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PHYTOSOCIOLOGICAL CHARACTERISTICS OF FORESTS OF GREY ALDER (*ALNUS INCANA* /L./ MOENCH) IN GORSKI KOTAR

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The paper presents vegetation research of grey alder stands (*Alnus incana* /L./ Moench) along the beds of the rivers Kupa, Kupica, Čabranka and Belica in Gorski kotar. The standard Central European phytosociological method was used to record and analyze eight phytosociological relevés from 2010. Research results revealed that it was the association of grey alder with deadnettle, *Lamio orvalae-Alnetum incanae*, recently recorded in the west of Slovenia (DAKSKOBLER, 2007, 2010). Growing under similar ecological conditions and containing common diagnostic species as the Slovenian stands, the stands in Gorski kotar are characterized by the abundant presence of *Helleborus dumetorum.* For this reason, they have been classified as a new geographic variant of the above mentioned association.

Key words: *Alnus incana* (L.) Moench, phytosociological characteristics, *Lamio orvalae-Alnetum incanae* Dakskobler 2010 var. geogr. *Helleborus dumetorum* var. geogr. nova hoc loco, Gorski kotar, Croatia

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U radu su prikazana vegetacijska istraživanja sastojina bijele johe (*Alnus incana* /L./ Moench) uz korita rijeka Kupe, Kupice, Čabranke i Belice u Gorskome kotaru. Pri tome je korištena standardna srednjoeuropska fitocenološka metoda kojom je snimljeno i analizirano osam fitocenoloških snimki iz 2010. godine. Rezultati istraživanja pokazali su da se radi o asocijaciji bijele johe s mrtvom koprivom *Lamio orvalae-Alnetum incanae*, nedavno ustanovljenoj u zapadnoj Sloveniji (DAKSKOBLER, 2007, 2010). Uz slične ekološke uvjete i zajedničke dijagnostičke vrste, sastojine iz Gorskog kotara odlikuju se obilnom nazočnošću vrste *Helleborus dumetorum*, pa su izdvojene kao nova geografska varijanta spomenute asocijacije.

Ključne riječi: *Alnus incana* (L.) Moench**,** fitocenološke značajke, *Lamio orvalae-Alnetum incanae* Dakskobler 2010 var. geogr. *Helleborus dumetorum* var. geogr. nova hoc loco, Gorski kotar, Hrvatska

INTRODUCTION

There are relatively few data concerning the distribution range and phytosociological characteristics of forests of grey alder (*Alnus incana* /L./ Moench) in Croatia. In their vegetation research of stands along the river Drava, TRINAJSTIĆ (1964), FRANJIĆ *et al*. (1999), and VRČEK (2011) registered the association *Equiseto hyemale-Alnetum incanae* Moor 1958. East of the Varaždin area, along the Drava course, grey alder occurs singly, within the communities featuring narrow-leaved ash, spreading elm or black alder as edifiers (RAUŠ, 1976, 1994; VUKELIĆ *et al*., 1999). HORVAT *et al*. (1974) and ŠEGULJA *et al.* (1998) found this species along the river Sava and its tributaries.

HORVAT (1962) provides brief descriptions of stands along the river Kupa and other smaller rivers in Gorski kotar, in the Dinaric part of its distribution range, and names them by the previously known broader European association *Alnetum glutinoso-incanae* Braun-Blanquet 1915. It was this study, as well as the need to survey the habitats within NATURA 2000, the European network of protected sites (VUKELIĆ *et al.*, 2008), that encouraged us to explore these exceptionally interesting stands in more detail.

Phytosociological research encompassed grey alder forests of Gorski kotar growing along the rivers Kupa, Kupica, Belica and Čabranka, in the length of approximately 200 km, in the border region with the Republic of Slovenia (Fig. 1).

These rivers are characterized by a canyon course with sporadic, terrace-like enlargements. The lower terraces are flooded, which is the main reason for grey alder stands remaining here as a relatively longer stage. The intensive shifting of pebbly, and somewhere sandy sediments on which aerated and humus soils are formed is attributed to the impact of floodwater. The climate of the area is continental. Inter-

Fig. 1. Research area

polation for climate data in the past 50 years shows that the average annual temperature is 11.7 °C and precipitation is 1,354 mm. The altitude of the study area is between 220 and 450 m.

MATERIALS AND METHODS

Phytosociological research in the study area did not encompass the entire course of the rivers, but only the selected parts in which plots suitable for phytosociological research were distributed. A method of the Zürich-Montpellier Phytosociological School (BRAUN-BLANQUET, 1964) with a six-point scale was applied in the study. The floristic composition was classified according to the social affiliation of the species, the plant nomenclature was adjusted to the *Flora Croatica* database (NIKOLIĆ, 2010), the moss nomenclature was adjusted to KOPERSKI *et al*. (2000), and that of the syntaxa followed the cited works of Croatian and Slovenian phytocoenologists. Tab. 1 provides an analytical presentation of eight relevés and their synthetic comparison with research in the neighbouring Slovenian area, when the association *Lamio orvalae-Alnetum incanae* (DAKSKOBLER, 2007, 2010) was described for the first time. A statistical comparison of the researched relevés was performed with relevés of the associations *Lamio orvalae-Alnetum incanae* in the Soča, Idrijica and Kanomljica Valley (DAKSKOBLER, 2007, 2010) and *Equiseto hyemale-Alnetum incanae* in Northern Croatia (TRINAJSTIĆ, 1964; VRČEK, 2011). All relevés were entered in TURBOVEG database (HENNEKENS & SCHAMINÉE, 2001) and were processed with multivariate analysis using SYN-TAX 2000 software (PODANI, 2001). Two methods of multivariate statistical analysis were used: cluster analysis (complete link, group average, simple average, incremental sum of squares) and multidimensional scaling (Principal coordinate analysis). They all yielded very similar results. The measure of dissimilarity or similarity was the complement of the »Similarity ratio« coefficient.

Fig. 2. Medium-aged mixed forest stand dominated by the grey alder along the river Kupa

RESULTS AND DISCUSSION

A total of 200 species of higher plants and mosses were registered in the eight relevés under study. Of these, twenty-three species of higher plants and three moss species occurred in only one relevé with the + or r value (Tab. 1). The tree layer is constituted relatively heterogeneously, with a permanent presence of grey alder and European ash, while the participation of other species is regulated by the geomorphological features of the microsite, distance from the watercourse, anthro-

Tab. 1. Floristic composition of the investigated stands

	Association : *Lamio orvalae-Alnetum incanae* Dakskobler 2010										**Gorski kotar**	Idrijica & Kanomlja valley (Dakskobler, 2007)
	Relevé number		1	2	3	4	5	6	7	8*		
	Date		5./2009.	5./2009.	5./2009.	7./2009.	7./2009.	7./2009.	6./2010.	6./2010.		
	Locality		Kupica	Kupica	Belica	Belica	Kupa	Kupa	Čabranka	Čabranka		
	Altitude (m)		295	235	225	333	314	294	430	350		
	Relevé area (m^2)		400	400	400	400	400	400	400	400		
	Cover (%):											
	Tree layer		85	70	70	75	90	90	90	90		
	Shrub layer		35	25	35	50	60	30	30	25		
	Herb layer		100	100	100	95	80	100	95	100		
	Moss layer		10	10	5	10	15	1	5	5		
	Number of species		56	75	90	84	78	48	45	68	**200**	241
	Number of relevés										**8**	25
	Differential species of the association										%	
AF	*Lamium orvala*	C	+	1	2	2	2	1	+	2	**100**	100
AF	*Scopolia carniolica*		+	.	.	.	.	.	.	1	**25**	56
	Geographical differential species* – var. *Helleborus dumetorum											
EC	*Helleborus dumetorum*		+	2	1	1	2	.	.	+	**75**	.
AI	***Alnion incanae***											
	Alnus incana	A	3	+	.	2	4	5	4	4	**87**	88
	Alnus glutinosa		3	1	3	.	.	.	.	2	**50**	8
	Alnus incana	B	+	.	+	+	3	1	+	+	**87**	56
	Viburnum opulus		+	+	2	+	+	+	.	.	**75**	20
	Salix eleagnos		.	.	.	+	.	.	.	.	**13**	4
	Frangula alnus		.	.	+	.	.	.	.	.	**13**	4
	Rubus caesius		.	.	.	.	.	.	.	+	**13**	
	Alnus glutinosa		.	.	.	.	.	.	.	.	**.**	4
	Stellaria nemorum	C	.	+	+	+	+	.	1	+	**75**	52
	Rubus caesius		2	2	+	.	.	.	+	.	**50**	76
	Equisetum arvense		.	.	.	+	.	2	+	+	**50**	56
	Festuca gigantea		.	.	.	.	+	1	+	.	**38**	36

	Cardamine impatiens		.	+	.	.	+	.	+	.	**38**	36
	Alnus incana		+	.	+	.	.	.	.	+	**38**	24
	Impatiens noli-tangere		.	+	.	.	+	1	.	.	**38**	16
	Carex remota		.	+	.	.	+	+	.	.	**38**	8
	Aconitum lycoctonum ssp. *vulparia*		.	1	+	+	+	.	.	.	**50**	44
	Carex pendula		.	.	+	.	.	+	.	.	**25**	4
	Listera ovata		.	+	1	.	.	.	.	+	**38**	40
	Carex brizoides		.	.	1	3	+	1	.	+	**63**	.
	Equisetum pratense		+	+	+	.	.	.	.	.	**38**	.
	Chaerophyllum hirsutum		.	.	.	.	.	.	.	.	**.**	64
	Chrysosplenium alternifolium		.	.	.	.	.	.	.	.	**.**	36
	Dryopteris carthusiana		.	.	.	.	.	.	.	.	**.**	28
	Matteuccia struthiopteris		.	.	.	.	.	.	.	.	**.**	20
	Equisetum hyemale		.	.	.	.	.	.	.	.	**.**	12
	Viburnum opulus		.	.	.	.	.	.	.	.	**.**	8
SP	***Salicetea purpureae***											
	Salix eleagnos	A	.	.	.	.	.	.	1	.	**13**	72
	Populus nigra		.	.	.	.	.	.	.	.	**.**	12
	Humulus lupulus		.	.	.	.	.	.	.	.	**.**	4
	Salix eleagnos	B	.	.	.	+	.	.	.	.	**13**	4
	Humulus lupulus		.	.	.	.	.	+	.	.	**13**	28
	Populus nigra		.	.	.	.	.	.	.	.	**.**	4
TA	***Tilio-Acerion***											
	Ulmus glabra	A	+	.	1	.	.	.	.	.	**25**	52
	Acer pseudoplatanus		.	.	.	.	.	.	1	.	**13**	72
	Acer platanoides		+	.	.	.	.	.	.	.	**13**	16
	Tilia platyphyllos		.	.	.	.	.	.	.	.	**.**	8
	Acer pseudoplatanus	B	+	+	+	+	+	+	+	+	**100**	80
	Ulmus glabra		.	+	1	+	+	.	.	.	**50**	72
	Euonymus latifolia		.	+	+	.	.	.	.	.	**25**	4
	Acer platanoides		.	.	.	.	.	.	.	.	**.**	32
	Tilia platyphyllos		.	.	.	.	.	.	.	.	**.**	12
	Petasites albus	C	.	1	+	+	+	1	3	+	**87**	52
	Arum maculatum		.	.	+	+	+	.	+	+	**63**	40
	Geranium robertianum		+	.	.	+	+	.	+	.	**50**	36
	Aruncus dioicus		.	.	+	.	+	.	+	+	**50**	44
	Lunaria rediviva		2	.	.	+	1	.	.	.	**38**	88
	Polystichum aculeatum		.	+	+	+	.	.	.	.	**38**	24
	Adoxa moschatellina		.	.	.	.	.	+	1	.	**25**	40
	Acer pseudoplatanus		.	.	.	.	.	.	.	.	**.**	56
	Dryopteris affinis		.	.	.	.	.	.	.	.	**.**	44
	Ulmus glabra		.	.	.	.	.	.	.	.	**.**	24
	Acer platanoides		.	.	.	.	.	.	.	.	**.**	20
	Tilia platyphyllos		.	.	.	.	.	.	.	.	**.**	4
EC	***Erythronio-Carpinion***											
	Primula vulgaris	C	.	+	+	1	+	.	.	.	**50**	48
	Epimedium alpinum		.	.	1	.	.	.	.	.	**13**	.
	Galanthus nivalis		.	.	.	.	.	.	.	.	**.**	56

	Helleborus odorus		.	.	.	.	.	.	.	.	**.**	52
	Ornithogalum pyrenaicum		.	.	.	.	.	.	.	.	**.**	8
AF	***Aremonio-Fagion***											
	Daphne laureola	B	.	.	.	+	.	.	.	.	**13**	16
	Cardamine trifolia	C	+	+	.	1	2	.	+	+	**75**	68
	Knautia drymeia		+	1	+	1	1	.	.	+	**75**	44
	Omphalodes verna		.	.	+	+	+	.	.	+	**50**	64
	Cyclamen purpurascens		.	.	.	1	+	.	.	.	**25**	32
	Vicia oroboides		+	.	+	.	.	.	.	+	**38**	4
	Hacquetia epipactis		.	.	+	.	+	.	.	.	**25**	48
	Helleborus niger		.	.	+	+	.	.	.	+	**25**	32
	Cardamine enneaphyllos		.	.	+	.	.	.	.	.	**13**	60
	Cardamine kitaibelii		+	.	+	.	.	.	.	.	**25**	.
	Polystichum setiferum		.	.	.	.	.	.	+	1	**25**	.
	Anemone trifolia		.	.	.	.	.	.	.	.	**.**	68
	Isopyrum thalictroides		.	.	.	.	.	.	.	.	**.**	44
	Euphorbia carniolica		.	.	.	.	.	.	.	.	**.**	20
	Geranium nodosum		.	.	.	.	.	.	.	.	**.**	8
F	***Fagetalia sylvaticae***											
	Fraxinus excelsior	A	1	+	2	+	1	.	1	.	**75**	88
	Carpinus betulus		1	3	2	3	2	.	.	1	**63**	36
	Fagus sylvatica		1	1	.	1	.	.	.	.	**38**	24
	Prunus avium		.	.	.	1	.	.	.	.	**13**	8
	Sambucus nigra		.	.	.	.	.	.	.	.	**.**	16
	Tilia cordata		.	.	.	.	.	.	.	.	**.**	40
	Fraxinus excelsior	B	1	+	1	+	2	+	+	+	**100**	84
	Carpinus betulus		+	.	1	1	+	.	.	+	**63**	64
	Sambucus nigra		.	+	.	.	.	2	1	+	**50**	68
	Fagus sylvatica		.	+	.	+	+	.	.	+	**50**	64
	Daphne mezereum		.	.	.	+	+	.	.	+	**38**	56
	Prunus avium		.	.	.	.	.	.	.	+	**13**	28
	Tilia cordata		.	.	.	.	.	.	.	.	**.**	52
	Laburnum alpinum		.	.	.	.	.	.	.	.	**.**	4
	Brachypodium sylvaticum	C	+	3	2	3	2	1	+	+	**100**	80
	Lamium galeobdolon		1	+	1	+	+	+	+	1	**100**	68
	Salvia glutinosa		+	1	+	1	1	.	1	1	**87**	56
	Asarum europaeum agg.		.	1	1	2	2	+	2	2	**87**	96
	Mercurialis perennis		1	+	+	1	1	.	+	1	**87**	96
	Pulmonaria officinalis		.	+	+	.	+	.	+	+	**63**	88
	Allium ursinum		5	1	2	.	.	.	2	4	**63**	84
	Circaea lutetiana		1	.	.	+	+	1	.	+	**63**	12
	Polygonatum multiflorum		.	.	+	+	+	.	.	+	**50**	44
	Symphytum tuberosum		+	+	1	.	.	.	.	+	**38**	92
	Cardamine bulbifera		1	+	.	.	.	.	+	.	**38**	80
	Carex sylvatica		.	.	+	.	+	+	.	.	**38**	20
	Dryopteris filix-mas		+	.	.	.	+	.	.	1	**38**	40
	Mycelis muralis		.	+	.	.	.	.	+	+	**38**	8
	Scrophularia nodosa		+	.	+	.	.	+	.	.	**38**	8
	Campanula trachelium		.	+	.	+	+	.	.	.	**38**	20

	Phyteuma spicatum agg.		.	.	1	.	+	.	.	+	**38**	16
	Paris quadrifolia		+	.	+	.	.	.	.	.	**25**	72
	Euphorbia dulcis		.	.	+	.	.	.	.	+	**25**	44
	Fraxinus excelsior		.	1	+	.	.	.	.	.	**25**	40
	Viola reichenbachiana		.	.	.	+	+	.	.	.	**25**	52
	Galium sylvaticum (laevigatum)		.	.	+	+	.	.	.	.	**25**	32
	Asplenium scolopendrium		.	.	.	+	+	.	.	.	**25**	24
	Lathyrus vernus		.	.	.	+	+	.	.	.	**25**	20
	Lilium martagon		.	.	+	+	.	.	.	.	**25**	12
	Ranunculus lanuginosus									+	**13**	76
	Heracleum sphondylium		.	.	.	.	+	.	.	.	**13**	40
	Melica nutans		.	+	.	.	.	.	.	.	**13**	24
	Fagus sylvatica		.	.	.	+	.	.	.	.	**13**	20
	Actaea spicata		.	.	.	.	.	.	.	+	**13**	12
	Galium odoratum		.	.	.	.	.	.	.	+	**13**	4
	Sanicula europaea		.	+	.	.	.	.	.	+	**25**	
	Galium schultesii		.	+	+	.	.	.	.	.	**25**	.
	Prunus avium		.	.	.	+	.	.	.	.	**13**	.
	Cardamine pentaphyllos		.	.	.	.	.	.	.	.	**.**	84
	Corydalis cava		.	.	.	.	.	.	.	.	**.**	40
	Anthriscus nitidus		.	.	.	.	.	.	.	.	**.**	36
	Tilia cordata		.	.	.	.	.	.	.	.	**.**	16
	Carpinus betulus		.	.	.	.	.	.	.	.	**.**	12
	Leucojum vernum		.	.	.	.	.	.	.	.	**.**	8
	Festuca altissima		.	.	.	.	.	.	.	.	**.**	8
	Euphorbia amygdaloides		.	.	.	.	.	.	.	.	**.**	8
	Laburnum alpinum		.	.	.	.	.	.	.	.	**.**	8
QP	***Quercetalia pubescentis***											
	Fraxinus ornus	A	.	.	+	.	.	.	.	.	**13**	.
	Ostrya carpinifolia		.	.	.	.	.	.	.	.		24
	Fraxinus ornus	B	.	.	+	+	.	.	.	1	**38**	8
	Euonymus verrucosus		.	.	.	+	.	+	.	.	**25**	.
	Ostrya carpinifolia		.	.	.	.	.	.	.	.	**.**	4
	Clematis recta	C	.	.	.	.	.	.	.	.	**.**	8
QF	***Querco-Fagetea***											
	Acer campestre	A	.	+	.	.	.	.	.	.	**13**	28
	Corylus avellana		.	.	.	.	.	.	.	.	**.**	80
	Hedera helix		.	.	.	.	.	.	.	.	**.**	44
	Malus sylvestris		.	.	.	.	.	.	.	.	**.**	4
	Corylus avellana	B	+	2	2	3	1	.	.	2	**75**	88
	Acer campestre		+	+	+	+	+	.	.	+	**75**	76
	Lonicera xylosteum		.	.	.	.	.	.	.	+	**13**	16
	Malus sylvestris		.	.	.	.	.	.	.	.	**.**	16
	Hedera helix		.	.	.	.	.	.	.	.	**.**	4
	Aegopodium podagraria	C	2	1	+	1	1	2	2	1	**100**	92
	Anemone nemorosa		+	+	1	+	+	.	.	.	**63**	80
	Hedera helix		2	1	1	1	.	.	.	1	**63**	84
	Carex digitata		.	+	1	.	.	.	.	+	**38**	48
	Cerastium sylvaticum		.	1	.	.	+	1	.	.	**38**	60

	Vinca minor		.	.	+	.	.	.	1	1	**38**	28
	Ranunculus auricomus agg.		+	1	+	.	.	.	.	.	**38**	20
	Cruciata gabra		.	.	.	+	+	.	.	.	**25**	4
	Hepatica nobilis		.	.	.	.	+	.	.	.	**13**	28
	Glechoma hirsuta		.	2	.	.	+	.	.	+	**38**	.
QRP	***Quercetalia robori-petraeae***											
	Anemone ranunculoides	C	.	.	.	.	.	.	.	.	**.**	92
	Ranunculus ficaria		.	.	.	.	.	.	.	.	**.**	76
	Acer campestre		.	.	.	.	.	.	.	.	**.**	48
	Veratrum nigrum		.	.	.	.	.	.	.	.	**.**	28
	Lathraea squamaria		.	.	.	.	.	.	.	.	**.**	20
	Gagea lutea		.	.	.	.	.	.	.	.	**.**	16
	Viola riviniana		.	.	.	.	.	.	.	.	**.**	16
	Moehringia trinervia		.	.	.	.	.	.	.	.	**.**	16
RP	***Rhamno-Prunetea***											
	Cornus sanguinea	A	.	.	.	.	.	.	.	.	**.**	12
	Crataegus monogyna		.	.	.	.	.	.	.	.	**.**	12
	Clematis vitalba		.	.	.	.	.	.	.	.	**.**	8
	Rhamnus catharticus		.	.	.	.	.	.	.	.	**.**	4
	Cornus sanguinea	B	2	1	+	+	+	.	+	+	**87**	72
	Crataegus monogyna		+	1	+	2	+	.	.	.	**63**	40
	Ligustrum vulgare		+	+	1	1	1	.	.	.	**63**	24
	Clematis vitalba					+	.	.	+	1	**38**	28
	Euonymus europaeus		+	.	1	.	.	.	.	.	**25**	52
	Viburnum lantana		.	.	+	+	.	.	.	.	**25**	12
	Rhamnus catharticus		.	.	.	.	+	+	.	.	**25**	4
	Berberis vulgaris		.	.	+	.	.	.	.	.	**13**	16
	Clematis vitalba	C	.	.	.	+	+	.	.	.	**25**	16
	Euonymus europaeus		.	.	.	+	.	.	.	.	**13**	.
	Cornus sanguinea		.	.	.	.	.	.	.	.	**.**	4
	Ligustrum vulgare		.	.	.	.	.	.	.	.	**.**	4
EA	***Epilobietea angustifolii***											
	Rubus idaeus	B	.	.	.	.	.	1	.	.	**13**	8
	Fragaria vesca	C	.	.	+	1	+	.	+	.	**50**	12
	Stachys sylvatica		.	.	.	.	+	2	1	.	**38**	16
	Galeopsis speciosa		.	.	.	+	.	1	+	.	**38**	4
	Eupatorium cannabinum		.	.	.	+	.	+	+	.	**38**	.
	Myosotis sylvatica		.	.	.	.	.	.	.	.	**.**	44
	Arctium nemorosum		.	.	.	.	.	.	.	.	**.**	8
VP	***Vaccinio-Piceetea***											
	Picea abies	A	.	.	.	.	.	.	.	2	**13**	48
	Abies alba		.	.	.	.	.	.	.	.	**.**	4
	Picea abies	B	.	.	.	.	.	.	.	1	**13**	56
	Abies alba		.	.	+	.	.	.	.	.	**13**	24
	Aposeris foetida	C	.	+	1	1	+	.	.	+	**63**	32
	Oxalis acetosella		.	.	+	+	+	.	.	1	**50**	44
	Abies alba		+	+	.	+	.	.	.	.	**38**	20

	Veronica urticifolia		.	.	+	.	.	.	.	.	**13**	8
	Streptopus amplexifolius		.	.	.	+	+	.	.	.	**25**	.
	Picea abies		.	.	.	.	.	.	.	.	**.**	16
	Soldago virgaurea		.	.	.	.	.	.	.	.	**.**	8
EP	***Erico-Pinetea***											
	Rubus saxatilis	B	.	.	.	1	.	.	.	.	**13**	.
	Rubus saxatilis	C	1	+	+	.	1	.	.	.	**50**	.
	Cirsium erisitales		.	.	+	.	.	.	.	.	**13**	4
	Carex alba		.	.	.	.	.	.	.	.	**.**	20
MuA	***Mulgedio-Aconitetea***											
	Senecio ovatus	C	.	.	+	+	.	+	1	+	**63**	16
	Athyrium filix-femina		+	.	.	.	.	+	+	1	**50**	28
	Veratrum album		.	+	2	.	.	.	.	.	**25**	40
	Silene dioica		.	+	.	.	.	.	+	.	**25**	12
	Thalictrum aquilegiifolium		.	.	.	+	.	.	.	+	**13**	28
	Doronicum austriacum		.	+	+	+	.	+	.	+	**63**	.
	Myrrhis odorata		.	.	.	.	.	.	.	.	**.**	20
	Aconitum degenii ssp. *paniculatum*	.	.	.	.	.	.	.	.	**.**	20	
	Senecie nemorensis		.	.	.	.	.	.	.	.	**.**	8
TG	***Trifolio-Geranietea***											
	Vicia sylvatica	C	.	+	.	.	.	.	.	.	**13**	4
	Clinopodium vulgare		.	.	.	+	+	.	.	.	**25**	.
AV	***Artemisietea vulgaris***											
	Erigeron annuus		.	.	+	+	.	.	.	.	**25**	.
GU	***Galio-Urticetea***											
	Geum urbanum	C	+	1	.	+	+	1	.	.	**63**	28
	Petasites hybridus		.	.	.	.	1	2	4	.	**38**	64
	Urtica dioica		.	.	.	.	.	2	2	.	**25**	56
	Lamium maculatum								+	1	**25**	16
	Alliaria petiolata		.	+	.	.	.	.	2	.	**25**	28
	Glechoma hederacea		.	.	.	.	.	+	2	.	**25**	12
	Chelidonium majus		.	.	.	.	.	+	+	.	**25**	8
	Stellaria media		.	+	.	.	.	.	.	.	**13**	8
	Solidago gigantea		.	.	.	.	.	+	.	.	**13**	12
	Geranium phaeum		.	+	.	+	+	.	.	.	**38**	
	Lapsana communis		.	.	+	.	+	.	.	.	**25**	.
	Chaerophyllum temulum		.	.	.	+	.	+	.	.	**25**	.
	Torilis japonica		.	.	+	.	.	.	.	.	**13**	.
	Anthriscus sylvestris		.	.	.	.	.	.	.	.	**.**	20
	Viola odorata		.	.	.	.	.	.	.	.	**.**	8
PM	***Phragmiti-Magnocaricetea***											
	Lysimachia vulgaris		+	.	+	.	.	+	.	.	**38**	.
CA	***Calthion***											
	Cirsium oleraceum	C	+	.	.	+	+	.	.	.	**38**	24

	Angelica sylvestris		1	.	+	.	.	.	.	.	**25**	76
	Crepis paludosa		.	.	+	.	.	.	.	.	**13**	8
	Scirpus sylvaticus		.	.	.	.	.	+	.	.	**13**	4
	Caltha palustris		.	.	.	.	.	+	.	.	**13**	24
	Colchicum autumnale		.	.	.	.	.	.	.	.	**.**	8
MA	***Molinio-Arrhenatheretea***											
	Deschampsia caespitosa	C	.	+	+	1	+	.	+	+	**75**	56
	Dactylis glomerata		.	.	.	.	+	.	.	.	**13**	12
	Poa trivialis		.	+	.	.	.	.	.	.	**13**	4
	Valeriana dioica		.	1	1	.	.	.	.	.	**25**	.
	Taraxacum officinale		.	.	.	.	.	.	.	.	**.**	8
	Allium schoenoprasum		.	.	.	.	.	.	.	.	**.**	8
TR	***Thlaspietea rotundifolii***											
	Petasites paradoxus	C	.	.	.	.	.	.	.	.	**.**	12
AT	***Asplenietea trichomanis***											
	Polypodium vulgare	C	.	.	.	.	.	.	.	+	**13**	12
O	***Other species***											
	Robinia pseudacacia	A	.	.	.	.	.	.	.	.	**.**	40
	Juglans regia		.	.	.	.	.	.	.	.	**.**	16
	Aesculus hippocastanum		.	.	.	.	.	.	.	.	**.**	4
	Acer negundo		.	.	.	.	.	.	.	.	**.**	4
	Juglans regia	B	.	.	.	+	.	.	.	.	**13**	12
	Aesculus hippocastanum		.	.	.	.	.	.	.	.	**.**	12
	Acer negundo		.	.	.	.	.	.	.	.	**.**	4
	Telekia speciosa	C	+	+	+	.	.	.	.	.	**38**	.
	Viola sp.		+	+	.	.	.	.	.	.	**25**	.
	Rubus hirtus		.	.	.	.	.	3	.	.	**13**	20
	Hemerocallis fulva		.	.	.	.	.	.	.	.	**.**	24
	Tussilago farfara		.	.	.	.	.	.	.	.	**.**	16
	Narcissus poeticus agg.		.	.	.	.	.	.	.	.	**.**	16
	Dactylorhiza fuchsii		.	.	.	.	.	.	.	.	**.**	12
	Impatiens glandulifera		.	.	.	.	.	.	.	.	**.**	12
ML	***Mosses***											
	Plagiomnium undulatum	D	1	1	+	1	2	.	+	+	**87**	92
	Anomodon attenuatus		+	+	.	+	+	.	.	.	**50**	8
	Brachythecium rutabulum		+	.	+	+	+	.	.	.	**50**	.
	Rhizomnium punctatum		.	+	.	+	+	.	.	.	**38**	.
	Plagiomnium medium		.	.	.	.	.	.	+	+	**25**	.
	Brachythecium rivulare		.	.	.	.	.	.	+	+	**25**	.
	Ctenidium molluscum		.	.	.	.	.	.	.	.	**.**	28
	Eurhynchium striatum		.	.	.	.	.	.	.	.	**.**	24
ha	*Isothecium alopecuroides*		.	.	.	.	.	.	.	.	**.**	20
	Conocephalum conicum		.	.	.	.	.	.	.	.	**.**	16
	Neckera complanata		.	.	.	.	.	.	.	.	**.**	8

The table excludes species that are represented in only one relevé with covering + and r in synoptic column from Slovenia.
* holotype geogr. var. *Helleborus dumetorum* nova hoc loco

pogenic impacts and similar. The shrub layer is highly varied and rich; together with the species from the tree layer, it consists of 34 species, of which *Acer pseudoplatanus*, *Fraxinus excelsior*, *Alnus incana*, *Cornus sanguinea* and *Corylus avellana* are present throughout the area. The ground layer is also very rich and luscious, consisting of 14 moss species and 150 species of higher plants.

Sociologically, the dominant role is played by the species of the order *Fagetalia* Pawlowski in Pawlowski, Sokolowski et Wallisch 1928 and the associated alliances. This is primarily the alliance *Alnion incanae* Pawlowski in Pawlowski, Sokolowski et Wallisch 1928, embracing *Alnus incana* and species of moist and occasionally flooded sites (*Viburnum opulus*, *Rubus caesius*, *Carex brizoides*, *Stellaria nemorum*, *Equisetum arvense* and others). In addition to this alliance, which determines the character of the association, species that belong to the south-eastern European alliances of beech forests (*Aremonio-Fagion* /Horvat 1938/ Borhidi in Török *et al.* 1989) and sessile oak--hornbeam forests (*Erythronio-Carpinion* /Horvat 1938/ Marinček in MUCINA *et al.*, 1993) are also highly significant. They are important because they discriminate these stands from other similar European communities of grey alder. They reflect the specific historical-genetic development of the flora and vegetation of south--eastern Europe, which eventually resulted in a specific sytaxonomic position. Of these species, *Lamium orvala*, *Cardamine trifolia*, *Knautia drymeia*, *Omphalodes verna*, *Helleborus dumetorum* and *Primula vulgaris* take a prominent place in the studied stands. Of the species from the alliance *Tilio-Acerion*, the already mentioned European ash and Scots elm are accompanied by *Petasites albus*, *Arum maculatum*, *Aruncus dioicus* and *Geranium robertianum.* Other species from the order *Fagetalia* in all the relevés include high amounts of *Brachypodium sylvaticum*, *Lamium galeobdolon*, *Salvia glutinosa*, *Asarum europaeum*, *Mercurialis perennis* and others.

The percentage of participation of sociological groups is given in Tab. 2, together with comparisons with the percentages of sociological groups from the Slovenian region in which DAKSKOBLER described this association (2007, 2010). The percentages of participation of particular syntaxa show a very high degree of compatibility, which is yet another proof of their belonging to the same association.

The investigated stands in Gorski kotar differ from those in Soča and Idrijica valley by the occurrence of the species *Helleborus dumetorum*, *Carex brizoides*, *Doronicum*

Tab. 2. Species participation according to syntaxonomic categories

Syntaxonomic categories	Gorski kotar, 2010		Idrijica & Kanomlja valley (DAKSKOBLER, 2007)
	Number of species	%	%
Alnion incanae	18	**9**	6.2
Tilio-Acerion	11	**5.5**	10
Aremonio-Fagion & *Erythronio Carpinion*	18	**9**	12.4
Fagetalia	44	**22**	26
Querco-Fagetea	19	**9.5**	12
Vaccinio-Piceetea	11	**5.5**	1.6
Galio-Urticetea	15	**7.5**	3.8
Other species	64	**32**	28

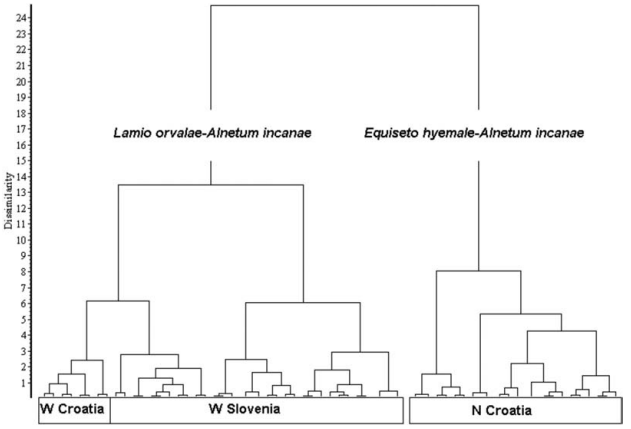

Fig. 3. Statistical comparison of associations *Lamio orvalae-Alnetum incanae* and *Equiseto hyemale-Alnetum incane* (Increment sum of squares method)

austriacum, and to a lesser degree of *Equisetum pratense*, *Glechoma hirsuta*, *Streptopus amplexifolius* and *Galium schultesii*. This is the reason that the conducted statistical comparison shows partial differences (Fig. 3). The differences are large enough to justify the establishment of a special geographic variant, although the Code of Phytosociological Nomenclature (WEBER *et al*., 2000) does not treat variants and although they are not common in the Croatian phytosociological practice. However, they are interesting from a scientific-natural aspect and allow comparisons with similar stands. The stands from Gorski kotar are characterized by the presence of *Hellebours dumetorum*; consequently, this species has determined the geographic variant. Relevé No. 8 in Tab. 1 is suitable as a nomenclatural type (*holotype*). The variant occurs on the Slovenian side of Kupa valley in stands of grey alder because ACCETO (1996) recorded *Helleborus dumetorum* there.

As for other differentiating species, especially the species *Carex brizoides*, the final decision should be made after studying and analyzing grey alder stands in Jasenačko polje, on Zrinska Gora in Banovina and elsewhere. A reconnaissance of these species was made during 2010. Quaking grass sedge (*Carex brizoides)* was found to be sporadically present in large quantities. The analysis of these investigations should also include stands of black alder with quaking grass sedge (*Carici brizoidis-Alnetum glutinosae* Horvat 1938), which have still not been clearly defined in Croatia.

The forest community *Lamio orvalae-Alnetum incanae* was compared with the results of other phytosociological research in Croatia and in similar areas in other countries and regions. In relation to the association *Equiseto-Alnetum incanae* (TRINAJSTIĆ, 1964; VRČEK, 2011) from the Varaždin are, the following expected differences were manifested: stands from Gorski kotar lacked any species of flooded and wet sites of the planar belt, including *Equisetum hyemale*, *Glechoma hederacea*, *Ranunculus repens*, *Lysimachia nummularia*, *Leucojum vernum*, *Myosoton aquaticum*, *Solidago gigantea*, *Quercus robur*, *Valeriana dioica* and others. On the other hand, there were many species of the mountainous belt, in the first place of the adjacent beech forests, such as *Fraxinus excelsior*, *Ulmus glabra*, *Fagus sylvatica*, *Carpinus betulus*, *Acer campestre*, *Corylus avellana*, *Petasites albus*, *Geranium robertianum*, *Aruncus dioicus*, *Adoxa moschatellina*, *Lunaria*

rediviva and many others. Their occurrence in the community *Equiseto hyemale-Alnetum incanae* of northern Croatia is out of question. The major differences between associations are also confirmed by a statistical analysis (Fig. 3).

Compared to the related European associations of the type *Alnetum incanae,* Fig l., *Aceri-Alnetum incanae* Berger 1922, *Alnetum glutinosae-incanae* Braun-Blanquet 1931 and others (SCHWABE, 1985; WALLNÖFER *et al*., 1993; WILLNER & GRABHERR, 2007), the stands from Gorski kotar did not show any record of *Prunus padus*, *Equisetum telmateia*, *Lysimachia nemorum*, *Primula elatior*, *Filipendula ulmaria*, *Galium mollugo*, *Carex acutiformis*, *Carex paniculata*, *Senecio alpinus*, *Viola biflora,* mosses *Eurhynchium striatum*, *E. swartzii*, species of the genus *Mnium* and many others. However, the already mentioned species from the alliances *Aremonio-Fagion* and *Erythronio-Carpinion,* which do not occur in the related European forests of grey alder, are distinctly present both in participation and cover. All this fully justifies the establishment of this independent association; for the time being it is limited to the sub-montane belt of the south--eastern Alpine – north-Illyrian floristic area, as rightly concluded by DAKSKOBLER (2010). In the syntaxonomic sense, the forest of grey alder with deadnettle belongs to the class *Querco-Fagetea* Braun-Blanquet et Vlieger in Vlieger 1937, the order *Fagetalia sylvaticae* Pawlowski in Pawlowski, Sokolowski et Wallisch 1928, and the alliance *Alnion incanae* Pawlowski in Pawlowski, Sokolowski et Wallisch 1928.

Within his research DAKSKOBLER (2010) made a detailed study of the syndynamic vegetation series in which the association *Lamio orvalae-Alnetum incanae* occurs. In simple terms, according to his scheme, the development of vegetation runs from pebbly, bare banks over different weed, ruderal and other communities (the most common stage in Gorski kotar is with *Petasites hybridus*), towards smaller groups of grey willow and purple osier (most commonly the community *Lamio orvalae-Salicetum eleagni* Dakskobler, Šilc et Čušin ex Dakskobler 2007). With terrain elevation, soil formation, less frequent floods and decreased humidity, they are converted into mixed forest stands of grey alder with sycamore, European ash, black alder, hornbeam and beech, including sometimes the spruce. Their development usually ends with zonal beech communities. These stages can be seen in Fig. 4, recorded along the course of the river Kupica. With such syndynamic development, a very common case in the study area involves the development of new young stands of grey alder from the seed dispersed over abandoned agricultural areas (Fig. 5). As a pioneer species, grey alder grows in very thick and homogeneous stands. These areas are positioned at relatively high altitudes and are flooded only exceptionally.

The investigation of the entire course of the rivers Kupa, Kupica, Belica and Čabranka would be exceptionally interesting and important for succession, but this will be the subject of some future research.

CONCLUSIONS

Phytosociological research into grey alder stands growing along the upper course of the river Kupa and its tributaries in Gorski kotar has resulted in the determination of the association *Lamio-orvalae-Alnetum incanae*, more recently described in western Slovenia (DAKSKOBLER, 2007, 2010). In addition to the species of the alliance *Alnion incanae*, the rich floristic composition of the association also consists of large amounts of species from the surrounding zonal beech forests of the order *Fagetalia*

Fig. 4. Succession stages along the river Kupica bed

Fig. 5. Grey alder on abandoned agricultural areas

and lower units. The differentiating species of *Lamium orvala* and *Scopolia carniolica* are decisive for the association *Lamio-orvalae-Alnetum incanae*, but diagnostically, species of the alliance *Aremonio-Fagion* and *Erythronio-Carpinion* are very important. In relation to stands from western Slovenia, forests of grey alder in Gorski kotar are characterized by the abundant presence of the *Helleborus dumetorum;* for this reason, they have been denoted as a new variant of the association *Lamio orvalae-Alnetum incanae* geogr. var. *Helleborus dumetorum* nova hoc loco.

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SAŽETAK

Fitocenološke značajke šuma bijele johe (*Alnus incana* /L./ Moench) u Gorskome kotaru

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U vegetacijskom razdoblju 2010. godine istraživali smo šume bijele johe uz gorsko-kotarske rijeke Kupu, Kupicu, Čabranku i Belicu. Rijeke karakterizira kanjonski tok s mjestimično razvijenim, povremeno plavljenim terasama na kojima smo klasičnom fitocenološkom metodom snimili osam ploha. Florni je sastav razvrstan po socijalnoj pripadnosti vrsta, nomenklatura biljaka je usklađena prema bazi podataka *Flora Croatica* (NIKOLIĆ, 2010), mahovina prema KOPERSKI *et al*. (2000), a sintaksona prema citiranim radovima hrvatskih i slovenskih fitocenologa. U tablici 1 analitički je prikazano 8 snimljenih ploha i njihova sintetska usporedba s istraživanjima u susjednom slovenskom području pri prvome opisu asocijacije *Lamio orvalae-Alnetum incanae* (DAKSKOBLER, 2007, 2010). Statistička usporedba istraživanih snimki provedena je sa snimkama asocijacije *Lamio orvalae-Alnetum incanae* iz Slovenije (DAKSKOBLER, 2007, 2010) i *Equiseto hyemale-Alnetum incanae* s područja sjeverne Hrvatske (TRINAJSTIĆ, 1964; VRČEK, 2011). Sve snimke su unešene u bazu podataka TURBOVEG (HENNEKENS *et* SCHAMINÉE, 2001) te obrađene multivarijatnom klasterskom analizom i multidimenzinalnim skaliranjem pomoću programa SYN-TAX 2000 (PODANI, 2001). Statističke metode dale su vrlo slične rezultate. Šumsku zajednicu *Lamio orvalae-Alnetum incanae* usporedili smo i s rezultatima ostalih fitocenoloških istraživanja u drugim zemljama odnosno regijama (SCHWABE, 1985; WALLNÖFER *et al*., 1993; WILLNER & GRABHERR, 2007). Asocijacija *Lamio orvalae-Fagetum* bogatog je floističkog sastava u kojem su uz vrste sveze *Alnion incanae* znatno zastupljene vrste okolnih zonalnih bukovih šuma reda *Fagetalia* i nižih jedinica. Za asocijaciju *Lamio orvalae-Alnetum incanae* presudne su razlikovne vrste *Lamium orvala* i *Scopolia carniolica*, ali dijagnostički su važne vrste sveza *Aremonio-Fagion* i *Erythronio-Carpinion*. U odnosu na sastojine iz zapadne Slovenije u dolinama rijeka Soče, Idrijice i Kanomljice, šume bijele johe u Gorskome kotaru odlikuju se obilnom nazočnošću vrste *Helleborus dumetorum*, pa smo ih označili kao novu varijantu asocijacije *Lamio orvalae-Alnetum incanae* geogr. var. *Helleborus dumetorum* nova hoc loco.