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Comparative Analysis of Pathology of Introduced and Indigenous Tree Species in Urban Plantings of Voronezh

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Abstract

One of the problems of urban planting is the necessity for choosing between indigenous and introduced tree species. Under conditions of Voronezh, Russia, the ratio is 1:4 in favor of the former, though the many years' experience shows that it is not substantiated from the perspective of vital capacity of trees in urban environment. The conducted research showed that the most popular introducents in the city (common horse chestnut, Lombardy poplar) are in better condition than the indigenous species (tillet, drooping birch, Norway maple). This difference is especially seen in linear, street, and riverside plantings.

Keywords: Indigenous Tree Species, Introducents, Pathological Characteristics of Trees, Tree Pathologies, Urban Plantings

1. Introduction

Green plantations are an essential element of improvement of city. To a greater extent, this applies to major cities. Green plantations affect temperature and humidity of the air of the city, have a bactericidal effect, reduce dust, and restore normal composition of the air[6].

Green areas have a number of distinctive features, such as broken or artificially created soils or artificial flora; duration of their existence is limited by lifespan of the constituent trees, since the complex is not capable of self-renewal[7].

It has long been known that inside city, tree species tend to have worse health status and live less than in the natural environment[1]. Besides, it was noticed that trees of indigenous nature in urban plantings often feel worse than introduced species. Considering that while creating of urban planting, gardeners always face a difficult choice, which species to use and in which proportions, knowledge of the comparative characteristics of the status of these species in adulthood can substantially facilitate this choice[5].

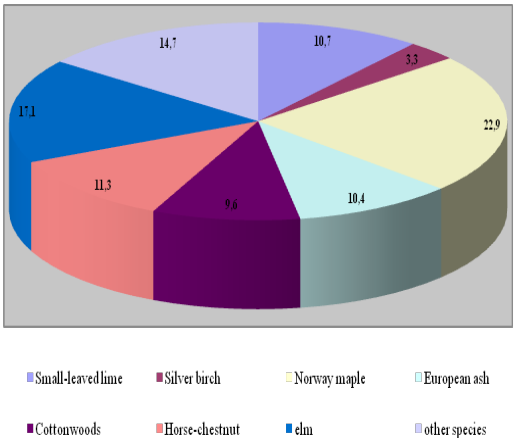

Figure 1. The ratio of the main wood species used in greening of Voronezh (%)

2. Materials and Methods

Based on this, we set ourselves to make a comparative analysis of forest pathologic state of indigenous and introduced trees in the urban plantings, on the example of the city of Voronezh.

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Table 1. Characteristics of the objects of research

Object of greening	Type of planting	Average age of implantations	Dominant species	Quantity of trees
Tsentralny district				
ul. Friedricha Engelsa	linear	35-65 (50)	Horse-chestnut	284
ul. Nikitskaya	linear	45-65 (55)	Small-leaved lime	238
ul. Mira	linear	45-65 (55)	Small-leaved lime	124
ul. K.Marksa	linear	40-65 (52)	Small-leaved lime	193
ul. Pyatnitskogo	linear	35-50 (42)	Norway maple	73
park 'Orlyonok'	group	40-55 (47)	Norway maple	385
park VSAU	group	40-65 (52)	Norway maple	385
Leninsky district				
ul. Platonova	linear	35-65 (50)	Norway maple	47
ul.Stankevitcha	linear	35-50 (42)	Small-leaved lime	105
Sovetsky district				
ul. 9 Janvarya	linear	35-50 (42)	Small-leaved lime	445
ul. Pirogova	linear	40-55 (47)	Cottonwoods	291
ul. Mashinostroiteley	linear	40-50 (45)	Cottonwoods	235
ul. Yuzhno-Moravskaya	linear	35-50 (42)	Cottonwoods	356
Kominternovsky district				
ul. Solnechnaya	linear	35-55 (45)	Cottonwoods	171
prospekt Truda	linear	35-50 (42)	Small-leaved lime	225
ul. Transportnaya	linear	30-45 (37)	Small-leaved lime	150
ul. Generala Lizyukova	linear	35-50 (42)	Cottonwoods	296
ul. Begovaya	linear	35-65 (50)	Cottonwoods	325
Levoberezhny district				
ul. Poliny Osipenko	linear	40-50 (45)	Norway maple	77
ul. Tziolkovskogo	linear	40-65 (5 2)	Norway maple	180
park 'Patriotov'	group	40-50 (45)	Norway maple	148
park 'Yuzhny'	group	40-65 (52)	Cottonwoods	922
ul. Bazovaya	linear	30-45 (37)	Cottonwoods	272
ul. Lebedeva	linear	35-50 (42)	White poplar	107
Zheleznodorozhny district				
ul. Perevertkina	linear	30-45 (37)	Cottonwoods	192
ul. Z.Kosmodemjanskoy	linear	40-45 (42)	Cottonwoods	132
park 'Delfin'	group	40-50 (45)	Cottonwoods	221
ul. Seraphimovicha	linear	35-65 (50)	Cottonwoods	212
ul. Minskaya	linear	35-50 (42)	Cottonwoods	270
ul. Dobrolyubova	linear	35-50 (42)	Norway maple	102
Total				7,367

The objects of research were chosen in such a way that, on the one hand, all types of urban planting and plant conditions were taken into account, and on the other, the most common in urban greening tree species were examined. Since 92% of urban planting in Voronezh are represented by deciduous vegetation, we restricted ourselves to examination of this particular species group.

The state of the plantings was determined by standard methods of forest pathology examination by conducting surveys on routes and temporary sample plots[4,8,9].

Field investigations were conducted during 2011-2014 in various types of plantations in 6 districts (Table 1).

3. Results

Trees of more than 100 species[2] can be found in street and park plantings of Voronezh; however, 89.6% of the urban trees are represented by 8 species, 6 of which are indigenous (white poplar, small-leaved lime, Norway

maple, European ash, elm, and silver birch) and 2 species - introducents (horse-chestnut, cottonwoods) (Figure 1).

These very species became the subject of our research in the first turn.

According to our research, the leading position of 8 major tree species used in greening of Voronezh is taken by Norway maple (22.9%) which is related to the typical natives of the forest-steppe zone[3]. The total share of natives in landscaping is 79.1%. Horse-chestnut is leading among introduced species (11.3%).

The pathological characteristics, registered during the process of research, were divided into 12 groups. Their quantitative and percentage values in group park plantings are presented in (Table 2).

Analysis of the data of the table shows that the most common type of pathology of all trees under research is pathology of trunk form. It is found in 96% of the analyzed trees. This pathology manifests itself at a high level (42.8-73.3%) in almost all indigenous species. This pathology is found in introducents many times rarer. Thus, in cottonwoods it constitutes 9.6%, and in horse-chestnut - 12.8%. Most often it is bifurcation (51.6%), slopes (28.4%) and thick main branches (13.9%).

Status of separate species by districts is assessed as weakened and poor (Table 2).

Table 2. Summary of the state of the analyzed species in the objects under research

Species	The weighted average category status
Street plantings	
Horse-chestnut Aesculus hippocastanum L.	1.57±0.0491
Small-leaved lime Tilia cordata Mill.	1.68±0.0235
Norway maple Acer platanoides L.	1.95±0.0260
European ash Fraxinus excelsior L.	3.18±0.1225
Cottonwoods Populus pyramidalis Borkh.	1.56±0.0158
Siberian elm Ulmus pumila L.	1.89±0.0973
White poplar Populus alba L.	2.13±0.0359
Silver birch Betula pendula Roth	2.50±0.0905
European White Elm Ulmus laevis Pall.	2.11±0.0800
Ash-leaved maple Acer negundo L.	1.44±0.1003
Park plantings	
Silver birch Betula pendula Roth	2.35±0.0542
Norway maple Acer platanoides L.	1.89±0.0291
Elm Ulmus laevis Pall.	2.25±0.1214
Small-leaved lime Tilia cordata Mill.	2.06±0.0417
White poplar Populus alba L.	2.49±0.0683
Horse-chestnut Aesculus hippocastanum L.	2.07±0.0426
Cottonwoods Populus pyramidalis Borkh.	1.86±0.0387
Siberian elm Ulmus pumila L.	1.99±0.0641
Ash-leaved maple Acer negundo L.	2.41±0.0910

So, on the basis of the data of Table 2 we see that most of the trees in street plantings are in better condition than in park zone, where the plants are extremely weakened. This process is confirmed by indicators of average weighted category of status (in street plantings - 1.44-3.18, in park - 1.86-2.49, in coastal - 1.44-4.85). In the worst condition the following were recorded: in street plantings - European ash *Fraxinus excelsior L.*- 3.18, silver birch *Betula pendula Roth* – 2.50, white poplar *Populus alba L.* – 2.13 and elm *Ulmus laevis Pall.* - 2.11; in park - white poplar *Populus alba L.* – 2.49, silver birch *Betula pendula Roth* – 2.35, Ash-leaved maple *Acer negundo L.*- 2.41 and elm *Ulmus laevis Pall.* - 2.25.

Weakening of plants was assessed visually and was fixed by primary and secondary external pathological signs of trees, indicating the category of its weakening (Table 3).

The listed abnormal forms of trunk do not directly affect the state and vitality of tree, but significantly increase the risk of windthrow, breaking of trunk, or large branches breakup. Accordingly, they can justifiably be considered as pathological, i.e. reducing the prospects of survival and prospects of tree.

Indigenous species, as compared with native species, in the park plantings have significantly less pathologies, such as damage by stem pests and mechanical damage (up to 10 times).

If we compare two systematically close woody species by presence of pathologies, one of which is an unconditional aborigine (Norway maple), and the second is an explicit introducent (Ash-leaved maple), it is evident that in a number of pathologies (abnormal shape of trunk, water sprouts, number of overgrown knots, etc.), the two species are almost identical (Figure 2).

Table 3. Occurrence of external pathological signs on trees in group park plantings.

Characteristics	Species, un./%								
	Indigenous species					Introduced species			
	White poplar	Norway maple	Small-leaved lime	Silver birch	European White Elm	Cottonwoods	Siberian elm	Horse-chestnut	Ash-leaved maple
Dried out main branches/ tree-tops	121 58.1	524 64.6	81 49.1	121 61.7	13 54.1	35 8.9	85 45.9	12 30.7	29 80.5
Flying holes	18 8.6	34 4.1	-	38 19.4	-	-	7 3.7	-	-
Mechanical damages, flanking	62 29.8	121 14.9	25 15.1	30 15.3	12 50	-	10 5.4	1 2.5	2 5.5
Water sprouts	150 72.1	603 74.3	139 84.2	-	24 100	-	125 67.6	21 53.8	27 75.0
Not overgrown knot	47 22.5	174 21.4	32 19.3	73 37.2	8 33.3	7 1.7	37 20	2 5.1	8 22.2
Frost clefts	-	25 3.1	-	-	-	42 10.6	33 17.8	-	9 25.0
Tumors	16 7.6	8 0.9	-	4 2.1	-	-	2 1.1	-	2 5.5
Fruit bodies	-	19 2.3	-	-	-	-	10 5.4	-	-
Pathological forms of trunk	144 69.2	576 71.1	121 73.3	84 42.8	16 66.6	38 9.6	97 52.4	5 12.8	25 69.4
Defoliation	-	46 5.6	49 29.6	28 14.2	-	-	-	9 23.1	-
Sponges, leaf miners	31 14.9	197 24.2	93 56.3	4 2.1	19 55.8	-	102 55.1	-	32 88.8
Leaf burns	-	82 10.1	57 34.5	-	5 20.8	-	-	33 84.6	-

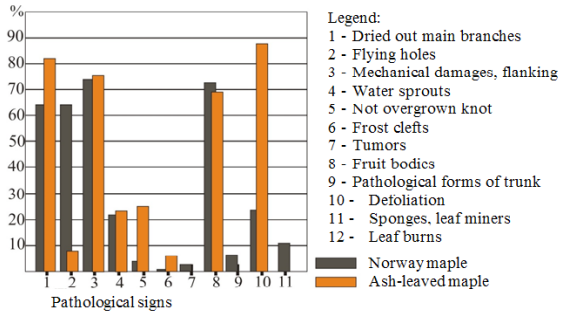

Figure 2. Occurrence of pathological signs on Norway maple and Ash-leaved maple in group park plantings.

At the same time, it is evident that introduced tree suffers much stronger from low temperatures and is damaged by leaf-mining insects.

Indigenous species have more mechanical damages, as well as more burns and eating of leaves by insects.

The analogous tendency in occurrence and diversity of pathological symptoms is noticed when comparing pairs of poplar (white and cottonwoods).

Thereby, it is possible to state that in group park plantings, pathological condition of introduced tree species is not much, but significantly better than the state of indigenous trees.

Table 4. Occurrence of external pathological signs on trees in linear street plantings.

Characteristics	Species, un./%							
	Indigenous species					Indigenous species		
	Small-leaved lime	Norway maple	Silver birch	Cottonwoods	European White Elm	Babylonian willow	Cottonwoods	Horse-chestnut
Dried out main branches/tree-tops	36 15.2	234 34.8	42 20.3	138 66.1	47 79.6	32 94.1	128 16.6	2 1.2
Flying holes	-	9 1,3	21 10.2	18 8.6	10 16.9	18 52.9	-	1 0.6
Mechanical damages, flanking	21 8.8	84 12.5	19 9.2	65 31.1	10 16.9	28 82.3	43 5.5	64 39.1
Water sprouts	176 74.2	621 92.5	7 3,4	185 88.5	45 76.2	28 82.3	-	62 37.8
Not overgrown knot	39 16.4	144 21.4	84 40.7	57 27.2	18 30.5	12 35.2	-	47 28.6
Frost clefts	9 3.7	15 2,2	-	14 6.7	8 13.5	29 85.2	41 5.3	-
Tumors	-	4 0.5	1 0.4	4 1.9	-	6 18	-	-
Fruit bodies	-	-	-	-	-	17 50	-	-
Pathological forms of trunk	184 77.6	432 64.3	156 75.7	171 81.8	33 55.9	29 85.2	49 6.3	48 29.2
Defoliation	13 5.4	37 5.5	-	-	-	4 12	-	-
Sponges, leaf miners	102 43.1	303 45.1	14 6.7	60 28.7	27 45.7	-	-	-
Leaf burns	203 85.6	178 26.5	-	29 14.1	12 20.3	-	10 1.2	147 89.0

Occurrence of pathological signs in linear street plantings significantly differs from park landings (Table 4).

This situation is diametrically opposed to that observed in park plantings. In our view, it is logical to assume that a higher percentage of damaged crowns of introducents by phytophages in park plantings is due to their heterogeneity and thickening, which encourages formation of natural biocenosis, which also implies presence of a parasite entomocomplex. In linear one-species plantings, this factor is excluded.

While comparing the most common species in street plantings - Small-leaved lime and horse-chestnut (Figure 3), it is seen that both the set of pathological symptoms and level of their importance for each of the species are very specific.

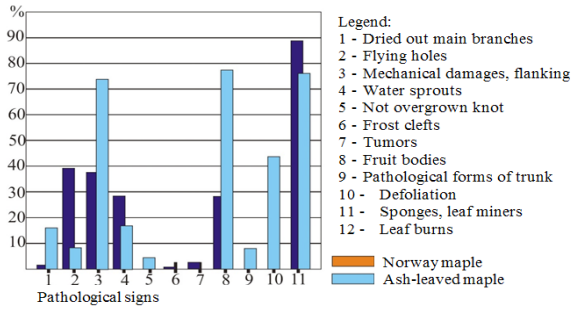

Figure 3. The occurrence of pathological signs in the small-leaved lime and horse-chestnut in linear street plantings.

Trees of lime do not have any pathology associated with damage of leaves and influence of low temperatures, but have much more mechanical damage, not overgrown

knots. Lime trees also have, though in a small amount, fruit bodies of wood-destroying fungi and cancer tumors which are not observed in horse-chestnut.

The same tendencies are noticed while comparing white poplar and cottonwoods.

4. Discussion

As compared to indigenous species, the introducents in park plantings feature less damage from trunk pests and mechanical damages (up to 10 times less).

More leaf burns, damages by leaf miners, and sponge-creators were noted in introduced species. Tumors, fruit bodies of wood-destroying fungi, and wood-defoliation are isolated cases.

All other pathologies have comparable percentage ratio between the analyzed groups of species.

Almost on all of the trees under research external symptoms of pathology are marked in some way. Most of the pathologies are not fatal (leaf burns, partial defoliation of crowns, insignificant mechanical damages of bark, etc.), but there is also a significant amount of pathologies which are irreversible (fruit bodies of wood-destroying fungus, large hollows, cancerous tumors, drying of a part of crown, etc.).

In street plantings, the introduced species have considerably less damaged leaves (burns, defoliation, leaf miners, etc.). The exception is the horse-chestnut, up to 89% of the trees of which have leaf burns in the middle of summer.

Trees of such introducent as brittle willow, which is not in park plantings, are also noted for extremely unsatisfactory state. The majority of trees of this species has pathological forms of trunk (85.2%) and dried out main branches (94.1%).

According to the other indicators, the introducents practically do not differ from indigenous species in street plantings.

5. Conclusion

According to the given data and analysis, it is possible to conclude that in park and in street plantings of Voronezh introduced species of trees, with all things being equal, feel at least no worse than the trees of indigenous species.

Considering that introduced species constitute only 20% of the green spaces of the city, their share may be significantly increased, which will undoubtedly improve the aesthetic qualities of urban landings without reducing their sanitary state.

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