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Expansion of *Acer negundo* L. in the forest parks of Yekaterinburg

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Abstract. The article studies the adaptive mechanism of the distribution of *Acer negundo* L. on the example of habitats in the Southwestern forest park based on population (age and vitality structure) and organismal parameters (morphometric indicators). An assessment of the invasive potential made it possible to establish similar features of the introduction of the ash-leaved maple in any of its habitats. All fragments of the cenopopulation were at the initial stage of introduction and began their expansion from open spaces, well settling in forest ecosystems, mainly in forb and horsetail-forb pine forests with a tree canopy density of 0.4–0.5. This trend of conquest of the territory by the "aggressor" species continues at the present time, and it can be said with confidence that this situation is typical for many regions of Russia, therefore, it is necessary to monitor the state of ecosystems.

1. Introduction

Out of 3.9% of the species of the Earth's flora naturalized in regions new to them [1], the greatest threat to the diversity of native communities is associated with transforming plants, which can block the normal course of successions [2-6]. The ash-leaved maple (*Acer negundo* L.) was chosen as the object of study not by chance, since it is one of the most aggressive tree species in the forest zone of Eurasia [7-8]. Therefore, the study of the processes that occur in the forest park zone of Yekaterinburg when the ash-leaved maple is introduced into them seems to be very relevant.

The purpose of the study is to study the invasion of the ash-leaved maple in the forest park zone of Yekaterinburg.

2. Materials and methods

Ash maple was studied in 2021 in seven fragments of cenopopulations (FTP) in the South-Western Forest Park of Yekaterinburg (56°47'54"N, 60°32'22"E) (table 1). Habitats were characterized using standard methods [9]. A comprehensive study was carried out on the basis of the age and vitality structure, organismal and population characteristics of individuals.

Table 1. Characteristics of the studied habitats of *Acer negundo* L.

Cenopopulation fragment number	Habitat characteristics			Total density, ind./ha	Morphometric indicators		
	Forest type	Forest stand			Height, m	Crown projection area, m²	Crown volume, m³
		Composition	Closeness of the tree canopy				
1	Forb pine forest	10C	0.5	2744	1.19±0.18	0.49±0.15	0.45±0.19
2	Forb pine forest	10C	0.4	577	0.37±0.06	0.05±0.01	0.01±0
3	Horsetail-forb pine forest	9C1B	0.5	1300	1.59±0.45	1.49±0.76	3.94±0.18
4	Horsetail-forb pine forest	9C1B	0.4	1933	0.65±0.08	0.10±0.02	0.03±0.01
5	Forb pine forest	10C	0.5	1477	0.74±0.12	0.11±0.02	0.05±0.01
6	Forb pine forest	10C	0.4	2044	1.36±0.17	0.13±0.02	0.08±0.02
7	Forb pine forest	10C	0.5	1244	0.48±0.09	0.09±0.03	0.03±0.02

3. Results

On the territory of the South-Western forest park, maple grows in mixed-grass and berry pine forests on 31.3 hectares (5.3% of the occupied area of the total area of the forest park) mainly in dense undergrowth (78.91%) at a density of 0.5 (figure 1).

Figure 1. Distribution of the ash-leaved maple in the Southwestern Forest Park.

The density of individuals in habitats varies from 577 to 2744 individuals per hectare (table 1). The maximum amount of maple was found in the forb pine forest with a canopy density of 0.5 (FTP1). The vital state of plants deteriorates with an increase in canopy density ($r = -0.80$, $p < 0.05$), varying from 63 to 84% with a predominance of weakened individuals (table 2). The highest efficiency index is typical for 5.6 FTP in mixed grass pine forest.

Table 2. Population characteristics of the habitats of Acer negundo L.

Fragment of cenopopulation	Vital spectrum, %					life condition index, %	Index			
	n_1 healthy individuals	n_2 weakened individuals	n_3 damaged individuals	n_4 dying individuals	n_5		age index	replacement index	recovery index	efficiency index
1	20	76.6	3.4	0	0	75	0.08	14	14	0.31
2	33.3	56.7	10	0	0	77	0.03	0	0	0.14
3	20	60	16.6	3.4	0	69	0.13	9	9	0.36
4	46.6	46.6	6.8	0	0	82	0.06	0	0	0.24
5	46.6	53.4	0	0	0	84	0.12	4	4	0.41
6	36.6	43.4	20	0	0	75	0.11	14	14	0.38
7	3.4	73.3	20	3.3	0	63	0.04	0	0	0.18

The vitality spectrum of maple in the Southwestern Forest Park is represented by the following plants: healthy individuals from 3.4 to 46.6%, weakened from 46.6 to 76.6%, severely damaged from 3.4 to 20 and dying 3.4%.

With an increase in the density of the forest stand, the proportion of generative individuals (r = 0.96, p <0.05) and their morphological parameters (height (r = 0.93, p <0.05), projection area (r = 0.79, p <0.05) and crown volume (r = 0.66, p <0.05)), but the vitality of individuals decreases with increasing maple age (r = 0.89, p <0.05). In the forest park, *Acer negundo* forms a life form - a single-stemmed tree. Two periods are distinguished in the age structure: pregenerative and generative (figure 2) and six ontogenetic states.

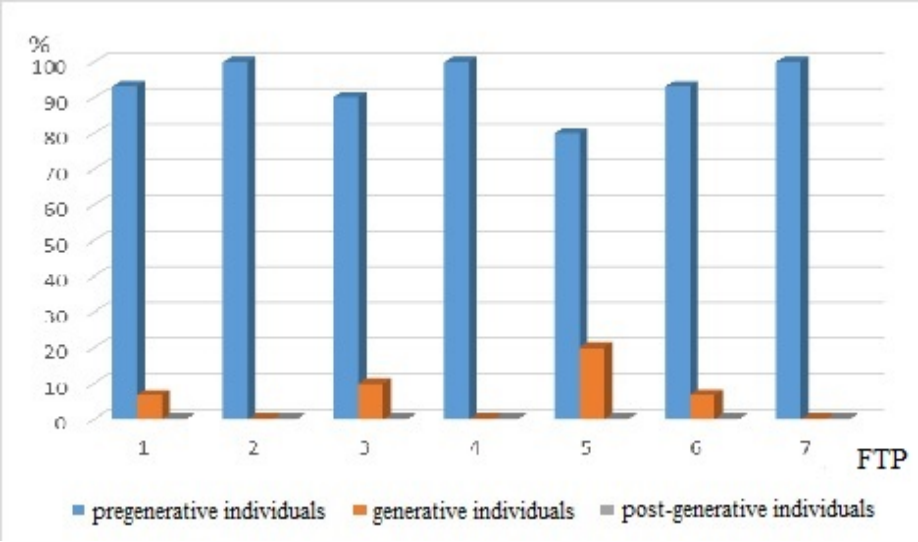

Figure 2. Ontogenetic spectrum of habitats of *Acer negundo* in the Southwestern Forest Park.

In all habitats of Acer negundo, pregenerative individuals dominate, accounting for from 80 to 100%, the share of the generative fraction is insignificant from 6.7 to 20%. All maple habitats according to L.A. Zhivotovsky are young (figure 3). In the prevailing part of the habitats, the maple has reached its regenerative capacity, which is confirmed by the high values of the restoration and

replacement indices, with the exception of FTP2,4,7, these fragments of the cenopopulation are at the initial stage of invasion.

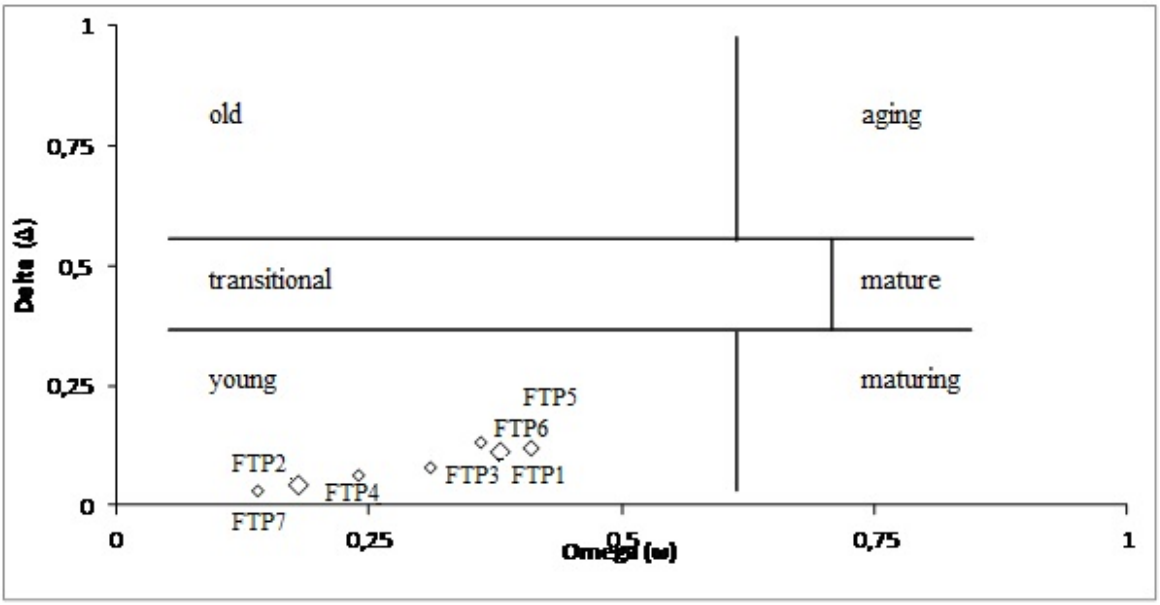

Figure 3. Distribution of *Acer negundo* cenopopulation fragments in "delta-omega" coordinates.

In a comprehensive assessment (table 3, figure 4), in the Southwestern Forest Park, the best ecological and phytocenotic conditions for the invasion of ash-leaved maple were found to be horsetail-forb (28 points) and forb (25 points) pine forests with a tree canopy density of 0.5 (FTP1, 3).

Table 3. Score estimates of the parameters of *Acer negundo* L.

Feature	Point				
	1	2	3	4	5
Organismal parameters of individuals					
Plant height, m	< 0.37	0.38-0.67	0.68-0.97	0.98-1.28	1.29-1.59
Crown projection area, m²	< 0.05	0.06-0.41	0.42-0.77	0.78-1.13	1.14-1.49
Crown volume, m³	< 0.01	0.02-0.99	1-1.97	1.98-2.95	2.96-3.94
Population parameters					
Density, pcs/ha	< 577	578-1119	1120-1661	1662-2203	2204-2744
Share g_1-g_2, %	< 80	81-85	86-90	91-95	96-100
Share *v*, %	< 0	0.1-5	5.1-10	10.1-15	15.1-20
Vitality index, %	< 63	64-68	69-73	74-78	79-84

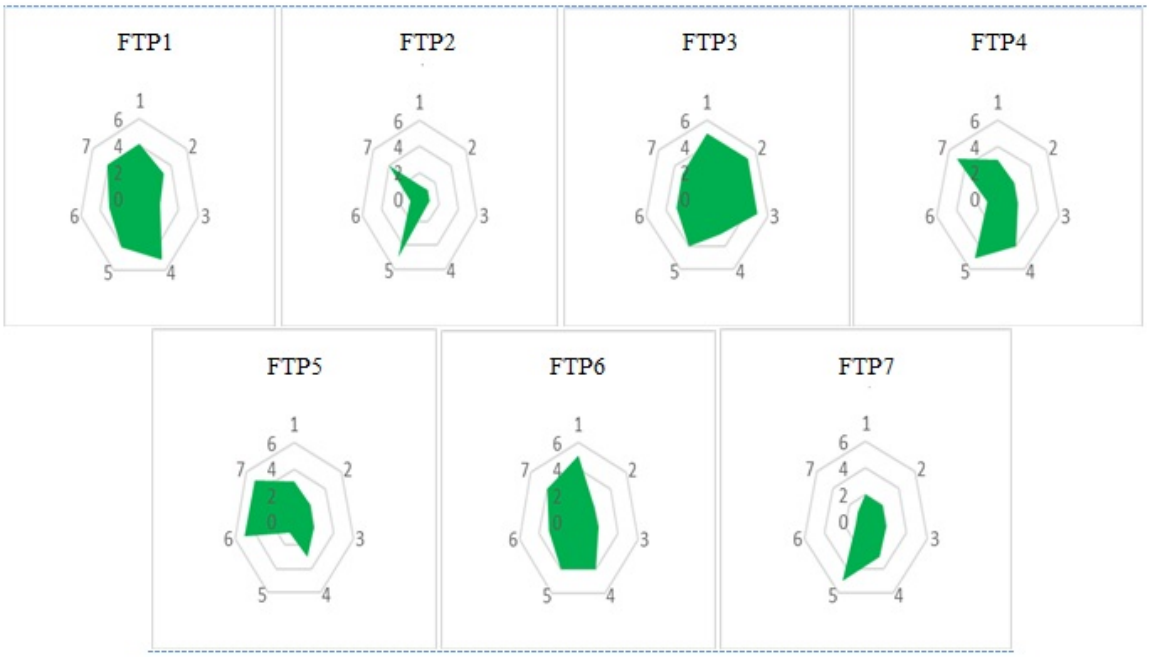

Figure 4. Estimation of the state of fragments of the coenopopulation *Acer negundo* (in points) in the Southwestern Forest Park (organismal parameters: 1 - plant height; 2 - crown projection area; 3 - crown volume. Population parameters: 4 - density of individuals; 5 - proportion g_1-g_2; 6 - proportion v; 7 - vitality index; 1–5 - points).

4. Discussion

Ash-leaved maple grows in 11 forest parks of Yekaterinburg out of 15 on an area of 228 hectares. 7 habitats in the Southwestern Forest Park were studied. The study area is characterized by a high anthropogenic load, because it is replete with numerous roads, a network of paths, picnic areas and campfires. *Acer negundo* starts its invasion from open spaces and penetrates well into forests, mainly into forb and horsetail-forb pine forests. The aggressiveness of the ash-leaved maple, combined with its shade tolerance, high fertility and growth rate, as well as the ability to withstand high recreational loads, forms multi-tiered thickets.

5. Conclusion

In the forest park under study, some regularities in invasion can be distinguished:

- Ecological niches – forb and horsetail-forb pine forests with tree canopy density of 0.4-0.5.
- The distribution strategy of the species during expansion in the Southwestern forest park consists in the development of open habitats, gradually penetrating deep into the forest stand, displacing the native flora.

The data presented indicate a pronounced expansion of the alien species and its significant invasive potential. Thus, these studies are of scientific interest in monitoring the state of a naturalized species in order to obtain reliable information about its phytocoenotic strategy in a new community and place in the structure of indigenous communities.

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