Analysis of crown features of *Acer negundo* L. individuals in forest parks of Yekaterinburg based on light parameters

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Abstract. The article studies the adaptation mechanism of the spread of *Acer negundo* L. using the example of habitats in the Central and Karasye-Ozersky forest parks. Lighting parameters in different parts of the crown of *Acer negundo* in virginal individuals, as well as the ability to intercept light, were studied. The percentage of light interception by the entire crown is 68.26% and 55.05% for *Acer negundo* habitats, respectively. Most of the set of lighting parameters correlate with each other to varying degrees, but their correlation with crown heights and diameters was not found. Lighting in the middle of the crown and under the crown is significantly less for habitats in Central Park, which is confirmed by analysis using the Mann-Whitney test, and the interception of light by both the upper half of the crown and the entire crown of trees in a given habitat is significantly greater. Differences in light interception values may be associated with differences in the parameters of tree crowns, possibly with a significant difference in heights. The tendency of the “aggressor” species to seize territory continues to this day, and this situation is typical for many regions of Russia, therefore it is necessary to monitor the state of ecosystems.

1 Introduction

Alien invasive plants in some cases are capable of exhibiting the properties of strong edificators [1]. Many scientists believe that invasive plants create a denser leaf canopy than native plants [2-5]. With regard to *Acer negundo* L., estimates of its shading effect in the secondary habitat are ambiguous: it may be stronger than that of local woody plants [6], or may not be different [5]. The purpose of the study is to analyze the characteristics of lighting in different parts of the crown of *Acer negundo* in forest parks in Yekaterinburg.

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2 Materials and methods

According to the botanical and geographical zoning of the Sverdlovsk region, the city of Yekaterinburg is located in the southern taiga boreal forest subzone [7], it is surrounded by forest parks and urban forests. The study of virginal individuals of *Acer negundo* was carried out in 2022 in four habitat fragments (HF) in the Central and four habitat fragments in the Karasye-Ozersky forest parks of Yekaterinburg. Standard methods were used to characterize habitats [8-9]. Illumination was assessed using a digital multifunctional environmental parameter meter MS-6300. Illumination indicators were measured: above the crown, in the middle of the maple height and at the base of the trunk.

The average values and standard errors of the initial lighting parameters in different parts of the crown and the same parameters after logarithm were calculated. Other statistics were calculated for logarithmic parameters. Correlations between the parameters of illumination and light interception at different levels of plant crowns, as well as crown heights and diameters, were analyzed. A comparison was made of differences in the parameters of samples of individuals in the habitats of two forest parks using the nonparametric Mann-Whitney test. The distributions of logarithmized illumination and illumination interception parameters were compared. Average heights (H) and minimum and maximum crown diameters (D_{min}, D_{max}) for habitats in the Central Forest Park (CFP) are: 1.06 ± 0.053 m, 0.4 ± 0.015 m, 0.51 ± 0.019 m; for habitats in the Karasye-Ozersky Forest Park: 0.77 ± 0.041 m, 0.42 ± 0.017 m and 0.56 ± 0.027 m, respectively.

3 Results

The density of individuals in habitats varies from 3700 to 6850 individuals per hectare (Table 1). The maximum amount of maple in forest parks was found in mixed-grass pine forests with a canopy density of 0.5 (HF5) - 0.6 (HF1).

Table 1. Characteristics of habitats of *A. negundo* L. in forest parks of Yekaterinburg.

Habitat				
Habitat fragment number	**tree stand**			**Total density, ind./ha**
	Forest type	**compound**	**tree canopy density**	
Central Forest Park				
1	Pine forest of various herbs	7C3B	0.6	6850
2	Pine forest of various herbs	10C	0.5	3700
3	Pine forest of various herbs	10C	0.4	4550
4	Pine forest of various herbs	10C	0.6	6150
$X \pm mx$			0.5	5312
Karasye-Ozersky Forest Park				
5	Pine forest of various herbs	5C5B	0.5	6400
6	Pine forest of various herbs	6C4B	0.6	4700
7	Pine forest of various herbs	5C5B	0.4	5350
8	Pine forest of various herbs	4C6B	0.5	5950
$X \pm mx$			0.5	5600

When studying the interception of light, the following average light parameters were obtained in different parts of the crown of *A. negundo* (designations L, Δ L: above - above the crown, inside - in the middle of the trunk height, below - under the crown at the base of the trunk) (Table 2) and identified the value of the relative interception of radiation to illumination above the crown (the last line is the relative interception of illumination by the entire crown) (Table 3).

Table 2. Average parameters of illumination and light interception in different parts of the crown of *A. negundo*.

Initial parameters (X ± mx)					
Lighting	**CFP**	**Karasye-Ozersky**	**Interception of lighting**	**CFP**	**Karasye-Ozersky**
L_{above} , lk	980.1±37.7	1070.1±45.8	$L_{above} - L_{inside}$, lk	451.6±29.7	353.6±34.0
L_{inside} , lk	528.5±22.0	716.6±36.5	$L_{above} - L_{below}$, lk	669±32.6	589.1±41
L_{below} , lk	311.1±13.9	481.0±31.1	$L_{inside} - L_{below}$, lk	217.4±15.2	235.6±24
Logarithmic parameters (X ± mx)					
Ln (L_{above})	6.78±0.049	6.89±0.050	Ln ($L_{above} - L_{inside}$)	5.79±0.095	5.44±0.119
Ln (L_{inside})	6.17±0.048	6.47±0.053	Ln ($L_{above} - L_{below}$)	6.33±0.067	6.16±0.079
Ln (L_{below})	5.64±0.046	6.02±0.063	Ln ($L_{inside} - L_{below}$)	5.03±0.1	5.02±0.118

Table 3. Relative light interception values in different parts of the crown of *A. negundo*.

Light interception rate	**Light interception percentage, %**	
(L_{above}–L_{inside})/L_{above}*100%	46.07	33.04
(L_{inside}–L_{below})/L_{above}*100%	22.18	22.01
(L_{above}–L_{below})/L_{above}*100%	68.26	55.05

Thus, the interception of light in the crown of *A. negundo* for the two habitats is 68% and 55%, respectively.

Correlations between logarithmized parameters of illumination and interception of illumination for cenopopulations located in the Central and Karasye-Ozersky forest parks are shown in Table 4.

Table 4. Correlations between light and light interception parameters in different parts of the crown of *A. negundo* for two forest parks (significant differences at the p<0.05 level are highlighted in bold).

Lighting options	**L_{above}**	**L_{inside}**	**L_{below}**	**L_{above}–L_{inside}**	**L_{above}–L_{below}**	**L_{inside}–L_{below}**
	Maple habitat in the Central Forest Park					
L_{above}	1.00	**0.658***	**0.574***	**0.753***	**0.941***	**0.454***
L_{inside}		1.00	**0.78***	0.121	**0.488***	**0.742***
L_{below}			1.00	0.185	**0.287***	0.218
L_{above}–L_{inside}				1.00	**0.809***	0.027
L_{above}–L_{below}					1.00	**0.479***
L_{inside}–L_{below}						1.00
	Maple habitat in the Karasye-Ozersky forest park					
L_{above}	1.00	**0.734***	**0.559***	**0.68***	**0.784***	**0.307***
L_{inside}		1.00	**0.693***	0.097	**0.362***	**0.546***
L_{below}			1.00	0.129	-0.0087	-0.1
L_{above}–L_{inside}				1.00	**0.772***	-0.071
L_{above}–L_{below}					1.00	**0.443***
L_{inside}–L_{below}						1.00

No correlations were found between any of the considered lighting parameters and the measured heights and diameters of tree crowns; apparently, there is no correlation between them. In accordance with Table 4, we can say that almost all parameters correlate with illumination above the crown, while there is no correlation between the interception of illumination by the upper half of the crown and illumination in the middle of the trunk, and the interception of illumination by the lower half of the crown and illumination under the crown. . There is also no correlation between the interception of illumination by the upper and lower halves of the crown.

Using the nonparametric Mann-Whitney test, results were obtained for comparing plant canopy parameters and logarithmized light parameters between two forest parks (Table 5).

Table 5. Results of comparison of *A. negundo* individuals according to tree crown and lighting parameters (significant correlations at the $p < 0.05$ level are highlighted in bold).

Parameter	Rank Sum CFP	Rank Sum Kar.-Oz. for. parks	U- statistics	Z- statistics	p-value
H	16717	12203	4943	4.196	0.000027*
D_{min}	14244.5	14675.5	6984.5	-0.4	0.689306
D_{max}	14234	14686	6974	-0.419	0.674981
L_{above},	8495	7436	3445	-1.332	0.182714
L_{inside},	7575	8356	2525	-4.03	0.000056*
L_{below}	7393.5	8537.5	2343.5	-4.562	0.000005*
$L_{above}–L_{inside}$	9858	6073	2992	2.661	0.007803*
$L_{above}–L_{below}$	9622.5	6308.5	3227.5	1.97	0.048829*
$L_{inside}–L_{below}$	8962.5	6968.5	3887.5	0.035	0.971936

As can be seen from Table 5, maple habitats differ significantly in the average height of individuals, also in the intensity of lighting inside and under the crowns, and in the parameters of light interception by the upper half of the crown and the entire crown of the plant.

The differences in the distributions for logarithmized lighting parameters between two forest parks (CFP - 1, Karasye-Ozersky forest park - 2) are illustrated in Figure 1 below. In graphs a and d, in accordance with Table 5, there are no significant differences in lighting parameters between habitats; in graphs b and c, the differences are significant.

4 Discussion

In both habitats of *A. negundo*, the light intensity above the tree crowns is not statistically different. At the same time, lighting in the middle of the crown and under the crown is significantly less for habitats in the Central Forest Park, which is confirmed by analysis using the Mann-Whitney test. Consequently, the interception of illumination by both the upper half of the crown and the entire crown of trees in a given habitat is significantly greater. The interception of illumination by the crown as a percentage of the illumination above the crown is equal to 68.26% and 55.05%, respectively, for the Central and Karasye-Ozersky forest parks. The maple habitats in the Central Forest Park also differ in significantly higher crown heights from the habitats in Karasye-Ozersky. Differences in light interception values may be associated with differences in the parameters of tree crowns, and possibly with differences in heights.

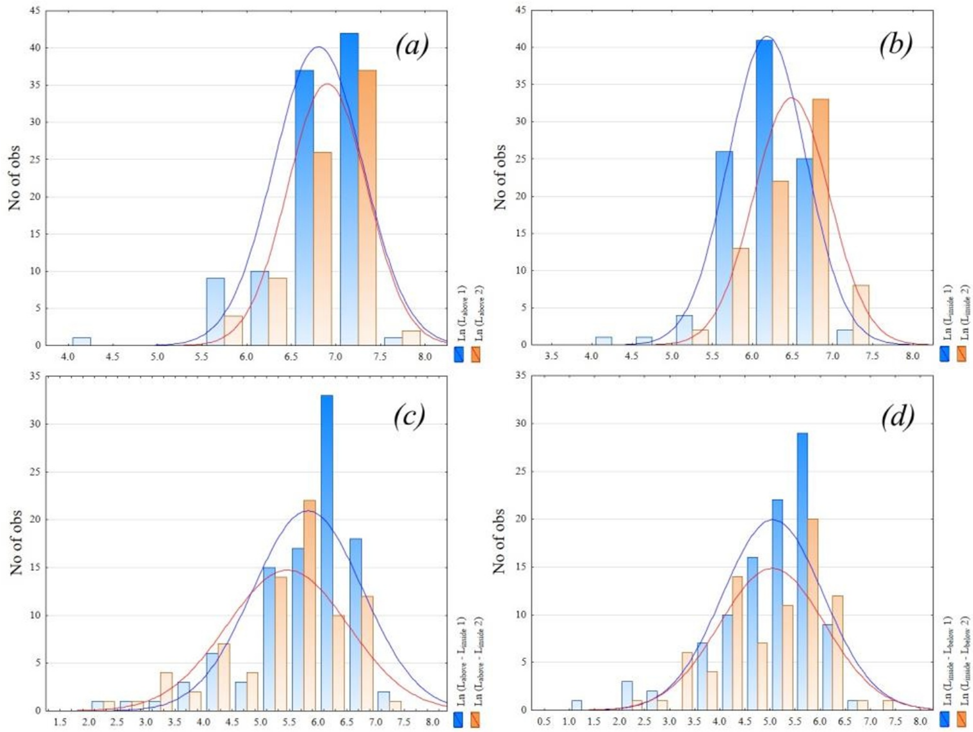

Fig. 1. Graphs of differences in distributions for logarithmic illumination parameters (*a* – illumination above the crowns; *b* – illumination in the middle of the crowns; *c* – interception of illumination by the upper half of the crowns; *d* – interception of illumination by the lower half of the crowns; habitats: CFP – 1, Karasye-Ozersky – 2).

Correlation analysis of signs of lighting and light interception (Table 4) revealed that lighting above the crown correlates to a greater or lesser extent with other lighting parameters, and light interception by the entire crown also correlates with other parameters, with the exception of the L_{above}–L_{below} correlation with L_{below}, which for habitats in the Central Forest Park is 0.286, and for Karasye-Ozersky it is completely absent. At the same time, there are no correlations between the interception of illumination by the upper half of the crown and illumination inside the crown, and the interception of illumination by the lower half of the crown and illumination under the crown. There are also no correlations between the dimensional parameters of the crown (H, D_{min}, D_{max}) and lighting parameters. These facts indicate the structural features of *A. negundo* tree crowns and their interception of light.

5 Conclusion

In conclusion, based on the results of the analysis of lighting data in different parts of the *Acer negundo* crown, it can be concluded that lighting parameters apparently depend on the structural features and shape of the crown, and differ for maple habitats in two forest parks. Individuals of *A. negundo* are presented, as a rule, in the form of a low multi-stemmed tree with inclined trunks and low-lying branches. However, within one forest park, many of these parameters are correlated, which also indicates the peculiarities of light interception by crowns. At the same time, the macroparameters of crowns—their heights and diameters—do not correlate with lighting parameters. Thus, the ability of ash maple to influence plant communities is due to a strong decrease in the intensity of the light regime, due to shading by the crown, available to other plants.

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