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Virgin Status Assessment of Plješevica Forest in Bosnia - Herzegovina

Ćemal VISNJIC[1)], Sead VOJNIKOVIC[1)], Florin IORAS[2)], Mirza DAUTBASIC[1)], Ioan Vasile ABRUDAN[3)], Dan GUREAN[3)], Ahmet LOJO[1)], Tarik TRESTIC[1)], Dalibor BALLIAN[1)], Muhamed BAJRIC[1)]

[1)] *University of Sarajevo, 20 Zagrebacka St., 71000 Sarajevo, Bosnia-Herzegovina; mirzad@bih.net.ba*

[2)] *Buckinghamshire New University, Queen Alexandra Road, Bucks HP11 2JZ-High Wycombe, United Kingdom; Florin.Ioras@bucks.ac.uk*

[3)] *Transilvania University, 1 Sirul Beethoven St., 500123 Brasov, Romania; abrudan@unitbv.ro*

Abstract

Virgin forests are relatively rare in the European temperate zone. This is due to the continuous use of forest historically and to increasing high population densities. Virgin forests are forest where the structure and dynamics have developed entirely under natural conditions, without any human interference or influence. This article assesses the Plješevica forest in Bosnia Herzegovina to establish whether it can be classified as virgin forest. The structure and components of the forest were assessed in a 1 ha sample plot and four 400m^2 quadrats. The values of the biodiversity indexes (as defined by Shannon and Weaver, Krebs and Meyer), species richness and evenness, the distribution of the different stand development stages and the proportion of dead wood lead to the conclusion that Plješevica forest presents a set of structural and dynamic characteristics close to the ones typical for virgin forests in Europe, so in order to maintain its status as such, in the meantime it should undergo a protection management programme.

Keywords: diversity, evenness, dead wood, unmanaged forest

Introduction

The term 'virgin forest' has many definitions in the forestry specific literature. Čermak (1910) defines virgin forest as "a forest which looks like it was never touched by a human", Leibundgut (1993) describes such forest as "a forest untouched by humans, with enormous trees, great volume of trunk, and hardly passable floor space with much dead wood", Rubner (1960) considers virgin forest to be "forest vegetation which belongs to the climatic climax stage of vegetation in terms of development and growth". According to Korpel (1995) the virgin forest is a "forest whose composition, development, growth and other life processes are driven by the ecological parameters, primarily by the climate characteristics".

What these definitions have in common is the belief that life processes in virgin forests are determined by ecological factors and that the human influence is negligible. In Europe, as well as in Bosnia Herzegovina (BiH), people have used forest resources in an unsystematic manner for centuries, taking what they needed when they needed it; such as material for construction, timber for firewood, wood for coal, etc. This kind of forest use inevitably influences the composition, the presence and the variety of species and the structural development of stands which we call natural forests.

The main differences between managed forest and virgin forest are considered to be related to the proportion of standing and dead trees (occurrence of dead trees in virgin forest is higher), the horizontal and vertical structure of the stand (in virgin forest, trees are found in all development stages), and the presence of natural regeneration (in virgin forest, the natural regeneration occurs throughout the area).

Virgin forests are important remnants of valuable and rare forest ecosystems. They provide a basis for close-to-nature silvicultural research and applications, for designing national networks of protected forest and for providing a reference for naturalness assessment of other forests more or less managed

Bosnia Herzegovina's forests (1.266.000 ha) are part of the *Piceo-Abieti-Fagetum* associations, beech, fir and Norway spruce representing more than 80 percent of Bosnia Herzegovina's forest area (Pintarić, 1978). The vast majority of forests in BiH are managed primarily for wood production; however, Bosnia-Herzegovina (BiH) has 0.3% of its forests classified as virgin forests, namely Perucica, Janj, Lom and Trstionica forests. Plješevica forest (Fig. 1) is considered to be the fifth virgin forest located in BiH, but no detailed studies have recently been carried out to confirm this status.

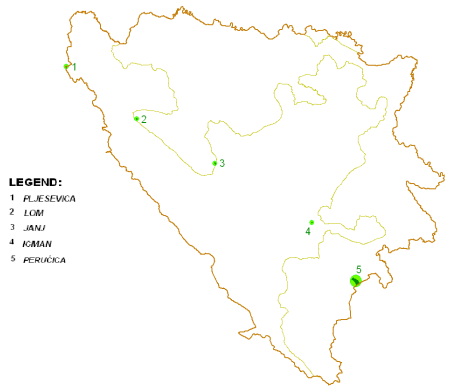

Fig. 1. Location of virgin forests in Bosnia Herzegovina

The only virgin forest in BiH which has been subject of several scientific investigations in the past is Perucica forest (1,434 ha). Most of the work was of a phytosociological and entomological nature, and was conducted by Drinić (1956), Fukarek (1962, 1964, 1964a), Leibundgut (1982), Pintarić (1978), Stefanović (1970, 1988). Recently a study was carried out on the virgin forests of Janj and Lom (Maunaga, 2001), and on a further small forest enclave in Trstionica near Kakanj, that was described by Ballian and Mikić (2002).

In the present study the authors conducted a vegetation survey in Plješevica forest in order to investigate the extent to which this forest has the characteristics of a virgin forest.

Study area

The study area is a forest stand of 38,8 ha, located at 44°45′north latitude, 15°45′east longitude, at an average altitude of 1120 m on a north-eastern slope of Plješevica Mountain, which is located east of the Una River, near the border between Croatia and Bosnia Herzegovina. Plješevica belongs to the Dinara Mountain system, which is mostly made up of Jurassic limestone. The dominant soil type is eutricambosol and small patches of renzina are also found.

The climate characteristics of the area are summarised in Tab. 1 based on the data provided by the meteorological stations of Bosanski Petrovac and Drinić, which are the closest ones to the investigated forest.

Methodology

In order to investigate the virgin status of Plješevica forest, species composition, distribution of the diameter classes and development stages, proportion of dead wood and dieback trees were assessed in a 1 ha (100x100m) sample plot situated in the centre of the studied forest.

Four polygons were randomly selected for phytocenosis assessment according to Braun – Blanquet method (1964) as well as for species richness by adopting a quadrat method (20 x 20 m size) - see Fig. 2.

Each species was recorded by frequency and coverage range and all plant species identified within the quadrat were recorded in a Turboveg 2.38 database (Hennekens and Schaminee, 2001), and exported to Juice 6.4 programme (Tichy and Holt, 2006) for analysis.

For each quadrat, the biodiversity and evenness indexes were calculated using the Shannon-Wiener Index (Krebs, 1999). Also, the identified plant species were cross checked against the Red Book of Bosnia and Herzegovina as enlisted by Šilić (1996). Each such species was scored according to IUCN standards as follows: E – highly endangered species, V – endangered or vulnerable species, R – rare or potentially endangered species.

Results and discussions

Forest phytocenosis

A total of 71 species were identified and recorded (based on the quadrats established in the study area), of which 4 were rare and/or endangered species. On the basis of floristic system analysis (Tab. 2) it resulted that the plant community is part of the Dinara forests of Abieti-Fagetum dinaricum association (Tregubov, 1957). This community of beech and fir belongs to Aremonio - Fagion alliance (Török *et al.* 1989). This alliance is stipulated in Annex I of the Habitat Directive (Directive 92/43/EEC) as habitat 91K0 - Illyrian Fagus sylvatica forests, which is of community interest.

The survey identified the presence of four species which are classified according to IUCN standards as endangered (Tab. 3).

The biodiversity indexes were also calculated for the study plots, and their values are presented in Tab. 4.

According to Krebs (1999), the maximum values of Shannon – Wiener index do not exceed 5,00 for biologi-

Tab. 1. Climate data

Meteorological station	Altitude (m)	Mean air temperature (°C)		Mean rainfall (mm)		Length of the growing season (days)	Potential evaporation in April-September (mm)
		Annual	April-September	Annual	April-September		
Bosanski Petrovac	650	8.7	14.6	1198	630	170	528
Drinić	730	7.6	12.4	1350	625	156	503

Tab. 2. Synoptic tab. with percentage constancy and coverage range [1,2)]

Group No.	1
No. of relevé	4
Euphorbia amygdaloides	100 +
Fagus sylvatica	100 1-4
Aremonia agrimonoides	100 +
Stellaria nemorum	100 +-2
Galium odoratum	100 +-1
Galium rotundifolium	100 1
Sanicula europaea	100 +-1
Prenanthes purpurea	100 +
Anemone nemorosa	100 2-4
Dryopteris filix-mas	100 +-1
Athyrium filix-femina	100 1-2
Oxalis acetosella	100 1-2
Abies alba	100 1-3
Viola reichenbachiana	100 +
Mycelis muralis	100 +
Cardamine enneaphyllos	75 +-1
Glechoma hirsuta	75 +-1
Fagus sylvatica	75 +-1
Polystichum lonchitis	75 +-1
Acer pseudoplatanus	75 +-1
Asplenium scolopendrium	75 +
Abies alba	75 +-1
Cardamine kitaibelii	75 1-2
Geranium robertianum	75 +
Senecio germanicus	75 +
Cardamine waldsteinii	75 +-2
Acer pseudoplatanus	50 +-1
Lonicera alpigena	50 +
Rubus hirtus	50 +
Abies alba	50 1
Arum maculatum	50 +
Rhamnus alpinus s. fallax	50 +-1
Symphytum tuberosum	50 +-1
Picea abies	50 +
Abies alba	50 1
Maianthemum bifolium	50 +
Hordelymus europaeus	50 +
Cardamine bulbifera	50 +
Polygonatum verticillatum	50 +
Ruscus hypoglossum	50 +
Actaea spicata	50 +
Paris quadrifolia	50 +
Solanum dulcamara	25 +
Lonicera nigra	25 1
Festuca altissima	25 1
Gentiana asclepiadea	25 +
Sorbus aucuparia	25 +
Carex sylvatica	25 +
Luzula sylvatica	25 +
Sambucus racemosa	25 +
Cystopteris fragilis	25 +
Vaccinium myrtillus	25 1
Picea abies	25 2
Picea abies	25 +
Epilobium angustifolium	25 +
Lilium martagon	25 +
Lonicera alpigena	25 +
Polygonatum multiflorum	25 1
Heracleum sphondylium	25 +
Daphne mezereum	25 +
Epilobium montanum	25 +
Lunaria rediviva	25 +
Fagus sylvatica	25 1
Polypodium vulgare	25 +
Daphne laureola	25 +
Scrophularia nodosa	25 +
Galeopsis speciosa	25 +
Rubus hirtus	25 1
Salvia glutinosa	25 +

[1)] Presence of the same species in the tab. is explained by the occurrence of species in several layers

[2)] Individual names of species are automatically converted by the software into names according to the standard database for Croatia, for example: *Asperula odorata* into *Galium odoratum* or *Senecio nemorensis* into *Senecio germanicus*.

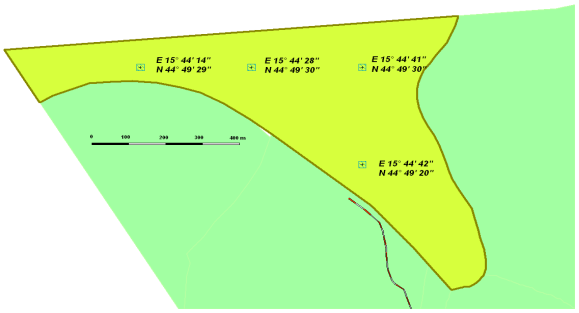

Fig. 2. Location of sample plots in Plješevica virgin forest

cal communities, therefore the diversity of higher plants in the examined area could be described as average. The index of 'Evenness' (Krebs, 1999) established for the study plots shows no over domination of one or more species.

Distribution of tree diameter

One indicator for the lack of past production management could be the diameter distribution of trees. Fig. 3 presents the stand composition by diameter classes and shows an uneven age structure with a slightly irregular distribution of trees in the higher diameter classes (from 65 to 105 cm).

Tab. 3. Rare and endangered species found in Plješevica forest

Study plot	Species	Status[1]	Y – coordinate	X - coordinate
1	*Cardamine kitaibelii*	V	5559179	4964186
2			5559261	4964207
3			5559199	4964329
1	*Daphne laureola*	R	5559179	4964186
2	*Lilium martagon*	V	5559261	4964207
4	*Ruscus hypoglossum*	E	5559179	4964186
			5559137	4964275

[1)] Species status according to the IUCN standards: E – highly endangered species, V – endangered or vulnerable species, R – rare or potentially endangered species.

Tab. 4. Indexes of diversity and evenness

Biodiversity indexes	P1	P2	P3	P4	Mean values
Number of species	33	32	35	33	33
Shannon – Wiener Index	2,59	3,12	3,10	2,76	2,89
Evenness	0,72	0,84	0,82	0,76	0,78

The size of these plots (400 m^2) is considered adequate for establishing the presence of different development stages in a virgin forest, as described by Meyer (1999). The distribution of the development stages within the studied plot is shown in Fig. 4, and their description and frequency is presented in Tab. 5.

It can be noticed that all the development stages typical for a virgin forest were identified within the 1 ha study area. Development stages are rotating on a relatively small area and have approximately the same frequency of occurrence. In order to assess the diversity of developme stages, the Shannon-Wiener index (Shannon and Weaver, 1976) and Evenness index (Pielou, 1966) were calculated by using the presence of individual development stages in relation to the area they covered, instead of the number of species.

The values of the Shannon's index (2.455) and Evenness index (0.807) for the study plot in the Plješevica forest are significantly above those calculated for some virgin forest reserves in Germany and Albania (presented in Tab. 6) (Tabaku, 1999), thus indicating a potential virgin forest.

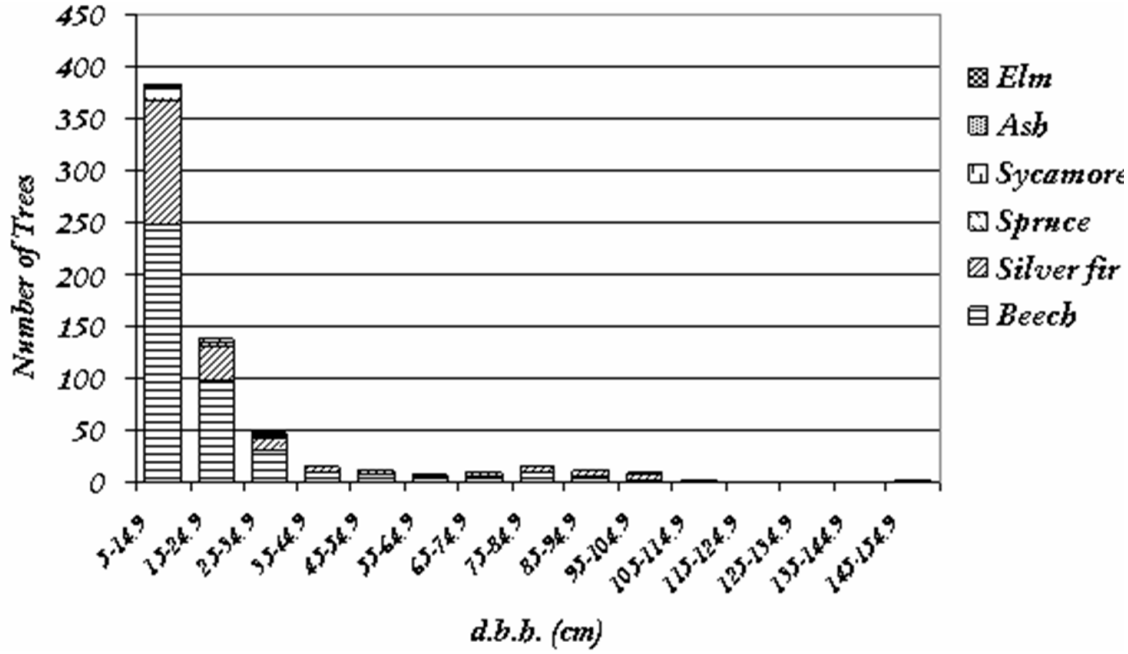

Fig. 3. Distribution of trees by species and diameter classes (10 cm) in the 1 ha study plot in Plješevica forest

The presence of large-size trees is one of the major indicators for a virgin forest according to Leibundgut (1993). In addition to this, in a managed forest the tree diameter does not usually exceed 80 cm (Pintarić, 1999), so the tree distribution by diameter classes in the studied forest is close to the diameter distribution typical for an uneven aged/un-managed forest.

Forest development stages

Within the 1 ha studied plot, the presence of different development stages was assessed in rectangular plots (quadrats) of 20 m x 20 m placed inside the study area.

Natural regeneration was found on 96% of the area, being well represented in all plots but one quadrat, where it covered less than 25% of the plot, indicating that the entire area surveyed in this study has gone through a natural process of rejuvenation, following a pattern found in unmanaged forests.

Dead wood and dieback trees

Presence of dead wood is important to biological diversity within a forest stand, and it is a critical factor for the development of some species like mushrooms, lichens, mosses, arthropods, rodents, birds etc. Based on research

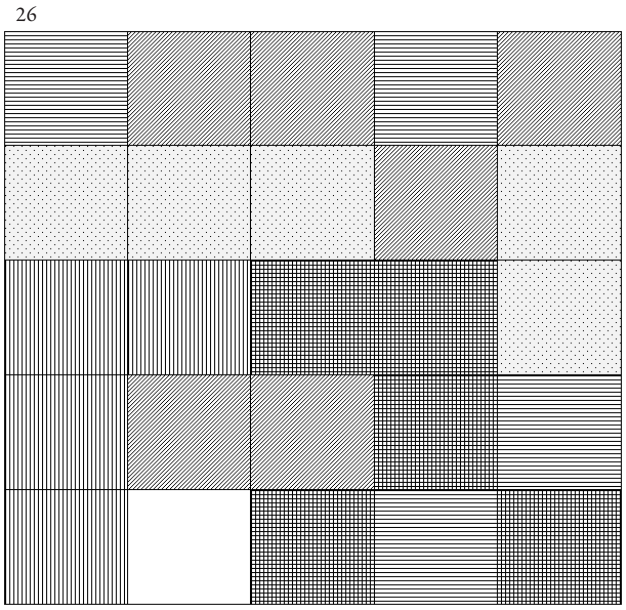

Fig. 4. Distribution of the development stages within the 1 ha study plot

Tab. 5. Frequency of the development stages within the study area

	Development stages within the study area of 1 ha	Frequency of occurrence
	Canopy opening – At least 25% of the area is covered by mature trees, and progeny and young trees cover less than 50% of the area	1
	Rejuvenating – Occurrence of the natural progeny within clearings in more than 50% of the area	5
	Intensive growth – Intensive increase of wood mass through competition between species	4
	Maturity – Increase of wood mass becomes constant and does not change	5
	Senescence – Increase of wood mass stagnates over a longer period, certain trees are dying back and the process of wood degradation starts	4
	Decaying – Decomposition of large wood mass relative to the increase of new wood mass	6

Tab. 6. Development stage diversity indexes for virgin forests reserves[1)] in Albania and Germany (Tabaku, 1999)

	Albania			Germany		
Virgin forest	Puka	Rajka	Miridita	Heilige Hallen	Bleicherode	Dassel
Shannon-Wiener Index	1.67	1.49	1.47	1.81	1.63	1.28
Evenness	0.80	0.72	0.75	0.92	0.84	0.66

[1)] Beech forest with silver fir and ash.

focused on optimising tree stand diversity, it has been suggested that the proportion of dead wood in relation to the total wood mass should be around 20-25 % (Siitonen, 2001; Alexander, 2003) in unmanaged forests. In managed forests that share is much lower, at around 1-10 % (Meyer, 1999). Thus, one can conclude that an increasing proportion of dead wood is followed by increased biological diversity. Current forest management does not encourage increased presence of dead wood and the management guidelines prescribe its removal, as the presence is perceived as an increased risk of pest infestation. Therefore, the higher proportion of dead wood found in an area the less probability of a production management plan being in place. This could be a further indication of a possible unmanaged/virgin forest presence.

The dead wood proportion in the forest of Plješevica is presented in Tab. 7.

This tab. shows that the proportion of dead wood is 12 % of total wood mass for the 1 ha study plot, and it is higher for fir (14 %) than for beech (9 %). The larger proportion of dead wood in the case of fir might be explained by its smaller proportion in lower diameter classes (Fig. 3). The proportion of dead wood is higher than in managed forests and yet is within the limits specified by Droessler (2006) for European virgin forests. On the other hand, Fig. 4 shows that the dieback trees and dead trunks (quite common for the decaying and senescence phases) are unevenly distributed all over the study area.

Conclusions

Despite the fact that the work presented in this paper has some limitations due to a relatively small number of plots, the results show clearly that Plješevica forest presents a set of structural and dynamic characteristics close to the ones typical for virgin forests in Europe. Further investigations are needed in this respect and a protection status for Plješevica forest is recommended considering the small area of virgin forests in Bosnia-Herzegovina.

Tab. 7. Proportion of dead wood in total wood mass in Plješevica forest

Species	Volume of living trees (m^3/ha)	Volume of dead wood (m^3/ha)	Total volume (m^3/ha)	% of dead wood
Beech	277.4	28.6	306.0	9.3
Fir	352.8	60.4	413.2	14.6
Spruce	17.5	0	17.5	0
Sycamore	3.4	0	3.4	0
European ash	0.4	0	0.4	0
Elm	0.001	0	0.001	0
TOTAL	651.5	89.0	740.5	12.0

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