Creating a map of reforestation on abandoned agricultural lands in Mari El Republic using satellite images

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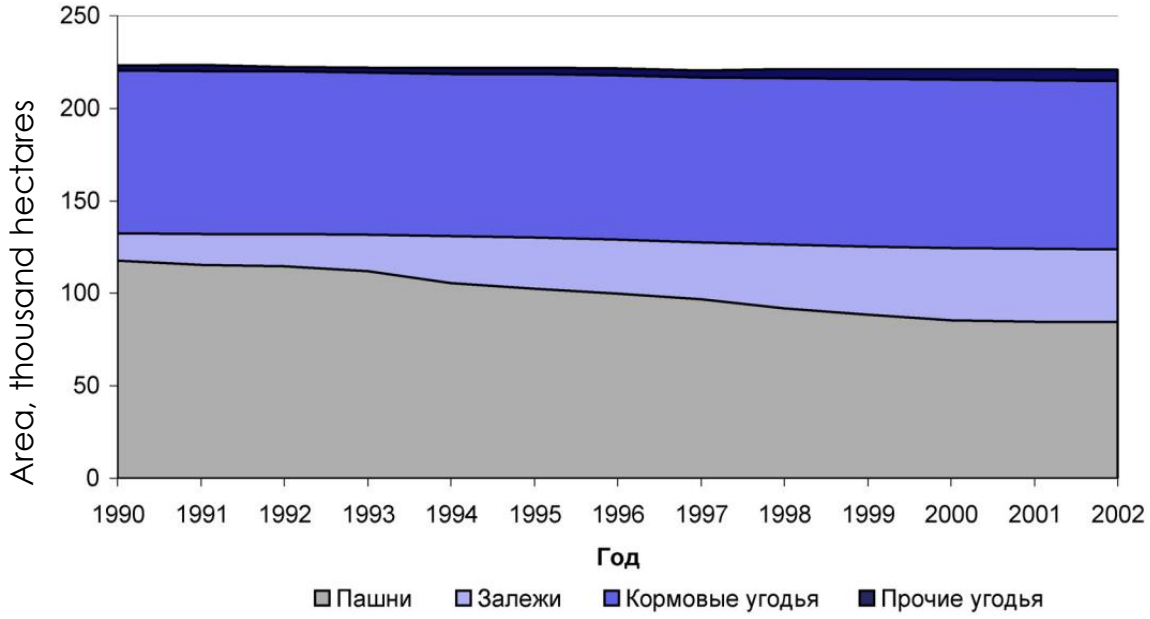
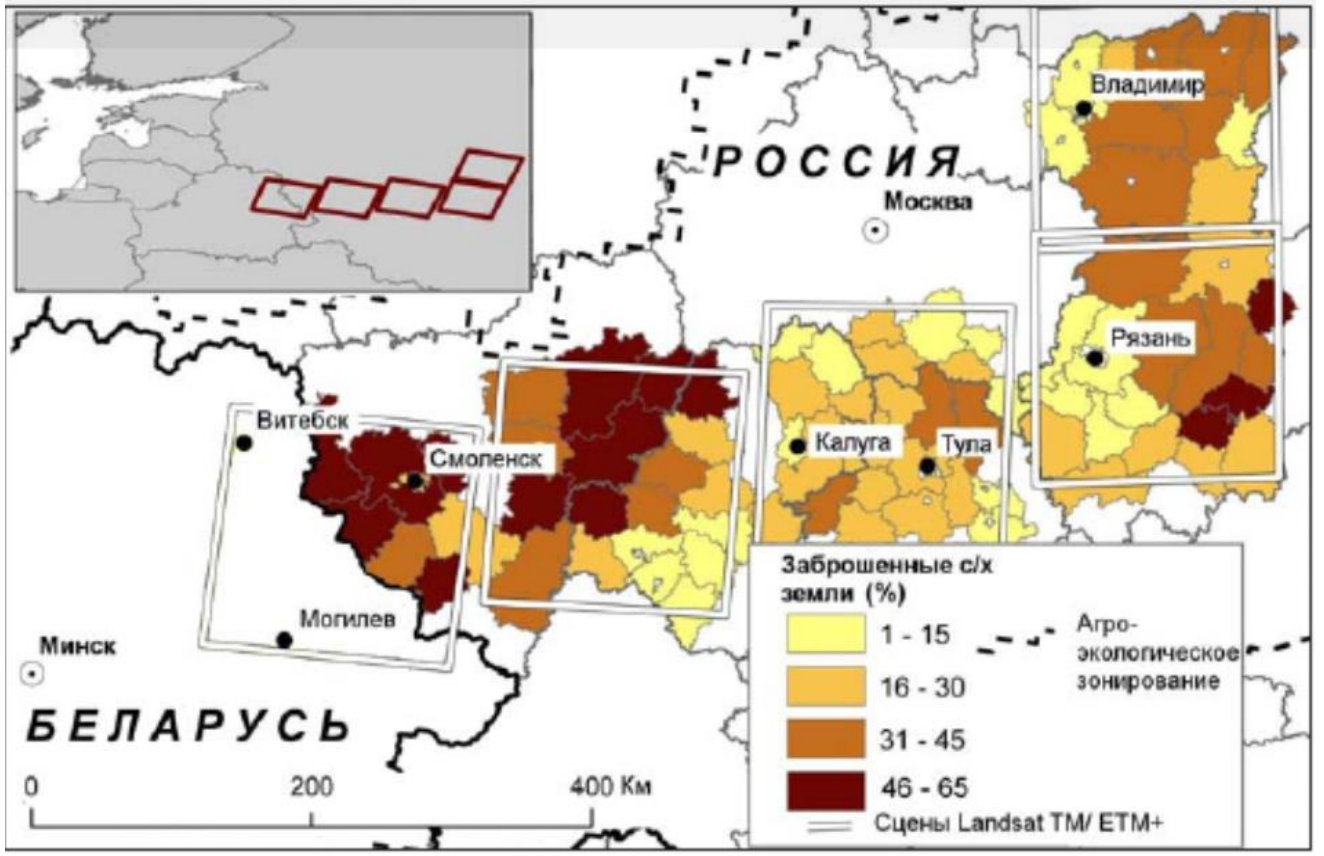


Dynamics of the areas of agricultural lands of the Russian Federation for 1990-2002.



The share of abandoned agricultural land in the European part of the Russian Federation

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Pine trees on the overgrown lands of the Uglich district of the Yaroslavl region

Fields of the Klin district of the Moscow region growing birch and pine

The growth of deposits of the Orshanka region of the Republic of Mari El with deciduous species

- Abandoned agricultural lands and deposits were actively captured by young tree species
- According to our legislation, such territories can not be used as a full-fledged forest, because the land on which they grows belongs to agricultural lands.

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- The relevance of the problem for the agricultural sciences is due to the importance of improving the methods for identifying and monitoring violations of the regime of agricultural land use, as evidenced by the following legislative documents:
- "On the approval of the development strategy for the Russian Federation forestry complex for the period until 2020" (2008)
- The federal law " On the Introduction of Amendments to Certain Legislative Acts of the Russian Federation Concerning the Improvement of the Circulation of Agricultural Land "(2011),
- " Concept the development of state monitoring of agricultural land and lands used or provided for agriculture in other categories of land, and the formation of state information resources on these lands for the period up to 2020 "(2010).

- In accordance with the Regulation on the Implementation of State Land Monitoring approved by the Government of the Russian Federation Decree No. 846 of November 28, 2002, it is necessary to collect information on the state of agricultural land, process it and find ways of storing it, conduct continuous monitoring of the land use regime, based on their purpose. It is important to assess and analyze the quality of farmland, taking into account the impact of anthropogenic and natural factors on them.

The methodology of such studies is the combination of satellite imagery and ground information obtained from topographic maps, as well as on the basis of previous studies or trial plot data. Technologies for decoding data on satellite images are being improved every year, which makes it possible to carry out further work to improve the accuracy of determination of plantation parameters while reducing costs for field measurements using modern technologies of computer modeling and geoinformation systems, which will lead to an increase in the productivity of work to identify and assess the overgrowing on deposits and will reduce their cost.

Part 1. Mapping of abandoned agricultural lands in 2011

- The purpose of the study was to create a database on the areas of overgrowing with tree vegetation on the deposits of the Republic of Mari El in 2011.

- The objects of research were young growths of coniferous and deciduous species growing on the deposits of the Mari EL. For the field period 2007-2011. 300 test plots were collected on the study area to collect forestry data from young forest and to assess the accuracy of thematic mapping.

Typical sample plots

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More than 300 test sites In the study area for mapping and verification/assesment

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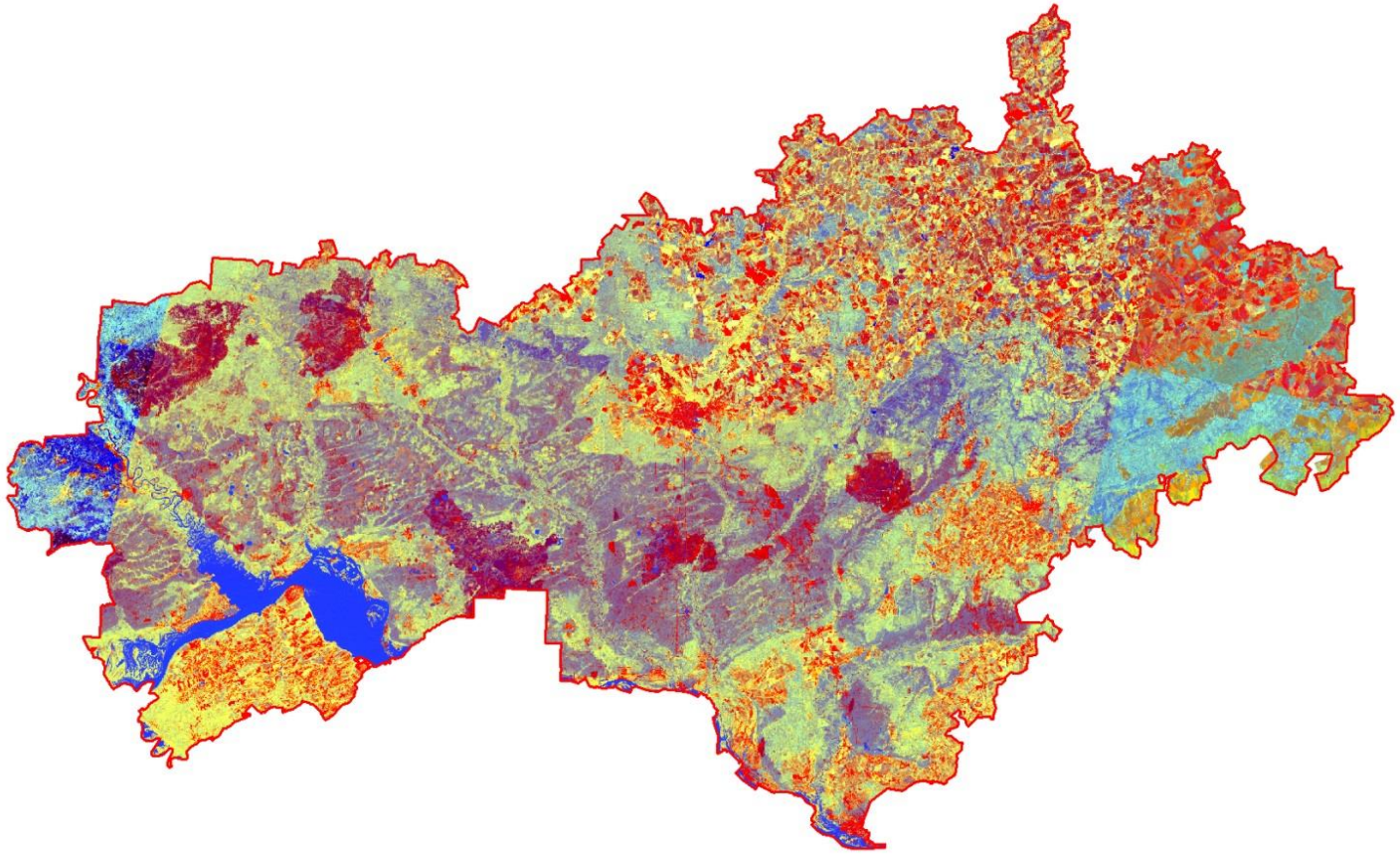
Preparation of satellite imagery for work:

- Landsat images for 2011, covering the territory of the Repulic of Mari El, were selected for work

Correction:

- Atmospheric (eliminates the influence of the atmosphere, the FLAASH module)
- Geometric (removes distortions at the edges, ties to the geographic system)
- Linear alignment (aligns images taken at different times of day, year, conditions)



Seamless mosaic of satellite images Landsat 7 on the territory of the study (synthesis of 5-4-1 spectral channels)

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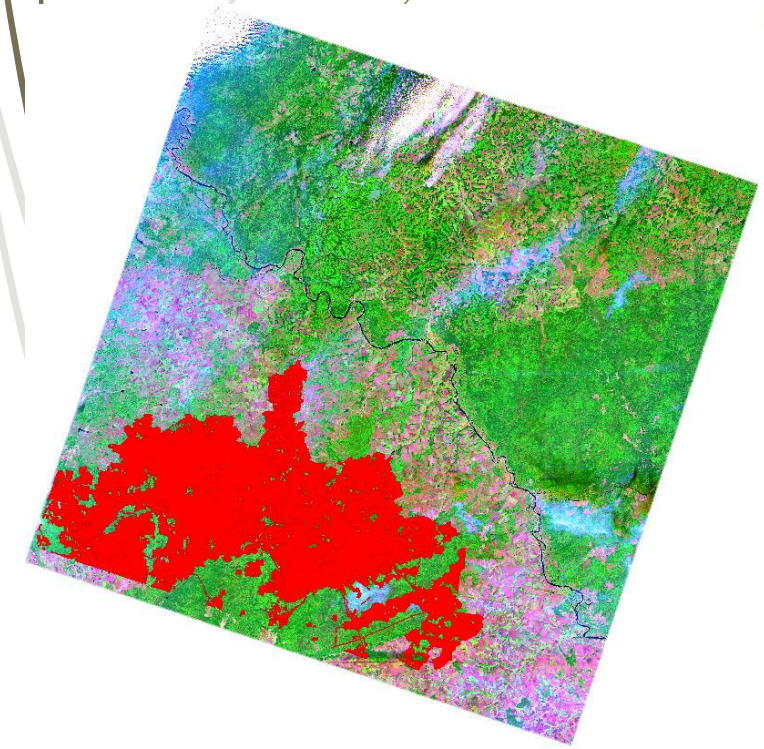

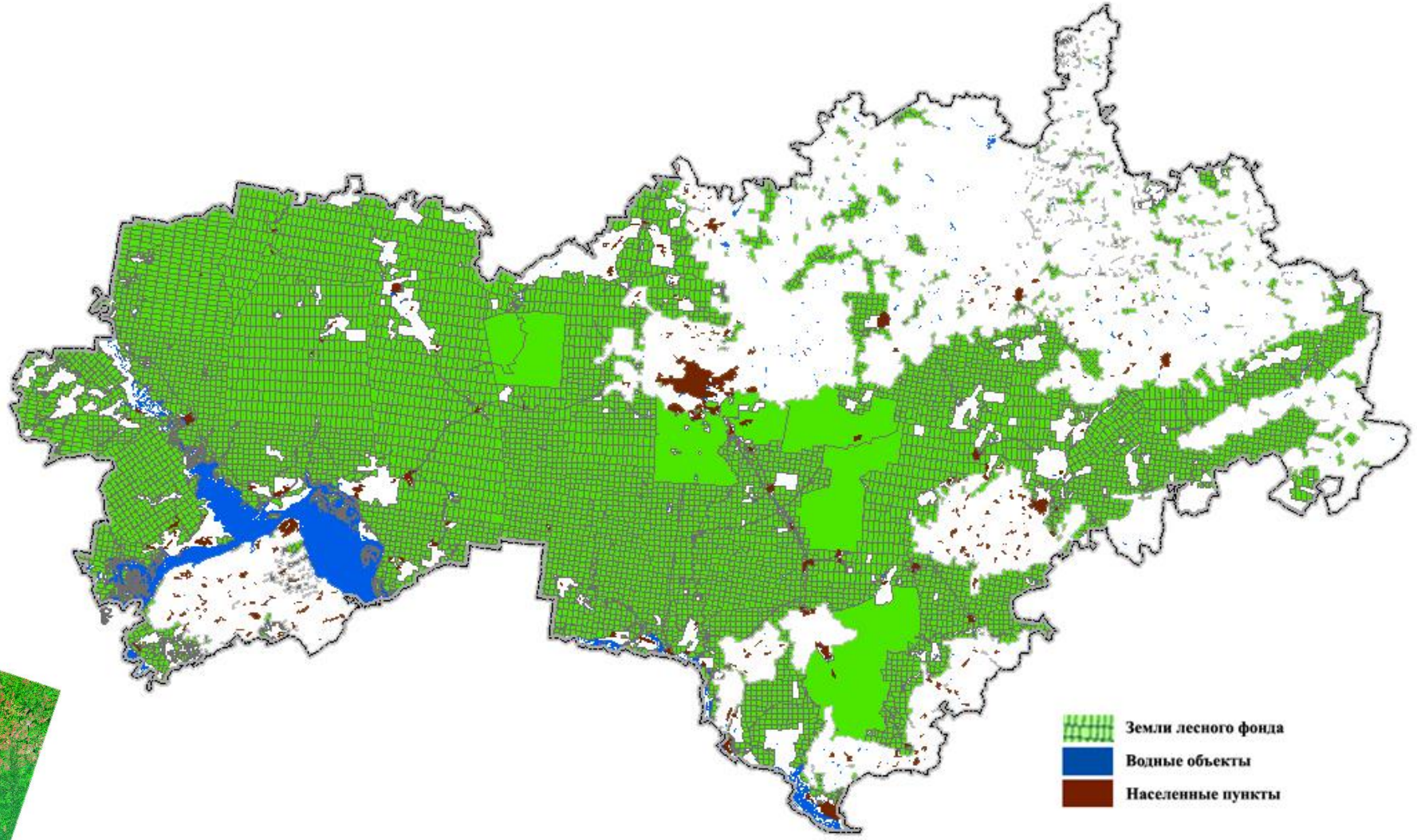

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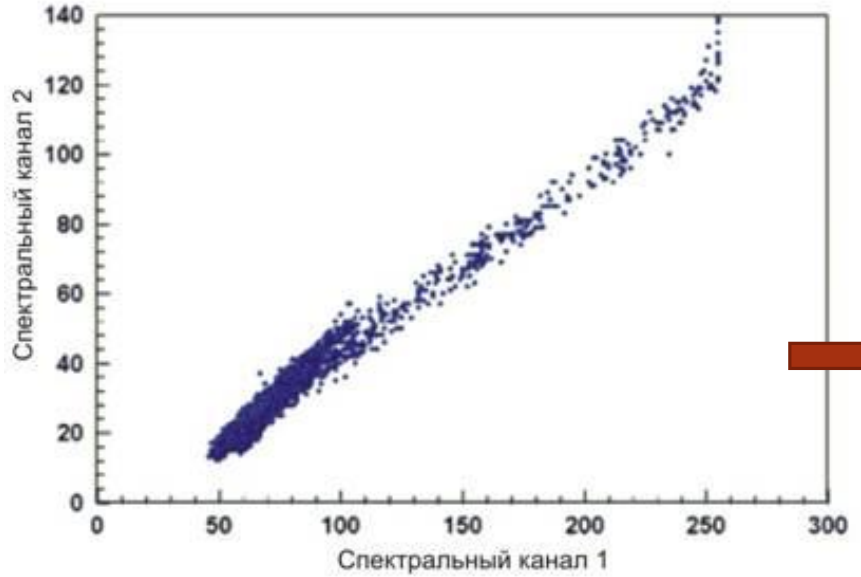

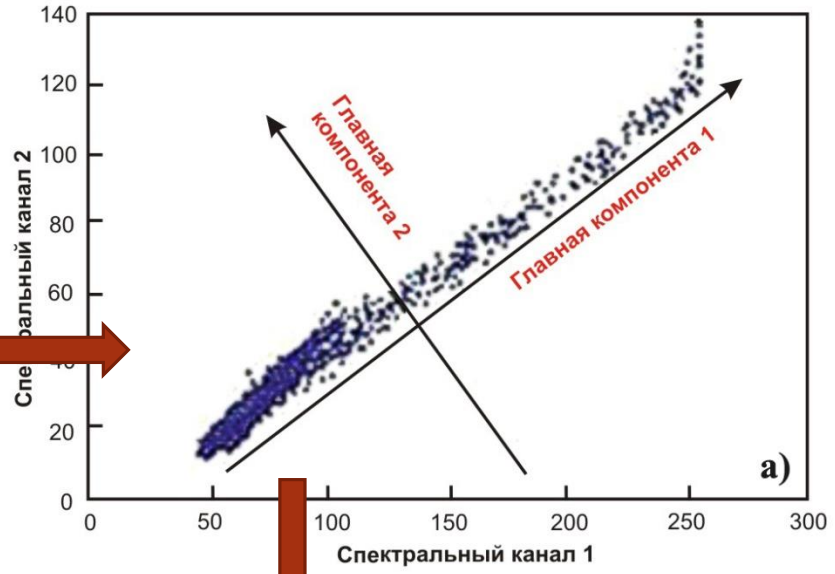

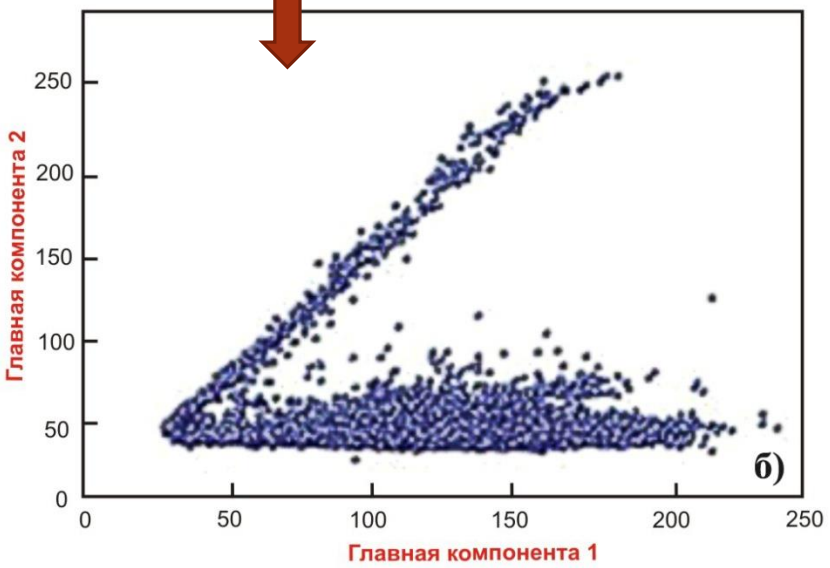

- Identification of young growths of coniferous and deciduous species on the lands of deposits by satellite images of the average resolution of Landsat is a difficult task. This is due to the spatial resolution of the images, as well as a significant influence on the spectral characteristics of the young ground grass cover.
- In our work, to improve the methodology for deciphering the young, we used the Principal Components Analysis (PCA) method, which is an analysis of the multispectral correlated data of the studied objects.
- In the PCA process, one of the components (the spectral values of the pixels in one spectral channel) unfolds perpendicular to the component of the spectral characteristics in another spectral channel. After the PCA transformation, the range of spectral characteristics of the studied objects along each axis will be maximized, which will lead to an increase in their color gamut in the image and, accordingly, to increase the degree of their visualization and interpretation.

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- In our study, one of the methods of analyzing the main components is used, namely the transformation of the fraction of the minimum "noise" (Minimum noise fraction transform, MNF-transformation).
- During the first stage of the PCA, a multispectral snapshot is analyzed for the presence of so-called "clean" and "noise" classes.
- «Clean» classes include those objects that can be explicitly highlighted in an image (for example, a forest, field or water object).
- Classes with "noise" include those objects that are located on the borders with "clean" ones. They can not be reliably identified either visually or with the help of modern complex programs. To such "noise" objects, it is also possible to include land plots of deposits that overgrow with tree species.

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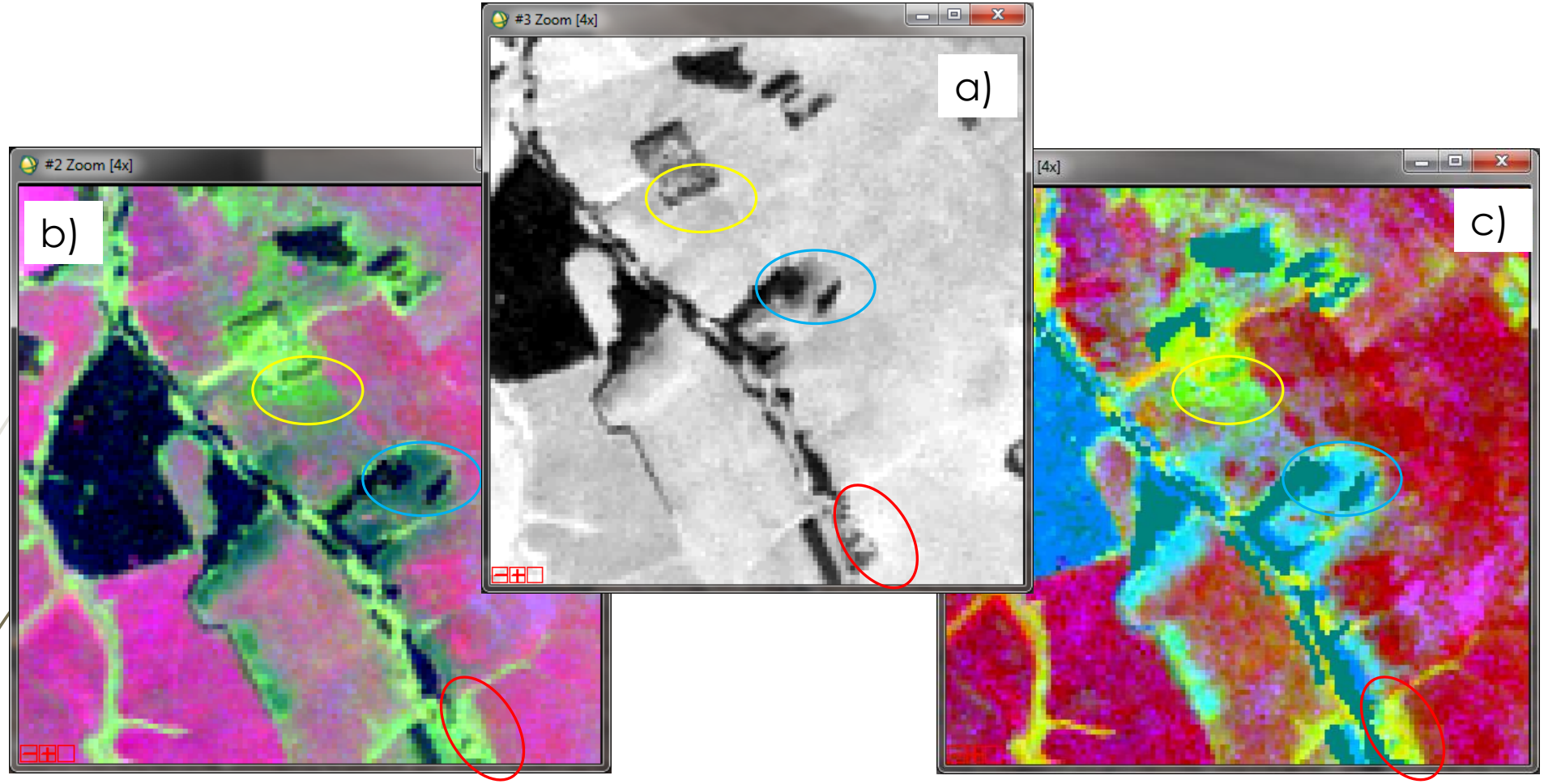

Fragment of the image: a) in the 5 spectral channel; b) in the synthesis of 5-4-1; c) after MNF-transformation

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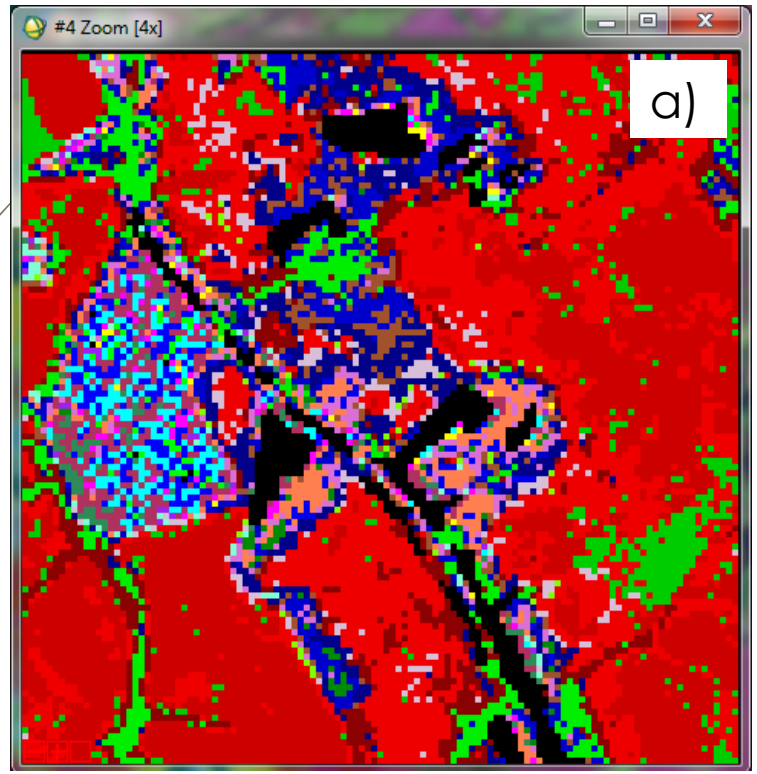
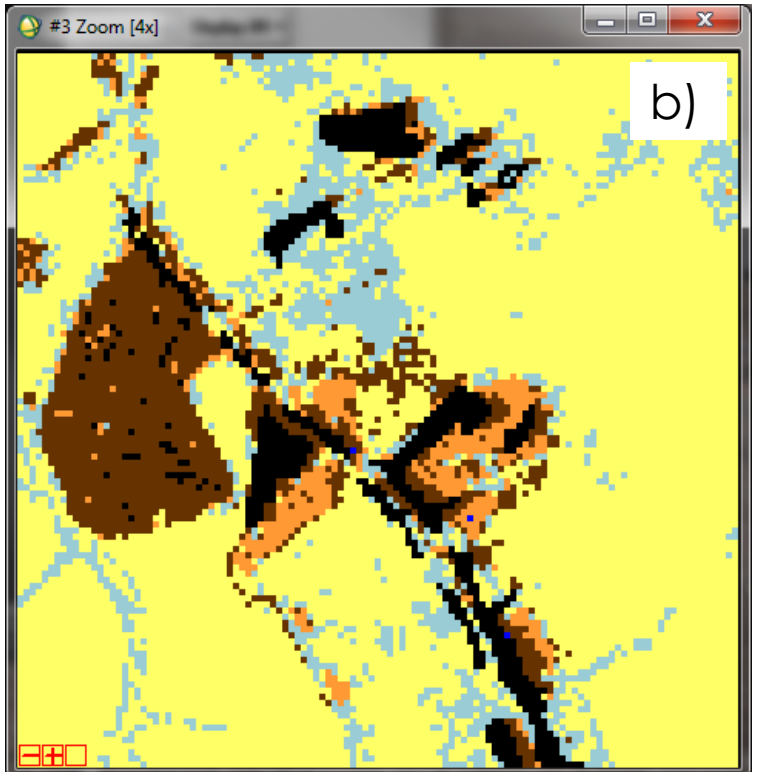
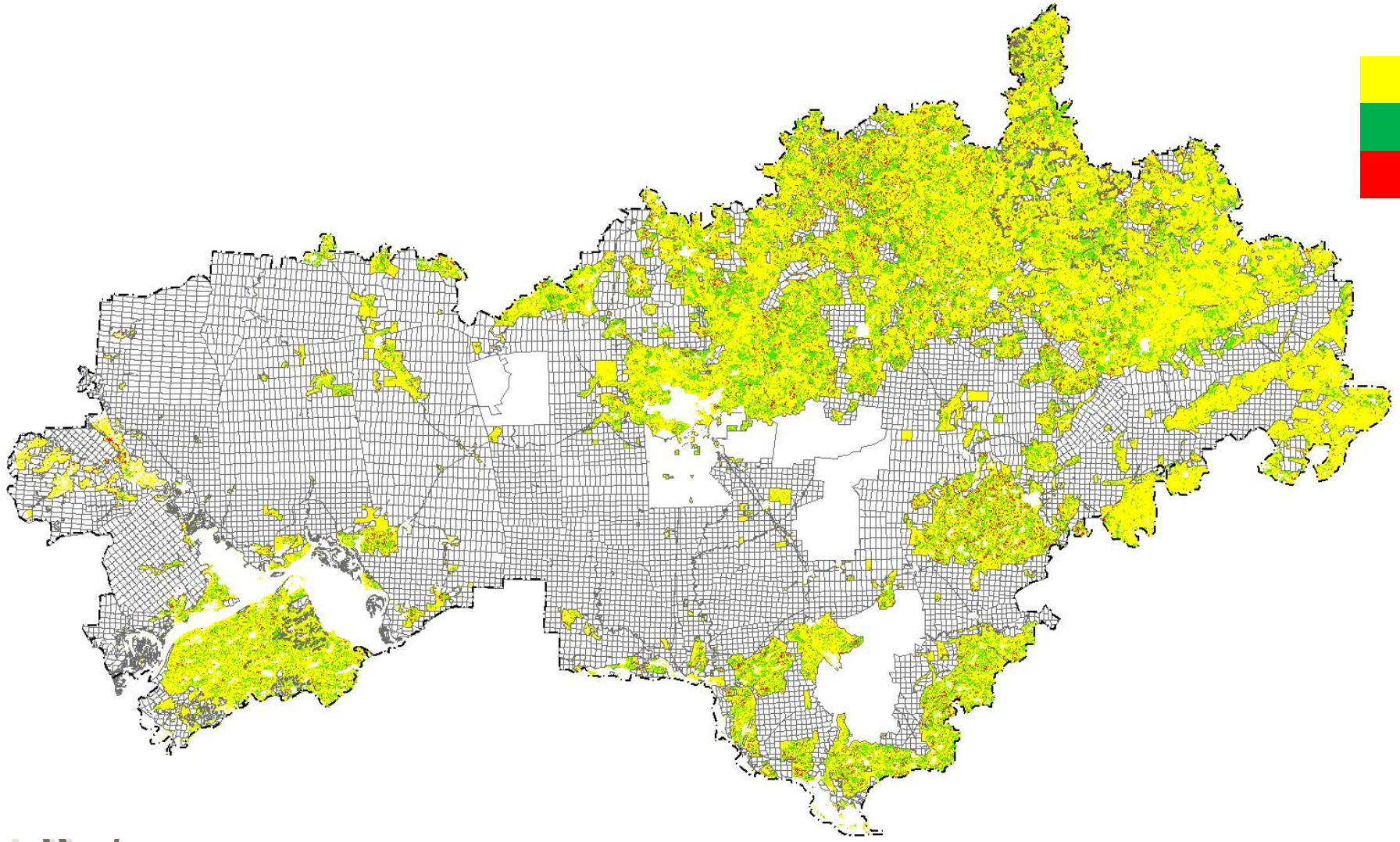
Thematic mapping of young growths of conifers and deciduous species

- Unsupervised classification for 25 classes. Allocation of agricultural lands, young growths of deciduous species, young growths of coniferous species.





A fragment of classification into 25 classes before the union of classes (a), after the union of classes (b)



Thematic map of agricultural lands with areas of young growths of deciduous and coniferous species for 2011.
Agricultural land - 766,805.49 ha, deciduous - 195848,19 ha, coniferous - 11826.54 ha. Kappa = 0.81

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Part 2: Mapping of abandoned agricultural lands in 2017

- The aim of the study was to find the optimal combination of the Landsat 8 satellite imagery channels for revealing the young trees on the former agricultural lands of the Republic of Mari El, and also to create a map of agricultural lands that are overgrown with tree species.

Objectives of the study

- Cloudless images of the satellite Landsat 8 on the investigated territory were selected for several time periods;
- Several spectral channels of Landsat 8 images were used to identify their optimal combination for research;
- Thematic mapping of selected three-channel images was carried out;
- Conclusions were drawn on the most optimal combination of the spectral channels of Landsat 8 satellite images for revealing tree vegetation in agricultural areas;
- The areas of agricultural lands of the Republic of Mari El, overgrown with tree species, were identified

The combinations of Landsat 8 satellite channels used in the study (scene 171-20)

Name	Date	The combination of spectral channel*
Spring_652	May 2017	6-5-2
Spring_654		6-5-4
Spring_751		7-5-1
Summer_652	July 2017	6-5-2
Summer_654		6-5-4
Summer_751		7-5-1
Autumn_652	September 2017	6-5-2
Autumn_654		6-5-4
Autumn_751		7-5-1

Note: 1 - spectral channel "coast and aerosols"; 2 - the blue channel; 4 - red channel; 5 - near infrared, NIR; 6 - shortwave near infrared, SWIR2; 7 - shortwave near infrared, SWIR3.

The spectral channels were selected on the basis of their optimum applicability for the study of crops (6-5-2), forest communities (6-5-4) and open soils (7-5-1)

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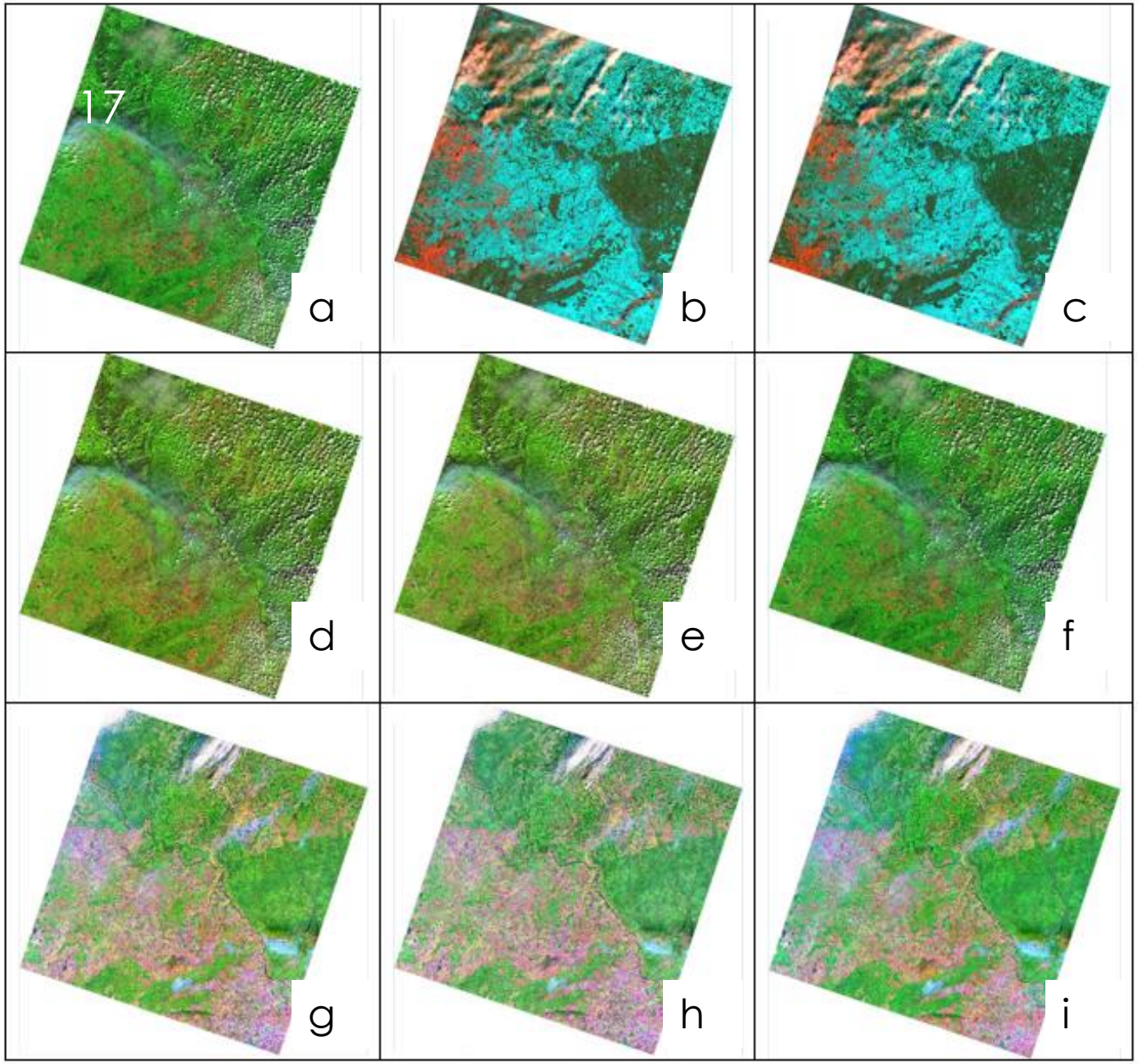

The combinations of Landsat 8 satellite channels used in the study (scene 171-20):

a) Spring_652; b) Spring_654;

c) Spring_751; d) Summer_652;

e) Summer_654; f) Summer_751;

g) Autumn_652; h) Autumn_654;

i) Autumn_751

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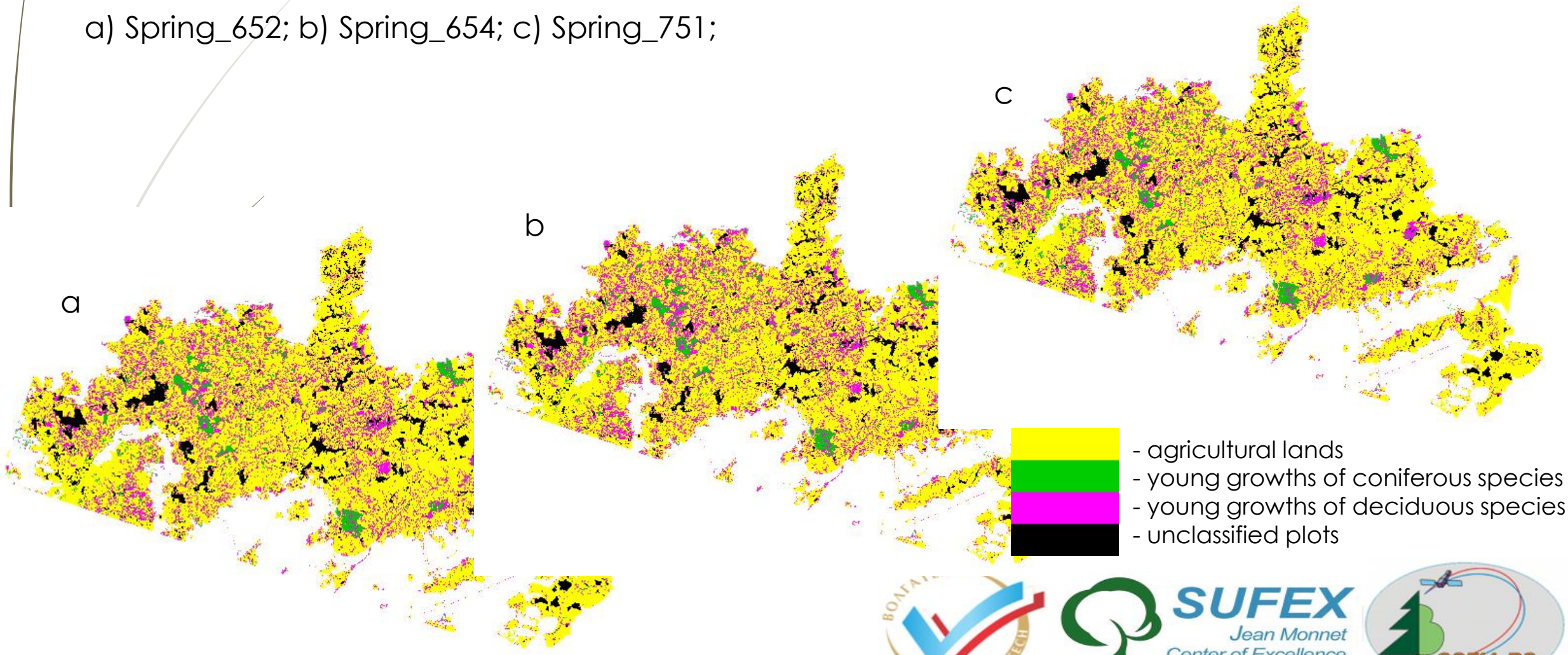
Results.

During the thematic mapping, 10 maps were obtained for several time periods

a) Spring_652; b) Spring_654; c) Spring_751;



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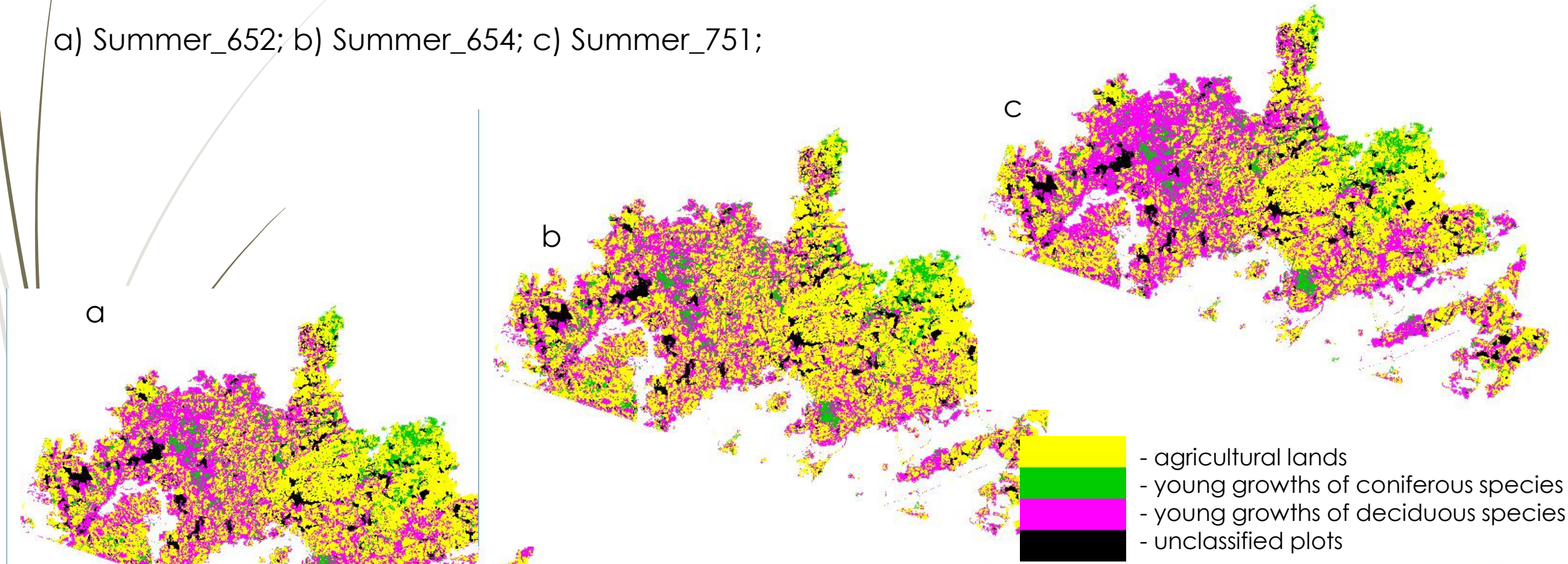
Results.

During the thematic mapping, 10 maps were obtained for several time periods

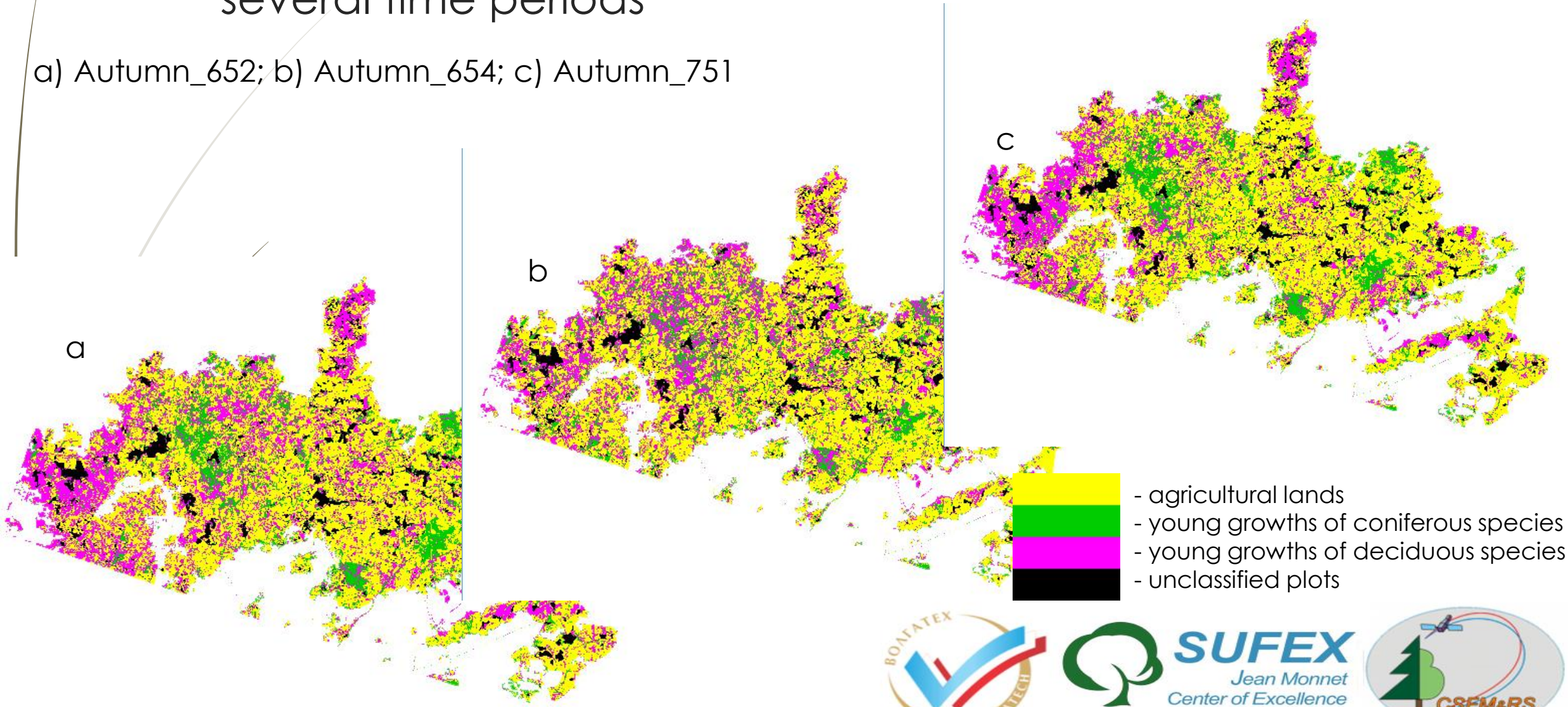
a) Summer_652; b) Summer_654; c) Summer_751;



Results.

During the thematic mapping, 10 maps were obtained for several time periods

a) Autumn_652; b) Autumn_654; c) Autumn_751



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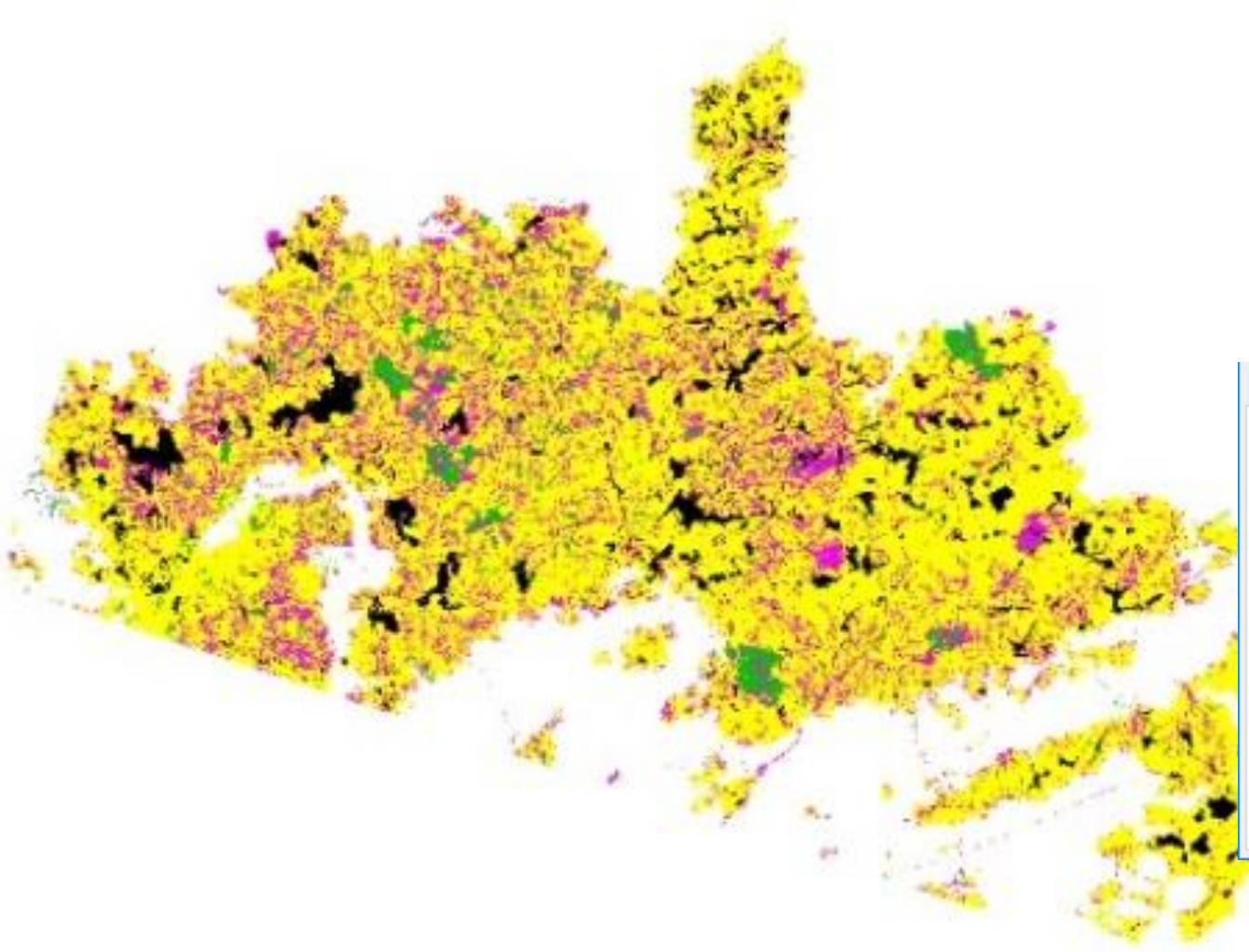
Accuracy of the obtained thematic maps

Thematic map	Overall accuracy, %	The Kappa coefficient (k)
Spring_652	87,89	0,67
Spring_654	86,87	0,66
Spring_751	87, 55	0,67
Summer_652	79,67	0,41
Summer_654	79,62	0,39
Summer_751	74,9	0,34
Autumn_652	65,93	0,16
Autumn_654	65,20	0,15
Autumn_751	67,42	0,19



Pixel Count | Percentage | Area (Square Meters) | Reference

Initial State

Final State	Field	Needl	Broad	Row Total	Class Total
Unclassified	0.000	0.000	0.000	0.000	100.000
field [Red] 11139 points	95.460	3.900	34.679	100.000	100.000
needl [Green] 343 points	0.198	66.848	0.171	64.213	100.000
broad [Blue] 1303 points	4.342	29.252	65.150	99.997	100.000
Masked Pixels	0.000	0.000	0.000	0.000	0.000
Class Total	100.000	100.000	100.000		
Class Changes	4.540	33.152	34.850		
Image Difference	5.355	10.130	-12.569		

Compare with verification map

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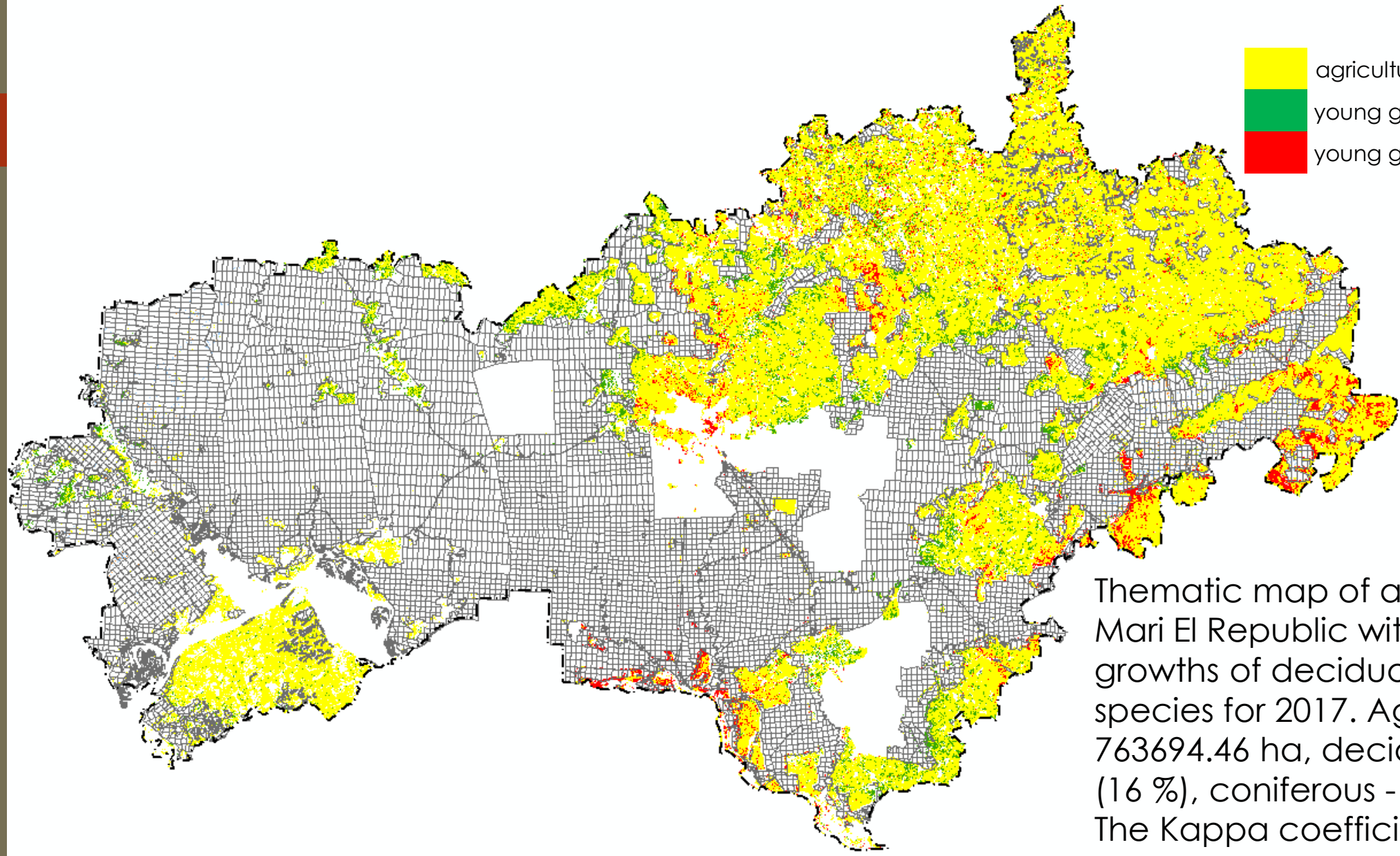

Thematic map of agricultural lands of Mari El Republic with areas of young growths of deciduous and coniferous species for 2017. Agricultural lands - 763694.46 ha, deciduous - 123776.19 ha (16 %), coniferous - 52557.12 ha (7 %). The Kappa coefficient = 0.87

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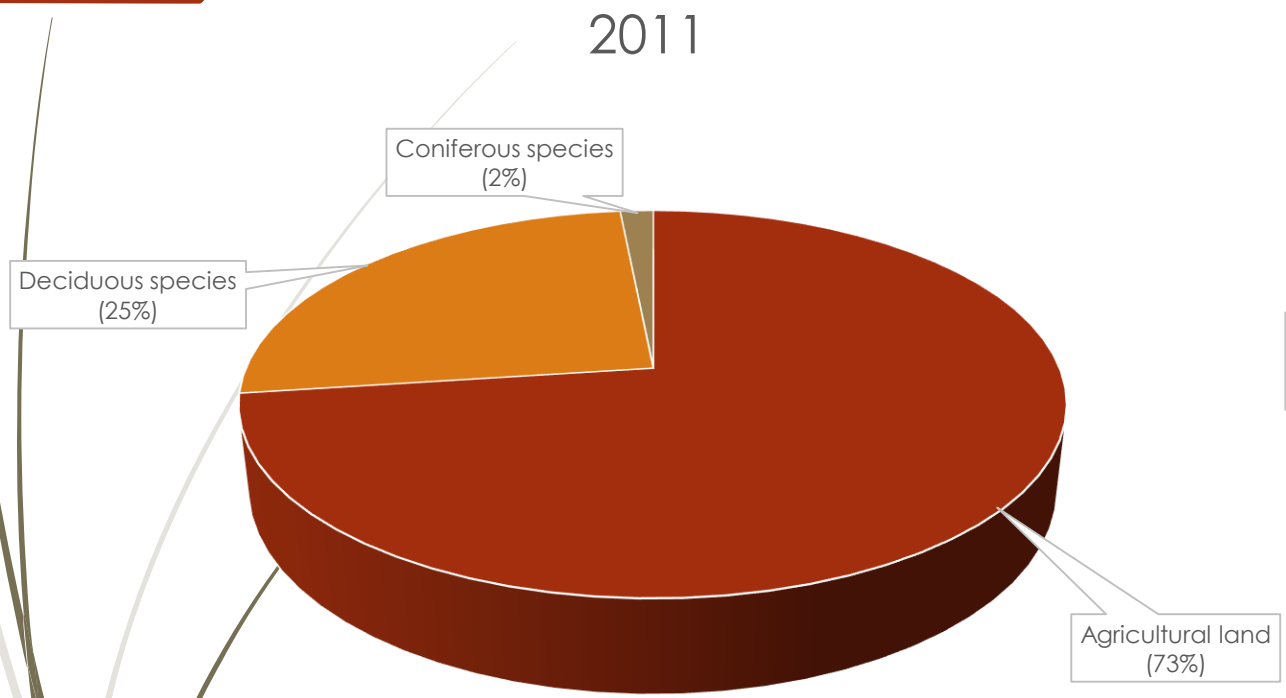
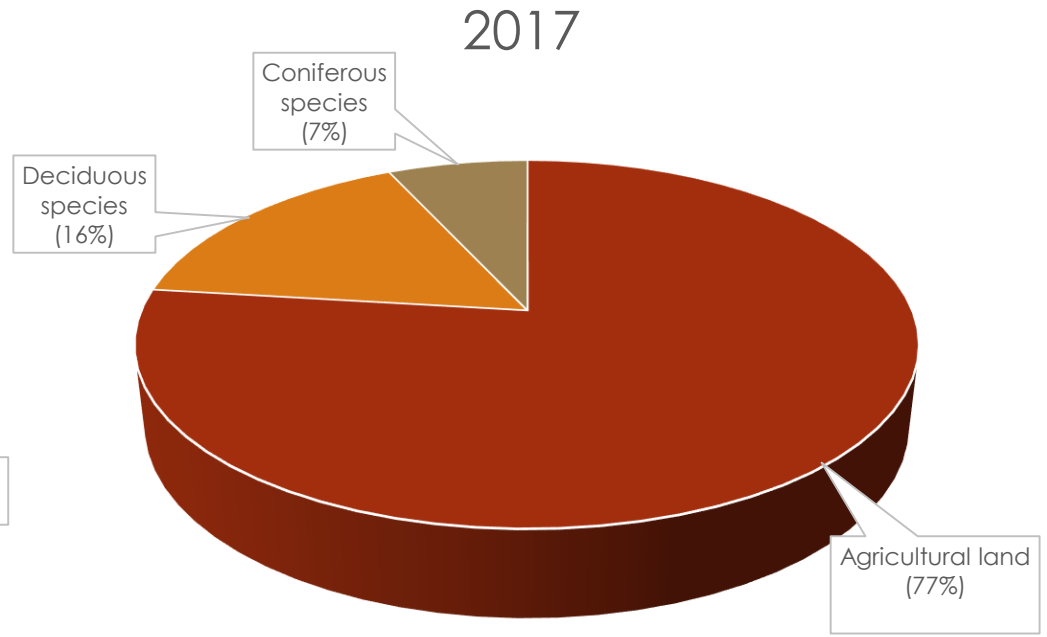
Dynamics of overgrown areas





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Part 3: Dynamics of spectral characteristics of coniferous and deciduous young growths on deposits, based on Landsat satellite data

Statistical indices of the spectral characteristics of the pixels of test areas of birch saplings in Landsat 2011

Spectral channel	X average	Xmin	Xmax	σ
1	153	65	211	57,6
2	178	116	197	43,56
3	245	219	254	42,0
4	147	99	199	30,9
5	43	21	87	19,5
7	140	99	173	32,6
NDVI	68	51	89	11,7

Statistical indices of the spectral characteristics of the pixels of the test plots of the young pine in Landsat 2011

Spectral channel	X average	Xmin	Xmax	σ
1	167	127	198	21,98
2	212	200	224	19,55
3	87	65	93	27,68
4	200	135	255	57,88
5	140	132	168	15,16
7	157	132	189	38,84
NDVI	92	86	111	10,88

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The average values of the brightness characteristics of the test areas in the 5th spectral channel Landsat and on the map of vegetation index NDVI

Spectral channel	Years							
	1985	1988	1998	1999	2001	2005	2010	2011
Sample plots with deciduous young trees								
5	218	253	254	254	157	148	143	140
NDVI	60	62	70	69	100	188	165	188
Sample plots with coniferous young trees								
5	250	243	210	198	218	167	68	49
NDVI	63	71	68	63	64	118	125	128

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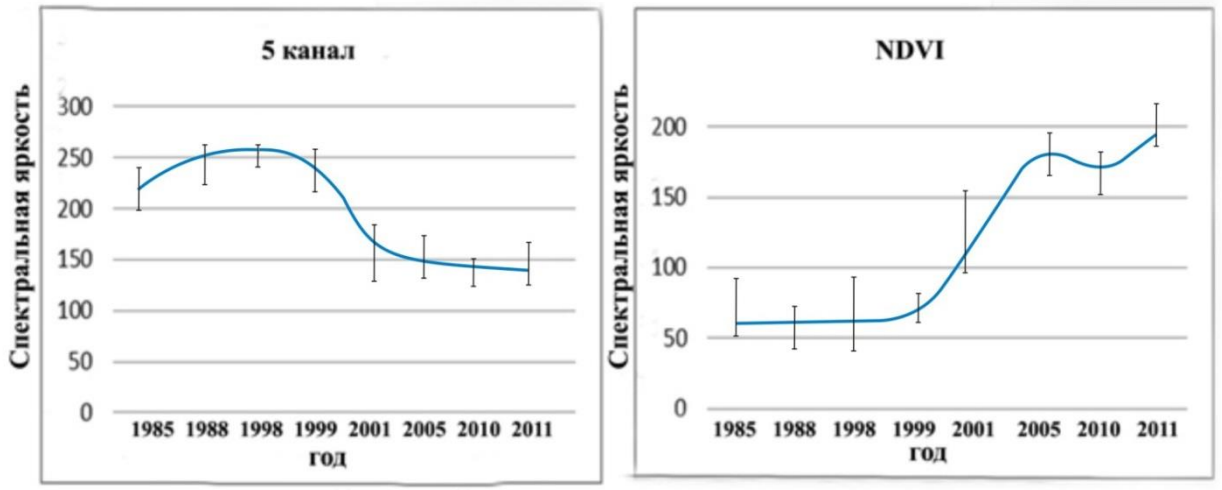
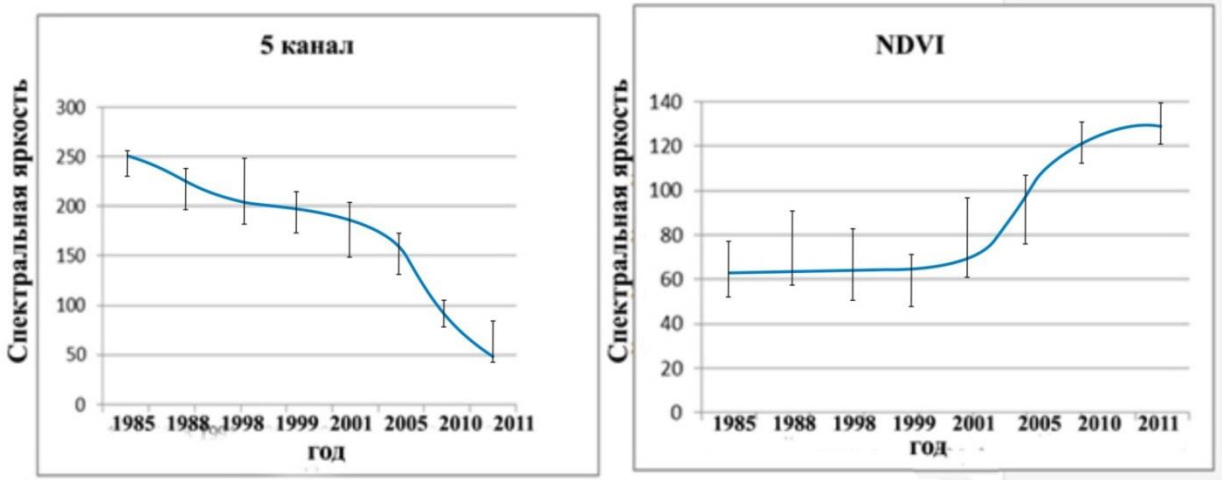
Dynamics of spectral characteristics of young deciduous growth



Dynamics of spectral characteristics of young coniferous growth



Results:

- The regularity of the temporal dynamics of the spectral characteristics of young growths of coniferous and deciduous species growing on deposits revealed the period of the beginning of the overgrowing of tree species.
- Tree species, exciting areas of former agricultural lands (deposits), begin to influence the spectral characteristics of the Landsat satellite image from a 3-4-year period.

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Conclusions

- The developed thematic maps testify to a stable process of mass overgrowing of young tree vegetation in the territory of the Republic of Mari El.
- Thematic mapping of young forests on deposits allowed to determine the area of overgrowth for 2017. The total area of agricultural land according to the obtained thematic map reaches 763694.46 hectares, while overgrowing of young growths of deciduous species up to 123776.19 hectares (16%), respectively, and overgrowth by young conifers species reaches 52557.12 ha (7%), respectively.
- The created thematic maps of coniferous and deciduous species on the Republic of Mari EL deposits can be used as a basis for their further study and monitoring
- The use of data on areas of overgrowing of deposits facilitates their alienation from owners and the possible transfer of such sites to the forest fund lands.

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Thank you for attention!

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