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Pregledni članak

VIRGIN FOREST OF ČORKOVA UVALA IN THE LIGHT OF PROVIDING NON-WOOD FOREST FUNCTIONS

PRAŠUMA ČORKOVA UVALA U SVJETLU PRUŽANJA OPĆEKORISNIH FUNKCIJA ŠUME

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The best known Croatian beech-fir virgin forest of Čorkova Uvala in the Plitvice Lakes National Park is the first virgin forest in Croatia to be scientifically explored. The decisive role in the shaping of the structure of this forest is played by soil depth and relief. Depending on karst phenomena, shallow brown soil on limestone (calcocambisol) and deep lessivated soil (luvisol) alternate in a mosaic-like pattern. The diversity of pedomicrosites has resulted in varied conditions for the growth of silver fir *(Abies alba* Mill.), common beech (*Fagus sylvatica* L.) and common spruce (Picea *abies* Karst.). This is responsible for the formation of an uneven-aged or selection structure of the virgin forest in the initial, optimal and ageing stage, which discriminates this virgin forest from other virgin beech-fir forests in Europe.

Research into the virgin forest development has shown that non-wood forest functions, especially those related to environmental protection, are not fulfilled in several of its developmental stages. It was found that, in comparison with a natural managed forest, a virgin forest does not produce non-wood functions as well as the former. Old growth stands should be preserved in principal forest ecosystems of Croatia to serve as sites for forestry and other research, while other forestland should be adequately managed according to natural principles to ensure optimal commercial and non wood functions.

Key words: virgin forest, nature-based forest management, non-wood forest functions, Čorkova Uvala, Plitvice Lakes National Park

INTRODUCTION
UVOD

The virgin forest of Čorkova Uvala in the Plitvice Lakes National Park is a part of the former spacious virgin forest complex of beech and fir that covered large areas in the mountainous part of the Croatian Dinaric mountain chain. The Croatian Dinarides are characterized by a typical karst relief that abounds in landforms such as sinkholes, dolines, cracks, stone blocks, crevices and fissures. The geological bedrock is made up of limestones with dolomite interbeds from the Upper Cretaceous. The bedrock is formed from vertically or laterally positioned plates (Prpić, 1972).

According to Seletković (201), the climate of beech-fir forests in Lika and Gorski Kotar is temperate warm-rainy and partially snowy-boreal. As indicated by some estimates, the average annual precipitation in Čorkova Uvala amounts to about 1,600 mm, while the mean annual air temperature is about 7° C. The dominant soil type is brown soil on limestone (calcocambisol) of varying depths (depending on area stoniness), which offers an array of conditions for the growth of forest trees. More shallow soils, melanosol on limestone and dolomite (calcomelanosol) have been identified in higher areas, while cracks and sinkholes contain deep lessivated soils (luvisol). Compared to other soils in the area, luvisol ensures much more favourable growth conditions to forest trees. Stone areas, especially plate-like layers with sporadic very shallow brown soil on limestone or melanosol on limestone provide exceptionally unfavourable conditions for the growth of forest trees (Figures 1 and 2). The virgin forest of Čorkova Uvala extends over 80 ha. Figure 1 shows a sample plot of 1 ha established in 1957. The proportion of stone area in this plot was 19%.

Figure 1: Contours and stoniness of the sample plot in the Čorkova Uvala virgin forest in Plitvice Lakes National Park

Slika 1. Prikaz slojnica i kamenitosti pokusne plohe u prašumi Čorkova uvala u Nacionalnom parku Plitvička jezera

In such places trees of silver fir, common beech and common spruce manifested much shower growth. Čorkova Uvala is situated at an altitude ranging from 860 to 1028 m. The exposition is eastern and north-eastern, and the slope is from 5 to 37 degrees.

A virgin forest is basically characterized by natural features. In other words, this is a forest in which growth and development evolves under the impact of natural biotic and abiotic factors. This results in the diversity of species, developmental stages and vitality. Viewed spatially and structurally, a virgin forest manifests several developmental stages. These are the initial (regeneration), the optimal, the terminal (ageing stage and decomposition stage) and the selection stage. In beech–fir virgin forests the life cycle that embraces all these developmental stages lasts for about 500 years. In the past 250 years the forestry profession has intensively drawn upon the insights gained by forestry, biological, technical and economic sciences. These insights also reflect the situation in a virgin forest, particularly the regeneration stage and the optimal stage. The development of a natural managed forest depends on biological and ecological relationships in the forest ecosystem, which are more or less under the impact of man. In contrast, in a virgin forest these relationships evolve without any human influence.

What discriminates Croatian beech-fir virgin forests from other European beech-fir virgin forests is the karst bedrock. The exceptional diversity of the parent material, as well as the diversity of soil types and depths, has resulted in varying diameter and height increments of virgin forest trees growing in different microsites. An uneven-aged structure of the forest stand, scientifically called the selection structure, has been observed in almost all developmental stages of the virgin forest, i.e. the initial, the optimal and the terminal stage. This is best illustrated by the number of trees per diameter class, which has the characteristic of the Liocourt curve.

In order to determine the impact of microsites on tree growth in the Čorkova Uvala virgin forest, we selected silver firs with breast diameters of about 40 cm from two microsite types. The first microsite type is in the stony part of the area, while the second microsite type has deeper soil. The annual rings from each sample type were analyzed for the period from 1960 to 1975. The annual rings from stony microsites were 2.4 times narrower than those from microsites with deeper soil (Prpić et al., 2001). Consequently, the impact of microsites on tree growth should be further investigated. Significant differences in diameters and heights of young trees growing in different microsites indicate a typical selection structure (Liocourt curve) in all developmental stages of the virgin forest, except that of regeneration. Similar results were also found in the virgin forest of Devčića Tavani in Northern Velebit (Prpić, 1972, 1979, Prpić and Seletković, 1996, Prpić et al., 1994, Prpić et al., 2001, Mayer et al., 1980, Kramarić and Iuculano, 1989). This was particularly confirmed by research of Mayer et al., and Kramarić and Iuculano, which encompassed a larger area of the virgin forest of Čorkova uvala (Prpić et al., 2001).

According to Anić (1965), the Čorkova Uvala virgin forest was in the late initial stage, or according to Korpel (1995), it was in the stage of intensive growth and the beginning of the optimal stage. Its growing stock amounted to 761 m^3/ha, but rose to

924 m³/ha in the following 30 years (1957 – 1987), which shows that the old growth stand in the sample plot entered the ageing stage (terminal stage).The tree mixture composition consisted of 56% of silver firs, 34% of common beeches and 10% of common spruces. Silver fir had the average volume of 5 m³, common spruce of 4 m³ and common beech of 1 m³. The number of common beeches declined in the mentioned period by 50% and that of silver firs and common spruces by 20%. Increased increment is mainly due to the common beech, which occurred in the virgin forest in the second generation since its life cycle is twice as short as that of silver fir.

Prebježić (2007) provided spatial presentation of the virgin forest as it was in 1957, including tree positions, crown projections, tree heights, positions of dead standing and fallen trees, and area stoniness. According to research based on the microsite method which involved emission pollution, the virgin forest of Čorkova Uvala was then not significantly contaminated with toxic gas emissions and acid rains, unlike the forests in the Plitvice area in the northern exposition (Glavač et al., 1985).

Figure 2 shows the area of the first sample plot of 1 ha, in which Academician Milan Anić launched his research in 1957 (Prebježić, 2007). According to Anić (1965) and Rauš (Prpić, 1979), the virgin forest belongs to the Dinaric beech-fir forest *Omphalodo-Fagetum* Marinček et al. 1992.

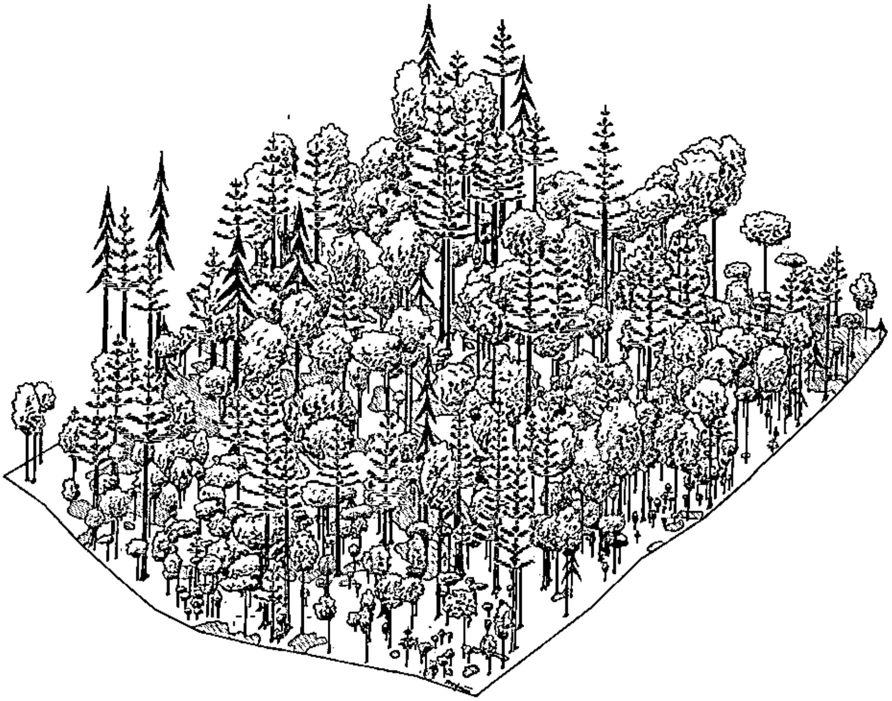

Figure 2: 3D view of the sample plot in Čorkova Uvala
Slika 2. Trodimenzionalni prikaz pokusne plohe u prašumi Čorkova uvala

WHICH NON-WOOD FOREST FUNCTIONS DOES A VIRGIN FOREST PROVIDE? KOJE OPĆEKORISNE FUNKCIJE ŠUMA PRUŽA PRAŠUMA?

Non-wood functions or forest services are indirect benefits that managed forests offer to the environment. They are closely related to the raw material forest service, which represents direct benefit. Non-wood forest functions are particularly important in the ecological and social sense due to their impact on more immediate or remote surroundings. Non-wood forest functions drew increased attention when damage to forests, incurred by modern technical civilization, began to come to light (degradation, forest destruction and decline). This damage was primarily caused by harmful gases (sulphur dioxide and nitrogen compounds) produced by industrial and traffic emissions. Forests grew increasingly contaminated by harmful gas emissions (dry and wet depositions), especially in the northern hemisphere where industry is highly developed. In some European countries forests were so badly contaminated that they virtually perished (Germany, Czech Republic).

Forests damaged to such an extent ceased to produce wood material. Aquatic and Aeolian soil erosion set in, water springs dried out, high water waves and floods grew in frequency, and the formerly unimaginable climatic extremes occurred. This was a clear indication that beneficial forest functions in the environment were no longer present. The second half of the twentieth century saw growing interest in the importance of non-wood forest functions (Prpić, 1992). In the initial estimates their value was within the value of timber; however, in the 1990s this value increased thirty-fold and showed further rising tendency (Sabadi et al., 2000). More recently, the high value of non-wood forest functions is attributed to the impact of forests on atmospheric carbon dioxide sequestration in the process of photosynthesis and mitigation of greenhouse effects.

Non-wood forest functions are divided into ecological (protective), social and combined (social-ecophysiological) (Prpić, 2003). Ecological functions embrace the hydrological function which balances water relations in the surroundings, the water-protective function which ensures potable water from ground courses and forest springs, the anti-erosion function which refers to the role of forests in preventing erosions, the climatic function which reduces wind severity and mitigates climatic extremes (in winter, temperature in the forest is several degrees higher and in summer several degrees lower than in an out-of-forest area), and finally the anti-emission function, expressed by the capacity of tree crowns to retain large quantities of harmful substances from the atmosphere (dry depositions and acid rains).

Social functions include aesthetic, recreational, health and tourist roles of a forest. Social-ecophysiological forest functions embrace genetic, biological-diverse, natural-protective and physiological functions. The genetic function refers to genofund conservation, the biological-diverse function protects the wealth of the forest's living world, the nature-protective role relates to different categories of forest protection, and the physiological function refers to enriching the atmosphere with oxygen and sequestering carbon dioxide in the process of photosynthesis.

In some developmental stages of a virgin forest (e.g. ageing and decomposition), some non-wood forest functions are reduced or are completely absent. In the developmental stage of decomposition, the death of trees and the occurrence of gaps lead to the decline of all forest functions, including the anti-erosion, climatic and anti-emission function, and, to a smaller extent, the hydrological and water protective function. A decrease in the photosynthetic impact in the developmental stage of ageing and decomposition leads to a decrease in the physiological functions of oxygen release and carbon sequestration. In a virgin forest in the developmental stage of regeneration and decomposition, carbon sequestration and oxygen release is of lower intensity in relation to a natural managed forest, where there are no ageing and decomposition stages and the regeneration stage is much shorter than in a virgin forest.

The function of preserving biological diversity of forests on the example of a virgin forest is prescribed by the FSC forest certification (Criterion 6.3) and a by-law. In a nature-based managed forest, where there are no dead trees to provide the ecological niche for a part of the living world, an agreed number of such trees must be preserved.

According to Mayer et al. (1980), the developmental stages of ageing, decomposition and regeneration in a virgin forest, in which the number of non-wood forest functions is reduced, last for about 300 years. This is a very long period in the 500-year-long life of a beech-fir virgin forest.

DISCUSSION AND CONCLUSIONS
RASPRAVA I ZAKLJUČCI

Modern forest management in Croatia is based on natural laws and processes occurring in a virgin forest. It encompasses natural regeneration, selection and competition, as well as the use of optimal site conditions. This is how a natural and stable forest stand is formed and maintained. Such a high-quality stand is capable of optimal fulfillment of non-wood forest functions. However, nature protection in the continental region is increasingly focused on natural forests. Owing to adequate forest management, these forests have for over two centuries served to protect nature and provide other non-wood forest functions. The intention is to convert these forests into secondary virgin forests by introducing different protection categories, such as national parks, nature parks and others, as well as implementing protection over about 5% of forested areas (about 1900,000 ha).according to the forest certification regulation. This will represent significant loss of some non-wood forest functions and complete loss of the raw material forest function. According to some recent findings, the most important non-wood forest functions are diminished or lost during about 60% of a virgin forest's life.

The problem of partial or complete loss of non-wood functions of a beech and fir virgin forest should be scientifically investigated so as to ensure the stability of forests in protected areas and guarantee maximal provision of non-wood forest functions. This refers primarily to carbon sinks in different developmental stages (regeneration, ageing and decomposition), in which photosynthetic effects are much smaller or completely absent. Depending on the relief, erosion and surface runoff in the developmental stage of decomposition and regeneration become more intensive, which in turn increases water waves and causes more frequent torrents and floods.

In a forest managed on close-to-nature principles there are no virgin forest stages of ageing or decomposition. Biologically, such a forest is less diverse due to the absence of old and dead trees that otherwise provide an ecological niche for a part of the forest's living world. However, this problem is currently solved by retaining a certain number of dead trees in a stand throughout the forest' life.

In order to monitor natural processes and relationships in virgin forests, it is necessary to preserve secondary virgin forests in the most important Croatian forest ecosystems. It is also necessary to apply silvicultural treatments in all other forests (managed and protected) with the goal of permanently maintaining the stability of forest ecosystems so that they could provide optimal non-wood and commercial functions. We believe that it is reasonable to utilize timber of high quality and simultaneously preserve and protect the nature and the environment.

Forests managed according to natural principles provide general nature protection and ensure other non-wood forest functions. By adhering to well known forestry principles which the forestry science has established in the course of studying virgin ecosystems, all benefits currently required from a forest ecosystem will be achieved. A stable and well tended forest ensures optimal non-wood forest functions (Prpić, 2001).

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PRAŠUMA ČORKOVA UVALA U SVJETLU PRUŽANJA OPĆEKORISNIH FUNKCIJA ŠUME

SAŽETAK

Najpoznatija hrvatska prašuma bukve i jele (*Omphalodo-Fagetum* /Marinček i dr. 1992/) u području Nacionalnoga parka Plitvička jezera prva je u Hrvatskoj znanstveno istražena. Presudnu ulogu u oblikovanju strukture te prašume ima dubina tla i reljef. U toj se prašumi, ovisno o krškim fenomenima mozaično izmjenjuju plitko smeđe tlo na vapnencu (kalkokambisol) i duboko lesivirano tlo (luvisol). Raznolikost pedomikrostaništa uvjetovala je različite uvjete uspijevanja stabala obične jele (*Abies alba* Mill), obične bukve (*Fagus sylvatica* L.) i obične smereke (*Picea abies* Karst.). Tako je oblikovana raznodobna, odnosno preborna struktura prašume u inicijalnoj, optimalnoj i fazi starenja, po čemu se ova prašuma razlikuju od ostalih bukovo-jelovih prašuma Europe. Proučavajući razvoj prašume utvrdili smo kako više njezinih razvojnih faza ne ispunjava u potpunosti općekorisne funkcije šume i to posebno neke vrlo značajne za zaštitu okoliša. Prema dosadašnjim spoznajama može se sa velikom sigurnošću tvrditi kako prašuma u svome dugom životnom vijeku obavlja u znatno manjoj mjeri općekorisne funkcije od prirodne gospodarske šume. U glavnim šumskim ekosustavima u Hrvatskoj potrebno je očuvati prašumske sastojine za potrebe šumarskih i drugih istraživanja, dok se sa ostalim šumskih površinama treba pravilno gospodariti prema prirodnim principima i s ciljem osiguranja optimalnih gospodarskih i općekorisnih funkcija šuma.

Ključne riječi: prašuma, prirodno gospodarenje šumom, općekorisne funkcije šuma, Čorkova uvala, Nacionalni Park Plitvička jezera