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# FEATURES OF INTERPRETATION OF PLANT ASSOCIATION OF NATIONAL NATURAL PARK «SLOBOZHANSKIY» USING LANDSAT 8 SATELLITE DATA

The article deals with the comparative analysis of the two methods of classification (unsupervised classification (ISODATA) and supervised classification (Spectral Angle Mapper)) of satellite images Landsat 8 to identify the plant associations of left-bank part of National Nature Park «Slobozhanskiy».
**Keywords:** unsupervised classification, supervised classification, satellite imagery, National Natural Park.

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**ОСОБЛИВОСТІ ДЕШИФРУВАННЯ РОСЛИННИХ УГРУПОВАНЬ НАЦІОНАЛЬНОГО ПРИРОДНОГО ПАРКУ «СЛОБОЖАНСЬКИЙ» ІЗ ЗАСТОСУВАННЯМ СУПУТНИКОВИХ ДАНИХ LANDSAT 8**

У статті проведено порівняльний аналіз застосування двох методів класифікації (без навчання (ISODATA) та з навчанням (Spectral Angle Mapper)) супутникових знімків Landsat 8 для ідентифікації рослинних асоціацій лівобережної частини національного природного парку «Слобожанський».
**Ключові слова:** класифікація з навчанням, класифікація без навчання, супутникові знімки, національний природний парк.

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**ОСОБЕННОСТИ ДЕШИФРИРОВАНИЯ РАСТИТЕЛЬНЫХ АССОЦИАЦИЙ НАЦИОНАЛЬНОГО ПРИРОДНОГО ПАРКА «СЛОБОЖАНСКИЙ» С ИСПОЛЬЗОВАНИЕМ СПУТНИКОВЫХ ДАННЫХ LANDSAT 8**

В статье проведен сравнительный анализ использования двух методов классификации (без обучения (ISODATA) и с обучением (Spectral Angle Mapper)) спутниковых снимков Landsat 8 для идентификации растительных ассоциаций левобережной части национального природного парка «Слобожанский».
**Ключевые слова:** классификация с обучением, классификация без обучения, спутниковые снимки, национальный природный парк.

**Introduction**. Over the last decade the number of objects of natural reserve fund, including National Nature Parks (NNP), significantly increased in Ukraine. However, one of major problems of created parks is a lack of necessary cartographic works that are the basis for research works conducted within the NNP territory.

One of these cartographic works is the landscape map of facies level. The creation of such map is a multistage process; one of the stages is an identification of plant communities. Indeed, since facies have the same geological structure, relief, humidifying regime, but different vegetation, facies mapping takes place outside of plant communities.

One of the most effective ways to obtain information on plant communities is the interpretation of satellite images. Of course, the possibility of their use is limited by their cost since majority of modern satellite data have a high cost. However, the Landsat 8 satellite data, which was launched in 2013, are in open access and are very promising for the identification of plant communities.

**Underlying assumptions.** The remote sensing (RS) data are widely used in landscape studies. Thus, in K. Kulik work [4] the method involved the use of medium- and large-scale satellite images in laboratory conditions and on the stage of decryption in field. In the work of A. Afanasyev and A. Zamyatin [1] a comparative analysis of eight research methods of landscape cover changes estimating based on satellite images use was conducted. In the research of A. Ufimtseva [9] RS data were used as a basis for landscape map creation for the agricultural land monitoring. A special attention should be paid to the Geographic Information System of «Taymyrskiy» reserve [6], thematic basis of which were vector layers, descramble circuits of RS data obtained in manual and semi-automatic modes. In the work of O. Fedorovsky et al. [10] the methods of structural and textural analysis for automating the process of landscape complexes decryption were reviewed. Finally, in the article of O. Sinna [7] the use of RS was supposed

on the inventory stage to determine the modern land cover of territory.

**The aim** of this work is a comparative analysis of methods of plant communities' identification on the left-bank part of NNP «Slobozhanskiy». To achieve this purpose following tasks were solved:

• plant communities identification with the use of unsupervised and supervised classification methods;

• comparative analysis of the results;

• identification of the opportunities and limitations of the obtained results application for the needs of landscape mapping.

**Presenting main material.** NNP «Slobozhanskiy» is a recently created object of natural reserve fund of Ukraine. It is located in the Krasnokutsk district of Kharkiv region. Its area is 5 244 hectares. NNP «Slobozhanskiy» is subordinated to the Ministry of Ecology and Natural Resources of Ukraine [5, 8].

The study was conducted in the part of the park, which is located within the first terrace above the floodplain of the Merla River Valley. This area was a hilly plain with elevations ranging from 115 to 145 m. It could be divided into lower and higher part, which have formed due to various geomorphological processes and had respectively different quaternary sediments. The higher part of the terrace was composed of the Upper Pleistocene sandy alluvial sediments, the lower one — of eolian sandy sediments, which formed numerous sandy mounds and inter-mounds depressions occupied by wetlands [3].

Pine forest (without undergrowth and with rowan and hazel in the undergrowth) and subor forest (linden-oak on the higher part of the terrace and aspen-birch on the lower one) dominated in the southern part of the park. Birch and birch in admixture with aspen dominated in the saucer-like depressions of the terrace.

The plantations which were not typical for upland terraces (poplar, alder and linden groups) were also observed. There was a large number of fellings due to the fact that the territory of the park for a long time belonged to Hutyanske forestry. Birch and alder thickets created conditions suitable for the existence of atypical for this area plants and animals.

An image of Landsat 8 OLI from May 16, 2014 was used as the initial data for the study. The application of Landsat images in the study of plant communities has a long history. However, in most studies the data of Landsat TM ([13, 14, 15]) or, rarely, ETM + SLC-on [11, 14] are primarily used. The main difference between OLI sensor and its predecessors is a greater radiometric resolution (12-bit to 8-bit in sensors TM and ETM +), allowing to identify even minor variations in reflectivity of objects of the earth's surface.

Following data were used in addition to the image:

• geological map;

• map of Quaternary sediments;

• soil map;

• forest inventory materials.

All data were presented as vector layers in *.shp format.

Reference materials on NNP «Slobozhanskiy» also were used in the course of the work.

The work was performed as part of the «Landscape studies within the NNP «Slobozhanskiy» territory» section of educational professional-oriented practice of 2nd year students of the Physical Geography and Cartography Department in June 2014.

Evaluation of reliability of the obtained thematic rasters was conducted in two stages. First, in laboratory conditions the results of classification were estimated directly by park workers, who have a good knowledge about the peculiarities of NNP territory. Second, the results were checked through the direct visits to the control sites and the determination of compliance in the field.

Identification of plant communities by unsupervised classification using.

ISODATA method was used as a method of unsupervised classification. Thematic rasters were built in the ENVI 5.0 software.

It is known that the main problem of unsupervised classification is the fact that, in any case, all pixels of researched area will be assigned to a particular class. So to get representative results, the most important thing is to choose the correct number of classes.

As part of this research a classification by the ISODATA method was conducted with a division on 10 and 13 classes. However, after the post-classification processing, it was found that despite the extension of classes as a result of classes combining, resulting thematic raster was divided into 9–10 classes. The combination of classes was carried out when one type of land covers (primarily plant communities) was artificially attributed to two classes.

In addition to the Combine Classes tool, such tools were used at the stage of post-classifica-

tion processing: Sieve to remove isolated pixels, Clump to merge adjacent areas and Majority filter to smooth classification results.

As a result of transformations following thematic raster was obtained (Fig. 1).

The results of the classification by the ISODATA method received relatively low quality score during the assessment done by workers of the park, due to the large amount of distortion. The third class got territories occupied by simultaneously mature and young pine without undergrowth. The site with mature pines without undergrowth was well allocated only in the south of the territory. In the central and northern parts the class corresponded to young pine with undergrowth. Class 4 interspersed significantly with subor in the central and southern parts. In addition, it included wetland plant communities located in the shaded part of the wetland. Class 5 combined birch in the northern part of the territory and subor in the central and southern parts. Class 6 was separated relatively well, especially in the case of cuttings which had overgrown. Nevertheless, meadow vegetation and alder groups were added to this class. In addition, this class had no clear boundaries with class 8 «Densely planted deciduous forest areas». Finally, the last class «Recent felling that is overgrowing with undergrowth and has open

sand» included a much larger area than those actually relating to fresh felling.

To improve the results an attempt was made to apply the ISODATA method to multispectral image Landsat, spatial resolution of which was artificially enhanced by Pansharpening tool due to panchromatic band. Unfortunately, improving of visualization was combined with a significant distortion of spectral information. As a result, after the ISODATA method application most homogeneous areas experienced significant fragmentation, which was expressed, above all, in a very considerable number of isolated pixels. Consequently, further analysis of thematic raster, obtained on the basis of an image with improved resolution, was found inappropriate.

Identification of plant communities by supervised classification using.

As an alternative to ISODATA method it was decided to choose supervised classification method, which could significantly improve the quality of the results of research. The most difficult was a hilly area in the north, where birch often varied with swampy areas. In addition to the type of vegetation, light exposure changed in this part of NNP. As a result, even if the signature sets had been selected correctly methods based on calculating the distance between pixels in a multidimensional spectral space would have led
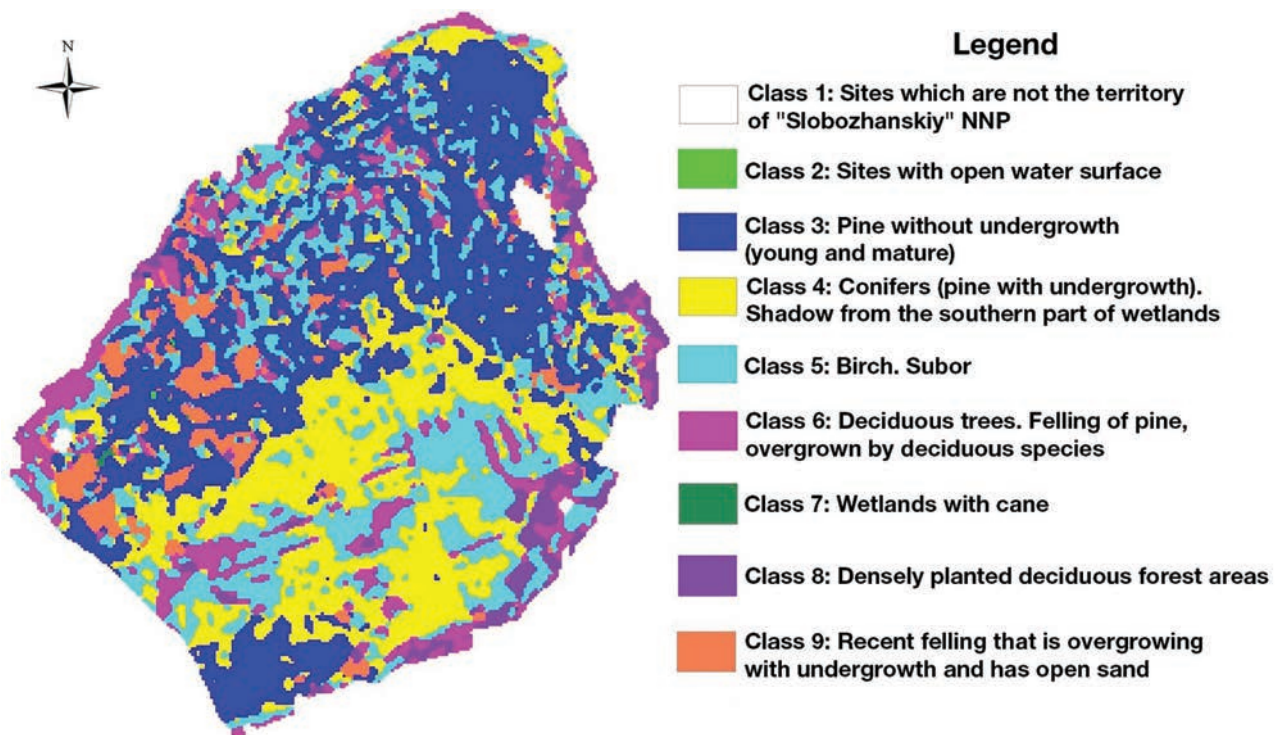


**Legend**

Class 1: Sites which are not the territory of "Slobozhanskiy" NNP

Class 2: Sites with open water surface

Class 3: Pine without undergrowth (young and mature)

Class 4: Conifers (pine with undergrowth). Shadow from the southern part of wetlands

Class 5: Birch. Subor

Class 6: Deciduous trees. Felling of pine, overgrown by deciduous species

Class 7: Wetlands with cane

Class 8: Densely planted deciduous forest areas

Class 9: Recent felling that is overgrowing with undergrowth and has open sand

*Fig. 1. Results of the allocation of plant communities and other land covers by the ISODATA method with division into 10 classes.*

to the assignment of pixels of territories with one type of vegetation to different classes.

An interesting alternative to the above-mentioned methods is a method of spectral angle (Spectral Angle Mapper — SAM). This method operates not with distances, but with limit lines of relationships between reflectivity in different bands of spectral feature space, defining the minimum and maximum dependence values. Thus, the range of signs that correspond to a certain class was determined by the angular value. As a result, the pixels belonging to the same type of land cover, but located in different lighting conditions, will refer to the same class. It should be noted that the use of SAM method does not always give unambiguous results. Thus, in the article [12], devoted to the identification of invasive plants by hyperspectral data, it was indicated that the SAM method gave only 40% of accuracy.

At the beginning of the supervised classification by SAM method a list of plant communities and other land covers was formed together with the experts from «Slobozhanskiy» National Park. For each class a spectral angle was selected then and polygons of typical sites were outlined, which were spectral signatures of these classes. As a result, following spectral angles for selected classes were identified (Table 1).

As a result of the classification such classes were well identified: «Young pine», «Sites with open water surface», «Recent felling that is overgrowing with undergrowth and has open sand», «Birch wood» and «Birch wood on dry soil».

The disadvantages of the built raster included

redundant areas assigned to «Birch wood» class and not clearly highlighted «Felling, overgrown with young trees, which has no open sand» class. Most errors were observed in the northern part of the image due to the fact that in this region the sites of different land surfaces were very small in size, the allocation of which by image with a resolution of 30 meters was a very complex task. Great inaccuracy was observed in the allocation of deciduous trees growing in place of former cutting. These areas in the classification were assigned to multiple classes (Fig. 2).

To improve results a series of Majority/Minority Analysis arrangements were applied to the thematic raster, primary purpose of which was removing of uninformative isolated pixels and reducing «Unclassified» class by including its pixels to the spatially adjacent classes. The results are shown in Fig. 3.

Verification of results of classification was carried out directly in field conditions with the use of a tablet computer with installed ArcGIS for Windows Mobile software.

According to the results of the field stage of the research and to the results of the analysis of the obtained thematic raster, conducted together with employees of «Slobozhanskiy» NNP, a degree of representativeness of allocation of each of the classes was defined.

«Recent felling that is overgrowing with undergrowth and has open sand» class separated well, in some cases there were redundant sites that emerged after the use of Majority tool, but the percentage of such sites was negligible.

*Table 1*

| № | Land cover type | Spectral angle (rad) |
|---|---|---|
| 1. | Recent felling that is overgrowing with undergrowth and has open sand | 0,062 |
| 2. | Sites with open water surface | 0,03 |
| 3. | Mature pine with undergrowth | 0,02 |
| 4. | Mature pine without undergrowth | 0,02 |
| 5. | Birch wood | 0,055 |
| 6. | Young pine | 0,025 |
| 7. | Alder | 0,025 |
| 8. | Felling, overgrown with young trees, which has no open sand | 0,025 |
| 9. | Felling, that is overgrowing with undergrowth and has no open sand | 0,02 |
| 10. | Oak forest | 0,025 |
| 11. | Birch wood on dry soil | 0,025 |
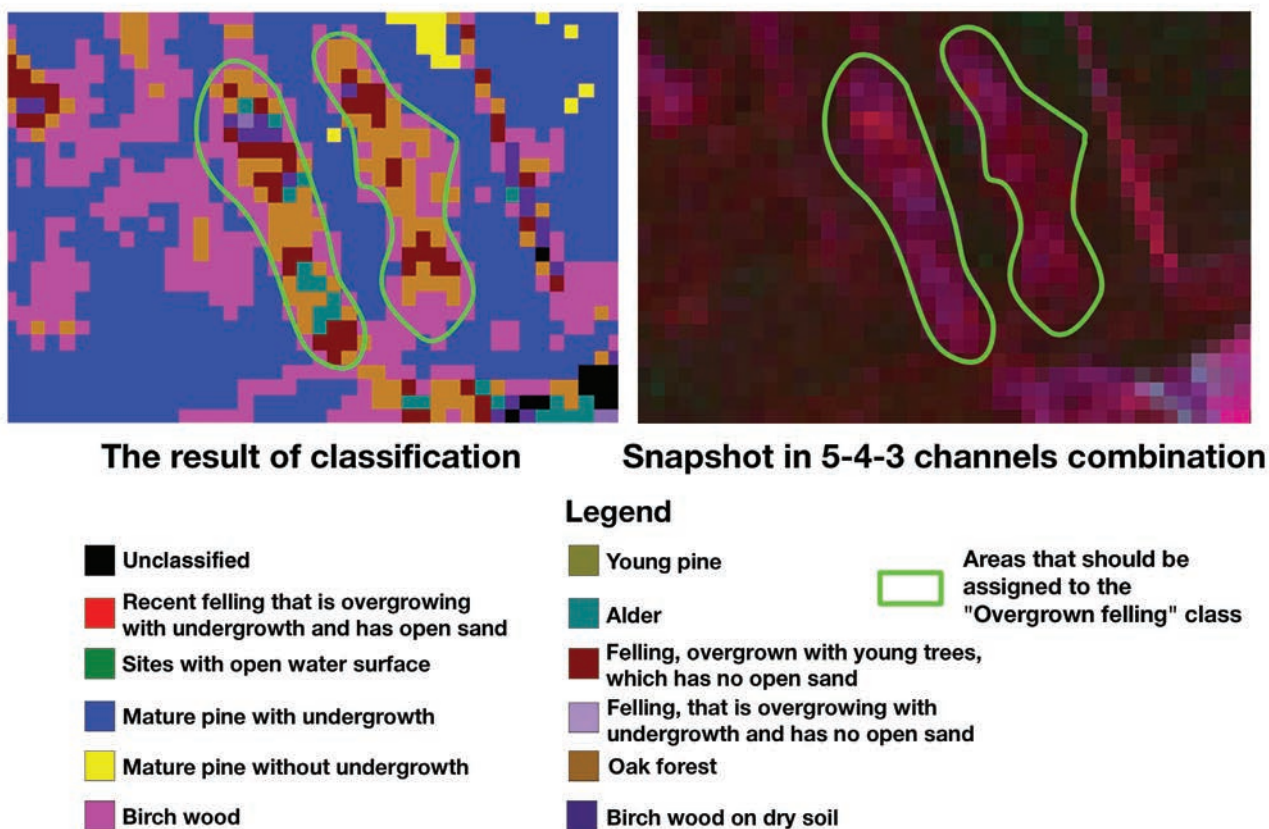
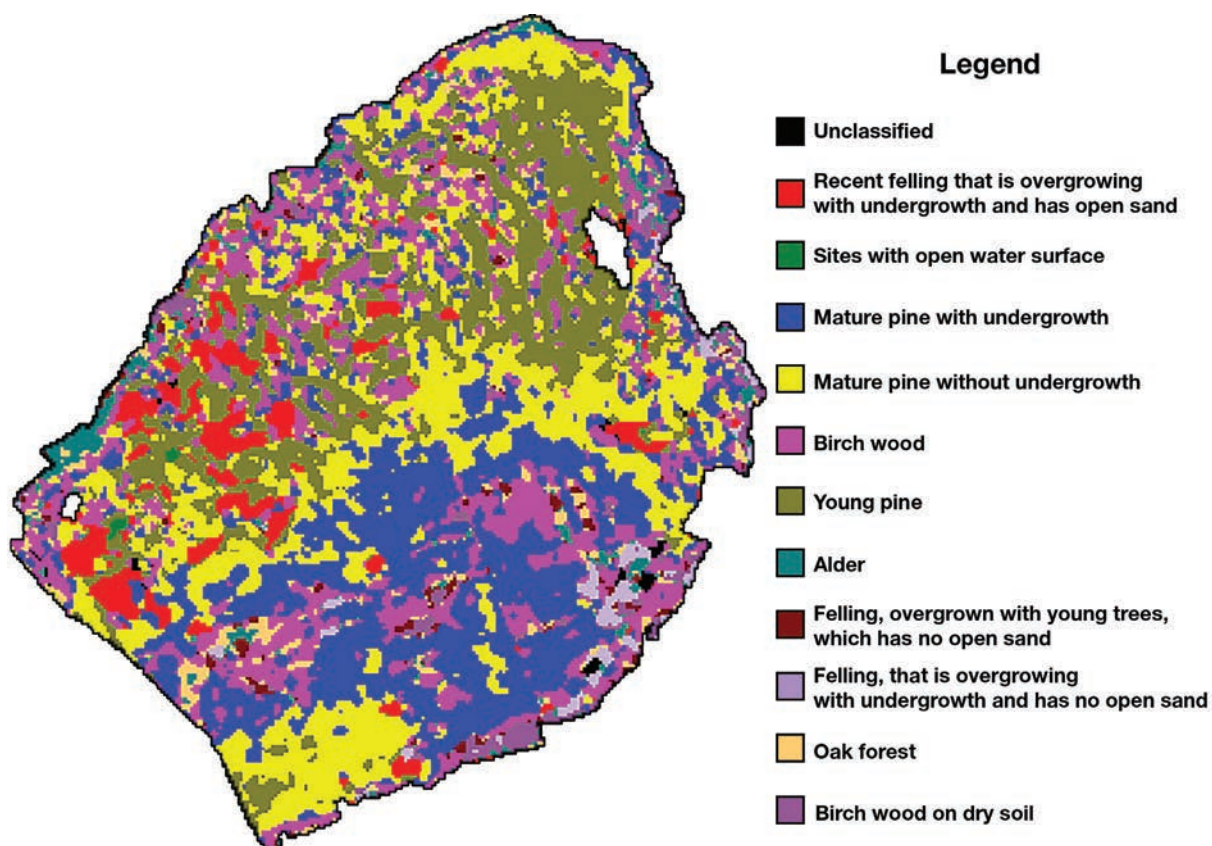Fig. 2. The division of sites of overgrown felling into several classes (SAM method).



Fig. 3. The results of the allocation of plant communities and other types
of land coverage by SAM method.

«Sites with open water surface» class also separated well without redundant sites.

«Mature pine with undergrowth» class was characterized by a large number of redundant sites in the northern part the territory. In the southern part this class was well allocated. Redundant sites in the northern part were associated with similar spectral characteristics of zones of transition from sites of young pine to birch wood. Birch wood could get there into one class with undergrowth. The same situation was observed in transition zones of young pine and alder and other hardwoods.

Class «Mature pine without undergrowth» had almost no redundant areas. A certain number of pixels of this class entered the class «Mature pine with undergrowth», but there was a few of such cases.

Class «Birch wood» was allocated badly. A lot of redundant areas with deciduous trees were assigned to this class, including alder, oak, linden associations and parts of subor (pine with oak and linden impurities) in the south and subor (pine with birch in admixture) in the north and others. Areas of birch themselves were often assigned to the neighboring classes («Mature pine with undergrowth», «Mature pine without undergrowth» and in some cases, «Young pine»). The reason for such outcome was the fact that according to the Landsat 8 data birch had similar spectral characteristics with other deciduous species, and it was hard to allocate it into one single class.

Class «Young pine» was allocated well, in some cases pixels of this class were classified as «Mature pine with undergrowth» or «Mature pine without undergrowth».

Class «Alder» was allocated relatively well, but some of sites covered with alder were classified as «Birch wood» due to similar spectral characteristics of these deciduous trees. The main part of this plant community was allocated well.

Class «Felling, overgrown with young trees, which has no open sand» was allocated badly. Pixels of this class distributed between «Birch wood» and «Alder» classes (Fig. 2).

Class «Felling that is overgrowing with undergrowth and has no open sand» was classified well but there were areas assigned to class «Birch wood». This class was a transition from class «Recent felling that is overgrowing with undergrowth and has open sand» to «Felling, overgrown with young trees, which has no open sand». The idea of the allocation of these areas in a separate class appeared during the identification of standard polygons (signatures) for classification.

Class «Oak forest» was allocated relatively well, but the degree of representativeness of assignment to oak of certain pixels was difficult to determine because not all territory with such vegetation was known. It is planned to visit classified areas in the future.

Class «Birch wood on dry soil» was highlighted well, but there was a certain amount of redundant pixels that didn't belong to this class. Some areas should have been classified as «Alder» but were attributed to this class due to the similar spectral characteristics.

**Conclusions and prospects.** By results of the research it was determined that for the identification of plant communities a supervised classification by SAM method gives much better results than a classification by ISODATA method. However, the above analysis of selected classes' representativeness suggests that even these improved results can be only partially used it the creation of landscape maps. A certain part of the plant communities that were not properly identified in the course of this research should be allocated by visual identification of ultrahigh-resolution images or directly in the field research.

In the future it is planned to explore the opportunities to improve results. The first way to improve results is the possibility of allocating classes by the series of Landsat images. A similar technique had been used by the authors for the problems of agricultural crops identification and gave positive results [2]. Another possibility is the analysis of plant communities on an image after Tasseled Cap transformation, which made it possible to obtain satisfactory results in some researches [11, 15]. Finally, many prospects can give the use of Sentinel 2 satellite data which was recently launched and which contains 13 spectral bands, especially in the red engle and near infrared bands.

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