GIS approaches to creating maps based on vegetation indices for forest management

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Abstract. The article considers the main approaches to providing information support for improving forest management on the territory, taking into account the most up-to-date experience, modern approaches and implementing sustainable forestry management based on the data of remote sensing and geoinformational modelling. To identify the state of vegetation in the area under analysis, the authors of the article propose to introduce the definition of a normalized differential vegetation index. A characteristic feature of vegetation and its state is spectral reflectivity, which is characterized by substantial differences in reflecting radiation from different wavelengths. To obtain the necessary MODIS packages, we used the LAADS DAAC service supported by NASA. The data of this service are freely accessible, convenient for the user, and they are taken from a large number of satellites and their spectra. The optimal option for solving the tasks of compiling NDVI maps is using the geographic information system QGIS. Among the main advantages of this GIS we can consider user-friendliness and its multi-platform basis. For proper visualization of the NDVI map, a special discrete scale of values is used, the purpose of which is to differentiate between organic and non-organic nature, as well as determine the density of vegetation. The introduction of the proposed technology will significantly increase the mobility and effectiveness of forest management.

1. Introduction

Forests are renewable natural resources and play an important role in providing the environment suitable for human life. Forests also act as habitats of wild animals, they contain water resources and recreation areas. Forestry includes managing a wide range of natural resources. Forest management in the modern world is becoming increasingly complex.

In this regard, developing more advanced methods of processing spatial data on forest territories and proper presentation of the results prove to be extremely important. These methods include geoinformational technologies that allow recording any changes in the state of forests in time and space with high precision. Geoinformational technologies provide foresters with powerful tools for accounting, analysing and decision making. Developing GIS technologies, global positioning system (GPS) and remote sensing (RS) allows us to collect and analyze a large amount of spatial data.

In this article we look into the territory of the tape boron within the Ozerno-Kuznetsovsky forestry located in the Uglovsky district in the south-west of the Altai Territory. Forests on the territory of this forestry belong to the West Siberian subtaiga forest-steppe zone. The climate of the region is sharply continental. The species composition of trees is limited by a small amount of rainfall at high summer
and low winter temperatures. Late spring and early autumn frosts with the vegetation period of 150-160 days are typical of this zone. Sandy soil with deep location of groundwaters determines the dominance of pine plantations.

2. Research methodology

To identify the state of vegetation of the area under study, in his article we propose to introduce the definition of a normalized differential vegetation index. A characteristic feature of vegetation and its state is spectral reflectivity which is characterized by substantial differences in reflecting radiation from different wavelengths. NDVI makes it possible to see in what way a specific plant is capable to absorb and reflect various wave spectra. This is the proper way to determine the state of the vegetation.

The main source of information is the data obtained from remote sensing which are widely used for accurate measurement and monitoring of vast forests [1, 2].

A GIS can be created to provide important, reliable spatial information about forest resources and can simplify forest planning and management, for example, accounting and updating forest inventories, reforestation, annual allowable cuts, biodiversity conservation, soil and water conservation [3].

Recent technological advances in the field of unmanned aerial vehicles (UAVs) and high-resolution satellite imagery with frequent time revisions have further expanded the possibilities of using information technologies [4, 5].

Thanks to satellite images, mankind can obtain rather numerous data on vital activity of plants in almost any part of the planet. Today, NDVI is the most common index for solving problems by using quantitative estimates of vegetation cover [6, 7, 8, 9, 10, 11].

NDVI provides an opportunity to see the difference in the intensity of reflected light in the red and infrared ranges, within a certain period of time.

NDVI is actively used to monitor soil moisture and saturation, evaporation and precipitation. In these cases, NDVI parameters are not always objective, because for measuring such data, one should take into account many features of the current location. The relevance of using NDVI is explained by its relative simplicity and speed of calculation, as well as the ability to work with satellite data of high resolution. In this regard, cartographers often use it for charting thematic and landscape maps.

Satellite images that allow you to work with the NDVI index are created by using various tools, one of which is the MODIS spectroradiometer. MODIS (Moderate Resolution Imaging Spectroradiometer) is a scanning image sensor designed for remote sensing of the planet. Currently, MODIS is located on two artificial Earth satellites «Terra» and «Aqua».

Due to the ratio of close spatial resolution and high temporal resolution, MODIS acts as an indispensable solution for daily monitoring of vegetation, nature landscapes, atmospheric dynamics and the earth cover as a whole.

To obtain the necessary MODIS packages, we are going to use the LAADS DAAC service which is supported by NASA and whose data are freely accessible, convenient for the user, and they are taken from a large number of satellites and their spectra. Most of the data obtained from LAADS DAAC are available in HDF format. Today, HDF4 is an obsolete version and is completely replaced by HDF5. The main difference between these versions is that HDF5 can contain a hierarchy of two types:
• Data sets that can be defined as sets of data and multidimensional arrays of objects of the same type;
• Groups that can be defined as certain containers for data sets and other groups.

Data in HDF5 are stored as a set of named object attributes that are contained in a special file system [12].

Primary packages with maps contain accurate information about 36 spectral channels. Each channel contains numerical data combined into a single database. Using the geographic information system, the process of constructing, calculating and visualizing the required index will be carried out. Storage of maps is provided for a sufficiently long amount of time.
For proper visualization of the NDVI map, a special discrete scale of values is used, the purpose of which is to differentiate between organic and non-organic nature, as well as determine the density of vegetation. As described earlier, a range of negative numbers tending to 0 are objects of non-organic nature. Positive numbers, within the range from 0 to 1, are objects of organic nature [13].

To display the NDVI index, a continuous gradient or discrete scale is used. More details about the belonging of values to types of objects are illustrated in table 1.

| Object type                              | NDVI value      |
|------------------------------------------|-----------------|
| Powerful, dense vegetation (forest)      | 0.7 – 1.0       |
| Sparse vegetation (shrubs, pastures)    | 0.2 - 0.5       |
| Open soil                                | 0.025 - 0.2     |
| Clouds                                   | 0               |
| Snow, ice, sand, rocks                   | -0.1 - 0.1      |
| Water                                    | -0.42 - -0.33   |
| Artificial materials (concrete, asphalt) | -0.5            |

After analyzing the table, we can conclude that values from -1 to 0 are assigned to inanimate objects and infrastructure: water, stones, sand, snow, etc. Wildlife objects, such as plants, are characterized by values ranging from 0 to 1.

The closer the value is to one, the denser vegetation prevails in the area. An example of a discrete NDVI scale is illustrated in figure 1.

![NDVI Discrete Scale](image)

**Figure 1. NDVI Discrete Scale**

### 3. Results of research

The optimal solution for the implementation of the tasks of constructing NDVI maps was the use of the geographic information system QGIS. Among the main advantages of this GIS we can consider user-friendliness and its multi-platform basis.

In order for the map to acquire color shades, you must first calculate the NDVI index by the ratio of the two added spectral channels. The resulting NDVI map is shown in figure 2.
Figure 2. The resulting NDVI map

Next, we will create maps for 2008-2017. All parts of the maps were grouped into subgroups, the names of which represent the year to which the image refers. The structure of these groups containing maps is shown in Figure 3.

Figure 3. Data structure of groups containing maps

A chart was drawn up depicting the process of monitoring the state of the tape boron of the Uglovsky district of Altai Territory, with the introduction of NDVI technology. This model is shown in figure 4.
The final step is to provide the obtained data for free access. After confirming the received data by forest management specialists, the map is published on the site managed by the site control system Wordpress. Currently, the above-mentioned method is the only possible way of operating the necessary data and creating NDVI maps. Despite the simplicity of calculating the NDVI index, ready-made maps in the public domain, covering the entire planet for a certain period of time, do not exist so far.

4. Conclusions
The normalized vegetation index NDVI is capable of visualizing even the most inaccessible areas of the forest involving the minimum spending of financial and human resources.

The proposed method is universal and can be used not only to monitor the state of the vegetation of the tape boron. It can provide an opportunity to monitor the state of soils, precipitation, as well as the impact of climate on various natural objects. The use of the NDVI index becomes especially necessary when tracking planted vegetation: during the planting period (spring), and during harvesting (autumn). Thus, it is possible to evaluate problematic and arid areas of crops in which the NDVI value will be less than 0.5.

The introduction of the proposed technology will significantly increase the mobility and effectiveness of forest management. Publication of the processed images in free access will allow departmental bodies, organizations, legal entities and individuals to independently study and analyze published information, without any documentation and at no cost. This method makes it possible to simplify the process of obtaining complicated data from satellites, and thus facilitate their visualization and understanding, without requiring significant investments.

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