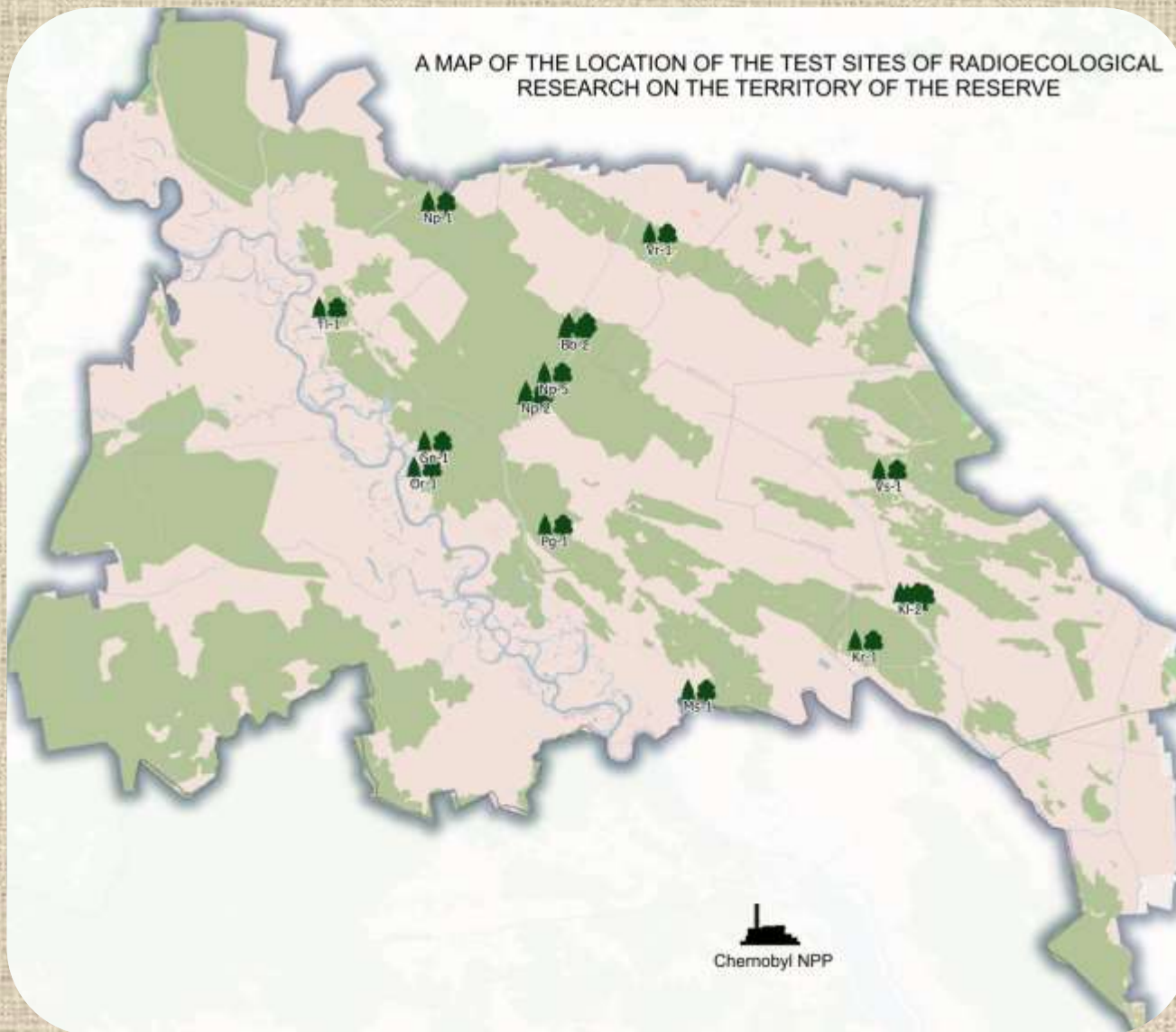
Distribution of ^{137}Cs and ^{90}Sr between components of ecosystem of bilberry (A), heath (B) and mossy (C) types of pine forest
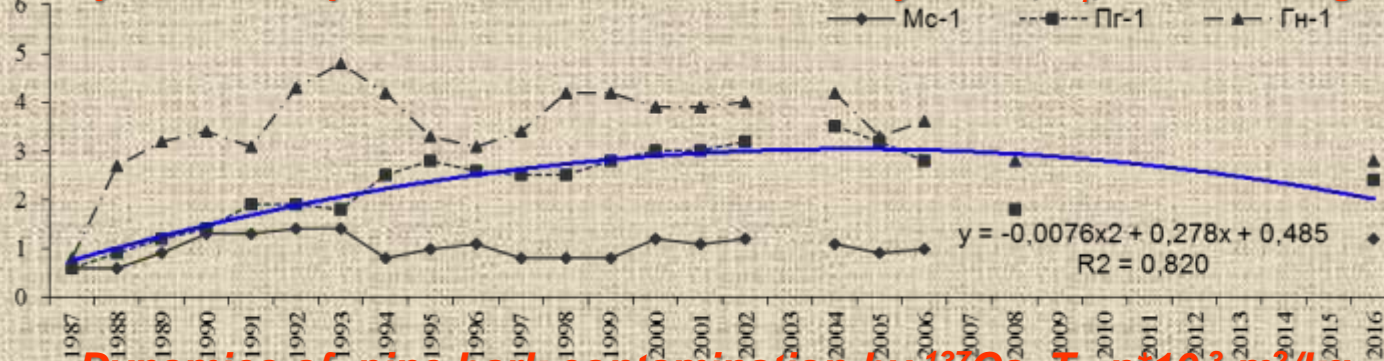
Dynamics of pine wood contamination by ^{137}Cs , Bq/kg

$$y = 0.78x^3 - 53.8x^2 + 966.8x + 520.7$$
$$R^2 = 0.863$$

Dynamics of pine wood contamination by ^{137}Cs, T_f, $n*10^{-3}$ m²/kg

$$y = -0.0076x2 + 0.278x + 0.485$$
$$R^2 = 0.820$$

Dynamics of pine bark contamination by ^{137}Cs, T_f, $n*10^{-3}$ m²/kg

$$y = 76.344x - 1.0794$$
$$R^2 = 0.889$$

$$y = 49.83x - 0.6567$$
$$R^2 = 0.907$$

$$y = 68.801x - 0.7417$$
$$R^2 = 0.814$$
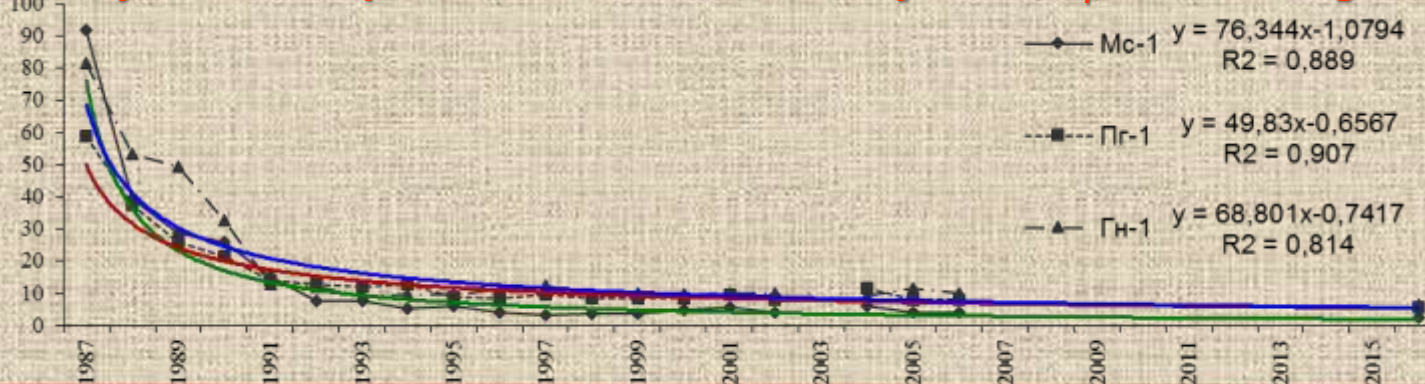
Floristic research in the exclusion zone

Dicotyledons - 874

Monocotyledons - 248

Ground pines - 4

Horsetails - 7

Ferns - 15

Conifers - 10
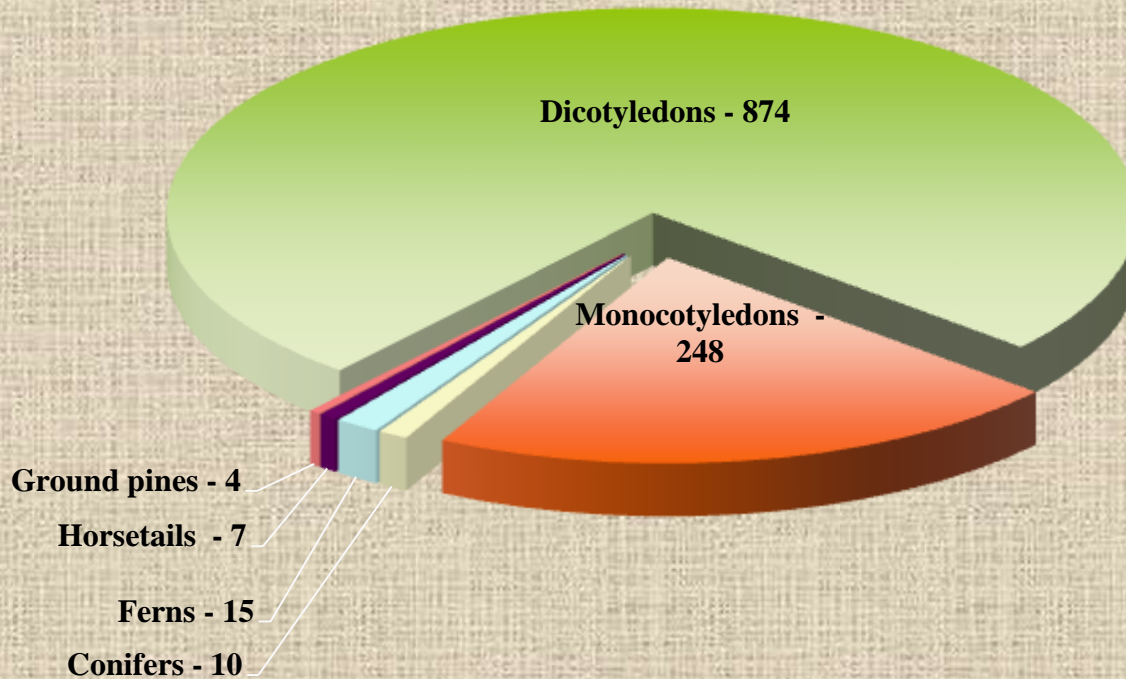
The PSRER flora of tracheophytes (vascular plants) amounts to 1162 species and 6 hybrids of 550 geni, 137 families, 8 classes, 5 orders: 4 *Lycopodiopsida* species (aka ground lines), 7 *Equisetophyta* species (aka horsetails), 15 *Polypodiophyta* species (ferns), 10 *Pinophyta* species (gymnosperms), 986 species of *Magnoliophyta* (angiosperms), incl. 767 dicots (*Magnoliopsida*), and 219 monocots (*Liliopsida*).

As of today, considering the existing literature references and the data from PSRER floristic researchers, there have been established 46 species of vascular plants, 2 species of mushrooms and 1 species of lichen enlisted in the Red Book of the Republic of Belarus.

FAUNA ECOLOGY DIVISION

Objective: assessment of terrestrial-aquatic environments and epidemic-epizootic situations in terms of zoonoses, as well as the state of fish fauna in various water basins within the exclusion zone.

Tasks:

- ✓ study the species composition, the number and density of animals in the forest, synanthropic (bats) and semi-aquatic (birds, tailless amphibians and reptiles) complexes;
- ✓ define the species composition of tailless amphibians in different types of water bodies;
- ✓ establish the factors affecting the population of endangered birds in the semi-aquatic complexes;
- ✓ study the reproductive potential of endangered birds species;
- ✓ specify the parasitological situations for the worm-infested wild mammals;
- ✓ determine the species diversity of helminths and the invasion degree;
- ✓ define the seasonal, species- and age-dependant levels of ^{90}Sr and ^{137}Cs accumulation in fish of various trophic statuses;
- ✓ elaborate suggestions on minimizing the effects of the most dangerous zoonoses in the natural environment of the reserve.

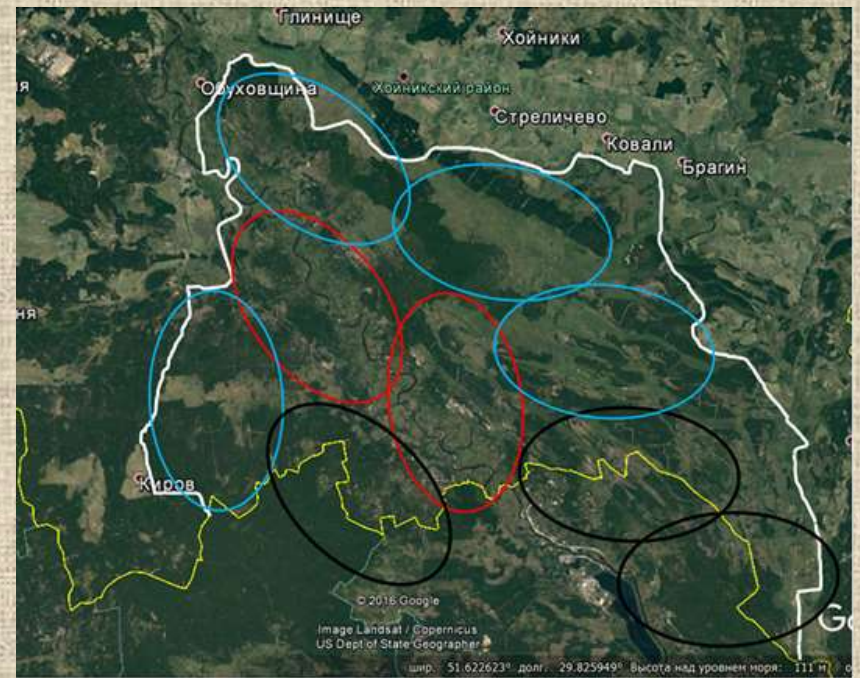## Monitoring of radionuclide concentrations in organs and tissues of wild animals
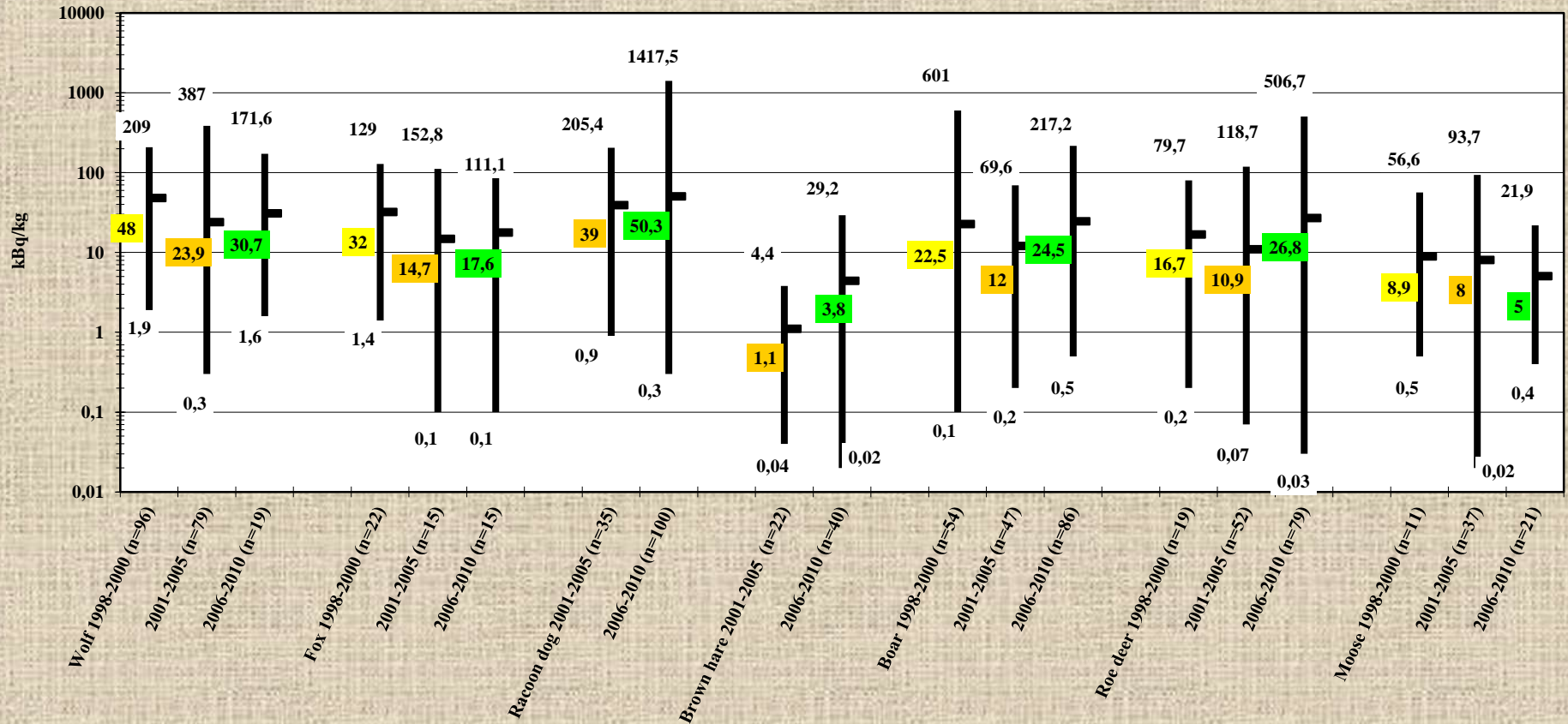
Spatial pattern of the wolf

Location of labeled packs within the reserve

Distribution of wolf packs in the theoretical context of the smallest possible habitat area of each pack

Based on the **tracking** research, there are 13-14 wolves within Pack 1 habitat (including stray loners) and 9-10 wolves in Pack 2.
92 detections were made by the **camera traps** during autumn-winter period, with total registered **157** wolves including **30** labeled ones. Population estimate for both packs was calculated: 25.5 +/- 4.03, with the average density of 0.48 wolves per 1000 hectares.
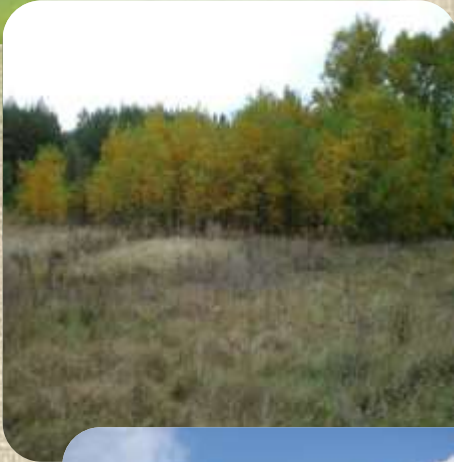
Some of the PSRER areas are now habitat of the bisons

○ the habitats of bison groupings

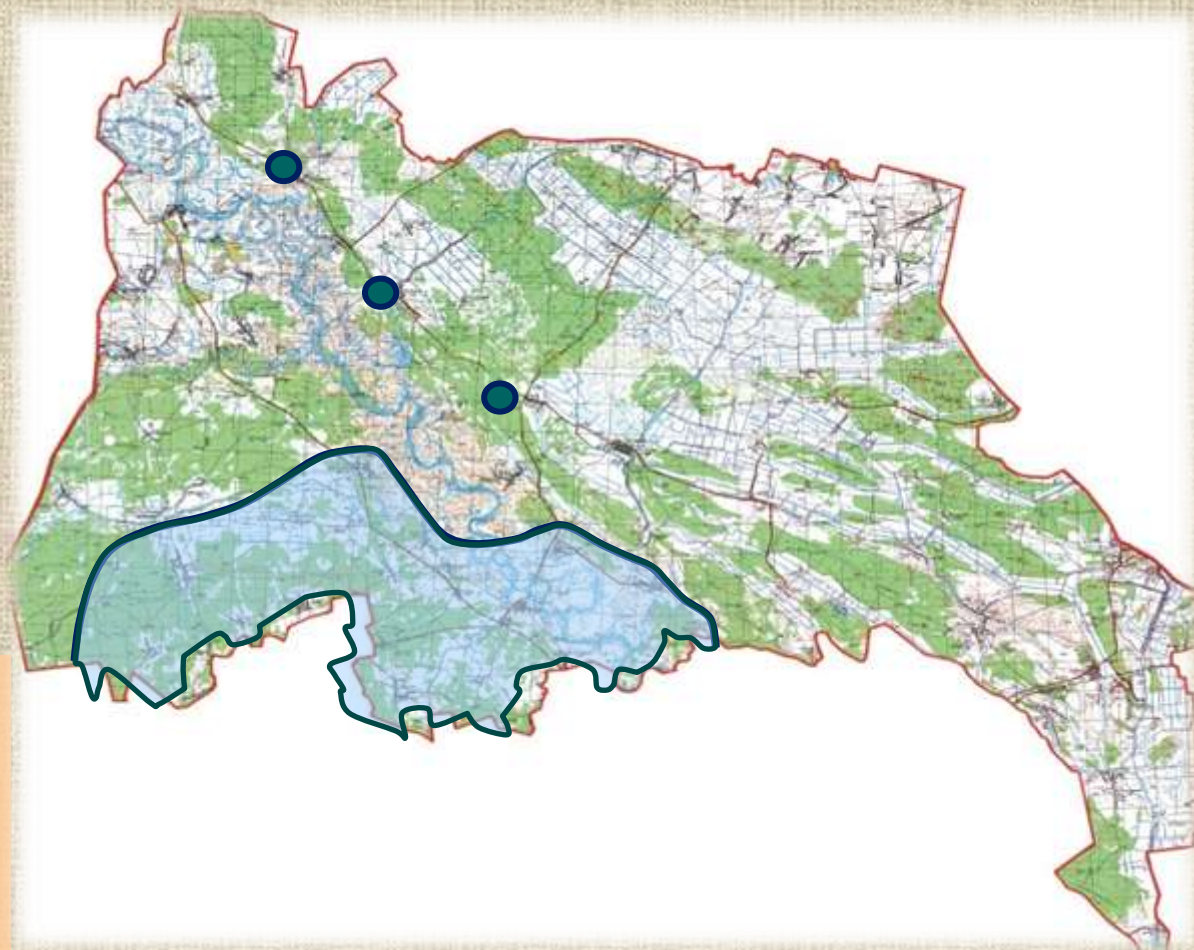⭕ total habitat area of bisons within the reserve
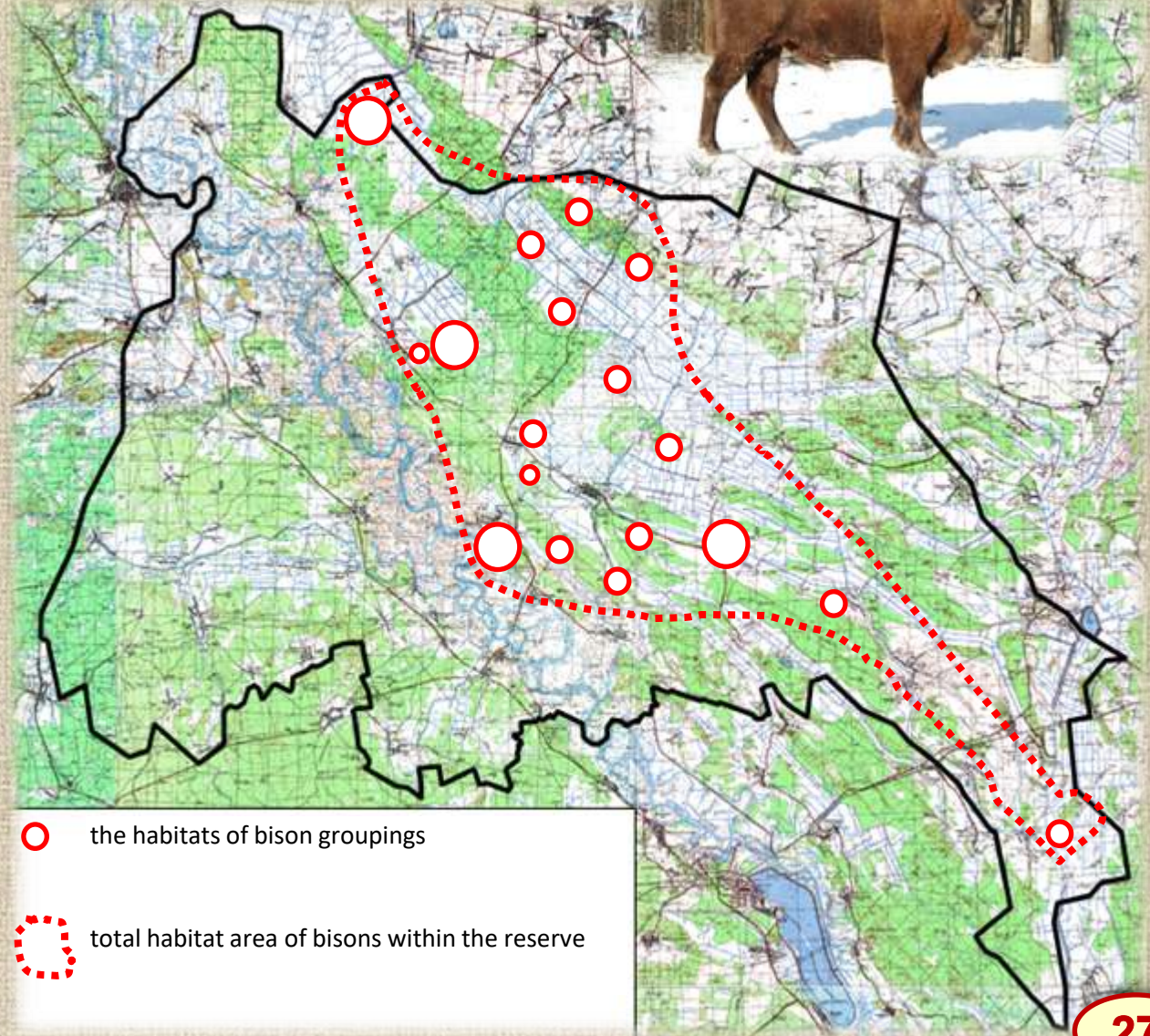
Przewalski's wild horse

Appeared here in 2007 and had successfully re-naturalized since then having consistent positive trends in population dynamics. The present number is above 30 horses.

The habitat of Przewalski 's horse

Mammals and reptiles included in the Red Book of endangered species of Belarus

Европейский зубр - Bison bonasus

Бурый медведь - Ursus arctos

Барсук - Meles meles

Лошадь Пржевальского
Equus ferus ssp. przewalskii Poliakov

Европейская рысь
Lynx lynx

Орешниковая соня
Muscardinus avellanarius

Соня-полчок
Glis glis

Медянка
Coronella austriaca

Болотная черепаха
Emys orbicularis

Малая вечерница
Nyctalus leisleri

Европейская широкоушка
Barbastella barbastellus

Прудовая ночница
Myotis dasycneme

Горностай
Mustela erminea

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Birds of PSRER included in the Red Book of endangered species of Belarus

Орлан-белохвост

Домовый сыч

Бородатая неясыть

Большой подорлик

Обыкновенный зимородок

Золотка

№ п/п	Вид		Категория охраны
	русское название	латинское название	
1.	Чернозобая гагара	Gavia arctica	II
2.	Большая выпь	Botaurus stellaris	III
3.	Малая выпь	Ixobrychus minutus	II
4.	Кваква	Nycticorax nycticorax	IV
5.	Черный аист	Ciconia nigra	III
6.	Шилохвость	Anas acuta	III
7.	Белоглазая чернеть	Aythya nyroca	I
8.	Длинноносый крохаль	Mergus serrator	II
9.	Большой крохаль	Mergus merganser	III
10.	Луток	Mergellus albellus	I
11.	Черный коршун	Milvus migrans	III
12.	Орлан-белохвост	Haliaeetus albicilla	II
13.	Змееяд	Circaetus gallicus	II
14.	Полевой лунь	Circus cyaneus	III
15.	Малый подорлик	Aquila pomarina	III
16.	Большой подорлик	Aquila clanga	I
17.	Беркут	Aquila chrysaetos	I
18.	Скопа	Pandion haliaetus	II
19.	Сапсан	Falco peregrinus	I
20.	Обыкновенная пустельга	Falco tinnunculus	III
21.	Кобчик	Falco vespertinus	I
22.	Дербник	Falco columbarius	III
23.	Чеглок	Falco subbuteo	IV
24.	Малый погоныш	Porzana parva	IV
25.	Коростель	Crex crex	III
26.	Серый журавль	Grus grus	III
27.	Кулик-сорока	Haematopus ostralegus	III
28.	Авдотка	Burhinus oedicnemus	I
29.	Галстучник	Charadrius hiaticula	II
30.	Золотистая ржанка	Pluvialis apricaria	II
31.	Турухтан	Philomachus pugnax	III
32.	Гаршнеп	Lymnocryptes minimus	IV
33.	Дупель	Gallinago media	II
34.	Большой веретенник	Limosa limosa	III
35.	Большой кроншнеп	Numenius arquata	II
36.	Средний кроншнеп	Numenius phaeopus	III
37.	Поручейник	Tringa stagnatilis	III
38.	Большой улит	Tringa nebularia	III
39.	Мородунка	Xenus cinereus	III
40.	Малая чайка	Larus minutus	III
41.	Сизая чайка	Larus canus	IV
42.	Малая крачка	Sterna albifrons	II
43.	Филин	Bubo bubo	II
44.	Воробьиный сыч	Glaucidium passerinum	IV
45.	Домовый сыч	Athene noctua	III
46.	Бородатая неясыть	Strix nebulosa	II
47.	Болотная сова	Asio flammeus	IV
48.	Обыкновенный зимородок	Alcedo atthis	III
49.	Золотистая щурка	Merops apiaster	III
50.	Сизоворонка	Coracias garrulus	I
51.	Зеленый дятел	Picus viridis	III
52.	Белоспинный дятел	Dendrocopos leucotos	IV
53.	Хохлатый жаворонок	Galerida cristata	IV
54.	Полевой конек	Anthus campestris	IV
55.	Вертлявая камышевка	Acrocephalus paludicola	I
56.	Мухоловка-белошейка	Ficedula albicollis	IV
57.	Усатая синица	Panurus biarmicus	IV
58.	Чернолобый сорокопут	Lanius minor	II
59.	Садовая овсянка	Emberiza hortulana	II
60.	Просянка	Miliaria calandra	IV

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INFORMATION SUPPORT SECTOR

Objective: solving research and applied problems that reflect the state of the natural-territorial complexes of the exclusion zone and their current radiation situation based on methods of remote sensing of the Earth and geographic information systems.
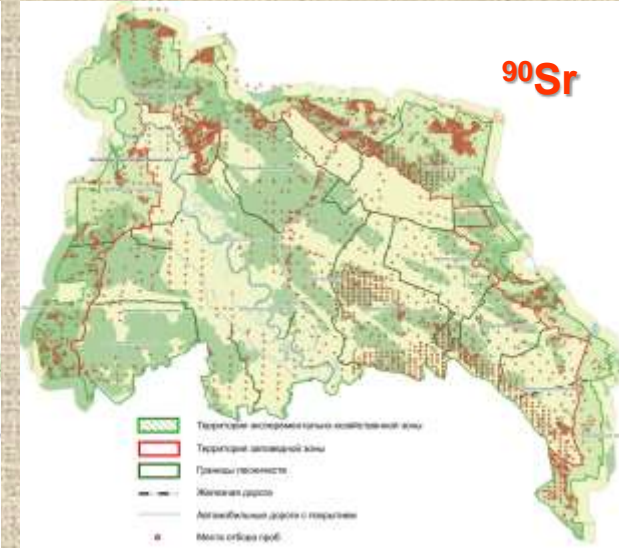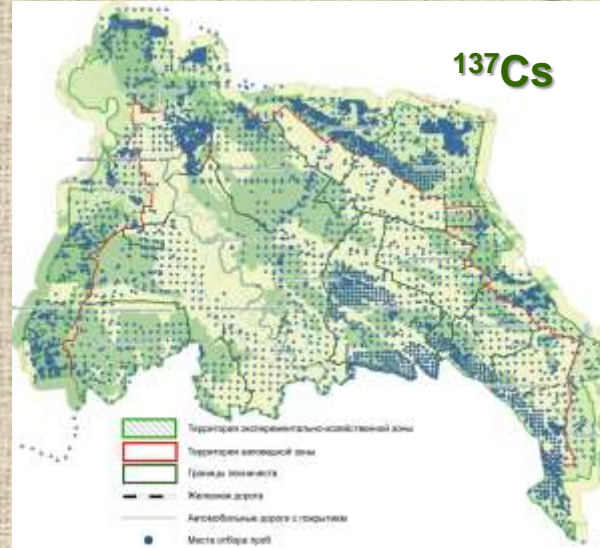
Tasks:

Creation and implementation of GIS in order to update the parameters of the radiation situation in the territory of the AO using GIS based on the accumulated and received information on the main long-lived radionuclides of Chernobyl origin (^{137}Cs, ^{90}Sr, ^{241}Am, ^{238,239,240,241} Pu).

Updating of data on the radiation situation of the exclusion zone on the basis of geoinformation technologies
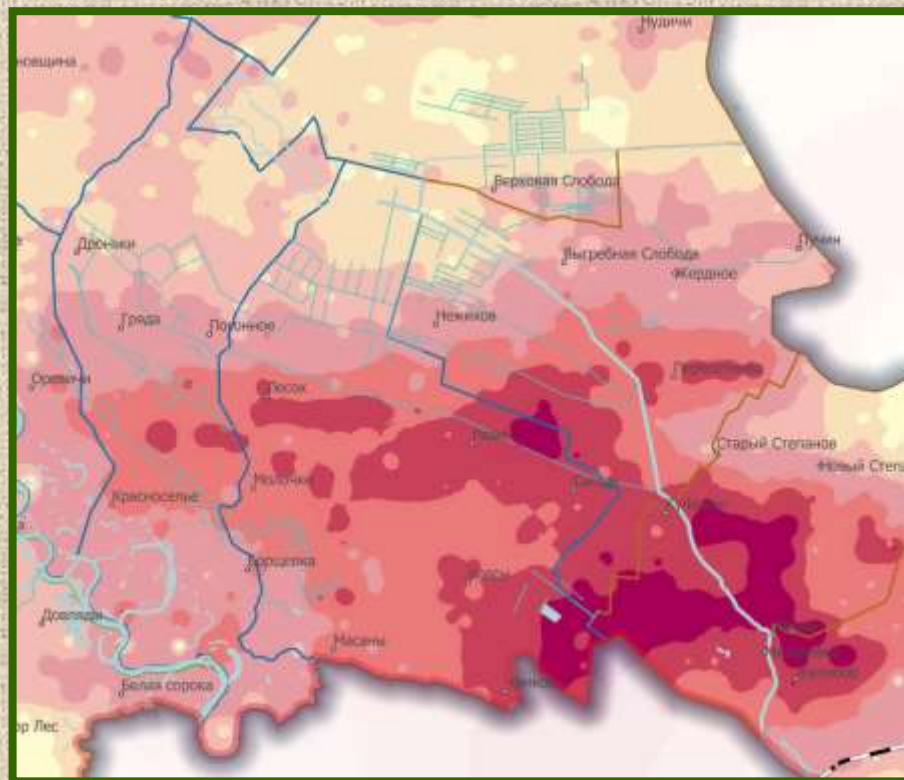

Fragment of the database of the results of measurements of radioactive soil contamination by transuranium elements
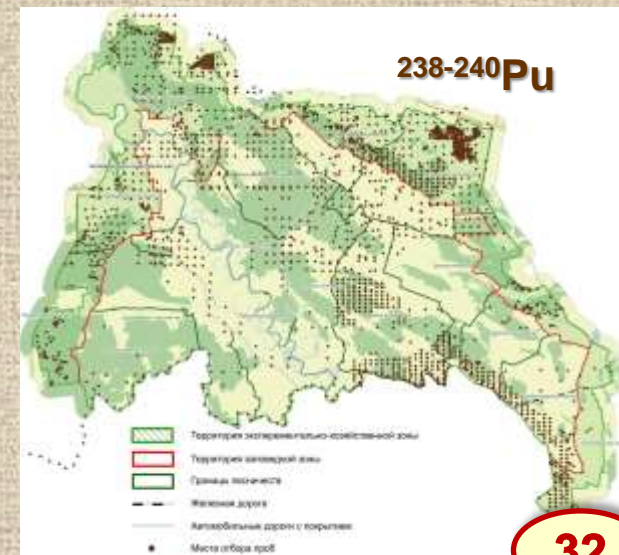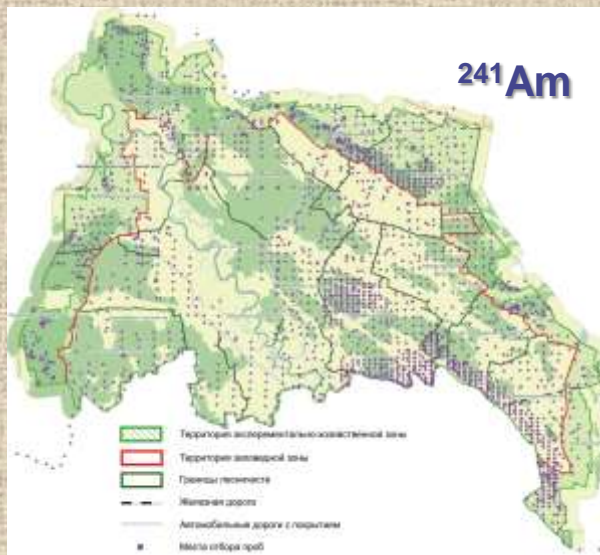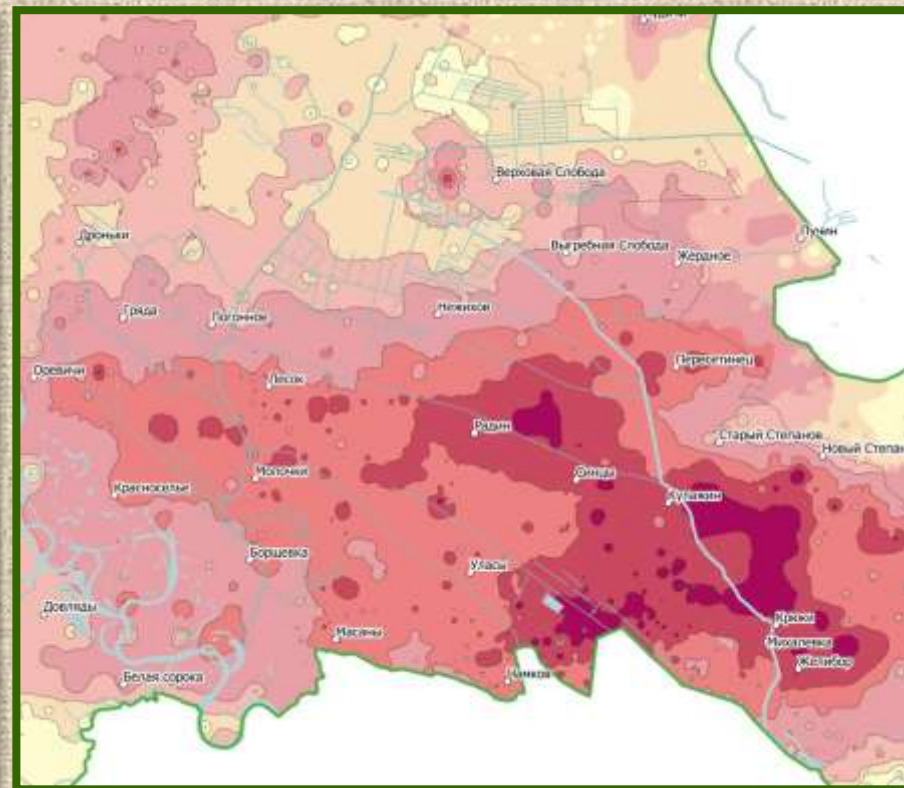
Comparison of maps of the density of radioactive contamination of the territory with ^{137}Cs, including a different number of samples (2020)

A fragment of a map containing **1974** samples of ^{137}Cs

A fragment of a map containing **5336** samples of ^{137}Cs

Promising areas of research and practical developments

- ✓ it is advisable in the future to conduct research to assess the state of radioactive waste, sealing of storage facilities and the flow of radionuclides into groundwater from these facilities, as well as components of the surrounding forest and meadow communities.

- ✓ to consider the possibility of organizing on the basis of the scientific part of the international research center, which could be an international platform for solving environmental issues, conducting radioecological, radiobiological research and study of the development of ecosystems, flora and fauna in a limited anthropogenic load. This approach will be in some way in line with the proposal to establish an international research centre within of the Union state.

- ✓ recommend an experimental research station "Masany" as am international ground for radioecological, radiobiological research, studies of biogeochemical cycles of long-lived radionuclides in the area affected by a nuclear accident.

- ✓ continue radioecological research to study the transfer of transuranium elements into plants, organs and tissues of the animal world.

- ✓ the past several years show that different foreign research centres willingly use the ground provided by the reserve to test their new methods and techniques related to environmental radiation monitoring.

- ✓ researchers-ornithologists of a number of foreign countries show a definite interest to this territory with no anthropogenic pressure (e.g. we have the ongoing one with the United Kingdom);

- ✓ in the context of forest monitoring research there is a typical interest in studying the natural dynamics of the key forest formations and flora species abundance in the PSRER territories. In spite of the exceptional diversity of the plant world in reserve, it is not much studied. There are only a few modern studies concerning mushrooms, mosses and lichen found in this area. Such studies could be subject to cooperation research projects with respective foreign institutions.

Thank you for your attention!