

## FLORISTIC AND ECOLOGICAL CHARACTERISTICS OF THE BEECH-FIR VIRGIN FORESTS IN CROATIA

### FLORISTIČKE I EKOLOŠKE ZNAČAJKE BUKOVO-JELOVIH PRAŠUMA U HRVATSKOJ

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#### Summary

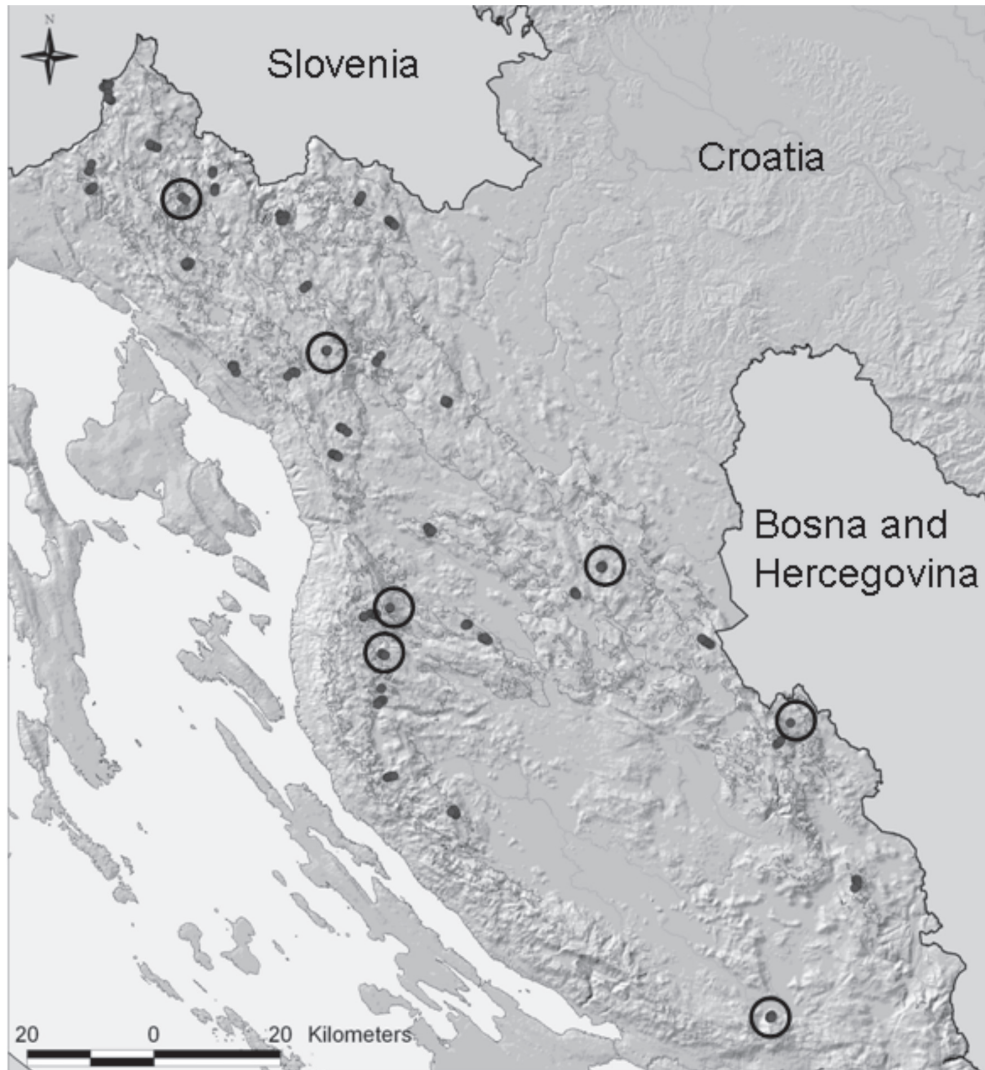
This research comprises seven localities of the beech-fir virgin forests at elevations ranging from 840 m (Čorkova uvala) to 1380 m (Nadžak bilo). Of the 21 surveyed plots (approx. 500m<sup>2</sup>) in optimal stage of development, 75% are situated on slopes exceeding 15 degrees, while northern and eastern aspect prevails. The average annual precipitation is 2200 mm, and the average annual temperature is 6°C, with range between -6°C and 21°C. The chorological spectrum analyses has shown that most represented plants belongs to Euro-Asian, European and South-European floristic elements, while the least represented were those belonging to Mediterranean, East-European and South-European elements, as well as adventive and cultivated plant species. With respect to life forms, hemicryptophyta and geophyta prevails, while the terophyta and chamaephyta are least frequent life forms. The average number of recorded plant species per plot is 31, with values ranging from 17 to 46. The average value of the Shannon-Wiener Diversity Index is 3.09, and of the Similarity Index 0.91. Based on the floral composition, the analysed stands belong to four *Omphalodo-Fagetum* [Tregubov 1957] Marinček *et al.* 1992 subassociations: *homogynetosum sylvestris*; *galietosum odorati*; *aceretosum pseudoplatani* and *seslerietosum autumnalis*. Future research should be extended to encompass initial and decomposition stage of virgin forests as well.

**Keywords:** *Omphalodo-Fagetum*, flora, diversity, Lika, Gorski kotar

#### UVOD

#### INTRODUCTION

Dinaric silver fir – beech forests *Omphalodo-Fagetum* [Tregubov 1957] Marinček *et al.* 1992. represents almost continuous area of 3000 km<sup>2</sup> of very complex terrain struc-



**Figure 1:** Position of surveyed Omphalodo-Fagetum plots. Seven localities with virgin stands are marked with black circles, namely from northwest to southeast: Javorov kal, Bijele i Samarske stijene, Devčića tavani, Nadžak bilo, Čorkova uvala, Plješivička uvala and Gaćešin varićak (secondary virgin forest)

*Slika 1. Položaji istraživanih Omphalodo-Fagetum ploha. Sedam prašumskih lokaliteta označeno je crnim kružnicama. Njihova imena smjerom od sjeverozapada prema jugoistoku su: Javorov kal, Bijele i Samarske stijene, Devčića tavani, Nadžak bilo, Čorkova uvala, Plješivička uvala i Gaćešin varićak (sekundarna prašuma)*

ture, making it the most widely distributed altimontane forest on Croatian karst. Although significant portion of it is managed, thanks to selective silvicultural system it still has natural composition of plant species, and very well preserved overall biodiversity. Majority of remaining Croatian virgin forest stands are situated here, making these forests very interesting even in wider European context of nature conservation.

Virgin forests in Čorkova uvala and Devčića tavani, from the forest science standpoint has been studied by Prpić (1979), Prpić and Seletković (1996), Rauš *et al.* (1996) and Božić (2003). Trinajstić (1970, 1972) has been investigated floristic and vegetation characteristics of Čorkova uvala, while Vukelić and Baričević (2002) done that in Štirovača. Trinajstić (1970, 1972) has compared floristic assemblage of releves from virgin forest, and nearby management stands.

This paper represents part of the unified survey (Jelaska 2006) across complete areal of silver fir – beech community with focus on virgin stands with respect to their floristic and ecological characteristics.

## **Study area**

### ***Područje istraživanja***

This research was carried out in the Dinaric silver fir–beech forests of the association *Omphalodo-Fagetum* plant community (Marinček *et al.*, 1992) on a limestone as a parent rock. Total of 21 circular plots with 25 m diameter, from seven localities were surveyed (Fig. 1). Plots were positioned with intention to cover existing spatial variability of elevation, slope and aspect within community.

## **MATERIAL AND METHODS**

### ***MATERIJAL I METODE***

#### **Floristic and environmental data**

##### ***Podaci o flori i staništu***

Data about the floristic assemblage, from May to July during the 2002 growing season, were gathered. The nomenclature follows the Croatian Flora Checklist (Nikolić 1994, 1997, 2000), combined with the CROFlora 2.0 database (<http://hirc.botanic.hr/fcd>).

For all plots climate data were available for the period 1956-1995 representing: total amount of yearly precipitation, mean temperature, minimum temperature, and maximum temperature. These data are available for complete research area as a raster-grid with 300 by 300 metres spatial resolution originating from Antonić *et al.* (2000, 2001).

Terrain parameters originating from 100-metres pixel DTM (digital terrain model) were used as well: elevation, slope and aspect.

**Table 1.** Descriptive statistics of four environmental variables for 21 plots of virgin *Omphalodo-Fagetum* stands in Croatia

**Tablica 1.** Deskriptivna statistika za četiri varijable okoliša za 21 plohu u *Omphalodo-Fagetum* prašumama Hrvatske

	min.	mean	max.
Elevation / <i>Nadmorska visina</i> [m]	840	1100	1380
Slope / <i>Nagib</i> [degrees]	2	19	32
Temperature / <i>Temperatura</i> [°C]	-6	6	21
Precipitation / <i>Padalina</i> [mm/year]	1830	2200	2640

## Data analysis

### *Analiza podataka*

Diversity of plant species were analysed as:

1. number of recorded vascular plant species;
2. Shannon-Wiener index (H)
3. Evenness index (J),  $J = H / \ln(N)$  where N is number of species per plot

for logged and for virgin stands in complete sample, and in four subassociations separately, where virgin plots exist, namely: *homogynetosum sylvestris*, *galietosum odorati*, *aceretosum pseudoplatani* and *seslerietosum autumnalis*.

The life forms are interpreted according to Ellenberg *et al.* (1992) and Pignatti (1982). Following adjusted groups have been attributed to each taxon: P: Phanerophyta and Nanophanerophyta, C: Chamaephyta (woody and herbaceous plants), H: Hemicryptophyta, G: Geophyta, T: Therophyta, and calculated for their proportion in the sample.

Chorological spectrum was analysed and compared for virgin and logged stands. Membership of recorded vascular plants to chorological elements followed that in Horvatić *et al.* (1967-68), Pignatti (1982), Simon (1992) and Šegulja *et al.* (1998).

## Rezultati s raspravom

### *Results and Discussion*

Diversity indices are shown in Table 2. Differences between virgin and logged stands in complete sample are minor, in fact negligible. Similar findings were found by Beus and Vojniković (2006) in their research in Bosna and Hercegovina. This is not

in line with findings of Trinajstić (1970, 1972, 1995) who has found smaller number of plant species in virgin than in managed stands. Furthermore, it can be seen that there is no unique trend when it comes to level of subassociations, except Evenness index that is slightly lower in all virgin stands. There are no differences in number of plant species and Shannon-Wiener index in virgin and managed stands in *galietosum odorati*, while *homogynetosum sylvestris* has higher both indices in virgin stands, contrary to those in *aceretosum pseudoplatani* and *seslerietosum autumnalis*. The latter can confirm findings of Trinajstić (1970, 1972) since Čorkova uvala, where Trinajstić conduct his research, accordings to Jelaska (2005, 2006) belongs to subassociation *aceretosum pseudoplatani* in which there is a smaller number of plant species in virgin stands than in managed ones (Table 2). Obviously, one has to be very specific when comparing virgin and managed stands of *Omphalodo-fagetum* forests.

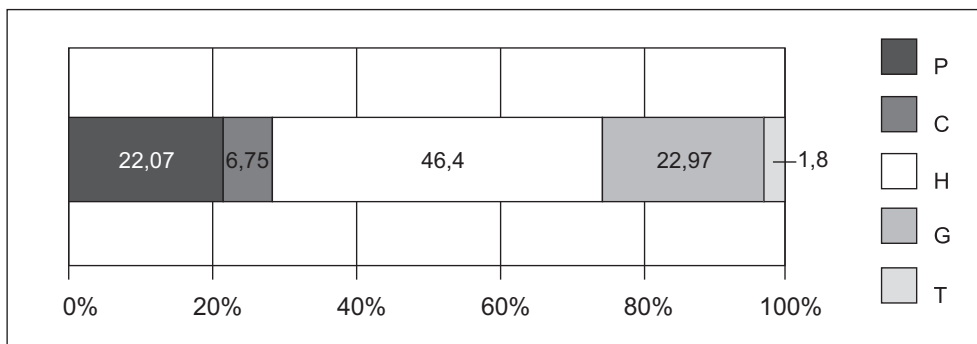
**Table 2.** Number of recorded vascular plant species, values of Shannon-Wiener index of diversity and Evenness index for logged and for virgin stands in complete sample, and in four subassociations separately, where virgin plots exist, namely: hom- *homogynetosum sylvestris*, gal- *galietosum odorati*, ace- *aceretosum pseudoplatani* and ses- *seslerietosum autumnalis* (n – number of plots in the subsample)

**Tablica 2.** Broj zabilježenih vaskularnih biljnih vrsta, vrijednosti Shannon-Wiener indeksa raznolikosti i indeksa jednolikosti za gospodarene i prašumske sastojine u cijelom uzorku, i pojedinačno za četiri subasocijacije u kojima postoje prašumske sastojine: hom- *homogynetosum sylvestris*, gal- *galietosum odorati*, ace- *aceretosum pseudoplatani* and ses- *seslerietosum autumnalis* (n - broj ploha u uzorku)

	virgin	logged	homvirg	homlog	galvirg	gallog	acevirg	acelog	sesvirg	seslog
No sp	32	33	41	31	31	31	28	36	36	41
shannon	3,093	3,180	3,356	3,095	3,099	3,100	2,929	3,269	3,228	3,364
evennes	0,913	0,925	0,913	0,921	0,917	0,923	0,906	0,927	0,915	0,916
n	21	130	3	10	11	49	6	45	1	4

Analyses of life form spectrum (Fig. 2) have shown that Hemycryptophyta prevails, followed by Geophyta and Phanerophyta, while Therophyta are least represented. More detailed analyses by subassociations in Jelaska (2006) has shown distinct trend consisting of increase of Phanerophyta towards more thermophilous subassociations, and decrease of Hemycryptophyta.

Chorological analyses (Figure 3.) has shown that, behind the comparison of core number of plant species, these species are partly a different plant species. The largest differences are in larger proportion of Euro-Asiatic floristic and smaller proportion of Circum-Holarctic elements in managed stands. The latter can be observed also for



**Figure 2.** Proportion of life forms in stands of Omphalodo-Fagetum forest in Croatia. Life forms: P – Phanerophyta and Nanophanerophyta, C – Chamaephyta, H – Hemicryptophyta, G – Geophyta, T – Therophyta.

*Slika 2.* Udjel životnih oblika u sastojinama Omphalodo-Fagetum šuma u Hrvatskoj. Životni oblici: P – Phanerophyta i Nanophanerophyta, C – Chamaephyta, H – Hemicryptophyta, G – Geophyta, T – Therophyta.

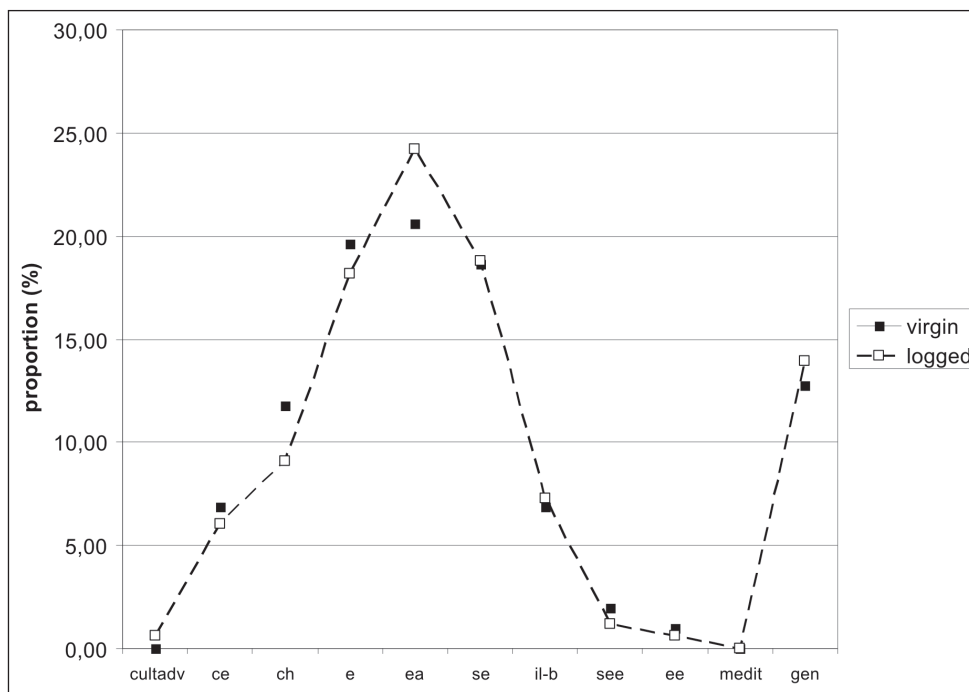
European, Central-European, Eastern-European and South-eastern European elements, while there is more adventive, cultivated and widespread plants in managed stands.

Jelaska (2006) and Jelaska *et al.* (2006) has found that amongst most important factors that influence floristic composition of these forests is canopy openness that in those researches was 25% higher in managed stands than in virgin ones. Beus and Vojniković (2006) deny importance of light on percentage of total ground vegetation cover. However, size of their plots is 2x2 meters which is quite small with respect to information about canopy cover.

Positive correlation of available light with number of plant species was found by Goldblum (1997) and Rankin & Tramer (2002) for mixed North-American forests and by Weisberg *et al.* (2003) and Jelaska (2004) for European fir-beech forests. Furthermore, direct influence of change of the size of canopy openness on composition and succession of present flora was shown by Von Schmidt-Vogt (1972), Goldblum (1997) and Rankin & Tramer (2002).

In the virgin stands, as a consequence of natural death of trees that creates the gaps of different size, light conditions are more heterogeneous and variable in time and space, than in managed stands. According to Martens *et al.* (2000) range of light conditions determines the development and dynamics of vegetative cover.

Obviously, to obtain as much accurate information about the plant diversity in silver fir-beech virgin forests we should conduct future research in all phases (i.e.



**Figure 3.** Proportion of floristic elements in virgin and logged stands of Omphalodo-Fagetum forest in Croatia. Chorological elements: Adventive and cultivated taxa (cultadv), Central European floristic element (ce), Circum-Holarctic floristic element (ch), European floristic element (e), Euro-Asiatic floristic element (ea), South European floristic element (se), Illyrian-Balkan floristic element (il-b), South-East European floristic element (see), East European floristic element (ee), Mediterranean floristic element (medit) and widespread plants (gen).

*Slika 3.* Udio flornih elemenata u prašumskim i gospodarenim sastojinama zajednice Omphalodo-Fagetum u Hrvatskoj. Florni elementi (rasprostranjenje): adventivne i kultivirane svojte (cultadv), središnjoeuropski (ce), cirkumholarktički (ch), europski (e), euroazijski (ea), južnoeuropski (se), ilirskobalkanski (il-b), jugoistočnoeuropski (see), istočnoeuropski (ee), mediteranski (medit) i biljke širokog/općeg rasprostranjenja (gen).

initial, optimal, ageing and decomposition stage) of virgin forests, and not just in optimal phase. Variability of light conditions that can be expected in all stages of virgin forests will significantly determine diversity of plant, and all other, species.

## Acknowledgement

### Zahvala

This research and paper was supported from several sources through the period of its creation: OIKON Ltd. – for applied ecology; Croatian Ministry of Science,



Education and Sport (Grants 119-0000000-3169 and 119-0682041-1208). I would like to thank them all.

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## Florističke i ekološke značajke bukovo-jelovih prašuma u Hrvatskoj

### Sažetak

Ovim istraživanjem obuhvaćene su bukovo-jelove prašume na sedam lokacija u rasponu nadmorske visine od 840 (Čorkova uvala) do 1.380 (Nadžak bilo) metara. Od 21 istražene plohe površine cca. 500 m<sup>2</sup>, njih 75% nalazi se na nagibima većim od 15 stupnjeva, dok su sjeverno i istočno orijentirane plohe češće od južno i zapadno orijentiranih. Prosjek godišnjih oborina je 2.200 mm, a srednje godišnje temperature 6°C s rasponom od -6° do 21°C. Analiza pripadnosti florinim elementima pokazala je da su najzastupljenije biljke euroazijskog, europskog i južnoeuropskog rasprostranjenja, a najmanje zastupljene one mediteranskog, istočnoeuropskog i južno-istočnoeuropskog rasprostranjenja kao i adventivne i kultivirane biljne vrste. S obzirom na životne oblike prevladavaju hemikriptofiti i geofiti, dok je najmanje terofita i hamefita. Srednji broj zabilježenih biljnih vrsta po plohi je 31, uz raspon vrijednosti od 17 do 46. Srednja vrijednost Shannon-Wiener indeksa raznolikosti je 3,09 te indeksa jednolikosti 0,91. Na temelju florističkog sastava, analizirane sastojine pripadaju sljedećim subasocijacijama zajednice *Omphalodo-Fagetum* [Tregubov 1957] Marinček i sur. 1992: *homogynetosum sylvestris*, *galietosum odorati*, *aceretosum pseudoplatani* i *seslerietosum autumnalis*. S obzirom na ranijim istraživanjima ustanovljen značaj otvorenosti sklopa krošnji na floristički sastav, istraživanja je potrebno proširiti na razvojne faze raspadanja i pomlađivanja koje nisu bile obuhvaćene ovim istraživanjem.

**Ključne riječi:** *Omphalodo-Fagetum*, flora, raznolikost, Lika, Gorski kotar

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