

A dense forest with tall, moss-covered tree trunks and a canopy of green and yellow leaves. In the bottom left corner, there is a white silhouette of a tree with many small leaves.

Forest biodiversity in Plitvice Lakes National Park

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Tomislav Kovačević,

General manager of the Plitvice Lakes National Park Public Institution

Editor

Nikola Magdić

Author

Ivan Martinić

Associates

Matija Landekić, Matija Bakarić, Fabijan Martinić

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**PLITVIČKA
JEZERA**
National Park



**PARKS OF
CROATIA**



United Nations
Educational, Scientific, and
Cultural Organization



Plitvice Lakes National Park
inscribed on the World
Heritage List in 1979



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2019.

Foreword

For the first time since Plitvice Lakes became a national park, the readers now have a chance to learn important facts related to the forests of the Park, owing to the author and the forestry experts of the Public Institution Plitvice Lakes National Park. Dominating the Park as it covers more than two-thirds of its area and features well-preserved natural forests, the forest ecosystem most certainly deserves this special edition.

The purpose of this handbook is to help readers better understand the forests and forest ecosystems, especially with respect to the significant contribution of Plitvice Lakes' natural forests to the conservation of the biodiversity of the National Park.

The handbook consists of seven chapters, which introduce the reader to the various aspects of the importance of forests, starting with their global role and moving on to the specific characteristics of individual forest habitats of the Plitvice Lakes National Park – with the purpose of better understanding of the complexity of the forest's functioning and raising awareness about the necessity of conserving the Park's forest ecosystems as a priceless component of the unique natural resource of this UNESCO World Heritage Site.

The editor

PLITVICE LAKES – the existence of the forest ecosystem without the water ecosystem and vice versa is unimaginable

In addition to the lakes and the waterfalls, the forests are the most recognisable frame of the unique natural heritage of the Plitvice Lakes National Park. They have a specific protected natural development status as a part of the natural heritage of the protected area; as such, they comprise an important part of the NATURA 2000 network in Croatia. Besides Plitvice Lakes, there is no place where the interconnectedness of the forest and the water is so prominent. The pristine natural forests represent an ideal habitat for a number of species that require both large areas and high quality of the habitat to survive.



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1. Introduction

About the biodiversity in Plitvice Lakes National Park

The vast forest complexes, the outstanding natural beauty of the 16 lakes and countless waterfalls, the abundance of flora and fauna represent a framework of a unique Plitvice Lakes National Park complex, designated as a World Heritage Site by UNESCO:

Plitvice Lakes National Park is situated in the mountainous part of Croatia at southern slopes of Mala Kapela mountain range, at an altitude of 450 to 1280 metres above sea level. It is an area of alpine topography that significantly influences the climatic phenomena and, consequently, the vegetation of the area. The wider area of the National Park encompasses rich forest and grassland habitats, with forest vegetation covering some 75 % of the Park and the areas modified by humans, including various grasslands, arable and abandoned lands and settlements, some 24 %.

The mutual effect of the geographic position, the horizontal and vertical stratification, as well as the geologic and pedologic specificities,

in relation to forest ecosystems, enables the development of rich and diverse flora of the Park. So far, some 1400 plant taxa have been recorded in the Park, including 50 orchid species and a large number of endemic species. The only location in Croatia where some species, such as Siberian leopard plant (*Ligularia sibirica*), can be found is the Park. One of the rare and interesting plant species of the Park is the hawksbeard grassland (*Crepido conyzifoliae*), which builds a special form of grassland association *Crepido conyzaefoliae-Molinietum altissimae* (Šegulja, 1992).

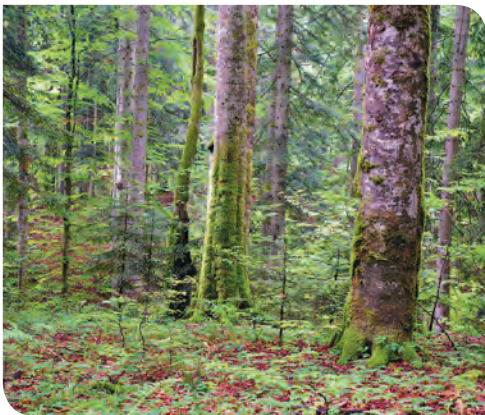


Figure 1 A detail of the virgin forest stand Čorkova uvala

¹ UNESCO designated Plitvice Lakes National Park a World Heritage Site in 1979, so it is one of the oldest such sites in the world.



This association has so far been recorded only at two sites in the mountainous region of Croatia.

As a dominant ecosystem of the Park, forests have an exceptional role in the preservation of the hydrological regime, providing a special value and adding to the beauty of the scenery together with the grasslands and the water areas.

Looking at the Park's forest zones, we can see that beech forests and beech-fir forests are dominant, representing the permanent vegetation form, i.e. the climate-zonal vegetation. A range of non-zonal vegetation communities developed within these zones with respect to relief, geological substrate, soil depth and moisture, e.g. forests of willow, European alder, hop hornbeam, silver pine, spruce, etc.

In line with the national habitat classification, the forests of Plitvice Lakes National Park comprise the following main forest communities:

- ▶ Dinaric beech-fir forest (*Omphalodo-Fagetum* (Tregubov 1957) Marinček et al. 1993)
- ▶ Spruce forest with black hellebore on dolomite (*Helleboro nigri-Piceetum* (Horvat 1958) Trinajstić et Pelcer 2005)
- ▶ Beech forest with giant dead nettle (*Lamio orvalae-Fagetum* (Ht. 1938) Borhidi 1963)
- ▶ Hop hornbeam forest with winter heath (*Erico carnea-Ostryetum carpinifoliae* (Ht. 1938) 1959)
- ▶ Silver pine forest with black hellebore on dolomite (*Helleboro nigri-Pinetum sylvestris* Ht. 1958)
- ▶ Hop hornbeam forest and thicket with autumn moor grass (*Seslerio autumnalis-Ostryetum carpinifoliae* Ht. et Hić in Ht. 1950)
- ▶ Common beech and black hellebore forest (*Helleboro nigri-Fagetum* Zukrigl 1973)

The Plitvice Lakes National Park Management Plan stresses the importance of conservation of forest ecosystems in the Plitvice Lakes National Park as one of the main goals of the preservation of the protected area.

Forest ecosystem

A forest is a complex biological system with a number of living components (plants, animals, fungi and microorganisms) intertwining with other, non-living, inorganic or abiotic ecosystem components (soil, climate, water, organic residue, rocks, etc.).

Forest diversity and distribution

Forests come in all shapes, sizes and types – from northern taigas to dryland thickets and tropical rainforests. They can be found on movable glaciers, in fresh and sea waters, on the slopes of Arctic mountains. The forest type of an area depends on a number of elements, including the climate, the soil, water sources, the altitude, the rainfall pattern and the human influence.



2. Global significance of forests

The forests are so much more than Sunday strolls, clean air, wild birds and mushrooms. In addition to being a home for a number of species, forests are indispensable when it comes to the overall health of the environment.

The forests are natural land ecosystems that have been developing for millions of years. Occupying some 40 % of the Earth's vegetation area, they comprise a complex but stable functional system that is renewed, organised and sustained by itself. Both in the past and today, the forests made a significant contribution to the forming of the possible and known forms of life.

Economically speaking, forests belong to most important natural resources. They continually produce wood biomass that can be used through rational and competent management, ensuring the sustenance for the inhabitants.

In global ecology, forests represent the foundation for the conservation of the biodiversity, which plays an important role in the resilience of each ecosystem, including the forest ones. It is important to keep in mind that the total efficiency of a forest surpasses the mere sum of individual effects of each tree. Nevertheless, the contribution of each tree is significant.

The complexity of forest ecosystems is reflected in their influence on the climate, the water resources and the forms of economy developed in different areas. In addition, forests provide a choice of recreational activities.

The forest biodiversity is extraordinarily important for the stability of a forest as it represents:

- ▶ an integral part of the forests' genetic pool
- ▶ an irreplaceable link in the food chain of numerous species and communities
- ▶ a factor of vitality and health resilience of forest stands.

Biologically speaking, the most significant type of forest today is the tropical rainforest. Some 45 % of all plant species and some 30 % of all birds in the world live in the tropical rainforests.



Globally, forests have numerous and various tasks:

- ▶ they balance the water system and the climate
- ▶ they protect from avalanches, slides and floods
- ▶ they mitigate the developmental burden imposed on the environment (forests serve as dust, smoke and gas filters and reduce noise)
- ▶ they represent an important area for relaxation, fun and recreational activities
- ▶ they are a home for a number of plant, animal and fungal species
- ▶ they are very appropriate excursion destinations and areas for research and environmental education
- ▶ they produce useful wood and other forest products.

Dead and deadwood are very important elements of a preserved forest habitat. The survival of some bird species (especially woodpeckers), but other animal and fungal species as well, depends on the existence of deadwood in a forest. Dry fallen trees and branches represent the feeding and nesting ground for numerous woodpecker species. Larger tree hollows are home to owls and stock doves, while the small ones are inhabited by tits. The bats are also common dwellers of larger tree hollows. After they fill the hollows with their excrement, the bats leave them. They are then inhabited by various invertebrates, who clean them and prepare for the following bat or bird dwellers.

General value and benefits of forests

The modern sustainable forest management concept does not emphasize the economic aspect of a forest, but equals it to its ecological and social function.

Forests have a series of tasks, providing direct or indirect benefits for humans:

- ▶ preventing avalanches, landslides and rockfalls from forming on the slopes.
- ▶ the moss layer and the highly absorbent soil prevent the quick drainage of surface waters; thus the flow in the forest streams doesn't change much. In this manner, the forests prevent the valuable hummus layer to be eroded, simultaneously serving as flood protection.
- ▶ a significant share of water from the soil evaporates and reaches the surface of the leaves within the so-called "small water cycle", increasing the rainwater retention. Due to that reason, the climate of forest areas is more uniform than that of the non-forest areas.

The deadwood

It is a natural process. The presence of deadwood and old trees in forests is a prerequisite for the survival of the often neglected but extremely important components of a forest ecosystem – starting with the larger ones such as owls, woodpeckers and bats to a multitude of small insects and spiders. Such trees are also home to a number of fungi, lichens and mosses. The existence of old and rotten trees in forests, either lying or standing, largely increases the biodiversity.





Figure 2 The forests of Plitvice Lakes National Park are the key framework of the abundant biodiversity and a very stable ecological foothold as well

- ▶ in forests, there are less anthropogenic pollutants (waste water, fertilizers, pesticides, herbicides, etc.), so the ground and spring waters in forests are impeccably clean and suitable for drinking, which is ascribed to the fact that forest soil acts as a filter.
- ▶ forests reduce noise.
- ▶ forests slow down the wind, protecting the nearby fields from drying and wind erosion. In addition, forests increase the air swirling, facilitating the mixing of the higher and lower air layers.
- ▶ forests are the most important provider of oxygen. A hectare of a forest covers the need for oxygen of some 10 people. Simultaneously, the leaves take in the carbon dioxide that originates from the degradation processes and combustion.
- ▶ most types of forests are home to a large number of animal and plant species; the mixed deciduous forests are the most abundant in species. The number of species and the population density primarily depend on the forest structure. It is proven that the bird life is more diverse and better developed where the forest is more diverse and of more irregular structure, meaning that it is composed of trees of different age and a large number of different tree and shrub species.
- ▶ forests also have a function related to hygiene, as they filter dust, smoke and exhaust gases. The deciduous forests with a prominent shrub layer have the most noticeable effect. One hectare of beech



forest can trap up to 68 tons of dust, while the same area of spruce forest traps only 32 tons.

- ▶ present and future forests have an important role as areas for relaxation and recreational activities. Increasing numbers of people go to forests in order to relax, keep in touch with the living nature, enjoy the fresh air and find peace or practice sports activities.
- ▶ Forests break down the landscape giving each area a recognisable mark. Forest also fulfils the function of a special aesthetic experience; from that point of view, the forests featuring trees and shrubs of various age and species are much more attractive than the uniform monocultures.
- ▶ Forests represent appropriate targets of excursions related to natural sciences. A forest provides us with an extraordinary possibility to gain insight into ecological relationships among groups of organisms, so the forest can be used as an area for learning in nature and as a field of work.
- ▶ Forests produce wood. Due to its characteristics inherent to natural materials, wood represents an irreplaceable raw material in industry and crafts. In some regions, wood still has an important role as a domestic energy source.

Ecosystem services of forests

Forest ecosystems have a crucial role in the survival and welfare of human population. The ecosystem services provided by forests make life on Earth possible. Forests provide multiple benefits with respect to the climate regulation, human health, recreational activities, providing shelter, ensuring drinking water supplies, etc.

Term **ecosystem services** is used since 1990 as an umbrella term for different products, services and functions provided by ecosystems. Currently, several international agreements and developmental policies related to the issue of ecosystem services are in force, including the Convention on Biodiversity and the newly established Intergovernmental Platform on Biodiversity and Ecosystem Services – MEA².

² The Millennium Ecosystem Assessment (MEA) – a four-year study involving more than 1300 scientists around the world with the purpose of popularisation of the ecosystem services approach and the interpretation of the ways in which the human population vitally depends on different services provided by the ecosystems. The working group for the Millennium Ecosystem Assessment – MEA was formed by the United Nations with the objective of assessing the consequences of ecosystem change for human well-being and defining the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being.

Ecosystem services of forests

These services represent a key link between the nature and the human welfare. Not understanding and accepting the values the ecosystem services have with respect to the quality of life, people are not likely to take the steps necessary for their protection. The discipline of environmental valuation attempts to put a monetary value on an entire range of ecosystem services, including those that do not have the established market value (e.g. the biodiversity conservation, protection of drinking water supplies, recreational services, etc.).



The ecosystem services represent conditions and processes by which the natural ecosystems and the species they consist of maintain and fulfil human life. Summarily, they represent a multitude of natural resources and services utilised by humans. The number of products and services provided by forests is large and the non-exhaustive list consists of: a) wood and non-wood products, e.g. the biomass energy; b) climate regulation, e.g. carbon binding; c) pollution control; d) soil protection and formation, e.g. erosion control; e) nutrients cycling; f) biodiversity protection; g) pollination and seed dispersal; h) water regulation and supply; i) tourism; j) cultural, aesthetic, recreational and health services, etc. (Figure 4).

The MEA working group defined the four main categories of ecosystem services:

- I. **Supporting services:** basic services that make all other ecosystem services possible (such as: soil formation, photosynthesis, nutrients cycling, dispersal of seed from a forest, erosion control, etc.).
- II. **Provisioning services:** encompass the products obtained from the ecosystem (such as lumber, water, mushrooms, medicinal herbs, genetic resources, etc.)
- III. **Regulating services:** maintain the world suitable and bearable for living (such as hydrological cycles, climate change mitigation, etc.).

Forest structure

Although a more or less dense vegetation characterises all forests, a cross-section of a forest reveals several recognisable layers. The tree level represents the most visible layer (Figure 3, levels A and B), encompassing all trees higher than 5 metres; it can be divided into two separate levels: level A with the individual tallest trees emerging and the level B, in which the trees comprise the primary forest canopy. The understory (Figure 3, level C) comprises shrubs and young trees reaching from 0.5 to 5 metres high, below which a layer of herbs is visible, with trees up to 0.5 m in height (in rare cases up to 1 m). The lowest layer is the forest soil (Figure 3, level D), comprising mosses, fungi and lichens.



Figure 3 Vertical cross-section of forest structure¹

¹ source: <http://eschooltoday.com/forests/structure-of-a-forest.html>



IV **Cultural services:** consist of non-material benefits people gain from ecosystems (such as aesthetic pleasure, spiritual enrichment and fulfilment, recreational activities, ecotourism, etc.).

Forest ecosystems and their biodiversity are strongly correlated. On one hand, the biodiversity largely depends on the integrity, health and vitality of forest areas and habitats. On the other hand, the biodiversity loss in forest ecosystems will lead to loss in the productivity and sustainability of forest areas. Thus, the sustainable forest management is aimed at supporting the utilisation of forest products and services with the simultaneous improvement of their biodiversity.

According to MEA working group, the biodiversity is intertwined with all four categories of ecosystem services, by facilitating the degradation of leaves, providing firewood, regulating watercourses and having a key role within the cultural services framework by serving as a foundation for the existence of value and recreational purpose. Unlike the ecosystem services such as recreation or water, the values related to the biodiversity conservation are not related solely to the active use, but are often considered a prerequisite for providing or existence of other services in the form of supporting and regulating services.

Forest flora and fauna – the disappearing world

Only a handful of data exists on the majority of forest plants, fungi and animals, so they often disappear without a trace from forest areas under our management. These species include a large number of insects (especially *Coleoptera* beetles), fungi, cavity-nesting birds and other species. The research have shown that such a state of affairs can easily be mended in case the appropriate measures for the conservation of biodiversity were applied to forest management. In addition to such measures, it is important to isolate forest stands with custom made management and as many forest reserves that would be completely left out of the management process and serve as means of preservation of the forest species gene pool.



Figure 4 Functions provided by a forest as ecosystem services



3. Forest biodiversity

Forest biodiversity – what does it encompass?

Forest biodiversity is expressed through the richness of their genetic pool, the number of species and the diversity of ecosystems. We can distinguish forest ecosystems by their species composition, genetic diversity within species, the size of their populations, ecological conditions and landscapes.

A community of living organisms in forest ecosystems comprises hundreds or even thousands of different species. Although all forests have a more or less dense canopy, shrubs and other undergrowth formations, they constitute neither biological nor ecological unity. As many as 200 different forest communities can be found in Croatia.

Each forest type provides an extraordinary possibility of gaining insight into the ecological relationships among groups or organisms. Each species usually participates in several food chains connected into food webs and finally comprising a food pyramid. The balance of the food pyramid is crucial for the stability of the community of living organisms of an ecosystem. Disappearance of any of the species causes the weakening or the breaking of the food chain, leading to the disturbance in populations of other species belonging to that chain.

Despite the fact that forest habitats belong to the group of most stable habitats when it comes to the threat of disappearance of certain species, there are endangered species within those habitats as well. The foresters who think ecologically take special care about the plant and animal diversity, because the songbirds, the hedgehogs and the shrews, some insects and other small animals significantly contribute to the preservation of biological balance in forests, reducing the pest-related risks. Thus, the forest biodiversity has to be considered with respect to space and time, including the anthropogenic influence. The interconnection of the abiotic factors (climate, water, soil, geological processes, etc.) with the biotic factors (interaction of organisms, ability to procreate, food chains, genetic mutations, etc.) is crucial for the survival of the forest biodiversity.

From biological perspective, forest edges, meadows and glades represent especially valuable and interesting parts of a wood, as they are



home to distinct types of flora and fauna. Those are parts of forests which their owners consider less valuable, so they often either afforest them or grub them up in order to align their farming areas.

Conservation of the forest edge shrubs is of key importance, as the inner area of the forest would be exposed to the wind, noise, dust and exhaust gases without them. Without the shrubs, numerous animals, especially birds and mammals, would lose their shelter and the possibility of nesting. Among the songbirds, those that nest in the shrubs and on the ground are the most affected. Some birds and small mammals would lose their precious winter foods (berries, nuts and other fruits) without the shrub layer.

How to recognise what is truly valuable in a forest from a biological perspective?

The most frequently asked question is how to recognise biologically important parts of a forest, i.e. the forest areas and sites where it is highly likely that endangered or rare habitats and species would be found. The increased biological value of forests may be indicated by areas with old forest stands that have no signs of human interference over multiple generations or by areas with rare forest communities, the appearance of biological or



Figure 5 A mosaic of meadow, grassland and forest habitats in Plitvice Lakes National Park

landscape elements that point at special habitat conditions, the presence of rare and endangered species, etc.

The key biological elements include visible indicators such as rotten trees, smaller forest glades, deadwood of various age as witnesses of the natural processes that take place in the forest.

Indicator species specific to a certain habitat serve as important biodiversity indicators. They are moderately sensitive to habitat changes occurring because of the anthropogenic influence. Thus they can be found in key habitats in large numbers and much more often than rare or endangered species. Indicator species point at the existence of habitat conditions appropriate for rare species in a certain area.

The final confirmation for defining a forest area as an area of special biological importance is the presence of rare or endangered species. Sometimes only a few weeks within the course of a year can be appropriate for the identification of rare species.

Often some special elements such as springs, streams and rivers, seasonally flooded areas, nearby fish ponds and lakes, river aits overgrown by old stands and driftwood vegetation, forests growing on steep slopes, geology objects – limestone reefs, terraces, large rocks, etc. – represent a prerequisite for forming the key biological elements.

The main elements pointing at the high potential of a forest with respect to biodiversity are as follows:

- ▶ diverse and dynamic forest structure in various development and renewal stages
- ▶ the presence of exclusively autochthonous tree species typical for the region
- ▶ trees of different age and dimensions
- ▶ a multitude of old, dry and deadwood, together with the decomposing wood on the ground
- ▶ small glades among tree crowns that allow the light to penetrate to the ground
- ▶ abundant ground vegetation layer
- ▶ intact surface waters and still bodies of water
- ▶ large areas of continuous forest vegetation with a limited network of forest roads, logging roads and trails
- ▶ diverse forest edges with a noticeable share of forest fruit trees



There is an entire corpus of handbooks on the conservation of biodiversity that can help the owners of forests in their efforts to understand the biological value of their forests. Thus a specific component of forest biodiversity can be understood with the aid of the book on forest trees and shrubs “Šumsko drveće i grmlje jestivih plodova” (authors: Šatalić and Štambuk, published by DUZO, Zagreb 1997).

Endangered forests

Today, there is a growing awareness of the fact that the disappearance of natural habitats represents the largest threat for the biodiversity. The decline in forest biodiversity can partially be ascribed to the pollution, the diseases and the climate change. In addition, it is a consequence of poor practices in forest management, which include years of forest management based on the economic logic resting on lumber, especially in privately-owned forests, while conservation of habitats, non-commercial tree and other plant species and the animal world in total was of no consequence to the forest owners.

The vulnerability and, consequentially, the degradation of forests can be equally observed through the decrease in the forest biomass production (decreased gain, wood deterioration, etc.), as well as through the loss of the natural protective capacity (ecological and biological) and the related aesthetic and recreational qualities.

Fungi

Forest habitats abound in fungal species, so they are very important when it comes to conservation of fungal biodiversity. By decomposing dead organic matter, fungi return nutrients to soil, having a crucial role in the health of the entire ecosystem. Some fungi grow closely to particular tree species, forming mycorrhizal associations with the roots of the plant – the fungus supplies mineral substances to the partner, while the tree ensures necessary hydrocarbons for the fungus. Without the fungi, the world as we know it would not exist!

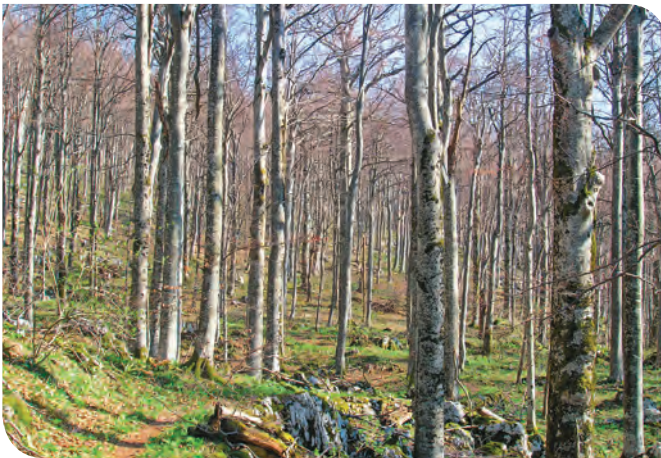


Figure 6 Beech forests represent only a part of Plitvice Lakes National Park forest communities' treasure



The ability of a forest to remain vital and to regenerate is decreased by various unfavourable environmental factors. The most visible consequence of human influence is reflected in non-sustainable management and destruction of forests for industrial purposes. A series of economic interventions within the scope of water management, transport, tourism and other branches over the course of the 20th century in Europe caused the disappearance of a number of natural forest ecosystems.

In many areas, primarily in Central Europe, it has been observed that the forest degradation corresponds with the increased air pollution.

The most common causes of forest vulnerability are linked to:

- ▶ pollution of air, water and soil
- ▶ change in natural characteristics of a hydrological regime due to hydrological engineering, primarily in lowland forests
- ▶ construction of roads, power lines, gas pipelines, etc.
- ▶ exploitation of mineral resources (quarries, gravel pits)
- ▶ excessive timber harvesting
- ▶ use of pesticides in forests
- ▶ inadequate care about the overall forest biodiversity
- ▶ forest fires
- ▶ global climate change and climatic extremes
- ▶ avoidance to apply regulations to forest management.

Threats to biodiversity – invasive species

The problem of invasive species reaches such extent that it might turn into one of the main threats to the conservation of biodiversity in the 21st century. On a global scale, invasive alien species are considered the second largest threat to biodiversity, immediately after the direct destruction of natural habitats.

The Environmental Protection Act defines the invasive alien species as a species whose introduction or spreading poses a threat to biodiversity or human health or causes economic damage. The alien species is a non-native species that usually does not exist in a certain ecosystem but it has arrived or can arrive there by its deliberate or accidental introduction. The allochthonous, non-native, non-indigenous, exotic, introduced or alien species – all those terms represent synonyms for a foreign species.



The ecological influence of the invasive alien species is expressed in a number of different manners. Thus the invasive alien species take up the space of the indigenous plants, use water and nutrients, change habitat conditions, structure and composition of communities, secrete substances that have negative impact on the growth and development of other indigenous plants and interbreed with the indigenous species. In addition, they change the environment, disturbing the stability of an ecosystem, they harm forest and water ecosystems, irreversibly influencing the composition of natural habitats and causing socio-economic damage in agriculture, forestry, tourism, cattle breeding, healthcare and elsewhere. Invasive alien species take the indigenous species' food and shelter and transmit various diseases to them.

The direct influence of the invasive species on human health is significant. The most obvious example of such influence is the ragweed, whose pollen is extremely allergenic and causes allergies in many people.

Today, the control of the invasive species and the decrease of their influence on the indigenous species and entire ecosystems represents a major challenge related to nature conservation. Unfortunately, an invasive alien species can almost never be eradicated from the habitat through which it had spread, except on islands and limited strips of land, as the action is mostly uneconomical. Thus, the early-stage detection of the presence of a potentially invasive alien species within the ecosystem is important, while the urgent measures for the control of its spreading and the eradication are often the only efficient measures that can be taken against such species.



4. Prescribed obligations related to conservation of forest biodiversity

Conservation of forest biodiversity is an important segment of the global policy of biodiversity conservation in general, as well as European and Croatian. On the other hand, forestry as an economy branch belongs to a range of trades that have key influence on the biodiversity, together with the agriculture, hunting, fishing, tourism and transport. Although forest ecosystems represent a framework for an extraordinary wealth of living world, the daily practice of forest management often seriously endangers and diminishes that wealth.

Starting from 1990s, the conservation of forest biodiversity became an important segment of forestry policies; in Croatia, such obligation is prescribed by *the Forest Act*. The law requires the alignment of forest management with the forest management plans that include the conservation and enhancement of the biological and landscape diversity of forests. This means that all forest owners have to abide by the following:

- ▶ conserve the natural composition of a forest, maintaining indigenous species
- ▶ increase the lifespan of economically important tree species where the necessary conditions are met and the need exists
- ▶ prefer indigenous species while selecting species for the artificial regeneration of forest stands and the rehabilitation of the degraded stands
- ▶ avoid the logging of preserved, rare and endangered tree species and forest fruit trees, as well as protect them and introduce them while rehabilitating a forest
- ▶ during the logging, a necessary number of old, hollow and rotten trees must be maintained, respecting a pattern and number that conserves the biodiversity
- ▶ the treatment of forests and logging have to be done in a manner that does not cause permanent damage to the ecosystem and the measures for the improvement and the conservation of the biodiversity have to be taken



- ▶ the type and manner of using different resources in the growing of forests and their exploitation and protection have to be adjusted to the specificities of the habitat and the species
- ▶ during the planning, the construction and the maintenance of forest infrastructure (roads, forest firebreaks, turning points, lay-bys, bridges, etc.) the damage to the forest habitat has to be minimalised, taking into account the care about the special geological, vegetational, hydrologic and other values, as well as special care about the ecologically extremely valuable parts such as constituents of the ecology network: rare and endangered habitat types, migration corridors of rare, vulnerable or endangered species.

All forests of the nature conservation areas are protected as special purpose forests. In addition, for the management of forests in national parks an obligation of creating and implementing a special *Forest protection programme* is prescribed. The public has to be given an insight into the proposal of such programme by the public institution that manages the national park.

The conservation of nature especially includes the conservation of rare forest communities, i.e. the rare and endangered forest habitat types. *The Ordinance on sorts of habitat types, habitat maps, endangered and rare habitat types and on measures for conservation of habitat types* prescribes special measures aimed at the conservation of the endangered and rare forest habitat types. The measures, bearing their respective designations, are the following:

- 121** the forest management should be done in line with the principles of forest certification;
- 122** during the final cutting of larger forest surface areas, smaller surfaces shall be left uncleared of trees wherever possible and appropriate;
- 123** forest management shall be executed in such a manner as to preserve forest clearings (meadows, pastures, etc.) and forest edges to the maximum extent;
- 124** within the context of forest management it is necessary to ensure the extension of the cutting maturity of native types of trees with respect to the physiological lifetime of individual species and the health condition of the forest community;
- 125** the use of chemical agents for plant protection and biological control agents in forest management shall be avoided, together with the use of genetically modified organisms;
- 126** biological species significant for the habitat type shall be preserved; foreign (allochthonous species and genetically modified organisms shall not be introduced);

Did you know?

Out of the total forest area in Europe, roughly covering 166.3 million hectares, as much as 5.1 to 11.9 million hectares are protected due to biodiversity, while the additional 17.3 million hectares are protected due to landscape diversity. In line with the EU Biodiversity Strategy to 2020, the 7th EU's Environment Action Programme and the EU Forest Strategy, the EU committed itself to include the conservation of biodiversity in forest management, to rehabilitate at least 15% of the degraded ecosystems and to ensure and prove by 2020 that all EU's forests are managed in line with the principles of the sustainable forest management.



Forest soil

Forest soil abounds with life. It encompasses the roots of higher trees, a part of the animal kingdom, as well as fungi and bacteria that break down the dead plant and animal matter. Forests have a crucial role in the preservation of the ground, protecting it from drying out and degradation, as well as the sliding and erosion. The soil erosion washes out the surface layer and the nutrients contained within, so the soil left behind becomes barren. Forests reduce and slow down erosion by their tree crowns, branches, root systems and fallen leaves.



- 127** it is necessary to ensure a permanent percentage of mature, old and deadwood (either lying or standing) in all forests, especially trees with holes;
- 128** in forest management, to ensure an appropriate care for the conservation of endangered and rare wild taxa, as well as the monitoring of their condition;
- 129** afforestation, where permitted by habitat conditions, shall be carried out with native tree species in a composition reflecting the natural composition and using nature-friendly methods; the afforestation of non-forest surface areas shall be carried out in places where it is justified, under the condition that non-forest and rare habitat types are not threatened.



5. Forest biodiversity in Plitvice Lakes National Park

Classification of forest ecosystems of Plitvice Lakes National Park

The special geographic position and specific geomorphological and climatic characteristics of the Plitvice Lakes National Park contributed to the creation of a number of natural phenomena and the rich biodiversity. Despite the proximity to the Mediterranean climate zone, the predominant climate in the Park is the moderate continental climate. It is a consequence of the position of the Velebit massif, which serves as a climatic barrier between the coastal region and Lika highlands. The very combination of the geographical, geological and climatic characteristics ensured the appearance and the development of the diverse forest communities of the Park. These communities change their typical composition, size and the appearance of colours and shapes over the seasons, each of them dominating in a certain period of a year.

The recent research of the phytocenological characteristics of the Plitvice Lakes National Park's forest ecosystems³³ established 13 forest communities in the form of forest associations, with the beech and beech-fir associations further divided into 9 sub-associations and variants.

The association of beech with giant deadnettle (*Lamio orvalae-Fagetum* (Ht. 1938) Borhidi 1963) is the most common forest association in the Park, spreading from the shores of the lakes to some 700 m.a.s.l. The second most common is the Dinaric beech-fir forest (*Omphalodo-Fagetum* (Tregubov 1957) Marinček et al. 1993), occupying areas higher than 700 m.a.s.l., comprising more than 250 species. The area of beech-fir forests is also home to two significant relict forest associations: the silver pine forest with black hellebore on dolomite (*Helleboro nigri-Pinetum sylvestris* Ht. 1958) and spruce forest with white sedge on dolomite (*Carici albae-Picetum* H. Mayer et al. 1967). In addition to the above forest communities, other communities are present not as often, but having no less importance, including:

³³ research conducted in 2013 by University of Zagreb Faculty of Forestry; researchers J. Vukelić. & I. Šapić



- ▶ Hop hornbeam with winter heath (*Erico herbaceae-Ostryetum* Ht. 1938 1956),
- ▶ Hop hornbeam forest and thicket with autumn moor grass (*Seslerio autumnalis-Ostryetum carpinifoliae* Ht. et Hič in Ht. 1950)
- ▶ Common beech and black hellebore forest (*Helleboro nigri-Fagetum* Zukrigl 1973) and

Beech forest with giant deadnettle (*Lamio orvalae-Fagetum* (Ht. 1938) Borhidi 1963) • within the scope of Plitvice Lakes National Park, this association can be found within “Medveđak” forest reserve, in the areas of Bačinovice, Riječice, Javornik, Plitvički klanac, the eastern part of Bršljanovica and the northern sides of Homoljačko polje and Brezovac. The association is located at the continental side, occupying the area between 400 and 800 m.a.s.l. and abounding in species. The common beech (*Fagus sylvatica*) dominates the tree layer, which also includes the sycamore (*Acer pseudoplatanus*), the Norway maple (*Acer platanoides*), the common ash (*Fraxinus excelsior*) and the wych elm (*Ulmus glabra*). The shrub layer consists of the meze-reon (*Daphne mezereum*), the spurge laurel (*Daphne laureola*), the red elderberry (*Sambucus racemosa*), the common holly (*Ilex aquifolium*), the alpine honeysuckle (*Lonicera alpigena*), the fly honeysuckle (*Lonicera xylostemum*), the broad-leaved spindle-tree (*Euonymus latifolius*) and other species. The lush understory abounds in species typical of Illyrian beech forests: the giant deadnettle (*Lamium orvala*), the hacquetia (*Hacquetia epipactis*), the henbane bell (*Scopolia carniolica*), the blue-eyed Mary (*Omphalodes verna*), the carnian spurge (*Euphorbia carniolica*), the large-flowered calamint (*Calamintha grandiflora*), etc.; it is also a home to species present in most European beech forests: the sweetscented bedstraw (*Galium odoratum*), the wood sanicle (*Sanicula europaea*), the baneberry (*Actea spicata*), the wood sedge (*Carex sylvatica*), the common lungwort (*Pulmonaria officinalis*), the wood anemone (*Anemone nemorosa*), the Turk’s cap lily (*Lilium martagon*), the dog’s mercury (*Mercurialis perennis*), the yellow archangel (*Lamium galeobdolon*), etc.

Beech-fir forest (*Omphalodo-Fagetum* (Tregubov 1957) Marinček et al. 1993) • within the scope of Plitvice Lakes National Park, this association can be found in Kik and Cigulj areas, the vicinity of Seliški vrh, the SW side of Veliki Javornik, in Gluhe Drage, Ciganska dolina, Kriva and Sužanjska Draga, Crni vrh and elsewhere. The silver fir (*Abies alba*) and the common beech (*Fagus sylvatica*) prevail in the tree layer, with the stable presence of the European spruce (*Picea abies*).

The shrub layer consists of the black elder (*Sambucus nigra*), the spurge laurel (*Daphne laureola*), the mezereon (*Daphne mezereum*), the buckthorn (*Rhamnus alpinus* ssp. *fallax*), the alpine honeysuckle (*Lonicera alpigena*), while the herbaceous plants layer in addition to the



prevailing faetal species features the elements of the *Aremonio-Fagion* association (*Omphalodes verna*, *Aremonia agrimonoides*, *Cardamine enneaphyllos*, *Cardamine trifolia*, *Cyclamen purpurascens*, *Euphorbia carniolica*, *Lamium orvala*) etc.

Spruce forest with black hellebore on dolomite (*Helleboro nigri-Piceetum* (Horvat 1958) · Trinajstić et Pelcer 2005) the spruce forest with black hellebore can mostly be found in the SE part of the Plitvice Lakes National Park in the Visibabe massif and south of Babin potok settlement in the area of Kriva draga. The fragments of the above association can also be found in other parts of the Park, e.g. in Sartuk and at the entrance to Čorkova uvala. The tree layer is primarily composed of mixed stands of the European spruce (*Picea abies*) and the silver fir (*Abies alba*), but observing smaller portions of the area, we can see that one of the two species often dominates. The shrub layer is dominated by the spruce and the silver fir, followed by the meze-reon (*Daphne mezereum*), the fly honeysuckle (*Lonicera xylosteum*), the common beech (*Fagus sylvatica*) and the common hazel (*Corylus avellana*), some buckthorn (*Rhamnus alpinus* ssp. *fallax*) and the common whitebeam (*Sorbus aria*) and rare specimens of the common juniper (*Juniperus communis*), the wayfaring tree (*Viburnum lantana*), etc. Due to specific ecological conditions, the association comprises, on one hand, the dolomite substrate species, such as the white sedge (*Carex alba*), the black hellebore (*Helleborus niger*), the common hepatica (*Hepatica nobilis*), the fingered sedge (*Carex digitata*), the common hedgenettle (*Betonica officinalis*), the big-flowered foxglove (*Digitalis grandiflora*), while on the other hand it is a home to acidophilous species dominant in other spruce or other acidophilous associations of the layer, such as the woodrush (*Luzula luzulina*), the wall hawkweed (*Hieracium murorum*), the round-leaved bedstraw (*Galium rotundifolium*), the common gypsyweed (*Veronica officinalis*), the eagle fern (*Pteridium aquilinum*) and other species.

Silver pine forest with black hellebore on dolomite (*Helleboro nigri-Pinetum sylvestris* Ht. 1958) · within the scope of Plitvice Lakes National Park, this association can be found at higher altitudes in Kriva draga on the other side of Babin potok, while Crni vrh with 1000 m.a.s.l. represents the highest point reached by the association. The Scots pine (*Pinus sylvestris*) prevails in the botanical composition of the tree layer, while the black pine (*Pinus nigra*) is somewhat scarcer; the understory abounds in the black hellebore (*Helleborus niger*), the winter heath (*Erica herbacea*), the silky broom (*Genista sericea*), the dwarf sedge (*Carex humilis*), the hellebore (*Helleborus multifidus*), the bedstraw (*Galium lucidum*) and other species.

Hop hornbeam with winter heath (*Erico carnea-Ostryetum carpini-foliae* (Horvat 1938) 1959) · within the scope of Plitvice Lakes National



Park, this association appears in fragments adjacent to Kozjak lake, in the hop hornbeam thickets on the upper slopes of Korana river canyon and at the Pogledalo location on the SE side of Crni vrh. The tree layer is dominated by the hop hornbeam, while the Bosnian maple (*Acer obtusatum*), the South European flowering ash (*Fraxinus ornus*) and the common whitebeam (*Sorbus aria*) can often be seen. The shrub layer comprises same species, with the addition that the area surrounding Kozjak lake abounds in the European smoketree (*Cotinus coggygria*). The prevalent species of the understory is the winter heath (*Erica herbacea*), followed by the white sedge (*Carex alba*), the hawkbit (*Leontodon incanus*), the ground virginsbower (*Clematis recta*), the wall germander (*Teucrium chamaedrys*), the common hedgenettle (*Betonica officinalis*), the bloody crane's-bill (*Geranium sanguineum*) and other xerophytes.

Hop hornbeam forest and thicket with autumn moor grass (*Sesleria autumnalis-Ostryetum carpinifoliae* Ht. et H-ić in Ht. 1950) • within the scope of Plitvice Lakes National Park, this association spreads on the both sides of Korana river canyon, as well as on the S and SW slopes of Lisina. The floristic composition of the association is diverse, with elements of the sub-Mediterranean forests featuring the downy oak with the hop hornbeam and the Oriental hornbeam and followed by the continental forests of beech and sessile oak. The hop hornbeam (*Ostrya carpinifolia*) is the dominant species, with the South European flowering ash (*Fraxinus ornus*) and the Bosnian maple (*Acer obtusatum*) appearing almost as often, while the downy oak appears only sporadically. The shrub layer comprises the thermophilic plants: the warty euonymus (*Euonymus verrucosa*), the checker tree (*Sorbus torminalis*), the wayfaring tree (*Viburnum lantana*), in addition to the mesophilic forest species such as the wild cherry (*Prunus avium*) and the field maple (*Acer campestre*), as well as species growing on forest edges, such as the Cornelian cherry (*Cornus mas*), the common hawthorn (*Crataegus monogyna*), the old man's beard (*Clematis vitalba*), etc. The understory comprises the autumn moor grass (*Sesleria autumnalis*), the black bryony (*Tamus communis*), the blue sedge (*Carex flacca*), the maidenhair spleenwort (*Asplenium trichomanes*), the bastard agrimony (*Aremonia agrimonoides*), the Alpine cyclamen (*Cyclamen purpurascens*), the common primrose (*Primula vulgaris*), the creeping charlie (*Glechoma hirsuta*), etc.

Common beech and black hellebore forest (*Helleboro nigri-Fagetum* Zukrigl 1973) • This association can be found in the SW part of the Plitvice Lakes National Park, growing on rendzina and calcocambisol soils on the dolomite substratum, which is the prerequisite for its existence. It is recognised by the following species: the white sedge (*Carex alba*), the giant deadnettle (*Lamium orvala*), the Bolander's reedgrass (*Calamagrostis varia*) and the fingered sedge (*Carex digi-*



tata), with the appearance of the wood fescue (*Festuca altissima*), the sweetscented bedstraw (*Galium odoratum*), the Alpine cyclamen (*Cyclamen purpurascens*), the Solomon's seal (*Polygonatum multiflorum*), the early dog violet (*Viola reichenbachiana*), etc. Those forest stands within the Plitvice Lakes National Park are the only ones in Croatia and they are excluded from the forest management.

Virgin forest Čorkova uvala · this famous forest is one of the best preserved virgin forests within the ecosystem of beech-fir forest associations in Plitvice Lakes National Park. Covering the area of 84 ha and situated at an altitude from 860 to 1028 metres, it displays all developmental phases of a virgin forest, with prominent maturing and decaying phases. The height attained by fir, spruce and beech trees is especially astonishing. According to its structure and specificities, Čorkova uvala is classified as a secondary virgin forest with occasional anthropogenic influence, mild enough so the virgin forest doesn't lose its authenticity. As such, Čorkova uvala was proclaimed a special reserve of forest vegetation in 1965.

Flora and fauna of forest ecosystem of Plitvice Lakes National Park

In addition to showcasing an abundant forest flora, the forests of Plitvice Lakes National Park are home to a number of animal species, with a large and stable population of owls and woodpeckers as recognised quality indicators in a forest ecosystem. When it comes to carnivores and other large mammals, the Park is inhabited by the brown bear, the wolf and the lynx, as well as the red deer, the roe deer and other species.

Within the boundaries of the park, there are interesting areas that are home to numerous species. Primarily, they encompass a narrow area adjacent to the lakes, virgin forest Čorkova uvala, Ljeskovačka bara bog, Rudanovac and Vrelo settlements – and represent the most significant and the most valuable areas of the Park besides the lakes, from hydrographic, environmental and botanical perspectives. These areas are of utmost importance when it comes to both plant and animal biodiversity.

The great diversity and the presence of relict, endemic, rare and protected species, the large number of which is listed in The Croatian Red book of threatened vascular plants and the IUCN's Red list of threatened plant species, make the park a very valuable floristic area, not only in Croatia, but in Europe and the world.

Within the park, 25 endemic plant species and subspecies have been identified, among which the endemic species described in this area





The grassy bells



The lady's-slipper orchid

for the first time are of special importance: the grassy bells (*Edraianthus tenuifolius*), the ranunculus (*Ranunculus scutatus*) and the meadow squill (*Scilla litardierei*) – the species abundantly represented within the moist valley meadows in the park. The lady's slipper orchid (*Cypripedium calceolus*) stands out as the most beautiful orchid in Europe⁴. The Siberian rocket (*Ligularia sibirica*) deserves special attention as a species listed in the IUCN Red List – in the category of endangered species. Plitvice Lakes National Park is the only site where it can be found in Croatia and the entire SE Europe. It can be found at two locations in the Park, within the moist valley meadows.

Carnivorous plants are especially interesting dwellers of the Park. The round-leaved sundew (*Drosera rotundifolia*) grows on the boggy (peaty) habitats in the park. Because of the rarity of these habitats, it is one of the rarest plants of Croatian flora. Within the wet valley meadows of the park it is common to encounter the common butterwort (*Pinguicula vulgaris*) – a rare carnivorous plant from the IUCN's Red List in the category of vulnerable species. The small bladderwort (*Utricularia minor*), a very rare aquatic carnivorous plant, was also recorded in this area.

The bird fauna, comprising 157 recorded species so far, ranks third on the scale of Croatian national parks when it comes to the number of species present. The white-throated dipper is especially interesting as a rare bird, dependent on clean aquatic habitats.

Plitvice Lakes National Park is home to more than 50 mammal species, including the dormouse, the shrew, the vole, the hedgehog, the pine marten, the beech marten, the wild boar, etc. The latest research established the existence of 20 bat species. Wolf, roe deer, deer, wild cat, lynx, otter and brown bear populations are of special interest as the crown animals of Plitvice Lakes' animal kingdom.

⁴ as a rare and endangered species of forest areas, it is listed in the Croatian Red book of threatened vascular plants and the IUCN's Red list of threatened plant species.



6. Natura 2000 forest habitats in Plitvice Lakes National Park

Natura 2000 ecological network and conservation of forest biodiversity

Natura 2000 ecological network is the key concept and form of strategic conservation of nature in the EU Member States. It is intended for conservation of more than thousand rare, threatened or endemic animal and plant species, as well as some 230 natural and semi-natural habitats. It currently encompasses more than 26 106 habitats, covering over 18 % of the territory of the 28 EU Member States.

In line with *The Government Order on the Ecological Network*, Plitvice Lakes National Park is included in the Natura 2000 ecological network as a unique area coded: #HR5000020. This Natura 2000 area includes one sclerophyllous maquis type and seven typical forest habitat types (Table 1) as targeted forest types.

Table 1 Types of forest habitats in line with Natura 2000 in the Plitvice Lakes National Park

TARGETED HABITATS (in line with <i>The Habitats Directive, Annex I</i>)	
Natura 2000 code	Habitat name
5130	<i>Juniperus communis</i> formations on heaths or calcareous grasslands
91K0	Illyrian <i>Fagus sylvatica</i> forests (<i>Aremonio-Fagion</i>)
9410	Acidophilous <i>Picea</i> forests of the montane to alpine levels (<i>Vaccinio-Piceetea</i>)
91R0	Dinaric dolomite Scots pine forests (<i>Genisto januensis-Pinetum</i>)
9180*	<i>Tilio-Acerion</i> forests of slopes, screes and ravines
91L0	Illyrian oak-hornbeam forests (<i>Erythronio-Carpinion</i>)
91M0	Pannonian-Balkanic turkey oak-sessile oak forests
91E0*	Alluvial forests with <i>Alnus glutinosa</i> and <i>Fraxinus excelsior</i> (<i>Alno-Padion</i> , <i>Alnion incanae</i> , <i>Salicion albae</i>)

* priority species and priority habitat types



The description of the Natura 2000 forest habitat types

Juniperus communis formations on heaths or calcareous grasslands Natura 2000 code 5130 • the common juniper (*Juniperus communis*) stands may develop on the acidic soil of heaths or on the substrate of calcareous grasslands which are no longer used for pasture. In Croatia, such habitats can be found in Lika (Plitvice and Sabor-sko) and in Gorski kotar (field of Lič), developed on the abandoned pastures. Since the pastures are in belts and comprise various communities, from sub-Mediterranean to continental, they are connected only by the *Juniperus communis*.



The common heather (*Calluna vulgaris*)



The German greenweed

When it comes to the valuation using the Standard Data Forms (the SDF valuation), the habitat type of the *Juniperus communis* stand on the acidic or alkaline substrate in the Plitvice Lakes National Park was ranked as follows: in line with the representativity criteria – A = excellent value; in line with the criteria related to the degree of conservation of the structure and functions of the habitat type – B = well preserved; in line with the criteria of the value of the site for conservation of the habitat type – B = good value.

Pannonian-Balkan turkey oak–sessile oak forests Natura 2000 code 91MO • sub-continental thermo-xerophile forests of turkey oak and sessile oak of the Pannonian region and Northern Balkans hilly and



Figure 7 The common juniper stand on a deserted pasture



lower mountainous region. They occupy the area between 250 and 600 (800) m.a.s.l. on various substrates: limestones, andesites, basalt, loess, clay, sand, etc. on slightly acidic, usually deep brown soils.

Plants specific for the habitat comprise: *Quercus petraea*, *Q. ceris*, *Q. fraineto*, *Q. dalechampii*, *Acer tataricum*, *Ligustrum vulgare*, *Euonymus europaeus*, *Festuca heterophylla*, *Carex montana*, *Poa nemoralis*, *Potentilla alba*, *Tanacetum corymbosum*, *Campanula persicifolia*, *Digitalis grandiflora*, *Lychnis viscaria*, *Lathyrus niger*.

The measures defined in the *Plitvice Lakes National Park management plan* related to the habitats of the Pannonian-Balkan turkey oak-sessile oak forests (91MO) include the preservation of the distinctive properties of the habitat and the favourable habitat conditions for the development of the thermophilic forest of sessile oak with black pea, in a manner that they should be left to their natural development besides the maintenance works on the visitors infrastructure.

Illyrian *Fagus sylvatica* forests (Aremonio-Fagion) Natura 2000 code 91K0 • beech forests of the Dinarides and of associated ranges and hills, reaching the SE Alps and the mid-Pannonian hills, where they are in contact with, or interspersed among, medio-European beech forests. Unlike the Central

European beech forests, the species diversity is greater in the beech forests of the Dinarides, constituting an important centre of species diversity. Plants specific for the habitat comprise: the common beech



The common beech – the leaf, the flower and the fruit (illustration)



The sweetscented bedstraw (*Galium odoratum*)



The giant deadnettle



The bastard agrimony

(*Fagus sylvatica*), the Bosnian maple (*Acer obtusatum*), the hop hornbeam (*Ostrya carpinifolia*), the silver fir (*Abies alba*), the silver linden (*Tilia tomentosa*), the three-leaved anemone (*Anemone trifolia*), the bastard agrimony (*Agrimonia agrimoes*), the large-flowered calaminth (*Calamintha randiflora*), the Alpine cyclamen (*Cyclamen purpurascens*), the common primrose (*Primula vulgaris*), the hacquetia (*Hacquetia epipactis*), the giant vetch (*Vicia oroboides*), the giant deadnettle (*Lamium orvala*), etc.

When it comes to the SDF valuation, the habitat type of the Illyrian *Fagus sylvatica* forests in the Plitvice Lakes National Park was ranked as follows: in line with the representativity criteria – A = excellent value; in line with the criteria related to the degree of conservation of the structure and functions of the habitat type – A = excellent value; in line with the criteria of the value of the site for conservation of the habitat type – also

A = excellent value.

Acidophilous *Picea* forests of the montane to alpine levels (*Vaccinio-Piceetea*) Natura 2000 code 9410 · Sub-alpine and alpine conifer forests dominated by the European spruce (*Picea abies*). Plants specific for the habitat comprise: the European spruce, the European blueberry (*Vaccinium myrtillus*), the mountain cranberry (*Vaccinium vitis-idaea*), etc.

When it comes to the SDF valuation, the habitat type of the Acidophilous *Picea* forests of the montane to alpine levels was ranked as follows: in line with the representativity criteria – A = excellent value; in line with the criteria related to the degree of conservation of the structure and functions of the habitat type – A = excellent value; in line with the criteria of the value of the site for conservation of the habitat type – also A = excellent value.

Dinaric dolomite Scots pine forests (*Genisto januensis-Pinetum*) Natura 2000 code 91R0 · Silver pine (*Pinus sylvestris*) forests of dolomites and dolomite rendzinas of the Dinarides, developed within the Illyrian beech forest zone (91K0) and often occupy somewhat higher elevations than the similar dolomite black pine forests. Plants specific for the habitat comprise: the silver pine, the winter heath (*Erica herbacea*), the broom (*Genista januensis*), the common columbine (*Aquilegia vulgaris*), the dwarf sedge (*Carex humilis*), branched St Bernard's lily (*Anthericum ramosum*), the shrubby milkwort (*Polygala chamaebuxus*), the common hepatica (*Hepatica nobilis*), the black hellebore (*Helleborus niger*), etc.



When it comes to the SDF valuation, the habitat type of the Dinaric dolomite Scots pine forests was ranked as follows: in line with the representativity criteria – A = excellent value, in line with the criteria related to the degree of conservation of the structure and functions of the habitat type – A = excellent value; in line with the criteria of the value of the site for conservation of the habitat type – also A = excellent value.

Tilio-Acerion forests of slopes, screes and ravines Natura 2000 code 9180* • mixed forest of maple, ash, elm and linden on rocky soils particularly on calcareous, but also on siliceous substrates. A distinction can be made between one grouping which is typical of cool and humid environments (hygroscopic and shade tolerant forests), dominated by the sycamore (*Acer pseudoplatanus*) and another, typical of dry, warm screes and generally dominated by lindens (*Tilia platyphyllos*, *Tilia cordata*) Plants specific for the habitat comprise: *Acer pseudoplatanus*, *Actaea spicata*, *Fraxinus excelsior*,



The spruce – the shoot, the cone, the fruit (illust.)



The European blueberry (*Vaccinium myrtillus*) (illust.)



The silver pine – the shoot, the cone, the fruit (illust.)



The broom (*Genista januensis*)



The sycamore – the leaf, the flower and the fruit (illust.)



The large-leaved linden (*Tilia platyphyllos*) (illust.)

Helleborus viridis, *Lunaria rediviva*, *Taxus baccata*, *Ulmus glabra*, *Tilia cordata*, *Tilia platyphyllos*.

When it comes to the SDF valuation, the habitat type of the forests of slopes, screes and ravines in the Plitvice Lakes National Park was ranked as follows: in line with the representativity criteria – B = good value; in line with the criteria related to the degree of conservation of the structure and functions of the habitat type – A = excellent value; in line with the criteria of the value of the site for conservation of the habitat type – also A = excellent value.

Illyrian oak-hornbeam forests (*Erythronio-Carpinion*) Natura 2000 code 91L0 • forests of turkey oak or pedunculate oak, sometimes even sessile oak and hop hornbeam on both calcareous and siliceous bedrocks, mostly on deep neutral to slightly acidic brown forest soils, with mild humus. They spread throughout the SE-Alpine-Dinaric region, West and Central Balkans, extending northwards to Lake Balaton, mostly in hilly regions. These forests are intermediate between oak-hornbeam forests (9170) of Central Europe and those of the Balkans that reach northwards to the Pannonian oak woods (91G0); they have a much higher species richness than the Central European oak forests. Plants specific for the habitat comprise: *Quercus robur*, *Q. petraea*, *Q. cerris*, *Carpinus betulus*, *Acer tataricum*, *Tilia tomentosa*, *Castanea sativa*, *Euonymus verrucosa*, *Lonicera caprifolium*, *Adoxa maschatelina*, *Asperula taurina*, *Dianthus barbatus*, *Tamus communis*, *Luzula forsteri*, etc.

When it comes to the SDF valuation, the Illyrian oak-hornbeam forests habitat type in the Plitvice Lakes National Park was ranked as follows: in line with the representativity criteria – A = excellent value; in line with the criteria related to the degree of conservation of the structure and functions of the habitat type – A = excellent value; in line with the criteria of the value of the site for conservation of the habitat type – B = good value.

Alluvial forests (*Alno-Padion*, *Alnion incanae*, *Salicion albae*) Natura 2000 code 91E0* • riparian forests of *Alnus glutinosa* and *Fraxinus excelsior* and of temperate and Boreal Europe, spreading from lowland (*Alno-Padion*) to the hilly region (*Alnion incanae*). This group also comprises arborescent galleries and forests of willows (*Salix alba*, *S. fragilis*) and the black poplar (*Populus nigra*). All types occur on soils periodically inundated by the annual rise of the river (or brook) level, but otherwise well-drained and aerated during low-water. Plants specific for the habitat comprise: *Alnus glutinosa*, *Alnus incana*, *Fraxinus excelsior*, *Populus nigra*, *Salix alba*, *Salix fragilis*, *Ulmus glabra* (in the tree layer),



while in the shrub layer there are *Angelica sylvestris*, *Cardamine amara*, *Cardamine pratensis*, *Carex acutiformis*, *Carex pendula*, *Carex remota*, *Equisetum telmateia*, *Filipendula ulmaria*, *Geum rivale*, *Galium palustre*, etc.

When it comes to the SDF valuation, the habitat type of the alluvial forests of Plitvice Lakes National Park was ranked as follows: in line with the representativity criteria – B. = good value. In line with the criteria related to the degree of conservation of the structure and functions of the habitat type – B = good value; in line with the criteria of the value of the site for conservation of the habitat type – B = good value.

Did you know?

The Red Books are publications presenting collective data on threatened species, i.e. taxa; their goal is the identification of the threatened taxa, establishing of the degree and cause of their endangerment with the purpose of determining the priority measures for their conservation. The first Red Books were published some 50 years ago and so far 76 000 species have been evaluated with respect to the risk of their extinction.

The Red List comprises the list of threatened species in Croatia with the corresponding categories designated in line with the IUCN Criteria. So far, Red Lists for 17 taxonomic groups have been published in Croatia, as well as the Croatian Red Book of Cave Fauna.



The sessile oak – the leaf, the flower and the fruit (illust.)



The hop hornbeam – the leaf, the flower and the fruit (illust.)



- 5. The black pine (a detail)
- 6. The black hellebore (*Helleborus niger*)
- 7. The South European flowering ash (a detail)





1. A beech forest
2. The giant deadnettle (*Lamium orvala*)
3. The silver fir (a detail)
4. The blue-eyed Mary (*Omphalodes verna*)



8. The autumn moor grass (*Sesleria autumnalis*)

9. The common butterbur (*Petasites hybridus*)

10. The Syberian rocket (*Ligularia sibirica*)



8



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- 11. The brown bear (*Ursus arctos*)
 - 12. The grey wolf (*Canis lupus*)
 - 13. The Eurasian otter (*Lutra lutra*)
 - 14. The pygmy owl (*Glaucidium passerinum*)
 - 15. The peregrine falcon (*Falco peregrinus*)
 - 16. The alpine salamander (*Salamandra atra*)



The guidelines for conservation of forest biodiversity in the Plitvice Lakes National Park

The following guidelines should be taken into account with respect to conservation of forest biodiversity in the Plitvice Lakes National Park:

- ▶ the dynamics of forest ecosystems should be identified and monitored as the basis for the adoption of detailed management measures resting on the continuous research and monitoring of the forest ecosystems; the monitoring should be precise and intense and it has to include the entire ecosystem, in line with all its elements⁵.
- ▶ collecting information related to the effects of the air pollution and other agents causing damage to forest ecosystems with the purpose of better understanding of the causal relations within forests should represent an important goal of forest monitoring.
- ▶ the current state of Natura 2000 areas with respect to protected and endangered species should be evaluated in cooperation with the Croatian Agency for Environment and Nature (HAOP)⁶; based on the findings, further monitoring of the protected and vulnerable species should be conducted.
- ▶ forestry journal should be kept with the data on the natural phenomena, the type and scope of damage to the forest, the status and the changes of the flora and fauna, the scientific research and other important occurrences.
- ▶ an integrated protection of forest ecosystems should be implemented, including the monitoring of the forest soil with respect to its natural condition and in relation to the protection of the tufa and the tufa-forming communities by monitoring their state and ensuring the adequate quantity and quality of water.
- ▶ the Plitvice Lakes management plan has to include action plans for the conservation of forest biodiversity, resting on the following sets of guidelines:

⁵ The International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forest – ICP Forests) was launched in 1985 under the Working Group on Effects of the Convention on Long-range Transboundary Air Pollution of UN/ECE (CLRTAP); the Republic of Croatia participates in the ICO forest programme since 1987 and the research of the damage done to the Plitvice Lakes National Park have been initiated in 2000 and are still continuously conducted.

⁶ It assumed all functions of the former Environmental protection agency (AZO) and the State Institute for Protection of Nature (DZZP) starting from 1 January 2019 The HAOP organisationally belongs to the Ministry of Environmental Protection and Energy (MZOE).



- **the guidelines for supporting the forest ecosystem development close to nature** in order to ensure the natural species composition and their natural self-renewal, the preservation of diverse age structure of the trees, the conservation of the diversity of the under-story and shrub layer, leaving the deadwood (dead trees) etc.
- **the guidelines for conserving the less frequently occurring habitat types** in forest ecosystems, such as grassland areas within forests, puddles, quagmires, bogs, etc.
- **the guidelines for species-specific requirements** arising from the relevant regulations and programmes related to the conservation of the endangered flora and fauna species and the protection of bird species, including the marking and protection of important micro locations, the establishment of quiet zones, suspending the major works during the seasons important for certain species, etc.
- **the guidelines for special measures and restrictions** concerning the approach and the visits to forest complexes of high biological value, such as special zoological reserves, etc.
 - ▶ In case of a mass appearance of tree pests, the protection of trees should be conducted based on the measures ordered by the competent authorities and in line with the *Forest protection programme*.
 - ▶ In order to maintain the safety of the visitors/users, the preventive controls of trees adjacent to the roads and the visitor infrastructure should be conducted and corrective measures (e.g. salvage harvesting) should be taken in line with the *Forest protection programme*.
 - ▶ the access to all forests has to be ensured, regardless of their ownership status, especially in areas where breeding and sanitary actions have to be taken with the purpose of improving the health and stability of forest ecosystems.
 - ▶ the education should be encouraged with the goal of better understanding and raising awareness about the role and importance of the forest biodiversity; educational points/stations describing topics related to the forests and the forestry should be erected.

It is important to mention that the protection, the preservation and the conservation of natural and other values of the protected areas are conducted based on international conventions, the Environmental Protection Act, the National Strategy and Action Plan for the Protection of Biological and Landscape Diversity of Croatia (NSAP) and other regulations and programmes.

The abundance and the diversity of forest habitat types is protected in line with the measures listed above, but especially through the implementation of the NSAP via the programmes and projects conducted by the Ministry of Environmental Protection and Energy (MZOE) and its agencies.



As stated above, the conservation of the biodiversity of forest ecosystems is done in line with the Environmental Protection Act, the Forest Act and other regulations.

The monitoring of forest ecosystems as the basis for the conservation of forest biodiversity in Plitvice Lakes National Park has not yet been established.

The lack of systematic collection of the data on forest ecosystems limits the possibilities of both the competent authorities and the Public Institution to establish the causes and trends and conduct integrated measures of the protection of forests in the Plitvice Lakes National Park.

Despite the systematic collection of data on numerous plant and animal species within the scope of the HAOP's activities through the National system for biodiversity monitoring, the handbook on the inventarisation and monitoring of forest biodiversity in protected areas has not been drafted yet. This means that the monitoring elements are not defined, that the methods are not standardised and that the operational monitoring system is not established. These are the prerequisites in planning the conservation activities i.e. In the preparation and implementation of action plans for the protection of endangered species and habitat types. Only the integration of the systematic scientific research and the monitoring will enable the efficient protection of the biodiversity of forest ecosystems, which is equally important for the preservation of the positive status of the targeted species and habitat types in Natura 2000 forest areas and for the management of forest ecosystems with respect to dessication, salvage harvesting, meadows and pastures keeping, etc.

When it comes to the conservation of the ecological network in the Plitvice Lakes National Park, it has to be mentioned that the management of each NATURA 2000 area has to ensure the permanent survival of the targeted species and habitat types – those that are the reason why that area was included in the network in the first place. This means that harmful activities that might significantly disturb a species or decrease the quality of a habitat because of which the area was selected should be avoided within a NATURA 2000 area. It equally means that the necessary positive measures should be taken, where necessary, with the goal of preserving and renewing a favourable status of the habitat and the species in their natural ranges. There are no general and/or unique rules for achieving a favourable preservation status of a species or a habitat; the manners depend on the specificities of each area and should take into account the changeable outside factors and the dynamics of ecological systems.



Conservation of biodiversity of private forests in Plitvice Lakes National Park

Regardless of a relatively small share of privately-owned forests in the Plitvice Lakes National Park, the preservation of the forests' numerous functions, especially those related to the conservation of the extraordinary biodiversity of forest ecosystems, rests on the equal encompassing of all forests – both state-owned and privately-owned – by the measures for protection and preservation of forests.

Forests cover 22 308 ha of the National Park's area, with 96.18 ha of those forests being privately-owned. Pursuant to *the Forest Act*, all forests of the nature conservation areas are protected as special purpose forests, not taking into account the form of their ownership. In line with that, the owners of both state and private forests in the area of Plitvice Lakes National Park do not manage those forests with respect to timber harvesting. Only under extraordinary circumstances (such as fires, insect infestations, tree damage due to snow, ice or wind, etc.) the forest owners have to conduct the appropriate activities in cooperation with the competent authorities.

When it comes to the obligation of conserving the forest biodiversity, the *Forest Act* binds all forest owners and/or forest holders equally, regardless whether they are the governmental of private holders of the ownership or holding rights or whether they are legal or natural persons. This is certainly justified, as only such approach guarantees the equally efficient protection of the entire forest complex of specially protected and the most valuable forest areas, i.e. of all forest systems of such areas.

In that sense, the *Forest Act* states that the state-owned forest administration company Hrvatske šume and private forest owners shall manage their forests taking into account and improving the biodiversity and landscape diversity of their forests, as well as the protection of the forest ecosystem:

- ▶ conserve the natural composition of a forest, maintaining indigenous species
- ▶ increase the lifespan of economically important tree species where the necessary conditions are met and the need exists
- ▶ the location and structure of artificially established stands should encourage the protection and restoration of natural forests and not increase the pressure on them
- ▶ in cases of the artificial afforestation and the renewal of the degraded stands, use the autochthonous specie based on

Virgin forest Čorkova uvala

Čorkova uvala is a virgin forest of beech and fir situated within the boundaries of Plitvice Lakes National Park; protected in 1965 as a special forest vegetation reserve; it encompasses the area of 75 hectares at an altitude from 860 to 1028 metres, covering all developmental phases of this area's virgin forest. Virgin forests are often called "schools of nature" because they provide the opportunity to understand the life cycle of an ecosystem (which may last up to 500 years), starting with the creation and ending with its decay and the self-regeneration. In order to facilitate the studying of the forest community development, virgin forests are almost always specially protected forest areas, mostly in the form of special reserves of forest vegetation.



the their overall appropriateness for the habitat's conditions and management goals

- ▶ use only those imported species, provenance or varieties whose influence on the ecosystem, the genetic integrity of the autochthonous species and the local provenance has been assessed by experts and whose negative influence cannot be avoided or decreased; avoid the logging of preserved, rare and endangered tree species, forest fruit trees and trees with berries, as well as protect them and introduce them while rehabilitating a forest,
- ▶ take care of other species belonging to an ecosystem that depend on dead and rotten trees, i.e. ensure that during the logging a necessary number of old and deadwood is maintained, respecting a pattern and number that conserves the biodiversity,
- ▶ support the traditional forest management system on appropriate habitats that forms a valuable ecosystem, when economically feasible,
- ▶ establish a comprehensive monitoring in order to review trends of negative processes in forests that are threatened by drying and natural disasters,
- ▶ the treatment of forests and logging have to be done in a manner that does not cause permanent damage to the ecosystem and the measures for the improvement and the conservation of the biodiversity have to be taken,
- ▶ the type and manner of using different resources in the growing of forests and their exploitation and protection have to be adjusted to the specificities of the habitat and the species,
- ▶ forest farming, utilisation and protection, as well as the construction and upkeep of forest infrastructure have to be aligned with the protection of soil and water with respect to avoiding harmful influences on the quality and quantity of springs and accumulations and the free movement of the surface and ground waters.

The Environmental Protection Act prescribes that a forest protection programme containing measures for the protection of forest ecosystems should be adopted for all protected areas in categories of strict reserves and national parks. In so doing, the public institution managing the protected area develops and implements the programme of preservation and protection of forests, which is made in line with the regulations relevant for forest management.

The Plitvice Lakes National Park management plan strictly forbids timber harvesting and other works related to forest property management in private forests located in the most strictly protected zones. It is suggested that private forest property in the most strictly pro-



tected zones should be bought out or the adequate financial compensation to such forest owners should be given on the grounds of unrealised gains.

Privately-owned forests situated in the most strictly protected zone, the active protection zone and the zone of use must have, in line with *the Forest Act*, the valid *Forest management programme* and use it in the management of privately-owned forests, including the implementation of biodiversity protection measures.

Under the circumstances when there are no relevant legally valid Forest management programmes for privately-owned forests, it is possible to designate trees suitable for logging under the *Regulation on the conditions and criteria for the approval of the necessary scope marking for trees in the private forests*.

A special attention has to be paid to the EU's financial support for forest owners that might be given to the owners of the forests located in the protected areas under suitable conditions. Such payments include, *inter alia*, the compensations for the unrealised gains arising from the fact that the forest owner adheres to the instructions and management rules set out in the EU regulations, strategies and programmes. The forest owner may gain the right to additional payments if he accepts the forest management criteria that exceed the legally set "good practice" in forestry. This may refer to planting the autochthonous tree species in ratios which naturally occur in the forests of an area. The payments are defined with respect to the size of an area for periods of 25–30 years, and the beneficiary of the funds is obligated to conduct certain measurements and monitoring, e.g. with respect to the conservation of biodiversity.

Education on forest ecosystems of Plitvice Lakes National Park

Complex ecological relations related to forests provide various benefits for humans, while their conservation and favourable condition directly contribute to a long-term nature conservation. A deeper understanding of these relations is crucial for preservation of the extraordinary biological value of forests, as well as for creation of a series of possibilities of their sustainable use. Thorough informing and education related to the specificities, the significance and the role of forests is the initial step of gaining such an understanding. The education strives to achieve the effects that are achieved through interactive communication with the participants of the education at the authentic forest locations, while educational programmes intended for children of the pre-school and school age are recognised as especially valuable. More precisely, it is considered that the sensory expe-

This is important to know!

The forests of Plitvice Lakes National Park constitute a complex mosaic of forest types and conditions necessary for the survival of numerous flora and fauna species. Concerning the specific requirements of certain species, especially birds, the Plitvice Lakes National Park has to support the dynamic approach to the forest management in order to ascertain which management type is suitable for achieving the favourable condition of the preservation of individual species, based on the research into forest structure and the species requirements. Sometimes the decrease of forestry-related activities in order to make an area return to "as natural as possible" state is not the best option.





Figure 8 Participants of the “Get to know your national park and be a ranger for a day” programme

rience related to spending time in nature and in forests makes possible for children to truly experience the nature that surrounds them, more than any other form of education. A special form of learning aimed at better understanding of forests throughout the world, especially in the protected areas, is the popular “forest classroom”, where education is conducted in the form of expert talks and workshops at original locations, during which the methods of observing the prepared forest materials are combined with practical exercises, drawing, writing, talking and presenting, etc.

For a past couple of years, similarly to global and national education formats, Plitvice Lakes National Park organises one-day educational events for pupils from local elementary schools called “Get to know your national park and be a ranger for a day”. One of the goals of the programme is explaining the forest ecosystems and raising awareness about the importance of preservation of forests through learning about the cycling of water in nature and the role of forests in the conservation of the lake system.

Educational programmes represent one of the most important components of the interpretation in the protected areas as they address the paramount need to educate the public, especially the local inhabitants and the young people about the importance of those areas; thus they are the key for maintaining the entire concept of protected areas.

The second equally important form of education about forest ecosystems is learning via educational trails. Plitvice Lakes National Park features a system of forest educational trails intended for learning about the abundance, the diversity and the structure of the park’s forest ecosystems. The model included the renewal of the trails and the existing forest paths and their connecting to the existing system of trails and walkways in the lakes zone. The first such trail system was the one in forest ecosystem Čorkova uvala, based on the two educational trails: the 21 km long Čorkova uvala trail and the 9 km long Plitvica trail. Each of these trails has multiple points with informational boards related to the specific characteristics of the forests. Due to their routes, the length and the features of the terrain that have to be conquered during their use, these trails also have a recreational aspect.



Taking into account the extraordinary role and the importance of forests for the conservation of the entire lake system and the importance of the transfer of knowledge about forest ecosystems, the trail leading to Tupi Medveđak summit was built back in 1894 for the visitors of Plitvice Lakes. The trail is meticulously intertwined with the scenery, as a proof of great attention that had already then been given to the protection of the area from which an unforgettable panoramic view of a part of Plitvice Lakes and the entire area between Mala Kapela and Lička Plješivica unfolds.

The main characteristic of the today's Medveđak trail, which is of equal mountaineering, recreational and educational value, is that it connects the Medveđak's tops overgrown by old beech forests left to their natural development. Such a free development comprises the key prerequisite for the diversity and abundance of plant and animal species inhabiting the area around the trail, especially of the species that are rare and endangered due to decreasing number of such habitats on a global scale.

In order to enhance the experience and facilitate the sightseeing for the visitors, brochures containing the basic information on the trails were printed.



Figure 9 A view of the lakes from the Medveđak hiking trail

7. Forest biodiversity – an information service

A brief glossary

alien species: a non-native species that usually does not exist in a certain ecosystem but it has arrived there by its deliberate or accidental introduction.

allochthonous species: a species which has been introduced to a certain habitat, in which it had not been present before, from another habitat.

anthropogenic factor: a term describing all states in the nature (mostly negative) occurring as a consequence of human actions and/or poor management.

areal: the area of natural expansion of certain plant or animal species or groups.

autochthonous species: a species originating from the habitat in which it thrives.

biocenosis: a biological community, i.e. a community of living organisms (plants and animals) inhabiting a certain area and persisting in some form under certain ecological conditions.

biological equilibrium: a quantitatively more or less stable ratio among various plant and animal species of an area.

biodiversity: a term used in biology and ecology in order to describe the overall diversity of life on Earth; it is the variety of all living organisms present in various ecosystems, including the diversity within species, diversity among species and biological communities, as well as diversity among ecosystems.

bog: an area on the peat ground, often marshy and contained within a forest, featuring specific marshland plants.

brief rotation: a period between two logging interventions in the same uneven-aged stand. It applies to the uneven-aged forests (the uneven-aged logging) and represents a time-interval in which the same type of logging is applied to all parts of a forest (economic unit), after which the logging starts from the same position again. This time interval usually lasts for 10 years.

brush: it appears as a further degradation of the thicket, having the outside bushy appearance similar to the thicket; the brush layer is characterised by various species of primarily heliophilic shrubs (brush) and low undergrowth, while forest trees are either rare or don't exist there at all.

canopy cover: the degree to which the forest soil is covered by canopy.

classification of stands: expresses a degree of quality (higher or lower) of a forest stand; designated with Roman numerals from I to V, with V being the worst grade.

clearcut logging: logging of all trees in a certain area (large and small areas).

compartment: the smallest permanent unit of spatial division of forests; a permanent basic unit of economic division of forests within the framework of an economic unit. Compartments are established with the purpose of easier management, monitoring and orientation in the field.



The size of a compartment cannot exceed 60 hectares, except in the case of unstocked forest production areas, thickets, brush areas and garrigues.

degradation: gradual decreasing or losing of a characteristic; the decrease of forest habitat's quality, making it unfavourable for inhabitation by a certain plant and/or animal species.

designation: selecting and marking trees for logging.

diameter at breast height: a tree diameter at the height of 1.30m.

ecological network: a system of mutually connected or spatially close ecologically significant areas that substantially contribute to the conservation of natural balance and biodiversity with their balanced biogeographical distribution.

ecological niche: the entirety of all environmental factors necessary and responsible for the existence of an organism in a certain habitat.

ecology: a science on the system of nature, on the composition and functioning of nature; science on the interactions and the mutual influence of living organisms and their biotic and abiotic environment.

economic unit: in forestry economics, it represents a unit of surface for which a management study is being made; the forests of a certain area (a community of stands) summed in an economic unit which is being managed in a unique manner and for which the etat and the forest-breeding works are separately defined.

ecosystem: a dynamic complex of plant, fungus, animal and microorganism communities and their non-living environment interacting as a functional unit.

ecosystem services of forests: term designating various products, services and functions the forest ecosystems provide for meeting the demand for upkeep and enrichment of human lives.

endangered species: a species that faces a certain probability that it would become extinct in the wild in the near future; there are various criteria that define a species as endangered. According to the IUCN (the International Union for Conservation of Nature), a species is endangered:

- if it had encountered or it is estimated that its population would be reduced by at least 50 % over the last 10 years or three generations
- if the extent of occurrence is estimated to be less than 5000 km²
- if a population is estimated to number less than 2500 mature individuals with the estimated continuing decline of at least 20 % within five years or two generations
- if a population is estimated to number less than 250 mature individuals and if quantitative analysis shows the probability of extinction in the wild is at least 20 % within 20 years.

endemic species: a species that appears in a very restricted geographical area. Within the meaning of the Habitats Directive, the term primarily applies to species restricted to an area of a single Member State that do not appear outside the EU.

environmental protection: a set of activities and measures aimed at preventing threats for the environment, preventing the damages or the pollution of the environment, decreasing or elimination of the environmental damage and recovery of the environment to a state prior to the damage.

etat: the allowed volume of trees to be logged annually in a certain forest area; expressed as annual or for every 10 years.

even-aged forest stand: a stand comprised of trees of same species of roughly equal age, height and diameters at breast height.

evergreen forest: a plant community of evergreen coniferous trees that usually does not shed needles.

extinct species: species that lived in the past and have no living representatives today.

fauna: a total of all animal species, the entire animal world, unlike the plant world (flora).

flora: the entire plant world, unlike the animal world (fauna).

favourable conservation status: is defined as a state in which the following conditions are met:

- population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats



- the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future
- there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

forest: is the forest soil overgrown with forest trees, shrubs and other plants, where the wooden matter and other goods are permanently produced and the balanced relations exist between the biocenosis and the habitat; a forest consists of forest stands.

forest grazing: allowing the cattle to feed, graze and eat acorns in forests and on forest land in order to feed the cattle.

forest roads: a primary network of permanent forest roads intended for mechanised transport of wood products.

forestry: the science, craft and art of managing and preserving forests and habitats, i.e. the forest ecosystem as a whole, for permanent societal, environmental and economic benefit.

garrigue: a community of low scrubs that develops on a dry, rocky substrate as a degraded type of the Mediterranean maquis; another term is phrygana; *Cistus* sp. commonly grows within that community.

green infrastructure: a multifunctional network of protected and other natural and man-made areas and other landscapes of high ecological and environmental value, which improve the ecosystem services.

habitat: a place where an animal or a plant lives, which fulfils the life conditions of the species; a term used for a joint influence of the climate, the soil, the relief and living creatures.

hygrophyte: a plant adapted to the conditions of habitats with abundant moisture.

intervention into nature: a temporary or permanent human activity that can disturb the natural balance in case that activity is not conducted with the purpose of preservation and conservation of nature.

introduction to nature: a deliberate or accidental settling or introduction of a species or a subspecies into an ecological system of an area in which it did not exist before.

invasive taxon: a taxon introduced into an area in which it does not occur naturally, and in which it is capable of sustaining a population without human or any other intervention, i.e. an alien species that represents a threat to biodiversity due to its settlement or expansion.

landscape: a part of space the character of which is the result of the interaction between natural and/or human factors

landscape diversity: a spatial structure of natural and man-made landscape components (biological, ecological, geological, geomorphological and cultural values).

logging intensity: a ratio between the logged trees (wood mass) and the total wood mass in an area shown as a percentage.

logging roads: a secondary network of forest roads as temporary construction objects intended for skidding logs using tractors.

low stump forests: forests consisting of trees sprouted from tree stumps.

maquis: evergreen thicket characteristic for the Mediterranean region, mostly consisting of xeromorphic shrubs.

mixed forest stands: stands that comprise a tree species with the addition of other tree species which exceed a 10 % share.

monitoring: observing the state of the environment through systematic measuring of the quality of environmental components (air, soil, water) and the systematic measuring of natural and other phenomena.

monoculture: in forestry, it denotes breeding of a single species on a relatively large area in a long period of time; as the culture cultivated is not changed, ecological conditions change in time (e.g. the acidic and eroded soil, a deficiency of certain mineral substances, pest and diseases infestations, etc.), thereby causing the biodiversity decline and the poorer vitality of such forest.

National park: a spacious, predominantly unchanged terrestrial and/or marine area with extraordinary and multiple natural values, covering one or more conserved or negligibly altered natural ecosystems, with the primary purpose of conserving the original natural values.



nature conservation: human actions aimed at conserving the unchanged (or modified to the least extent) parts of nature or processes necessary for life of ecological communities (biocenoses), of ecosystems and natural landscapes.

neophyte: a plant species that is not autochthonous in a geographical region, but recently introduced to an area.

phytocenosis: it consists of various plant species in a habitat, uniformly associated based on distinct living conditions.

population: a group of spatially, temporally and ecologically connected individuals of a same species.

protected area: a clearly defined area that is managed with the purpose of permanent conservation of its nature, the ecosystem services it provides and the pertaining cultural values, in a manner prescribed by the law or another efficient manner.

pure forest stands: stands in which at least 90 % of the trees in the main canopy are of single species.

ratio: a percentage of tree species in a stand, usually expressed as volume shares of tree species.

Ramsar area: a wetland area of international importance protected under the Ramsar Convention – the international treaty on the protection of wetland habitats (1971).

Red List of threatened species: a catalogue comprising a list of rare plant and animal species and of the species threatened by extinction compiled in line with the IUCN classification (IUCN – the International Union for Conservation of Nature) on a national and/or global level.

regular forest: a forest comprising even-aged forest stands.

stand: a part of a forest that differs from the adjacent communities in the forest with respect to tree species, their origin, manner of breeding, age, developmental stage and the characteristics of the habitat.

rotation: a term related to even-aged forest stands, representing a period starting with the formation of the stand and ending with the logging of all trees in the stand and the successful rejuvenation.

seed plants (spermatophytes): all or nearly all trees within a stand developed from seed, while the

stand is generatively rejuvenated on regular basis.

shrubs: woody plants for which it is impossible or nearly impossible to differentiate between the trunk and the crown, usually less than 5 m high.

site: a geographically defined area with clearly specified borders.

skidding: a mechanised transport of wood products from the harvesting site to a landing.

stump forest: a low breeding type of forest in which most trees grew from tree stumps.

sub-compartment: the smallest unit of forest management; usually represents a stand and is not a permanent division unit; a sub-compartment is a temporary smallest basic unit of the economic division of a forest within a compartment, which is the subject of separate management, like a stand. The size of a sub-compartment cannot be less than a hectare.

succession: primary succession encompasses spreading to an entirely new habitat which has never been colonized before, while the secondary succession refers to the renewal of previously destroyed plant communities.

sustainable development: the development of the society which as basic criteria includes environmental, economic and social and cultural sustainability, and which through the aim of improving the quality of life and meeting the needs of the present generation respects the same ability of future generations to meet their own needs and enables long-term conservation of environmental quality, geodiversity, biological diversity and the landscape.

sustainable management: exploitation of forest resources in a manner which satisfies current needs, but which also leaves enough for future generations.

taxon: a term introduced during the Linnean era with the purpose of easier orientation in the plant classification, usually denoting the species and the classification units (taxa) of a higher and lower rank.

thicket: the first degradation stage in a continental forest. It is a low stump forest under a permanent anthropogenic influence with shrub-sha-



ped trees and abundant undergrowth. It reaches a maximum of 2 metres.

trees: wooden plants consisting of clearly visible trunk and crown, which can grow at least 5-8 metres high.

uneven-aged forests: forests with stands that comprise trees of all ages; in such forests, the trees in the same area are of various different heights, breast diameters and ages, and their regeneration is natural. The appearance of the

entire area of an uneven-aged stand is uniform. **increment:** the increase of a tree's dimensions within a given time; e.g. increase in diameter, growth or volume.

virgin forest: a forest that had been developing without an organised human influence, exclusively under the influence of natural factors; in a more restricted sense it designates tropical rainforests.

Did you know?

- according to scientists' estimates, at least 10,000 species become extinct each year. This period is considered the sixth mass extinction in the history of planet Earth.
- the most endangered species are proclaimed strictly protected by the Environmental Protection Act. After the Red Book is made, it serves as a sort of expert grounds which helps in the protection of an endangered species, taking into account other aspects, such as economic or cultural.



Ecologically important dates

2 February	World Wetlands Day
21 March	International Day of Forests
22 March	World Water Day
22 April	Earth Day
22 May	International Biodiversity Day
22 May	Croatian Nature Conservation Day
24 May	European Day of Parks
5 June	World Environment Day
8 June	Croatian Day of Mountain Nature Protection
16 September	International Day for the Preservation of the Ozone Layer
26 September	World Day of Clean Mountains
4 October	World Animal Day
11 December	International Mountain Day

Did you know?

- The International Day of Forests is marked for the past 40 years, on the first day of spring, the 21 March. Each year on that day, various celebrations, educational events and activities are organised around the world with the purpose of raising the awareness about the benefits, the beauty and the overall importance of forests for the human and animal survival.
- Forests represent an important component of national and nature parks; in Croatia, we can enjoy numerous national parks – Risnjak, Northern Velebit, Mljet, Plitvice Lakes and Krka, as well as nature parks Papuk, Žumberak-Samoborsko gorje, Lonjsko polje, Medvednica, Kopački rit, Velebit and Biokovo, which pride themselves on their well-preserved forests.
- Forest conservation is a forestry branch that deals with detecting and identification of external phenomena and the agents causing damage to forest ecosystems. It encompasses research and prescribing measures for the prevention and suppression of damage that are implemented through a series of diverse actions and related to all kinds of forestry activities.



small forest clearings and bogs



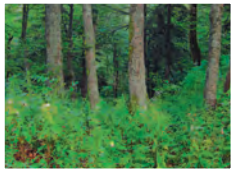
endangered and protected animal species



dead-wood and rotten trees



protected tree species



abundant ground vegetation layer

rare and endangered habitats



diverse forest edges



decaying tree



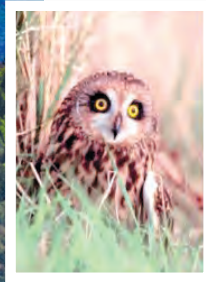


old stands with no human influence and rare forest communities

fungi



dry trees with active nests



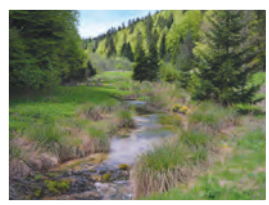
endangered bird species



forest fruit trees



autochthonous trees of various species and age



standing waters and open brooks



rare, endangered and endemic species



Sources

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**PLITVIČKA
JEZERA**
Nacionalni park
National Park



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Plitvice Lakes National Park
inscribed on the World
Heritage List in 1979