The experience of developing large-scale geobotanical maps based on field and remote sensing data

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Abstract. The article discusses the experience of compiling large-scale vegetation maps, the advantages of using aerial photography data from a radio-controlled unmanned aerial vehicle (UAV) and the technology of geo-information systems in combination with ground-based traditional geobotanical mapping methods. The use of remote sensing data is one of the ways to quickly obtain data for vegetation mapping. Currently this method is actively used and developed. However, satellite data has several disadvantages. The use of UAV is a promising direction for timely and cost-effective environmental monitoring. Using the aerial photo obtained in this way, it is possible, on the one hand, to trace the dynamics of vegetation during one season, and on the other, to identify and map both different plant communities and populations of individual species that do not coincide in the phenological phase of development with each other. The aim of the study was to reflect the heterogeneity of vegetation cover on a detailed geobotanical map in a simple way, which will act as the basis for further research. The map constructed by the described method is the most objective reflection of the state of the vegetation cover.

1. Introduction

Currently, the need for cartographic data on vegetation cover is increasing due to the heightened interest in assessing the transformation of the natural environment under conditions of climate change and anthropogenic pressure.

Mapping is a visual way to reflect the patterns of spatial and structural distribution of vegetation. The complexity of mapping of vegetation cover is due to its heterogeneity and complex structure, seasonal dynamics, variability under the influence of natural and anthropogenic factors. Thus, the most important problem of mapping the vegetation cover is operative to obtain reliable information about its spatial characteristics and condition. The use of remote sensing data is one way to quickly obtain data for mapping plants. Currently this method is actively used and developed.

Efficiency, accuracy, availability and variety of remote sensing source data make it possible in a short time to map the area of interest with the desired accuracy. However, satellite data has several disadvantages. For example, low spatial, low temporal resolution, high cost and inaccessibility for most researchers. The use of UAV is a promising direction for timely and cost-effective environmental monitoring [1]. The advantages of the UAV include the possibility of choosing the spatial and temporal resolution [2].

The aim of the study was to reflect completely and easily the heterogeneity of vegetation cover on a detailed geobotanical map, which should be the basis for further research.
2. Models and Methods

To study the spatial and structural organization of plant cover diversity the key area was chosen. The area is characterized by steppe vegetation on the background of fallow succession - Kazachya mountain, located on the tails of the spurs of Tsagan-Daban ridge on the right bank of the Selenga river (Tarbagatay district, the Republic of Buryatia). During the field work performed about 40 geobotanical descriptions, which took into account the slopes of different exposure, steepness and shape. The IBIS program is used for storage, primary sorting and data processing using ecological scales [3]. Under field conditions phytocenoses were distinguished according to the ecological and physiognomic principle. Characteristics of the selected plant communities were carried out according to the generally accepted geobotanical methods [4,5]. The vertical and horizontal structure of phytocenoses were described, their main floristic composition was revealed.

To compile a large-scale map of the vegetation of the key area during the growing season, aerial photography was performed. Aerial photography was carried out with the help of a radio-controlled unmanned aerial vehicle (UAV) - drone DJI Phantom 3 Pro in 2017 and DJI Mavic Pro in 2018. Both devices are equipped with a high-resolution RGB camera mounted on a gyro-stabilized gimbal that provides additional stabilization of the camera. The survey was performed from a height of 500 m, which gives a spatial resolution of 0.5 m. Each image is geo-referenced. The program Agisoft PhotoScan was used to create the mosaic. It allows to automatically carry out the entire cycle of necessary operations from the geometric correction of lens distortion to the construction of a geolocated orthophotomap. The orthophotoplans obtained in this way served as a cartographic basis for geobotanical mapping of the steppes. Taking into account the data of the field geobotanical survey of the territory in the ArcGIS 10.0 software carried out a visual decoding of a geolocated orthophotomap.

3. Results and Discussion

The purpose of drawing up any map is to visualize on a certain scale objects of observation and research in order to identify the patterns of distribution of these objects and analyze them in conjunction with each other and other elements of the space in which they are located. The study area is confined to moderately dry bunchgrass steppe and grassland and wormwood-bunchgrass steppe. The grass cover is dominated by Stipa krylovii, Carex pediformis, Agropiron cristatum, Cleistogenes squarrosa, Koeleria cristata. The composition of the steppe communities is characterized by participation Caragana pygmaea.

During the cameral processing based on the analysis of geobotanical descriptions, a matrix of similarity measures was obtained by pairwise comparing coenoflora according to the floristic criterion using the similarity coefficient of Jacquard [6]. The resulting dendrogram of primary coenoflor served as the basis for the allocation of the phytocoenotic classification. The development of the classification of vegetation as the basis of the legend of the map is an important condition for a more complete knowledge of the patterns of its spatial and temporal structure. As a result of cluster analysis in the study area as part of the vegetation cover identified dry bunchgrass and shrub steppes. They include Caragana, herb-sedge, grass-sedge, wheat- wormwood, Cymbaria, Ephedra and sedge-feather-grass communities.

In addition to the classification, which is based on the characteristics of vegetation (species composition, its coenotic properties), the assessment of external factors is also important. They determine the development, structure of communities and their distribution in space. For the purpose of conjugate analysis of community structure and ecological conditions, environmentally significant environmental factors responsible for the phytocoenotic diversity and vegetation structure of the study area were determined using gradient analysis. According to the results of the ordinational analysis, the communities were conditionally divided into several groups. More moist and less saline habitats occupied the grass-sedge, herb-sedge and sedge-feather-grass communities. On the contrary, Cymbaria communities prefer less moist and more saline conditions. Similar conditions are typical for ephedra communities. Fallow phytocenoses occupied a middle position both in terms of the moisture factor and in terms of the salinity factor. The group of shrub communities that occupies the least moist position is distinguished.
The relief is one of the leading factors that have a great influence on the formation of the landscape as a whole, as well as on the spatial distribution of vegetation cover. It significantly deepens the analysis and the possibility of biogeographical interpretation of the data obtained in combination with the data obtained by ordination. Among the elements of the topography, the most significant are the height of the terrain above sea level, the exposition and the steepness of the slope [7,8]. The construction of ecological models reflecting the differentiation of vegetation depending on the elements of the relief is relevant for the disclosure of spatial structure. One of these models is the "model of the hill" [9]. We have made adjustments to this model, where an additional attribute to the graphical representation, in addition to the characteristics of the slopes (steepness, exposure), is relative heights.

Aerial photography data from the UAV were also used to obtain a map of vegetation, relief, angles of inclination of the earth's surface and exposure of slopes. Using the photogrammetric method for stereo pairs of images from UAVs and using the interpolation of point clouds obtained from laser scanning, modeling of the relief of the key area was performed. The terrain model is the basis for the creation of digital maps of exposure and terrain slopes.
Figure 3. Sketch map of steepness of slopes according to aerial photography.

Both relief analysis approaches were necessary. Modeling by orthophoto to highlight contours taking into account ecology and geography on a map, and a hill model for analysis and more spatial representation.

Use as a basis for mapping an orthophotomap obtained with the help of a UAV and a GPS receiver provides high accuracy of the mapping objects and their boundaries in contrast to the traditionally used topographic maps. Compared with satellite images, the orthophotomap has a significantly higher resolution. The natural colors of such an orthophotomap make it much easier and more objective to identify the mapping objects.

When conducting aerial photography, it is very important to choose the time of shooting relative to the phenological phase, during which certain plant communities and species will stand out most clearly and contrast [10]. Based on this, during the vegetation period, several series of images were taken at different phenological phases of plant development, taking into account changes in plant aspects.

Large-scale mapping of vegetation of the key area was carried out (M 1:15000). The map reflects the current state of the vegetation cover.

The legend of the map is based on ecological-geographical principles, reflecting the connection of the steppes with the landscape features of the territory, taking into account the phytocenotic, ecological and geographical features of plant communities.

The data obtained as a result of the analysis allowed to identify some of the patterns inherent in the steppe plant communities, as well as the relationship of the distribution of vegetation in accordance with the natural features of the territory.

On the tops of the ridge, in the zone of manifestation of primary rocks and on steep gravelly parts of the slope, petrophyte-grass steppes with bushes are formed. Cymbaric and ephedra-feathering communities occupy steeper slopes with occasional primary rocks. The composition of these steppes is characterized by the presence of petrophytic herbs. The slopes of the north-western exposition are represented by herb-grass and sedge-feather-grass communities.

The south-western slope of the exposition is a system of erosion troughs, beams, fragmentary overgrown with Pinus sylvestris and communities of dry steppes. They are characterized by expositional combinations of Cymbaria and Ephedra-feather-grass communities with steppe
herb-sedge communities on the erosion gully along the bottom. Combinations of steppe communities of the southern slopes are characterized by the participation of many xeropetrophytic species.

On the territory of the key area about 60% of the territory is occupied by fallow lands at different stages of restoration: Agropyron-Koeleria-Artemisia fallow with *Ulmus pumila* on leveled areas, and Potentilla-Poa fallow on the slopes of the south-eastern exposition.

The authors do not claim that the chosen approach is ideal. Probably, in the future both the classification and the legend based on it will be corrected, since research continues.

4. Conclusion
Mapping of this territory in scale of 1:15000 is carried out. As the basis of the map for the first time used orthophotoplan obtained from aerial photographs taken using an unmanned aerial vehicle.

The use of UAVs, unlike expensive images from spacecraft or conventional aircraft (airplanes and helicopters), allows aerial photography under the most favorable conditions, during periods of different phenological phases of plant development. Using the aerial photo obtained in this way, it is possible, on the one hand, to trace the dynamics of vegetation during one season, and on the other, to identify and map both different plant communities and populations of individual species that do not coincide in the phenological phase of development with each other.

Obtained in the natural visible spectrum of aerial photographs (as opposed to satellite images with conditional colors) make it possible to more objectively find the interpretation signs of mapped plant communities and correctly map their ranges and boundaries to the map. To compile a geobotanical map, we used a joint analysis of satellite images, digital elevation models and data obtained as a result of the classification of field geobotanical descriptions, which were used for the ecological-phytocenotic classification of vegetation. The map constructed by the described method is the most objective reflection of the state of the vegetation cover. It can also serve as the initial geobotanical basis for monitoring the dynamics of vegetation with the identification of its patterns. The resulting map allowed us to reflect the vegetation in close connection with the geographic environment.

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