CENOECOLOGICAL CHARACTERISTICS OF GREEK MAPLE (*ACER HELDREICHII* ORPH.) IN SERBIA

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Abstract. This paper deals with the cenoecological characteristics of Greek maple (*Acer heldreichii* Orph.) in Serbia, a subendemic species of the Balkan Peninsula which is a strictly protected species in Serbia. The research included the six most representative Greek maple localities in Serbia. Plant communities were defined according to standard Braun-Blanquet method. Ecological spectra (life forms, plant relation to moisture, soil reaction, nitrogen content in soil, light and warmth), as well as chorological spectra were produced. CA vegetation analysis was done using software CANOCO 4.5. It is concluded that Greek maple in Serbia occurs in two plant communities: as a dominant species in beech-Greek maple community (*Aceri heldreichii-Fagetum* B. Jov. 1957) and as a differential species in beech-fir-spruce community (*Piceo-Abietetum* Čolić 1965 subass. *aceretosum heldreichii*). CA analysis distinguishes phytocoenological relevés in three groups. According to life forms spectrum, plant communities have hemicryptophyte-geophyte-phanerophyte character. According to moisture requirement they are mesophilous, according to soil reaction they are mostly neutrophilous, to soil nitrogen content communities are mostly mesotrophic. According to light requirements they range from shade tolerant to semitolerant, and according to the temperature they are mesothermic. Results of chorological analysis show that the Central European floral group is the most frequent, which indicates the mesophilous character of the communities.
Keywords: *endemic, ecology, Balkans, primeval forests, plant community*

Introduction

Greek maple (*Acer heldreichii* Orph.) is a native woody plant species in the flora of Serbia, which represents subendemic species of the Balkan Peninsula and a tertiary relic (Zoranović et al., 2021). This species is strictly protected in Serbia (Službeni glasnik Republike Srbije, 2011). Greek maple is montane species and occurs only at altitudes of 900-2100 m, while individually stretches above the timberline (Alexandrov and Pandeva, 2003). Its ability to grow in conditions suitable only to small number of tree species, stresses its ecological importance on natural sites, where this species protects the soil from erosion, improves ecological conditions for other plant species and provides food and shelter for various animal species. In Serbia, this species was recorded on the following mountains: Rudnik, Goč, Željin, Jastrebac, Tara, Javor, Golija, Kopaonik, Javorje, Stara Planina, Prokletije, Žljeb and Šarplanina (Cvjetićanin and Perović, 2016). According to the data of Serbian National Forest Inventory (Banković et al., 2009), there are totally 816528 individual trees of this species, with a volume of 95318 m³, and a volume increment of 3179 m³.

Taxon *Acer heldreichii* subs. *heldreichii* is endemic in the Balkan Peninsula and grows in Serbia, Bosnia and Herzegovina, Montenegro, Northern Macedonia, Bulgaria, Greece and Albania (Perović et al., 2021), while on Caucasus Mt. occurs *Acer heldreichii* subsp. *trautvetteri* (Medvedev) Murray. Greek maple taxonomically belongs

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to section Acer L., series Acer, so its closest relatives are *Acer pseudoplatanus* L., *A. velutinum* Boiss. and *A. caesium* Wallich ex Grandis (van Gelderen et al., 2010).

This paper investigates cenoecology of Greek maple in Serbia. This species has limited distribution and commercial importance and it was not extensively researched in the past. Since genetic variation is considered an important factor in determining the survival of species in a changing environment and is a fundamental component of biodiversity (Yeon et al., 2021), results of this research, which contribute to the better knowledge of ecological characteristics of Greek maple, will enable more efficient protection and *in situ* conservation of gene pool of this strictly protected species.

Materials and methods

The research was conducted in year 2014. on six localities in Serbia, on the following mountains: Rudnik, Goč, Jastrebac, Stara Planina, Golija and Javorje (*Fig. 1*). The following localities contain the most abundant Greek maple populations in Serbia, with the exception of locality Rudnik, where this species is sparse, but it presents the northernmost border of its global distribution. Coordinates of researched populations are presented in *Table 1*.

Table 1. *Coordinates of researched populations in Serbia*

Locality	Coordinates	Elevation (m a.s.l.)
Rudnik	44° 08’ N; 20° 32’ E	1000-1100
Golija	43°21’ N; 20°16’ E	1400-1700
Goč	43°32’ N; 20°47’ E	1400-1550
Jastrebac	43°24’ N; 21°26’ E	1350-1450
Javorje	43°33’ N; 19°19’ E	1300-1400
Stara planina	43°20’ N; 22°47’ E	1500-1600

Phytocoenological research was conducted by standard method of Braun-Blanquet (Braun-Blanquet, 1964), based on 45 collected phytocoenological relevés, 10 relevés per localities Jastrebac, Goč and Golija, and 5 relevés per localities Rudnik, Javorje and Stara Planina (Perović, 2014). Determination of species was done by „Flora of Serbia” I-X (Josifović et al., 1972-1977; Sarić et al., 1986, 1992; Stevanović et al., 2012). Phytocoenological tables were made on the basis of collected phytocoecological relevés, and plant associations and subassociations were set apart. Names of plant associations were given according to „Codex of Phytocoenological Nomenclature” (Weber et al., 2006) and „Forest phytocenoses of Serbia (Tomić and Rakonjac, 2013). On the basis of the produced phytocoenological tables, ecological and chorological spectra were made using indicator values made by Kojić et al. (1997) and Ellenberg and Leuschner (2010). Ecological spectra include spectrum of life forms and spectra of ecological characteristics (plant relation to moisture, soil reaction, soil nitrogen content, light and warmth). Also, the chorological spectrum was made according to Gajić (1980, 1984). CA vegetation analysis was made using software CANOCO 4.5 (Lepš, Šmilauer, 2002). Transformation of frequency and coverage values for every species was conducted according to method of Van Der Maarel (1979).

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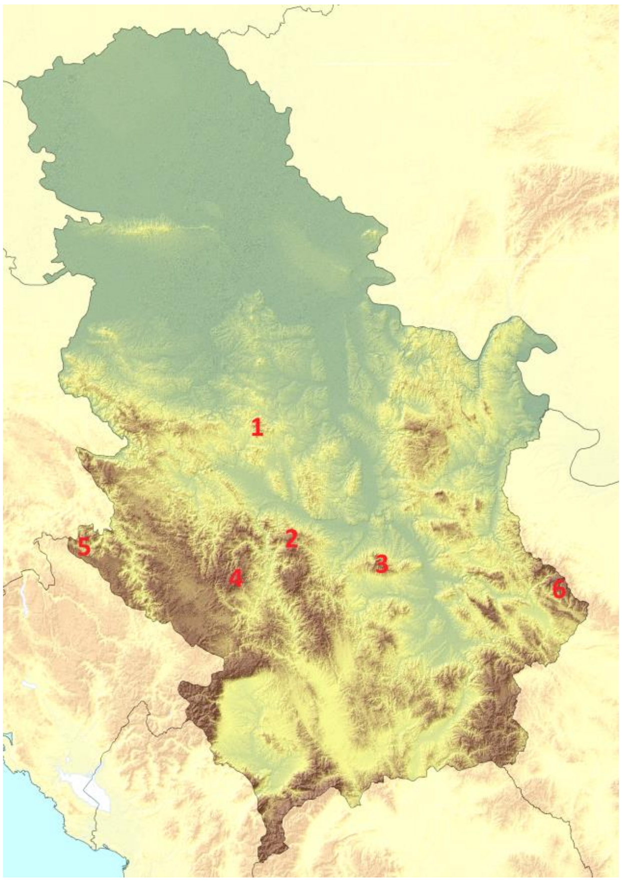

Figure 1. *Map of Serbia with position of researched Greek maple populations. Legend: 1. Rudnik; 2. Goč; 3. Jastrebac; 4. Golija; 5. Javorje; 6. Stara Planina*

Orographic characteristics were determined in the field on all researched sites, and include: elevation, aspect and inclination.

Results and discussion

Coenological characteristics

It is determined that Greek maple (*Acer heldreichii* Orph.) in researched localities grows only in montane vegetation zone, mainly at elevations 1300-1700 m a.s.l., and only in Rudnik it descends to 1000-1100 m a.s.l. This maple grows in various aspects, but mostly in the cold and moist (northern, northwestern), and it was not recorded in the southern aspect. It usually grows on areas without pronounced inclinations, from flat (inclination 0°), to moderately steep terrains (inclination 15-25°), rarely on steeper slopes.

The presented phytocoenological tables contain 97 vascular plant species. In the researched localities, Greek maple occurs in two plant communities. It mostly occurs as a codominant species in plant communities with beech, and builds mixed forest of beech and Greek maple (*Aceri heldreichii-Fagetum* B. Jov. 1957) (localities Rudnik, Goč, Jastrebac and Javorje; *Fig. 2*), where this species reaches its coenological optimum (Milošević and Novaković-Vuković, 2019). In this association, 71 vascular plant species were recorded in 30 phytocoenological relevés. Within this association, two

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subassociations were set apart - subass. *typicum* and subass. *carpinetosum betuli*. Subass. *typicum* is placed within subalpine vegetation zone where populations from localities Goč, Jastrebac and Javorje belong, while subass. *carpinetosum betuli*, recorded on Rudnik, develops in montane vegetation zone, on the lowest recorded elevations for Greek maple in Serbia. Within subass. *typicum* beech and Greek maple completely dominate in tree and shrub layer, with very low number of individuals of other tree species. The most frequent species in the ground layer are *Rubus hirtus* Waldst&Kit., *Dryopteris filix mas* (L.) Schott, *Glechoma hirsuta* Waldst&Kit. and *Acer heldreichii* Orph. regenetation. In subass. *carpinetosum betuli* Greek maple grows in warmer conditions compared to typical *Aceri heldreichii-Fagetum* subas. *typicum* community, which influences floristic composition of *carpinetosum betuli* subassociation, characterized by higher number of plant species not recorded in typical beech and Greek maple community. It mostly refers to the presence of typical mesophyte, common hornbeam (*Carpinus betulus* L.), which is a differential species of *Aceri heldreichii-Fagetum* subass. *carpinetosum betuli* community. Tree layer is much more diverse than in subassociation *typicum*, so apart from beech, Greek maple and hornbeam, *Acer platanoides* L., *Acer pseudoplatanus* L. and *Tilia cordata* Mill have significant participation. Warmer climate in which this community develops favours development of phanerophytes. Shrub layer is completely dominated by regeneration of beech, and to a lesser degree of Greek maple. The most frequent species in the ground layer are *Rubus hirtus* Waldst&Kit., *Dryopteris filix mas* (L.) Schott, *Glechoma hirsuta* Waldst&Kit., *Lamium galeobdolon* (L.)Ehrend, *Athyrium filix femina* (L.) Roth and *Polystichum aculeatum* (L.) Roth (Perović and Cvjetićanin, 2009).

Figure 2. *Forest of beech and Greek maple, Jastrebac Mt.*

Apart from mixed forests with beech, Greek maple occurs as a differential species in beech-fir-spruce mixed forests with Greek maple (ass. *Piceo-Abietetum* Čolić 1965 subass. *aceretosum heldreichii*, syn. *Piceo-Fago-Abietetum* Čolić 1965, subass. *heldreichietosum*) (on Golija and Stara planina; *Fig. 3*). In 16 researched phytocoenological relevés of this association, 51 vascular plant species were recorded. Dominant species in the tree layer are *Picea abies* (L.) Karst., *Fagus sylvatica* L. *subsp. moesiaca* (Maly)Szafer and *Acer heldreichii* Orph. were recorded in almost all relevés, while *Abies alba* Mill. and *Sorbus aucuparia* L also showed significant presence.

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Relatively low participation of fir (presence level II) is probably the consequence of anthropogenic influence in the past, to which fir poorly adapted, being ecologically stenovalent species, compared to, in present site conditions, biologically stronger species of beech and spruce. Also, anthropogenic factor caused secondary increase of Greek maple abundance in this sites, because this species, being protected by law, stands outside of forest management regime and thus competes easier with dominant tree species in this community. In the shrub layer the most frequent species are *Fagus sylvatica* L. *subsp. moesiaca* (Maly)Szafer, *Acer heldreichii* Orph. and *Sorbus aucuparia* L. In the ground layer, the most frequent species are *Rubus hirtus* Waldst&Kit., *Dryopteris filix mas* (L.)Schott, *Lamium galeobdolon* (L.) Ehrend, *Veratrum album* L., *Adenostyles alliariae* (Gouan) A. Kern., *Gentiana asclepiadea* L., *Prenanthes purpurea* L., *Polygonatum verticilatum* (L.) Al, *Poa nemoralis* L., *Rubus idaeus* L., and *Acer heldreichii* Orph regeneration.

Figure 3. *Forest of beech, spruce and fir with Greek maple, Golija Mt.*

Forests with Greek maple on Golija were described in the past also as mixed beech and spruce forests, where Greek maple presents differential species, specified as association *Piceeto-Fagetum silicicolum*, subass. *heldreichietosum* Gajić 1989 (Gajić, 1989). Considering that this mixed beech-spruce community was described in zone where climax beech-fir-spruce forests develop in Serbia (Tomić, 2004), and that individual fir specimens also occur in that community, it is very likely that in this case occurs degraded beech-fir-spruce community *Piceo-Abietetum* Čolić 65 (syn. *Piceo-Fago-Abietetum* Čol. 1965), where the fir was almost completely eradicated due to negative anthropogenic influence. Thus recent phytocoenological nomenclature (Tomić, 2006; Tomić and Rakonjac, 2013) does not accept existence of mixed beech and spruce forests without fir, although they are recorded in several localities in Serbia.

Greek maple mostly builds mixed forests with subalpine beech, and very rarely with spruce, due to its lower frost tolerance compared with spruce, and its similarity to beech in this regard. So, Kojić et al. (1997) put Greek maple and beech in the group of mesothermic species, while spruce is treated as microthermic/mesothermic species. That is the reason that Greek maple in Serbia mostly occurs in conditions with increased maritime climate which is closer to climate conditions of the western part of the Balkan Peninsula. However, Greek maple is more microthermic species than beech and better

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tolerates late spring frosts, which enables it to occur at higher elevations than beech that forms on some mountains narrow vegetation belt above subalpine beech belt, or to occur in pure stands within subalpine beech belt (Lakušić, 1989).

Results of CA analysis showed that phytocoenological releves form three groups (*Fig. 4*), where the left side of the graph contains relevés of mostly beech forests species, while the right side contains relevés of conifer forests species as well. High floristical similarity was observed among relevés from localities Javorje, Goč, Rudnik and Jastrebac (where Greek maple builds mixed forests with beech). On these localities, apart from domination of beech (*Fagus sylvatica* L. *subsp. moesiaca* (Maly)Szafer) and Greek maple (*Acer heldreichii* Orph.), typical species of beech forests occur (*Fig. 5*): *Lunaria rediviva* L., *Daphne mezereum* L, *Geranium macrorrhizum* L., *Acer pseudoplatanus* L., *Salvia glutinosa* L. etc. The other group involves releves from Stara planina. In this group, the occurrence of conifer forest species can be observed, with segregated fir (*Abies alba* Mill). Apart from fir, typical species of beech-fir or spruce forests are: *Vaccinium myrtillus* L, *Prenanthes purpurea* L., *Rubus idaeus* L., *Sorbus aucuparia* L. etc. The third group contains relevés from Golija. It contains even more pronounced participation of conifer forest elements, with increasing disappearance of elements of broadleaf forest. Dominant elements are these of subalpine conifer forests: *Picea abies* Karst, *Abies alba* Mill., *Sorbus aucuparia* L, *Gentiana asclepiadea* L. etc.

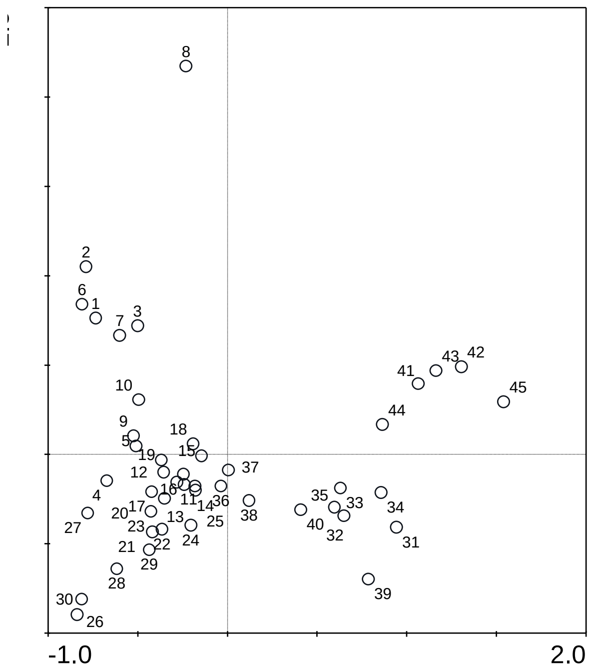

***Figure 4.** CA ordination bi-plot for relevés, (○ - relevé representation), relevés from: 1-10 Jastrebac; 11-20 Goč; 21-25 Javorje; 26-30 Rudnik; 31-40 Golija; 41-45 Stara planina*

Greek maple in Serbia mostly occurs in vegetation zone of subalpine beech forests, where apart from being a mixed species, it can be a dominant species of beech-Greek maple forests (*Aceri heldreichii-Fagetum* Jov. 1957) (Mišić, 1997). Much more rarely, it grows in spruce forest zones.

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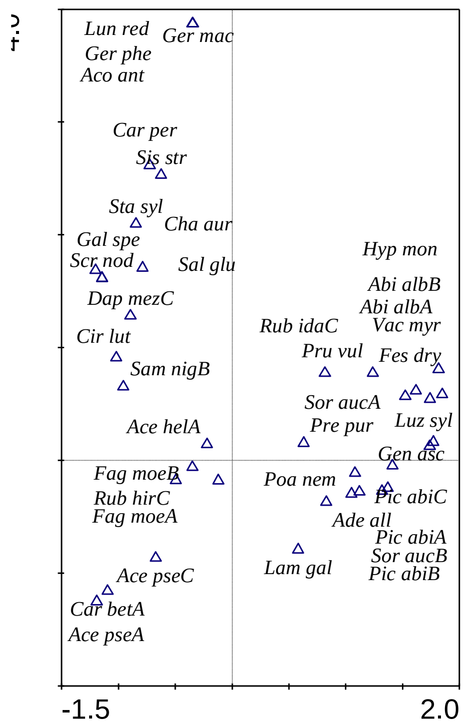

***Figure 5.** CA ordination bi-plot for species, fit range for species 15-100%, 39 species (Δ-species representation). Abbreviations for species: Lun red- Lunaria rediviva; Ger mac- Geranium macrorrhizum; Ger phe- Geranium pheum; Aco ant- Aconitum anthora; Car per- Carduus personata; Sis str- Sisymbrium strictissimum; Sta syl- Stachys sylvatica; Cha aur- Chaerophyllum aureum; Gal spe- Galeopsis speciosa; Scr nod- Scrophularia nodosa; Sal glu- Salvia glutinosa; Dap mez- Daphne mezereum; Cir lut- Circaea lutetiana; Sam nig- Sambucus nigra; Ace hel- Acer heldreichii; Hyp mon- Hypericum montanum; Abi alb- Abies alba; Rub ida- Rubus idaeus; Vac myr- Vaccinium myrtillus; Pru vul- Prunella vulgaris; Fes dry- Festuca drymeia; Sor auc- Sorbus aucuparia; Pre pur- Prenanthes purpurea; Luz syl- Luzula sylvatica; Gen asc- Gentiana asclepiadea; Fag moe- Fagus sylvatica; Rub hir- Rubus hirtus; Ace pse- Acer pseudoplatanus; Car bet- Carpinus betulus; Poa nem- Poa nemoralis; Pic abi- Picea abies; Ade all- Adenostyles alliariae; Lam gal- Lamium galeobdolon. (The abbreviation following the species denotes A-tree layer, B-shrub layer, C-ground flora layer)*

On Ozren mountain in southwestern Serbia, plant community *Pancicio-Aceri heldreichii-Piceetum abietis* Matović 1993 was described, where dominant species are Greek maple and endemic herbacious species of *Pancicia serbica* Vis. This community is of secondary character and represents progradation phase of vegetation development on devastated site of beech-fir-spruce forest. Greek maple, which were mixed species in the previously mentioned primary community, increased its frequency and took position of dominant species, while *Pancicia serbica* Vis., together with other mesophilous species, penetrated from surrounding meadows in thinned forest and became dominant in ground layer (Rakonjac, 2002).

Ecological spectra

Table 2 shows that hemicryptophytes absolutely dominate in both communities, with 54%, i.e. 59% of all plant species. Dominance of hemicryptophytes is expected since this life form is most abundant in the Serbian flora and also represents dominant life

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form in the temperate climate (Diklić, 1984). Both communities show hemicryptophitic-geophytic-phanerophytic character. Community *Piceo-Abietetum* contains somewhat lower share of geophytes and therophytes compared to community *Aceri heldreichii-Fagetum*. Higher share of geophytes was observed (16% in *Piceo-Abietetum* and 21% in *Aceri heldreichii-Fagetum* community) compared to normal life form spectrum in Serbia, where this life form participates with 9% (Jovanović, 2007). This was due to low winter temperatures on researched localities, which resulted in short vegetation period, so the accumulation of nutrients in underground parts enabled flowering of plants at the beginning of the vegetation period (Stevanović and Janković, 2014), when temperature conditions are still unfavorable for photosynthesis. Community of beech and Greek maple contains slightly higher number of geophytes than beech-fir-spruce community. Diklić (1984) states that the highest participation of geophytes occurs in beech forests. This phenomenon is caused by pronounced seasonal light differences in beech forests, which have a very shade tolerant character after leaf development, so they contain significant number of efemorophytes, which finish their life cycle within a very short period (Allaby et al., 2015).

Table 2. *Spectrum of life forms (vascular plant species number and their percentage share)*

Plant community	Life forms				
	Phanerophytes	Chamaephytes	Hemicryptophytes	Geophytes	Therophytes
Aceri heldreichii-Fagetum	12 (17%)	1 (1%)	38 (54%)	15 (21%)	5 (7%)
Piceo-Abietetum subass. *aceretosum heldreichii*	10 (20%)	2 (4%)	30 (59%)	8 (16%)	1 (2%)

Table 3 shows that mesophytes absolutely dominate in both communities (98% of mesophytes and submesophytes in community *Piceo-Abietetum*, and 93% in community *Aceri heldreichii-Fagetum*), so both communities are strongly mesophilous.

Table 3. *Relation of plant species toward soil moisture (vascular plant species number and their percentage share)*

Plant community	Ecological groups of plants			
	Xerophytes	Subxerophytes	Submesophytes	Mesophytes
Aceri heldreichii-Fagetum	1 (1%)	4 (6%)	53 (75%)	13 (18%)
Piceo-Abietetum subass. *aceretosum heldreichii*	-	1 (2%)	44 (86%)	6 (12%)

Table 4 shows that both plant communities have neutrophilous character (48% neutrophilous species in *Aceri heldreichii-Fagetum*, and 45% in *Piceo-Abietetum* community). It can be noted that community *Piceo-Abietetum* contains lower share of alkaliphilous species in comparison with *Aceri heldreichii-Fagetum* (14% to 25%), which is caused by high soil acidification in this community.

Table 5 shows that both communities have mesophitic character, with participation of mesophitic species of 56%, i.e. 52%. That confirms the observation that Greek maple occurs on relatively favorable sites, with developed soil profiles, well provided with nutrients (Lakušuć, 1989). Its main associate, beech is also a typical mesotrophic species (Houston Durrant et al., 2016). There is a slight increase of eutrophic and significant decrease of oligotrophic species in community *Aceri heldreichii-Fagetum* compared to community *Piceo-Abietetum* (7% of oligotrophic species compared to 20%

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in *Piceo-Abietetum*), which implies that forest of beech and Greek maple is more favorable for plant species development regarding nutrient supply.

Table 4. *Relation of plant species toward soil reaction (vascular plant species number and their percentage share)*

Plant community	Ecological groups of plants				
	Acidophiles	**Acidophiles-neutrophiles**	**Neutrophiles**	**Neutrophiles-alkaliphiles**	**Indifferent species**
Aceri heldreichii –Fagetum	1 (1%)	2 (3%)	34 (48%)	18 (25%)	16 (23%)
Piceo-Abietetum subass. *aceretosum heldreichii*	1 (2%)	4 (8%)	23 (45%)	7 (14%)	16 (31%)

Table 5. *Relation of plant species toward nitrogen content in soil (vascular plant species number and their percentage share)*

Plant community	Ecological groups of plants			
	Oligotrophes-mesotrophes	**Mesotrophes**	**Mesotrophes-eutrophes**	**Eutrophes**
Aceri heldreichii-Fagetum	5 (7%)	40 (56%)	23 (32%)	3 (4%)
Piceo-Abietetum subass. *aceretosum heldreichii*	10 (20%)	27 (53%)	14 (27%)	

Table 6 shows that in both communities tolerant and tolerant-semitolerant species are the most frequent group with 49%, i.e. 51% share, followed by semitolerant with 39%, i.e. 37% share. That implies that both communities possess tolerant to semitolerant character. That is expected in forests with shade tolerant dominant species of beech, fir and spruce, and beech is one the most shade tolerant tree species in its range (Houston Durrant et al., 2016).

Table 6. *Relation of plant species toward light (vascular plant species number and their percentage share)*

Plant community	Ecological groups of plants			
	Tolerant	**Tolerant-semitolerant**	**Semitolerant**	**Semitolerant-intolerant**
Aceri heldreichii-Fagetum	2 (3%)	33 (46%)	28 (39%)	8 (11%)
Piceo-Abietetum subass. *aceretosum heldreichii*	3 (6%)	23 (45%)	19 (37%)	6 (12%)

Table 7 shows that both communities have mesothermic character (63%, i.e. 69% of mesothermic species). It is noted that community *Piceo-Abietetum* contains significantly lower number of mostly thermophilous species (8% compared to 21%), as well as increased participation of mostly microthermic species (24% compared to 15%) in relation to community *Aceri heldreichii-Fagetum*, which confirms that this community grows in colder climate conditions than the forest of beech and Greek maple.

Analysis of chorological spectra (*Tables 8* and *9*) shows that both communities have mesophilous character, since central European chorological group is the most frequent (44% in *Aceri heldreichii-Fagetum* and 41% in *Piceo-Abietetum*). Members of this group optimally develop from submontane to subalpine areas and indicate dominantly mesophilous character (Gajić, 1984). Species of wide ecological amplitude (Eurasian, circumpolar and cosmopolitan floral groups) have significant presence in both

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communities (40% in *Piceo-Abietetum*, and 34% in *Aceri heldreichii-Fagetum*). Community *Piceo-Abietetum* contains higher number of microthermic boreal species compared to *Aceri heldreichii-Fagetum* (12% to 4%), and smaller number of mostly thermophilous species of Submediterranean group (6% to 11%), which implies that this community occurs in colder climate conditions.

Table 7. *Relation of plant species toward warmth (vascular plant species number and their percentage share)*

Plant community	Ecological groups of plants			
	Microthermic-mesothermic	**Mesothermic**	**Mesotermic-thermophilous**	**Thermophilous**
Acerii heldreichii-Fagetum	11 (15%)	45 (63%)	13 (18%)	2 (3%)
Piceo-Abietetum subass. *aceretosum heldreichii*	12 (24%)	35 (69%)	3 (6%)	1 (2%)

Table 8. *Spectrum of floral elements in community Aceri heldreichii-Fagetum*

Group of floral elements	Vascular plant species number and their percentage share
Centraleuropean	31 (44%)
Euroasian	15 (21%)
Cirkumpolar and cosmopolitan	9 (13%)
Submediterranean	8 (11%)
Pontic-Centralasian	5 (7%)
Boreal	3 (4%)

Table 9. *Spectrum of floral elements in community Piceo-Abietetum subass. aceretosum heldreichii*

Group of floral elements	Vascular plant species number and their percentage share
Central European	21 (41%)
Eurasian	10 (20%)
Cirkumpolar and cosmopolitan	10 (20%)
Boreal	6 (12%)
Submediterranean	3 (6%)
Pontic-Central Asian	1 (2%)

Conclusions

Based on the analysis of 45 phytocoenological releves from the six most important Greek maple (*Acer heldreichii* Orph.) localities in Serbia, it is determined that this species occurs in two plant communities: as a dominant species in beech-Greek maple community (*Aceri heldreichii-Fagetum* B. Jov. 1957) (on Rudnik, Goč, Jastrebac and Javorje) and as a differential species in beech-fir-spruce community (*Piceo-Abietetum* Čolić 1965 subass. *aceretosum heldreichii* (syn. *Piceo-Fago-Abietetum* Čolić 1965), subass. *heldreichietosum*)) (on Golija and Stara Planina). Within association *Aceri heldreichii-Fagetum* B. Jov. 1957 two subassociations were set apart: subass. *typicum* and subass. *carpinetosum betuli*, which was recorded only on Rudnik. Subassociation *carpinetosum betuli* occurs at lower elevations and warmer climate conditions

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compared to subass. *typicum* and it is characterized by the presence of common hornbeam (*Carpinus betulus* L.), as a differential species.

CA analysis distinguishes three groups of phytocoenological relevés. There is high floristical similarity among releves from localities Javorje, Goč, Rudnik and Jastrebac (where Greek maple builds mixed forests with beech). The other group are relevés from Stara Planina, where the occurrence of conifer forest species can be observed, and the third group are releves from Golija, with more pronounced participation of conifer forest elements, and increasing disappearance of elements of broadleaf forest.

On the basis of ecological characteristics analysis, it is noted that both communities possess hemicryptophyte-geophyte-phanerophyte character according to life forms spectrum. According to moisture requirement they are strongly mesophilous. According to soil reaction both communities are mostly neutrophilous. Community *Piceo-Abietetum* contains less species with alkaline character compared to *Aceri heldreichii-Fagetum*, which is conditioned by higher soil acidification in this community. According to soil nitrogen content, both communities are mostly mesotrophic. Community *Aceri heldreichii-Fagetum* contains less oligotrophic species, so it is more favorable for plant species development regarding nutrient supply. According to light requirements both communities are shade tolerant to semitolerant, and according to the temperature they are mesothermic, noted that community *Piceo abietetum* subass. *aceretosum heldreichii* is more microthermic compared to community *Aceri heldreichii-Fagetum*. According to floral elements analysis, the Centraleuropean floral group is the most frequent in both investigated communities, which indicates their mesophilous character. Community *Piceo-Abietetum* is more microthermic compared to community *Aceri heldreichii-Fagetum*, because it contains double share of species which belong to boreal and arctic-alpine floral groups.

Since this research comprised all significant sites of Greek maple throughout Serbia, its results will contribute to better understanding of the Greek maple ecological characteristics, which is a protected species in several countries, and will enable its more efficient protection and *in situ* conservation of gene pool.

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APPENDIX

Appendix 1. *Phytocoenological table Aceri heldreichii-Fagetum community*

Association	***Aceri heldreichii – Fagetum*** B. Jov.																														Presence level
Subasociation	***Typicum***																									***Carpinetosum betuli***					
Locality	Jastrebac-V Elika Đulica										Goč-Crni vrh										Javorje-Prokosi-Javorići					Rudnik-Srednji Šturac, Mali Šturac					
Releve number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Elevation (m)	1450	1400	1400	1350	1350	1400	1450	1350	1350	1350	1400	1400	1450	1500	1550	1550	1500	1500	1450	1400	1300	1300	1300	1350	1350	1000	1000	1000	1050	1050	
Aspect	W	W	W	SW	E	W	SW	NW	SW	SW	N	NW	N	NW	W	N	N	W	-	E	NW	N	SW	SW	E	NW	NW	NW	N	N	
Inclination (°)	20	15	10	20	10	10	30	15	20	20	15	10	10	5	5	10	5	15	0	0	5	5	5	10	5	20	15	25	20	15	
TREE LAYER																															
Canopy	0.7	0.8	0.7	0.5	0.5	0.9	0.6	0.8	0.9	1.0	0.6	0.6	0.6	1.0	0.8	0.7	0.7	0.9	0.5	0.7	1.0	0.8	0.9	0.7	0.6	0.7	0.7	0.8	0.8	0.8	
Average height (m)	16	17	18	20	14	11	18	17	20	15	20	22	22	10	15	16	17	20	20	20	23	30	30	24	30	16	11	16	20	18	
Average diameter (cm)	40	40	40	50	30	17	45	35	45	20	40	45	35	15	30	35	40	40	50	40	34	37	37	32	35	20	25	25	45	35	
Average distance (m)	5	5	6	7	7	2	6	6	5	1	6	7	6	1	4	5	5	5	7	6	4	3	4	5	5	5	4	3	6	5	
Acer heldreichi Orph.	2.1	5.5	5.5	1.2	3.2	2.2	2.1	5.5	2.2	3.3	2.1	2.1	1.2	1.2	3.3	3.2	3.3	2.2	1.2	1.2	2.3	2.2	3.3	2.1	3.2	1.1	2.1	1.2	1.2	1.2	**V**
Fagus sylvatica L. subsp. ***moesiaca***	2.2	+	+	1.1		3.3	2.2		2.2	2.2	3.2	3.1	2.2	4.4	1.1	1.2	1.2	2.2	3.2	3.3	3.2	3.3	2.2	3.3	2.2	3.3	2.1	3.3	2.2	2.2	**V**
Acer pseudoplatanus L.				+																						1.1				2.2	**I**
Carpinus betulus L.																										2.2	2.1	1.1	1.1	2.1	**I**
Acer platanoides L.																												1.1	+	1.1	**I**
Tilia cordata Mill.																												1.1		1.1	**I**
SHRUB LAYER																															
Canopy	0.6	0.2	0.2	0.7	0.5	0.1	0.6	0.5	0.7	-	0.7	0.7	0.7	0.1	0.5	0.4	0.5	0.4	0.4	0.6	0.3	0.4	0.5	0.5	0.7	0.1	0.2	0.3	0.1	0.2	
Average height (m)	4	3	3	4	3	2	5	4	2		4	5	5	5	3	4	2	4	5	4	2	3	2	3	4	3	4	5	2	4	
Fagus sylvatica L. subsp. ***moesiaca***	3.2	+	1.2	3.3	2.2		3.3	1.1	3.3		4.4	5.5	4.4	1.2	2.2	2.2	3.3	3.3	2.2	3.3	1.1	2.2	1.2	1.2	2.2	1.2	1.2	2.2	1.2	1.2	**V**
Acer heldreichii Orph.	+	1.1	+	1.2	1.2		+	2.3	+		+	+	+		1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	2.2	2.2	3.4			+		+	**IV**
Sambucus nigra L.	+	1.2	1.2	1.2	+	+.2	+		+														+				+				**II**

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Rubus idaeus L.							1.2																								**I**
Acer platanoides L.	+																														**I**
Acer pseudoplatanus L.				+																	1.2	+				+					**I**
Carpinus betulus L.																							+	+		+					**I**
Fraxinus excelsior L.																							+								**I**
Prunus avium L.																								+							**I**
Corylus avellana L.																											+				**I**
GROUND LAYER																															
Coverage	0.9	1.0	0.9	1.0	0.9	0.6	0.4	1.0	0.5	0.2	0.1	0.2	0.3	0.3	0.4	0.9	1.0	0.9	1.0	1.0	0.8	0.8	0.9	0.9	0.9	1.0	0.9	0.6	0.6	0.6	
Dryopteris filix mas (L.) Schot	+	+	+	+	+		+	+		+	+		+	+	+	+.2	+	+	+	+	+.2		+.2	1.3	+.2	+	+	+	+.2	+	**V**
Rubus hirtus Waldst&Kit.	5.5	5.5	5.5	5.5	5.5		2.2		3.3	1.2	+.2	+.2	1.2	2.2	3.3	5.5	5.5	5.5	5.5	5.5	4.4	3.3		3.4	3.3	5.5	5.5	3.3	3.3	3.3	**V**
Acer heldreichii Orph.		+	+	+	+		+		+		+				1.2			+		+	1.1	2.2	1.1	1.1	2.2						**III**
Glechoma hirsuta Walds&Kit.	+.2	+	+				+.2	+			+.2	1.2	+.2		+	+	+.2									1.2		1.2	1.2	1.2	**III**
Veratrum album L.											+		+	+		+	+		+	+		+.2	+	+.2	+.2						**II**
Daphne mezereum L.	+	+.2	+	+		+	+	+	+	+																					**II**
Athyrium filix femina (L.)Rot	+					+	+			+		+	+														+		+.2	+	**II**
Paris quadrifolia L.						+	+			+			+	+	+	+					+			1.1	+.2						**II**
Senecio nemorensis L.		+	+			+	+						+	+					+												**II**
Galium odoratum (L.)Scop.	1.2					5.5		+													2.3	2.3	3.3		+.2			+		+	**II**
Fagus sylvatica L. subsp.***moesiaca***					1.2													+.2		+	2.3	3.3	1.2	+.2	1.1	+					**II**
Prenanthes purpurea L.	+		+												+	+		+			+	+	+		+						**II**
Polygonatum verticillatum (L.)A.											+	+	+	+		+	+	+				+	+	+							**II**
Adenostyles alliariae (Gou)Kern.																								+.2	+						**I**
Rubus idaeus L.								3.3								+.2								1.1	+.2						**I**
Festuca drymeia Mert.			+					+							+.2			+						+.2							**I**
Geranium robertianum L.						+	+																+								**I**
Chaerophyllum aureum L.		+				+																									**I**
Tanacetum macrophyllum Sch.			+			+																									**I**

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Aegopodium podagraria L.						+																		+.2							**I**
Epilobium montanum L.							+			+																					**I**
Stellaria nemorum L.	+						+																								**I**
Circaea lutetiana L.	+					+.2		+																		+	+				**I**
Sambucus nigra L.		+.2			+																										**I**
Rumex sanguineus L.			+																+												**I**
Salvia glutinosa L.	+	+																													**I**
Scrophularia nodosa L.	+	+																													**I**
Senecio fuchsii Gmelin.	+	+																+	+				+								**I**
Cardamine bulbifera (L.) Crant.	+.2																				3.3	1.1	2.1	1.1	3.4						**I**
Urtica dioica L.				1.2																			+.2	+	+		+				**I**
Carduus personata (L.) Jacq.	+							+																							**I**
Heracleum sphondylium L.					+	+	+																								**I**
Sisymbrium strictissimum L.							+	+																							**I**
Galeopsis speciosa Mill.		+				+	+	+										+													I
Oxalis acetosella L.													+.2			+	+									+.2					I
Polystichum aculeatum (L) Roth.																		+									+		+	+	I
Acer pseudoplatanus L.																					1.1	+	+	+		+					I
Euphorbia carniolica Jacq.																					+	+.2		+							I
Arum maculatum L.																							+.2	+.1							I
Galanthus nivalis L.																							+	+.2							I
Stachys silvatica L.	+	+	+					+																							I
Lamium galeobdolon (L)Cr.																										+		+	1.2		I

Species occuring only in one releve in herbacious layer (with releve number): ***Cardamine enneaphyllos*** Crant.(6), ***Galeopsis tetrachit*** L.(10), ***Cicerbita alpina*** (L.)Wallr.(6), ***Aconitum vulparia*** Rchb.(3), ***Campanula glomerata*** L. (3), ***Prunus avium*** L.(3), ***Campanula patula*** L.(2), ***Galium aparine*** L.(2), ***Solidago virgaurea*** L.(2), ***Acer platanoides*** L.(1), ***Asperula taurina*** L.(1), ***Lunaria rediviva*** L.(8), ***Geranium pheum*** L.(8), ***Impatiens noli-tangere*** L.(8), ***Aconitum anthora*** L.(8), ***Lilium martagon*** L.(8), ***Geranium macrorrhizum*** L.(8), ***Gentiana lutea*** L.(16), ***Pteridium aquilinum*** (L.) Kuhn(17), ***Aruncus vulgaris*** (Maxim) Raf.(23), ***Aconitum lamarckii*** (Ten)Nyman(23), ***Isopyrum thalictroides*** L.(24), ***Viola silvestris*** Lam.(26), ***Helleborus odorus*** Waldst.&Kit.(26), ***Campanula latifolia*** L.(27)

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Appendix 2. *Phytocoenological table Piceo-Abietetum community*

Association	***P i c e o-A b i e t e t u m*** Čolić 1965 (*Piceo-Fago-Abietetum* Čolić 1965)															Presence level
Subassociation	***Heldreichietosum*** Gajić															
Locality	Golija-Golijska reka										Stara planina-Toplodolska reka-Belege					
Releve number	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	
Compartment	49	49	49	49	49	50	50	50	50	50	59	60	60	61	61	
Elevation (m)	1700	1650	1650	1650	1450	1400	1400	1400	1450	1450	1600	1500	1500	1600	1600	
Aspect	N	N	E	NE	NE	N	N	NW	N	NE	N	NE	NE	NW	NW	
Nagib (°)	20	20	25	20	25	20	20	30	25	30	40	40	35	30	25	
TREE LAYER																
Canopy	0.8	0.6	0.8	0.7	0.7	0.8	0.7	0.7	0.8	0.8	0.7	0.7	0.8	0.7	0.7	
Average height (m)	25	24	28	30	25	26	26	30	28	28	15	24	22	23	15	
Average diameter (cm)	22	20	30	32	23	26	23	34	34	40	22	35	30	30	23	
Average distance (m)	4	5	4	3	4	4	5	5	4	5	4	6	6	5	4	
Acer heldreichi Orph.	1.1	1.1	2.2	2.2	3.3	3.3	2.2	2.3	1.1	1.1	1.1	1.1	1.2	1.1	1.1	**V**
Fagus sylvatica L. subsp. ***moesiaca***	+	1.1	1.1	1.1	1.1	2.2	3.4	1.2	3.3	3.3	3.3	2.2	2.2	4.4	1.1	**V**
Picea abies (L)Karst.	4.3	4.4	3.4	3.2	1.2	1.1	+	2.2	2.2	2.2	1.1	1.1	1.1	+	2.2	**V**
Abies alba Mill.										+	1.2	2.2	1.1	1.1	2.2	**II**
Sorbus aucuparia L.	+								+		1.1	+			1.1	**II**
Betula pendula Roth.															+	**I**
SHRUB LAYER																
Canopy	0.1	0.3	0.2	0.4	0.4	0.6	0.4	0.3	0.1	0.4	0.7	0.2	0.2	0.3	0.1	
Average height (m)	1	3	2	1	2	2	3	4	2	2	4	3	3	3	2	
Fagus sylvatica L. subsp. ***moesiaca***		+	+	+		4.4	2.2	1.1		2.2	3.3			2.2		**III**
Acer heldreichii Orph.		+.2	+	1.2	1.2							1.2	2.2	1.1	1.1	**III**
Sorbus aucuparia L.		+		+	+				+	+		+			+	**III**
Picea abies (L.)Karst.	+		+	1.3	1.2			1.1				+				**II**
Sambucus racemosa L.				+			+						+			**I**
Abies alba Mill.												+	+	1.1		**I**
Ribes alpinum L.													1.2			**I**
GROUND LAYER																
Coverage	0.4	0.8	0.7	0.9	0.8	0.8	0.7	0.8	0.6	0.7	0.9	0.9	0.9	0.8	0.8	
Rubus hirtus Waldst&Kit.	+.2	+.2	+.2		+.2	3.4	2.3	2.2	1.2	2.3		+		1.1		**IV**

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Dryopteris filix-mas (L.) Schott	1.3	3.3	1.2	2.2	2.2	3.3	2.2	3.2			+		2.2	2.2	1.1	**IV**
Lamium galeobdolon (L.) Ehend.	2.3	1.2	1.3	+.2	+.2				1.2	+						**III**
Veratrum album L.	+	+	+.3	+	+.2	2.2	1.2									**III**
Acer heldreichii Orph.	+.2	+.2	1.2	3.3	4.4					1.1				1.1	+	**III**
Adenostyles alliariae (Gouan) A. Kern.	+.2	+	+.2	3.4	2.2	1.2							+			**III**
Gentiana asclepiadea L.	+	+.2	+.2	+	+.2						1.1			+	1.1	**III**
Prenanthes purpurea L.	+		+	+						+	2.2	1.2	+	+	1.1	**III**
Polygonatum verticillatum (L.) Al.	1.1	+.2	1.3	+.2							+		+	+		**III**
Poa nemoralis L.		+.2		3.3		1.2		1.1				+		1.1	+	**III**
Rubus idaeus L.			+	+	1.2		1.2				1.2	1.2	1.1	+	2.2	**III**
Paris quadrifolia L.	+.2	+	1.2	+.2	+.2		+									**II**
Anemone nemorosa L.			+.2		+.2		2.3	1.2		1.1						**II**
Stellaria nemorum L.		+	+.2			2.3	2.3									**II**
Galium odoratum (L.)Scop.				+.2		1.1		1.2	+							**II**
Glechoma hirsuta Waldst &Kit.							2.3	1.1	+	1.1						**II**
Picea abies (L.)Karst.		+		+.2	+										+	**II**
Cardamine bulbifera (L.) Crantz.						+	1.1	2.2					+			**II**
Luzula sylvatica (Huds.) Gaud.	+.2								+.2		1.1			1.1	3.3	**II**
Senecio nemorensis L.									1.1		1.1	+	+	+		**II**
Festuca drymeia Mert.											4.4	4.4	4.4	1.1	1.1	**II**
Doronicum austriacum Jacq.			+	+.2												**I**
Lilium martagon L.			+	+												**I**
Fagus sylvatica L. subsp. ***moesiaca***					+				1.1							**I**
Impatiens noli-tangere L.						+	1.1									**I**
Geranium robertianum L.						+		+								**I**
Ajuga reptans L.						+			1.1							**I**
Parietaria officinalis L.							1.1	1.1								**I**
Dryopteris carthusianorum Pter.									2.2	1.2						**I**
Sambucus nigra L.	+															**I**
Lactuca muralis (L.)Gaertn.	+															**I**
Sorbus aucuparia L.			+											+		**I**
Geum urbanum L.				+												**I**
Myosotis silvatica Ehrh.						1.1										**I**

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Fragaria vesca L.						+										**I**
Luzula luzuloides (Lam.)Wilmott									2.2							**I**
Polygonatum multiflorum (L.) All.	+.2	+.1			+											**I**
Abies alba Mill.									+					+		**I**
Athyrium filix-femina (L.) Roth.										1.2	+			+		**I**
Epilobium angustifolium L.										1.2			+			**I**
Senecio fuchsii Gmelin.		+				1.1										**I**
Hypericum montanum L.													1.1	+	1.1	**I**
Polystichum aculeatum (L.)Roth											+	2.2				**I**
Vaccinium myrtyllus L.											+	1.1				**I**
Prunella vulgaris L.													1.2	1.1		**I**
Ranunculus platanifolius L.											1.1					**I**
Rumex acetosa L.												+				**I**
Arum maculatum L.														+		**I**

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