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Abstract. This study examines the use of GIS-materials of various specifications for the inventories of objects of cultural heritage on the example of the object of federal importance "Kharitonov Palace, XIX century", the city of Yekaterinburg. The paper presents a detailed algorithm for making vegetation inventories in historical garden-park complexes. A comparative assessment of accuracy of the established standards and the developed methods of inventory process is given. As a result of this approach, it was possible to give a comprehensive description of the entire territory of the Kharitonov garden as part of the restoration and biological assessment of the vegetation, landscape and architectural survey, individual plant inventory of cultural heritage object of federal importance " Kharitonov Palace, XIX century".

1. Introduction

Modern technologies significantly expand the possibilities of using information resources in various branches of forestry and related areas such as municipal park management, urban planning and land use. The development of information technologies is aimed at automation of recording the object changes and maintenance planning [1, 2]. The most relevant and rapidly developing tool is Geographic Information Systems.

The parks, which represent still largely unscientific historical-cultural stratum of the entire region, are among the objects of urban parks management. Working with cultural heritage objects requires extreme precision, as it aims to give the object a protection status [3], the resulting materials are used to recreate the lost appearance. However, the existing methods of inventory [4] do not reflect the specificity of the objects of this rank, as they are aimed at working with aggregated indicators. Carrying out such work is relevant due to the fact that the objects often do not have fixed boundaries of the territory in the urban environment and free access to existing administrative materials for public organizations.

Problems were identified during the work on vegetation restoration, landscape and architectural survey and individual plant inventory of cultural heritage objects of Federal importance "Kharitonov Palace, XIX century" located at: Ekaterinburg, 44 Karla Libknekhta St.

The purpose of the presented work is to show the effectiveness of the inventory methods developed on the basis of the available GIS materials usage (administrative resources, Google Maps, Yandex Maps) applied to work with the landscape objects of cultural heritage.

2. Materials and methods

The initial data for the inventory of Kharitonov garden were materials of the State Archive of the Sverdlovsk region [5], historical photographs [6], topographic plans of 2010 and 2015 in a scale of 1:500, Google Maps, Yandex Maps, Requirements of the Moscow Government Resolution of 04.10.2005 N 770-PP [4], V S Teodoronskii's recommendations for the maintenance [7], zoning map of the territory of the municipal entity "Ekaterinburg city" [8], public cadastral maps of the Federal registration service of Russia [9].

At the initial stage of the research, the inventory of the object was carried out according to the methodology established by the requirements of the Moscow Government resolution [4]. The park was divided into 10 sections. The allocation of each section was defined along the boundaries of the path network according to their historical significance, functional purpose and features of the terrain.

At the field stage of the research [7] the spatial data were clarified: the existing path network and objects with constant contours, such as park fence elements, walls of buildings, lighting poles and power lines. In the course of work all trees, shrubs, mass plantings, flower beds, designed and desire paths were included to the plan, at the same time the serial number, type of park vegetation, a vital form, a species of plant, numerical characteristics, a sanitary condition on 6-point scale [10], notes and recommendations were written in the working sheet.

At the stage of post-processing of the results the obtained working drawings were correlated with the topographic plan and the previous inventory materials, where the historical specimens of particular value were acknowledged.

3. Results

In the study process it was revealed that the existing topographic plans contained insufficient data or did not coincide with the results of the field imaging. Thus, the boundaries of the garden were not indicated on the administrative maps, and in different years (inventory in 2015 and 2016) the fence along the southern border of the territory was changed. The area and location of flower beds, existing paths and grounds, the shape of the southern island with a rotunda fountain did not correspond to the reality, unpaved paths, desire paths were absent (Table 1).

Table 1. The comparative analysis of topographic and field inspection materials

Land Category	**Area according to topographical survey**		**Area according to field inventory**	
	sq.m	**%**	**sq.m**	**%**
1. Greening				
1. Trees	636	0.9	1051	1.5
2. Shrubs	0	0.0	145	0.2
3. Lawns	43741	62.9	42437	61.0
4. Flowerbeds	17	0.0	198	0.3
Total	**44393**	**63.8**	**43831**	**63.0**
2. Paths and grounds				
1. Asphalted	6161	8.9	7981	11.5
2. Gravel and sand pavement	7273	10.5	4178	6.0
3. Desire paths	0	0.0	1837	2.6
Total	**13433**	**19.3**	**13996**	**20.1**
3. Buildings and structures	**836**	**1.2**	**836**	**1.2**
4. Water bodies	**10913**	**15.7**	**10913**	**15.7**
Total area	**69576**	**100.0**	**69576**	**100.0**
Landscapes ratio				
Non-open landscape	0	0	10523	15.0
Semi-open landscape	34245	49.0	42286	61.0
Open landscape	35331	51.0	16766	24.0

The coverage area of the roads and paths network marked on the plans did not correspond to the actual dimensions of the paths, in some areas the discrepancy of the widths reached 2 m, including those tracks and sites where the existing hard surface was sodded due to lack of use.

Significant discrepancies in the location of the paths were observed in isolated cases, which was connected, most likely, with the locating on the plans of historical sites belonging to the Soviet period – 1937-91 (Figure 1).

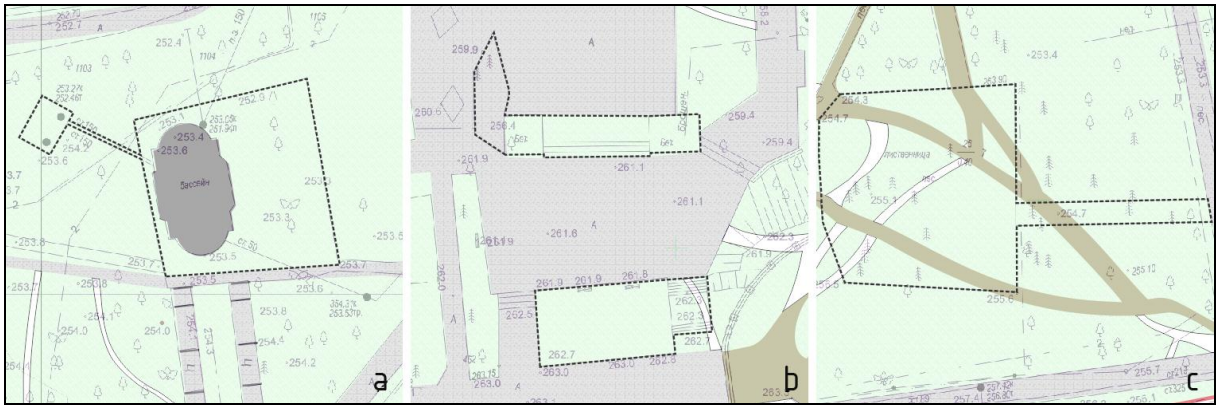

Figure 1. Path network based on geo-survey and field survey. The dotted line outlines the selected sites of 1937-91., no longer present. (a)-section № 1, area at the exit to the Theatre square; (b) – section №1, area of the former Summer theatre, South exit; (c) – section №6, area at the South-East exit.

Desire paths with a total area of 1837 m^2, which have great importance for the reconstruction work, for estimating the level of anthropogenic impact and further path network design, are absent at the topographic plans. In some cases, the actual boundaries of the existing paths did not coincide with the latest topographic map of 2015. The earlier plans of 2010 reflect a more relevant situation. It is also noteworthy that topographical plans do not reflect the condition of the pavement, junction elements, roads and paths network and other characteristics important for the reconstruction project.

However, archival topographic maps in many cases allowed to find out the material of the path's pavement, which was not always obvious within the field survey due to alluvion coverage and sodding.

The available topographic materials also did not coincide with the obtained tree inventory maps, which is reflected in Figure 2.

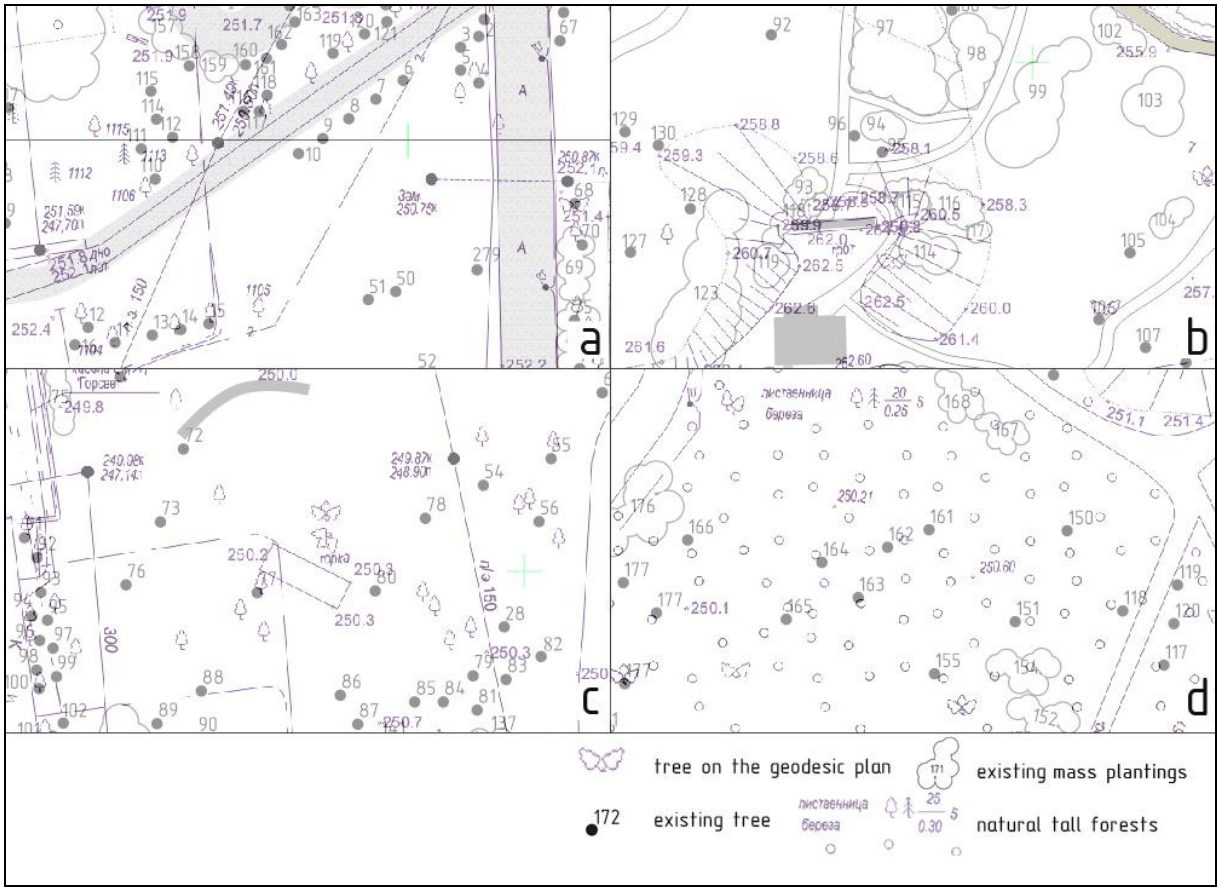

Figure 2. Layout of trees according to the materials of topographical-survey and field survey. (a)- section № 1, area at the exit to the Theater square; (b)– section №6, area with a wine grotto and a Lost Chinese gazebo; (c) – section №9, area behind the building of the theater of the Young Spectator; (d) – section № 10, the Western part along the Central alley.

It is important to understand that topographic survey is often carried out by the companies which are not familiar with the specificity of cultural heritage objects. Mostly implementers are referring to Moscow Government Resolution N 770-PP [4], whereby individual tree topographic survey aims to record all the trees that have reached a diameter of 8 cm at a height of 1.3 m. Coniferous and deciduous trees of the 1st group (spruce, pine, larch) are distinguished [11], if necessary, other deciduous trees [4] that are important in the composition plan can be distinguished. When applying the common methodology, 778 trees and shrubs up to 8 cm in diameter (13.2% of the total share of the vegetation) were excluded from the record of the garden plantings.

A significant disadvantage of the mentioned common methodology is the lack of the recording of maple, apple tree, rowan, bird cherry species on the plan (Figure 2-a,C), which is, according to the inventory, 39.5 % (1021 pcs.) of the garden plantings. Also, all types of shrubs, which estimated at 18.7 % (483 pcs.) of the total number of woody plants of the garden are not taken into account.

Sites that are currently occupied with mass plantings, are represented on the topographic plan by an empty fragments free of plantings (Figure 2-B,D), conditionally marked as "natural tall forests" [12] with the metric data that does not correspond to reality. The absence of trees mass plantings on the plans is unacceptable when working with objects of cultural heritage, as their presence affects the decrease in the aesthetic qualities of landscape compositions and leads to a change in a type of spatial structure of the Park to a more non-open one (Table 1).

Locating trees on topographic maps also has a number of controversial points. The discrepancies in the location of trees up to 5 m are found, while the accuracy tolerance for such mapping is 0.1% [7], which is 0.5 m on a scale of 1: 500.

After evaluating all the advantages and disadvantages of using existing GIS materials, the following algorithm for the inventory of plantings of historical park and garden complexes was proposed:

1) clarify the compliance to the declared scale by the original topographic plans. In case of non-compliance of the distance between the signs of the coordinate grid on the topographic plan, to bring to a set distance of 10 cm on the plan [13]. To verify, calculate the area of the object on the plan and in Yandex Maps Internet service using the tool "ruler". In the absence of the coordinate grid signs, select an object on site with constant contours, measure it. Compare the obtained areas and bring the map to a scale corresponding to the standard [4].

2) divide the object by landscape areas (stratums) within the boundaries of the path network, or other objects with constant contours, the areas should be numbered.

3) affix to the constant contours of all the elements on the plan. Estimate the possibility of an affixment with Yandex Maps satellite images. At the very least, split the area into a coordinate grid, which must also be affixed to objects with constant contours.

4) include the scaled topographic plan with plotted horizontals and without vegetation layer to the preparatory package of the documentation: one of a general view, that includes the entire object, and the detailed one, showing individual sections and worksheets.

5) study the panoramic images of Google Maps with the Google Street view tool in the different seasons, to highlight the high density vegetation on Yandex Maps satellite images, to analyze the topography on the plans of topographical survey, identify possible hard-to-reach areas (isolated areas, ravines, wetlands).

6) clarify, during the field survey, the boundaries of the object, previously established by satellite images. Plot them to the general plan and verify the location of the objects with the constant contours: fences, buildings, path network. Write characteristics of the paths into the worksheet: pavement materials, junction elements, recommendations for the maintenance.

7) During the field survey divide one site according to the selected method and locate the trees with the trunk diameter from 1 cm, shrubs from 0.5 cm. This approach will provide the necessary accuracy, as the share of trees and shrubs up to 8 cm in a diameter, represented in mass plantings, young woody vegetation, wildings in the composition of the greenery is significant.

8) mark all woody plants on the site's work plan, apply the contours of mass plantings, flower beds, desire paths. At the same time, the following characteristics should be recorded in the working sheets: an identification number, type of park vegetation (TPV), the vital form (VF), a type of plant, diameter at height of 1,3 m, height, quantity, the score of a sanitary condition on the 6-point scale (PSC), notes and recommendations. Numbering of elements should be carried out for each site separately.

9) digitize work plans during the stage of post-processing data (Figure 3). Controversial issues and hard-to-reach areas (unreachable lands, conserved sites, such as the Northern island) must be remotely studied by the Google Street View tool.

Figure 3. The plan made by digitizing a field survey material with an overlay of the topographic plan.

10) determine the age of woody plants. During the computer processing impose an additional layer of the topographic plan on the maps, matching the signs of a grid. Using materials from previous inventories, distribute the elements into categories: up to 40 years, up to 100 years, more than 100 years (for trees); up to 10 years, up to 20 years, more than 20 years (for shrubs).

4. Conclusions and recommendations

The methodology has been developed to work with cultural heritage objects and has been tested on the objects with an area up to 35 ha (the complex of manor houses and park facilities of the museum-reserve "Park Monrepo", Vyborg, Leningrad oblast; Park "Kharitonov Palace", city of Yekaterinburg, Sverdlovsk oblast; gardens "Fairy Tale" and "English" by A E and F A Teploukhov in the village of Ilyinsky, Perm region).

Working according to the presented methodology made it possible to level the differences in inventory materials, to achieve the required accuracy of the study, to characterize hard-to reach areas (like the Northern island) and get a full specification of the entire territory of the Kharitonov garden within the work on restoration and biological assessment of the vegetation, landscape and architectural survey and individual plant inventory of cultural heritage object of federal importance "Kharitonov Palace, XIX century".

Possible limitations when using this methodology may be the absence or insufficient number of objects with constant contours, the lack of hard-to-reach areas of the studied object presented on Google Street View panoramas.

Detailed results of the inventory carried out by field survey will allow to create a spatial database [14] and subsequently update, development of the attribute information database which will contain detailed data on each element of historical planting, including lawns (with indication of the type, dominant species, the area of the projective cover, the percentage of digression), flower beds (with indication of the type, area, used perennial species). These studies will reduce labor costs when updating inventory materials every three to five years, and to have numerical data on the dynamics of changes in the state of the recorded elements.

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