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The possibilities of using satellite data to analyze the spectral features of woody vegetation

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Abstract: The article presents the results of a study of the possibilities of using satellite data to assess and monitor forest ecosystems, which is a key task in the context of sustainable management of natural resources. The research is aimed at developing a methodology for differentiating forest-forming rocks of the temperate zone based on the analysis of their seasonal spectral dynamics using modern Earth remote sensing technologies (Landsat 8-9) and a geoinformation systems tool (ArcGIS 10.8). The results of a study of the spectral characteristics of tree species based on an analysis of their reflectivity in various ranges of the electromagnetic spectrum in a temperate climate zone are presented. It has been established that the most contrasting spectral differences, which make it possible to reliably identify deciduous and coniferous tree species, are observed during certain phenological periods (spring and summer), which confirms the importance of taking into account the time factor when deciphering forests. The calculations carried out to establish boundaries and determine the area of forest areas affected by fire confirm the efficiency and effectiveness of using remote sensing methods and geoinformation technologies. The results and algorithm of actions of the conducted research are of practical importance for forestry in order to determine the species composition of forests, their inventory and monitoring, timely response to possible threats such as forest fires and logging, as well as assessment of their consequences.

Keywords: remote sensing; satellite imagery; optical spectral analysis; channel combinations; forest resources; tree species; forest fires.

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1. Introduction

Modern methods of remote sensing of the Earth (RS) are a key tool for obtaining objective data on the state of terrestrial ecosystems, including forests (Holzwarth et al., 2020; Gonets et al., 2025; Savin et al., 2022; McRoberts et al., 2010).

The use of multispectral satellite systems makes it possible to record the spectral response of vegetation in various ranges of the electromagnetic spectrum, thereby providing the opportunity to differentiate tree species, assess their physiological state, and identify trends in vegetation degradation or restoration (Faruque et al., 2022).

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The development of satellite technologies, from early Landsat missions to modern Sentinel and KazEOSat systems, has significantly expanded the spectral and spatial monitoring capabilities of natural resources (Ahmed et al., 2018; Dostalova et al., 2016; Wulder et al., 2012).

Forest ecosystems, being the most important part of the biosphere, play an essential role in climate regulation, water protection and soil protection processes, provide biodiversity and perform a wide range of ecosystem functions (Zhumadina et al., 2022; Drüke et al., 2022; Acharya et al., 2019). Therefore, assessing the state of vegetation based on satellite data is an important area for detecting disturbances, such as the effects of fires, anthropogenic transformations or changes related to climatic stresses. Spectral index analysis, including NDVI and SAVI, is widely used to diagnose vegetation cover density, determine the degree of degradation, and assess the dynamics of forest land conditions over a long period (Mancino et al., 2014; Zhanguzhina et al., 2025; Ozgeldinova et al., 2024).

Research conducted in Kazakhstan demonstrates the increasing role of satellite monitoring in assessing the state of forest resources and other natural complexes (Bissenbayeva et al., 2024). According to a review of domestic works, the use of remote sensing technologies made it possible for the first time to perform large-scale mapping of the country's forests, identify areas of degradation, determine the boundaries and condition of plantings, and assess the consequences of forest fires and other disruptive factors (Kabdulova et al., 2019; Babu et al., 2019; Volokitina et al., 2021; Sagynbaeva et al., 2023). This highlights the importance of spectral methods for the analysis of forest-forming rocks and vegetation in general, especially in conditions of increasing exposure to climatic and anthropogenic factors (Gauthier et al., 2014; Nizamutdinov et al., 2022).

2. Materials and methods

Remote sensing is based on the detection of electromagnetic radiation reflected or emitted by objects on the Earth's surface. Electromagnetic radiation includes a wide range of waves, from the ultraviolet to the microwave range. Each object has a unique ability to reflect or absorb radiation, which makes it possible to identify it using remote sensing.

The optical-spectral remote sensing method is based on the analysis of the spectral characteristics of reflected solar radiation detected using specialized sensors mounted on satellites or aircraft. Unlike the traditional optical approach, this method focuses not only on the visual characteristics of the image, but also on the spectral signature of objects, that is, on how different materials reflect or absorb electromagnetic radiation in specific spectral ranges.

Each type of vegetation, soil, water, or artificial object has a unique spectral reflection curve. Due to its high spectral resolution, the optical spectral method makes it possible to accurately distinguish between forest-forming species, assess the condition of plantings, detect the presence of stresses (for example, caused by drought, pests or pollution), and monitor seasonal and long-term changes. The use of optical spectral analysis is especially relevant in the tasks of monitoring forest ecosystems. For example, based on the analysis of spectral data, it is possible not only to determine the type of tree species (coniferous, deciduous), but also to identify signs of forest degradation, disease foci and areas susceptible to anthropogenic impact. In addition, this method allows you to track the effects of forest fires, determining the degree of burnout and the nature of vegetation restoration.

The spectral characteristics of tree species depend on many factors, including biochemical composition, leaf and needle structure, tree age, seasonal changes, and environmental conditions. The main parameters used in spectral analysis include reflection coefficients in various spectral ranges. For example, hardwoods have a high reflection in the near infrared range, while conifers have lower reflectivity values.

Vegetation has a characteristic spectral signature, which is determined by the interaction of light with pigments, cellular structure, and water content. The main ranges of the spectrum in which the distinctive features of tree species are manifested:

1. Visible range (400-700 nm): Absorption in the blue (400-500 nm) and red (600-700 nm) ranges is due to chlorophyll, so the leaves are green, as green light (500-600 nm) is partially reflected.

2. *Near infrared range* (NIR, 700-1300 nm): characterized by strong reflection due to the internal structure of leaves and needles, which makes this range important for the classification of tree species.

3. *Mid-infrared range* (MIR, 1300-2500 nm): the reflectivity of which is related to the water content in plant tissues and may vary depending on their condition, for example, during drought or disease.

Coniferous trees (spruce, pine, cedar) have a lower reflection in the near infrared range compared to deciduous trees (oak, birch, aspen), which is associated with a high density of needles and its lower water content. At the same time, hardwoods have a more pronounced reflection in the NIR range, as their leaves have a more developed internal structure (Komarova et al., 2016; Zharko et al., 2014).

The spectral properties of tree species can change under the influence of various factors:

1. *Seasonal changes*: in autumn, a decrease in chlorophyll levels increases the reflection in the red range, giving the foliage yellow and orange hues. In winter, when deciduous trees shed their leaves, the spectral characteristics of the forest cover change significantly, which is important to take into account when interpreting remote sensing data.

2. *Age and structure of foliage*: young leaves have a higher reflectivity in the visible range, which makes it possible to distinguish young stands from old-age forests.

3. *Health status*: drought, disease, and environmental pollution affect spectral characteristics, especially in the SWIR range. For example, pest-affected trees may exhibit reduced reflectivity in the near-infrared range.

4. *Soil type and humidity*: Wet and swampy areas can affect the spectral properties of tree species by changing their reflectivity.

Data from satellite systems (Landsat, Sentinel, MODIS) make it possible to distinguish tree species by their spectral characteristics. Multispectral and hyperspectral analysis methods are used to map forests, assess their productivity, and monitor vegetation conditions (Banskota et al., 2014; Kurbanov et al., 2018; Chernikhovskii et al., 2019).

Multispectral imagery from the EarthExplorer platform developed by the United States Geological Survey (USGS) was used to analyze forest-forming rocks. This web resource provides access to an extensive archive of remote sensing data, including images from the Landsat, Sentinel, MODIS and other satellite systems. The study used images from the Landsat 8-9 OLI/TIRS C2 L2 satellite, providing an optimal ratio of spatial resolution and time frequency of observations.

The choice of this satellite is due to its following parameters:

- Wide spectral range. Landsat 8 and 9 satellites detect reflected radiation in 11 spectral ranges, including blue, green, red, near infrared and mid infrared, which makes them particularly useful for classifying forest-forming species and assessing changes in forest ecosystems.
- Optimal shooting frequency. The area is re-covered approximately once every 16 days, allowing you to track seasonal vegetation changes and analyze ecosystem dynamics.
- Minimal cloud cover. As part of the data search on EarthExplorer, you can additionally set filtering criteria by cloud level, which will allow you to select images with the least amount of atmospheric interference.
- The presence of thermal channels. The TIRS Thermal Infrared Sensor contains two infrared channels with a resolution of 100 m, which makes it possible to analyze thermal anomalies, detect soil moisture and determine the state of vegetation.
- Support for radiometric and atmospheric correction. C2 L2 (Level 2) level data has already been calibrated and processed for atmospheric distortion, making it more accurate for scientific analysis (Munzer, 2021).

There are inherent limitations associated with the spatial resolution of Landsat imagery (30 m per pixel), primarily related to the mixed pixel effect and the minimum mapping unit. However, for regional-scale monitoring of relatively homogeneous forest stands whose area exceeds several image pixels, the spatial resolution of Landsat data is considered sufficient and is widely applied both in scientific research and in operational forest management practice.

As part of the study, satellite images of the territory of the Burabai State National Nature Park in the Akmola region, obtained from the Landsat 8-9 spacecraft for April, May and the summer period of 2024, were analyzed. During scene selection, images with minimal cloud cover were prioritized. Given the extremely low proportion of cloud cover and the study's focus on the analysis of homogeneous forest areas, no additional cloud and cloud-shadow masking procedures were applied, as they did not exert a significant influence on the interpretation of the delineated territories. The primary objective of the study was to demonstrate a methodological workflow for seasonal spectral differentiation of forest vegetation types and for assessing fire impacts based on open-access Landsat Level-2 data within a GIS environment. Accordingly, the emphasis was placed on the logic of the analytical processing and the sequence of operations rather than on the documentation of specific scenes.

Special attention was paid to the vegetation cover, as well as to changes in the surface structure in different seasons. The use of satellite data allows for comprehensive monitoring of the state of landscapes without the need for ground-based observations, which is especially important for remote and vast territories.

The images were preprocessed in the ArcGIS 10.8 program, which included correction procedures, channel combinations, and image preparation for visual analysis. Thanks to this, it was possible to obtain high-quality composites suitable for interpreting seasonal changes within the study area.

3. Results

The results of visual analysis of satellite image data of the territory of the Burabai State National Nature Park make it possible to trace changes and identify differences between coniferous (Pinus sylvestris) and deciduous (birch (Betula pendula), aspen (Populus tremula) in different phases of the growing season. Further analysis includes a detailed consideration of the spectral characteristics of landscapes in different seasons based on the processed images.

Spectral brightness indicators for different types of forest vegetation vary depending on the season and manifest themselves differently in different parts of the electromagnetic spectrum. In April, when hardwoods do not yet have a developed leaf mass, the differences between coniferous and deciduous forests are especially clearly revealed in images obtained using various combinations of spectral channels. The evaluation of spectral band combinations was deliberately based on visual interpretability, as the study is oriented toward applied forestry objectives, where false-color composites are traditionally employed by field practitioners.

Based on the analysis of the April satellite images for 2024 using data from the Landsat 8-9 satellite, the possibilities of visual separation of tree species were studied. Coniferous forests in April show a pronounced increase in reflectivity in the near–infrared range (channel 5 - NIR) and moderate values in the SWIR ranges (channels 6 and 7). Deciduous forests, in the absence of foliage in April, are characterized by reduced reflectivity in the near-infrared range, but have comparatively higher values in the middle IR (channels 6 and 7). The difference between forest types is particularly pronounced in channel 7, which makes it possible to effectively use it for vegetation classification.

During the study, various color combinations of Landsat 8-9 channels were considered:

In the 6,5,4 (SWIR1, NIR, Red) combination, coniferous forests are visualized in green and dark green tones due to the presence of chlorophyll. At the same time, hardwoods appear more faded or grayish, allowing them to be visually distinguished from the other landscape elements (Figure 1).

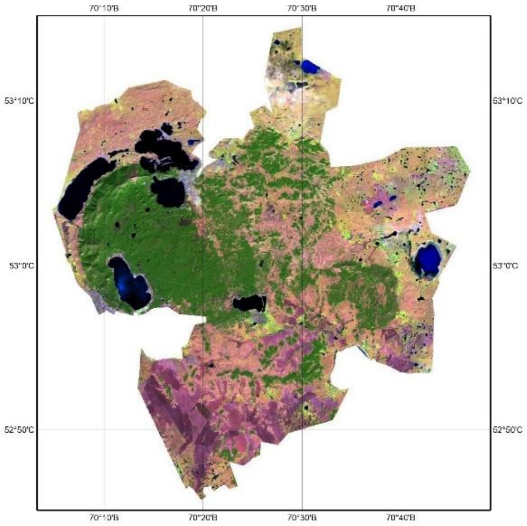


Figure 1. Channel combinations 6, 5, 4

In the combination 5,4,3 (NIR, Red, Green), traditionally used to assess vegetation, coniferous forests acquire a bright red hue, reflecting the activity of photosynthesis (Figure 2). Deciduous forests, in the absence of foliage, look more dull, often gray or brownish-green.

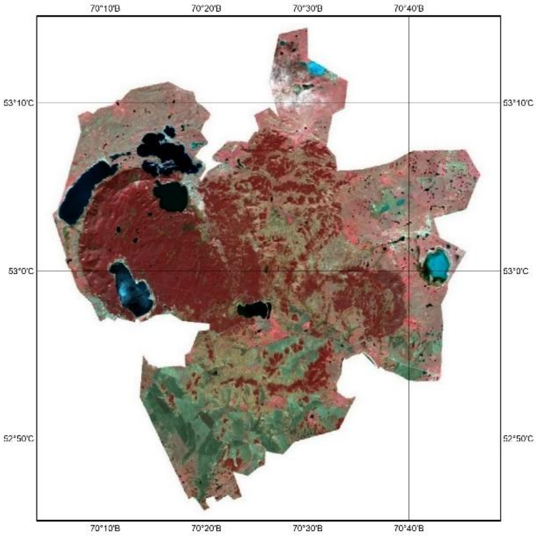


Figure 2. Channel combinations 5, 4, 3

In the combination of 7,6,5 (SWIR2, SWIR1, NIR), which excludes channels of the visible range, coniferous forests are displayed in bluish-blue tones and stand out most clearly against the background of other types of vegetation (Figure 3). This combination is considered the most effective for isolating coniferous plantations in the April period.

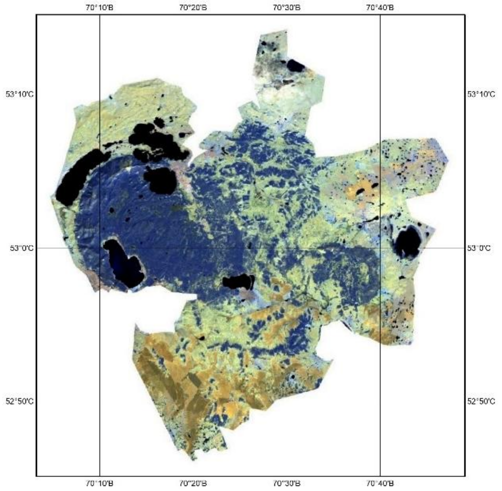


Figure 3. Channel combinations 7, 6, 5

Thus, the combination of channels 6, 5, and 4 is the most informative for the purposes of classifying forest stands by type in the April period, as it makes it possible to distinguish conifers most clearly against the background of deciduous and open areas. In April, coniferous forests retain active photosynthetic activity and reflect a greater amount of near and mid-infrared radiation, while hardwoods that do not yet have developed foliage are characterized by low reflectivity. This makes the combination of 6, 5, and 4 especially effective for visually highlighting coniferous plantations in early spring.

The satellite images from May, reflecting the state of the territory during the active beginning of the growing season, show an increase in the values of the spectral brightness index in the near-infrared range for hardwoods. This is due to the formation of the leaf apparatus and the beginning of photosynthetic activity.

During the visual analysis, it became obvious that the combination of channels 7, 6, and 5, displaying spectral information in the mid- and near-infrared ranges, demonstrates the greatest information content when separating coniferous and deciduous tree species in the May period (Figure 4). In this composition, coniferous forests acquire a distinct blue hue, which makes them stand out clearly from the rest of the landscapes. Deciduous plantings in this combination look less contrasting, which makes it easy to distinguish between both types of forests.

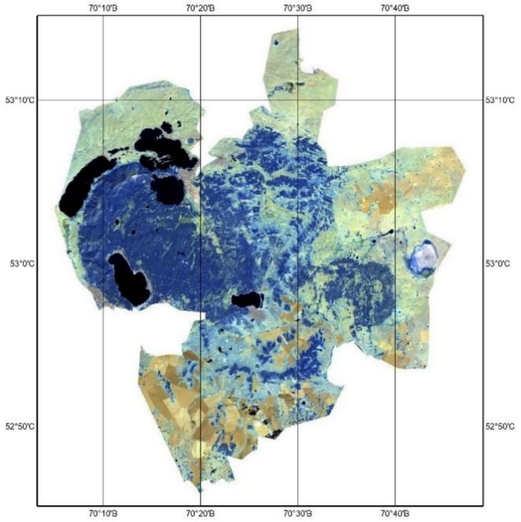


Figure 4. Channel combinations 7, 6, 5

Combinations 5,4,3 and 6,5,4 were also used for comparative analysis. In combination 6,5,4, coniferous forests are visualized in dark green tones, and deciduous forests in light green, which also gives satisfactory differentiation (Figure 5).

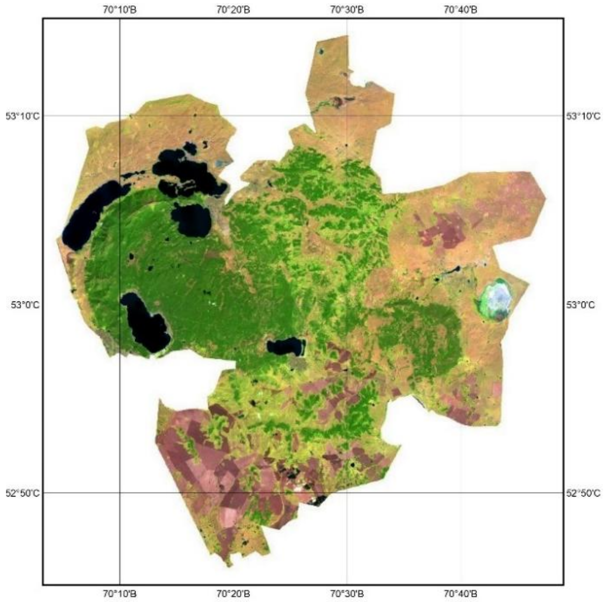


Figure 5. Channel combinations 6, 5, 4

The combination of 5, 4, 3, despite the overall contrast enhancement, is inferior to the combination of 7, 6, 5 in terms of the severity of differences between the species (Figure 6).

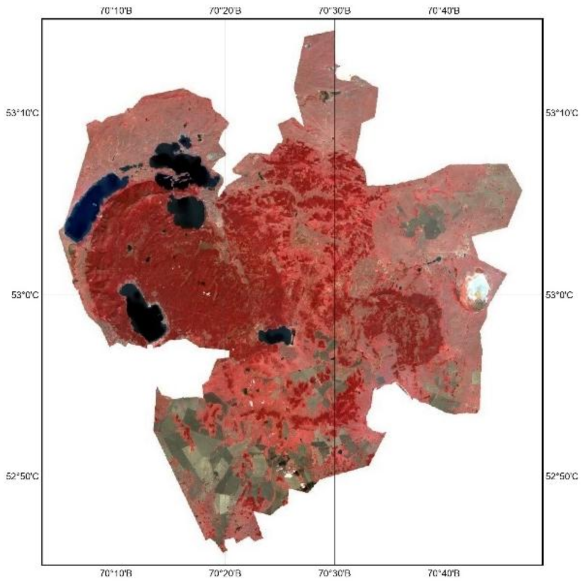


Figure 6. Channel combinations 5, 4, 3

Analysis of satellite images from May showed that, at the beginning of the active vegetation period, hardwoods increase their infrared reflectivity. The clearest difference between coniferous and deciduous forests was provided by the combination of channels 7, 6, and 5, where conifers stand out in blue. Combinations of 5, 4, 3, and 6, 5, 4 also produced good results, but they separated the types of woody vegetation less expressively.

In the summer months, when vegetation reaches its maximum development, there is a significant increase in reflectivity in the entire near-infrared range for all types of tree species. This is due to the high density of the leaf cover and active photosynthetic processes. Despite the general increase in spectral brightness, the differences between coniferous and deciduous species persist. These differences make it possible to continue effective rock separation even during the peak of the growing season.

5, 4, 3 (NIR, Red, Green) is a traditional vegetation combination in which all vegetation is displayed in red shades (Figure 7). However, in the summer, when both deciduous and coniferous forests are at their peak of activity, the visual difference between them in this composition becomes less pronounced. The entire vegetation cover looks rich red and it is difficult to distinguish between tree species.

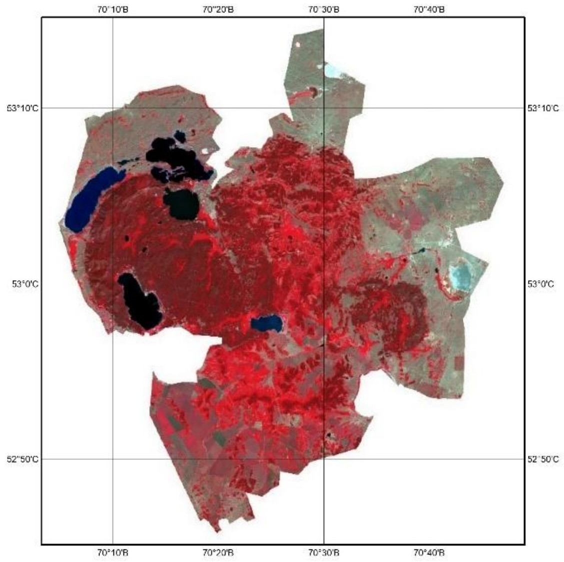


Figure 7. Channel combinations 5, 4, 3

6, 5, 4 (SWIR1, NIR, Red) is a composition that allows for differences in moisture content and vegetation structure. In this combination, coniferous forests look saturated green, while deciduous forests are lighter and less contrasting (Figure 8). Arable land, meadows, and agricultural land are also clearly distinguishable, which makes this combination useful for a comprehensive landscape analysis.

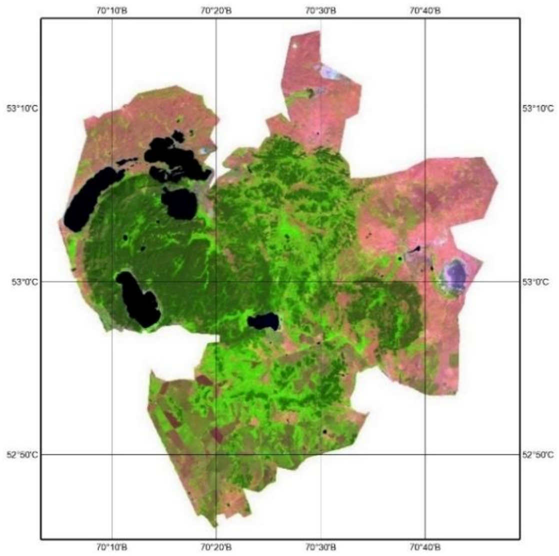


Figure 8. Channel combinations 6, 5, 4

7, 6, 5 (SWIR2, SWIR1, NIR) is a combination that excludes visible channels, but effectively reflects differences in vegetation structure. In this color scheme, conifers are visualized in blue and light blue tones, clearly standing out against the background of deciduous forests and farmland (Figure 9). This combination is particularly good at showing the internal heterogeneity of the vegetation cover and makes it possible to confidently classify the types of tree species.

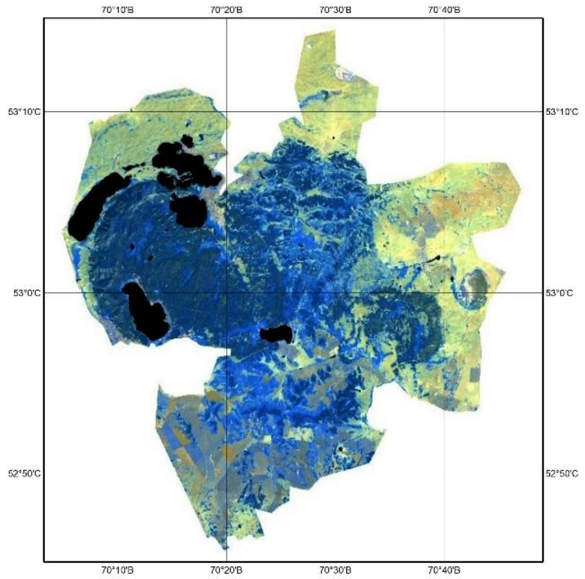


Figure 9. Channel combinations 7, 6, 5

Based on the visual analysis of the summer images, the combination of channels 7, 6, and 5 proved to be the most informative for distinguishing coniferous and deciduous forests. It allows coniferous plantations to be clearly distinguished due to the characteristic blue spectral response and demonstrates high sensitivity to differences in vegetation structure. Despite the overall increase in spectral brightness in all breeds, this combination retains a clear contrast and reliably captures differences between forest types during the peak growing season.

One of the illustrative areas of practical application of the optical spectral method is the assessment of the consequences of natural disasters, including forest fires. The use of satellite data combined with the capabilities of GIS technologies makes it possible to quickly and objectively identify the boundaries of affected areas, differentiate the degree of burnout, and distinguish between the types of damaged vegetation.

A striking example of the devastating effects of wildfires is the emergency that occurred in the Abai region in June 2023, which resulted in the destruction of about 65,000 hectares of forest areas. The optical spectral method was used to obtain quantitatively accurate information about the area of burnt forests and to determine the proportion of coniferous vegetation within the burnt area (Figure 10). Landsat 8-9 scenes from May and June 2023 were used as the primary material. A combination of channels 6, 5, and 4 was used as the working color combination.

Although standard burn severity and fire-related indices (NBR, dNBR) constitute effective tools for the quantitative assessment of post-fire impacts, the delineation of burned areas based on pronounced spectral contrast in the SWIR and NIR ranges is conceptually consistent with the principles underlying the NBR calculation and may be applied within the framework of rapid assessment.

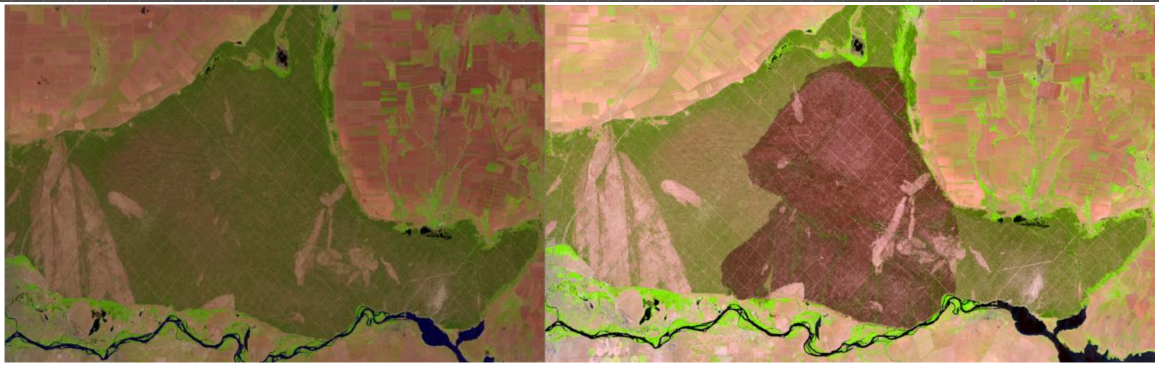

A) B)

Figure 10. Processed image of the forest of the Abai region before (A) and after (B) the fire

After connecting spectral channels 6, 5, and 4, the pixel values of the image data were reclassified by type of underlying surface using the "Reclassify" tool in the ArcGIS environment. Since the study was aimed at demonstrating the conceptual applicability of spectral differentiation rather than at developing a universal threshold-based model with fixed parameter values, the reclassification was performed automatically in ArcGIS using the Maximum Likelihood algorithm. In this approach, the classifier computes the probability that a given pixel belongs to the class “Water,” “Vegetation,” or “Built-up area,” and each raster pixel is assigned to the class for which this probability (likelihood) is the highest. The resulting classified raster was converted into a vector format using the "Raster to Polygon" tool, on the basis of which coniferous plantations were identified (Figure 11).

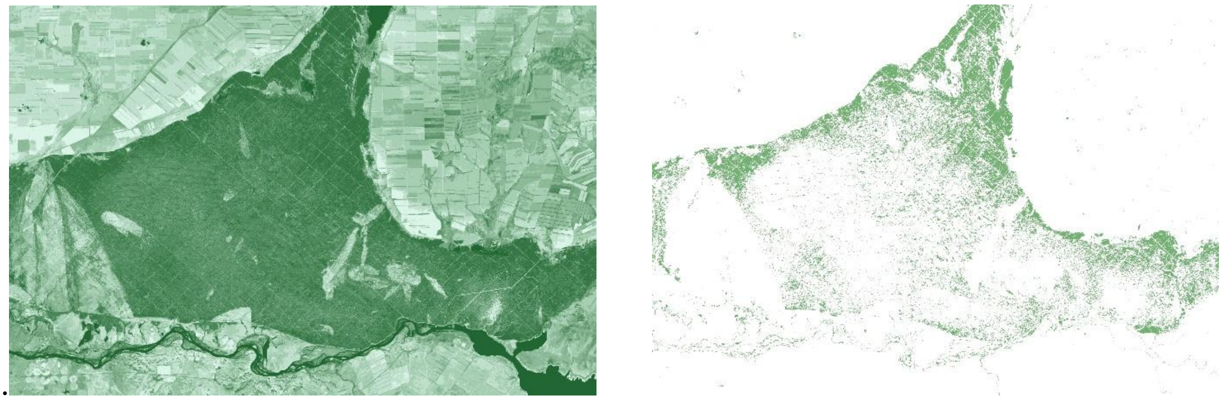
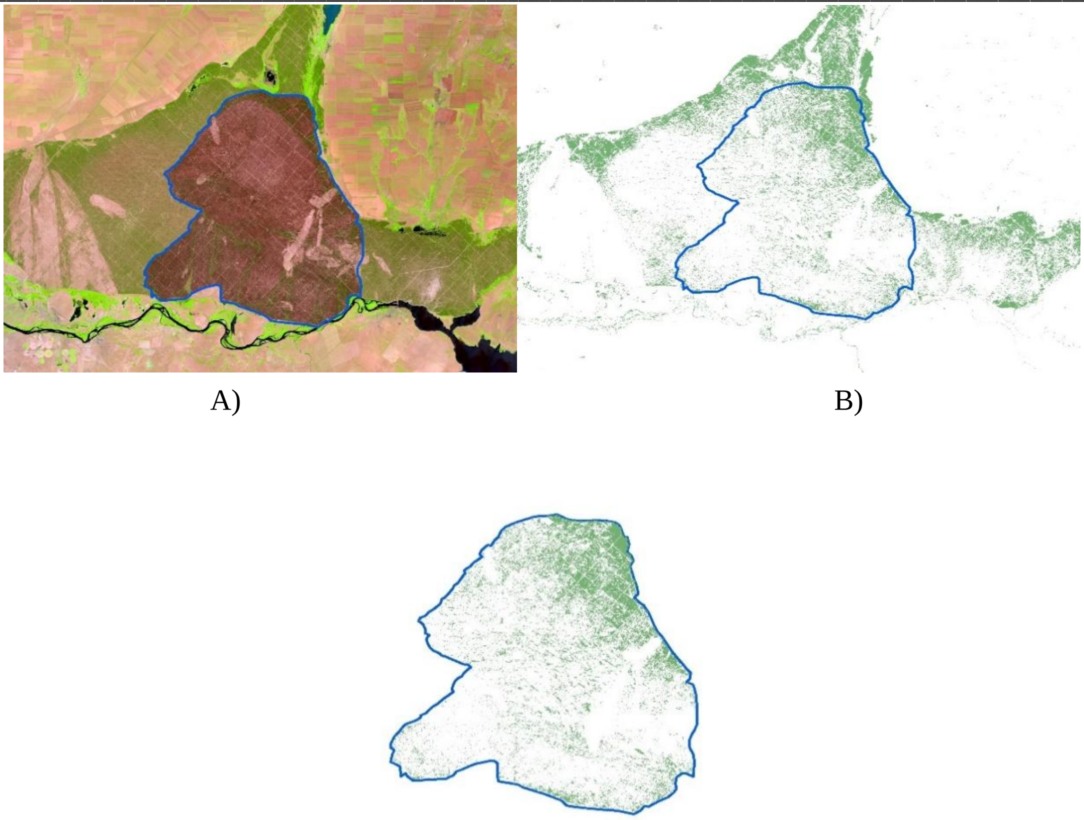

A) B)

Figure 11. A reclassified snapshot of the forest of the Abai region (A) and a vector layer of coniferous plantations (B)

The reclassification procedure was also carried out for the satellite image of the forests of the Abai region after the fire, on the basis of which a separate polygonal layer corresponding to the fire area was created (Figure 12). The next step is to overlay the resulting polygon on a vector layer of coniferous plantations and select them inside the polygon using the Selection by Location tool.



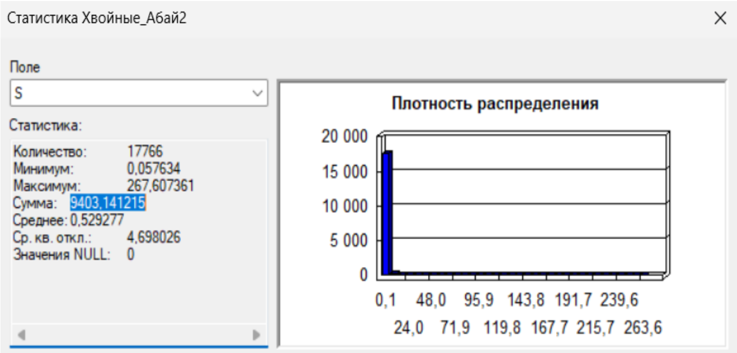
A)

B)

C)

Figure 12. Identification of coniferous plantations within the fire area based on a reclassified satellite image of forests in the Abai region

At the final stage of the analysis, a quantitative assessment of the area of coniferous forests trapped in the fire contour was carried out (Figure 13). For this purpose, an attribute table of the coniferous plantation layer was used, in which the area values of each site were stored. Using the built-in statistics function in ArcGIS, the total area of coniferous forests within the fire zone was obtained. According to the results, the total area of burnt coniferous plantations was 9403.14 hectares, which is shown in the "Sum" column of field S on the distribution density diagram.



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Статистика Хвойные_Абай2

Поле
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Статистика:
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Сумма:    9403,141215
Среднее: 0,529277
Ср. кв. откл.:    4,698026
Значения NULL:    0
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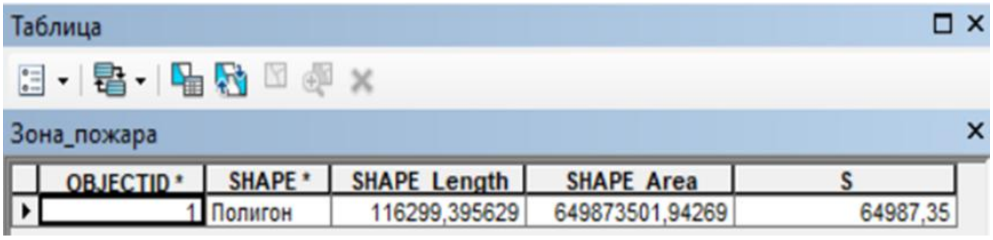
Figure 13. Calculations of the fire area of coniferous plantations

To obtain an accurate estimate of the scale of a natural fire in the Abai region, the attribute table of the polygon marking the boundaries of the fire zone was analyzed (Figure 14). As a result of the analysis, it was found that the total area of the fire was 64 987.35 hectares, which confirms the official data on the disaster that occurred in the summer of 2023.



OBJECTID *	SHAPE *	SHAPE_Length	SHAPE_Area	S
1	Полигон	116299,395629	649873501,94269	64987,35

Figure 14. Calculations of the total fire area

The obtained indicators allowed us to determine the percentage of coniferous forests to the affected area, which was 14.5%.

4. Discussion

The analysis of the spectral characteristics of forest-forming rocks of the temperate zone demonstrates the following features: coniferous species (spruce, pine, cedar) have a lower reflection in the near infrared range (NIR) compared with deciduous species (birch, aspen), which is associated with a high density of needles and a lower content of water in the needles. The use of the near-infrared range in composite images has made it possible to more effectively identify the types of woody vegetation in satellite images.

It has been revealed that the most suitable combination of spectral channels for conifers is a combination of channels 6, 5 and 4, in which conifers are most clearly distinguished from deciduous trees. For hardwoods, the best combination is 7, 6, 5, the spectrum of which is characterized by a light blue color.

Calculations based on the spectral method the calculation of the area of coniferous trees affected by fire in the territory of the Abai region in 2023 corresponds to official data.

The use of multispectral data makes it possible to quickly track changes in vegetation cover, differentiate vegetation types, assess the degree of moisture in territories, and identify structural features of the landscape during different growing seasons. The analysis of the reflectivity of wood in various ranges of the electromagnetic spectrum makes it possible to identify stress conditions of plants caused by changes in climatic conditions, anthropogenic impact or pest damage.

5. Conclusion

The analysis of seasonal satellite images from Landsat 8-9 confirmed the effectiveness of remote sensing for monitoring forest resources. The optical spectral method provides high information content with minimal resource expenditure, which makes it a particularly valuable tool for environmental research, environmental planning, and analysis of the dynamics of natural processes. The results obtained confirm the expediency of using satellite data in regional monitoring and classification of natural complexes. Further advancement of spectral data processing technologies, specifically through the implementation of a validation procedure using an error matrix and the development of a statistically optimized classification model, will not only improve the accuracy of forest species composition assessment but also enhance methods for monitoring forest condition under conditions of global environmental change, thereby opening new opportunities for ecological monitoring and the rational management of natural resources.

6. Supplementary Materials: no additional materials.

7. Author Contributions

Conceptualization, methodology development, supervision – I.S.; methodology development, software and project management, research material provision – S.I.; methodology development, supervision – P.D.; text preparation and editing – I.S., S.I.; analysis – S.I., P.D. All authors have read and agreed to the published version of the manuscript.

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Ағаш өсімдіктерінің спектрлік ерекшеліктерін талдау үшін спутниктік мәліметтерді пайдалану мүмкіндіктері

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Андатпа. Мақалада табиғи ресурстарды тұрақты басқару контекстіндегі негізгі міндет болып табылатын орман экожүйелерінің жағдайын бағалау және мониторингілеу үшін спутниктік мәліметтерді пайдалану мүмкіндіктерін зерттеу нәтижелері берілген. Зерттеу Жерді қашықтықтан зондтаудың заманауи технологияларын (Landsat 8-9) және географиялық ақпараттық жүйе құралын (ArcGIS 10.8) пайдалана отырып, олардың маусымдық спектрлік динамикасын талдау негізінде қоңыржай белдеудегі орман құраушы түрлерін саралау әдістемесін әзірлеуге бағытталған. Мақалада қоңыржай климаттық жағдайларда электромагниттік спектрдің әртүрлі диапазонында олардың шағылысу қабілетін талдау негізінде ағаш түрлерінің спектрлік сипаттамаларын зерттеу нәтижелері берілген. Өрттен зақымданған орман алқаптарының шекарасын белгілеу және ауданын анықтау бойынша жүргізілген есептеулер қашықтықтан зондтау әдістері мен геоақпараттық технологияларды қолданудың тиімділігін растайды. Зерттеудің нәтижелері мен іс-шаралар жоспары ормандардың түрлік құрамын анықтау, оларды түгендеу және мониторингілеу, орман өрттері мен ағаш кесу сияқты ықтимал қауіптерге дер кезінде ден қою және олардың зардаптарын бағалау мақсатында орман шаруашылығы үшін практикалық маңызы бар.

Түйін сөздер: Қашықтықтан зондтау; спутниктік суреттер; оптикалық-спектрлік талдау; арналар комбинациясы; орман ресурстары; ағаш түрлері; орман өрттері.

Возможности использования спутниковых данных для анализа спектральных особенностей древесной растительности

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Аннотация. В статье представлены результаты исследования возможностей использования спутниковых данных для оценки состояния и мониторинга лесных экосистем, что является ключевой задачей в контексте устойчивого управления природными ресурсами. Исследование направлено на развитие методики дифференциации лесообразующих пород умеренного пояса на основе анализа их сезонной спектральной динамики с использованием современных технологий дистанционного зондирования Земли (Landsat 8-9) и инструмента геоинформационных систем (ArcGIS 10.8). Представлены результаты исследования спектральных характеристик древесных пород на основе анализа их отражательной способности в различных диапазонах электромагнитного спектра в условиях умеренного климатического пояса. Установлено, что наиболее контрастные спектральные различия, позволяющие надежно идентифицировать лиственные и хвойные породы деревьев, наблюдаются в определенные фенологические периоды (весенний и летний), что подтверждает важность учета временного фактора при дешифрировании лесов. Проведенные расчеты по установлению границ, определению площади пострадавших от пожара лесных массивов подтверждают оперативность и эффективность использования методов дистанционного зондирования и геоинформационных технологий. Результаты и алгоритм действий проведенного исследования имеют практическое значение для лесного хозяйства с целью определения породного состава лесов, их инвентаризации и мониторинга, своевременного реагирования на возможные угрозы, такие как лесные пожары и вырубка, а также оценку их последствий.

Ключевые слова: дистанционное зондирование; спутниковые снимки; оптико-спектральный анализ; комбинации каналов; лесные ресурсы; древесные породы; лесные пожары.