Formation of the cultural landscape of urban environment using Geographic Information Systems Technology

S M Khamitova1, P S Khamitov2, E I Fedchenko1, M A Ivanova1,3, D E Yuzhakov1

1Vologda State University, 15 Lenina street, Vologda 160000, Russian Federation
2Vologda State Dairy Farming Academy by N V Vereshchagin, 2 Shmidtta street, Vologda, village Molochnoe 160555, Russian Federation
3North (Arctic) Federal University, 17 Severnaya Dvina Embankment, Arkhangelsk 163002, Russian Federation

*Corresponding email: xamitowa.sveta@yandex.ru

Abstract. This article is devoted to the formation of the cultural landscape of an urbanized environment using Geographic Information Systems Technology. Urban plantations are the predominant elements of the natural environment. Urban plantations form the basis of cultural landscapes with their areas and diversity. The article describes the green spaces in an urban environment. In 2019, the greening of the streets of the city of Vologda was carried out. We have created an electronic greening map of the city of Vologda in the program Quantum GIS. Such a map will allow monitoring the improvement and landscaping of the territory, which will save all the useful information about the creation of plantings.

1. Introduction

One of the urgent problems of landscape architecture is to solve the issues of greening urban areas. Green spaces in urban environment represent a unique urban ecosystem. This urban ecosystem requires continuous monitoring of both its condition as a whole and its components. The most important component of landscaping in the city is woody and shrubby vegetation.

Plants have many useful properties [1]. Plants deposit carbon dioxide, produce oxygen in the atmosphere. Plants produce volatile substances (volatile substances) that kill pathogenic microorganisms. Plants act as a way to protect against air pollution from industrial waste and dust, and under certain conditions reduce the effects of noise. Green areas of plants have a positive effect on microclimatic conditions, reducing wind speed and increasing air humidity. Thus, plants regulate the thermal regime. Besides, it is impossible to do without green spaces during the engineering arrangement of cities. The reason is that plants are used in the fight against soil erosion, which is very important for urban improvement.

Plants have an important place in creating the architectural and artistic image of the city. Increasing the attractiveness and comfort of the urban environment contributes to improving the quality of life of citizens and the development of tourism. Plants are an integral element of the city due to their architectural and planning, sanitary and hygienic and economic importance.

Plants, as part of public space, have significant social, cultural, educational, and historical significance. The significant life span of trees determines their value for continuity between generations of citizens. The responsibility being formed in society before solving the problem of preserving cultural landscape objects contributes to the development of civil society institutions. Thus,
The current system of accounting for tree and shrub vegetation does not meet new trends. The improvement of such a system must now take into account the current level of information technology. Information technologies allow saving important information about the state of plants, conducted and planned care for it. Moreover, information technology allows saving historical information about plantings and people directly involved in this [2]. This information is of great importance in the practical activities of people engaged in urban landscape issues. Information technology allows drilling down to a specific tree. This information will allow saving information about the tree throughout the entire period of its life. The introduction of this system will make it possible to organize tourist routes in the future with visits to individual memorial trees planted by prominent public and political figures. The information technology implementation will also contribute to the environmental education of the population.

The research problems are to analyze the composition of the arboriflora of the city of Vologda and to draw up an electronic map of green plantations for further monitoring.

2. Methods and Materials

The object of research is the green spaces of the cultural landscape of the city of Vologda. Geographically, the city of Vologda, is located in the southwest of the Sukhonsky Depression. Most of the city’s territory, which is part of the residential area, is an artificially created soil cover. The exception is parks and gardens. In parks and gardens, the soil layer is unchanged and in composition, mainly sod-podzolic. The city of Vologda is located in the subzone of southern taiga. Therefore, in the forests surrounding it, mainly boreal forest formers grow, such as *Picea abies*, *Pinus sylvestris*, *Populus tremula* and *Betula pendula*. These forests have a dense undergrowth, one can find immoral flora, such as *Fraxinus excelsior*, *Tilia cordata*, *Quercus robur*, *Acer platanoides*. In the undergrowth, one can find *Lonicera xylosteum*, *Sorbus aucuparia*, and *Ribes nigrum*. The historical, cultural landscape of the environs of Vologda is sung in poetry and prose by V.A. Gilyarovskiy, N.M. Rubtsova, O.A. Fokina, and many other famous authors. The historical, cultural landscape of the environs of Vologda has become a kind of standard of beauty for the inhabitants of the European North of Russia. Within the urbanized territory, vegetation is represented by artificial plantations, the total area of which is about 515 hectares. The assortment of dendrology of the city is much more extensive than natural ecosystems due to the use of introducers [3-5].

The analysis of arboriflora composition was carried out on the basis of the results of quantitative accounting of green plantations in the city of Vologda.

The subject of this study is to explore the possibilities of using geographic information systems for monitoring and accounting for green spaces in the city in the context of its cultural landscape.

In this work, we used visualization methods using GIS [6-8]. The most suitable program for supporting a green space monitoring system is Quantum GIS. Quantum GIS is a geographic information system for creating, editing, visualizing, analyzing, and publishing geospatial information [9]. QGIS is available for most modern platforms (Windows, Mac OS X, Linux). QGIS combines vector and raster data support. Also, this program can work with data provided by various cartographic web servers and many common spatial databases [10]. As a cartographic basis, a raster image of the city’s territory from the Yandex Maps. The vector layer "Trees" contains green spaces. Markers of different colors, depending on the species of a particular tree, were chosen as conventional signs. The semantic information of the Trees vector layer is contained in the attribute data table.

3. Results and Discussion

Our analysis of the composition of arboriflora allows conclusion that mainly trees like *Betula pubescens*, *Betula verrucosa*, *Populus balsamifera*, *Ulmus laevis*, *Acer platanoides*, *Acer ginnala*, *Acer negundo*, *Sálix fragilis*, *Tilia cordáta*, *Tilia platyphyllos*, *Fráxinus excélsiro*. Less common: *Lárix sibírica*, *Pícea púngens*, *Thúja occidentális*, *Sálix álba*, *Pópulus álba*, *Aéšculus hippocástanum*, *Quercus róbur*, *Ulmus parvifolia*, *Malus domestica*, *Málu sylvéstris*, *Malus baccata*, and other tree species.
The following shrubs and low trees most often grow in this area: *Cotoneáster lucidus*, *Caragána arboréscens*, *Crateagus sanguínea*, *Bérberis vulgáris*, *Rósa spinóssíssima* and *Rósa rugósa*, *Syringa vulgáris* and *Syringa josikaea*, *Physocarpus opulifólius*. Rarely are *Spiráea salicifólia*, *Spiráea betulífolia* Pall. and *Spiráea media*, *Sorbaria sorbífolia*, *Córns álba*, *Symphoricarpos albus*, *Vibúrnnum òpulus* and *Vibúrnnum lántana*, *Lonicera xylóstegum* and *Lonicera edulis*, *Sambúcus racemósa*.

In 2019, we carried out work on landscaping some areas of the city of Vologda. When planning green plantings, ecological and biological features, decorative qualities and reproductive strategies of woody plants, their environment-forming potential, resistance to the effects of a complex of various negative factors, the specifics, and nature of the city’s development were taken into account. For landscaping, the streets, *Acer platanóides*, *Acer ginnala*, *Tília cordáta*, *Ulmus laeves*, and *Quercus robur* were selected. The choice of the range of tree species is based on such characteristics as the prospect of its use for landscaping in local urban ecosystems, the presence of dendroflora in the composition and preferences of the local population.

*Acer platanóides* is a tree that can reach a height of 30 m, with a dense and wide-round crown. This type of tree is decorative in the initial flowering period and is no less attractive in summer due to the presence of a dense dark green crown. *Acer platanóides* is especially appreciated in decorative gardening. The value of this tree is associated with its quality, such as its large size, slender trunk, beautiful dense crown, highly ornamental foliage.

*Acer ginnala* is one of the best breeds for single and alley plantings, colorful, powerful groups. All forms of maple are hardy winter-hardy, retain the typical growth form for the species, and have the excellent shoot-forming ability. Besides, it should be noted and a very positive perception of maple in the culture of the population of northern cities, causing associations of youth and beauty.

*Tília cordáta* is a deciduous open-flowered shrub or low tree, reaching from 3 to 10 m in height. The sprawling tent-shaped crown has an unusual beautiful red-carmine color of three-lobed leaves. The leaves of this species grow on the petioles of the original pinkish hue. *Acer ginnala* has a dark green color at the beginning of the growing season, and in autumn the foliage turns yellow, orange and red. *Acer ginnala’s* blooms in spring at the same time as the leaves bloom. The flowers have a greenish-yellow color, are small-sized fragrant panicles. It belongs to the most frost-resistant maples. The use of *Acer ginnala* in modern landscape design is quite widespread. Maple also looks excellent in the form of spectacular single plantings, informed hedges, in combined plantings with conifers.

*Tília cordáta* is deciduous tree 20–38 m tall with a hipped crown. *Tília cordáta* is the most massive tree in urban plantings. *Tília cordáta* is decorative, overgrows, develops a large leaf mass, well retaining dust and soot. *Tília cordáta* transfers undercutting and forming of a crown. *Tília cordáta* takes root in a new place when transplanted in an adult state; it smells nice during flowering. One of the main advantages of *Tília cordáta* is its nectar-bearing.

*Ulmus laeves* in nature is a sturdy, tall tree or shrub. In landscaping the cities of the European North of Russia, it is advisable to use *Ulmus laeves* is a new zonal species for taiga forests. Its leaves are serrated and can vary in size and shape, forming a beautiful lace – the so-called ligature. One of the brands in the region is precisely the Vologda lace. Red-violet flowers collected in inflorescences of several pieces appear in March or early April. After pollination, small, winged fruits, which are carried by the wind, are tied in place of flowers. *Ulmus laeves* smooth is widely used in forest reclamation of landscapes and landscaping of cities.

*Quercus robur* is a large tree with a sturdy crown and a dominant trunk. *Quercus robur* reaches a height of 20 – 40 m and can live up to 2000 years. English oak tolerates gas contamination. Therefore it is used for residential landscaping areas, industrial zones. It is used both in single and in group plantings. Looks perfect for oak also in alley plantings. It forms the basis of park and forest plantations. In public consciousness, an oak is formed as a tree, symbolizing strength and durability.

When landscaping the streets, designing garden and park alleys, the plants were arranged in one or several rows in a straight or curved line at a certain distance from each other [11]. Ordinary tree plantings were carried out along the streets of the city of Vologda; in some territories, single and alley plantings were used.

Based on the results of landscaping and landscaping, an electronic map of the city of Vologda was...
created with the plot of all planted green spaces and information about them (figure 1).

Figure 1. Map of the landscaping of the city of Vologda in 2019.

The Quantum GIS program was used for creating the map. This program will make it possible to add information on newly planted trees to the map in the future, to correct important information about the state of plantings, their maintenance, and planned maintenance, as well as historical information about their planting and people directly involved in them. The Quantum GIS program can connect any alternative graphic background. Such a map will allow monitoring the improvement and greening of the territory and the preservation of all useful information about the establishment of the planting.

Tree planting was carried out on 15 streets of the city of Vologda. *Acer platanoides* and *Acer ginnala* were planted along with the houses along the streets of Gagarin, Batyushkov, Renaissance, Severnaya, S. Preminina, Pushkinskaya, on Sovietsky Avenue (figure 2). These stands perform a protective function. Namely, they protect pedestrians from dust and exhaust gases from vehicles. These stands are located along streets with heavy traffic between the sidewalk and the traffic lane. Also, *Acer platanoides* and *Acer ginnala* were planted in the courtyards of houses on the street Solodunova.

Figure 2. Maple planting on Renaissance Street and oak on Okrugny highway.

*Ulmus laeves* were planted on Poshekhonskoye highway on a dividing green strip between carriageways from Okrugny highway to Kazakova Street. Such tree planting reduces head-on glare, noise, and exhaust emissions. Elm trees were also planted along with houses on Herzen Street and at Veteran Park on Karl Marx Street.

*Quercus robur* were planted on Predtechenskaya Street next to the Panorama shopping center and residential buildings, as well as on the Okrugny highway near the Maxi shopping center. Alley planting of *Quercus robur* was carried out on Victory Avenue near the Quantorium children’s industrial park (figure 3). This territory with green spaces can be used for environmental education and research activities of schoolchildren studying at the Quantorium.
On the Ring Highway near the RRT-Vologda car dealership, *Tilia cordata* were planted. On the territory of the Vvedensky cemetery along Dobrolyubova street, a memorial planting of blue spruces was carried out. Veterans took part in the maple planting on the Revolution Square near the Eternal Flame, dedicated to Victory Day on May 9, 2019.

On the territory of Pioneer Square on Zosimovskaya Street, *Acer platanoides* and *Acer ginnala* and *Picea abies* were planted as part of the landscaping work to replace sawn trees and to renew the species composition (figure 4).

The map we created allows visually seeing the location of each tree, as well as information about it: breed, age, height, planting date (figure 5).

In the future, when monitoring these stands, it will be possible to update and supplement information about each tree, including its sanitary condition.
4. Summary
At present, measures to improve the environment, landscaping, and improvement of cities and populated areas are becoming increasingly important. The importance of fundamental nature in the landscaping of a settlement, the formation of its external appearance, is growing.

The main result of this study is recommendations on the greening of several territories of Vologda, which were implemented in various areas of the city. Design, care of plants, and maintenance of landscaping objects will be carried out using GIS technologies. Interactive map data can be used in the assessment of urban green spaces and the inventory of recreational facilities. Over time, the role of landing information stored in the electronic environment will increase, since this data can be used for compiling tourist and excursion routes. Moreover, in the future, it will be possible to take into account the attitude of certain social groups (youth, pensioners, workers of various industries), who initiated the creation of green spaces in public spaces as part of voluntary public actions. The population regularly holds such actions with the city administration. The use of GIS technologies allows evaluating and making changes in the composition of arboriflora. As a result, it becomes possible to promptly make changes to the cultural landscape of specific urban areas.

The presented work results are of great practical importance for the formation of a high-quality green zone of the regional center. Based on these studies, tree care will be carried out in order to improve the sanitary and aesthetic conditions.

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