

CHARACTERIZATION OF NORWAY MAPLE'S FLOWER AND INFLORESCENCE FOR CONSERVATION OF ITS GENE POOL

SIMOVIĆ, I.^{1*} – OCOKOLJIĆ, M.²

¹*Biosense Institute, Dr Zorana Djindjića, 21000 Novi Sad, Serbia
(phone: +381-21-485-2137)*

²*Faculty of Forestry, Kneza Višeslava 1, 11000 Belgrade, Serbia
(phone: +381-11-305-3990)*

**Corresponding author*

e-mail: isidora.simovic@biosense.rs; phone: +381-21-485-2137

(Received 8th Jun 2022; accepted 14th Sep 2022)

Abstract. Determining Norway maple's traits variation, especially the variation of flowers, in different environments, and isolating superior individuals enables strategic use and prediction of its prospects. In Serbia's natural and urban populations, Norway maple populations were sampled for morphology of the flowers and inflorescence and its sex was determined. Norway maple inflorescence's width and the number of the flowers vary the most and are a mechanism of adaptation to various environments. The sex of flowers, diameter, and the number of petals characterize the species. A negative correlation between the size and the number of flowers in inflorescence and a positive correlation between inflorescence's width and the number of flowers per inflorescence reflects the species' tendency toward the same size of inflorescences. The morphology of flowers in the natural population varies the most. Based on the inflorescence's width, the number of flowers per inflorescence, and the size of flowers of superior individuals, microflora and macroflora cultivars can be isolated. Variations in inflorescences' morphology are partially explained by environmental conditions. The morphology of urban population is not significantly different from the natural populations nor does it stand out in any of the parameters. This species' large morphological variability enables survival in various environments.

Keywords: *Acer platanoides L., adaptability, morphology, reproductive organs, superior individuals*

Introduction

Norway maple is praised for its adaptability and resilient nature (Nowak and Rowntree, 1990), but it is regarded as invasive species among native species in natural habitats (Webb et al., 2000, 2001; Bertin et al., 2005). Due to its attractive form and adaptable nature, *Acer platanoides* L. is a common species in urban parkways in the USA and Europe (Nowak and Rowntree, 1990), as well as in Belgrade (Anastasijević, 1979). Even though it is an important species in urban landscapes, its morphology is not well covered in the literature.

Research in the 21st century tends to redirect the focus of ecology based on the species to the ecology of the specific characteristics of plant parts (Messier et al., 2010). The importance of these studies is confirmed by the variation of morphometric characteristics of Norway maple's leaves depending on the location of parent trees, as well as bilaterally symmetrical Norway maple's fruits that are particularly suitable for this type of research (Simović et al., 2015, 2013). Norway maple has a wide distribution and therefore has large genetic variation, and distant climate populations have evolved in response to different environmental conditions (Yao and Tigerstedt, 1995; Westergaard, 1997; Joyce et al., 2002). Studying its traits in various environments could contribute to the creation of the basis for the distinction of lower taxa.

Ecologists increasingly appreciate that within-species variation can have consequences for community dynamics and structure (Bolnick et al., 2003; Clark and McLachlan, 2003; Clark, 2005). Studies of functional traits can more efficiently provide ecologically informative insights into community composition and ecosystem function (Lavorel and Garnier, 2002; McGill et al., 2006; Westoby and Wright, 2006). Previous studies remind us that ecologists interested in community assembly have much to gain by shifting their focus from species to traits (Lavorel and Garnier, 2002; McGill et al., 2006). Despite the increasing importance of functional traits for the study of plant ecology, we do not know how variation in a given trait changes across ecological scales, which prevents us from assessing potential scale-dependent aspects of trait variation (Messier et al., 2010).

In a taxonomic and evolutionary sense, a flower is the most important part of the plant. Therefore, research in this paper is focused on identifying variations of flowers and inflorescence of Norway maple through different ecological scales in order to specify the variation in characteristics in relation to different aspects of the environment.

The aim of this study is to characterize *Acer platanoides* L. according to its flower structure and determine which mechanisms does Norway maple use to adapt to various environments. This is especially important as this is a widely used species in landscape architecture, valued for its morphology and especially important as a species tolerant to a variety of environments and resistant to pollutants in urban areas.

Conserving favorable traits in lower taxa such as ecotypes is especially important for practitioners and landscape architects that are restricted to tolerant and adaptive species in urban environments. Securing various ecotypes increases the species' viability under changing climate conditions and enhances their adaptive potential. With further degradation of our surroundings, adaptive species might be the only ones able to mitigate the effects of global warming in cityscapes. The need for intra-specific diversity conservation in trees has been widely recognized before by the research community (Kapeller et al., 2012; Leites et al., 2012; Rodríguez-Quilón et al., 2019) and there is a development of studies that are focusing on the population level of biodiversity to improve the conservation of forest ecosystems (Garnier-Géré and Ades, 2001).

Material and methods

Location

For this study, 100 trees from natural populations were selected from each of three locations in the cadastral municipality Rudnik (Section 63, Section 64, and Section 73) in the management unit "Rudnik II" and 100 trees from the urban population (from 23 streets in the city center of Belgrade) (*Fig. 1*). The selective parameter for choosing the trees, apart from their location, was the age of the trees.

Rudnik 1 population is settled in section 63 at the altitude of 780-920 m.a.s.l. and the age of specimens is around 70 years. Rudnik 2 is at somewhat similar altitude (700-890 m.a.s.l.) but the trees are around 120 years old. The third natural population is Rudnik 3 which is at the highest altitude (800-1110 m.a.s.l.) and the age of trees varies from 70 to 120 years (Forestry Planning and Design Bureau, 2007). Urban population also has a wide span of the age of trees – 40 to 100 years old and is at the lowest altitude – 150 m.a.s.l (Anastasijević, 1979).

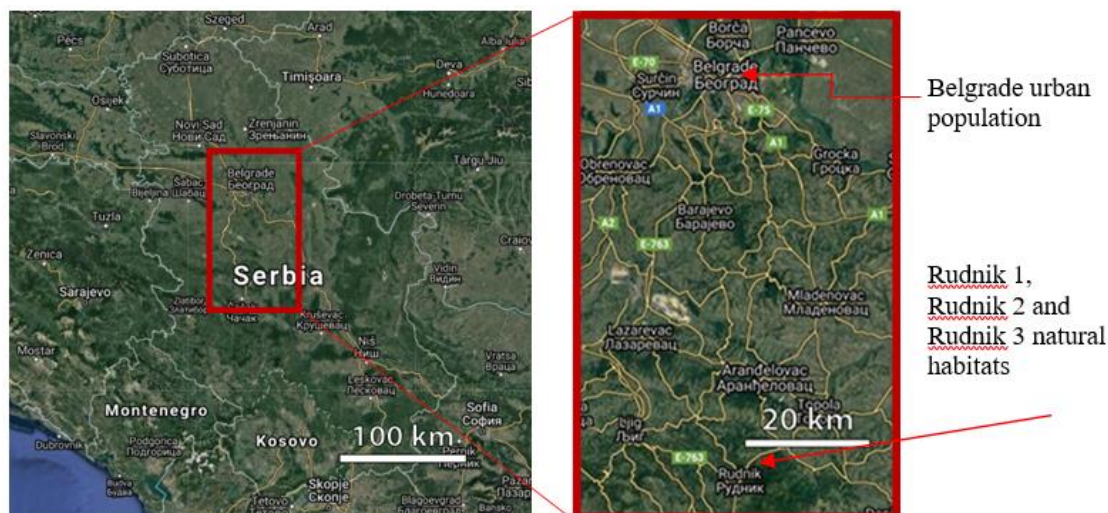


Figure 1. Location of Norway maple's selected populations (Source: Map data 2022 © Google)

Flower and inflorescence measurements

Samples were taken from chosen trees from 4 populations of 100 fully developed inflorescence and the following parameters were determined: the sex of flowers, the number of flowers in an inflorescence, and the number of flower petals. The inflorescences were taken from the lower third of the crown, from the southern side. The total number of collected inflorescence samples was 40 000. The width of the inflorescence and diameter of flowers in inflorescence were measured (Fig. 2). The measurements were carried out on a computer, in Image tool program.



Figure 2. Schematic preview of measurements of flowers and inflorescence

Statistics

The flowers and inflorescences were scanned and measured in UTHSCSA ImageTool 3.0 (IT) software. Measurements did not have a normal distribution, therefore, nonparametric tests Kruskal-Wallis's and Mann-Whitney test-W were used for the determination of differences between groups.

Analysis of variance and Duncan's multiple intervals test were used to determine the differences in inflorescences' morphology of samples from different locations and cluster analysis showed the similarities between the samples. Principal component analysis was used for verification if the samples are grouped by certain morphological characteristics. The data was processed in Microsoft Excel 2019 and IBM SPSS Statistics Version 26 (2019).

Results

The width of the inflorescences on selected Norway maple trees varies from 42 to 106 mm and the diameter of the individual flowers in inflorescence varies from 5.04 to 8.74 mm. The biggest mean value of the inflorescence width is in population Rudnik 2, and the minimum mean value of the inflorescence width is in population Rudnik 3. The greatest mean value of the diameter of flowers is found in the flowers of population Rudnik 1 and Rudnik 2, and the minimum mean value of the diameter of flowers is in population Rudnik 3. The number of flowers per inflorescence varies from 9 to 39 in all populations, and the mean value is the largest in population Rudnik 2, while the smallest is in population Rudnik 1 (*Table 1*).

Table 1. Descriptive statistics of morphometric characteristics of flowers and inflorescence

Characteristic/Population	Belgrade	Rudnik 1	Rudnik 2	Rudnik 3
Inflorescence width (mm)	\bar{x} 78.42	\bar{x} 78.76	\bar{x} 79.18	\bar{x} 77.95
	SD 10.00	SD 9.70	SD 9.42	SD 10.34
	me 79.00	me 80.00	me 80.00	me 79.00
	min 42.00	min 42.00	min 42.00	min 42.00
	max 106.00	max 106.00	max 106.00	max 106.00
Number of flowers per inflorescence (number)	\bar{x} 19.67	\bar{x} 19.59	\bar{x} 19.71	\bar{x} 19.62
	SD 5.35	SD 5.32	SD 5.27	SD 5.42
	me 19.00	me 19.00	me 19.00	me 19.00
	min 9.00	min 9.00	min 9.00	min 9.00
	max 39.00	max 39.00	max 39.00	max 39.00
Diameter of flowers (mm)	\bar{x} 7.91	\bar{x} 7.92	\bar{x} 7.92	\bar{x} 7.90
	SD 0.29	SD 0.24	SD 0.21	SD 0.33
	me 7.94	me 7.94	me 7.94	me 7.94
	min 5.04	min 5.04	min 5.04	min 5.04
	max 8.74	max 8.74	max 8.74	max 8.74

Kruskal-Wallis's and Mann-Whitney test-W

Having determined that the data does not have a normal distribution, nonparametric tests were selected as an adequate method for statistical data processing. For the analysis of quantitative characteristics Kruskal-Wallis's test is used, and then Mann-Whitney test-W to determine between which populations the differences were statistically significant.

There are significant differences in the width of the inflorescences among populations (Test statistic = 68.37; $p < 0.05$). The differences in the width of the inflorescences were determined between all the populations: Belgrade and Rudnik 1 ($W = 4,90624E7$; $p < 0.05$), Belgrade and Rudnik 2 ($W = 4,79693E7$; $p < 0.05$), Belgrade and Rudnik 3 ($W = 4,87877E7$; $p < 0.05$), Rudnik 1 and Rudnik 2 ($W = 4,89072E7$; $p < 0.05$), Rudnik 1 and Rudnik 3 ($W = 4,78523E7$; $p < 0.05$), Rudnik 2 and Rudnik 3 ($W = 4.67625$; $p < 0.05$). The lowest mean value of the width of the inflorescence was notified in population Rudnik 3, and the largest width of the inflorescence was registered in population Rudnik 2 (Fig. 3).

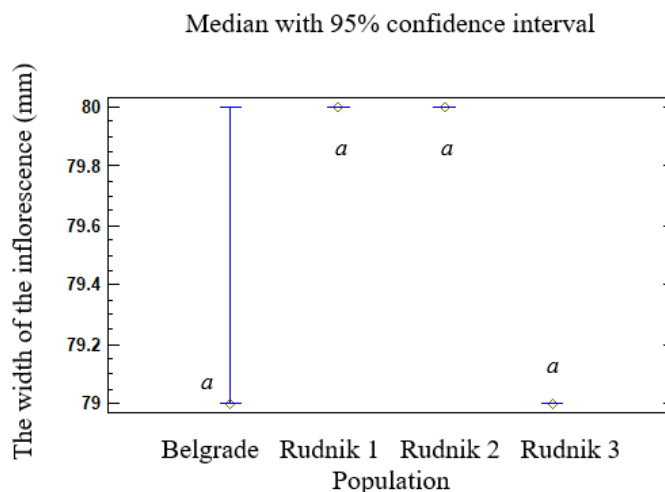


Figure 3. Kruskal-Wallis's test for the width of the inflorescence. *significantly different populations are marked with the letter a

There are no statistically significant differences in the number of flowers in inflorescence among populations (Test statistic = 3.71; $p > 0.05$). The lowest mean value of the number of flowers in the inflorescence are noted on trees of population Rudnik 1, and the largest mean value of the number of flowers in inflorescence characterize trees in population Rudnik 2 (Fig. 4).

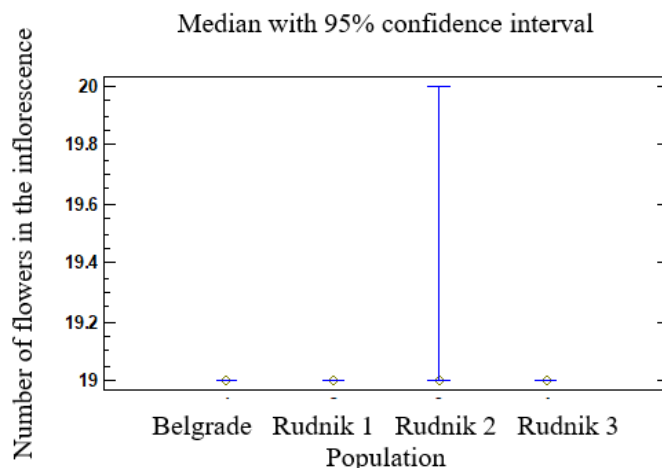


Figure 4. Kruskal-Wallis's for number of flowers in the inflorescence

There are 5 petals in flowers. There are exceptions in each population, on different individuals, and in different inflorescences. The number of flowers with six flower petals is below 1%, as well as the number of flowers with four flower petals. Inflorescences nor the individuals with all the flowers with 4 and/or 6 petals were not registered. In the Belgrade population, only two flowers with 6 flower petals were noted. In population Rudnik 1 a single flower with 6 flower petals was registered and 4 flowers with 4 flower petals on different individuals and in different inflorescences. In population Rudnik 2 only one flower with 6 petals was registered. Population Rudnik 3 had the highest number of flowers (5) with 6 flower petals in various inflorescences and on different individuals. No inflorescences in which each flower had 4 flower petals were registered. In population Rudnik 3 one flower with 4 flower petals and two flowers with 6 flower petals were found.

There are no statistically significant differences in the diameter of individual flowers in inflorescences between populations (Test statistic = 6.00; $p > 0.05$). The diameter of individual flowers was the largest in populations Rudnik 1 and Rudnik 2, and the smallest in population Rudnik 3 (Fig. 5).

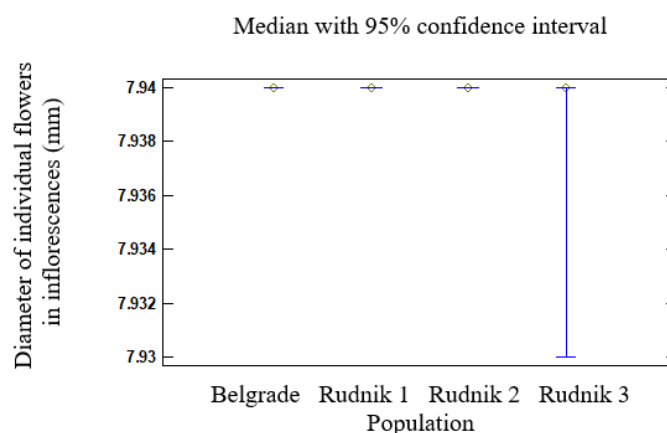


Figure 5. Kruskal-Wallis's test for diameter of individual flowers in inflorescences

There are statistically significant differences in the sex of flowers between populations (Test statistic = 15.63; $p < 0.05$). Differences in the sex of flowers exist between population Belgrade and Rudnik 2 ($W = 4,92150E7$; $p < 0.05$), Rudnik 1 and Rudnik 3 ($W = 4,90100E7$; $p < 0.05$), Rudnik 2 and Rudnik 3 ($W = 4,86950E7$; $p < 0.05$), while among other population differences were not statistically significant (Fig. 6). Mean values indicate that in all populations dominate unicameral trees of Norway maple and unipolar flowers. In all populations, the number of female flowers is greater than the number of male flowers. The highest average number of male flowers is registered among trees of population Rudnik 3 (4793), while the highest average number of female flowers is noted in trees in population Belgrade (5311) and Rudnik 2 (4792). Bipolar flowers were registered on 1% of the trees.

Cluster analysis

Cluster analysis based on the average value of the morphological characteristics of flowers and inflorescences (inflorescence diameter, number of flowers in the

inflorescence, and the diameter of the individual flowers) indicates the separation of homogeneous groups on the low level of the hierarchy of populations of Belgrade and Rudnik 1. Somewhat more distant is the population Rudnik 2 and the outermost is population Rudnik 3 (Fig. 7). Populations Belgrade and Rudnik 1 are similar in the width of the inflorescence and the diameter of individual flowers in the inflorescence.

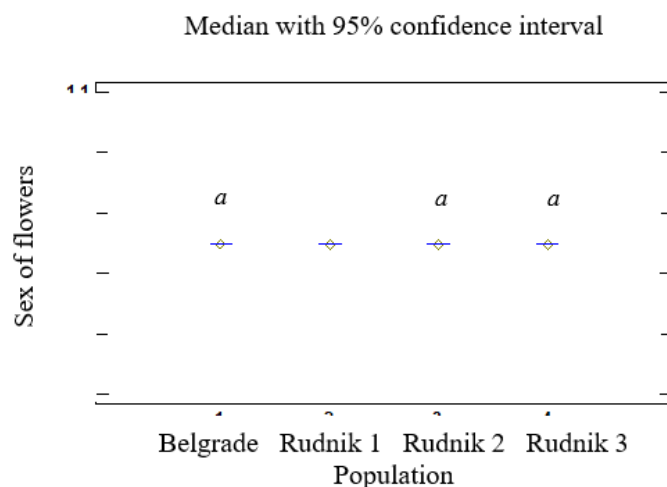


Figure 6. Kruskal-Wallis's test for sex of flowers. *significantly different populations are marked with the letter a

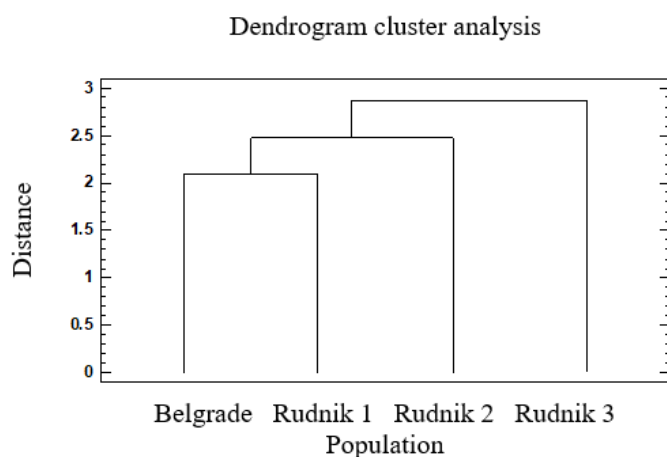


Figure 7. Dendrogram cluster analysis of characteristics of flowers and inflorescences

The hypothesis that the populations from natural habitats in Rudnik will be grouped has not been confirmed by dendrogram analysis. As the most similar, populations of Belgrade and Rudnik 1 were grouped. The other two populations in Rudnik have been grouped as follows: Rudnik 2 is the closest to the homogeneous pair, while Rudnik 3 stands at the same distance as compared to the homogeneous group and to population Rudnik 2. Populations Belgrade and Rudnik 1 whose age of the trees is approximately the same were clustered. Population Rudnik 2 is located at a smaller distance from the homogeneous pair compared to population Rudnik 3 and by the altitude of the location,

it is more similar to homogeneous pair of populations than Rudnik 3. Population Rudnik 3 is located at the highest altitude and is characterized by trees of various ages.

Cluster analysis shows that the trees of the same population Rudnik 3 differ the most one from another by the characteristics of flowers and inflorescences. Trees differ in all the characteristics and cluster showed that tree number 382 stands out (which is characterized by: mean diameter of the inflorescence of 74.20 mm, the average number of flowers per inflorescence 21.10, the average number of flower petals 5.00 and the mean diameter of individual flowers of 7.70 mm) as well as the tree number 395 (which is characterized by: mean diameter of the inflorescence of 71.70 mm, the average number of flowers per inflorescence 19.20, the average number of flower petals 5.00, and the mean diameter of individual flowers from 7.80 mm).

Tree number 382 is in characteristics of flowers and inflorescence similar to trees (314, 307, 325, 354, 397, 375, 381, 333, 384, and 362) from the same population as well as the trees (284, 209, 216 and 249) from population Rudnik 2. Tree number 395 is also similar in characteristics of flowers and inflorescence to trees (388, 393, and 394) from the same population and trees (222 and 215) from population Rudnik 2. This finding is consistent with the dendrogram analysis of flowers and inflorescence at the population level, which shows the closeness of populations Rudnik 2 and Rudnik 3. Dendrogram analysis confirmed that between the trees of population Rudnik 3 exists great variability in the morphological characteristics of flowers and inflorescences.

Superior individuals isolated by the cluster analysis are distinguished by the greater width of the inflorescence and a larger number of flowers in the inflorescence. This indicates morphological differences that point to lower taxonomic units.

Principal component analysis

To determine which of the qualities bear the greatest part of variability and to confirm the grouping of individuals determined by cluster analysis, an analysis of the principal components was conducted. Principal component analysis shows a separation of two main components of flowers and inflorescences. The most significant one is the width of the inflorescence and the number of flowers in the inflorescence (*Table 2*). The cumulative variance was 60.67%. The first component is the width of the inflorescence and the variance is 33.27% (*Table 2*).

Table 2. *Principal component analysis*

Components	Value	Variance	Cumulative %	Component 1	Component 2
The width of the inflorescence	1.33096	33.274	33.274	0.733834	0.182106
Number of flowers per inflorescence	1.09573	27.393	60.667	0.657035	-0.434749
Diameter of individual flowers	0.99840	24.960	85.627	0.169693	0.874448

Principal component analysis of flowers and inflorescence does not show a clear grouping to different populations (*Fig. 8*).

Correlations

Correlations between the components are statistically highly significant but weak. The highest correlation was found between the number of flowers in inflorescence and inflorescence width ($r = 0.32$; $p < 0.05$), while a weak negative correlation was noted

between the number of flowers per inflorescence and the individual flower diameter ($r = -0.11$; $p < 0.05$) (Table 3).

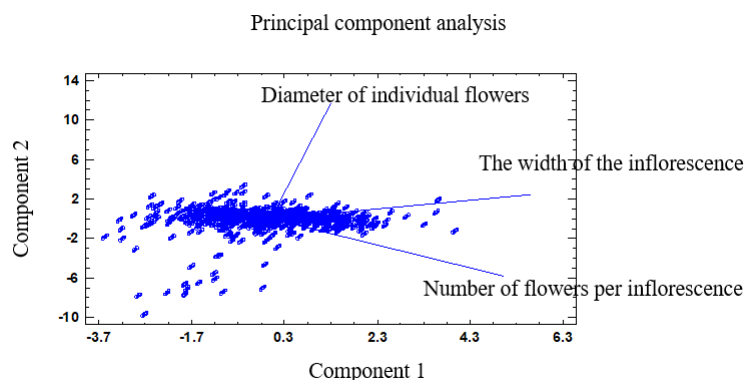


Figure 8. Principal component analysis of flowers and inflorescence

Table 3. Correlations of morphometric characteristics of flowers

Characteristic	The width of the inflorescence	Number of flowers per inflorescence	Diameter of individual flowers
The width of the inflorescence (number of samples)		0.3229 (40000)	0.1789 (40000)
P-value		0.0000	0.0000
Number of flowers per inflorescence (number of samples)	0.3229 (40000)		-0.1149 (40000)
P-value	0.0000		0.0000
Diameter of individual flowers (number of samples)	0.1789 (40000)	-0.1149 (40000)	
P-value	0.0000	0.0000	

Analysis of variance and Duncan's multiple intervals test

The differences in morphology between the flowers and the inflorescence of samples taken from different locations were significant ($p < 0.01$), but they are not the result of different locations of trees ($r^2 < 1\%$) (Table 4).

The morphology of the flowers and the inflorescence is different in all studied populations for the parameters: the sex of the flowers ($F = 5$, $DF = 3$, $p < 0.01$), the number of flowers per inflorescence ($F = 1$, $DF = 3$, $p < 0.01$), inflorescence width ($F = 28$, $DF = 3$, $p < 0.01$) and diameter of the individual flowers in inflorescence ($F = 18$, $DF = 3$, $p < 0.01$).

Duncan's multiple intervals test shows that differences in the morphometric characteristics of flowers and inflorescences are not the result of different locations of trees for any of the measured parameters ($p > 0.01$ for the sex of flowers, the number of flowers per inflorescence, the number of flower petals, inflorescence width, and diameter of the individual flowers in inflorescence).

Table 4. Analysis of variance

Effect		Value	F	Degrees of freedom (DF)	Error df	Significance (Sig.)
Intersections	Pillai's Trace	0.999	9621192.641 ^b	4.000	39993.00	0.000
	Wilks' Lambda	0.001	9621192.641 ^b	4.000	39993.00	0.000
	Hotelling's Trace	962.288	9621192.641 ^b	4.000	39993.00	0.000
	Roy's Largest Root	962.288	9621192.641 ^b	4.000	39993.00	0.000
Population	Pillai's Trace	0.003	9.993	12.000	119985.00	0.000
	Wilks' Lambda	0.997	10.003	12.000	105811.82	0.000
	Hotelling's Trace	0.003	10.011	12.000	119975.00	0.000
	Roy's Largest Root	0.003	29.287 ^c	4.000	39995.00	0.000

Discussion

The great genetic potential enables Norway maple to acclimatize and survive in different environments (Yao and Tigerstedt, 1995; Westergaard, 1997; Joyce et al., 2002; Eriksson et al., 2003). It can adapt to changed environmental conditions by varying the morphological characteristics of habitus and individual plant parts. Although the appearance of the flowers, inflorescence, leaves, and fruits is generated by general characteristics of the species (Poorter and Rozendaal, 2008) and developmental stability of Norway maple generally is not disturbed by the unfavorable growing conditions, variations of a specimen can be taken as a representative of the species (Messier et al., 2010).

According to the literature data, the length of Norway maple flower petals is 3 - 4 mm (Vukićević, 1982), while the diameter of the individual flowers in the studied population is in the range of 5.04 to 8.74 mm. The width of the inflorescence, number of the flowers, and the diameter of individual flowers of the tested samples are in accordance with the literature data. The variability is the greatest in the number of flowers per inflorescence and the diameter of the flower has the smallest variation. Unicameral trees with a larger number of female flowers dominate, although no tree or population is singled out by the sex.

The number of the flowers in the inflorescence, diameter of flowers, and the number of petals does not significantly differ among the sites (plots) and proves to be among the key characteristics of the species, while the sex and the width of the inflorescence have the potential to finetune to the various environments. The sex of the flowers depends on many factors and this characteristic of Norway maple must be examined in the laboratory as it is primarily on the genetic level and it is less likely that environmental conditions significantly affect the sex of Norway maple (Irish and Nelson, 1989; Charlesworth, 2002). On the other hand, the size of the inflorescence differed significantly among all the populations. One of the mechanisms of adaptation that facilitates pollination is developing inflorescence in which insects can pollinate more flowers at the same time. The size of the flower is another mechanism that facilitates pollination. The small flowers are easier to be moved by the wind and, thus, this

characteristic of flowers is particularly favorable for pollination. These characteristics affect the survival of Norway maple in different environments.

The third of variability in inflorescence comes from the differences in the width of the inflorescence and with the number of the flowers in the inflorescence explains two-thirds of the variability in the Norway maples' inflorescence traits. The cumulative variance of these characteristics is 60.67%, of which 33.27% are the variation in the width of the inflorescence. Correlations between the components are statistically significant but weak. The number of flowers per inflorescence expectedly correlates with the width of the inflorescence ($r = 0.32$; $p < 0.05$), while a weak negative correlation exists between the number of flowers in inflorescence and the diameter of the individual flowers ($r = -0.11$; $p < 0.05$). These data show that, based on the characteristics that vary the most, we can select superior individuals and use them for the selection of cultivars with smaller or bigger flowers (*macroflora* and *microflora*). The trees with a larger width of the inflorescence and a large number of flowers in the inflorescence, as well as those with significantly smaller flowers and inflorescences can be used as a starting material for multiplication and further research. The thresholds would be based on the mean values and significantly smaller or bigger size of the flowers and smaller or bigger size of the inflorescence (such examples are trees number 382 and 395 of the same populations but also 284, 209, 216, 249, 314, 307, 325, 354, 397, 375, 381, 333, 384, and 362 similar to the sample 382 and 222, 215, 388, 393, and 394 similar to sample 395). Dendrogram cluster analysis of single trees highlights those that stand out by all the parameters and that is the methodology of singleing out the samples with the superior characteristics. Their selection and reproduction in nurseries would benefit the interests of landscape design. This is especially valuable for urban green areas where Norway maple is commonly used.

Analysis of variance and Duncan's multiple intervals test also show that the differences are statistically significant for each of the parameters ($p < 0.01$), but they are not the result of different locations of trees ($r^2 < 1\%$) similarly to some other characteristics of Norway maple (Pagter et al., 2010). Results indicate that we can't speak about ecotypes but rather an adjustment of certain characteristics to the environment. Therefore, the process driving trait variation is not the location but might be a single parameter of the environment or a few determinative ones.

Cluster analysis shows the great similarity of morphological characteristics of flowers and inflorescences between populations Belgrade and Rudnik 1. Populations Rudnik 2 is somewhat more distant, and the most distant is population Rudnik 3 characterized by the smallest flowers and inflorescences. The fact that individuals of similar characteristics might be found in different populations supports the similarities among populations shown by cluster analysis. Therefore, it is in line with the fact that the number of trees with flowers of the biggest width of the inflorescence is largest in populations Belgrade and Rudnik 3 although they are the most distant.

Trees in population Rudnik 3 show the greatest variability in the appearance of the flowers. In population Rudnik 3 a tree (382) stands out with the largest average diameter of the inflorescence (74.20 mm), the largest number of flowers per inflorescence (21.10), and smaller diameter of individual flowers (7.70 mm), but also a tree (395) with the smallest average diameter of the inflorescence (71.70 mm), the lowest average number of flowers per inflorescence (19.20) and the biggest diameter of individual flowers which indicates a large variability of Norway maple's morphological characteristics. This is also in accordance with the negative correlation between these

traits. This within-species variation relations to dynamics and structure of the community proved to be important once again like stated in previous studies (Bolnick et al., 2003; Ibanez et al., 2004; Clark, 2005).

On the other hand, Rudnik 1 and Beograd population are the most similar and, although the environmental conditions are not identical, they are placed at the same altitude, proving the importance of this environmental feature to the characteristics of Norway maple's flowers and inflorescences. The inflorescences of trees in population Belgrade do not stand out in the number of flowers in inflorescence compared to the other populations. The researchers cite high estimated coefficients of Norway maple for extra variation that suggests good potential for adaptation to the changed environmental conditions. Thus, species that are adapted to urban conditions have priority for inclusion in the network of populations as a source of genes (Eriksson et al., 2003).

Conclusion

Identifying the variabilities in morphological characteristics of flowers of Norway maple enables preservation of the gene pool and has a practical application in characterization of the species, assessing the potential of the species and the prospects for the application of selected cultivars.

The differences between populations were registered in relation to the width of inflorescences, the number of flowers in the inflorescence, and the size of individual flowers of Norway maple. Out of 5 selected parameters, only the number of flowers in the inflorescence, diameter of flowers, and the number of petals proved to be sustainable throughout various environments and pivotal in the characterization of the species. The great variability of the width of the inflorescence and the size of the individual flowers allows Norway maple to adjust to different environments. The greatest variability potential is in the width of the inflorescence although the number of flowers in the inflorescence and diameter of flowers are negatively correlated, tending, as a result, to the same width of the inflorescence.

The great genetic potential of Norway maple enables its survival in different environments and provides successful methods of acclimatization. From population Rudnik 3, which varies the most, genotype 395 was isolated with the minimum average size of flowers and inflorescences as well as 382 with the biggest flowers. Isolation of individual genotypes indicates the great variability of morphological characteristics of flowers and inflorescences of Norway maple. In that sense, this research is a good basis for further nurturing the lower taxa (*microflora* and *macroflora*).

Cluster analysis confirms the great variability of population Rudnik 3 while showing that populations Belgrade and Rudnik 1 are the most similar. Although morphology between populations from various locations is significantly different, the environment accounts for very little variations in morphology but might be related to a certain parameter. Such examples are populations Belgrade and Rudnik 1 that are at the same altitude and are closest in the appearance of their inflorescences. The research on biometric characteristics of inflorescence showed that the urban population does not stand out compared to populations from natural habitats, thus proving the potential of the species for usage in the urban green areas.

It can be concluded that the sanitary and aesthetic functions of Norway maple in green areas and in natural populations remains unchanged through different environmental conditions. Therefore, this species has a good perspective for use in

urban areas, while the large morphological variability will ensure good reproducibility and survival in changed climatic and edaphic conditions. Isolation of different cultivars and genotypes creates a starting point for creating scale of genetic and morphological variability in relation to different environments.

Acknowledgements. Research was funded through project of Ministry of Education, Science, and Technological development of Serbia, grant number TR31041.

Authorship contribution statement. Isidora Simovic: Investigation, Formal analysis, Data curation, Writing - original draft; Mirjana Ocookoljic: Conceptualization, Writing – original draft, reviewing and editing, Funding acquisition.

Conflict of Interests. The authors declare that they have no competing interests, or other interests that might be perceived to influence the results and/or discussion reported in this paper.

REFERENCES

- [1] Anastasijević, N. (1979): The age of ally trees along the streets of Belgrade city center (in Serbian: Starost stabala drvoreda duž ulica središnjeg dela Beograda). – University of Belgrade, Serbia.
- [2] Bertin, R. I., Manner, M., Larrow, B., Cantwell, T., Berstene, E. (2005): Norway Maple (*Acer platanoides*) and Other Non-Native Trees in Urban Woodlands of Central Massachusetts. – *The Journal of the Torrey Botanical Society*. Torrey Botanical Society 132(2): 225-235. Available at: <http://www.jstor.org/stable/20063763>.
- [3] Bolnick, D., Svanbäck, R., Fordyce, J., Yang, L., Davis, J., Hulsey, C., Forister, M. (2003): The Ecology of Individuals: Incidence and Implications of Individual Specialization. – *The American naturalist* 161: 1-28. doi: 10.1086/343878.
- [4] Charlesworth, D. (2002): Plant sex determination and sex chromosomes. – *Heredity* (Edinb) 88(2): 94-101. doi: 10.1038/sj.hdy.6800016.
- [5] Clark, J. S. (2005): Why environmental scientists are becoming Bayesians. – *Ecology Letters* 8(1): 2-14. doi: <https://doi.org/10.1111/j.1461-0248.2004.00702.x>.
- [6] Clark, J. S., McLachlan, J. S. (2003): Stability of forest biodiversity. – *Nature* 423(6940): 635-638. doi: 10.1038/nature01632.
- [7] Eriksson, G., Black-Samuelsson, S., Jensen, M., Myking, T., Rusanen, M., Skrøppa, T., Vakkari, P., Westergaard, L. (2003): Genetic Variability in Two Tree Species, *Acer platanoides* L. and *Betula pendula* Roth, With Contrasting Life-history Traits. – *Scandinavian Journal of Forest Research* 18(4): 320-331. doi: 10.1080/02827580310015422.
- [8] Forestry Planning and Design Bureau (in Serbian: Биро за планирање и пројектовање у шумарству: ЈП “Србијашуме”) (2007): Special map for forestry management for management unit "Rudnik II" (2007-2016) (in Serbian: Посебна основа газдовања шумама за ГЈ “Рудник II” (2007-2016)). – ШГ “Крагујевац” Крагујевац, ШУ Горњи Милановац, Belgrade, Serbia.
- [9] Garnier-Géré, P. H., Ades, P. K. (2001): Environmental Surrogates for Predicting and Conserving Adaptive Genetic Variability in Tree Species. – *Conservation Biology* 15(6): 1632-1644. ISSN 15231739.
- [10] Ibanez, I., Clark, J. S., LaDeau, S. (2004): Fecundity of Trees and the Colonization–Competition Hypothesis. – *Ecological Monographs* 74(3): 415-442.
- [11] Irish, E. E., Nelson, T. (1989): Sex Determination in Monoecious and Dioecious Plants. – *The Plant Cell* 1(8): 737. doi: 10.2307/3868981.

- [12] Joyce, D., Lu, P., Sinclair, R. W. (2002): Genetic variation in height growth among populations of eastern white pine (*Pinus strobus* L.) in Ontario. – *Silvae Genetica* 51: 136-142.
- [13] Kapeller, S., Lexer, M. J., Geburek, T., Hiebl, J., Schueler, S. (2012): Intraspecific variation in climate response of Norway spruce in the eastern Alpine range: Selecting appropriate provenances for future climate. – *Forest Ecology and Management* 271: 46-57. <https://doi.org/10.1016/j.foreco.2012.01.039>.
- [14] Lavorel, S., Garnier, E. (2002): Predicting changes in community composition and ecosystem functioning from plant traits: revisiting the Holy Grail. – *Functional Ecology* 16(5): 545-556. doi: <https://doi.org/10.1046/j.1365-2435.2002.00664.x>.
- [15] Leites, L. P., Robinson, P., Rehfeldt, G. E., Marshall, J. D., Crookston, N. L. (2012): Height-growth response to changes in climate differ among populations of interior Douglas-fir: a novel analysis of provenance-test data. – *Global Change Biology* 22: 154-165.
- [16] McGill, B. J., Enquist, B., Weiher, E., Westoby, M. (2006): Rebuilding community ecology from functional traits. – *Trends in Ecology & Evolution* 21(4): 178-185. doi: <https://doi.org/10.1016/j.tree.2006.02.002>.
- [17] Messier, J., McGill, B. J., Lechowicz, M. J. (2010): How do traits vary across ecological scales? A case for trait-based ecology. – *Ecology Letters* 13(7): 838-848. doi: <https://doi.org/10.1111/j.1461-0248.2010.01476.x>.
- [18] Nowak, D., Rowntree, R. (1990): History and range of Norway maple. – *Journal of Arboriculture* 16(11).
- [19] Pagter, M., Kristoffersen, A., Brønnum, P., Jensen, M. (2010): Phenotypic differences in development of cold hardiness in three latitudinal populations of *Acer platanoides* L. – *Scandinavian Journal of Forest Research* 25: 412-420. doi:10.1080/02827581.2010.512872.
- [20] Poorter, L., Rozendaal, D. M. A. (2008): Leaf size and leaf display of thirty-eight tropical tree species. – *Oecologia* 158(1): 35-46. doi: 10.1007/s00442-008-1131-x.
- [21] Rodríguez-Quilón, I., Santos-Del-Blanco, L., Serra-Varela, M. J., Koskela, J., González-Martinez, S. C., Alia, R. (2019): Capturing neutral and adaptive genetic diversity for conservation in a highly structured tree species. – *Ecol. Appl.* 26(7): 2254-2266.
- [22] Simović, I., Ocokoljic, M., Obratov-Petkovic, D., Vilotic, D. (2013): Variability of morphological characteristics of Norway maple leaves in urban and natural populations (In Serbian: 'Varijabilnost morfoloških karakteristika lista mleča u urbanoj sredini i prirodnim populacijama'). – *Ecologica* 20(72).
- [23] Simović, I., Ocokoljic, M., Obratov-Petkovic, D., Vilotic, D. (2015): Genetic variability of bilaterally symmetrical fruits of Norway maple in function of species biodiversity conservation. – *Turkish Journal of Agriculture and Forestry* 39: 387-393. doi: 10.3906/tar-1404-148.
- [24] Vukićević, E. (1982): Decorative dendrology (in Serbian: Dekorativna dendrologija). – Belgrade, Serbia.
- [25] Webb, S. L., Dwyer, M., Kaunzinger, C., Wyckoff, P. (2000): The myth of the resilient forest: Case study of the invasive Norway maple (*Acer platanoides*). – *Rhodora* 102(911): 332-354. Available at: <http://www.jstor.org/stable/23313384>.
- [26] Webb, S. L., Pendergast, T. H., Dwyer, M. E. (2001): Response of Native and Exotic Maple Seedling Banks to Removal of the Exotic, Invasive Norway Maple (*Acer platanoides*). – *The Journal of the Torrey Botanical Society* 128(2): 141-149. Available at: <http://www.jstor.org/stable/3088736>.
- [27] Westergaard, L. (1997): Genetic variation in seedling growth and phenology in four latitudinal provenances of Norway maple. – *Forestry* 71(3): 219-227. doi:10.1093/forestry/71.3.219.
- [28] Westoby, M., Wright, I. J. (2006): Land-plant ecology on the basis of functional traits. – *Trends in Ecology & Evolution* 21(5): 261-268.

doi: <https://doi.org/10.1016/j.tree.2006.02.004>.

- [29] Yao, Y., Tigerstedt, P. M. A. (1995): Geographical variation of growth rhythm, height, and hardiness, and their relations in *Hippophae rhamnoides*. – *Journal of the American Society for Horticultural Science* 120(4): 691-698. doi: 10.21273/jashs.120.4.691.