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FOREST VEGETATION IN THE CITY OF ZAGREB AND THE ZAGREB COUNTY

ŠUMSKA VEGETACIJA GRADA ZAGREBA I ZAGREBAČKE ŽUPANIJE

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The paper presents the results of phytocoenological research into the forests of the City of Zagreb and the Zagreb County. These forests take up approximately 143,000 ha. The forest vegetation occurs in various climatic, pedological and other conditions at altitudes ranging from 120 to 1,033 m. For this reason, there are about twenty more or less distinctive forest associations, of which ten are accompanied with phytocoenological tables and presented in more detail. A well-known method of research and presentation devised by the Zurich-Montpellier Phytocoenological School has been used. The result of the research is the forest vegetation map of the studied area on a scale 1:100,000, of which only two characteristic fragments giving an approximate cross-section of the lowlands and the region of lower and higher hills is given for technical reasons.

Key words: forest vegetation, floral composition, the City of Zagreb and the Zagreb County

INTRODUCTION
UVOD

The City of Zagreb and the Zagreb County are located in the most densely populated region in the west of Croatia. Although this region was settled very early and developed a relatively rapid and significant industrial, infrastructural and other features, the forests in the studied area cover over 143,000 ha or almost 40%. They have largely retained their natural composition and structure and are very su-

itable for phytocoenological research. This area is a very good example of vertical zoning of the forest vegetation in the south-west of the Pannonian plain with many pre-Alpine floral-genetic properties continuing into neighbouring Slovenia. The altitudinal difference between the studied forest communities is slightly less than one thousand meters, which contributes to the wealth and diversity of the floral composition of these associations.

Forest vegetation is presented in altitudinal belts. In the lowland belt from 80 to 150 meters above sea level, the Rivers Sava, Lonja, Česma, Kupa and a number of smaller, largely ameliorated watercourses are responsible for the basic features of the geological-lithological and pedological structure and for the vegetational picture. The belt of low hills between 150 and 400 (500) meters, the belt of higher hills from 400 to 800 meters and the mountain belt above 800 meters have very different pedological and climatic conditions. For this reason, the phytocoenological composition displays clear vertical zoning in which the principal species are sessile oak, followed by common beech in the belt of higher hills and beech and fir in the mountainous belt. Different lithological substrates condition a large number of forest associations belonging to various syntaxonomic categories. The twenty basic forest associations are classified into seven alliances, three orders and two classes, which is partly shown in four phytocoenological tables.

The forest vegetation of the City of Zagreb and the Zagreb County has been studied for the past four years. In the course of the research, phytocoenological literature of other authors has been drawn upon, first of all of Anić (1940), Baričević (1998), Cestar *et at.* (1978-1982), Glavač (1958 and 1959), Rauš (1969 and 1996), Rauš *et al.* (1992), Rauš & Vukelić (1993), Šegulja (1974), Šugar (1972), and Vukelić (1991). The survey is accompanied with a printed phytocoenological map on a scale 1:100.000 with 13 most important phytocoenoses. Some associations occur in fragments over very small areas (various riparian associations, broadleaved forests of good quality) or they mix intensively due to well-developed terrain orography and changes in synecological conditions. For this reason they cannot be determined and shown accurately on the 1:100.000 scale.

A DESCRIPTION OF FOREST ASSOCIATIONS
OPIS ŠUMSKIH ZAJEDNICA

THE LOWLAND (PLANAR) VEGETATION BELT
NIZINSKI (PLANARNI) POJAS

The lowland or planar vegetation belt, extending between 80 and 150 meters above sea level, accounts for half of the forest vegetation in the studied area. It represents the initial level of the vertical occurrence of forest vegetation in this area and is characterised primarily by forests of pedunculate oak, narrow-leaved ash, black alder, willows and poplars. Their origin and survival is more or less linked to

surface water and groundwater. In terms of orography, the localities where these species and forest associations occur are the plains between rivers, with alternations of bogs, micro-depressions, depressions, wide humid terraces, non-differentiated micro-elevations and drained and fresh micro-elevations. The soils are hydromorphous and are still developing depending on the time of origin and degree of moisture. However, the most common are mineral-swampy and gleyic soils and lowland pseudogley on elevations. The macroclimate of the area is continental with a mean annual temperature of 9°C and the precipitation quantity of 1,000 mm.

The decisive ecological factor for the growth and development of the forest vegetation of the planar belt is water, whether in the form of floodwater, (poplar and willow forests), groundwater (forests of pedunculate oak), or both kinds of water (forests dominated by black alders and narrow-leaved ashes).

The forest vegetation of the planar belt in Croatia is characterised by relatively well preserved forest complexes, very valuable forests of pedunculate oak, the occurrence of narrow-leaved ash and very distinctive biological diversity. However, these characteristics are more prominent in Central Posavina and East Croatia than in the studied area.

The phytocoenological picture of the forests in the lowland vegetation belt is complex, consisting of riparian forests along riverbeds, forests in bogs and micro-depressions and forests on micro-elevations.

Riparian forests along riverbeds and bogs
Ritske šume uz rječna korita i bare

These forests belong to the alliance of riparian forests *Salicion albae.* They occur along the river Sava, Kupa, Česma, Lonja and their tributaries. However, they are arranged in very narrow and mosaic-like fragments because the riverbanks - the potential sites of these associations - have been regulated with dams. More significant complexes are found along the river Sava.

Proper riparian forests are those forests that extend along rivers, are regularly flooded with periodical floods, display distinct syndynamic relations and grow on intensively developing soils. Forest associations are paraclimatic, and the degree of soil development, the occurrence of willow shrubs, the formation of plant communities and other structural relationships are dependent on the frequency, height and duration of floods. The basic forest species in riparian forests participating in almost all succession stages are: *Salix triandra, Salix purpurea, Salix alba, Populus alba, Populus nigra, Ulmus laevis, Fraxinus angustifolia* and *Quercus robur.* Three associations have been identified in the studied area:

The shrub of purple willow (*Salicetum purpureae* Wend. - Zel. 1952) is a frequent, fragmentarily distributed association on the islands and banks of large rivers, but also of smaller, economically insignificant streams. It has a transitional character and forms a border forest association towards swampy phytocoenoses, primarily reeds. The soils of the association are shallow and undeveloped, but well supplied with nutrients due to matter sedimentation.

Salix purpurea dominates in the first, upper layer of several meters, while the very dense lower layer of ground vegetation consists of *Rubus caesius, Ranunculus repens, Euphorbia salicifolia, Iris pseudacorus, Solanum dulcamara, Polygonum lapatifolium* and other species.

The forest of white willow with bedstraw (*Galio-Salicetum albae* Rauš 1973) is developed in micro-depressions on alluvial carbonates, undeveloped soils along bogs and large water areas, continuing onto the purple willow association or directly onto reeds or marshy phytocoenoses. Floods are common in this association, and this is the reason why willows form adventitious roots from the stem. When the water retreats, the roots remain hanging, giving the forest a peculiar appearance. Such old trees can be found along the rivers Lonja and Česma.

The most important element in the floral composition of the association is white willow, while the ground layer consists of *Galium palustre, Carex elata, Iris pseudacorus, Agrostis alba, Rubus caesius, Lysimachia nummularia, Lysimachia vulgaris, Ranunculus repens, Lythrum salicaria, Bidens tripartita* and others.

It should be mentioned that the former large areas of this phytocoenosis have been meliorated and either covered with cultures of hybrid poplars or turned into agricultural areas.

The forest of white willow and black poplar (*Salici albae-Populetum nigrae* Tx. 1931) is a mixed association with the principal edifying species being the white willow and black poplar. It is especially developed in Croatian Podunavlje, but fragments can also be found along the river Sava from Podsused to Sisak. The building of dams and ameliorative operations have caused this forest to lose its natural appearance and structure, and classical floods and synecological conditions, such as those occurring on the Danube islands, are absent. There, the floods are rarer and last for shorter periods than the floods in the forest of white willow and bedstraw, but are more copious and distinct than on the higher positions taken up by the stands of black and white poplars.

Salix alba and *Populus nigra* participate equally in the tree layer, while in the shrub and ground layer, apart from the species of the flooded sites from the alliance *Salicion albae*, there are plants of less humid sites, such as *Circaea lutetiana, Carex remota, Scrophularia elata* and *Lycopus europaeus*.

A particularly interesting feature of the studied area consists of very well preserved remnants of the former stands of this association on Lakes Jarun and Bundek in the Town of Zagreb.

Forests of bogs and micro-depressions
Šume udubina i niza

This group is composed of forest associations in which the edifying species are the pedunculate oak, black alder, narrow-leaved ash, lowland elm and spreading elm. They inhabit depressions ranging in size from half a hectare, which mostly belong to forests of black alder or ash, to a complex of several hundred ha with fo-

rests of pedunculate oak. In the past these forests were regularly flooded. Today, however, depending on the terrain orography and the distance from rivers, some parts are periodically flooded, while others only have a high level of groundwater and long-standing (stagnant) precipitation water due to specific soil composition. There are three basic associations in the entire studied area, of which the forest of pedunculate oak and great green weed (*Genisto elatae-Quercetum roboris* Ht. 1938) is shown in two sub-associations due to humidity.

The forest of black alder with buckthorn (*Frangulo-Alnetum glutinosae* Rauš 1968). The forest of black alder with buckthorn is fragmentarily arranged over an area of several ha. It grows in specific micro-relief and hydrological conditions. Most commonly, these are old beds of waterways and sometimes swamps. The pioneering role of the black alder comes to light here, because the moment suitable conditions are formed, the tree covers the old waterways and over several generations creates normal forest soil and conditions for the growth of other tree species. It is found in all management units of the lowland region, especially in Žutica and the Pokuplje basin.

The forest of black alder with buckthorn is developed on organogenic-swampy soil of mildly acid reaction with about 5.7 pH at a depth of 50 cm. The phytocoenosis is covered with 20 - 70 cm-deep surface water (sometimes more) for the most part of the year. This stagnant surface water is the reason why black alder develops special conical butts which collect mud and turn it into soil, so the alder manages to vegetate despite surface water covering a part of its root system.

The most important species in the tree layer is black alder (*Alnus glutinosa*) with frequent occurrence of narrow-leaved ash (*Fraxinus angustifolia*) and spreading elm (*Ulmus laevis*).

The shrub layer, ranging from 1 to 10%, is rather poor in cover. Apart from the species from the tree layer, the most common elements in it are *Frangula alnus, Viburnum opulus* and *Salix cinerea* on the butts of black alder trees.

There are two structural units (sinusions) in the ground layer, of which one (mesophytic) develops on the conical butts of black alder trees, that is, on the soil linked to the alder root system. These cones may sometimes have a diameter of 1 to 2 meters at the soil base and a height of 50 to 120 cm above the level of stagnant water. They are home to *Dryopteris carthusiana, Sympthytum tuberosum, Glechoma hederacea, Rubus caesius, Solanum dulcamara* and others, as well as to some mosses.

The other (hygrophytic) sinusion of the ground vegetation occurs on the soil itself, between the cones of black alders, and is made up of distinct hygrophytes, such as *Polygonum lapatifolium, Galium palustre, Sium latifolium, Lythrum salicaria, Stachys palustris, Lemna trisulca, Roripa amphibia, Hottonia palustris, Iris pseudacorus, Glyceria fluitans, Glyceria maxima, Symphytum officinale, Caltha palustris, Sparganium erectum, Urtica radicans, Peucedanum palustre* and many others. The entire floral composition of the association in the studied area can be seen in Table 1, columns 1 and 2.

The syndynamic development of the forest of black alder with buckthorn is very interesting, above all due to the pioneering and ameliorative role played by the black alder in the lowland region of Croatia. There are three stages in its development: in the initial stage beginning in old waterways, only the ground vegetation of rushes and similar is developed, to continue onto grey sallow, white sallow, fragile willow, buckthorn, white poplar, narrow-leaved ash and black alder on micro-elevations (slight undulations, facies: *Glyceria maxima*).

The black alder originating from seed and stump, with or without a conical butt and with an addition of spreading elm with narrow-leaved ash is in the optimal developmental stage.

In its terminal stage, the black alder is gradually declining and giving place to the pedunculate oak, and even a sporadic maple and common hornbeam.

We should point out that in the case of the association *Frangulo-Alnetum glutinosae,* black alder forests did not develop from the glacial, but represent pioneering and transitional stands in which the black alder has invaded the terrain, formed it phytocoenosis and gradually created conditions for the occurrence of other species. All these processes in current stands of black alder have taken place over the past few centuries, and can be accelerated with ameliorating the terrain (regulating water with canals). However, this is not necessary because these sites are highly diverse biologically owing to the annual rhythm of changes in the conditions. For this reason, they form not only important phytocoenoses, but also various zoocoenoses.

The forest of narrow-leaved ash with autumn snowflake *(Leucoio-Fraxinetum angustifoliae* Glav. 1959). The forest of narrow-leaved ash with autumn snowflake extends over a clayly alluvial terrain from Sisak to Spačva. In some earlier research and in the one conducted for this study, it was also found in the Česma basin, in Turopoljski Lug and in a large part of Pokuplje basin.

The most important factors determining the development of the association are the micro-relief and the relating stagnant and groundwater. The soil is distinctly undulating and can be neutral to acid. Of all the lowland phytocoenoses, this one is the most subjected to longer periods of surface water and high groundwater. In the winter, surface water (with an average depth of 1 m) often freezes and ice inflicts extensive damage on ash trees. Therefore, the micro-relief characteristics of the depressive terrain, the regime of high water and the properties of the soil are the fundamental ecological factors that determine the phytocoenosis.

In terms of orography, the phytocoenosis invades depressions (bogs and plates), open or closed holes in the soil. Water either runs from the higher plates to the lower (open) ones, or when it cannot leave at all (closed), it evaporates. In these bogs there are deeper plates in which precipitation water from the neighbouring areas collects and stagnates and only leaves with evaporation. Such shallow depressions are conducive to the growth of a typical forest of narrow-leaved ash, since

ash has reached the extreme boundary of forest survival (swampy forest boundary). Marshy ground lying in deeper depressions is not covered with forest trees.

Narrow-leaved ash forms pure stands because the competitive ability of other tree species is weak. The tree layer covers 60 to 80 % of the area on average and is composed of narrow-leaved ash in the dominant storey with a rare presence of lowland elm, spreading elm and sometimes pedunculate oak.

The shrub layer is poorly developed and covers 0 to 5% of the area on average. Apart from tree species in the form of shrubs, it is also composed of *Genista elata, Frangula alnus, Salix cinerea* and others.

The layer of the ground vegetation covers 80 to 100 % of the area. It is very lush and is made up of a large number of species, shown in Table 1, columns 3 and 4.

Narrow-leaved ash is an outstandingly important tree species in the planar belt of Croatia from several standpoints. Apart from being important as a pioneering tree species, it grows in unfavourable, mostly swampy conditions in which other tree species cannot survive and where it does not meet any competition. Moreover, when stands of pedunculate oak in the association *Genisto elatae-Quercetum roboris* desiccate due to bogging or other changes in the biotop, ash is an unavoidable species in salvaging the stand after dieback. In the first phase, until conditions for the recurrence of pedunculate oak are created, it takes on the main role together with the black alder. This was shown in the recovery of the forests Kalje, Turopoljski Lug, the forests in the Pokuplje basin and in other places. To sum it up, ash is a highly desirable and valued economic species, which may reach the same price as pedunculate oak under certain conditions.

The forest of pedunculate oak with great green weed *(Genisto elatae-Quercetum roboris* Ht. 1938). Natural sites of pedunculate oak in the studied area are the micro-depressions of the Posavina, Pokuplje and Česma basins, especially the complex between the motorway and the river Sava. The forests of Žutica, Jastrebarski Lugovi, Draganički Lugovi, Turopoljski lug and others are located here. Pedunculate oak forms two basic forest associations: the forest of pedunculate oak and great green weed in micro-depressions and the forests of pedunculate oak and common hornbeam on micro-elevations.

The forest of pedunculate oak and great green weed occurs above the forests of willow, poplar, black alder and narrow-leaved ash in complexes exceeding several thousand ha, which is unique in Europe and in the world. The terrain on which it grows is several meters above the normal level. It is periodically flooded, but floods last for short periods, or the terrain is out of reach of floods but still abundantly fresh. It is found on mineral-swampy soil of stronger or weaker acidity and on pseudogleyic, or podzolic, mildly acid to neutral soil.

The lush tree layer is dominated by pedunculate oak, but a considerable share of the composition (sometimes even 40%) consists of narrow-leaved ash, black alder, lowland elm, spreading elm, black and white poplar and sporadic fruit-bea-

ring trees. In the western part of the association there are pure oak forests, the result of bad management and excessive felling of other tree species, which today has a negative effect on the stability of hundred-year-old stands. Nowhere has the necessity of supporting mixed stands in their natural composition been shown more clearly than in this association, because it is a prerequisite for stability, biological diversity and productivity of forest stands.

The shrub layer is also lush and diverse, which makes this association fundamentally different from the forest of pedunculate oak and common hornbeam. Apart from the species in the tree layer, the cover of 10 to 50 % consists of great green weed (*Genista elata*), hawthorn (*Crataegus oxyacantha*), common hawthorn (*Crataegus monogyna*), blackthorn (*Prunus spinosa*), wild pear (*Pyrus pyraster*), guelder rose (*Viburnum opulus*), buckthorn (*Frangula alnus*), blackberry (*Rubus caesius, Rubus fruticosus*), rose (*Rosa* sp.) and other species.

The layer of ground vegetation has a cover of 80 to 100% and is particularly lush in the spring after floods. It consists of some hundred species (Table 1, columns 5-8), of which the most important are *Carex remota, Carex strigosa, Rumex sanquineus, Cerastium sylvaticum, Valeriana dioica, Lycopus europaeus, Solanum dulcamara, Glechoma hederacea, Poa trivialis* and others.

The eco-indicative properties of the species in the ground layer in general point to the characteristics of the site and especially to its hydrological conditions. The majority of these and other species thriving in the forest of pedunculate oak and great green weed indicate humid, wet and occasionally flooded sites. The species leading to extremes, that is, to dry or complete swampy and flooded terrains, are absent.

From a phytocoenological standpoint, the forest of pedunculate oak and great green weed is divided into several sub-associations, but two are of special importance for the studied area: with quaking sedge (*Genisto elatae-Quercetum roboris caricetosum brizoides* Ht 1938), and with remote sedge (*Genisto elatae-Quercetum roboris caricetosum remotae* Ht 1938). The sub-association with remote sedge represents the optimum in the development of this association in which the renowned Slavonia oak thrives, while the sub-association with quaking sedge represents a transition towards pedunculate-hornbeam forests on micro-elevations and is susceptible to changes and forest decline. An example of this is Turopoljski Lug, Kalje near Lekenik, Žutica and other forests.

Forests of micro-elevations
Šume mikrouzvisina

Micro-elevations out of reach of floodwater, in which groundwater is much lower than in previously described associations, have been differentiated in the course of lowland region development. They are home to pedunculate oak, common hornbeam and even common beech in some places. This is an important vegetative

Table 1. Forest associations of flooded areas
Tablica 1. Šumske zajednice poplavnih područja

Association:		*Frangulo-Alnetum glutinosae*		*Leucoio-Fraxinetum angustifoliae*		*Genisto elatae-Quercetum roboris*			
Subassociation		*typicum*		*alnetosum glutinosae*		*caricetosum brizoides*		*caricetosum remotae*	
Area:		Žutica	Česma	Žutica	Pokupski bazen	Žutica	Pokupski bazen	Žutica	Pokupski bazen
Number of recordings:		10	5	10	5	10	10	10	5
Plot size (m^2):		400	400	400	400	400	400	400	400
FLORAL COMPOSITION									
Characteristic and distinguishing species of the alliance (*Alnion glutinosae*):									
Frangula alnus Mill.	B	V	IV	III	IV	V	V	III	V
Salix cinerea L.		IV	IV	II	I	I	II	I	IV
Solanum dulcamara L.	C	V	III	III	IV	III	III	II	II
Myosotis palustris L.		III	I	III	II	IV	IV	III	IV
Galium palustre L.		V	IV	V	V	IV	III	V	V
Peucedanum palustre (L.) Monch.		V	III	IV	III	III	IV	III	III
Iris pseudacorus L.		IV	III	IV	IV	III	I	V	V
Ranunculus repens L.		I	I	III	V	II	III	IV	V
Lysimachia vulgaris L.		III	V	IV	I	III	V	IV	V
Cardamine dentata L.		II	.	II	V	I	II	I	II
Leucoium aestivum L.		II	I	III	V	.	.	III	I
Carex elongata L.		III	V	II	II	II	.	III	I
Frangula alnus Mill.		.	.	.	I	I	II	.	I
Carex riparia Curt.		V	V	III	II	.	.	I	II
Roripa amphibia (L.) Bess.		II	.	I	.	.	.	I	.
Sium latifolium L.		I	.	.	IV	.	.	.	.
Urtica radicans Balla.		.	III	.	.	.		.	.
Characteristic and distinguishing species of the alliance (*Alno-Quercion roboris*):									
Genista tinctoria subs. *elata*	B	.	.	II	II	I	III	II	I
Viburnum opulus L.		I	II	.	III	II	III	I	IV
Rumex sanquineus L.	C	I	.	III	III	III	III	III	IV
Cerastium silvaticum W.K.		I	.	I	.	II	I	III	.
Lycopus europaeus L.		III	.	IV	II	IV	II	III	IV
Lysimachia nummularia L.		I	.	II	V	III	V	IV	V
Glechoma hederacea L.		II	.	II	IV	IV	I	IV	V
Caltha palustris L.		I	II	II	IV	.	I	II	V
Stachys palustris L.		III	III	IV	V	II	III	III	V
Carex remota L.		I	.	III	V	II	.	V	V
Carex strigosa Huds.		.	.	.	V	.	.	III	V
Valeriana dioica L.		.	.	II	V	I	II	I	III
Viburnum opulus L.		.	.	I	III	.	I	.	II
Genista tinctoria subs. *elata*		.	.	.	.	.	II	.	I
Characteristic and distinguishing species of order (*Alnetalia glutinosae*) and class (*Alnetea glutinosae*):									
Quercus robur L.	A	I	I	I	V	V	V	V	V
Alnus glutinosa (L.) Gartn.		V	V	IV	V	V	IV	II	V

Fraxinus angustifolia Vahl.	I	II	V	V	II	I	I	IV
Ulmus carpinifolia Gled.	.	.	.	V	I	I	.	II
Ulmus laevis Pall.	.	III	III	III	.	.	.	I
Populus alba L.	.	.	.	.	.	.	.	I
Ulmus carpinifolia Gled. B	I	III	I	II	IV	I	III	IV
Acer tataricum L.	I	.	I	.	I	.	I	.
Sambucus nigra L.	I	I	.	I	I	I	I	III
Alnus glutinosa (L.) Gartn.	III	IV	III	II	IV	IV	III	IV
Ulmus laevis Pall.	I	III	.	II	.	.	II	.
Quercus robur L.	I	.	I	I	I	II	.	I
Fraxinus angustifolia Vahl.	I	IV	IV	III	II	I	IV	III
Rubus ceasius L.	I	.	IV	II	.	IV	.	I
Populus alba L.	.	.	I	.	.	I	.	II
Spirea salicifolia L.	.	I	.	.	.	.	.	.
Quercus robur L. C	.	.	II	.	II	V	III	V
Nephrodium spinulosum Strempel.	V	III	III	III	II	IV	I	III
Impatiens noli tangere L.	I	.	I	.	II	I	I	II
Rubus ceasius L.	III	I	.	III	IV	III	V	III
Angelica silvestris L.	I	.	I	I	II	I	I	II
Carex brizoides L.	I	.	.	.	V	V	.	III
Fraxinus angustifolia Vahl.	.	.	.	I	.	.	I	.
Ulmus carpinifolia Gled.	.	.	.	.	.	II	I	.
Acer tataricum L.	.	.	.	.	.	.	I	.
Alnus glutinosa (L.) Gartn.	.	.	.	I	.	I	.	I
Characteristic species of order (*Fagetalia*) and class (*Querco-Fagetea*):								
Carpinus betulus L. A	.	.	.	III	II	II	.	III
Acer campestre L.	.	.	I	.	I	I	.	.
Pyrus pyraster (L.) Borkh.	.	.	.	I	.	I	.	I
Crataegus oxyacantha L. B	I	.	II	IV	III	IV	III	V
Prunus spinosa L.	I	II	.	II	II	II	I	I
Pyrus pyraster (L.) Borkh.	I	.	I	II	II	III	I	I
Carpinus betulus L.	.	.	.	.	III	III	.	III
Corylus avellana L.	I	.	.	.	I	V	.	II
Acer campestre L.	I	.	.	.	III	II	II	III
Crataegus monogyna Jacq.	I	.	.	II	II	III	I	II
Euonimus europaea L.	.	.	I	II	I	II	I	I
Circaea lutetiana L. C	III	.	I	.	IV	II	II	II
Urtica dioica L.	IV	II	IV	V	IV	I	V	III
Aegopodium podagraria L.	II	.	I	.	I	II	I	V
Humulus lupulus L.	I	.	II	I	II	I	I	I
Lamiastrum galeobdolon (L.) E. et P.	.	.	.	.	I	II	.	I
Brachypodium silvaticum (Huds.) R.S.	.	.	I	.	II	.	.	.
Paris quadrifolia L.	.	.	.	.	I	.	.	.
Galium odoratum (L.) Scop.	I	.	.	.	I		.	
Geranium robertianum L.	.	.	.	.	I	II	.	I
Stellaria holostea L.	.	.	.	.	I	IV	.	.
Veronica montana L.	.	.	.	.	II	III	.	II
Viola reichenbachiana Jor. ex Bor.	.	.	.	.	I	I	I	I
Scrophularia nodosa L.	.	.	.	.	.	III	I	III
Ajuga reptans L.	.	.	I	.	I	IV	I	III

Geum urbanum L.	I	.	I	.	I	I	I	I
Dryopteris filix mas (L.) Sch.	.	.	.	.	IV	II	I	.
Acer campestre L.	.	.	I	.	.	I	I	.
Polygonatum multiflorum (L.) All.	I	.	.	.	.	.	.	.
Crataegus oxyacantha L.	.	.	.	.	.	.	.	I
Ranunculus lanuginosus L.	.	.	.	.	.	I	.	.
Carex silvatica Huds.	.	.	.	.	I	I	.	.
Arum maculatum L.	.	.	.	.	I	.	.	.
Euonimus europaea L.	.	.	.	II	.	.	.	.
Carex maxima Huds.	.	.	.	.	.	I	.	II
Cucubalus baccifer L.	.	.	.	.	.	I	.	I
Leucoium vernum L.	.	.	.	.	.	I	.	I
Other species of wet and flooded sites:								
Polygonum hydropiper L. C	III	III	IV	III	IV	III	III	III
Deshampsia caespitosa (L.) Beaur.	I	.	I	I	V	IV	II	I
Symphytum officinale L.	I	.	I	.	I	.	III	.
Carex elata All.	II	III	IV	II	.	.	II	II
Euphorbia palustris L.	II	I	IV	.	.	.	IV	.
Poa palustris L.	.	.	I	.	I	III	I	I
Juncus effusus L.	I	.	II	II	III	V	III	V
Senecio fluviatilis Wallr.	.	.	.	.	II	.	I	II
Festuca gigantea (L.) Vill.	I	.	I	.	I	.	I	.
Lytrum salicaria L.	II	.	III	II	III	II	II	III
Succisa pratensis Mch.	.	.	I	II	I	I	I	V
Alisma plantago aquiatica L.	I	III	I	.	I	.	.	I
Carex vulpina L.	.	.	I	.	.	.	I	.
Carex vesicaria L.	III	III	V	I	.	.	I	.
Mentha aquatica L.	I	I	I	III	.	II	I	III
Thalictrum flavum L.	.	.	I	.	.	.	I	.
Stellaria aquiatica	.	.	.	.	.	.	I	.
Sparganium erectum L.	III	.	.	.	.	.	.	.
Lemna trilusca L.	I	I	.	.	.	.	.	.
Hottonia palustris L.	I	I	.	.	.	.	.	.
Lemna minor L.	I	II	.	.	.	.	.	.
Senecio aquiatica Huds.	I	I	I	.	.	.	.	.
*Cardamine flexuosa*With.	.	.	.	III	.		.	
Filipendula ulmaria (L.) Maxim.	.	.	.	.	.	.	I	III
Chrysosplenium alternifolium L.	.	.	.	I	.	.	.	.
Glyceria fluitans (L.) R. Br.	.	I	.	.	.	.	.	III
Other species:								
Fraxinus americana A	I	.	.	.	.	.	.	.
Malus silvestris (L.) Mill.	.	.	.	II	.	I	.	I
Rhamnus cathartica L. B	II	II	I	III	I	I	III	.
Cornus sanquinea L.	I	.	.	III	I	II	I	II
Rosa canina L.	.	.	.	.	I	I	I	II
Fraxinus americana	I	.	I	.	.	.	.	.
Amorpha fruticosa L.	.	.	I	.	.	.	.	.
Galeopsis tetrahit L. C	IV	.	III	.	V	V	III	.
Hedera helix L.	.	.	I	.	I	.	I	.

Athyrium filix femina (L.) Roth.	I	.	I	.	III	II	I	.
Prunella vulgaris L.	.	.	.	.	I	II	I	II
Pulmonaria officinalis L.	.	.	.	.	I	.	I	.
Aristolochia clematitis L.	I	.	.	.	I	.	I	.
Hypericum acutum L.	.	.	.	.	II	.	I	.
Lychnis flos cuculi L.	I	.	I	.	I	I	I	I
Bidens tripartitus L.	II	.	.	.	I	I	I	I
Agrostis alba L.	.	.	.	.	I	.	I	.
Stellaria media (L.) Mill.	.	.	I	.	.	.	II	.
Galium aparine L.	.	.	.	.	I	.	.	.
Ballota nigra L.	.	.	.	.	I	.	.	.
Eupatorium canabinum L.	III	.	.	.	I	II	.	.
Moehringia trinervia (L.) Clairv.	I	.	.	.	.		.	
Trifolium repens L.	.	.	.	.	.	II	.	I
Rhamnus cathartica L.	.	.	I	II	.	.	.	.
Torilis anthriscus (L.) Gmel.	.	.	.	.	I	.	.	
Galium silvaticum L.	II	.	I	.	I	.	.	.
Amorpha fruticosa L.	.	.	.	.	.	.	I	.
Solidago sp.	.	.	.	.	.	.	I	.
Melandrium rubrum Garcke.	I	.	I	.	.	.	I	.
Tamus communis L.	.	.	.	.	.	.	I	.
Vitis silvestris Gmel.	I	.	.	.	.	.	.	.
Ranunculus ficaria L.	.	.	.	II	.	I	.	II
Melampyrum silvaticum L.	.	.	.	.	.	II	.	.
Potentilla erecta (L.) Hampe.	.	.	.	.	.	III	.	.
Cynanthum vincetoxicum (L.) Pers.	.	.	.	.	.	I	.	.
Verbatum album	.	.	.	.	.	II	.	.

Explanation of abbrevations: A - Tree layer, B - Shrub layer, C - Ground vegetation layer, I - V - Degree of participation

property of this part of Croatia, because the stands in Stupnički Lug, Kupčina, Gornjak in Turopoljski Lug, Bukovac near Vrbovec Dubrava and in Žutica have special significance.

It should be pointed out that in the floral and systematic sense, this association is fundamentally different from the forest of pedunculate oak, although both are found in the planar belt and are often intertwined. The forest of pedunculate oak with common hornbeam belongs to the alliance *Carpinion betuli* and the order *Fagetalia,* and by its composition and synecological conditions it resembles the west and central European association *Stelario-Carpinetum.*

The forest of pedunculate oak and common hornbeam *(Carpino betuli-Quercetum roboris* Rauš 1969). One of the best-known and best-studied forest associations is found in the lowland part of Croatia and in the valley of the river Mirna in Istria. The largest complexes occur in the Spačva Basin and along the entire course of the river Sava in Croatia.

The soil of this forest is not exposed to flooding, but is saturated with water in winter. In its composition the forest differs considerably from the forest of pedunculate oak with great green weed. It occurs on drained, but abundantly fresh terra-

ins and is developed on mildly acid to neutral pseudogleyic, that is, podzolic soils on elevations. This type includes the most highly situated pedunculate oak forests in the Croatian lowland region. There is considerable participation of common hornbeam and maple, as well as a number of shrubs and herbaceous plants of drained terrain, such as those growing in hilly regions.

Common hornbeam is the best indicator of stagnant water and groundwater, because it tolerates short, passing floods, but does not tolerate stagnant water and high levels of groundwater. It grows only up to the medium groundwater table between 2 and 3 m, which is found only on elevations (Dekanić 1962).

Pedunculate oak, which plays a decisive role in the structure of a typical forest, is different in this respect. It has a large share in the phytocoenosis and exerts a vital influence on its structure and economic value. In spite of this, pedunculate oak is far less important for limited communities (associations and sub-associations) than common hornbeam because it also occurs equally frequently in the association with great green weed, to which the association with common hornbeam is connected in vertical sense.

The shrub layer is poor in species and often contains *Corylus avellana, Cornus sanguinea, Euonimus europaea, Rosa arvensis, Daphne mezereum, Crataegus* sp., and other species, while the ground vegetation consists of the species from the alliance *Carpinion betuli* and the species thriving on fresh and humid terrains. The phytocoenological composition is shown on the basis of 30 recordings in Table 2.

The mentioned characteristics refer to a typical sub-association (*subas. typicum*) while another significant sub-association in the studied area is that with beech (*Carpino betuli-Quercetum roboris fagetosum* Rauš 1971).

The pedunculate oak - hornbeam forest with beech is a relict association that inhabits the lowland regions of Croatia within a typical forest of pedunculate oak and common hornbeam. It grows on lowland pseudogley, exclusively on micro-elevations out of reach of floodwater, where beech has remained since the Sub-Boreal period, when it spread low down into the plains and invaded the present sites of pedunculate oak (Soó 1940). The soil is drained but fresh, mildly acid to neutral. The association grows in fragments of several hectares in about fifty lowland localities in Croatia and is incomparably less represented than a typical sub-association. Among the most famous localities are those in the Zagreb County and even Stupnički Lug and a part of Maksimir Park in the City of Zagreb.

The composition of ground vegetation makes this forest significantly different from a typical forest of pedunculate oak and common hornbeam, primarily in terms of differentiating species *Fagus sylvatica, Mercurialis perennis, Dentaria bulbifera, Cardamine trifolia, Allium ursinum, Luzula pilosa, Maianthemum bifolium, Anemone hepatica, Ruscus aculeatus, Rubus hirtus, Staphylea pinnata* and others. In phenological sense, the phytocoenosis is characterised by early flushing of hornbeam and beech, while pedunculate oak starts leafing only ten days after.

Mixed forests of pedunculate oak, common hornbeam and beech came into being during secular climate changes and in the past extended over much larger areas in the Pannonian Plain.

Table 2. Floral composition of mesophylic oak forest
Tablica 2. Florni sastav mezofilnih hrastovih šuma

Association:		*Carpino betuli-Quercetum roboris* Rauš 1969		*Epimedio-Carpinetum betuli* (Ht. 1938) Borh. 1963	
Area:		Žutica	Pisarovina	Sljeme	Vukom. Gorice
Number of recordings:		20	10	10	25
Plot size (m^2):		400	400	400	100-500
FLORAL COMPOSITION					
Characteristic and distinguishing species of the association (*Carpino betuli-Quercetum roboris*):					
Quercus robur L.	A	V	V	.	I
Quercus robur L.	B	I	.	.	.
Ruscus aculeatus L.		II	.	.	.
Veronica montana L.	C	IV	II	.	.
Quercus robur L.		IV	V	.	.
Carex brizoides L.		IV	III	.	.
Lysimachia nummularia L.		II	I	.	.
Carex remota L.		II	I	.	.
Glechoma hederacea L.		I	II	.	.
Luzula pilosa (L.) Willd.		I	.	.	.
Characteristic and distinguishing species of the association (*Epimedio-Carpinetum betuli*):					
Quercus petraea Lieb.	A	.	.	V	V
Fagus sylvatica L.		III	II	V	V
Prunus avium L.		.	.	I	I
Castanea sativa Mill.		.	.	III	I
Fraxinus ornus L.		.	.	I	.
Fagus sylvatica L.	B	I	I	V	IV
Quercus petraea Lieb.		.	.	IV	IV
Rosa arvensis Huds.		.	.	III	I
Prunus avium L.		.	.	II	I
Lonicera caprifolium L.		.	.	II	III
Castanea sativa Mill.		.	.	IV	I
Fraxinus ornus L.		.	.	III	.
Staphylea pinnata L.		.	.	I	.
Knautia drymeia Heuff.	C	.	.	IV	III
Prunus avium L.		.	.	IV	II
Quercus petraea Lieb.		.	.	IV	V
Fagus sylvatica L.		I	I	IV	II
Primula vulgaris Huds.		II	.	II	III
Lonicera caprifolium L.		.	.	II	IV
Helleborus dumetorum W. K.		.	.	I	.
Luzula luzuloides (Lam.) D. W.		.	.	IV	II
Erythronim dens canis L.		.	.	II	.
Castanea sativa Mill.		.	.	III	I
Staphylea pinnata L.		.	.	I	.
Hacquetia epipactis (Scop.) DS.		.	.	II	.
Salvia glutinosa L.		.	.	I	I
Carex pilosa Scop.		.	.	II	.
Hepatica nobilis Schreb.		.	.	II	.
Fraxinus ornus L.		.	.	I	.

Characteristic and distinguishing species of the alliance (*Carpinion betuli*) and distinguishing species of suballiance (*Lonicero-Carpinenion*):					
Carpinus betulus L.	A	V	V	IV	V
Quercus cerris L.		.	.	I	I
Corylus avellana L.		.	.	.	I
Acer campestre L.		.	.	.	II
Carpinus betulus L.	B	IV	IV	IV	V
Euonimus europaea L.		III	I	I	.
Acer campestre L.		III	I	II	III
Corylus avellana L.		III	V	V	V
Quercus cerris L.		.	.	I	.
Ruscus hypoglossum L.		.	.	I	II
Stellaria holostea L.	C	IV	II	II	IV
Vinca minor L.		I	I	.	.
Acer campestre L.		II	.	II	II
Carpinus betulus L.		II	.	IV	IV
Euonimus europaea L.		.	II	.	.
Aposeris foetida (L.) Cass.		.	.	IV	IV
Cruciata glabra (L.) Ehrend.		.	I	III	III
Cyclamen purpurascens Mill.		.	.	III	II
Vicia oroboides Wulf.		.	.	II	.
Lamium orvala L.		.	.	I	.
Epimedium alpinum L.		.	.	III	IV
Quercus cerris L.		.	.	I	.
Melampyrum nemorosum L.		.	.	II	.
Corylus avellana L.		.	.	.	II
Euphorbia dulcis L.		.	.	.	II
Cardamine savensis Schulz.		.	.	.	I
Characteristic species of order (*Fagetalia*) :					
Pyrus pyraster (L.) Borkh.	A	I	II	.	II
Ulmus glabra Mill.		.	.	I	.
Acer pseudoplatanus L.		.	.	.	I
Acer platanoides L.		.	.	.	I
Crataegus oxyacantha L.	B	III	V	I	.
Crataegus monogyna Jacq.		II	II	I	II
Daphne mezereum L.		.	.	III	I
Pyrus pyraster (L.) Borkh.		I	II	I	III
Acer pseudoplatanus L.		.	.	II	I
Ulmus glabra Mill.		.	.	I	.
Circaea lutetiana L.	C	V	III	I	I
Viola reichenbachiana Jor. ex Bor.		V	III	III	II
Lamiastrum galeobdolon (L.) E. et P.		V	IV	I	III
Polygonatum multiflorum (L.) All.		V	III	III	III
Ajuga reptans L.		V	IV	I	I
Dryopteris filix mas (L.) Sch.		IV	III	I	II
Brachypodium silvaticum R.S.		III	I	.	II
Carex silvatica Huds.		II	I	II	V
Asarum europaeum L.		II	I	II	V
Scrophularia nodosa L.		II	III	II	.
Galium odoratum (L.) Scop.		V	.	IV	IV
Carex maxima L.		III	.	.	.

Anemone nemorosa L.		III	.	IV	.
Paris quadrifolia L.		III	.	.	.
Pulmonaria officinalis L.		I	.	IV	III
Sanicula europaea L.		I	.	IV	V
Euphorbia amygdaloides L.		I	.	I	I
Lathyrus vernus (L.) Borh.		.	I	IV	II
Dentaria bulbifera (L.) Cr.		.	.	III	I
Acer pseudoplatanus L.		.	.	III	I
Acer platanoides L.		.	.	II	
Mycelis muralis (L.) Rchb.		I	.	II	II
Symphytum tuberosum L.		III	I	IV	
Platanthera bifolia (L.) Rich.		I	.	II	I
Senecio nemorensis L.		I	.	II	
Melica uniflora Retz.		.	.	I	I
Mercurialis perennis L.		.	.	II	.
Alliaria petiolata Scop.		.	.	II	.
Ulmus glabra Mill.		.	.	I	.
Heracleum sphondylium L.		.	.	II	.
Ranunculus lanuginosus L.		.	.	II	I
Crataegus monogyna Jacq.		.	.	I	I
Lilium martagon L.		.	.	I	.
Phyteuma spicatum L.		.	.	II	.
Daphne mezereum L.		.	.	.	I
Oxalis acetosella L.		.	.	.	I
Pyrus pyraster (L.) Borkh.		.	.	.	I
Characteristic species of class (*Querco-Fagetea*):					
Sorbus torminalis (L.) Cr.	A	.	.	.	I
Viburnum opulus L.	B	II	III	I	I
Sorbus torminalis (L.) Cr.		.	.	II	I
Cornus sanquinea L.		.	.	I	II
Ligustrum vulgare L.		.	II	II	II
Chamaecytisus hirsutus (L.) Lk.		.	.	.	I
Tilia cordata Mill.		.	.	.	I
Rubus caesius L.		I	IV	.	III
Prunus spinosa L.		.	.	.	I
Euphorbia dulcis L.	C	.	I	V	.
Hedera helix L.		III	IV	IV	III
Festuca drymeia L.		.	.	III	I
Tamus communis L.		.	.	II	.
Potentilla micrantha Ram.		.	.	II	.
Lathyrus niger (L.) Bernh.		.	.	II	I
Melittis melissophylum L.		.	.	II	I
Tanacetum corymbosum (L.) S.-B.		.	.	II	.
Sorbus torminalis (L.) Cr.		.	.	.	II
Cornus sanquinea L.		.	.	.	I
Campanula trachelium L.		.	.	.	I
Clematis vitalba L.		.	.	.	I
Viburnum opulus L.		.	.	.	I
Chamaecytisus hirsutus (L.) Lk.		.	.	.	I
Ligustrum vulgare L.		.	.	.	I

Other species:					
Alnus glutinosa (L.) Gaertn.	A	.	.	.	I
Fraxinus angustifolia Vahl.		.	I	.	.
Malus silvestris L.		.	I	.	.
Ulmus carpinifolia Gled.	B	II	II	.	.
Sambucus nigra L.		I	II	.	.
Frangula alnus Mill.		I	III	.	.
Rhamnus cathartica L.		III	.	.	.
Fraxinus angustifolia Vahl.		.	II	.	.
Rosa canina L.		.	I	.	.
Juniperus communis L.		.	.	.	II
Betula pendula Roth.		.	.	.	I
Robinia pseudacacia L.		.	.	.	I
Oxalis acetosella L.	C	V	I		.
Galeopsis tetrahit L.		V	IV	.	II
Fragaria vesca L.		III	II	V	III
Rubus hirtus W.K.		IV	.	IV	I
Geum urbanum L.		II	I	.	.
Aegopodium podagraria L.		II	I	.	I
Athyrium filix femina (L.) Roth.		II	IV	.	III
Angelica silvestris L.		II	I	.	.
Festuca gigantea (L.) Vill.		II	I	.	.
Urtica dioica L.		I	I	.	.
Deschampsia caespitosa (L.) Beauv.		I	V	.	.
Melampyrum silvaticum L.		I	II	.	II
Nephrodium spinulosum Stremp.		I	I	.	.
Lapsana communis L.		I	I	.	.
Cerastium silvaticum W.K.		II	.	.	I
Impatiens noli tangere L.		II	.	.	.
Hieracium racemosum W. K.		.	.	III	II
Geranium robertianum L.		I	.	.	.
Hieracium sylvaticum L.		.	.	II	.
Veronica chamaedrys L.		I	.	II	.
Moehringia trinervia (L.) Clairv.		I	.	.	.
Galium aparine L.		I	.	.	.
Galium palustre L.		I	.	.	.
Galium silvaticum L.		I	.	IV	I
Pteridium aquilinum (L.) Kuhn		.	.	III	IV
Hypericum hirsutum L.		I	.	.	I
Cardamine savensis Schulz.		I	.	.	.
Maianthemum bifolium (L.) Schm.		I	.	.	.
Ranunculus ficaria L.		I	.	.	.
Millium effusum L.		I	.	.	II
Myosotis scorpyoides L.		I	.	.	.
Rumex sanquineus L.		I	.	.	I
Cephalanthera rubra (L.) L.C. Rich.		I	.	.	I
Torylis anthriscus (L.) Gmel.		I	.	.	.
Euphorbia carniolica L.		.	II	.	.
Cynanchum vincetoxicum Pers.		.	II	.	I
Bidens tripartita L.		.	II	.	.

Peucedanum palustre (L.) Mch.	.	II	. .	.
Lysimachia vulgaris L.	.	I	.	.
Solidago virgaurea L.	.	.	II	I
Prenanthes purpurea L.	.	.	II	.
Polygonum hydropiper L.	.	I	.	.
Gentiana asclepiadea L.	.	I	III	I
Convallaria majalis L.	.	I	V	.
Doronicum austriacum Jacq.	.	.	II	.
Lycopus europaeus L.	.	I	.	.
Frangula alnus Mill.	.	I	.	.
Prunella vulgaris L.	.	.	.	II
Glechoma hirsuta W. K.	.	.	.	I
Lathrea squamaria L.	.	.	.	I

Explanation of abbrevations: A - Tree layer, B - Shrub layer, C - Ground vegetation layer, I - V - Degree of participation

THE VEGETATION BELT OF LOW HILLS (COLIN)
BREŽULJKASTI (KOLINSKI) VEGETACIJSKI POJAS

This vegetation belt continues onto the lowland belt and is located between 150 and 400 (500) m above sea level. It is characterised by very favourable climate and edaphic conditions for the growth of forest vegetation. This contributes to the relatively rich floral composition and lush physiognomy of forest associations. However, this is also the reason why these forests have been largely cleared, as they grow in exceptionally favourable conditions for human life and activities. The vegetation belt of low hills consists of hills and lower slopes of the Pannonian chain. It encircles higher hills and mountains, such as Medvednica, Ivanščica or Slavonian hills and takes up all the bordering areas below the belt of beech forests.

The principal tree species is undoubtedly sessile oak. It occurs in acidophilic, neutrophilic-mesophilic and thermophilic-basophilic associations over various geological substrates and soils. Of other tree species the more important are common hornbeam and beech, as well as sweet chestnut, birch, Turkey oak, pubescent oak, maple, cherry and other species. Depending on synecological conditions there are three groups of forest associations in the hilly belt that differ in the floral-systematic sense:

- the Central European vegetation zone of acidophilic forests growing on silicates dominated by the associations of the alliance *Castaneo-Quercion*;
- the peri-Illyrian oak-hornbeam forests of the sub-alliance *Lonicero caprifoliae-Carpinenion betuli* within the alliance *Carpinion betuli* on more or less neutrophilic soils;
- phytocoenoses belonging to the alliance *Quercion pubescentis-petraeae* within the order *Quercetalia pubescentis* occurring in the Central European vegetation zone of thermophilic forests.

Forests on acidophilic soils
Šume na kiselim tlima

These are forest associations on silicate rocks and dystric cambisols of various depths at altitudes up to 500 m. Some associations are distinctly dominated by sessile oak in pure stands, while others are mixed and composed equally of chestnuts, birches or other tree species. It is the chestnut and the acido-thermophilic species that give this alliance its south-eastern European character differing it from the Central European alliance *Quercion roboris-petraeae*. The characteristic and differentiating species of the alliance *Castaneo-Quercion* are *Castanea sativa, Chamaecytisus supinus, Genista germanica* f. *heteracantha, Hieracium racemosum, Lembotropis nigricans, Festuca heterophylla, Genista ovata*, while exclusively differentiating species are *Fraxinus ornus, Serratula tinctora, Cruciata glabra* and others. Naturally, they are combined with the species of the Central European alliance, such as *Genista tinctoria, Frangula alnus, Luzula luzuloides, Hieracium umbellatum, Calamagrostis arundinacea, Lathyrus montanus, Luzula forstery, Viola riviniana, Viscaria vulgaris, Hieracium sabaudum, Veronica officinalis* and others.

Two very interesting forest associations from this group are found in the area of the City of Zagreb and the Zagreb County.

The forest of sessile oak and sweet chestnut (*Querco-Castaneetum sativae* Ht. 1938). The forest of sessile oak and sweet chestnut builds the largest complexes on Mount Medvednica and in the surroundings of Samobor, and more rarely on other hills of the studied area. This forest thrives at altitudes between 250 and 550 m, sometimes higher, on mild slopes and dystric cambisols, typical, medium deep to deep, over clayly schists, shales and phyllites, where it achieves its full development in sociological and taxonomic sense. As a rule, the sites include warmer localities, plateaux, saddles or mild slopes where deeper soils can accumulate so that the chestnut can spread its roots 1m in depth.

The tree layer is composed of sweet chestnut and sessile oak, with frequent presence of common hornbeam and beech. However, chestnut dieback has caused the majority of the stands and even entire complexes to lose their typical floral composition and structure. As a result, the former rich chestnut forests are undergoing changes in terms of vegetation and management methods.

The shrub layer is very luscious and made up of well-known acidophytes *Chamaecytisus supinus, Lembotropis nigricans, Genista tinctoria, Genista germanica, Vaccinium myrtillus* and naturally, the species from the tree layer. The acidophilic species in the ground vegetation *Melampyrum pratense, Hieracium sylvaticum, Hieracium racemosum, Festuca heterophylla, Luzula luzuloides, Pteridium aquilinum, Lathyrus montanus, Viscaria vulgaris* and mosses *Hypnum cupressiforme* and *Polytrichum commune* are very important for the phytocoenosis (Table 3). Apart from these, favourable climatic and edaphic conditions enable the occurrence of many less acidophilic and neutrophilic species, even thermophytes such as, for example, *Fraxinus ornus*. The participation of beech and common hornbeam is

very important, since they repair the empty spaces caused by chestnut dieback in some stands on plateaux. This is made possible by favourable edaphic conditions. Depending on the exposition, the association more or less transcends into acidophilic forests of beech or sessile oak with considerable presence of hornbeam on milder terrains and plateaux. This process can be seen clearly in the stands above Šestine towards Medvedgrad and above Gračani.

Disturbed and degraded stands will not be analysed here, but some steeper localities with the species *Vaccinium myrtillus* are worth mentioning.

The acido-thermophilic forest of sessile oak with hawkweed (*Hieracio racemosi-Quercetum petraeae* Vukelić /1990/ 1991). The association *Hieracio racemosi-Qercetum petraeae* is best developed on the mountains of north-western Croatia, especially on Medvednica. It occurs most commonly on the substrate of schists and sandstones, almost exclusively on southern and south-western expositions at altitudes between 300 and 750 m. It grows on ridges, crests and shallow saddles in characteristic elongated fragments, and more rarely on wide slopes. In the upper area it is usually surrounded with acidophilic beech forests, and in the lower area, where the terrain is less sloped, it ends with the association of sessile oak and chestnut. The soils are dystric cambisols, typical and illimerised, usually shallow and medium deep.

Sessile oak with its edifying role is particularly prominent in the tree layer. It frequently forms mono-dominant stands with an occasional *Sorbus torminalis,* Manna ash (*Fraxinus ornus*) and chestnut (*Castanea sativa*). Chestnut is much less frequent and has poorer vitality than in the association *Querco-Castaneetum,* because shallow soils do not allow it to grow successfully. The shrub and ground vegetation is very rich, especially in more open stands. An important role is played by characteristic species that differentiate this association from the more widely spread European association *Luzulo-Quercetum*. The majority of them are acidophilic, but in south and south-eastern Europe they have a more distinct thermophilic character and are more widely distributed. These are *Chamaecytisus supinus, Hieracium racemosum, Festuca heterophylla, Serratula tinctoria, Campanula persicifolia, Dactylis polygama, Achillea distans* and proper thermophytes such as *Tanacetum corymbosum, Lathyrus niger* and *Sedum maximum*. These species are either absent or are very rare in the related associations in Europe, which justifies the definition of this association and determines its independence - above all towards the association *Luzulo-Quercetum*. Of other species there is ample presence of *Luzula luzuloides, Melampyrum pratense, Hieracium sylvaticum, Calamagrostis arundinacea, Convallaria majalis, Solidago virgaaurea, Veronica chamaedrys, Prenanthes purpurea* and others (Table 3).

The forest of sessile oak with hawkweed is mostly of primary origin, but many stands in the north-west of Croatia are in regression as a result of anthropogenic influence, improper felling and the removal of leaf litter. In the progressive direction, the coenosis is developing towards the forests of sessile oak and sweet chestnut, and the regression ends with bracken and heath.

Table 3. Forest on acidophilic soils
Tablica 3. Šume na kiselim tlima

Association:		*Hieracio racemosi-Quercetum petraeae* Vukelic (1990) 1991	*Querco-Castanetum sativae* Ht. 1938
Area:		Medvednica	Medvednica
Number of recordings:		20	10
Plot size (m^2):		250-400	300-400
FLORAL COMPOSITION			
Characteristic and distinguishing species of the association (*Querco-Castanetum sativae*):			
Castanea sativa Mill.	A	II	V
Castanea sativa Mill.	B	V	V
Hieracium sylvaticum (L.) L.	C	IV	V
Melampyrum pratense (Pers.) Ronn.		V	V
Castanea sativa Mill.		IV	V
Characteristic and distinguishing species of the association (*Hieracio racemosi-Quercetum petraeae*):			
Fraxinus ornus L.	A	I	I
Fraxinus ornus L.	B	IV	III
Chamaecytisus supinus (L.) Lk.		III	III
Chamaecytisus hirsutus (L.) Lk.		II	.
Fraxinus ornus L.	C	III	II
Galium sylvaticum L.		V	V
Tanacetum corymbosum (L.) C.H. Sch.		IV	I
Cruciata glabra (L.) Ehrend.		IV	III
Campanula persicifolia L.		IV	II
Festuca heterophylla Lam.		IV	II
Dactylis polygama Horv.		II	II
Achyllea distans W.K.		II	.
Sedum maximum (L.) Sut.		II	.
Characteristic and distinguishing species of the alliance (*Castaneo-Quercion petraeae*):			
Genista germanica L.	B	II	II
Hieracium racemosum W.K.	C	V	III
Lathyrus niger (L.) Bernh.		IV	I
Serratula tinctoria L.		II	III
Genista germanica L.		II	.
Characteristic species of order (*Quercetalia robori-petraeae*) and class (*Querco-Fagetea*):			
Genista tinctoria L.	B	III	III
Lembotropis nigricans (L.) Griseb.		II	I
Genista ovata W.K.		I	.
Frangula alnus Mill.		.	II
Luzula luzuloides (Hoffm.) DC.	C	V	V
Calluna vulgaris Hull.		II	I
Pteridium aquilinum (L.) Kuhn.		II	III
Calamagrostis arundinacea (L.) Roth.		III	I
Hieracium sabaudum L.		III	I
Hieracium umbellatum L.		II	I
Lathyrus montanus Bernh.		II	I
Genista tinctoria L.		III	.

Molinia coerulea (L.) Moench.		II	.
Avenella flexuosa (L.) Parl.		II	.
Polypodium vulgare L.		I	.
Viscaria vulgaris Bernh.		.	II
Viola riviniana Rchb.		.	II
Veronica officinalis L.		.	I
Luzula forsteri (Sm.) D.C.		.	I
Other species:			
Quercus petraea (Matt.) Liebl.	A	V	V
Fagus sylvatica L.		II	V
Rubus hirtus W.K.		II	.
Carpinus betulus L.		.	II
Quercus petraea (Matt.) Liebl.	B	IV	III
Fagus sylvatica L.		IV	V
Carpinus betulus L.		III	III
Corylus avellana L.		II	III
Juniperus communis L.		I	I
Sorbus torminalis (L.) Cr.		II	II
Sorbus aria (L.) Cr.		II	I
Acer pseudoplatanus L.		I	.
Quercus petraea (Matt.) Liebl.	C	V	IV
Convalaria majalis L.		III	II
Vaccinium myrtillus L.		II	II
Solidago virgaurea L.		III	IV
Carpinus betulus L.		II	II
Poa nemoralis L.		II	II
Fagus sylvatica L.		I	II
Platanthera bifolia (L.) Rich.		I	II
Polygonatum multiflorum (L.) All.		I	II
Acer pseudoplatanus L.		I	I
Veronica chamaedrys L.		III	II
Lathyrus vernus (L.) Bernh		II	I
Prenanthes purpurea L.		III	II
Potentilla micrantha Ram.		II	III
Fragaria vesca L.		II	III
Cephalantera longifolia (L.) Fritsch.		II	II
Gentiana asclepiadea L.		I	II
Symphytum tuberosum L.		II	II
Euphorbia dulcis L.		II	III
Melica uniflora Retz.		II	II
Stellaria holostea L.		II	.
Kneutia drymeia Heuff.		II	.
Cephalantera alba Simk.		II	.
Melittis melyssophyllum L.		II	.
Campanula patula L.		II	.
Campanula rotundifolia L.		I	.
Dryopteris filix mas (L.) Schott.		I	.
Potentilla erecta (L.) Hampe.		I	.
Carex montana L.		I	.
Vicia sepium L.		I	.

Aposeris foetida (L.) Less.	.	IV
Rubus hirtus W.K.	.	II
Sanicula europaea L.	.	II
Asarum europaeum L.	.	II
Erythronium dens canis L.	.	II
Scrophularia nodosa L.	.	II
Pulmonaria officinalis L.	.	II
Hedera helix L.	.	II
Festuca drymeia M.K.	.	I
Prunus avium L.	.	I
Cyclamen purpurascens L.	.	I
Athyrium filix femina (L.) Roth.	.	I
Campanula trachelium L.	.	I
Galium odoratum (L.) Scop.	.	I
Dentaria bulbifera L.	.	I
Mycelis muralis (L.) Dum.	.	I
Lonicera caprifolium L.	.	I
Salvia glutinosa L.	.	I
Festuca gigantea (L.) Vill.	.	I
Primula vulgaris Huds.	.	I
Dicranum scoparium (L.) Hedw. D	I	II
Hypnum cupressiforme L.	I	III
Leucobryum glaucum (L.) Schpr.	I	I
Polytrichum commune L.	.	IV
Polytrichum formosum	III	.
Mnium undulatum (L.) Weis.	.	I
Mnium sp.	.	I
Pleurozium sp.	.	I

Explanation of abbrevations: A - Tree layer, B - Shrub layer, C - Ground vegetation layer, D - Moss layer, I - V - Degree of participation

Thermophilic forests on alkaline soils
Termofilne šume na bazičnim tlima

This zone is not widely represented in Croatia. It consists of two clearly distinct and spatially important associations. Sessile oak (*Quercus petraea*), pubescent oak (*Quercus pubescens*), hop hornbeam (*Ostrya carpinifolia*), Manna ash (*Fraxinus ornus*), Turkey oak (*Quercus cerris*), *Acer obtusatum* and whitebeam (*Sorbus aria*) dominate in the tree layer while the species of the order *Quercetalia pubscentis* appear in other layers.

The forest of sessile oak with black pea (*Lathyro-Quercetum petraeae* Ht. /1938/ 1958). The forest of sessile oak with black pea is an unusual association belonging to the alliance *Quercion pubescentis-petraeae*. It is best developed on carbonate substrates and rendzic leptosols in warmer and more exposed localities in the hills of north-west Croatia at altitudes between 300 and 550 m. The phytocoenosis is connected with the forest of pubescent oak and hop hornbeam, but contains only some of its elements. The most important species in the tree layer are *Qu-*

ercus pubescens, Fraxinus ornus, Sorbus aria and *Quercus cerris*, and in the shrub layer *Cornus mas, Ligustrum vulgaris, Viburnum lantana* and *Berberis vulgaris*. In the ground vegetation the most important are neutrophilic-basophilic elements of which the most prominent are *Lathyrus niger, Dactylis polygama, Calamintha clinopodium, Tanacetum corymbosum, Cynanchum vincetoxicum, Melittis melissophyllum, Campanula persicifolia, Galium lucidum, Digitalis grandiflora* and others. On more shallow soils and more inclined slopes the thermophilic character of the association disappears in order to be replaced by a more acidophilic one. Hop hornbeam and other basophilic species are absent in the first place. As a result, there are the majority of indifferent, as well as acidophilic species on Kalnik, such as *Hieracium sylvaticum, Veronica chamaedys, Festuca heterophylla* and *Pteridium aquilinum* (Vukelić 1991). East of Kalnik, and even on Moslavačka Gora, there is a related, but still acidophilic phytocoenosis of sessile oak with fescue.

The forest of sessile oak and pea has a very high protective importance. The areas are fragmentary, poorly represented, and many stands in private forests in Croatian Zagorje are seriously degraded. Syndynamically, the phytocoenosis usually develops towards the forest of sessile oak and common hornbeam.

The forest of pubescent oak and hop hornbeam (*Ostryo-Quercetum pubescentis* Ht. 1938). The forest of pubescent oak and hop hornbeam occurs fragmentarily over areas of several hectares on Medvednica, Žumberak and Samoborsko Gorje. It inhabits altitudes of 300 to 600 m over alkaline substrates of marl, dolomite, lithotamnium limestones and less commonly sandstone. The most common soils are rendzic leptosols, and the terrain consists of steep, exposed, dry and warm slopes. The stands of pubescent oak are a relict of the thermophilic Tertiary vegetation which remained in extremely dry sites of the continental part of Europe in the post-glacial period and the onslaught of Central European mesophilic species. The floral composition is dominated by the species of the order *Quercetalia pubescentis*. The most important species in the tree layer are *Quercus pubescens, Quercus cerris, Ostrya carpinifolia, Acer obtusatum, Sorbus aria, Acer monspesulanum, Fraxinus ornus* and *Sorbus torminalis*, and in the shrub layer *Cornus mas, Chamaecytisus hirsutus, Clematis vitalba, Prunus spinosa, Viburnum lantana, Berberis vulgaris* and *Ligustrum vulgare*. In the ground layer there are *Tamus communis, Asparagus tenuifolius, Mercurialis ovata, Carex humilis, Trifolium rubens, Bromus erectus, Melittis melissophyllum, Litospermum purpureo-coeruleum, Dictamnus albus, Carex flacca, Brachypodium sylvaticum, Tanacetum corymbosum, Dactylis glomerata, Teucrium chamaedrys, Betonica officinalis, Cyclamen purpurascens, Galium mollugo* and others. The forest of pubescent oak and hop hornbeam is most commonly a coppice dominated by hop hornbeam. This refers primarily to privately owned forests that should be improved over a relatively longer period. However, almost all of the pubescent oak stands have a protective character and are excluded from regular management. Their true importance lies in the preservation of biological diversity and the gene fund.

Forests on neutrophilic soils
Šume na neutralnim tlima

The most important zone is the belt of higher hills in which the basic association is that of the forest of sessile oak and common hornbeam. In its floral-genetic development this forest differs from the related European oak-hornbeam forests in that it is rich with authentic Illyrian or Illyroid species. Among them special mention should be made of *Lonicera caprifolium, Epimedium alpinum, Erythronium dens canis, Vicia oroboides, Knautia drymeia, Crocus vernus, Helleborus dumetorum, Cruciata glabra, Aposeris foetida, Ruscus hyppoglossum* and others. Therefore, they are placed not only into separate associations, but also a sub-alliance, while the basic species of the alliance *Carpinion betuli* are the same as in other European *Carpinion* associations.

The Illyrian forest of sessile oak and common hornbeam (*Epimedio-Carpinetum betuli* /Ht. 1938/ Borh. 1963). This is a widely distributed climatozonal association that inhabits hills, lower mountains and foots of larger massifs, in humid climatic conditions, on eutric cambisols, luvisols and pseudogley on slopes over various substrates. Very beautiful stands are found in the entire ring around Mount Medvednica, in the hilly area between Vrbovec and Zelina, in private forests of Croatian Zagorje, and especially in the forests in Pokupsko belonging to the Forest Administration Sisak, in the area between Pokupsko, Kravarsko, Pisarovina and Velika Gorica. In the past, this association was even more widely distributed than it is today. Namely, large areas in hilly and sub-mountainous positions that potentially belonged to this association were cleared in the past and are presently used as agricultural land, vineyards, roads, industrial plants and settlements.

In his explanation why this association represents the vegetative climax of a larger part of Croatia, Horvat (1938) concludes that it is because it inhabits those habitats in which "general climatic conditions are fully present and undisturbed soil development is enabled".

The forest of sessile oak and common hornbeam grows at altitudes of 150 to 450 m on luvisols, eutric cambisols and calcocambisols over limestones and dolomites, soft limestones, conglomerates, marls and other substrates, and only the sub-association *erythronietosum* also occurs on dystric cambisols over sandstones.

In the tree layer, but also in the entire phytocoenosis, the most important edifying species is sessile oak. Apart from the oak, the understorey regularly features bigger or smaller groups of common hornbeam, one of the sociologically most significant species. Many stands, especially those in the valleys of streams and ditches, have been turned into pure hornbeam forests. Except for its sociological importance, hornbeam is also outstandingly important as an ameliorative species used in stand tending. It assists the growth of good-quality oak trees during the whole rotation, improves the soil with its leaf litter, and plays an irreplaceable role

in stand regeneration. Common beech often accompanies sessile oak and hornbeam, but it does not have such big importance as in the related association *Festuco drymeiae-Carpinetum betuli*. Of trees, cherry (*Prunus avium*) and maple (*Acer campestre*) are very important, while sycamore and Norway maple (*Acer pseeudoplatanus* and *A. platanoides*), elm (*Ulmus glabra*) and chestnut (*Castanea sativa*) are less common.

In the shrub layer, the following species are important: *Rosa arvensis, Euonymus europaea, Lonicera caprifolium, Corylus avellana, Crataegus monogyna, Pyrus pyraster, Daphne mezereum* and *Crataegus oxyacantha*, while those in the ground layer are *Knautia drymeia, Primula vulgaris, Helleborus dumetorum, Stellaria holostea, Vinca minor, Melampyrum nemorosum, Cruciata glabra, Cyclamen purpurascens, Vicia oroboides, Lamium orvala, Aposeris foetida, Epimedium alpinum, Galium odoratum, Anemone nemorosa, Dentaria bulbifera, Sanicula europaea, Pulmonaria officinalis, Symphytum tuberosum, Lathyrus vernus, Viola reichenbachiana, Polygonatum multiflorum, Mycelis muralis, Carex sylvatica* and others (Table 2).

Festuca drymeia and *Rubus hirtus* are common and important plants in the regeneration of stands. They sporadically form pure facies. *Hedera helix, Galium sylvaticum, Convallaria majalis* and others are also regular accompanying species.

Mosses do not have any sociological importance for this association. However, their occurrence and wide-spread presence are the result of trampling the soil in the stands, building roads and skidding tracks, removing the leaf litter and converting these forests into pure oak forests, which will be discussed in more detail in the phytocoenosis syndynamics.

The syndynamics of the phytocoenosis *Epimedio-Carpinetum betuli* is very important because almost half of the forests of sessile oak and hornbeam are in some of the syndynamic stages. To sum it up, the removal of leaf litter, irrational felling operations, excessive trampling of the soil in the stands or other negative impacts have caused the regression to take two directions, depending on the type and depth of the soil and on the parent substrate. If the soil is acidified, hornbeam retreats from the stand and pure sessile oak stands of ever decreasing quality take its place, to be replaced by sessile coppice and finally a tangled growth dominated by various more or less acidophilic or neutrophilic shrubs. If, however, the soil becomes alkaline (shallow, more or less carbonate soils), sessile oak retreats and hornbeam remains. The forest gradually turns into a tangled growth of common hornbeam with various more or less basophilic shrubs.

In concordance with earlier correct understanding, and on the basis of phytocoenological recordings, the association *Epimedio-Carpinetum betuli* is divided into three sub-associations: *erythronietosum, caricetosum pilosae* and *staphyletosum*. All three of them occur in the studied area, which makes this area very important because the forest of sessile oak and common hornbeam with its sub-associations has been described for the first time.

THE VEGETATION BELT OF HIGHER HILLS (MOUNTAIN)
BRDSKI (MONTANSKI) VEGETACIJSKI POJAS

The vegetation belt of higher hills is very significant in the forest vegetation of the City of Zagreb and the Zagreb County because of its principal species - the common beech. It extends from 500 m above sea level to its upper boundary between 700 and 900 m, depending on the location and macroclimate. It has already been said in this work that beech alone may occur at a much lower altitude, starting from 100 m in the planar belt.

Common or European beech (*Fagus sylvatica* L.) represents the most important commercial species in the forest economy of Croatia today. In the vertical distribution of forest vegetation of the continental part of Croatia, beech is a very significant species and occurs in basic associations in almost all vegetation belts. It may occur in mixtures with other species in the planar belt at heights between 90 and 150 m, which is the belt of the forest of pedunculate oak and common hornbeam (*Carpino betuli-Quercetum roboris fagetosum*). Its share in the mixture is much more prominent in the next, hilly belt at heights of 150 to 400 m. However, it achieves the peak of its development and the highest commercial value at heights to 800 m, where it distinctly dominates climatozonal associations. Humid climate in the Illyrian hilly area is highly suitable for the beech, making it a very competitive tree species. The combination of climatic conditions in the past and present and the floral-genetic development of the flora and vegetation are the reason why Illyrian forests are so rich in species. Due to the wealth of the species, these forests have been classified into a separate alliance of Illyrian beech forests *Aremonio-Fagion*.

In the belt of higher hills there are three groups of associations differing in synecological and floral sense:

Acidophilic beech forests of the alliance *Luzulo-Fagion* in which the basic association is *Luzulo-Fagetum;*

Neutrophilic Illyrian beech forests of the alliance *Aremonio-Fagion*, which comprises the association *Lamio orvalae-Fagetum* within the sub-alliance *Lonicero-Fagenion*;

Basophilic-thermophilic beech forests of the alliance *Ostryo-Fagion* with the basic association *Ostryo-Fagetum*.

Apart from the basic forest associations in the vegetation belt of higher hills, there are several other forest associations of little economic significance but high value in phytocoenological and scientific sense. Some of them have an important protective role in repairing and covering eroded areas and steep terrains. All of them are outstandingly important for the preservation of the genofund of relatively rare authochthonous tree species. A relict forest of lime and yew (*Tilio-Taxetum*) is especially important for the studied area.

The forest of beech with woodrush (*Luzulo-Fagetum sylvaticae* Mausel 1937). Analogously to acidophilic forests of sessile oak in the hilly belt, the mountain belt is home to pure acidophilic forests of common beech (*Luzulo-Fagetum sylvaticae* Mausel 1937). They take up relatively large areas on Medvednica and Samoborsko Gorje and inhabit steep, most commonly northern slopes in the first place. They occur on shallow and medium deep dystric cambisols and podzolic soils over silicate substrates at altitudes up to 800 m.

Beech dominates in the tree layer. In lower areas, beech is accompanied with sessile oak, sweet chestnut and birch, and in higher area with fir and spruce. The shrub layer is undeveloped, with only *Genista tinctoria,* as well as *Vaccinium myrtillus* over larger areas. The ground vegetation and mosses are dominated with acidity-indicating species. These are woodrush *Luzula luzuloides, Hieracium sylvaticum* and *H. racemosum* in the first place, as well as *Pteridium aquilinum, Veronica officinalis, Melampyrum vulgatum,* and mosses *Polytrychum attenuatum, Dicranum scoparium, Dicranella heteromalla.* In cases of milder slopes and deeper soils the share of neutrophilic-mesophilic species increases and this coenosis passes into the hilly beech forest with dead nettle. These fundamentally different beech forests have not yet been accurately differentiated in our country.

Sessile oak and common beech, with intensive participation of other species, occur equally in certain transitional stands in the Žumberak and Samobor chains, especially at the points where the terrain and expositions change. Phytocoenological differentiation is difficult to carry out in such areas. Such stands were described earlier in Slovenia under the name *Querco-Luzulo-Fagetum* Mar. *et* Zup. 1979.

Table 4 shows the floral composition of this association on the basis of 25 recordings from the studied area.

The Illyrian hilly beech forest with dead nettle (*Lamio orvale-Fagetum sylvaticae* Ht. 1938). The Illyrian hilly beech forest belongs to the alliance *Aremonio-Fagion* and is the most important climatozonal association of the hilly belt in Croatia. It occurs at altitudes between 400 and 800 m on Mount Medvednica, and more rarely on other hills of the studied area. This is primarily the result of the lithological substrate and soil, because silicate and dystric cambisols support the earlier described forest of beech with woodrush. Beech forest with dead nettle thrives on various expositions, flat terrain, plateaux, less conspicuous ridges and not very steep slopes. In the Dinara region it grows most commonly on brown soils on limestones and mollic leptosols, and in the Pannonian hills it inhabits a wide spectre of different soils types, but most commonly it is found on deep dystric cambisols and on luvisols on silicates.

Beech is the dominant edifying species in the tree layer. However, unlike acidophilic beech forests of the alliance *Luzulo-Fagion*, mixed stands are much more common in this phytocoenosis. In lower areas, there are additions of sessile oak and common hornbeam, and in the higher of sycamore, Norway maple, common

maple and wych elm. The shrub layer is often very rich. Apart from the species from the tree layer, there are also *Daphne mezereum, D. laureola, Sambucus racemosa, Ilex aquifolium, Lonicera xylosteum, L. alpigena, Euonymus latifolia* and others. The particularly rich ground layer is characterised by some specific species of Illyrian beech forests (*Lamium orvala, Haquetia epipactis, Epimedium alpinum, Scopolia carniolica, Euphorbia carniolica, Omphalodes verna, Calamintha grandiflora, Dentaria polyphylla, Geranium nodosum* and others), but the species characteristic for the majority of European beech forests often surpass these in terms of coverage and richness. These include *Galium odoratum, Sanicula europaea, Actaea spicata, Carex sylvatica, Pulmonaria officinalis, Anemone nemorosa, Lilium martagon, Mercurialis perennis, Lamiastrum galeobdolon, Mycelis muralis, Dentaria bulbifera, Viola reichenbachiana, Euphorbia amygdaloides, Galium sylvaticum, Fragaria vesca* and others (Table 4).

Unlike many neighbouring and other regions in Central Europe, beech in this region occurs in its natural distribution range. Therefore, it has not been massively destroyed and replaced by spruce and pine cultures. Beech stands in this area have been preserved because this hilly and mountainous region is relatively difficult to reach, and the area has therefore not been given over to settlements, roads, vineyards or agricultural land.

A relict association of lime and yew (*Tilio-Taxetum* Glavač 1959) is fragmentarily distributed in the belt of the forest of mountain beech with dead nettle. It exists as a permanent stage on steep limestone blocks that often appear on the surface. Beech, broad-leaved lime, yew and beam-tree dominate a broken tree canopy. Elements of the orders *Fagetalia* and *Quercetalia pubscentis* occur frequently in the shrub and ground layers. Of special interest are the species *Polypodium vulgare, Phyllitis scolopendrium, Valeriana tripteris, Sesleria kalnikensis*, endemic *Iris croatica* and others.

Of basophilic hilly beech forests, special mention should be made of the forest of beech forest with hop hornbeam (*Ostryo-Fagetum sylvaticae* Wraber /1950/ 1968). This is a thermophilic, continental association of beech forests, parallel with littoral beech forest with autumn sesleria (Trinajstić 1972). It grows in sunny positions in the sub-mountainous and mountainous belt on carbonate substrates and basophilic soils, most frequently on mollic leptosols and rendzic leptosols on dolomite. It reaches heights of 700 m and is best represented in the Samobor chain. The tree layer is dominated by beech, but large-sized hop hornbeam, Italian maple, beam-tree and flowering ash are also common. Apart from these species, the shrub layer consists of *Rosa arvensis, Daphne mezereum, Cornus mas* and *Euonymus verrucosa,* while the rich layer of ground vegetation is dominated by basophilic-thermophilic species, such as *Erica carnea, Helleborus macranthus, Buphtalmum salicifolium, Peucedanum oreoselinum*, but also by the species of continental beech forests.

MOUNTAINOUS VEGETATION BELT (ALTIMOUNTAINOUS)
GORSKI (ALTIMONTANSKI) VEGETACIJSKI POJAS

In the area of the City of Zagreb and the Zagreb County this vegetation belt is very distinct and simply constructed. It is characterised by beech-fir forests, which occur as low as 500 m on the north side of Mount Medvednica and 800 m on its south side. Apart from these, another important association is the association of sycamore and common ash, which can sometimes be found at higher positions in the lower hilly region.

The forest of beech and fir (*Abieti-Fagetum "pannonicum"* Rauš 1969 prov.). Compared to beech-fir forests in the Dinara region, the beech-fir forests between the Rivers Sava and Drava thrive in conditions of warmer climate, less precipitation, deep dystric soils and silicate substrate in a disjunct area of Ravna Gora, Trakošćan, Macelj, Ivanščica, Strahinjščica, Medvednica and Papuk. Since they continue onto a prominent vegetation belt of mountain beech forests, these forests were managed as even-aged stands due to smaller areas in the major part of the distribution belt. Selection management, which favours mutual relationships and characteristics of the principal tree species - the beech and the fir, has only recently been prescribed in these forests. The floral composition of these forests is relatively poor.

On Medvednica, the association occurs on deep dystric cambisols and illimerised soils over a silicate substrate. The phytocoenosis thrives in all expositions and inclinations, and descends low down in ditches.

The Pannonian beech-fir forests belong to the amphi-Pannonian vegetation zone of the European-altimontane belt, as has already been mentioned.

The edifying species determining the appearance of the association are beech and fir, while other important tree species include *Acer pseudoplatanus, Acer platanoides, Ulmus glabra* and *Fraxinus excelsior*. In the shrub layer the dominant species are *Daphne laureola* and *D. mezereum*, while the ground layer consists of *Athyrium filix femina, Dryopteris filix mas, Dryopteris montana, Polystichum lobatum, Festuca drymeia, Lunaria rediviva, Cardamine enneaphylos, C. savensis, Dentaria bulbifera, Sanicula europaea, Galium odoratum, Actaea spicata, Pulmonaria officinalis, Corydalis cava* and *C. solida* and others.

Medvedović (1990) differentiates two sub-associations in the Pannonia beech-fir forests: *typicum* and *dentarietosum trifoliae* on carbonate rocks and the soils of the calcocambisol type in Croatian Zagorje. Their differentiating species are of basophilic-thermophilic character (*Viburnum lantana, Sorbus aria, Berberis vulgaris, Sorbus torminalis, Cornus mas, Ruscus hypoglossum, Ligustrum vulgare, Lathyrus niger, Melittis melissophyllum, Fraxinus ornus*).

The forest of sycamore and common ash (*Chrysanthemo macrophylli-Aceretum pseudoplatani* /Ht. 1938/ Borh. 1963). The forest association of sycamore and common ash, originally named *Aceri-Fraxinetum excelsioris* (Horvat 1938),

occurs in the area of beech-fir forests on Medvednica, in humid and protected valleys in which the soil is richly saturated with large quantities of snow in winter. One of the main ecological properties of the valleys is a long presence of snow on the soil, which leads to increased humidity, but also to a shorter period for micro-organism activity. Such conditions are conducive to the formation of deep humus-accumulative soil horizon, because the production of organic matter exceeds its dissolution. This is the reason why the phytocoenosis is characterised by numerous nitrophilic species, of which *Lunaria rediviva* is particularly important.

The tree layer is dominated by precious broad-leaved species of sycamore (*Acer pseudoplatanus*), common ash (*Fraxinus excelsior*), and frequently wych elm (*Ulmus glabra*). Other species from adjacent beech-fir forests are also common, among which the Norway maple (*Acer platanoides*) is particularly prominent. The shrub layer is completely dominated by red-berried elder (*Sambucus racemosa*), with the presence of mezereon and spurge laurel (*Daphne mezereum* and *D. laureola*), fly honeysuckle (*Lonicera xylosteum*) and broad-leaved spindle tree (*Euonymus latifolius*).

The luscious and species-rich layer of ground vegetation is dominated by nitrophilic species. The following species are of particular significance as indicators of the association: *Lunaria rediviva, Senecio nemorensis, Chrysanthemum macrophyllum, Geranium pheum, Corydalis cava, C. solida* and *Telekia speciosa*. Phytocoenological recordings from Mount Medvednica reveal frequent presence of *Galium odoratum, Dentaria bulbifera, Cardamine trifolia, C. enneaphyllos, Leucoium vernum, Aruncus dioicus, Athyrium filix femina, Dryopteris filix mas, Circaea lutetiana, Petasites albus, Petasites niveus, Petasites hybrida, Chaerophyllum sylvaticum, Actaea spicata, Phyllitis scolopendrium* and others.

Although of a relatively modest distribution range, this association is economically very important, primarily due to the growth of relatively rare and valuable species such as sycamore, common ash, Norway maple and wych elm.

Table 4. The forest associations with beech
Tablica 4. Šumske zajednice s bukvom

Association:		*Luzulo-Fagetum sylvaticae* Mausel 1937		*Lamio orvalae-Fagetum sylvaticae* Ht. 1938		*Abieti-Fagetum "pannonicum"* Rauš 1969 prov.
Area:		Vukomeričke g.	Samoborsko g.	Medvednica	Vukomeričke g.	Medvednica
Number of recordings:		11	14	10	18	30
Plot size (m^2):		100-500	100-200	400	100-500	400
FLORAL COMPOSITION						
Characteristic and distinguishing species of the association *(Luzulo-Fagetum)* and alliance *(Luzulo-Fagion)*:						
Pteridium aquilinum (L.) Kuhn.	B	V	.	.	II	.
Juniperus communis L.		II	.	.	.	.
Luzula luzuloides (Lam.) D. W.	C	V	V	III	II	III
Pteridium aquilinum (L.) Kuhn.		III	V	.	I	I

Hieracium umbellatum L.		IV	I	.	.	I
Vaccinium myrtillus L.		.	V	I	.	.
Melampyrum pratense L.		V	IV	II	II	.
Veronica officinalis L.		IV	I	I	.	.
Hieracium racemosum W.K.		V	II	I	III	.
Genista germanica L.		IV	.	.	.	
Genista tinctoria L.		III	I	.	.	.
Calluna vulgaris (L.) Hull.		II	III	.	.	.
Polytrichum attenuatum Menz.	D	V	V	.	III	.
Leucobrium glaucum(L.) Schpr.		V		.	.	.
Characteristic and distinguishing species of the associations (*Lamio orvalae-Fagetum* and *Abieti-Fagetum*) and alliance (*Aremonio-Fagion*):						
Daphne laureola L.	B	.	.	.	.	I
Ruscus hypoglossum L.		.	II	I	.	.
Dentaria trifolia W. K.	C	.	.	.	III	II
Dentaria enneaphyllos L.		.	.	I	.	III
Cyclamen purpurascens L.		.	.	.	.	IV
Hacquetia epipactis (Scop.) D.C.		.	.	I	.	I
Calamintha grandiflora (L.) Mch.		.	.	.	.	I
Festuca drymeia M. K.		.	.	.	.	III
Mercurialis perennis L.		.	.	II	.	.
Ruscus hypoglossum L.		.	.	.	V	I
Lamium orvala L.		.	.	II	.	I
Aposeris foetida (L.) Less.		.	II	.	IV	I
Primula vulgaris Huds.		.	.	.	.	I
Knautia drymeia Heuff.		.	.	.	I	I
Vicia orobides Wulf.		.	.	II	.	.
Cardamine trifolia L.		.	.	IV	.	II
Stellaria holostea L.		.	.	.	III	.
Epimedium alpinum L.		.	.	.	I	.
Cardamine polyphylla (W.K.) Schulz.		.	.	II	.	.
Characteristic species of order (*Fagetalia sylvaticae*):						
Fagus sylvatica L.	A	V	V	V	V	V
Acer pseudoplatanus L.		.	.	I	I	I
Acer platanoides L.		.	.	III	.	I
Fraxinus excelsior L.		.	.	I		I
Fagus sylvatica L.	B	V	V	IV	V	III
Acer pseudoplatanus L.		.	.	I	II	III
Sambucus racemosa L.		.	.	.	.	II
Daphne mezereum L.		.	.	I	I	I
Ulmus glabra Huds.		.	.	I	.	I
Fraxinus excelsior L.		.	.	I	.	I
Acer platanoides L.		.	.	I	.	II
Athyrium filix femina (L.) Roth.	C	II	I	II	III	IV
Dryopteris filix mas (L.) Schott.		II	.	IV	IV	V
Galium odoratum (L.) Scop.		II	I	V	V	V
Senecio nemorensis L.		.	.	III	.	V
Acer pseudoplatanus L.		.	.	III	I	IV
Mycelis muralis (L.) Rchb.		IV	.	II	IV	IV
Sanicula europaea L.		II	II	II	V	.

Brachypodium sylvaticum (Huds.) L.S.	III	I	I	I	I
Fagus sylvatica L.	IV	II	I	III	.
Carex sylvatica Huds.	IV	.	.	V	II
Lamiastrum galeobdolon (L.) E.P.	.	.	.	IV	IV
Dentaria bulbifera L.	.	.	I	IV	IV
Polystichum aculeatum (L.) Roth.	.	.	.	.	I
Pulmonaria officinalis L.	.	.	IV	.	I
Salvia glutinosa L.	.	.	I	II	I
Prenanthes purpurea L.	.	IV	I	.	II
Euphorbia amygdaloides L.	.	.	.	I	I
Viola reichenbachiana Jord.	.	.	I	IV	III
Paris quadrifolia L.	.	.	I	.	I
Scrophularia nodosa L.	.	.	I	.	III
Phyllitis scolopendrium (L.) Newm.	.	.	.	.	I
Polygonatum multiflorum (L.) All.	.	.	I	II	.
Actaea spicata L.	.	.	II	.	.
Symphytum tuberosum L.	.	.	II	I	I
Lunaria rediviva L.	.	.	I	.	III
Asarum europaeum L.	.	.	I	IV	I
Glechoma hirsuta W.K.	.	.	I	.	III
Campanula trachelium L.	.	.	I	I	I
Ranunculus lanuginosus L.	.	.	.	II	II
Geranium robertianum L.	.	.	.	.	I
Acer platanoides L.	.	.	II	.	III
Melica nutans L.	.	.	.	.	I
Sambucus racemosa L.	.	.	.	.	I
Fraxinus excelsior L.	.	.	I	.	I
Arum maculatum L.	.	.	I	.	I
Polystichum lonchitis (L.) Roth.	.	.	.	.	II
Aruncus sylvestris Kostel	.	.	.	.	I
Alliaria petiolata Andrz.	.	.	II	.	I
Neottia nidus avis (L.) L.C. Rich	.	.	.	II	.
Ulmus glabra Huds.	.	.	I	.	.
Cyclamen europaeum L.	.	.	III	II	.
Euphorbia dulcis L.	.	.	I	II	.
Polygonatum odoratum (Mill.) Dr.	.	.	.	II	.
Characteristic species of class (*Querco-Fagetea*):					
Carpinus betulus L. A	I	I	I	III	II
Acer campestre L.	.	.	.	I	.
Tilia cordata Mill.	.	.	.	I	.
Corylus avellana L.	.	.	.	I	.
Quercus cerris L.	I		.	I	.
Carpinus betulus L. B	I	II	II	III	I
Sorbus torminalis (L.) Cr.	I	III	.	I	.
Corylus avellana L.	.	.	III	I	III
Prunus avium L.	I	.	I	.	I
Acer campestre L.	.	.	.	II	.
Crataegus monogyna Jacq.	II	.	.	II	.
Pyrus pyraster (L.) Borkh.	I	.	.	II	.
Crataegus oxyacantha L.	.	.	.	I	.
Rubus caesius L.	.	.	.	I	.

Ligustrum vulgare L.		.	.	.	I	.
Cornus sanquinea L.		I	.	.	I	.
Lonicera caprifolium L.		.	.	.	I	.
Tilia cordata Mill.		.	.	.	I	.
Chamaecytisus hirsutus (L.) Lk.		I		.	.	.
Carpinus betulus L.	C	II	I	.	II	I
Hedera helix L.		.	I	V	III	III
Anemone nemorosa L.		.	.	III	.	III
Circaea lutetiana L.		.	.	III	III	I
Melittis melissophyllum L.		.	.	.	I	I
Lathyrus vernus (L.) Bernh.		.	.	I	III	.
Prunella vulgaris L.		III	.	.	III	.
Chamaecytisus hirsutus (L.) Lk.		II	.	.	I	.
Moehringia trinervia (L.) Clairv.		.	.	.	.	II
Corydalis cava (L.) Schw. K.		.	.	.	.	II
Clematis vitalba L.		.	.	.	I	I
Aegopodium podagraria L.		.	.	.	.	I
Platanthera bifolia (L.) L.C. Rich.		.	.	I	II	.
Geum urbanum L.		.	.	I	.	.
Prunus avium L.		.	I	.	II	.
Galium vernum Scop.		.	.	.	III	.
Tamus communis L.		.	.	I	II	.
Sorbus torminalis (L.) Cr.		.	.	.	II	.
Lonicera caprifolium L.		.	.	.	II	.
Acer campestre L.		.	I	.	I	.
Convallaria majalis L.		.	II	.	I	I
Tilia cordata Mill.		.	.	.	I	.
Lathyrus venetus (L.) Wohlf.		.	.	.	I	.
Lycopus europaeus L.		.	.	.	I	.
Cerastium sylvaticum W.K.		.	.	.	I	.
Cynanchum vincetoxicum (L.) Pers.		.	.	.	I	.
Cephalanthera rubra (L.) L.C. Rich.		.	.	.	I	.
Carex remota L.		.	.	.	I	.
Cornus sanquinea L.		.	.	.	I	.
Lonicera xylosteum L.		.	.	.	I	.
Festuca altissima All.		.	.	.	I	.
Other species:						
Quercus petraea Lieb.	A	III	V	IV	V	I
Castanea sativa Mill.		II	IV	I	I	I
Abies alba Mill.		.	.	III	.	V
Populus tremula L.		I	.	.	.	.
Alnus glutinosa (L.) Gaertn.		.	.	.	I	.
Fraxinus ornus L.		.	II	.	.	.
Castanea sativa Mill.	B	III	V	I	I	I
Rubus sp.		IV	II	.	III	V
Abies alba Mill.		.	.	V	.	V
Quercus petraea Lieb.		I	III	.	I	.
Rubus idaeus L.		.	.	.	.	III
Sambucus nigra L.		.	.	III	.	.
Frangula alnus L.		I	II	.	.	.
Rosa arvensis Huds.		.	.	.	I	.

Hieracium sylvaticum L. C	II	III	II	I	I
Quercus petraea Lieb.	IV	III	.	V	I
Gentiana asclepiadea L.	II	II	.	II	I
Doronicum austriacum Jacq.	III	I	I	.	II
Abies alba Mill.	.	.	I	.	V
Fragaria vesca L.	III	.	.	II	III
Oxalis acetosella L.	.	.	.	II	III
Rubus sp.	.	.	III	I	I
Galium sylvaticum L.	.	III	I	II	I
Castanea sativa Mill.	I	II	II	.	I
Polypodium vulgare L.	II	.	.	.	I
Festuca gigantea (L.) Vill.	.	.	.	.	I
Maianthemum bifolium (L.) Schm.	.	.	.	.	I
Galium rotundifolium L.	.	.	.	.	I
Galeopsis speciosa Mill.	II		I	II	.
Dryopteris dilatata (Hoffm.) A. Gray	.	.	.	.	II
Petasites albus Gartn.	.	.	II	.	II
Galeopsis pubescens Bess.	II	I	I	.	.
Solidago virga aurea L.	.	II	.	.	II
Urtica dioica L.	.	.	I	.	II
Solanum dulcamara L.	.	.	.	.	I
Glechoma hederacea L.	.	.	.	I	.
Eupatorium cannabinum L.	.	.	I	.	I
Carex pilosa Scop.	.	.	.	.	I
Geranium phaeum L.	.	.	II	.	II
Calamagrostis arundinacea (L.) Roth.	.	I	.	.	.
Polygonatum verticillatum (L.) All.	.	.	II	.	.
Potentilla micrantha Ram.	.	.	II	.	.
Aruncus sylvestris Kostel.	.	I	II	.	.
Carex maxima Huds.	.	.	II	.	.
Cephalantera alba (Cr.) Simk.	.	.	I	.	.
Primula sp.	.	.	I	.	.
Staphylea pinnata L.	.	I	I	I	.
Siler trilobium (L.) Cr.	.	.	I	.	.
Melandrium rubrum (Schk.) Roehl.	.	.	I	.	.
Lycopodium sp.	.	.	I	.	.
Juncus effusus L.	.	.	I	I	.
Carex humilis Leyss.	.	.	I	.	.
Sambucus nigra L.	.	.	I	.	.
Veronica montana L.	.	.	I	.	.
Cephalantera longifolia (L.) Fritsch	.	.	I	.	.
Hypericum montanum L.	II	.	.	.	.
Potentilla erecta (L.) Raeusch.	II	.	.	.	.
Molinia litoralis Host	.	II	.	.	.
Melampyrum silvaticum L.	.	I	.	.	.
Serratula tinctoria L.	.	II	.	.	.
Fraxinus ornus L.	.	I	.	.	.
Tussilago farfara L.	.	I	.	.	.

Explanation of abbrevations: A - Tree layer, B - Shrub layer, C - Ground vegetation layer, D - Moss layer, I - V - Degree of participation

THE PHYTOCOENOLOGICAL MAP OF THE STUDIED AREA
FITOCENOLOŠKA KARTA ISTRAŽIVANOG PODRUČJA

To draw up a phytocoenological map of the forests in the City of Zagreb and the Zagreb County, printed and hand-written maps have been used (Baričević and Vukelić 1997, Pelcer *et al.* 1976 - 1982, Rauš 1980 and 1993, Rauš and Vukelić 1996, Trinajstić *et al.* 1992, Vukelić 1990), as well as documentation from the Forest Management Service in the Public Enterprise "Croatian Forests". As these maps are in much larger scales, it has not been possible to include all details and units.

The enclosed phytocoenological map is a good illustration of the diversity and wealth of the forest vegetation. The vertical distribution of forest associations, encompassing the amplitude of 1,000 m and ranging from the banks of rivers to the top of Medvednica, is particularly vivid. Forest associations in state forests have been accurately and reliably defined since they have been studied in detail. The same could not be done consistently for private forests because some of them have never been mapped. This refers primarily to Croatian Zagorje, the northern part of the Samobor chain, and a smaller part of Jastrebarsko and Vrbovec areas. The forest associations in these areas have been clearly identified for the purpose of this study and the accuracy of the phytocoenological identification is unquestionable. However, a more precise spatial demarcation should be conducted in some future phytocoenological research.

A relatively similar problem relates to the demarcation of certain associations dominated by one species, such as beech, for example. Three beech associations have been included in one cartographic unit (*Luzulo-Fagetum, Lamio orvalae-Fagetum* and *Ostryo-Fagetum*), because they have not been spatially defined so far. However, such deviations do not influence the validity of the survey, because the descriptions are detailed enough to indicate specific properties and differences among certain vegetation units. Moreover, the material needed for making this study is complemented with original phytocoenological recordings.

We should also point out that forest cultures over larger areas are marked only with signs, because they, as for example locust trees in private forests of the Vrbovec-Zelina area, dominate the entire area, but in separate fragments of several acres to several hectares.

The phytocoenological map contains not only the descriptions of forest associations and research documentation, but represents a very valuable basis for the assessment of the forest fund from the standpoint of biological and genetic diversity, and provides a starting point for planning in forestry and other interventions in this region.

CONCLUSIONS
ZAKLJUČCI

Forest vegetation in the studied area was studied in depth relatively early. It is composed of about 20 basic associations distributed in four vegetation belts. A ma-

jor part of the continental associations of Croatia with highly diverse and rich floral composition is represented here. Their systematic position is as follows:

Salicetea purpureae Moor 1958
Salicetalia purpureae Moor 1958
Salicion albae Soó 1940
Salicetum purpureae Wendl.-Zel. 1952
Galio-Salicetum albae Rauš 1973
Salici albae-Populetum nigrae Tx. 1931
Alnetea glutinosae Br.-Bl. Et Tx. 1943
Alnetalia glutinosae Tx. 1937
Alnion glutinosae Malcuit 1929
Frangulo-Alnetum glutinosae Rauš 1968
Leucoio-Fraxinetum angustifoliae Glavač 1959
Alno-Quercion roboris Ht. (1937) 1938
Genisto elatae-Quercetum roboris Ht. 1938
Querco-Fagetea Br.-Bl. et Vlieger 1937
Quercetalia pubescentis Br.-Bl. (1931) 1932
Ostryo-Carpinion orientalis Ht. (1954) 1958
Ostryo-Quercetum pubescentis Ht.1938
Quercion pubescentis-petraeae Br.-Bl. 1931
Lathyro-Quercetum petraeae Ht. (1938) 1958
Quercetalia robori-petraeae Tx. 1937.
Castaneo-Quercion petraeae (Soó 1962) Vukelić 1990
Querco-Castaneetum sativae Ht. 1938
Hieracio racemosi-Quercetum petraeae Vukelić (1990) 1991
Fagetalia sylvaticae Pawl. 1928
Carpinion betuli Isll. 1932
Carpino betuli-Quercetum roboris (Anić 1959) Rauš 1969
Epimedio-Carpinetum betuli (Ht. 1938) Borhidi 1963
Luzulo-Fagion Lohm. et. Tx. 1954
Luzulo-Fagetum sylvaticae Meusel 1937
Aremonio-Fagion (Ht. 1938) Török *et al.* 1989
Lamio orvalae-Fagetum sylvaticae Ht. 1938
Abieti-Fagetum "pannonicum" Rauš 1969 prov.
Chrysanthemo macrophylli-Aceretum pseudoplatani (Ht. 1938) Borh. 1963
Ostryo-Fagetum sylvaticae Wraber (1950) 1958
Tilio-Taxetum Glavač 1959

The riparian vegetation, whose major part consists of forests of willows and poplars (*Salici-Populetum s.l.*), is developed in the lowland or planar belt along the banks of rivers. However, the forests in this belt were cleared in the past to make way for agricultural land. In the depressions of the lowland belt the principal edifying species are the pedunculate oak, narrow-leaved ash, black alder, lowland elm and spreading elm. The growth of these associations is closely related to the relatively high level of groundwater, whose drop, caused by ameliorative treatments, has led to the dieback of forests, such as for example in Turopoljski Lug, Žutica and elsewhere. On the other hand, excessive bogging of the biotop with stagnant surface water is equally harmful. The basic associations of these humid biotops are the forest of pedunculate oak with great green weed *(Genisto elatae-Quercetum roboris*), narrow-leaved ash with autumn snowflake (*Leucoio-Fraxinetum angustifoliae*) and black alder with buckthorn (*Frangulo-Alnetum glutinosae*). The third type of the association of the lowland region are forests of pedunculate oak with common hornbeam (*Carpino betuli-Quercetum roboris*) on micro-elevations (lowland pseudogley) with lower levels of groundwater and no floods.

The belt of lower hills extends from 150 to 400 (500) m above sea level, and is represented by the edges of Medvednica, the hills of Žumberak and Samobor, Vukomeričke Gorice and elsewhere. The basic association is the forest of sessile oak and common hornbeam (*Epimedio-Carpinetum betuli*), whose composition contains some of the species from the Illyrian floral element, which places them among the richest in Europe. Apart from them, acidophilic forests of sessile oak and sweet chestnut (*Querco-Castaneetum sativae*), acido-thermophilic forests of sessile oak and hawkweed (*Hieracio racemosi-Quercetum petraeae*) and thermophilic forest associations of sessile oak and black pea (*Lathyro-Quercetum petraeae*) and pubescent oak with hop hornbeam (*Ostryo-Quercetum pubescentis*) are also significant.

The belt of higher hills (400 - 800 m above sea level) is characterised by the most represented tree species in Croatia - the common beech. It occurs in the well-known Illyrian association with dead nettle (*Lamio orvalae-Fagetum sylvaticae*), in the acidophilic forest with woodrush (*Luzulo-Fagetum sylvaticae*), and in the thermophilic-basophilic association with hop hornbeam (*Ostryo-Fagetum sylvaticae*). The relict forest of lime and yew (*Tilio-Taxetum*) is of particular importance due to its rarity and natural-scientific characteristics.

The mountain belt (above 700 - 800 m above the sea) is dominated by the forest association of beech and fir (*Abieti-Fagetum s.l.*), similar to that in the Dinara region of Croatia. It is distributed only on Medvednica and has prominent economic and protective functions. The forest of sycamore and common ash (*Chrysanthemo macrophylli-Aceretum pseudoplatani*) also occurs sporadically.

The studied forest associations have a natural composition and contain a relatively large number of species, of which those of the Illyrian and south-east European character are particularly prominent. The western part of the studied area is much more indented in terms of the relief and is richer in forests and forest associations. The eastern part contains half the amount of forests, but their economic and ecological value is outstanding. The south-east part of Zagreb (especially the part along the course of the River Sava) is very poor in forests, and should be afforested in the future given the importance of forests in regulating the water regime.

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ŠUMSKA VEGETACIJA GRADA ZAGREBA I ZAGREBAČKE ŽUPANIJE

SAŽETAK

U radu su prikazani rezultati fitocenoloških istraživanja šumske vegetacije Grada Zagreba i Zagrebačke županije. Grad Zagreb i Zagrebačka županija nalaze se u zapadnom, najgušće naseljenom području Hrvatske. Unatoč vrlo ranoj naseljenosti, relativno brzom i značajnom industrijskom, infrastrukturnom i svakom drugom razvitku, šume se prostiru na 143000 ha ili na gotovo 40 % istraživanoga područja. One su uvelike sačuvale prirodan sastav i strukturu pa su vrlo pogodne za fitocenološka istraživanja, pogotovo što ovo područje vrlo dobro predstavlja vertikalno zoniranje šumske vegetacije jugozapadnoga dijela Panonske ravnice s mnogim predalpskim florno-genetskim obilježjima kakva se nastavljaju u susjednoj Sloveniji. Visinska razlika istraživanih šumskih zajednica iznosi nešto manje od tisuću metara (od 120 do 1 033 m n.v.) pa su šumske zajednice bogate i raznolike u flornom sastavu.

Prikaz šumske vegetacije dan je po visinskim pojasima. U nizinskom pojasu od 80 do 150 m nadmorske visine temeljno obilježje geološko-litološkoj i pedološkoj građi, kao i vegetacijskoj slici daju riječni tokovi Save, Lonje, Česme, Kupe i brojni manji vodotoci koji su većinom meliorirani. Brežuljkasti pojas od 150 do 400 (500) metara, brdski od 400 do 800 i gorski iznad 800 m nadmorske visine vrlo su različitih pedoloških i klimatskih uvjeta pa fitocenološki sastav pokazuje jasno vertikalno zoniranje, u kojem su glavne vrste hrast kitnjak, iznad njega u brdskom pojasu obična bukva, a u gorskom bukva i jela. Različite litološke podloge uvjetuju velik broj šumskih zajednica koje pripadaju različitim sintaksonomskim kategorijama.

Šumska vegetacija na istraživanom području relativno je rano i dobro istražena. Mi smo je istraživali u posljednje četiri godine, no obilno smo se služili fitocenološko, literaturom i drugih autora, u prvom redu Anića (1940), Cestara i dr. (1978–1982), Glavača (1958. i 1959), Rauša (1969. i 1996), Rauša i dr. (1992), Rauša i Vukelića (1993), Šegulje (1974), Šugara (1972) i Vukelića (1991).

Dvadeset temeljnjih šumskih zajednica svrstano je u sedam sveza, tri reda i dva razreda, što smo samo djelomice prikazali u četiri fitocenološke tablice.

Uz prikaz je izrađena fitocenološka karta mjerila 1:100000 s 13 najvažnijih fitocenoza. Razlog je tomu što neke zajednice dolaze fragmentarno na vrlo malim površinama (različite ritske zajednice, šume plemenitih listača) ili se zbog razvijene orografije terena i promjene sinekoloških uvjeta intenzivno miješaju, pa ih u mjerilu 1:100000 nije moguće prikazati i točno odrediti. Karta zbog formata nije mogla biti tiskana uz rad i nalazi se u arhivu Zavoda za uzgajanje šuma, Šumarskoga fakulteta Sveučilišta u Zagrebu.

Može se ustvrditi da se na istraživanome području prostire velik dio kontinentalnih zajednica Hrvatske te da su raznolikoga i bujnoga flornoga sastava. Njihov sistematski položaj je sljedeći:

Salicetea purpureae Moor 1958
Salicetalia purpureae Moor 1958
Salicion albae Soó 1940
Salicetum purpureae Wendl.-Zel. 1952
Galio-Salicetum albae Rauš 1973
Salici albae-Populetum nigrae Tx. 1931
Alnetea glutinosae Br.-Bl. et Tx. 1943
Alnetalia glutinosae Tx. 1937
Alnion glutinosae Malcuit 1929
Frangulo-Alnetum glutinosae Rauš 1968
Leucoio-Fraxinetum angustifoliae Glavač 1959
Alno-Quercion roboris Ht. (1937) 1938
Genisto elatae-Quercetum roboris Ht. 1938
Querco-Fagetea Br.-Bl. et Vlieger 1937
Quercetalia pubescentis Br.-Bl. (1931) 1932
Ostryo-Carpinion orientalis Ht. (1954) 1958
Ostryo-Quercetum pubescentis Ht.1938
Quercion pubescentis-petraeae Br.-Bl. 1931
Lathyro-Quercetum petraeae Ht. (1938) 1958
Quercetalia robori-petraeae Tx. 1937
Castaneo-Quercion petraeae (Soó 1962) Vukelić 1990
Querco-Castaneetum sativae Ht. 1938
Hieracio racemosi-Quercetum petraeae Vukelić (1990) 1991
Fagetalia sylvaticae Pawl. 1928
Carpinion betuli Isll. 1932
Carpino betuli-Quercetum roboris (Anić 1959) Rauš 1969
Epimedio-Carpinetum betuli (Ht. 1938) Borhidi 1963
Luzulo-Fagion Lohm. et Tx. 1954
Luzulo-Fagetum sylvaticae Meusel 1937

Aremonio-Fagion (Ht. 1938) Török *et al.* 1989
Lamio orvalae-Fagetum sylvaticae Ht. 1938
Abieti-Fagetum "pannonicum" Rauš 1969 prov.
Chrysanthemo macrophylli-Aceretum pseudoplatani (Ht. 1938) Borh. 1963
Ostryo-Fagetum sylvaticae Wraber (1950) 1958
Tilio-Taxetum Glavač 1959

U nizinskom ili planarnom pojasu uz korita rijeka razvijena je ritska vegetacija čiji glavni dio čine vrbove i topolove šime (*Salici-Populetum s. l.*). No, u tom su pojasu šume u prošlosti iskrčene, a tlo privedeno poljoprivrednoj proizvodnji. U udubinama i nizama nizinskoga pojasa glavne su edifikatorske vrste hrast lužnjak, poljski jasen, crna joha, nizinski brijest i vez. Pridolazak tih zajednica u uskoj je vezi s relativno visokom razinom podzemnih voda čije spuštanje zbog meliorativnih zahvata izaziva sušenje šumskih sastojina, na primjer u Turopoljskom lugu, Žutici i drugdje. S druge strane, jednako je opasno i prekomjerno zamočvarenje biotopa zastojnom površinskom vodom. Temeljne su zajednice tih vlažnih staništa šuma hrasta lužnjaka s velikom žutilovkom (*Genisto elatae-Quercetum roboris*), poljskoga jasena s kasnim drijemovcem (*Leucoio-Fraxinetum angustifoliae*) i crne johe s trušljikom (*Frangulo-Alnetum glutinosae*). Treći tip zajednica nizinskoga područja su šume hrasta lužnjaka i običnoga graba (*Carpino betuli-Quercetum roboris*) na gredama (nizinski pseudoglej) s nižom razinom podzemnih voda i bez poplava.

Brežuljkasti ili kolinski vegetacijski pojas prostire se na rubovima Medvednice, Žumberačkoga i Samoborskoga gorja, u Vukomeričkim goricama i drugdje. Temeljna je zajednica šuma hrasta kitnjaka i običnoga graba (*Epimedio-Carpinetum betuli*), u čijem se sastavu nalaze neke vrste ilirskoga flornoga elementa, što ih svrstava među najbogatije u Europi. Uz njih su značajne acidofilne šume hrasta kitnjaka i običnoga kestena (*Querco-Castaneetum*), acidotermofilne šume hrasta kitnjaka s runjikom (*Hieracio racemosi-Quercetum petraeae*) te termofilne šumske zajednice hrasta kitnjaka i crnoga grahora (*Lathyro-Quercetum petraeae*) i hrasta medunca s crnim grabom (*Ostryo-Quercetum pubescentis*).

Brdski ili montanski pojas obilježava najproširenija vrsta drveća u Hrvatskoj – obična bukva, i to u poznatoj ilirskoj zajednici s mrtvom koprivom (*Lamio orvalae-Fagetum sylvaticae*), u acidofilnoj šumi s bekicom (*Luzulo-Fagetum sylvaticae*) i u termofilno-bazafilnoj zajednici s crnim grabom (*Ostryo-Fagetum sylvaticae*). Po rijetkosti i prirodoznanstvenoj zanimljivosti na Medvednici se ističe reliktna šuma lipe i tise (*Tilio-Taxetum*).

U gorskom ili altimontanskom pojasu prevladava bukovo-jelova šumska zajednica (*Abieti-Fagetum s.l.*), slična onoj u Dinaridima Hrvatske. Rasprostire se samo na Medvednici i istaknute je gospodarske i zaštitne funkcije. Uz nju sporadično pridolazi šuma gorskoga javora i običnoga jasena (*Chrysanthemo macrophylli-Aceretum pseudoplatani*).

Istražene šumske zajednice prirodnoga su sastava, s relativno velikim brojem vrsta u kojima se ističu vrste ilirskoga i jugoistočnoeuropskoga karaktera. Zapadni,

reljefno mnogo razvedeniji dio istraživanoga područja bogatiji je šumama i šumskim zajednicama. U istočnom dijelu dvostruko je manje šuma, no one su gospodarski i ekološki iznimno vrijedne. Šumama je vrlo siromašno područje jugoistočno od Zagreba (poglavito uz savski tok), pa će ga u budućnosti trebati pošumiti zbog velikoga značenja šuma u reguliranju vodnoga režima.

Ključne riječi: šumska vegetacija, florna struktura, Grad Zagreb, Zagrebačka županija