Abstract: The production of selected and reproductive material of known origin makes it necessary to designate the regions of provenance of our most significant forest tree species. The regions of provenance are defined as one or more areas with similar ecological characteristics, in which the stands of a species, subspecies or variety have similar phenotype or genotype characteristics. Two regions of provenance of closely related species, narrow-leaved ash (Fraxinus angustifolia Vahl.) and Balkan ash (Fraxinus pallisae Wilmott) were designated in Serbia based on the analysis of their actual distribution and on the study of ecological vegetation characteristics of their populations.

Keywords: narrow-leaved ash, Balkan ash, region of provenance, ecological-vegetation characteristics, Fraxinus angustifolia, Fraxinus pallisae.

РЕГИОНИ ПРОВЕНИЈЕНИЦЈА Fraxinus angustifolia Vahl. И Fraxinus pallisae Wilmott У СРБИЈИ

Извод: Производња селекционисаног и репродуктивног материјала познатог порекла намеће потребу дефинисања региона провенијенција наших најзначајнијих врста шумског дрвећа. Региони провенијенције се дефинишу као једна или више области са сличним еколошким карактеристикама, у којима састојине врсте, подврсте или варијетета имају сличне фенотипске или генотипске карактеристике. Два региона провенијенције веома сродних врста — пољског јасена (Fraxinus angustifolia Vahl.) и маљавог пољског јасена (Fraxinus pallisae Wilmott) су дефинисана у Србији на основу њиховог стварног распрострањења и проучавања еколошко-ветгетацијских карактеристика њихових популација

Кључне речи: пољски јасен, маљави пољски јасен, регион провенијенција, еколошко-ветгетацијске карактеристике, Fraxinus angustifolia, Fraxinus pallisae.

1. INTRODUCTION

Modern plant production must be based on good-quality seed and planting material of known origin and, for this reason, the organisation of production of forest reproductive material must be based on scientific foundations, with the
legal regulation of the matter.

Since the early 1990s, Europe has been developing a policy network that supports the concept that “local is the best”, at least in the context of planting for non-production objectives. Regarding seed sources, European forest policy has a strong focus on local planting material, and defining more varied roles of forests. According to the Helsinki Guidelines developed by the Second Ministerial Conference on the Protection of Forests in Europe (MCPFE 1993), “native species and local provenances should be preferred where appropriate”. The “appropriate” context for local material is in planting primarily for conservation and environmental objectives, and this criterion does not necessarily need to be applied in plantations for timber, where the best selected material may not be local (FRAXIGEN 2005). For common ash and narrow-leafed ash, genetic improvement programs remain important at both national and regional levels to identify superior reproductive material for production planting within a plantation environment. At the same time, there is a growing interest in seed sourcing for enrichment planting and ecological restoration. The principles of the Helsinki Guidelines have been repeated in the resolutions adopted by the subsequent MCPFE conferences in Lisbon (1998) and Vienna (2003).

The EC Council Directive 1999/105/EC on the marketing of Forest Reproductive Material (FRM) expanded the list of species subject to regulation to 46, which includes *Fraxinus angustifolia* Vahl. The directive is interpreted through legislation in each member state, controlling the marketing of FRM of these species. Serbia also has harmonized its legislation on FRM with this directive. In Serbia, regions of provenances are defined for several species, using different methodologies. For example, regions of provenances were defined based on: variability of chloroplast DNA of sessile oak (Šijačić-Nikolić, M. *et al.* 2009), genetic variability of Austrian pine (Lučić, A. *et al.* 2010), genetic-ecological variation of Scots pine (Lučić, A. *et al.*, 2011), and spatial distribution of population of beech (Ivetić, V. *et al.*, 2012).

The Law on Forest Reproductive Material (“Official Gazette of the Republic of Serbia”, No. 135/2004, 8/2005) defines the four categories of reproductive material:

1. **Source identified** reproductive material derived from trees or stands, of which the altitude and the region of provenance are known;
2. **Selected** reproductive material produced in seed stands;
3. **Qualified** reproductive material derived from parent trees, clones, clonal mixtures or from seed orchards, phenotypically selected at individual level;
4. **Tested** reproductive material produced in seed stands and seed orchards, derived from parent trees, clones or clonal mixtures whose superior quality must be recognised by comparative tests, compliant with the regulations on the release of forest plant varieties, or evaluated based on the genetic quality of the parts of basic material.

Only the selected, qualified or tested reproductive materials may be used for forest establishment and regeneration. Source identified reproductive material can be used only within the same region of provenance, if there is not a sufficient supply of the selected, qualified or tested seeds, or if the volume of afforestation has to be additionally increased because of force majeure (forest fire, natural...
disasters, etc.).

The production of the selected material and source identified reproductive material makes it necessary to designate the regions of provenance of our most significant forest tree species. The regions of provenance are defined as one or more areas with similar ecological characteristics, in which the stands of a species, subspecies or variety have similar phenotype or genotype characteristics.

The genus *Fraxinus* (Fam. Oleaceae) includes 65 species, mostly in temperate regions, less often in subtropical and tropical zones. In Serbia there are 4 native species in this genus: flowering ash (*F. ornus* L.), white ash (*F. excelsior* L.), narrow-leaved ash (*F. angustifolia* Vahl.), and Balkan ash (*F. pallisae* Willmott) (Jovanović, B., 1973). The last two species are closely related, and many authorities consider them to be conspecific (e.g. FRAXIGEN 2005). In this paper, regions of provenances of two closely related species, narrow-leaved ash and Balkan ash were designed based on the analysis of their actual distribution and on the study of ecological vegetation characteristics of their populations. Based on our research, it was possible to designate homogeneous units - regions distinguished by similar climate, soil and vegetation characteristics of the site, as well as by phenotype and genotype similarities of the analysed populations.


Speaking about native narrow-leaved ashes, *Fraxinus angustifolia* Vahl. is distributed along the coasts of the Mediterranean Sea and the Black Sea, the Atlantic in Portugal, in western France, and in the region of Pannonia, while *Fraxinus pallisae* Wilmott grows in southern Ukraine, Moldavia, Romania, Bulgaria, Macedonia and north eastern Serbia (Jovanović, B., 2007). On the Balkan Peninsula, *Fraxinus angustifolia* Vahl. ranges along the sea coast and in the river valleys in Albania, Greece, Romania and Bulgaria. In Serbia, *Fraxinus angustifolia* Vahl. is distributed in the region of Pannonia and in river valleys, where it has probably been preserved thanks to the effect of water bodies (Jovanović, B., 1991). The only recorded native site of *Fraxinus pallisae* Wilmott is in the extreme eastern Serbia, around Negotin - former Negotinsko blato (Jovanović, B., 1957, 2007). This extreme eastern part of Serbia - Krajina, possesses climatic peculiarities, compared to other parts of Serbia, caused by its remoteness from the sea and openness to the Wallachian lowland, so this area is one of the driest in former Yugoslavia, and possesses the most pronounced continental climate in Serbia (Jovanović, B., 1997).

**2. MATERIAL AND METHODS**

With the aim of determining the actual distribution of narrow-leaved ashes in Serbia, as the base for the designation of the regions of provenance of these
species, we started from the data of the National Forest Inventory of the Republic of Serbia, which were collected within the framework of the Project of the same name, realised by the Faculty of Forestry, University of Belgrade. The collected data refer to clusters – reference points in which narrow-leaved ash was recorded.

The clusters, i.e. sets of sample plots, were surveyed in order to assess the state of the growing stock and to evaluate the tendencies of its development. Cluster network was designed in the grid of 4 x 4 km; the distance between cluster centres (reference points) was 4 km. By the applied methodology, each cluster consists of four sample plots. The centre of the first sample plot at the point of the intersection of the cluster network, i.e. in the reference points, and the other three sample plots are distributed on the vertexes of the square, the side of which is 200 m. The centres of clusters and sample plots are determined by the coordinates, and the reference points (centres of clusters) are located in the field by the application of the GPS unit (National Forest Inventory of the Republic of Serbia – Technical Manual).

Each reference point (cluster) has an organised data base consisting of: coordinates, general cluster and sample plot indications (district, municipality, management unit, compartment and subcompartment, site description (soil type, altitude, slope, aspect, ownership, soil risk, dead cover and humification process) and stand description (tree species, age, stand classification, stand origin and structure, stand development stage, mixture, canopy closure, main characteristics of regeneration, naturalness, and the possibility of site treatment).

3. RESULTS AND DISCUSSION

Distribution of Fraxinus angustifolia Vahl. and Fraxinus pallisae Wilmott is, based on the data of the National Forest Inventory of the Republic of Serbia, presented in Table 1.

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| № 1665 | 4938000 | 7404000 | Владимировци | 113 | private | nat.gen.stand | clean broad.st. |
| № 1443 | 4954200 | 7384000 | Шабац | 128 | private | nat.gen.stand | clean broad.st. |
| № 1347 | 4966200 | 7392200 | Шабац | 765 | private | nat.copp.stand | mix.broad.st. |

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| № 1807 | 4930200 | 7432000 | Ub | 91 | private | nat.gen.stand | mix.broad.st. |
| № 1807 | 4930200 | 7432200 | Ub | 101 | private | nat.gen.stand | clean broad.st. |
| № 1804 | 4930000 | 7420000 | Ub | 133 | private | nat.gen.stand | clean broad.st. |
| № 1938 | 4922000 | 7428000 | Ub | 166 | private | nat.copp.stand | mix.broad.st. |
| № 2173 | 4910200 | 7416200 | Valjevo | 235 | Private | nat.copp.stand | clean broad.st. |

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| № 1686 | 4938000 | 7488000 | Smederevo | 75 | Private | nat.copp.stand | clean broad.st. |
| № 2093 | 4914200 | 7508200 | V. Плана | 100 | Private | nat.copp.stand | mix.broad.st. |</p>
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**13 POMORAVSKI DISTRICT**

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The studied species were recorded in 14 districts, at the altitudes between 100 and 300 m. Almost all recorded sites are that of *Fraxinus angustifolia* Vahl.

In *Srednje-Banatski District*, narrow-leaved ash was recorded in one cluster in the municipality Zrenjanin, at the altitude of 75 m.

In *Zapadno-Bački District*, narrow-leaved ash was recorded in 9 clusters, in the municipalities Apatin and Sombor, at the altitudes up to 100 m.

In *Južno-Bački District*, it was recorded in the municipality Bač (5 clusters), at the altitudes up to 100 m.

In *Sremski District*, it was recorded in 43 clusters, in the municipalities Śid, Pećinci, Sremska Mitrovica and Ruma, at the altitudes between 70 and 100 m.

In *Mačvanski District*, it was recorded in the municipalities Šabac, Bogatić, Vladimirci and Loznica, in 19 clusters, at the altitudes from 70 to 765 m.

In *Kolubarski District*, it was recorded in the municipalities Ub and Valjevo at the altitudes from 100 to 235 m.

In *Podunavski District*, it was recorded in the municipalities Smederevo, Smederevska Palanka and Velika Plana at the altitudes from 75 to 170 m.

In *Braničevski District*, it occurred in a greater number of municipalities, at the altitudes between 80 and 190 m.

In *Šumadijski District*, narrow-leaved ash was recorded at the altitudes from 168 to 288 m. It occurred in the municipalities Knić, Rača, Aranđelovac and Kragujevac.

In *Pomoravski District* and *Borski District*, there was only one cluster with narrow-leaved ash, at the altitudes above 200 m.

In *Moravički District*, it was recorded in the municipality Čačak, at the altitudes between 230 and 320 m.

In *Raški District*, it was recorded in the municipality Kraljevo, at the altitudes from 217 to 240 m.

In *Belgrade city* territory, it was recorded in the municipalities Obrenovac, Zemun, Lazarevac and Mladenovac, mainly at the altitudes up to 100 m, except in the municipalities Lazarevac and Mladenovac, where it grows at the altitudes 110, i.e. 170 m, respectively.

*Borski District* is specific, because it is the only region where, apart from *Fraxinus angustifolia*, *Fraxinus pallisae* was also recorded. That was the basis to set apart this district, as a separate region of provenance.

Therefore, two regions of provenance of narrow-leaved ashes were established in Serbia (Map 1).
Map 1. Regions of provenance of *Fraxinus angustifolia* Vahl. and *Fraxinus pallisae* Willmott in Serbia-green squares represent clusters with recorded studied species, and numbers correspond to District codes in Table 1.

Region One consists of narrow-leaved ash forests (*Fraxinus angustifolia* Vahl.) in Podunavlje and Posavina in Vojvodina (Srednje-Banatski, Zapadno-Bački, Južno-Bački, Sremski, Mačvanski and Kolubarski Districts), and in Posavina, Pomoravlje and Podunavlje in Central Serbia (Podunavski, Braničevski, Šumadijski, Pomoravski, Moravički and Raški Districts, and the territory of
Belgrade city). Narrow-leaved ash in this region forms pure and mixed forests. Pure communities of narrow-leaved ash (Carici remotae-Fraxinetum angustifolii Jovanović et Tomić 2004), and the forests of narrow-leaved ash with grey sallow (Saliceto cinerea-Fraxinetum angustifoliae B. Jovanović 1979) are coenologically stable, but the ecological optimum of narrow-leaved ash is developed in mixed forests with common oak (Fraxino angustifoliae-Quercetum roboris B. Jovanović et Tomić 1979 and Querco roboris-Fraxinetum moesiacae Rudski 1949), at considerably more productive sites (Tomić, Z., 2004; Tomić, Z., Rakonjac, Lj., 2013). In the forest-steppe zone in Vojvodina (in the Danube Basin and Southeast Srem), in the considerably more contrasting climate conditions, narrow-leaved ash forms mixed forests with European white elm (Fraxino-Ulmetum effusae Slavnić 1952). In this area, the prevailing climate is continental (dry) steppe climate except in Šumadija region where the climate is humid (Kolić, B., 1988).

Region Two includes narrow-leaved ash forests in Borski District and East Serbia (Borski District), covering a relatively small geographic area. In this region, in addition to Fraxinus angustifolia, Fraxinus pallisae was also recorded and described, forming the community Querco roboris-Fraxinetum pallisae B. Jovanović (1951)1982, with common oak in Negotinsko Blato. This area is characterised by highly contrasting continental climate (with very cold winters and warm summers) (Kolić, B., 1988).

4. CONCLUSIONS

Narrow-leaved ashes (Fraxinus angustifolia Vahl. and Fraxinus pallisae Willmott), were recorded in 14 Districts in Serbia, at the altitudes between 100 and 300 m, based on the data of the National Forest Inventory of the Republic of Serbia. They form pure and mixed forests (mainly with common oak), which are conditioned by additional moisture - flood or high levels of underground water.

In Serbia, two regions of provenance were designated based on the collected data on narrow-leaved ash species, distribution, plant communities and climate characteristics, as well as the need to define the optimal and operative regions of provenance.

This conclusion on two broad provenance regions for Serbia is in compliance with the general summary of FRAXIGEN research (FRAXIGEN 2005), conducted in narrow-leafed ash populations in several European countries (Bulgaria, Croatia, Greece, Hungary, Italy, Moldova, Romania, Slovakia, Slovenia, Spain and Turkey), on reproductive biology, genetic variation and local adaptation of the species. The main inference of this research has been:

“High levels of gene flow and broad adaptability suggest that the definition of a “local seed source” needs to be broad (up to 250 km scale), and that collection should stress increased distances between seed trees to ensure genetically diverse collections. Too narrow a vision of what is “local” (e.g. only one stand) is likely to result in the use of genetically less diverse material, with poorer adaptive potential”.

The Act on the designation of the region of provenance was passed by the Minister of Forestry. It contains the data on tree species, latitude and longitude, area, altitude, as well as other necessary data. Furthermore, a Map with clearly
defined boundaries of the regions of provenance for each species is a component part of the Act.

Within the designated regions of provenance, it is necessary to analyse the spatial pattern of the locations of the designated seed sources, their number and their actual state. In the cases of non-uniform distribution, insufficient number, or unsatisfactory state of seed forests within individual regions, it is necessary to designate the new ones, to cover the complete ecological, coenological and population diversity of the species.

In this manner, by abandoning the technology of forest seed and planting material production at the level of species, and accepting the level of the region of provenance, the representatives of which are the already designated seed sources, or the seed sources that are still to be designated, the production of forest reproductive material for the purposes of forest regeneration and forest establishment will be enhanced and intensified.

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РЕГИОНИ ПРОВЕНИЈЕНИЦИЈА Fraxinus angustifolia Vahl. И Fraxinus pallisae Wilmott У СРБИЈИ
Раде Цојетићаннин
Мириана Шијачић-Николић
Јелена Миловановић
Марко Иеровић
Маријана Новаковић-Буковић
Резиме
Производња селекционисаног и репродуктивног материјала познатог порекла намеће потребу дефинисања региона провенијенција наших најзначајнијих врста шумског дрвећа, а једна од њих је пољски јасен (Fraxinus angustifolia Vahl.) и њему врло сродна врста маљави пољски јасен (Fraxinus pallisae Wilmott). Пољски јасен је према подацима Националне инвентуре шума Републике Србије, евидентиран на територији 14 округа. Засновано на сагледавању стварног распрострањења пољског јасена и промања еколошко-вегетационских карактеристика његових популација дефинисана су два региона провенијенције ове две врсте у Србији. Први регион чине шуме пољског јасена у Подунављу, Посавини, Поморављу, Шумадији и западној Србији. За овај регион карактерично је присуство само пољског јасена (Fraxinus angustifolia Vahl.), који гради чисте и мешовите шуме (углавном са лужњаком) које су условљене допунским влагањем-поплавном или високим нивоом подземне воде. Други регион чине шуме пољског јасена у Борском округу и источној Србији. За овај регион карактеристично је присутство само пољског јасена (Fraxinus angustifolia Vahl.), који гради чисте и мешовите шуме (углавном са лужњаком) који су условљене допунским влагањем-поплавном или високим нивоом подземне воде. Други регион чине шуме пољског јасена у Борском округу и источној Србији, који су присутне на релативно малом географском подручју, на коме је прелом пољског јасена (Fraxinus angustifolia Vahl.) забележен и описан и маљави пољски јасен (Fraxinus pallisae), који у Неготинском блату, са лужњаком, гради заједницу Querco roboris-Fraxinetum pallisae B. Jovanović (1951) 1982. Унутар дефинисаних региони региона провенијенција потребно је сагледати просторни распоред локација на којима су издвојени семенски објекти, њихов број и трендитно стање. У случају неравномерног распореда у оквиру појединих региона, недовољног броја или незадовољајучег стања семенских објеката потребно је извршити издвајање нових, како би у потпуности била обухваћена еколошка, ценолошка и популяциона разноврсност пољског јасена.

„ШУМАРСТВО” 3-4