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RESEARCH ARTICLE

Influence of the Urban Environment on the English Oak (*Quercus Robur L.*) Growth and Development

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ABSTRACT

The morphological parameters of the maternal trees growth, seed progeny and seedlings, and the value of the fluctuating asymmetry (FA) of the leaves of adult plants under urban influence were estimated. Urban oak groves have a low growth rate of shoots. Rural and suburban oak groves are characterized by an increase in the shoot. The coefficients of variation (Cv) in the length and width of leaf blades are generally low; only for 1 territory near urban radius and experiencing the influence of industrial enterprises, the Cv of the length of the leaf blade is 29.3% and the width of the leaf blade - 30.4%. FA for all oak forests, with the exception of Chizhovskoe tract (0.056), not exceed 0.04, thus, they are resistant to the anthropogenic factor. The average growth of seedlings is 13-14 cm. The coefficient of variation for shoot length for most groups of seedlings exceeds 30%. The suburban seedlings have the largest shoot thickness and exceed 0.3 cm. Among urban seedlings, the oak population in the most distant from the city (middle circle), is close to this indicator. The areas of the lowest emission load of pollutants coincide with the forest areas of the city.

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Introduction

The study focuses on the possibility of using long-lived deciduous trees of the species *Quercus robur L.* as basic tree spices in reconstruction of the large cities green belt.

Urban forests are among the most effective conservation solutions for sustainable management of the environment, especially in urban areas, the basis of infrastructure that contributes to sustainable development and the urban environment planning (Kleiber et al. 2019, Amini et al. 2019). Experience in oak stands integrated into a natural green belt is essential to manage the urban environment.

Modern large cities can be divided into 2 types: with preserved forest areas and with local greening, when every object of green infrastructure counts (New York, Banzhaf 2020), parks are few. There is also a division into green and gray zones within the city (Banzhaf 2020).

In many large cities of the world, different types of oak are found in parks, forests and local landscaping, for example, in New York (Banzhaf 2020), Berlin (Nickel et al. 2019), US cities (Hill and Barone 2005, Earles et al. 2018), Nikolaev (Kozlova et al. 2019), Krakow (Klamerus-Iwan et al. 2018), UK (Coombes et al. 2019), Tbilisi and Kutaisi (Abramidze et al. 2017) and other.

Assessment of the state of forest plantations is an important and mandatory item in the preparation of landscaping projects (Suchocka and Kostrzewa 2019, Suchocka et al. 2019). Morphological indicators are a reflection of all processes occurring in the plant, its balance of energy production and consumption, can developing morphological adaptations (Duarte et al. 2020, Khan et al. 2020); their analysis is available - on the basis of a modern system of computerized phenodata processing, it is much easier to conduct monitoring studies. In addition, signs of viability (shoot length, tree height) and habit are predictors of plant damage by pathogens of various nature (Field et al. 2019).

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Ecosystem services provided by green spaces in cities are diverse and of great importance, such as improving temperature and microclimate, storing carbon, reducing storm flow, absorbing pollutants from the air (Tallis et al. 2011; Ross et al. 2012, Fantozzi et al. 2013). In Russia, greening of large areas is based on native species, for central Russia it is: g. *Pinus sylvestris, Betula pendula, Acer platanoides, Quercus robur* and others. However, the english oak, despite its important ecological and socio-cultural significance, is not always used for landscaping local green areas, giving way to rapidly growing species - birch, maple, catalpa and evergreen conifers.

As a result of the "Tree Cities" project, Voronezh became a city of trees in Russia in 2020 (https://treecitiesoftheworld.org/tree-cities.cfm?chosen=RUS), even though it is a large metropolis of the Central Black Earth Region of the Russian Federation. The analysis of the environmental quality of green cities, carried out in the same year by Moscow State University (https://www.msu.ru/science/main_themes/uchenye-predlozhili-novyy-podkhod-k-otsenke-zelenykh-zon-gorodov-rossii.html), showed that Voronezh ranked second among large cities in Russia in terms of the availability of green zones, the formation of a comfortable urban environment and their sustainability (Klimanova and Illarionova 2020).

According to the Forest Plan of the Voronezh Region, oak prevails in the forest fund with 45.9% coverage (https://roslesinforg.ru/atlas In Russian). The creation of additional forest areas took place in 1951, when the administration of the Voronezh region transferred to the Voronezh regional forestry department urban land with an area of 6039 hectares for the creation of green spaces around the city of Voronezh in order to consolidate sands and ravines and organize forest parks on the basis of this as a basis for cultural and full-fledged recreation of the population in a natural environment. In this area, a comprehensive agroforestry survey was carried out and the following measures were planned: continuous afforestation of sands, - planting of protective forest plantations, afforestation of existing ravines and girders (Krugliak 2006). These works were carried out in the period from 1951 to 1955. Existing plantations, both natural and artificial, are the basis of "green belt" of Voronezh, species composition which forms the common oak, along with Scots pine and birch. The experience of Voronezh, a large metropolis, can serve as an example of a good sustainable strategy for greening large cities, based on the conservation of native species that are located in a ring around the city. Experience of Voronezh, a large metropolis, is an example of a good stable of large urban greening strategy based on maintaining native species, which are arranged in a ring around the city (https://www.msu.ru/science/main_themes/uchenye-predlozhili-novyy-podkhod-k-otsenke-zelenykh-zon-gorodov-rossii.html). The aim of the study is the phenomonitoring of urban and suburban populations of English oak in Voronezh, the detection of the most stable populations, the issue of inheriting the activity of growth processes in offspring - the question of the sustainability of forest-forming species in the urban environment; - with a multitude of techniques and approaches. The phenotype of a tree is largely a reflection of its adaptability to life in specific conditions.

We assume that oak forests are stable even when they are in a ring of strong anthropogenic impact, in turn, performing the most important ecological functions to maintain a favorable environment for the biotechnosphere of large cities. Despite the activity of the load, oaks have a high adaptive potential, which is realized in maximizing the growth parameters of seedlings when they get into favorable growth conditions. A strong decrease in growth parameters and the transmission of a similar tendency to offspring at a non-morphological level were not observed.

The goals of this study is to assess the state of urban and suburban oak groves, which are part of the green belt of a large industrial city of Voronezh, based on the morphological criteria of maternal trees, seed progeny, seedlings.

Materials and Methods

Oak Forests and Stands, which were studied during the Monitoring of Growth Processes

Voronezh located in the European part of Russia (geographical coordinates: 51.660781, 39.200269) in the temperate climate zone. According to the local weather station of Voronezh State Agricultural University, the average annual temperature was +8.0◦C, average January temperature -9.5◦ C, average July - +20◦C; the absolute minimum – 36◦C (January), absolute maximum +37.5◦C (July). The duration of the growing season at the temperatures above +10° C was152 days (from April 29 to September 27). The sum of effective temperatures during the growing season was 2800o C. The frost-free period is 150-155 days. Average annual rainfall was 670 mm. Relative humidity in summer was 45-60 %, in winter - 75-90 %.

The ecological framework of the city is based not only on forests, but also on water bodies. A large waterway - the Voronezh reservoir - runs through the entire city and beyond. The forest area covered with forest is 32,071 hectares (86.7%), which determines the high forest cover of this territory - 36.1%. Historically, Voronezh has not always been such a green city - on the right bank of the river the city was surrounded by oak forests, on the left bank - mostly sandy soil, not suitable for the growth of oak; Scots pine and hanging birch are located there. Most of the forest areas have a nature conservation status and are part of a wildlife sanctuary, reserve and forestry.

The object of the research is the English oak stands, the seed material (acorns) collected from them, the seedlings grown from the analyzed seed material. Thus, morphological parameters are studied on two generations: the maternal and its offspring. This approach will allow comparing growth processes in populations and offspring, assessing the effect of acorn biomass on the growth parameters of seedlings. To assess the impact of man-made pollution of the city on the growth of English oak, plantations in different areas of the city were selected. There are several zones according to the intensity of the load: urban (red line, areas № 1,2,3,4,5, Figure 1), suburban (yellow line, areas № 6,7,8, Figure 1), rural (green line, area № 9,10, Figure 1).

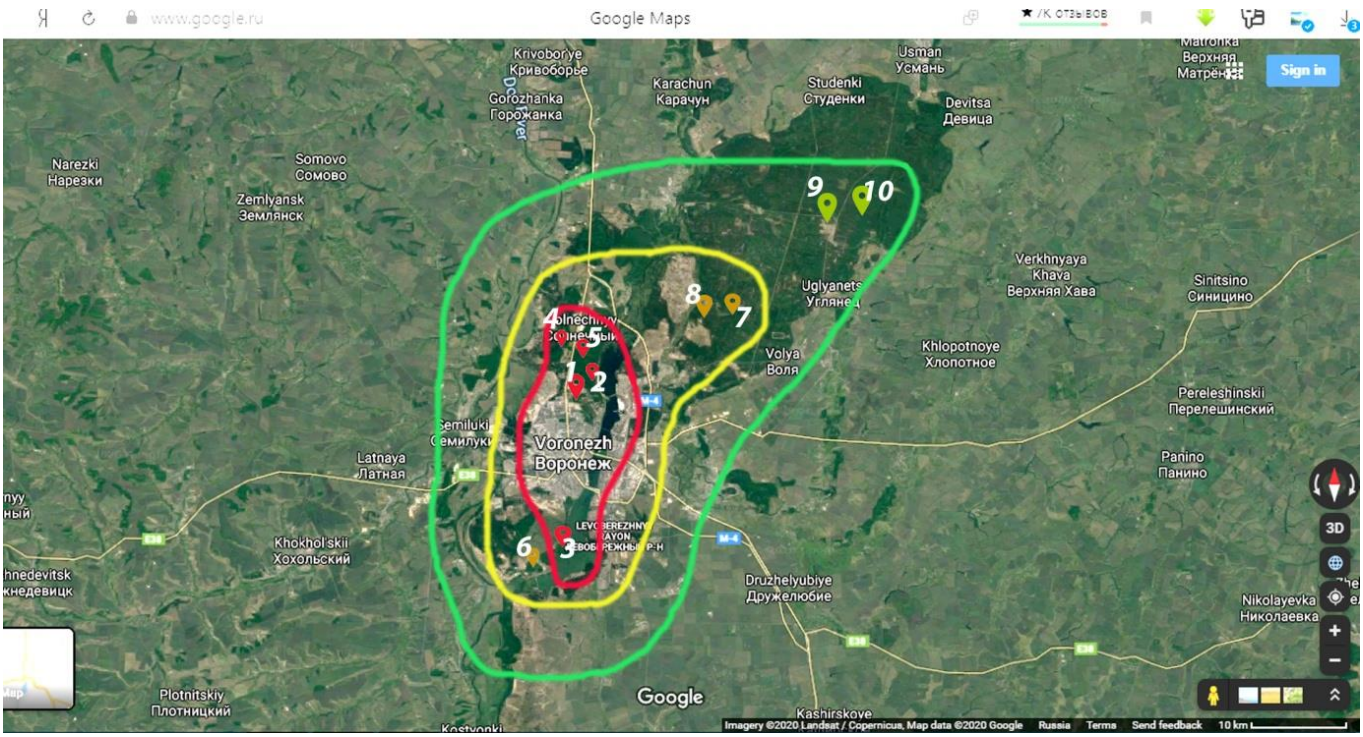

Figure 1. Distribution of studied areas (1 - 10) on the map of Voronezh city and suburban's.

The regions are characterized by different anthropogenic load, which is caused by the presence of large highways, industrial enterprises, and recreational load. The studies were carried out in the following 10 large oak forests located in different urban areas (Figure 1):

Area 1. Oak stand on Moskovsky Prospekt St., Voronezh (dot 1 on Figure 1; geographical coordinates: 51°42'44.6"N 39°10'57.3"E), located in close proximity to a gas station and a major highway connecting Shishkov St. and Pobedy Boulevard, as well as Moskovsky Avenue (heavy traffic load).

Area 2. Oak forest Right Bank "Pravoberezhny forestry" (dot 2 on Figure 1; geographical coordinates: 51°43'10.5"N 39°13'29.1"E) - teaching and experimental forestry Voronezh State Forestry University (VGLTU), located on the northern edge of the city district (impacted by road transport and recreational stress).

Area 3. Oak forest of the Chizhovskoye tract (dot 3 on Figure 1; geographical coordinates: 51°37'14.1"N 39°11'07.0"E), located on the southwestern outskirts of Voronezh (pollution is caused by the peculiarities of the wind rose of the city, the chemical production is located nearby, although it is closer to the city of Voronezh).

Area 4. Oak forest village Zadonye, located at a distance from the Zadonskoye highway by about 2 km (northern outskirts of the city) (dot 4 on Figure 1; geographical coordinates: 51°46'02.7"N 39°11'06.5"E).

Area 5. Oak forest, located in the area of 9 km of the Zadonskoye highway (dot 5 on Figure 1; geographical coordinates: 51°45'18.1"N 39°11'22.5"E), near the Olympic Sports Complex (heavy traffic load, constant all-season recreational load).

Area 6. Oak forest of the Gremyachensky forestry "Shilovskaya Nagornaya Dubrava" (dot 6 on Figure 1; geographical coordinates: 51°34'08.7"N 39°08'50.0"E), located on the southern outskirts of the city (pollution is caused by the peculiarities of the wind rose of the city, the chemical production is located nearby).

Control territories, taken on the basis of distance from a city:

Area 7. Oak forest of the Biological Educational and Scientific Center "Venevitinovo" (dot 7 on Figure 1; geographical coordinates: 51°48'27.4"N 39°25'02.3"E).

Area 8. The oak forest of the Kozhevenny cordon (dot 8 on Figure 1; geographical coordinates: 51°48'33.5"N 39°19'19.3"E).

Area 9. The oak forest "Krasnolesnyi", located near Voronezh Biosphere Reserve (dot 9 on Figure 1; geographical coordinates: 51°52'34.5"N 39°34'10.4"E).

Area 10. The territory is a nature reserve, the oak forest of the Voronezh Biosphere Reserve (dot 10 on Figure 1; geographical coordinates: 51°53'59.3"N 39°33'10.3"E).

Morphological Parameters of Mother Trees

From each plantation, 50 by 50 m, standard for ecological conditions, 10 trees were selected on each of them. We measured the length of the annual growth of axial shoots from the bud ring, and the morphological parameters of the leaves on the measured shoots: the length from the base of the leaf blade along the central vein, the width of the leaf blade was measured at the widest point. The measurements were carried out in September, when growth processes are dying out and preparations for the winter period are in progress. Measurements were carried out using a ruler in cm, with an

accuracy of mm. To reveal the value of fluctuating asymmetry, we measured the width of the left and right leaf halves, the length of the second-order vein, second from the leaf base, the distance between the bases of the first and second second-order veins, the distance between the ends of the same veins, the angle between the main vein and the second from the leaf base vein of the second order. The range of values of the integral indicator of developmental stability up to 0.040 corresponds to the first point (conditional norm), from 0.040 to 0.044 - to the second point, from 0.045 to 0.049 - to the third point, from 0.050 to 0.054 - to the fourth point, from 0.054 and above - to the fifth point (critical condition) (https://courses.lumenlearning.com/suny-natural-resources-biometrics/).

Morphological Parameters of Seed Progeny

Seed material was assessed by weight, longitudinal and transverse dimensions of the acorn. 100 seeds were collected from each test area. Acorns were weighed on electronic scales (with an accuracy of 1 mg), the diameter and length of the acorn were measured with a caliper (with an accuracy of 0.1 cm). There are several theories about the influence of acorn weight on the subsequent growth of seedlings.

Planting Seed Material for all Studying Populations in Order to Obtain Seedlings. Morphological Parameters of Seedlings

The acorns selected for sowing were stored in wet sawdust in a refrigerating chamber for sowing in the spring on the territory of the Zhivotinovsky forestry of the training and experimental forestry enterprise of the Voronezh State Forestry University (coordinates: 51.735385, 39.188353). An area with grey forest soils suitable for oak growth was chosen. 70 - 80 seeds were sown from the experimental and control territories. Since long-term observations are planned, planting was carried out in rows, with row spacing of 4 m and a distance in rows between acorns of 1 m. The height and thickness of the shoot at the base of the seedlings were measured. The height of the shoot was measured from the soil surface (most often the remains of the cotyledons were in this place), to the top of the shoot with a ruler, in cm, with an accuracy of a millimeter. Shoot thickness was measured at the base of the shoot with a caliper, accurate to 2 digits after the decimal point in cm.

Statistical Data Processing, Analysis of the Integration of Oak Forests into the Urban Environment

Statistical data processing was performed using the Stadia software. To assess the variation of features, the coefficient of variation was calculated. The significance of differences for parameters were calculated by student's e criterion (**t**) and Fisher's criterion (**F**).

Results and Discussion

A survey of the phenotypic state of 10 large plantations of English oak in the city of Voronezh and its suburbs was carried out, the morphological parameters of seed material and progeny (seedlings) were evaluated (Tables 1-3).

Morphological Analysis of Maternal Populations of English Oak Trees

Morphological parameters of English oak are presented in Table 1.

Table 1. Morphological parameters of English oak in urban and suburban plantings

Oak forest and stand	Morphological parameters						
	Shoot length, $\bar{x} \pm s_{\bar{x}}$	Cv[1], %	Leaf blade length, $\bar{x} \pm s_{\bar{x}}$	Cv, %	Leaf blade width, $\bar{x} \pm s_{\bar{x}}$	Cv, %	FA[2]
Urban oak forest and stands							
Area 1	10,0±1,3	80,9	13,7±0,4	21,9	7,9±0,3	27,8	-0,001
Area 2	30,6±0,7	22,2	10,8±0,2	22,8	6,5±0,2	31,2	-0,018
Area 3	10,1±1,5	55,2	10,5±0,4	29,3	5,7±0,2	30,4	-0,056
Area 4	13,6±1,4	67,5	13,7±0,3	16,4	7,9±0,2	18,0	0,0028
Area 5	8,4±0,9	67,6	12,5±0,3	20,2	7,1±0,2	28,4	-0,028
Suburban oak forest							
Area 6	37,1±4,5	32,5	13,7±0,3	16,8	8,0±0,2	14,9	0,015
Area 7	12,9±1,7	95,3	13,1±0,3	24,4	7,8±0,3	34,8	0,0011
Area 8	33,9±4,6	38,6	14,1±0,3	16,9	7,8±0,2	18,7	0,0044
Rural oak forest							
Area 9	31,8±4,3	27,2	15,0±0,7	19,3	8,4±0,4	20	0,012
Area 10	35,5±5,1	35,2	14,0±0,3	15,8	7,4±0,2	18,9	0,013

[1] Cv – coefficient of variation; [2] FA - magnitude of the fluctuating asymmetry.

Among the studied indicators, the most variable is the growth of the shoot during the growing season. Oak groves, which are located within the city limits (near radius), have a low growth rate of shoots. Area 6 is located a bit farther, the oak forest of area 2 is removed from major highways and merges with the reservoir. These oak forests are characterized by an increase in the shoot (37.1 ± 4.5; 30.6 ± 0.7) comparable to that of suburban oak forests (area 10 - 35.5 ± 5.1; area 9 - 31.8 ± 4.3; area 8 - 33.9 ± 4.6 cm). Among the suburban areas, the territory of area 7 settlement falls out of the general group (an increase of only 12.9 ± 1.7 cm). Oaks in this area are located near a water body (Lake Maklokskoye), in the year of analysis in the reservoir there was a decrease in the water level by more than 2 times, absolutely dry areas appeared, the morphological parameters of acorns here also are not differ in large parameters (Table 2).

Table 2. Morphological parameters of seed progeny in the studied populations

Morphometric acorns indicators	Study area							
	1	2	3	4	5	6	7	10
Weight, gr $\bar{x} \pm S_{\bar{x}}$	3,8±0,1	5,0±0,05	1,5±0,1	1,3±0,05	3,2±0,05	4,0±0,1	1,8±0,1	5,6±0,04
Length, cm $\bar{x} \pm S_{\bar{x}}$	3,0±0,03	3,0±0,04	2,0±0,02	2,1±0,02	2,1±0,03	3,4±0,02	2,2±0,02	3,3±0,04
Width, cm $\bar{x} \pm S_{\bar{x}}$	1,6±0,01	1,3±0,02	1,3±0,01	1,3±0,01	1,5±0,02	1,6±0,2	1,4±0,01	1,6±0,04

The size of the leaf blade for English oak is a fairly stable indicator (table 1), the coefficients of variation in the length and width of leaf blades are generally low, only for 1 territory – area 3, located in the inner circle and experiencing the effect of industrial enterprises: Cv of leaf length was 29.3%, the leaf width was 30.4%. For this area, the smallest parameter of both indicators of measurement of the leaf blade is noted. Urban populations of area 4 and area 1 experiencing the whole complex of biotechnosphere factors have an increase in the coefficient of variation up to 28% (Table 1).

Fluctuating asymmetry (FA) in the sample may indicate a disturbance in developmental stability caused by environmental and / or genomic stress (Rodrigues-Gonzalez et al., 2020). The magnitude of the fluctuating leaf asymmetry is an indicator of developmental stability, as well as a marker of the quality of the habitat, used for both plants and animals (Abdulsamad et al. 2020, Gottardini et al. 2020, Francuski et al. 2020). By the value of FA (Table 1), it is important to note that all oak forests, with the exception of the area 3 (0.056), have coefficients not exceeding 0.04, thus they are resistant to the anthropogenic factor. Considering modern research on fluctuating asymmetry and the assumption of the need to consider this parameter in a set of indicators (Albert et al. 2011), the obtained FA values were used as an additional criterion for the stability of the plantings.

Morphological Analysis of English Oak Acorns

The morphometric parameters of acorns are presented in Table 2.

The largest acorns (phenotypically plus) are characteristic of oak populations growing in area 6 and area 10. It is interesting to note that in the control area 7, acorns are small, heavily damaged by larvae of parasitic insects. Acorns from two urban areas also have high rates - area 2 and an oak grove area 1. It was not possible to collect acorns deep in the forest area 4, although it was possible to find single representatives, but they were all damaged and unsuitable for further analysis. For the area 3, the number of acorns is significantly less than in other populations.

It is believed that good seed material should have high parameters both in size and weight, thus correspond to "plus". Naturally, the cotyledons have a supply of nutrients for the growth of the seedling. When acorns germinated, the following pattern was observed: small acorns germinated quickly, while acorns with high mass and size required a long period for germination. From the point of view of plant adaptation to climatic conditions, for the preservation and restoration of the English oak population, the presence of all forms in the population, both extreme and median according to these parameters, is necessary. Elimination of extreme forms was observed for urban oak populations; in control - the distribution of acorns by weight and size is close to the normal Gaussian distribution.

Morphological Analysis of Seedlings Grown from Seed Progeny of the Studied Plantations of English Oak

Plants grown from suburban acorns from area 7 (18.5 ± 0.4) have the maximum growth of seedlings for one growing year, plants from the suburban area 10 have the smallest growth (11.6 ± 0.6) (Table 3). The average growth of seedlings is 13-14 cm. The coefficient of variation for shoot length remains high and for most groups of seedlings exceeds 30% (Table 3), the differences between the variants of origin are generally different (Table 4) for the analyzed parameters of seedlings. No significant differences were found between areas 2 and 1, 5 and 2, 6 and 1, 9 and 2, 7 for seedlings diameters. For seedlings height no significant differences

were found between areas 1 and 7, 2 and 7, 3 and 8, 5 and 7, 7 and 9, 8 and 9 (Table 4).

Table 3. Morphological analysis of seedlings

Oak forest and stand	Morphological parameters of seedlings					
	Shoot length, cm $\bar{x} \pm s_{\bar{x}}$	Coefficient of variation, Cv, %	Shoot thickness at the base, cm $\bar{x} \pm s_{\bar{x}}$	Coefficient of variation, Cv, %	Average number of leaves	Coefficient of variation, Cv, %
Seedlings grown from acorns of urban plantings						
Area 1	13,4±0,8	38,3	0,25±0,01	24,3	3,3±0,3	65,5
Area 2	15,2±0,4	23,9	0,21±0,004	22,3	3,8±0,2	53,15
Area 3	12,8±0.5	22.4	0.22±0.01	22.2	4,1±0,2	52,3
Area 4	14,9±0,3	21,2	0,28±0,01	25,1	4,8±0,2	36,2
Area 5	15,3±0,5	28,2	0,26±0,007	22,7	4,2±0,2	38,1
Seedlings grown from suburban acorns						
Area 6	16,7±0,4	25,1	0,32±0,4	23,7	4,8±0,2	40,13
Area 7	18,5±0,4	38, 4	0,36±0,01	25,6	4,1±0,5	42,4
Area 8	13,5±0,7	33,6	0,34±0,01	18,8	9,1±0,7	56,1
Seedlings grown from rural acorns						
Area 9	13,3±1,1	45,8	0,32±0,01	24,1	7±0,5	37,3
Area 10	11,6±0,6	38,2	0,34±0,01	25,9	8,0±0,5	42,4

Table 4. The significance of differences for parameters the height and diameter of the seedlings, calculated by student's e criterion (**t**) and Fisher's criterion (**F**)

The significance of differences by setting the diameter of the seedlings	Oak forest and stand	1	2	3	4	5	6	7	8	9	The significance of differences by setting the height of the seedlings
	1	t / F	* / -	* / ***	- / ***	- / *	- / ***	- / -	* / ***	- / ***	
	2	- / -	t / F	*** / -	* / *	* / -	- / **	- / -	** / -	* / -	
	3	* / ***	- / *	t / F	* / **	* / -	*** / ***	** / -	- / -	* / -	
	4	*** / -	*** / -	*** / -	t / F	- / **	* / *	- / ***	- / *	- / *	
	5	* / -	- / -	- / **	*** / -	t / F	- / ***	- / -	* / *	- / *	
	6	- / -	- / *	* / ***	*** / -	* / -	t / F	- / ***	* / ***	- / **	
	7	* / ***	- / **	- / *	*** / -	- / ***	* / ***	t / F	* / -	- / -	
	8	*** / ***	** / ***	*** / ***	*** / -	* / ***	*** / ***	* / ***	t / F	- / -	
	9	** / ***	* / **	- / -	*** / -	- / ***	** / ***	- / -	* / ***	t / F	

Notation: ***** - differences with the territories are significant P < 0.05; ****** - P < 0.01; ******* - P < 0.001; **-** No significant differences were found.

Seedlings grown from suburban acorns have the largest shoot thickness and exceed 0.3 cm. Of the urban seedlings, the population of area 6, which is the most remote from the city (middle circle), is close to this indicator. The coefficient of variation for the indicator of shoot thickness does not

exceed 25% for all populations. The smallest variation is typical for the seedlings of the area 8.

The obtained data showed a high activity of growth processes among mature maternal trees. The only area 3 with high FA, low growth of shoots, weak seed production, as results of the urbanization influence were revealed. Area 3 is experiencing a complex anthropogenic load: an unfavourable wind rose, proximity to industrial enterprises and highway. Previous studies by Searle et al. (2012) on red oak seedlings showed more active growth of plants in urban conditions, in comparison with the suburbs. However, at the same time, the authors revealed an imbalance development of aboveground and underground biomasses and disturbances in the respiration processes in seedlings in an urban. The presence of such changes is associated with the correlation of the seedlings growth with an increased temperature in the city, with the so-called heat islands, high night temperatures and concentration of carbon dioxide in the atmosphere. On mature trees, we did not reveal an increase in growth processes and no sharp differences in comparison with the suburbsin the urban environment. The data may be a consequence of the accumulation of ecological plasticity in mature trees.

The English oak seedlings grown by us from the acorns showed generally high growth dynamics for all plantings, especially urban ones. It is interesting to note that, in terms of the thickness of the shoot at its base, the seedlings from suburban populations are superior to those from urban populations. Seedlings of suburban origin are more heterogeneous in morphological parameters. Comparison of all morphological parameters for seedlings showed that with normalization of growth conditions, all seed material, regardless of the weight and volume of acorns, gives an average aligned offspring. High dependence of seedling viability at the size of acorns in our experiment did not reveal. Bogdziewicz et al. (2019) report that larger acorns were more likely to survive a weevil attack (i.e. the embryo was not damaged by pests). Bartlow et al., (2018) showed that cotyledons are important for dispersal, and remain viable in the case of partial consumption of seeds, the mass of seeds explained only a few differences in productivity. Large cotyledons in acorns can be important in attracting seed spreaders and maintaining partial damage, as well as providing energy to young seedlings.

The sizes of leaf blades change slightly. The obtained data on seedlings indicate the stability oak growth in the urban environment, about the complete passage of the phenophases by trees of the annual cycle, the seed offspring are viable with high growth potential. Oak is one of the long-lived plant species, it competes with pine, the biodiversity of flora is much wider in mixed and oak forests than in pine forests (Amezaga and Onaindia 1997, Augusto et al. 2003). Oaks, due to their extensive crown and large leaf area, reduce the temperature of the air and improve its composition. Oak forests and mixed forests are less susceptible to natural fires.

English oak forms plantations that are capable of self-healing and make a great contribution to the ecosystem services necessary to improve the quality of urban environment. In the classic sense, "green belts" should consist primarily of forest zones in which there is no economic activity. There are few of such examples of large cities with untapped forests, along with the term “green” city, the “gray” city is widely used (Runflora and Huges 2014). Rapid urbanization of territories leading to deforestation and their fragmentation. Fragmented forests provide a greater volume of environmental services for air purification, in comparison with urban artificial plantations (Vieira et al. 2018), but sanitary care and attention to the individual characteristics of trees are necessary (Woodall et al. 2005).

In the Voronezh region, forests are highly fragmented, but exist protected areas in the suburbs (such as Voronezh State Natural Biosphere Reserve named after V.M. Peskov), part of the forest territories are confined to and continuous along the water protection zone. The heterogeneous a population is the more resistant and adaptive it is to changing environmental conditions. Bouchon et al. (2011) showed that oak pollen can spread up to 80 km, taking into account the geographical extent of the city, when between its farthest points from north to south 30 km, and from west to east - 16 km, we can talk about the contribution of migration of pollen with air streams between island plantations of English oak. According to the results of a study by Moscow State University, Voronezh came 2nd among the green cities of Russia, we can talk about the success of the 1955 program for creating a green infrastructure of the city. Artificial forest cultures, together with old-growth natural forests, have formed the green belt of the city.

In our study, it was shown that, the English oak populations are stable, bear fruit, and the offspring are aligned in morphological parameters. The formation of stable offspring for all populations (the only exception is the area 3) is an important indicator of population stability.

Conclusions

The analysis of the morphological parameters of the English oak among the parent trees, seed progeny, and seedlings in different districts of the city of Voronezh and its suburbs suggests the stability of the English oak plantations in urban, and good integration into the green belt system. In the same time differences in tree morphological parameters in the forest structure under pressure and environmental were found. Thus, the length of shoots of mother trees, the thickness of seedlings, and the thickness of acorns were significantly less for most urban areas. Morphological parameters of leaf blades were less variable, the length and width of the leaf for English oak is weakly variable indicators under the pressure of the urban environment on plant objects. Analyzed parameters developing morphological adaptations and can be an indicator of the plasticity of the species. For sustainable green infrastructure, it is necessary to take aboriginal species as a basis, filling the existing gaps in the green belt with mixed plantations, the basis of which can be an English oak. Variations in indicators do not allow monitoring by any one parameter; a comprehensive assessment of the parameters of different levels of organizations is required.

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