Environmental spatial survey of the Nikitsky Botanical Garden

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Abstract. The article presents the results of environmental survey of the Nikitsky Botanical Garden. The research introduces the concept of territorial environmental model. The article recommends to introduce the term of spatial ecology, which refers to the issues of structural territorial analysis and spatial layout. Spatial ecology studies legal issues. The tasks of spatial ecology are solved by surveyors within the framework of geodetic support. The article shows that such survey is based on the methods of geodesy, photogrammetry, cadastre, remote sensing data and geoinformatics data. The research identified inconsistencies and violations.

1. Introduction
Environmental studies are divided into global and local. Jay Forrester, an American scientist, was the founder of global environmental sustainability analysis. His first and simplest model [1] took into account two factors: the population and the environmental pollution of the Earth. It should be noted that the level of pollution is a major environmental factor. Global models of the world and global assessments are formulated in terms of theory and composite indices while local assessments of the state of territories are formulated in terms of "management practice" and specific parameters. This simplification makes it possible to take prompt decisions without resorting to global theoretical models. Local territory state models allow improving the local ecology, thus contributing to the global ecology of the Earth. Local environmental improvement is complementary [2, 3] to the global environmental improvement [4]. The studies presented in this article concern the issues of local ecology. The spatial analysis of environment is often referred to as landscape ecology [5, 6]. Landscape ecology can also include a wide range of research, such as chemical, biological, hydrogeological, etc. [7]. Such a comprehensive study requires the involvement of different experts. It is possible to introduce the term of spatial ecology, which refers to issues of structural territorial analysis and spatial layout [8]. The geoinformatics methods and geodata are widely used as an integrated information resource for the purpose of spatial analysis [9]. It is possible to introduce the concept of territorial environmental model (TEM). This model explores spatial relationships and spatial structures. A TEM studies the spatial landscape configuration and the spatial landscape knowledge. A wide range of technologies are used to develop a TEM, such as geodetic technologies, photogrammetric technologies, cartographic technologies and space monitoring technologies. The whole complex is a part of the geodesic support of environmental research. From a cognitive point of view, environmental research is associated with the search for implicit knowledge [10] and the transformation of implicit knowledge into explicit knowledge. Due to the diversity of initial data and
technologies, a TEM is spatial and complex. Therefore, it is advisable to study it from the standpoint of geoinformatics [11].

2. List of works
Geodetic measurements of contours of spatial objects on the territory of the Nikitsky Botanical Garden;
Photographic evidence of objects located on the territory of the Nikitsky Botanical Garden;
Uploading of current and archived space survey data;
Uploading of a fragment of the archived 1:25000 topographic map;
Uploading of cadastral data;
Spatial reference of land plot plans;
Development of the TEM based on geodetic measurements, space surveys, topographic maps, cadastral information in the geographic information system.
Identification of environmental violations [12]
Mapping of survey results for the territory of the Nikitsky Botanical Garden.

3. Scope of works
The geodetic measurements were made using the satellite geodetic measurement method and the geodetic method (according to the Order of the Ministry of Economic Development of Russia No. 90 dated 1 March 2016). Due to limited time, the satellite geodetic measurements were made in RTK mode from the YALT base station of the Hexagon SmartNet network in the coordinate system SK-63 (district X, zone 5) with additional localization at the points of the state geodetic network "Nikita Yuzhny" (point of triangulation of class III) and "Massandra Novaya" (point of triangulation of class III). The accuracy of measurements was 30 cm in plan before localization, and 10 cm in plan after localization.

The reference points of objects, which operation is unrelated to the garden's activities, were subject to coordination for the purpose of its study. Two types of work were performed for this purpose. The first type of identification of objects, unrelated to the garden's activities, was based on remote sensing data, cartographic materials, and data of the Unified State Register of Real Estate (USRRE). The second type of work was a itemized referencing of satellite images that served as the basis for the land use map of the territory. The geodetic measurements were made in open areas using satellite measurements by the Leica GS15 receiver, and in other areas (impossible to access due to dense forest vegetation) by the Leica TCR 1205+ total station from the base points measured by the satellite and temporarily fixed on the ground.

As the photographic evidence was collected, a log containing descriptions of the recorded objects and the time of recording was maintained, thus making it possible to compare the obtained photos with the geodetic measurement data, the space surveys and the archived topographic map.

To analyze the current land use, a fragment of an ultra-high-resolution satellite image dated 28 August 2018 was uploaded via Google Earth. This is due to the fact that open sources do not contain more current spatial data of ultra-high spatial resolution of 0.5 m, required for this work. The satellite images dated 11 July 2014 were used for the retrospective analysis.

For the purpose of retrospective analysis of land use in the Soviet time, the archived data of space survey SPOT (Controlled Image Base) of medium resolution (10 m) on the territory of the Nikitsky Botanical Garden (image # n45e034) were uploaded using the Earth Explorer tool of the United States Geological Survey (USGS). This material was used to determine the clusters of capital construction objects for the interpretation of built-up areas.

For the purpose of retrospective analysis of land use on the territory of the Nikitsky Botanical Garden in the Soviet time, a fragment of topographic map sheet (scale 1:25000) dated 1987, covering the territory of the Nikitsky Botanical Garden, was downloaded from http://www.etomesto.ru/.

The spatial reference of the downloaded satellite images was based on the geodetic measurements. The mean square reference deviation according to the used software (ArcGIS V. 10.4.1, ArcMap) was...
2.2 m, which was sufficient to complete the tasks of this research.

The spatial reference of the topographic map fragment was performed using the above mentioned software along the lines of a normal cartographic grid. According to clause 13 of the Order of the Ministry of Economic Development of Russia No. 90 dated 1 March 2016, the mean square deviation of coordinate values determined on 1:25000 maps is 12.5 m. In this regard, this map together with the space image SPOT CIB # n45e034 was used to determine the clusters of capital construction objects, and to determine the presence of major capital construction objects on the ground in 1987.

When overlaying the geodetic measurements, the space surveys, the topographic maps and the cadastral data in the ArcGIS geographic information system, the violations were identified and the chronology of violations was analyzed.

In addition to the above works, the experts analyzed the external boundaries of the specified land plots with cadastral numbers 90:25:000000:434 and 90:25:000000:474 according to the delimitation plans in comparison with their external boundaries established by the state acts on the right of permanent indefinite land use dated 1970 and 6 April 1976.

To obtain the coordinates of measured points according to the state acts on the right of permanent indefinite land use, the graphical part (land plan) of the 1970 state act was linked to the characteristic points located along the Black Sea coastline, the boundaries of the land plot with the cadastral number 90:25:000000:1606 (represented by the forest edge and the contour of ploughed agricultural land). The resulting reference model was verified by line measures and points, also shown on the delimitation plan. It was found that the mean square reference deviation for the delimitation plan was 7.5 m. The land plot area according to the spatially referenced land plan was 267.20 ha, which is 1.17 ha more than indicated in the text of the state act.

Further, the studied state acts were aligned and the spatial reference of the land plan under the state act dated 6 April 1976 was carried out for points # 42-45, the line measures and points of which coincide with the points mapped on the southern boundary of the land plot according to the state act dated 6 April 1976. The land plot area according to the spatially referenced land plan was 2.54 ha, which is 0.05 ha less than indicated in the text of the state act.

Taking into account the above, the experts concluded that the resulting reference model is reliable and can be used to prepare the progress report.

The identified situations and violations were mapped on the territory of the Nikitsky Botanical Garden (figure 1) and numbered.

4. Results

When detecting violations, the Ukrainian State Land Cadastre and the Land Code of Ukraine were also used as the basis. In the course of analysis, topological modelling was performed based on the geodata [13] to clarify the layout and correspondence of its position to the data in cadastral documentation.

1 – Territory of the Nikita village (TNV). At the moment, only the land plot, where the Nikitskaya secondary school is located, is registered in the cadastral register. This territory is not connected with the activities of the Nikitsky Botanical Garden. There is a reason to exclude the village territory from the boundaries of the Nikitsky Botanical Garden.

1a – Territory of individual residential buildings that is functionally connected with the territory of the Nikita village. The analysis of the topographic map and the satellite image from 1989 shows that these objects did not exist in 1987–1989. According to the Google Earth data, five individual residential buildings had been built by 2004, and the sixth house was built between 2004 and 2009. Neither houses nor land plots under them are registered in the cadastral register. This territory is not connected with the activities of the Nikitsky Botanical Garden, and its inclusion into the boundaries of this special protected natural area contradicts articles 28-30 of the Federal Law "On special protected natural areas" No. 33-FZ dated 14 March 1995; it cannot be attributed to any of three functional zones provided for in part 2 of article 29 of the Federal Law No. 33-FZ dated 14 March 1995.
Figure 1. Photographic evidence of the work results or territorial environmental model.

2 – TNV. Currently, there is no land plot registered in the cadastral register, apart from an apartment building, two sheds and the head reservoir of the water supply system. This territory is not connected to the activities of the Nikitsky Botanical Garden, and its inclusion into the boundaries of this special protected natural area contradicts articles 28-30 of the Federal Law dated 14 March 1995.

3 – Recreational complex. Currently, there is no land plot or capital construction object mentioned in the cadastral register. At the same time, recreational activities are carried out on this territory; there are two buildings and a swimming pool. This territory is not connected to the activities of the Nikitsky Botanical Garden, and its inclusion into the boundaries of this special protected natural area contradicts articles 28-30 of the Federal Law "On special protected natural areas" No. 33-FZ dated 14 March 1995.

4 – TNV This territory is not connected to the activities of the Nikitsky Botanical Garden, and its inclusion into the boundaries of this special protected natural area contradicts articles 28-30 of the Federal Law No. 33-FZ dated 14 March 1995.

5 – Highways that are not registered in the cadastral register as capital construction objects.

6 – Cemetery that is located within the land plot boundaries and its designated use is funeral activity. Currently, there are no new burials in the cemetery. This territory is not connected to the activities of the Nikitsky Botanical Garden, and its inclusion into the boundaries of this special protected natural area is contradicts the above law. The experts think that reburial in order to release this territory for use by the Nikitsky Botanical Garden is impractical.

7 – Vegetable gardens. There are no entitling documents.

8 – Water supply facilities.

9 – Meteorological station.

10 – Land plots that are located outside the cadastral boundaries of the specified land plot. This is a cadastral error.

11 – The Console-Sport Nikita hotel is located within the boundaries of the Nikitsky Botanical Garden and is privatized. There is a violation of the Land Code of Ukraine on the privatization of special protected natural areas.

12 – Delfin-Chernomorsky Resort. According to the Google Earth data, a demolished multi-storey building was previously located on a part of the land plot.
13, 13a, 13b, 13c, 13d, 13e – Individual residential development. It was established that within the boundaries of the territory allocated to the Nikitsky Botanical Garden, there are numerous intersperses where individual residential buildings are located or which are intended for their placement based on the permitted land use types. Verification of entitling documents is required.

5. Conclusion
The Nikitsky Botanical Garden is a special protected natural area. The study of territorial environmental systems is a prerequisite for the functioning of special protected natural territories. For the purpose of spatial objects modelling, it is advisable to use geoinformatics methods; for the purpose of parametric modelling, it is advisable to use computer science methods; and for the purpose of environmental analysis, it is necessary to use landscape ecology. The work demonstrated that the territorial environmental survey can be completely implemented by the methods of geodetic support. It is proposed to introduce the concept of "territorial environmental model" (TEM). It is proposed to introduce the concept of "territorial environmental survey". This is a type of survey that identifies only structural disfigurement of the landscape and does not consider the others. The advantage of such a survey is that it can be carried out by expert surveyors without involving other specialists. In other words, such a survey is performed in a quick and meaningful way. The results of environmental study transform implicit knowledge into explicit spatial knowledge [14]. It is advisable to introduce the concept of "spatial ecology", the tasks of which can be completely solved by the methods of geodetic support [15].

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