

AVALIAÇÃO DO ESTADO DAS PLANTAS VERDES SOB AS CONDIÇÕES DE URBANIZAÇÃO**EVALUATION OF THE STATE OF GREEN PLANTS UNDER THE CONDITIONS OF URBANIZATION****ОЦЕНКА СОСТОЯНИЯ ЗЕЛЁНЫХ НАСАЖДЕНИЙ В УСЛОВИЯХ УРБАНИЗАЦИИ**

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RESUMO

A formação de um ambiente urbano ecológico é uma tendência do tempo atual. É necessário solucionar os problemas do paisagismo das cidades, pois, na atual fase, observa-se a deterioração do estado dos espaços verdes e a diminuição da área que eles ocupam. O artigo apresenta dados sobre o estado da vegetação arbórea no maior parque de Vologda (região de Vologda, Rússia). De acordo com os resultados da avaliação dendrométrica no Mira Park, foi revelado o número de tipos de desvantagens em cada espécie de árvore em um determinado diâmetro do tronco. Vale a pena notar que os tipos mais comuns de inconvenientes em tílias no Mira Park são danos mecânicos e fissuras por geadas. A investigação foi realizada com base no "Procedimento de levantamento de inventário para plantações urbanas". Na maioria das vezes, os inconvenientes da madeira nessa espécie ocorrem nos diâmetros do tronco na faixa de 40 a 52 cm. Com base na avaliação bioecológica realizada no Mira Park, pode-se afirmar que o maior percentual de bom estado de saúde das árvores foi encontrado no pinheiro - 67,3%, o maior percentual satisfatório de estado de saúde das árvores foi encontrado no olmo - 35,7% e o maior percentual de péssimo estado de saúde das árvores foi encontrado no carvalho - 16,1%. De acordo com os resultados da investigação, pode-se dizer que a maioria das plantas arbóreas está em boas e satisfatórias condições. A maior porcentagem de problemas de saúde foi encontrada em espécies de árvores como carvalho e álamo. Basicamente, existem falhas comuns nas plantações de árvores como danos mecânicos, uma fenda congelada e um tronco curvo. A situação atual no maior parque da cidade de Vologda é estável. No entanto, para melhorar a condição sistemática, é necessário realizar uma série de atividades que devem preservar e diversificar as plantações de árvores e arbustos, além de ajudar a resolver problemas existentes.

Palavras-chave: *ecologia urbana, poluição, plantações urbanas verdes, espécies arbóreas, biodiversidade*

ABSTRACT

The formation of an urban ecological environment is a local trend of the current time. It is necessary to solve the problems of city landscaping since, at the present stage, the deterioration of the state of green spaces and a decrease in the area that they occupy are observed. The article presents data on the state of tree vegetation in the largest park in Vologda (Vologda Region, Russia). According to the dendrometric assessment results in Mira Park, the number of drawback types in each tree species at a specific diameter of the trunk was revealed. It is worth noting that the most common types of drawbacks in linden trees in Mira Park are mechanical damage and frost cleft. The investigation was carried out based on the "Inventory Survey Procedure for Urban Plantations." Most often, wood drawbacks in this species occur on the trunk diameters in the range from 40 to 52 cm. Based on the bioecological assessment performed in Mira Park, it can be stated that the highest percentage of good tree health status was found in pine – 67.3%, the highest percentage of satisfactory tree health status was found in

elm – 35.7% and the highest percentage of poor tree health status was found in oak – 16.1%. According to the results of the investigation, it can be said that most of the tree plants are in good and satisfactory condition. The highest percentage of poor health status was found in tree species such as oak and poplar. There are such common flaws on tree plantations as mechanical damage, a frozen slot, and a curved trunk. The current situation in the biggest park in the city of Vologda is stable. However, to improve the systematic condition, it is necessary to hold some activities that should preserve and diversify the tree and shrub plantations, as well as help to solve existing problems.

Keywords: *urban ecology, pollution, green urban plantations, tree species, biodiversity*

АННОТАЦИЯ

Формирование экологической городской среды является актуальной тенденцией современности. Необходимо решить проблемы городского благоустройства, поскольку на современном этапе наблюдается ухудшение состояния зеленых насаждений и уменьшение площади, которую они занимают. В статье приводятся данные о состоянии древесной растительности крупнейшего парка г. Вологды (Вологодская область, Россия). По итогам проведения дендрометрической оценки в парке Мира выявлено количество видов пороков у каждой древесной породы на определенном диаметре ствола. Стоит отметить, что наиболее встречающиеся виды пороков у липы в парке Мира – это механическое повреждение и морозобойная трещина. Чаще всего пороки древесины у данной породы встречаются на диаметрах ствола в интервале от 40 до 52 см. Исследование проводилось на основе «Процедуры инвентаризации городских плантаций». На основании проведения биоэкологической оценки, выполненной в парке Мира, можно констатировать, что наибольший балл хорошего санитарного состояния деревьев был выявлен у сосны – 67,3 %, наибольший процент удовлетворительного санитарного состояния деревьев был выявлен у вяза – 35,7 %, наибольший балл плохого санитарного состояния деревьев был выявлен у дуба – 16,1 %. По результатам проведения исследований можно сказать, что большая часть древесных растений находится в хорошем и удовлетворительном состоянии. В основном встречаются такие распространенные недостатки на плантациях деревьев, как механические повреждения, замерзшая щель и изогнутый ствол. Текущая ситуация в самом большом парке города Вологды является устойчивой. Однако, для улучшения общего состояния необходимо выполнять ряд мероприятий, которые должны сохранить и разнообразить древесно-кустарниковые насаждения, а также помочь в решении существующих проблем.

Ключевые слова: *экология города, загрязнение, зелёные городские насаждения, древесные породы, биоразнообразие*

1. INTRODUCTION:

The urban environment is a complex of natural, human-made, and socio-economic factors, which are a radical means of improving the ecology of the city and the human environment. On the lands of settlements, green spaces perform many functions that contribute to the formation of stable conditions for the optimal life of the townspeople (Yu *et al.*, 2019). Green urban plantings are not only the most important element of greening the urban environment, but also a severe urban planning, architectural, planning, and social factor (Voronkova *et al.*, 2019).

A green plantation is a community of trees, shrubs, and grassland vegetation in a particular area (Avdeev *et al.*, 2018; Khamitova *et al.*, 2017a, b; Wang *et al.*, 2018). In urban land, green plantations perform many functions that contribute to the formation of acceptable conditions for various activities of citizens (Pozdnyakov, 2017; Landis and Leopold, 2014).

The urban environment is a system of natural, anthropogenic, and socio-economic factors that can severely affect city residents (Naliukhin *et al.*, 2018a,b; Kozlov *et al.*, 2018). It can be represented as a complex of material and spiritual areas that includes the city itself and has specific features of internal configuration and development (Lomova *et al.*, 2019; Kosenchuk *et al.*, 2019; Hu *et al.*, 2017).

Investigation objective is to assess the state of green plantations by the example of the Vologda city park and make recommendations for improving their territories. To implement the specified objective, the following assignments were set: to analyze the state of tree species in the parks of the city of Vologda; to choose and describe the objects of investigation; to find out the quantitative and percentage distribution of tree species; to identify common tree drawbacks; to offer recommendations for improving the park's territory.

2. MATERIALS AND METHODS:

The investigation area is the city of Vologda, which is located in the North of the European part of Russia. Vologda has an area of 116 square km. The city is situated on both banks of the Vologda River. Urban climate can be called moderately continental, as it is formed in the conditions of a small amount of solar radiation and a strong influence of the Northern seas. Weather in Vologda is unstable: many thaws happen in winter, low temperatures, and temperature differences are observed in spring. Winter in Vologda lasts a long time and is moderately cold (the general period lasts about six months). Autumn and spring in the city are quite cool, and the summer period is warm. The coldest month during the year is January, and the warmest one is July. The air pollution level in the city is quite high. Vehicle exhaust can be called the main source of pollution. Also, large enterprises such as the VologdaGorTeploset, Vologda Optical, and Mechanical Plant, Vologda Bearing Factory, etc. contribute a substantial stake to the deterioration of the urban ecology.

The investigation was carried out at the Vologda city park: Mira Park. Mira Park is the largest park in the city of Vologda. Its area has been increased several times since its creation and currently is 155 hectares (Figure 1).

Mira Park has a vibrant history. It was founded in May 1939 and was named initially as Central Park of Culture and Recreation. About two thousand residents of the city took part in the large-scale event on the construction and arrangement of the park: the citizens planted about five thousand trees and shrubs. After the end of the Great Patriotic War in 1945, Central Park was renamed into Mira Park. In the 1950s-1960s, the park was improved actively. The species composition of plantings was expanded, mass plantings were performed, the park area was planned, and a beach on the bank of the Vologda River was opened.

Today, Mira Park is one of the most visited places. It can be called a favorite recreation place of Vologda residents both in summer and winter. However, the park is of great value not only as a place of leisure and recreation but also as the largest nature reserve of the plant world, with the possibility of penetration of its particular species into the urban environment. Its diversity and originality distinguish the park's flora. In addition to the species that were cultivated by humans, a large number of natural vegetation representatives may be found as well. Mira Park is a complex of

urban phytocenoses and small areas of natural phytocenoses that are presented in the park territory. Rare and exciting specimens of tree, shrub, and grassland vegetation can be found in the park.

The investigation was carried out based on the "Inventory Survey Procedure for Urban Plantations" (The methodology of the inventory of urban green spaces, 1997). This method describes the purposes for which the inventory survey of green plantations is carried out and reveals the procedure for conducting field works. Besides, GOST 2140-81 "Visible Wood Drawbacks. Classification, Terms and Definitions, Methods of Measurement," which describes external defects that can be identified with the naked eye was used during the work (GOST 2140-81, 2006).

During field research (perpetual inventory) at the facility, each tree species was taken into account and identified, on which the taxation diameter of the tree trunk was measured at the height of 1.3 m using a measuring fork. Each tree had a general sanitary condition on a 3-point scale and a variety of defects.

Wood drawbacks are various defects that reduce the quality of the wood structure and reduce the possibility of its use for practical purposes: defects in the wood structure, chemical stains, wood-destroying fungi, biological damage, knots, defects in the shape of the tree trunk, cracks, mechanical damages, foreign deposits, defects obtained in the process of wood machining, casting (Bukharina, 2012).

Landscape and taxation analysis was carried out in the territory of nine parks in Vologda, which included a comprehensive assessment of tree vegetation morphological indicators. In this regard, a continuous inventory survey was conducted. In each park, a dendrometric assessment was carried out, which included fixing such parameters as the specific name of the tree, the diameter of the trunk, the number of trunks on multi-stem specimens. The bioecological assessment assumed identification of the general state of the tree. At the same time, all considered specimens of trees were divided into three groups: (1) Good health status of trees is characterized by high resistance to low temperatures, the normal shape of the trunk and leaves, the correct process of flowering and fruiting, harmonious and bright color of the foliage; (2) Satisfactory health status of trees – these are trees that are characterized by weak growth, the presence of dry shoots in the crown, weak flowering and small leaf size; and (3)

Poor health status of trees – these are trees that have top drying, weak flowering or complete absence of the latter, poor leafing, poor resistance to low temperatures, the presence of various types of damages that appeared due to the activities of insect pests and diseases.

Mira Park is one of the largest and most visited urban parks; its area includes both banks of the Vologda River. During the investigation of this object, landscape and taxation analysis was carried out, which included a comprehensive assessment of tree vegetation morphological indicators. In this regard, a continuous inventory survey was carried out, and a dendrometric evaluation was performed, which included fixing such parameters as the specific name of the tree, the diameter of the trunk, the number of trunks on multi-stem specimens.

3. RESULTS AND DISCUSSION:

In total, 3,017 trees of ten species were found in Mira Park. The predominant species is linden, which makes up 38.8% of the total number of trees growing in the park. The second place is occupied by poplar, which makes up 29.2% of the total number of trees. Birch is in the third-place – 15.1%. The least common species in the park are spruce and rowan. Their percentage of the total number of trees is 1.3 and 0.4%, respectively. The total quantity and percentage distribution of tree species in Mira Park are shown in Table 1.

According to the dendrometric assessment results in Mira Park, the number of drawback types in each tree species at a specific diameter of the trunk was revealed (Marfenin, 2006). The results for each tree species are presented in tables. It is worth noting that the most common types of drawbacks in linden trees in Mira Park are mechanical damage and frost cleft. Most often, wood drawbacks in this species occur on the trunk diameters in the range from 40 to 52 cm.

It can be said that the most common types of drawbacks in poplar trees in Mira Park are a frost cleft and a crooked trunk. Most often, wood drawbacks in this species occur on the trunk diameters in the range from 44 to 52 cm. It should be emphasized that the most common types of disadvantages in birch trees in Mira Park are mechanical damages and frost cleft. Most often, wood drawbacks in this species occur on the trunk diameters in the range from 44 to 48 cm and from 51 and 54 cm.

It is worth noting that the most common types of drawbacks in oak trees in Mira Park are

frost cleft and mechanical damages. Most often, wood drawbacks in this species occur on the trunk diameters in the range from 48 to 51 cm. It can be said that the most common types of cons in larch trees in Mira Park are mechanical damages and a crooked trunk. Most often, wood drawbacks in this species occur on the trunk diameters in the range from 48 to 50 cm. It should be emphasized that the most common types of disadvantages in ash trees in Mira Park are a crooked trunk and mechanical damages. Most often, wood drawbacks in this species occur on the trunk diameters in the range from 45 to 48 cm.

It is worth noting that the most common types of drawbacks in elm trees in Mira Park are mechanical damage and burr. Most often, wood drawbacks in this species occur on the trunk diameters in the range of 46-47 cm. It can be said that the most common types of cons in pine trees in Mira Park are mechanical damages and frost cleft. Most often, wood drawbacks in this species occur on the trunk diameters in the range of 48-49 cm.

It should be emphasized that the most common types of drawbacks in spruce trees in Mira Park are mechanical damages and burr. Most often, wood drawbacks in this species occur on the trunk with a size of 43, 47, and 48 cm. It is worth noting that the most common type of drawbacks in rowan trees in Mira Park is the frost cleft. Most often, wood drawbacks in this species occur on the trunk diameter of 45 cm.

Also, a bioecological assessment was carried out as a part of the investigation, i.e., the general condition was found out for each tree species. All considered specimens of trees were divided into three groups: 1. Good condition – flowering and fruiting of the tree are normal, there is a bright color of the leaves, the tree has high winter hardiness, dry branches are completely absent, the presence of drawbacks was not detected; 2. Satisfactory condition – minor drawbacks in the trees, a small number of dry branches, a lag in the growth of trees are observed; 3. Poor condition – the trees have significant drawbacks, the presence of strong dryness, noticeable damages caused by harmful insects and diseases, weak resistance of the tree to low temperatures. The quantitative and percentage ratio of the health status of all wood species in Mira Park is shown in Table 2.

Based on the bioecological assessment performed in Mira Park, it can be concluded that the highest percentage of good tree health status was found in pine – 67.3%, the highest percentage

of satisfactory tree health status was found in elm – 35.7% and the highest percentage of poor tree health status was found in oak – 16.1%.

In current conditions, green plantations are an integral part of the city's structure and perform many essential functions. Green plantations have the ability to affect the ecology of the urban environment positively, so they should be created in places where people live and work. The fact that the city should be a biocenosis that is not entirely favorable, but at least does not cause harm to people's health has great importance. The organization of parks is one of the solutions to the problem of improving the environmental situation of urban areas (Voronkova *et al.*, 2019). Green plantations are directly involved in creating favorable microclimatic and sanitary and hygiene conditions, and also increase the artistic expressiveness of architectural ensembles (Tetior, 2013).

Parks in urban areas contribute to solving various problems related to environmental sustainability. The primary important function of green urban plantations is to reduce air pollution in the city (Sokolov *et al.*, 2017). Green plantations are an effective means of noise control because tree stands with dense crowns, dense foliage, and a large number of small branches can reduce the noise level significantly. Parks are involved in reducing the dust and gas content of the air, reducing the harmful concentration of gases that are in it (Betancurt *et al.*, 2017; Ferrini *et al.*, 2014). The impact of green plantations located in the park on reducing the concentration of gases in the air is caused by the density of their plantings. The formation of parks with line plantings of woody vegetation, which reach a width of up to 50.0 m, and a height of 15.0 ... 20.0 m, respectively, reduces the pollution of the air basin by 70.0 ...75.0%.

According to the results of the investigation, it can be said that most of the tree plants are in good and satisfactory condition. The most common species are linden, birch, poplar, and elm. The highest percentage of poor health status was found in tree species such as oak and poplar. The most common types of drawbacks in tree plantations are mechanical damage, frost cleft, and a crooked trunk. Thus, it can be concluded that the current situation in the largest park in the city of Vologda is stable. However, to improve the systematic condition, it is necessary to hold some activities that should preserve and diversify the tree and shrub plantations, as well as help to solve existing problems.

First, plantings need care to improve their quality and create favorable conditions for growth and development. It is necessary to remove shrunken, dry-top, stunted, diseased trees, besides, those species that do not represent decorative value. Second, when treating trees with dry-top shoots, it is necessary to remove the tops and dry branches, and for damaged trees, it is needed to disinfect injuries with a 5.0% solution of copper sulfate. In the place of cuts, the wound should be covered with tree-wound paint (garden putty). In addition, it is necessary to make a complex of organic and mineral fertilizers in the soil under the trees, loosening the soil, sowing perennial grass stands, forming artificial places for nesting birds, feeders, etc. The above-mentioned measures will help to restore and improve the state of the grass cover, as well as its decorative parameters, the appearance of self-seeding of tree species, and increase the growth of woody plants. Third, great attention should be paid to preventive measures, which should consist of regular monitoring of the number of trees of different types and insect pests that should be treated with biological products.

Together with forestry and silvicultural measures, an active agitation campaign should be carried out to protect green plantations from fires, various damages of grass stand, etc. Agitation tools such as periodicals, television and radio broadcasts, and posters should be used. To increase the decorative value of tree plantations, it is necessary to increase biodiversity by introducing new tree species, create flower beds, shrubberies, and lawn coverings that differ in a variety of shapes and colors.

4. CONCLUSIONS:

1. Green plantations are of great importance for preserving and improving the favorable environmental situation in modern cities. They perform many essential functions that help in creating the best microclimatic and hygiene and sanitary conditions for the life of urban citizens. Green plantations directly affect the microclimate of modern cities, actively absorb harmful substances from the air, improve the wind regime in localities, and are important in fighting fires, snow shifts, and soil erosion.
2. Urban parks are the most important components of the general structure of landscaping the city's territories, which perform recreational, architectural, artistic, and other significant functions. Today, urban parks are not only a natural area of urban

space but also a unique territory for communication, a place for outdoor sports, and an area where interesting entertainment events would be held. The main purpose of green urban plantations is to form a recreation for citizens.

3. A large number of trees with poor conditions were found in Mira Park, which has the most significant area among all parks. The most common types of tree drawbacks in this park were frost cleft and mechanical damage, and the highest percentage of poor tree health status in Mira Park was found in oak.

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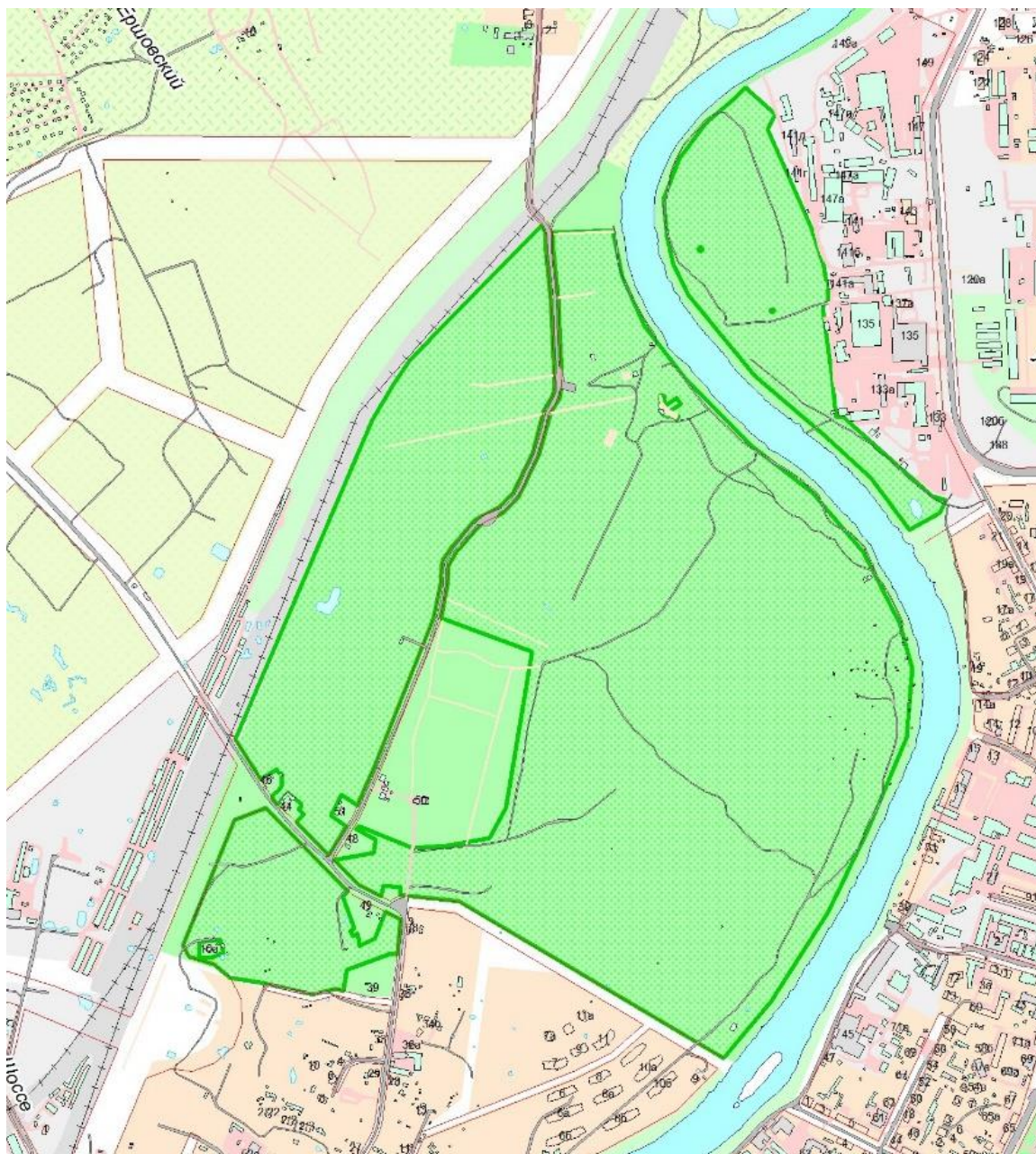


Figure 1. Plan of Mira Park in Vologda. Source <https://vologda.4geo.ru/maps/>

Table 1. Quantitative distribution of tree species in Mira Park

Specific name	The number of trees, pcs.	%
Linden	1,172	38.8
Poplar	880	29.2
Birch	455	15.1
Oak	186	6.2
Larch	92	3

Ash	77	2.6
Elm	56	1.8
Pine	49	1.6
Spruce	39	1.3
Rowan	11	0.4
Total	3,017	100

(Source: Data collected by the authors during the study)

Table 2. Quantitative ratio of health status indicators of wood species in Mira Park

Specific name	Heath status	The number of trees, pcs.	%
<i>Linden</i>	<i>Good</i>	630.0	53.8
	<i>Satisfactory</i>	367.0	31.3
	<i>Bad</i>	175.0	14.9
<i>Poplar</i>	<i>Good</i>	475.0	54
	<i>Satisfactory</i>	278.0	31.6
	<i>Bad</i>	127.0	14.4
<i>Birch</i>	<i>Good</i>	245.0	53.9
	<i>Satisfactory</i>	149.0	32.7
	<i>Bad</i>	61.0	13.4
<i>Oak</i>	<i>Good</i>	101.0	54.3
	<i>Satisfactory</i>	55.0	29.6
	<i>Bad</i>	30.0	16.1
<i>Larch</i>	<i>Good</i>	53.0	57.7
	<i>Satisfactory</i>	27.0	29.3
	<i>Bad</i>	12.0	13
<i>Ash</i>	<i>Good</i>	47.0	61
	<i>Satisfactory</i>	25.0	32.5
	<i>Bad</i>	5.0	6.5
<i>Elm</i>	<i>Good</i>	32.0	57.1
	<i>Satisfactory</i>	20.0	35.7
	<i>Bad</i>	4.0	7.2

<i>Pine</i>	<i>Good</i>	<i>33.0</i>	<i>67.3</i>
	<i>Satisfactory</i>	<i>12.0</i>	<i>24.5</i>
	<i>Bad</i>	<i>4.0</i>	<i>8.2</i>
<i>Spruce</i>	<i>Good</i>	<i>24.0</i>	<i>62.6</i>
	<i>Satisfactory</i>	<i>13.0</i>	<i>33.3</i>
	<i>Bad</i>	<i>2.0</i>	<i>5.1</i>
<i>Rowan</i>	<i>Good</i>	<i>7.0</i>	<i>63.6</i>
	<i>Satisfactory</i>	<i>3.0</i>	<i>27.3</i>
	<i>Bad</i>	<i>1.0</i>	<i>9.1</i>

(Source: Data collected by the authors during the study)